Advanced Water Purification Facility Study Report

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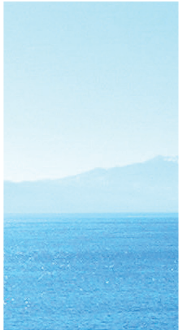

CITY OF SAN DIEGO

Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility

THE CITY OF SAN DIEGO

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AWP Facility Study Report

Acknowledgements

This Advanced Water Purification (AWP) Facility Study Final Report summarizes the results of the City of San Diego's AWP Facility Study, conducted as part of the City's multi-faceted Water Purification Demonstration Project (Demonstration Project) to evaluate the feasibility of indirect potable reuse through reservoir augmentation to provide safe and reliable water for San Diego. The combined contributions of the project team, regulatory agency representatives, Independent Advisory Panel members, and local stakeholders were invaluable completing this project. This page recognizes the efforts of participants that contributed substantially to this effort.

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Abbreviations, Acronyms, and Glossary

Abbreviations and Acronyms

Ace-K	acesulfame-k
ADI	acceptable daily intake
AWP	advanced water purification
AWP Facility	advanced water purification facility
Basin Plan	Water Quality Control Plan for the San Diego Basin
Bay-Delta	Sacramento-San Joaquin Bay-Delta
BDCM	bromodichloromethane
CDPH	California Department of Public Health
CEC	constituent of emerging concern
CIP	clean in place
City	City of San Diego
cm	centimeter
CTR	California Toxics Rule
CWA	Clean Water Act
DBCM	dibromochloromethane
DCS	distributed control system
DEET	N,N-diethyl-meta-toluamide
C	Celsius
Demonstration Project	Water Purification Demonstration Project
DLR	CDPH detection limit for reporting
DP	distribution panel
DWEL	Drinking Water Equivalent Level
DWR	California Department of Water Resources
EDR	electrodialysis reversal
EEO	electrical energy per order
ENR	Engineering News Record
EPA	U. S. Environmental Protection Agency
ft^2	square feet
gfd	gallons per day per square foot
gpm	gallons per minute
H_2O_2	hydrogen peroxide
HAA5, Total	Haloacetic Acids
HMI	human machine interface
HP	horsepower
HVAC	heating, ventilating, and air conditioning
I&C	instrumentation and controls
IAP	Independent Advisory Panel
in^2	square inches
IPR	indirect potable reuse
IPR/RA	indirect potable reuse/reservoir augmentation
IRWM	Integrated Regional Water Management
KV	kilovolts
KVA	kilovolts-amperes
kW	kilowatt
kWh	kilowatt-hours
kWh/d	kilowatt-hours per day
kWh/yr	kilowatt-hours per year

L	liter
LPHO	low pressure high output
LRL	laboratory reporting level
LSI	Langelier Saturation Index
MCL	maximum contaminant level
MDL	method detection limit
MF	microfiltration
m	meter
MCC	motor control center
MG	million gallons
mg/L	milligrams per liter
mg/L-N	milligrams per liter as nitrogen
mg/L-P	milligrams per liter as phosphorus
mgd	million gallons per day
mL	milliliter
mL/min	milliliters per minute
min	minute
mJ/cm^2	millijoules per square centimeter
MPN	most probable number
mV	millivolt
µg/L	micrograms per liter
µg/L-P	micrograms per liter as phosphorus
µS/cm	microsiemens per centimeter
N/A	not applicable
North City	North City Water Reclamation Plant
ND	not detectable or not quantifiable
NDEA	N-Nitrosodiethylamine
NDMA	N-Nitrosodimethylamine
ng/L	nanograms per liter
NL	notification level
NPDES	National Pollution Discharge Elimination System
NR&C	Natural Resources and Culture Committee
NTU	Nephelometric Turbidity Units
O&M	operation and maintenance
ORP	oxidation reduction potential
pCi/L	picocuries per liter
PLC	programmable logic controller
Point Loma	Point Loma Wastewater Treatment Plant
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
psi	pounds per square inch
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
Q1	Quarter 1
Q2	Quarter 2
Q3	Quarter 3
Q4	Quarter 4
QA/QC	quality assurance/quality control
RA	Reservoir Augmentation
Regional Board	San Diego Regional Water Quality Control Board
RfDs	Reference Doses

RO	reverse osmosis
SDG&E	San Diego Gas & Electric
SDI	silt density index
SIP	State Board Policy for Implementation of Toxics Standards for Inland Surface Water, Enclosed Bays, and Estuaries of California
South Bay	South Bay Water Reclamation Plant
State Board	State Water Resources Control Board
STD	standard deviation
T&M Plan	Testing and Monitoring Plan
TCEP	tris (2-chloroethyl) phosphate
TCPP	tris (1-chlor-2-propyl) phosphate
TDI	tolerable daily intake
TDS	total dissolved solids
THMs	trihalomethanes
Title 22	Title 22 of California Code of Regulations
TOC	total organic carbon
UCMR	Unregulated Contaminant Monitoring Rule
UF	ultrafiltration
UV	ultraviolet light
UV254	UV 254 Absorbance
UVT	ultraviolet light transmittance
VOC	volatile organic compound
Water Authority	San Diego County Water Authority
WSE	water surface elevation

Glossary

1, 4- Dioxane: A chemical contaminant primarily used as an industrial stabilizer to enhance performance of solvents in manufacturing processes. Commonly used in food and food additives or in personal care products such as cosmetics, deodorants, soaps and shampoos. Currently there is not a federal or state MCL; however, the CDPH has established a notification level of 1 ppb. CDPH also specifies in the 2011 Draft Groundwater Recharge Reuse Regulations that AOP systems required for direct injection applications can be designed to achieve 0.5 log removal of 1,4-dioxane. Alternatively, AOP sizing can be based on demonstrated log removals of select indicator compounds from different functional groups.

Advanced Oxidation: A set of chemical treatment processes designed to destroy organic material through the breakdown of their molecular structure. The advanced oxidation process used at the AWP Facility employs ultraviolet light and hydrogen peroxide, which break down into natural elements, such as carbon, hydrogen and nitrogen.

Advanced Water Purification Facility (AWP Facility): A facility that produces purified water by utilizing advanced treatment technologies: membrane filtration (microfiltration [MF] or ultrafiltration [UF]), reverse osmosis (RO), disinfection, and advanced oxidation.

Advanced Water Purification (AWP) Facility Study: One element of the multi-faceted Demonstration Project. The AWP Facility Study included two primary elements: (1) the design, installation, and operation of a one million gallon per day (mgd) Demonstration Facility located at North City and (2) a conceptual design and cost estimate for a potential Full-Scale Facility.

Advanced Water Purification (AWP) Facility Study Report: Final report documenting the observations and findings of the AWP Facility Study.

Analyte: a chemical substance that is the subject of chemical analysis.

Backwash: The process of reversing the direction of flow through a filtration system in order to remove contaminants that had been filtered out in a water purification process, e.g. membrane filtration. The backwash process is necessary in order to maintain the treatment capacity of membrane filtration.

Bacteriophage: Viruses present among coliform bacteria. Have a high presence in wastewater.

Ballast: An electronic device on the UV system designed to generate a constant UV intensity and maximize UV lamp life.

Blending: Mixing or combining one water source with another such as purified water with raw water sources.

California Groundwater Recharge Reuse Draft Regulations: The November 21, 2011 Groundwater Recharge Reuse Draft Regulations, which are used as a guidance document for the conceptual design of the Full-scale Facility since regulations for reservoir augmentation with purified water do not yet exist. Also referred to as the draft groundwater recharge regulations.

Clean in place: The in-situ chemical cleaning of membranes that consists of soaking membranes in one or more chemical solutions (typically acid and caustic solutions) to remove accumulated foulants and restore permeability.

Concentrate: A continuous waste stream, typically containing concentrated dissolved solids, from the membrane process.

Constituent: In water, a constituent is a dissolved chemical element or compound or a suspended material that is carried in the water.

Constituents of Emerging Concerns (CECs): CECs are not regulated and include commonly used pharmaceuticals, personal care products, flame retardants and unregulated pesticides.

Contaminant: An organic or inorganic substance found in the water. Some contaminants have a health effect in people consuming the water, and thus is regulated in drinking water. Not all contaminants are unsafe. Iron and manganese are contaminants, but in excess simply causing staining. See Maximum Contaminant Level.

Critical alert limit: Measurement of a critical limit parameter that requires urgent corrective action in order for the corresponding critical control point to function as intended.

Critical control point: A point or step within the AWP Facility process train at which critical limit parameters can be monitored in order for corrective actions to be taken should critical alert limits be exceeded.

Critical limit parameter: A parameter that indicates whether or not a control measure is within the alert limit or critical alert limit for the corresponding critical control point.

Demonstration Facility: The one-mgd advanced water purification facility that was designed, installed, and operated as part of the City's Water Purification Demonstration Project.

Detection limit for the purposes of reporting (DLR): The DLR is a parameter that is set by regulation for each reportable analyte. It is not laboratory-specific and it is independent of the analytical method used (in cases where several methods are approved). The DLR cannot be changed by the laboratory. It is expected that a laboratory can achieve a reporting limit that is lower than or equal to the DLR set by the California Department of Public Health (CDPH).

Disinfection: The removal, inactivation or destroying of microorganisms present in a water supply that may be harmful to humans. Commonly used disinfectants include chlorine (and its derivatives), ultraviolet (UV) light, and ozone. Chlorine and its derivatives are used to disinfect drinking water because they provide residual disinfection that protects the water as it goes through the pipes to homes and businesses.

Disinfection byproduct: A compound that is formed through the reaction of a disinfectant (chlorine, ozone, chlorine dioxide, hydrogen peroxide) with organic or inorganic material present in the water. Some disinfection byproducts have been found to be harmful to human health and are regulated by the EPA or under consideration for future regulation.

Drinking water: Water that meets federal drinking water standards as well as state and local water quality standards so that it is safe for human consumption. Water treatment facilities that produce drinking water require a state permit. Also referred to as potable water.

Drought: A defined period of time when rainfall and runoff in a geographic area are much less than average.

Endocrine disrupting compounds (EDCs): A chemical substance or mixture that alters the normal hormone functions in humans and animals. These chemicals can come from pharmaceuticals and personal care products such as detergent and synthetic hormones. They may also come from some industrial wastes and pesticides. EDCs are also contained in natural agricultural products such as soybeans, alfalfa, and natural hormones in animals.

Effluent: The water leaving a water or wastewater treatment process or facility. If effluent has been treated to a high enough standard, it may be considered to be recycled water and can be used for beneficial purposes.

EEO-electrical energy per order: The amount of energy required to destroy 1 log order (i.e. 90%) of a given contaminant per 1000 gallons of water treated. EEO values are both reactor and water quality specific and used to baseline differences in reactor configurations and UV lamp intensities to establish comparative removals of a given constituent such as NDMA and 1,4- dioxane.

Environmental Impact Statement / Environmental Impact Report (EIS/EIR): Detailed analysis of impacts of a project on all aspects of the natural and human environment. An EIS is required by the federal National Environmental Policy Act (NEPA) for federal permitting or use of federal funds. An EIR is required by the California Environmental Quality Act (CEQA) for local projects.

Filtrate: A continuous stream of water that passes through a filter.

Filtration: A process that separates small particles from water by using a porous barrier to trap the particles and allow the water to pass through.

Flux: The unit rate at which water passes through the membrane expressed as flow per unit of membrane area (e.g., gallons per square foot per day (gfd)).

Fouling: The accumulation of contaminants on the membrane surface, within membrane pores, or media surface that inhibits the passage of water.

Full-Scale Facility: The proposed AWP Facility for the full-scale IPR/RA project. The Full-Scale Facility will have a capacity of 18 mgd and annual average purified water production of 15 mgd.

Groundwater recharge: Naturally or artificially adding water back into a groundwater basin.

Hydrogen peroxide: Chemical added in the UV disinfection/advanced oxidation step.

Imported water: A water source that originates in one hydrologic region and is transferred to another hydrologic region. In San Diego's case, water is imported from Northern California or the Colorado River and travels to this region in large above ground aqueducts or underground pipelines.

Imported raw aqueduct water: The raw imported water conveyed to the City's three water treatment plants for treatment prior to being introduced into the City's drinking water distribution system. For the AWP Facility Study, imported raw aqueduct water specifically refers to the imported water that was sampled at the Miramar Water Treatment Plant, per the Testing and Monitoring Plan.

Indicator Compounds or Indicator Organisms: A common method to evaluate water or wastewater quality using representative chemicals or organisms that are characteristic of a larger group of related chemicals or organisms. Coliform bacteria are common indicator organisms, and trihalomethanes, benzene, and NDMA are examples of indicator compounds.

Indirect potable reuse (IPR): The process of blending purified water into a natural water source (groundwater basin or reservoir) that can be used as a source of drinking water.

Influent: Flow entering a process.

Inorganic chemicals: Inorganic chemicals are substances that do not contain both carbon and hydrogen. Generally, inorganic chemicals are minerals. Most minerals are not a cause for concern in water. Water contains many natural minerals from the rocks the water has come into contact with on its journey to the water treatment plant. Nutrients, such as phosphorus and nitrogen, and metals, such as calcium, iron, sodium, potassium, and zinc, are inorganic chemicals. Some inorganic chemicals, when they are too abundant, are considered contaminants in water.

Integrity monitoring: Performance evaluation of a treatment process in order to verify that the process meets its intended treatment performance on a continuous basis.

Laboratory reporting level (LRL): The lowest concentration at which an analyte can be quantified and reported with an acceptable degree of accuracy. Laboratory reporting levels can vary based on the analytical method used, the laboratory, and the concentration being tested.

Maximum Contaminant Level (MCL): The highest allowable amount of a contaminant in drinking water mandated by the Safe Drinking Water Act, established by the U.S. Environmental Protection Agency as a regulatory standard.

Membrane filtration: A type of filter used to separate particles from the water. Membrane filters are characterized by the pore openings size from the largest to the smallest pore size: microfiltration, ultrafiltration, and nanofiltration. Membrane filters remove suspended solids, bacteria, protozoa, and other material from water.

Method detection limit (MDL): The lowest concentration at which an analyte can be detected in a sample and reported with greater than 99 percent certainty using a particular analytical method.

Microfiltration (MF): A low-pressure membrane filtration process where tiny, hollow straw-like membranes separate small suspended particles, bacteria and other materials out of the water. MF provides the most efficient preparation of water for reverse osmosis. MF is used in commercial industries to process food, fruit juices and soda beverages; in computer chip manufacturing; and to sterilize medicines that cannot be heated.

Micron: Equal to one-millionth of a meter or 1/25,400 of one inch. The eye can see particles only to about 40 microns. Used to describe the size of bacteria.

Non detectable and non quantifiable (ND): Laboratory sample results of a constituent reported as less than the laboratory reporting level or method detection limit (MDL).

Nitrosodimethylamine (NDMA): A semi-volatile, yellow, oily liquid of low viscosity that has been extensively used in industry for several decades (USEPA, 2001). NDMA is found at low levels in numerous items of human consumption including cured meat, fish, beer, and tobacco smoke. Currently there is not a federal or state MCL; however, the CDPH has established a notification level of 10 ng/L. Until revision of the Draft Groundwater Recharge Reuse Regulations in 2011 CDPH required that AOP systems required for direct injection applications be designed to achieve 0.5 log removal of 1,4-dioxane and 1.2 log removal of NDMA.

Non-potable water: Water that is not suitable for drinking because it has not been treated to drinking water standards.

North City Water Reclamation Plant (North City): Wastewater treatment plant that produces recycled water through a series of processes: primary treatment (screening and sedimentation), secondary treatment (aeration and clarification), and tertiary treatment (filtration and disinfection).

National Pollutant Discharge Elimination System (NPDES): A federal permit authorized by the Clean Water Act, Title IV, which is required for discharge of pollutants to navigable waters of the United States, and includes any discharge to surface waters: lakes, streams, rivers, bays, the ocean, wetlands, storm sewer, or tributary to any surface water body.

Organic chemicals: Chemicals that contain both carbon and hydrogen. There are millions of organic compounds, both naturally occurring and man-made. Naturally occurring organic compounds include amino acids (the building blocks of proteins), sugars, fats, hormones, and vitamins. All living matter is made up of natural organic chemicals. Synthetic (manmade) organic chemicals have been developed because they exhibit features that are valuable to us. These synthetic organic chemicals include herbicides, insecticides, pharmaceuticals, food coloring and flavors, personal care products, dyes, paints, adhesives, detergents, polymers, and plastics.

Osmotic pressure: The amount of pressure that must be applied to stop the natural osmosis-driven flow of water across a semi-permeable membrane.

Oxidation: A treatment step often used in disinfection, where chlorine, hydrogen peroxide, ozone, or another oxidizing agent is added to water to produce a chemical reaction that removes or aids in removal of harmful substances.

Pathogens: Disease-causing organisms. The general groupings of pathogens are viruses, bacteria, protozoa, and fungi.

Permeate: A continuous stream of water that passes through membrane. Typically used for water that passes through a reverse osmosis membrane (i.e., reverse osmosis permeate). Also referred to as filtrate or product.

Personal care product: Products that can be found in wastewater such as shampoos, fragrances, soap, and deodorant.

Pharmaceutically-active compound: Hormone-based compounds found within EDCs. Examples of these compounds include antibiotics, anti-epileptic medications, heart medications, pain medications, and cancer medications, along with veterinary drugs and feed additives used for livestock.

Phenolic Compounds: A class of aromatic organic compounds commonly used in the manufacture of plastics, cosmetics, and antiseptics, and as preservatives for wood and rubber. Several of these compounds are regulated for surface water (11 compounds), drinking water (1 compound), and air (5 compounds), based on observed toxicity. Phenolic compounds are commonly found in bottled water and are sometimes classified as endocrine disrupting compounds.

Point Loma Wastewater Treatment Plant (Point Loma): Advanced primary wastewater treatment plant that discharges treated wastewater into the Pacific Ocean.

Potable water: See drinking water.

Purified water: Recycled water that has been treated to an advanced level beyond tertiary treatment, so that it can be added to water supplies ultimately used for drinking water. The treatment includes membrane filtration with microfiltration (MF) or ultrafiltration (UF), reverse osmosis (RO), and advanced oxidation that consists of disinfection with ultraviolet light (UV) and hydrogen peroxide (H_2O_2). Purified water may be discharged into a groundwater basin or surface water reservoir that supplies water to a drinking water treatment facility.

Quarterly Testing Reports: Four quarterly testing reports were prepared to summarize the testing data collected at the Demonstration Facility. Quarterly Testing Report No. 4 includes all of the data collected at the Demonstration Facility and is included as an appendix to the AWP Facility Study Report.

Raw water: Water that has not been treated for use. Examples of raw water are water in the Colorado River aqueduct, the State Water Project aqueduct, open reservoirs (whether filled with imported water or runoff), rivers, naturally occurring lakes and some well water.

Reactor: A vessel or tank where physical or chemical treatment processes occur.

Reclaimed water: See recycled water.

Recovery: The volumetric percent of feed water that is converted to filtrate or permeate.

Recycled water: Treatment of wastewater beyond secondary treatment using tertiary filtration and chlorination. Water treated to this tertiary level is considered to be recycled water, which is suitable for many beneficial uses including irrigation or industrial processes. Recycled water meets treatment and reliability criteria established by Title 22, Chapter 4, of the California Code of Regulations.

Reservoir: A manmade lake or tank used to collect and store water.

Reservoir augmentation (RA): The process of adding purified water to a surface water reservoir. The purified water undergoes advanced treatment (membrane filtration, reverse osmosis and UV disinfection/advanced oxidation). The purified water is then blended with untreated water in a reservoir. The blended water is then treated and disinfected at a conventional drinking water treatment plant and is distributed into the drinking water delivery system. Also known as surface water augmentation.

Reverse osmosis (RO): A high-pressure membrane process that forces water through the molecular structure of several sheets of thin plastic membranes to filter out minerals and contaminants, including salts, viruses, pesticides, and other materials. The RO membranes are like microscopic strainers -- bacteria and viruses as well as inorganic and most organic molecules cannot pass through the membranes.

Scaling: The precipitation or crystallization of salts on a surface (e.g., on the feed side of a membrane).

Stage: A group of membrane units operating in series. In a two-stage configuration, concentrate from the first stage travels to the second where more water is produced.

Storage: Water held in a reservoir for later use.

Surface water: Water located on the Earth's surface in a river, stream, lake, pond or surface water reservoir.

Surrogate Compounds or Surrogate Parameters: A common method used to evaluate water quality using a compound or parameter viewed as representative of a non-related class of chemicals or organisms. Surrogates are used when the analytes of interest are more difficult to quantify and measure through standard laboratory practices. Examples of surrogate parameters include turbidity, conductivity, UV254, and total organic carbon.

Tertiary effluent prior to chlorination: Tertiary effluent prior to chlorination is wastewater that has undergone primary treatment, secondary treatment, and tertiary filtration, but has not been disinfected with chlorine. This is the feed water to the AWP Facility. Sometimes referred to as recycled water even though it has not been disinfected.

Testing and Monitoring Plan (T&M Plan): This plan was prepared as part of the AWP Facility Study to outline the testing and monitoring that was conducted at the Demonstration Facility. The plan was reviewed and commented on by the Independent Advisory Panel (IAP), the California Department of Public Health (CDPH), and the San Diego Regional Water Quality Control Board (Regional Board). More information about the T&M Plan is included in Section 2 and the plan is included as an appendix.

Total dissolved solids (TDS): The concentration of mineral salts dissolved in water. Salinity may be measured by weight (TDS) or by electrical conductivity. Salinity and TDS are both measures of the amount of salt dissolved in water, and the terms are often used interchangeably. Generally, salinity is used when referring to water with a lot of salt (e.g., seawater), whereas TDS is used to refer to water with little salt (e.g., freshwater).

Total organic carbon (TOC): A measure of the amount of carbon that is bound in organic molecules, including all natural and man made chemicals.

Transmembrane pressure: The difference in pressure from the feed (or feed-concentrate average) to the permeate across the membrane.

Turbidity: A measure of suspended solids in water; cloudiness.

Ultrafiltration (UF): Identical to microfiltration, except membrane pore size is smaller.

Ultraviolet (UV) disinfection and advanced oxidation: During ultraviolet disinfection, water is exposed to ultraviolet (UV) light, just like instruments in medical and dental offices, to provide disinfection. Additionally, ultraviolet light combined with hydrogen peroxide creates an advanced oxidation reaction that eliminates any remaining compounds in water by breaking them down into harmless compounds.

Vessel Array: Physical arrangement of pressure vessels in a reverse osmosis (RO) system. For example, a 10 by 5 by 3 vessel array indicates a three-stage RO system with 18 total vessels: stage one has 10 vessels, stage two has 5 vessels, and stage three has 3 vessels.

Wastewater: Untreated water collected in the sewer system from residences and businesses (e.g., from bathtubs, showers, bathroom sinks, clothes washers, toilets, kitchen sinks, dishwashers, and industrial processes). It consists of mostly water with some impurities. Also known as sewage.

Water Purification Demonstration Project (Demonstration Project): The second phase of the City of San Diego's Water Reuse Program. During this phase the Demonstration Facility will operate for approximately one year and will produce one million gallons of purified water per day. A study of the

San Vicente Reservoir is being conducted to test the key functions of reservoir augmentation and to determine the viability of a full-scale project. No purified water was sent to the reservoir during the demonstration phase.

Water Purification Demonstration Project (Demonstration Project) Report: Final report documenting the findings of the Demonstration Project.

Water purification process: The process of using water purification technology on recycled water to produce a water supply that can be used for reservoir augmentation and ultimately for drinking water purposes. The process of water purification starts with recycled water, which has already been treated to produce a supply of water safe enough for irrigation and industrial purposes. This recycled water is further treated with water purification technology. The resulting purified water can be used to augment local reservoir supplies, which would be treated once more at a potable water treatment plant to produce drinking water.

Water purification technology: The technology used for purifying treated wastewater, including membrane filtration with microfiltration (MF) or ultrafiltration (UF), reverse osmosis (RO), and ultraviolet (UV) disinfection and advanced oxidation.

Water reuse: The planned use of recycled water that would otherwise return to the natural hydrologic (water) system for a specific beneficial purpose.

Water Measurement Terms

Milligrams per liter (mg/L) also known as parts per million (ppm): A measurement describing the amount of a substance (such as a mineral, chemical or contaminant) in a liter of water; a unit used to measure water concentrations (parts of something per million parts of water). One part per million is equal to one milligram per liter. (This term is becoming obsolete as instruments measure smaller particles.) This is equivalent to one drop of water diluted into 50 liters (roughly the fuel tank capacity of a compact car) or about thirty seconds out of a year.

Micrograms per liter (µg/L) also known as parts per billion (ppb): A frequently used measurement for water concentration (parts of something per billion parts of water). One part per billion is equivalent to one second of time in 32 years or one drop of water in a typical backyard swimming pool (a typical residential swimming pool is 30 feet by 15 feet with an average depth of 6 feet or 60 cubic meters). One thousand parts per billion is equal to one part per million.

Nanograms per liter (ng/L) also known as parts per trillion (ppt): A very high level of measurement for water concentration (parts of a constituent per trillion parts of water). This is equivalent to one drop of water diluted into 20 London Olympics swimming pools (2,500 cubic meters times 20 = 50,000 cubic meters) or about three seconds out of every 100,000 years.

Million gallons per day (mgd): This term is used to describe the volume of water treated and distributed from a treatment plant daily.

Acre foot (AF): A unit of water commonly used in the water industry to measure large volumes of water. It equals the volume of water required to cover one acre to a depth of one foot. An acre-foot is 325,851 gallons and is considered enough water to meet the needs of two families of four with a house and yard for one year.

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Advanced Water Purification Facility Study Report

Executive Summary

The City of San Diego (City) has limited local water sources and relies on importing approximately 85 percent of its water supply. In the past, importing water from the Colorado River and Northern California has been a reliable option, but environmental stresses, court-ordered pumping restrictions in Northern California, and a historic dry period and drought on the Colorado River have reduced the amount of water that can be delivered to San Diego. These circumstances and the possibility of further limitations have intensified the need for new sources of water that are under local control.

As part of the City's effort to provide a local and sustainable water supply, the Water Purification Demonstration Project (Demonstration Project) evaluated the feasibility of indirect potable reuse through reservoir augmentation (IPR/RA) to provide safe and reliable water for San Diego. The Demonstration Project results will help the City to determine if IPR/RA is a feasible option for San Diego, and if the City should move forward with implementation.

One component of the multi-faceted Demonstration Project was the Advanced Water Purification (AWP) Facility Study. The AWP Facility Study included two primary elements: (1) the design, installation, operation, and testing of a one million gallon per day (mgd) Demonstration Facility located at the North City Water Reclamation Plant (North City) and (2) a conceptual design and cost estimate for a potential Full-Scale Facility (18-mgd capacity and 15-mgd annual average purified water production).

The following summarize the key findings of the AWP Facility Study, which are further discussed in this report:

- Over 9,000 water quality tests were performed throughout the testing period that demonstrated that the water purification process can reliably produce purified water that consistently meets all drinking water quality standards and anticipated reuse regulations.
- Beyond the 231 monitored constituents related to existing or anticipated regulations, 127 additional unregulated constituents were monitored (111 when accounting for duplication with regulated constituents), including unregulated constituents identified for monitoring by the U.S. Environmental Protection Agency (EPA) and other constituents and constituents of emerging concern (CECs) identified in the Testing and Monitoring Plan. Of the 111 additional constituents sampled, only six were found to be quantifiably detected in the purified water at any time.
- Sixteen constituents were monitored as potential performance indicators and removals generally exceeded 95 percent by reverse osmosis, and in some cases greater than 99.9 percent, indicating the integrity and performance reliability of the RO process. The advanced oxidation process was shown to further remove or destroy these constituents to below quantifiable levels.
- Water quality goals included nutrients, which are specific to Reservoir Augmentation. The Demonstration Facility produced water that was below the established water quality goals for nutrient removal. This information was used for the Demonstration Project to make conclusions about maintaining reservoir water quality.

- Energy consumption was monitored at the Demonstration Plant. Power costs make up a substantial portion of the operation and maintenance cost (O&M) costs (33 percent). Testing showed that utilizing a two-stage RO configuration equipped with energy recovery devices can reduce the energy consumption by up to 16 percent compared to operating full-scale facilities that use a three-stage configuration without energy recovery.
- The estimated capital cost for an 18-mgd Full-Scale Facility (excluding the purified water pump station and pipeline) is $144,700,000. The estimated annual O&M cost is $8,145,000.
- Almost 3,000 visitors toured the Demonstration Facility during the 13.5 month start up and testing period, supporting the City's goal to educate the public about the Demonstration Project.

ES.1 AWP Facility Study Background

The primary purpose of the City's Demonstration Facility is to demonstrate the feasibility of water purification technologies to produce purified water that can be sent to the San Vicente Reservoir, a raw water reservoir, to blend with existing water supplies. Prior to distribution to City water customers, water from the reservoir is treated at a drinking water treatment plant. To achieve this primary purpose, the following objectives were defined for the Demonstration Facility and the AWP Facility Study:

- Demonstrate the feasibility of an AWP Facility to reliably produce purified water that is consistently in compliance with all drinking water quality standards.
- Implement a monitoring plan for CECs that is tailored to the wastewater received at North City.
- Demonstrate integrity monitoring techniques and performance reliability measures for the treatment equipment.
- Generate data to be able to make conclusions on maintaining reservoir water quality.
- Assess energy consumption and develop energy conservation opportunities.
- Develop recommendations for design and operation of a Full-Scale Facility that assures only safe purified water leaves the plant.
- Develop a cost estimate for a Full-Scale Facility.
- Educate the public about the Demonstration Project through community outreach, informational materials, and AWP Facility tours.

Figure ES-1 represents the IPR/RA concept for the City's potential full-scale project and a schematic of the demonstration-scale project. The figure shows that wastewater, generated at our homes and businesses, is currently treated at North City to recycled water quality standards. The City uses the recycled water for traditional recycled water uses that include irrigation and industrial use. For the Demonstration Project, a portion of this recycled water is directed to the Demonstration Facility where it is treated by membrane filtration, reverse osmosis, and advanced oxidation. Since this is a demonstration project, the purified water is sent to the recycled water system. If the project is approved for full-scale, the purified water would be conveyed to the San Vicente Reservoir, as represented by the dashed arrow. After detention time in the reservoir, the water would be treated at one of the City's drinking water treatment plants before being introduced into the drinking water distribution system to be used in our homes and businesses.

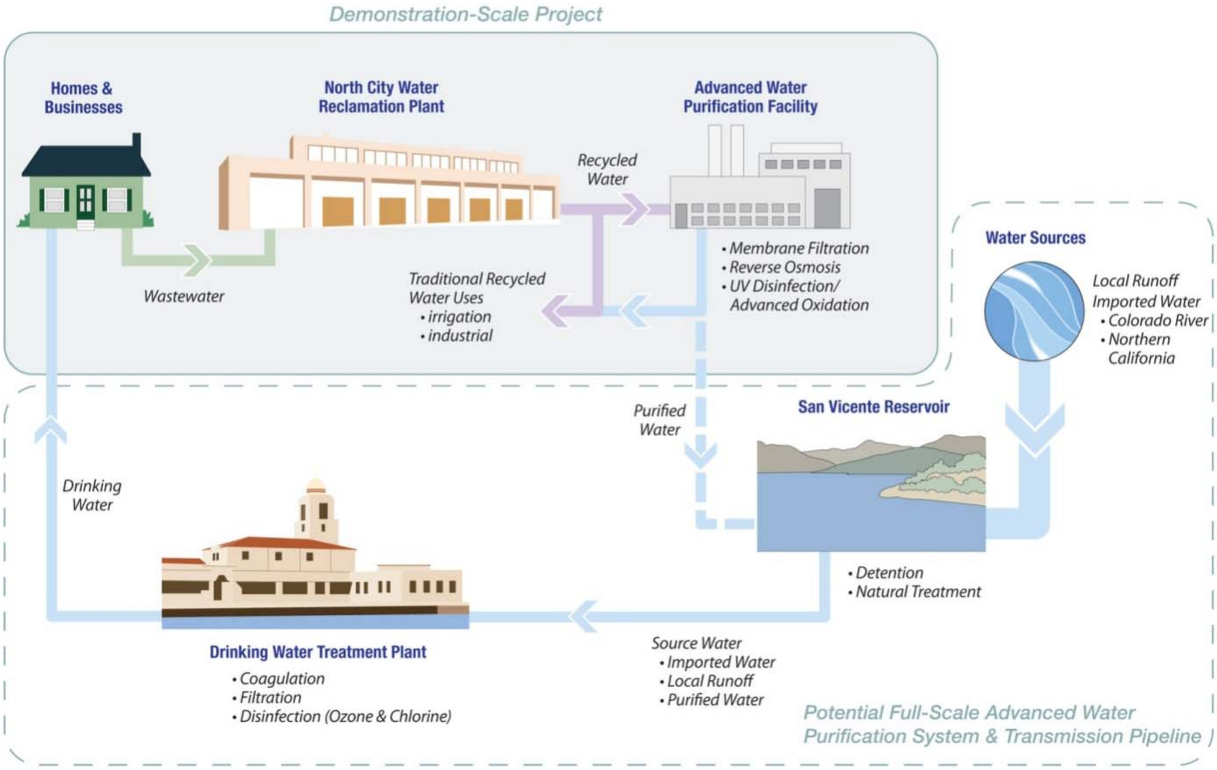


Figure ES-1
Demonstration-Scale and
Potential Full-Scale IPR/RA Projects Schematic

This AWP Facility Study Report summarizes the results and conclusions from the Demonstration Facility, and includes a conceptual design and cost estimate for a Full-Scale Facility. The overall Demonstration Project is summarized in the Demonstration Project Report. Additional discussion on the background of the overall Demonstration Project and the AWP Facility Study is presented in Section 1.

ES.2 Demonstration Facility Description and Observations

This section includes a description of the Demonstration Facility and an overview of the observations made during operations. This information is presented in more detail in Section 2.

ES.2.1 Demonstration Facility Description

The one-mgd Demonstration Facility is located at and treats recycled water produced by North City (tertiary effluent prior to chlorination) using the following water purification processes:

- Membrane filtration: parallel microfiltration (MF) and ultrafiltration (UF) systems
- Reverse osmosis (RO) system with two parallel trains to test two different configurations: two-stage (Train A) and three-stage (Train B)

- Ultraviolet (UV) light disinfection and advanced oxidation system

As shown in Figure ES-1, during the demonstration phase the purified water is returned to the North City recycled water system and is used for irrigation and industrial purposes. Figure ES-2 presents a flow diagram of the Demonstration Facility processes.

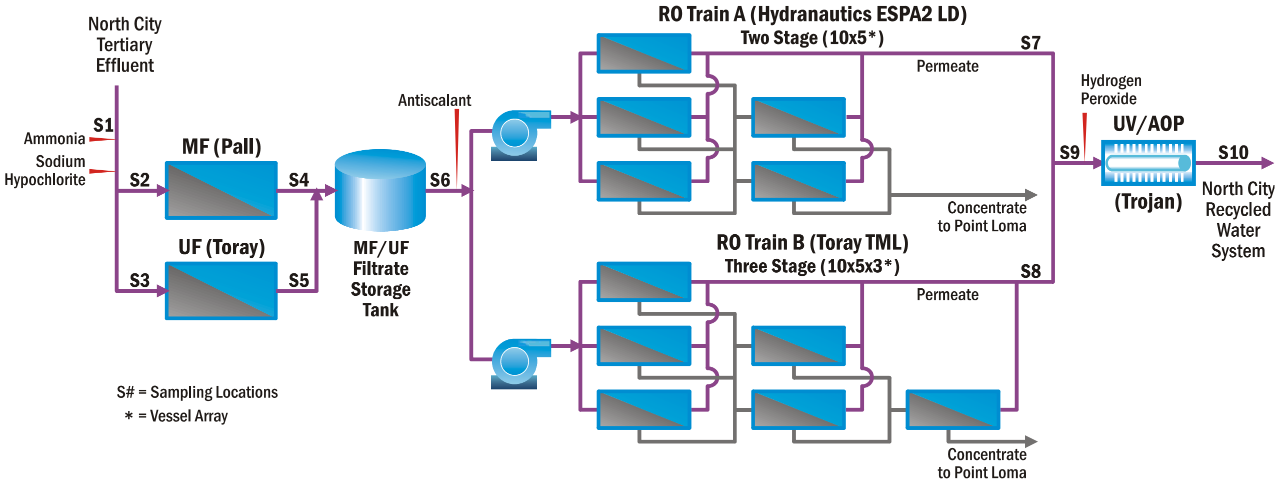


Figure ES-2
Demonstration Facility Processes

The Demonstration Facility was designed, installed, operated, and tested between 2010 and 2012, which is shown graphically in Figure ES-3. The facility start-up period was 1.5 months (mid-June 2011 through the end of July 2011) with full operational testing continuing for one year (August 2011 through July 2012). The results and conclusions from this 13.5-month period are the focus of this report. The Demonstration Facility is continuing to operate after the testing period for tours.

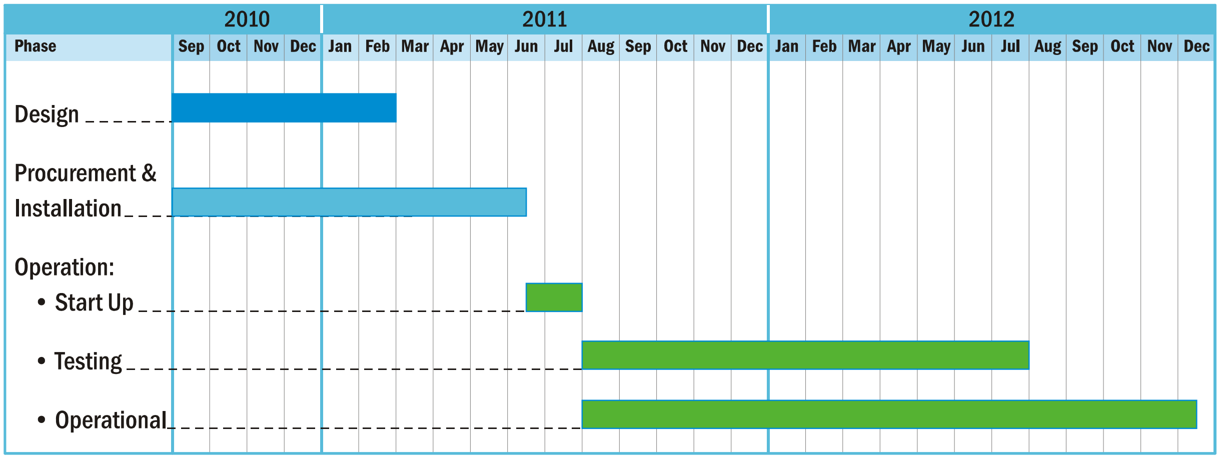


Figure ES-3
Demonstration Facility Schedule

During the testing period of the Demonstration Facility, the purified water and the integrity of the water purification processes were tested to determine the effectiveness of the processes in removing contaminants. Operational data were gathered and analyzed to refine O&M cost estimates for a Full-Scale Facility.

ES.2.2 Demonstration Facility Public Outreach and Tours

One of the objectives of the Demonstration Facility was to support public education and outreach activities to acquaint San Diego residents and stakeholders with the concepts and processes related to IPR/RA. The Demonstration Facility was designed and constructed to facilitate public tours as part of the City's ongoing Education and Outreach program.

The Demonstration Facility tours fulfilled four critical purposes:

- Introduce and graphically illustrate the water purification processes and technologies.
- Show how North City, the potential Full-Scale Facility, the approximately 23-mile pipeline, the San Vicente Reservoir, and the City's drinking water treatment plants work together to provide multiple barriers of protection.
- Communicate information about expert oversight and continuous monitoring of treatment processes to enhance public trust in the reliability of these facilities to provide a safe and clean supply of water.
- Place the water purification process in a water cycle context to reframe mental models about how water is continuously used and reused.

The Demonstration Project Public Education and Outreach program is summarized in the Demonstration Project Report.

ES.2.3 Summary of Operations

The Final Testing and Monitoring Plan (CDM Smith/MWH, 2011) established the testing program and water quality goals for the Demonstration Facility. The Testing and Monitoring Plan was reviewed and commented on by the Demonstration Project's Independent Advisory Panel (IAP), the California Department of Public Health (CDPH), and the San Diego Regional Water Quality Control Board (Regional Board). As a result of the comments received, the Testing and Monitoring Plan was expanded to include sampling for additional water quality parameters and increased frequency and number of samples for constituents that were identified in the draft plan. These comments and a description of how the comments were addressed are included as an appendix to the Testing and Monitoring Plan (the Testing and Monitoring Plan is included as Appendix A to this report). The first quarter testing and monitoring results were presented to the IAP in December 2011. As a result of the comments received, the third and fourth quarter sampling was focused on improving the correlation of indicator compounds for performance and integrity monitoring.

Full-time operation of the Demonstration Facility began on June 16, 2011. The operation and testing results were presented in quarterly reports over the operating period as summarized in Table ES-1. The data collected in previous quarters were included in subsequent reports (e.g., Quarterly Testing Report No. 3 includes data from Quarter 1 [Q1] through Quarter 3 [Q3]) and Quarterly Testing Report No. 4 and this report include all of the operations and testing results gathered over the one year operational testing period.

Table ES-1 Demonstration Facility Testing Periods

Testing Period	Testing Quarter	Operating Period		Report Date
		Test Period Start	Test Period End	
Testing Period 1	Quarter 1 (Q1)	6/16/2011	10/31/2011	December 2011
Testing Period 2	Quarter 2 (Q2)	11/1/2011	2/10/2012	March 2012
Testing Period 3	Quarter 3 (Q3)	2/11/2012	5/14/2012	June 2012
Testing Period 4	Quarter 4 (Q4)	5/15/2012	7/31/2012	September 2012

The following subsections summarize the operations of the membrane filtration, reverse osmosis, and UV disinfection and advanced oxidation systems.

ES.2.3.1 Membrane Filtration

The membrane filtration equipment used at the Demonstration Facility included two parallel 0.63-mgd systems, each treating half the facility flow. One system was a Pall MF system utilizing membranes with a nominal pore size of 0.1 micron, while the second system was an engineered UF system utilizing Toray membranes with a nominal pore size ten times smaller at 0.01 micron. Although both systems were expected to be efficient in removal of suspended solids, bacteria, and protozoa as the first step in the multi-barrier process, previous testing of UF membranes suggested that the smaller pore size might provide better treatment, but with potentially higher energy requirements (Reardon et al, 2006). Therefore, side-by-side testing was performed to determine the feasibility of using either MF or UF for the Full-Scale Facility.

Based on the similarities in operational performance and water quality performance, both MF and UF are suitable systems for membrane filtration in a Full-Scale Facility. For the Full-Scale Facility, pilot testing of the specific MF and UF systems being considered should be conducted to confirm recommended operating conditions and to allow the City to select the membrane filtration system on a lifecycle basis.

The results of the testing showed the following:

- **Recovery:** The MF system operated at a recovery of 93 percent, and the UF system operated at 95 percent recovery.
- **Chemical Cleaning:** Two chemical cleanings were conducted on both the MF and UF systems during Testing Periods 1 through 3, and one was conducted on the UF system during Testing Period 4. These cleanings were effective at restoring the performance to the level observed when the membranes were new.
- **Energy Use:** The side-by-side testing showed that the smaller pore size on the UF membrane did not result in higher pressure/energy requirements. The MF and UF system pressures and resulting energy consumption were essentially equal.
- **Water Quality:** Water quality monitoring of the MF and UF systems showed that both consistently produced water with similar concentrations for key water quality parameters including turbidity, total organic carbon (TOC), and UV 254 absorbance (UV254). Pathogen testing indicted that both MF and UF removed protozoa and bacteria to undetectable

concentrations. The MF was shown to remove more than 99 percent of the measured virus. The UF provided even greater virus removal, which was attributed to its smaller pore size.

ES.2.3.2 Reverse Osmosis

Two reverse osmosis configurations were tested for energy consumption and fouling characteristics: Train A, a two-stage configuration; and Train B, a three-stage configuration. Each RO train was equipped with an energy recovery device designed to transfer energy from the concentrate to the feed of the last stage, reducing the total energy required to treat the water and improving the flow balance between the stages. The different configurations were tested to compare hydraulic conditions and potential operating advantages of one configuration over the other. The two-stage configuration was anticipated to use less energy than the three-stage configuration; however, the three-stage configuration is more commonly used at other AWP facilities.

Two types of membranes were also tested to determine if one had higher removal of targeted constituents compared with the other (focusing primarily on expected differences in total nitrogen rejection).

The results of the testing showed:

- **Recovery:** For the first 8.5 months, both Trains A and B were operated at 80 percent recovery. For the last 3.5 months, both Trains A and B were operated at 85 percent recovery. Testing showed that both the two-stage and three-stage configurations can reliably operate at 85 percent recovery, although the rate of fouling in the final stage was higher for the three-stage configuration than the two-stage configuration.

- **Chemical Cleanings:** Per manufacturers' recommendations, two chemical cleanings were performed for Trains A and B.

- **Energy Use:** The power monitors on the RO system Train A (two-stage) and Train B (three-stage) showed that the three-stage configuration required on average 8 percent more energy than the two-stage configuration. An interstage boost from the energy recovery device resulted in an additional 8 percent energy reduction for Train A and 5 percent for Train B.

- **Water Quality:** The two types of membranes consistently produced water with nearly identical water quality characteristics. Nitrate rejection had been expected to be higher for the Train B membranes than the Train A, however, actual rejection was better than expected for Train A, and lower than expected in Train B, resulting in identical total nitrogen concentrations from both trains.

ES.2.3.3 Ultraviolet Disinfection and Advanced Oxidation

During the testing period, the UV disinfection and advanced oxidation system, which includes ultraviolet light and hydrogen peroxide, was operated to achieve a target 1.2-log (94 percent) removal of N-Nitrosodimethylamine (NDMA) and 0.5-log (68 percent) removal of 1,4-dioxane based on the 2008 CDPH Groundwater Replenishment Reuse Draft Regulations. While the NDMA removal requirement was removed in the most current draft regulations released in November 2011, the permit for the Full-Scale Facility will include NDMA permit limits based on the California Toxics Rule (CTR). Throughout the testing period, the UV disinfection and advanced oxidation process achieved the target NDMA and 1,4-dioxane removal defined in the 2008 and 2011 CDPH Groundwater Replenishment Reuse Draft Regulations.

The average electrical energy per order (EEO) value predicted for NDMA was 0.26 kWh/1000 gallons/log removal; however, when directly measured during the testing period, the EEO was better than projected ranging from 0.18 to 0.21 kWh/1000 gallons/log removal. This EEO is similar to the tested EEO of 0.19 to 0.23 kWh/1000 gallons/log removal for the UV disinfection and advanced oxidation system at the West Basin Municipal Water District's Edward C. Little Water Recycling Facility, a full-scale AWP Facility. The EEO observed for 1, 4-dioxane destruction ranged from 0.5 to 0.7 kWh/1,000 gallons/log removal with a peroxide dose of 2.5 mg/L. This EEO is similar to the EEO of 0.5 kWh/1,000 gallons/log removal reported by the Orange County Water District after initial testing at their Groundwater Replenishment System.

ES.2.4 Water Quality and Regulatory Relevance

This section discusses the water quality monitoring objectives and goals for the Demonstration Project, the regulatory relevance of the water quality monitoring results for regulated constituents, a summary of the water quality monitoring results for other non-regulated constituents, and results of the integrity and reliability monitoring conducted at the Demonstration Facility.

ES.2.4.1 Water Quality Monitoring Objectives and Goals

Water quality tests were performed before and after each water purification process (membrane filtration, RO, and advanced oxidation) and imported aqueduct water. Over 9,000 tests were performed to measure 342 constituents. These constituents included all 231 regulated constituents and 111 unregulated constituents, which are considered to be of potential concern for indirect potable reuse facilities.

The Testing and Monitoring Plan also identified 21 key water quality parameters to serve as a primary focus of the water quality testing, with project specific goals established for each parameter. These key constituents were identified because they can be challenging to remove by the treatment processes employed or because they are widely used parameters to measure performance of water treatment processes. Additionally, nutrients are a specific concern when introducing purified water to the San Vicente Reservoir, and five specific nutrient goals were identified as part of the key water quality parameters. A comparison of these key water quality results and the Demonstration Facility goals is presented in Table ES-2. The table shows that the average concentrations of all constituents measured in the purified water are below the established Demonstration Facility goals.

Table ES-2 Comparison of Key Water Quality Results and Demonstration Goals

Constituent		Units	Laboratory Reporting Level	Purified Water			Water Quality Goal[b]
				Number of Samples	Average Concentration[a]	Maximum Concentration	
Removal Challenge	Bromoform	µg/L	0.5	9	ND	ND	0.5
	Methylene Chloride	µg/L	0.50	9	ND	0.59	4.7
	Trihalomethanes, Total	µg/L	2.0	9	ND	ND	80
	Bromodichloromethane	µg/L	0.5	9	ND	0.7	0.56
	Dibromochloromethane	µg/L	0.5	9	ND	ND	0.5
	Haloacetic Acids (HAA5)	µg/L	1	9	ND	ND	60
	N-Nitrosodiethylamine (NDEA)	ng/L	2	12	ND	4.9	10
	N-Nitrosodimethylamine (NDMA)	ng/L	2	12	ND	5.5	2
	1,4-Dioxane	µg/L	0.5	16	ND	ND	1
	1,2-Dichloroethane	µg/L	0.5	16	ND	ND	0.5
	Boron	mg/L	0.01	28	0.23	0.29	1.0
Common Parameters	Total Organic Carbon[d]	mg/L	0.3	97	ND	ND	0.5
	Total Dissolved Solids	mg/L	10	29	14	19	300
	Chloride	mg/L	0.5	29	3.1	4.3	50
	Sulfate	mg/L	0.5	28	ND	1.1	65
	Turbidity	NTU	-	298	0.05	0.10	0.2
Nutrients	Nitrate as N	mg/L	0.11	74	0.65	1.2	1
	Nitrite as N	mg/L	0.09	71	ND	0.1	1
	Ammonia as N (unionized)	mg/L	varies[c]	71	<0.007[c]	0.027[c]	0.025
	Phosphorus, Total	mg/L	0.01	66	0.02	0.42	0.10
	Nitrogen, Total	mg/L	0.1	74	0.8	1.3	1

Notes:

a. Average concentration calculation assumes non-quantifiable results are half of the laboratory reporting level and non-detectable results are half of the method detection limit.
b. See Testing and Monitoring Plan, Table 5-2 (Appendix A).
c. Unionized values of ammonia were estimated based on EPA's *Aqueous Ammonia Equilibrium – Tabulation of Percent Un-ionized Ammonia (EPA-600/3-79-091)* using average values of temperature and pH measured on-site.
d. Laboratory results showed a single positive result of 1.4 mg/L on January 12, 2012. However, online monitoring for that same day recorded that the TOC was <0.1 mg/L. See Section 2.5.1 for more information on the online monitoring of TOC.

Acronyms:

ND – Not detectable or not quantifiable, shown for all values below laboratory reporting level
mg/L – milligrams per liter, equivalent to parts per million (ppm)
µg/L – micrograms per liter, equivalent to parts per billion (ppb)
ng/L – nanograms per liter, equivalent to parts per trillion (ppt)
NTU – Nephelometric Turbidity Units

ES.2.4.2 Water Quality Monitoring Results – Regulated Constituents

A full-scale IPR/RA project will be subject to requirements put forth by CDPH and the Regional Board. At this time, definitive requirements have not been established. However, results from the water quality monitoring show that the Demonstration Facility produced purified water that reliably met drinking water quality standards. The water also met all water quality requirements of the 2008 and 2011 CDPH Groundwater Replenishment Reuse Draft Regulations.

Water quality monitoring results relative to the current regulations and guidelines are summarized in Table ES-3:

- **Federal and State Drinking Water Maximum Contaminant Levels (MCLs)**
    - **Primary MCLs:** Results from the water quality monitoring show that the purified water consistently meets all primary MCLs established at both the federal and state levels. The federal drinking water MCLs are established by the U.S. Environmental Protection Agency (EPA) and the state MCLs are established by CDPH.
    - **Secondary MCLs:** The purified water met all numerical secondary drinking water MCLs, which are established for non-health based concerns.
    - **Microbial:** Microbial tests were all non-detect in the purified water.
- **CDPH Notification Levels:** During the testing period, the 30 constituents for which CDPH has established Notification Levels were monitored quarterly. Results from the monitoring show that the purified water was consistently below all the Notification Levels established by CDPH. These are advisory levels that require actions on the part of a water agency should concentrations in drinking water exceed the Notification Levels.
- **Groundwater Replenishment Reuse Draft Regulations:** The most recent Groundwater Replenishment Reuse Draft Regulations were issued in November 2011 as part of an informal stakeholder process prior to CDPH initiating a formal rulemaking process to adopt the regulations. Additionally, CDPH is currently developing draft regulations for the use of recycled water for surface water augmentation that have not been released for public review. For the time being, a reasonable assumption is that the CDPH water quality and treatment conditions for a groundwater recharge project that uses 100 percent purified water for groundwater recharge can be used as possible CDPH requirements for this project. Purified water from the Demonstration Facility met all of the water quality requirements in these draft regulations.
- **Regional Board Requirements for the Reservoir:** The San Diego Regional Board's Water Quality Control Plan (Basin Plan) has been established to preserve and enhance water quality and protect the beneficial uses of all regional water bodies. All of the requirements of the Basin Plan have not been defined for the Full-Scale Facility; however, it is expected that the Full-Scale Facility must comply with the Basin Plan numeric and narrative water quality objectives and the CTR criteria for Priority Pollutants. CTR is a federal regulation established to protect both aquatic life and human health by limiting surface water discharges based on 105 priority toxic pollutants. During the testing period, general parameters of the Basin Plan numeric objectives were sampled on a weekly, bi-weekly or monthly basis and Priority Pollutant testing was conducted quarterly. Results from the monitoring show that the purified water produced at the Demonstration Facility consistently met the Basin Plan objectives for those parameters that

have been defined. In addition, requirements have not yet been defined for the CTR, due to uncertainty regarding the applicability of mixing zones. The City will assess the water quality results of the Demonstration Facility and the final permit limits based on the remaining Basin Plan objectives and CTR criteria when they are established.

Table ES-3 Water Quality Monitoring Results of Regulated Constituents

Regulating Authority	Regulation and Guideline Group	Number of Constituents / Parameters	Total Number of Tests[1]	Purified Water Results
Federal and State MCLs	Primary Drinking Water MCL [2]	90	1,781	√ Meets all
	Secondary Drinking Water MCL [3]	18	1,290	√ Meets all
	Microbial [4]	4	1,547	√ Non-Detect
CDPH	CDPH Notification Level [5]	30	716	√ Below all
	CDPH Groundwater Replenishment [6]	142	2,244	√ Meets all
Regional Board	Regional Board Requirements for the Reservoir [7]	143	4,404	√ Meets all
	Total Number of Constituents / Parameters[8]	231[8]	7,523[8]	-----------------

Notes:

[1] The total number of tests represents the approximate number of tests conducted at all sample locations shown in Figure ES-2 and the Imported Raw Aqueduct Water.

[2] Maximum Contaminant Levels and Regulatory Dates for Drinking Water U.S. EPA VS. California November 2008.

[3] California Code of Regulation: Title 22, Division 4, Environmental Health Chapter 15. Domestic Water Quality and Monitoring Regulations Article 16. Secondary Water Standards. Purified water met all Federal and State Secondary MCLs with the exception of pH and corrosivity. The potential Full-Scale Facility would include post treatment to meet these requirements.

[4] EPA Total Coliform Rule (published 29 June 1989/effective 31 December 1990). Samples from the Demonstration Facility were analyzed for the following microbial contaminants: Total coliform, Fecal Coliform, and Viruses (Somatic and Male Specific Bacteriophage).

[5] Drinking Water Notification Levels and Response Levels: An Overview. CDPH Drinking Water Program Last Update: December 14, 2010.

[6] 2011 CDPH Groundwater Replenishment Reuse Draft Regulations. Purified water meets all numerical water quality requirements for indirect potable reuse via groundwater replenishment.

[7] EPA Numeric Criteria for Priority Pollutants Toxic Pollutants for the State of California Rule. Regional Board San Diego Basin Plan Numeric objectives; note, some objectives have not been defined.

[8] Because some constituents and parameters are in multiple regulations / guidelines the total of unique parameters is less than the sum.

ES.2.4.3 Water Quality Monitoring Results – Non-regulated Constituents

Additional non-regulated constituents were monitored at various locations in the purification process and the imported raw aqueduct water. These constituents are grouped into two main categories: those included in the 2012 EPA Unregulated Contaminant Monitoring Rule (UCMR3) and other CECs, such as pharmaceutical compounds and personal care products. In addition, lithium was monitored in the purified water, based on the recommendation of the Demonstration Project Independent Advisory

Panel, and six nitrosamine compounds were monitored beyond the two nitrosamine compounds (NDMA and N-Nitrosodiethylamine [NDEA]) already being tested for in the routine water sampling. All together, 127 non-regulated constituents were evaluated, 111 when accounting for duplication with regulated constituents.

Of the 111 additional non-regulated constituents sampled for at the Demonstration Facility, only six were found to be quantifiably detected in the purified water at any time, including three constituents from the UCMR3 list and three CECs. These six constituents are discussed further in Section 2 of this report. Table ES-4 provides a summary of the six constituents, including average and maximum values measured in both the purified water and imported raw aqueduct water. The following sections present the results for these compounds grouped as UCMR3 constituents and CECs.

Summary of UCMR3 Sampling Results

Results from the testing period show that 27 of the 30 compounds included in the UCMR3 were consistently below quantifiably detectable levels in the purified water. Three constituents, bromochloromethane, hexavalent chromium, and strontium, were quantifiably detected in the purified water. The first two of these constituents can be considered disinfection byproducts and may have been formed at low levels within the treatment processes. The third constituent is a naturally occurring metal used as a dietary supplement and in manufacturing. Additional information on these three constituents is presented in Section 2.4.4.

Summary of CEC Sampling Results

The CEC results in Table ES-4 (the last three constituents shown in the table) are presented in the units of nanogram per liter (ng/L). Analogies commonly used to describe the quantity represented by a concentration of one ng/L are 1 penny in 10 billion dollars or one drop in 20 Olympic-size swimming pools. When assessing low level CEC results such as these it is important to keep in mind that analytical variability and influence of false positive/negative results becomes a more significant issue at such minute levels. Technologies were not available to measure compounds at these low concentrations a decade ago, and there is still considerable debate about the significance of such low measured concentrations.

Results showed the RO and advanced oxidation process are effective at removing the majority of the CECs present in the North City tertiary effluent, and advanced oxidation further reduced the remaining constituents. For constituents found in significant concentrations in the tertiary effluent, the purification process achieved greater than 98 percent removal. Only three CECs were detected at quantifiable concentrations in the purified water. These compounds were iohexal, acesulfame-k, and triclosan. Additional information on these three constituents is discussed in Section 2.4.4.

Drinking Water Equivalent Levels

Since these UCMR3 and CEC constituents do not have regulatory limits, it can be difficult to interpret these water quality results. One method to interpret the results is to compare concentrations to the constituent's Drinking Water Equivalent Level (DWEL) or to an EPA identified Health Reference Level, when such information is available. DWELs and Health Reference Levels both represent an acceptable concentration in drinking water, assuming an average person consumes two liters of water (about 8.5 cups) per day over 70 years. DWELs are developed from tolerable daily intakes (TDIs) or acceptable daily intakes (ADIs), or EPA identified References Doses (RfDs), which all describe a daily dose below which risks to public health are judged to be minimal, assuming repeated daily exposure over a lifetime through consumption of drinking water. DWELs or Health Reference Levels were available for all of the six constituents quantifiably detected in the purified water, with detected values between 18 times and 10 million times lower thant the associated DWEL or Health Reference Level.

Additional information on these six constituents and the potential significance of the measured concentrations are discussed Section 2.4.4.

Table ES-4 Summary of Other Non-regulated Constituents in Purified Water and Imported Raw Aqueduct Water (Detected Constituents of 111 Monitored)

Constituent	Classification/ Common Use	Units	Laboratory Reporting Level	Purified Water			Imported Raw Aqueduct Water		
				Number of Samples	Average Concentration[a]	Maximum Concentration	Number of Samples	Average Concentration[a]	Maximum Concentration
Bromochloromethane	UCMR3 Disinfection byproduct	µg/L	0.06	4	0.23	0.25	4	ND	0.08
Chromium (VI)[b]	UCMR3 Disinfection byproduct, industrial byproduct	µg/L	0.02	4	0.09	0.16	4	0.05	0.05
Strontium	UCMR3 Naturally occurring metal, Dietary Supplement	µg/L	0.3	4	ND	0.37	4	405	610
Acesulfame-K	CEC Sugar Substitute	ng/L	20	9	ND	50	4	343	370
Iohexal	CEC X-ray contrast agent	ng/L	10	9	ND	19	4	43	55
Triclosan	CEC Antibacterial	ng/L	10	9	ND	19	5	ND	ND

Notes:

a. Average concentration calculation assumes non-quantifiable results are half of the laboratory reporting level and non-detectable results are half of the method detection limit.

b. Three Chromium (VI) samples were sent to another lab and all results were below the detection limit of 0.0059 µg/L. The CDPH Detection Limit for purposes of Reporting (DLR) is 1 µg/L.

Acronyms:

ND – Not detectable or not quantifiable, shown for all values below laboratory reporting level
µg/L – micrograms per liter, equivalent to parts per billion (ppb)
ng/L – nanograms per liter, equivalent to parts per trillion (ppt)

ES.2.5 Integrity and Reliability Monitoring

Verifying the integrity and reliability of the water purification processes is critical to assure that only safe water leaves a Full-Scale Facility. To develop recommendations for monitoring at the Full-Scale Facility, the Demonstration Facility processes were evaluated closely. Integrity monitoring was conducted using a mix of direct and indirect methods during operations. In addition, a critical control-point monitoring plan was implemented to identify any changes in performance of the treatment processes that could adversely impact final water quality. Integrity monitoring and critical control point monitoring showed that the equipment remained intact, met the intended treatment performance on a continuous basis, and was reliable throughout the operational period. This evaluation process also made it possible to identify useful procedures for the Full-Scale Facility, as outlined in Section 4.3.

The critical control point monitoring implemented for the Demonstration Facility is summarized in Table ES-5. During the design phase for the Full-Scale Facility, the City would develop a similar on-line monitoring and response plan that provides sufficient features and assurances that any foreseeable malfunction could be promptly identified and appropriate responses applied.

Table ES-5 Summary of Demonstration Facility Critical Control Point Monitoring

Critical Control Point	Critical Limit Parameter	Monitoring Frequency	Alert Limit	Critical Limit	Example Corrective Actions
MF/UF	Pressure Decay	1 per day	Value above baseline that approaches critical limit.	0.4 psi / 5 min based on the maximum decay predicted to achieve 4-log removal Cryptosporidium	Confirm Results. Assess fiber breakage. Isolate/ repair/replace damaged membrane.
RO	TOC, Conductivity	Continuous	Percent change of measured concentration in combined RO permeate	Online permeate conductivity = 150 µS/cm. Online permeate TOC = 100 ppb or greater for five consecutive measurements.	Automatic shutdown (conductivity). Monitor individual RO trains. Verify analyzer accuracy. Conduct vessel probing.
UV	Reactor Power Level	Continuous	System ramps up 100% if 2 to 7 lamps fail or 1 to 3 ballasts fail	0% (8 or more lamp failures or 4 ballast failures)	System alarm. Automatic increase of reactor power to 100% or system shutdown. Check/ replace lamps and/or ballasts.
UV	Hydrogen peroxide dose rate/Continuous Flow Confirmation	1 per day by draw down Continuous flow confirmation	Minimum dose (~22 mL/min.) to provide 3 mg/L peroxide	0 mL/min indicating pump failure or loss of flow confirmation	Check dosing system. Recalibrate pump. Auto switch to standby pump.

Acronyms:

TOC – total organic carbon
mL/min – milliliters per minute
mg/L – milligrams per liter
psi – pounds per square inch
min – minute
µS/cm – microsiemens/centimeter
ppb – parts per billion, equivalent to micrograms per liter (µg/L)

The Demonstration Facility testing also included performance indicator monitoring to determine if any constituents could be used to indicate the treatment efficiency of the RO and advanced oxidation processes. Many of the constituents monitored at the Demonstration Facility were removed by the RO to levels at or below quantifiable limits, demonstrating strong performance of the RO process. Therefore, identifying usable performance indicators to accurately measure advanced oxidation removal was a challenge.

Sixteen constituents were monitored as performance indicators and removal generally exceeded 95 percent within the RO when sufficient quantities were present in the membrane filtration filtrate to calculate such removals. In some cases, greater than 99.9 percent removal was observed.

Surrogate compounds, such as TOC, conductivity, ammonia, monochloramines, and UV 254, may prove to be more reliable as CEC removal performance indicators due to their ease of measurement and their reliable presence in the water downstream of both the RO and advanced oxidation. For the RO process, the average removal results were: TOC = 99.6 percent, conductivity = 99.0 percent, and UV254 = 88.8 percent. For the advanced oxidation process, the average removal results were: UV254 = 68.7 percent and monochloramines = 72.8 percent.

The results of the performance indicator monitoring are summarized in Table ES-6.

Table ES-6 Performance Indicator Monitoring Results

Category	Compound	Units	Average RO Feed	Average RO Perm.	Average UV/AOP	RO Removal	UV/AOP Removal
CEC Potential Indicators	Acesulfame-K	ng/L	33,000	<27	<22	>99.9%	>16.5%
	Amoxicillin	ng/L	220	<6.4	<6.4	>97%	-
	Carbamazepine	ng/L	190	<5	<1.2	>99%	-
	Dilantin	ng/L	120	<13	<13	>88.8%	-
	Diuron	ng/L	77	<1.8	<5	>97.7%	-
	Fluoxetine	ng/L	84	<10	<10	>88%	-
	Lidocaine	ng/L	170	<1.1	<1.1	>99.3%	-
	Lopressor	ng/L	340	<20	<5.1	>97.6%	-
	NDMA	ng/L	3	<2	<0.96	>65.5%	-
	Primidone	ng/L	100	<4.8	<4.8	>95.4%	-
	Sucralose	ng/L	55,000	<100	<42	>99.9%	-
	Sulfamethoxazole	ng/L	950	<2.8	<2.8	>99.7%	-
	TCEP	ng/L	300	<10	<10	>98.3%	-
	TCPP	ng/L	2,000	<100	<100	>97.6%	-
	Triclosan	ng/L	48	<10	<10	>84.1%	-
	Trimethoprim	ng/L	330	<5	<5	>99.1%	-
Online Monitoring Surrogates	Conductivity	µS/cm	1,348	14	--	99.0%	--
	Monochloramine	mg/L	--	3.14	0.85	--	72.8%
	TOC	mg/L	7.2	0.031	--	99.6%	--
	UV254	cm^{-1}	0.158	0.018	0.006	88.8%	68.7%

Notes:

a. For calculating average concentrations, results reported below the laboratory reporting level were considered the value of the laboratory reporting level and for values reported below the method detection limit, the value of the method detection limit was used.

b. Dashes are shown for values that were not measured or could not be calculated.

Acronyms:

mg/L – milligrams per liter, equivalent to parts per million (ppm)
µS/cm – microSiemens per centimeter
cm^{-1} – centimeters to the negative first power
ng/L – nanograms per liter, equivalent to parts per trillion (ppt)

ES.3 Full-Scale Facility Considerations

This section describes design considerations for the Full-Scale Facility that were developed based on the Demonstration Facility operations. Since energy conservation will be a major focus of the Full-Scale Facility, design considerations related to energy conservation are summarized in Section ES.3.1. Other design considerations are summarized in Section ES.3.2. See Section 3 for more information.

ES.3.1 Energy Conservation

Water purification processes are energy intensive and power costs are a substantial part (33 percent) of the annual operations cost for an AWP facility. Therefore, one of the objectives of Demonstration Facility was to understand the power requirements of a Full-Scale Facility and identify potential energy conservation opportunities. These energy conservation opportunities are summarized below.

Membrane Filtration

- **AWP Facility Influent Pumps:** The pumps should be equipped with variable frequency drives making it possible to efficiently ramp up and ramp down pump speed.

- **Membrane Filtration Overall Power Requirements:** The membrane filtration system for the Full-Scale Facility should be selected based on a lifecycle cost evaluation that takes power usage into account. Candidate membrane filtration systems should be pilot tested to gather actual operational data to be used for the lifecycle bid evaluation.

Reverse Osmosis

- **Two-stage RO System:** The power monitors on the RO system Train A (two-stage) and Train B (three-stage) showed that the two-stage configuration required on average 8 percent less energy than the three-stage configuration. A two-stage RO system should be considered to reduce the overall Full-Scale Facility power usage.

- **Energy Recovery Devices:** Energy recovery devices used at the Demonstration Facility were shown to reduce the energy use by 8 percent. Manufacturer's projections were used to estimate the efficiency of the energy recovery devices for the Full-Scale Facility. Based on these projections, energy recovery devices are estimated to reduce energy use by 4 percent to 7 percent over the life of the membranes, which equates to a payback period of less than six years for the future Full-Scale Facility.

UV Disinfection and Advanced Oxidation

- **Electrical Energy per Order**: Multiple UV vessels in series should be considered to improve reactor hydraulics to further reduce the energy requirements. Candidate UV system suppliers should be pilot tested to gather actual operational data from alternative UV systems to be used for the lifecycle bid evaluation.

- **UV Reactor Controls:** The design for the Full-Scale Facility should optimize the UV system to provide effective treatment allowing power to increase only to the extent needed to respond to lamp and/or ballast failure.

ES.3.2 Other Full-Scale Facility Considerations

In addition to energy, additional design considerations for the Full-Scale Facility are summarized in Table ES-7.

Table ES-7 Other Full-Scale Facility Considerations

Design Consideration	Effect
Membrane Filtration System	
Evaluate multiple manufacturers	• Promote competitive bidding • Determine best available equipment
Increase flux rate	• Smaller facility footprint • Reduce capital cost • Increase fouling, operational pressure, and O&M costs
Use of chemically enhanced backwashes	• Decreased clean in place frequency • Increase chemical usage
Reverse Osmosis	
Evaluate multiple manufacturers	• Promote competitive bidding
85 percent recovery	• Maximize water production
Increase flux rate	• Smaller facility footprint • Reduce capital cost • May improve hydraulics and reduce fouling/scaling potential
Add pH suppression capability	• Reduce potential fouling if water quality changes
UV Disinfection and Advanced Oxidation	
Evaluate multiple manufacturers	• Promote competitive bidding • Determine best available equipment
Reduce hydrogen peroxide dose	• Reduce chemical usage

ES.4 Full-Scale Facility Conceptual Design

A conceptual design for the Full-Scale Facility was developed consistent with the water purification processes that were operated at the Demonstration Facility. The Full-Scale Facility conceptual design is described in detail in Section 4. The design consists of the following components:

- AWP Facility influent pump station.
- Membrane filtration (MF or UF) system, which includes pretreatment chemical addition (chloramination for biofouling control) and break tank.
- RO system, which includes RO transfer pumps, cartridge filters, RO feed pumps, RO pre-treatment chemical addition (antiscalant and sulfuric acid for scale control).
- UV disinfection and advanced oxidation using ultraviolet light with hydrogen peroxide.
- Post treatment/stabilization chemical addition (pH and LSI adjustment for corrosion control).
- Purified water pump station and approximately 23-mile pipeline to San Vicente Reservoir (see the Purified Water Conveyance System Final Conceptual Design Report for more information).

The City's Full-Scale Reservoir Augmentation Capacity Analysis Technical Memorandum (RMC, 2011) has defined a capacity for the Full-Scale Facility of 18 mgd, which considers the capacity of North City and the need to continue supplying recycled water to existing and planned customers. Design criteria and preliminary equipment layouts are presented for the 18-mgd capacity Full-Scale Facility in Section 4. The capital cost estimates presented in Section 5 are based on a capacity of 18 mgd, while the O&M cost estimates are based on an annual average production of 15 mgd.

The proposed project site will be located on the property immediately north of North City. Process areas not enclosed in a building will be installed under canopies. A pipe gallery/access tunnel will be provided under Eastgate Mall Road, connecting North City just west of the guard shack to the Full-Scale Facility.

North City treats wastewater flows that would otherwise be treated at the Point Loma Wastewater Treatment Plant (Point Loma). North City can divert flow to Point Loma and go offline any time either by ceasing diversion from the sewer or diverting off-specification water back to the sewer for treatment at Point Loma. The Full-Scale Facility will also have the capability to go offline by ceasing to receive recycled water from North City. Because the Full-Scale Facility has the ability to shut-down at any time, the conceptual facility design includes limited redundancy. The redundancy provided will allow the Full-Scale Facility to continue to operate at capacity when a single unit is offline for maintenance or cleaning.

Instrumentation and automation will be provided to continuously verify conditions are maintained for sustainable operation and effective treatment. The controls system is provided with this electronic monitoring so that if a problem is detected in the system, then the system will automatically shut itself down to prevent water that does not meet the water quality requirements from being introduced into the reservoir. Manual checks will also be made of water produced by individual units within each system to identify operational trends and detect anomalies that require attention. These electronic systems controls and manual procedures, in concert with the critical control point monitoring described in Section ES.2.5, will assure that only safe water leaves the Full-Scale Facility.

ES.5 Estimated Costs

This section summarizes the estimated capital and O&M costs for the Full-Scale Facility, as well as for the Full-Scale Project.

ES.5.1 Estimated Costs for the Full-Scale Facility

The estimated capital costs was prepared based on the conceptual design for an 18-mgd Full-Scale Facility and O&M cost estimates were based on an annual average production of 15 mgd. For the construction cost, Appendix D includes a breakdown of each of the process areas and buildings. The construction cost includes the contractor direct costs plus construction allowances, permits and sales tax.

The O&M cost estimate is based on the preliminary design criteria developed for the Full-Scale Facility (see Section 4) and considers power costs, chemical costs, equipment replacement costs, maintenance costs, and labor costs. The average power demand for the Full-Scale Facility (annual average purified water production of 15 mgd) is approximately 2.1 to 3.1 megawatts, and the estimated total annual power consumption is 18,200,000 to 27,400,000 kilowatt-hours per year (kWh/yr).

The estimated capital and O&M costs for the Full-Scale Facility are presented in Table ES-8 and Table ES-9, respectively. Additional detail is provided in Section 5.

The estimated O&M cost for the Full-Scale Facility was compared to the O&M cost of the Demonstration Facility. The estimated O&M costs for the Full-Scale Facility for most of the unit processes are within 5 to 30 percent of the O&M costs for the Demonstration Facility. The differences are within an appropriate level of contingency, since the Demonstration Facility was operated within the first year of the equipment and membrane life, and many variables are anticipated to change over the course of the facility operation as the membrane filtration and RO membranes age. Additional discussion of the differences between the assumptions for the Full-Scale Facility and the operations data collected at the Demonstration Facility are included in Section 5.

Table ES-8 Estimated Construction Cost for the Full-Scale Facility

Parameter	Capital Cost[2,3]
Construction Costs[4]	
AWP Facility Influent Pump Station	$2,800,000
Site Civil/Yard Piping[5,6]	$5,800,000
Operations, Maintenance, and Administration Building	$1,600,000
Membrane Filtration Break Tank and Pump Station	$4,000,000
Chemical Storage Area #1 (Pre-Treatment Chemical Facility)[7]	$2,400,000
Membrane Filtration Facility[8]	$25,300,000
Reverse Osmosis Facility[9]	$21,300,000
UV Disinfection and Advanced Oxidation System[10]	$9,900,000
Chemical Storage Area #2 (Post-Treatment Chemical Facility)[11]	$2,100,000
Construction Subtotal	**$75,200,000**
Contingency (30% of Construction Total)	$22,600,000
Overhead & Profit	$9,800,000
Insurance & Bond	$2,900,000
Construction Total	***$110,500,000***
Implementation Costs	
Engineering & Pre-Construction (20% of Total Construction Cost)	$22,100,000
Environmental Documentation	$1,000,000
Construction Management (10% of Total Construction Cost)	$11,100,000
Implementation Total	***$34,200,000***
Total Capital Cost (Construction Total + Implementation Total) [12]	**$144,700,000**

Notes:

1) This table presents costs for the Full-Scale AWP Facility only. For costs related to the Purified Water Pump Station and Purified Water Pipeline, refer to Table ES-10 and the Demonstration Project Report.
2) Includes installation costs and indirect costs (project management, field management and support, training, quality assurance and control, project safety, construction allowances, permits, and sales tax).
3) All costs are in February 2012 dollars. The Engineering News Record (ENR) Construction Cost Index is 9267.57 and the ENR Building Cost Index is 5144.49 for February 2012.
4) Construction duration is assumed to be 30 months. Based on a 40 hour work week with no overtime.
5) No rock excavation is assumed to be required. Only nominal dewatering is assumed to be needed. No consideration for contaminated soils or hazardous materials (e.g. asbestos, lead) is included. Site grading, drainage and containment are included with assumptions made based on the aerial photograph.
6) Includes pressure membrane filtration feed pipeline, gravity membrane filtration backwash, pressure RO concentrate pipelines, and chemical feed pipelines.
7) Includes sodium hypochlorite, ammonium hydroxide, sulfuric acid, and antiscalant.
8) Includes citric acid and sodium hydroxide system for membrane filtration chemical cleaning systems.
9) Includes cartridge filters and RO feed pumps.
10) Hydrogen peroxide system is included with the UV disinfection and advanced oxidation system.
11) Includes calcium chloride and sodium hydroxide.

Table ES-9 Estimated Annual O&M Costs for the Full-Scale Facility

Parameter	Annual O&M Cost[1]
Power Costs[2]	
AWP Facility Influent Pump Station	$306,000
Membrane Filtration System	$43,000
Reverse Osmosis System	$1,614,000
UV Disinfection and Advanced Oxidation System	$185,000
Miscellaneous Equipment	$7,000
Buildings	$481,000
Power Costs – Subtotal	***$2,636,000***
Chemical Costs	
Membrane Filtration Pretreatment	$223,000
Reverse Osmosis Pretreatment	$431,000
Hydrogen Peroxide for Advanced Oxidation	$216,000
Post Treatment	$358,000
Membrane Cleaning	$103,000
Chemical Costs – Subtotal	***$1,331,000***
Replacement of Consumables (Equipment Replacement)	
Membrane Filtration Membranes	$441,000
Reverse Osmosis Cartridge Filters and Reverse Osmosis Membranes	$319,000
UV Lamps and Ballasts	$281,000
Replacement of Consumables – Subtotal	***$1,041,000***
Maintenance Costs[3]	***$1,409,000***
Other Costs (Compliance Testing and Security)[4]	***$310,000***
Labor Costs[5]	***$1,418,000***
Total Annual O&M Cost	**$8,145,000**

Notes:

1) All costs are in February 2012 dollars.
2) Power cost is assumed to be $0.12 per kilowatt-hours (kWh).
3) Assumed to be 1.7% of the equipment construction cost based on a review of actual maintenance costs for the Orange County Water District’s Groundwater Replenishment System.
4) The annual compliance testing cost is assumed to be $150,000/year. This is based on half of the Demonstration Facility compliance testing cost of $300,000/year.
5) Estimated staffing = 12 personnel plus outside lab allowance, based on information provided by the City. The estimated staffing of 12 personnel was based on assessment of the department wide resources and additional needs to support and integrate this new facility as part of the City's existing treatment facilities. However, it is anticipated that this labor estimate will be updated in the future when the full-scale facility is constructed and the evaluation of new treatment technology provided at that time.
6) This table presents costs for the Full-Scale Facility only. For costs related to the Purified Water Pump Station and Purified Water Pipeline, refer to Table ES-11 and the Demonstration Project Report.

ES.5.2 Estimated Costs for the Full-Scale Project

The estimated costs for the Full-Scale Project incorporate the Full-Scale Facility, Purified Water Pump Station, and the Purified Water Pipeline. Table ES-10 presents the estimated construction costs for the Full-Scale Project, Table ES-11 presents the estimated O&M costs for the Full-Scale Project, and Table ES-12 presents the estimated additional auxiliary program costs to support the Full-Scale Project. The Full-Scale Project and the associated costs are discussed in more detail in the Demonstration Project Report

Table ES-10 Estimated Construction Costs for the Full-Scale Project

Parameter	Capital Cost
Total Full-Scale Facility Capital Cost (Construction Total + Implementation Total)[1]	**$144,700,000**
Purified Water Pipeline System Construction Costs[2]	
Purified Water Pump Station	$8,000,000
Purified Water Pipeline	$114,200,000
Pipeline System Construction Total	***$122,200,000***
Pipeline System Implementation Costs	
Contingency (30% of Construction Total)	$36,700,000
Engineering & Construction Management (30% of Construction Total)[3]	$36,700,000
Environmental Documentation and Mitigation	$24,400,000
Land Acquisition	$4,500,000
Pipeline System Implementation Total	***$102,300,000***
Total Pipeline System Capital Cost (Construction & Implementation)[2]	**$224,500,000**
Total Capital Cost (Full-Scale Facility and Pipeline System)	**$369,200,000**

Notes:

1) Refer to Table ES-8 for a breakdown of the Full-Scale Facility construction costs.
2) From the Demonstration Project Report.
3) Includes costs associated with regulatory compliance and permitting.

Table ES-11 Estimated Annual O&M Costs for the Full-Scale Project

Parameter	Annual O&M Cost[1]
Full-Scale Facility[1]	$8,145,000
Treatment at North City to Support Full-Scale Facility[2]	$3,965,000
Purified Water Pump Station[2,3]	$1,885,000
Purified Water Pipeline[2,4]	$1,500,000
Total Annual O&M Cost	**$15,495,000**

Notes:

1) Refer to Table ES-9 for a breakdown of the Full-Scale Facility O&M costs.
2) From the Demonstration Project Report.
3) Includes power and maintenance.
4) Includes maintenance.

Table ES-12 Estimated Auxiliary Program Costs for the Full-Scale Project[1]

Parameter	Auxiliary Cost
Auxiliary Upfront Cost	
Source Control Program Upfront Cost[2]	$500,000
Auxiliary Annual Cost	
Source Control Program Annual Costs[3]	$50,000
Public Outreach Annual Program Costs[4]	$700,000

Notes:

1) From the Demonstration Project Report.
2) Source control upfront costs include a chemical inventory program and GIS tracking database (approximately $50,000), a pollutant prioritization program to be completed by existing City staff (approximately $50,000 for initial set-up work), and a local limits evaluation for North City (approximately $400,000). For additional information on source control program costs, refer to the Enhanced Source Control Plan for the Full-Scale Advanced Water Purification Facility Technical Memorandum (RMC, 2013).
3) Source control annual costs include $25,000/yr for annual updates to the chemical inventory program and GIS tracking database, an average of $10,000/yr for periodic updates to the pollutant prioritization program, and $15,000/yr, on average, for updates to the local limits analysis. For additional information on source control program costs, refer to the Enhanced Source Control Plan for the Full-Scale Advanced Water Purification Facility Technical Memorandum (RMC, 2013).
4) Public outreach annual costs include initial start-up of outreach efforts. Annual public outreach costs will be scaled back following full-scale reservoir augmentation project operations.

ES.6 Conclusions

The primary purpose of the City's Demonstration Facility was to demonstrate the feasibility of water purification technologies to produce purified water for the City to determine the feasibility of a full-scale IPR/RA project. A full-scale project would assist with the City's effort to provide a local and sustainable water supply. To achieve this primary purpose, the following objectives were defined for the Demonstration Facility and the AWP Facility Study:

- Demonstrate the feasibility of an AWP Facility to reliably produce purified water that is consistently in compliance with all drinking water quality standards.
- Implement a monitoring plan for constituents of emerging concern (CECs) that is tailored to the wastewater received at North City.
- Demonstrate integrity monitoring techniques and performance reliability measures for the treatment equipment.
- Generate data to be able to make conclusions on maintaining reservoir water quality.
- Assess energy consumption and develop energy conservation opportunities.
- Develop recommendations for design and operation of a Full-Scale Facility that assures only safe purified water leaves the plant.
- Develop a cost estimate for a Full-Scale Facility.
- Educate the public about the Demonstration Project through community outreach, informational materials, and AWP Facility tours.

The Demonstration Facility and AWP Facility Study met all of these established objectives and the results of this project are supporting the City's pursuit of a full-scale IPR/RA project. Table ES-13 summarizes how the each objective was met.

Table ES-13 Demonstration Facility and AWP Facility Study Objectives and Key Findings

Objectives	Key Findings
Demonstrate the feasibility of an AWP Facility to reliably produce purified water that is consistently in compliance with all drinking water quality standards.	Water quality monitoring throughout the testing period demonstrated that membrane filtration, followed by RO, and UV disinfection and advanced oxidation can reliably produce water that meets or exceeds all of the drinking water requirements and also provides multiple barriers for regulated and unregulated chemical and microbial constituents.
Implement a monitoring plan for constituents of emerging concern (CECs) that is tailored to the wastewater received at North City.	Key constituents and water quality goals for each were identified in the Testing and Monitoring Plan. The average concentration of each constituent measured in the purified water is below the established Demonstration Facility goals.
Demonstrate integrity monitoring techniques and performance reliability measures for the treatment equipment.	Sixteen constituents were monitored as performance indicators, and removal generally exceeded 95 percent in the RO. In some cases, greater than 99.9 percent removal was observed, demonstrating strong performance of the RO process. Five surrogate compounds were also identified. The RO process averaged 99 percent or greater removal for TOC and conductivity and 88.8 percent for UV254. The advanced oxidation process further removed UV254 by 68.7 percent and monochloramines by 72.8 percent.
Generate data to be able to make conclusions on maintaining reservoir water quality.	143 constituents/parameters were monitored based on anticipated Regional Board requirements for the San Vicente Reservoir. The results were used to conclude that the addition of purified water would not impair existing conditions of the San Vicente Reservoir, and could improve nutrient-related water quality issues as further discussed in the Demonstration Project Report.
Assess energy consumption and develop energy conservation opportunities.	Energy consumption was monitored at the Demonstration Plant and, combined with experience from other Full-Scale Plants, energy conservation opportunities for the Full-Scale Facility were recommended. Energy recovery devices tested at the Demonstration Facility were successful in reducing energy consumption and are estimated to reduce energy use at a Full-Scale Facility by 4 to 7 percent over the life of the membranes. Use of a two-stage RO configuration at the Full-Scale Facility instead of a three stage RO configuration will reduce energy consumption by approximately 8 percent, while producing the same quality and quantity of RO permeate.
Develop recommendations for design and operation of a Full-Scale Facility that assures only safe purified water leaves the plant.	Design criteria, purification process layouts, system controls, and monitoring for a Full-Scale Facility were developed to assure that only water that meets all drinking water standards leaves the plant.
Develop a cost estimate for a Full-Scale Facility.	Operational data and observations collected from the Demonstration Facility testing period were used to estimate construction costs and annual operation and maintenance costs for a Full-Scale Facility. For a Full-Scale Facility with 18-mgd capacity with an annual average production of 15 mgd, the estimated capital cost is $144,700,000, and the estimated annual O&M cost is $8,145,000.
Educate the public about the Demonstration Project through community outreach, informational materials, and AWP Facility tours.	Almost 3,000 visitors toured the Demonstration Facility during the 13.5-month start up and testing period.

Section 1

Introduction

This report summarizes the results of the City of San Diego (City) Advanced Water Purification (AWP) Facility Study, conducted as part of the City's multi-faceted Water Purification Demonstration Project (Demonstration Project). The Demonstration Project evaluated the feasibility of indirect potable reuse through reservoir augmentation (IPR/RA) to provide safe and reliable water for San Diego.

The AWP Facility Study included two primary elements: (1) the design, installation, operation, and testing of a 1 million gallon per day (mgd) Demonstration Facility located at the North City Water Reclamation Plant (North City) and (2) a conceptual design and cost estimate for a potential Full-Scale Facility (18-mgd capacity and 15-mgd annual average purified water production), which would be located north of North City. This introduction section includes background information on both the overall Demonstration Project and the AWP Facility Study, as well as an overview of this AWP Facility Study Report.

1.1 Demonstration Project Background

The City has limited local water sources and relies on importing approximately 85 percent of its annual water supply. In the past, importing water from the Colorado River and Northern California has been a reliable option, but environmental stresses, court-ordered pumping restrictions in Northern California, and a historic dry period and drought on the Colorado River have reduced the amount of water that can be delivered to San Diego. These circumstances and the possibility of further limitations have intensified the need for new sources of water that are under local control.

One such source being considered is the use of IPR/RA. IPR/RA is a multi-step process that uses water purification technologies to produce purified water from a wastewater source, sending this purified water to the San Vicente Reservoir to blend with existing water in the reservoir, treating the blended water at a drinking water plant, and then distributing the drinking water to City water customers. This form of potable reuse is considered "indirect" because of the environmental buffer and natural treatment which occur within the reservoir before the water is used as a source of drinking water supply.

The potential benefits of implementing an IPR/RA program in San Diego could include:

- Providing a local and sustainable supply of high-quality drinking water for San Diego,
- Improving the quality of water in the San Vicente Reservoir,
- Decreasing dependence on imported water,
- Increasing utilization of recycled water,
- Providing a supply of water that uses less energy than imported water, and
- Having a positive impact on the environment by producing less discharge into the ocean and working toward lower carbon emissions.

The IPR/RA concept for the City is shown in Figure 1-1. For the Demonstration Project, the one-mgd Demonstration Facility treats recycled water (tertiary effluent prior to chlorination) from North City using membrane filtration (microfiltration [MF] and ultrafiltration [UF]), reverse osmosis (RO), and ultraviolet (UV) light disinfection and advanced oxidation to produce purified water. During the demonstration phase, the purified water is returned to the North City recycled water system and is used for irrigation and industrial purposes.

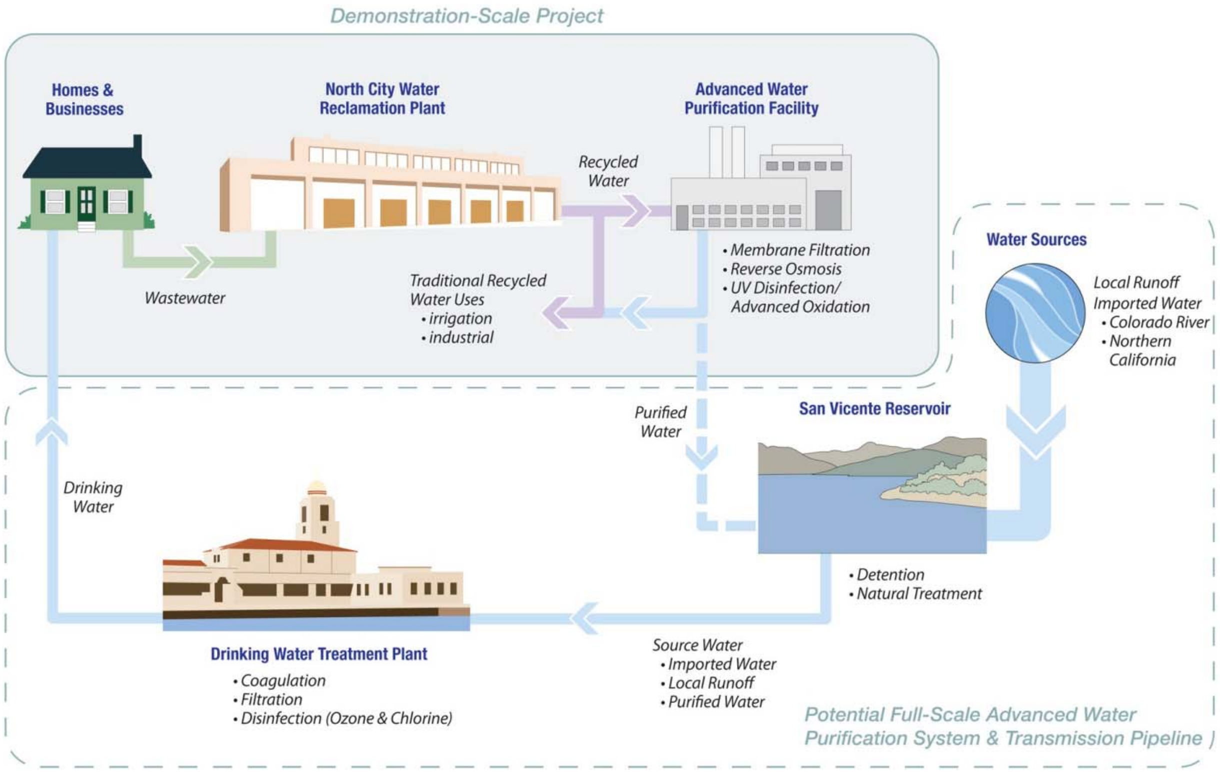


Figure 1-1
Demonstration-Scale and
Potential Full-Scale IPR/RA Projects Schematic

The City has initiated the Demonstration Project to evaluate the feasibility of using IPR/RA to provide a new source of local water to meet future water supply needs. The Demonstration Project is the second phase of the City's three-phase Water Reuse Program, which seeks to maximize the reuse of recycled water and purified water. The three phases are as follows:

- **Phase I:** In 2006, the City completed the Water Reuse study, which identified a series of strategies that could be implemented to increase water reuse in San Diego. The Water Reuse Study stakeholders and the San Diego City Council (City Council) independently identified augmentation of the City's San Vicente Reservoir with purified wastewater as their preferred alternative to meet the City's water reuse goals. On July 19, 2006, the City's Natural Resources and Culture Committee (NR&C) accepted the Final Draft Report of the Water Reuse Study (Phase I) as fulfilling City Resolution R-298781. On October 29, 2007, the City Council voted to accept the Water Reuse Study and directed the Mayor and City staff to implement actions to demonstrate the feasibility of the IPR/RA concept. Through this and other City Council directives, the components of the Demonstration Project were clarified.

- **Phase II:** This phase of the City's Water Reuse Program is the Demonstration Project, in which the feasibility of augmenting San Vicente Reservoir supplies with purified water is being examined.
- **Phase III:** If IPR/RA is deemed feasible and approved by the Mayor and City Council, then Phase III will involve implementation of a full-scale IPR/RA project to augment the San Vicente Reservoir with purified water. The full-scale IPR/RA project would include construction of an 18-mgd Full-Scale Facility located north of North City and an approximately 23-mile pipeline that will transport the purified water to San Vicente reservoir for blending and retention prior to distribution to the region's drinking water treatment plants for further treatment. Implementation of the full-scale IPR/RA project is contingent on Mayoral and City Council authorization.

The majority of the costs associated with the Demonstration Project were funded by a temporary water rate increase, which was approved by City Council in November 2008. This temporary rate increase was in effect from January 2009 to August 2010 and collected funds to pay for the project. In addition, the Demonstration Project was partially funded by grants from the California Department of Water Resources' Integrated Regional Water Management Program through Proposition 50, and the United States Bureau of Reclamation in the approximate amount of $1.07 million and $2.95 million, respectively. The Demonstration Project has a total estimated cost of $11.8 million.

Components of the Demonstration Project include the following:

1. **Conduct a public outreach and education program:** In 2010, the City launched a comprehensive public outreach and education program for the Demonstration Project. The program included tours of the City's Demonstration Facility to educate City leadership, regulators, public, and other interested parties about advanced water purification and how a full-scale IPR/RA project would benefit the City.
2. **Design, construct, operate, and test a Demonstration Facility at North City:** This component of the Demonstration Project is included in the AWP Facility Study detailed in this report.
3. **Conduct a Limnology and Reservoir Detention Study for the San Vicente Reservoir:** A study of the San Vicente Reservoir was conducted to test the key functions of reservoir augmentation and to determine the viability of a full-scale project. The study evaluated dilution and established residence time and short-circuiting conditions of purified water in the reservoir.
4. **Define the regulatory requirements for a full-scale IPR/RA project:** Since the full-scale IPR/RA project would be the first of its kind in California, the regulatory requirements were defined as part of the Demonstration Project. The City has conducted meetings with the California Department of Public Health (CDPH) and the San Diego Regional Water Quality Control Board (Regional Board) to understand both the anticipated regulatory requirements and the approval process for the Full-Scale Facility.

5. **Convene an Independent Advisory Panel (IAP):** An IAP provided oversight on project research to determine (1) if the purification system satisfies all water quality, safety and regulatory requirements of the CDPH, and (2) the behavior of the reservoir and what will happen if the purified water is added. For the Demonstration Facility, the IAP reviewed and commented on the testing and monitoring plan, the testing results, and this AWP Facility Study report.
6. **Perform a pipeline alignment (water conveyance) study:** The Purified Water Conveyance System Final Conceptual Design Report was prepared to present the alignment and costs for conveying the purified water from the Full-Scale Facility to the San Vicente Reservoir.
7. **Perform an independent energy and economic analysis for water supply options in the City's Long-Range Water Resources Plan:** The City is updating their 2012 Long-Range Water Resources Plan (CDM Smith, 2012) to evaluate the City's water supply options. As part of this plan, IPR/RA was confirmed to be a cost-effective water supply option.

Through implementation of the steps outlined above, the Demonstration Project is being completed in 2012. The Demonstration Project Report will summarize all of the elements of the project and include a summary of the reports completed for the individual tasks:

- AWP Facility Study Report (the report presented herein)
- Limnology and Reservoir Detention Study
- Purified Water Conveyance System Final Conceptual Design Report
- 2012 Long-Range Water Resources Plan

At the conclusion of the Demonstration Project, the Demonstration Project Report will be presented to the Mayor and City Council. If deemed technically and financially feasible and following Mayoral and City Council authorization, a full-scale IPR/RA project would be implemented.

1.2 AWP Facility Study Background

The purpose of the AWP Facility Study was to provide operational information from a one-mgd Demonstration Facility, identifying recommendations for energy optimization and scale-up considerations for a future 18-mgd Full-Scale Facility, and developing a conceptual design and cost estimate for this Full-Scale Facility. The following specific objectives were defined for the project:

- Demonstrate the feasibility of an AWP Facility to reliably produce purified water that is consistently in compliance with all drinking water quality standards.
- Implement a monitoring plan for constituents of emerging concern (CECs) that is tailored to the wastewater received at North City.
- Demonstrate integrity monitoring techniques and performance reliability measures for the treatment equipment.
- Generate data to be able to make conclusions on maintaining reservoir water quality. Assess energy consumption and develop energy conservation opportunities.

- Develop recommendations for design and operation of a Full-Scale Facility that assures only safe purified water leaves the plant.
- Develop a cost estimate for a Full-Scale Facility.
- Educate the public about the Demonstration Project through community outreach, informational materials, and AWP Facility tours.

The one-mgd Demonstration Facility was designed, installed, operated, and tested between 2010 and 2012. During operation of the Demonstration Facility, the water was tested to evaluate the effectiveness of the treatment processes in removing constituents; operational data was gathered and analyzed to refine operation and maintenance (O&M) estimates for a Full-Scale Facility; and tours conducted as part of the public outreach effort.

The Demonstration Facility treats recycled water (tertiary wastewater effluent prior to chlorination) from North City to produce purified water. The Demonstration Facility uses water purification processes, including membrane filtration (MF and UF), RO, and UV disinfection and advanced oxidation. During the demonstration phase, the purified water was returned to the North City recycled water system and was used for irrigation and industrial purposes. No purified water was sent to the reservoir during the demonstration phase.

Figure 1-2 summarizes the schedule for design, testing, and operation of the Demonstration Facility. The facility was started up over a 1.5 month period (mid-June 2011 through the end of July 2011) and was tested for one year (August 2011 through July 2012). The results and conclusions from this 13.5-month period are the focus of this report. The Demonstration Facility is continuing to operate after the end of the testing period for tours.

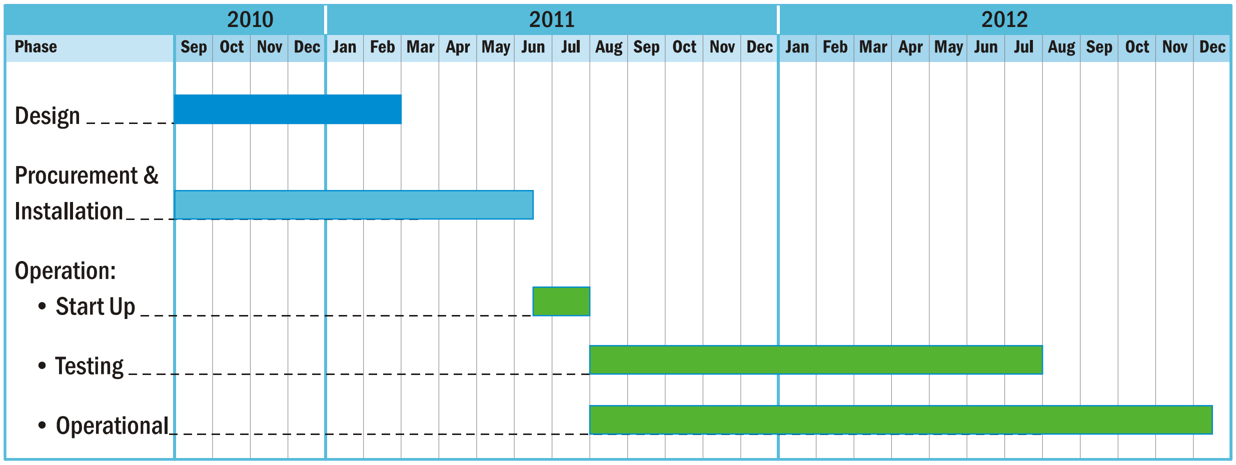


Figure 1-2
Demonstration Facility Schedule

1.3 Coordination with Other Activities and Deliverables

As a major component of the Demonstration Project, the AWP Facility Study was closely coordinated with other Demonstration Project activities and deliverables. The information was coordinated with the other project elements as follows:

- **Demonstration Project Report:** this AWP Facility Study Report is summarized in the Demonstration Project Report.
- **Purified Water Conveyance System Final Conceptual Design Report:** the Purified Water Conveyance System Final Conceptual Design Report presents the conceptual design for the purified water pump station and the approximate 23-mile pipeline to convey the purified water from the Full-Scale Facility to the San Vicente Reservoir. Information about the purified water pump station is included in Section 4. The pump station footprint is included on the Full-Scale Facility site plan (Figure 4-4) and the design criteria are included with the overall Full-Scale Facility design criteria (Figures 4-5 and 4-6).
- **Full-Scale Reservoir Augmentation Capacity Analysis Technical Memorandum:** the sizing of the Full-Scale Facility is documented in the Full-Scale Reservoir Augmentation Capacity Analysis Technical Memorandum. This document is included as an appendix to this AWP Facility Study Report for reference.

1.4 AWP Facility Study Report Overview

This report provides information on the Demonstration Facility and a conceptual design and cost estimate for the potential Full-Scale Facility. This AWP Facility Study Report is summarized in and appended to the Demonstration Project Report, which summarizes the overall results of the Demonstration Project. The remaining sections of this AWP Facility Study Report are organized into the following sections:

- Section 2 Demonstration Facility Description and Observations
- Section 3 Full-Scale Facility Considerations
- Section 4 Full-Scale Facility Conceptual Design
- Section 5 Full-Scale Facility Estimated Costs
- Section 6 References
- Appendices
  - A – Testing and Monitoring Plan
  - B – Quarterly Testing Report No. 4
  - C – Full -Scale Reservoir Augmentation Capacity Analysis Technical Memorandum
  - D – Estimated Capital Cost Process Area Breakdown
  - E – Estimated O&M Cost Process Area Breakdown
  - F – Demonstration Facility Power Consumption

Section 2

Demonstration Facility Description and Observations

This section provides a description of the Demonstration Facility, summarizes the operations and testing results, discusses the regulatory relevance of those results, and describes the integrity and reliability monitoring measures used to confirm that each water purification process functioned reliably. The information provides a basis for energy optimization and full-scale considerations discussed in Section 3 as well as the conceptual design and cost estimate for the Full-Scale Facility, presented in Sections 4 and 5, respectively.

2.1 Demonstration Facility Description

The Demonstration Facility was designed with a 1-mgd production capacity and consists of the following water purification processes: parallel membrane filtration processes; parallel-two stage and three-stage RO processes; and UV disinfection and advanced oxidation. A flow diagram of the Demonstration Facility and sampling locations (designated as S1 through S10) is provided in Figure 2-1.

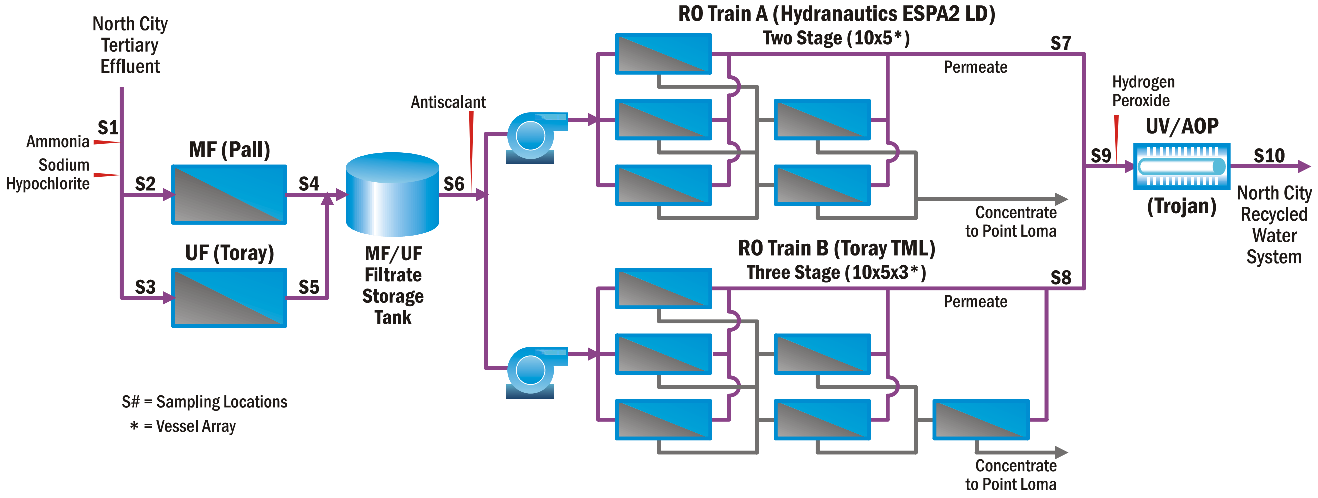


Figure 2-1
Advanced Water Purification Treatment Process

2.1.1 Demonstration Facility Location

The Demonstration Facility is located at North City located at 4949 Eastgate Mall, San Diego, California 92121. North City has a total design capacity of 30 mgd, but the current average annual demand of recycled water customers serviced by North City is only 7.3 mgd; thus, the plant’s capacity is not fully utilized. The majority of current customers use the recycled water for irrigation, and the remainder for industrial purposes.

The Demonstration Facility is located on a concrete pad adjacent to the existing electrodialysis reversal (EDR) units #4 and #5. The Demonstration Facility pad area is 3,800 square feet (50 feet x 76 feet). The western edge of the pad houses the EDR #6 and was not part of the Demonstration Project. The operations trailer is located on the existing Research Pad, which has an area of 2,000 square feet (40 feet x 50 feet).

The Demonstration Facility is connected to the North City plant tertiary effluent by an 8-inch Schedule 80 polyvinyl chloride (PVC) pipe designed to deliver water to the Demonstration Facility at 980 gallons per minute (gpm) and a pressure between 40 to 50 pounds per square inch (psi). The water is delivered by the same pumps that feed EDRs #4, #5 and #6. Two drains are provided for liquid process and cleaning waste. The drains are routed in the Demonstration Facility and EDR #6 areas and then routed to discharge to an existing manhole and eventually discharged to Point Loma. Water produced by the Demonstration Facility is blended with North City tertiary effluent upstream of the chlorine contact tanks. The product water piping is routed overhead in the Demonstration Facility and EDR #6 areas and then routed below grade to discharge into the tertiary effluent line immediately upstream of the chlorine contact tanks.

2.1.2 Membrane Filtration

Membrane filtration is most commonly done using hollow fiber membranes, with each membrane fiber typically less than a millimeter in diameter and three to six feet in length. Filtration occurs across the surface of each individual membrane fiber. Tens of thousands of these fibers are packaged together and sold as removable membrane elements, typically within a self-contained pressure vessel. Dozens of these elements can then be manifolded together into a larger, modular operating unit, typically referred to as a membrane skid. A complete membrane system consists of the membrane skid or multiple skids, along with various ancillary equipment, often located off of the skid(s). Full scale facilities often contain multiple membrane skids, each operated independently through frequent backwash and production cycles.

The membrane filtration equipment used at the Demonstration Facility includes two parallel 0.63-mgd systems, each treating half the facility flow. One system is a Pall MF system utilizing membranes with a nominal pore size of 0.1 micron, while the second system is a semi-universal UF system utilizing membranes with a nominal pore size ten times smaller at 0.01 micron. The UF system used Toray membranes but is capable of operating with membrane elements (filter modules) from multiple vendors. Selection of the two systems was based on review of other operational advanced purification facilities and on the City's goal of comparing alternative membrane filtration systems to develop the most efficient and effective approach for a potential Full-Scale Facility.

Design Flux and Materials

Membrane system filtration rate, or flux, represents the amount of permeate flow produced per day (gallons per day) per unit area of membrane (square feet [ft^2]). A membrane system containing 20,000 ft^2 of membrane area, which produces 1.0 million gallons per day, would be operating with a flux of 50 gallons per day per square foot (gfd). Membrane filtration systems for wastewater applications are generally designed to operate at relatively low fluxes (20 to 35 gfd), to reduce the rate of fouling on the membranes. Fouling occurs more frequently at higher fluxes, particularly when treating water containing relatively high organic content, as treated wastewater often does. The MF and UF systems used at the Demonstration Facility were operated at fluxes between 29 and 30 gfd.

In addition to flux, specific flux, also known as permeability, is flux per unit pressure (gfd/psi). The specific flux is generally corrected for temperature, based on the viscosity of the water. The reference temperature for membrane filtration is 20 degrees Celsius (C), while it is 25 degrees C for RO.

The majority of the wastewater membrane filtration facilities in California are currently using MF membranes, which are made from either chlorine resistant polyvinylidene fluoride (PVDF) material or from chlorine-sensitive polypropylene. Facilities using PVDF membranes include the Water Replenishment District Leo J. Vander Lans Water Treatment Facility in Long Beach, California, and the Scottsdale Water Campus in Scottsdale, Arizona. Facilities using PVDF membranes often utilize chlorine enhanced backwashes to reduce organic fouling and biological growth on the membranes. However, chlorine enhanced backwashes cannot be used at facilities employing membranes sensitive to chlorine (i.e. polypropylene). Facilities using such chlorine sensitive polypropylene membranes include the Orange County Water District's Groundwater Replenishment System and the West Basin Edward C. Little Water Reclamation Facility, both in California.

Most indirect potable reuse plants, including facilities in the United States, Singapore, and Australia, employing membrane filtration and RO as treatment processes, maintain a continuous chloramine residual through the entire treatment process to prevent biological growth on the membrane filters and the RO membranes. At the Demonstration Facility, a total chlorine residual between 3 and 4 milligrams/liter (mg/L) was maintained through the membranes to prevent such biological growth.

Standardization of Membrane Filtration Membranes

Three manufacturers currently supply approximately 90 percent of the municipal membrane filtration systems in the United States, including Siemens/Memcor, Pall Corporation, and GE/Zenon. These systems generally are not compatible with each other, due to differences in membrane module configurations, dimensions, piping, and flow configurations. Due to the proprietary nature and complexity of these systems, membrane selection is commonly completed during the preliminary design phase of a project, allowing better integration of the systems into the overall design.

As the industry has matured in recent years, the system designs have become more standard. Today GE/Zenon makes a pressurized UF membrane that is relatively compatible in size and configuration to the Pall system. In addition, alternative membrane manufacturers are supplying domestic facilities with membranes that are far more standardized than systems sold a decade ago. A semi-universal membrane unit, capable of operating with membranes from several different suppliers, is now possible to design or purchase from third party vendors. Such a design benefits treatment system owners during the design phase and during bidding.

The City therefore selected a non-proprietary system design to treat half of the flow at the Demonstration Facility in order to promote future competition for the potential Full-Scale Facility. This UF system for the Demonstration Facility was designed to be compatible with membranes from three alternative membrane suppliers: Pentair, Dow, and Toray. Membrane element design conditions for each of these suppliers are included in Table 2-1.

Table 2-1 Membrane Elements Considered in Design of Semi-Universal UF Skid Design

Model	Pentair Aquaflex	Dow SFD-2860	Toray HFU-2020
Length	2.2 m	2.0 m	2.2 m
Diameter	0.2 m (8-inch)	0.2 m (8-inch)	0.22 m (8.5-inch)
Area	55 m^2 (85,250 in^2)	77 m^2 (119,350 in^2)	72 m^2 (111,600 in^2)
Flow Configuration	Inside-out	Outside-in	Outside-in

Microfiltration System Design

The microfiltration system selected for the Demonstration Facility was a Pall Aria system which produced 0.63 mgd for the downstream RO process. The Asahi membranes used with the Pall system were PVDF material with a nominal pore size of 0.1 micron. These membranes were selected as a baseline to compare against the UF, based on their successful operation in wastewater applications with low membrane fouling and few fiber breaks. The MF membranes were operated at a flux of 29 gfd and recovery of 93 percent. While the system was designed to incorporate chemically enhanced backwashes, they were not used during the initial operation of the Demonstration Facility in order to reduce the amount of downtime for the membrane filtration unit. Chemical enhanced backwashes may be required in the future if more aggressive operating conditions are use (e.g. higher flux, higher recovery).

Ultrafiltration System Design

The Demonstration Facility uses Toray HFU membranes in the UF system, which also produced 0.63 mgd for the downstream RO membranes. The UF system operates in parallel to the MF system. Toray UF membranes were selected for the UF system because these membranes are CDPH-certified. The Toray UF membranes are PVDF material, similar to the Pall MF membranes, but have a nominal pore size ten times smaller than the MF membranes. Toray membranes can be used in a standardized skid configuration, which could accommodate UF membranes from Norit, Dow, or Toray. This provides flexibility with the Demonstration Facility if the City decides to test another UF manufacturer, and could also provide advantages for membrane replacement in the Full-Scale Facility. The Toray UF membranes are chlorine resistant PVDF material with a nominal pore size of 0.01 micron. The smaller pore size of the UF membrane allows for the removal of smaller constituents, such as viruses. The UF system was operated at a flux of 30 gfd and 95 percent recovery. While the system was designed to incorporate chemically enhanced backwashes, they were not used during the initial operation of the Demonstration Facility in order to reduce the amount of downtime for the membrane filtration unit. Chemically enhanced backwashes may be required in the future if more aggressive operating conditions are use (e.g. higher flux, higher recovery).

The Demonstration Facility was the first municipal installation in the United States to use the relatively new Toray HFUF (hollow fiber ultrafiltration); however, the membranes had previously been used at wastewater facilities in Asia, and are now currently being used for other facilities being built or in recent operation within the United States. Because of differences in port dimensions and locations, it will be necessary to change out portions of the piping if and when the membranes are changed to an alternative manufacturer in the future. In addition, the inside-out flow configuration for the Pentair system will require modifications in the controls. The majority of the piping, controls, and the pumping system for the UF unit were designed to accommodate the alternative membrane suppliers.

2.1.3 Reverse Osmosis

Reverse osmosis membranes are most commonly manufactured as flat sheets, with a thin membrane layer coating a larger support structure used to resist the high pressures seen in reverse osmosis. Individual sheets are glued together in pairs to form membrane envelopes, with separation of dissolved ions occurring across the membrane surface. Desalinated water passes into the center of the membrane envelope, while salts and other contaminants remain on the outside of the membrane sheets. These sheets are typically rolled into spiral wound membrane elements, with hundreds of square feet of membrane area contained inside a single 8-inch by 40-inch element. The elements are most commonly loaded into pressure vessels in series, with six to eight elements per vessel. Multiple vessels are then manifolded together into a modular operating unit typically referred to as a train. Reverse osmosis facilities will operate with one or more membrane train, each operating independently through extended cleaning cycles.

The reverse osmosis equipment used at the Demonstration Facility included two parallel systems, each treating half the flow. Two alternative membranes were used, and two alternative RO configurations, one operated as a two-stage (Train A) and one as a three-stage (Train B) system. RO systems for wastewater applications are typically designed to operate at low fluxes, ranging from 10 to 12 gfd. These fluxes are more in line with traditional fluxes used at seawater desalination facilities than at brackish water plants; however, early operation at Water Factory 21 in California and other pilot studies suggested that the lower fluxes were needed to prevent fouling from high concentrations of organic material in the wastewater sources.

Design recoveries for RO units at all of the existing AWP facilities in California are 85 percent, but problems with scaling in downstream stages have resulted in some of these facilities operating at reduced recoveries—as low as 75 percent. A recovery of 80 percent was initially selected for the Demonstration Facility, which was the proven recovery demonstrated during the City's previous pilot testing of water purification processes (conducted in 2005-2006). As discussed in Section 2.3.2, the recovery was successfully increased to 85 percent to maximize water production.

Reverse Osmosis System Design

Similar to the membrane filtration system, two parallel reverse osmosis systems were used for the Demonstration Facility – one representing a baseline condition and the second representing an alternative design approach. Train A includes Hydranautics ESPA2-LD elements operated in a two-stage configuration, which was used as the baseline. ESPA2-LD membranes have a rated salt rejection of 99.6 percent, based on Hydranautics standard testing procedures, using a 1,500 mg/L sodium chloride solution and a 150 psi feed pressure. This train utilized seven elements per vessel within a 10 vessel by 5 vessel array. An Energy Recovery Incorporated turbocharger (also referred to as an energy recovery device) was used to recover residual energy from the second stage concentrate, boosting the pressure to the second-stage feed. The RO system was operated at 12 gfd at both 80 percent and 85 percent recovery.

The second parallel RO system (Train B) utilized Toray TML20 membranes in a three-stage RO configuration to improve system hydraulics at higher recovery rates. TML20 membranes have a rated salt rejection of 99.7 percent, based on Toray standard testing procedures, using a 2,000 mg/L sodium chloride solution and 225 psi feed pressure. Six element pressure vessels were used to reduce the differential pressure loss, with a 10 by 5 by 3 vessel array. An energy recovery device was used to recover residual energy from the third stage concentrate, boosting the pressure to the third stage feed.

The Toray TML20 membranes were projected to have a higher nitrogen rejection than the baseline ESPA2 membranes. Total nitrogen may be a controlling water quality limitation for reservoir augmentation, making the rejection of the RO membranes a critical evaluation parameter. A goal of 1.0 mg/L total nitrogen was set for the Demonstration Facility; however, the final requirement will be determined by the Regional Board. ESPA2 elements were not projected to meet this nitrogen goal, based on Hydranautics design software, however, the Toray membranes were projected to deliver considerably lower total nitrogen levels.

2.1.4 UV Disinfection and Advanced Oxidation

The RO permeate from the two RO trains are combined and treated through an advanced oxidation process, comprised of UV coupled with hydrogen peroxide. Trojan UVPhox, a low pressure and high output (LPHO) UV system was used to demonstrate the UV disinfection and advanced oxidation process. This reactor is the same model that is being used at the Groundwater Replenishment System in Orange County. The Trojan model used was selected based on discussions with Trojan, given the capacity of the Demonstration Facility. For more details on the selection of the reactor, see Appendix C, Attachment A of the Testing and Monitoring Plan (T&M Plan) (Appendix A).

There was an initial concern that the single reactor would not be as efficient as a full scale facility. Based on discussions with the manufacturer, this system was expected to be less efficient due to differences in hydraulic conditions, compared to a full scale system. However, based on results from the spiking experiment, the calculated electrical energy per order (EEO) values at the Demonstration Facility were similar to those predicted at Orange County's Groundwater Replenishment District, under similar conditions.

The advantages of LPHO UV, compared to medium pressure UV, include electrical efficiency, longer lamp life, and narrower UV wavelength targeted for microbial destruction. Trojan LPHO UV systems have a proven history with advanced water treatment in California with systems installed at the Orange County Water District's Groundwater Replenishment System, the West Basin Municipal Water District's Edward C. Little Water Recycling Facility, and the Water Replenishment's District Leo J. Vander Lans Advanced Water Treatment Facility.

2.1.5 Purified Water

The water that has been treated by the membrane filtration, RO, and UV disinfection and advanced oxidation processes is considered purified water. This purified water meets water quality requirements for full advanced treatment under the November 2011 Groundwater Replenishment Reuse Draft Regulations, including primary and secondary drinking water standards, total nitrogen, total organic carbon (TOC), and CDPH Notification Levels. If the IPR/RA project is approved for full-scale implementation, the purified water would be conveyed to the San Vicente Reservoir to supplement existing raw water supplies to the reservoir. Additional post-treatment through blending or adding stabilizing chemicals would be required for the Full-Scale Facility to address the aggressive nature of highly purified water. Since this project was for demonstration purposes only, the purified water produced by the facility was blended with existing recycled water and distributed through the existing recycled water system for irrigation and industrial uses. No water from the Demonstration Facility was used to supplement any drinking water supplies.

2.2 Demonstration Facility Public Outreach and Tours

One of the objectives of the Demonstration Facility was to support public education and outreach activities to acquaint San Diego residents and stakeholders with the concepts and processes related to IPR/RA. The Demonstration Facility, pictured in Figure 2-2, was designed and constructed to facilitate public tours as part of the City's ongoing Water Purification Education and Outreach program.

The Demonstration Facility tours fulfilled four critical purposes:

- Introduce and graphically illustrate the water purification processes and technologies.
- Show how North City, the potential Full-Scale Facility, the approximately 23-mile pipeline, the San Vicente Reservoir, and the City's drinking water treatment plant work together to provide multiple barriers of protection.
- Communicate information about expert oversight and continuous monitoring of treatment processes to enhance public trust in the reliability of these facilities to produce a safe and clean supply of water.
- Place the water purification process in a water cycle context to reframe mental models about how water is continuously used and reused.

The Demonstration Project Public Education and Outreach program is summarized in the Demonstration Project Report.

Figure 2-2
Demonstration Facility

2.3 Summary of Operations

The following subsection summarizes Demonstration Facility operation during the time period of 6/16/11 to 7/31/12. The facility start-up period was 1.5 months (mid-June 2011 through the end of July 2011) with full operational testing continuing for one year (August 2011 through July 2012). The results and conclusions from this 13.5-month period are the focus of this report. The Demonstration Facility is continuing to operate after the testing period for tours.

Each water purification process was operated continuously over this time period with minimal offline time due to routine maintenance, cleaning (membrane systems), and unscheduled minor repairs. Based on a comparison of actual time to run hours, the system was producing purified water 87 percent of the time during this period. Each of the water purification processes performed as required during this period of operation.

The operation and testing results were presented in quarterly reports over a 12-month testing period as summarized in Table 2-2:

Table 2-2 Demonstration Facility Testing Periods

Testing Quarter	Operating Period		Report Date
	Test Quarter Start	Test Quarter End	
Quarter 1 (Q1)	6/16/2011	10/31/2011	December 2011
Quarter 2 (Q2)	11/1/2011	2/10/2012	March 2012
Quarter 3 (Q3)	2/11/2012	5/14/2012	June 2012
Quarter 4 (Q4)	5/15/2012	7/31/2012	September 2012

The Quarterly Testing Report No. 4 includes the comprehensive water quality data for all Testing Periods and is provided in Appendix B.

2.3.1 Summary of Membrane Filtration Operation

The following includes a description of the membrane filtration system operation and a comparison of the operational and water quality performance of the two systems.

Microfiltration System

The Pall Aria MF system was operated for over 8,700 hours (12 months) under the operating conditions presented in Table 2-3. The feed water for the MF system was tertiary effluent prior to chlorination from North City. Membrane fouling was assessed during the operational period by monitoring the temperature corrected specific flux under constant flux operation. Figure 2-3 presents operational performance data including specific flux, flux, transmembrane pressure and temperature based on daily operational readings. These parameters are plotted versus run hours, the plot also includes dates at each 1,000 run hour interval. In general, the MF system experienced minimal membrane fouling. Following the initial operating period, a full chemical cleaning was conducted at run hour 2,277 (3.2 months). The chemical cleaning was effective at restoring the temperature corrected specific flux to values observed when the membranes were new. Following the initial chemical cleaning, the system was operated for an additional 3,962 hours (5.5 months). During this time, the specific flux was observed to remain constant prior to decreasing steadily around run hour 5,400. A second chemical cleaning was completed at run hour 6,239, which was effective at restoring the specific flux to values observed when the membranes were new.

Table 2-3 Summary of Pall MF System Operating Conditions

Parameter	Value
Target feed water chloramines dose	3 mg/L
Instantaneous flux	29 gfd
Average feed water recovery	93 percent
Backwash frequency	19 minutes or 10,000 or filtrate gallons
Backwash duration	96 seconds
Strainer backwash frequency	1,440 minutes
Pressure Decay Test frequency	24 hours

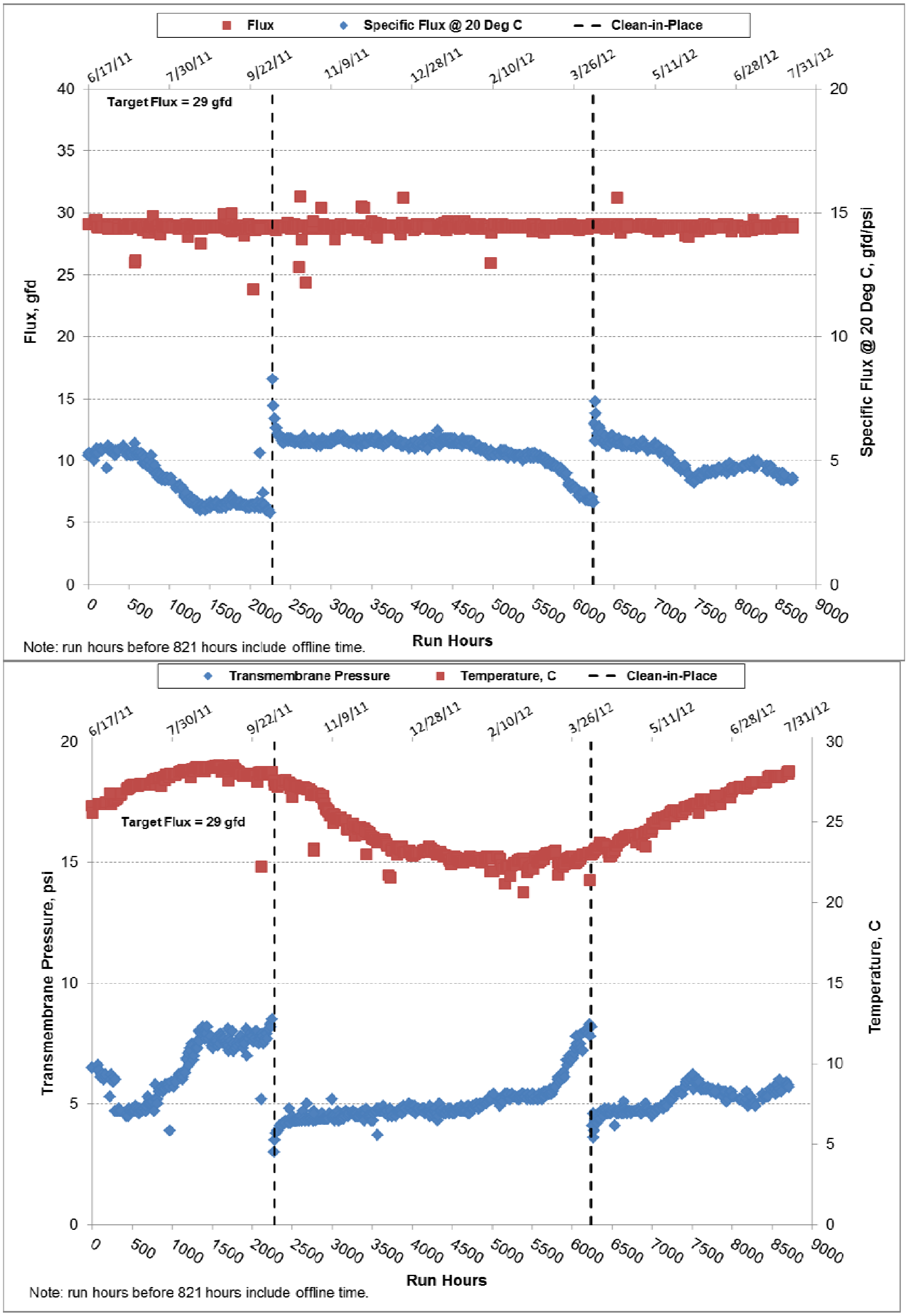


Figure 2-3
Summary of Pall MF System Operational Performance

Ultrafiltration System

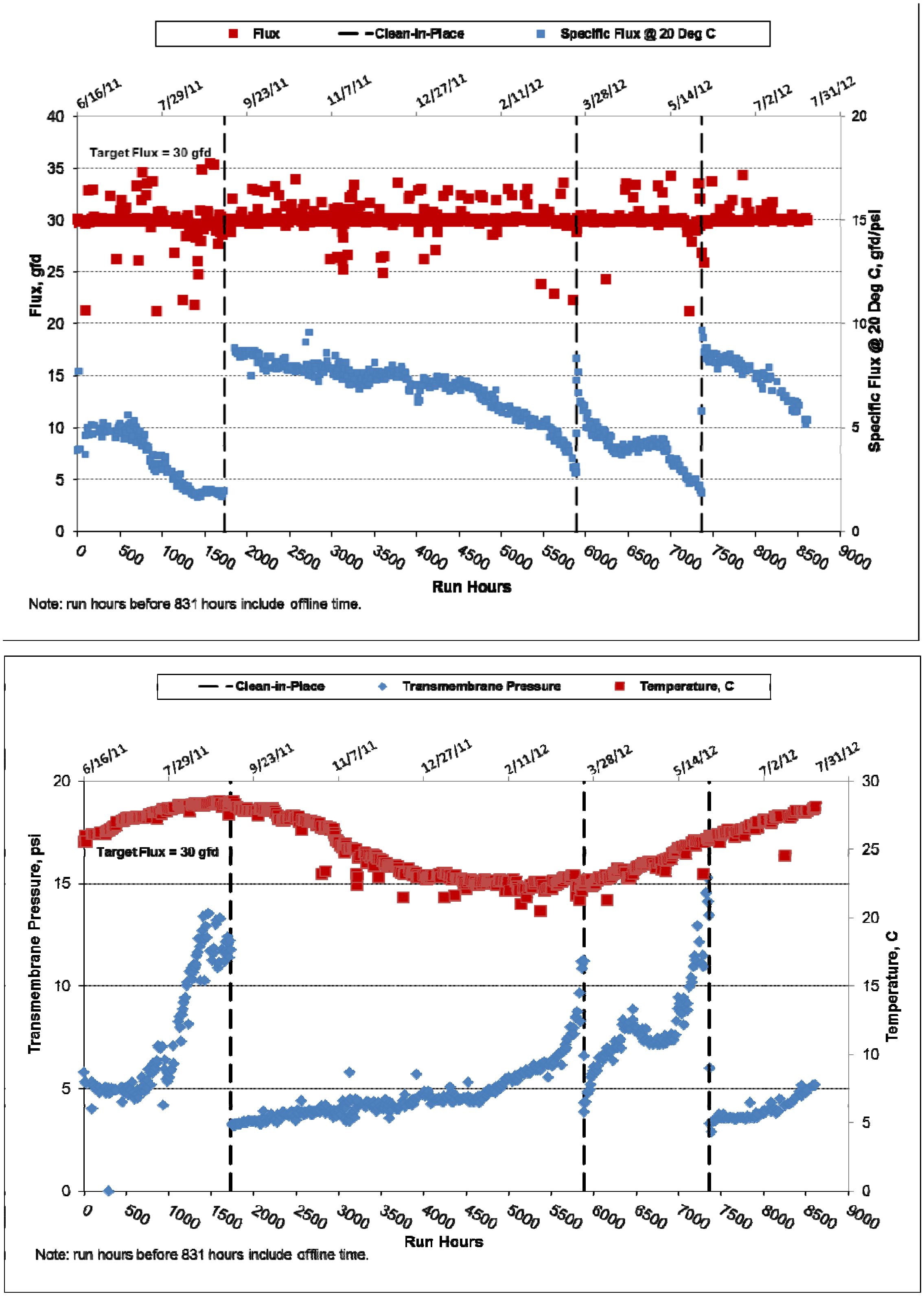
The Toray UF system was operated for over 8,600 hours (12 months) under the operating conditions provided in Table 2-4. The UF system was also fed from the tertiary effluent prior to chlorination produced by North City. Membrane fouling was assessed during the operational period by monitoring the temperature corrected specific flux under constant flux operation. Figure 2-4 presents operational performance data including specific flux, flux, transmembrane pressure and temperature based on daily operational readings. These parameters are plotted versus run hours; the plot also includes dates at every 1,000 run hour interval.

In general, the rate of decrease in specific flux for the UF system observed during the Q1 and Q2 Testing Periods showed minimal fouling; however, an increased rate of fouling was observed during the Q3 Testing Period. It is important to note the UF system was operated at a higher recovery than the MF system over the course of the operating period, resulting in overall less backwash waste flow. This higher recovery could therefore be partially responsible for the higher rate of observed fouling in the UF system.

Following the initial operating period, a chemical cleaning was conducted at run hour 1,729 (2.4 months). The chemical cleaning was effective at restoring the temperature corrected specific flux to values observed when the membranes were new. Following the initial chemical cleaning, the system was operated for an additional 4,156 hours (5.8 months). During this time, the specific flux was observed to remain steady prior to trending downward at a moderate rate around run hour 3,850. The rate of decline increased around run hour 4,540 and was consistent for the remainder of the operating period. A second chemical cleaning was completed at run hour 5,885, which was effective at restoring the specific flux to the previously observed post-clean value. The UF membranes fouled at a faster rate during the Q3 and Q4 Testing Periods than in the previous periods. A final chemical cleaning was conducted at run hour 7,360 (10.2 months).

Table 2-4 Summary of Toray UF System Operating Conditions

Parameter	Value
Target feed water chloramines dose	3 mg/L
Instantaneous flux	30 gfd
Average feed water recovery	95 percent
Backwash frequency	30 minutes
Backwash duration	195 seconds
Strainer backwash frequency	1,440 minutes
Pressure Decay Test frequency	24 hours



Target Flux = 30 gfd

Note: run hours before 831 hours include offline time.

Target Flux = 30 gfd

Note: run hours before 831 hours include offline time.

Figure 2-4
Summary of the Toray UF Operational Performance

Comparison of Membrane Filtration System Operation

The MF System (Pall) and UF system (Toray) were operated side by side for similar runtimes to compare the operational and water quality performance of the systems.

A summary of operational performance of the membrane filtration systems is provided in Table 2-5. Operating Period 1 is defined as the operational time period between the completion of the first and second chemical cleanings. During this time, the MF system operated for 5.5 months and the UF system for 5.7 months with similar fouling rates of 11 percent (decline in specific flux per month). During this time the UF system operated with a slightly lower average transmembrane pressure (4.6 psi vs. 5.0 psi); however, the UF system required a higher average feed pressure (16 psi vs. 15 psi), due to a higher permeate backpressure from the longer discharge piping between the UF system and the break tank. Backpressure on the UF averaged 11.3 psi, but averaged 8.5 psi for the MF system, located immediately adjacent to the break tank. The differences in feed pressure should therefore not be considered representative of the two systems, but are rather the result of the unique flow configuration of the intermediate piping downstream of each system.

Operational Period 2 is defined as the operational period following the completion of the second chemical cleaning. The MF system operated for over 3.4 months with a calculated fouling rate of 12 percent and did not require a third cleaning through the end of the 12 month testing period. In comparison, the UF system operated for 2 months before requiring cleaning during this operating period. During this time the fouling rate for the UF was 38 percent, which was significantly greater (> 3 times) than that observed on the MF system over a similar time period, and considerably greater than the fouling rate observed during Operational Period 1. The UF manufacturer recommended that an aggressive low pH (pH 1.5) cleaning be performed to try to decrease the unexpected transmembrane pressure rise seen during this operational period.

Operational Period 3 (UF only) is defined as the operational period following the completion of the third chemical cleaning. The UF system operated for 1.7 months with a lower fouling rate (26 percent vs. 38 percent) and much lower average transmembrane pressure (2.7 psi vs. 6.8 psi) than observed during Operational Period 2. The decrease in fouling is attributed to the lower target pH (1.5 vs. 3) used during the third cleaning as opposed to the target pH of the second cleaning.

Water quality monitoring of the membrane filtration systems showed that both consistently produced filtrate with similar water quality: turbidity (<0.1 NTU), TOC (6.5 mg/L), and UV 254 Absorbance (UV254) (0.17 cm^{-1}). With regards to pathogen removal, concentrations of total and fecal coliforms were consistently non detect (ND) in the filtrate from both systems; however, it was observed that the UF system achieved a slightly higher log removal of bacteriophage (viruses), than the MF system, which is attributable to the smaller pore size in the UF membranes. The average (n=20) log removal for somatic and male specific bacteriophage for the MF system were greater than 3.0 and 1.1, respectively. The average (n=20) log removal of somatic and male specific bacteriophage for the UF system were calculated as greater than 3.7 and 2.2, respectively. No quantifiable hits of either somatic or male specific bacteriophage were recorded in the UF product, suggesting that higher log removal values may have been observed had concentrations in the feed been higher. It should be noted that the composite reduction for the two types of viruses monitored was greater than 99 percent for both the MF and UF system.

Table 2-5 Summary of Membrane Filtration Operation

Operational Period following Chemical Cleanings	Run Time Hours (Months)	Average Feed Pressure (psi)	Average Filtrate Pressure (psi)	Total Delta H between Feed & Filtrate Pressure Transmitters (psi)	Average Transmembrane Pressure[1] (psi)	Fouling Rate (% decrease temp. corrected specific flux per month)
MF System						
Operating Period 1 (10/6/11 to 4/5/12)	3,962 (5.5)	15.0	8.5	1.5	5.0	11
Operating Period 2 (4/6/12 to 7/31/12)	2,444 (3.4)	15.2	8.6	1.5	5.1	12
UF System						
Operating Period 1 (9/8/11 to 3/22/12)	4,138 (5.7)	16.0	11.3	1.3	3.4	11
(Operating Period 2 (3/23/12 to 5/31/12)	1,472 (2)	19.4	11.3	1.3	6.8	38
Operating Period 3 (6/2/12 to 7/31/12)	1,225 (1.7)	15.3	11.3	1.3	2.7	26

Notes:

a. Transmembrane pressure was calculated as Average Feed Pressure minus Average Filtrate Pressure minus total Delta H (difference in elevation between feed and filtrate pressure transmitters).

b. Chemical cleanings performed on the MF system on 10/5/11 and 4/5/12.

c. Chemical cleanings performed on the UF system on 9/7/11, 3/22/12, and 5/31/12.

2.3.2 Reverse Osmosis

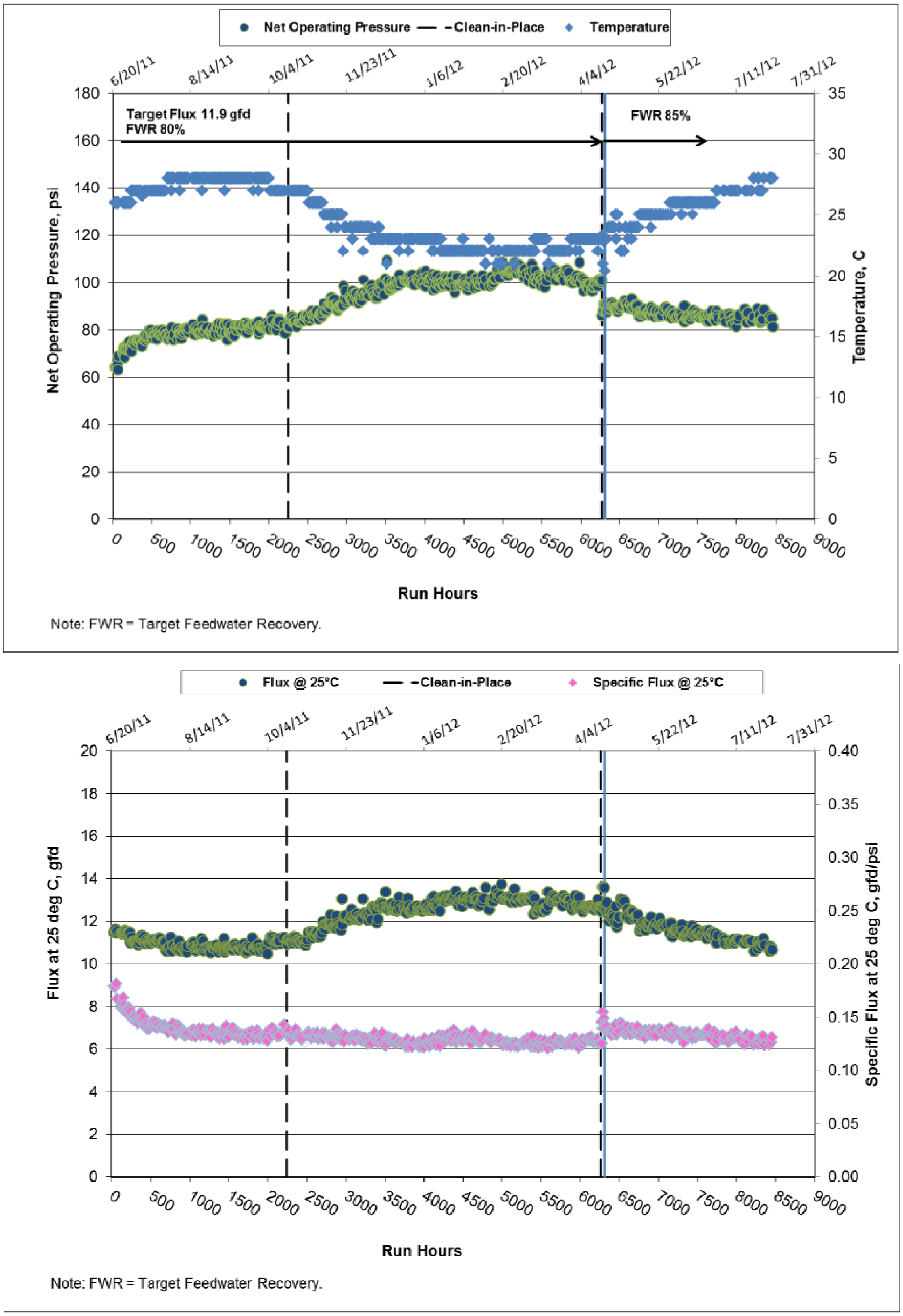
During the testing period the RO system (Trains A and B) was operated using combined filtrate from the membrane filtration systems for 8,500 hours (11.8 months) of runtime. The RO trains were operated under similar operating conditions for the entire testing period as shown in Table 2-6. Each RO train was also equipped with an energy recovery device that was designed to transfer pressure from the concentrate to the feed of the last stage. The RO trains were designed without the use of cartridge filtration as pre-treatment because of the controlled environment upstream of the RO system (closed membrane filtration break tank), which eliminated the introduction of particulates upstream of RO. Chloramines and antiscalant were applied upstream of RO to prevent biofouling and control scaling of the membranes.

Table 2-6 Summary of the RO System Operating Conditions

Parameter	Value
RO Train A	
Antiscalant dose	3 mg/L
Average flux	11.9 gfd
Feed water recovery	80 to 85 percent
RO Train B	
Antiscalant dose	3 mg/L
Average flux	11.6 gfd
Feed water recovery	80 to 85 percent

RO Train A Operation

Operational performance parameters including net driving pressure, flux, specific flux, and feed water temperature for the RO system Train A are illustrated in Figure 2-5. Membrane fouling was assessed during the operational period by monitoring the decline in temperature corrected specific flux, or permeability, under constant flux operation.



Note: FWR = Target Feedwater Recovery.

Note: FWR = Target Feedwater Recovery.

Figure 2-5
Membrane Performance of the RO System Train A

During the initial operation period, a decrease in the specific flux was observed prior to becoming level around run hour 900 (5 weeks). Since this decrease was predominantly in the first stage elements, it was believed that it may have been related to organic fouling or to biological regrowth. To prevent further fouling, the target feed water concentration of chloramines was increased from 1.5 to 3.0 mg/L. Following this adjustment, the membranes operated with little to no decrease in specific flux for approximately 1,345 hours of operation. A full chemical cleaning was performed on Train A on 10/14/11 (run hour 2,245). The membranes were cleaned in accordance to the manufacturer's protocol using caustic soda followed by citric acid. A summary of cleaning results for both RO Systems is provided in Table 2-7**.** Comparison of the specific flux measured before and after the cleaning of Train A on 10/14/11 indicates the cleaning had no effect on restoring the average membrane specific flux. These results suggest that the decrease in specific flux observed during the initial operation may have been related to conditioning of the membranes rather than entirely from membrane fouling. It is also possible that the cleaning procedures chosen were not sufficient to entirely remove the foulant layers.

Following cleaning, the system was restarted and the specific flux remained steady with little decline for the next 4,000 hours (5.5 months) of operation. On 4/26/12 a second chemical cleaning was performed before changing the RO recovery. During this cleaning, the order of cleaning chemicals was changed (citric acid followed caustic) and the soak and recirculation times were extended. Data collected before and after the chemical cleaning showed the specific flux was restored by about 15 percent.

Table 2-7 Summary of RO Membrane Cleaning Results

RO System	Date of Cleaning	Pre-Clean Temperature Corrected Specific Flux (gfd/psi@ 25 Deg C)	Post Clean Temperature Corrected Specific Flux (gfd/psi @ 25 Deg C)	Cleaning Effectiveness (% change in specific flux pre to post clean)	Cleaning Chemicals
Train A	10/14/11	0.14	0.14	0 %	Caustic followed by citric acid
Train A	4/26/12	0.13	0.15	15%	Citric acid followed by caustic
Train B	10/7/11	0.11	0.13	18%	Caustic followed by citric acid
Train B	4/18/12	0.12	0.14	17%	Citric acid followed by caustic
Train B (3rd Stage Only)	6/7/12	0.05	0.11	120%	Citric acid followed by caustic

Following completion of the chemical cleaning, the system was operated under the same target operating conditions as stated above with the exception that the feed water recovery FWR was increased to 85 percent at run hour 6,314. Following the adjustment, little to no fouling was observed as measured by the limited decline in overall specific flux for the remainder of the testing period. In all, the system operated for 2,144 hours (3 months) under these operating conditions without a cleaning. The fouling rate averaged 2 percent per month during these final 3 months of operation.

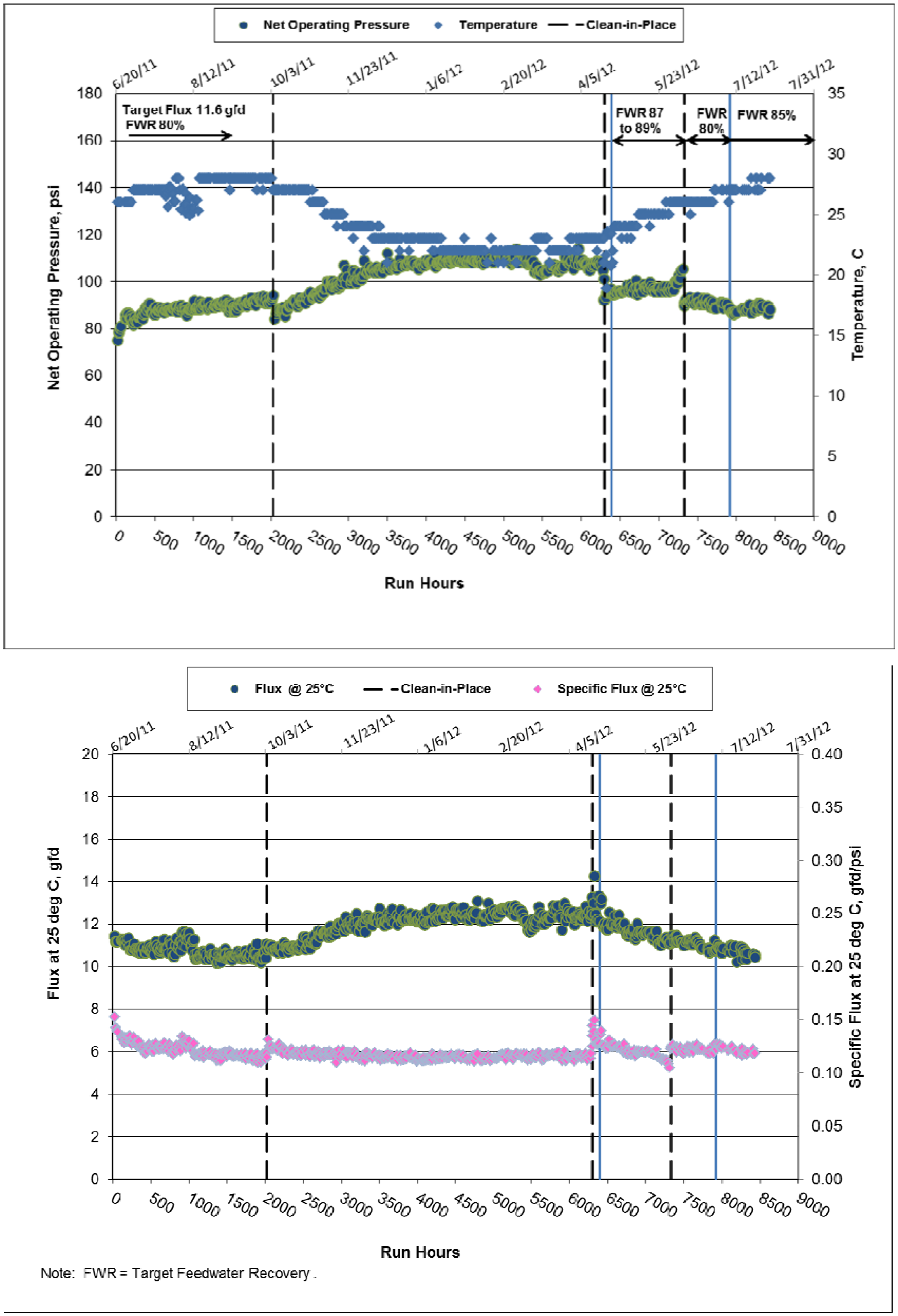
The performance of the RO Train A energy recovery device was also closely monitored over the testing period. During Q1 and Q2 Testing Periods, the energy recovery device performed far below optimal conditions. The device was removed from the system and sent to the manufacturer for repair. The unit was repaired and reinstalled at run hour 5,015. Comparison of performance data before and after the repair showed that the average boost pressure increased from 8.9 to 23 psi, which was within the range of the design projections of the energy recovery device. It was also observed that the average boost pressure dropped significantly (23 psi to 12 psi) when the recovery increased to 85 percent, because of the lower concentrate flows available to power the energy recovery device.

RO Train B Operation

Operational performance parameters monitored for the RO system Train B are shown in Figure 2-6. Membrane fouling was assessed during the operational period by monitoring the decline in temperature corrected specific flux under constant flux operation.

During the initial 160 hours (1 week) of operation, the specific flux (gfd/psi @25 degrees C) of the new Toray TML membranes declined steadily from an initial value of 0.15 to 0.13. The specific flux further declined slightly over the next 740 run hours to approximately 0.12 gfd/psi. The target feed concentration of chloramines was increased from 1.5 to 3.0 mg/L (same modification as Train A) at run hour 941. The specific flux remained steady with little or no decline for the next 1,126 hours (1.6 months) of operation.

A full chemical cleaning was performed on Train B at run hour 2,027. The membranes were cleaned in accordance with the manufacturer's protocol using both caustic soda and citric acid. Assessment of the membrane performance before and after the cleaning shows the cleaning was partially effective at restoring the specific flux in the second and third stage membranes. Following the cleaning, the specific flux remained steady with little to no decline for 4,253 hours (5.9 months) of operation. A second chemical cleaning was conducted at run hour 6,297. Due to the suboptimum effectiveness of the chemical cleaning conducted on all three stages of the RO system during the Q1 Testing Period (as well as the positive experience with RO Train A chemical cleaning), the cleaning protocol was modified to change the order of cleaning chemicals (citric acid followed caustic) and the soak and recirculation times were extended. Data collected before and after the cleaning showed the specific flux was restored by about 14 percent. The specific flux increased by 6 percent after the acid cleaning and an additional 8 percent after the caustic cleaning.



Note: FWR = Target Feedwater Recovery.

Figure 2-6
Membrane Performance of RO System Train B

Following completion of the chemical cleaning, the system was operated under the same target operating conditions as previously operated with the exception that the feed water recovery was increased to 85 percent at run hour 6,391. Since that change, little fouling was observed in either the first or second stage, however, significant scaling appears to have occurred within the third stage. By run hour 7,311, the third stage specific flux had dropped by 40 percent of the initial value observed at the start of 85 percent feed water recovery. In addition, the permeate conductivity of the third stage had increased by more than 158 percent. The increase in salt passage (higher permeate conductivity) and decrease in specific flux, are both indicators of inorganic scale formation in the final membrane stage. At this time, a chemical cleaning was conducted on the third stage membranes. Results of the cleaning show the cleaning was effective at restoring the specific flux to the values seen at the start of the 85 percent feed water recovery operation. After completion of this cleaning Train B was restarted at a target feed water recovery of 80 percent, while the cause of the scale formation was evaluated.

Because Train B scaled at a much faster rate than Train A during operation at 85 percent, an investigation was undertaken to identify the possible cause. The investigation included verification of the accuracy of the flow transmitters equipped on the RO skids as well as verifying the feed water recovery of the systems based on sulfate values measured in the feed, permeate, and concentrate. The flow transmitters equipped on both RO skids were checked against measurements using an ultrasonic flow meter provided by Toray. Comparing results showed the flow transmitters were within acceptable agreement with the ultrasonic flow meter with the exception of the concentrate flow transmitter on Train B, which read 22 percent higher than the flow measured by the ultrasonic meter. Based on this information, recovery calculations were revised to use the permeate and feed flow meters rather than the concentrate. In addition, sulfate mass balance calculations were performed, confirming the accuracy of the revised recovery calculations. It was therefore determined that Train B had operated at a feed water recovery between 87 and 89 percent instead of the targeted 85 percent feed water recovery during the time the scaling was observed. In order to rectify the issue, the scale factor on the concentrate flow meter was adjusted to accommodate the measured discrepancy. The feed water recovery was then returned to 85 percent at run hour 7,942. During the following 493 hours (3 weeks), the overall specific flux declined by approximately 9.9 percent and the third stage by 25 percent, which was still a significantly higher fouling rate than what was seen on RO Train A. Because a limited amount of run time was conducted on Train B at 85 percent recovery, it was recommended that further operation be conducted to more accurately assess the fouling rate at this recovery.

The performance of the RO Train B energy recovery device was also closely monitored over the testing periods. The average boost pressure during operation at a target feed water rate of 80 percent was 23 psi with a noticeable decrease at run hour 5,022. This decrease corresponds with a manual adjustment made on the concentrate valve to decrease the concentrate flow in order to maintain the target feed water recovery. Further adjustment was made to the concentrate valve at run hour 6,391 to increase the target feed water recovery to 85 percent. The average boost pressure measured during operation at 85 percent over the remainder of the testing period was 6.4 psi due to the lower concentrate flows available to power the device at 85 percent recovery.

Comparison of RO System Train A and Train B Operation

A comparison of operational performance of RO System Trains A and B is provided in Table 2-8.

Operating Period 1 is defined as the operational time period between the completion of the first and second chemical cleaning. During this time the systems operated for 5.6 months (Train A) and 5.9

months (Train B) with similar fouling rates of 1.4 percent and 1.6 percent (decline in specific flux per month), respectively. Train B operated with a higher feed pressure. The higher pressure required for Train B is attributed to the difference in configuration (three stages vs. two stages), as the specific flux were found to be similar for both membranes and were nearly identical for the first stage elements (see Table 2-8).

Table 2-8 Summary of the RO System Trains A and B Operation

Operational Period following Chemical Cleanings	Run Time Hours (Months)	Target Feed Water Recovery (%)	Average Feed Pressure (psi)	Net Driving Pressure(psi)	Average Specific Flux or Permeability (gfd/psi@25 Deg. C)	Fouling Rate (% decrease temperature corrected specific flux per month)
Train A (Two-stage)						
Operating Period 1 (10/16/11 to 4/16/12)	4,020 (5.6)	80%	133	98	1st Stage: 0.12 2nd Stage: 0.14	1.4
Operating Period 2 (4/19/12 to 7/31/12)	2,144 (3)	85%	124	87	1st Stage: 0.13 2nd Stage: 0.16	2.1
Train B (Three-stage)						
Operating Period 1 (10/6/11 to 4/17/12)	4,254 (5.9)	80%	139	104	1st Stage: 0.12 2nd Stage: 0.13 3rd Stage: 0.10	1.6
Operating Period 2 (4/23/12 to 6/7/12)	920 (1.3)	85%[1]	138	97	1st Stage: 0.13 2nd Stage: 0.14 3rd Stage: 0.10	15 (Stage 3 = 40)
Operating Period 3 [2] (6/8/12 to 7/9/12)	591 (0.8)	80	130	91	1st Stage: 0.12 2nd Stage: 0.13 3rd Stage: 0.10	2.1
Operating Period 4 (7/10/12 to 7/31/12)	493 (0.7)	85	130	88	1st Stage: 0.12 2nd Stage: 0.13 3rd Stage: 0.10	9.9

Note:

1. The actual feed water recovery during Operating Period 2 was determined to be between 87 to 89%.
2. No cleaning was performed between Operating Period 3 and Operating Period 4.

Specific flux for the first stage elements are presented in Figure 2-7. First stage permeability is impacted primarily by organic fouling, particulates, and biological growth and should not be impacted significantly by whether the membranes are operated in a two-stage or three-stage configuration. The first stage permeability therefore allows a direct comparison of the organic fouling rate between the TML20 and ESPA2 membranes for this feed water, along with a comparison of intrinsic resistance within the membranes (the membranes natural resistance to pushing water through). Specific flux decline for the two membranes was similar, with both showing a rapid initial decline during the first 20 days (500 hours) of operation, followed by relatively flat permeability (around 0.12 gfd/psi) until the membranes were cleaned after 260 days (6,250 hours). Fouling of the membranes was low compared with many operational AWP facilities.

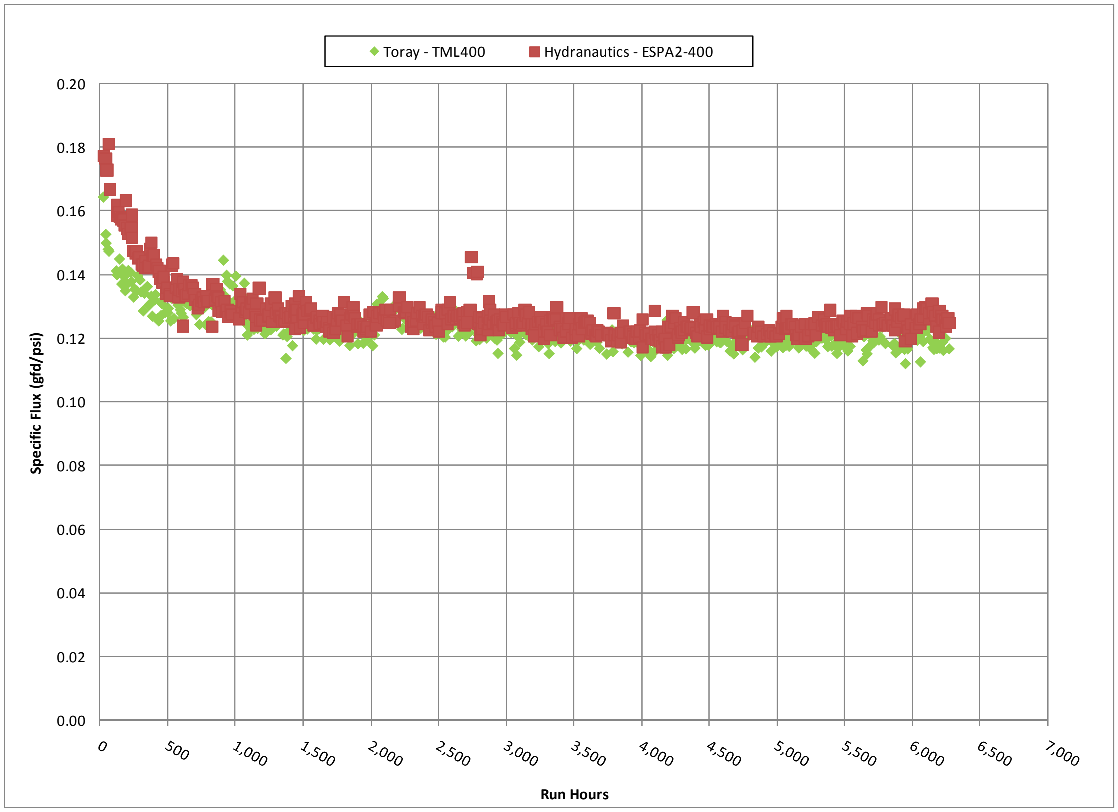


Figure 2-7
Membrane Permeability for RO System Trains A and B First-stage Membranes

Operational Period 2: is defined as the operational period following the completion of the second chemical cleaning, which was conducted at run hour 6,265 for Train A and run hour 6,297 for Train B. During this time the target feed water recovery for both systems was 85 percent. Following the second cleaning, Train A operated for 2,144 run hours (3 months) with little fouling (2.1 percent per month). However, Train B only operated for 920 run hours (1.3 months) due to the aforementioned issue with the concentrate flow meter which led to the system being operated above the target recovery (i.e. 87 to 89 percent). During this time fouling rate was 15 percent based on the decline in the overall specific flux, however the Stage 3 fouling rate was 40 percent. At this time, the third stage was cleaned.

Operational Period 3 (Train B only) is defined as the operational period following the cleaning of the third stage membranes. During this period the system was operated with a target recovery of 80 percent during which time the issue with the concentrate flow meter was investigated and resolved. During this period the system operated for 591 run hours with a modest fouling rate of 2.1 percent.

Operational Period 4 (Train B only) is defined as the operational period during which the system was operated at 85 percent recovery upon resolving the aforementioned issue with the concentrate flow meter. During this time the system operated for 493 run hours (0.7 months) with a measured fouling rate of 9.9 percent. Because a limited amount of run time was conducted on Train B at 85 percent recovery, it is recommended that further operation be conducted to more fully assess the fouling rate at this recovery.

Table 2-9 presents the water quality data for RO System Trains A and B for several key water quality parameters. The two types of membranes were projected to differ on some water quality parameters, but both systems consistently produced permeate with similar water quality characteristics. Software projections for both membranes predicted less rejection of total dissolved solids (TDS) and chloride, with the Hydranautics ESPA2 elements (Train A) closer to projections for TDS and the Toray TML20 elements (Train B) closer for chlorides. Nitrate rejection was significantly under-estimated for the ESPA2 elements, projecting a total nitrogen concentration of 1.3 mg/L in the product, but measuring an average concentration nearly half of this, at 0.78 mg/L. In contrast, the TML20 software over estimated the nitrate rejection, predicting a total nitrogen of 0.3 mg/L, but measuring an average concentration more than double this, at 0.78 mg/L. Overall, there was very little difference between the permeate produced by the two RO membranes tested, in spite of the initial projections that had suggested much higher nitrogen removal with the TML20 elements.

Table 2-9 Comparison of RO System Trains A and B Permeate Water Quality

Contaminant	Units	Number of Samples (n)	Train A Permeate (Hydranautics ESPA2) (Average ±STD)	Train B Permeate (Toray TML) (Average ±STD)
Nutrients				
Ammonia, Total	mg/L-N	20	0.39 ±0.13	0.40 ±0.14
Nitrate	mg/L-N	20	0.38 ±0.09	0.40 ±0.09
Nitrite	mg/L-N	14	0.02 ±0.00	0.02 ±0.00
Nitrogen, Total	mg/L-N	20	0.78 ±0.12	0.77 ±0.09
Phosphorus, Total	µg/L-P	21	5 ±2	4 ±2
Inorganic				
TDS	mg/L	17	14 ±2	14 ±2
Sodium	mg/L	15	2.8 ±0.4	2.8 ±0.4
Chloride	mg/L	18	2.3 ±1.9	2.2 ±0.3
Boron	mg/L	15	0.22 ±0.02	0.22 ±0.02
Manganese	mg/L	15	0.002 ±0.001	0.002 ±0.001
Fluoride	mg/L	17	0.03 ±0.00	0.03 ±0.00
Organics				
TOC	mg/L	9	0.18 ±0.01	0.18 ±0.01
UV 254	cm-1	41	0.016 ±0.00	0.016 ±0.00
Microbial				
Total / Fecal Coliform	MPN/100 mL	73	<1	<1

Comparison of RO Configurations

Figure 2-8 presents the RO feed pressure for the two-stage and three-stage flow configurations. Since membrane permeabilities did not differ significantly between the two systems, the higher feed pressure seen with Train B (the Toray membranes) is the result of higher differential pressure losses associated with the three-stage operation. In a two-stage configuration, differential pressure loss occurs as water passes along the feed spacers of seven first-stage elements followed by seven second-stage elements, averaging 12 psi of loss within the first stage and 11 psi within the second. This pressure loss is partially overcome by an interstage boost from the energy recovery devices; however, the differential pressure loss still results in a decrease in net driving pressure and a lower water production in the tail end elements. For the three-stage configuration, differential pressure loss occurs across three separate stages, although with only six elements in each stage, rather than the more typical seven elements used in the two-stage configuration. An average 11 psi of differential pressure loss occurred within the first stage, 15 psi in the second, and 13 psi in the third. As with the two-stage configuration, the differential pressure loss was partially overcome using an interstage boost from the energy recovery device.

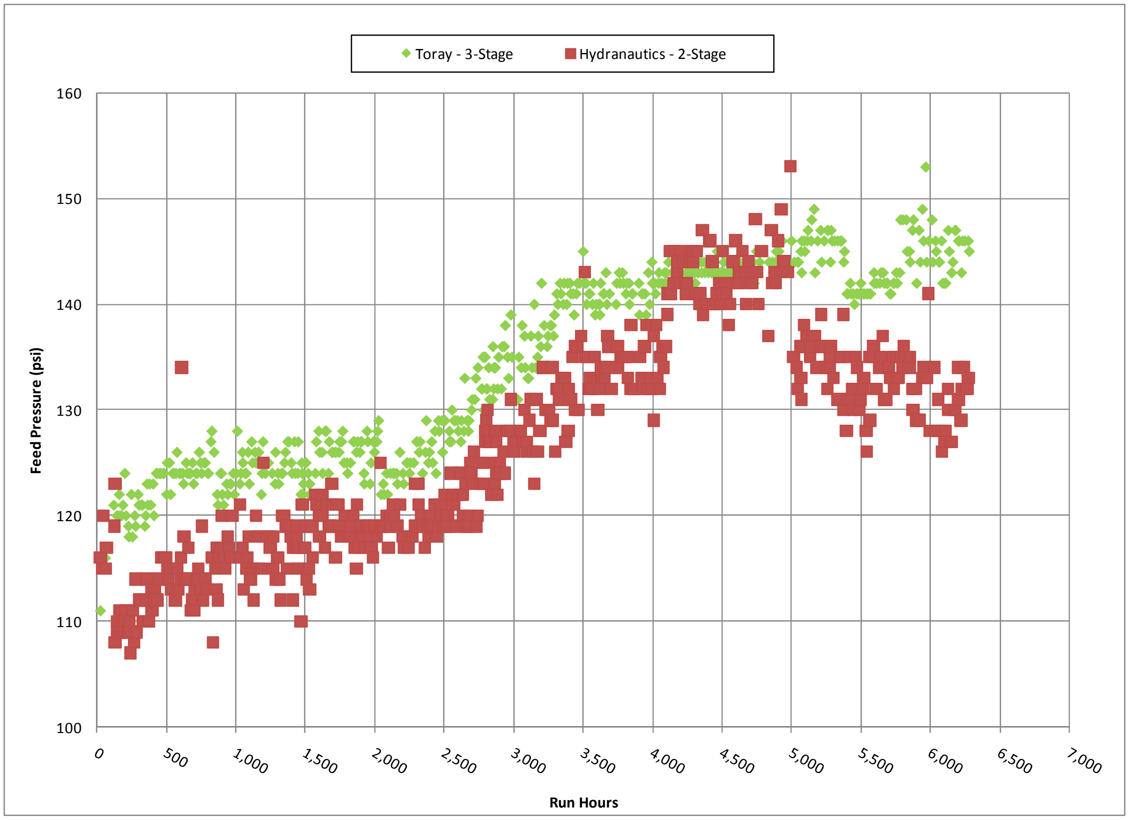


Figure 2-8
Feed Pressures for RO System Trains A and B

The operating results presented in Figure 2-8 demonstrate that the higher differential pressure loss experienced with the three-stage configuration resulted in a feed pressure between 10 to 15 psi higher than the two-stage configuration. This higher feed pressure relates directly to higher operating costs and energy demands for a three-stage configuration.

The rapid increase in feed pressure seen in the two-stage system after 170 days shown in Figure 2-7 resulted from removal of the energy recovery device for repair. The two-stage system operated at a feed pressure nearly identical to the three-stage system during the period in which no energy recovery device was used with the two-stage system, however, when the repaired energy recovery device was returned to service at 209 days, the feed pressure for the two-stage system dropped to approximately 15 psi below the three-stage system. Additional information on the comparison of the energy usage of the two-stage versus three-stage RO configuration is presented in Section 2.3.5.

2.3.3 UV Disinfection and Advanced Oxidation

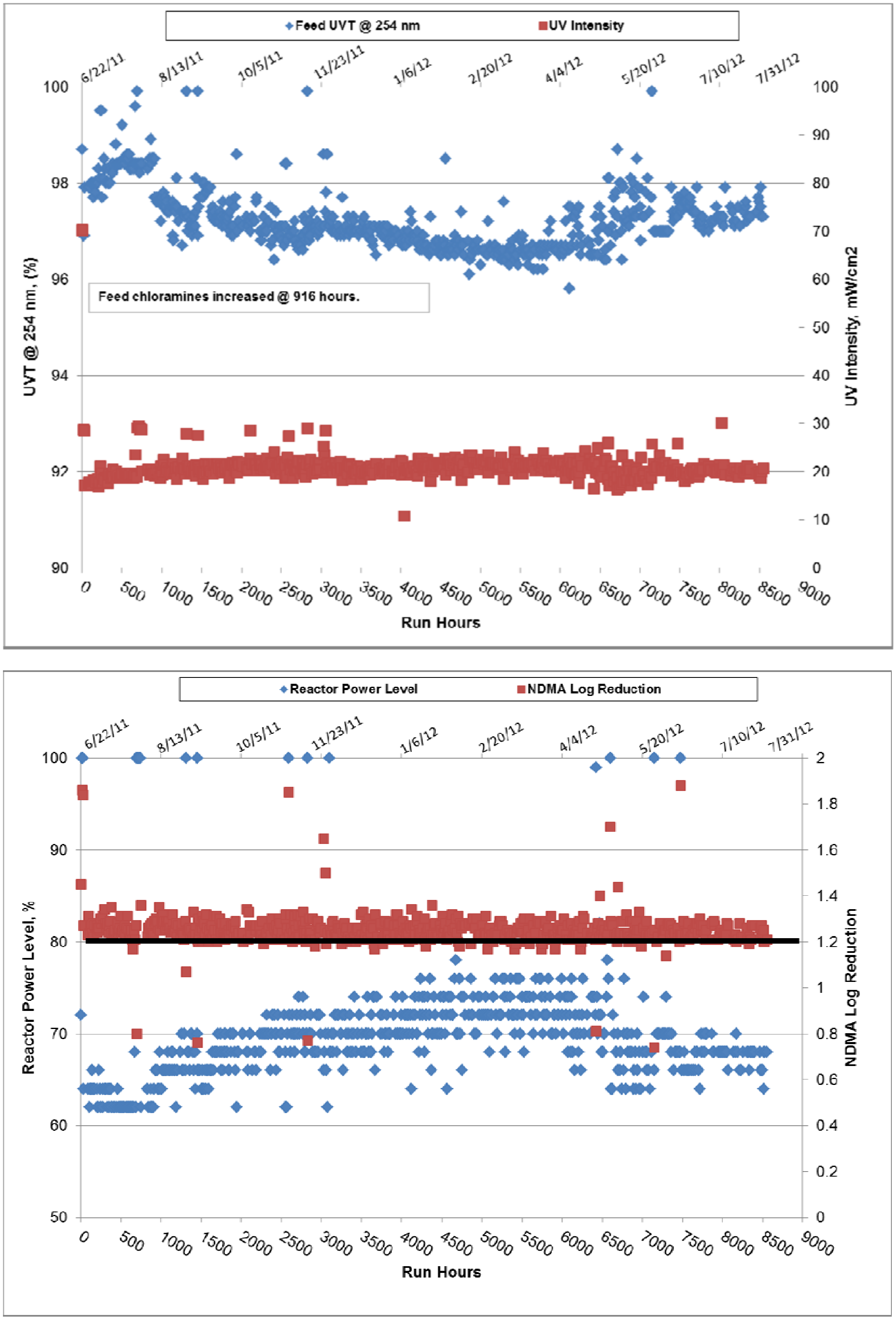
The UV disinfection and advanced oxidation system was operated to achieve a target log removal of NDMA and 1,4-dioxane of 1.2-logs and 0.5-logs, respectively, based on the 2008 CDPH Groundwater Replenishment Reuse Draft Regulations. After the commencement of this project, CDPH issued revised Groundwater Replenishment Reuse Draft Regulations (November 2011) that did not include the requirement for 1.2-log NDMA removal. The revised draft regulations maintained the requirement for 1,4-dioxane removal and included a requirement to meet the 10 nanogram per liter (ng/L) Notification Level for NDMA. However, testing conducted at the Demonstration Facility has shown that these low NDMA levels were met in the tertiary effluent before treatment, which means it may not ultimately be necessary to provide treatment for NDMA at the Full-Scale Facility. NDMA levels in the tertiary effluent are lower than other operating AWP facilities.

The target hydrogen peroxide dose applied to the UV disinfection and advanced oxidation feed water was held constant at 3 mg/L, targeting the required 0.5-log destruction of 1,4-dioxane. The ultraviolet light transmittance (UVT) at the 254 nanometer wavelength measured in the feed ranged from approximately 97 percent to 98.5 percent, which was determined to be impacted by the chloramines residual concentration. The Trojan control system adjusted the reactor power to maintain the target log removals using an algorithm, which takes into account feed flow, temperature, UVT, and lamp age.

Operating parameters monitored on the UV system for nearly 8,500 hours of operation are provided in Figure 2-9. The average reactor power level required to achieve the target NDMA removal as predicted by the Trojan control system was approximately 67 percent, which corresponds to an average power of 12.6 kilowatt (kW). A slight increase in the power required to achieve the target removal was observed to increase with an increase in runtime. The increased power was attributed to the decrease in temperature during the winter months as well as lamp aging, both of which increased the applied power to achieve a target contaminant removal. The average electrical energy per order (EEO) value as predicted by the Trojan algorithm and displayed on the human machine interface (HMI) over the testing period was 0.26 kilowatt-hours (kWh)/1,000 gallons/ log removal.

The UV system at the Demonstration Facility had five ballast failures which caused the reactor power to increase to 100 percent. The manufacturer indicated that the ballast failures were caused by failures in weak components of the faulty ballasts. The design of the Full-Scale Facility should include power monitoring of the Full-Scale Facility power sources to determine if a transient voltage surge suppressor should be included in the UV system design. Further discussion related to power optimization is provided in Section 3.1.3.

The EEO values and NDMA removal performance of the UV disinfection and advanced oxidation system were confirmed by conducting an initial spiking experiment. The spiking experiment was conducted by injecting a laboratory prepared NDMA stock solution to the UV and advanced oxidation feed water. The results of the spiking experiment are summarized in Figure 2-10. Overall the results showed that the Trojan system achieved NDMA removals between 1.5 to 2.1 log units over the span of power settings that were tested (60 percent to 100 percent). In addition, the system operated more efficiently than predicted by the Trojan algorithm. Calculated values of EEO based on results of the spiking experiment ranged from 0.18 to 0.21 kWh/1,000 gallons/log removal over the range of power settings tested. This EEO is similar to the tested EEO of 0.19 to 0.23 kWh/1,000 gallons/log removal for the UV disinfection and advanced oxidation system at the West Basin Municipal Water District's Edward C. Little Water Recycling Facility, a full-scale AWP Facility



Feed chloramines increased @ 916 hours.

Figure 2-9
UV Disinfection and Advanced Oxidation Process System Performance

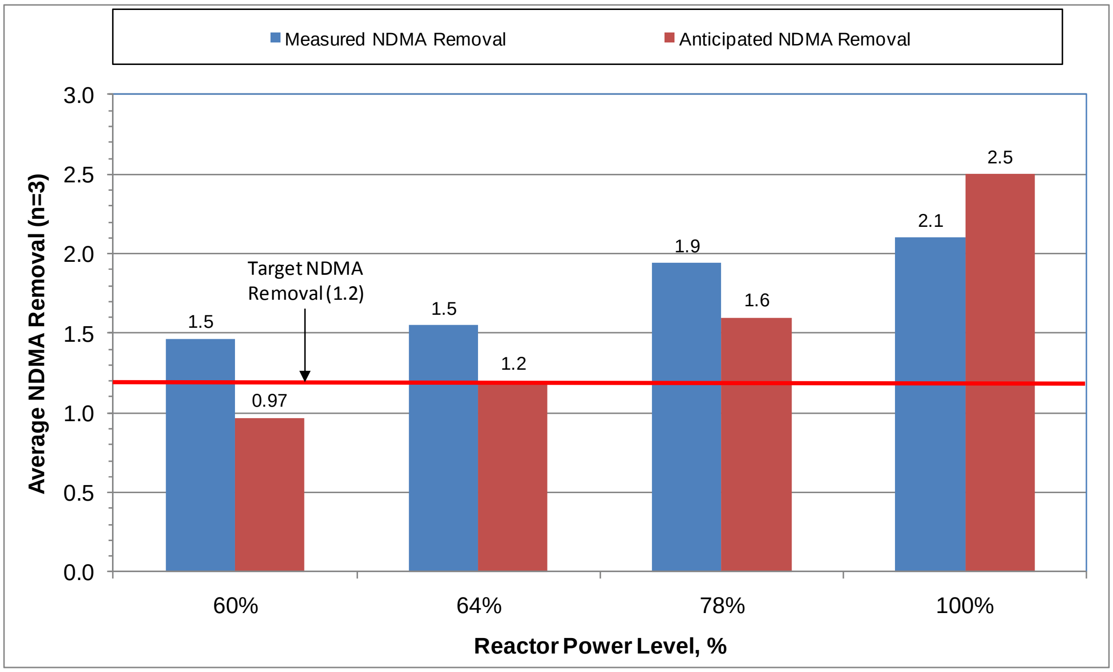
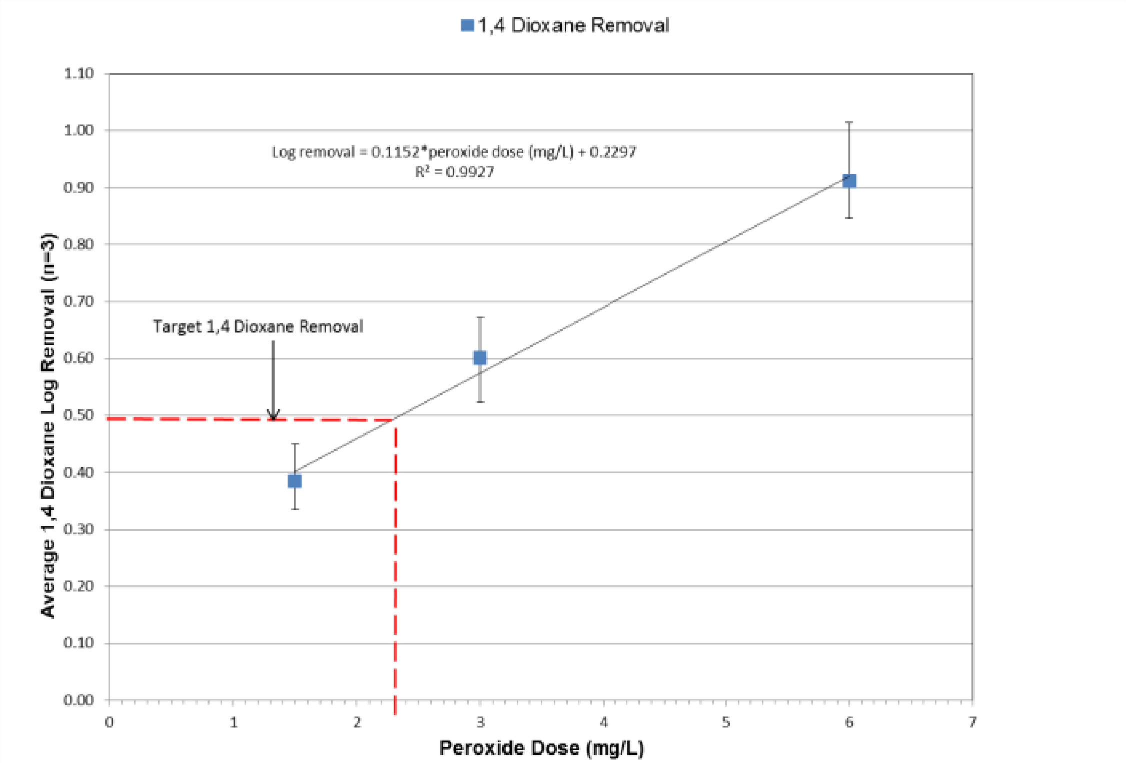


Figure 2-10
UV Disinfection and Advanced Oxidation NDMA Spiking Experiment Results

A second spiking experiment was conducted to demonstrate the performance of the reactor at removing both NDMA and 1,4-dioxane, the results of which are summarized in Figure 2-11. A laboratory-prepared 1,4-dioxane stock solution was injected into the UV and advanced oxidation feed water. The UV/AOP system achieved 0.6-log removal (74.9 percent) of 1,4-Dioxane under the design conditions. This exceeded the log-removal goal of 0.5 (68.7 percent) based on 2011 Groundwater Recharge Reuse Draft Regulations. Figure 2-11 plots log removal of 1,4-dioxane versus target peroxide dose for Tests 1 to 3. The results show a linear relationship between log removal and peroxide dose ($R^2 = 0.99$). Based on this relationship, a predicted target dose of 2.3 mg/L would be required to achieve 0.5 log removal of 1,4-dioxane. The significance of these results is that it may be possible to optimize the peroxide dose to reduce O&M costs of the UV/AOP if it is considered that there is a balance between electrical energy and peroxide dose needed to achieve the optimal operating conditions.

The EEO observed for 1,4-dioxane destruction ranged from 0.5 to 0.7 kWh/1,000 gallons/log reduction with a peroxide dose of 2.5 mg/L. This EEO is similar to the EEO of 0.5 kWh/1,000 gallons/log reduction reported by the Orange County Water District after initial testing at their Groundwater Replenishment System.



Note: Measured Peroxide Feed Concentrations:: Test 1 = 1.3 mg/L, Test 2=2.6 mg/L, and Test 3 = 4.9 mg/L.

Figure 2-11
UV Disinfection and Advanced Oxidation 1,4 Dioxane Spiking Experiment Results

2.3.4 Chemical Consumption

The consumption of chemicals was monitored over the testing period. Key information and observations related to chemical consumption during the testing period for the various Demonstration Facility water purification processes are summarized below.

The Demonstration Facility used four chemicals during routine operations: ammonium hydroxide, sodium hypochlorite, antiscalant, and hydrogen peroxide. Table 2-10 provides specific information for each chemical used including target dose, location, stock concentration and purpose. Chemicals were fed into the process stream using diaphragm metering pumps. The speeds of the pumps are flow paced to maintain a constant dose when changes in flow occur. The most notable flow change throughout the Demonstration Facility operations was the feed flow when the MF or UF system goes into backwash or pressure decay test mode. Cylinder draw downs were completed daily to make sure that each chemical was being fed accurately and in the proper quantity.

Table 2-10 Summary of Chemicals used by the Demonstration Facility Water Purification Processes

Chemical	Stock Concentration (w/w)	Injection Location	Target Dose (mg/L)	Purpose
Ammonium hydroxide	19%	MF/UF Influent	1.5	To combine with sodium hypochlorite to form chloramines for membrane biofouling control.
Sodium hypochlorite	13%	MF/UF Influent	3.8	To combine with ammonia to form chloramines for membrane biofouling control.
Antiscalant	100%	RO Influent	3	To prevent scaling of RO membranes.
Hydrogen peroxide	30%	UV Influent	3	Reacts with UV light to form free hydroxyl radicals to provide advanced oxidation.

Monitoring of the chemical consumption of the Demonstration Facility water purification processes was conducted throughout the testing period. Table 2-11 provides information related to chemical usage for the MF, UF, RO and UV disinfection and advanced oxidation systems. The table provides the total amount of each chemical delivered during each testing period as well as the estimated average daily consumption per 1-mgd production of purified water.

The average daily consumption of each chemical represents the average of values determined from each testing period. During the Q1 Testing Period the daily consumption for each chemical was estimated based on full capacity production for a 24 hour period and the target dose rate. During the Q2 through Q4 Testing Periods, the actual average daily consumption usage of each chemical was determined by monitoring the level of each chemical storage tank before and after each delivery. The volume of each chemical used over the testing period was then calculated based on the difference in tank levels recorded at the beginning and end of the testing period, the total volume delivered over the testing period and the estimated storage capacity per foot of each chemical tank. The total calculated usage over the testing period was then divided by the total number of days in the testing period to estimate the average daily usage. No chemical usage above that expected was required during any of the testing periods.

Table 2-11 Summary of Chemical Consumption

Chemical	Total Amount Delivered Start up and Testing Period 1 5/3/11 to 10/31/11 (gallons)	Total Amount Delivered Testing Period 2 11/1/11 to 2/10/12 (gallons)	Total Amount Delivered Testing Period 3 2/11/11 to 5/14/12 (gallons)	Total Amount Delivered Testing Period 4 5/15/11 to 7/31/12 (gallons)	Estimated Average Daily Consumption per 1 mgd (gallons)
Ammonium hydroxide	1,593	1,007	1,208	928	11
Sodium hypochlorite	4,229	2,932	3,464	2,636	31
Antiscalant	440	275	220	164	3
Hydrogen peroxide	1,784	869	550	546	8

2.3.5 Energy Consumption

The power consumption of each Demonstration Facility water purification process was monitored during the demonstration period by taking daily readings of power consumption totals displayed on the Demonstration Facility control system. The totals are based on daily power logged by the individual power monitors (Electro Industries Model Shark 200) installed in each individual water purification processes (MF, UF, RO and UV disinfection and advanced oxidation systems). An additional power meter was also installed to monitor the total power being used by the Demonstration Facility. The purpose of the main power meter was to capture the power usage of the entire Demonstration Facility, including MF, UF, RO and UV disinfection and advanced oxidation systems; chemical storage and feed systems for pre-treatment; and loads such as lights, air conditioning, and ancillary equipment (e.g., auto-samplers, TOC analyzer, etc.) plugged into the 120V receptacles. Table 2-12 summarizes the power monitors and associated equipment monitored by each power monitor.

Table 2-13 summarizes the monthly power usage by each water purification process for the days that the Demonstration Facility was in operation. Appendix F provides daily power totals logged from the main control system screen for each water purification process from 8/1/11 to 7/31/12.

The following observations were made regarding the Demonstration Facility power usage:

- Since the membrane filtration feed pumping was provided by the EDR feed pump located external to the Demonstration Facility, the power usage of the membrane filtration feed pumping was not monitored continuously. The power consumption of the EDR feed pump feeding the membrane filtration systems was monitored for three days and average daily power consumption was 960 kWh/d. The major power requirement for the membrane filtration systems is influent pumping.

- The UF power usage is consistently higher than the MF power usage, which was attributed to the oversized air compressor and other inefficient design components. The UF power usage is discussed in more detail below.

- Following the replacement of the inlet valve electro-pneumatic positioner with a pneumatic actuator on 1/18/12, the daily UF power totals were observed to increase by approximately 50 kWh/d.

- The measurements in the MF power monitor increased in October 2011 and April 2012 due to increased power usage required to heat the cleaning chemicals for the chemical cleanings conducted in those months. However, the increase in power usage of chemical cleanings was offset by reduced power usage from MF downtimes.

- Comparison of the sum of the individual power meters for the water purification processes to Demonstration Facility power meter show that the power usage for ancillary equipment not specific to MF/UF, RO or UV disinfection and advanced oxidation systems was approximately 3 percent to 4 percent of the total Demonstration Facility power usage.

Table 2-12 Demonstration Facility Power Monitors

Power Monitor		Equipment Monitored	Equipment Not Monitored
1	MF System	MF strainer MF skid including recirculation pump and reverse feed pump MF skid including hot water pump MF/UF/RO CIP tank heater MF air compressor system	MF control panel and MF air dryer are on 120 V power source and captured by the Demonstration Facility main power monitor
2	UF System	UF strainer UF skid including backwash pump UF air compressor system UF chemical transfer pumps	
3	RO Train A System	RO Train A including Train A feed pump	RO cleaning skid including permeate flush pump and cleaning pump are captured by the Demonstration Facility main power monitor
4	RO Train B System	RO Train B including Train B Feed pump	
5	UV Disinfection and Advanced Oxidation System	UV system Hydrogen peroxide feed pumps	
6	Demonstration Facility Main	All equipment located within Demonstration Facility, including: RO cleaning skid with permeate flush pump and cleaning pump; ancillary process equipment such as sodium hypochlorite feed pump, ammonium hydroxide feed pump, disinfection carrier water pump, sulfuric acid feed Pump, antiscalant feed pump, sump pump; analyzer equipment such as auto-samplers, TOC analyzer, etc.; lights; and air conditioning.	EDR feed pump for MF/UF feed pumping

Reference:

Indirect Potable Reuse/Reservoir Augmentation Demonstration Project Advanced Water Purification Facility at North City WRP, Approved for Construction Drawings, CDM Smith/MWH, February 2011, Drawings 28-E-3 and 28-E-4.

Table 2-13 Demonstration Facility Power Usage Monthly Summary

Month	Total Monthly Power Consumption (kWh) [8]									
	MF [1]	UF [2]	RO Train A	RO Train B	UV	Ancillary Loads [3]	Total including MF/UF Feed Pumping [4]	Total including MF/UF Feed Pumping [5]	Total without MF/UF Feed Pumping [6]	Total without MF/UF Feed Pumping [7]
Aug 2011	14,200	16,100	14,400	18,100	6,600		69,300		45,000	
Sep 2011	13,500	15,200	17,200	17,100	5,300		68,300		45,600	
Oct 2011	14,800	19,000	21,900	22,200	8,600		86,600		61,200	
Nov 2011	14,900	18,100	21,300	22,400	8,300		85,000		59,700	
Dec 2011	16,600	20,100	25,800	27,500	8,900	3,200	98,900	102,000	70,900	74,100
Jan 2012	16,600	20,800	25,400	27,100	8,800	3,200	98,600	102,000	70,400	73,600
Feb 2012	16,200	21,100	25,600	26,900	8,900	3,000	98,700	102,000	71,200	74,200
Mar 2012	17,800	21,600	24,700	26,600	8,900	3,300	99,500	103,000	70,400	73,700
Apr 2012	18,100	21,000	22,700	27,300	9,000	3,400	98,200	102,000	70,200	73,600
May 2012	15,000	17,300	19,100	21,700	7,500	2,500	80,700	83,000	56,000	58,600
June 2012	14,000	16,700	18,800	21,600	7,200	2,700	78,300	81,000	55,400	58,100
July 2012	14,400	17,200	19,200	22,500	9,100	2,400	82,400	84,000	58,000	59,200
Total Power (kWh)	**186,000**	**224,200**	**256,100**	**281,100**	**97,100**		**1,044,500**		**734,000**	
Total Flow Treated (MG)	**172**	**174**	**161**	**161**	**324**	**324**	**324**	**324**	**324**	**324**
Average Power Consumption per Flow (kWh/MG)	**1,100**	**1,300**	**1,600**	**1,700**	**300**		**3,200**		**2,300**	

Notes:

[1] Includes power measured by MF system power monitor, estimated power usage for MF feed pumping, and estimated power usage for MF control panel and MF air dryer that are powered through the 120V system. MF feed pumping is based on average feed flow of 570 gpm and 35-40 psi of pressure. Feed pressure was reduced at the PRV located upstream of MF. The MF control panel is estimated to use 14 kWh/day and the MF air dryer is estimated to use 2.9 kWh/day.

[2] Includes power measured by UF system power monitor and estimated power consumption for UF feed pumping. UF feed pumping is based on average feed flow of 552 gpm and 35-40 psi of pressure. Feed pressure was reduced at the PRV located upstream of UF.

[3] Includes power usage for: RO cleaning skid with permeate flush pump and cleaning pump; ancillary process equipment such as sodium hypochlorite feed pump, ammonium hydroxide feed pump, disinfection carrier water pump, sulfuric acid feed pump, antiscalant feed pump, sump pump; analyzer equipment such as auto-samplers, TOC analyzer, etc.; lights; and air conditioning.

[4] Total estimated power usage for UF, MF, RO and UV disinfection and advanced oxidation systems, including membrane filtration feed pumping. Does not include RO cleaning skid, ancillary process equipment, analyzer equipment, lighting and air conditioning.

[5] The total Demonstration Facility power usage measured by the main power monitor plus the estimated power usage for membrane filtration feed pumping. The main power monitor was installed on 11/8/11.

[6] Total estimated power usage for UF, MF, RO and UV disinfection and advanced oxidation systems. Does not include membrane filtration feed pumping. Does not include RO cleaning skid, ancillary process equipment, analyzer equipment, lighting and air conditioning.

[7] The total Demonstration Facility power usage measured by the main power monitor. Does not include the estimated power usage for membrane filtration feed pumping.

[8] For days that power totals were not recorded from the meters, power usage was estimated based on the estimated runtime and typical power usage over a 24-hour period.

Membrane Filtration Power Consumption

The detailed breakdown of monthly total membrane filtration power consumption is summarized in Table 2-14.

Table 2-14 Membrane Filtration Power Consumption

Month	MF					UF		
	MF Power Monitor[1]	MF Feed Pumping[2]	MF Control Panel[3]	MF Air Dryer[4]	Total MF	UF Power Monitor[5]	UF Feed Pumping[6]	Total UF
Aug 2011	1,621	12,114	361	72	14,168	3,953	12,190	16,143
Sep 2011	1,668	11,449	341	68	13,526	4,027	11,213	15,241
Oct 2011	2,438	11,953	356	71	14,818	5,561	13,460	19,021
Nov 2011	1,566	12,860	383	77	14,885	5,593	12,464	18,056
Dec 2011	1,811	14,271	425	85	16,591	6,337	13,753	20,090
Jan 2012	1,720	14,331	427	85	16,563	6,902	13,890	20,791
Feb 2012	1,737	13,948	415	83	16,184	7,554	13,519	21,073
Mar 2012	2,277	14,996	446	89	17,809	7,342	14,124	21,466
Apr 2012	3,401	14,210	423	85	18,119	7,225	13,773	20,998
May 2012	1,942	12,638	376	75	15,031	5,330	11,995	17,325
June 2012	2,057	11,469	341	68	13,935	5,294	11,448	16,741
July 2012	1,577	12,396	369	74	14,416	5,211	12,014	17,225
Total Power (kWh)	**23,816**	**156,633**	**4,663**	**933**	**186,044**	**70,327**	**153,843**	**224,170**
Total Flow Treated (MG)	**172**	**172**	**172**	**172**	**172**	**174**	**174**	**174**
Average Power Consumption per Treated Flow (kWh/MG)	**139**	**913**	**27**	**5**	**1,084**	**404**	**885**	**1,289**

Notes:

[1] Measured by MF system power monitor. MF power usage for membrane skids and ancillary equipment includes power usage from chemical cleaning system tank heater, which was also used for UF and RO cleanings. Therefore, MF power usage is slightly overestimated.

[2] Calculated value based on average feed flow of 570 gpm and 35-40 psi of pressure.

[3] MF control panel is powered through the 120V system. The MF control panel is estimated to use 14 kWh/day.

[4] MF air dryer is powered through the 120V system. The MF air dryer is estimated to use 2.9 kWh/day.

[5] Measured by UF system power monitor. UF power usage for membrane skids and ancillary equipment does not include power usage from chemical cleaning system tank heater (measured as part of MF system) or chemical cleaning system pumps (measured separately and accounted for as part of ancillary loads). Therefore, UF power usage is slightly underestimated.

[6] Calculated value based on average feed flow of 552 gpm and 35-40 psi of pressure.

Power Monitoring of the Membrane Filtration Feed Pump (EDR Feed Pump)

The power to pump the tertiary recycled water to the membrane filtration systems is separate from the power to the Demonstration Facility and not measured with the Demonstration Facility power monitor. The membrane filtration feed pump is shared with the City's EDR system and is set to pump at a discharge pressure of approximately 35 to 40 psi, which is later reduced down to 15.5 psi and 17.2 psi to meet the membrane filtration system influent pressure requirements (the estimated average feed pressure required for the MF and UF are 15.5 psi and 16.0 psi, respectively, after accounting for the backpressure on the UF system). The membrane filtration feed configuration in the Demonstration Facility is not reflective of the Full-Scale Facility influent pumping configuration, since the Full-Scale Facility will be located north of North City and will have different head requirements (see Section 4).

The City performed short-term power monitoring of the EDR feed pump that supplies feed water to the membrane filtration systems to determine how much power was used to feed the membrane filtration systems at the Demonstration AWP Facility. An external power meter was connected to the feed pump for approximately nine days. Based on the total power recorded over this time period, the power usage of the feed pump per day was approximately 960 kWh/day to feed both membrane filtration systems. The membrane filtration feed pumping accounted for approximately 30 percent of the total Demonstration Facility power consumption.

Estimated Power Usage for Membrane Filtration Feed Pumping

Since approximately 18 to 25 psi of pressure was lost, on average, across the pressure reducing valves located upstream of the membrane filtration, a more realistic power requirement for membrane filtration feed pumping was estimated based on the average transmembrane pressure across the membrane filtration membranes that were measured during the Demonstration Facility testing period. Based on this calculation, the membrane filtration feed pumping was reduced to approximately 10 percent of the total Demonstration Facility power consumption. Table 2-15 shows a detailed breakdown of the membrane filtration power consumption with the EDR feed pump used for membrane filtration feed pumping.

Table 2-15 Average Power Consumption per Flow Treated for Membrane Filtration

Equipment	Average Power Consumption per Flow Treated (kWh/MG)			
	MF[1]		UF[2]	
	Pumping with EDR Feed Pump	Estimated Pumping based on transmembrane pressure	Pumping with EDR Feed Pump	Estimated Pumping based on transmembrane pressure
Feed Pumping	913 (Average Feed Pressure = 35-40 psi)	232 (Average Feed Pressure = 15.5 psi)	885 (Average Feed Pressure = 35-40 psi)	232 (Average Feed Pressure = 16.0 psi)
Membrane Skids and Ancillary Equipment	171	170	404	408
Total	**1,084**	**402**	**1,289**	**640**

Notes:

[1] MF power usage for membrane skids and ancillary equipment include power usage from the chemical cleaning system tank heater, which was also used for UF and RO cleanings. Therefore, MF power usage is slightly overestimated.

[2] UF power usage for membrane skids and ancillary equipment does not include power usage from the chemical cleaning system tank heater (measured as part of MF system) or the chemical cleaning system pumps (measured separately and accounted for as part of ancillary loads). Therefore, UF power usage is slightly underestimated.

Investigation of UF Power Usage

As shown in Table 2-15 and Appendix F, the UF system required approximately 18 percent more power than the MF system during the Demonstration Project. Table 2-15 shows that the difference in power consumption is greater (59 percent) once the influent pumping requirements are adjusted to eliminate excess pumping, as discussed above.

The City conducted additional power monitoring of the UF system with an external power meter to confirm the power usage. The power meter was connected to the main UF power supply for approximately 14 days. Based on the total power recorded over this time period, the power usage of the UF system was determined to be approximately 200 kWh/day, which correlates to the values logged from the power monitor equipped on the system.

Next, the power usage of the air compressor on the UF system was monitored for nearly 14 days using the external power meter. Based on the total power recorded over this time period the power usage of the air compressor was determined to be 105 kWh/day, which is about half of the total UF power. It is expected that differences in the size and efficiency of the compressors equipped on the UF and MF systems may account for the discrepancy in power totals. The UF system air compressor is 40 HP and requires 50 amps while the MF system air compressor is about 8 horsepower (HP) and requires 7.9 amps. It seems that the UF system air compressor was oversized and the design could be optimized for the Full-Scale Facility.

Reverse Osmosis

Comparison of Two-stage versus Three-stage RO Systems

Two RO configurations were tested at the Demonstration Facility, two-stage and three-stage configurations, both incorporating energy recovery devices that were designed to provide approximately 23 psi of interstage boost. As previously discussed, the three-stage configuration (RO Train B) provided no improvement in performance over the two-stage configuration (RO Train A), but required a feed pressure 5 to 10 percent higher. As shown in Table 2-16 below, the three-stage configuration (RO Train B) required on average 9 percent more energy than a two-stage configuration (RO Train A).

Table 2-16 Comparison of Two-stage RO and Three-stage RO Power Consumption

Month	Total Monthly Power Consumption (kWh)		
	RO Train A [1] (Two-Stage Configuration)	RO Train B [2] (Three-stage configuration)	Ancillary Loads [3]
Aug 2011	14,400	18,100	
Sep 2011	17,200	17,100	
Oct 2011	21,900	22,200	
Nov 2011	21,300	22,400	
Dec 2011	25,800	27,500	3,200
Jan 2012	25,400	27,100	3,200
Feb 2012	25,600	26,900	3,000
Mar 2012	24,700	26,600	3,300
Apr 2012	22,700	27,300	3,400
May 2012	19,100	21,700	2,500
June 2012	18,800	21,600	2,700
July 2012	19,200	22,500	2,400
Total Power (kWh)	**256,100**	**281,100**	
Total Flow Treated (MG)	**161**	**162**	**324**
Average Power Consumption per Treated Flow (kWh/MG)	**1,600**	**1,700**	

Notes:

[1] Measured by RO Train A power monitor. Two-stage system. Energy recovery device is ERI Turbocharger LPT-250.

[2] Measured by RO Train B power monitor. Three-stage system. Energy recovery device is ERI Turbocharger LPT-150.

[3] Includes power usage for: RO cleaning skid with permeate flush pump and cleaning pump; ancillary process equipment such as sodium hypochlorite feed pump, ammonium hydroxide feed pump, disinfection carrier water pump, sulfuric acid feed pump, antiscalant feed pump, sump pump; analyzer equipment such as auto-samplers, TOC analyzer, etc.; lights; and air conditioning.

A two-stage configuration is currently used at the City of Los Angeles' Terminal Island AWP Facility, Water Replenishment District's Leo J. Vander Lans Water Treatment Facility, and one of the West Basin Municipal Water District's AWP facilities; however, a three-stage configuration is used at the Orange County Groundwater Replenishment System and another of the West Basin Municipal Water District's AWP facilities. The preliminary layout, design criteria, and cost estimate are based on a two-stage configuration, based on three quarters of operating data, which showed that a three-stage configuration required approximately 8 percent more energy with no improvement in performance over a two-stage configuration.

Evaluation of Energy Recovery Devices

Both RO trains are equipped with energy recovery devices to utilize wasted energy from the RO concentrate to boost feed pressures to the final stage. Energy recovery devices have been employed successfully at brackish water RO facilities in California and other western states, but have not yet been incorporated into an AWP Facility in the region. While energy recovery devices will reduce the required feed pressure and energy usage at an RO facility, the ability of the operational savings to offset the cost of the equipment will depend on the salinity of the water, the residual energy in the concentrate, and the efficiency of the energy recovery device. Because of the limited data available on full-scale operation of these devices in AWP facilities, a focus of the Demonstration Facility was to confirm the accuracy of projected energy recovery estimated using RO design models (IMSDesign v. 2009).

Table 2-17 presents information on the energy recovery devices used in the RO systems for the Demonstration Facility and the impacts these devices had on operating pressures. Section 3 includes additional information on the energy recovery devices. The average boost to the final stage shown in the table was measured directly from the systems; however, values for the two-stage configuration include only data from after 209 days of operation when the energy recovery device had been repaired. Initial operation with the energy recovery device only resulted in a 5 to 10 psi boost in interstage pressure for the two-stage system. After several months of trouble-shooting with the RO system supplier and ERD manufacturer, the device was removed and sent for testing and repairs. When the repaired device was returned to service, the interstage boost averaged 23 psi. The reduction in feed pressure listed in Table 2-17 for the two-stage system was calculated as the average feed pressure when the device was offline (between 170 and 209 days) minus the average feed pressure after the device was returned to service (after 209 days). The reduction in feed pressure for the three-stage system, in contrast, was calculated using an energy balance, the measured pressure boost to the final stage, and the flow ratio between the final stage and the first stage. Total energy reduction was calculated by dividing the calculated reduction in feed pressure by the measured feed pressure. The following formulas were used for these calculations:

Reduction in Feed Pressure (Three-stage)

$P_r = P_b * Q_{3f}/Q_{1f}$

where P_r = Reduction in feed pressure

P_{3b} = Boost pressure to third stage

Q_{3f} = Feed flow to the third stage (calculated from concentrate plus third-stage permeate flow)

Q_{1f} = Feed flow to the first stage

Total Energy Reduction

$E_r = (P_r/P_{1f})*100$

where E_r = Reduction in energy (%)
P_r = Reduction in feed pressure
P_{1f} = Feed pressure to the first stage

Concentrate Energy Recovered (Three-stage)

$E_{cr} = (P_b*Q_{3f}/(P_c*Q_c))*100$

where E_{cr} = Concentrate energy recovered (%)
P_{3b} = Boost pressure to third stage
Q_{3f} = Feed flow to the third stage
P_c = Final concentrate pressure
Q_c = Final concentrate flow

Table 2-17 Impact of Energy Recovery Devices on RO Operation

	RO Train A Two-Stage Configuration	RO Train B Three-Stage Configuration
Equipment Model Number	ERI Turbocharger LPT-250	ERI Turbocharger LPT-125
Average Boost to Final Stage	23 psi	24 psi
Reduction in Feed Pressure	10 psi	7.4 psi
Concentrate Energy Recovered	42%	27%
Total Energy Reduction	8%	5%

For the energy recovery devices used at the Demonstration Facility, the two-stage configuration resulted in a higher overall recovery of energy. An average of 42 percent of the hydraulic energy present in the concentrate stream was recovered in the interstage boost, compared with only 27 percent energy recovery achieved in a three-stage configuration. The energy recovery resulted in an overall energy savings of 8 percent and 5 percent for the two-stage and three-stage systems, respectively. Efficiencies of the energy recovery devices are impacted by operating pressures, concentrate and interstage flows and should not be assumed to remain constant over the full duration of plant operation.

UV Disinfection and Advanced Oxidation

The average reactor power level required to achieve the target NDMA removal as predicted by the Trojan control system was approximately 67 percent, which corresponds to an average power of 12.5 kW. The power required to achieve the target removal was observed to increase as runtime increased. The increased power was attributed to the decrease in temperature during winter months, as well as lamp aging, both of which increased the applied power to achieve a target contaminant removal. The average EEO value predicted over the testing period for NDMA was 0.26 kWh/1,000 gallons/ log removal. When measured during the testing period, however, the EEO was better than projected at 0.19 kWh/1,000 gallons/log removal. For the Full-Scale Facility, multiple UV vessels in series will likely be used to improve overall reactor hydraulics, further reducing the EEO.

2.4 Water Quality and Regulatory Relevance

This subsection includes a discussion of the water quality data collected during the operation of the Demonstration Facility and the regulatory relevance of the data in regards to future permitting of the Full-Scale Facility. Non-regulated water quality constituents are also discussed, in regards to potential health impacts associated with constituents monitored in the purified water.

2.4.1 Regulatory Background

As described in the T&M Plan (Appendix A), a future Full-Scale Facility will be subject to requirements put forth by CDPH and the Regional Board. At this time, specific requirements for reservoir augmentation have not been established by any state agencies, creating a degree of uncertainty regarding the ultimate requirements which will need to be met. For purposes of evaluating the regulatory relevance of the water quality observed at the Demonstration Facility, water quality goals were developed for the T&M Plan based on:

- Compliance with all federal (U.S. Environmental Protection Agency [EPA]) and state (CDPH) drinking water maximum contaminant levels (MCLs) and secondary maximum contaminant levels.
- Remaining below all CDPH notification levels (NLs).
- Compliance with all requirements of the August 2008 and November 2011 CDPH Groundwater Replenishment Reuse Draft Regulations. These draft requirements were used because CDPH has not issued draft regulations for surface water augmentation. (Note that in November 2011, after the Demonstration Facility design and T&M Plan were completed, CDPH released updated Groundwater Replenishment Reuse Draft Regulations. The goals included here-in comply with requirements from both the 2008 and the 2011 draft regulations.)
- Compliance with all established discharge requirements from the Regional Board, including Basin Plan Objectives, California Toxics Rule (CTR) requirements for freshwater and for human health, and State Board Policy for Implementation of Toxics Standards for Inland Surface Water, Enclosed Bays, and Estuaries of California (SIP). It should be noted here that not all requirements for the CTR or the nutrient limits of the Basin Plan have been firmly established for discharges to San Vicente Reservoir and some uncertainly therefore remains on these specific requirements.
- Compliance with project specific goals established for the Demonstration Facility.

Twenty-one key water quality parameters were identified to serve as a primary focus of the water quality testing, with project specific goals established for each parameter as listed in Table 2-18. These key constituents were identified because they can be challenging to remove by the treatment processes employed or because they are widely used parameters to measure performance of water treatment processes. Additionally, nutrients are a specific concern when introducing purified water to the San Vicente Reservoir, and five specific nutrient goals were identified as part of the key water quality parameters. Several of the water quality goals were based on CTR limits for consumption of water and organisms, without accounting for a mixing zone, as would typically be applied. The goals are considered conservative with respect to potential requirements of the CTR. Of particular note are the goals established for bromoform, bromodichloromethane, and dibromochlormethane, which are three of the four trihalomethanes that also regulated for drinking water with an MCL of 80 μg/L for the sum of all four trihalomethanes. The goals listed in Table 2-18 for these three trihalomethanes are more than 100 times lower than this drinking water MCL and are based on CTR limits that may not be applicable once potential mixing zones are accounted for in the reservoir.

All water quality goals defined in the T&M Plan were reviewed and commented on by CDPH, the Regional Board, and the Demonstration Project Independent Advisory Panel. As a result of the comments received, the T&M Plan was expanded to include sampling for additional water quality parameters and increased frequency and number of samples for constituents that were identified in the draft plan. These comments and a description of how they were addressed are included as an Appendix to the T&M Plan.

Table 2-18 Demonstration Facility Project Specific Water Quality Goals

Constituent		Units	Water Quality Goal[a]
Removal Challenge	Bromoform	µg/L	0.5
	Methylene Chloride	µg/L	4.7
	Trihalomethanes, Total (TTHMs)	µg/L	80
	Bromodichloromethane	µg/L	0.56
	Dibromochloromethane	µg/L	0.5
	Haloacetic Acids (HAA5)	µg/L	<60
	N-Nitrosodiethylamine (NDEA)	ng/L	10
	N-Nitrosodimethylamine (NDMA)	ng/L	2
	1,4-Dioxane	µg/L	1
	1,2-Dichloroethane	µg/L	0.5
	Boron	mg/L	1.0
Common Parameters	Total Organic Carbon (TOC)	mg/L	0.5
	Total Dissolved Solids (TDS)	mg/L	300
	Chloride	mg/L	50
	Sulfate	mg/L	65
	Turbidity	NTU	0.2
Nutrients	Nitrate as N	mg/L	1
	Nitrite as N	mg/L	1
	Ammonia as N (unionized)[b]	mg/L	0.025
	Phosphorus, Total	mg/L	0.1
	Nitrogen, Total	mg/L	1

Note:

[a] See T&M Plan, Table 5-2 (Appendix A).

[b] Unionized values of ammonia are not directly measured, but are estimated using EPA's Aqueous Ammonia Equilibrium – Tabulation of Percent Un-ionized Ammonia (EPA-600/3-79-091) along with average values of temperature and pH.

2.4.2 Summary of Water Quality Testing

The T&M Plan outlined an extensive water quality monitoring plan for the Demonstration Facility. Water quality testing was conducted in the following seven constituent categories.

- *Routine Water Quality Monitoring.* This category consisted of nutrients (nitrogen and phosphorus); volatile organic compounds (trihalomethanes, methylene chloride, 1,2-dichloroethane); nitrosamines; 1,4-dioxane; and TOC. Sampling frequencies ranged from bi-weekly to monthly depending on the specific parameter.

- *Microbial Monitoring.* This category consisted of total coliform and fecal coliform, in which sampling was initially conducted daily and then weekly. Somatic and male specific bacteriophage (viruses) sampling was initially conducted weekly, then monthly.

- *Basin Plan Objectives Monitoring.* This category consisted of parameters with Basin Plan numeric objectives not addressed in other sampling categories: TDS, Chloride, Sulfate, Sodium, Iron, Manganese, Boron, Color, Fluoride, Phenolic compounds, pH, Temperature, Dissolved Oxygen, and Turbidity. Sampling frequencies ranged from daily to bi-monthly.

- *Quarterly Monitoring.* This category consisted of: (1) compounds with Federal and State drinking water MCLs; (2) compounds included on EPA's priority pollutant list; (3) compounds with current CDPH NLs; (4) compounds on the US EPA's current Unregulated Contaminant Monitoring Rule (UCMR3) list; (5) other Radionuclides (Cesium-137, Iodine-29, Iodine-131); 6) other compounds recommended by the IAP (Lithium, benzo(k)fluoranthene, hexavalent chromium). Samples were collected quarterly.

- *Constituents of Emerging Concern (CECs).* During the Q1 and Q2 Testing Periods, an initial characterization study was conducted based on four monthly sampling events for 91 CECs, including pesticides, herbicides, pharmaceuticals, and ingredients in personal care products representing a wide range of chemical and physical properties. Following the initial characterization study, the CEC monitoring program was modified to include the health-based and performance-based indicators recommended by the State Board's expert panel on CEC monitoring for groundwater recharge projects that utilize RO/advanced oxidation. The complete report produced by the expert panel can be found online at the following website: http://www.waterboards.ca.gov/water_issues/programs/water_recycling_policy/recycledwater_cec.shtml. One sample was collected for this suite of CECs. In addition, 37 CECs were selected for monitoring as potential treatment performance indicators based on occurrence in the RO feed water as measured during the initial characterization study or CECs recommended by the IAP. Weekly samples were collected over a period of four weeks.

- *Whole Effluent Toxicity Testing*. This program, conducted during the Q2 Testing Period, consisted of acute and chronic toxicity assays for a blend of purified water and Lake Murray (local reservoir primarily holding imported water) and a control sample. The chronic test organisms were *Ceriodaphnia dubia* (water flea), *Pimephales promelas* (fathead minnow) and *Selenastrum capricornutum* (green algae). The test organisms used for the acute testing were *Ceriodaphnia dubia* and *Pimephales promelas*.

- *Quality Assurance/Quality Control (QA/QC) Testing*. A QA/QC Plan was developed for the project consisting of the collection and analysis of field duplicates, blind duplicates, travel blanks, field blanks, and split samples. In addition, third-party validations were performed by Laboratory Data Consultants, Inc. using EPA Level IV guidelines to assess data quality and review laboratory and sample handling procedures by WECK and MWH Labs.

There was some overlap for parameters in the different categories. For example some of the constituents included in the routine monitoring category were also assessed as part of the quarterly monitoring category.

2.4.3 Water Quality Monitoring Results – Regulated Constituents

Results from water quality monitoring conducted through the Q4 Testing Period showed that the Demonstration Facility produced purified water that reliably met drinking water and the 2008 and 2011 CDPH Groundwater Replenishment Reuse Draft Regulations, while providing multiple barriers to chemicals and pathogens. The purified water met all regulatory requirements and goals defined for the project.

Project Specific Goals

A summary of water quality monitoring results of regulated constituents is presented in Table 2-19, and a comparison of key water quality results and project specific goals is presented in Table 2-20. Table 2-20 shows values for all parameters returning quantifiable laboratory results above the laboratory reporting level. Sample results less than the laboratory reporting level (LRL) or the method detection limit (MDL) were considered to be not quantifiable or not detectable, both shown as "ND" in the table. It should be noted that CDPH has established detection limits for purposes of regulatory reporting (DLRs) for all parameters listed in existing CDPH regulations. In some cases the DLR was higher than the laboratory reporting level, resulting in values shown in Table 2-20 that would be considered non-detectable under standard CDPH reporting. As analytical methods advance in the industry, it has allowed the measurement of compounds at increasingly low concentration. Standard, approved analytical methods were used for all constituents, when available.

For purposes of calculating average values and standard deviations, non-quantifiable values below the laboratory reporting level were assumed to be 50 percent of that value, while values below the method detection limit were assumed to be 50 percent of that value. Calculated average values less than the laboratory reporting level are considered non-quantifiable and shown as "ND" in Table 2-20. Average concentrations for all constituents measured in the purified water were below the project specific goals for the Demonstration Facility.

Federal and State Drinking Water Maximum Contaminant Levels

All constituents currently regulated for drinking water supplies were monitored quarterly in the tertiary effluent prior to chlorination, purified water, and imported raw aqueduct water. Primary drinking water standards are established by the EPA and CDPH, and are based on MCLs, established to provide the maximum feasible protection to public health, based on EPA health guidelines for both acute (short term) and chronic (long term) health risks. In addition, secondary MCLs have been established for non-health concerns, based on aesthetic issues, such as taste, odor, or color in the water. Secondary MCLs are considered guidelines rather than enforceable limits, as they are not related to public health at these concentrations. Currently, the EPA has established primary MCLs for 81 constituents, including 17 inorganic constituents, 51 organic compounds, 6 radionuclides, 4 disinfection byproducts, and three disinfectants. In addition, CDPH has establishing state specific MCLs for 11 additional constituents, including 2 inorganic constituents and 9 organic compounds, resulting in a total of 92 primary MCLs relevant to drinking water supplies in California. CDPH and EPA have established secondary MCL's for 15 contaminants. Federal and CDPH primary and secondary MCL's and results from quarterly monitoring are provided in Quarterly Testing Report No. 3 (Appendix B).

Results from the quarterly monitoring have shown that the purified water consistently met all primary MCLs established by both EPA and CDPH. In addition, the purified water met all numerical secondary drinking water MCLs. CDPH has also established a non-numerical secondary MCL to have non-corrosive water. This standard can be met either by blending with other water supplies or by adding stabilizing chemicals to address the aggressive nature of highly purified water.

Table 2-19 Water Quality Monitoring Results of Regulated Constituents

Regulation and Guideline Group		Number of Constituents / Parameters	Total Number of Tests[1]	Purified Water Results
Federal and State MCLs	Primary Drinking Water MCL [2]	90	1,781	√ Meets all
	Secondary Drinking Water MCL [3]	18	1,290	√ Meets all
	Microbial [4]	4	1,547	√ Non-Detect
CDPH	CDPH Notification Level [5]	30	716	√ Below all
	CDPH Groundwater Replenishment [6]	142	2,244	√ Meets all
Regional Board	Regional Board Requirements for the Reservoir [7]	143	4,404	√ Meets all
	Total Number of Constituents / Parameters[8]	**231**[8]	**7,523**[8]	-----------------

Notes:

[1] The total number of tests represents the approximate number of tests conducted at all sample locations shown in Figure 2-1 and the Imported Raw Aqueduct Water.

[2] Maximum Contaminant Levels and Regulatory Dates for Drinking Water U.S. EPA VS. California November 2008.

[3] California Code of Regulation: Title 22, Division 4, Environmental Health Chapter 15. Domestic Water Quality and Monitoring Regulations Article 16. Secondary Water Standards. Purified water met all Federal and State Secondary MCLs with the exception of pH and corrosivity. The potential Full Scale Facility would include post treatment to meet these requirements.

[4] EPA Total Coliform Rule (published 29 June 1989/effective 31 December 1990). Samples from the Demonstration Facility were analyzed for the following microbial contaminants: Total coliform, Fecal Coliform, and Viruses (Somatic and Male Specific Bacteriophage).

[5] Drinking Water Notification Levels and Response Levels: An Overview. California Department of Public Health Drinking Water Program Last Update: December 14, 2010.

[6] CDPH Groundwater Replenishment Reuse DRAFT Regulation 2011. Purified water meets all numerical water quality requirements for indirect potable reuse via groundwater replenishment.

[7] EPA Numeric Criteria for Priority Pollutants Toxic Pollutants for the State of California Rule. San Diego Regional Water Quality Control Board San Diego Basin Plan Numeric objectives; note some objectives have not been defined.

[8] Because some constituents and parameters are in multiple regulations / guidelines the total of unique parameters is less than the sum.

Table 2-20 Comparison of Key Water Quality Results and Demonstration Goals

Constituent		Units	Laboratory Reporting Level	Purified Water			Water Quality Goal[b]
				Number of Samples	Average Concentration[a]	Maximum Concentration	
Removal Challenge	Bromoform	µg/L	0.5	9	ND	ND	0.5
	Methylene Chloride	µg/L	0.50	9	ND	0.59	4.7
	Trihalomethanes, Total	µg/L	2.0	9	ND	ND	80
	Bromodichloromethane	µg/L	0.5	9	ND	0.7	0.56
	Dibromochloromethane	µg/L	0.5	9	ND	ND	0.5
	Haloacetic Acids (HAA5)	µg/L	1	9	ND	ND	60
	N-Nitrosodiethylamine (NDEA)	ng/L	2	12	ND	4.9	10
	N-Nitrosodimethylamine (NDMA)	ng/L	2	12	ND	5.5	2
	1,4-Dioxane	µg/L	0.5	16	ND	ND	1
	1,2-Dichloroethane	µg/L	0.5	16	ND	ND	0.5
	Boron	mg/L	0.01	28	0.23	0.29	1.0
Common Parameters	Total Organic Carbon[d]	mg/L	0.3	97	ND	ND	0.5
	Total Dissolved Solids	mg/L	10	29	14	19	300
	Chloride	mg/L	0.5	29	3.1	4.3	50
	Sulfate	mg/L	0.5	28	ND	1.1	65
	Turbidity	NTU	-	298	0.05	0.10	0.2
Nutrients	Nitrate as N	mg/L	0.11	74	0.65	1.2	1
	Nitrite as N	mg/L	0.09	71	ND	0.1	1
	Ammonia as N (unionized)	mg/L	varies[c]	71	<0.007[c]	0.027[c]	0.025
	Phosphorus, Total	mg/L	0.01	66	0.02	0.42	0.10
	Nitrogen, Total	mg/L	0.1	74	0.8	1.3	1

Notes:

a. Average concentration calculation assumes non-quantifiable results are half of the laboratory reporting level and non-detectable results are half of the method detection limit.

b. See Testing and Monitoring Plan, Table 5-2 (Appendix A).

c. Unionized values of ammonia were estimated based on U.S. Environmental Protection Agency's *Aqueous Ammonia Equilibrium – Tabulation of Percent Un-ionized Ammonia (EPA-600/3-79-091)* using average values of temperature and pH measured on-site.

d. Laboratory results showed a single positive result of 1.4 mg/L on January 12, 2012. However, online monitoring for that same day recorded that the TOC was <0.1 mg/L. See Section 2.5.1 for more information on the online monitoring of TOC.

Acronyms:

ND – Not detectable or not quantifiable, shown for all values below laboratory reporting level
mg/L – milligrams per liter, equivalent to parts per million (ppm)
µg/L – micrograms per liter, equivalent to parts per billion (ppb)
ng/L – nanograms per liter, equivalent to parts per trillion (ppt)
NTU – Nephelometric Turbidity Units

CDPH Notification Levels

Notification levels (NLs) are health-based advisory levels established by CDPH for chemicals in drinking water that do not have MCLs. When chemicals are found at concentrations greater than their NL's, certain reporting requirements apply. In addition, CDPH has established Response Levels at two to three times higher than each NL, where CDPH recommends removal of a drinking water source from service to protect public health. Currently, the CDPH has established NLs and Response Levels for 30 constituents. During the testing period, these constituents were monitored quarterly in the tertiary effluent prior to chlorination, purified water and imported raw aqueduct water. CDPH NL's and results from quarterly monitoring are provided in Quarterly Testing Report No. 4 (Appendix B). Results from the quarterly monitoring have shown that the purified water is consistently below all NLs as established by CDPH.

Groundwater Replenishment Reuse Draft Regulations

The CDPH's Division of Drinking Water and Environmental Management is responsible for establishing standards for wastewater reuse in accordance with the "Water Recycling Criteria" in Title 22 of the California Code of Regulations. In conjunction with the CDPH and the State Board, the Regional Boards have permitting and oversight authority for Groundwater Recharge Reuse Projects. Groundwater Replenishment Reuse Draft Regulations were developed and updated most recently in November 2011. These regulations are currently in the formal regulation adoption process. CDPH is working to adopt uniform water recycling criteria for groundwater recharge by December 31, 2013.

The Groundwater Replenishment Reuse Draft Regulation is provided at the following website: http://www.cdph.ca.gov/HealthInfo/environhealth/water/Pages/Waterrecycling.aspx

Additionally, CDPH is developing draft regulations for the use of recycled water for surface water augmentation, but has not yet released a draft for public review. For the time being, an assumption has been made that CDPH requirements will be similar to those for groundwater replenishment. These treatment requirements include:

- Compliance with primary and secondary drinking water MCLs in the final recycled water.
- Total nitrogen cannot exceed 5 mg/L.
- TOC cannot exceed 0.5 mg/L divided by the CDPH-specified maximum average Recycled Water Contribution.
- The turbidity of the RO product water cannot exceed 0.2 NTU more than 5 percent of the time in any 24-hour period and can never exceed 0.5 NTU.
- The RO permeate UVT must be 90 percent or greater at 254 nanometers (nm).
- The final recycled water must be disinfected such that the 7-day median number of total coliforms cannot exceed 2.2 total coliform bacteria per 100 mL and the number of total coliform organisms cannot exceed 23 total coliform bacteria per 100 mL in more than one sample in any 30-day period.
- Advanced oxidation must achieve 0.5-log reduction in 1,4-dioxane, whether it is present or not in the source water. Additionally, the removal of indicator compounds or surrogates can be substituted for the reduction of 1,4-dioxane.

Purified water from the Demonstration Facility has met the requirements listed above. Detailed data tables can be found in the Quarterly Testing Report No. 3 (Appendix B).

Regional Board Requirements for the Reservoir

In California the regulation, protection and administration of environmental water quality are carried out by the State Board and nine Regional Boards. The San Diego region is designated as Region (9) and is governed by the San Diego Regional Board. Each Regional Board adopts a Water Quality Control Plan or Basin Plan, which recognizes and reflects differences in existing water quality, the beneficial uses of the region's ground and surface water and the local water quality conditions and problems. The Basin Plan is designed to preserve and enhance the water quality and protect the beneficial uses of all regional water bodies.

The Basin Plan includes designated beneficial uses of the San Vicente Reservoir, water quality objectives to protect those uses, the state anti-degradation policy for surface water, and toxicity requirements (including applicable federal and state standards). The Basin Plan establishes beneficial uses for surface waters and groundwater in the region and numeric and narrative water quality objectives to protect those uses. Permit limits are established for those constituents that have the reasonable potential to cause or contribute to an excursion above any water quality objective. The Basin Plan allows for a mixing zone (e.g., dilution factor) to be considered for inland surface waters on a case-by-case basis. If a dilution factor is approved, the permit limit (and reasonable potential evaluation) could be based on modified water quality objectives. The designated beneficial uses of San Vicente Reservoir are:

- Municipal and Domestic Supply
- Agricultural Supply
- Industrial Process Supply
- Industrial Service Supply
- Contact Water Recreation: fishing from shore or boat is permitted, but other water contact recreational (REC-1) uses are prohibited. However, per Section 115840(a) of the Health and Safety Code, CDPH allows the reservoir to be used for body contact recreation, and thus other REC-1 uses apply.
- Non-body Contact Water Recreation
- Warm Freshwater Habitat
- Cold Freshwater Habitat
- Wildlife Habitat

The Basin Plan includes various numerical and narrative water quality standards for numerous constituents. Narrative and numeric nutrient requirements are also included. For waste discharge requirements established for recycled water discharges to surface water such as the San Vicente Reservoir, the Basin Plan allows the Regional Board to use the phosphorus goal for flowing waters (0.1 mg/L) as a guideline or to determine compliance with the narrative objective using four factors, including use of best available technology economically feasible for the removal of nutrients. It should be noted that the nutrient requirements (including phosphorus and nitrogen) for the potential Full-Scale Facility have not yet been established.

During the testing period, general parameters with Basin Plan numeric objectives were sampled on a weekly, bi-weekly or monthly basis. Sampling locations varied by constituent as presented in the T&M Plan and included tertiary effluent prior to chlorination, RO feed, RO permeate and purified water. The results are presented in Quarterly Testing Report No. 3 (Appendix B).

Overall the results for all samples collected to date in the purified water met the Basin Plan objectives. Important observations and information related to these results follow:

Phenolic Compounds - On four occasions in 2011, the total phenolic compounds were reported above the Basin Plan numeric objective of 1 µg/L. The first monthly sample of the purified water was analyzed using EPA Method 420.4 total phenolics (method detection level =10 µg/L) for which the result was at 22 µg/L. Because this method has a method detection level greater than the Basin Plan numeric objective it was suspected that the method was not sensitive enough to accurately quantify the low concentrations of phenolic compounds expected in the purified water. After the first monthly sample, all subsequent samples for phenolic compounds were analyzed with a more sensitive method EPA 8270 C-SM. This method analyzes 14 individual phenolic compounds with method detection level between 1 to 2 µg/L.

On three additional occasions, one or more of the 14 compounds (phenol) was reported above the numeric objective for total phenolic compounds of 1 µg/L. These compounds were not found in the RO permeate upstream of the advanced oxidation, indicating that the positive results may have been caused by sample mix-up or by inadvertent contamination of the sample. Phenol is a common compound used in plastics and in water bottles. While phenol free bottles were used for all sampling, outside contamination cannot be altogether ruled out as the cause of the two quantifiable results. Following these occurrences, the frequency of sampling for phenolic compounds was therefore increased (from monthly to bi-weekly) to confirm the purified water met the required objective. The results showed both the RO permeate and purified water for 15 additional sample dates were always below quantifiable levels.

pH - The pH measured in the purified water was within the expected range of 5.5 to 6.5. The potential Full-Scale Facility would be designed with post-treatment to adjust pH to a value which would meet the Basin Plan numerical objective. The objective for pH states the change in pH level cannot exceed 0.5 units and that pH shall not be depressed below 6.5 or raised above 8.5.

Nitrogen and Phosphorus – Although the Basin Plan nutrient requirements for the potential Full-Scale Facility were not established at the time this report was prepared, nitrogen and phosphorous were tested in the purified water. The testing results showed that the water purification process achieved a high removal of these nutrients with total nitrogen being removed to an average concentration of 0.8 mg/L and total phosphorus being removed to an average concentration of 0.02 mg/L.

EPA California Toxics Rule (CTR)

The California Toxics Rule (CTR) is a federal regulation established to protect both aquatic life and human health by limiting surface water discharges based on 105 priority toxic pollutants. EPA promulgated the rule after a State court overturned California's water quality control plans in 1994, which had contained state specific water quality criteria for priority toxic pollutants. Implementation procedures for the CTR were established by the State Board through the SIP. The SIP includes: i) procedures to determine which priority pollutants need effluent limitations (e.g., reasonable potential analysis); ii) methods to calculate water quality-based effluent limitations; and iii) policies regarding mixing zones, metals translators, monitoring, pollution prevention, reporting levels for determining compliance, and whole effluent toxicity control. Permit limits are established for those CTR constituents that have the reasonable potential to cause or contribute to an excursion above any applicable criteria including consideration of dilution (Section 1.3 of the SIP). If a dilution factor is approved, the permit limit would be based on this modification of the water quality criteria in addition to other factors as set forth in Section 1.4 of the SIP. The CTR criteria are presented in the T&M Plan (Appendix A).

The CTR requirements for the potential Full-Scale Facility have not been defined yet by the Regional Board. The City will assess the water quality results and the final permit limits based on CTR criteria when they are established by the Regional Board.

Whole Effluent Toxicity Testing

Whole Effluent Toxicity refers to the aggregate toxic effect to aquatic organisms from all pollutants contained in a facility's wastewater (effluent). It is one way that the EPA implements the Clean Water Act's prohibition of the discharge of toxic pollutants in toxic amounts. Whole Effluent Toxicity tests measure wastewater's effects on specific test organisms' ability to survive, grow and reproduce.

The test methods are specified at 40 CFR 136.3, Table IA, and consist of exposing living aquatic organisms (plants, vertebrates and invertebrates) to various concentrations of a sample of wastewater, usually from a facility's effluent stream. These tests are used by the National Pollutant Discharge Elimination System (NPDES) permitting authority to determine whether a facility's permit will need Whole Effluent Toxicity requirements.

At this time it is unknown if the potential Full-Scale Facility would be permitted under the NPDES however, in order to get some preliminary information on the toxicity of the purified water, WET testing was done one time during the reporting period utilizing both acute and chronic freshwater bioassays. All tests were performed by Nautilus Environmental Laboratories (San Diego, CA). Tests were conducted per EPA protocols: EPA/821/R-02/013 (2002) Chronic Manual and EPA/821/R-02/012 (2002) Acute Manual. The chronic test organisms included: Ceriodaphnia dubia (water flea), Pimephales promelas (fathead minnow) and Selenastrum capricornutum (green algae). The test organisms used for the acute testing included water flea and fathead minnow.

The sample water was comprised of a blend of purified water collected from the Demonstration Facility and imported raw aqueduct water collected from Lake Murray. The final blend was made up of 67 percent purified water and 33 percent imported raw aqueduct water to achieve the target total hardness of 50 mg/L. Prior to testing, the pH of the blended sample was raised to approximately 8.5 using sodium hydroxide. In addition, sodium thiosulfate was added to the sample to remove residual chlorine and hydrogen peroxide. Laboratory control water was EPA moderately hard mineral water (20 percent diluted). A reference control consisting of deionized water (67 percent) mixed with raw aqueduct water (33 percent) was also utilized.

Overall, the results showed there was no toxicity observed in the sample for any of the acute and chronic tests performed. The statistical results of the purified sample follow:

- No Observed Effect Concentration values (percent effluent) for all species and endpoints tested were reported as 100 percent.
- Lowest Observed Effect Concentration values (percent effluent) for all species and endpoints tested were reported as >100 percent.
- Toxic Units were reported as 1.0 for all species and end points tested with the exception of the Water Flea 96-hr Acute survival TU = 0.41 and the Fathead minnow 96- hr acute survival TU=0.

2.4.4 Water Quality for Other Non-Regulated Constituents

Additional non-regulated constituents were monitored at various locations in the purification process and the imported raw aqueduct water. These constituents are grouped into two main categories: those included in the 2012 EPA Unregulated Contaminant Monitoring Rule (UCMR3) and other CECs, such as pharmaceutical compounds and personal care products. In addition, lithium and six nitrosamine compounds beyond the two nitrosamine compounds mentioned previously in Section 2.4.3 (NDMA and N-nitrosodiethylamine) were monitored in the purified water, based on the recommendation of the Demonstration Project Independent Advisory Panel. All together, 127 non-regulated constituents were evaluated (111 when accounting for duplication with regulated constituents) beyond the constituents discussed previously in Section 2.4.3.

Unregulated Contaminant Monitoring Rule (UCMR)

The UCMR3 is the latest of the UCMR series, issued by the EPA. The third Unregulated Contaminant Monitoring Rule (UCMR3) was signed by the EPA Administrator on April 16, 2012. UCMR3 will require monitoring for 30 contaminants using EPA and/or consensus organization analytical methods during 2013-2015. Once every five years, the EPA issues a new list of no more than 30 unregulated contaminants to be monitored by public water systems, in accordance with 1996 amendments to the Safe Drinking Water Act. The UCMR provides scientifically valid data on the occurrence of contaminants in drinking water. These data provide information that the agency uses to develop regulatory decisions. UCMR3 was published in the Federal Register on May 2, 2012 (77 FR 26072).

The UCMR3 is divided into three lists of constituents:

- Assessment Monitoring (List 1) includes 21 constituents listed in six individual EPA methods (200.8, 218.7, 300.1, 522, 524.3, and 537). Any systems serving a retail population greater than 10,000 must monitor for List 1.
- Screening Survey Monitoring (List 2) includes seven natural and synthetic hormones (EPA method 539). All very large systems (greater than 100,000 retail population) must also monitor for List 2. A randomly selected set of 320 large systems (greater than 10,000 retail population) must also monitor for List 2.
- Pre-Screen Testing (List 3) – 2 Constituents. A representative selection of 800 undisinfected groundwater public water systems serving 1,000 or fewer people will participate in monitoring for two constituents.

A complete summary of the methods, reporting limits and required sample locations is shown at: http://water.epa.gov/lawsregs/rulesregs/sdwa/ucmr/ucmr3/methods.cfm.

Sampling and testing of water at the Demonstration Facility included List 1 and List 2 of the UCMR3. Samples were collected quarterly on the feed water (tertiary effluent prior to chlorination) to the Demonstration Facility, the purified water, and the imported raw aqueduct water.

Constituents of Emerging Concern

The term constituents of emerging concern (CEC) refers to new classes of manufactured chemicals, such as pharmaceuticals, personal care products, pesticides, and other industrial chemicals. While many CECs are present in water supplies, the detection of many of these chemicals is so recent that robust methods for their quantification and toxicological data for interpreting potential human or ecosystem health effects are unavailable. The water purification process is designed to provide a multiple barrier approach for removal of CECs. In 2010, under the Recycled Water Policy, the State Board established a Science Advisory Panel to provide guidance for developing potential CEC threats to human and aquatic life.

As part of the robust water quality monitoring program implemented at the Demonstration Facility, CEC monitoring was conducted at multiple locations throughout the water purification process. The monitoring plan also included the collection of samples from imported raw aqueduct water. The target list of CECs consists of 90 compounds commonly found in treated wastewater effluent representing a wide range of chemical and physical properties. The list includes compounds identified by the Science Advisory Panel to have toxicological relevance. These compounds along with their common description includes: NDMA (rocket fuel, disinfection by-product), 17 beta-estradiol (estrogenic hormone), caffeine (stimulant) and triclosan (anti-microbial). The list includes compounds identified by the Science Advisory Panel as indicators of treatment performance. The specific performance indicator compounds along with their common description include: DEET (mosquito repellant), gemfibrozil (lipid regulator), iopromide (X-ray contrasting agent) and sucralose (artificial sweetener) along with certain surrogate parameters (e.g. ammonia, dissolved organic carbon, conductivity). The complete list of CECs monitored during the testing period along with their common use is presented in Appendix B.

The main objectives of the CEC monitoring plan as detailed in the T&M Plan (Appendix A) are as follows:

- Characterize the tertiary effluent prior to chlorination
- Identify appropriate performance indicator compounds to be monitored on an on-going basis
- Identify surrogate parameters, and assess and compare removal efficiency to indicator compounds
- Assess the ability of the water purification process to remove CECs
- Compare the water quality of the purified water to imported raw aqueduct water

The overall CEC monitoring plan consisted of three phases as described below:

- **Initial Characterization** – Samples were collected monthly for four months from the following sample locations: tertiary effluent (prior to chlorination), RO feed, RO permeate, purified water and imported raw aqueduct water. Samples were analyzed for the 91 compound list described above.

- **On-going Characterization -**Based on assessment of results from the initial characterization phase, five compounds were identified for on-going characterization. Four of these compounds (NDMA, 17 beta-estradiol, caffeine and triclosan) were identified by the Science Advisory Panel based on toxicological relevance. The fifth compound (1,4-dioxane) is currently presented as an option for sizing and evaluating advanced oxidation performance for direct groundwater injection reuse applications as specified in the CDPH November 2011 Groundwater Replenishment Reuse Draft Regulation. Samples were collected on a quarterly basis from the following locations: tertiary effluent prior to chlorination, RO feed, RO permeate, purified water, and imported raw aqueduct water.

- **Identification of Potential Performance Indicator Compounds -**Based on assessment of results from the initial characterization phase, 37 compounds were identified as potential performance indicator compounds. These compounds were selected based on one or more of the following factors: 1) identified by the Science Advisory Panel as potential performance indicators for groundwater injection (via surface spreading or direct injection) reuse applications 2) consistency of occurrence in the RO feed during the initial characterization, 3) recommendations from the IAP. Samples were collected weekly for four weeks from the following locations: RO feed, RO permeate, and purified water. Results of the performance indicator compound testing are discussed in Section 2.5 Integrity and Reliability Monitoring.

Non-Regulated Constituents Results

While 127 non-regulated constituents were measured, only 111 were unique constituents after accounting for overlaps with regulated compounds and among non-regulated lists. Of the non-regulated constituents measured at the Demonstration Facility, only six were found to be quantifiably detected in the purified water. Table 2-21 provides a summary of these six constituents, including average and maximum values measured in both the purified water and imported raw aqueduct water. These six constituents are discussed in more detail below. Since these constituents do not have regulatory limits, the results are discussed in terms of either the Health Reference Level identified by the EPA, or the Drinking Water Equivalent Level (DWEL), where no Health Reference Level has been provided by the EPA. Health Reference Levels and DWELs represent an acceptable concentration in drinking water, assuming an average person consumes two liters of water (about 8.5 cups) per day over 70 years. DWELs are developed from tolerable daily intakes (TDIs), acceptable daily intakes (ADI), or EPA identified Reference Doses (RfDs), which all describe a daily dose below which risks to public health are judged to be minimal, assuming repeated daily exposure over a lifetime through consumption of drinking water.

Table 2-21 Summary of Other Non-regulated Constituents in Purified Water and Imported Raw Aqueduct Water (Detected Constituents of 111 Monitored)

Constituent	Classification/ Common Use	Units	Laboratory Reporting Level	Purified Water			Imported Raw Aqueduct Water		
				Number of Samples	Average Concentration[a]	Maximum Concentration	Number of Samples	Average Concentration[a]	Maximum Concentration
Bromochloromethane	UCMR3 Disinfection byproduct	µg/L	0.06	4	0.23	0.25	4	ND	0.08
Chromium (VI)[b]	UCMR3 Disinfection byproduct, industrial byproduct	µg/L	0.02	4	0.09	0.16	4	0.05	0.05
Strontium	UCMR3 Naturally occurring metal, Dietary Supplement	µg/L	0.3	4	ND	0.37	4	405	610
Acesulfame-K	CEC Sugar Substitute	ng/L	20	9	ND	50	4	343	370
Iohexal	CEC X-ray contrast agent	ng/L	10	9	ND	19	4	43	55
Triclosan	CEC Antibacterial	ng/L	10	9	ND	19	5	ND	ND

Notes:

[a] Average concentration calculation assumes non-quantifiable results are half of the laboratory reporting level and non-detectable results are half of the method detection limit.

[b] Three Chromium (VI) samples were sent to another lab and all results were below the detection limit of 0.0059 µg/L. The CDPH Detection Limit for purposes of Reporting (DLR) is 1 µg/L.

Acronyms:

ND – Not detectable or not quantifiable, shown for all values below laboratory reporting level
µg/L – micrograms per liter, equivalent to parts per billion (ppb)
ng/L – nanograms per liter, equivalent to parts per trillion (ppt)

TDIs are derived from published information about pharmacology and toxicity for constituents. DWELs are not regulatory limits, but have been established by professional organizations for some constituents typically sampled for in water supplies to assist with the interpretation of water quality results for constituents without regulatory limits. More information on DWELs can be found in the following publications:

- Monitoring Strategies for Chemicals of Emerging Concern in Recycled Water, Recommendations of a Science Advisory Panel (State Board, Final Report, June 25, 2010)
- Development and Application of Tools to Assess and Understand the Relative Risks of Drugs and Other Chemicals in Indirect Potable Reuse Water (WateReuse Research Foundation, 2010)

Unregulated Contaminant Monitoring Rule

Results from the testing show 27 of the 30 compounds included in the UCMR3 were consistently below quantifiably detectable levels in the purified water. The three constituents, which were detected, included bromochloromethane, hexavalent chromium, and strontium. It should be noted that on May 2, 2012, the EPA issued the Final Rule Promulgation, which removed two constituents from the original List 1: n-Propylbenzene and sec-Butylbenzene. While these two constituents were removed from the final UCMR3 list, they had both been monitored as part of the 30 compounds previously referenced, and were never detected at any point in the treatment process. Additional information about the detected UCMR3 constituents, and their occurrence in the purified water, is presented below and in Quarterly Testing Report No. 4 (Appendix B).

Bromochloromethane

Bromochloromethane, also called Halon 1011, is used as a fire-extinguishing fluid and to suppress explosions, as well as a solvent in the manufacturing of pesticides. It may also occur as a disinfection byproduct in drinking water, when chlorine used for disinfection reacts with organic material in the water.

Bromochloromethane was detected four times out of four samples in the purified water, with an average value of 0.22 μg/L and a maximum value of 0.25 μg/L.

The DWEL for bromochloromethane is 40 μg/L (40,000 ng/L) (State Board, June 2010), which is more than 170 times higher than the concentration measured in the purified water, suggesting that the concentrations measured in the purified water do not pose a health risk for human consumption.

Hexavalent Chromium (Chromium-6)

Chromium is an odorless, tasteless metallic element found naturally in rocks, plants, soil and volcanic dust, and animals. Chromium is commonly found in two forms: trivalent chromium (chromium-3) and hexavalent chromium (chromium-6). The trivalent form is a required nutrient and has very low toxicity. The hexavalent form, also commonly known as chromium-6, is more toxic and has been known to cause cancer when inhaled. In recent scientific studies in laboratory animals, chromium-6 has also been linked to cancer when ingested. Chromium-6 is currently regulated in California as part of the total chromium MCL of 50 μg/L, which was originally established assuming all of the chromium present is in the hexavalent form.

In 2008, EPA began a rigorous and comprehensive review of chromium-6 health effects based on new scientific information. When this human health assessment is finalized, the EPA will carefully review the conclusions and consider all relevant information to determine if the current chromium standard should be revised. The lowest reference dose for chromium-6 currently identified by EPA as not having evidence of adverse health effects is 0.9 µg/kg/day (IRIS, Draft 75 FR 60454 EPA/635/R-10/004C), which is equivalent to a DWEL of 11 µg/L. Chromium-6 concentrations measured in the purified water were approximately 500 times lower than the current MCL and more than 100 times lower than the DWEL associated with the lowest reference dose identified by EPA.

Additional information on hexavalent chromium can be found at: http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chromium6.aspx .

CDPH is in the process of developing an MCL specific to chromium-6. Currently CDPH is collecting data associated with the risks and prevalence of chromium-6 and has established a detection limit for purposes of reporting (DLR) of 1 µg/L. This detection limit is 33 to 50 times higher than the laboratory reporting level used by the primary laboratory where chromium-6 samples were taken during the Demonstration Facility operation. As a result, data from the Demonstration Facility includes concentrations that are currently considered undetectable based on CDPH guidelines.

During the Demonstration Facility operation, chromium-6 samples were sent for analysis to two separate labs. Information about the sampling of chromium-6 is provided below and in Quarterly Testing Report No. 4 (Appendix B).

- For Lab 1, the method used was EPA 218.6 (laboratory reporting level = 0.02 µg/L) / EPA 218.7 (laboratory reporting level = 0.03 µg/L). Chromium-6 was found at quantifiable concentrations in the purified water four times out of four samples, with an average value of 0.09 µg/L and a maximum value of 0.16 µg/L. The laboratory reporting level, using EPA 218.7, is in accordance with current UCMR3's reporting level.
- Chromium-6 was not detected in the tertiary effluent by Lab 1, suggesting that chromium-3 may have been oxidized by the advanced oxidation process to form the low levels of chromium-6 measured in the purified water. A contaminate created by a disinfection process is known as a disinfection byproduct.
- Lab 2 analyzed chromium-6 using method EPA 218.6 with all results in purified water reported below detectable levels. The Lab 2 laboratory reporting level was 0.3 µg/L, which is higher than Lab 1.
- All results from both labs were below the CDPH detection limit (DLR) of 1 µg/L.

Strontium

Strontium is a naturally-occurring metal that is used as a dietary supplement and in various industrial applications, such as pyrotechnics and automobile manufacturing. Strontium was detected in one of the four quarterly samples analyzed from the purified water, with a concentration measured as 0.37 µg/L and a blind duplicate sample reported as 0.41 µg/L.

While the EPA has not established an MCL for strontium, a health reference level of 4.2 mg/L (4,200 µg/L) was identified as part of the 2009 Contaminant Candidate List 3 (CCL3). This health reference level is more than 10,000 times higher than the single detectable value measured in the purified water, indicating that the concentrations measured in the purified water do not pose a health risk for human consumption.

In addition, USEPA regulates a radioactive isotope of strontium (strontium 90), with an MCL of 8 pCi/L. Sample results for strontium 90 were consistently below the minimum detectable levels in both the tertiary effluent and the purified water.

Constituents of Emerging Concern

Results from the initial characterization phase of CEC monitoring are presented in Appendix B (Section 3). CEC results measured at the various sample locations are presented in the units of nanograms per liter (ng/L), or parts per trillion. Analogies used to describe a 1 ng/L concentration would be the equivalent of 1 penny in 10 billion dollars or 1 drop in 20 Olympic size swimming pools. When assessing low level CEC results such as these, it is important to keep in mind that analytical variability and influence of false positive/negative results becomes a more significant issue at such minute levels. Technologies were not available to measure compounds at these low concentrations a decade ago, and there is still considerable debate about the significance of such low measured concentrations. Therefore, it is important to assess results as a whole data set including quality control sample results before making conclusions on the significance of a single result.

Thirty-nine of the 90 CEC compounds were detected at quantifiable levels in the tertiary effluent prior to chlorination with values generally ranging from 5.5 to 9,500 ng/L. Higher levels were seen for the artificial sweeteners sucralose and acesulfame-k, which were detected at concentrations averaging 40,000 and 30,000 ng/L, respectively.

Results showed the RO process was effective at removing the majority of the CECs present in the tertiary effluent, and advanced oxidation further reduced the remaining constituents. For constituents found in significant concentrations in the tertiary effluent, the purification process achieved greater than 98% removal. This is further discussed in 2.5.3. Only three CECs found at quantifiable concentrations in the purified water. These compounds include iohexal, acesulfame-k, and triclosan. Additional information on all three compounds and the potential significance of the measured concentrations are discussed below.

Acesulfame-K (Ace-K): Acesulfame Potassium (Ace-K) is a widely used artificial sweetener. Ace-K is used in a variety of consumables, including soft drinks, sports drinks, chewable and liquid medications, and other foods. During the testing period, Ace-K was below quantifiable levels in the purified water in seven of nine samples analyzed, with an average concentration below quantifiable levels and maximum concentration of 50 ng/L (laboratory reporting level=20 ng/L). Ace-K was below detectable levels in the RO permeate or RO permeate duplicate in samples collected on the same day that results in the purified water (after advanced oxidation) were reported above the laboratory reporting level, suggesting that even the low levels measured on these days may have resulted from sampling or analytical error.

The Food and Drug Administration has established an acceptable daily intake (ADI) for Ace-K of 50 mg/kg. Based on this, the calculated DWEL for Ace-K is 525 mg/L, which is a concentration 10 million times greater than the maximum value reported in the purified water. This suggests that the concentrations of Ace-K measured in the purified water (and in the tertiary water before purification) do not pose a threat to public health.

Iohexal: This compound is a contrasting agent used in x-ray procedures, such as coronary angiographs. Iohexal is typically injected into the body, allowing organic iodine compounds to block x-rays as they pass through the body. This allows for delineation between body structures containing iodine and structures that do not contain iodine. This compound was below quantifiably detectable levels in the purified water for eight of nine samples analyzed, with an average value of below quantifiable levels and a maximum value of 19 ng/L (laboratory reporting level=10 ng/L). RO permeate and RO permeate duplicate QC samples collected during the same sampling event as the single positive result were below quantifiable levels, suggesting that the single positive result may have been the result of analytical error.

The DWEL for this compound is 720,000 ng/L (State Board, June 2010), which is nearly 38,000 times higher than the maximum concentration reported in the purified water, suggesting that the concentrations measured do not pose a threat to public health.

Triclosan: 2,4,4' –trichloro-2'-hydroxydiphenyl ether (triclosan) is used as a synthetic broad-spectrum antibacterial agent. Triclosan is used in a variety of consumer products, such as antimicrobial hand soaps, toothpaste, and over-the-counter drugs. It also functions as a material preservative in adhesives, fabrics, vinyl, plastics (toys, toothbrushes), polyethylene, polyurethane, polypropylene, floor wax emulsions, textiles (footwear, clothing), caulking compounds, sealants, rubber, carpeting, and a wide variety of other products. In commercial, institutional, and industrial equipment, triclosan is used to prevent microbial growth in conveyor belts, fire hoses, dye bath vats, HVAC coils, and ice-making equipment. This compound was found to be below quantifiable levels in seven out of nine samples, with an average value below quantifiable levels and a maximum value of 19 ng/L. Duplicate samples collected for a second lab from the RO permeate and purified water at the same time as one of the two positive results were found to be below detectable levels.

A number of factors suggest that the two results reported above the laboratory reporting level in the purified water may have resulted from sample contamination. The first factor is the widespread use of this compound in personal care products. Though careful measures (use of gloves, avoidance of products that contain triclosan, etc.) were taken during all sampling events to minimize the possibility of field contamination, such contamination cannot be ruled out. All sample bottles used were one time use EPA certified bottles; however, the laboratory conducting the analysis reported that because there are no commercially available preserved containers for the CECs, bottles are preserved by lab staff prior to shipping to clients for collection. This introduces the risk of contamination. Another important factor is that duplicate quality control samples taken from both the RO permeate and purified water (collected on the same day as one of the two samples reported above the laboratory reporting level) were analyzed by a second lab and reported non-detectable values (less than 2.5 ng/L).

It should be noted that the CDPH Science Advisory Panel recommended a more practical reporting limit of 50 ng/L for triclosan, which would suggest that all of the samples measured in the purified water should be considered below quantifiably detectable levels.

The DWEL for triclosan ranges between 350 to 2,600,000 ng/L (State Board, June 2010), which is 18 to nearly 137,000 times higher than the maximum concentration reported in the purified water, suggesting that no public health concerns are associated with the low levels of triclosan which may or may not have been present in the purified water.

2.4.5 Data Validation

Third-party validation was performed on the water quality data from WECK Laboratory and MWH Labs for the first quarterly sampling event. The purpose of the validation was to assess data quality and to review laboratory and sample handling procedures in order to identify possible procedural alterations to be implemented for subsequent sampling events. The third party validation process showed all the data validated to be acceptable. It was also confirmed that the majority of the data met the strict analytical standards of the EPA Contract Laboratory Program.

For two CEC compounds (oxolinic acid and n-diethyl-meta-toluamide (DEET)), false positive results were initially reported by one of the laboratories, suggesting that quantifiable values of oxolinic acid and DEET had been detected in the purified water; however, subsequent testing and further comparison of test results with method blanks indicated that the original laboratory reporting level for these compounds had been set too low. The laboratory therefore revised the testing reports, confirming that quantifiable results for these two compounds had not been detected at any point in the purified water. Such anomalies are common when attempting to quantify organic compounds at such low detection levels using test methods that have not yet been fully standardized. Additional information on these two compounds is discussed below.

DEET: DEET is the most common active ingredient in insect repellents. DEET is used to repel biting flies, biting midges, black flies, chiggers, deer flies, fleas, gnats, horse flies, mosquitoes, no-see-ums, sand flies, small flying insects, stable flies, and ticks. Product types include liquids, pressurized liquids, ready-to-use formulations and impregnated material. Product concentrations range from 4 percent to 100 percent of DEET as an active ingredient.

DEET was originally reported to have been detected at a concentration of 8.7 ng/L in a single sample, based on a laboratory reporting level of 2 ng/L; however, the analytical laboratory conducting the analysis later revised the laboratory reporting level to 10 ng/L, based on continued variability in test blank results. The original test report was therefore revised, confirming that none of the nine samples contained quantifiable levels of DEET in the purified water. In addition, a duplicate sample of the purified water taken at the same time as the original positive value and analyzed by a second laboratory reported the result as not detectable, based on detection limit of 2.5 ng/L. Such variability in test results is common when attempting to quantify organic compounds at such low detection levels.

Oxolinic Acid: This compound is an antibiotic commonly used as veterinary medication for animals such as fish, calves, pigs, and poultry. It is delivered to the animal through an oral route. Oxolinic acid inhibits bacterial DNA-gyrase replication, and is commonly used to treat urinary tract infections in humans outside the U.S., a use which has not yet been approved by the U.S. Food and Drug Administration.

Oxolinic acid was originally reported to have been detected at a concentration of 5.5 ng/L in a single sample, based on a laboratory reporting level of 5 ng/L; however, the analytical laboratory conducting the analysis revised the laboratory reporting level to 10 ng/L, based on variability in test blank results. The original test report was therefore revised, confirming that none of the four samples contained quantifiable levels of oxolinic acid in the purified water.

2.5 Integrity and Reliability Monitoring

The integrity and reliability of the Demonstration Facility water purification processes were evaluated closely during the testing period. Integrity monitoring was conducted using several direct and indirect methods employed at various stages in the testing period. In addition, critical control point monitoring was implemented to identify any changes in the performance of the treatment processes that can adversely impact the final water quality. Overall integrity monitoring results showed the processes met their intended treatment performance on a continuous basis. The specific methods used to evaluate each water purification process and results are summarized below.

2.5.1 Summary of Integrity Monitoring Results

Membrane Filtration

The integrity monitoring of the membrane filtration systems included the performance of daily pressure decay tests along with online filtrate turbidity monitoring. Results showed both the membrane filtration systems were intact over the testing periods. The filtrate turbidity was consistently below 0.05 NTU, lower than the limit of 0.2 NTU (0.5 NTU maximum). The pressure decay values were consistently below 0.1 psi over 5 minutes, which is below the limit of 0.4 psi over 5 minutes and corresponds to greater than 4-log (99.99 percent) calculated removal of *Cryptosporidium* and *Giardia* for each of the two membrane filtration systems. Over the testing period, estimates of the log removal value of *Cryptosporidium* and *Giardia* achieved by the membrane filtration systems were performed based on the measured values of pressure decay. These estimated log removal values were determined using the equation for air liquid conversion ratio as presented in the EPA Membrane Filtration Guidance Manual, 2005. This equation requires several inputs categorized as operating parameters, direct integrity test parameters, and unit and membrane characteristics. Values for these parameters were obtained from the membrane manufacturers and / or by field verification.

Reverse Osmosis

The integrity monitoring of the RO systems included the performance of vacuum/pressure decay testing of individual elements (pre-installation), conductivity vessel probing (post-element installation) along with online monitoring of conductivity and TOC during normal operation. Results of the vacuum/pressure decay testing indicated the RO elements to be intact with no breaches in glue lines or membrane material prior to installation. Vessel probing results were indicative of intact RO systems with no leaks at interconnectors or end caps. Both RO systems achieved consistent conductivity rejection throughout the testing period with average values of 98.7 percent (Hydranautics) and 98.5 percent (Toray). Eleven months of online TOC monitoring showed the combined RO permeate TOC was consistently below 100 µg/L, indicating TOC removal ranging from 98.8 – 99.8 percent.

It should be noted that TOC values measured online in the RO permeate throughout the testing period (ranging from 0.02 to 0.08 mg/L) were much lower than the laboratory reporting limit of 0.3 mg/L for samples sent offsite for laboratory analysis. Online TOC analyzers are known to be capable of detecting lower concentrations of organic content compared with desktop analyzers used by most laboratories, due to the decreased presence of organic interferences in the measurement system. During the collection of field samples for laboratory analysis, samples can be contaminated with organics from the several sources, including the sample vials themselves and carbon dioxide from the atmosphere. Because of the increased precision that the online analyzers have at low concentrations, they are considered a more appropriate method for measuring TOC in RO permeate, compared with the lower precision laboratory analysis.

UV Disinfection and Advanced Oxidation

The integrity monitoring of the UV disinfection and advanced oxidation system included continuous online power monitoring of the UV reactor and daily drawdown testing of the hydrogen peroxide dosing pump. On several occasions during the Q1 Testing Period, the UV disinfection and advanced oxidation system experienced a ballast failure which caused the control system to automatically increase the reactor power to 100 percent thereby maintaining treatment performance at all times.

During the Q2 Testing Period, no ballast failures occurred. One ballast and one lamp failed during the Q3 Testing Period. One ballast failure occurred during the Q4 Testing Period, which makes a total of six ballast failures during the Q1 through Q4 testing period.

2.5.2 Summary of Critical Control Point Monitoring Results

Table 2-22 provides a summary of the initial critical control point monitoring implemented during the Demonstration Facility testing period. The plan identified critical control points for the membrane filtration, RO, and UV disinfection and advanced oxidation systems, as well as critical limit parameters, critical limits, and corrective actions. The values of limits and corrective actions were refined and further defined throughout the testing period.

Table 2-22 Summary of Demonstration Facility Critical Control Point Monitoring

Critical Control Point	Critical Limit Parameter	Monitoring Frequency	Alert Limit	Critical Limit	Example Corrective Actions
MF/UF	Pressure Decay	1 per day	Value above baseline that approaches critical limit.	0.4 psi / 5 min based on the maximum decay predicted to achieve 4-log removal Cryptosporidium	Confirm Results. Assess fiber breakage. Isolate/ repair/replace damaged membrane.
RO	TOC, Conductivity	Continuous	Percent change of measured concentration in combined RO permeate	Online permeate conductivity = 150 µS/cm. Online permeate TOC = 100 ppb or greater for five consecutive measurements.	Automatic shutdown (conductivity). Monitor individual RO trains. Verify analyzer accuracy. Conduct vessel probing.
UV	Reactor Power Level	Continuous	System ramps up 100% if 2 to 7 lamps fail or 1 to 3 ballasts fail	0% (8 or more lamp failures or 4 ballast failures)	System alarm. Automatic increase of reactor power to 100% or system shutdown. Check/ replace lamps and/or ballasts.
UV	Hydrogen peroxide dose rate/Continuous Flow Confirmation	1 per day by draw down Continuous flow confirmation	Minimum dose (~22 mL/min) to provide 3 mg/L peroxide	0 mL/min indicating pump failure or loss of flow confirmation	Check dosing system. Recalibrate pump. Auto switch to standby pump.

Acronyms:

TOC – total organic carbon
mL/min – milliliters per minute
mg/L – milligrams per liter
psi – pounds per square inch
min – minute
µS/cm – microsiemens/centimeter
ppb – parts per billion, equivalent to micrograms per liter (µg/L)

Table 2-23 provides a summary of the critical control point monitoring results obtained during the testing period. During the Q1 Testing Period, one exceedance of the established critical alert limit for pressure decay occurred on the UF system. After further investigation, it was determined the high pressure decay rate resulted from a leak in the air piping not the actual membrane(s). Upon repair of the leak, the measured pressure decay test results were well below the critical alert limit for the remainder of the reporting period. During the Q1 Testing Period, the critical alert limit for the UV reactor power level was not met on four separate occasions, each due to ballast failures. In response, the reactor power automatically increased to 100 percent. Based on the reactor performance to date it has been determined that a reactor power level of approximately 70 percent is required to achieve the target log removal of NDMA. As a result, the occurrences of ballast failures are highly unlikely to have jeopardized the treatment performance and UV disinfection and advanced oxidation because the reactor was sized to meet the water quality goals when operating at 70 percent power. The programming of the UV reactor called for the reactor to adjust to 100 percent power when two lamps or a single ballast failed. No exceedances of critical alert limits were identified for any of the critical limit parameters during the Q2 Testing Period. However two critical alert limits were exceeded in the Q3 Testing Period.

During the Q3 Testing Period, two critical alert limit exceedances occurred. The first incident was due to the loss of flow confirmation on the hydrogen peroxide dosing pump of the UV disinfection and advanced oxidation system. Once this occurred, the system automatically switched to the stand-by pump. However, the stand-by pump also shut off due to low flow resulting from air lock, thereby causing the system to automatically shut down. The Demonstration Facility operations staff was present when the event occurred and quickly restarted the system with no issues for the remainder of the testing period. The second incident was due to a single ballast failure on the UV disinfection and advanced system. The system automatically increased power to 100 percent to accommodate power loss thereby maintaining treatment performance. An alarm notified the operations team of this occurrence, and shortly after the system was taken offline and the ballast was replaced.

During the Q4 Testing Period, six critical alert limit exceedances occurred. Five of these were due to the loss of flow confirmation on the hydrogen peroxide dosing pump of the UV/AOP system. Once this occurred, the system auto switched to the stand-by pump. On two occasions the switch to duty pump was successful and the system operated without interruption. However, on the other three occasions, the stand-by pump also shut off due to low flow resulting from air lock, thereby causing the UV/AOP system to automatically shut down. The operations staff were notified by alarms when the unit was shut down, shortly after the system was restarted after operating both pumps in manual to remove entrained air. The issue was resolved by making adjustments to the degassing interval and pulse length on the peroxide dosing skid and opening a valve on the pump skid to allow off gas to return to the peroxide storage tank.

The sixth critical alert limit exceedance occurred due to a single ballast failure on the UV/AOP system. The system automatically increased power to 100 percent to accommodate power loss thereby maintaining treatment performance. An alarm notified the operations team of this occurrence, shortly after the system was taken offline and the ballast was replaced.

Table 2-23 Summary of Demonstration Facility Critical Control Point Monitoring Results

Critical Control Point	Critical Limit Parameter	Monitoring Frequency	Number of Exceedances Above Limits				Notes
			Q1	Q2	Q3	Q4	
MF/UF	Pressure Decay	1 per day	1 (UF)	0	0	0	Pressure decay above limit due to leak in air piping not membrane integrity. Repair made, pressure decay test repeated and passed.
RO	TOC, Conductivity	Continuous	0	0	0	0	None.
UV Disinfection and Advanced Oxidation	Reactor Power Level	Continuous	4	0	1	1	Exceedances due to occurrences of single failed ballasts. System automatically increased power to 100% to accommodate power loss.
UV Disinfection and Advanced Oxidation	Hydrogen Peroxide Dose/ Continuous Flow Confirmation	1 per day (draw down) Continuous (flow confirmation)	0	0	1	5	Q3 -Duty pump auto switched to standby pump and standby pump shutoff, due to low flow (air lock). System automatic shutdown. Restarted shortly after issue self-resolved. Q4 - Pump failures due to air locking. Adjustments made to degas interval and return off gas piping.

2.5.3 CEC Performance Indicator Monitoring

During the reporting period four performance indicators identified by the State Board Science Advisory Panel were monitored quarterly (Caffeine, 17 β-estradiol, NDMA, triclosan) along with 1,4-dioxane to serve as potential performance indicators for the Demonstration Facility and potentially the Full-Scale Facility. In addition, 37 CECs were considered as potential performance indicators, with 16 selected for additional monitoring, based on consistently quantifiable concentrations in the tertiary effluent used as the source water. Differential removal was calculated based on the average (n=4) concentrations measured in the feed and product of each water purification process as follows:

- RO Removal = [RO Feed – RO Permeate] / [RO Feed]
- Advanced Oxidation Removal = [Advanced Oxidation Process Influent –Advanced Oxidation Process Product] / [Advanced Oxidation Process Influent]

The removal results for the 16 selected constituents are included in Table 2-24, demonstrating nearly complete removal of all compounds with the combined processes of RO and UV/AOP.

Table 2-24 CEC Potential Indicator Characterization Results

Compound	Units	MDL	LRL	Average RO Feed (n = 5)	Average RO Perm. (n = 5)	Average UV/AOP (n = 5)	RO Removal	UV/AOP Removal
Acesulfame-K	ng/L	20	20	33,000	<27	<22	>99.9%	>16.5%
Amoxicillin	ng/L	6.4	20	220	<6.4	<6.4	>97%	-
Carbamazepine	ng/L	1.2	5	190	<5	<1.2	>99%	-
Dilantin	ng/L	13	20	120	<13	<13	>88.8%	-
Diuron	ng/L	1.8	5	77	<1.8	<5	>97.7%	-
Fluoxetine	ng/L	10	10	84	<10	<10	>88%	-
Lidocaine	ng/L	1.1	5	170	<1.1	<1.1	>99.3%	-
Lopressor	ng/L	5.1	20	340	<20	<5.1	>97.6%	-
NDMA	ng/L	0.96	2	3	<2	<0.96	>65.5%	-
Primidone	ng/L	4.8	5	100	<4.8	<4.8	>95.4%	-
Sucralose	ng/L	42	100	55,000	<100	<42	>99.9%	-
Sulfamethoxazole	ng/L	2.8	5	950	<2.8	<2.8	>99.7%	-
TCEP	ng/L	3.2	10	300	<10	<10	>98.3%	-
TCPP	ng/L	20	100	2,000	<100	<100	>97.6%	-
Triclosan	ng/L	6.3	10	48	<10	<10	>84.1%	-
Trimethoprim	ng/L	1.8	5	330	<5	<5	>99.1%	-

Notes:

a. For calculating average concentrations, results reported below the LRL were considered the value of the LRL and for values reported below the MDL, the value of the MDL was used.

b. Dashes shown for the UV/AOP Removal indicate the average concentrations in the RO permeate and UV/AOP were both below the LRL or MDL and removal could not be quantified.

Acronyms:

ng/L – nanograms per liter, equivalent to parts per trillion (ppt)
LRL – laboratory reporting level
MDL – method detection limit

Because many of these constituents were removed by the RO to levels at or below quantifiable limits, removal within the UV could not be accurately measured, creating challenges with identifying usable performance indicators. Of the four constituents recommended by the Science Advisory Panel, only triclosan was found at any time in the RO product, but even here it was at concentrations too low to use as a reliable performance monitor for advanced oxidation. Similarly, 1,4-dioxane was removed to levels below quantifiable limits by the RO process, making it too low to monitor performance of the advanced oxidation using this compound.

For the 16 constituents monitored as performance indicators (Table 2-24), removal generally exceeded 95 percent within the RO when sufficient quantities were present in the source water to calculate such removals. In some cases, greater than 99.9 percent removal was observed (sucralose and Ace-K). For the advanced oxidation process, however, no reliable performance indicator was found, due to the low levels present in the RO product. The most promising constituents measured were tris (2-chloroethyl) phosphate, tris (1-chlor-2-propyl) phosphate (two flame retardant compounds), and Ace-K, which sometimes had low levels measurable in the RO product (ranging from non-quantifiable to 160 ng/L). These low concentrations in the RO product allowed a measured reduction by the advanced oxidation of up to 40 percent, however, higher removals may have been observed had higher concentrations been present.

During the initial two weeks of the performance CEC sampling period, surrogate compounds (TOC, conductivity, monochloramine, and UV254) were monitored daily. Results from this monitoring are shown in Table 2-25. For the RO process, the average removal results were: TOC = 99.6 percent; conductivity = 99.0 percent; and UV254 = 88.8 percent. For the advanced oxidation process, the average removal results were: UV254 = 68.7 percent; and monochloramine = 72.8 percent. Figure 2-11 presents the observed reduction in monochloramine across the UV disinfection and advanced oxidation process during operation of the Demonstration Facility.

Table 2-25 Removal of Online Monitoring Surrogates by Unit Processes

Compound	Units	Avg RO Feed (n = 14)	Avg RO Perm. (n = 14)	Avg UV/AOP (n = 14)	RO Removal	UV/AOP Removal
TOC	mg/L	7.2	0.031	--[a]	99.6%	--
Conductivity	µS/cm	1,348	14	--	99.0%	--
UV254	cm^{-1}	0.158	0.018	0.006	88.8%	68.7%
Monochloramine	mg/L	--	3.14	0.85	--	72.8%

Notes:

a. Dashes shown for values that were not measured.

Acronyms:

mg/L – milligrams per liter, equivalent to parts per million (ppm)
µS/cm – microSiemens per centimeter
cm^{-1} – centimeters to the negative first power

Results from field testing demonstrated that the removal of UV254 and monochloramine within the UV Disinfection and advanced oxidation process was due primarily to UV photolysis rather than advanced oxidation, however, the reliable presence of these constituents in the water downstream of both RO and advanced oxidation, and their ease of sampling and consistent removal suggests that they could serve as reliable surrogates for Full-Scale Facility performance monitoring.

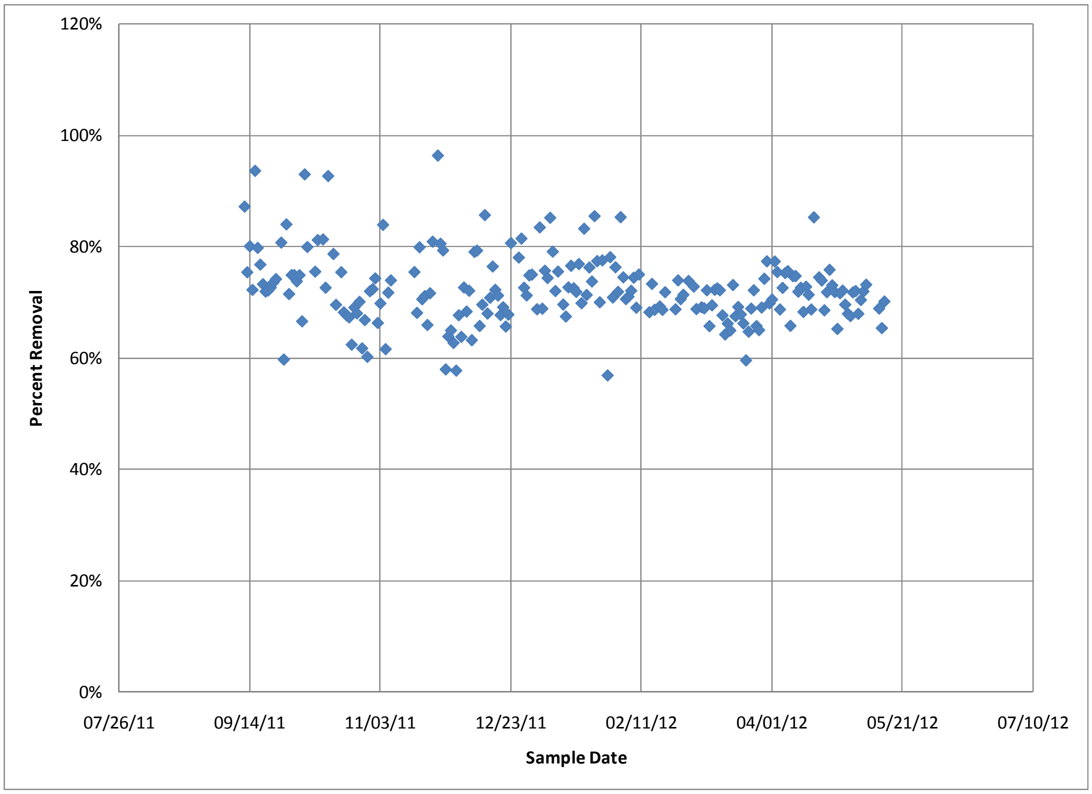


Figure 2-12
Monochloramine Removal by UV and Advanced Oxidation

Although not part of the initial surrogate monitoring, ammonia was also evaluated as a potential surrogate compound for advanced oxidation performance, due to its consistent removal within the AOP and an associated increase seen in the nitrate residual. Since ammonia is not expected to be oxidized to nitrate without the presence of an oxidizing agent, it was considered that ammonia could potentially serve as a surrogate parameter for the overall advanced oxidation process rather than just the UV component. Figure 2-12 presents the percent reduction of ammonia by the UV/AOP, based on biweekly grab samples sent off-site for laboratory analysis. The results show an ammonia reduction between 30 to 70 percent; however, results varied considerably from day to day, and may have been influenced by variability in the sampling procedure associated with offsite analysis. It is not known if the use of an online ammonia analyzer could provide a more consistent measure of AOP performance, providing a more reliable tool for surrogate monitoring. Further research should consider the use of ammonia as a potential surrogate, as it was consistently present both upstream and downstream of advanced oxidation.

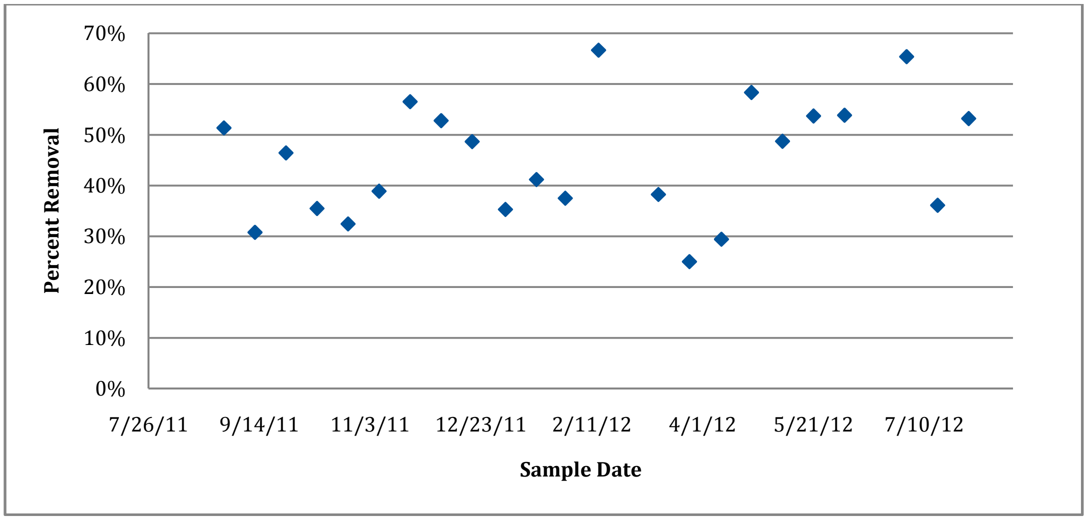


Figure 2-13
Ammonia Removal by Advanced Oxidation

2.6 Independent Advisory Panel

The Independent Advisory Panel (IAP) was convened in May 2009 to provide expert peer review of technical, scientific, regulatory, and policy aspects for the Demonstration Project. At their first meeting in May 2009, the IAP provided input on the Demonstration Facility project components, including the treatment train. During the course of the Demonstration Project the IAP reviewed work products and provided feedback on various aspects of the project including the Demonstration Facility and potential Full-Scale Facility. The IAP activities associated with the AWP Facility Study are summarized below.

- Review of Demonstration Facility T&M Plan (October 2010)
- Review of Demonstration Facility preliminary testing results (December 2011)
- Review of the AWP Facility Study Report (November 2012)

2.6.1 Testing & Monitoring Plan

The Final T&M Plan (Appendix A) established the testing program and water quality goals for the Demonstration Facility. The T&M Plan was reviewed and commented on by the IAP in October 2010. As a result of the comments received, the T&M Plan was expanded to include sampling for additional water quality parameters and increased frequency and number of samples for constituents that were identified in the draft plan. These comments and a description of how the comments were addressed are included as an appendix to the T&M Plan.

2.6.2 Preliminary Testing Results

The first quarter testing and monitoring results were presented to the IAP in December 2011. As a result of the comments received, the third and fourth quarter sampling was focused on improving the correlation of indicator compounds for performance and integrity monitoring.

2.6.3 AWP Facility Study Report

The AWP Facility Study Report was reviewed and commented on by the IAP in November 2012. Based on the results presented in this report, the IAP concluded that the purified water produced at the Demonstration Facility "met or exceeded all of the drinking water requirements and also provided multiple barriers for regulated and unregulated chemical and microbial constituents. The water produced is of a higher quality than any source available to the City of San Diego."

Additional information on the IAP and its advisory activities can be found in the Demonstration Project Report.

2.7 Conclusions

The primary purpose of the City's Demonstration Facility was to demonstrate the feasibility of water purification technologies to produce purified water for the City to determine the feasibility of a full-scale IPR/RA project. A full-scale project would assist with the City's effort to provide a local and sustainable water supply. To achieve this primary purpose, operation of the Demonstration Facility supported the project goals by the following means:

- Water quality monitoring throughout the testing period demonstrated that membrane filtration, followed by RO, and UV disinfection and advanced oxidation can reliably produce purified water that consistently meets all drinking water quality standards.

- Energy consumption was monitored at the Demonstration Facility, providing background data for energy requirements of a potential full-scale facility, including the evaluation of opportunities for energy saving measures.

- Operational data and observations collected from the Demonstration Facility testing period can be used to estimate construction costs and annual operation and maintenance costs for a Full-Scale Facility.

- Further research should also consider the use of ammonia as a potential surrogate for advanced oxidation performance, as it is not impacted by photolysis and was found to be consistently present upstream and downstream of advanced oxidation.

Section 3

Full-Scale Facility Considerations

This section presents energy conservation opportunities and other design considerations for the Full-Scale Facility based on observations made during operation of the Demonstration Facility.

3.1 Energy Conservation

The energy conservation considerations for the Full-Scale Facility provided herein are based on operational experience of the Demonstration Facility from start-up in mid-June 2011 through the end of the Q4 Testing Period (ending July 31, 2012). Energy conservation considerations are presented for the water purification processes: membrane filtration, reverse osmosis, and UV disinfection and advanced oxidation.

3.1.1 Membrane Filtration

At the Demonstration Facility, the power consumption of the UF system was consistently higher than the MF system; however, this is attributed to differences in the size and type of compressors used to control automatic valves. The UF system air compressor design may have been oversized and could be optimized in full-scale design. Both MF and UF similarly achieved the membrane filtration water quality goals throughout the testing period. A full-scale MF system is not anticipated to have significantly lower power consumption than a full-scale UF system and, therefore, both MF and UF should be equally considered for the Full-Scale Facility.

Variable Speed Feed Pumps

The AWP Facility influent pumps will pump tertiary effluent prior to chlorination from North City to the Full-Scale Facility. The pumps will need to ramp up and down through a wide range of speed settings to accommodate backwashing (approximately twice an hour for each membrane filtration skid) and daily integrity testing. The flow can be modulated using either throttling valves or variable speed drives; the throttling valves will be less expensive on a capital cost basis, but variable speed drives will use power more efficiently and are expected to be less expensive on a lifecycle cost basis. Variable speed feed pumps should therefore be considered for the Full-Scale Facility to conserve energy and reduce overall project costs.

Lifecycle Selection for Membrane Filtration System

Before detailed design, it is recommended that the City conduct additional side-by-side pilot testing of multiple membrane filtration system vendors. The purpose of the testing would be to prequalify vendors and establish design criteria for the vendor’s most-recent equipment designs to gather actual operational data to be used for the lifecycle bid evaluation. The data for each vendor could be used to allow the City to procure the membrane filtration system on a lifecycle-cost basis to select the most cost-effective system in terms of both capital and O&M costs (including power usage) and be confident that the selected equipment can meet the design criteria.

3.1.2 Reverse Osmosis

Two energy saving measures recommended for the RO system are the use of a two-stage design rather than a three-stage and the incorporation of energy recovery devices.

Two-Stage Reverse Osmosis System

During the testing period, it was observed that the three-stage system required an average eight percent higher feed pressure than the two-stage system under similar operating conditions (i.e., flux, recovery, antiscalant dose, temperature). The higher pressure requirement is attributed to the vessel configuration rather than differences in the membranes, because the specific flux for the membranes used in both trains were identical. Similar water quality results (as measured by TOC, UV254, nitrate, etc.) were observed by both RO systems throughout the testing period. A two-stage RO system should, therefore, be considered for the Full-Scale Facility to reduce the power usage.

Energy Recovery Devices

The design of the Demonstration Facility included energy recovery devices to reduce the overall power usage of the RO systems and evaluate their potential benefits for the Full-Scale Facility. While numerous types of energy recovery devices are available and in use at desalination facilities, recovering as much as 98 percent of the waste energy from concentrate streams, the lower efficiency centrifugal-type devices are generally the only devices applicable for low salinity applications, such as this. Figure 3-1 illustrates the configuration of the centrifugal style TurboCharger energy recovery devices employed at the Demonstration Facility. These devices make use of residual energy from the concentrate stream of the second RO stage to drive a turbine coupled with a pump (the turbine/pump combination represents the energy recovery device). The pump then provides a pressure boost to the interstage water feeding the second RO stage. Using an energy recovery device in this manner has two intrinsic benefits: first, the pressure boost to the second stage reduces the required feed pressure for the overall system; and second, by providing an interstage boost, the production of the first and second stage can be more evenly balanced, reducing the risk of fouling from poor hydraulic conditions within the RO membranes. While the immediate economic benefits of reduced feed pressure can be easily calculated, the longer term benefits from reduced rates of fouling are more difficult to quantify, and are therefore not included in the evaluation presented below.

The actual energy savings achieved by the energy recovery devices at the Demonstration Facility was compared against values predicted during design using RO design software and efficiency projections from the energy recovery device manufacturer (Energy Recovery Inc). IMSDesign software (v.2012) was used to model the two-stage side of the Demonstration Facility, and an interstage boost of 24 psi (boost pressure to the second stage) was projected for one-year-old membrane elements, based on the average water quality conditions seen during the first twelve months of operation. Actual interstage boost for this side of the system averaged 23 psi after initial repairs on the device had been completed, indicating that the projected efficiency was within five percent of the values measured. This same software model was then used to estimate the potential energy savings for the Full-Scale Facility, assuming an average feed water TDS of 1,100 mg/L, based on historic concentrations observed at North City. A two-stage RO system was assumed, using Hydranautics ESPA2 membranes and a hydraulic recovery of 85 percent. Projections were run for three different membrane ages, with older membranes characterized by higher feed pressures and higher available energy for the recovery devices.

Table 3-1 presents results of the energy recovery projections for initial operation (year zero), three years, and five years. The table includes the anticipated boost pressure to the second stage, the expected impact this boost will have in reducing the overall feed pressure to the RO system, and the overall efficiency at which energy is expected to be recovered from the concentrate under these operating conditions. The table also includes assumed design criteria for the energy recovery device and the anticipated cost and economic benefit of employing the devices for the Full-Scale Facility.

The potential annual power cost savings were estimated based on reduced feed pumping pressure, assuming that the RO system will be designed with five trains (four duty and one standby), each with 4.5 mgd capacity. The energy savings are based on normal operation of four energy recovery devices for the four duty trains, but the capital cost is based on five energy recovery devices, one for each train. It should be noted that the assumption of a redundant RO train was used for conservative planning purposes. Redundant RO trains are not common, even in drinking water treatment facilities, due to increased risks of fouling under low flow conditions and to the operational challenges of moving RO units in and out of stand-by mode. In the event that the future facility does not include a redundant RO unit, the capital cost of the devices would be expected to be 20 percent lower than the number shown in Table 3-1.

Projected energy savings from the energy recovery devices are approximately $113,800 annually for a two-stage RO configuration, assuming a power cost of $0.12/kWh, and that conditions at year three are generally representative of the average conditions over the life of the membranes (five to seven years). Estimated capital cost for incorporating the devices into the facility is $607,500, including equipment, installation, and other implementation costs discussed further in Section 5. Based on these numbers, the anticipated payback period for the energy recovery devices is less than six years. The expected life of the Turbocharger devices is 20 years, indicating that the economic benefit of utilizing the devices is expected to significantly exceed the cost of their incorporation. The benefits and costs of incorporating energy recovery into the future Full-Scale Facility should therefore be further evaluated at a future date.

Table 3-1 Impact of Energy Recovery Devices on RO Operation

Parameter	Year 0	Year 3	Year 5.5
Average Boost to Second Stage [1,2]	23 psi	37 psi	53 psi
Reduction in First-Stage Feed Pressure [1,2]	6 psi	11 psi	17 psi
Concentrate Energy Recovered [1,2]	55%	59%	61%
Total Energy Reduction	4%	6%	7%
Equipment Model Number	ERI Turbocharger LPT-2000		
Number of Units	4 Duty, 1 Standby		
Total Capital Cost for Energy Recovery Devices [3]	$607,500		
Total Power Usage Savings [4,5]	$113,800		
Payback Period [5]	6 Years		

Notes:

1) RO Projections assumed 85% recovery, 1,100 mg/L of TDS in feed water, and Hydranautics ESPA2 membranes.
2) As membranes age, the RO feed pressures and concentrate pressures increase, requiring more energy to produce the water, but also allowing for more energy to be recovered.
3) Capital cost includes five energy recovery devices (one for each RO train).
4) Power usage savings assumes four operating units and 12¢/kWh average power cost.
5) Three-year old membranes were assumed to be average conditions for total power savings and payback period calculations.

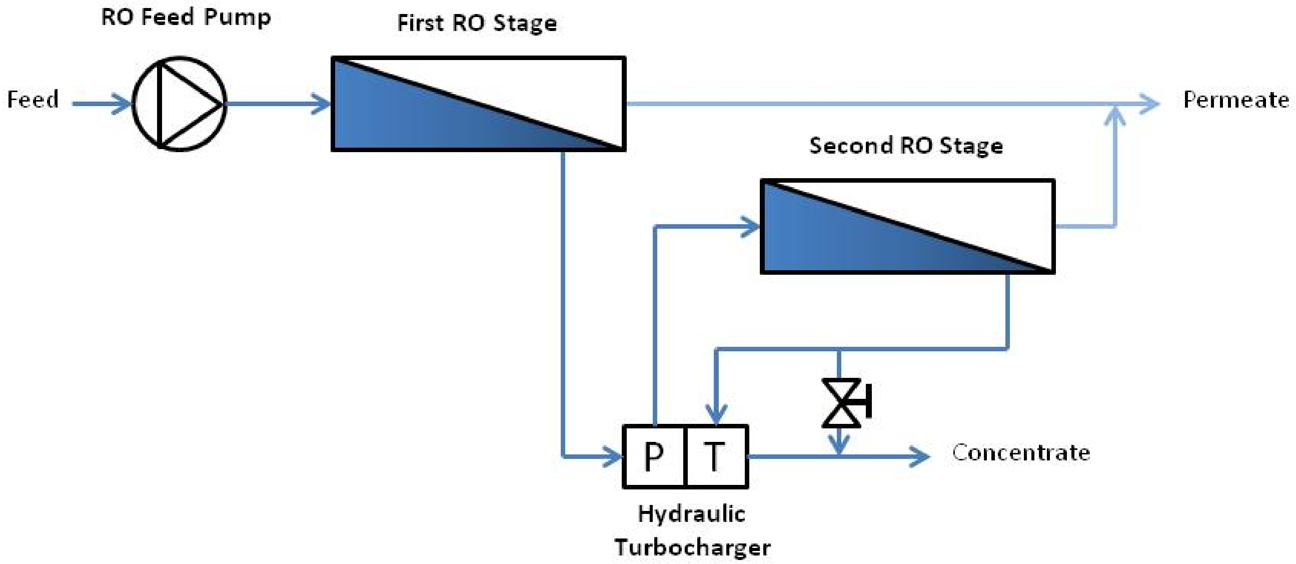


Figure 3-1
Two-Stage RO Design with Energy Recovery Device (Hydraulic Turbocharger)

3.1.3 UV Disinfection and Advanced Oxidation

The following are UV disinfection and advanced oxidation energy conservation considerations for the Full-Scale Facility.

More Efficient UV System Design

The average reactor power level required to achieve the target NDMA removal as predicted by the Trojan control system was approximately 67 percent, which corresponds to an average power of 12.6 kW. The power required to achieve the target removal was observed to increase as runtime increased. The increased power was attributed to the decrease in temperature during winter months, as well as lamp aging, both of which increased the applied power to achieve a target contaminant removal. The average EEO value predicted over the testing period was 0.26 kWh/1000 gallons/ log removal. However, when measured during the testing period, the EEO was better than projected at 0.19 kWh/1000 gallons/log removal. For the Full-Scale Facility, multiple UV vessels in series will likely be used, similar to existing full-scale facilities, achieving further increases in efficiency and lower EEO values.

Improved Reactor Controls

The reactor power of the UV disinfection and advanced oxidation system at the Demonstration Facility increased to 100 percent when a minimum of two lamps or one ballast failed on the system or when there was no flow to the UVT analyzer. The Full-Scale Facility design should be coordinated with the manufacturer to determine how the system can be optimized so that the default is not to ramp up power to 100 percent power while still providing adequate treatment. Ramping up to 100 percent power while the UV system is providing adequate treatment would cause the Full-Scale Facility to use unnecessary power.

The UV reactors for the Full-Scale Facility could be designed to adjust to 100 percent power only when more of the allowable number of ballasts and lamps are out of service. In addition, the UV disinfection and advanced oxidation system could be specified to have a lag time before adjusting to 100 percent power if the UVT analyzer experiences no flow. The flow to the UVT analyzer can be corrected by operations staff based on a system alarm.

3.2 Other Design Considerations

This section summarizes other design considerations for the Full-Scale Facility based on observations made during operation of the Demonstration Facility. These considerations are summarized in Table 3-2 and discussed in this section.

Table 3-2 Other Full-Scale Facility Considerations

Design Consideration	Effect
Membrane Filtration System	
Evaluate multiple manufacturers	• Promote competitive bidding • Determine best available equipment
Increase flux rate	• Smaller facility footprint • Reduce capital cost • Increase fouling, operational pressure, and O&M costs
Use of chemically enhanced backwashes	• Decreased clean in place frequency • Allows higher fluxes and lower capital cost • Higher chemical usage
Reverse Osmosis	
Evaluate multiple manufacturers	• Promote competitive bidding
Increase recovery (85 percent or higher)	• Maximize water production • Increase cleaning frequency
Increase flux rate	• Smaller facility footprint • Reduce capital cost • May improve hydraulics and reduce fouling/scaling potential
Add pH suppression capability	• Reduce potential fouling if water quality changes
UV Disinfection and Advanced Oxidation	
Evaluate multiple manufacturers	• Promote competitive bidding • Determine best available equipment
Reduce hydrogen peroxide dose	• Reduce chemical usage

3.2.1 Membrane Filtration

The following are other membrane filtration design considerations for the Full-Scale Facility.

Membrane Filtration Technology Selection

Two types of membrane filtration systems were tested at the Demonstration Facility: a Pall MF system and a Toray UF system. As mentioned above, both the MF and UF achieved the membrane filtration water quality goals of the Demonstration Facility; therefore, either system could be considered for the Full-Scale Facility. In addition to the two membranes tested during the Demonstration Facility, there are other membrane systems that may be considered for the Full-Scale Facility. It is recommended that other systems be considered to obtain competitive equipment pricing for the Full-Scale Facility. These include pressure systems, similar to those used at the Demonstration Facility, and submerged systems, such as the system used at the Orange County Water District Groundwater Replenishment

System. While there are basic conceptual differences between these two systems, the more significant differences are between manufacturers and systems in operating pressures, recovery, and efficiency between the systems and operating configurations. Therefore, lifecycle evaluations of multiple membrane filtration system vendors are recommended (refer to Section 3.1.1). Any manufacturer/equipment considered should meet the minimum qualifications discussed in Section 4.2.10.

Optimize Membrane Filtration Operating Conditions

Based on the relatively low membrane fouling rates observed for the MF and UF systems during the reporting period, it may be possible to optimize the operating conditions for the potential Full-Scale Facility by increasing the operating flux and feed water recovery. Such changes would result in a smaller footprint (i.e., fewer number of skids) to achieve the target production capacity thereby reducing the initial capital cost. Increasing the feed water recovery would also reduce the volume of backwash waste that would be required to be discharged to North City. This would also increase the Full-Scale Facility capacity based on the fixed available capacity of tertiary effluent.

Increasing these parameters could also increase the membrane fouling rates and operating pressure, which would result in higher O&M costs by increasing the frequency of chemical cleanings and feed pump pressure requirements. Optimization of these parameters would be specifically beneficial for the MF system as the system was operated at a lower feed water recovery than the UF system and exhibited a lower fouling rate.

Another operating condition that could be investigated is the use of chemically enhanced backwashes or frequent (daily or weekly) maintenance cleans to lessen membrane fouling thereby decreasing the number of full chemical cleanings required over a given time period. Both of these actions would increase the chemical usage (and O&M cost) of the Full-Scale Facility.

Flow Equalization of Membrane Filtrate

During operation of the Demonstration Facility, excess filtrate water produced from the MF and UF systems overflowed the filtrate tank to the drain. The filtrate storage tank was sized to accommodate downtime of the MF and UF system during the daily PDTs conducted on each system. It was also observed that the overflow of filtrate water from the storage tank increased when the feed water recovery of the RO systems was increased from 80 percent to 85 percent recovery as the RO feed water flow to meet the design permeate flow decreased. The design and operating strategy of the MF or UF system and filtrate storage tank for the Full-Scale Facility should be optimized to avoid wasting filtrate water and meet the demand of the RO system.

3.2.2 Reverse Osmosis

The following are other RO design considerations for the Full-Scale Facility.

Reverse Osmosis Technology Selection

Comparison of the two-stage and three-stage RO system performance during this reporting period showed similar membrane fouling rates and permeate water quality despite the fact that the Hydranautics ESPA2 LD membranes are advertised as low fouling membranes and the Toray TML membranes were projected to achieve higher rejection of nitrate. In addition to the two membranes tested during the Demonstration Facility, there are other RO membranes that should be considered for the Full-Scale Facility and new membranes will be developed before the Full-Scale Facility is designed. It is recommended that other membranes be tested to assess their operating performance (i.e., scaling and fouling rates) and permeate water quality in order to obtain competitive equipment pricing for the Full-Scale Facility. Any manufacturer/equipment considered should meet the minimum qualifications discussed in Section 4.2.10.

85 Percent RO Recovery to Maximize Water Production

Based on the low fouling rates observed on the RO systems during nearly six months of operation at 80 percent recovery, the RO systems were successfully increased to 85 percent recovery to maximize water production. In previous pilot testing conducted by the City, stable operations were not achievable at 85 percent recovery due to excessive fouling and scaling. The same effects have not been observed at the Demonstration Facility, possibly due to improved system hydraulics from higher fluxes (the piloting was done at fluxes between 10 and 12 gfd), or due to changes in water quality since the piloting was completed. Further consideration of recoveries as high as 87 to 88 percent could also be considered if additional water production is required, however, these higher recoveries should be successfully tested at the Demonstration Facility before considering them for full-scale design.

While increasing the recovery would increase the overall capacity of the Full-Scale Facility, long term operation at the higher recovery rates may warrant more O&M requirements. Such requirements may include an increase in the number of chemical cleanings due to increased membrane fouling and scaling and increased membrane replacement frequency. Although the antiscalant type and dose was sufficient without acid to prevent fouling during operation of the Demonstration Facility, water quality will change over time and could require changes in antiscalant or potentially the use of acid to maintain operation at 85 percent recovery for the Full-Scale Facility. If further increases above 85 percent recovery are considered, additional changes may be required, such as increases in RO flux or the addition of a third RO stage.

Higher RO Design Flux

While RO systems at the Demonstration Facility were tested at design flux of 12 gfd and feed water recoveries of 80 and 85 percent, the Full-Scale Facility design may consider a higher flux rate of 14 gfd. A pilot study performed at the Los Angeles Donald C. Tillman Water Reclamation Plant (Wetterau et al, 2011) observed that poor hydraulic conditions—high beta values or low crossflow velocities—can contribute to fouling in a two-stage RO configuration when an overall average flux below 12 gfd is maintained with a recovery of 85 percent. These findings are supported by challenges with scaling that have been experienced at the Leo J. Vander Lans Water Treatment Facility and the Terminal Island AWP Facility, both designed with two-stage RO and 85 percent recovery. Both facilities are in the process of expanding, and both will be operated at fluxes above 12 gfd when the expansions are complete.

It is recommended that an RO flux of 14 gfd be considered for the Full-Scale Facility in a two-stage configuration to take advantage of improved hydraulics and reduced scaling potential, and to allow some degree of turn-down for the RO skids during low supply flow conditions. To confirm the reliability of plant operation under such conditions, a higher flux should be tested with North City's tertiary effluent before the design of the Full-Scale Facility.

3.2.3 UV Disinfection and Advanced Oxidation

The following are other UV disinfection and advanced oxidation design considerations for the Full-Scale Facility.

Power Monitoring for Ballast Failure

The UV system at the Demonstration Facility had several ballast failures. While it is suspected that the ballast failures were caused by faulty ballasts, there is a chance that they could have been caused by power surges. The design of the Full-Scale Facility should include power monitoring of the Full-Scale Facility power sources to determine if a transient voltage surge suppressor should be included in the UV system design.

Optimize UVT Analyzer Inlet Connection

For the Full-Scale Facility, the UVT analyzer inlet connection should be located in a pipe run that is always running full with RO permeate and away from areas where air entrainment could be introduced. Air entrainment in the UVT analyzer inlet connection caused the UVT analyzer to malfunction several times at the Demonstration Facility, due primarily to the need for overhead piping at the Demonstration Facility. Such flow configurations should be avoided, to the extent possible, in the Full-Scale Facility design.

Optimize Hydrogen Peroxide Dose

The UV disinfection and advanced oxidation system at the Demonstration Facility was designed to achieve 1.2-log removal of NDMA based on the draft 2008 CDPH Groundwater Recharge Reuse Regulations. During the testing period, however, the CDPH revised the draft regulations (November 21, 2011) to specify that advanced oxidation be sized to achieve only 0.5-log removal of 1,4-dioxane or on demonstrated log removals of select indicator compounds from different functional groups. This change may make it possible to design the UV disinfection and advanced oxidation system at the Full-Scale Facility a lower UV dose. Based on initial studies completed by the Orange County Water District, it may also be possible to reduce the hydrogen peroxide dose below 3 mg/L and still achieve the 0.5-log removal requirement for 1,4-dioxane.

3.2.4 Chemical Systems

The following are other chemical systems design considerations for the Full-Scale Facility.

Prevent Air Locking

The chemical in the full scale design should be designed to prevent air locking, locating metering pumps sufficiently below the low level in the feed tanks to maintain pressures and prevent off-gassing.

Chemical Cleanings

The membrane filtration and reverse osmosis systems will require chemical cleanings. Based on the chemical cleanings that were conducted at the Demonstration Facility, the following elements for the clean-in-place system should be considered for the Full-Scale Facility design:

- Minimizing the volume of piping between the clean in place tank and equipment skids would reduce the cleaning solution volume requirement.
- Optimizing the clean in place tank configuration to limit the volume required to submerge the pump used to recirculate cleaning solution would reduce the cleaning solution volume requirement.
- The addition of flow meters on chemical cleaning solution dosing pumps would prevent over dosing and overuse of cleaning chemicals.

- The inclusion of an inline pH meter on the clean in place skid would be useful to help ensure target pH is met through the recirculation process and minimize over usage of chemicals needed to make pH adjustments.
- The inclusion of a designated neutralization tank (s) should be considered to allow more aggressive cleanings (e.g., pH below City's current discharge requirements).
- The use of acid followed by caustic was observed to be more effective than caustic followed by acid during clean in place procedures conducted on the RO systems.
- Use of North City cogeneration facility waste heat to heat chemical tanks during cleaning should be investigated prior to final design.

Increasing soak and recirculation times of standard chemical solutions on the RO systems improved cleaning efficiency and avoided the need for proprietary costly cleaning solutions.

3.2.5 Online Water Quality Instrumentation

This section describes lessons learned and observations made during operation of the Demonstration Facility regarding the online water quality instrumentation utilized throughout the testing program. Table 3-3 provides a list of online water quality analyzers installed at the Demonstration Facility. The table provides the location, purpose, and manufacturer and model for each analyzer. A brief description of the purpose and operational experience with each instrument is provided below.

Table 3-3 Water Quality Instruments Utilized at the Demonstration Facility

Analyzer Location	Parameter Measured	Instrument Manufacturer and Model	Purpose
MF filtrate	Turbidity	HACH 1720 E	MF integrity monitoring
UF filtrate	Turbidity	HACH 660 SC	UF integrity monitoring
Pre MF/UF filtrate storage tank	Total chlorine	HACH CL-17	Chlorine dosing control
Post MF/UF filtrate storage tank	Total chlorine	HACH CL-17	RO membrane protection
RO feed	Oxidation reduction potential	HACH pHD sc Digital Differential Sensor	RO membrane protection
RO feed	Conductivity	HACH probe	RO integrity monitoring
Train A RO permeate	Conductivity	HACH probe	RO integrity monitoring
Train B RO permeate	Conductivity	HACH probe	RO integrity monitoring
Combined RO permeate/RO feed	Total organic carbon	GE / Sievers 5310C	RO integrity monitoring
UV influent	UV transmittance	TrojanOptiView	UV dose adjustment
UV influent/product	Monochloramine	HACH Pocket Colorimeter II	Advanced oxidation integrity monitoring

- **Oxidation Reduction Potential (ORP) Analyzer –** The Demonstration Facility included an ORP analyzer at the feed of the RO systems. The purpose of this meter was to detect changes in ORP, which may be indicative of the presence of free chlorine that can damage the RO membranes. Throughout the testing the ORP of the feed water stayed fairly consistent around 400 millivolt (mV). The control system was set to give a warning if the ORP reached 500 mV and shut down if the value reached 550 mV. As a redundant measure, a flow confirmation switch was installed on the ammonia hydroxide pump to directly monitor that ammonia was being added at all times to form combined chlorine.

- **Chlorine Analyzers –** The Demonstration Facility included two online chlorine analyzers and one portable monochloramine analyzer. One online analyzer was located upstream and the other downstream of the MF/UF filtrate storage tank. The intention of the upstream meter was for chemical dosing, to ensure the target chloramine concentration was present in the membrane filtration filtrate to prevent biological fouling of the MF, UF, and RO systems. The downstream analyzer was tied to a control loop, which was set to alarm if total chlorine in the feed exceeded 4.0 mg/L, the maximum concentration allowed by the RO membrane manufacturers. The portable monochloramine analyzer was used in conjunction with the UV system to evaluate the use of monochloramine as a surrogate for CEC destruction. Based on successful correlation of monochloramine destruction at the Demonstration Facility, it is recommended that online analyzers be considered at the Full-Scale Facility to monitor the integrity of the UV process.

- **Turbidimeters –** Online turbidimeters were equipped on both the MF and UF systems to monitor filtrate turbidity on a continuous basis. Average filtrate turbidities based on readings taken twice per day from the online analyzer displays were 0.05 NTU for the MF system and 0.016 NTU for the UF system. The lower turbidity values measured on the UF system were attributed to the fact that this system uses a laser turbidimeter (HACH Model Filter Trak 660 SC), which uses advanced incident light, whereas the MF system uses a conventional incandescent light turbidimeter (HACH 1720 E). The specifications on the laser turbidimeter states the unit can detect changes in turbidity as low as 0.0003 NTU. Based on experience at the Demonstration Facility, both turbidimeters worked as intended and are suitable for the Full-Scale Facility.

- **UVT Analyzer** – The UV disinfection and advanced oxidation system was equipped with an online UVT analyzer located at the UV reactor influent. The purpose of the UVT analyzer was to provide feedback to the UV control system to adjust reactor power based on the measured UVT in the influent water. During the course of operation the analyzer operated as intended with the exception of the low flow alarms causing the reactor to alarm. Discussion on the possible use of online UVT for integrity monitoring and the Full-Scale Facility is discussed in Section 4.3.3.

- **Portable TOC Analyzer –** The RO system was equipped with one online TOC analyzer (GE Model 5310 C). The main purpose of the analyzer was to provide continuous monitoring of TOC in the RO permeate. However, the unit was also used each quarter to characterize the RO feed water TOC over a one to two-week period. The unit was also used to measure the TOC in grab samples from various locations in the Demonstration Facility process including MF filtrate, UF filtrate, and in the permeate from each RO Train. In general the analyzer operated as expected during the testing period. However, in order to achieve accurate measurements of the low concentrations of TOC (e.g., less than 100 ppb) in the RO permeate it was necessary to install an inorganic carbon removal unit on the analyzer. It was also observed during December 2011 that the accuracy of the analyzer was impacted by large swings in the internal cell and ambient temperature. Lastly, it is was necessary to frequently replace consumables on the unit including oxidizer and acid reagents, UV lamp, tubing, and resin per the manufacturer's recommended maintenance schedule. Additional recommendation on the use of online TOC monitoring for the full-scale integrity monitoring is provided in Section 4.3.3.

- **Conductivity Analyzers –** The RO system was equipped with online conductivity analyzers on the feed water and permeate. During the course of operation the analyzer operated as intended and correlated well with daily measurements taken with a hand held meter. Discussion of the use of online conductivity monitoring and the Full-Scale Facility is presented in Section 4.3.3.

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Section 4

Full-Scale Facility Conceptual Design

This section presents the recommendations for design of a Full-Scale Facility consistent with the water purification processes that are being operated at the Demonstration Facility. As discussed in Section 2, these water purification processes produced purified water that meets the required regulatory limits.

4.1 Full-Scale Facility Overview

The Full-Scale Facility consists of the following treatment components, as shown in the process flow diagram presented in Figure 4-1.

- AWP Facility influent pump station
- Pretreatment chemical addition (chloramination for biofouling control)
- Membrane filtration system (MF or UF)
- Membrane filtration break tank
- RO transfer pumps
- RO pre-treatment chemical addition (antiscalant and sulfuric acid for scale control)
- Cartridge filters
- RO feed pumps
- RO system
- UV disinfection and advanced oxidation system using ultraviolet light with hydrogen peroxide (UV/H_2O_2)
- Post treatment/stabilization chemical addition (pH and LSI adjustment for corrosion control)
- Purified water pump station and pipeline to San Vicente Reservoir (see the Purified Water Conveyance System Final Conceptual Design Report for more information)

Figure 4-2 shows the preliminary hydraulic profile of the Full-Scale Facility.

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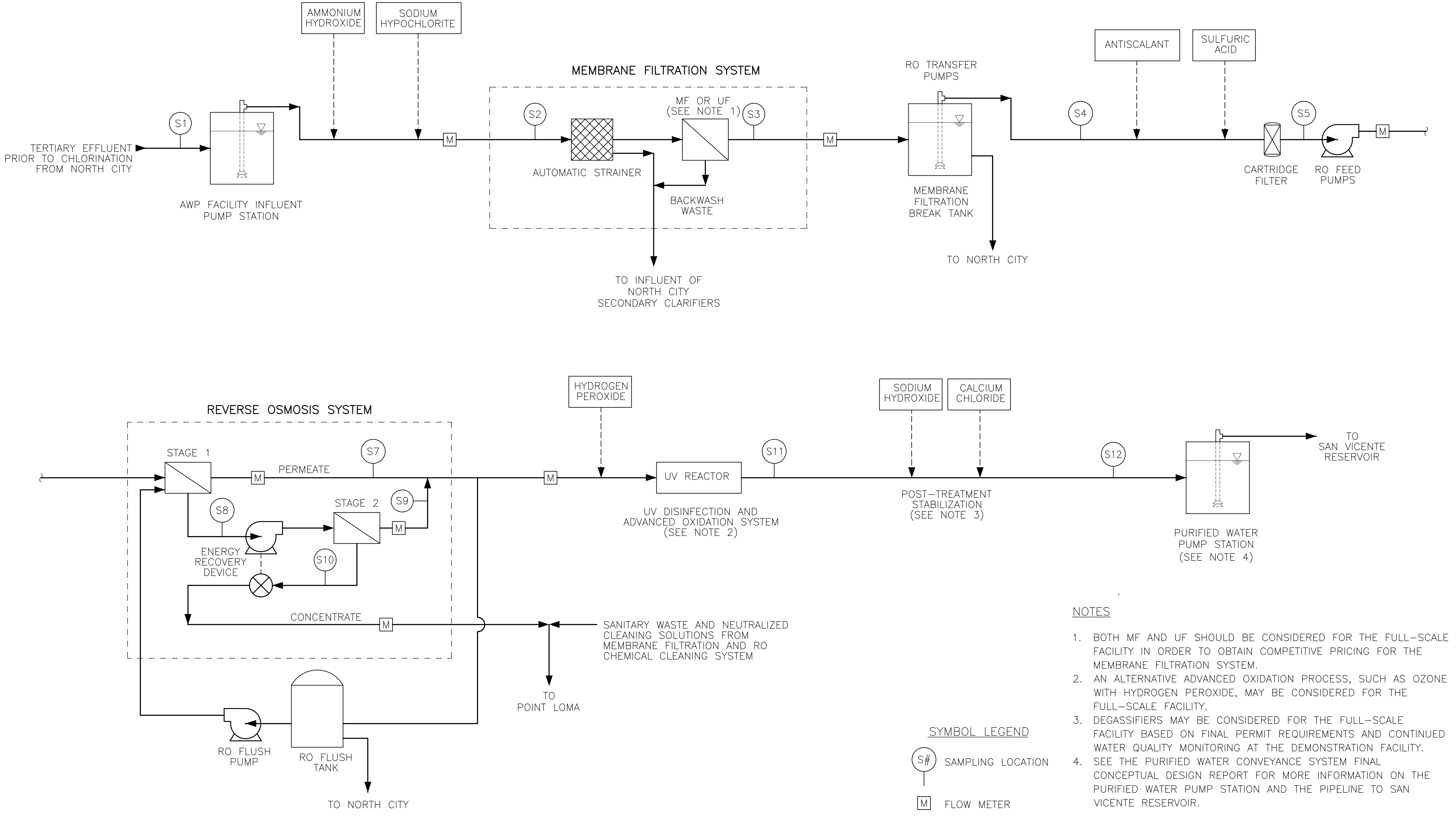

NOTES

1. BOTH MF AND UF SHOULD BE CONSIDERED FOR THE FULL–SCALE FACILITY IN ORDER TO OBTAIN COMPETITIVE PRICING FOR THE MEMBRANE FILTRATION SYSTEM.
2. AN ALTERNATIVE ADVANCED OXIDATION PROCESS, SUCH AS OZONE WITH HYDROGEN PEROXIDE, MAY BE CONSIDERED FOR THE FULL–SCALE FACILITY.
3. DEGASSIFIERS MAY BE CONSIDERED FOR THE FULL–SCALE FACILITY BASED ON FINAL PERMIT REQUIREMENTS AND CONTINUED WATER QUALITY MONITORING AT THE DEMONSTRATION FACILITY.
4. SEE THE PURIFIED WATER CONVEYANCE SYSTEM FINAL CONCEPTUAL DESIGN REPORT FOR MORE INFORMATION ON THE PURIFIED WATER PUMP STATION AND THE PIPELINE TO SAN VICENTE RESERVOIR.

CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR
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FULL-SCALE FACILITY PROCESS FLOW DIAGRAM (JANUARY 2013)

FIGURE 4-1

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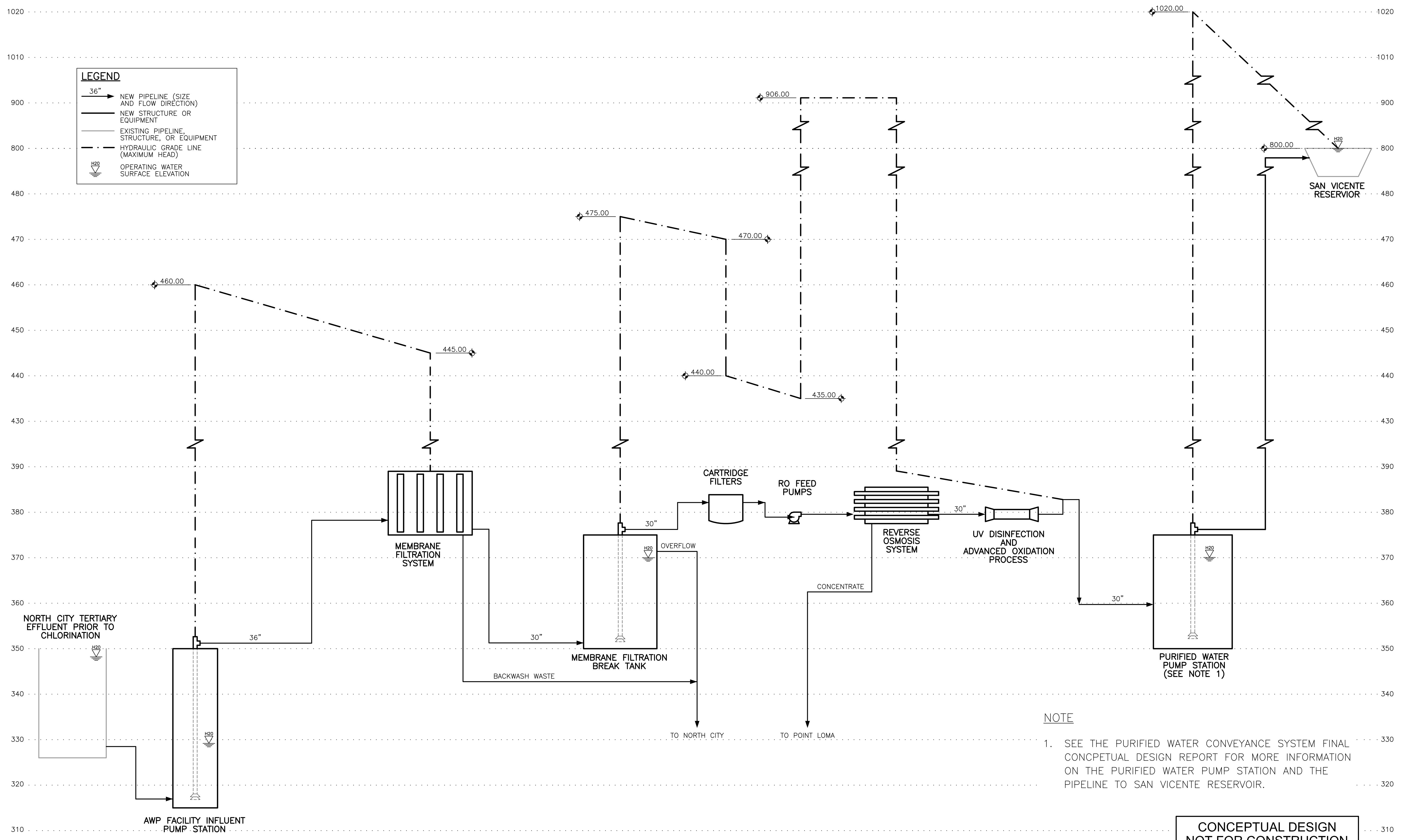

NOTE

1. SEE THE PURIFIED WATER CONVEYANCE SYSTEM FINAL CONCPETUAL DESIGN REPORT FOR MORE INFORMATION ON THE PURIFIED WATER PUMP STATION AND THE PIPELINE TO SAN VICENTE RESERVOIR.

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FULL-SCALE FACILITY HYDRAULIC PROFILE (JANUARY 2013)

FIGURE 4-2

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4.1.1 Capacity

The City's Full-Scale Reservoir Augmentation Capacity Analysis Technical Memorandum has defined a capacity for the Full-Scale Facility of 18 mgd, which would produce an annual average of 15 mgd of purified water. This sizing is based on the capacity of the North City, maintaining recycled water available for existing recycled water users, and a 95 percent online factor.

Maintaining recycled water available for existing recycled water users requires that the Full-Scale Facility sizing account for the seasonal demands of recycled water. The Full-Scale Facility will operate at the design capacity (18 mgd) in winter when recycled water demands are lowest, and will operate at a reduced production in summer when recycled water demands are highest. This seasonal variation, in combination with the online factor, will result in an average annual production of 15 mgd of purified water from the Full-Scale Facility. Therefore, the estimated capital costs presented in Section 4 are based on a capacity of 18 mgd, while the estimated O&M costs are based on annual average production of 15 mgd.

The City's Full-Scale Reservoir Augmentation Capacity Analysis Technical Memorandum is included in Appendix C.

4.1.2 Location

The proposed project site will be located on approximately 8.7 acres of available City-owned property immediately north of North City. A pipe gallery /access tunnel will be provided under Eastgate Mall Road connecting North City just west of the guard shack to the Full-Scale Facility. The tunnel will be sized to accommodate the following:

- Tertiary effluent/Full-Scale Facility feed pipeline (pressure)
- Membrane filtration backwash pipeline (gravity)
- RO concentrate pipeline (pressure)
- Electrical conduit
- Instrumentation and control conduit
- Maintenance cart travel

The footprint of the proposed Full-Scale Facility is approximately 6.0 acres. The site layout is based on locating the Operations, Maintenance, and Administration Building on the south for visitor access. Process areas not enclosed in a building will be installed under canopies.

Figure 4-3 shows the existing North City site; the location of the Full-Scale Facility site north of North City; the location of the AWP Facility influent pump station at North City; the preliminary routing of the tertiary effluent, membrane filtration backwash, RO concentrate, and instrumentation and control conduit at North City; and the tunnel between North City and the Full-Scale Facility site. Figure 4-4 shows the preliminary site layout for the Full-Scale Facility.

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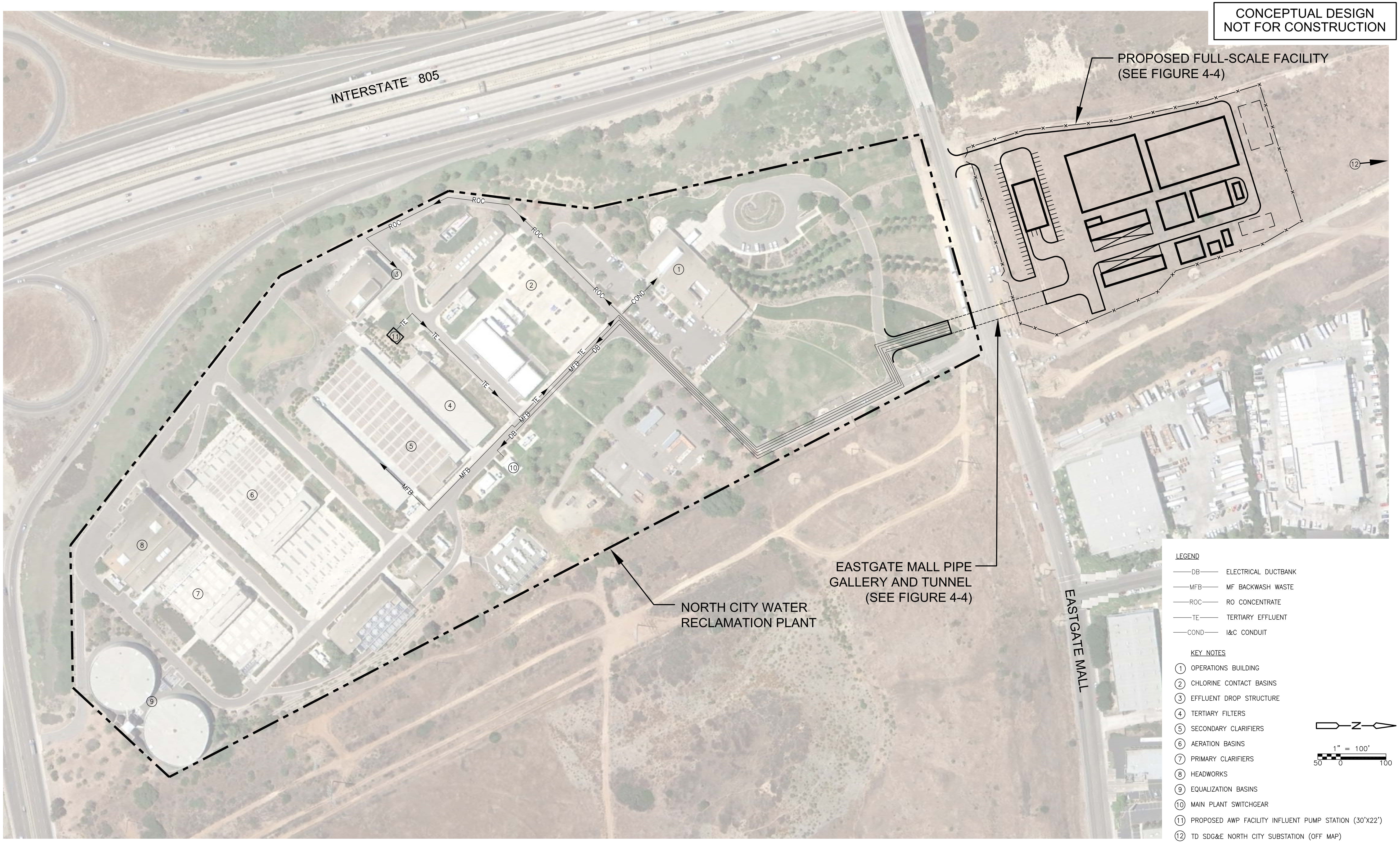

LEGEND

——DB——	ELECTRICAL DUCTBANK
——MFB——	MF BACKWASH WASTE
——ROC——	RO CONCENTRATE
——TE——	TERTIARY EFFLUENT
——COND——	I&C CONDUIT

KEY NOTES

① OPERATIONS BUILDING
② CHLORINE CONTACT BASINS
③ EFFLUENT DROP STRUCTURE
④ TERTIARY FILTERS
⑤ SECONDARY CLARIFIERS
⑥ AERATION BASINS
⑦ PRIMARY CLARIFIERS
⑧ HEADWORKS
⑨ EQUALIZATION BASINS
⑩ MAIN PLANT SWITCHGEAR
⑪ PROPOSED AWP FACILITY INFLUENT PUMP STATION (30'X22')
⑫ TD SDG&E NORTH CITY SUBSTATION (OFF MAP)

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FULL-SCALE FACILITY PROPOSED IMPROVEMENTS (JANUARY 2013)

FIGURE 4-3

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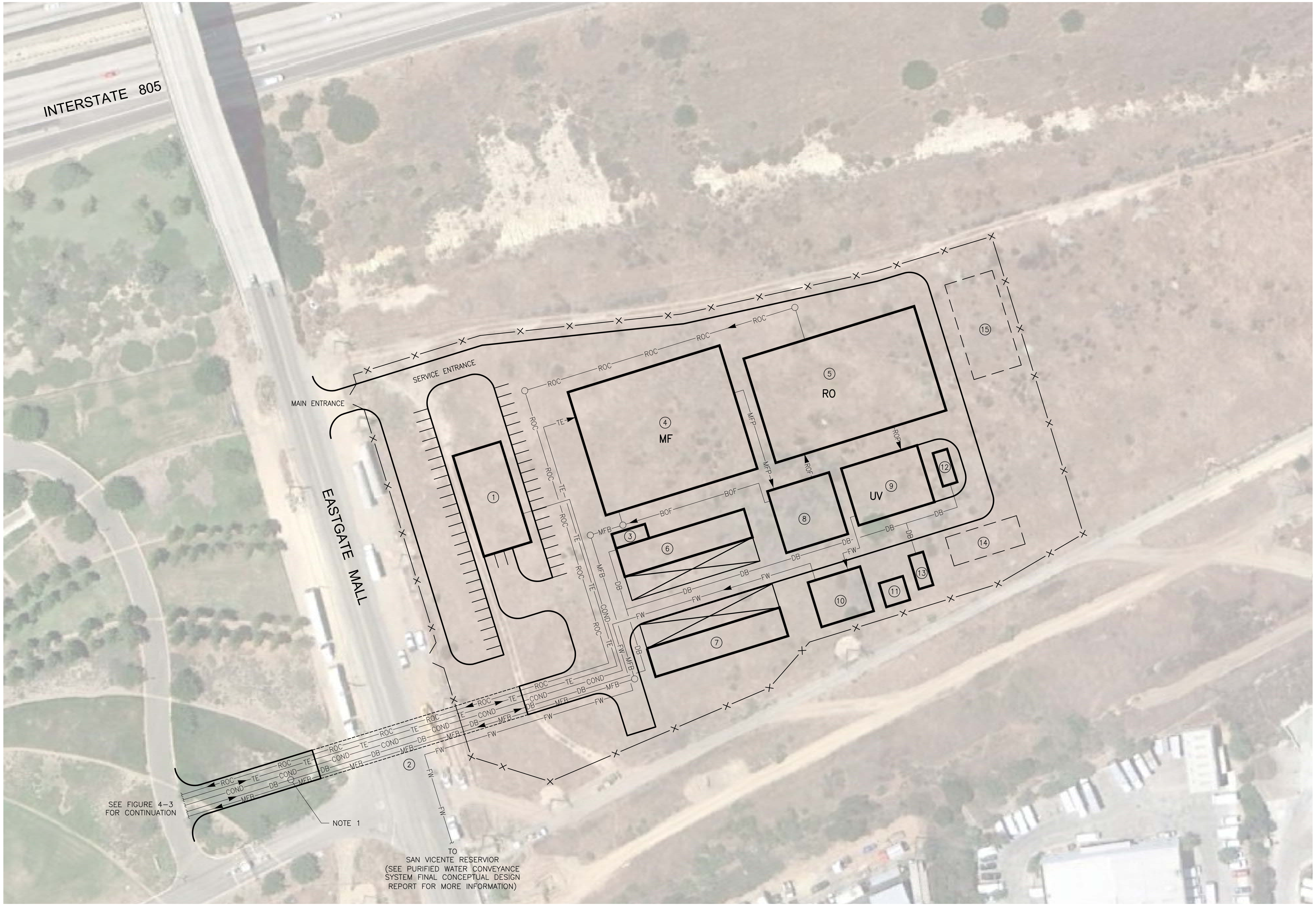

LEGEND

—X—X—	CHAIN LINK FENCE
☒	LOADING PADS (25' WIDE)
—BOF—	BREAK TANK OVERFLOW
—COND—	I&C CONDUIT
—DB—	ELECTRICAL DUCTBANK
—FW—	FINISHED WATER
—MFB—	MF BACKWASH WASTE
—MFP—	MF PERMEATE
—ROF—	RO FEED
—ROC—	RO CONCENTRATE
—ROP—	RO PERMEATE
—TE—	TERTIARY EFFLUENT

KEY NOTES

① OPERATIONS, MAINTENANCE, AND ADMINISTRATION BUILDING (106' X 50')
② EASTGATE MALL PIPE GALLERY AND TUNNEL
③ ELECTRICAL SUBSTATION 700USS (15' X 35')
④ MF BUILDING (160' X 130')
⑤ RO BUILDING (180' X 110')
⑥ CHEMICAL STORAGE AREA (135' X 30')
⑦ POST-TREATMENT CHEMICAL STORAGE AREA (140' X 30')
⑧ MF BREAK TANK, CARTRIDGE FILTERS, AND BOOSTER PUMPS (65' X 65')
⑨ UV FACILITY (80' X 60')
⑩ PURIFIED WATER PUMP STATION (55' X 47')
⑪ SURGE TANK (25' X 25')
⑫ ELECTRICAL SUBSTATION 680USS (15' X 35')
⑬ ELECTRICAL SUBSTATION 690USS (15' X 35')
⑭ FUTURE DEGASSIFIER (75' X 30')
⑮ FUTURE TESTING AREA (50' X 100')

NOTE

1. DUCTBANK FROM NCWRP TO AWPF TO SUPPLY COGENERATION POWER TO THE FULL-SCALE AWPF. COGENERATION POWER WILL PROVIDE BACKUP POWER FOR RO FLUSH PUMPS AND CONTROL SYSTEM IN THE EVENT OF AN SDG&E POWER OUTTAGE.

N

1" = 50'
25 0 50

CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR
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FULL-SCALE FACILITY SITE PLAN (JANUARY 2013)

FIGURE 4-4

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4.2 Process Descriptions and Preliminary Design Criteria

Preliminary design criteria for each process area are described herein and are summarized in Figures 4-5 and 4-6.

4.2.1 AWP Facility Influent Pump Station

The influent pump station to pump tertiary effluent prior to chlorination to the membrane filtration facility will be located on the North City site west of the tertiary filters. Figure 4-7 shows a preliminary layout for the influent pump station. A total of four multi-stage vertical turbine pumps (three duty and one standby) will be used to supply influent water to the Full-Scale Facility. The wet well will receive tertiary effluent from the existing tertiary filtered water line. A slide gate and/or valves will be installed in the existing tertiary filtered water line to allow flow to be directed to the pump station. The water surface elevation within the wet well will "float" with the water surface elevation in the tertiary filtered water line maintaining the same water surface elevations. As recommended in Section 3.1.1, the pumps will be equipped with variable frequency drives to supply tertiary influent at varying flow conditions. The tertiary effluent will be pumped through a pipeline that will be installed in the tunnel under Eastgate Mall Road to the Full-Scale Facility.

4.2.2 Membrane Filtration

The membrane filtration system provides pretreatment for the RO system to reduce the particulate and biological fouling of the RO membranes. The membrane filtration system will effectively remove inert particulates, organic particulates, colloidal particulates, pathogenic organisms, bacteria and other particles by the size-exclusion sieve action of the membranes. As described in the Demonstration Project Report, membrane filtration could provide 4-log reduction of *Cryptosporidium* and *Giarda* towards the overall reduction goals (see the Demonstration Project Report for more information on the overall log reduction goals for the potential full-scale IPR/RA project; note that the concentrations of *Cryptosporidium* and *Giarda* were not high enough in the tertiary effluent prior to chlorination and membrane filtration filtrate to demonstrate these log reductions at the Demonstration Facility). These log removal credits will be approved by CDPH provided that approved membranes and required integrity monitoring are used (e.g., daily pressure decay tests and online turbidimeters). Table 4-1 presents the membrane filtration water quality goals.

Table 4-1 Membrane Filtration Water Quality Goals

Constituent	Design Criteria
Cryptosporidium	Undetectable[1]
Giardia	Undetectable[2]
Suspended Solids	Undetectable[3]
95th Percentile Filtrate Turbidity	<0.1 NTU
Filtrate Silt Density Index (SDI)	<3

Notes:

1) EPA Method 1623. Method detection limit for Cryptosporidium is 1 Oocysts/100L, so the membrane filtration water quality goal is zero Oocysts/100L.
2) EPA Method 1623. Method detection limit for Giardia is 1 Cysts/100L, so the membrane filtration water quality goal is zero Cysts/100L.
3) EPA Method 160.2. Method detection limit is 1.0 mg/L, so the goal is to be <1.0 mg/L.

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Advanced Water Purification Facility Design Criteria

Design Product Water	18.0	mgd
AWP Facility Influent Flows		
Design Flow	22.8	mgd
Minimum Flow	14.8	mgd
1-RO Train	5.7	mgd

AWP Facility Influent Pump Station		
Design Flow	22.8	mgd
Minimum Flow	14.8	mgd
1-RO Train	5.7	mgd
Pump Type	Vertical Turbine/Submersible	
No. of Duty Pumps	3	units
No. of Standby Pumps	1	units
Design Flow per Pump	5,857	gpm
Minimum Pressure	50	psi
Variable Frequency Drive (VFD)	Yes	

MF System		
Minimum Recovery	93%	
MF Permeate Flow, Design	21.2	mgd
MF Permeate Flow, Minimum	13.8	mgd
MF Permeate Flow, 1-RO Train	5.3	mgd
MF Strainer		
Type	Auto-Backwash Strainer	
No. of Duty Units	4	units
No. of Standby Units	1	units
Screen Pore Size, Minimum	300	microns
Strainer Recovery, Minimum	100%	
Clean Strainer Headloss, Maximum	1.0	psi
Dirty Strainer Headloss, Maximum	10	psi
Strainer Size	18	inch
Flow per Strainer	5,000	gpm/unit
Configuration		
No. of Duty Skids	12	skids
No. of Standby Skids	2	
Redundancy	N + 2	
Capacity per Skid	1.90	mgd/skid
MF Recovery, Minimum	93%	
Instantaneous Flux, Maximum	35	gfd
Average Flux, Maximum	33	gfd
Total Membrane Area Required	699,551	sf
Total No. of Membrane Modules Required	1,300	modules
No. of Membrane Modules per Skid	116	modules/skid
Membrane Area per Skid	62,408	sf/skid
No. of Backwashes per skid	48	per day
Backwash time	90	seconds
Backwash Interval	25 to 30	minutes
MF Backwash Waste Flow, Design	1.6	mgd
MF Backwash Waste Flow, Design (1)	2,000	gpm
MF Backwash Waste Flow, Minimum	1.0	mgd
MF Backwash Waste Flow, Minimum	1,250	gpm
MF Backwash Waste Flow, 1-RO Train	0.4	mgd
MF Backwash Waste Flow, 1-RO Train	307	gpm
Maintenance Wash Interval, Minimum	1	week
CIP Interval, Minimum	30	days
Typical CIP Duration, Each Skid, Each Clean	4-6 hours	
Air Compressor	Provided by Vendor	

(1) Flow is based on actual flow per minute for a backwash. Differs from daily flow.

Design Product Water	18.0	mgd
MF CIP Pumps	Provided by vendor	
No. of Duty Pumps	1	units
No. of Standby Pumps	1	units
Citric Acid Day Tank		
No. of Duty Tanks	1	units
Days of Storage	14	days
Total Storage Volume Required	580	gal
CIP Citric Acid Transfer Pumps		
No. of Duty Pumps	1	units
No. of Standby Pumps	1	units
Pump Type	Diaphragm Metering	
CIP Sodium Hydroxide Transfer Pumps		
No. of Duty Pumps	1	units
No. of Standby Pumps	1	units
Pump Type	Diaphragm Metering	
CIP Sodium Hypochlorite Transfer Pumps		
No. of Duty Pumps	1	units
No. of Standby Pumps	1	units
Pump Type	Diaphragm Metering	

Membrane Filtration Break Tank		
No. of Duty Tanks	2	units
No. of Standby Tanks	-	units
Residence Time, Minimum	25	min
Volume Required, Total	368,000	gal

RO Transfer Pump Station		
Design Flow	21.2	mgd
Minimum Flow	13.8	mgd
1-RO Train	5.3	mgd
Pump Type	Vertical Turbine	
No. of Duty Pumps	4	units
No. of Standby Pumps	1	units
Design Flow per Pump	4,085	gpm
Minimum Pressure	50	psi

Cartridge Filters		
Design Flow	21.2	mgd
Minimum Flow	13.8	mgd
No. of Units	7	units
No. of Standby Units	1	units
Pore Size, Minimum	5	microns
Filter Material	Polypropylene	
Filtration Rate	3	gpm/10 inch
Filtration Rate	12	gpm/40 inch
Filters per Vessel	176	
Capacity per Filter	2,112	gpm
Capacity per Filter	3.04	mgd

RO Feed Pump Station		
Design Flow	21.2	mgd
Minimum Flow	13.8	mgd
1-RO Train	5.3	mgd
Pump Type	Vertical Turbine	

Design Product Water	18.0	mgd
RO Feed Pump Station (con't)		
No. of Duty Pumps	4	units
No. of Standby Pumps	1	units
Design Flow per Pump	4,085	gpm
Target Pressure	290	psi
Variable Frequency Drive (VFD)	Yes	

RO System		
Recovery	85%	
Feed Design Flow	21.2	mgd
Feed Minimum Flow	13.8	mgd
Feed 1-RO Train	5.3	mgd
Permeate Flow, Design	18.0	mgd
Permeate Flow, Minimum	11.7	mgd
Permeate Flow, 1-RO Train	4.5	mgd
Concentrate Flow, Design	3.2	mgd
Concentrate Flow, Minimum	2.1	mgd
Concentrate Flow, 1-RO Train	0.8	mgd
Material	Composite Polyamide	
Configuration	Spiral Wound	
Type	High Rejection, Low Fouling	
Element Size	8	inch diameter
Membrane Area per Element	400	sf
No. of Duty RO Trains	4	
No. of Standby RO Trains	1	
Capacity per Train	4.5	mgd
No. of Elements per Vessel	7	
No. of Stages	2	

Energy Recovery		
No. Energy Recovery Devices	5	units
Energy Recovery Boost	20	psi

RO Flush Tank		
No. of Duty Tanks	2	units
No. of Standby Tanks	-	units
Total Storage Volume Required	19,790	gal

RO Flush Pumps		
Pump Type	Horizontal Centrifugal	
No. of Duty Pumps	2	units
No. of Standby Pumps	1	units
Flush Time per Train	3	min
Total Flush Time	8	min
Design Flow per Pump	1,097	gpm

CIP System		
CIP Tanks		
No. of Duty Tanks	1	units
No. of Standby Tanks	1	units
No. of Tank Immersion Heaters	2	units
Heating Frequency/Duration	30 hours/6-months	
Heater Power Requirements	200	kW
Flush Volume per Train	3,290	gal
Tank Volume, Each (+25%)	4,100	gal

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FULL-SCALE FACILITY DESIGN CRITERIA I (JANUARY 2013)

FIGURE 4-5

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Design Product Water	18.0	mgd
RO CIP Pumps		
Pump Type	Horizontal Centrifugal ANSI	
No. of Duty Pumps	2	units
No. of Standby Pumps	1	units
Recirculation Time	5	min
Design Flow per Pump	658	gpm
Minimum Pressure	60	psi
Citric Acid Day Tank		
No. of Duty Tanks	1	units
No. of Standby Tanks	0	units
Total Storage Volume Required	500	gal
CIP Citric Acid Pumps		
No. of Duty Pumps	1	units
No. of Standby Pumps	1	units
Pump Type	Diaphragm Metering	
Sodium Hydroxide Day Tank		
No. of Duty Tanks	1	units
No. of Standby Tanks	0	units
Total Storage Volume Required	500	gal
CIP Sodium Hydroxide Transfer Pump		
No. of Duty Pumps	1	units
No. of Standby Pumps	1	units
Design Flow per Pump	10	gpm
Minimum Target Pressure	20	psi
Variable Frequency Drive (VFD)	No	
Sodium Hydroxide Feed Pump		
No. of Duty Pumps	1	units
No. of Standby Pumps	1	units
Pump Type	Diaphragm Metering	

UV Disinfection and Advanced Oxidation		
Criteria (see Note 2)	0.5 log 1,4 dioxane removal	
Type of UV System	Low-Pressure High-Output (LPHO)	
Flow Capacity	6	mgd/train
Power Draw	18.5	kW/single reactor
Maximum Power Draw	333	kW
No. of Duty Trains	3	units
No. of Standby Trains	0	units
No. of Chambers per Train	3	units
No. of Reactors per Chamber	2	units
No. of Lamps per Reactor	72	units
Total No. of Lamps	1,296	units
Hydrogen Peroxide		
Concentration	50%	
Dose, Design	5.0	mg/L
Dose, Minimum	2.0	mg/L
No. of Duty Tanks	2	units
No. of Standby Tanks	0	units
Days of Storage	30	days
Total Storage Volume Required	4500	gal
No. of Duty Pumps	4	units
No. of Standby Pumps	1	units
Pump Capacity, Each	1.94	gph
Pump Type	Diaphragm Metering	

Design Product Water	18.0	mgd
Ammonium Hydroxide		
Concentration	19%	
Dose, Design	1.5	mg/L
Dose, Minimum	0.8	mg/L
No. of Duty Tanks	2	units
Days of Storage	30	days
Total Storage Volume Required	5,900	gal
No. of Duty Pumps	3	units
No. of Standby Pumps	1	units
Pump Capacity, Each	3.3	gph
Pump Type	Diaphragm Metering	

Sodium Hypochlorite		
Concentration	12.5%	
Dose, Design	5.0	mg/L
Dose, Minimum	3.0	mg/L
No. of Duty Tanks	2	units
Days of Storage	14	days
Total Storage Volume Required	10,720	gal
No. of Duty Pumps	3	units
No. of Standby Pumps	1	units
Pump Capacity, Each	13.0	gph
Pump Type	Diaphragm Metering	

Antiscalant		
Concentration	100%	
Dose, Design	4.0	mg/L
Dose, Minimum	2.0	mg/L
No. of Duty Tanks	2	units
Days of Storage	30	days
Total Storage Volume Required	2,100	gal
No. of Duty Pumps	3	units
No. of Standby Pumps	1	units
Pump Capacity, Each	1.2	gph
Pump Type	Diaphragm Metering	

Sulfuric Acid		
Concentration	93%	
Dose, Design	60.0	mg/L
Dose, Minimum	20.0	mg/L
No. of Duty Tanks	3	units
Days of Storage	30	days
Total Storage Volume Required	22,300	gal
No. of Duty Pumps	3	units
No. of Standby Pumps	1	units
Pump Capacity, Each	12.7	gph
Pump Type	Diaphragm Metering	

Sodium Bisulfite		
Concentration	38%	
No. of Duty Tanks	Drum	units
Days of Storage	N/A	days
Total Storage Volume Required	55	gal
No. of Duty Pumps	1	units
No. of Standby Pumps	1	units
Pump Capacity, Each	6.5	gph
Pump Type	Diaphragm Metering	

Design Product Water	18.0	mgd
Post Treatment		
LSI	-1.0 to 1.0	
pH	6.5 - 9.0	
Calcium Chloride		
Concentration	34.7%	
Dose, Design	20.0	mg/L
Dose, Minimum	10.0	mg/L
No. of Duty Tanks	3.3	units
Days of Storage	30	days
Total Storage Volume Required	23,100	gal
No. of Duty Pumps	2	units
No. of Standby Pumps	1	units
Pump Capacity, Each	13.2	gph
Pump Type	Diaphragm Metering	
Sodium Hydroxide		
Concentration	50.0%	
Dose, Design	15.0	mg/L
Dose, Minimum	5.0	mg/L
No. of Duty Tanks	3	units
Days of Storage	30	days
Total Storage Volume Required	10,840	gal
No. of Duty Pumps	2	units
No. of Standby Pumps	1	units
Pump Capacity, Each	6.1	gph
Pump Type	Diaphragm Metering	

Design Product Water	18	mgd
Purified Water Pump Station (See Note 1)		
Design Flow	18	mgd
Minimum Flow	3.5	mgd
Pump Type	Vertical Turbine	
No. of Duty Pumps	3	units
No. of Standby Pumps	1	units
Design Flow per Pump	4,200	gpm
Head At Design Flow (C=120)	651	feet
Pump Speed	1770	RPM
Motor HP	900	HP
Drive Type	Variable Speed	

NOTE:

1. SEE THE PURIFIED WATER CONVEYANCE SYSTEM FINAL CONCPETUAL DESIGN REPORT FOR MORE INFORMATION ON THE PURIFIED WATER PUMP STATION AND THE PIPELINE TO SAN VICENTE RESERVOIR.
2. THE UV DISINFECTION AND ADVANCED OXIDATION SYSTEM SIZING WILL ALSO BE BASED ON FINAL CTR REQUIREMENTS (ONCE THEY ARE DEFINED). SEE SECTION 4.2.4 FOR MORE INFORMATION.

CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR
AUGMENTATION DEMONSTRATION PROJECT

FULL-SCALE FACILITY DESIGN CRITERIA II (JANUARY 2013)

FIGURE 4-6

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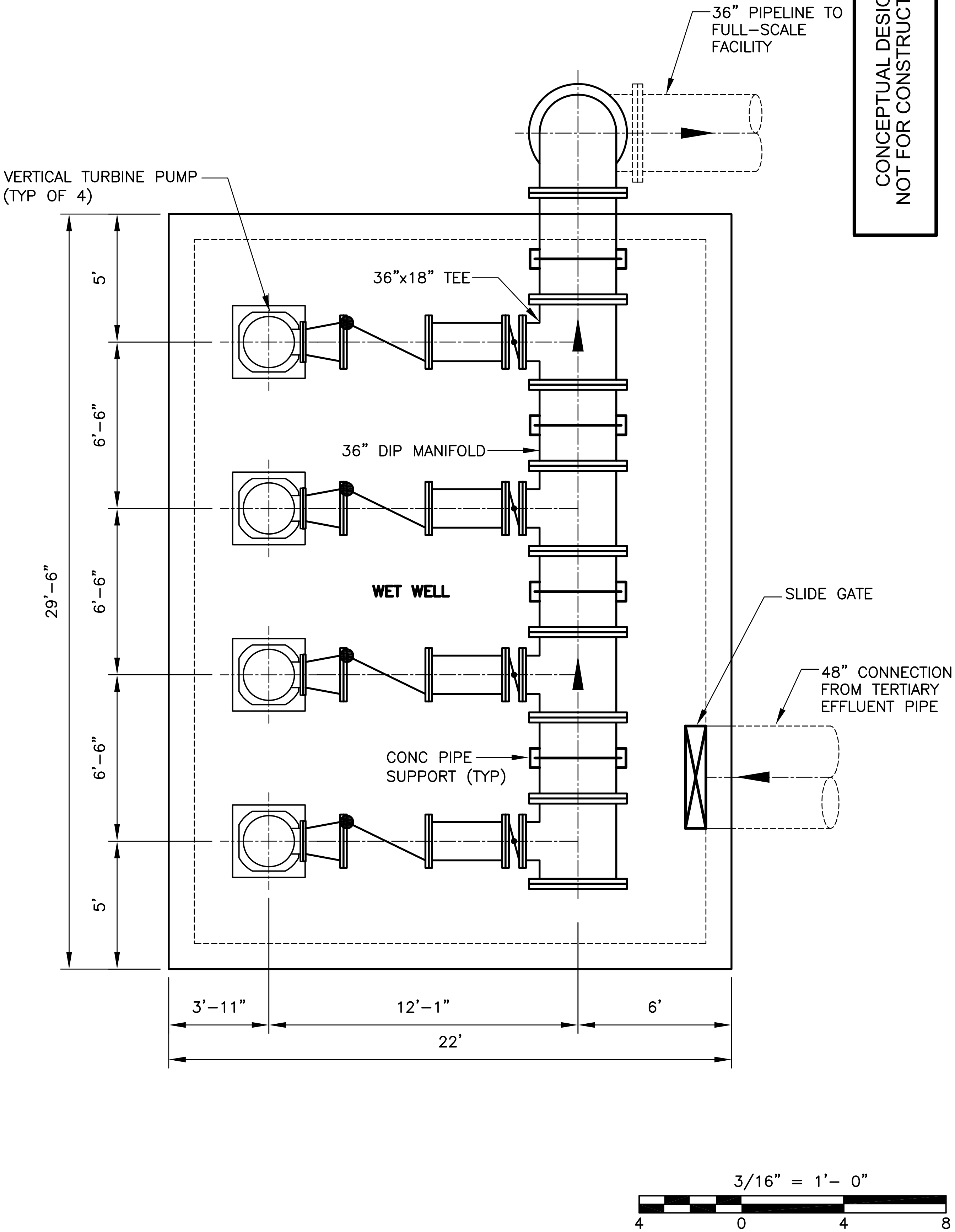

CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR
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FULL-SCALE FACILITY INFLUENT PUMP STATION LAYOUT (JANUARY 2013)
FIGURE 4-7

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Pre-Treatment Chemical Addition

Ammonium hydroxide and sodium hypochlorite will be added downstream of the membrane feed pumps and upstream of the membrane filtration pre-filters for chloramination to control the biological fouling of the membrane filtration membranes. The target combined chlorine concentration (chloramines) is 3 to 5 mg/L, which is used at the Demonstration Facility. The chemicals will be flow paced based on the membrane filtration feed flow rate and trimmed based on the combined chlorine concentration.

Membrane Filtration Pre-Filters

The membrane filtration pre-filters or strainers will be provided immediately upstream of the membrane filtration membranes to protect the membrane filtration membranes from damage and/or fouling due to larger particles. Pre-filters are typically provided by the membrane manufacturers as part of a complete membrane filtration system package and are required by the membrane filtration system warranty.

Membrane Filtration Systems

Two types of membrane filtration systems were tested at the Demonstration Facility: a Pall MF system and a Toray UF system. As discussed in Section 2, both the MF and UF achieved the membrane filtration water quality goals described above in Table 4-1; therefore, either system could be considered for the Full-Scale Facility. The preliminary design criteria, layouts, and cost estimates are presented herein are based on the Pall MF system since Pall meets the minimum recommended qualifications, is more conservative from a space requirement, and has lower capital and O&M costs.

Figure 4-8 shows the membrane filtration system layout based on the Pall MF system. The layout is based on the 35 gfd instantaneous flux rate (33 gfd average flux rate at 93 percent MF recovery) that has been demonstrated. However, the good membrane performance and long cleaning cycles imply that a higher flux rate may be achievable. The membrane filtration footprint could be reduced if a higher flux rate is utilized. After the vendor prequalification and equipment pre-selection, the size of the membrane filtration building will need to be adjusted to accommodate the pre-selected membrane filtration system vendor.

See Sections 3.1.1 and 3.2.1 for energy conservation and other design considerations, respectively, for the membrane filtration systems.

Membrane Filtration Break Tank

The membrane filtration break tank will serve as a flow equalization reservoir for the membrane filtration filtrate prior to being pumped to the RO system. The membrane filtration filtrate will be conveyed to the membrane filtration break tank with residual pressure from the membrane filtration system. The membrane filtration break tank will mitigate the impact of the variations in the membrane filtration filtrate flow (resulting from backwashes, cleanings, and integrity tests) by providing equalization volume equivalent to approximately 25 minutes of the maximum RO feed flow between the membrane filtration and RO processes. The membrane filtration filtrate flow varies due to the membrane filtration backwashes (occur every 25 to 30 minutes for each unit), daily maintenance cleans, and daily membrane integrity tests.

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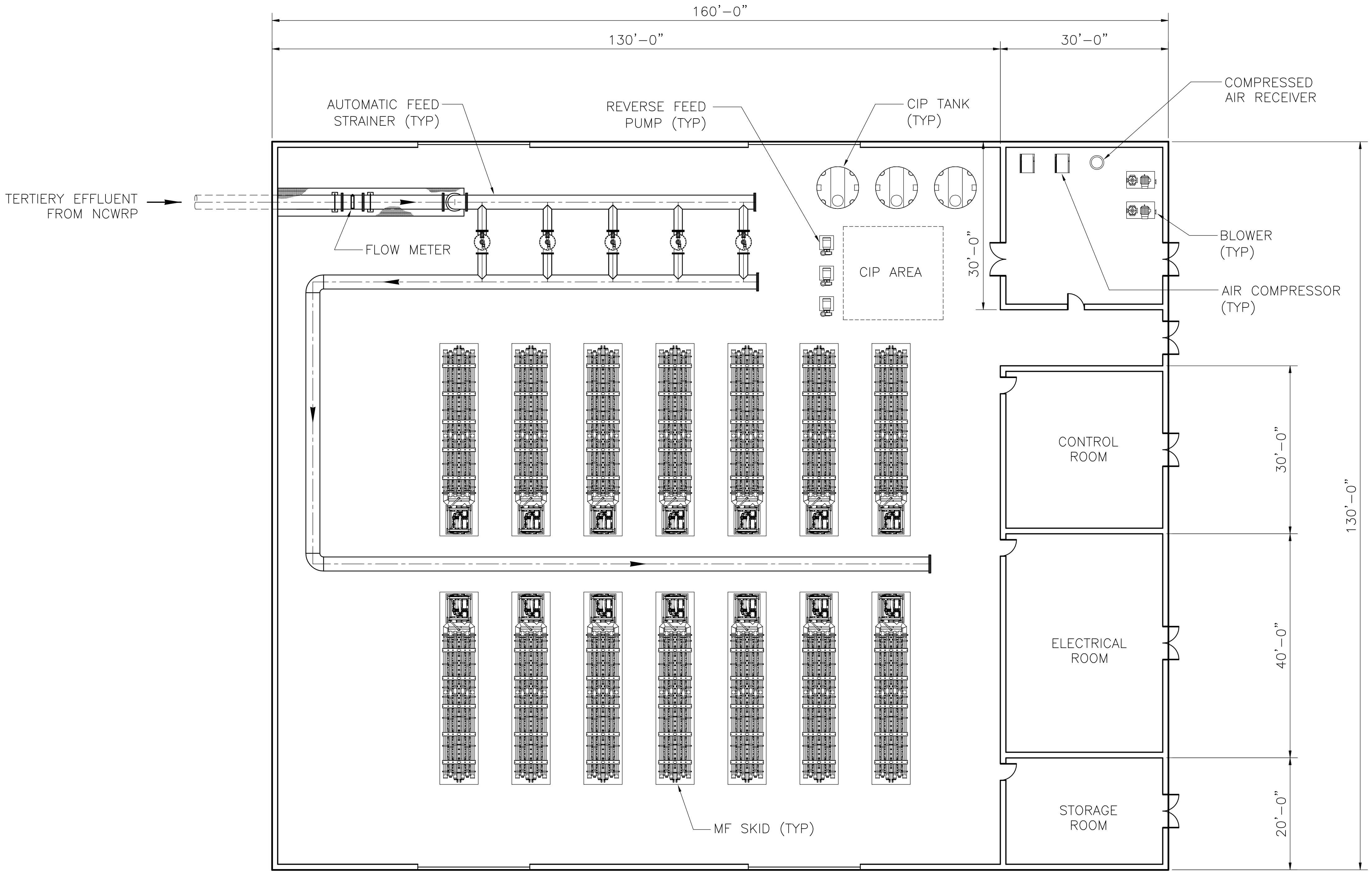

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FULL-SCALE FACILITY MF SYSTEM LAYOUT (JANUARY 2013)

FIGURE 4-8

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4.2.3 Reverse Osmosis

While RO is traditionally used for purification and desalination in water treatment, it also has a long history of being effectively utilized in wastewater treatment processes for removal of a wide array of dissolved constituents. RO has also proven to be effective at removing dissolved organic material, including regulated synthetic organic compounds, volatile organic compounds (VOCs), and unregulated CECs, such as pharmaceutical compounds, personal care products, pesticides, herbicides, and other industrial products. RO is recognized as the best available technology for reducing TDS and most trace organic constituents in wastewater effluent intended for groundwater replenishment and as tested here for reservoir augmentation.

RO is expected to receive 2-log (99 percent) removal credit from CDPH for viruses, *Giardia*, and *Cryptosporidium* towards the overall log reduction goals for the potential full-scale IPR/RA project (see the Demonstration Project Report for more information on the overall log reduction goals for the potential full-scale IPR/RA project). These log removal credits will be approved by CDPH provided online monitoring can verify a minimum 2-log reduction in some type of surrogate monitoring parameter, such as conductivity, UV254, or TOC. To date, CDPH has permitted one facility granting such credits to an RO system, a seawater desalination facility using conductivity as the surrogate (Sand City, California). Monitoring results from the Demonstration Facility did not show a consistent 2-log reduction in conductivity, but did show greater than 2-log reduction in TOC, providing an opportunity to use TOC monitoring as the surrogate parameter.

It should be noted that somatic and male specific coliphage (viruses) measured during the Demonstration Facility operation were generally below detectable levels in the RO feed water, making it impossible to measure a removal across the RO membranes without spiking the water with additional viruses (which was not done as part of the AWP Facility Study). Removal of numerous organic and inorganic compounds (including CECs) were observed, as discussed in Section 2.

The RO facility includes the following processes:

- RO transfer pumps
- RO pre-treatment chemical addition (antiscalant and sulfuric acid for scale control)
- Cartridge filters
- RO feed pumps
- RO system

The RO transfer pumps will pump membrane filtration filtrate from the membrane filtration break tank through the RO cartridge filters to the RO feed pumps.

The cartridge filters, located upstream of the RO, help protect the RO membranes from particulates that may be introduced in the membrane filtration break tank or through chemical addition. Note that cartridge filters were not used at the Demonstration Facility because of the controlled environment upstream of the RO system (closed plastic membrane filtration break tank and no acid feed), which eliminated the introduction of particulates upstream of RO. At the Demonstration Facility, the membrane filtration break tank was also painted black and located under the Demonstration Facility canopy to control algae growth.

Antiscalant will be added to control scaling of the RO membranes. Antiscalant will be fed upstream of the RO cartridge filters.

Although the Demonstration Facility has operated successfully without the addition of sulfuric acid or any other type of acid, many full-scale AWP Facilities use sulfuric acid to lower the pH of the RO feed water to control scale from the sparingly soluble salts, such as calcium carbonate, calcium phosphate, and magnesium hydroxide. While concentrations of these constituents were not high enough to require acid during operation of the Demonstration Facility, the historic water quality data suggest that acid could be required at some point in the future. The preliminary layouts and cost estimates are based on adding sulfuric acid upstream of the RO cartridge filters.

Each RO train will be paired with a dedicated feed pump. Note that these pumps are required in addition to the RO transfer pumps as the pressure needed to feed RO is greater than the rated pressure of most cartridge filter vessels. Design alternatives are available for avoiding these transfer pumps, such as using high pressure cartridge filters or directly coupling the membrane filtration process with the RO; however, use of these measures are not common and a conservative, more traditional approach has been assumed for planning purposes.

The required RO feed pump pressure is a function of the incoming pressure from the RO transfer pumps, the headloss in the cartridge filters upstream and the associated piping, and the required feed pressure into the RO system. The required discharge pressure for the RO feed pumps will vary as the RO operating pressure changes due to water quality changes and RO membrane fouling. Therefore, variable frequency drives will be used for the RO feed pumps to adjust to varying pressure requirements. The rated design point for the pumps will be selected from within this range such that the pumps will operate near best efficiency for the most common operating conditions.

As discussed in Section 3.1.2, the RO System is recommended to have a two-stage membrane configuration with energy recovery devices, which is the basis for the preliminary layout, design criteria, and cost estimate. Additional design considerations for the RO system are discussed in Section 3.2.2.

The RO trains are assumed to have 8-inch elements (see Figure 4-5), which are the most common size in the IPR and desalination industries to date. Sixteen-inch elements are available as an alternative and are being used at one facility in Scottsdale, Arizona; however, a more traditional and conservative design using 8-inch elements was assumed for planning purposes. The final RO skid requirements, including vessel size, should be determined during detailed design.

The preliminary layout, design criteria, and cost estimate are also based on a flux rate of 12 gfd, consistent with how the Demonstration Facility was operated for the first two quarters. The preliminary layout for the RO system is shown on Figure 4-9.

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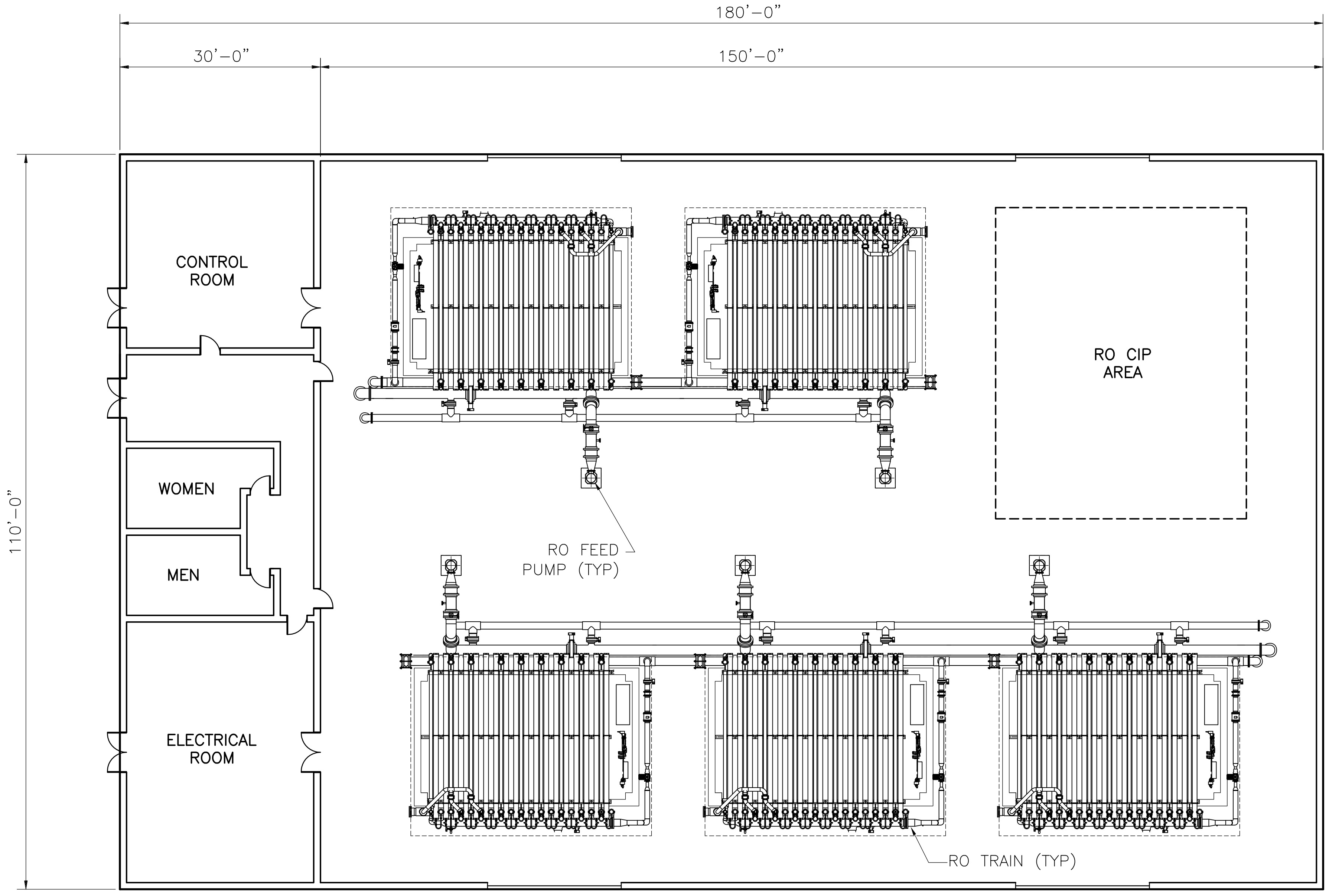

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FULL-SCALE FACILITY RO SYSTEM LAYOUT (JANUARY 2013)

FIGURE 4-9

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4.2.4 UV Disinfection and Advanced Oxidation

The final water purification process is disinfection and advanced oxidation, which is required per the November 2011 CDPH Groundwater Recharge Reuse Draft Regulations for full advanced treatment. A disinfection process is needed so the Full-Scale Facility and IPR/RA process meet the pathogenic microorganism control requirements included in the regulations. Based on the Demonstration Project Report, UV must provide a 6-log reduction of viruses, *Cryptosporidium,* and *Giarda* towards the overall reduction goals (see the Demonstration Project Report for more information on the overall log reduction goals for the potential full-scale IPR/RA project). Note that no viruses, bacteria, or protozoa were found at any time in the RO permeate/UV system feed at the Demonstration Facility, making it impossible to directly measure pathogen removal without spiking them into the water. Removal credits must be based on challenge testing and the associated credits granted by CDPH.

Advanced oxidation is considered the best available technology to destroy CECs that pass through RO membranes due to their low molecular weight and low ionic charge, notably NDMA and flame retardants. To date, the only advanced oxidation process that has been permitted at full-scale AWP facilities in California is UV/H_2O_2. UV/H_2O_2 destroys microconstituents through two simultaneous mechanisms:

- The first mechanism is through UV photolysis (exposure to UV light) where UV photons are able to break the bonds of certain chemicals if the bond's energy is less than the photon energy.
- The second mechanism is through UV light reacting with H_2O_2 to generate hydroxyl radicals. The H_2O_2 is added to the RO permeate upstream of the UV process at a dose ranging between 1.0 to 5.0 mg/L.

As with the Demonstration Facility, the conceptual design for the Full-Scale Facility includes UV reactors for the dual purpose of disinfection and advanced oxidation. Table 4-2 provides a summary of the driving factors for UV system design for disinfection.

Table 4-2 UV Disinfection Design Considerations

Function/Constituent	Log Reduction	UV Dose
Enteric virus	6-log [1]	286 mJ/cm^2 [2]
Cryptosporidium oocyst	6-log [1]	27.8 mJ/cm^2 [4]
Giardia cyst	6-log [1]	27.2 mJ/cm^2 [3]

Notes:

1) See Demonstration Project Report. Note that the concentrations of MS2 coliphage (a surrogate for enteric viruses), Giardia, and Cryptosporidium were not high enough in the RO permeate and purified water to demonstrate these log reductions at the Demonstration Facility.
2) Per EPA UV Guidance Manual (November 2006), a 4-log virus removal requires 186 mJ/cm^2. An additional 2-log removal requires another 100 mJ/cm^2. Therefore, a minimum UV dose for 6-log virus removal is estimated to be 286 mJ/cm^2.
3) Per EPA UV Guidance Manual (November 2006), a 4-log Cryptosporidium removal requires 22 mJ/cm^2. An additional 2-log removal requires another 5.8 mJ/cm^2. Therefore, a minimum UV dose for 6-log Cryptosporidium removal is estimated to be 27.8 mJ/cm^2.
4) Per EPA UV Guidance Manual (November 2006), a 4-log Giardia removal requires 22 mJ/cm^2. An additional 2-log removal requires another 5.2 mJ/cm^2. Therefore, a minimum UV dose for 6-log Giardia removal is estimated to be 27.2 mJ/cm^2.

Acronym:

mJ/cm^2 – millijoules per square centimeter

The UV/H_2O_2 system will also be designed to meet the draft groundwater recharge regulations requirements for advanced oxidation, i.e., the advanced oxidation system shall provide at least a level of treatment equivalent to a 0.5-log 1,4-dioxane reduction or a 0.3 to 0.5-log removal of an approved indicator compound. It is generally accepted that an equivalent UV dose for NDMA and 1,4-dioxane removal is higher than the UV dose needed for disinfection, e.g., the required UV dose for 1-log reduction of NDMA could be in the range of 500 to 1,000 millijoules per square centimeter (mJ/cm^2), Hence, the sizing of the UV system will be governed by the UV dose required for advanced oxidation.

Testing at the Demonstration Facility indicated that NDMA concentrations in the purified water were below the CDPH notification limit of 10 ng/L. The Full-Scale Facility will also need to meet an NDMA requirement per the CTR, which was not fully defined at the time this report was written. Therefore, the UV sizing requirements need to take into account both the CDPH notification level and the final NDMA requirements per the CTR once those requirements have been fully established for adding the water to the San Vicente Reservoir.

The preliminary layout for the UV system is shown on Figure 4-10.

4.2.5 Post-Treatment/Stabilization

The product water from the Full-Scale Facility will be pumped to the San Vicente Reservoir approximately 23 miles east of the Full-Scale Facility. Product water quality must minimize corrosion of the purified water pipeline and the pumping equipment (Langelier Saturation Index [LSI]). Table 4-3 summarizes the stabilization goals for the purified water.

Table 4-3 Purified Water Post-Treatment/Stabilization Goals

Constituent	Design Criteria
pH	6.5 – 9.0
Hardness	>20 mg/L as $CaCO_3$
LSI	-1.0 to 1.0

The post-treatment strategy assumed for the preliminary layouts and cost estimate for the Full-Scale Facility includes the addition of calcium chloride to increase hardness and the addition of caustic soda to increase pH. This strategy allows operators to control hardness and pH independently, producing stable purified water that can be matched to any desired combination of pH, hardness, and alkalinity.

While not shown on Figure 4-4, degassifiers may be considered for the Full-Scale Facility. This issue needs to be evaluated when the CTR requirements are defined and as the City moves towards preliminary design and permitting for the Full-Scale Facility. As part of the CTR there will be a limit for bromodichloromethane (BCDM) for the Full-Scale Facility, which has not been established yet. Depending on the BDCM limits, degassifiers may be needed to decrease the BDCM concentration.

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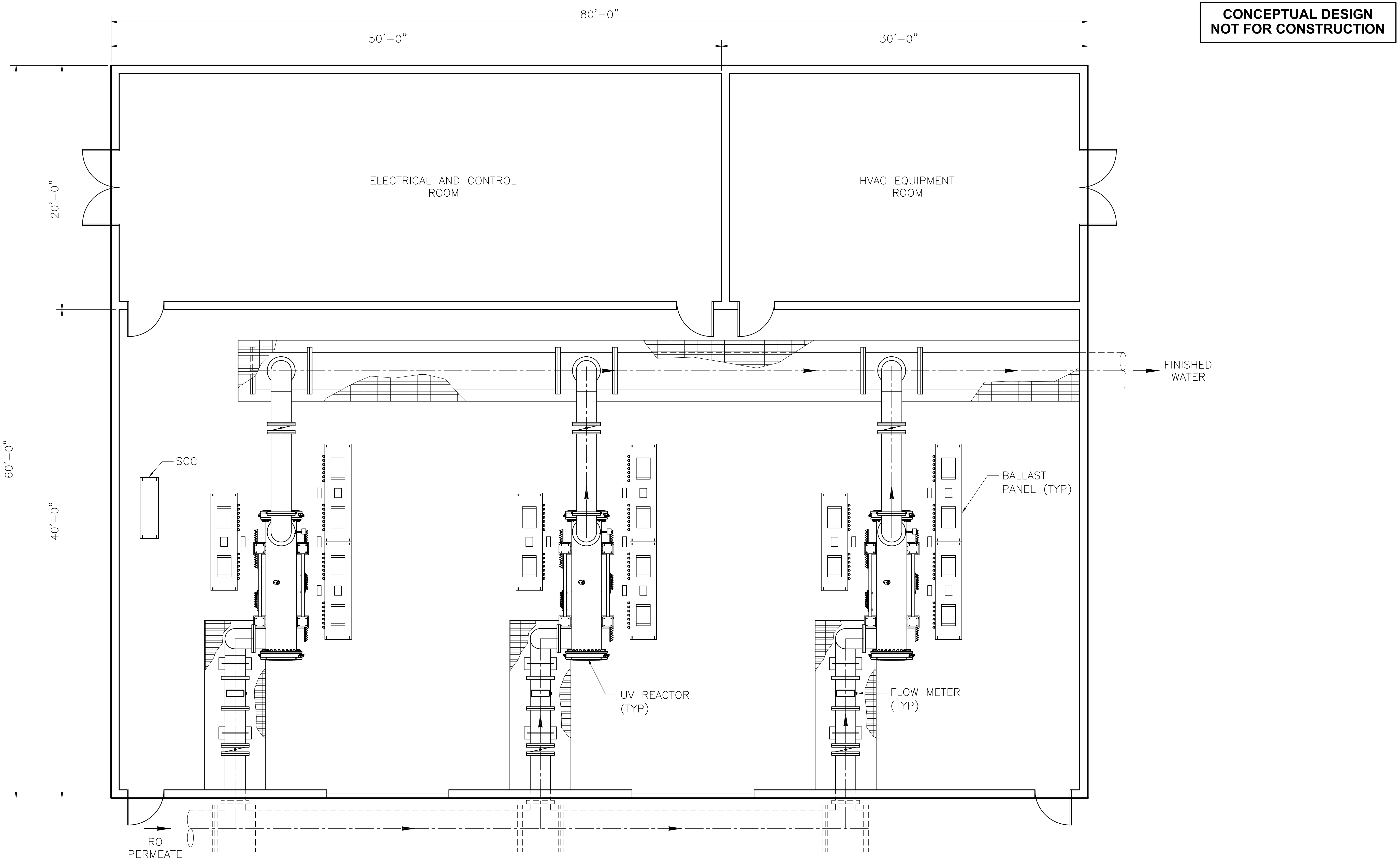

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FULL-SCALE FACILITY UV DISINFECTION AND ADVANCED OXIDATION SYSTEM LAYOUT (JANUARY 2013)

FIGURE 4-10

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4.2.6 Chemical Cleaning Systems

Citric acid will be used to clean the membrane filtration and RO membranes. The cleaning requirements are specific to each membrane system vendor, so the citric acid system design would be completed after the membrane filtration equipment pre-selection. Caustic soda will be used intermittently for the neutralization of the membrane filtration chemical cleaning waste, the RO chemical cleaning and waste neutralization. A preliminary list of chemical cleaning system equipment requirements is included in Figure 4-6. It was assumed that electrical power will be used to heat the chemical cleaning solutions. Use of waste heat from the North City cogeneration facility to heat chemical tanks during cleanings should be investigated prior to final design.

4.2.7 Waste Streams

The waste streams of the Full-Scale Facility include membrane filtration prefilters backwash flows, membrane filtration backwash waste, RO concentrate, spent chemical cleaning solutions, and sanitary waste (i.e., restrooms). It is assumed that the membrane filtration backwash will be routed to the influent of the North City secondary clarifiers for treatment and the RO concentrate, neutralized CIP solutions, and sanitary waste streams will be discharged to North City's effluent drop structure for ultimate treatment at the Point Loma Wastewater Treatment Plant (Point Loma). Alternatively, sanitary waste streams could be discharged into the existing 10-inch sewer in Eastgate Mall for treatment at North City. The waste streams are summarized in Table 4-4.

Table 4-4 Full-Scale Facility Waste Stream Flows

Flows	Frequency	Percent of Feed Flows	TDS (mg/L)
Membrane Filtration Pre-filters Backwash Flows	Intermittent	2% of Full-Scale Facility Influent Flow	Average 1,000 Maximum 1,100
Membrane Filtration Backwash Waste Flows	Intermittent	5% of Full-Scale Facility Influent Flow	Average 1,000 Maximum 1,100
RO Concentrate Flows	Continuous	15% of RO Feed Flow	Average 6,500 Maximum 7,200

Note: Chemical cleaning waste is intermittent. Volumes will be confirmed during the preliminary design phase.

4.2.8 Operations, Maintenance, and Administration Building

The Operations, Maintenance, and Administration Building will be located on the southern part of the site and is assumed to have a total building square footage of 5,300 square feet, based on 12 full-time employees. It is also assumed that all laboratory functions will be conducted at North City; thus, laboratory space will not be provided at the Full-Scale Facility. Table 4-5 summarizes the spatial planning assumed for this building.

Table 4-5 Operations, Maintenance, and Administration Building Spatial Planning

Space Designation	Area, square feet
Lobby/Reception	450
Offices/Cubicles	1,500
Break Room/Kitchenette	240
Conference Room	340
Control Room	600
Restrooms/Lockers/Showers	440
Mechanical/Electrical	240
Maintenance Shop/Storage	1,000
Circulation	490
Total	**5,300**

4.2.9 Preliminary Electrical Design Criteria

Full-Scale Facility (Except for the AWP Facility Influent Pump Station)

Power will be supplied to the Full-Scale Facility from San Diego Gas & Electric's (SDG&E) Eastgate Mall Substation, which is located north of the proposed Full-Scale Facility site location. The Eastgate Mall Substation will feed an assumed power supply of 12 kilovolts (KV) to the Full-Scale Facility Main Switchgear, which would then feed six transformers. The expected power requirement for the Full-Scale Facility is around 6,500 kilovolt-amperes (KVA) demand load as summarized in the Full-Scale Facility preliminary load list presented in Table 4-6.

Table 4-6 Full-Scale Facility Preliminary Load List

Substation	Switchgear	Bus A (Amps)	Bus B (Amps)	Voltage (KV)	Bus A (KVA)	Bus B (KVA)
68USS	68SWGR1A/68SWGR1B	1,412	1,412	0.48	1,173	1,173
69USS	69SWGR1A/69SWGR2B	114	228	4.16	821	1,642
70USS	70SWGR1A/70SWGR2B	1,111	879	0.48	923	730
Subtotal KVA					2,916	3,544
Total KVA						6,460

The six pad mounted transformers will be fed from the Full-Scale Facility Main Switchgear and will feed 480 Volt 3-phase power to double- ended switchgears 68SWGR1A and 68SWGR1B, 4160 Volt 3-phase power to double-ended switchgears 69SWGR1A and 69SWGR1B, and 480 Volt 3-phase power to double-ended switchgears 70SWGR1A and 70SWGR1B.

68SWGR1A and 68SWGR1B will feed the five RO Feed Pumps (see Figure 4-11). 69SWGR1A and 69SWGR1B will feed the four Finished Water Pumps (see Figure 4-12). 70SWGR1A and 70SWGR1B (see Figure 4-13) will feed the two double-ended motor control centers (MCC-1A/1B, 2A/2B) (see Figures 4-14 and 4-15, respectively) and Distribution Panel (DP-1). MCCs will in turn feed power to the integral horsepower motors and other large loads. A dry type distribution transformer will feed the lighting panel board. The lighting panel board will feed 120 Volt single phase power to the fractional horsepower motors, lighting, receptacles and other small loads.

The six main transformers shall be less-flammable liquid filled three-phase pad mounted type, dead front with externally clamped high voltage bushing wells for 200A fused loadbreak elbow connectors and surge arresters. The use of less flammable insulating liquid in transformers allow them to be located close to building structures without undue risk of fire; and in addition, the liquid is bio-degradable and non-toxic.

There will be two switchgears rated at 3,200 Amps, 480Volts and one switchgear rated at 600 Amp 4,160 Volt. The 3,200-Amp switchgear consists of 3,200A main breakers at bus “A” and bus “B” and a 3,200A tie breaker between bus “A” and bus “B.” The 600-Amp switchgear consists of 600A main breakers at bus “A” and bus “B” and a 600A tie breaker between bus “A” and bus “B.” The Kirtkey interlocks will be incorporated in the main and tie circuit breakers of the switchgears. The switchgears shall be provided with a circuit monitor.

The new transformers and the switchgears will be fully rated double-ended systems, so in the event that one end is not available, the other end can carry the whole loads on bus A and bus B without going into load shedding mode. Similar to North City, Bus B can be supplied from the Genesee substation to provide additional redundancy to the system.

The electrical system will not be solidly grounded system, but instead will have the system neutral grounded through a high resistance. A high resistance pulsing neutral grounding unit will be provided to improve process reliability by avoiding downtime due to line to ground faults and assist in trouble shooting such faults.

The motor control centers shall be in NEMA 1A gasketed structures with NEMA Class II type B factory wiring and tinned copper main horizontal and vertical buses. The Kirtkey interlocks will be incorporated in the main and tie circuit breakers of the MCCs. The motor control centers shall be provided with circuit monitors, transient voltage surge suppression and active harmonic correction units.

The AWP Facility influent pumps, RO feed pumps, and finished water pumps shall be provided with circuit monitors.

AWP Facility Influent Pump Station

Since the AWP Facility influent pump station would be located at North City west of the existing tertiary filters (see Figure 4-3), the four new influent pumps would be powered from the existing North City switchgear 61SWBD1/2. The existing switchgear 61SWBD1/2 has an approximate existing demand load of 1,395/1,045A. The four new influent pumps will add approximately 906 amps, totaling approximately 3,346 amps (approximately 2,777 KVA). The existing transformers on bus A and bus B are 2000/2300/2576 KVA OA/FA 55/65 degree C.

A coordination study needs to be completed during preliminary design to determine the actual electrical demand on the 61USS substation, where the 61SWBD1/2 switchgear is located. The overall loading to the 68 Main Plant Switchgear (68 MPS) will also need to be evaluated. If there is not enough capacity on the 61SWBD1/2 with the four new influent pumps, then the following options could be considered:

- Eliminate the future North City influent pump no. 2 from the 61SWBD1/2 load since the existing four influent pumps should be able to satisfy the flow to North City.
- Install forced air cooling fans on the transformer radiators to accommodate the added loads.
- Keep the tie breaker open. If one bus source is down, the tie breaker could be closed, but only after following a load shedding schedule.
- Upsize the existing transformer such that any one transformer could carry loads on both bus A and bus B.

Table 4-7 presents the approximate existing North City loads on 61USS, as well as the approximate future demands on 61USS substation with the four new AWP Facility influent pumps, and Figure 4-16 shows the single line diagram. The existing and future loads connected to 61SWBD1/2 need to be confirmed during preliminary design.

Table 4-7 Approximate Existing and Proposed Loads on 61USS Substation Powered from the North City Main Plant Switchgear (68MPS)

61USS Substation	Switchgear/ Switchboard	Bus A (Amps)	Bus B (Amps)	Voltage (KV)	Bus A (KVA)	Bus B (KVA)
Existing	61SWBD1/61SWBD2	1,395	1,045	0.48	1,158	868
Future	61SWBD1/61SWBD2	2,000	1,347 [1]	0.48	1,660	1,119

Notes:

1) The standby AWP Facility influent pump is assumed to be connected to bus B.

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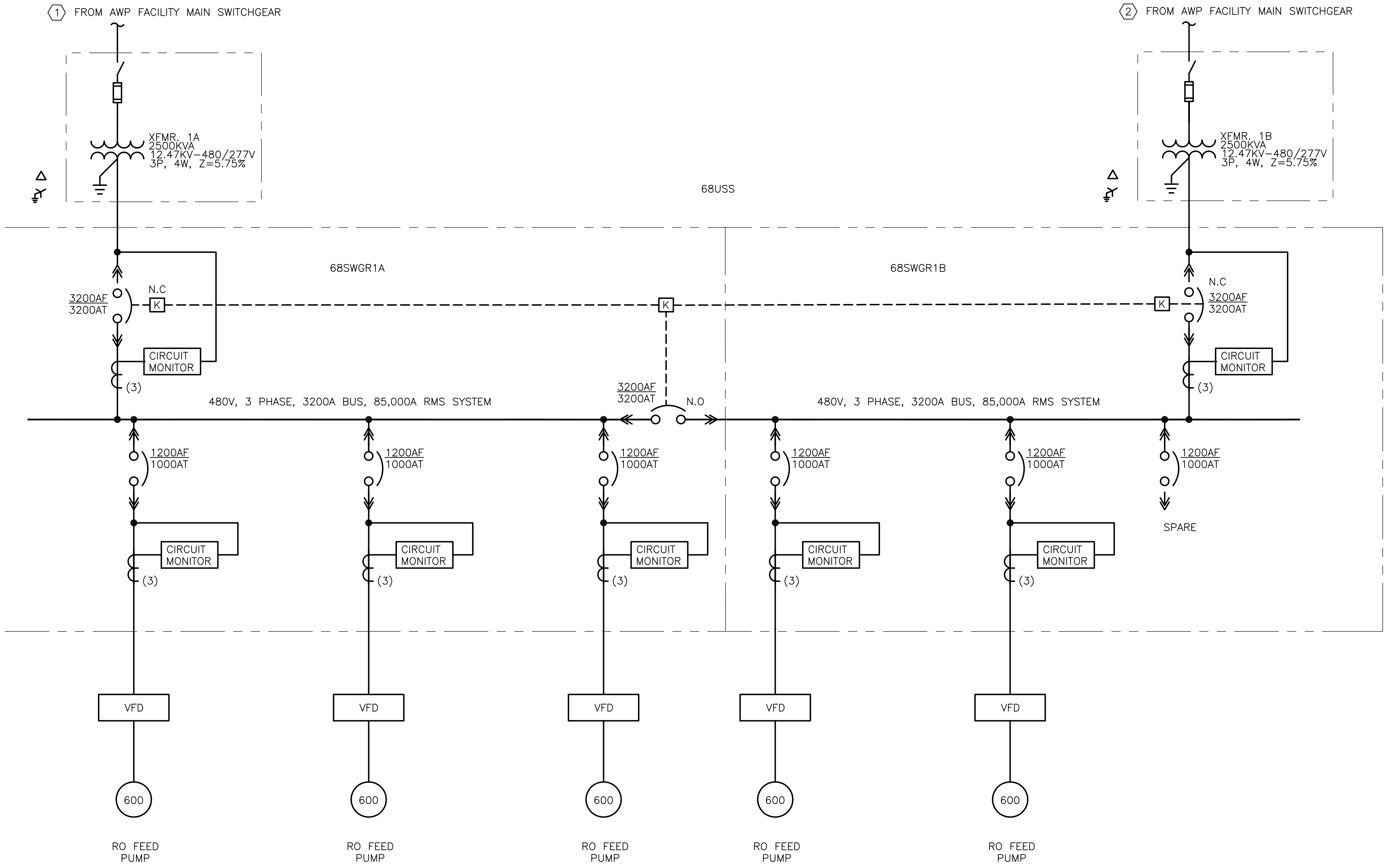

68SWGR1A AND 68SWGR1B

ONE LINE DIAGRAM

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FULL-SCALE FACILITY ONE LINE DIAGRAM 1 (JANUARY 2013)

FIGURE 4-11

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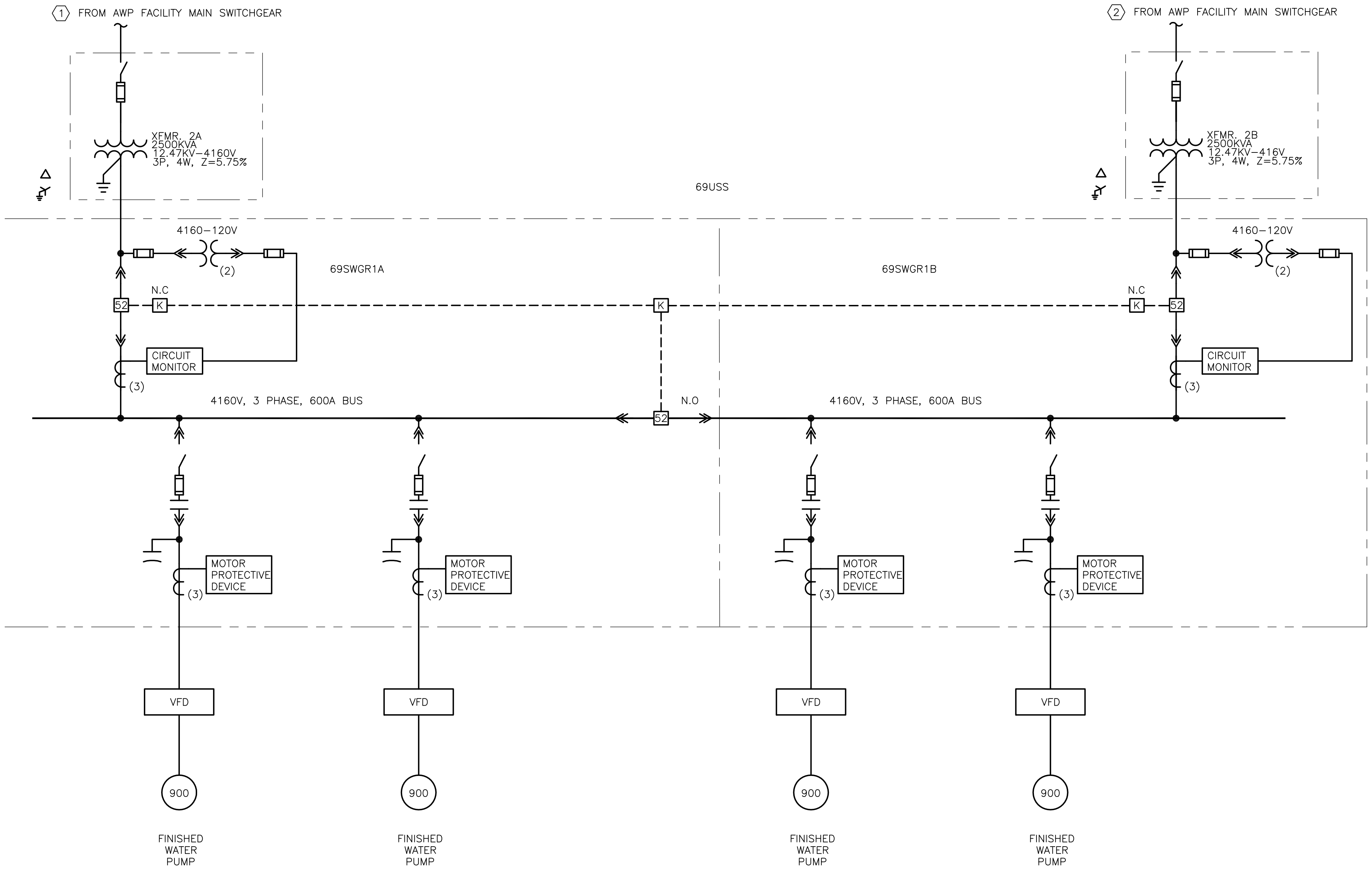

69SWGR1A AND 69SWGR1B

ONE LINE DIAGRAM

N.T.S.

CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR
AUGMENTATION DEMONSTRATION PROJECT

FULL-SCALE FACILITY ONE LINE DIAGRAM 2 (JANUARY 2013)

FIGURE 4-12

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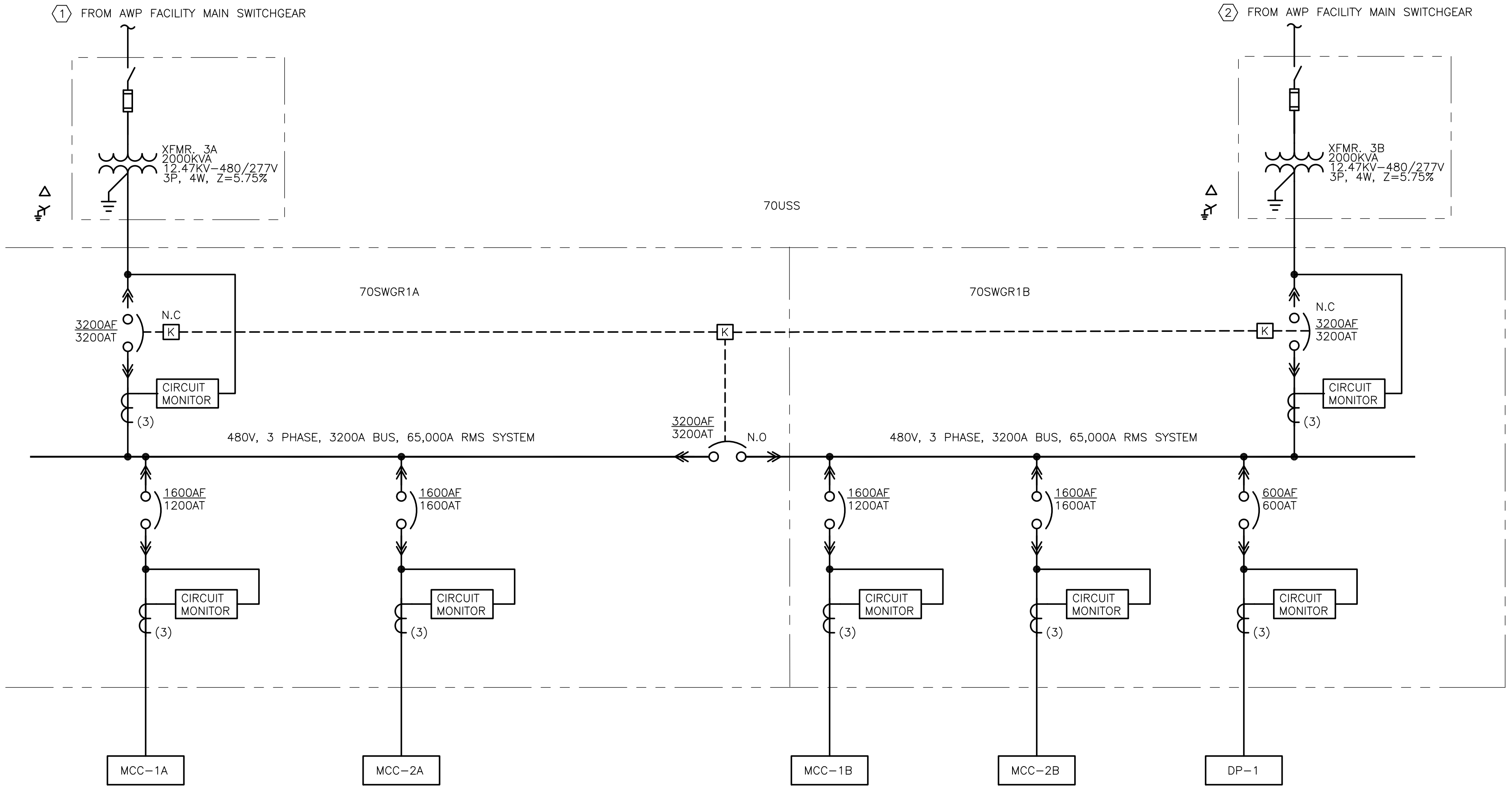

70SWGR1A AND 70SWGR1B

ONE LINE DIAGRAM

N.T.S.

CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR
AUGMENTATION DEMONSTRATION PROJECT

FULL-SCALE FACILITY ONE LINE DIAGRAM 3 (JANUARY 2013)

FIGURE 4-13

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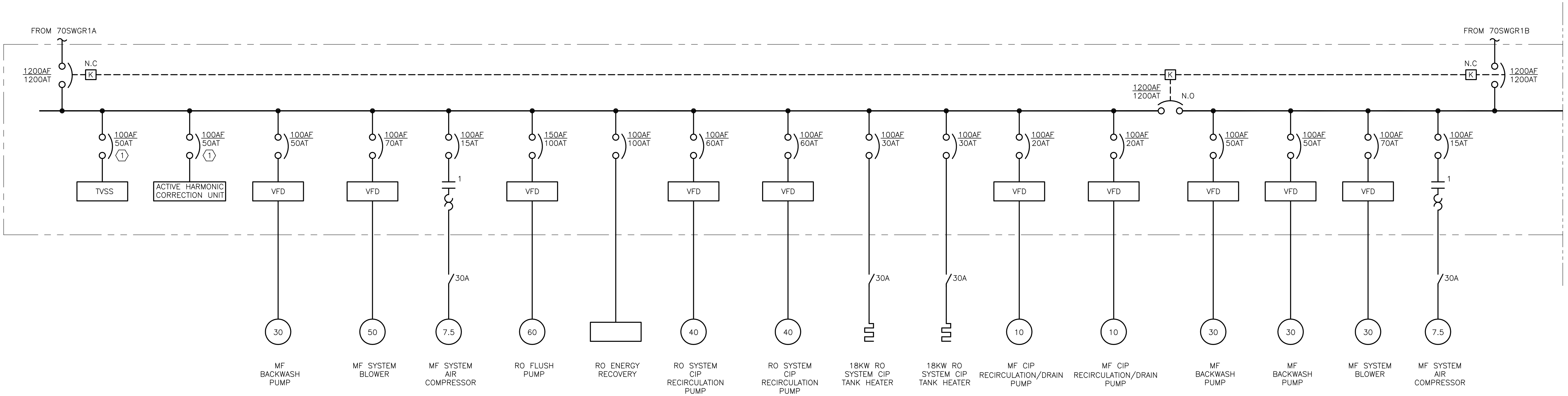
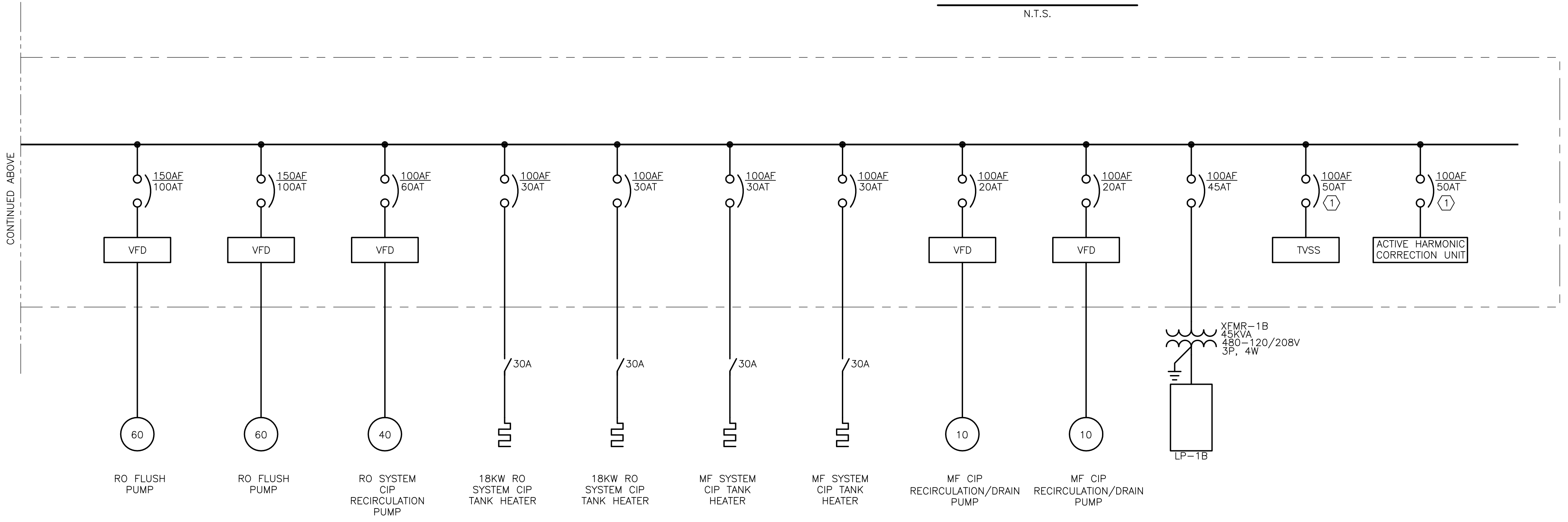


MCC–1A AND MCC–1B

ONE LINE DIAGRAM

N.T.S.



NOTES:

⟨1⟩ SIZED BY MANUFACTURER.

CONCEPTUAL DESIGN
NOT FOR CONSTRUCTION

CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR
AUGMENTATION DEMONSTRATION PROJECT

FULL-SCALE FACILITY ONE LINE DIAGRAM 4 (JANUARY 2013)

FIGURE 4-14

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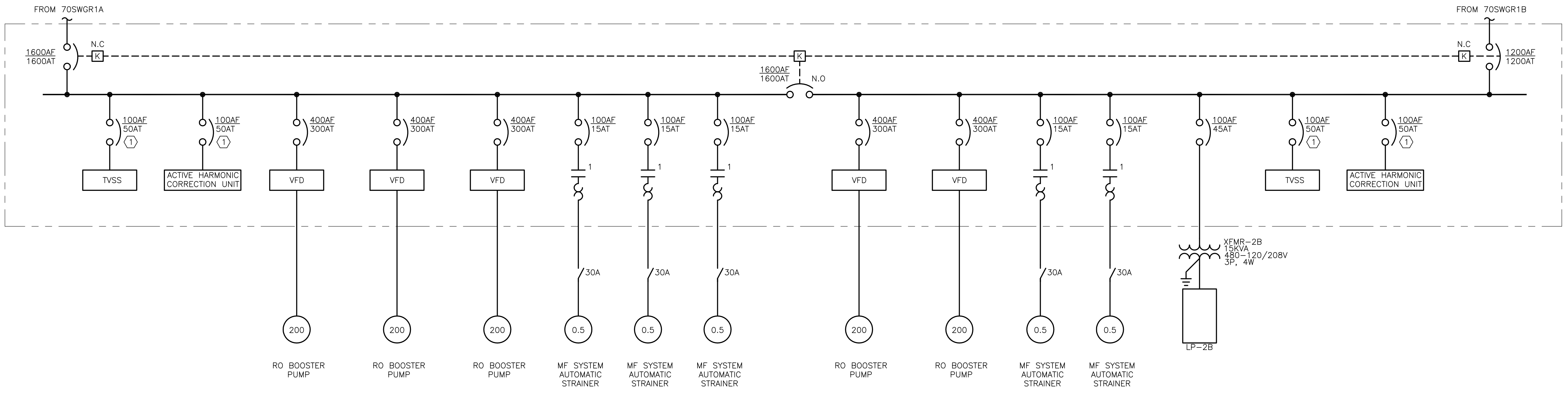
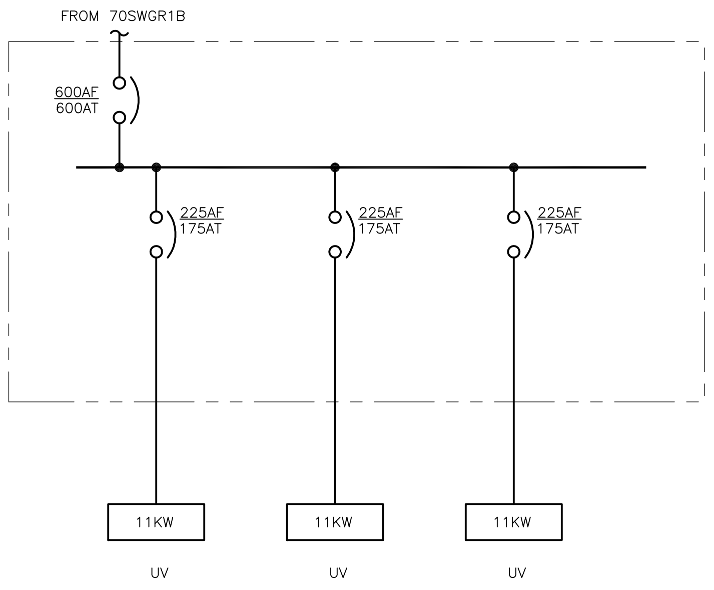


MCC-2A AND MCC-2B

ONE LINE DIAGRAM

N.T.S.



DP-1

ONE LINE DIAGRAM

N.T.S.

NOTES:

⟨1⟩ SIZED BY MANUFACTURER.

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CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR
AUGMENTATION DEMONSTRATION PROJECT

FULL-SCALE FACILITY ONE LINE DIAGRAM 5 (JANUARY 2013)

FIGURE 4-15

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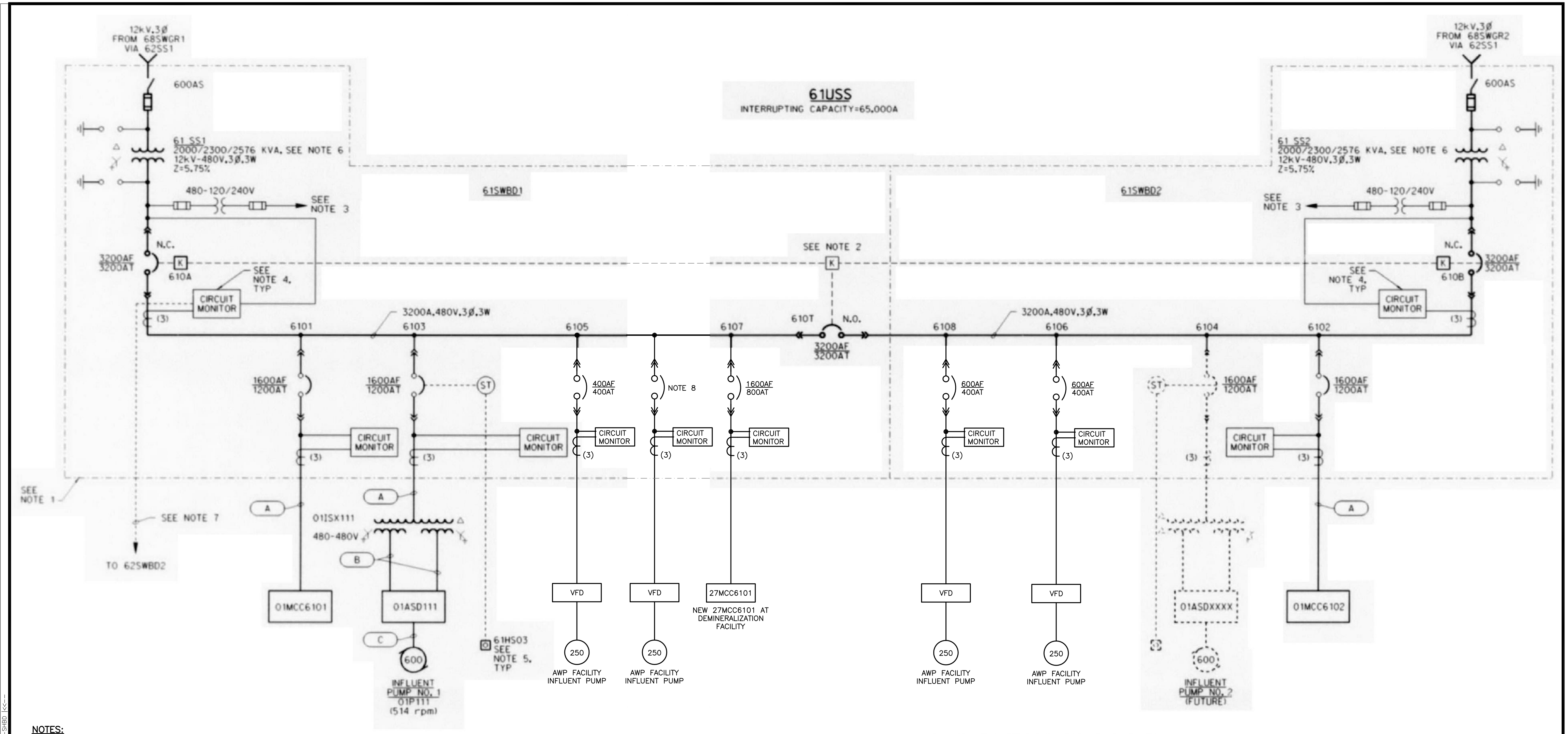

NOTES:

1. ALL CONDUCTORS SHALL ENTER THE BOTTOM OF THE EQUIPMENT.
2. KEY INTERLOCKED SO THAT ONE BREAKER MUST BE OPEN.
3. SUBSTATION TRANSFORMER FANS. FAN CONTROLS, ETC.
4. SOLID STATE MONITOR SYSTEM,. SEE SPECIFICATIONS FOR DETAILED REQUIREMENTS.
5. SHUNT TRIP PUSHBUTTON LOCATED AT INFLUENT PUMP STATION.
6. TRANSFORMER KVA RATINGS AS INDICATED ARE OA 55°C/FA 55°C/FA 65°C.
7. TWISTED SHIELD PAIR (TYPE 3) DATA HIGHWAY.
8. FIELD VERIFY SPARE SPACE.

480V FEEDER SCHEDULE: *(THIS DWG ONLY)

TYPE	CONDUIT		CONDUCTORS PER CONDUIT		
	QTY	SIZE	PHASE	NEUT	GRD
A	4	4"	3-350KCM	—	*3/0
B	2	3"	3-350KCM	—	*1
C	3	3"	3-500KCM	—	*2/0

* FOR REFERENCE ONLY. FEEDER DESCRIPTION IN CIRCUIT AND RACEWAY SCHEDULE SHALL TAKE PRECEDENCE.

**CONCEPTUAL DESIGN
NOT FOR CONSTRUCTION**

CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR
AUGMENTATION DEMONSTRATION PROJECT

FULL-SCALE FACILITY INFLUENT PUMPS ONE LINE DIAGRAM (JANUARY 2013)

FIGURE 4-16

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4.2.10 Proven Water Purification Processes and Equipment Manufacturers

The information in this report is based on the water purification processes and equipment manufacturers that were used for the Demonstration Facility. These are proven technologies and most of the equipment manufacturers that provided the equipment for the Demonstration Facility have provided process equipment for other AWP Facilities of similar size and complexity. During the detailed design phase of this project, additional equipment manufacturers should be considered based on the specifications summarized herein. The minimum qualifications for consideration include:

- Technology and equipment shall have been used for water reuse applications for IPR in the United States, at recycled water treatment facilities of 5.0 mgd capacity or greater;
- Technology shall have operating experience and equipment that has been approved by the CDPH; and,
- Automated pressure decay or equivalent integrity test (for membrane filtration systems only).

4.3 System Controls, Redundancy, and Reliability

4.3.1 Automated Control Systems

The Full-Scale Facility will be operated on a fully-automated control system. The membrane filtration, RO, and UV systems will each have a vendor-provided control system with programmable logic controller (PLC) that monitors and operates the respective treatment process based on flows, pressures, levels, and water quality parameters, such as pH, ORP, chlorine residual, turbidity, and conductivity. All equipment will be provided with instruments (such as flow transmitters, pressure transmitters and switches, level transmitters and switches, water quality analyzers, high temperature switches, vibration switches, lamp intensity) that allow the control system to monitor and alert the operators of abnormal conditions with alarms and notifications. The overall control system for the Full-Scale Facility will communicate with each of the membrane filtration, RO, and UV control systems, as well as provide controls for the miscellaneous process equipment including chemical storage and feed systems and finished water reservoirs.

Since the Full-Scale Facility will treat tertiary effluent prior to chlorination from North City, the overall control system for the Full-Scale Facility will also communicate with the North City control system. The tertiary effluent flow available to the Full-Scale Facility will vary depending on North City’s recycled water demands; these demands are typically highest in the summer and significantly lower in the winter. Therefore, the tertiary effluent flow and water levels in the effluent channel will likely be included in the information communicated from North City to the Full-Scale Facility.

4.3.2 Equipment Redundancy

Redundancy is based on the required reliability of the facility or process, and different levels of redundancy are required based on available back up services (e.g., redundant primary electrical feeds) and emergency maintenance capabilities (e.g., available uninstalled back-up equipment).

The Full-Scale Facility has the ability to shut-down at any time because it has the option to go offline by ceasing to receive tertiary effluent from North City. North City, which treats wastewater flows that would otherwise be treated at Point Loma, also has the capability and option to divert flow to Point Loma and go offline any time either by ceasing diversion from the sewer or diverting off-specification water back to the sewer for treatment at Point Loma. Therefore, the Full-Scale Facility is considered a non-essential facility and will have limited redundancy. The redundancy provided will allow the Full-

Scale Facility to continue to operate at capacity when a single process unit is offline for maintenance or cleaning. Equipment redundancy is identified in the design criteria for the unit processes shown in Figures 4-5 and 4-6.

As discussed in Section 4.1.1, the capacity of the Full-Scale Facility (18 mgd) takes into account a 95 percent online factor and the seasonal demands of the recycled water to be able to produce an annual average of 15 mgd of purified water. The assumed online factor allows for the facility to be offline for 5 percent of the year for maintenance and repairs and still meet annual production goals.

The components that require redundant capacity at a non-essential facility such as the Full-Scale Facility are as follows:

- Process mechanical (membrane filtration, RO, UV, chemicals)
- Instrumentation and controls (networks, computers)
- Monitoring/alarm/notification system
- Electrical (power)
- Civil/site facilities (raw and purified water tankage, warehouse, yard piping)
- Other portions of the facility, including occupied structures; heating, ventilating, and air conditioning (HVAC); electrical; plumbing; and conveyance systems are often critical for the plant operation, but not always provided with redundancy

The following parameters were used to assess the required reliability/redundancy of the Full-Scale Facility and its components:

- Operating standards
- Maintainability
- Critical operating and maintenance concerns
- Spare parts availability
- Regulatory requirements
- Life safety requirements

The following addresses general requirements for the major process systems (membrane filtration, RO and UV).

Membrane Filtration

The membrane filtration system consists of modular operating units called “skids.” Due to the frequent cleaning cycles (backwashes every 20-30 minutes, daily maintenance cleans, and monthly recovery cleans) and integrity testing, the membrane filtration system will be designed with a minimum of N+2 configuration (where N is equal to the number of units for design condition) to allow the system to operate at the design flux during cleanings and maintenance events. A minimum of two “spare” skids will be provided. The “spare” skid will operate in conjunction with other units that are producing water, and the system as a whole will operate at a flux rate lower than the design flux rate under normal operating conditions. When one skid is taken out of service for major cleaning or maintenance, the whole system will be capable of operating at design flux rate even during backwash cycles.

Reverse Osmosis

The RO system consists of modular operating units called “trains,” each with an operating flow that is not as flexible as the membrane filtration units, due to the sensitive chemical balance of the concentrated salts on the feed side of the membrane. Operating other trains at a higher flow to accommodate a train down for service could result in excess fouling if unacceptable RO fluxes, feed pressures, or flow velocities result from such a change; however, careful design considerations and strict limits on flow conditions can avoid such challenges. While the RO membranes are not cleaned as often as the membrane filtration units, the cleaning process can typically require a day or two to conduct. In addition, the RO feed pumps can have long lead times for repairs or replacement if they are taken out of service. For these reasons, it is assumed that an N+1 configuration (where N is equal to the number of units for design condition) could be implemented as shown in the design criteria. It should be noted, however, that redundant RO trains are not common, even in the drinking water industry, and that operational challenges can be experienced under lower than optimal flow conditions or when RO trains are taken out and put back into service frequently. A minimum average flux for the RO system of 12 gfd should be maintained if operating at 85 percent recovery, regardless of whether or not a redundant unit is used.

The RO flush system is a critical component to prevent irreversible fouling of the RO membranes, which would require membrane replacement. RO membrane elements represent a significant investment and need to be protected. Replacement also requires considerable time so assuring that the membranes are operated and flushed properly cannot be overstated. The flush system pumps, and associated valves and instruments must be provided with backup power to assure that the membranes are protected in the event of plant shutdown due to power failure (see Section 4.4.1).

UV Disinfection and Advanced Oxidation

The UV reactors are designed with three duty and zero standby trains. However, each train is designed with three dual reactors. Since the lamps could be replaced without draining the reactor vessels and because each reactor could be shut down independently, the shutdown of an entire train is not required to replace lamps and/or ballasts. In addition, the failure of lamps or ballasts does not require immediate replacement since the intensity of the UV lamps can be automatically increased to compensate for the failed lamps. When the numbers of lamps and/or ballasts that have failed reaches the maximum amount allowed before replacement, the operator could replace the lamps and/or ballasts by shutting down the affected reactors or corresponding ballast panels one at a time.

For replacement of lamps, only the affected reactor needs to be shut down, which would reduce the treatment capacity of the respective train by one-sixth. The flow through the train would remain the same, and the UV light intensity could be increased to compensate for the reduced number of UV lamps for the duration of the reactor shutdown, which can typically be accomplished in less than one hour. Similarly, for the replacement of ballasts, only the affected ballast enclosure needs to be shut down, the treatment capacity of the UV train would be reduced by one-sixth, and the reduced treatment capacity could be compensated by increasing the intensity of the UV lamps in service.

4.3.3 Integrity Monitoring

Monitoring and controls at the Full-Scale Facility will be critical to monitor the system performance and confirm the integrity of the treatment processes. Integrity monitoring was included in the design and operations of the Demonstration Facility, which is summarized in Section 2.5. A key component of the integrity monitoring plan is the critical control point monitoring to identify any changes in the performance of the treatment processes that can adversely impact the final water quality. Critical control points (e.g. membrane filtration, RO, and disinfection and advanced oxidation systems) were identified as well as critical limit parameters, alert limits, critical limits, and corrective actions.

During the design phase for the Full-Scale Facility, the City would develop a similar on-line monitoring and response plan that provides sufficient features and assurances that any foreseeable malfunction could be promptly identified and appropriate responses applied.

Based on the integrity and critical control point monitoring experience with the Demonstration Facility, the following points should be taken into consideration when designing the control system for the Full-Scale Facility.

- If a pressure decay test yields a result higher than the critical limit, then the affected membrane filtration skid should be taken offline and a standby skid brought online.
- If the critical limit for conductivity or TOC is exceeded on the RO system, then the affected RO skid should be taken offline and the standby skid brought online.
- Based on consistent conversion of ammonia to nitrate by the advanced oxidation process, online monitoring of ammonia should be evaluated as a potential integrity monitoring method for advanced oxidation.
- Consider alternatives for response to lamp and ballast failures on the UV system. See Section 3.1.3.
- Consider using an online instrument to measure peroxide concentration which would be tied into the pump speed control logic and make automatic adjustments to maintain the desired dose rate. Also consider adding a flow meter to provide constant feedback on the chemical flow rate.

4.4 Operation During Abnormal Conditions

As discussed in Section 4.3.2, since North City has the ability to divert influent flow or off-specification tertiary effluent to the Point Loma. Likewise the Full-Scale Facility will have the ability to shut down during abnormal operating conditions. This eliminates the need for typical equipment redundancy and backup power that would be required to ensure a 100 percent online factor, which reduces the overall capital and O&M costs for the Full-Scale Facility.

4.4.1 Operation During Power Outages

The Full-Scale Facility will not have backup power (dual power feed or emergency generators). The Full-Scale Facility is planned to have a ductbank connection between North City and the Full-Scale Facility (see Figure 4-3), which would allow North City to provide power to the Full-Scale Facility. North City power is mainly generated from the cogeneration system, supplemented by SDG&E power.

The cogeneration or SDG&E power from North City would be used to power critical equipment at the Full-Scale Facility, including the distributed control system and the RO flush pumps.

For momentary outages, the Full-Scale Facility can be restarted when power is restored.

For extended outages (i.e., outages lasting longer than 5 to 10 minutes), the RO system should be flushed after 5 minutes of outage using RO flush system. The RO flush pumps will be on North City cogeneration or SDG&E power to allow continued operation during a power outage. The Full-Scale Facility can be restarted when power is restored.

The distributed control system should also be provided with an uninterruptable power supply.

4.4.2 Operation During Equipment Failure, Maintenance, or Cleaning

The conceptual design for the Full-Scale Facility includes sufficient equipment redundancies to prevent the loss of purified water production if a single process unit is out of service due to malfunction, maintenance, or cleaning. The Full-Scale Facility can continue to operate normally under these conditions. If more units than accounted for by redundancy need to be taken out of service, then the production of the Full-Scale Facility would need to be reduced until the equipment is repaired. During these conditions, North City would need to divert flow to Point Loma.

The Full-Scale Facility will not operate at the maximum production capacity year-round; rather, the facility will operate at the maximum production capacity in winter when North City's recycled water demands are lowest and will operate at less than the maximum production capacity in summer when the recycled water demands are the highest (see the Purified Water Conveyance System Final Conceptual Design Report in Appendix C for more information). During summer when the influent flows to the Full-Scale Facility are lower, the facility will have more equipment redundancy and could accommodate a higher number of units out of service for maintenance, cleaning, or equipment failure than during winter when the facility will be operating at the maximum production capacity.

In the unlikely case of pipe failures, the Full-Scale Facility (or a portion) would need to be shut down until the pipe is repaired.

4.4.3 Operation During Process Upsets

The operations of the Full-Scale Facility will need to be modified when there are process upsets at North City and the recycled water does not meet permit requirements (off-specification water), or if the purified water quality does not meet permit requirements.

In the event that there is a process upset at North City (e.g., addition of extra coagulant, bypassing of tertiary filters) and the tertiary effluent does not meet permit requirements, then the North City operations staff should notify the Full-Scale Facility operations staff. The tertiary effluent prior to chlorination fed to the Full-Scale Facility will have online monitoring that alarms through the control system if the influent turbidity exceeds the Title 22 requirements for turbidity (i.e., exceeds 2 NTU). If North City operations staff thinks that the turbidity excursion will be short-term, then the Full-Scale Facility may remain in operation until it is resolved. If the excursion is anticipated to be longer-term, then the City may want to shut down the Full-Scale Facility until the issue is resolved to avoid the need to perform more frequent cleanings of the membrane filtration system, which will increase the Full-Scale Facility operating costs. If the Full-Scale Facility is shut down, then North City would divert water to Point Loma. The permit to operate will specify specific influent water quality requirements to assure safe purified water and protect water purification equipment.

The permits for the Groundwater Replenishment System and Alamitos Barrier Recycled Water Project both include requirements that the turbidity at inlet to RO cannot exceed 0.2 NTU more than 5 percent of the time within a 24-hour period (1.2 hours) and 0.5 NTU at any time. Based on the operational data from the Demonstration Facility, the Full-Scale Facility will be able to meet these requirements based on the current water quality produced by North City. As presented in Section 2, the feed turbidity was always less than 2 NTU and the MF and UF filtrate turbidity (RO influent) was always less than 0.2 NTU. Based on the Demonstration Facility data, it may be possible to continue running the Full-Scale Facility even if North City is having a process upset, as long as North City is still providing primary, secondary, and tertiary treatment (i.e., not bypassing a unit process because of the upset) and the MF and UF filtrate meets the permit requirements.

Based on the Alamitos Barrier Recycled Water Project permit, there also may be biological oxygen demand, total suspended solids, and total organic carbon influent requirements for the Full-Scale Facility feed water. If similar requirements are included for the Full-Scale Facility, then excursions of these constituents should prompt discussion between the North City and Full-Scale Facility operations staff and determine whether or not the Full-Scale Facility needs to be shut down until the process upset is resolved.

The other type of process upset is if there is a malfunction at the Full-Scale Facility. This hypothetical event is characterized as a malfunction of a water purification process or processes at the Full-Scale Facility. As discussed in Section 4.3.3, the Full-Scale Facility would incorporate integrity monitoring to confirm the unit processes are operating as designed and according to the permit. As a worst case, a malfunction could allow filtered North City effluent to flow into the purified water conveyance pipeline. As described in the Demonstration Project Report, the purified water conveyance pipeline would provide up to 10 hours to identify a malfunction, validate the malfunction, and stop flows in the conveyance pipeline before the off-specification water would be released into San Vicente Reservoir. If necessary, water in the conveyance pipeline could be diverted into the sanitary sewer system and treated at Point Loma.

Section 5

Full-Scale Facility Estimated Costs

This section provides the estimated capital costs and O&M costs the Full-Scale Facility, as well as costs for the overall project.

The capital costs were estimated based on the proposed Full-Scale Facility capacity of 18 mgd, while the O&M costs were estimated for the annual average purified water production of 15 mgd. The difference in the capacity for the capital and O&M costs is based on the seasonal variation of recycled water demands, which impacts how much tertiary effluent that can be treated at the Full-Scale Facility. The Full-Scale Facility will operate at the design capacity (18 mgd) in winter months when recycled water demands are lowest and will operate at a reduced production in summer months when recycled water demands are highest. This will result in an annual average purified water production of 15 mgd.

5.1 Estimated Capital Costs for the Full-Scale Facility

This section provides the estimated capital costs for the conceptual Full-Scale Facility. The conceptual design for the Full-Scale Facility is described in Section 4. The estimated construction cost for the Full-Scale Facility is presented in Table 5-1 below.

Appendix D includes additional breakdown of estimated construction cost for each of the process areas and buildings. The breakdown includes Total Amount and Grand Total columns. The Total Amount column represents the direct costs to the contractor, which include labor, materials, subcontractors, and equipment. The Grand Total includes the contractor direct costs plus construction allowances, permits and sales tax, which are estimated as summarized below based on previous construction project experience:

- Maintenance of traffic allowance – 5 percent
- Miscellaneous metals allowance – 2 percent
- Painting allowance – 2 percent
- Instrumentation and controls allowance – 8 percent
- Electrical allowance – 18 percent
- City of San Diego permits – 1 percent
- Sales tax (materials, equipment, and other) – 7.75 percent

Table 5-1 Estimated Construction Cost for the Full-Scale Facility[1]

Parameter	Capital Cost[2,3]
Construction Costs[4]	
AWP Facility Influent Pump Station	$2,800,000
Site Civil/Yard Piping[5,6]	$5,800,000
Operations, Maintenance, and Administration Building	$1,600,000
Membrane Filtration Break Tank and Pump Station	$4,000,000
Chemical Storage Area #1 (Pre-Treatment Chemical Facility)[7]	$2,400,000
Membrane Filtration Facility[8]	$25,300,000
Reverse Osmosis Facility[9]	$21,300,000
UV Disinfection and Advanced Oxidation System[10]	$9,900,000
Chemical Storage Area #2 (Post-Treatment Chemical Facility)[11]	$2,100,000
Construction Subtotal	**$75,200,000**
Contingency (30% of Construction Total)	$22,600,000
Overhead & Profit	$9,800,000
Insurance & Bond	$2,900,000
Construction Total	***$110,500,000***
Implementation Costs	
Engineering & Pre-Construction (20% of Total Construction Cost)	$22,100,000
Environmental Documentation	$1,000,000
Construction Management (10% of Total Construction Cost)	$11,100,000
Implementation Total	***$34,200,000***
Total Capital Cost (Construction Total + Implementation Total) [12]	**$144,700,000**

Notes:

1) This table presents costs for the Full-Scale AWP Facility only. For costs related to the Purified Water Pump Station and Purified Water Pipeline, refer to Table 5-4 and the Demonstration Project Report.
2) Includes installation costs and indirect costs (project management, field management and support, training, quality assurance and control, project safety, construction allowances, permits, and sales tax).
3) All costs are in February 2012 dollars. The Engineering News Record (ENR) Construction Cost Index is 9267.57 and the ENR Building Cost Index is 5144.49 for February 2012.
4) Construction duration is assumed to be 30 months. Based on a 40 hour work week with no overtime.
5) No rock excavation is assumed to be required. Only nominal dewatering is assumed to be needed. No consideration for contaminated soils or hazardous materials (e.g. asbestos, lead) is included. Site grading, drainage and containment are included with assumptions made based on the aerial photograph.
6) Includes pressure membrane filtration feed pipeline, gravity membrane filtration backwash, pressure RO concentrate pipelines, and chemical feed pipelines.
7) Includes sodium hypochlorite, ammonium hydroxide, sulfuric acid, and antiscalant.
8) Includes citric acid and sodium hydroxide system for membrane filtration chemical cleaning systems.
9) Includes cartridge filters and RO feed pumps.
10) Hydrogen peroxide system is included with the UV disinfection and advanced oxidation system.
11) Includes calcium chloride and sodium hydroxide.

5.2 Estimated O&M Costs for the Full-Scale Facility

The O&M cost estimate for the Full-Scale Facility considers power costs, chemical costs, equipment replacement costs, maintenance costs, laboratory costs, and labor costs. Table 5-2 presents the estimates for annual O&M costs for the Full-Scale Facility. Additional detail is provided in Appendix B. The largest annual O&M costs are anticipated to be power (33 percent), maintenance and equipment replacement (13 + 17 = 30 percent), labor (17 percent), and chemical consumption (16 percent).

Table 5-2 Estimated Annual O&M Costs for the Full-Scale Facility

Parameter	Annual O&M Cost[1]	Approximate Percentage of Annual O&M Costs
Power Costs[2]		
AWP Facility Influent Pump Station	$306,000	
Membrane Filtration System	$43,000	
Reverse Osmosis System	$1,614,000	
UV Disinfection and Advanced Oxidation System	$185,000	
Miscellaneous Equipment	$7,000	
Buildings	$481,000	
Power Costs – Subtotal	***$2,636,000***	***33%***
Chemical Costs		
Membrane Filtration Pretreatment	$223,000	
Reverse Osmosis Pretreatment	$431,000	
Hydrogen Peroxide for Advanced Oxidation	$216,000	
Post Treatment	$358,000	
Membrane Cleaning	$103,000	
Chemical Costs – Subtotal	***$1,331,000***	***16%***
Replacement of Consumables (Equipment Replacement)		
Membrane Filtration Membranes	$441,000	
Reverse Osmosis Cartridge Filters and Reverse Osmosis Membranes	$319,000	
UV Lamps and Ballasts	$281,000	
Replacement of Consumables – Subtotal	***$1,041,000***	***13%***
Maintenance Costs[3]	***$1,409,000***	***17%***
Other Costs (Compliance Testing and Security)[4]	***$310,000***	***4%***
Labor Costs[5]	***$1,418,000***	***17%***
Total Annual O&M Cost[6]	**$8,145,000**	**100%**

Notes:

1) All costs are in February 2012 dollars.
2) Power cost is assumed to be $0.12/kWh.
3) Assumed to be 1.7% of the equipment construction cost based on a review of actual maintenance costs for the Orange County Water District's Groundwater Replenishment System.
4) The annual compliance testing cost is assumed to be $150,000/year. This is based on half of the Demonstration Facility compliance testing cost of $300,000/year.
5) Estimated staffing = 12 personnel plus outside lab allowance, based on information provided by the City. The estimated staffing of 12 personnel was based on assessment of the department wide resources and additional needs to support and integrate this new facility as part of the City's existing treatment facilities. However, it is anticipated that this labor estimate will be updated in the future when the full-scale facility is constructed and the evaluation of new treatment technology provided at that time.
6) This table presents costs for the Full-Scale Facility only. For costs related to the Purified Water Pump Station and Purified Water Pipeline, refer to Table 5-5 and the Demonstration Project Report.

The O&M cost estimate is based on the preliminary design criteria developed for the Full-Scale Facility (see Section 4). The assumptions used for the O&M cost estimate are summarized below:

- The power consumption for each major water purification process was estimated taking into consideration efficiency of equipment and motors, and variation in equipment performance over time (e.g., membrane fouling over time will increase membrane feed pumping pressure and, therefore, increase power consumption). The average power demand for the Full-Scale Facility (annual average purified water production of 15 mgd) is approximately 2.1 to 3.1 megawatts, and the estimated total annual power consumption is 18,200,000 to 27,400,000 kilowatt-hours per year.

- The chemical consumption was estimated based on a range of dose rates defined in the design criteria.

- The replacement costs for microfiltration membrane modules assume a seven-year membrane life. The replacement costs for RO cartridge filters and RO membrane modules are based on other AWP facilities of similar size. The replacements costs for UV lamps and ballasts are based on 12,000 hours of life per lamp and seven years of life for ballasts based on information provided by Trojan.

- The annual maintenance cost for equipment is assumed to be 1.7 percent of the equipment construction cost based on a review of actual maintenance costs for GWRS.

- The annual compliance testing cost is assumed to be $150,000 per year. This is based on half of the Demonstration Facility compliance testing cost of $300,000 per year.

- The labor cost assumes 12 personnel based on information provided by the City of San Diego.

5.2.1 Comparison with Data from the Demonstration Facility

The estimated annual O&M costs for the Full-Scale Facility were compared to the O&M cost of the Demonstration Facility based on the first three quarters of operations. The estimated unit O&M costs for the Full-Scale Facility for most of the process areas are within 5 percent to 30 percent of the O&M costs for the Demonstration Facility (see Table 5-3). The differences are within an appropriate level of contingency since the Demonstration Facility has been operating within the first year of the equipment and membrane life, and many variables are anticipated to change over the course of the facility operation as the membranes age and water quality changes.

The largest difference between the estimated O&M costs for the Full-Scale Facility and the actual costs for the Demonstration Facility was for the RO system in which the estimated O&M costs for the Full-Scale Facility were estimated to be 60 percent higher than the Demonstration Facility. The differences between the two costs are discussed in more detail below. Additional information about energy conservation opportunities for the Full-Scale Facility RO system, including a discussion of using a two-stage RO system and energy recovery devices, are presented in Section 3.

Table 5-3 Full-Scale Facility Estimated O&M Costs Compared with the Demonstration Facility Operations Data

Process Area	Comparison	Notes
Membrane Filtration System	Full-Scale Facility unit power consumption estimate is approximately 10% lower than the unit power consumption of the Demonstration Facility.	Power consumption for Demonstration Facility included power consumption from chemical cleaning of RO system (chemical cleaning system was shared with RO, but measured as part of MF system).
RO System	Full-Scale Facility unit power consumption estimate is approximately 60% higher than the Demonstration Facility data.	RO feed pressure during first year of Demonstration Facility was operated at 126 psi (pump was sized for 175 psi). For the Full-Scale Facility the RO feed pumps are sized to operate at average feed pressure of 180 psi at year 2.5 (pump is sized for 230 psi at year 5). The increase in average pressure takes into consideration membrane age and potential increase in influent water TDS. Also, the Demonstration Facility did not have cartridge filters, which require additional booster pumping. These are included in the estimated O&M costs for the Full-Scale Facility.
UV System	Full-Scale Facility unit power consumption estimate is the same as the Demonstration Facility data.	Used 70% of maximum power draw value to estimate power consumption for the Full-Scale Facility.
Sodium Hypochlorite	Full-Scale Facility chemical usage estimate is 25% higher than the Demonstration Facility data.	Assumed 5 mg/L dose for the estimated O&M costs for the Full-Scale Facility. Dosed 3.8 mg/L at the Demonstration Facility. Higher dose is based on expected changes in water quality from both variations in the supply and higher salt passage as the RO membranes age.
Ammonium Hydroxide	Same	Assumed 1.5 mg/L dose for the estimated O&M costs for the Full-Scale Facility. Same dose was used at the Demonstration Facility.
Antiscalant	Full-Scale Facility chemical usage estimate is 29% higher than Demonstration Facility data.	Assumed 4.0 mg/L dose for the estimated O&M costs for the Full-Scale Facility. Dosed 3.0 mg/L at the Demonstration Facility.
Hydrogen Peroxide	Full-Scale Facility chemical usage estimate is 25% higher than Demonstration Facility data.	Assumed 5.0 mg/L dose for the estimated O&M costs for the Full-Scale Facility. Dosed 3.0 mg/L at the Demonstration Facility.
Sulfuric Acid	Not used at Demonstration Facility.	Assumed 60 mg/L dose for the estimated O&M costs for the Full-Scale Facility in the event that water quality changes. Did not use at the Demonstration Facility.

RO Booster Pumps

The Demonstration Facility does not include booster pumps or cartridge filters, which are included in the Full-Scale Facility conceptual design. Cartridge filters were not needed at the Demonstration Facility since concrete or concrete-lined tanks and piping, which could introduce debris into RO feed water, were not used between the membrane filtration and RO membranes. Cartridge filters are typically used upstream of the RO membranes to remove any particulate material inadvertently introduced after the membrane filtration system (spalled concrete, impurities in chemicals such as sulfuric acid, etc.). RO booster pumps are required to pump water through the cartridge filters ahead of the main RO feed pumps. In a larger facility, avoiding the use of concrete and concrete lined materials will be more challenging. While it has been done successfully in a handful of membrane filtration/RO facility, planning for the Full-Scale Facility should allow for a more conventional design approach with RO booster pumps and cartridge filters, as presented in Section 4.2.3. Based on these assumptions, it was estimated that four duty RO booster pumps rated at 200 horsepower each will be required for the Full-Scale Facility.

RO Recovery

The RO system Trains A and B were operated at both 80 and 85 percent recovery during the testing period and has operated well at both recoveries. The pumping requirements for the Full-scale Facility are based on a recovery of 85 percent to maximize water production.

Influent Water Quality

The water quality of the tertiary filter effluent, which feeds the Demonstration Facility, has been lower in TDS when compared with historic TDS levels prior to 2011. The TDS concentrations influence the feed pressures required for the RO system, as higher TDS results in higher osmotic forces that must be overcome in the RO process. The TDS observed at the Demonstration Facility since August 2011 has averaged 860 mg/L. There has been a downward trend in the TDS levels in the NCWRP effluent since 2006, when TDS concentrations were as high as 1,260 mg/L. TDS levels can change depending on San Diego's source of drinking water (low salinity State Project Water vs. higher salinity Colorado River Water) and conservation efforts, which tend to drive TDS higher. It is expected that the TDS levels could again approach 1,100 to 1,150 mg/L if the drought, which started in 2011, continues or the contribution of water from the Colorado River increases. The estimated RO feed pressure for the Full-Scale Facility is based on 1,100 mg/L, instead of the 860 mg/L that is currently being measured at the Demonstration Facility, to represent the average of the range of TDS that the Full-scale Facility could potentially treat. This higher TDS results in a higher RO feed pressure and higher power consumption when compared to the Demonstration Facility.

Membrane Age

The other factor that influences the RO feed pressure is the membrane age. As the membranes age, higher pressures are required to force the flow through the membranes. RO membrane projection software (Hydranautics IMSDesign v2009) was used to compare the feed pressures required at year one and year five of an RO membrane. At year one with 85 percent recovery and 1,100 mg/L TDS, the feed pressure required is estimated to be 132 psi for a two-stage system including energy recovery. At year five the feed pressure is estimated to be 206 psi for the same operating conditions and system configuration. The average over the life of the membrane must be considered; therefore, 180 psi was used for the estimated O&M costs. This is compared to current pressure of 126 psi at the Demonstration Facility after twelve months of operation (June 2011 to May 2012) under lower influent TDS conditions and operating at both 80 to 85 percent recovery.

5.3 Estimated Costs for the Full-Scale Project

The estimated costs for the Full-Scale Project incorporate the Full-Scale Facility, Purified Water Pump Station, and the Purified Water Pipeline. Table 5-4 presents the estimated construction costs for the Full-Scale Project, Table 5-5 presents the estimated O&M costs for the Full-Scale Project, and Table 5-6 presents the estimated additional auxiliary program costs to support the Full-Scale Project. The Full-Scale Project and the associated costs are discussed in more detail in the Demonstration Project Report.

Table 5-4 Estimated Construction Costs for the Full-Scale Project

Parameter	Capital Cost
Total Full-Scale Facility Capital Cost (Construction Total + Implementation Total)[1]	**$144,700,000**
Purified Water Pipeline System Construction Costs[2]	
Purified Water Pump Station	$8,000,000
Purified Water Pipeline	$114,200,000
Pipeline System Construction Total	***$122,200,000***
Pipeline System Implementation Costs	
Contingency (30% of Construction Total)	$36,700,000
Engineering & Construction Management (30% of Construction Total)[3]	$36,700,000
Environmental Documentation and Mitigation	$24,400,000
Land Acquisition	$4,500,000
Pipeline System Implementation Total	***$102,300,000***
Total Pipeline System Capital Cost (Construction & Implementation)[2]	**$224,500,000**
Total Capital Cost (Full-Scale Facility and Pipeline System)	**$369,200,000**

Notes:

1) Refer to Table 5-1 for a breakdown of the Full-Scale Facility construction cost.
2) From the Demonstration Project Report.
3) Includes costs associated with regulatory compliance and permitting.

Table 5-5 Estimated Annual O&M Costs for the Full-Scale Project

Parameter	Annual O&M Cost[1]
Full-Scale Facility[1]	$8,145,000
Treatment at North City to Support Full-Scale Facility[2]	$3,965,000
Purified Water Pump Station[2,3]	$1,885,000
Purified Water Pipeline[2,4]	$1,500,000
Total Annual O&M Cost	**$15,495,000**

Notes:

1) Refer to Table 5-2 for a breakdown of the Full-Scale Facility O&M costs.
2) From the Demonstration Project Report.
3) Includes power and maintenance.
4) Includes maintenance.

Table 5-6 Estimated Auxiliary Program Costs for the Full-Scale Project[1]

Parameter	Auxiliary Cost
Auxiliary Upfront Cost	
Source Control Program Upfront Cost[2]	$500,000
Auxiliary Annual Cost	
Source Control Program Annual Costs[3]	$50,000
Public Outreach Annual Program Costs[4]	$700,000

Notes:

1) From the Demonstration Project Report.
2) Source control upfront costs include a chemical inventory program and GIS tracking database (approximately $50,000), a pollutant prioritization program to be completed by existing City staff (approximately $50,000 for initial set-up work), and a local limits evaluation for North City (approximately $400,000). For additional information on source control program costs, refer to the Enhanced Source Control Plan for the Full-Scale Advanced Water Purification Facility Technical Memorandum (RMC, 2013).
3) Source control annual costs include $25,000/yr for annual updates to the chemical inventory program and GIS tracking database, an average of $10,000/yr for periodic updates to the pollutant prioritization program, and $15,000/yr, on average, for updates to the local limits analysis. For additional information on source control program costs, refer to the Enhanced Source Control Plan for the Full-Scale Advanced Water Purification Facility Technical Memorandum (RMC, 2013).
4) Public outreach annual costs include initial start-up of outreach efforts. Annual public outreach costs will be scaled back following full-scale reservoir augmentation project operations.

Section 6

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Advanced Water Purification Facility Study Report

Appendix A

Testing and Monitoring Plan

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Final Testing and Monitoring Plan

August 31, 2011

CITY OF SAN DIEGO

Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility

THE CITY OF SAN DIEGO

City of San Diego
PUBLIC UTILITIES
Water & Wastewater

CDM

in association with:
MWH

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List of Acronyms & Abbreviations

°C	Degrees Celsius
°F	Degrees Fahrenheit
AQWATEC	Advanced Water Technology Center, Colorado School of Mines
AOP	Advanced Oxidation Process
ASTM	American Standard Technical Method
AWP	Advanced Water Purification
Basin Plan	San Diego Basin Plan
BAT	Best Available Technology
BOD	Biological oxygen demand
CCP	Critical control point
CDPH	California Department of Public Health
CDWR	California Department of Water Resources
CEC	Chemicals of Emerging Concern
CFD	Computational fluid dynamics
CFU/mL	Colony forming units per milliliter
CIP	Clean-in-place
City	City of San Diego
City Council	San Diego City Council
CLP	Contract Lab Program
CWA	Clean Water Act
/day	Per day
DBP	Disinfection By-product
DO	Dissolved oxygen
DMA	Dimethylamine
DP	Differential pressure
EBEP	Enclosed Bay and Estuaries Plan
EEO	Electrical Energy per Order
ELAP	Environmental Laboratory Accredited Program
gpm	Gallons per minute
g/mol	Grams per mol
gfd	gallons per square-foot day
gpm	gallons per minute
GWRS	Ground Water Replenishment System
H_2O_2	Hydrogen peroxide
HACCP	Hazard Analysis and Critical Control Point
HRT	Hydraulic residence time
IAF	Integrated averaging factor
IAP	Independent Advisory Panel
in	Inch
IMP	Integrity Monitoring Plan
IPR	Indirect Potable Reuse
ISWP	Inland Surface Waters Plan
kW	Kilowatt
L/m^2	Liters per square meter

lb	Pound
LDC	Laboratory Data Consultants, Inc.
LPHO	Low pressure high output
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	Maximum contaminant limit
MF	Microfiltration
MGD	Million gallons per day
mg/L	Milligrams per Liter
MPN/100 mL	Most probable number per 100 milliliters
MRL	Method reporting level
MTBE	Methyl tert-butyl ether
MTL	Monitoring Trigger Level
MW	Molecular weight
µg/L	Micrograms per Liter
N	Nitrogen
NA	Not applicable
NaOCl	Sodium hypochlorite
NC	North City
NCWRP	North City Water Reclamation Plant
ND	Non Detect
NDMA	N-nitrosodimethylamine
NDBA	N-nitrosodi-n-butylamine
NDEA	N-nitrosodiethylamine
NDPA	N-nitrosodi-n-propylamine
NH2Cl	Monochloramine
NMEA	N-nitrosomethylethylamine
NPIP	N-nitrosopiperidine
NTR	National Toxics Rule
NYPR	N-nitrosopyrrolidine
ng/L	nanograms per liter
NTU	Nephelometric Turbidity Units
O&M	Operations and maintenance
OCWD	Orange County Water District
OH	Hydroxyl radical
P	Phosphorus
PAT	Project Advisory Team
PCPP	Pharmaceutical and Personnel Care Products
POM	Point of monitoring
ppm	parts per million
ppb	parts per billion
ppt	parts per trillion
psi	Pounds per square inch
PVC	Polyvinyl chloride
QA	Quality assurance
QC	Quality control
QCP	Quality control point

RA	Reservoir Augmentation
RO	Reverse osmosis
RWC	Recycled Water Contribution
RWQCB	Regional Water Quality Control Board
SAP	Science Advisory Panel
SCADA	Supervisory control and data acquisition
SVI	Sludge volume index
SWRCB	State Water Resources Control Board
T&M	Testing and Monitoring
TDS	Total dissolved solids
TLD	Trace leak detection
TMP	Transmembrane pressure
TN	Total nitrogen
TOC	Total organic carbon
UF	Ultrafiltration
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
UVT	Ultraviolet transmittance

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Section 1
Background

1.1 City of San Diego Indirect Potable Reuse / Reservoir Augmentation Demonstration Project

In January 2004, the San Diego City Council (City Council) directed the City Manager to conduct a study to evaluate options to increase the use of recycled water produced at the City of San Diego's (City) two water reclamation plants. The City Council mandated the study to also include research on the health effects of reuse options and to facilitate active involvement of the public.

The Water Reuse Study (City of San Diego, Draft Final Report, March 2006) resulted in the identification of six potential options to maximize the use of the City's existing recycled water. The various project stakeholders identified the North City-3 (NC-3) strategy to be the most beneficial reuse strategy. The NC-3 option includes reservoir augmentation of the City's San Vicente Reservoir using highly purified tertiary water from the City's North City Water Reclamation Plant (NCWRP).

The Water Reuse Study represented Phase I of a three phase program that may lead to the implementation of full scale indirect potable reuse reservoir augmentation (IPR/RA) project. Phase II is the current demonstration project and Phase III will be the full scale IPR/RA project. In October 2007, the City Council voted to proceed with the demonstration project consisting of the following components:

- Design, construct, operate and test a demonstration scale Advanced Water Purification Facility (AWP Facility) at the NCWRP.
- Conduct a Limnology and Reservoir Detention study for the San Vicente Reservoir to establish residence time and short circuiting conditions of advanced treated water in the reservoir.
- Conduct a public outreach and education program.
- Convene an Independent Advisory Panel (IAP) to provide expert review of the technical, scientific, and regulatory aspects of the project.
- Define regulatory requirements for a full scale IPR/RA project (Phase III of the program).

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Section 2
Objectives, Development and Organization

A key component to the operation and testing of the AWP Facility is the development and implementation of a comprehensive Testing and Monitoring (T&M) Plan. This section provides specific objectives of the testing and monitoring component of the AWP Facility, information on how the T&M Plan was developed, and a roadmap as to where key components of the plan are located in the document.

2.1 Testing and Monitoring Objectives

The ultimate goal of testing and monitoring the AWP Facility is to generate the necessary data to support the regulatory approval and permitting of the proposed full-scale IPR/RA project. Specific objectives of the testing and monitoring component are provided in the following paragraphs.

- **Demonstrate that the proposed AWP technology, operation and performance meets the criteria outlined by the California Department of Public Health (CDPH) and California Department of Water Resources (CDWR) 1996 proposed framework for Regulating IPR by Surface Water Augmentation.** The selection of the treatment technologies, operational strategy and water quality sampling plan associated with the AWP Facility will target meeting the following criteria:

    - Enable CDPH to find that the proposed technology will ensure that the recycled water meets or exceeds all applicable primary and secondary drinking water standards and poses no significant threat to public health

    - Compliance with the draft 2008 CDPH groundwater recharge criteria for injection.

    - Maintenance of reservoir quality.

    Other criteria established by the proposed IPR/RA project framework, which are also being evaluated as part of the overall demonstration project, and supported by the operation of the AWP Facility, include:

    - Maintenance of appropriate San Vicente Reservoir residence time based on reservoir dynamics.

    - Provision of an effective source control program for discharges into the wastewater collection system.

- **Evaluate nutrient removal performance of the baseline AWP Facility treatment train.** A key objective of the demonstration testing will be to collect nutrient removal data and associated product water quality of the AWP Facility. The performance goals for product water nutrient levels of the proposed full-scale facility are driven by the Regional Water Quality Control Board (RWQCB) as outlined in the San Diego Basin Plan (Basin Plan). The Basin Plan sets a threshold limit for total phosphorus concentration for any streams at the point of entering inland standing body surface waters, such as San Vicente Reservoir, of 0.05 milligrams phosphorus per liter (mg-P/L). Though the RWQCB has not established nitrogen thresholds, the Plan references the use of natural nitrogen to phosphorus (N:P) ratios of 10:1, which would establish a total nitrogen threshold at 0.5 milligrams of nitrogen per liter (mg-N/L). However, the Basin Plan notes certain exceptions to these levels can be made on a case-by-case basis for discharges of reclaimed water to surface waters. A goal of the overall demonstration project is to work with the RWQCB to establish specific nutrient goals for the full scale IPR/RA project. The established regulatory requirements and nutrient removal performance of the baseline AWP Facility treatment train will dictate if any additional treatment would be needed beyond the baseline treatment train.

- **Implement a monitoring plan for Chemicals of Emerging Concern (CECs) tailored to the NCWRP tertiary water characteristics and current recommendations of the State Water Resources Control Board (SWRCB).** The proposed T&M Plan includes a specific CEC monitoring program to be implemented over the demonstration period. The basis of the plan is the prioritization framework and recommendations presented in the Final Report "Monitoring Strategies for Chemicals of Emerging Concern in Recycled Water," published by the SWRCB on June 25, 2010. The compounds selected for monitoring can be classified into two general categories including compounds that have toxicological relevance and compounds that serve as suitable performance indicators. The specific compounds incorporated into the T&M Plan are based on previous CEC data captured during the City's Advanced Water Treatment Research Studies (2005) and the on-going NCWRP sewer shed investigation, as well as occurrence data for secondary/tertiary treated effluents summarized in the SWRCB report. The proposed plan is multi-tiered with the intention of being carried over to the monitoring requirements of the full-scale IPR/RA project.

- **Demonstrate integrity monitoring techniques and performance reliability measures for the AWP Facility treatment train, which can be implemented at the full-scale facility.** The overall T&M Plan includes a comprehensive plan to monitor the integrity and reliability of each unit process throughout the demonstration period to achieve water quality objectives. The foundation of this T&M Plan is the use of a surrogate/indicator approach for continuous performance monitoring of each unit process. A correlation is made between removals of indicator compounds (i.e., an individual compound that is present in the source water with characteristics of a larger family of compounds) and surrogate compounds (i.e., quantifiable change of bulk parameter corresponding to performance of individual unit process). The T&M Plan also includes direct and indirect measures of the microfiltration/ultrafiltration (MF/UF) and reverse osmosis (RO) membrane integrity, as well as the ultraviolet (UV) system of the advanced oxidation process

(AOP). With regards to RO integrity monitoring, a tiered approach is proposed with the use of different direct and indirect monitoring methods corresponding to different stages of RO commissioning and operation.

- **Validate the performance of AWP Facility unit processes using full-scale treatment equipment.** The AWP Facility baseline treatment train will use a multiple barrier approach consisting of MF/UF, RO, and UV/AOP with a total production capacity of approximately 1 million gallons per day (MGD). The design of the system incorporates the use of MF, UF, and RO membranes which are the same size, specification, and configuration as those that could be utilized for the full-scale IPR/RA facility. UV/AOP system selection was based on review of the system used at the Orange County Water District's (OCWD's) Groundwater Replenishment (GWR) System and consultation with representatives of Trojan, Inc., the UV System manufacturer. The proposed UV/AOP demonstration system is the UV Phox Model 72AL75, which is a single chamber version of the reactors used at OCWD. During the initial phase of testing, the ability of the unit to achieve 1.2-log (93.7%) removal of N-Nitrosodimethylamine (NDMA) at a flow of 1 MGD will be verified. Results obtained during initial testing will establish the power setting at which to operate the system for the remainder of the operations period.

- **Define vendor pre-qualification criteria for the full-scale AWP Facility.** As part of the testing program, vendor pre-qualification criteria will be developed for the full-scale AWP Facility. Testing will include two different low pressure (MF/UF) membranes and two different RO membranes. The performance of the Trojan UV Phox system will be monitored to access and gain further insight on AOP performance. Both water quality and operational performance observed during the demonstration plant study will be utilized to develop pre-qualification criteria for consideration during procurement of equipment for the full-scale facility. Though operation and testing of the AWP Facility will provide useful information to develop vendor pre-qualification criteria it is not intended to pre- qualify vendors for the potential full-scale AWP. Pre-qualification of vendors for the full scale AWP would require further evaluation outside the current scope of work.

- **Monitor and collect operational performance and maintenance requirements of the AWP Facility equipment -** During the testing period, key operational parameters and maintenance requirements of each unit process (MF/UF, RO and UV/AOP) will be monitored on a routine basis. This information will be evaluated to assess ways to improve operational efficiencies and provide a basis for estimating operations and maintenance (O&M) costs for the full-scale AWP Facility.

- **Evaluate the degradation and by-product formation of nitrosamines and 1, 4-dioxane by UV/AOP and compare alternative chloramines application conditions to mitigate NDMA formation.** Nitrosamines and 1,4-dioxane will be monitored in the AWP Facility product water by performing an initial spiking experiment and performing quarterly sampling to demonstrate log removal requirements established by the CDPH and assess the ability of the treatment train to meet current notification limits, respectfully. In addition, possible by–products, that may form as a result of the oxidation of nitrosamines (*e.g. NDMA, NDBA, NDEA, NDPA, NMEA, NPIP, NYPR*) and 1, 4-dioxane will be evaluated during the testing period. Based on monitoring data from the AWP Facility and an initial literature review performed by the project team, bench-scale testing may be performed to simulate worse conditions to identify potential UV/AOP by-products and at what level and conditions they occur. Should bench testing be conducted, results may be used to adjust operating conditions for the UV/AOP component of the AWP Facility and tailor the monitoring program for the product water. As part of the overall T&M Plan, the use of pre-formed chloramines and sequential chloramines formed in-situ will be evaluated to reduce the formation potential of nitrosamine compounds due to chloramination upstream of the RO system, which is required to prevent biological fouling.

2.2 T&M Plan Development

Several sources of information serve as the basis of this T&M Plan, which include:

- Final Report of the *May 11-12, 2009 Meeting of the Independent Advisory Panel (IAP) for the City of San Diego IPR/RA Demonstration Project* (IAP Final Report), NWRI, September 2009.
- CDPH comments to the IAP Final Report, December 2009, and the City's response to comments, May 2010.
- City of San Diego, *Advanced Water Treatment Research Studies* conducted at the NCWRP, 2005.
- Final Report *Monitoring Strategies for CECs in Recycled Water, Recommendations of Science Advisory Panel*, SWRCB, June 25, 2010.
- CDPH Groundwater Recharge Reuse Draft Regulations, August 2008.
- IAP Subcommittee Findings and Recommendations of the Advanced Water Purification Facility Subcommittee Meeting, November 15, 2010, NWRI.
- Input received from the project team's Project Advisory Committee (PAC):
  - Professor Dr. Jörg Drewes, Advanced Water Technology Center (AQWATEC), Colorado School of Mines.
  - Professor Dr. Shane Snyder, University of Arizona, Arizona Laboratory for Emerging Contaminates.

  - Professor Dr. Bill Cooper, University of California, Irvine, Urban Water Research Center.
  - Professor Dr. Greg Leslie, UNSW Global, University of New South Wales.
  - Ms. Margie Nellor, Nellor Environmental.

- Comments received from the IAP/CDPH/RWQCB on the *City of San Diego IPR/RA Demonstration Project Advanced Water Purification November 30, 2010 Final Draft Testing and Monitoring Plan.*

2.3 T&M Plan Organization

This T&M Plan conforms to the recommendations outlined in the IAP Final Report (September 2009), CDPH comments to the IAP Final Report (December 2009), and the City's response to CDPH comments (May 2010). The T&M Plan is organized as follows:

Section 1 - Background

Section 2 – Objectives, Development and Organization

Section 3 – Materials and Methods

Section 4 – Process Operation, Activities, and Schedule

Section 5 – Demonstration Facility Process Evaluation

Section 6 – Specialty Testing

Section 7 – Quality Assurance / Quality Control

Section 8 – Additional Scope of Services

Section 9 – References

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Section 3
Materials and Methods

3.1 Demonstration Testing Site

3.1.1 North City Water Reclamation Plant

The AWP Facility is located at the City of San Diego's North City Water Reclamation Plant (NCWRP) located at 4949 Eastgate Mall, San Diego, California 92121.

The NCWRP currently produces 22.5 MGD of recycled water of which approximately 7.3 MGD is used for the non-potable beneficial use in the surrounding area. NCWRP has a total design capacity of 30 MGD. The recycled water distribution system consists of approximately 83 miles of recycled water pipeline, two reservoirs and three pump stations.

A general schematic of the NCWRP treatment process is provided in **Figure 3-1.** As shown the AWP Facility will receive feed water from the tertiary filters, product water will be returned to the NCWRP recycled water upstream of the chlorine contact chamber.

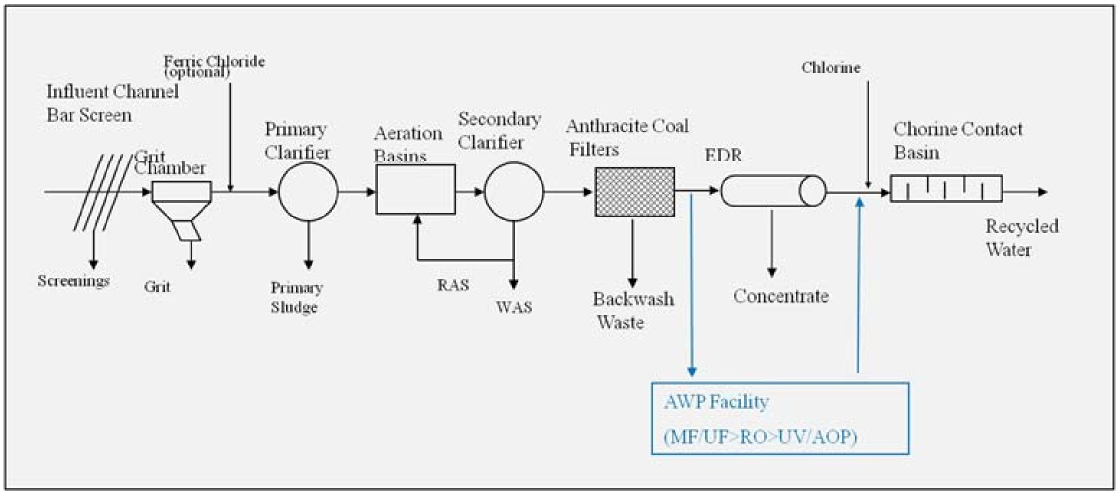

Figure 3-1
NCWRP Treatment Process

The NCWRP is a tertiary treatment plant and consists of the following major treatment processes:

- Influent headworks – consists of bar screen and grit chamber to remove large debris and coarse sediments.
- Primary Treatment – consists of primary sedimentation basins to remove settable solids not removed in the grit chamber.

- Secondary Treatment – consists of aeration basins (anoxic and aerobic) that promote biological treatment of wastewater through microbial decomposition and secondary clarifiers, which remove the settled activated sludge.
- Tertiary Treatment – consists of anthracite coal filters to remove particulate matter.
- Demineralization - utilizes electrodialysis reversal (EDR) for partial demineralization.
- Disinfection - consists of chlorine contact chambers where chlorine is applied to the water to kill bacteria and other microbes prior to distribution to recycled water customers through the recycled water distribution system.

The AWP Facility is located on a concrete pad adjacent to the existing EDRs #4 and #5. The new pad area is 3,800 square feet (50 feet x 76 feet). The western edge of the new pad houses the EDR unit #6 and is not part of this project. The operations trailer is located on the existing Research Pad, which has an area of 2,000 square feet (40 feet x 50 feet). An aerial photograph of the NCWRP showing the demonstration facility site in proximity to NCWRP unit processes is provided in **Figure 3-2**.

3.1.2 AWP Facility Layout

A layout of the AWP Facility showing the location of main components including equipment skids, chemical storage tanks, and the trench drain is provided in **Figure A-1 (Appendix A)**. The AWP Facility is laid out to facilitate public tours through the facility in order of treatment process: MF/UF, RO, and UV/AOP.

Both pads have steel frame roofs with 18 feet of vertical clearance. The Research Pad is equipped with lights, outlets, raceways, and electrical panels.

The AWP Facility is connected to the NCWRP product water by an 8-inch Schedule 80 polyvinyl chloride (PVC) pipe anticipated to deliver water to the demonstration plant at 980 gallons per minute (gpm) and a pressure between 50 to 70 pounds per square inch (psi). The water is delivered by the same pumps that feed EDRs #4, 5 and 6. Two drains are provided for liquid process and cleaning waste. The drains are routed overhead in the AWP Facility and EDR #6 areas and then routed below grade to discharge to an existing manhole. Water produced by the AWP Facility is discharged into the tertiary effluent piping upstream of the chlorine contact tanks. As with the drain piping, the product water piping is routed overhead in the AWP Facility and EDR #6 areas and then routed below grade to discharge into the existing product water pipeline.

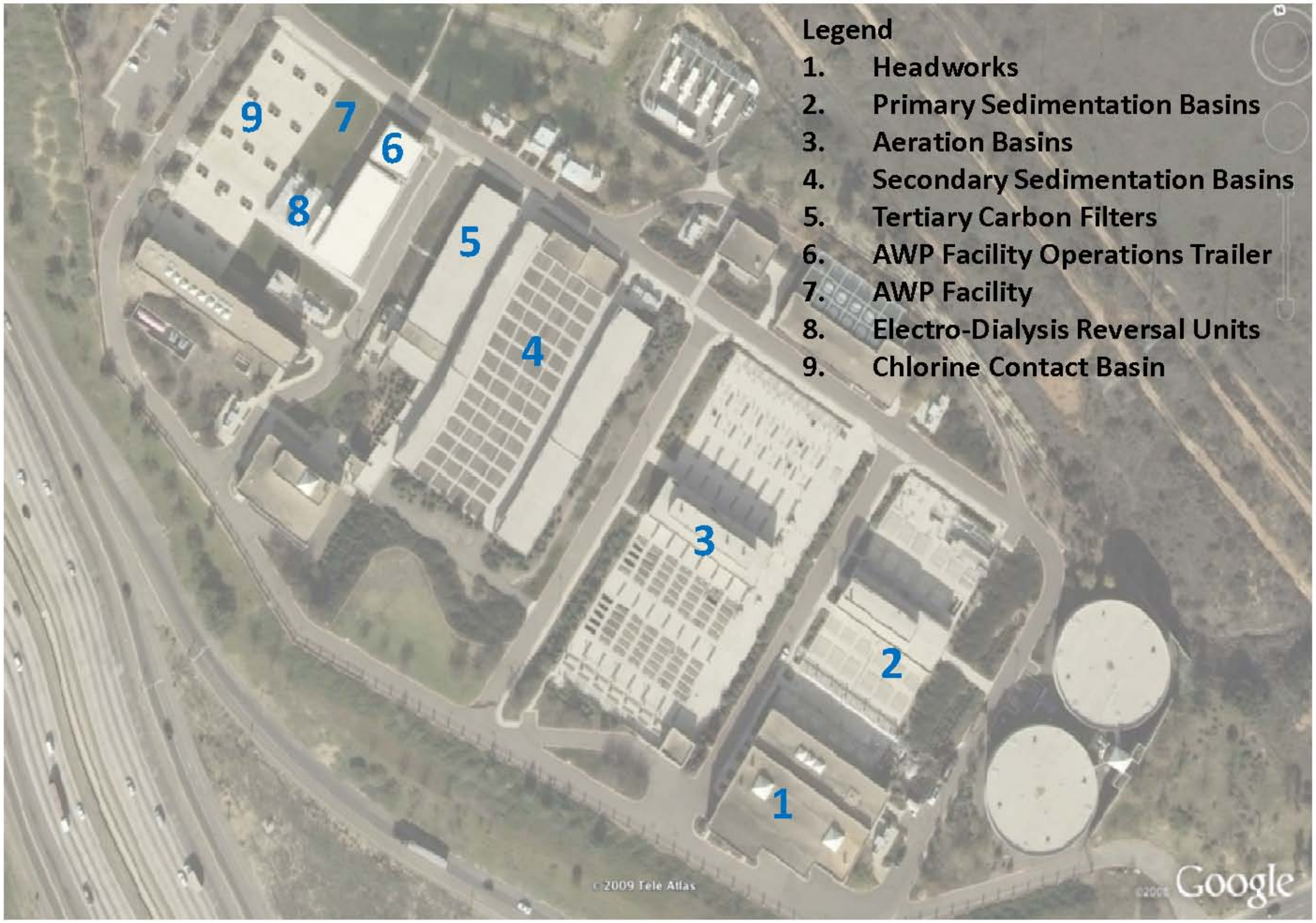

Figure 3-2
Aerial Photograph of the NCWRP

3.1.3 Feed Water Characteristics

The AWP Facility testing will be conducted using tertiary treated water (prior to chlorination and demineralization) from the NCWRP. **Table 3-1** presents water quality of disinfected tertiary filtered effluent based on data collected at NCWRP during the 2009 annual monitoring report. While the water quality shown in **Table 3-1** is based on measurements made post chlorination it should be representative (with the exception of microbial parameters: heterotrophic plate count, total coliform and total coliphage) of the filtered effluent which will be used during the testing.

Table 3-1
NCWRP Disinfected Effluent Water Quality Data

Parameter	Unit	Value
pH	--	7.13 [1]
TSS	mg/L	ND [1]
VSS	mg/L	ND [1]
Turbidity	NTU	0.63 [1]
Ammonia-N	mg/L	ND [2]
TKN	mg/L	ND [2]
Aluminum	µg/L	86 [1]
Arsenic	µg/L	0.58 [1]
Boron	µg/L	325 [1]
Chloride	mg/L	240 [1]
Sulfate	mg/L	217 [1]
Silica	mg/L	14 [4]
Iron (total)	µg/L	113 [1]
Calcium	mg/L	62.3 [1]
Magnesium	mg/L	26.7 [1]
Conductivity	micromhos/cm	1,530 [2]
TDS	mg/L	893 [1]
Hardness	mg/L	265 [1]
Alkalinity (bicarbonate)	mg/L	103 [1]
BOD	mg/L	ND [1]
HPC	cfu/mL	ND [3]
Total Coliphage	MPN/ 100mL	ND [3]
Total Coliforms	MPN/ 100mL	ND [1]

[1] Average value measured in December 2009, NCWRP Annual Monitoring Report
[2] Based on measurement October 6, 2009
[3] Based on data presented in Long Term Testing Experimental Plan (MWH, 2005)
[4] Based on average values collected July 14 - 19, 2005 (MWH, 2007)

3.1.3.1 NCWRP Operational Changes to Reduce Effluent Total Nitrogen

In January 2008 the City began a 12-month study to assess improving the NCWRP recycled water quality by enhancing the plant's denitrification process (Trussell et al., 2010). The purpose of this project was to document the plant's nitrogen removal performance over that time period and to provide recommendations to improve water quality and nitrogen removal. Results of the study produced five possible immediate action recommendations and two potential future capital improvements to further reduce total nitrogen. The five possible immediate actions include:

- Increase aeration solids retention time from 5.8 days to 10 days to ensure complete nitrification (< 1 mg/L of ammonia) and to encourage the filamentous bacteria growth which will increase sludge volume index (SVI).

- Take a primary sedimentation tank offline and cease the addition of coagulant to the primary treatment process, in order to increase primary effluent Biochemical Oxygen Demand (BOD).

- Bring down the dissolved oxygen (DO) set point to 1 mg/L to improve denitrification efficiency at the anoxic zones by carrying less oxygen in the internal recycling streams. Before changing the DO set point, preventive maintenance for the air control system should be performed to ensure accurate airflow control and avoid DO deficits at the aerobic zones. It is also recommended to first set the DO set point to 2 mg/L to make sure the DO controller is reliable before bringing the DO set point down to 1 mg/L.

- Lab use the Environmental Laboratory Accredited Program (ELAP) approved methods for nitrate analyses and elimination of weekly ammonia effluent sampling.

- Take two additional secondary sedimentation tanks offline, one tank at a time, to reduce energy and reduce maintenance costs.

The two potential future capital improvements to further reduce total nitrogen include:

- Increase anoxic volume from 20% to 40% of the total aeration volume to allow additional anoxic contact time for denitrification. With anoxic volume at 40%, a DO set point of 2 mg/L will be required to avoid air deficits at the aerobic zones.

Increase internal recycle rate from 1.6 times the average primary effluent flow to 3 times the average primary effluent flow to introduce more nitrates to the anoxic zone for oxidation of influent biodegradable organic matter. With the optimization of the NCWRP's operations per Trussell Technologies' recommendations, the nitrification process will be more stable and the total nitrogen should be reduced by approximately 10 to 15%. If all of Trussell Technologies recommendations, including some capital improvement projects (CIP), were to be implemented then the total nitrogen in the NCWRP tertiary water could be reduced by more than 50%.

Figure 3-3 provides average monthly values of nitrate measured in the NCWRP between January 2010 and September 2010. As shown, the values have shown an overall decreasing trend with an average nitrate value of 11.5 mg-N/L based on samples measured between May 1 2010 to August 31 2010. This improvement is credited to on-going changes to the plant process per findings of the study described above. The changes are being made gradually with final adjustments to be completed in December 2010 prior to start up of the AWP Facility scheduled for February 2011. The ongoing enhancements may result in ultimate lower nitrogen values in the AWP Facility product water which is an important aspect over the overall IPR/RA project with respect to reservoir quality.

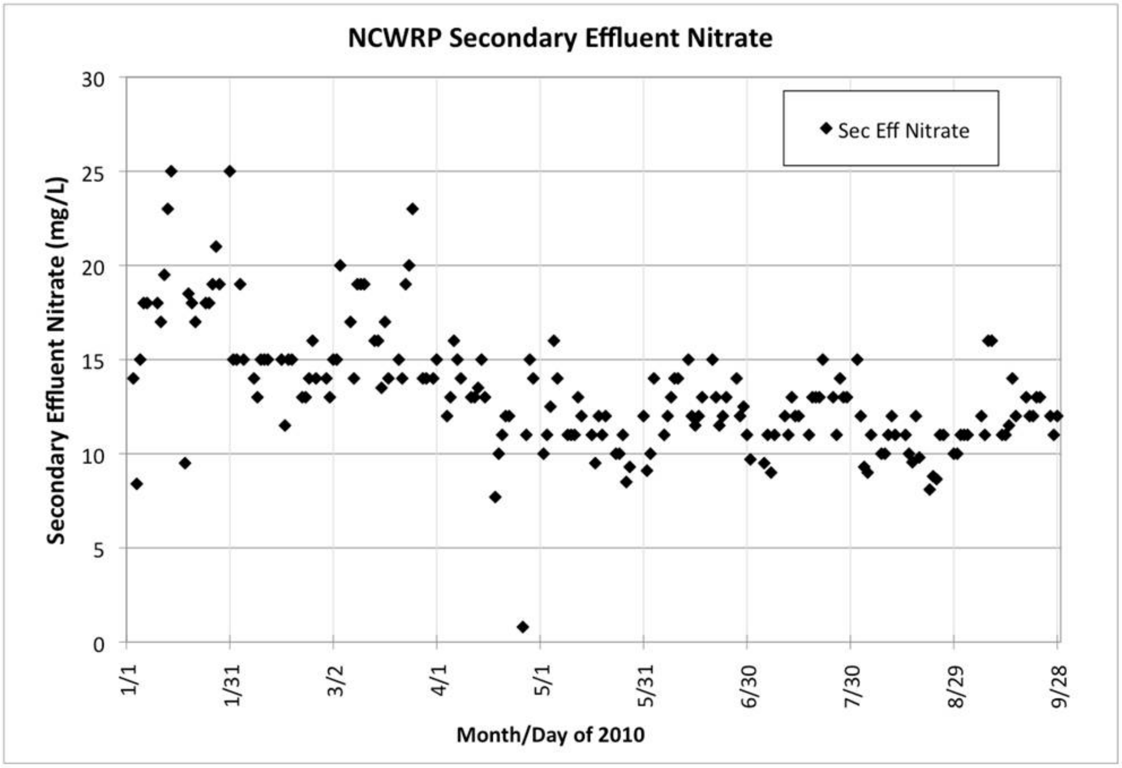

Figure 3-3
NCWRP Effluent Nitrate Data

3.1.3.2 CECs

A key component in characterizing the NCWRP tertiary water for the AWP Facility is analyzing the water for new classes of chemicals potentially impacting recycled water quality, or CECs. CECs include currently used pesticides, industrial chemicals, endocrine disrupting compounds (EDCs), and pharmaceuticals and personal care products (PPCPs). The majority of CECs are not part of the Citys NCWRP annual water quality monitoring; however, analysis for CECs in NCWRP tertiary water was conducted as part of the City's AWT Research Studies conducted in 2005. **Table 3-2** presents concentration for 29 CEC compounds measured in the NCWRP tertiary water. As described later in **Section 5**, this data was considered during the development of the specific CEC monitoring plan for the AWP Facility.

Table 3-2
[1]NCWRP Tertiary Effluent Water CEC Data

Parameter	**Unit**	**Value (3/23/05)**	**Value (4/13/05)**
Hydrocodone	ng/L[2]	80	87
Trimethoprim	ng/L	383	346
Acetaminophen	ng/L	1	ND
Caffeine	ng/L	ND	ND
Erythromycin-H_2O	ng/L	335	311
Sulfamethoxazole	ng/L	758	817
Fluoxetine	ng/L	46	36
Pentoxifylline	ng/L	ND	ND
Meprobamate	ng/L	252	271
Dilantin	ng/L	133	117
TCEP	ng/L	353	225
Carbamazepine	ng/L	223	327
DEET	ng/L	146	393
Atrazine	ng/L	1	1
Diazepam	ng/L	4.5	1.2
Oxybenzone	ng/L	ND	1.4
Estriol	ng/L	ND	ND
Ethynylestradiol	ng/L	ND	ND
Estrone	ng/L	18	6.3
Estradiol	ng/L	ND	ND
Testosterone	ng/L	ND	ND
Progesterone	ng/L	ND	ND
Androstenedione	ng/L	4.4	4.9
Iopromide	ng/L	633	453
Naproxen	ng/L	48	23
Ibuprofen	ng/L	24	28
Diclofenac	ng/L	52	71
Triclosan	ng/L	94	171
Gemfibrozil	ng/L	146	222
NDMA	ng/L	14	23
1,4-Dioxane	µg/L[3]	43	ND

[1] Data Collected for the 2005 AWP Pilot Study (MWH, 2007)
[2] ng/L – nanograms per liter
[3] µg/L – micrograms per liter

3.1.3.3 NCWRP Collection System Catchment Area Investigation

Under a separate contract, the City recently completed a desktop study to identify specific contaminants of concern in the NCWRP collection system based on a survey of industrial dischargers. The final technical memorandum prepared by RMC (**provided in Appendix B**) provides results of data review conducted on 30 industries within the NCWRP collection system area categorized in the TM as follows:

- Two Class 1, federally regulated, pharmaceutical manufacturers;
- Twenty Class 2 industries with the greatest industrial wastewater flow; and
- Nine industries (mainly R&D) geographically clustered on Nancy Ridge Drive, including one Class 2 industry.

The major findings of the study include a comprehensive listing of chemicals used or stored by each facility. This list was reviewed by the project team in the development the T&M Plan for the AWP Facility provide in Section 5. Based on this review, it is recommend that the City follow up with two discharges (02-0730 and 02-0972) for further screening based on the number of reported compounds present. A first step would be to assemble flow data for each discharger, which could be either concentration or mass load estimates. Based on this information it may be possible for the City to identify specific contaminants to add to the monitoring program.

Under a separate contract, the City recently completed a desktop study to identify specific contaminants of concern in the NCWRP collection system based on a survey of industrial dischargers. The final technical memorandum prepared by RMC (provided in Appendix B) provides results of data review conducted on 30 industries within the NCWRP collection system area categorized in the TM as follows:

- All (total of 2) Class 1, federally regulated, pharmaceutical manufacturers;
- Twenty Class 2 industries with the greatest industrial wastewater flow; and
- Nine industries (mainly research and development) geographically clustered on Nancy Ridge Drive, including one Class 2 industry.

3.2 AWP Facility Configuration

This section includes information about the AWP Facility equipment and configuration, including the process flow diagram, information about the selected equipment, discussion of the dual-train configuration, and scale-up rationale and suitability for the equipment.

3.2.1 Process Flow Diagram

The AWP Facility with sample locations is shown on the process flow diagram provided in **Figure A-2** located in **Appendix A**.

3.2.1.1 Selected Equipment and Dual-Train Configuration

The AWP Facility is configured to test MF and UF side-by-side to allow comparison of their effectiveness for RO pretreatment. Operational performance parameters, such as flux, fouling, cleaning intervals, and chemical consumption, as well as filtrate water quality will be directly compared for the MF and UF.

Pall MF membranes were selected because Pall MF system has a strong record of reliability and membrane integrity at numerous reuse and drinking water facilities.

Toray UF membranes were selected for the UF system because these membranes are CDPH-certified, use PVDF material, similar to the Pall MF membranes, but have approximately a 5 times smaller pore size. Toray membranes can be used in a standardized skid configuration, which could accommodate UF membranes from Norit, Dow, or Toray. This provides flexibility with the AWP Facility if the City decides to test another UF manufacturer, and could also provide advantages for membrane replacement in the full-scale plant.

Chlorine and ammonia are injected in the common header pipe upstream of the MF and UF trains, for chloramination or break-point chlorination, to ensure that the feed water for MF and UF have the same water quality.

In addition, the AWP Facility is configured to test two 0.5 mgd capacity RO trains side-by-side to allow the following evaluation:

- Comparison of two different RO membranes to quantify the trade-offs between greater rejection and lower feedwater pressure; and

- Comparison of 2-stage and 3-stage configuration to quantify the impacts on energy recovery and fouling rate.

The two types of RO membranes selected for testing include the lower pressure, Hydranautics ESPA 2 membranes, and the higher pressure and higher rejection, Toray TML20-400 membranes. The Hydranautics ESPA 2 membranes are used in other advanced treatment facilities, such as OCWD's GWR System. The Toray membranes were selected as they are anticipated to have higher nitrate rejection than the Hydranautics membranes.

The MF and UF filtrate are combined in the MF/UF Filtrate Tanks, upstream of the RO, and antiscalant is injected in the common RO feed water pipe upstream of the RO feed pumps, to provide the same feed water quality to both RO trains. Providing each RO train the same quality feed water is critical to the above-listed evaluation to confirm that the differences in RO performance in the two trains are not attributable to the differences in feed water quality.

The RO permeate from the two RO trains are combined and treated through an AOP, comprised of ultraviolet light (UV) coupled with hydrogen peroxide (H_2O_2). Trojan

UVPhox™, a low pressure and high output (LPHO) UV system is used to demonstrate UV/H_2O_2 AOP. The advantages of LPHO UV include electrical efficiency, longer lamp life, narrower UV wavelength targeted for microbial destruction. Trojan LPHO UV systems have a proven history with advanced water treatment in California with systems installed at the OCWD GWR System, the West Basin Edward C. Little Water Recycling Facility, and the Water Replenishment District Leo J. Vander Lans Advanced Water Treatment Facility.

The sampling locations are also shown on **Figure A-2**. In addition to the 12 sampling points shown on **Figure A-2**, the sampling ports for the permeate from each RO membrane vessel of each train and the concentrate from each RO stage of each train will be provided on the RO skid.

3.2.2 Scale-Up Rationale and Suitability

The MF, UF, and RO systems are directly scalable to the full-scale plant. The systems can be scaled up or down based on the flux (i.e., by using the same flux tested in the AWP Facility for the full-scale plant). For a given flow, the desired flux could be achieved by adjusting the number of membrane elements provided (total membrane area).

Because of reactor hydraulics, the UV system is the most difficult process to scale-up from the AWP Facility to the full-scale plant. The larger the UV system, the more electrically efficient the system will be. If the AWP Facility UV system were scaled-up for the full-scale plant, then the full-scale system would be much more electrically inefficient than a system designed specifically for the full-scale plant. It is typical for the UV vendors to use bench scale testing, UV transmittance (UVT), contaminant removal goals, and computational fluid dynamics (CFD) modeling to size the UV systems. Therefore, the UV system for the AWP Facility is sized for the 1 MGD plant capacity and to achieve the NDMA and 1,4-dioxane reduction requirements in the 2008 draft CDPH regulations. The primary goal of the AWP Facility AOP system is to focus on demonstrating AOP effectiveness at the 1 MGD capacity to prove the required removal efficiencies to gain public acceptance.

It should be noted, it is not the goal of the UV/AOP demonstration testing to validate reactor performance for the potential the future full-scale AWP Facility. Validation testing of the exact reactor configuration designed for the full-scale AWP Facility would be required during plant commissioning. This would include verification the UV/AOP system can achieve log removal requirements for NDMA and 1, 4 dioxane as specified in the August 4, 2008 CDPH Draft Groundwater Recharge Regulations. **Appendix C** contains a TM provided by the project team to the City on May 21, 2010 which describes the selection process of the specific UV / AOP system unit to be tested as part of the demonstration testing. The City provided this memorandum to CDPH in June 2010 for review and comment.

3.3 Description of Certified Laboratories

For thorough water quality analysis, several different laboratories were selected to conduct analysis of samples collected during the demonstration period, which include MWH Laboratories, Weck Laboratories, Biovir Laboratories, and the AQWATEC Laboratory at the Colorado School of Mines. In addition, Laboratory Data Consultants, Inc. (LDC) was selected to perform data validation of the laboratory analyses. Selecting multiple laboratories allows for specific analysis to be performed by labs that specialize in that area, increasing accuracy and lowering detection levels. Additionally, multiple laboratories allows for labs with overlapping capabilities to perform redundant analysis for increased quality assurance (QA)/quality control (QC), via split sampling.

The commercial and specialty laboratories that will be used over the course of the testing period to perform water quality analysis per the T&M Plan are presented in **Section 5**. **Table 3-3** identifies the laboratories to be used, and provides specific information on their credentials and types of analysis they will perform as part of the test plan. The laboratories performing analysis of regulated compounds will utilize EPA-approved methods. Laboratories performing analysis on non-regulated compounds (e.g., CECs) were carefully selected based on use of peer-reviewed methods utilizing state of the art analytical equipment. Laboratory analysis data validation will be performed by LDC, Inc. as described in **Section 7.5**.

Table 3-3
Water Quality Analysis Laboratories and Data Validation

Laboratory Name and Address	Certifications / Credentials	Area of Specialty	Analysis to be Performed
MWH Laboratories 750 Royal Oaks Dr, Ste 100 Monrovia, CA 91016	CDPH NELAP USEPA UCMR2 WaterRF project 4176 – Principal Investigator	Potable and recycled water analysis, CECs	CECs UCMR3 QC Weck Lab Analysis
Weck Laboratories, Inc. 1489 E. Clark Ave City of Industry, CA 91745	CDPH NELAP USEPA UCMR2 California MBE	Water, soil, and hazardous waste analysis	General Parameters Federal and CA MCLs Priority Pollutants CDPH Notification Limits AOP Byproducts
Biovir Laboratories, Inc. 685 Stone Rd, Unit 6 Benicia, CA 94510	NELAC CDPH NELAP	Water microbiology	Coliphage
Colorado School of the Mines, Environmental Science and Engineering Dept / AQWATEC 1500 Illinois St Golden, CO 80401		Water quality issues and engineering solutions in indirect potable reuse	QC MWH CEC analysis
LDC, Inc. 7750 El Camino Real, Ste 2L Carlsbad, CA 92009	State of CA Certified Small Business	Data quality, data validation, and environmental chemistry	Laboratory sampling data validation
On-Site Laboratory Components	NA	Continuous process performance monitoring	Routine analysis of general water quality and process performance parameters

3.4 On-site Lab Description

The AWP Facility will include an operations trailer which will be used to house desks, lap top computers, filing cabinets and phones for on-site operations staff as well as an on-site laboratory. The on–site lab will be used to perform routine water quality analysis as identified in **Section 5**.

3.5 Description of AWP Facility Process Equipment

The following section describes the major AWP Facility process equipment including the MF/UF systems, RO systems and the UV/AOP system. Information is also provided for ancillary equipment including strainers, chemical dosing systems, and on-line water quality monitoring instrumentation.

3.5.1 Pre-Filtration System

A pre-filter system will be used upstream of the MF/UF systems to remove particles present in the NCWRP tertiary water. Specifications for the filtration system are provided in **Table 3-4.**

Table 3-4
Technical Specification Pre-filtration System

Parameter	Unit	Toray	Pall
Manufacturer		Amiad	Amiad
Model	---	SAF 3000	Filtomat 014C
Maximum Flow Rate	USgpm	660	350
Minimum working pressure	psi	30	30
Maximum working pressure	psi	150	150
Filter Area	in2	465	232.5
Screen size	micron	150	300
Inlet / Outlet diameter	in	(3”, 4”, 6”)	(3”, 4”)
Maximum Temperature	°C	50	55
Weight (empty)	lb	232 (3”)	66 (3”)

3.5.2 MF/UF Systems

The MF system utilizes the Aria Water Treatment System manufactured by Pall Corporation (Port Washington, NY). The UF system is designed around a standardized skid(s) configuration which can accommodate several manufacturers’ membranes. Initially, UF membranes manufactured by Toray will be used and tested. The skid system has been designed and supplied by H2O Innovation (Poway, CA).

The major components of the MF/UF system are:

- MF/UF Skids;
- Reverse Flow system comprised of a reverse flow pump, reverse flow storage tank, pressure sensors and pressure switches;
- Compressed Air system comprised of rotary screw compressor, air receiver tanks, coalescing filters, pressure gauges, flow meters;
- Chemical, Hot Water and Neutralization System comprised of recirculation tank, heater, hot water transfer pumps, chemical transfer pump, flow switches, temperature gauges and transmitters and control panel;
- Chlorine injection system comprised of chlorine dosing pump, dilution tank, containment tank and calibration column;

- Sodium Metabisulfate feed system comprised of dosing pump, dilution tank, containment tank and calibration column; and
- Coagulant feed system comprised of dosing pump, dilution tank and containment tank.

The skids will be painted steel frames. **Table 3-5** provides general specifications for the MF/UF membranes.

Table 3-5
MF and UF Membrane Specifications

Manufacturer	Pall	Toray
Mode of Operation	Pressured/ Outside-in	Pressured/ Outside-in
Type	Aria packaged model AP-6	Toray membranes in standard skid
No. of Fibers per Module	6,350	
Membrane area per module	538 sq ft	775 sq ft
No. of modules per unit	48	32
Dimensions of modules	6” diameter x 80” long	
Removal Rating/Nominal pore size	0.1 um	0.02 um
Membrane material	PVDF	PVDF
Min/Max inlet Pressure	15/45 psi	15/45 psi
Maximum Operating Temperature	40 ° C	40 ° C

3.5.3 RO System

The major components of the RO system are:

- RO Skid;
- High Pressure Feed Pumps;
- Chemical pre-treatment anti-scalant system comprised of anti-scalant chemical pumps, chemical tank;
- Cleaning system comprised of RO cleaning storage tank, cleaning pump, immersion heater, bag filter unit, flow meters, pressure gauges and indicators, temperature gauges and indicators;
- Permeate flushing system comprised of a storage tank, flow meter and flushing pump;
- Sampling Panel; and
- Control Panel.

Skid Configuration

The RO system will consist of two independent trains housed on one skid designed and supplied by Enaqua (Poway, CA). The skids are composed of structural steel with baked epoxy and powdered coated for corrosion resistance. **Table 3-6** provides specifications of the RO skid.

Table 3-6
Technical Specification RO Membrane Skid

Parameter	**Unit**	**Value**
Approximate Dimension (LXWXH)	Feet	25X9X9
Number of Passes	----	1
Number of Trains	----	2
Train 1 array	----	11x6
Train 2 array	----	11x6x3
Train 1 Membranes per vessel	----	7
Train 2 Membranes per vessel	----	6

RO Membranes

Specifications for the RO membranes to be tested during the demonstration period are provided in **Table 3-7.**

Table 3-7
Technical Specification RO Membranes

Parameter	**Unit**	**Hydranautics**	**Toray**
Commercial designation	‘------	ESPA2	TML
Membrane Material		Polyamide (thin film composite)	Polyamide (thin film composite)
Nominal membrane area per element	ft2	400	400
Operating pH Range		2-10.6	2-11
Cleaning pH Range		1-12	1-12
Maximum feedwater turbidity	Nephelometric Turbidity Units (NTU)	1	
Maximum feedwater SDI (15 min.with 0.45 micron)		5	5
Maximum Feed Water Chlorine Concentration		<0.1 parts per million (ppm)	ND
Maximum Operating Temperature	°F	113	113
Maximum Operating Pressure	psig	600	600
Spiral Wound Configuration			
Element length	Inches	40	40
Element diameter	Inches	7.89	7.9
Permeate channel diameter (O.D.)	Inches	1.125	1.125

3.5.4 UV-AOP System

The demonstration facility will utilize a UVPhox UV-oxidation treatment system by Trojan Technologies for UV treatment. The UV unit is a LPHO amalgam lamp system. The lamp power can be adjusted between 100% and 60% in 2% increments. General design criteria for the UV/AOP system are provided in **Table 3-8.**

Table 3-8
UV-AOP Design Criteria

Flow Rate	1 MGD
UVT @ 254 nm	95%
Target Contaminant	NDMA
Target Contaminant Reduction	1.2 Log NDMA Reduction
Target Contaminant	1,4 Dioxane
Target Contaminant Reduction	0.5 Log 1,4 Dioxane Reduction
Radical Parent Compound	Hydrogen Peroxide
Parent Compound Dose	3 mg/l

The UV system consists of the following major components:

- Trojan UVPhox Model 72AL75 stainless steel pressure reactor vessel; and
- H_2O_2 dosing and storage skid system – Includes metering pumps, H_2O_2 holding tank with double containment, and remote monitoring equipment.

Specifications for the UV /AOP system are provided in **Table 3-9**.

Table 3-9
Trojan UV System Specification

Parameter	**Unit**	**Value**
Manufacturer		Trojan Technologies, Inc
Model and ID Number		UVPhox Model 72AL75
Inside Diameter of Reactor	Inches	75
Lamp Type		LPHO
Enclosure Dimensions (HxWxD)	Inches	84x48x24
Overall Length	Inches	86
End Cap Diameter	Inches	41
Required end space for service	Inches	72

Table 3-9
Trojan UV System Specification

Parameter	**Unit**	**Value**
Flange Size	Inches	(20,16,12,8)
Maximum Operation Pressure	Psi	65
Number of Lamps		72
Electrical Supply		480V, 3 phase
Approximate Panel Draw	kW	18.5
Weight: Dry/Wet	Lb	2100/3700

3.5.5 Auxiliary Systems

The demonstration facility will include several auxiliary systems including:

- Membrane CIP System (MF/UF and RO)
- Chemical Dosing systems
  1. Anti-Scalant
  2. Sulfuric Acid (if required)
  3. Coagulant (if required)
  4. Pre-formed Chloramines
- On-line Water Quality Monitoring Equipment
  1. Turbidimeters
  2. Conductivity/pH meters
  3. ORP Analyzer
  4. Chlorine Analyzers
  5. Total Organic Carbon (TOC) Analyzer
  6. Ultraviolet Transmittance (UVT) Analyzer

3.6 Integrity Monitoring Experimental Methods

Several integrity monitoring techniques will be employed during the demonstration testing period to assess the integrity of the MF/UF and RO membrane systems. Experimental methods for these techniques to be followed during the test period are provided below. The integrity monitoring plan to be implemented during the testing and monitoring period is provided in **Section 5**. **Additional services related to integrity monitoring included November 30, 2010 Final Draft Testing and Monitoring Plan not in the current scope are provided in Section 8.**

3.6.1 Testing of RO Membranes Prior to Installation

As part of this demonstration testing program, RO membrane suppliers will be requested to provide the project team with vacuum decay or pressure hold test results on all membranes supplied for testing. In accordance to American Society for Testing and Materials (ASTM 2003) D3923-94 the acceptable pressure decay rate for RO membranes is 0.2 bar /minute. The manufacturers will be required to provide documentation that all membrane products meet or exceed these criteria. In addition, manufacturers will be requested to provide wet testing data for each membrane which includes measured salt rejection under set flow and recovery conditions. Lastly, the RO suppliers will also be requested to provide a statement that all membranes supplied for testing were selected randomly from a standard production lot.

3.6.2 Vessel Probing

Following complete installation of the membranes into each of the pressure vessels, conductivity probing will be conducted on each vessel to develop product water conductivity profiles.

The probing method to be employed was adapted from specific testing protocols developed by the project team and individual RO membrane manufacturers. (Adham et al., 1998c; Hydranautics 1998; Film Tec 2003). In general, conductivity measurements are made by taking grab samples at various locations along an individual pressure vessel during operation at set flow conditions. A general schematic of the conductivity probing set up which will be used during the test period is provided in **Figure 3-4.**

Each pressure vessel will be equipped with a ½ inch valve and tube connector located at one end to allow permeate samples to be taken from various locations. The location of each sampling point identified along a vessel (typical) is described in **Table 3-10**. Samples will be collected from each sampling point by letting product water flow for several minutes until values stabilize. Conductivity will be measured using a hand held conductivity meter.

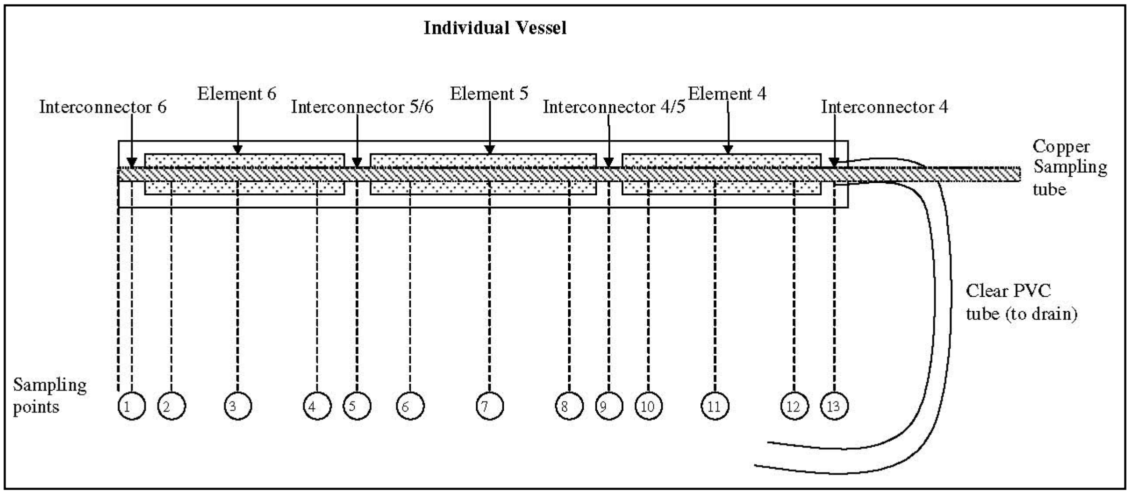

Figure 3-4
Example of RO Vessel Probing Set-up

Table 3-10
Vessel Conductivity Probing Sampling Locations

Location Number	Description	Approx. Distance from edge (Inches)
1	Interconnector 1	3.75
2	Element 1 –12 inch off center	10.75
3	Element 1-center	22.75
4	Element 1-12 inch off center	34.75
5	Interconnector 1/2	42.75
6	Element 2-12 inch off center	50.75
7	Element 2 center	62.75
8	Element 2-12 inch off center	74.75
9	Interconnector 2/3	82.75
10	Element 3-12 inch off center	90.75
11	Element 3-center	102.75
12	Element 3-12 inch off center	114.75
13	Interconnector 3/4	122.75
14	Element 4-12 inch off center	130.75
15	Element 4-center	142.75
16	Element 4-12 inch off center	154.75
17	Interconnector 4/5	162.75
18	Element 5-12 inch off center	170.75
19	Element 5-center	182.75
20	Element 5-12 inch off center	194.75
21	Interconnector 5/6	202.75
22	Element 6-12 inch off center	210.75
23	Element 6-center	222.75
24	Element 6-12 inch off center	234.75
25	Interconnector 6/7	242.75
26	Element 7-12 inch off center	250.75
27	Element 7-center	262.75
28	Element 7-12 inch off center	274.75
29	Interconnector 7	282.75

Section 4
Process Operation, Activities and Schedule

4.1 Operational Test Plan

During the test period, the performance of the various unit processes of the AWP Facility treatment train will be evaluated at different conditions. **Table 4-1** provides values for various operational conditions associated with each unit process to be used over the test period.

Table 4-1
Operational Monitoring Parameters of the AWP Facility Treatment Train

Unit Process	**Operational Criteria**
Microfiltration / Ultrafiltration	*Pre-treatment*
	Pre-screen (300 micron)
	Free or combined chlorine dose = 3 mg/l
	Sulfuric Acid Dose = 0 to 50 mg/L
	Coagulant dose = 0 to 10 mg/L
	Membrane System
	Flow Mode = direct (dead end filtration)
	Maximum Instantaneous Flux = 30 gfd
	Minimum Feedwater Recovery = 95%
	Backwash Frequency = 15 to 30 min.
	Backwash Flow Rate = 520 to 680 gpm for 1 minute
Reverse Osmosis	*Pre-treatment*
	Anti-scalant dosing = 1 to 3 mg/L
RO System 1: Hydranautics ESPA 2	*Membrane System*
	Number of Stages: 2
	Flux (average)= 11.9 gfd
	Feedwater Recovery = 80%
RO System 2: Toray TML20-400	*Membrane System*
	Number of Stages: 3
	Flux (average)= 11.6 gfd
	Feedwater Recovery = 80%

Table 4-1
Operational Monitoring Parameters of the AWP Facility Treatment Train (Cont.)

Ultraviolet / Advanced Oxidation	Influent Flow = 694 gpm
	Type of UV System= LPHO
	Number of Lamps= 72
	Watts per Lamp= 260 W
	Lamp power setting: 60 to 100%
	Hydrogen peroxide dose = 3 mg/L
	Total Power Draw= 18.5 kW

Testing of the AWP Facility is divided into several components including: Testing, Commissioning, and Start-up; Initial Testing Activities; Phase I Testing; Phase II Testing; and Phase III Testing. A description of each testing period is described below.

4.1.1 Testing, Commissioning, and Start-Up

A 30-day period has been designated to testing, commissioning, and start-up of the AWP Facility. A separate Start-Up Procedures and Operational Plan was developed as part of the project. This document includes details on field functional equipment testing, loop checks, system integration, and acceptance testing, equipment QA/QC, and calibration of instruments, gauges and meters.

4.1.2 Initial Testing Activities

A 10 week period has been designated to conducting initial test activities for the AWP Facility.

Tasks to be completed over this period for each unit process are summarized in **Table 4-2**. As shown, the integrity of the membrane systems will be checked by performing Online turbidity monitoring (MF/UF), Pressure Decay Tests (MF/UF), Online conductivity and TOC monitoring (RO) and vessel probing (RO). In addition, the productivity of the new membranes will be established by measuring the flux and pressure of the membranes. Lastly, the UV system will undergo check of the intensity sensor (if required) along with performance of NDMA spiking experiments to establish flow and power settings required for 1.2-log removal of NDMA. These settings will be used for remainder of the testing period.

Table 4-2
Initial Testing Activities

Unit Process	**Testing Activity**
Microfiltration / Ultrafiltration	Pressure Decay Testing
	Flux Testing
	Calibrate Online Turbidimeters
Reverse Osmosis System (s)	Online Conductivity Monitoring
	Vessel Probing
	Set up chloramines dosing system
	Verify Pressure gage accuracy
	Set up online TOC Analyzer
Ultraviolet / Advanced Oxidation	Calibration of online UVT Analyzer
	NDMA Spiking experiment

Phase I Establishment of Baseline Operating Conditions

Phase I testing will include the operation of the Pall MF and Toray UF systems for a runtime of 60 to 90 days to establish baseline operating parameters including coagulant dose, flux, maintenance cleaning requirements and the feedwater recovery of each system. During this time, filtrate from the two low pressure (MF/UF) membrane systems will be combined to provide feed water to two RO systems, which will utilize Toray Model TML20-400 (Train B) and Hydranautics Model ESPA2 (Train A) membranes, respectfully. Product water from the two RO systems will be combined to supply feed water to the UV/AOP system. Upon completion of the Phase I testing period, all membrane systems will be cleaned, regardless of the degree of fouling that has occurred, to allow fouling trends during Phase II to be established using clean membranes.

During the initial period the MF and UF systems will be operated at a nominal flux and water recovery of 30 gallons per square foot per day (gfd) and 95%, respectively. The actual operating conditions will be based on recommendations provided by the manufacturers, based on the NCWRP tertiary water characteristics, historical performance of the membranes on similar waters and technical judgment of parameters that most likely will result in successful long term operation with minimal membrane cleanings. The performance under these conditions will be judged based on the success criteria and action plan shown in **Table 4-3**. During Phase I testing the MF and UF systems will be operated without the use of coagulant addition pretreatment. Should fouling exceed success criteria, coagulant dosing will be required per the manufacturer’s recommendations.

During the initial operating period the Train A and Train B RO systems will be operated with a two and three-stage configuration , respectfully under the flux conditions provided above and an equivalent recovery of 80%. During this time the pH of the feedwater will not be suppressed. Success criteria for the RO systems during Phase I is provided in **Table 4-3**. As shown, if the temperature corrected specific flux either membrane decreases by more that stated limit (after an initial cleaning) and/or the membranes do not produce filtrate total nitrogen (TN) requirement, the recovery for that system may be reduced to 75% for Phase II testing. In addition depending on the type of fouling observed it may be required to suppress the pH of the feed water using sulfuric acid. Note information gained during this time will also be used to adjust operational set points during Phase III of the AWP Facility testing.

During the initial test period the UV/AOP system will be operated under the manufacturers recommend lamp power and peroxide dose settings to achieve 1.2-log removal of NDMA and 0.5-log removal of 1,4-dioxane based on a flow rate of 1 MGD. The performance of the UV/AOP system at various power settings will be verified by conducting spiking experiments. During the initial test period lamp fouling and aging will be assessed per criteria list in **Table 4-3**.

Table 4-3
Phase I Success Criteria / Alternative Action Plan

Measured Parameter	**Success Criteria (30 day runtime)**	**Options if Success Criteria not met**
MF/UF Systems		
Increase in Temperature Corrected TMP	Max. Increase 20% (to be confirmed with mfg) from clean membrane TMP in 720 hours.	Perform CIP. Restart system. Lower flux. Add coagulant pre-treatment Phase II. Add chlorine to backwash (BW). Increase BW frequency
Pressure Decay (daily)	<1 psi /min	Repeat PDT test. Repair broken fibers. Check / repair leaks on air lines / fittings.
Turbidity	Filtrate not to exceed 0.15 NTU. Avg 24 hour <0.10 NTU for 95% of the time.	Perform maintenance / calibration of on-line turbidimeter. Perform PD test. Repair fibers.
SDI (207 kPa, 15 mins., 0.45 micron)	Filtrate < 3	Check / flush filtrate storage tank. Perform PD test. Repair fibers.
RO Systems (Toray TML/Hydranautics ESPA2)		
Decrease in Temperature Corrected Specific Flux	Max. 20% from clean membrane value	Clean membranes. Restart. Increase feed chloramines Reduce recovery Acidify feed

Table 4-3
Phase I Success Criteria / Alternative Action Plan

RO Systems (Toray TML/Hydranautics ESPA2)		
Measured Parameter	**Success Criteria (30 day runtime)**	**Options if Success Criteria not met**
Decrease in conductivity rejection	Max. 0.5%	Profiling and probing of pressure vessels. Clean membranes. Restart if decrease occurs again reduce recovery to 75% for Phase II testing
Increase in Feed to Concentrate Differential Pressure (DP)	Max. 7% from initial conditions	Flush feed lines and feed tank. Clean membranes.
Total Nitrogen	Permeate NTE 0.5 mg/L TN	Reduce recovery. Change RO feedwater pH. Assess need for IX. Check for change in feed water concentration.
UV /AOP System		
Lamp fouling /aging	% drop intensity / delivered dose over 720 hours	Clean lamps; flush feed line, replace lamps if needed
Intensity Sensor	Within set % of reference sensor after 720 hours	Replace sensor.
NDMA	1.2 log removal	Adjust lamp power and / or flow settings. Check feedwater concentration: has it changed?
1,4 Dioxane	0.5 log removal	Adjust lamp power and / or flow settings; increase peroxide dose. Check feedwater concentration: has it changed?
Power Draw	~11 kw	Check power setting. Replace bad ballast(s) or lamp(s)
Hydrogen Peroxide Feed Concentration	3 mg/L	Check dosing pump / measure draw down/ adjust pump speed.

Phase II Steady State Operation

Phase II testing will be conducted over a target runtime of 208 days (~5,000 hours) to collect long term operational and water quality performance data of the MF/UF, and RO systems.

The 5,000 hours is based on target runtime of the MF/RO and UF/RO treatment trains at the design flow rate. The 5,000 hours does not include downtime due to routine shutdowns (e.g. maintenance, testing, cleanings, process modifications, etc. which may take from 2 hours to 36 hours). For example, if after operating for 500 hours of continuous operation any component of a train requires to be taken offline for a routine shutdown requiring 24 hours, upon start up the runtime clock for said train would begin at 500 hours. For non-routine events that result in downtimes exceeding 36 hours, the project team will meet with the City and their Project

Management consultant to discuss the most appropriate option to meeting the target 5,000 hours of runtime. Examples of non-routine event may an upset in the NCWRP that may impact the availability of tertiary water in terms of quantity and/or quality, damage to membranes due to chlorine, or irreversible fouling.

During Phase II a key focus of the RO monitoring will be to compare the nitrogen rejection, operating pressure and overall energy consumption of the two RO systems. The Toray TML membrane is designed for higher nitrate rejection but operates and higher pressure. The Phase II will also allow performance data to be collected on a two-stage versus three-stage system.

Phase III Collect Information on Improving Operational Efficiency

Time allowing, the final phase of the overall 12 month testing will be designated to gaining preliminary information on options for increasing efficiency the of the various unit processes based on information obtained during Phase II. Phase III will occur over an approximately 45 day period. Parameters to be considered include:

- Chemical usage
- Membrane flux, recovery
- Backwashing frequency
- Reduction of UV dose
- Others

Upon completion of Phase III testing, the project team will develop pre-qualification criteria to be considered during procurement of equipment for the full scale facility.

4.2 Chemical Addition

4.2.1 Chlorine Dosing / Ammonium Hydroxide & Preformed Chloramines

During part of the testing phase, it is planned to dose free chlorine upstream of the MF and UF systems followed by ammonium hydroxide immediately downstream to form combined chloramines to inhibit microbial growth through the RO membranes. However, as part of the NDMA and Chloramines Investigation Plan provided in **Section 6**, trials with pre-formed chloramines dosed upstream of the MF/UF systems will also be tested to assess inhibition of NDMA formation. The dose rates will be set to 2 to 3 mg/L combined chlorine in the MF/ UF product.

4.2.2 Acid and Anti-scalant

RO performance projections indicate that fouling from calcium carbonate and calcium phosphate can be controlled for the NCWRP water at an 80% recovery without the use of acid. An acid system will be provided should it be required at any point to maintain stable operation. Acid will be fed upstream of the MR/UF systems to prevent plugging of RO membranes from impurities in the acid solution.

Anti-scalant containing a dispersant will be added to the RO influent to minimize precipitation of soluble salts as well as disperse colloidal fouling. A nominal dose of 1 to 3 mg/L, per the manufacturer's recommendations, will be the starting point for anti-scalant design criteria. At least two different anti-scalants provided by different manufacturers will be tested over the demonstration period, including products from King Lee Technologies (San Diego, CA) and Avista Technologies, Inc. (San Marcos, CA).

4.2.3 Coagulant Dosing

Coagulant dosing will be tested as pretreatment to the UF system to enhance membrane productivity by increasing particle floc size, which can lead to decreased pore plugging, reduce cake layer resistance and increase backwashing efficiency. Typical coagulants and doses provided by the manufactures include Poly Aluminum Chloride at 0.5 – 1 mg/L as Al.

4.2.4 Hydrogen Peroxide Dosing

Hydrogen peroxide will be dosed upstream of the UV system to form free-hydroxyl radicals. These strong oxidizing agents will oxidize trace organics including UV photolysis products which can result in the re-formation of NDMA. The nominal dose of peroxide to be employed during normal operation based on experience at currently operating full scale AWP Facilities is 3 mg/L. However spiking experiments will be conducted to assess the impact of operating with lower peroxide dose on 1,4 dioxane removal. Reduction of peroxide dose may reduce the degree of by-product formation and result in overall O&M savings.

4.2.5 Chemical Cleaning of Membranes

The chemical cleaning of the MF/UF systems typically employs a chlorine soak (250 - 500 mg/L) followed by an acid (pH 2-3) cleaning soak. Each cleaning step includes a rinse and drain cycle before the membrane system is returned to operation. Past studies by the project team have shown the free chlorine residual of the filtrate returned to 0 mg/L after the filtration of 2.0 liters per square meter (L/m^2) per unit membrane area following the chlorine cleaning step and the pH returned to background levels after approximately 18 L/m^2 per unit membrane area following the acid cleaning step. This information will be used as a guideline to determine the need to waste filtrate after start up following a cleaning. Specific cleaning protocols to be followed during the testing period have been provided by the MF and UF system by Pall and Toray, respectfully, and are included in **Appendix E**.

The RO membranes will be cleaned using the manufacturers recommended chemical cleaning procedures. In general, the type and concentration of chemicals used for cleaning RO membranes are specific to the type of fouling. For example, for organic fouling which can occur after long term operation of RO membranes on wastewater, cleaning solutions with a high pH (10 - 11) such as sodium hydroxide, in combination with sodium dodecysulfate, are required. A caustic (high pH) cleaning solution is also effective for removing silicates from RO membranes should silica scaling or fouling occur. However, for inorganic fouling, such as metal oxides, a low pH (4) cleaning using a weak acid such as citric acid is required. Specific cleaning protocols to be followed during the testing period have been provided by the RO membrane suppliers, Toray and Hydranautics, respectfully, are included in **Appendix E.**

4.2.6 Calculated Parameters

Membrane Systems

A number of calculated parameters will be needed to establish the performance of the MF, UF, and RO membrane systems. These calculated parameters are defined as follows:

Transmembrane Pressure (TMP)

The average net driving force for the MF/UF and RO membrane systems will be calculated according to the following equation:

$$P_{net} = \frac{(P_i + P_o)}{2} - P_p - \Delta\pi \qquad (1)$$

where,

P_{net} = net driving force

P_i = pressure at the inlet of the membrane module

P_o = pressure at the outlet of the membrane module

P_p = permeate pressure

$\Delta\pi$ = net osmotic pressure of the feed and permeate

It should be noted that osmotic pressure for the MF and UF membranes is negligible since the membranes do not remove dissolved salts. Hence, the net driving force (Pnet) is referred to as the transmembrane pressure by neglecting the net osmotic pressure term from equation 1. Thus, equation 1 reduces to the following:

$$P_{tm} = \frac{(P_i + P_o)}{2} - P_p \qquad (2)$$

where,

Ptm = transmembrane pressure

For the RO membranes equation 1 will be used to determine net operating pressure. An integrated averaging factor (IAF) assuming 100% salt rejection can be used to estimate the average osmotic pressure as follows:

$$\Delta\pi = IAF\,\pi_f$$

where,

πf = osmotic pressure of the feed stream

IAF = Ln [1/(1-R)] / R, (R = recovery expressed as decimal) = 2.2 (for 85% recovery)

The following approximation can be used to determine osmotic pressure of the feed stream:

- 1,000 mg/L NaCl solution ~ 11.6 psi of osmotic pressure, π

A correlation between NaCl concentration and conductivity can be assumed (1.6 micromhos of conductivity = 1mg/l NaCl)

Temperature Adjustment for Flux Calculation

Temperature correction to 20°C for flux of the MF/UF membranes will be made according to Equation 3, which is based on the variation of water viscosity with temperature:

$$J_{tm}(\text{at}20°\text{C}) \equiv \frac{Qp \times e^{-0.0239\times(T-20)}}{S} \tag{3}$$

Where,

J_{tm} = instantaneous flux, (L/h-m^2)

Q_p = permeate flow, (L/h)

T = temperature, (°C)

S = membrane surface area, (m^2)

Temperature corrections to 25°C for transmembrane flux of the RO membranes will be made according to the manufacturer's temperature correction factors.

Determination of Specific Flux

The specific flux or permeability is the relationship between flux and the net driving pressure. The relationship is defined by the formula:

$$J_{SP} = \frac{J_{tm}}{P_{Net}} \tag{4}$$

where,

J_{SP} = specific flux (lmh/bar)

Likewise, the temperature-corrected specific flux can be calculated using the temperature corrected flux.

Determination of Differential Pressure

Differential pressure of the RO membranes is the difference between the feed pressure and concentrate pressure, calculated as follows:

$$\Delta P = Pf - Pc \tag{5}$$

where,

ΔP = differential pressure

P_p = pressure measured in RO feed

P_c = pressure measured in RO concentrate

Because the differential pressure varies with flow rate and temperature in the spiral wound membrane, values should be normalized to compare measured values with initial values.

Normalized Differential Pressure

Differential pressure of the RO membranes can be normalized with respect to concentrate and permeate as follows:

Where,

$$\Delta Pn = \Delta P \frac{(2 * Q_{c0} + Q_{p0})^{1..5}}{(2 * Q_c + Q_p)^{1.5}} \tag{6}$$

ΔPn = normalized differential pressure (bar)

ΔP = differential pressure (bar)

Q_{c0} = initial concentrate flow (lpm)

Q_{p0} = initial permeate flow (lpm)

Determination of Feed Water Recovery (FWR)

The parameter "feed water recovery" (FWR) represents the net water production of the MF/UF and RO systems. The FWR will be calculated according to the following equation:

$$\text{FWR} = [1 - \frac{\text{Vol. of water wasted}}{\text{Vol. of raw water used}}] \text{ x } 100\% \tag{7}$$

FWR represents the percent recovery of feed water and accounts for: (1) the permeate water used for backwashing and maintenance cleaning of the membranes (MF/UF system only), and (2) the concentrate water bleed (RO system only).

Rejection

The rejection of constituents by MF/UF process will be calculated as follows:

$$R = (1 - \frac{C_P}{C_F}) * 100\ \% \tag{8}$$

Where:

R = Rejection,

C_P = Product water concentration, (mg/L)

C_F = Feed water concentration, (mg/L)

Normalized RO Salt Passage (Rejection)

Because temperature and flow impact salt passage through RO, salt rejection is normalized as follows:

$$\mathrm{SP_n} = (\frac{Q_p}{Q_{p_n}}) * (\frac{STCF_n}{STCF}) * SP \qquad (9)$$

where,

SP_n = normalized salt passage (%)

SP_a = actual salt passage (%)

Qp = permeate flow rate measured at given temperature

Qp_n = permeate flow rate normalized to 25 deg C

$STCF_n$ = salt transport temperature correction factor at 25 deg C

STCF = salt transport temperature correction factor at given temperature

Actual salt passage through RO is impacted by the feedwater recovery and is calculated as follows:

$$\mathrm{SP_a} = (\frac{C_p}{C_{fb}}) \qquad (10)$$

Where,

SP_a = actual salt passage (%)

C_p = permeate concentration (mg/L)

C_{fb} = feed – concentrate concentration (mg/L) = C_f * IAF

R = Salt Rejection = (1 – SP) * 100

4.3 Testing & Activities Schedule

The schedule for the AWP Facility testing program is provided in **Figure 4-1**. The schedule covers a 24-month period and consists of Tasks 1-5, as described below.

Task 1 will include approximately 12-week period dedicated to the installation and start up of the demonstration equipment to be conducted by the project team's construction group. Starts up activities to be conducted for the 15-day period following equipment installation include: field functional equipment testing, loop checks, and system integration.

Task 2 includes a 12-month testing period of the AWPF which includes four phases. During the initial testing phase (10-weeks) specific testing, as provided in **Figure 4-1,** will be conducted to ensure the membrane processes are intact, determine flow and power settings for the UV/AOP system, optimize chloramines dosing, and assess performance of the systems under "new" conditions. Phase I Testing (12-weeks) is designed to establish baseline operating conditions and performance for each unit process. Specific acceptance criteria and "alterative action" plans for each unit process have been established for this time period as presented in **Table 4-3.** The focus of Phase II testing is to operate the membrane systems for 5,000 hour of operation under steady state conditions to monitor operational and water quality performance. Phase III (time allowing) is planned for 6 weeks to gain additional information on each unit processes based on information obtained during previous testing phase.

Task 3 allocates 6-months to continued operation of the AWP Facility primarily for public tours and education as well as optional additional testing to be conducted at the City's discretion.

Task 4 will span the entire demonstration testing period to assess the operational and water quality performance of the MF, UF, RO and UV/AOP systems. Quarterly progress reports will be produced throughout the 12 month test period. These reports will include valuable information including current performance data on all systems, changes to testing protocols, and overall progress. The PAC members will review the reports to ensure the quality of data and to make any suggestions regarding any necessary changes to the demonstration testing protocols. Should a drastic change occur in performance at any time during the test period the PAC would be notified and provided data immediately via email or telephone to ensure quick feedback on potential cause/solution of the problem. The City will also distribute these reports to the IAP members and Regulatory Agencies for review.

Task 5 allocates 12 months to allow for preparation of the final AWPF. This report shall contain experimental procedures and analytical methods used over the test period, statistical and graphical representation of the results, interpretation of results, regulatory relevance of the results, and optimization of operating conditions.

Other Testing Activities - The schedule also identifies when the various components of the water quality monitoring program and integrity monitoring plan will be implemented. The water quality monitoring plan includes several components including: 1) routine sampling, 2) quarterly sampling, 3) initial CEC monitoring and 4) microbial monitoring As shown in **Figure 4-1**, the routine water quality sampling plan is scheduled to begin 6-weeks after the start of the 12 month test period to allow the treatment systems to stabilize and ensure they are operating at steady state to obtain representative data as recommended by the IAP in comments received on the November 30, 2010 Final Draft Testing and Monitoring Plan. Details on the water quality monitoring program and integrity testing plan are provided in **Section 5**.

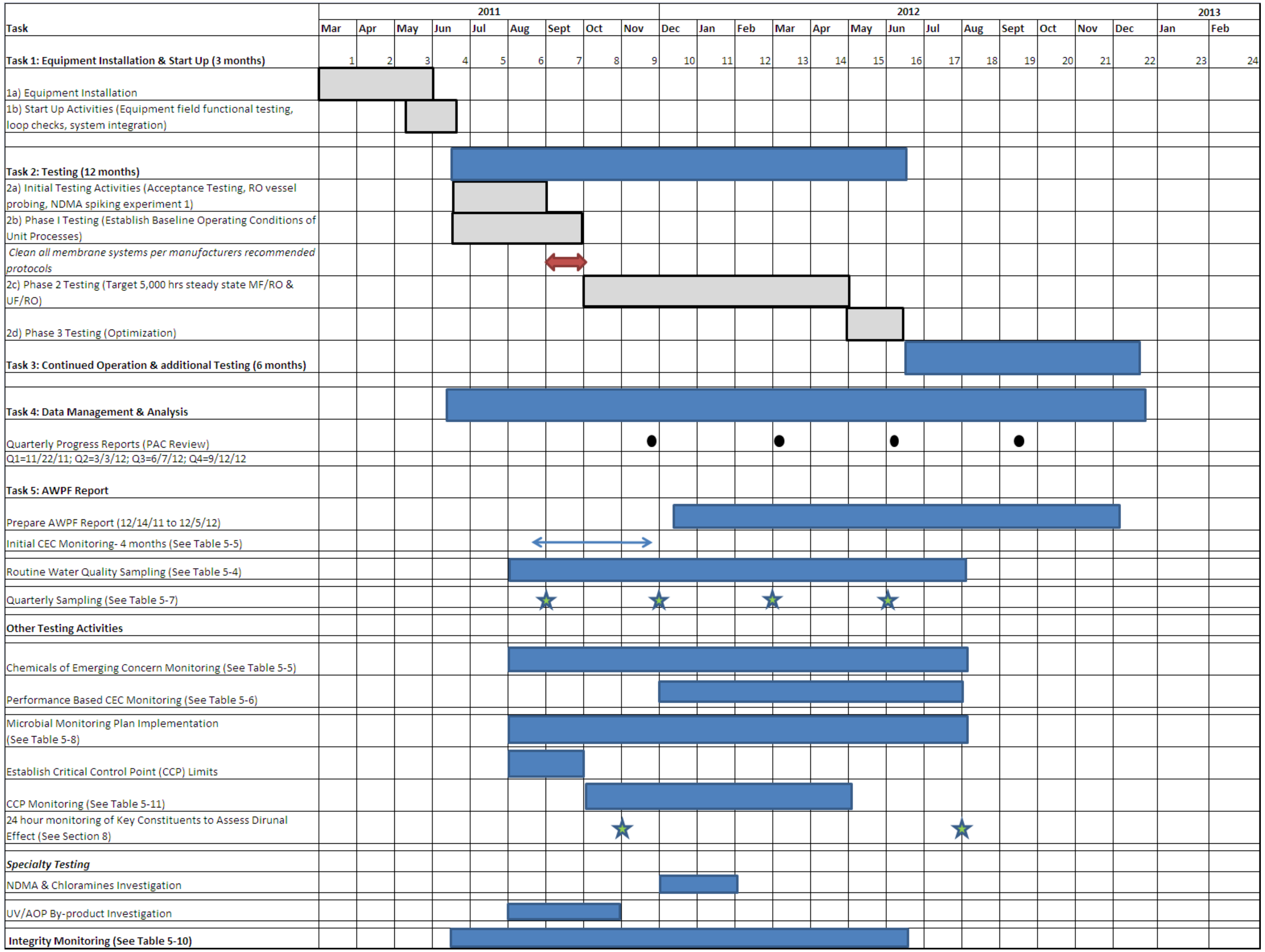

Figure 4-1
Testing Schedule City of San Diego AWP Facility

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4.4 Maintenance Requirements for Test Equipment

The maintenance requirements for the AWP Facility test equipment will be included in the vendor-supplied O&M manuals, which will be included in the Start-Up Procedures and Operational Plan. In general, the O&M manuals for the AWP Facility equipment will include the following information. This outline will be tailored for the specific equipment or skid.

1. System description
2. Installation instruction
3. Operations
    a. Start-up
    b. Shut down
    c. Normal operating conditions
    d. Membrane cleaning
4. Maintenance
    a. Spare Parts
    b. Lubricants
    c. Maintenance Records
5. Troubleshooting
6. Warranty

Table 4-4 summarizes the Demonstration Plant major equipment that will require maintenance during the 18-month operational period. The maintenance procedures for this equipment will be included in the Start-Up Procedures and Operational Plan.

Table 4-4
Demonstration Plant Major Equipment Requiring Maintenance

Skid or Equipment	Equipment Requiring Maintenance
MF Skid	Strainer Valves (automatic and manual) Backwash pump and motor Air compressor system and motor Turbidimeter
UF Skid	Strainer Valves (automatic and manual) Backwash pump and motor Air compressor system Turbidimeter
RO Skid	RO feed pumps and motor RO flush pumps and motor Energy recovery system Flow meters Valves (automatic and manual)
UV Skid	UV lamps, Peroxide dosing system, Intensity Sensor
CIP System	CIP pump and motor CIP tank heater Valves (automatic and manual)
Chemical Systems (sulfuric acid, sodium hypochlorite, ammonium hydroxide, antiscalant, and hydrogen peroxide)	Chemical pumps Anti-Siphon valves Pressure Relief valves
Tanks	Valves Level indicators
Sump Pump	Sump pump and motors
Other	Pressure reducing valves (PRVs) on MF and UF influent piping Flow meters Valves (automatic and manual) Pressure Relief valve
Online Instruments	pH/temperature meter Chlorine analyzer ORP analyzer Conductivity analyzer
Field Instruments and Analytical Equipment	See Table 5-3.

4.5 Residuals Management Plan for Process and Cleaning Wastes

This section identifies the residuals that will be generated from the AWP Facility and how the residuals will be managed. **Table 4-5** identifies the process and cleaning wastes that will be generated from the AWP Facility, the frequency of flow (i.e., continuous or intermittent), and the discharge point.

Table 4-5
Residuals Management Plan for Process and Cleaning Wastes

Process and Cleaning Wastes	Continuous (C) or Intermittent (I)	Discharge Point
MF & UF Skids		
Automatic strainer backwash	I	Hard piped to trench drain, pumped to existing 8” AWT SDR with sump pump
MF/UF backwash	I	Hard piped to existing 8” AWT SDR from the MF and UF skids through overhead piping (not pumped with sump pump), drains by gravity (no back pressure on this line)
Chemically enhanced backwash (CEB)	I	Hard piped to existing 8” AWT SDR from the MF and UF skids (not pumped with sump pump)
RO Skid		
Concentrate	C	Hard piped to existing 8” AWT SDR from the RO skid (not pumped with sump pump)
Permeate flush	I	Hard piped to existing 8” AWT SDR from the RO skid (not pumped with sump pump)
MF/UF filtrate tank and RO permeate tank, drains and overflows	I	Temporary piping to trench drain from tank drain when needed, modulate drain flow with tank drain valve so do not overflow sump, pumped to existing 8” AWT SDR with sump pump
Clean-in-place (CIP) tank, drains and overflows[1]	I	Pumped to the existing 8” AWT SDR from the CIP tank by the CIP pumps
Washdown water	I	Drain by gravity across pad to trench drain, pumped to existing 8” AWT SDR with sump pump
Chemical wastes (residual chemicals remaining at end of plant operational period)	I	If there are residual chemicals at the end of the Demonstration Plant operational period, determine if the City can use them in their process or return to chemical vendors

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Section 5
AWP Facility Process Evaluation

5.1 Operational Performance Monitoring

The operational performance of each unit process will be monitored by taking frequent manual readings and downloading data from the Supervisory Control and Data Acquisition (SCADA) system. **Table 5-1** provides specific parameters to be monitored from each system along with the manual monitoring frequency of each parameter. Parameters collected by SCADA will be recorded every 2 to 5 minutes and downloaded routinely and as needed. The manual data collection sheets to be used for each unit process are provided in **Appendix F**.

Table 5-1
Operational Monitoring Parameters of the AWP Facility Treatment Train

Monitoring Parameter	Location	Frequency
MF/UF Systems		
Temperature	Feed	1/day
Flow Rate	Permeate, backwash, chemical dosing pumps	1/day
Chlorine Concentration	Permeate (Filtrate)	1/day
Pressure (before and after backwash)	Feed, permeate (Filtrate)	1/day
Power	Main supply	1/day
Reverse Osmosis Systems		
Temperature	Feed	2/day
Flow Rate	Permeate (stage 1/ stage 2 / stage 3), combined, acid dosing pump, anti-scalant dosing pump	1/week
Pressure	Feed, permeate, concentrate (Stage 1 / Stage 2 / Stage 3)	2/day
Conductivity	Feed, permeate (stage 1,2 3 and combined)	2/day
Power	Main supply	2/day
UV/AOP System		
[1] Power	Lamp input	2/day
[2]UV Intensity	UV Chamber/Intensity Sensor	2/day
UV Transmittance	Feed	2/day
Flow rate	Feed, peroxide dosing pump	1/day

[1] A power factor adjustment will be requested from Trojan to estimate full scale power usage of the UV/AOP system based on actual power usage of the demonstration system. [2] Once per quarter the accuracy of the online UV intensity sensor will checked using a reference sensor

Operational data collected from the various unit processes will be used to calculate key performance parameters. Membrane fouling associated with the MF, UF and RO systems will be assessed by monitoring temperature corrected specific flux and TMP throughout the test period. A decrease in the temperature corrected specific flux under constant flux operation will indicate membrane fouling is occurring. When the acceptable drop in temperature corrected flux or maximum TMP level has been reached over the specified time period provided in Table 4-3, membrane cleaning will be performed. RO performance will also be assessed by monitoring the feed to concentrate DP normalized to initial DP values. An increase in normalized DP values with operation time will indicate the feed channels of the membranes have become plugged making it necessary to perform membrane cleaning. In addition, the conductivity rejection of the RO membranes will be continuously monitored. A significant decrease in conductivity rejection will necessitate membrane cleaning or repair of damaged o-rings, as appropriate.

Operational data collected from the UV system will be used to assess fouling and aging associated with UV lamps and intensity sensors along with lamp wiper efficiency. On a quarterly basis the UV intensity sensor will be verified using a reference sensor to assess its accuracy.

5.2 Water Quality Performance Monitoring

The following section outlines the specific treated water quality goals of the AWP Facility based on existing recycled water regulations, as well as anticipated future regulatory requirements specific to the City's proposed full-scale AWP Facility, which would be used to augment the current raw drinking water source at San Vicente Reservoir. The overall approach for water quality performance demonstration monitoring is to collect water quality data at different locations throughout the AWP Facility treatment process to analyze process performance, and to compare treated water quality to objectives, screening levels, and existing water supplies. This water quality monitoring program has four main objectives:

- Assess the overall AWP Facility treatment trains ability to meet the established and anticipated treated water quality goals relevant to the full scale AWP Facility surface water augmentation of San Vicente Reservoir.
- Monitor water quality throughout the treatment train to assess performance and efficiency of each unit process.
- Identify CECs in NCWRP tertiary effluent and evaluate removal efficiency of those CECs by the AWP Facility system.
- Compare AWP Facility system end-of-pipe water quality to the water quality of the City's existing raw water supply.

The water quality monitoring will be conducted through sampling and analysis of AWP Facility system water, at various points through the treatment process, by both on-site and off-site laboratory facilities. Water quality parameters that need to bedetermined frequently to control the operation of the treatment process will be analyzed on-site using batch, on-line, and/or portable water quality test units. On-site monitoring will typically be conducted on a daily basis. Water quality parameters that do not require daily monitoring will be analyzed through sampling sent to one of four off-site laboratories. Off-site facilities utilized in this monitoring program will be MWH Labs, Weck Labs, Biovir Labs, and the Colorado School of Mines Laboratory. For a discussion of qualifications and certifications of each of these facilities, refer to **Section 3**.

Individual analytical parameters are chosen for several different reasons as listed:

- Indicators that assist in monitoring AWP Facility performance;
- Federal and/or state regulated constituents;
- Constituents that are monitored at the request of federal and/or state regulators, but not regulated; and
- CECs as identified by the Recycled Water Science Advisory Panel convened by the SWRCB.

The water quality monitoring plan contains four individual components, which are identified below and described in detailed referenced Sections.

- Routine Water Quality Sampling Plan (Section 5.2.2)
- Chemicals of Emerging Concern Monitoring Plan (Section 5.2.3)
- Quarterly Monitoring Plan (Section 5.2.4)
- Microbial Monitoring Plan (Section 5.2.5)

Note: the specific sampling regimes associated with the various components of the overall water quality sampling plan listed above are subject to modification throughout the testing period based on the project team's assessment of analytical results, comments received from the reviewers of the Quarterly Progress reports and development of regulatory requirements for the potential full scale project. Such changes will be documented in the Quarterly Progress reports and adjustments will be made to the existing sampling regime to ensure the overall analytical budget is not exceeded. Changes which require an increase in the analytical budget would be presented to the City for approval prior to implementation.

5.2.1 Treated Water Quality Goals

The City's IPR/RA AWP Facility includes three separately contracted tasks by others that are underway, but not yet completed. These tasks will provide key information that will shape the final regulatory-based water quality goals for the AWP Facility at NCWRP. The three tasks are:

- Defining state and federal regulatory requirements for a full-scale project;
- Performing a limnology and reservoir study for the San Vicente Reservoir, which will provide recommendations related to controls for nutrients; and
- Providing an independent expert review of the technical, scientific, and regulatory aspects of the project by the IAP.

Since this work is still underway, it is not feasible at this time to define the ultimate regulatory-based water quality goals for the demonstration plant. However, proposed interim goals are presented here for review by CDPH, RWQCB and the IAP as described below.

Regulatory Requirements

The overall purpose of the demonstration project is to prove that the AWP Facility meets all federal and state regulatory requirements that would be applied to a full-scale project as permit limits. These requirements would be primarily based on:

- The CDPH requirements for use of recycled water for nonrestricted recreational impoundments. These regulations require that recycled water meet the requirements for disinfected tertiary effluent, which will be met by the AWP Facility based on design.
- Recommendations from CDPH regarding the use of recycled water for surface water augmentation. CDPH is currently developing draft regulations for this use, but has not yet released a draft for public review. For the time being, a reasonable assumption is that the CDPH treatment conditions for the OCWD's GWR System for 100% reuse of advanced treated recycled water for groundwater recharge can be used as interim requirements in evaluating the AWP Facility. These treatment requirements are:
    - Compliance with primary and secondary drinking water maximum contaminant levels (MCLs) in the final recycled water.
    - TN cannot exceed 5 mg/L.

  - TOC cannot exceed 0.5 mg/L divided by the CDPH-specified maximum average Recycled Water Contribution (RWC)[1]. Based on the OCWD's RWC of 100 percent, the TOC cannot exceed 0.5 mg/L.
  - The turbidity of the RO product water cannot exceed 0.2 NTU more than 5 percent of the time in any 24-hour period and can never exceed 0.5 NTU at any time.
  - The RO permeate UV transmittance must be 90 percent or greater at 254 nanometers (nm).
  - The final recycled water must be disinfected such that the 7-day median number of total coliforms cannot exceed 2.2 total coliform bacteria per 100 mL and the number of total coliform organisms cannot exceed 23 total coliform bacteria per 100 mL in more than one sample in any 30-day period.
  - AOP must achieve at a minimum a 1.2 log NDMA reduction and 0.5 log 1,4-dioxane reduction, whether NDMA and 1,4-dixoane are present or not.

- The Basin Plan, including designated beneficial uses of the San Vicente Reservoir, water quality objectives to protect those uses, the state anti-degradation policy for surface water, and toxicity requirements (including applicable federal and state standards). The Basin Plan establishes beneficial uses for surface waters and groundwater in the region and numeric and narrative water quality objectives to protect those uses. Permit limits are established for those constituents that have the reasonable potential to cause or contribute to an excursion above any water quality objective. The Basin Plan allows for a mixing zone (e.g., dilution factor) to be considered for inland surface waters on a case-by-case basis. If a dilution factor is approved, the permit limit (and reasonable potential evaluation) could be based on this simplified modification of the water quality objectives in the Basin Plan[2]:

$$Ce = Co + Dm\,(Co)$$

where
Ce = the effluent limitation
Co = the water quality objective to be met at the completion of initial dilution
Dm = minimum probable initial dilution expressed as parts water per part wastewater (the Dm is not the same as the CDPH RWC)

The designated beneficial uses of San Vicente Reservoir are:

- Municipal and Domestic Supply (MUN).

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[1] The maximum RWC has not yet been established for the project and is dependent on the outcome of the limnology studies.

[2] This calculation does not consider ambient concentrations of constituents. It will be necessary to work out how a mixing zone would be specifically (if at all) with the RWQCB. For example: Ce = Co + Dm (Co – Cs), where Cs is the background surface water concentration (which must be less than the Co).

- Agricultural Supply (AGR).
- Industrial Process Supply (PROC).
- Industrial Service Supply (IND).
- Contact Water Recreation: fishing from shore or boat is permitted, but other water contact recreational (REC-1) uses are prohibited. However, per Section 115840(a) of the Health and Safety Code, CDPH allows the reservoir to be used for body contract recreation, and thus other REC-1 uses apply.
- Non-body Contact Water Recreation (REC-2).
- Warm Freshwater Habitat (WARM).
- Cold Freshwater Habitat (COLD).
- Wildlife Habitat (WILD)
- Applicable numeric water quality objectives in the Basin Plan include: Total dissolved solids (TDS), chloride, sulfate, percent sodium, iron, manganese, boron, turbidity, color, fluoride, nutrients (nitrogen and phosphorus), unionized ammonia, fecal coliform, dissolved oxygen, pH, primary and secondary MCLs, and phenolic compounds. These requirements are presented in **Appendix G**.

Narrative water quality objectives have been established for oil and grease, pesticides, radionuclides, sediment, suspended and settleable solids, taste and odor, temperature, and toxicity.

Narrative and numeric nutrient requirements are included in the Basin Plan. For waste discharge requirements established for reclaimed water discharges to surface water such as the San Vicente Reservoir, the Basin Plan allows the RWQCB to use the phosphorus goal for flowing waters (0.1 mg/L) as a guideline or to determine compliance with the narrative objective using four factors, including use of best available technology (BAT) economically feasible for the removal of nutrients. Additional input on potential nutrient requirements (including phosphorus and nitrogen) will be available in approximately 6 months after completion and review of the limnology study results.

- Water quality criteria established for priority pollutants by the U.S. Environmental Protection Agency (USEPA). The Clean Water Act (CWA) requires states to adopt numeric water quality criteria for those toxic pollutants which the USEPA has issued advisory CWA 304(a) criteria and which may reasonably be expected to interfere with the maintenance of designated beneficial uses. In 1991, California adopted water quality "objectives" (equivalent to the federal "criteria" component of federal water quality standards) for a number (but not all) of the priority pollutants designated by USEPA in the Inland Surface Waters Plan (ISWP) and Enclosed Bays and Estuaries Plan (EBEP). After adoption, USEPA disapproved portions of the plans because California had not had not issued objectives for all of the priority pollutants. In 1992, USEPA promulgated the National Toxics Rule (NTR) to bring non-complying states into compliance with the CWA. The 1992 NTR established federal standards in California for roughly 40 priority pollutants not covered in the ISWP and EBEP. In 1994, the ISWP and EBEP were overturned in state court in due to failure of the SWRCB to comply with state law in adopting the objectives contained in the plans. In 1995, USEPA elected to proceed with adopting the CWA 304(a) water quality criteria for California.

In 2000, USEPA promulgated the California Toxics Rule, that that included aquatic life criteria for 23 priority pollutants and human health criteria for 57 priority pollutants. In adopting criteria in the CTR, the USEPA updated some of the CWA 304(a) criteria based on new or revised reference doses and cancer potency factors and updated aquatic life toxicity data sets. The human health criteria are comprised of two categories. First are the “water and organism” criteria, which are based on a cancer risk of 10^{-6} and an assumed exposure through consumption of drinking water and eating fish. The “water and organism” criteria are applied to protection of MUN beneficial uses. Second are the “organism only” criteria, which are based on a cancer risk of 10^{-6} and an assumed exposure through eating fish. The “organism only” criteria are applied to protection of REC-1 and REC-2 beneficial uses. The aquatic life criteria are based on toxicity and are applied to pertinent wildlife beneficial uses. For any “discharge” to a water of the United States, the most stringent criteria for all beneficial uses must be met. The CTR criteria are presented in **Appendix G**.

- Implementation procedures for the CTR established by the SWRCB through the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SIP). The SIP includes i) procedures to determine which priority pollutants need effluent limitations (e.g., reasonable potential analysis), ii) methods to calculate water quality-based effluent limitations, and iii) policies regarding mixing zones, metals translators, monitoring, pollution prevention, reporting levels for determining compliance, and whole effluent toxicity control. Permit limits are established for those CTR constituents that have the reasonable potential to cause or contribute to an excursion above any applicable criteria including consideration of dilution (Section 1.3 of the SIP). If a dilution factor is approved, the permit limit would be based on this modification of the water quality criteria in addition to other factors as set forth in Section 1.4 of the SIP.

Water Quality Goals for Regulated Constituents

As part of the AWP Facility demonstration study, two types of monitoring activities will be undertaken for regulated parameters:

- Collection of data for all regulated parameters in the final product water and/or designated points in the treatment process. These data will be compared to anticipated limits. It is expected that for the most part, these constituents will be below reporting levels.
- Targeted collection of data for key regulated compounds (target constituents) to optimize treatment as discussed below.

A review of pilot plant data collected for the City of San Diego Advanced Water Treatment Research Studies (MWH, 2007), provides insight on those regulated compounds that should be more closely evaluated for the demonstration testing (e.g., those compounds that potentially provide a challenge to the treatment process). The goals established for the proposed target constituents will differ from the regulated limits. These goals have been established to ensure optimization of the various treatment processes rather than to establish specific goals for a future full scale AWP Facility. It is expected that additional input will be provided on target constituents based on review by CDPH and the IAP.

Table 5-2 presents a preliminary set of target constituents, anticipated regulatory requirements and proposed demonstration goals.

Table 5-2 Anticipated Water Quality Goals for Regulated Constituents: San Diego AWP Facility

Constituent	Units	Proposed Demonstration Goal (average)	Anticipated Regulatory Limit (maximum)	Basis	Critical Beneficial Use/Issue
Total organic carbon (TOC)	mg/L	0.5	[1]0.5	CDPH	MUN
Ammonia (unionized as N)	ug/L	25	25 or Ce=25+Dm(25)	Basin Plan	Habitat
Nitrate (as N)	mg/L	[2]1	10 or Ce=10+Dm(10)	CDPH & Basin Plan	MUN
Total nitrogen	ug/L	[2]1000	[1]5000	CDPH	MUN
			[1,2]1000	Basin Plan	Biostimulation
Total phosphorus	ug/L	[2]100	[1,2]100	Basin Plan	Biostimulation
N-nitrodisodimethylamine (NDMA)	Log reduction	> 1.2-log	[1]1.2- log	CDPH	MUN
	ng/L	Not detected	[3]0.69 or Ce=0.69+Dm(0.69)	CTR/SIP	
1,4-Dioxane	Log reduction	> 0.5-log	[1]0.5- log	CDPH	MUN
1,2-Dichloroethane	ug/L	< 0.38	[3]0.38 or Ce=0.38+Dm(0.38)	California Toxics Rule	MUN
Total trihalomethanes	ug/L	< 80	[1]80	CDPH	MUN
Bromoform	ug/L	Not detected	[3]4.3 or Ce=4.3+Dm(4.3)	California Toxics Rule	MUN
Chlorodibromomethane	ug/L	Not detected	[3]0.401 or Ce=0.401+Dm(0.401)	California Toxics Rule	MUN
Dichlorobromomethane	ug/L	Not detected	[3]0.56 or Ce=0.56+Dm(0.56)	California Toxics Rule	MUN
Halo acetic acid (HAA)	ug/L	< 60	[1]60	CDPH	MUN
Methylene chloride	ug/L	< 4.7	[3]4.7 or Ce=4.7+Dm(4.7)	California Toxics Rule	MUN
Turbidity	NTU	< 0.2	[1]0.2	CDPH	MUN
Chloride	mg/L	50	[3]50 or Ce=50+Dm(50)	Basin Plan	MUN
Total dissolved solids (TDS)	mg/L	300	[3]300 or Ce=300+Dm(300)	Basin Plan	MUN

1. Potential limit based on best available information developed to date. Value subject to change.
2. Tentative goals based on providing best available treatment economically achievable and achieving Basin Plan total nitrogen and total phosphorus objectives for flowing waters.
3. Based on simplified version for determining California Toxics Rule (CTR) permit limits for priority pollutants. Section 1.4 of the State Implementation Plan contains specific steps and procedures that take into consideration ambient background concentration, the coefficient of variation of measured concentration data, and dilution credit. In some cases, the calculated effluent limitation can be lower than the CTR criterion. Ce - effluent concentration; Dm – dilution factor.

5.2.2 Routine Water Quality Sampling Plan

Table 5-3 and **Table 5-4** present a routine sampling plan which includes parameters that will be measured on-site using handheld and on-site lab equipment along with parameters that will measured by outside certified laboratories, respectfully. Routine sampling is intended to assess performance and control of individual unit processes as well as collect characterization data on NCWRP tertiary water. The routine sampling regime proposed in **Table 5-4** has been developed to assess the ability of the AWP Facility to meet the initial water quality objectives provided in **Table 5-2**. The proposed specific parameters, target demonstration goals, sampling frequency and sample collection methods are based on the following:

1. Input received to date on the anticipated regulatory requirements for the potential full scale AWP facility;

2. Information required to assess treatment performance;

3. Information required to support future permit applications for the potential full scale AWP Facility;

4. Compare the water quality performance of the two RO Systems;

5. Data typically required by CDPH and RWQCB as part of compliance for similar discharges.

Sample locations are defined in the process flow diagram provided in **Figure 5-1** below.

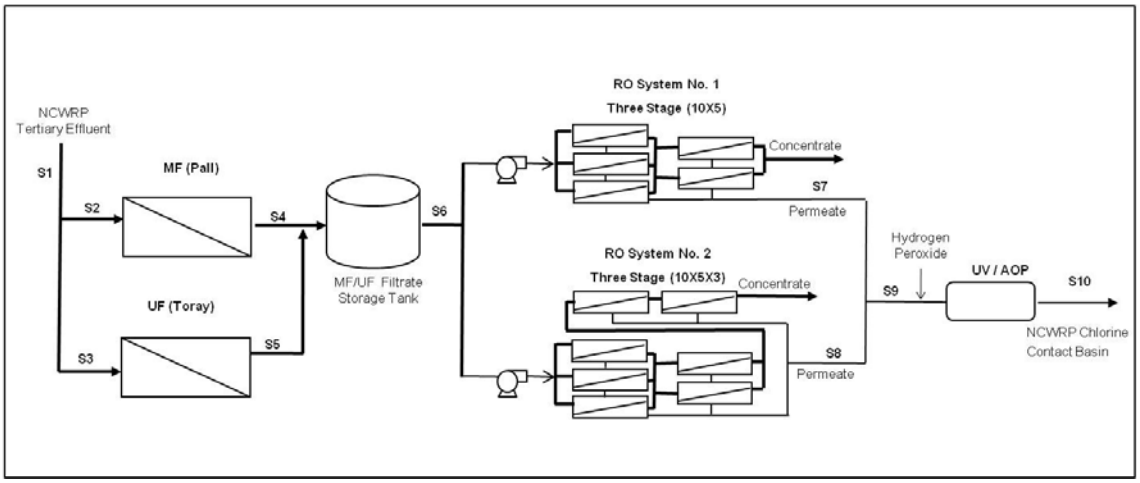

Figure 5-1
AWPF Process Schematic

As indicated in Table 5-3, a portable low range TOC analyzer (dynamic operating range of 0.03 parts per billion [ppb] to 50 ppm) will be used to monitor TOC concentrations at various points in the AWP treatment train to identify any large variations in measured concentrations which would indicate a change in the NCWRP tertiary water quality and / or possible integrity breach of the AWP Facility unit processes(s). The portable unit will be set up for on-line measurement (similar to OCWD Groundwater Replenishment System) of TOC in the RO combined product water. The portable unit will also be used to measure grab samples taken daily from various locations of the AWP train. It should be noted the location of the on-line TOC analyzer may be moved to other locations in the train i.e. RO feed for a short time during the testing period to capture continuous TOC data.

Table 5-3
On-site Routine Water Quality Monitoring Plan for the San Diego AWP Facility

Analyte / Contaminant Group	[1]Sampling Location(s)	[2] Initial Sampling Frequency	Sampling Equipment/ Method	Sample Type
On-site				
Temperature	S1, S6, S9, S10	daily	Portable meter HACH SensION156	Grab
pH	S1, S6, S9, S10	daily	Portable meter HACH SensION156	Grab
Turbidity	S1,S4,S5,S6, S9, S10	daily	HACH 2100 Q Portable Turbidimeter)	Grab
Turbidity	S1, S4,S5	continuous	Turbidimeter (HACH 1720D / FilterTrack 660)	On-line
UV 254	S1, S4, S5, S6, S7, S8	1/week	Spectrophotometer (HACH)	Grab
UV 254	S9, S10	daily	Spectrophotometer (HACH)	Grab
[3]TOC	S7, S8, S10	weekly	[2] GE Sievers 900 Portable TOC Analyzer	Grab
[3]TOC	S6,S9	daily	GE Sievers 900 Portable TOC Analyzer	[4]Grab/Online
Dissolved Oxygen (DO)	S10	weekly	Portable meter HACH SensION156	Grab
Conductivity	S6, S7, S8	daily	Conductivity probe	Online
Conductivity	S6, S7, S8	weekly	Portable meter HACH SensION156	Grab
Silt Density Index	S6	1/week	ASTM D4189	Grab
Total Chorine Residual	S4/S5 combined	daily	HACH CL-17	On-line
Total Chorine Residual	S1, S3, S6, S9, S10	daily	Chlorine Pocket Colorimeter HACH	Grab
Free Chorine Residual	S6	daily	Chlorine Pocket Colorimeter HACH	Grab

1. Sampling locations are shown in Figure 5-1.
2. Sampling frequencies / locations will be reassessed periodically.
3. Dynamic operating range is 0.03 ppb to 50 ppm.
4. S9 to be monitored on-line all other sampling locations via grab sampling.

Table 5-4
Certified Laboratory Routine Water Quality Monitoring Plan for the San Diego AWP Facility

Constituent	[1] Sample Location	[2,3] Type of Sample	[4] Analytical Method	Monitoring Frequency	[5] Total Number of Samples per location
Total organic carbon (TOC)	S6, S7, S8	Grab	SM5310C	Monthly	3
TOC	S9	24-Hour Composite	SM5310C	Monthly	12
TOC	S10	24-Hour Composite	SM5310C	2 per week	104
Ammonia Nitrogen	S6, S7, S8	Grab	EPA 350.1	Bi-weekly (once per 2 weeks	6
Ammonia Nitrogen	S9	24-Hour Composite	EPA 350.1	Bi-weekly (once per 2 weeks	26
Ammonia Nitrogen	S10	24-Hour Composite	EPA 350.1	2 per week	104
Nitrate / Nitrite	S6, S7, S8	Grab	EPA 353.2	[5] Bi-weekly (once per 2 weeks	6
Nitrate / Nitrite	S9	24-Hour Composite	EPA 353.2	[5] Bi-weekly (once per 2 weeks	26
Nitrate / Nitrite	S10	24-Hour Composite	EPA 353.2	2 per week	104
Total Nitrogen	S6, S7, S8	Grab	Various (Determined by Calculation)	[5] Bi-weekly (once per 2 weeks)	6
Total Nitrogen	S9	24-Hour Composite	Various (Determined by Calculation)	[5] Bi-weekly (once per 2 weeks)	26
Total Nitrogen	S10	24-Hour Composite	Various (Determined by Calculation)	2 per week	104
Total phosphorus	S6, S7, S8	Grab	EPA 365.1	[5] Bi-weekly (once per 2 weeks)	104
Total phosphorus	S9	24-Hour Composite	EPA 365.1	[5] Bi-weekly (once per 2 weeks)	6
Total phosphorus	S10	24-Hour Composite	EPA 365.1	2 per week	26
Nitrosamines	S1, S6	Grab	EPA 521	Monthly	12

1. Sampling locations are shown in Figure 5-1.
2. All samples to be taken as grab samples for the initial 2 months due to delays in the receipt and installation of auto-samplers.
3. Composite samples to be collected on a time weighted basis.
4. MDLs, RLs, TATs, sample hold times for each method are provided in Appendix I.
5. Total samples based on a sampling period of 3 months (S6, S7, S8) and 12 months (S1, S9 and S10).

Table 5-4
Certified Laboratory Routine Water Quality Monitoring Plan for the San Diego AWP Facility (Cont.)

Constituent	[1] Sample Location	[2,3] Type of Sample	[4] Analytical Method	Monitoring Frequency	[5] Total Number of Samples per location
Nitrosamines	S7, S8	Grab	EPA 521	Monthly	3
Nitrosamines	S9, S10	24-Hour Composite	EPA 521	Monthly	12
1,4-Dioxane	S6, S7, S8	Grab	EPA 3520C	Monthly	3
1,4-Dioxane	S9, S10	24-Hour Composite	EPA 3520C	Monthly	12
[6]VOCs	S1, S9, S10	Grab	EPA 524.2	Monthly	12
Halo acetic acids (HAA5)	S1, S6	Grab	EPA 552.2	Monthly	12
Halo acetic acids (HAA5)	S7, S8	Grab	EPA 552.2	Monthly	3
Halo acetic acids (HAA5)	S9, S10	24-Hour Composite	EPA 552.2	Monthly	12
Phenols	S10	24-Hour Composite	EPA 8270-SM	Monthly	12
Chloride, Fluoride, Sulfate	S6, S7, S8	Grab	EPA 300.0	Bi-weekly (once per 2 weeks	6
Chloride, Fluoride, Sulfate	S10	24-Hour Composite	EPA 300.0	Bi-weekly (once per 2 weeks	26
Total dissolved solids (TDS)	S6, S7, S8	Grab	SM 2540C	Bi-weekly (once per 2 weeks	3
Total dissolved solids (TDS)	S10	24-Hour Composite	SM 2540C	Bi-weekly (once per 2 weeks	26
Metals (Fe, Na, Mn, B)	S10	24-Hour Composite	SM 2540C	Bi-weekly (once per 2 weeks	26
Color	S10	24-Hour Composite	SM 2540C	Bi-weekly (once per 2 weeks	26

1. Sampling locations are shown in Figure 5-1.
2. All samples to be taken as grab samples for the initial 2 months due to delays in the receipt and installation of auto-samplers.
3. Composite samples to be collected on a time weighted basis.
4. MDLs, RLs, TATs, sample hold times for each method are provided in Appendix I.
5. Total samples based on a sampling period of 3 months (S6, S7, S8) and 12 months (S1, S9 and S10).
6. Include: 1,2 dichloroethane, methylene chloride, tri-halomethanes (THM).

5.2.3 Chemicals of Emerging Concern Monitoring Plan

5.2.3.1 Background

The SWRCB adopted a Recycled Water Policy in February 2009 with the purpose of providing permitting clarity to California projects that use recycled water for non-potable landscape irrigation and for groundwater recharge (surface spreading and injection). The Policy did not address projects that use recycled water for surface water augmentation. A key component of the Policy was how to address new classes of chemicals referred to as CECs. CECs include pharmaceuticals, current use pesticides, and industrial chemicals. Many CECs are potentially present in recycled water however the detection of many is so recent that robust methods for their quantification and toxicological data for interpreting potential human or ecosystem health effects are unavailable.

Under the Recycled Water Policy, the SWRCB established a Science Advisory Panel (SAP) to provide guidance for developing monitoring programs that assess potential CEC threats to human and aquatic.

The SAP included six panel members versed in a mix of disciplines: chemistry, biochemistry, toxicology, epidemiology, risk assessment, and engineering. During September of 2009 and May 2010, four in person meetings and several conference calls occurred. These meetings were designed to allow for stakeholder input to clarify the SAP's charge, exchange information, dialog with the SAP, and allow considerations of public comments in the report. Overall four products were developed by the SAP to assist the SWRCB to refine the direction of the Recycled Water Policy regarding CEC monitoring (SWRCB, 2010):

Product 1 - Conceptual Framework to determine which CEC's to monitor

1) Measured Environmental Concentration (MEC) of CECS in source water (secondary or tertiary effluent) for reuse projects

2) Monitoring Trigger Level (MTL) for each compound or group of compounds based on toxicological relevance

3) Compare MEC to MTL. CECs with MEC/MTL > 1 should be prioritized for monitoring. CECs with a ratio of less than "1" should only be considered if they represent viable treatment process performance indicators; and,

4) Screen the list from step 3 to ensure that a commercially-available robust analytical method is available for that compound.

Product 2 - Application of the framework to identify a list of chemicals that should presently be monitored

1) Through a survey that was shared with Californian stakeholders, the SAP compiled available California MEC data. In this effort, the SAP made conservative assumptions on MEC's: 1) that reported concentrations were representative of the

entire state and 2) that analytical methods used to quantify data are accurate – these two assumptions maximized the number of candidate chemicals that are toxicologically relevant.

2) For groundwater recharge projects (e.g., surface spreading, direct injection), four compounds were identified as possible indicator compound based on their toxicological relevance. In addition, four additional CECs were identified for surface spreading and direct injection operations as viable performance indicator compounds along with certain surrogate parameters (e.g., ammonia, dissolved organic carbon, conductivity). The SAP also recommended method reporting levels (MRLs) that were compound specific and that ranged from 1 to 100 ng/L for the following CECs.

   Indicator compounds based on toxicological relevance:

   a. NDMA,

   b. 17beta-estradiol

   c. Caffeine

   d. Triclosan

   Performance Indicators:

   a. DEET (N,N-Diethyl-meta-toluamide)

   b. Gemfibrozil

   c. Iopromide

   d. Sucralose

The SAP believed it was critical to emphasize that if a compound exceeds its respective MTL at the point of monitoring (POM), the finding does not necessarily indicate a public health risk. The MEC/MTL framework was only developed for the purpose of prioritizing CECs for monitoring. The SAP's proposed MEC/MTL ratios should not be used to make predictions about risk.

Lastly, the SAP strongly recommended to the SWRCB to reapply the prioritization process on at least a triennial basis. The regular review process would fill data gaps for compounds with little or no occurrence and toxicological information in California. In order to fill data gaps for CECs with limited or no information on MECs in California, the SAP suggested that the State initially conduct a more thorough review of CECs likely to occur in recycled water using MEC and predicted environmental concentration (PEC) data from the peer-reviewed literature and occurrence studies outside California. Those CECs that exhibit MEC/MTL ratios above “1” could be placed on a secondary monitoring list that is measured less frequently to confirm absence or presence of these CEC in California. In addition, this secondary monitoring list could be populated by CECs that exhibit a relatively low MTL (less than 500 ng/L) but could have the potential to trigger a MEC/MTL ratio of larger than “1”. The Panel suggested monitoring select CECs for which currently no California MECs are available in secondary/tertiary treated effluent but analytical methods exist:

- 1,2,3-Trichloropropane
- Hydrazine
- Quinoline

Product 3 A Sampling design and approach for interpreting results from CEC monitoring programs

The SAP provided recommendations for a phased, performance-based approach for implementing landscape irrigation and groundwater recharge recycled water monitoring programs and multi-tiered framework for interpreting the data. The first phase involves screening that would be initiated at project start-up and continue through the early years of project operation. If a specific CEC consistently exhibits low occurrence, the SAP recommended deleting the CEC from further monitoring provided that production data do not suggest a significant increase in use. If CECs exceed thresholds identified in the report, the SAP recommended moving to a second phase of enhanced monitoring to confirm the presence and frequency of such CEC(s). The third phase, should concentrations continue to be high, would require initiation of source identification and/or toxicology studies. The final phase would involve engineering removal studies and/or modification of plant operation if found to be warranted by the results of the third phase.

Product 4 Priorities for future improvements in monitoring and interpretation of CEC Data

The science of CEC investigation is still in its early stages and the recommended that the State could undertake several activities that would greatly improve both monitoring and data interpretation for recycled water management, including:

- Develop and validate more and better analytical methods to measure CECs in recycled water;
- Encourage development of bioanalytical screening techniques that allow better identification of the “unknown unknown” chemicals; and,

- Develop a process to predict likely environmental concentrations of CECs based on production, use and environmental fate, as a means for prioritizing chemicals on which to focus method development and toxicological investigation.

In addition to these research recommendations, the SAP recommended that the State develop a process to rapidly compile, summarize, and evaluate monitoring data as they become available.

The SWRCB intends to adopt specific recommendations on CEC monitoring for recycled water landscape irrigation and groundwater recharge projects taking into consideration the suggestions from the SAP.[3]

5.2.3.2 Proposed CEC Monitoring Plan for City of San Diego AWP Facility

The project team worked with several SAP members to tailor the overall recommendations of SAP report to produce a monitoring program specific for the City's AWP Facility. The project team acknowledged that the SAP framework was originally not developed for surface water augmentation projects. However, since surface water augmentation requires treatment standards that are similar or potentially more stringent than direct injection projects, applying the SAP framework in concept was deemed appropriate.

In deriving such a monitoring program for the City's AWP Facility, the following aspects were addressed:

- Application of the conceptual framework developed by the SAP to the City's AWP Facility demonstration-scale project
- Comparison of CECs recommended for monitoring identified during the SAP's initial CEC occurrence survey for secondary/tertiary treated effluent in California to CECs quantified in the NCWRP tertiary effluent in the past
- Phased / Performance Based Approach to Monitoring CECs
- Sampling Protocols

Application of SAP Framework to San Diego's AWP Facility

Concentrations of CECs measured in NCWRP tertiary treated effluent based on pilot testing conducted in 2005 are summarized in **Table H-1** (**Appendix H**). The list of CECs has been augmented by chemicals that where identified by the SAP as toxicological relevant. MEC/MTL ratios for each compound based on the SAP report and MEC/MTL values based on average concentrations measured in NCWRP tertiary effluent are also provided in the table. Only two compounds exceed a MEC/MTL

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[3] The SWRCB may adopt recommendation in November 2010.

ratio of 1 and confirm the recommended list of CECs to be included in recycled water monitoring programs as proposed by the SAP.

Table 5-5 provides the proposed CEC monitoring plan for the AWP Demonstration Facility. The overall CEC monitoring plan includes an initial feed water characterization period which includes sampling of the NCWRP tertiary water monthly for the first four months. During this time, samples will be analyzed for a list of ninety-one (91) EDC/PPCP compounds representing a wide range of chemical and physical properties. The sampling locations for this period also include RO feed, combined RO product, UV/AOP product and imported aqueduct water. Information used from the initial characterization period will used to 1) characterize NCWRP tertiary effluent, 2) identify appropriate AWP performance indicator compounds to be monitored on an on-going basis, 3) assess AWP unit process CEC removal performance and 4) compare AWP product water quality to the City's imported raw drinking water. The proposed CEC monitoring plan also includes an initial list of CEC compounds to be monitored on an on-going basis (i.e. sampled quarterly). Currently, the proposed list contains compounds prioritized based on toxicological evidence by the SAP (SWRCB, 2010). These compounds have maximum environmental concentrations (MEC) values that exceeded monitoring trigger limits (MTLs). In addition, the on-going characterization includes specific compounds recommended by the IAP (NWRI, 2010), CDPH and the State Board. As noted in Table 5-4, information obtained from the initial feed water characterization period will be used to make modifications to the list of compounds to be monitored on an on-going basis.

Table 5-5
Proposed CEC Water Quality Monitoring Plan for the San Diego AWP Facility

CEC Contaminant Group	[1] **Sampling Locations**	**Rationale for Monitoring**
Initial Feed Water Characterization (sample monthly for the first four months)		
[2] List of 91 CECs analyzed by MWH Laboratories	S1, S6, S9, S10 Imported Aqueduct Water	- Characterize NCWRP tertiary water. - Identify appropriate indicator constituents. - Assess AWP unit process CEC removal performance. - Compare water quality of AWP to imported water.
1, 4-Dioxane	S1, S6, S9, S10 Imported Aqueduct Water	
NDMA	S1, S6, S9, S10 Imported Aqueduct Water	
[3] ***Preliminary List for On-going Characterization (Quarters 3 and 4)***		
Caffeine	S6, S9, S10	Compounds prioritized based on toxicological evidence. Measured environmental concentration (MEC) greater than monitoring trigger level (MTL), as developed in SWRCB, 2010.
E2 (17β-Estradiol)	S6, S9, S10	
NDMA	S6, S9, S10	
Triclosan	S6, S9, S10	
DEET	S6, S9, S10	[4] IAP Sub-committee Recommendation
Carbamazepine	S6, S9, S10	[4] IAP Sub-committee Recommendation / [5] CDPH
Primidone	S6, S9, S10	[4] IAP Sub-committee Recommendation
PFAA's	S6, S9, S10,	[4] IAP Sub-committee Recommendation
1,4 dioxane	S6, S9, S10	[4] IAP Sub-committee Recommendation / [5] CDPH
UCMR3 (selective)	S6, S9, S10	[4] IAP Sub-committee Recommendation
Hydrazine	S6, S9, S10	[4] IAP Sub-committee Recommendation
Quinoline	S6, S9, S10	[4] IAP Sub-committee Recommendation
Nicotine	S6, S9, S10	[4] IAP Sub-committee Recommendation
Bisphenyl A	S6, S9, S10	[5] CDPH/State Board
Chlorate	S6, S9, S10	
Boron	S6, S9, S10	
Chromium, hexavalent (CrVI)	S6, S9, S10	
Diazinon	S6, S9, S10	
Naphthalene	S6, S9, S10	
Nitrosamines (NDPA, NDEA, NPYR, NMEA)	S6, S9, S10	
1,2,3 Trichloropropane	S6, S9, S10	
TCEP	S6, S9, S10	
Vanadium	S6, S9, S10	

[1] Sample locations shown in Figure 5-1.
[2] List contains pesticides, herbicides, PPCPs see **Appendix I** for complete list. :
[3] Compounds selected for On-going characterization may change based on results of initial feed water characterization.
[4] CECs recommended for monitoring memorandum: Findings and Recommendations of the AWPFr Purification Facility Sub-committee Meeting, November 15, 2010, NWRI (Appendix K).
[5] CDPH letter to State Board September 13, 2010 in response to SWRCB 2010 Report.

Performance-Based Approach to Monitoring CECs

Tables 5-6 provides the proposed initial list of surrogate parameters and indicator CECs to be measured for the performance-based monitoring program for the AWP Facility. This program will be initiated after the first quarter of operation is complete and operating at steady state conditions. During the first four weeks, differentials between RO feed and permeate and UV-AOP feed and final product water will be determined for performance surrogate parameters and performance CEC indicators. The operational set-points for RO (i.e., flux and recovery) and the UV/AOP process (i.e., EEO or dose and H_2O_2 dose) shall be maintained constant. After start-up, monitoring for CEC indicators is reduced to quarterly while surrogate parameters are measured more frequently to demonstrate that the pre-determined differential values can be achieved. After start-up, those operational set-points should be selected that were set during the initial performance evaluations. If set-points are modified, the differentials for surrogate and indicator CECs will need to be determined again. Based on recommendations from the IAP sub-committee (NWRI 2010), the initial list of proposed performance indicators will be re-evaluated based on information obtained from the initial feed water CEC monitoring program provided in Table 5-5.

Additional services related to performance based CEC monitoring based on comments received on the November 30, 2010 Final Draft Testing and Monitoring Plan from the CDPH not in the current Testing and Monitoring scope are described in Section 8.

Table 5-6
Proposed performance-based CEC Monitoring Plan for the San Diego AWP Facility

Parameter	Sampling Locations	Purpose
[1] Initial RO Performance Characterization		
Δ Conductivity (online)	S6, S7, S8	Determine initial differential removal of surrogate parameter for process performance validation.
ΔTOC (daily for 2 weeks)	S6, S7, S8	
ΔDEET (once a week for first four weeks)	S6, S7, S8	Identified for surface spreading and direct injection operations as viable performance indicator compounds along with certain surrogate parameters (SWRCB, 2010).
ΔSucralose (once a week for first four weeks)	S6, S7, S8	
ΔNDMA (once a week for first four weeks)	S6, S7, S8	
ΔCaffeine (once a week for first four weeks)	S6, S7, S8	
[1] Initial UV/AOP Performance Characterization		
[2]ΔUVA-254 nm (daily)	S9, S10	Determine initial differential removal of surrogate parameter for process performance validation.
Δ NDMA (once a week for first four weeks)	S9, S10	Identified for surface spreading and direct injection operations as viable performance indicator compounds along with certain surrogate parameters (SWRCB, 2010).
Δ Total Chloramines (daily)	S9, S10	Determine initial differential removal to assess viability of use as a surrogate parameter for process performance validation.).
***On-going Monitoring to Assure RO Performance* (Quarters 2,3,4)**		
ΔConductivity (online)	S6, S7, S8	Determine differential removal of surrogate parameter for process performance validation
ΔTOC (once a week)	S6, S7, S8	
ΔDEET (every quarter)	S6, S7, S8	
ΔSucralose (every quarter)	S6, S7, S8	
ΔNDMA (every quarter)	S6, S7, S8	
ΔCaffeine (every quarter)	S6, S7, S8	
On-going Monitoring to Assure UV/AOP Performance		
ΔUVA-254 nm (daily)	S9, S10	
Δ NDMA (every quarter)	S9, S10	
[1] Note initial performance characterization is to begin after the first quarter of testing is complete. [2] UV 254 will be measured by grab samples using a HACH DR 4000 Spectrophotometer with 10 cm sample cell to increase accuracy. Values will be compared to UV 254 values calculated from UVT values measured by the on-line analyzer equipped on the feed of the Trojan UV/AOP system. The location of the on-line analyzer will be changed from the feed to product once per day for 1 hour to assess the sensitivity of the on-line analyzer to measure UV 254 removal.		

Sampling Protocols

Methods used to quantify indicator CECs need to meet stringent QA/QC measures, including blanks, replication, and matrix spikes. The SAP recommended the use of isotope-dilution and tandem mass spectrometry whenever possible, for details see

SWRCB (2010). Additional details on specific measure to be taken during sampling of CEC is provided in **Section 7**.

5.2.4 Quarterly Monitoring Plan

Table 5-7 identifies various contaminant groups that will be monitored on a quarterly basis by collecting grab samples from various locations throughout the AWP Facility treatment train. The purpose of the quarterly sampling for various groups are categorized as public health regulatory, reservoir regulatory, and AWP Facility unit process performance.

Quarterly sampling locations will include imported aqueduct water collected by the City staff at the Miramar Water Treatment Plant. This will allow comparison of water quality from the AWP Facility to source waters which supply the City's drinking water facilities. As indicated in Figure 4-1, quarterly sampling will not begin until the AWP Facility unit processes have been stabilized and are operating at steady-state conditions, which is anticipated to be 8 weeks after Phase 1 Testing begins.

Table 5-7
Quarterly Water Quality Monitoring Plan for the San Diego AWP Facility

[1] Contaminant Group	[2,3] Sampling Location(s)	Purpose
Compounds regulated under Federal and State Primary and Secondary Drinking Water Standards.	S1, S10, Imported Aqueduct Water	Public Health Regulatory
Disinfection by-products (trihalomethanes, haloacetic acids, bromated chlorite, NDMA, chlorate).	S1, S6, S9, S10, Imported Aqueduct Water	Public Health / Reservoir Regulatory
Compounds included on USEPA's Priority Pollutant List.	S1, S10, Imported Aqueduct Water	Public Health Regulatory
Compounds with current CDPH Notification Limits.	S1, S10, Imported Aqueduct Water	Public Health Regulatory
Unregulated Contaminant Monitoring Rule (UCMR 3) Proposed Contaminants Assessment Monitoring (List 1).	S1, S10, Imported Aqueduct Water	Public Health Regulatory
TOC, Total Nitrogen, Total Phosphorus.	S1, S10, Imported Aqueduct Water	Public Health / Reservoir Regulatory
Unregulated Radionuclides (cesium -137, iodine 129 & 131).	S1, S10, Imported Aqueduct Water	Public Health
Others: Lithium, Benzo(k)fluroanthene, hexavalent chromium.	S1, S10, Imported Aqueduct Water	Public Health Regulatory
CECs.	See Table 5-5	Public Health Regulatory & AWP performance
Surrogates for Performance Assessments.	See Table 5-6	AWP Unit process performance

[1] Individual compounds comprising each contaminant group and information on analytical methods to be employed for each parameter are provided in Appendix G.
[2] Sampling locations designated S# represent various locations in the AWP Facility treatment train-See Figure 5-1.
[3] All Quarterly samples to be collected as grab samples.

5.2.5 Microbial Monitoring Plan

As stated in the Final IAP report, the ability to demonstrate the selected AWP Facility treatment train provides control of microorganisms is a key component of the testing. Based on specific monitoring recommendations provided in the IAP report and input from the project team's water quality experts, a specific microbial monitoring plan has been developed as described below.

5.2.5.1 Routine Bacteria and Virus Surrogate Sampling

The microbial testing program includes routine sampling of fecal indicator bacteria and virus surrogates for a 12 month monitoring period, as provided in **Table 5-8**. The purpose of the routine microbial sampling regime is to enumerate bacterial and viral surrogates after each step of the AWP Facility train. This will capture seasonal variability of the AWPF performance (if any). The routine bacteria and virus surrogate sampling plan includes the measurement of total and fecal coliform, F-coliphage and Somatic coliphage before and after each treatment stage of the AWPF. After 1-month of data collection, the sampling frequency for parameters being measured daily (e.g., total & fecal coliform) will be reduced to weekly. Likewise, the sampling frequency for parameters being measured weekly (F-coliphage and Somatic coliphage) will be reduced to monthly after 3 months of data collection.

Additional services related to microbial monitoring based on comments received on the November 30, 2010 Final Draft Testing and Monitoring Plan from the IAP not in the current Testing and Monitoring scope are described in Section 8.

Table 5-8
Routine Bacteria and Virus Surrogate Monitoring Plan for the San Diego AWP Facility

Monitoring Parameter	**Units**	**[1]Analytical Methods**	**MDL**	**[2]Sampling Location**							**[3] Initial Sampling Frequency**	**Monitoring Period** (months)
				S1	**S4**	**S5**	**S6**	**S7**	**S8**	**S10**		
Total & Fecal Coliform	MPN	SM 9221B	2/100 ml	√	√	√	√	√	√	√	Daily (Mon-Fri)	12
F-& Somatic coliphage	pfu/ml	EPA 1602	1 /100 ml	√	‘---	‘---	‘---	‘---	‘---	‘---	Weekly	12
F-& Somatic coliphage	pfu/ml	EPA 1601	Presence/Absence in 1000 ml		√	√	√	√	√	√	Weekly	12

[1] TATs, sample hold times for each method are provided in Appendix I.
[2] Sampling locations are shown in Figure 5-1.
[3] Initial sampling frequencies will be reduced to <u>weekly</u> and <u>monthly</u> after the first month and third month of the test period for parameters being measured daily and weekly, respectfully.

5.2.6 Integrity Monitoring Plan

The integrity of the various AWP Facility processes is a crucial aspect of ensuring the overall system meets the water quality objectives, and achieves the multiple barrier concept required by the Department of Public Health. The following section provides a specific Integrity Monitoring Plan (IMP) to be implemented during the demonstration test period. The main purpose of the IMP is to provide a systematic approach to apply existing tools, techniques, and practices that have been developed to monitor and maintain the integrity of the various AWP Facility unit processes. Key components of the plan which have been adopted from published Guidance Manuals (USEPA 2005) and studies (USBR 2000, MWH 2006) follow:

- Confirm and establish baseline performance of each unit process under "intact" conditions prior to start–up;
- Maintain continuous verification of integrity throughout the operational period;
- Implement on-going maintenance and operational practices to mitigate integrity breaches on all unit processes;
- Record and analyze collected integrity data; and
- Develop measurable performance criteria and action plans if changes in performance occur due to breaches in integrity.

A key objective of the AWP Facility demonstration program is to demonstrate the reliability of the membrane processes (MF/UF and RO) to consistently produce, high-quality product water. As a result, an integrity-monitoring plan will be implemented throughout the test period to verify the membrane systems are intact at the onset of testing and assess any degradation of integrity which may occur during long term operation. This will be accomplished by performing different types of direct and indirect monitoring techniques.

5.2.6.1 Integrity Monitoring Methods & Implementation Schedule

A summary of the various integrity methods and techniques to be used for each unit process is provided in **Table 5-9**. Information for each method includes the purpose, frequency of implementation and at what stage(s) in the AWP Facility construction and operation the methods will be employed. Specific information and testing protocols to be used for each method are provided in **Section 3**.

The integrity of the MF and UF systems will be assessed directly by conducting periodic air pressure hold tests. This test can be conducted on several membrane elements (modules) simultaneously; thus, it can test the integrity of a full rack of membrane elements used for full-scale systems. The test is conducted by pressurizing the filtrate side of the membrane lumen after which the pressure will be held and the decay rate will be monitored over time. Minimal loss of the held pressure at the feed side indicates a passed test, while a significant decrease of the held pressure indicates a failed test. The MF and UF systems will include an automated air pressure-hold test function, which can be initiated from the system's control panel. This function will also allow the user to adjust the time interval between tests. In addition to pressure decay, the integrity of the MF/UF will be assessed by continuously monitoring the filtrate turbidity of the system by a highly sensitive turbidity meter. An intact MF/UF membrane is expected to produce product water with turbidity ≤0.2 NTU.

Several methods will be employed at various times during the test period to assess the integrity of the RO membrane systems, which serve as the heart of the overall AWP Facility treatment train. As part of this demonstration testing program, RO membrane suppliers have been be requested to provide the project team with vacuum decay or pressure hold test results on all membranes supplied for testing. In accordance to ASTM D3923-94 the acceptable pressure decay rate for RO membranes is 0.2 bar/minute. After installing the membranes, the integrity of the membrane systems will be assessed by conducting probing of each pressure vessel. This method involves measuring conductivity at various locations along the inside of the RO membrane element's permeate tubes of an individual vessel as the system is operating. Because salts are being rejected in the direction of the feedwater flow a gradual increase in permeate conductivity is expected in intact vessels. A sudden spike or jump in conductivity at a given location inside the permeate tube often indicates a breach in system integrity. Such breaches could be due to membrane defects and/or faulty or misaligned o-rings, interconnectors or end caps.

During the operations phase, RO membrane integrity will be monitored continuously by on-line measurement of electrical conductivity in the feed and permeate. Loss of integrity in the RO membrane elements, o-rings, interconnectors and/or end caps may be detected by detecting an increase in the RO permeate conductivity by this indirect method. In addition, TOC will be monitored in the feed and permeate of the RO systems by taking daily grab samples. Measurement of TOC will be made on-site using a highly sensitive analyzer to allow a higher log removal than the conductivity monitoring method. As an overall integrity check of the RO systems and to detect changes in the NCWRP tertiary water quality, the TOC analyzer will also be used to provide on-line measurement of the combined RO product water.

In addition to the implementation of the methods described above periodic monitoring of select water quality parameters for each unit process will be employed through the test period. This will allow verification of integrity throughout the operational period. The specific parameters selected are based on treatment removal mechanism of each unit process and past performance data, as described in **Section 5**.

Table 5-9
Summary of Integrity Monitoring Methods proposed for the San Diego AWP Facility

Unit Process	Method	Purpose	Plant Stage	Frequency
MF/UF	Pressure Decay Testing	Direct check of membrane integrity	Start up and Operation	1 per 24 hours
MF/UF	On-line turbidity monitoring	Indirect check of membrane integrity	Start Up and Operation	Continuous
RO	Vacuum decay / pressure hold testing	Direct check of membrane integrity (glue lines, tears / holes in membrane material)	Prior to delivery of RO products from suppliers	One time unless used as diagnostic tool for individual elements
RO	Vessel Probing (conductivity)	Indirect check of RO membrane system integrity (o-rings, inter-connectors, end caps, etc.)	Post RO membrane installation and during operation if needed	One time all vessels with periodic checks of individual vessels as needed
RO	Continuous on-line RO permeate conductivity monitoring	Indirect method of checking RO membranes, o-rings, interconnectors and end caps.	Post RO membrane installation and continuously during operation	Continuous
RO	RO permeate TOC monitoring	Indirect method of checking RO membranes, o-rings, interconnectors and end caps.	Post membrane installation and daily during operation	On-line RO product combined. Grab RO feed Daily
MF, UF, RO, UV	[2] Indicator / Surrogate Monitoring	Indirect check of integrity / system performance	Start Up and during Operation	Periodic

[1] Based on guidelines integrity methods used for membrane systems to comply with the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR).[2] See Table 5-5 for specific performance indicators / surrogates to be measured for each unit process throughout the test period.

5.2.7 Critical Control Point Monitoring

A key component of the integrity monitoring plan will be to develop a procedure to identify any change in the performance of the treatment process that can adversely impact the final water quality before the out of specification water leaves the plant. One approach that can be used to assess the performance of the treatment process without the need for end point monitoring is the use of Hazard Analysis and Critical Control Point (HACCP) techniques. HACCP techniques were developed for the food industry and codified in the Guidelines for the Application of the Hazard Analysis Critical Control Point (HACCP) System (Codex Alimentarius, ALINORM 95/13, Annex to Appendix III).

The HACCP process is used to identify specific potential hazard(s) that can be present in the feed to a recycled water treatment process and establish preventative measures for their control. The HACCP process results in the development of a management system that monitors, evaluates and controls the potential hazards, rather than relying on analysis of the final product water quality inspection.

An important part of the HACCP process is the identification of key monitoring points at different stages of the treatment process. Analysis at these monitoring sites can provide information that can be used as a critical control point (CCP) or a quality control point (QCP). The purpose of the critical control point is to monitor a process parameter, such as turbidity, conductivity, power consumption, chlorine residual and total organic carbon that relates to the reduction in concentration of specific hazards at that part of the treatment process. Operational limits are established for these critical control points so that continuous monitoring of the CCP parameters will provide information on how the treatment process is performing on the removal of these parameters.

An important part of this study will be to use the HACCP process to establish CCP's for the dual membrane and AOP process and set performance limits and a set of procedures for corrective actions that would be taken in the event that the limit values are exceeded. **Table 5-10** provides a summary of the CCP monitoring to be conducted as part of Phase II testing. The specific baseline values, alert limits, critical limits and corrective action plans corresponding to each CCP will be established during the Phase I testing period.

Table 5-10
Summary of Critical Control Point Monitoring for the San Diego AWPF

Critical Control Point	Critical Limit Parameter	Monitoring Frequency	[1]Alert Limit	[1]Critical Limit	[1]Corrective Action
MF/UF	Pressure Decay	1 per day	Value above baseline that approaches Critical limit.	1 per 24 hours	Confirm Results. Assess fiber breakage.
RO	TOC UVT	Continuous	% change of measured concentration in combined RO permeate.	Above value which changes LRV.	Monitor individual RO trains. Verify analyzer accuracy. Conduct vessel probing..
UV/AOP	Reactor Power Draw	Continuous	Value above baseline that approach critical limit.	One time unless used as diagnostic tool for individual elements	System alarm and shutdown. Check / replace lamps and/or ballasts.
UV/AOP	Hydrogen peroxide dose rate	1 per day by draw down	Value above baseline that approach critical limit.	Below minimum dose to provide 3 mg/L peroxide.	Check dosing system. Recalibrate pump.

[1] specific limit values and corrective actions to be established during Phase I Testing.

Section 6
Specialty Testing

6.1 Introduction

Several specialty testing evaluations will be conducted during the course of the demonstration testing period. Specific evaluations include:

- Spiking experiments on the UV/AOP system to determine reactor power and hydrogen peroxide set points to achieve 1.2 log removal of NDMA and 0.5 log removal using product water from the RO systems.

- Chloramines and nitrosamines investigations to evaluate and compare sequential versus preformed chloramines application to inhibit organic and biological fouling of the RO systems and assess nitrosamines formation.

- Evaluation of UV/AOP by-products.

The above testing activities were identified based on recommendations and technical issues identified in the IAP report and CDPH comment responses along with input from the project team's PAC. Details on the specific objectives and test methods to be employed for each evaluation are provided below.

6.2 NDMA and 1,4-Dioxane Spiking Experiment

6.2.1 Background/Objective

The testing outlined in this section will demonstrate the specific NDMA and 1,4-Dioxane reduction ability of the AWP Facility UV/AOP process. The design criterion stipulates that the UV System will achieve 1.2 $\log_{10}$ reduction of NDMA and 0.5 log reduction of 1,4-Dioxane at a system peak flow rate of 1 MGD.

The City conducted a pilot test of the proposed AWP Facility train (MWH 2007)) and demonstrated that the effluent water downstream of the NCWRP contained background concentrations of NDMA ranging between 10 to 80 ng/L (10 to 80 parts per trillion [ppt]) that were too low to obtain the necessary resolution to demonstrate the required resolution; therefore, NDMA will be spiked to concentrations between 700 to 1000 ng/L.

Similar to NDMA, concentrations of 1,4-Dioxane are not present in the effluent water at levels to obtain the necessary resolution to demonstrate the required removal rate and therefore 1,4-Dioxane will be spiked. A concentrated NDMA and 1,4-Dioxane solution will be injected upstream of the inline static mixer designed for mixing of hydrogen peroxide.

The specific objectives of the NDMA and 1,4-Dioxane investigation are as follows:

- Establish and confirm manufacturers' reactor power set point to achieve 1.2 log removal of NDMA for the TrojanUVPhox Model 72AL75 UV-AOP system under the design flow and UVT conditions.
- Determine the maximum NDMA log removal rate of the TrojanUVPhox Model 72AL75 UV-AOP system under design flow rate and UVT conditions.
- Collect data on the impact of H2O2 dose on the removal of 1,4-Dioxane by UV/AOP.

6.2.2 Mixing Study

A mixing test to be performed with H2O2 to measure the residence time distribution within the system and determine the equilibration time required for the subsequent tests. The test will determine the relevant hydraulic residence times (HRT) that the experiment should be allowed to run before obtaining samples after a process change. The test involves the following steps:

- H_2O_2will be turned off for a period of 15 minutes prior to the test to ensure that it is flushed from the system. Samples will be collected at the AOP effluent to verify that there is no H_2O_2 residual using a Hydrogen Peroxide Test Kit (HACH Model HYP-1). Once it is verified no $H_2O_2$is present, the test can begin.
- The mixing test will be completed by starting the hydrogen peroxide injection at t=0. H_2O_2will be continuously injected at 3 mg/L into the influent stream with the UV lamps off. Samples will be collected at the UV system influent (after static mixer) and the effluent to capture the start of H_2O_2 injection and will continue until the H_2O_2concentration is at steady state concentrations, typically 2-3 HRT's. The results of the mixing study will be used to optimize the spiking experiments.

6.2.3 NDMA and 1,4-Dioxane Spiking Test Plan

The test plan consists of two separate spiking experiments. During experiment one NDMA only will be spiked upstream of the UV/AOP and the reactor power will be varied between the minimum and maximum settings. During this experiment the reactor will be operated at the design flow rate of 1 MGD and UV transmittance (UVT) of approximately 97%. In addition, the expected chloramines residual present in the UV/AOP is 3 mg/L. The log removal of NDMA will be determined for each set point. In addition 1,4 dioxane will be measured in the UV/AOP feed and effluent to assess removal of inherent concentrations present. The results will be plotted to establish the relationship between NDMA LRV and reactor power under design conditions. In addition, values of electrical energy per order (EEO) for the reactor will be calculated based on results of the spiking experiment.

During experiment two NDMA and 1,4 dioxane will be spiked upstream of the UV/AOP and the peroxide dose will be varied between 1 and 5 mg/L. It should be noted during normal operation and sampling events the UV/AOP peroxide dose will be set at 3 mg/L based on the dose currently approved by CDPH for the OCWD Groundwater Replacement System. However, the purpose of the spiking experiment is to gain information on the impact of peroxide dose on 1,4 dioxane removal by the UV/AOP. During this experiment the reactor will be operated under the reactor power conditions determined in Experiment 1 to achieve 1.2 log removal of NDMA. The log removal of 1,4 dioxane & NDMA will be determined for each set point.

The testing apparatus/equipment required to conduct the spiking experiments shall be per **Figure 6-1** and is comprised of the following equipment:

- Chemical Storage tank and cover– 30 gallon black polyethylene
- Chemical Storage tank mixing rod
- Chemical dosing pump
- Hydrogen Peroxide monitoring kit
- Piping and valving to make the connections between the components
- Stock spiking solution 1 L prepared by certified laboratory experienced with preparing spiking solutions.

Table 6-1 provides details on the experimental test runs that will be conducted as part of spiking experiment 1. The log removal of NDMA and 1,4-Dioxane will be calculated.

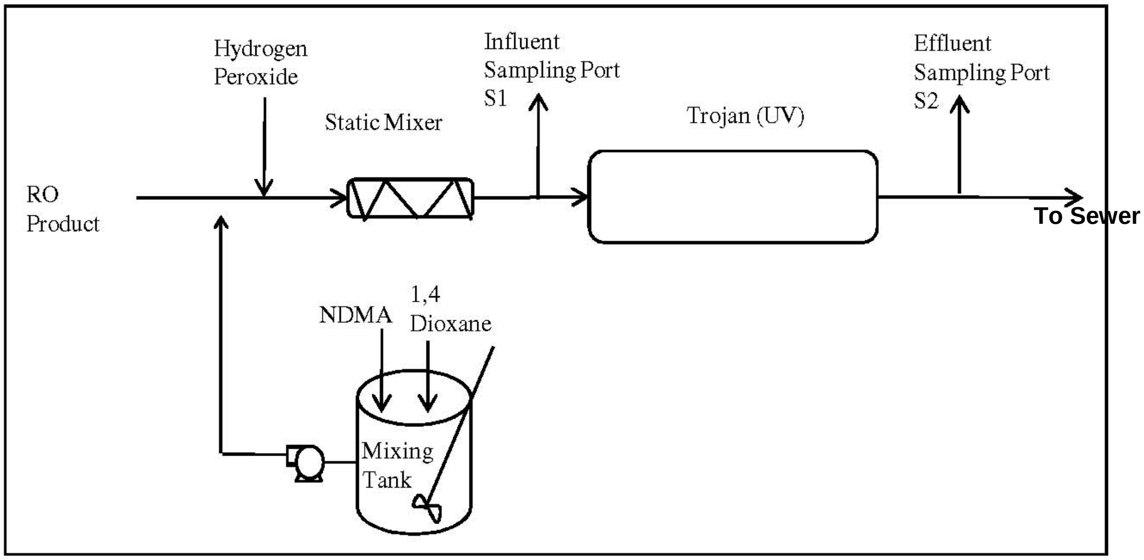

Figure 6-1
Spiking Set-up

Table 6-1
Spiking Experiment 1

Sample ID	Target LRV	Target Flowrate (gpm)	Target UVT (%)	Target NDMA Feed Concentration (ng/l)	[1] Target Reactor Power (%)	Target Peroxide Dose (mg/L)
Batch	NA	NA	NA	NA	NA	NA
Control IN	0	695	97	1000	0	0
Control OUT	0	695	97	1000	0	0
Control IN	0	695	97	1000	0	3
Control OUT	0	695	97	1000	0	3
RUN 1	1.2	695	97	1000	66	3
RUN 2	1.6	695	97	1000	80	3
RUN 3	1.0	695	97	1000	60	3
RUN 4	2.5	695	97	1000	100	3

[1]. Target reactor power settings were recorded from the TrojanUVPhox Model 72AL75 human interface (HMI) screen at different Target LRV's (user set point) during operation at the target flow and UVT.

For each sample run, three individual 1.0 L influent samples will be taken from the influent sample port and three effluent samples will be grabbed from the effluent sample port. Samples will be collected in UV proof (dark glass bottles) bottles with preservative. Samples will be sent to a certified lab and tests shall be performed per EPA analytical methods. All samples will be analyzed for NDMA and 1 influent and 1 effluent will be analyzed from each run will be analyzed for 1,4 dioxane.

Concurrent sampling and recording of feed UVT, effluent H_2O_2concentration, feed flow, temperature, target reactor power, actual reactor power, target LRV, actual LRV EEO, and lamp hours will be performed. Documentation of the number of lamps in service will also be recorded.

- Control – The test plan includes two runs in which the UV unit is in the off position. This will act as the control experiment. Samples will be collected from the influent and effluent with and without peroxide.

- Run 1 will consist of operating the UV unit at the manufacturers recommended power setting to achieve 1.2 log removal of NDMA at 695 gpm. The H_2O_2 will be dosed at 3 mg/L. Three influent and three effluent samples will be collected at approximately 5 minutes apart.

- Run 2 will increase the UV power setting to 80% of the maximum output of the UV unit and the H_2O_2 will be dosed at 3 mg/L. Three influent and three effluent samples will be collected at approximately 5 minutes apart.

- Run 3 will reduce the UV power settings approximately 60% (minimum power setting). Three influent and three effluent samples will be collected at approximately 5 minutes apart.
- Run 4 will reduce the UV power settings approximately 60% (minimum power setting). Three influent and three effluent samples will be collected at approximately 5 minutes apart.

A total of (29) NDMA and (8) 1,4 dioxane samples will be collected analyzed as part of this spiking experiment. The spiking experiment will last approximately 2 to 2-1/2 hours. The first 15-30 minutes will be to set-up and verify that the testing and dosing apparatus are operating correctly and to give the system time to reach equilibrium as determined in the mixing study per **Section 6.2.2**.. During the spiking experiment the UV/AOP effluent will be directed to sewer. Any remaining volume in the mixing tank at the conclusion of the experiment will be run through the UV unit to completely destroy any remaining chemical. A minimum of two mixing tank volumes of clean water will be run through the testing apparatus to flush the system of chemicals prior to putting UV/AOP product back into the NCWRP recycled water system.

Table 6-2 provides details on the experimental test runs that will be conducted as part of Spiking Experiment 2. The purpose of this experiment is to assess the impact of hydrogen peroxide concentration on 1,4 dioxane removal by UV/AOP.

Table 6-2
Spiking Experiment 2

Sample ID	Target NDMA / 1,4 dioxane LRV	Target Flowrate (gpm)	Target UVT (%)	Target NDMA & 1, 4 Dioxane Feed Concentration (ng/l)	[1] Target Reactor Power (%)	Peroxide Dose (mg/L)
Batch	NA	NA	NA	NA	NA	NA
Control IN	0	695	97	1000	0	0
Control OUT	0	695	97	1000	0	0
Control IN	0	695	97	1000	0	3
Control OUT	0	695	97	1000	0	3
RUN 1	1.2 / 0.5	695	97	1000	66	1
RUN 2	1.2 / 0.5	695	97	1000	66	3
RUN 3	1.2 / 0.5	695	97	1000	66	5

1. Final flow and power set points to be based on spiking experiment 1 result.

For each sample run, three individual 1.0 L influent samples will be taken from the influent sample port and three effluent samples will be grabbed from the effluent sample port. Samples will be collected in UV proof (dark glass bottles) bottles with preservative. Samples will be sent to a certified lab and tests shall be performed per EPA analytical methods. All samples will be analyzed for 1,4 dioxane and 1 influent and 1 effluent will be analyzed for NDMA.

Concurrent sampling and recording of feed UVT, effluent H_2O_2concentration, feed flow, temperature, target reactor power, actual reactor power, target LRV, actual LRV EEO, and lamp hours will be performed. Documentation of the number of lamps in service will also be recorded.

- Control – The test plan includes two runs in which the UV unit is in the off position. This will act as the control experiment. Samples will be collected from the influent and effluent with and without peroxide.
- Run 1 will consist of operating the UV unit at the manufacturers recommended power setting to achieve 1.2 log removal of NDMA at 695 gpm. The H_2O_2 will be dosed at 1 mg/L. Three influent and three effluent samples will be collected at approximately 5 minutes apart.
- Run 2 will consist of operating the UV unit at the manufacturers recommended power setting to achieve 1.2 log removal of NDMA at 695 gpm. The H_2O_2 will be dosed at 3 mg/L. Three influent and three effluent samples will be collected at approximately 5 minutes apart.
- Run 3 will consist of operating the UV unit at the manufacturers recommended power setting to achieve 1.2 log removal of NDMA at 695 gpm. The H_2O_2 will be dosed at 5 mg/L. Three influent and three effluent samples will be collected at approximately 5 minutes apart.

A total of (23) 1,4 dioxane and (11) NDMA samples will be collected analyzed as part of this spiking experiment. The spiking experiment will last approximately 2 to 2-1/2 hours. The first 15-30 minutes will be to set-up and verify that the testing and dosing apparatus are operating correctly and to give the system time to reach equilibrium as determined in the mixing study per **Section 6.2.2**. During the spiking experiment the UV/AOP effluent will be directed to sewer. Any remaining volume in the mixing tank at the conclusion of the experiment will be run through the UV unit to completely destroy any remaining chemical. A minimum of two mixing tank volumes of clean water will be run through the testing apparatus to flush the system of chemicals prior to putting UV/AOP product back into the NCWRP recycled water system.

6.3 Chloramines and Nitrosamines Investigation

6.3.1 Background/Objective

The City's AWP Facility will utilize chloramines to control organic and biological fouling of the MF, UF, and RO membranes. It is well documented that the combination of chloramines and nitrogenous precursors present in wastewater, such as dimethylamine (DMA), are common pathways for disinfection by-product (DBP) formation (Mitch et al., 2003). Previous research shows that NDMA formation is dependent on such factors as the individual water matrix, the level of chlorine/chloramines addition and pH (Mitch et al., 2004). In addition, the formation is linked directly to the chloramines dose, pH and hence chloramines species. Formation control and treatment processes are used to limit NDMA in treated water. Chloramines can be created either by sequential addition of ammonia (aqueous ammonia) and chlorine (sodium hypochlorite) directly to the wastewater or by a side stream process that pre-forms chloramines prior to application to the wastewater. The latter has been shown to be an effective method to reduce by-product formation as it results largely in mono-chloramines formation (MWH, 2010).

The specific objectives of the chloramines and nitrosamine investigation follows:

- Gain operational performance data on the RO systems at different chloramines feed concentrations to optimize and develop criteria for the full-scale AWP Facility.
- Evaluate nitrosamines formation under different chloramines application conditions including pre-formed, sequential with and without acid addition (will acid make a difference?).

6.3.2 Description of Chloramines Dosing Alternatives

Figure 6-2 provides a general flow schematic of the chloramine dosing alternatives to be evaluated during the testing period. Option 1 will include sequential addition of sodium hypochlorite (NaOCl) the tertiary water upstream of MF and UF followed by ammonium hydroxide (NaOH) to the MF/UF product water. Option 2 will include the addition of ammonium hydroxide into a carrier water (RO permeate) followed by subsequent dosing with sodium hypochlorite. The solution will then be stored in a large pressure vessel to allow for approximately 10 minutes of detention time to form monochloramine (NH_2Cl), which will be dosed into tertiary water upstream of the MF and UF systems.

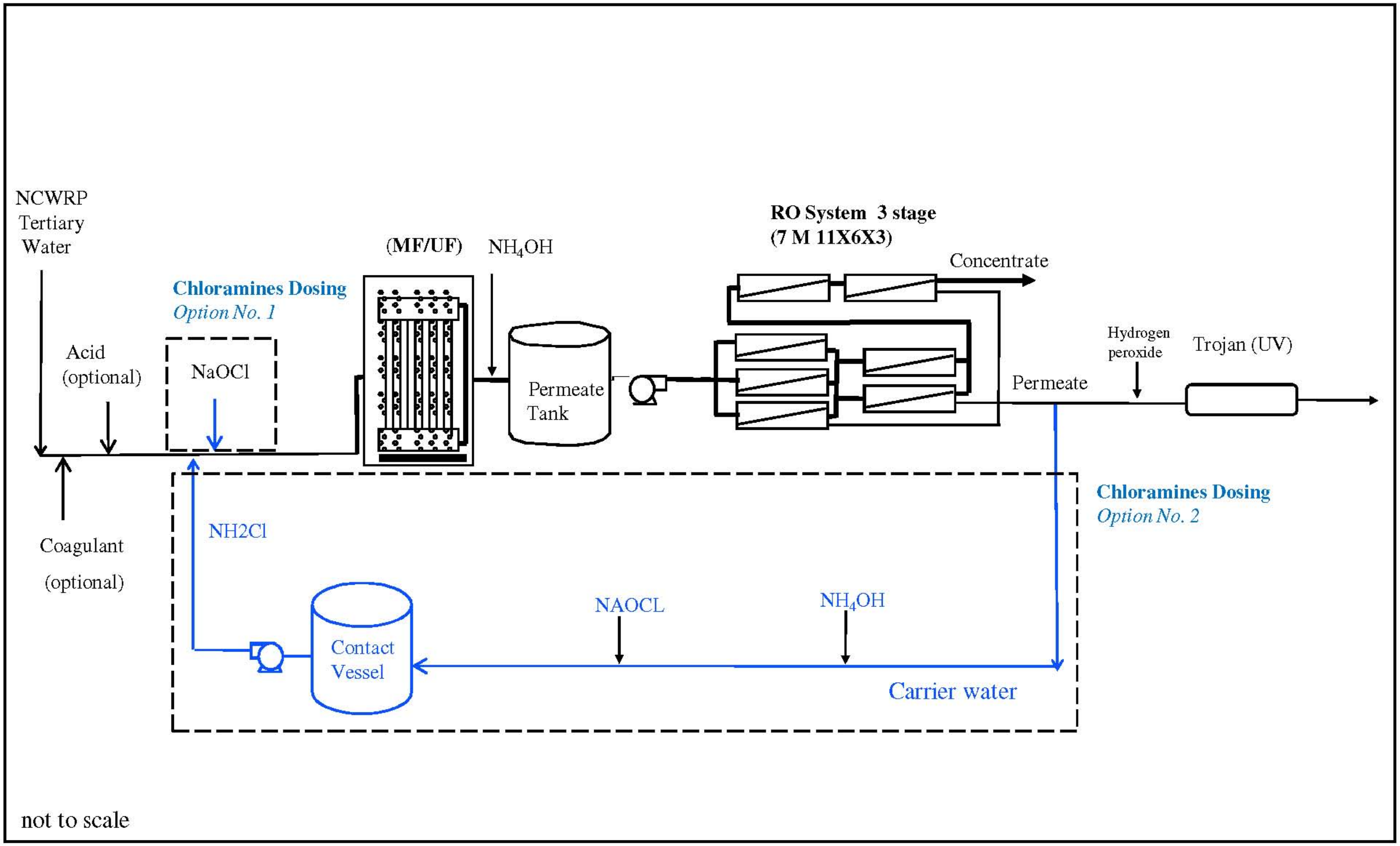

Figure 6-2
General schematic of chloramines dosing alternatives

6.3.3 Performance Monitoring

A sampling regime will be put in place during phase II of the demonstration test period to compare the two chloramines dosing alternatives described above. **Table 6-3** provides the specific parameters, locations, and frequency of the proposed sampling regime. Samples will be collected weekly from the tertiary water and RO feed to assess NDMA formation associated with chloramination. Other nitrosamines, less likely to be formed, along with precursors (DMA) will be measured once over the test period. The various forms of chloramines, along with free chlorine, total chlorine, free ammonia, temperature and pH will be monitored daily for process control. Nitrosamines samples will be sent to off-site certified laboratories for analysis, all other parameters will be analyzed in the on-site lab. The sampling regime will be conducted over a 2 month period with 30 days designated to using sequential chloramines application, followed by a 30 day period during which pre-formed chloramines will be utilized. Two alternatives will be compared in terms of NDMA formation, mono-chloramines production, stability, etc. Based on results, one of the two alternatives will be selected for use during remainder of the 12 month test period. Optimization of the selected chloramines dosing strategy including the identification of the minimal dose necessary to prevent RO fouling will be completed during the testing period. The starting dose of chloramines will be based on the RO manufacturer's permissible limits. The impact of adding acid to the feed water for RO scaling control on chloramines specification and NDMA formation will also be evaluated during this time.

Table 6-3
[1]NDMA and Chloramines Sampling Regime

Parameter	Sampling Location	Frequency
NDMA	S1, S6, S10	1/week
DMA	S1, S6, S10	1/month
NDEA	S1, S6, S10	1/month
NMEA	S1, S6, S10	1/month
NPIP	S1, S6, S10	1/month
NYPR	S1, S6, S10	1/month
NDBA	S1, S6, S10	1/month
Total Chloramine	S6, S9, S10	1/day
Mono Chloramine	S6, S9, S10	1/day
Di Chloramine	S6, S9, S10	1/day
Nitrogen trichloride	S6, S9, S10	1/day
Free Chlorine	S6, S10	1/day
Free ammonia	S6, S10	1/day
pH	S6, S10	1/day
temperature	S6	1/day

[1] Note the sampling regime provided will be conducted over two 30 day periods. During the first 30 days, option 1 - sequential chloramines conditions will be in place. For the next 30 day period, option 2 -pre-formed chloramines conditions will be in place. Sampling locations shown in Figure 5-1.

6.4 UV/AOP By-product Evaluation

Comments made by the CDPH on the IAP report indicate that by-products of NDMA and 1,4-Dioxane from the UV/AOP process may be a concern. There has been limited research into by-product formation and as part of development of this Testing and Monitoring Plan, a review of past research was performed by Dr. William J. Cooper at the University of California, Irvine. A summary of key findings and recommendations are provided below.

6.4.1 N-Nitrosodimethylamine (NDMA)

The UV/H_2O_2 process when applied to NDMA is a two step process, 1) photolysis of the NDMA by 254 nm UV light, and 2) oxidation of the products primarily thorough the hydroxyl radical (•OH) mediated reactions. The photolysis of NDMA has been studied at pH 3 and 7 with the major difference being the rate of destruction, i.e. at pH 3 NDMA is destroyed approximately six times faster than at pH 7. In both cases the major organic reaction by-product was DMA. Formaldehyde was observed at both pH 3 and 7 and was shown to be tenfold less that the DMA at pH 3 and fivefold less than DMA at pH 7. Therefore, the lower the pH during the photolysis, the more effective the photolysis of NDMA.

The advanced oxidation of DMA has not been studied in any detail; however, it is possible that decomposition would likely form formaldehyde and thus is the source of that observed in the studies reported.

6.4.2 1,4-Dioxane

The oxidation of 1,4-dioxane is considerably more complicated than that of NDMA. Focusing only on hydroxyl radical (•OH) oxidation there was a comprehensive study conducted by Stefan and Bolton (2002) and documented the loss of the parent compound (1,4-dioxane) and the formation of a number of reaction by-products. These by-products were 1,2-ethanediol diformate; 1,2-ethanediol monoformate; methoxyacetic acid, acetic acid, formic acid, oxalic acid, glyoxal, acetaldehyde and formaldehyde.

For the most part, these by-products will be easily biodegraded and likely cause no alarm. The one exception may be formaldehyde. As both NDMA and 1,4-dioxane result in the formation of formaldehyde this may be the compound to analyze to determine the efficiency of the processes.

Table 6-4 presents the predicted formaldehyde concentrations (by-product formation from UV/AOP process) expected from 100 ng/L NDMA and 1,4-dioxane concentration doses.

Table 6-4
Predicted Formaldehyde Formation from UV/AOP Process

Compound	Parent Concentration		pH	Formaldehyde Concentration	
	Weight concentration	Molar concentration		Weight concentration	Molar concentration
NDMA[1]	100 ng/l	1.4 nM	3	10.4 ng/l	0.14 nM
NDMA	100 ng/l	1.4 nM	7	21 ng/l	0.28 nM[2]
1,4-dioxane[3]	100 ng/l	1.14 nM	Not specified	17 ng/l	0.19 nM

[1] Stefan, Mihaela I.; Bolton, James R. UV direct photolysis of N-nitrosodimethlyamine (NDMA): kinetic and product study. *Helvetica Chimica Acta*, **2002**, *85(5)*, 1416-1426.

[2] The maximum concentration of formaldehyde was observed after 60 minutes irradiation, pH = 7, which was the time it took in lab experiments to approach 1.2 log removal of the NDMA. The concentration was 10 % of the influent NDMA concentration. Therefore it appears that at lower the lower pH the reaction will be faster and less formaldehyde will be formed.

[3] Stefan, Mihaela I.; Bolton, James R. Mechanism of the Degradation of 1,4-Dioxane in Dilute Aqueous Solution Using the UV/Hydrogen Peroxide Process. *Environmental Science and Technology*, **1998**, *32(11)*, 1588-1595.

During the 2005 AWT studies conducted at NCWRP NDMA was measured in the NCWRP tertiary effluent at concentrations ranging from 14-80 ng/l. Based on the data presented in **Table 6-4** the expected formaldehyde concentration that would result from UV/AOP would be significantly less than the current CDPH Drinking Water Notification Level of 0.1 mg/L. Also the concentration of 1,4-dioxane measured in the RO feed ranged from 43 to 71 ug/L (43,000 to 71,000 ng/L) and in the RO permeate ranged from 4.7 to 6.9 ug/L (4,700 to 6,900 ng/L). Based on the predicted rate of formation, it is expected that formaldehyde concentrations of 0.007 to 0.012 mg/L may be formed which is significantly below the Notification Levels for formaldehyde.

Recommended AOP Byproduct Monitoring Plan

Based on information found in peer reviewed literature and past pilot testing conducted at NCWRP it does not appear UV/AOP byproduct formation will be an issue. These findings will be confirmed by taking grab samples from (S9) and (S10) and measuring formaldehyde on a weekly basis during the 8 weeks of the routine sampling period. Based on results bench scale experiments may be developed and employed to gain further insight on UV/AOP byproducts. The bench scale experiments will be conducted at concentrations higher than found in natural waters so as to enable the identification of reaction by-products. From these, a kinetic model that describes the destruction of the parent compounds and the reaction by-products will be developed. A UV 254 irradiation system will be used and methods that they have been used for determining reaction mechanisms for other DBPs, and for evaluating AOP destruction of methyl tert-butyl ether (MTBE), emerging CECs, harmful algal bloom toxins and pharmaceuticals. LC/MS and LC/MS-MS and LC/MS-MS-MS and high resolution NMR for reaction by-product identification will be employed.

Section 7
Quality Assurance/Quality Control (QA/QC)

The following section provides a general description of QA/QC procedures to be employed during the demonstration testing period, including data analysis, lab testing, field sampling procedures, sample handling and storage, data validation and equipment.

7.1 Data Analysis and Laboratory Testing

Some of the analysis required for routine sampling will occur at the on-site laboratory, while more specialized analyses will be sent to a certified laboratory. All laboratory testing procedures conducted on-site and at the external laboratory will comply with EPA testing procedures. Laboratories will follow protocols of California ELAP, TNI2011 standards, and the 5th Edition EPA Manual for the Certification of Laboratories for Drinking Water, as applicable.

Data collected and analyzed on-site will be regularly verified with data from the certified laboratory analyses. This will result in a comprehensive database, which can be used for data analysis, retrieval, reporting and graphics. All data will be checked and verified by the operations manager / project engineer before and after entry into the database. The collection of data files will be sent to selected PAC members on a regular basis for review and analyses. **Table 7-1** shows QA/QC measures to be taken for onsite and laboratory analysis. **Table 7-2** displays specific laboratory QC procedures that will be utilized during CEC analysis, as provided by MWH Laboratories.

Table 7-1
On-Site & Certified Laboratory QA/QC Measures

pH (report to nearest 0.1 pH unit)	Weekly 3 point calibration with certified pH buffers in the range of measurements (4.0, 7.0 and 10.0)
Temperature (report to nearest 0.1 ° C)	Initial and quarterly verification against NIST thermometer
Turbidity, online (report to nearest 0.05 NTU for filtrate)	Weekly comparison to bench top turbidimeter; recalibrate if difference is > 20%
Turbidity, bench top (report to nearest 0.05 NTU for filtrate)	Initial and weekly calibration with primary standards of 20 ,100 and 800 NTU. Daily verification with 10 NTU standard.
Conductivity, online	Weekly comparison to portable meter, recalibrate if difference is > 20%
Conductivity, portable meter	Initial and weekly calibration with primary standards of 23 uS/cm and 2,764 uS/cm.
Water Quality Analysis Outside Laboratories	Follow California ELAP procedures, TNI2011 standards, and the 5th Edition EPA Manual for the Certification of Laboratories for Drinking Water, as applicable
Microbial Analysis Outside Laboratory	Follow federal NELAP and California ELAP procedures, and USEPA Standards and Protocols for Testing Microbial Water

Table 7-2
Laboratory QC Measures for CEC Analysis

Quality Control	**Criteria**
Method Blank	< MRL
MRL Level Check Sample	50 - 150%
LCS and LCSD	70 - 130% or 60 - 140%, depending on compound
MS / MSD	60 – 140%

7.2 Sampling Procedures

The following sections describe the equipment and procedures that will be utilized to collect demonstration water quality samples. A summary of the proposed water quality monitoring and sampling plan is provided in **Section 5** of this report.

Water sample collection activities will be conducted by two project team operations personnel with the exception of sample processing, which will be conducted by the contracted laboratory. Sampling procedures will be provided by the contracted laboratories to follow USEPA guidelines.

7.2.1 General Sampling Procedures

Sampling personnel will utilize clean handling techniques when processing the samples such that only new powder- and phthalate-free vinyl gloves (nitrile) will be worn when handling the sample bottles. In general, personnel will wear clean vinyl gloves during all sample retrieval operations and change gloves frequently, usually with each change in task.

After opening stainless steel sample location valves and allowing treated water to flow for two to three minutes, personnel will collect water samples from appropriate locations along the AWP Facility treatment train, label sample collection bottles appropriately, and place them into coolers packed with ice packs/blue ice at the conclusion of the sampling event. Personnel will then ship the sealed coolers under chain-of-custody to the contracted laboratory. The laboratory will process and analyze the samples in accordance with their standard operating procedures.

Strict adherence with the sample volume quantities, preservation methods and hold times provided by the certified laboratories for each analytical method will be followed in order to meet reporting limits.

7.2.2 CEC Sampling Procedures

In addition to the above general sampling procedures, certain steps will be taken to ensure the integrity of samples that will be analyzed for trace CECs. These steps include avoiding smoking and handling or ingesting pharmaceuticals or caffeinated beverages shortly before and during sampling events. Contracted laboratories will follow additional protocols and recommendations set forth in the Science Advisory Panel's *Monitoring Strategies of Chemicals of Emerging Concern in Recycled Water* Final Report.

7.2.3 Microbial/Biological Parameters Sampling Procedures

Collecting water samples for analysis for biological parameters requires additional procedures to ensure sample integrity. A general description of sampling procedures to be followed for various microbial parameters is provided below with more detailed information provided in **Appendix J**.

Bacterial parameters

- Requires sterilization of the sample valve prior to collecting the grab sample. Sterilization will be conducted with a hand-held propane torch.
- Samples will be stored with blue ice and at a target temperature of 3-8 °C.
- Follow sample collection and handling procedures as specified in USEPA Methods 1602 (F- and somatic coliphage), 1682 (salmonella), and SAP 2009 Draft (E. coli O157), and method SM 9221 (coliform).

Virus analysis

- Follow sampling procedures detailed in the USEPA *Information Collection Requirements Rule – Protozoa and Enteric Virus Sample Collection Procedures*.
    - Note: This method (1995) specifies a 1MDS electropositive filter, the filter type now being used is a NanoCeram electropositive filter.
- Requires the use of a virus sampling apparatus (chlorine sterilized filter concentrator).
    - The sampling apparatus, and training on the use of the device, will be provided by Biovir Laboratories.
    - Prior to sampling the apparatus must be flushed with 20 gallons (76 liters) of water.
- Samples for virus analysis will be stored with blue ice and at a target temperature of 4 ° C.

Cryptosporidium (not in current sampling plan)

- Follow sample collection procedures detailed in Biovir's Example Procedure for Collecting Filtered Water Samples (Using HV Envirochek Capsule Filters) for Method 1622/23 Analysis.
- Samples will be cooled as quickly as possible by immersion in an ice bath, and kept at a target temperature of 4 ° C. Care will be taken to avoid shipping samples with unnecessary ice/cold packs to keep from freezing the filter element.
- Sample will be dechlorinated using sodium thiosulfate.

7.2.4 Sampling Equipment and Supplies

Sampling equipment and supplies include the equipment required for the collection of demonstration water quality samples, associated sample collection and handling supplies, decontamination equipment, sample collection bottles and coolers, etc. Equipment to be utilized during sampling events includes the following:

- Gloves
- Rinse Bottles
- Ice packs
- Coolers
- Propane Torches (microbial)

- Timers
- Virus Sampling Apparatus (Chlorine Sterilized Filter Concentrator)

7.3 Sample Designation and Handling

Sample handling and designation procedures are included to provide sufficient project-specific QA/QC measures. Project-specific QA/QC requirements and procedures described in the following sections include:

- QC sample collection requirements.
- Sample container requirements and preservation.
- Sample documentation and handling.
- Chain-of-custody documentation.

7.3.1 QC Sample Collection Requirements

Field and laboratory QC samples will be collected and analyzed as a quality check of sampling and analytical procedures, as described below. Quality Control sample collection frequencies for this project are presented below in **Table 7-3**. The following field and laboratory QC samples will be collected during the demonstration period:

- Field Duplicate. A portion of the collected sample volume will be analyzed identically to evaluate laboratory precision, reproducibility of sample handling and analytical procedures, sample heterogeneity, and analytical procedures.
- Split Sample. A portion of the collected sample volume will be analyzed by a separate laboratory with overlapping capabilities utilizing identical analytical methods to evaluate laboratory accuracy, reproducibility of sample handling and analytical procedures, sample heterogeneity, and analytical procedures.

Table 7-3
QC Sampling

QC Sample Type	Frequency	Sample Location
Duplicate Sample	Collect one blind duplicate per quarterly sampling event	Rotated quarterly
Split Sample	**First Quarter**: Collect split sampling for all quarterly monitoring parameters listed in Table 7-4. **Quarterly**: Collect split sampling for CECs	UV/AOP product water

Laboratories split analysis responsibilities for samples collected during quarterly monitoring are presented below in **Table 7-4**.

Table 7-4
Quarterly Sampling Event Split Sampling

Contracted Laboratory	Split Analysis Responsibilities
MWH Labs	• Primary State/Federal Drinking Water Standards • Secondary State/Federal Drinking Water Standards • USEPA Priority Pollutants • Potential AOP Byproducts • CDPH Drinking Water Notification Compounds
Colorado School of the Mines	• Constituents of Emerging Concern

7.3.2 Sample Containers

The contract laboratories will provide certified clean sample collection containers as appropriate for the required analyses. Sample container quality protocols will be strictly enforced and assured by the laboratory. The laboratory will retain certificates of analyses from each lot of containers for a period of at least 5 years. Sample containers will be kept closed until used. The sample containers, preservation, and holding time requirements for this project are presented in **Appendix J**.

7.3.3 Sample Preservation and Holding Time

The use of proper chemical and thermal preservation is critical to maintain the validity of project samples. Sample bottles will be placed into a cooler packed with wet ice. The target temperature for the cooler is 6° C, with the exception of coolers containing samples for biological parameters which will be cooled as is described in the above microbial/biological parameters sampling procedures. If samples are received by the lab the same day as sampling occurred target temperatures need not be reached; however, samples must show evidence of chilling. Samples will be shipped under chain-of-custody to the contract laboratory as soon as possible after sample collection activities. The laboratory will document the sample temperature upon receipt.

7.3.4 Sample Storage, Packaging, and Transport

Proper sample handling procedures will be followed so sample quality is not compromised after the collection of the sample and prior to submitting the sample to the laboratory. Each sample will be handled according to the protocol specific to the environmental media.

Sample Storage

Collected samples will remain in the possession of a designated project team representative at all times until custody is relinquished to the laboratory (in person or through shipment), or until the samples are placed in a secure storage location.

Sample Packaging

Samples will be transported in the same coolers used for temporary sample storage. Samples will be accompanied by a completed chain-of-custody form, sealed in a Ziploc® or equivalent bag to prevent damage to the document, and taped inside the lid of the cooler. Individual glass sample containers will be wrapped in bubble wrap bags or placed in foam packaging, and placed in polyethylene bags to prevent any potential compromising of sample integrity.

Sample Transport

Samples destined for out-of-area laboratories will be repackaged (as necessary) for shipping. Bubble wrap and foam will be used to help prevent sample bottle breakage during shipping. Samples will be placed into coolers packed with wet ice and labeled appropriately for shipping. Express delivery from common carriers will be used for shipping. A chain-of-custody form will accompany each cooler during shipment.

7.4 Documentation

Verifiable sample custody is of primary importance during field and laboratory procedures. Such practices ensure samples have been properly acquired, preserved, and identified. This information will be collected in a variety of formats, specific to the function they perform in the sampling procedure (e.g., field logbooks, sampling field forms, sample labels, chain-of-custody forms, etc.). Sampling records create a complete record of field procedures, including circumstances of collection and integrity of the samples. This will also allow for detailed tracking of each sample from collection through transport and laboratory analysis. The following information outlines specific procedures that will be implemented during sampling events.

7.4.1 Logbook

Sampling activities will be documented in a logbook. The first entry at the beginning of each sampling event will include the date and time, project number, names of personnel on-site, and the purpose of the sampling event (e.g., routine monitoring, quarterly monitoring). Each subsequent page will be started with the project number and the date.

Information included in the field logbook will include the following items:

- Observations relevant to the sampling event, equipment conditions, and events that may have occurred prior to sampling that may influence the integrity or the representativeness of the sample.

- Observations of site activities not covered under regular activities, including presence of persons on-site not related to the sampling activities, and actions by those people affecting work performance.
- Sketches of relevant information.
- Information relevant to a change in scope or change in Work Plan procedure, with documentation of subsequent approval.
- Type and/or level of health and safety equipment used.

Information compiled in the field logbook will be written legibly in language that is clear, concise, and without interpretation.

7.4.2 Chain-of-Custody Procedures

The chain-of-custody is an integral component of the sampling process as it stands as a permanent record of sample holding and shipment. Sample custody is documented from collection through transport, analysis, and reporting.

Samples will remain in the custody of authorized personnel or appropriate staff until receipt by the laboratory or relinquished to the shipper. The corresponding chain-of-custody form will be in plain view at all times, in physical possession, or in a locked location where no tampering will occur. The chain-of-custody form will be crosschecked for errors and signed by the sampler.

Coolers with their respective chain-of-custody form(s) will be checked into the laboratory by a laboratory representative, and the chain-of-custody form will be relinquished to the laboratory by signing and dating the custody form appropriately. The project team operations staff will retain one copy of the signed chain-of-custody form for the project files. The laboratory representative will verify cooler temperature, sample designation, and other relevant sample conditions. The original chain-of-custody form or a photocopy will be returned to the project manager with the analytical results and kept in the project files.

7.5 Data Analysis

The data collected for this project will be reviewed prior to reporting. The following sections describe data validation and preliminary statistical analysis that will be performed on collected laboratory analytical data.

7.5.1 Data Validation Review

A complete third-party data validation of the AWP Facility product water (S10) will be performed on laboratory results obtained for the first quarterly sampling event. Results of this validation will be used to determine data quality and review laboratory procedures. Labs will make procedural alterations based on this data validation as necessary.

Third party validation is beneficial whenever analytical data may be subject to intense scrutiny that could result in the accuracy of the reported data being challenged in a court of law. The USEPA issued guidance documents detailing analytical data evaluation and review processes for inorganic and organic data produced under the USEPA Contract Lab Program (CLP). The CLP supports a major portion of the sample analysis needs of the USEPA Superfund Program. Due to the potential for legal challenges, samples submitted under this program must be analyzed in conformance with specified analytical protocols and the assembled data package must go through a technical quality assurance review (validation) prepared by an independent third party. In 1986, the Director of the Office of Emergency and Remedial Response proposed several levels of data validation.

Commercial third party specialists performing water quality data validation utilize the guidance issued under the USEPA CLP program. Level IV review is the most rigorous and is characterized by QA/QC protocols and documentation resulting in a complete qualitative and quantitative analysis of the analytical data (USEPA 1987). Data that fulfills the requirements of this level of third party validation fulfills the minimum data quality standards needed to allow the data to be used for its intended objective.

The data validation will consist of an evaluation of sample and measurement collection, custody, analysis, and reporting to identify any quality control deficiencies. Data collected will either be used as reported, qualified as estimated, or rejected for its intended use.

Analytical data validation will comprise the bulk of the data validation effort, and will be performed in accordance with applicable USEPA data validation guidelines for organic and inorganic parameters. LDC, Inc., an independent, third-party, will evaluate the quality of the work based on this document and an established set of laboratory guidelines to ensure the following:

- Sample preparation information is correct and complete.
- Analysis information is correct and complete.
- Appropriate procedures have been followed, specifically with adherence to holding times.
- Analytical results are correct and complete.
- Laboratory QC check results for absence of blank contamination, initial and continuing calibrations, surrogate compound recoveries within limits, allowable matrix spike/duplicate recoveries, accurate internal control standard recoveries, and adequate instrumental performance, are within appropriate QC limits (**Table 7-2**).

- Documentation is complete (observed anomalies in the preparation and analysis have been documented and holding times are documented).
- Laboratory qualifiers have been assigned to each sample with data usability limitations.

7.5.2 Data and Statistical Analysis

Following each quarterly sampling event, validated results for all CEC data will be provided to PAC members. Those PAC members will produce a letter providing scientific interpretation of the data, identifying any anomalies, and providing recommendations for re-sampling or increases in sampling frequency.

Final review of the reported data performed by project team personnel will include an examination of the data in terms of the qualitative data quality objectives and the logbook will be reviewed for completeness and correctness. The data may be qualified based on significant concerns related to representativeness, comparability, and completeness. Each will be discussed, as appropriate, in terms of the deficiencies and associated project impacts. A basic statistical analysis of the data will be performed for collected quarterly monitoring data including determination of the mean, variance and standard deviation for all monitored constituents. The results of this statistical analysis will be provided to select PAC members for final QA/QC and recommendations.

7.5.2.1 Determination of the Number of Samples to Obtain Statistically Significant Data

A key component of the design of the water quality monitoring plan for the AWP Facility is the determination of the number of samples to be collected for the various parameters of interest. A proposed strategy was presented in **Section 5** based on the overall objective of the demonstration program and to provide an acceptable level of effectiveness based on the budget for the demonstration project. The design also took into consideration variability in the NCWRP tertiary water, data from the prior AWT pilot testing, and performance results from full-scale AWT facilities, such as those operated by OCWD for the GWR System and West Basin Municipal Water District for the West Basin Barrier Project. For most parameters the historical AWT data are at or below levels of detection; for detected constituents, the concentrations are typically below regulatory levels. Thus, the sampling frequency for the AWP Facility will generate sufficient numbers of samples to further substantiate this historical data set. The purpose of this section is to review that design in light of the 2009 IAP recommendations and subsequent input from CDPH.

In its 2009 report, the IAP recommended that:

> *"The frequency of monitoring should be adequate to enable statistical analysis of the data and provide the public with confidence on the*

> *performance of the treatment technologies and the extent to which wastewater-derived contaminants are controlled."*

For chemicals, the IAP did not provide a specified sampling frequency. For pathogens, the IAP provided recommendations on initial sampling frequencies for different methods in **Table 6.3.**.. In its comments on the IAP report, CDPH indicated that 1) a UV system designed to achieve a 1.2-log NDMA reduction would provide higher doses than what is required for adenovirus; and 2) requested more information on the specifics of the epifluorescence microscopy program.

The project team proposes a framework for discussion with the IAP and CDPH to define what criteria will drive the data collection needs for statistical certainty. The proposed approach would allow various analytes to be sorted into higher or lower monitoring levels.

Criteria requiring higher statistical certainty which will mean more frequent initial monitoring (at least initially):

- Variations in influent concentration and low effluent requirements (i.e. nitrogen);
- Need to consistently demonstrate non-detects through direct measure and/or indirect surrogate measure (e.g. emerging contaminants); and
- Process operations outside of previously demonstrated envelope.

Based on comments received by the IAP Subcommittee on the initial Draft Testing and Monitoring Plan (NWRI, 2010), factors to consider for the routine sampling plan:

- Appropriate sample volumes required to meet target detection limits;
- Sampling frequency and timing;
- Parameters to be collected using grab samples versus composite sampling;
- The need to collect composite samples on a time weighted or flow paced basis;
- Statistical analysis to be performed on water quality data sets to determine statistical certainty.

7.6 AWP Facility Equipment

All equipment associated with the AWP Facility unit process equipment such as pressure gages, flow meters, and safety switches will be calibrated on-site or checked for factory calibration during start up. In addition the accuracy of key components will be check on a periodic basis as summarized in **Table 7-5**.

Table 7-5
Equipment QC Criteria

Parameter	Equipment	Frequency	Acceptance Criteria
Flow Rates	On-line turbidity meters	Daily	+/- 20%
	Chemical dosing pumps	Daily	+/- 15%
	System rotameters and digital flow meters	Quarterly	+/- 10%
Pressure Gages	System pressure and vacuum gauges	Quarterly	+/- 5%

Calibration or verification records will be kept for flow meters, pressure gages, and on-line water quality analyzers.

Section 8
Additional Scope of Services

The following section provides details of additional scope of services outside of the Final Testing and Monitoring Plan. Theses scope items were either included in the November 30, 2010 Draft Testing and Monitoring Plan (Draft T&M Plan) or developed by the project team based on comments received from the IAP/CDPH/RWQCB on the Draft T&M Plan (**See Appendix K**). The project team will implement all or select scope items upon authorization from the City.

8.1 Integrity Monitoring Methods

Two additional integrity RO monitoring methods identified in the Draft T&M Plan include challenge testing with MS2 virus and TRASAR fluorescent dye. The City will reassess the possibility of MS2 virus challenge testing in the 3rd quarter once the regulatory requirements for the full scale project become more defined. Detail of each method is provided in the following sections.

8.1.1 MS2 Virus Challenge Testing

Though it is not an objective of the testing plan to demonstrate the ability of the RO membranes to remove viruses, conducting virus challenge experiments is a powerful means of monitoring RO system integrity. Accordingly, an optional service for consideration, challenge experiments can be performed on each RO system during start up and upon completion of the target 5,000 hour test period.

If required, challenge experiments would be conducted using MS2 virus. MS2 virus is not a human pathogen; however, this organism is similar in size (0.025 microns), shape (icosahedron) and nucleic acid (RNA) to polio virus and hepatitis virus. Because MS2 is not a human pathogen, live MS2 virus will be used in the seeding experiments. Organism stocks can be obtained from Biovir laboratories and upon receipt would be stored refrigerated at 4 C in the dark for less than 2 days prior to being used in the seeding experiments. The ATCC strain number of the virus to be used is 15597 and the bacterial host will be E.Coli (ATCC#700891).

A schematic of the proposed virus seeding set up is provided in **Figure 8-1.** The figure is based on a three stage system operating at 75% recovery. Samples will be taken from the following seven locations for the 3-stage system:

- S1 - RO feed (common)
- S2 - RO stage 1 permeate
- S3 - RO stage 2 permeate

- S4 - RO inter-stage 1/2
- S5 - RO stage 3 permeate
- S6 – RO inter-stage 2/3
- S7 – RO system 1 permeate (combined)

All samples will be analyzed by Biovir Laboratories, which is State-certified to perform MS2 analysis.

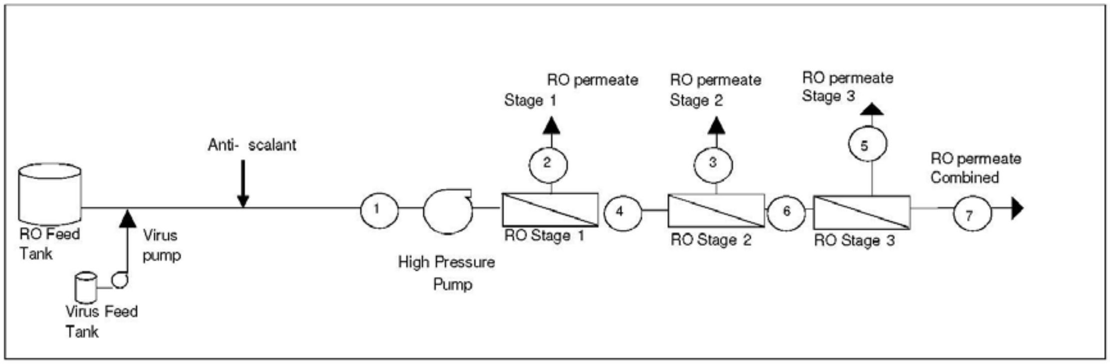

Figure 8-1
Virus Seeding Set-up 3-Stage RO System

Table 8-1 provides details on the sampling locations, QA/QC samples and total number of samples required per challenge experiment. Challenge experiments will be scheduled to be conducted one per system during start up to establish baseline performance and one following 5,000 hours of operation to demonstrate performance reliability over the test period.

Table 8-1
Sampling Details for MS2 Virus Challenge Experiments (Optional)

RO System	RO System Sample Frequency	QA/QC Sample quantity and description	Total number of samples per experiment	Scheduled experiments
3-stage Toray	Samples to be collected: S1, and S7 every 5 min. for 30 min.	2 samples @ virus feed tank (begin and end of experiment) 1 negative control samples experiment @ RO permeate prior to MS2 injection	17	(1) during start up; (1) @ completion of testing
2-stage Hydranautics	Samples to be collected: S1 and S7 every 5 min. for 30 min.	2 samples virus feed tank (begin and end of experiment) 1 negative control samples experiment @ RO permeate prior to MS2 injection	17	(1) during start up; (1) @ completion of testing

Table 8-2 provides details associated with virus seed stock and RO feed concentrations, based on 1.20 MGD RO feed flow.

Table 8-2
MS2 Phase Challenge Experiment Details Required for 1.20 MGD Feed Flow

Stock Volume Required (mL)	1000
Stock Virus Concentration (pfu/mL)	1.00E+11
Total MS2 virus in Send Tank (pfu)	1.00E+14
Seed Tank Volume (gallons)	50
Virus Injection Concentration (pfu/mL)	5.29E+08
Injection flow rate (mL/min)	4000
Feed Flow (gpm)	868
Feed Virus Concentration (pfu/100mL)	6.44E+07
Time Stock will last (minutes)	47.3

8.1.2 TRASAR Challenge Testing

Should the City choose to add it, challenge experiments can also be conducted during the testing period using a chemical product named TRASAR® offered by Nalco, Inc (Naperville, IL). TRASAR® is composed of fluorescent molecules (molecular weight

[MW] = 614 grams per mol [g/mol]) and has been historically used for chemical dosing control in drinking water and industrial applications (Zeiher et al, 2003). Dosing control can be achieved by adding a known quantity of TRASAR® to a given chemical (such as antiscalant) and measuring its concentration using Nalco's trace leak detection (TLD) system. The TLD system detects TRASAR® by measuring fluorescence. A feedback control system can then be used to adjust the chemical dose based on the measured TRASAR® concentration.

Recently, Nalco has further modified the TLD system to detect TRASAR® at low concentrations (ng/L) which enables it to act as an RO integrity monitoring system (Zeiher et al., 2002). In principle for RO membrane system integrity monitoring, the TRASAR® is injected into the RO feedwater and if the membrane system is intact, then the TRASAR® is rejected by the RO membranes and is not detected in the RO permeate. If there is a breech in the integrity of the RO membrane system which allows the TRASAR to leak into the RO permeate the TLD system should detect its presence and thus signal a loss of membrane integrity. Details of the TRASAR system provided by Nalco are provided in **Appendix D**. For challenge testing TRASAR® will be dosed continuously over a 10-minute period to the feed of the RO system to achieve a target concentration between 10-15 mg/L and upto 5-6 LRV sensitivity.

8.2 CEC Spiking Experiment to Assess UV/AOP Efficacy

The CDPH comments (CDPH, 2011) on the Draft T&M Plan suggested a Surrogate / Indicator Framework including challenge or spiking studies be applied during the AWPF testing to assess the effectiveness of the AOP process. Based on this comment, the project team recommends one spiking experiment be conducted after the first quarter of testing is complete to demonstrate the removal of several indicator compounds with the removal of surrogate parameters (UVA, chloramines), which can be easily measured on a frequent basis. The indicator compounds to be included in the spiking experiment will be based on occurrence data collected in the feed and product water of the AOP process with the overall goal of selecting compounds that will serve as good indicator compounds representative of wide range of characteristics for ongoing monitoring. The project team will work closely with the project advisory committee including Dr. Jorg Drewes and Dr. Shane Snyder to develop the list of compounds to be included in the CEC spiking experiment. The CEC spiking experiment will be conducted under UV/AOP conditions determined from the results of the NDMA, 1,4 dioxane spiking experiment presented in Section 6.2 using a similar experimental set up.

This added scope item would require the following:

- Certified lab preparation of the spiking solution containing (10) selected indicator compounds.

- Certified lab analysis of approximately 12 samples taken from the influent and effluent of the UV/AOP system including control samples.
- Labor required for set up and administration of the spiking experiment.
- Supplies and equipment.
- Data analysis.

8.3 Assessment of AWPF Product Water Stabilization Requirements

Upon review of the Draft T&M Plan, the IAP Subcommittee provided the project team with a series of comments including a recommendation to consider evaluating options to stabilize the AWPF product water (NWRI, 2010). The primary objective of the assessment would be to determine the extent to which secondary disinfection and / or corrosion control in addition to lime treatment may be required for the potential full-scale AWPF. The IAP Subcommittee presented the option of conducting pilot testing using a pipe-loops or annular reactors to achieve the aforementioned objectives. After consideration of this information, the project team recommends the City consider conducting an initial bench scale study during the AWPF Demonstration phase to gain insight on corrosion and biogrowth potential of AWP product water and to identity possible post treatment strategies that could be considered from the full scale AWPF. Based on the information gained from the bench testing, the City may decide to conduct pipe-loop studies at a later stage in the approval and decision process to move forward with a full- scale AWPF.

The specific objectives of the proposed product water stabilization bench scale testing follow:

- Assess the microbial re-growth and corrositivity potential of the AWPF product water.
- Identify possible post treatment strategies to inhibit corrosion of the conveyance system of the full scale AWPF.
- Identify possible secondary disinfection strategies to inhibit bio-growth in the conveyance system of the full scale AWPF.
- Assess nitrogenous disinfection byproduct (DBP) formation potential of the AWP product water under various secondary disinfection strategies
- Provide recommendation on further testing required prior to the selection and design of the post treatment system for the potential full-scale AWPF

8.3.1 Bench Scale Testing Approach

The following provides a proposed outline of the bench scale testing approach to meet the above objectives:

The specific objectives of the proposed product water stabilization bench scale testing follow:

- Characterize the assimilable organic carbon (AOC) and biodegradable organic carbon (BDOC) content of the AWPF Demonstration product water.
- Collect, treat and analyze batch samples of the AWPF product water to evaluate options for achieving a neutral or slightly positive Langelier Saturation Index (LSI). Strategies to be considered include: 1) increasing the hardness and alkalinity using lime or calcite contractor along with carbon dioxide addition for pH adjustment, 2) adding polyphosphate or silicate inhibitor 3) simply raising the pH with lime addition only.
- Perform chlorine demand decay tests of the AWPF product water to determine the chlorine demand and Nitrogenous DBP formation potential.
- Assess biofilm growth and corrosion of pipe coupons configured in an annular reactor (with and without secondary disinfection & corrosion control) using pipe material and hydraulic detention times under similar conditions being considered with regards to the conveyance system for the full-scale AWPF.

8.4 Microbial Monitoring

Upon review of the Draft T&M Plan, the IAP suggested that it may be possible to reduce the monitoring frequency for Cryptosporidium (before MF/UF) by sampling for aerobic spores like B. subtilis as potential surrogates for Cryptosporidium. B subtilis are much smaller than Cryptosporidium and thus would be a conservative indicator that can be analyzed quickly and inexpensively. B. subtilis analyses could be performed in conjunction with Cryptosporidium studies and more frequently as potential MF/UF process performance indicators. The use of aerobic spores would be appropriate if the spores service the prior disinfection process. This would need to be evaluated.

The project team agrees B. subtilis may serve a good surrogate for Cryptosporidium as it is smaller and should be removed by sieving. However, it is unknown if the spores will survive the addition of chloramines upstream of the MF/UF systems to have substantial levels. Also, it may be difficult to differentiate whether observations of reduced concentrations in the MF/UF filtrate is due to disinfectant contact time during filtration, or actual removal. In order to answer these questions, the project team would recommend conducting conventional microbial inactivation bench scale experiments using B. subtilis under various conditions including chloramines concentration, pH and contact time.

8.5 Provisions to Address the State Water Board's draft Policy for Toxicity Assessment and Control

The RWQCB's comments (California Regional Water Quality Control Board – San Diego Region, 2011) on the Draft T&M Plan specified that the Plan should include provisions for addressing the State Board's draft Policy for Toxicity Assessment and Control.

Based on this comment, the project team recommends discussing with the State Board the option of conducting quarterly Whole Effluent Toxicity testing on the AWPF effluent using current Standard EPA test methods. Each test would include 3 freshwater species (algae, fish and invertebrate) per the EPA protocol. The initial sample volume per test would be 5 gallons with 3 discreet samples required per test over a 7 day period. Based on their local experience conducting similar testing for Padre Dam Municipal Water District it is recommended that Nautilus Environmental Laboratories (NEL) perform the testing. Based on initial discussion with NEL it is suggested AWPF effluent samples be remineralized to specific pH, alkalinity and hardness prior to conducting the testing. Turnaround time on the analytical results in approximately 2weeks.

8.6 Assessment of Diurnal Effect on Key Constituents

Per comments received by the CDPH on the November 30, 2010 Final Draft Testing and Monitoring Plan, it is recommended that two 24 hour sampling events during the 12 month operating period be conducted to assess diurnal variations of key constituents by collecting grab samples of the RO feed (S6) every 4 hours for the following compounds:

- Caffeine (14 samples total)
- Sucralose (14 samples total)
- Total nitrogen(14 samples total)
- Nitrate / Nitrite(14 samples total)
- Total phosphorus (14 samples total)
- 1,4 dioxane (14 samples total)
- NDMA(14 samples total)

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Section 9
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APPENDIX A – AWP FACILITY DRAFT PFD & SITE LAYOUT

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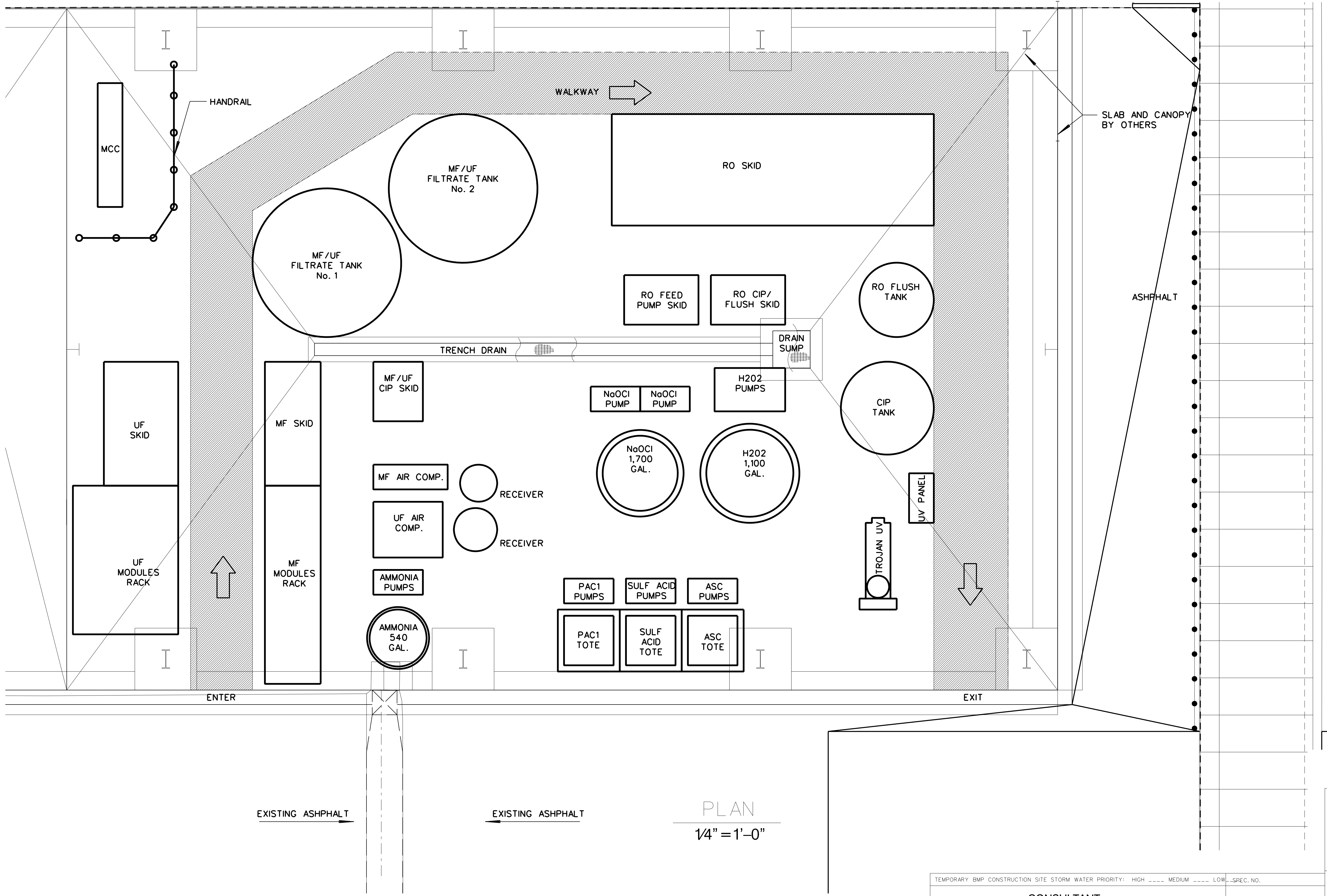


PLAN

1/4" = 1'-0"

N

A-1

INDIRECT POTABLE REUSE/RESERVIOR AUGMENTATION DEMONSTRATION PROJECT ADVANCED WATER PURIFICATION FACILITY

MECHANICAL PLAN

TEMPORARY BMP CONSTRUCTION SITE STORM WATER PRIORITY: HIGH ____ MEDIUM ____ LOW ____ SPEC. NO.

CONSULTANT

CONSULTANT

STAMP

CITY OF SAN DIEGO, CALIFORNIA
ENGINEERING AND CAPITAL PROJECTS DEPARTMENT
SHEET OF SHEETS

WBS 0-00000
WBS 0-00000

APPROVED:
FOR CITY ENGINEER
DATE

SUBMITTED BY:
ASSOCIATE ENGINEER

DESCRIPTION	BY	APPROVED	DATE	FILMED
ORIGINAL	XX/XX			

PROJECT ENGINEER

SEE SHEETS
CCS27 COORDINATE

SEE SHEETS
CCS83 COORDINATE

CONTRACTOR ____________ DATE STARTED ____________
INSPECTOR ____________ DATE COMPLETED ____________

19905-XX-D

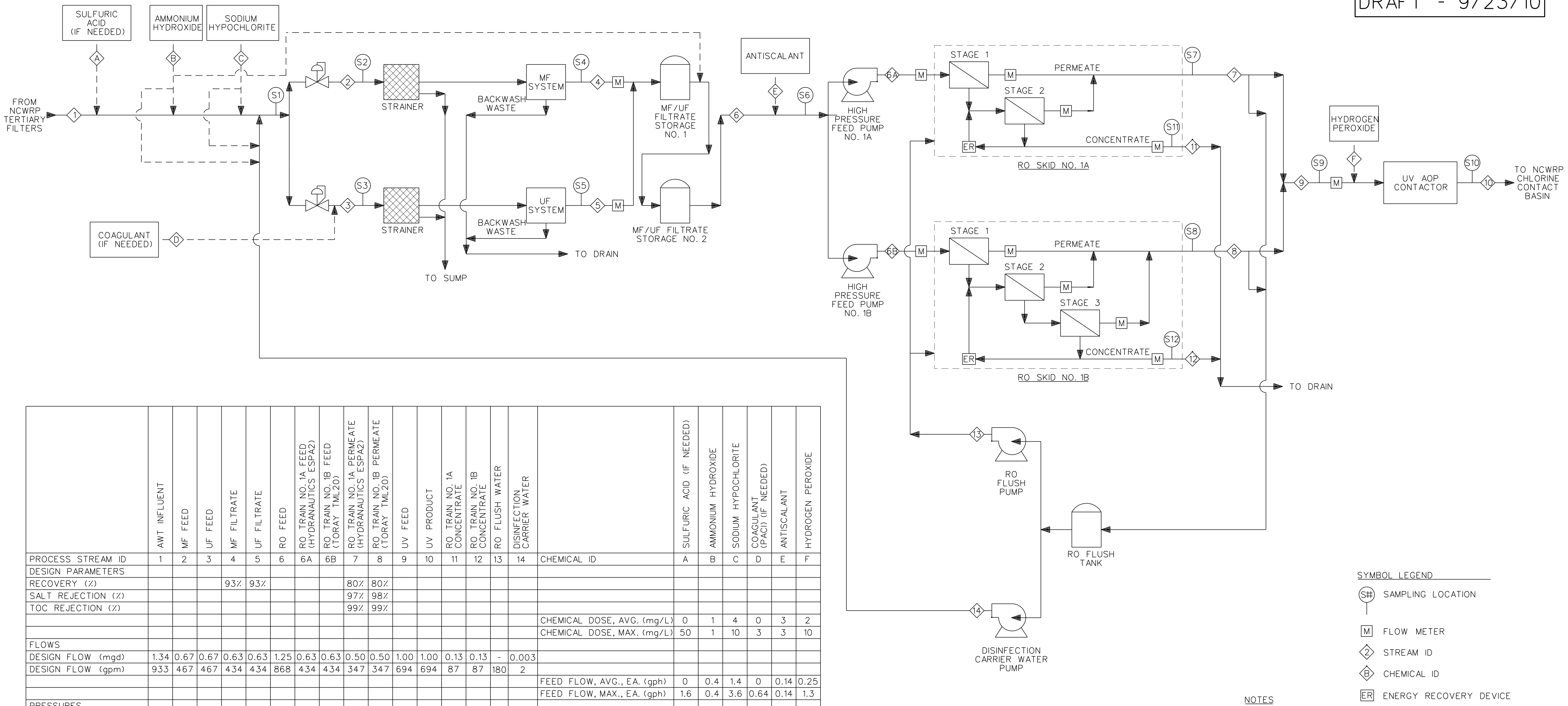
CONSTRUCTION CHANGE / ADDENDUM

CHANGE	DATE	AFFECTED OR ADDED SHEET NUMBERS	APPROVAL NO.

WARNING
0 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.

CITY OF SAN DIEGO
PUBLIC WORKS PROJECT

DRAFT - 9/23/10



	AWT INFLUENT	MF FEED	UF FEED	MF FILTRATE	UF FILTRATE	RO FEED	RO TRAIN NO. 1A FEED (HYDRANAUTICS ESPA2)	RO TRAIN NO. 1B FEED (TORAY TML20)	RO TRAIN NO. 1A PERMEATE (HYDRANAUTICS ESPA2)	RO TRAIN NO. 1B PERMEATE (TORAY TML20)	UV FEED	UV PRODUCT	RO TRAIN NO. 1A CONCENTRATE	RO TRAIN NO. 1B CONCENTRATE	RO FLUSH WATER	DISINFECTION CARRIER WATER		SULFURIC ACID (IF NEEDED)	AMMONIUM HYDROXIDE	SODIUM HYPOCHLORITE	COAGULANT (PACl) (IF NEEDED)	ANTISCALANT	HYDROGEN PEROXIDE
PROCESS STREAM ID	1	2	3	4	5	6	6A	6B	7	8	9	10	11	12	13	14	CHEMICAL ID	A	B	C	D	E	F
DESIGN PARAMETERS																							
RECOVERY (%)				93%	93%				80%	80%													
SALT REJECTION (%)									97%	98%													
TOC REJECTION (%)									99%	99%													
																	CHEMICAL DOSE, AVG. (mg/L)	0	1	4	0	3	2
																	CHEMICAL DOSE, MAX. (mg/L)	50	1	10	3	3	10
FLOWS																							
DESIGN FLOW (mgd)	1.34	0.67	0.67	0.63	0.63	1.25	0.63	0.63	0.50	0.50	1.00	1.00	0.13	0.13	-	0.003							
DESIGN FLOW (gpm)	933	467	467	434	434	868	434	434	347	347	694	694	87	87	180	2							
																	FEED FLOW, AVG., EA. (gph)	0	0.4	1.4	0	0.14	0.25
																	FEED FLOW, MAX., EA. (gph)	1.6	0.4	3.6	0.64	0.14	1.3
PRESSURES																							
PRESSURE, AVG. (psi)	60	30	50	0.4	0.4	0.4	217	217	4.3	4.3	4.3	4.3	0	0	60	65							
PRESSURE, MAX. (psi)	60	30	50	5.6	5.6	5.6	228	228	4.3	4.3	4.3	4.3	0	0	60	75							
CONSTITUENTS																							
pH, AVG.	7.1	7.2	7.2	7.2	7.2	7.2	7.2	7.2	5.9	5.2	5.6	5.6	7.8	7.8	5.6	5.6		0.03	11.6	12	1.5-2	2-4	3.3
pH, MIN.	7.0	6.4	6.4	6.4	6.4	6.4	6.4	6.4	5.1	4.6	4.9	4.9	7.0	7.0	4.9	4.9							
pH, MAX.	7.3	7.7	7.7	7.7	7.7	7.7	7.7	7.7	6.4	6.2	6.3	6.3	8.3	8.0	6.3	6.3							
TDS, AVG. (mg/L)	920	925	925	925	925	925	925	925	28	19	23	23	4510	4550	23	23							
TDS, MAX. (mg/L)	980	991	991	991	991	991	991	991	30	20	25	25	4840	4880	25	25							
TOC, AVG. (mg/L)	8.5	8.5	8.5	8.5	8.5	9.4	9.4	9.4	0.1	0.1	0.1	0.1	47	47	0.1	0.1							
TOC, MAX. (mg/L)	10	10	10	10	10	11	11	11	0.1	0.1	0.1	0.1	55	55	0.1	0.1							
TOTAL CL2, AVG. (mg/L)	0.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5							
TOTAL CL2, MAX. (mg/L)	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0							

NOTES

BACKWASH SYSTEMS FOR MF AND UF AND CIP SYSTEMS FOR MF, UF AND RO ARE NOT SHOWN FOR CLARITY.

A-2

INDIRECT POTABLE REUSE/RESERVOIR AUGMENTATION DEMONSTRATION PROJECT ADVANCED WATER PURIFICATION FACILITY

PROCESS FLOW DIAGRAM

TEMPORARY BMP CONSTRUCTION SITE STORM WATER PRIORITY: HIGH ____ MEDIUM ____ LOW ____ SPEC. NO.

CONSULTANT

CDM
Camp Dresser & McKee Inc
1925 Palomar Oaks Way, Suite 300
Carlsbad, California 92008
Tel: (760) 438-7755

consulting • engineering • construction • operations

IN ASSOCIATION WITH
MWH

CONSULTANT

STAMP

CITY OF SAN DIEGO, CALIFORNIA
ENGINEERING AND CAPITAL PROJECTS DEPARTMENT
SHEET __ OF __ SHEETS

WBS 0-00000
WBS 0-00000

APPROVED:
FOR CITY ENGINEER ____ DATE ____

SUBMITTED BY:
ASSOCIATE ENGINEER

PROJECT ENGINEER

DESCRIPTION	BY	APPROVED	DATE	FILMED
ORIGINAL	XX/XX			

SEE SHEETS
CCS27 COORDINATE

SEE SHEETS
CCS83 COORDINATE

CONTRACTOR ____ DATE STARTED ____
INSPECTOR ____ DATE COMPLETED ____

19905–XX–D

CONSTRUCTION CHANGE / ADDENDUM

CHANGE	DATE	AFFECTED OR ADDED SHEET NUMBERS	APPROVAL NO.

WARNING

0 1

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.

CITY OF SAN DIEGO
PUBLIC WORKS PROJECT

$plot$date$time$$ $user$

APPENDIX B – TECHNICAL MEMORANDUM: SURVEY OF NCWRP INDUSTRIAL DISCHARGERS PREPARED BY RMC

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Technical Memorandum

City of San Diego Water Purification Demonstration Project

Subject: **Survey of North City Water Reclamation Plant Industrial Dischargers**
Prepared For: City of San Diego Public Utilities Department
Prepared by: Tish Berge
Reviewed by: Tom Richardson
Date: June 21, 2010
Reference: 0104-004

The purpose of this technical memorandum is to outline the process used to identify specific contaminates of concern in the North City Water Reclamation Plant (NCWRP) sewershed based on industrial discharger information and to report the results of this process. This TM is organized as follows:

- Background
- Approach
- Findings

1 Background

The scope of services for the City of San Diego Water Purification Demonstration Project Advanced Water Purification (AWP) Demonstration Plant includes a Local Contaminates Investigation. The RMC team was tasked with identifying specific contaminates of concern in the NCWRP sewershed based on industrial discharger information. This information will be provided to the AWP consultant for use in identifying analytes and indicators included in a Testing and Monitoring Plan.

1.1 NCWRP Sewershed Industrial Base

The NCWRP sewershed has a large concentration of pharmaceutical/research and development (R&D) facilities. Generally only R&D biomedical industry activity is conducted in the area and the discharge may differ daily due to the intermittent nature of the business and frequent turnover of tenants. The team worked with the City of San Diego Public Utilities Industrial Wastewater Control Program to identify the information available for these dischargers via the industrial permitting process.

1.2 City of San Diego Pretreatment Program Permits

The City of San Diego Industrial Wastewater Control Program issues permits to industrial dischargers in San Diego and the 16 Participating Agencies that constitute the Metro sewer system tributary area. Permits issued are based upon industrial type and flow as follows:

- Class 1 – Federally regulated industry - pharmaceutical manufacturer.
- Class 2 – Potential for toxics – laboratories are required to follow Best Management Practices and Toxic and Prohibited Organic Chemical Management Plan (TOMP). For reference, these documents are provided at the end of this technical memorandum as Attachments 1 and 2.
- Class 3 – Potential for conventional pollutants (i.e. biochemical oxygen demand [BOD] and total suspended solids [TSS]) in quantities that could interfere with the collection system or upset the wastewater treatment plant's biological processes. Class 3 permits are not discussed further here

as typical Class 3 pollutants are not discharged in large quantities from R&D biomedical industries.

- Class 4 – Flow is less than 25 gallons per day and permit is not necessary. Class 4 permits are not discussed further as R&D biomedical industries generally done fall within this category.

1.2.1 Class 1 Permits

The US Environmental Protection Agency (EPA) regulates certain classes of industrial waste dischargers as significant industrial users. Significant Industrial User is defined by the US EPA as an industrial user that discharges process wastewater into a publicly owned treatment works (POTW) and meets at least one of the following:

1. All industrial users subject to Categorical Pretreatment Standards under the Code of Federal Regulations - Title 40 (40 CFR) Part 403.6, and CFR Title 40 Chapter I, Subchapter N- Effluent Guidelines and Standards; and
2. Any other industrial user that:
    a. Discharges an average of 25,000 gallons per day or more of process wastewater to the POTW (excluding sanitary, non-contact cooling and boiler blowdown wastewater); or
    b. Contributes a process wastestream which makes up 5 percent or more of any design capacity of the POTW treatment plant; or
    c. Has a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard or requirement.

1.2.2 Class 2 Permits

Each industry is required to submit a list of chemicals stored or used onsite with the initial permit application and every four years thereafter. Most of the chemicals are not expected to be found in the sewer as the discharge of concentrated toxic organics to the sewer is prohibited.

The TOMP requires the following:

- No disposal of chemicals to the sewer
    - There may be a small amount of chemical disposed due to laboratory glassware washing
    - Materials are concentrated and disposed of as a liquid/solid waste
- Provide an inventory of chemicals, which is included in the permit application
- Certify twice a year that the facility is following the TOMP

1.2.3 Permit Information Available

Each permit file includes the permit application, the TOMP, and lists other chemicals maintained on site. The TOMP identifies the CWA priority pollutant toxic organics used (using a checklist and separating into halogenated and non-halogenated) and flammable chemicals used or stored. For the other chemicals maintained and used on site, the type and quantity of data varied greatly with some users reporting in excess of 10,000 chemicals. Data were available in either electronic of hardcopy format. Larger hardcopy files were scanned for text recognition using optical character recognition.

2 Approach

Given the number of permits for industries in the NCWRP sewershed, and the extensive lists of chemicals associated with those industries, the team decided to use a representative subset of industries in developing the inventory. Within the NCWRP sewershed, there are 198 industries with City of San Diego permits. Of these 198 industries, 102 are either biotech R&D or some other type of R&D with the remaining 96 industries covering 49 different industry types from car washes and gas stations to electronic equipment manufacturers and veterinary services. Due to the large prevalence of biotech and

R&D industries within the sewershed, the team selected a subset of these 102 industries. The subset totaled 30 industries and included the following:

- All (two total) Class 1, federally regulated, pharmaceutical manufacturers;
- Twenty Class 2 industries with the greatest industrial wastewater flow; and
- Nine industries (mainly R&D) geographically clustered on Nancy Ridge Drive, including one Class 2 industry.

2.1 Data Review

With the assistance of the City of San Diego Public Utilities Industrial Wastewater Control Program, the team reviewed the permit files for each of the selected industries. Based on information provided in the TOMP, the team compiled a list of the toxic organics used by each industry. Each industry also included a comprehensive list of other chemicals stored or used on site. These varied from one list of just a dozen chemicals/products to lists of more than 10,000 chemicals / products. Therefore, the team decided to use the US EPA's Contaminant Candidate List 3 (CCL3) to prioritize the chemicals and aid in review.

As a result, the final data list provides a listing of toxic organics used (as identified in the TOMP), flammable chemicals used/stored (as identified in the TOMP), and CCL3 chemicals used/stored.

2.1.1 Chemicals of Emerging Concern (CEC)

Constituents/chemicals of emerging concern (CECs) represent a challenging problem for regulators to address, owing to the lack of approved analytical methods to identify and quantify the presence of CECs and limited scientific knowledge about their sources, fates, and effects. The California State Water Resources Control Board (SWRCB) recently issued a Recycled Water Policy that, among other efforts, attempts to incorporate the most current science on CECs into regulatory policies for use by various state agencies. As a part of this policy, Southern California Coastal Water Research Project (SCCWRP) was asked to convene a panel of six experts to provide recommendations to the SWRCB. This "blue ribbon" panel addressed several questions, including:

1. What are the appropriate constituents to be monitored in recycled water, and what are the applicable monitoring methods and detection limits?
2. What are the possible indicators (i.e. surrogates) that represent a suite of CECs?

Based on the information compiled by the SCCWRP panel, the team used the List of Contaminants on US EPA's Contaminant Candidate List 3 (CCL3) [Table D-1, Final Report (Draft for Public Comments) Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water Recommendations of a Science Advisory Panel, April 15, 2010]. The U.S. Government has a long history of developing regulations for contaminants in drinking water to protect public health; the process has evolved over several decades and includes the placement of currently non-regulated contaminants to be further evaluated on the USEPA's Candidate Contaminant List (or CCL). The most recent CCL is CCL3, which utilized the expert opinions provided by the National Research Council as well as the National Drinking Water Advisory Council. This multi-step process includes three key elements:

- Identification of a broad universe of potential biological chemical and chemical contaminants (CCL Universe);
- Application of screening criteria based on potential occurrence and human health relevance (preliminary CCL or PCCL); and,
- Selection of priority contaminants based on more detailed occurrence and health effect data as well as expert judgment, public comment, and external advisory committees (draft and final CCL).

A draft of the CCL3 was released in February of 2008 and the final CCL3 was published in October of 2009; the list was then referenced in the recent report by the “blue ribbon” panel.

3 Findings

Based on the available data set and the criteria for review, the team assembled a comprehensive listing of chemicals used or stored by facility. This table appears on the following page.

Facility No.	02-0033	02-0043	02-0059	02-0332	02-0518	02-0641	02-0715	02-0721	02-0730	02-0744	02-0751	02-0752	02-0756	02-0880	02-0761	02-0762	02-0795	02-0803	02-0806	02-0808	02-0843	02-0861	02-0913	02-0939	02-0961	02-0972	02-0978	02-1047	03-1041	03-1081
TOXIC ORGANIC, HALONGENATED																														
aldrin																										x				x
benzofluoranthene																										x				
carbon tetrachloride	x		x	x			x	x	x	x		x								x			x			x				X
chlordane																										x				
chlorinated benzenes	x		x			x	x	x	x			x								x						x				X
chloroalky ethers																				x						x				
chlorinated naphthalene								x	x																	x				X
chlorinated phenols						x	x	x	x			x								x			x			x				
chloroform	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	X
chlorinated cresols																										x				
DDT and metabolites							x			x																x				
dichlorobenziden																							x			x				
dichloroethylenes			x						x																	x				
dichloropropane									x										x							x				
dichloropropene																										x				
dieldrin																										x				x
endrin and metabolites																										x				
fluoranthene																										x				
freons							x		x	x		x														x				
haloethers						x						x			x					x			x			x				
halomethanes (inc. methylene chloride)	x					x	x	x	x	x		x			x	x		x	x	x		x	x	x		x				x
heptachlor and metabolites																										x				
hexachlorobutadiene																										x				
hexachlorocyclohexane									x																	x				
hexachlorocyclopentadiene	x								x																	x				
pentachlorophenol							x		x			x														x				

Facility No.	02-0033	02-0043	02-0059	02-0332	02-0518	02-0641	02-0715	02-0721	02-0730	02-0744	02-0751	02-0752	02-0756	02-0880	02-0761	02-0762	02-0795	02-0803	02-0806	02-0808	02-0843	02-0861	02-0913	02-0939	02-0961	02-0972	02-0978	02-1047	03-1041	03-1081
polychlorinated byphenyls (PCBs)																										x				
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)																														
tetrachloroethylene	x		x			x			x			x														x				
toxaphene																										x				
1,1,1-trichloroethane									x	x																x				
trichloroethylene				x				x	x			x		x									x			x				
vinyl chloride																										x				
chlorinated ethanes								x																						
TOXIC ORGANIC, NON-HALOGENATED																														
acenapthene																										x				x
acrolein	x					x		x	x			x							x	x			x			x				
acrylonitrile	x					x			x			x	x							x			x			x				x
benzene	x		x			x	x	x	x	x		x							x	x		x	x			x				x
benzidine	x						x		x														x			x				
chrysene									x			x														x				
2,4-dimethylphenol									x			x														x				
dinitrotoluene						x			x			x														x				
diphenylhydrazine									x			x														x				
endosulfan and metabolites												x														x				
ethylbenzene			x				x		x			x														x				x
isophorone									x																	x				
napthalene	x		x			x	x		x				x									x	x			x				x
nitrobenzene	x					x		x	x			x									x		x			x				
nitrophenols	x					x	x	x	x	x		x						x					x			x				
nitrosamines												x														x				
phenol	x	x				x	x	x	x	x		x						x	x		x	x	x		x	x	x		x	
phthalate esters						x			x																	x				x

Facility No.	02-0033	02-0043	02-0059	02-0332	02-0518	02-0641	02-0715	02-0721	02-0730	02-0744	02-0751	02-0752	02-0756	02-0880	02-0761	02-0762	02-0795	02-0803	02-0806	02-0808	02-0843	02-0861	02-0913	02-0939	02-0961	02-0972	02-0978	02-1047	03-1041	03-1081
polynuclear aromatic hydrocarbons						x			x			x														x				
toluene	x	x	x			x	x	x	x	x		x		x	x	x		x	x	x	x	x	x	x		x				x
CHEMICAL OF EMERGING CONCERN (CCL3)																														
1,1,2,2-tetrachloroethane									x														x							
1,1-dichloroethane									x																					
1,1-dichloropropene																														
1,2,4-trimethylbenzene									x																					x
1,2-diphenylhydrazine									x			x														x				
1,3-dichloropropane																														
1,3-dichloropropene									x																					
2,2-dichloropropane									x																					
2,4,6-trichlorophenol									x														x							
2,4-dichlorophenol									x														x							
2,4-dinitrophenol	x						x		x	x			x																	x
2,4-dinitrotoluene									x																					
2,6-dinitrotoluene									x																					
2-methyl-Phenol (AKA o-cresol)								x	x																					
Acetochlor																														
Alachlor ESA & other acetanilide pesticide degradation products																							X							
Aldrin																										x				x
Aluminum									x														x							
atrazine-desethyl																														
Boron																														
Bromobenzene								x	x														x							x
DCPA de-acid																														

Facility No.	02-0033	02-0043	02-0059	02-0332	02-0518	02-0641	02-0715	02-0721	02-0730	02-0744	02-0751	02-0752	02-0756	02-0880	02-0761	02-0762	02-0795	02-0803	02-0806	02-0808	02-0843	02-0861	02-0913	02-0939	02-0961	02-0972	02-0978	02-1047	03-1041	03-1081
degradate																														
DCPA mono-acid degradate																														
DDE									x																					
Diazinon	x																													x
Dieldrin																										x				x
Disulfoton																														
Diuron									x																					
EPTC (s-ethyl-dipropylthiocarbamate)																														
Fonofos																														
Hexachlorobutadiene																										x				
Linuron																														
Manganese									x				x																	
Methyl bromide (AKA Bromomethane)								x	x																					
Methyl-t-butyl ether (MTBE)							x		x	x			x			x		x					x							
Metolachlor																														
Metribuzin																														
Molinate																														
Naphthalene	x		x			x	x		x				x									x	x			x				x
Nitrobenzene	x					x		x	x			x									x		x			x				
Organotins																														
Perchlorate																														
p-Isopropyltoluene (p-cymene)									x																					
Prometon																														
RDX																														
Sodium	x						x		x	x			x										x							
Sulfate																														

Facility No.	02-0033	02-0043	02-0059	02-0332	02-0518	02-0641	02-0715	02-0721	02-0730	02-0744	02-0751	02-0752	02-0756	02-0880	02-0761	02-0762	02-0795	02-0803	02-0806	02-0808	02-0843	02-0861	02-0913	02-0939	02-0961	02-0972	02-0978	02-1047	03-1041	03-1081
Terbacil																														
Terbufos																														
Triazines & degradation products of triazines including but not limited to Cyanazine																														
Vanadium																														

ATTACHMENT 1

Best Management Practice Requirements for Laboratories within NCWRP Sewershed

Waste Handling Best Management Practices for Laboratories

The Industrial Wastewater Control Program has compiled the following list of required and recommended practices to help your business comply with Industrial Waste Discharge Requirements and to promote pollution prevention and waste minimization in laboratories.

Requirements

- Do not dispose of hazardous waste to the sewer or storm drain; such disposal is strictly prohibited. For assistance in determining whether a waste is hazardous, contact the San Diego County Hazardous Materials Management Division at (619) 338-2231.

- Prevent leaks or spills from accidentally entering the sewer.

  Drain protection can be accomplished through one of the following four options: 1) Move the fluids to an area from which they could not flow to the drains. 2) Plug the drains or cap the drain pipes, as applicable. 3) Install a raised lip or curb around the drains or extend the drain pipes, a minimum of four inches above any area features which could contain fluids. 4) Construct spill containment for the fluids, of capacity equal to the largest fluid vessel plus any fire water volume required by fire codes, and exclude the drains from the containment area. Drain plugs, raised lips, drain curbs, or containment walls must be of a permanent nature and materials resistant to corrosion by the fluids, e.g. epoxy grout or epoxy coated concrete. Drain pipe caps or extensions must be welded or glued.

- Never use sinks as secondary containment or for chemical storage.

- Eliminate or reduce single-pass water to less than 500 gpd.

- Implement the approved Management Plan for Toxic and Prohibited Organic Chemicals on file with this office.

- All biohazardous medical wastes must be managed and discharged in compliance with the July 2005 California Medical Waste Management Act and revisions and amendments thereto, as set forth in the California Health and Safety Code, Sections 117600 - 118360.

Recommendations

Waste Minimization

- Substitute less toxic materials in production and cleanup operations when feasible.

- Order chemicals in the minimum quantities necessary for a process/protocol; this eliminates waste resulting from process changes and expiration dates passing.

- Work with the minimum amount of chemicals required by a process/protocol; this reduces waste in the event of a spill and encourages prudent chemical handling.

- Reuse/Recycle spent solvents when possible.

revised Feb 2010

- Practice water conservation by installing flow restrictors and recycling water when possible.

Drain Protection

- Utilize secondary containment to prevent leaks or spills from accidentally entering the sewer. Trays or plastic holders can be used for small volumes; larger volumes should be stored in bermed or diked storage areas. Secondary containment should be kept dry. Never store incompatible chemicals together in the same containment area. Other spill prevention measures include:
    - Using coated containers to reduce spills caused by breakage.
    - Storing chemicals in latched cabinets and using shelf barriers.
    - Checking storage container integrity on a regular basis.
    - Storing chemicals in approved cabinets or on low shelves.

- Maintain a written spill response plan and be sure that all employees are familiar with it. Be sure that spill clean up supplies are adequately stocked and easily accessible.

- Keep a mercury spill clean up kit in labs where mercury is used. Consider substituting electronic sensing devices for mercury containing equipment to prevent spills associated with breakage. Mercury in thermometers is the most likely source of this contaminant in labs.

Other

- Post signs next to lab sinks and drains to remind employees that disposal of hazardous waste to the sewer is prohibited.

- Practice good housekeeping by cleaning up spills immediately, clearly labeling all containers, utilizing proper chemical storage practices, and keeping clutter to a minimum.

- Be sure that all employees have been informed of your company's chemical handling and disposal protocols as well as the spill response plan. Periodic refresher training will keep employees informed of changes and updates.

- Film Processing: Refer to the City's Best Management Practice Requirements for Silver-Rich Solutions.

For more information, contact:

The City of San Diego
Industrial Wastewater Control Program
9192 Topaz Way, MS 901D
San Diego, CA 92123-1119
(858) 654-4100

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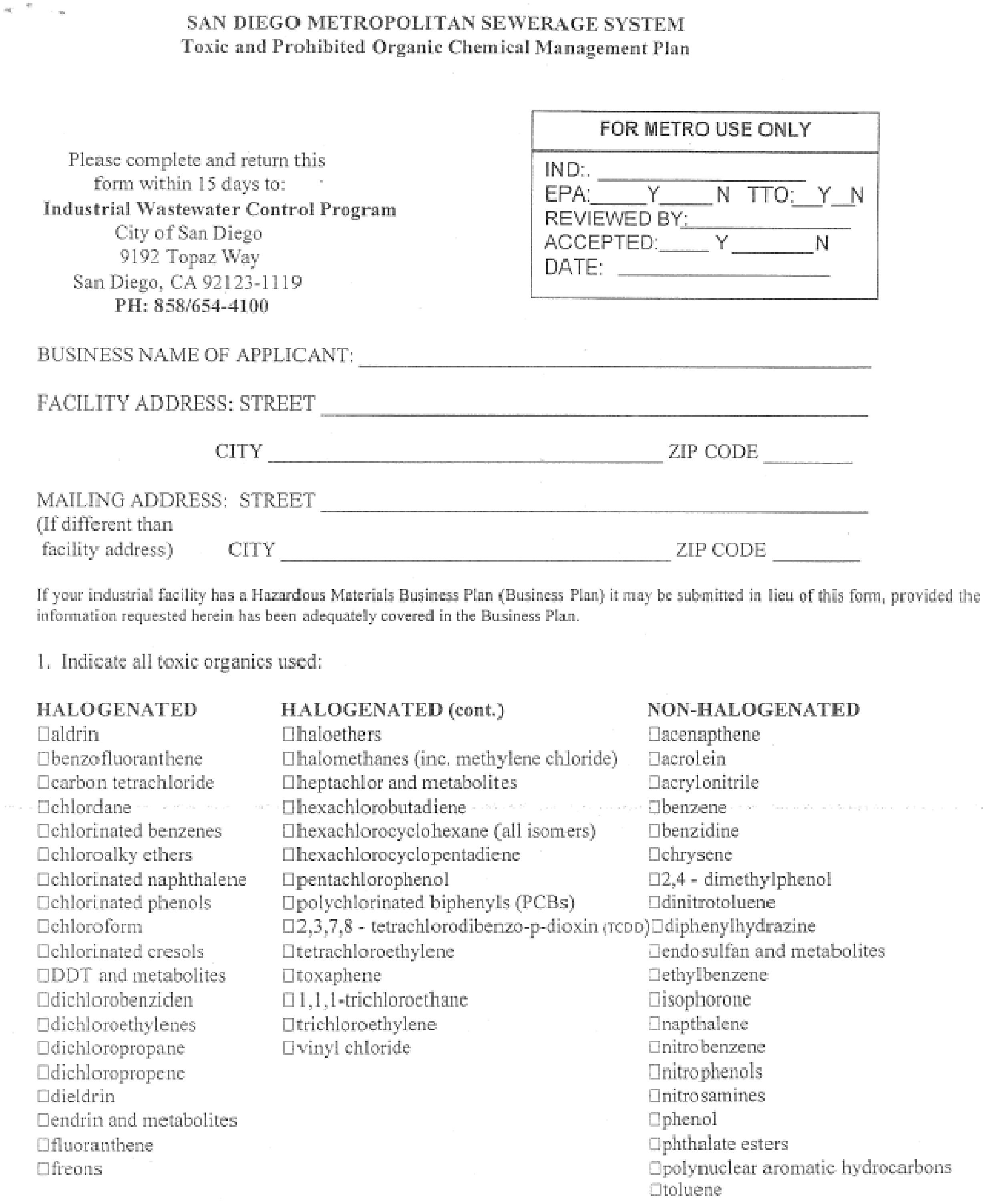
ATTACHMENT 2

TOMP for Industries within NCWRP Sewershed



SAN DIEGO METROPOLITAN SEWERAGE SYSTEM
Toxic and Prohibited Organic Chemical Management Plan

FOR METRO USE ONLY

IND:. ____________________
EPA:_____Y_____N TTO:__Y__N
REVIEWED BY:________________
ACCEPTED:_____ Y________N
DATE: ____________________

Please complete and return this
form within 15 days to:
Industrial Wastewater Control Program
City of San Diego
9192 Topaz Way
San Diego, CA 92123-1119
PH: 858/654-4100

BUSINESS NAME OF APPLICANT: ____

FACILITY ADDRESS: STREET ____

CITY ______________________________ ZIP CODE ________

MAILING ADDRESS: STREET ____
(If different than
facility address) CITY ______________________________ ZIP CODE ________

If your industrial facility has a Hazardous Materials Business Plan (Business Plan) it may be submitted in lieu of this form, provided the information requested herein has been adequately covered in the Business Plan.

1. Indicate all toxic organics used:

HALOGENATED

☐aldrin
☐benzofluoranthene
☐carbon tetrachloride
☐chlordane
☐chlorinated benzenes
☐chloroalky ethers
☐chlorinated naphthalene
☐chlorinated phenols
☐chloroform
☐chlorinated cresols
☐DDT and metabolites
☐dichlorobenziden
☐dichloroethylenes
☐dichloropropane
☐dichloropropene
☐dieldrin
☐endrin and metabolites
☐fluoranthene
☐freons

HALOGENATED (cont.)

☐haloethers
☐halomethanes (inc. methylene chloride)
☐heptachlor and metabolites
☐hexachlorobutadiene
☐hexachlorocyclohexane (all isomers)
☐hexachlorocyclopentadiene
☐pentachlorophenol
☐polychlorinated biphenyls (PCBs)
☐2,3,7,8 - tetrachlorodibenzo-p-dioxin (TCDD)
☐tetrachloroethylene
☐toxaphene
☐1,1,1-trichloroethane
☐trichloroethylene
☐vinyl chloride

NON-HALOGENATED

☐acenapthene
☐acrolein
☐acrylonitrile
☐benzene
☐benzidine
☐chrysene
☐2,4 - dimethylphenol
☐dinitrotoluene
☐diphenylhydrazine
☐endosulfan and metabolites
☐ethylbenzene
☐isophorone
☐napthalene
☐nitrobenzene
☐nitrophenols
☐nitrosamines
☐phenol
☐phthalate esters
☐polynuclear aromatic hydrocarbons
☐toluene

2. List all flammable chemicals used/stored:

☐ acetonitrile
☐ acetone
☐ ethanol
☐ ethyl acetate
☐ fuels
☐ methanol
☐ mineral spirits/paint thinner

☐ pyridine
☐ toluene
☐ xylene
☐ other ____________________
____
____

3. Total volume of waste organics generated monthly ______________________________

4. Do you routinely dispose of any of the chemicals listed in 1) or 2) above to the sewer? __ Y __ N

5. Do you segregate organic wastes for disposal? __ Y __ N. List the segregation criteria/categories.

____
____
____

6. How do you manage/dispose of organic wastes?
☐ On-site recovery/reuse
Contract hauling for:
☐ Off-site recovery/reuse
☐ Energy recovery
☐ Incineration
☐ Landfill

7. What is the largest volume of chemicals
a) Stored in a single container? ________
b) Moved as one load? ________

8. Are there any drains leading to the sewer in areas of chemical storage or use? ___ Y ___ N

9. What spill **prevention** measures does your company have in place?
☐ Training ☐ Equipment

Describe: ____
____
____

10. What spill **containment** provisions does your company have?
☐ Training ☐ Equipment

Describe: ____
____
____

Attach any sketches, plans, procedures, or extra sheets required to describe your facility=s organic chemical management plan.

CERTIFICATION: (This plan must be signed by an authorized representative.)

I hereby certify that the information provided in this questionnaire is familiar to me, is complete, and represents an accurate statement of fact to the best of my knowledge.

PRINT NAME: ______________________________ TITLE: ____________________

SIGNATURE: ______________________________ DATE: __________ PH: (   ) ____________

APPENDIX C – TECHNICAL MEMORANDUM: INITIAL PLANNING FOR THE UV/AOP COMPONENT OF THE AWP FACILITY PREPARED BY CDM/MWH

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CDM

1925 Palomar Oaks Way, Suite 300
Carlsbad, CA 92008
Ph: (760) 438-7755
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Attachment A

Memorandum

To: *Anthony Van, Bill Pearce - City of San Diego*

From: *Randy Hill, Greg Wetterau (CDM), Jay DeCarolis (MWH)*

Date: *May 21, 2010*

Subject: Initial planning for the UV/AOP component of the City of San Diego AWT Demonstration Plant, in response to CDPH comments to the UV System section of the IAP Report

Background

The purpose of this technical memorandum is to document the CDM/MWH's initial recommendation with regards to the selection of the UV system to be procured and operated as part of the City of San Diego's AWT Demonstration Project. The memorandum is written to address comments presented by the California Department of Public Health (CDPH) in regards to the IAP report as provided below:

CDPH Comment: "The Trojan Phox ultraviolet (UV) system at Orange County Water District (OCWD) consists of three reactors per treatment train (8.75 millions of gallons per day [mgd] capacity). Each reactor has two chambers. Each chamber has 72 lamps. Conceivably, if the exact same reactor is used, the capacity of one chamber is 1.46 mgd. OCWD's demonstration project was 5 mgd. The specifics of the UV demonstration unit should be addressed in the engineering report that is submitted for our review and approval.

UV Reactor Selection

As part of developing recommendations on the specific UV unit(s) to be tested during the City of San Diego's AWT demonstration project, the CDM/MWH team 1) reviewed the design and operation of the OCWD's UV/AOP system used at the GWRS and 2) spoke with representatives from Trojan.

Review of design and operation of OCWD AOP system used for the GWRS.

A basic flow diagram of the OCWD GWRS UV system is provided in Figure 1 (attached). As shown, the configuration of each train is consistent with the CDPH comment (see above). Each train passes a total flow of 8.75 mgd, contains three (3) reactors, and each reactor contains 2 chambers each with 72 lamps. Other pertinent information considered when reviewing the OCWD system follows:

- The system contains 8 primary trains configured in parallel; however, the (3) three reactors of each individual train are stacked vertically and configured in series, with two chambers in series within each reactor.

- Based on the series configuration, 8.75 mgd flows through each train, reactor, and chamber, resulting in significantly different hydraulic conditions than a single chamber reactor operated at 1.46 mgd. The GWRS UV system is configured to provide sufficient contact time and optimal hydraulics in the six chambers to achieve the required log removal established by CDPH.

Discussions with Trojan

The project team contacted Trojan to assess the feasibility of using a single reactor of the exact same model used in the OCWD train (dual chamber UVPhox Model D72AL75) operated at a flow rate needed to achieve an identical residence time as the OCWD reactors. Trojan confirmed that a flow rate of 2.92 mgd would be required to achieve an identical residence time with this dual chamber reactor; however, the hydraulics would remain considerably different due to the reduced flow rate when using a single reactor rather than the three in series used at OCWD. Because the demonstration plant is being sized for 1 MGD product capacity, operating the UV at 2.92 mgd in batch mode would require a large volume storage tank, VFD driven pumps, and additional controls, and would prevent the ability to continuously operate the AOP system at the demonstration plant.

As an alternative, Trojan recommended using a UVPhox Model 72AL75, which is a single chamber version of the reactors used at OCWD (In the name designation, "D" represents a dual chamber reactor, "72" the number of lamps per chamber, and "75" the diameter of the reactor in centimeters). Trojan has projected that this reactor will achieve 1.3-log NDMA removal at 1 mgd, with a hydraulic residence time roughly 33 percent longer than the OCWD reactors. It should be noted that a flow of 1.46 mgd would be required to achieve an identical residence time as the OCWD reactors, however, Trojan has projected that only 1.1-log destruction of NDMA would be achieved at this higher flow rate due to the poorer hydraulic conditions at the demonstration plant compared with the multiple reactors in series used at OCWD. At the 1-mgd flow, lamp intensity would need to be reduced to achieve 1.2-log NDMA destruction during operation and water quality monitoring at the demonstration plant.

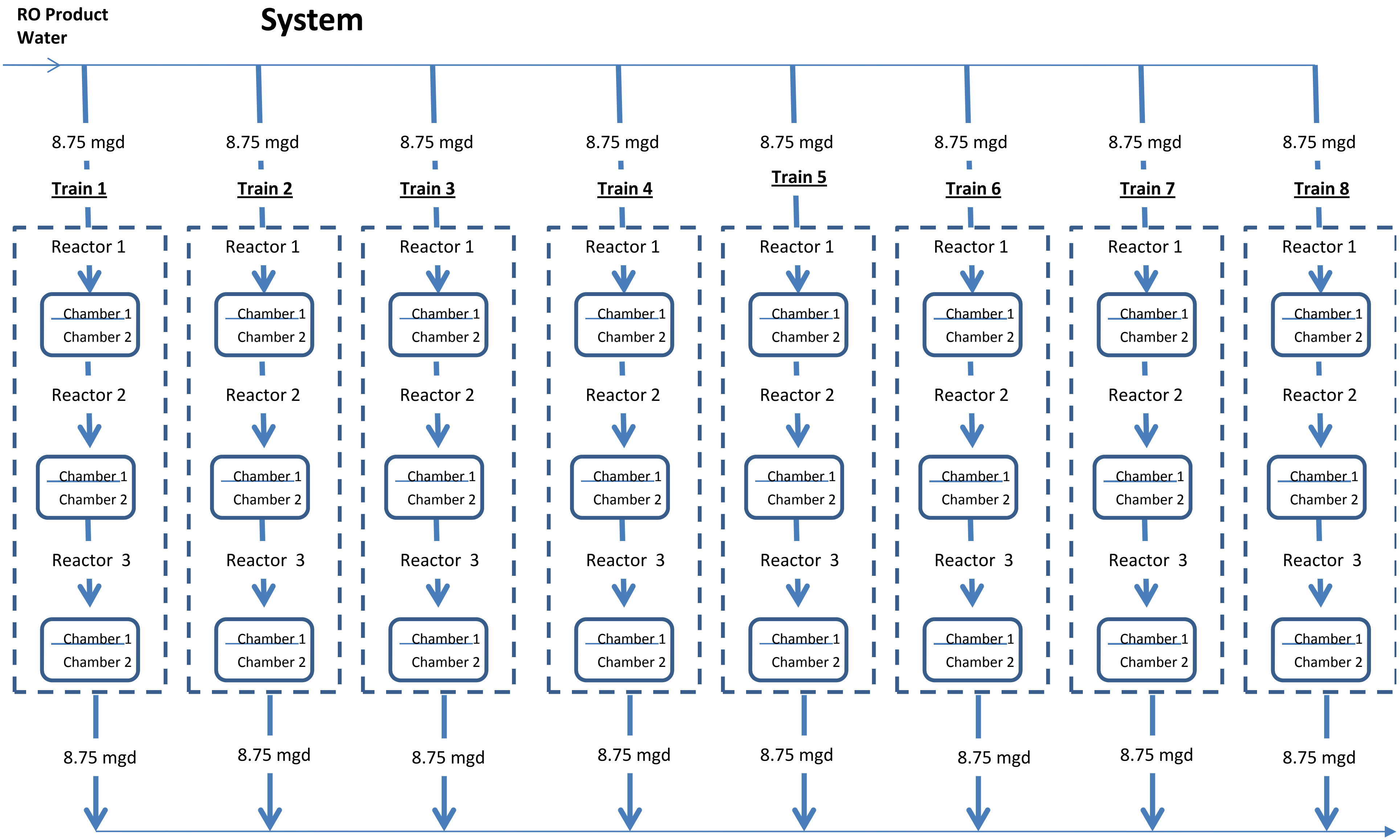
Testing Recommendations

Based on review of OCWD's UV configuration and discussion with Trojan, the project team recommends testing the Trojan UVPhox Model 72AL75 reactor for the San Diego AWT demonstration plant. During the initial phase of the demonstration operation the project team will verify the UV unit can meet 1.2 log removal of NDMA at 1 mgd flow rate by conducting spiking experiments, allowing the team to determine the exact power setting the unit requires for 1.2 log NDMA removal. The unit will then be operated under these settings for the remainder of the demonstration period during all routine and quarterly water quality sampling events.

Should CDPH require, the project team will perform UV collimated beam studies to assess the delivered dose required to reach the 1.2 log NDMA removal. This will include the development of standard curves for log removal by exposing RO product spiked with NDMA to UV light under different intensity settings and exposure time periods using a bench scale collimated beam unit. CDPH may also request that MS2 phage spiking be done to demonstrate 4-log virus removal; however, testing done at OCWD and West Basin has demonstrated that the dose required to achieve NDMA destruction is more than sufficient for achieving 4-log virus reduction.

Because the UV system proposed for the demonstration plant would not be completely identical to the full scale (slightly different reactors and different train configuration) the energy efficiency obtained from the demonstration plant would not be directly comparable to that of the full scale system. Accordingly, for the full scale plant the City would have the option to either use the exact reactor and train configuration as OCWD or another operational advanced treatment facility or to selected a different system and conduct validation testing of the full-scale unit during plant commissioning, similar to the approach taken by the existing advanced treatment facilities operating in southern California.

Figure 1 -Basic Configuration of OCWD's GWR UV / AOP System

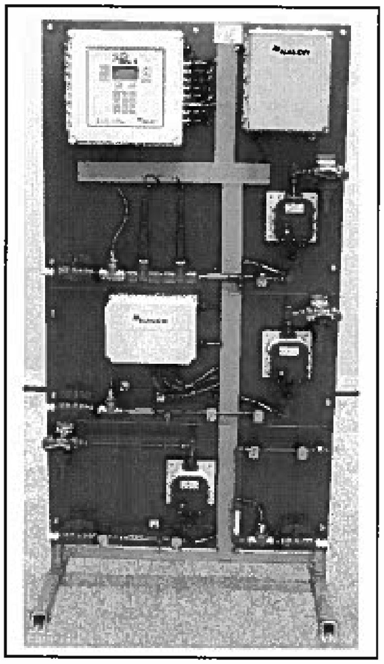


APPENDIX D – TECHNICAL SPECIFICATIONS: 3D TRASAR® AUTOMATION SYSTEM FOR RO SYSTEMS , NALCO INC.

Nalco SPECIFICATION # TBA

3D TRASAR® Automation for Reverse Osmosis Systems

- Optimize performance of Reverse Osmosis systems through data collection, trending and interpretation
- Improve control of antiscalant treatment programs even as operating conditions and water quality change
- Continuously monitors the system and alerts operators to "out of desired range" conditions permitting corrective action before performance is affected
- Availability of treatment program data, operational data and reports via the web simplifies process assurance compliance and troubleshooting.
- Modular design enables the system to be customized to meet customer needs.
- User-friendly interface makes the system easy to install, configure and operate



Description

3D TRASAR Automation for Reverse Osmosis Systems is a modular control platform designed to provide advanced control of antiscalant treatment programs and enable operational data collection for performance analysis. The system uses an updated version of the tried-and-true 3D TRASAR controller coupled with Nalco patented fluorescence technology to optimize control of antiscalant programs and enhance monitoring of pH adjustment and oxidant destruction programs. The expanded capabilities of this new 3D TRASAR controller permit continuous measurement of the key reverse osmosis system parameters.

- Feedwater: Fluorescence (treatment and background), conductivity, temperature, pH, ORP, and flow
- Permeate: Conductivity, temperature, flow and pressure
- Concentrate: Fluorescence, conductivity, temperature, flow and pressure
- Membrane/Interstage: Pressure

The data, along with operating data from the customer's DCS can be wirelessly transmitted back to Nalco for analysis, trending and interpretation. This web capability provides easy access to data, system reporting and enables alerting of key personnel to conditions outside of "best practices".

The 3D TRASAR Automation for Reverse Osmosis Systems is a modular system. It can be customized to handle a variety of reverse osmosis system configurations and upgraded as changes are made to operating conditions or process equipment. Quick-connectors simply installation, sensor calibration/maintenance and in-field upgrades.

3D TRASAR Automation for Reverse Osmosis Systems is just one more example of how Nalco innovation protects your reverse osmosis system, saves water and energy and increases efficiency. 3D TRASAR technology detects, determines and delivers the next dimension in reverse osmosis water management.

Modular Design

The heart of the 3D TRASAR for Reverse Osmosis Systems is the Feedwater System. It provides the sensors, controller and communications interface needed to automate antiscalant treatment programs. They are available as either frame-mount or panel-mount (to mount on the wall) versions.

Feedwater System

Standard Features:

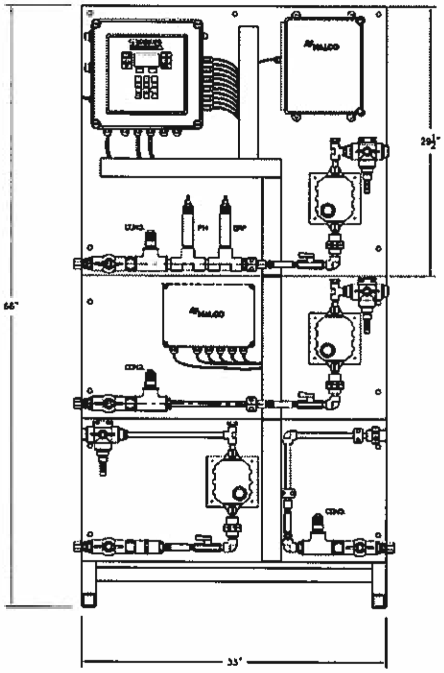
- 3D TRASAR Controller
- Fluorometer
- Conductivity & Temperature
- Sample Flow Switch
- Nalco Global Gateway (Regional Standards)

Options:

- pH & ORP Probes
- Analog Input Modules (provides 6 inputs prewired to accept pressure transmitters and 2 user-wireable inputs)

Mounting

Panels should be mounted on a flat wall so that the controller is at eye level. Add-On Module panels are mounted on the frame below the mains system panel. Wall mounted Add-On Modules must be close enough to the main panel for the probe cables to be connected.



060-RO6011.88 System with 060-RO1000.88 and 060-RO1120.88 Add-On Modules mounted on frame

Add-On Modules

There are 4 Add-On Modules for the 3D TRASAR for Reverse Osmosis Systems. They are all supplied as panel that con be mounted on the frame of the Feedwater System or on the wall.

Fluorometer/Conductivity Add-On Module

- Fluorometer
- Fluorometer Splitter Box (permits up to 4 fluorometers to be connected to the 3D TRASAR Controller)
- Conductivity (5-10,000 µS) & Temperature
- Sample Flow Switch

Fluorometer Add-On Module*

- Fluorometer
- Sample Flow Switch

Note: Requires temperature input from another module.

Permeate Conductivity Add-On Module

- Conductivity (1-500 µS) & Temperature
- Sample Flow Switch

Fluorometer & Permeate Conductivity Add-On Module

- Fluorometer
- Conductivity (1-500 µS) & Temperature
- Sample Flow Switch

To Order

Systems & Add-On Modules

Part No.	Description
060-RO4000.88	Fluorometer/Conductivity System, Wall Mount (No pH, ORP, or Analog Input Module)
060-RO4001.88	Fluorometer/Conductivity System, Frame Mount (No pH, ORP or Analog Input Module)
060-RO6000.88	Fluorometer/Conductivity System, Wall Mount (No Analog Input Module)
060-RO6001.88	Fluorometer/Conductivity System, Frame Mount (No Analog Input Module)
060-RO6010.88	Fluorometer/Conductivity System, Wall Mount, Analog Input Module
060-RO6011.88	Fluorometer/Conductivity System, Frame Mount, Analog Input Module
060-RO1000.88	Fluorometer/Conductivity Add-On Module
060-RO1100.88	Fluorometer Add-On Module
060-RO1120.88	Fluorometer + Permeate Conductivity Add-On Module
060-RO1110.88	Permeate Conductivity Add-On Module

Accessories

Part No.	Description
060-ROFSB100.88	Fluorometer Splitter Box
060-ROAIM100.88	Analog Input Module
060-ROSRB100.88	4-20mA Signal Repeater (split/repeat up to 4 signals)
060-ROHP500.88	Pressure Transducer, 500 psi, 1/4" MNPT
060-ROLP145.88	Pressure Transducer, 150 psi, 1/4" MNPT
060-ROEXC005.88	Cable, Extension, 5 m, (for Pressure Transducer)
060-ROEXC010.88	Cable, Extension, 10 m, (for Pressure Transducer)
060-ROEXC030.88	Cable, Extension, 30 m, (for Pressure Transducer)

Spare & Replacement Parts

Part No.	Description
060-TR3220.88	Fluorometer
TBA	Cable, Fluorometer, 4 ft, with quick-connect
6041271	Conductivity Sensor,1.0K (5-10,000 µS), with quick-connect
6041272	Conductivity Sensor,0.1K (1-500 µS)), with quick-connect
6042175	Flow Switch, with quick-connect
060-TR5411.88	pH Replacement probe
060-TR5412.88	Cable, 6 ft, pH
060-TR5421.88	ORP Replacement probe
060-TR5422.88	Cable, 6 ft, ORP
060-TR5222.88 *	Desiccant canister (fluorometer)
060-TR5223.88 *	Desiccant indicator (fluorometer)
991-19432523.88 *	Fuse, 10 A, 250V SLO-BLO (main fuse)
991-05047661.88	Ethernet crossover cable, 6' (2m), orange

Calibration Solutions & Supplies

460-S0940.75 *	TRASAR Calibration solution, 1L bottle
460-S0800.75	10% Sulfuric Acid, 1:1, 1L bottle
500-P2817.88	Flow cell brush, 16"
500-P0116.88	Beaker, 800 ml, plastic (3 each required)
500-P2147.88 *	Syringe, 60cc, plastic (2 each required)
001-H07641.88 **	Conductivity standard solution, 10,000 S/cm, 500 mL
001-H07642.88 **	Conductivity standard solution, 5000 S/cm, 500 mL
460-S0297.75 **	Conductivity standard solution, 3000 S/cm, 1L
460-S0298.75 **	Conductivity standard solution, 600 S/cm, 1L
460-S0743.75 **	Conductivity standard solution, 200 S/cm, 1L
460-S0299.75 **	Conductivity standard solution, 40 S/cm, 1L
460-S0408.75 **	pH standard solution, pH 10 buffer, 1L
460-S0407.75 **	pH standard solution, pH 7 buffer, 1L

APPENDIX E – MEMBRANE CLEANING PROTOCOLS

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Issued in June 2008

TORAY MEMBRANE MODULE
Instruction Manual

Model: Pressured Type PVDF Hollow Fiber Membrane Module "HFU Series"

issued by Toray Industries, Inc.

Water Treatment & Environment Division

8-1, Mihama 1-chome, Urayasu, Chiba 279-8555 Japan
Tel: +81-47-350-6033
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URL: http://www.toray.com

BJJHJEBG

Content

I. Introduction

Toray PVDF Hollow Fiber Membrane Module “HFU series” is the pressured type hollow fiber UF (ultra filtration) membrane module developed with the polymer science and the membrane fabrication technologies accumulated for a long time in Toray Industries, Inc.

The membrane material is Poly-vinylidene Fluoride (PVDF). The nominal molecular weight cut off of the membrane is 150,000 daltons. Testing has confirmed that more than 90% of 150,000 daltons model polymers is consistently removed.

The module, with Polyvinylchloride (PVC) casing, is pressure-driven which products much purified water than siphon-driven. The maximum operating pressure is 300 kPa (43.5 PSI). The flow direction is outside-to-inside which is suitable for high turbidity water treatment because the air-scrubbing can be adopted to remove suspended solid effectively.

1. Characteristics of Toray "HFU series" Membrane Modules

(1) High Filtration Flux

HFU series provides high filtration flux and stable operation for the filtration of various raw water sources. The membrane is made with a special spinning method, which enables high permeability and high fouling resistance.

(2) Excellent Water Quality

HFU series provides very good water quality for the filtrate, extremely low turbidity since the membrane has 150,000 dalton nominal molecular weight cut off. HFU series is recommended to be applied to tertiary treatment of sewage water and RO pretreatment in seawater desalination.

(3) High Mechanical Strength

The membrane of HFU series has very high mechanical strength because it is made of PVDF with the special spinning method developed by Toray. HFU series provides high integrity and durability under recommended operating conditions.

(4) High Chemical Durability

The membrane material of HFU series is PVDF, which allows you to clean the membrane with high concentrations of chlorine and with high concentrations of acid resulting in better cleaning and longer sustainable membrane flux rates.

2. Applications of Toray "HFU series" Membrane Modules

- Tertiary Treatment of Sewage Water
- RO Pretreatment in Seawater Desalination
- Industrial Water Production
- Reuse of Industrial Waste Water

II. For Your Safety

- Please be sure to read and follow the instructions below before using HFU series. This manual should be retained for future reference.

- Follow the safety precautions as they are intended to protect operators and equipment from various risks such as physical harm and/or property damage. The following table shows a level of potential risk for each indicated symbol.

⚠ **DANGER**	This symbol indicates an imminent hazardous situation which will result in serious injury or death when the instruction is not observed.
⚠ **WARNING**	This symbol indicates a potentially hazardous situation which will result in serious injury or death when the instruction is not observed.
⚠ **CAUTION**	This symbol indicates a potentially hazardous situation which might result in injury or property damage when the instruction is not observed.

- The following table explains the information to be noted.

🛇 Prohibited	"Prohibited" This symbol indicates a prohibited action or procedure.
! Instruction	"Instruction" This symbol indicates an important action or procedure which has to be taken without fail.

1. Safety Instruction for Unpacking and Installation

⚠ DANGER

❗ Instruction

Be sure to wear safety gear such as rubber gloves and safety glasses for unpacking. The membrane is packaged in sodium hypochlorite solution (100mg/l). If the solution happens to splash onto the skin, wash the affected part with running water. If the solution happens to get in the eyes or mouth, wash the affected part with sufficient amounts of clean running water for more than 15 minutes and see a doctor immediately.

⚠ WARNING

❗ Instruction

Be sure to wear safety gear such as a helmet and safety shoes to avoid injury.

⚠ CAUTION

🚫 Prohibited

The preservative solution should be drained out before using the modules. After that, keep clean water in the modules to prevent the hollow fiber membrane from drying out. Do not allow the modules to dry out even for a few hours.

🚫 Prohibited

The membrane modules should not be frozen.

🚫 Prohibited

Be careful not to damage or dent the modules during handling.

❗ Instruction

Victaulic clamps are applied for connecting the modules of HFU-2020 or HFU-1020 to the piping. Follow the instruction of the G-type Victaulic Joint Set-up Guide at the connection point. Wrong connections may damage the modules.

Instruction

IDF/ISO Clamp Union Fittings 1.5 are applied for connecting the modules of HFU-2008 or HFU-1010 to the piping. Do not over-tighten the clamp as damage to the module may occur.

Prohibited

Keep the connection surface free of any dirt or oils.

Instruction

Be sure to install the modules vertically for effective air scrubbing.

2. Safety Instruction for Filtration Operation

⚠ **DANGER**

Instruction

Flush all the piping out with clean water and make sure no debris is remaining in the piping prior to connecting the modules.

Instruction

Confirm that the preservative chemical in the modules is completely drained out before starting the filtration operation. The preservative chemical is harmful to humans.

Flush the modules at low pressure, filling from the bottom, and vent to remove any air from the modules. Air left in the modules may cause water hammer and may result in damage to the membrane. Prior to use, make certain modules are flushed and filtrate water meets the required quality.

⚠ WARNING

Instruction

Always monitor filtrate water quality such as turbidity and/or the number of particles during filtration, and stop the operation if abnormal water quality is detected.

Prohibited

Do not exceed the maximum applicable pressure of 300 kPa (43.5 PSI). Higher pressures can damage the modules. Do not exceed the maximum temperature of 40 degree C (104 degree F). The higher temperature damages the modules.

Prohibited

Do not freeze the membrane modules.

Instruction

The operating conditions, including the filtration flux and the periodical physical cleaning, must be properly set-up otherwise the trans-membrane pressure may rise too quickly. The operation range is described in the latter section of this manual.

Instruction

Do not overfeed air to the modules. Excessive scrubbing air damages the membranes and/or shortens the membrane life.

The air flow rate should be within the range below for each module type.

HFU-2020: 4.8 – 9.0 Nm^3/h (2.8 – 5.3 scfm)
HFU-2008: 0.7 – 1.2 Nm^3/h (0.4 – 0.7 scfm)
HFU-1020: 4.8 – 9.0 Nm^3/h (2.8 – 5.3 scfm)
HFU-1010: 1.2 – 2.2 Nm^3/h (0.7 – 1.3 scfm)

Instruction

Integrity tests, such as Pressure Decay Test (PDT) or Diffusive Air Flow (DAF) Test, must not exceed an air pressure of 100kPa (14.5 PSI). Keep the source air pressure lower than 200 kPa (29 PSI), to prevent module damage.

3. Safety Instruction for Chemical Cleaning

⚠ DANGER

Instruction

Take special precautions when handling chemicals during chemical cleaning. Wear the safety gear such as safety glasses and protective gloves. If chemicals come in direct contact with your skin or your clothes, treat appropriately based on the MSDS.

Prohibited

Do not mix sodium hypochlorite with acid. Such mixture generates toxic chlorine gas.

Instruction

Stop operation whenever any anomaly occurs with the equipment or any signs of an anomaly are observed.

⚠ CAUTION

Instruction

In the chemical cleaning, strictly follow the procedure described in the latter section of this manual. Otherwise you may damage the modules or negatively affect the membrane performance.

4. Safety Instruction for Disposal

⚠ WARNING

! Instruction

When dispose modules, please apply a service of a qualified waste disposing company. When modules are to incinerate, please dispose by appropriate facilities which can neutralize hydrogen fluoride (HF) gas. HF gas is generaterd at membrane incineration.

III.

Specifications of Toray "HFU series" Membrane Modules

Table 1. Specifications of membrane *1)

Membrane Material		PVDF (Polyvinylidene fluoride)
Nominal Molecular Weight Cut Off		150,000 *2)
Trans-Membrane Pressure	Maximum *3)	300 kPa (43.5 PSI)
	Normal Operation	Lower than 200 kPa (29.0 PSI)
Operating Temperature Range		0 – 40 degree C (32 – 104 degree F)
Operating pH Range		1 – 10

*1): Please note that the specifications are subject to changes from time to time.

*2): The nominal molecular weight cut off is determined with the model test of dextran.

*3): TMP should be below 300 kPa (43.5 PSI) at any time even when the feed pump is not stable.

Table 2. Feed water limits *1)

Turbidity	Intermittent Peak *4)	100 NTU
	Continuous Maximum	30 NTU
TSS	Intermittent Peak *4)	100 mg/L
	Continuous Maximum	30 mg/L
Pretreatment Filter Mesh Size		smaller than 200 micron meter
Temperature Range		0 – 40 degree C (32 – 104 degree F)
pH Range		1 – 10
Maximum Feed Pressure		300 kPa (43.5 PSI)

*1): Please note that the specifications are subject to changes from time to time.

*4): The duration time should be less than 48 hours and the occurrence frequency should not exceed more than once a month.

Table 3. Cleaning limits *1)

Cleaning pH Range	0 – 12
Cleaning Temperature Range	0 – 40 degree C (32 – 104 degree F)
Maximum concentration of NaClO as Cl_2	3,000 mg/L
Maximum NaClO exposure (lifetime contact time) as Cl_2	1,000,000 mg/L hours
Maximum acid contact time	1,000 hours (pH$\geq$0)

*1): Please note that the specifications are subject to changes from time to time.

Table 4. Specifications of modules *1)

Module Type		HFU-2020	HFU-1020	HFU-1010 (small module for pilot test)	HFU-2008 (small module for pilot test)
Membrane Surface Area (Outer Surface)		72 m^2 (775 ft^2)	29 m^2 (312 ft^2)	7.0 m^2 (75 ft^2)	11.5 m^2 (124 ft^2)
Dimensions	Diameter	216 mm (8.50 inches)	216 mm (8.50 inches)	114 mm (4.49 inches)	89 mm (3.50 inches)
	Length	2,160 mm (7.087 ft.)	1,120 mm (3.675 ft.)	1,078 mm (3.537 ft.)	2,000 mm (6.562 ft.)
Weight	Full of water	110 kg (243 lbs)	60 kg (132 lbs)	15 kg (33 lbs)	18 kg (40 lbs)
	Drained	67 kg (148 lbs)	40 kg (88 lbs)	9 kg (20 lbs)	11 kg (24 lbs)
Materials	Housing	Polyvinylchloride			
	Potting	Epoxy Resin			
Connections	Top	Victaulic joints 80A	Victaulic joints 80A	IDF/ISO Clamp Union Fittings 1.5s	IDF/ISO Clamp Union Fittings 1.5s
	Bottom	Victaulic joints 80A	Victaulic joints 80A	IDF/ISO Clamp Union Fittings 1.5s	IDF/ISO Clamp Union Fittings 1.5s
	Side	Victaulic joints 65A	Victaulic joints 65A	IDF/ISO Clamp Union Fittings 1.5s	IDF/ISO Clamp Union Fittings 1.5s
Operating Conditions	Max. Feed Water Flow	12 m^3/h (53 gpm)	4.8 m^3/h (21 gpm)	1.2 m^3/h (5.1 gpm)	2.0 m^3/h (8.4 gpm)
	Max. Backwash Flow	13.5m^3/h (59 gpm)	5.4 m^3/h (23 gpm)	1.3 m^3/h (5.7 gpm)	2.1 m^3/h (9.4 gpm)
	Max. Air Flow	9.0 Nm^3/h (5.3 scfm)	9.0 Nm^3/h (5.3 scfm)	2.2 Nm^3/h (1.3 scfm)	1.2 Nm^3/h (0.7 scfm)
	Filtration Method	Outside-to-inside, Dead End or Cross Flow			
	Max. Inlet Pressure	300 kPa (43.5 psi)			
	Maximum Temperature	40 degree C (104 degree F)			

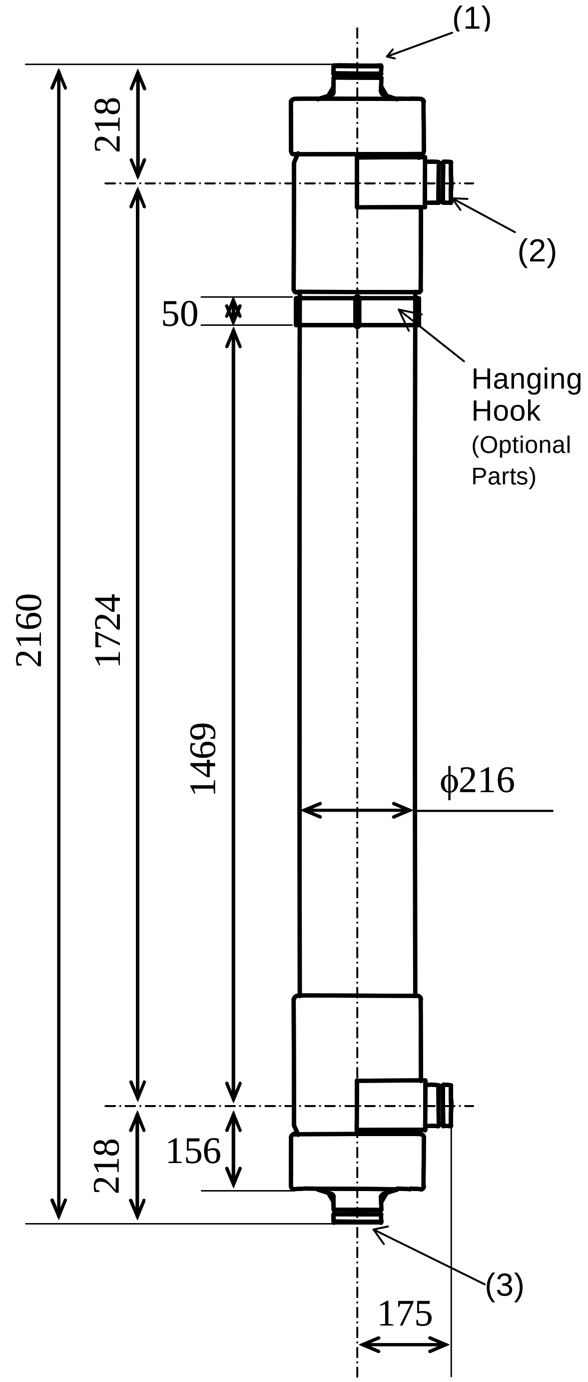
*1): Please note that the specifications are subject to changes from time to time.

⚠ **CAUTION**

Handle and operate the modules within the ranges and the limits indicated in Table 1 to 4. Operation outside these ranges or limits may damage the modules, may affect filtration performance, and will void the warranty.

IV.

Configuration of Toray "HFU Series" Membrane Modules



(1): Filtrate Outlet / Inlet of Backwash Water

(2): Air Outlet / Backwash Water Outlet

(3): Feed Water Inlet / Air Inlet / Drain Outlet

Connections

	Pipe fitting outer diameter mm (in)	Connectors
(1)	89.1 (3 1/2”)	Victaulic joints 80A
(2)	76.3 (3”)	Victaulic joints 65A
(3)	89.1 (3 1/2”)	Victaulic joints 80A

Fig. 1 Type: HFU-2020

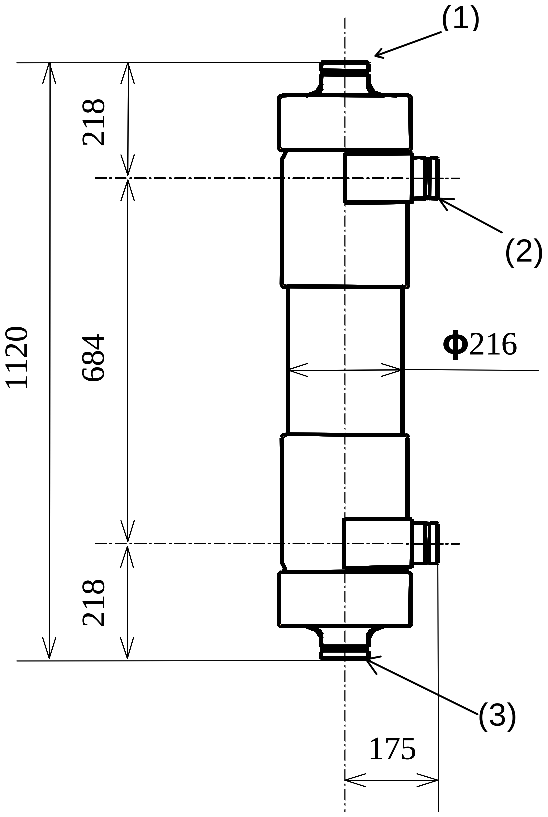


Fig. 2 Type: HFU-1020

(1): Filtrate Outlet / Inlet of Backwash Water

(2): Air Outlet / Backwash Water Outlet

(3): Feed Water Inlet / Air Inlet / Drain Outlet

Connections

	Pipe fitting outer diameter mm (in)	Connectors
(1)	50.5 (2”)	IDF/ISO Clamp Union Fittings 1.5s
(2)	50.5 (2”)	IDF/ISO Clamp Union Fittings 1.5s
(3)	50.5 (2”)	IDF/ISO Clamp Union Fittings 1.5s

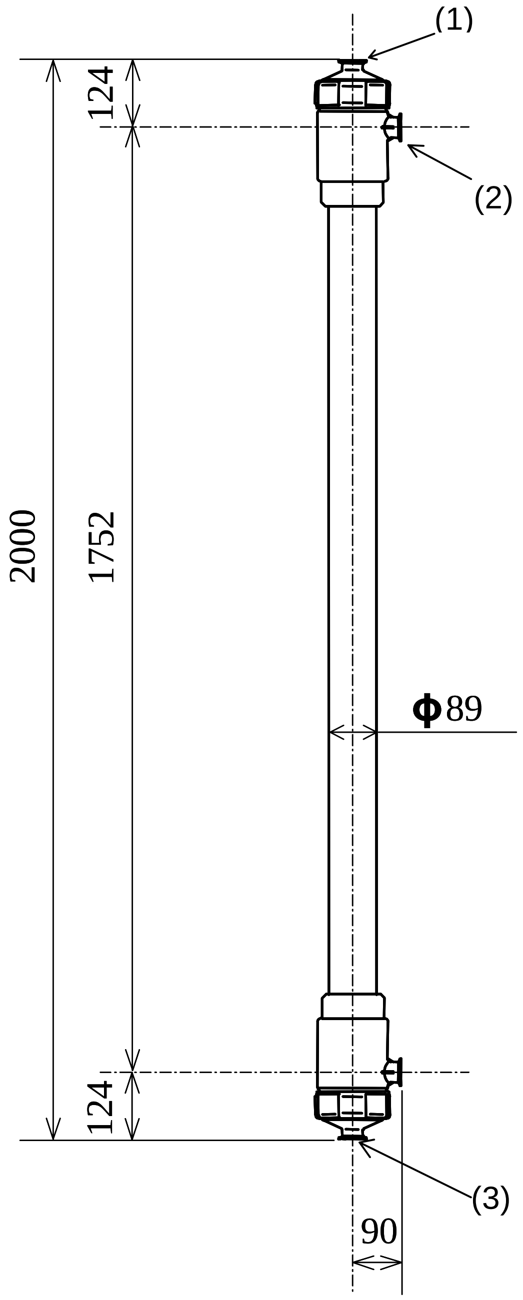


Fig. 3 Type: HFU-2008

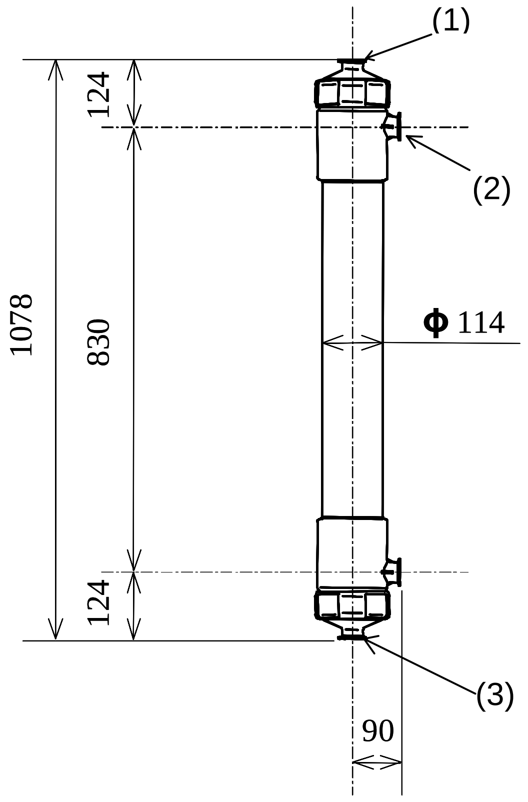


Fig. 4 Type: HFU-1010

Installation

The standard method to install the membrane modules is described below.

1. Unpack the membrane module from wooden box or corrugated box.
2. Remove plugging plate from each nozzle of the module.
3. Drain out the preservative solution from the module.

⚠ **DANGER**	- Wear rubber gloves and safety glasses when you drain the preservative chemical. Note that the preserving chemical is sodium hypochlorite solution (100 mg/l of chlorine). If this solution splashes onto your skin, wash the affected part with running water. If the solution gets in your eyes or mouth, wash the affected part with enough amounts of running water for over 15 minutes and see a doctor immediately.

4. Put the module vertically on the pedestal in the module rack. Fix the module upright with the hanging hook and/or the supporting belt. (see Fig. 5)

⚠ **WARNING**	- Don't drop the module. - Use equipment such as chain blocks, a crane, or a forklift truck when you handle the module. The HFU-2020 module is too heavy to handle by hand.
⚠ **CAUTION**	- Be careful not to install the module upside down. Confirm the module is installed in the right direction. - Don't over-tighten the module with the hanging hook and/or the supporting belt, or you may damage the module. - Don't allow the hollow fiber membrane to dry out even for a few hours, especially in summer. - Don't freeze the module.

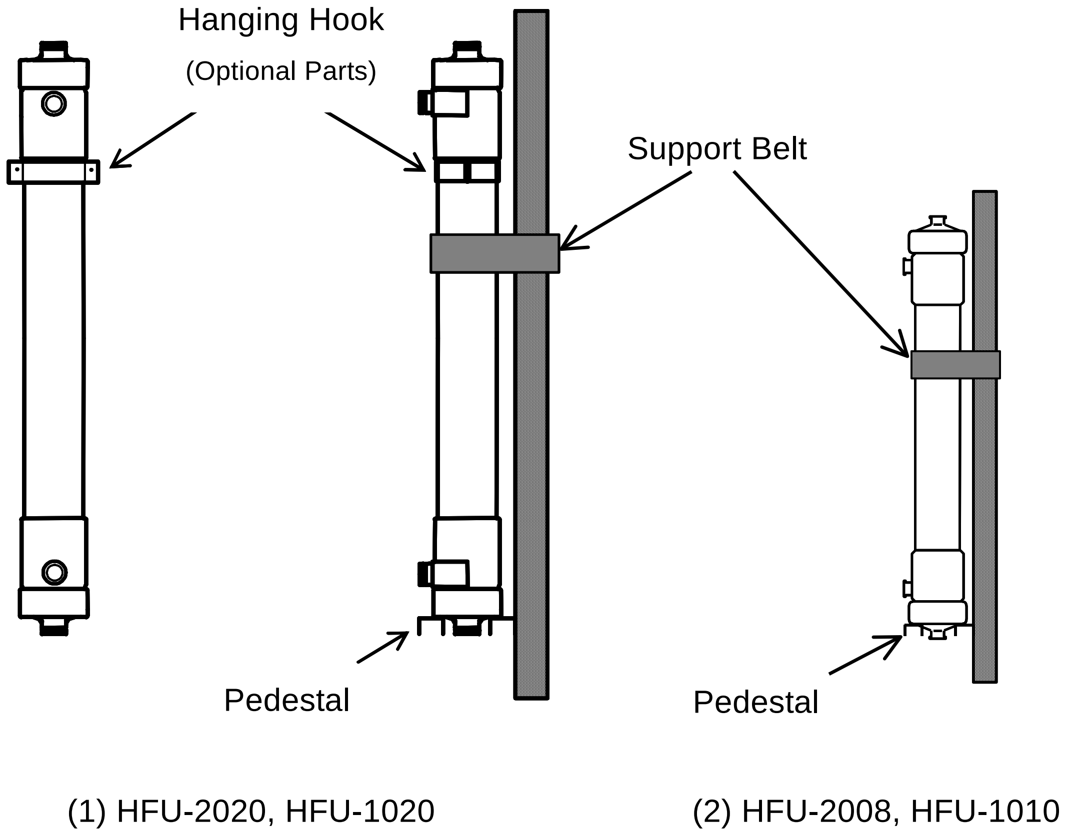


Fig. 5 Installation of the membrane module

5. Connect the piping to each connection point of the module with Victaulic clamps (HFU-2020, HFU-1020) or ferrule joints (HFU-2008, HFU-1010). (see Fig. 6)

⚠ **CAUTION**	- Keep the connection surface free of any dirt or oils. - Follow the instruction of the G-type Victaulic Joint Set-up Guide when using Victaulic Joint. A wrong use may cause the damage to the module. - Do not overtighten the clamp when using ferrule joint (IDF/ISO Clamp Union Fittings 1.5s), or you may damage the module.

6. Make sure that the module is installed vertically.

⚠ **CAUTION**	- If the module is not installed vertically, the effect of the air scrubbing would be reduced and effective filtration will be impaired.

VI. Operation

1. Filtration

(1) Check that all piping is connected appropriately and flushed out prior to the operation. Fig. 6 shows a typical example of piping.

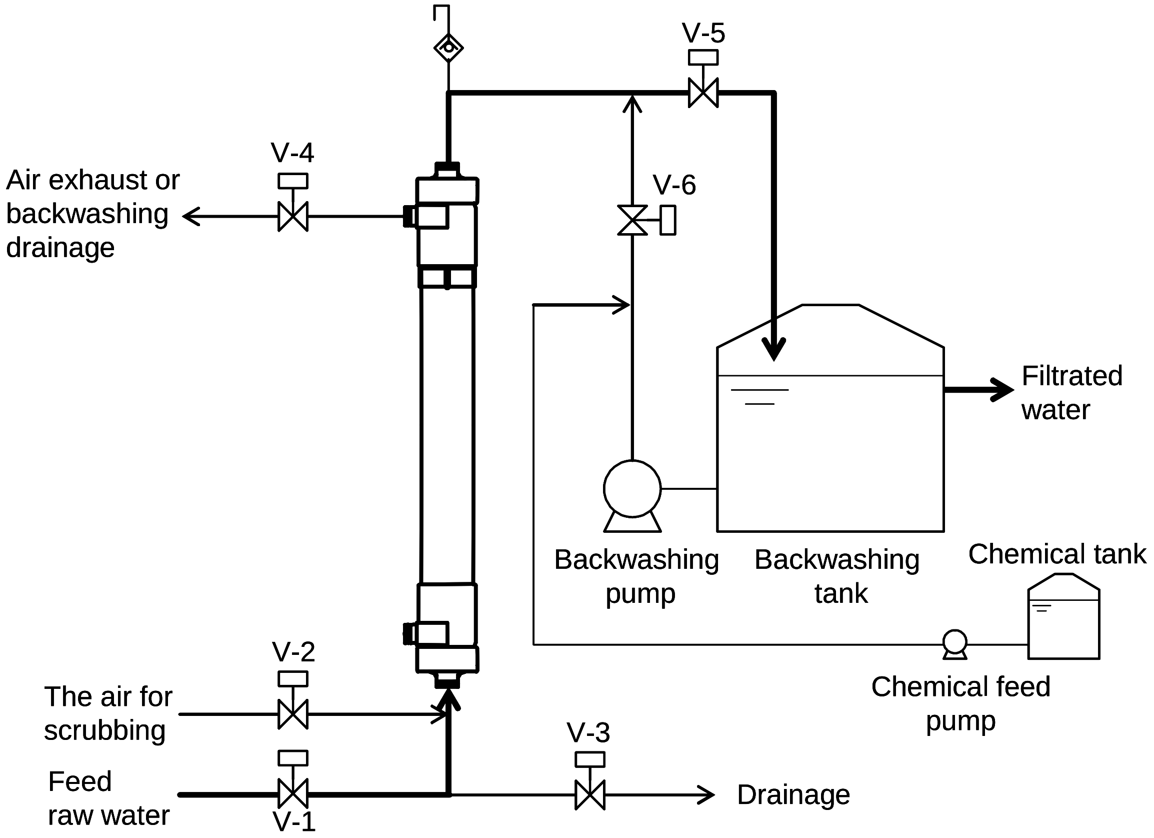


Fig. 6 Typical example of piping

(2) Make sure the feed water valve (V-1), the drainage valve (V-3), and the valve for the scrubbing air (V-2) are “closed”.

(3) Make sure the filtrate water line is open. Open the air exhaust valve (V-4).

(4) Gradually open the feed water valve (V-1) and charge the feed water to the module to purge any air out.

CAUTION

- Don't open the feed water valve (V-1) quickly, or water-hammer may occur and the module could be damaged.

(5) Confirm that the air is out of the module, and then close the air exhaust valve (V-4).

(6) Set appropriate volume of filtrate water flow.

CAUTION

- Don't exceed 300 kPa (43.5 PSI) to avoid damage to the module.
- Operating conditions including the filtration flux and the physical cleaning should be properly set up, observing the rise of trans-membrane pressure. (Details are described in the next session.) Please contact us if you need technical support.

(7) When stopping operation, gradually close the feed water valve (V-1).

2. Backwash and Air-scrubbing

The physical cleaning with backwash followed by air-scrubbing should be carried out periodically and automatically for the continuous filtration. The frequency of the physical cleaning mainly depends on the raw water quality. (Typical frequency is once every 30 minutes normally for surface water filtration. Please contact us if you need technical support.) Fig. 7 shows a typical example of the flow diagram for backwash and air-scrubbing. Don't carry out the backwash and the air-scrubbing simultaneously since it may damage the membrane.

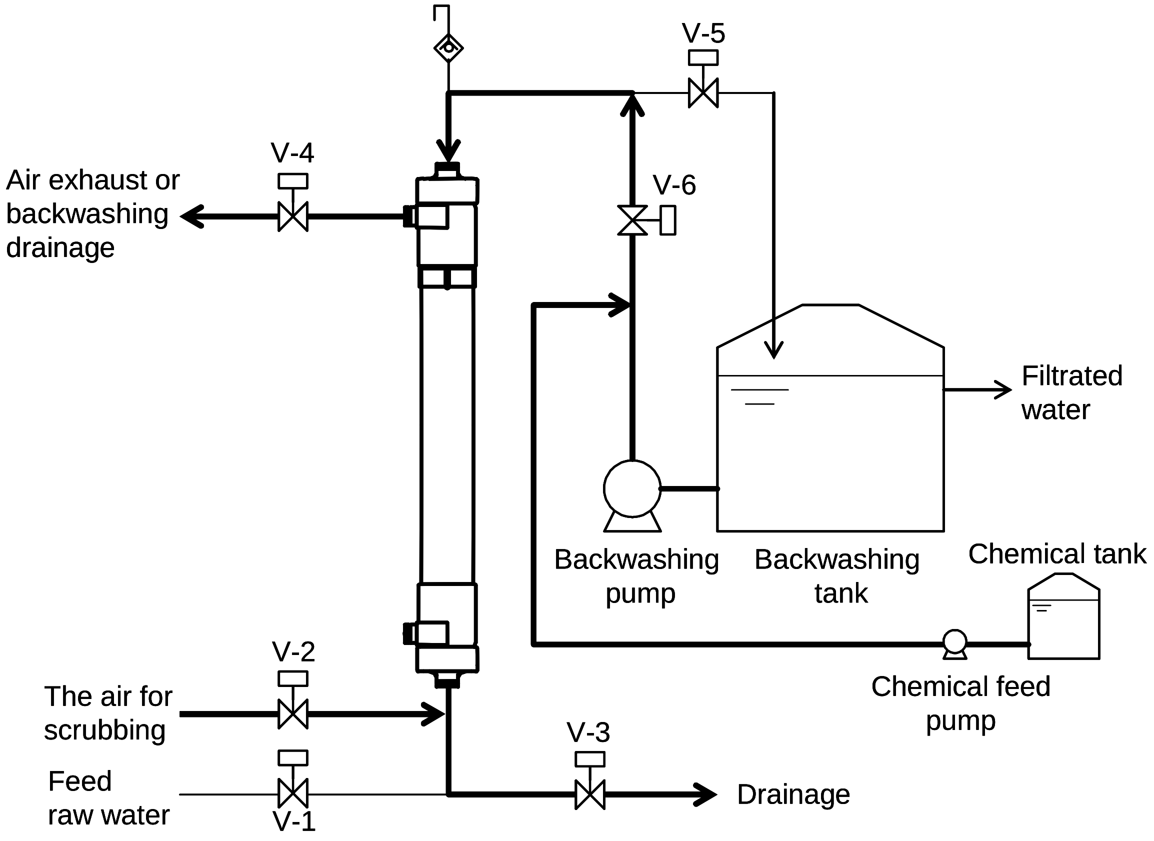


Fig. 7 Flow diagram for backwash and air-scrubbing

(1) Close the feed water valve (V-1) and stop the feed water pump.

(2) Open the air exhaust valve (V-4).

(3) Close the filtrate water valve (V-5) and open the backwashing valve (V-6) to feed back the filtrate water from the backwashing tank to the membrane module. During backwash, chemical feed pump can be operated to dose chemical to the backwash water. The dosing chemical is usually sodium

hypochlorite and the dosing ratio should be up to 50 mg/L as Cl_2.
The flow rate of backwash water is set up in advance for 1.0 to 1.5 times filtrate water flow rate (don't exceed Max. Backwash Flow described in Table 4).

(4) After backwashing for a fixed time (normally 30 seconds, up to 60 seconds), close the backwashing valve (V-6) and stop the backwashing pump.

(5) Open the air exhaust valve (V-4) and the air-scrubbing valve (V-2) for air-scrubbing for a fixed time (normally 30 seconds, up to 60 seconds).

⚠ CAUTION

- The air flow rate for air-scrubbing should be within the range below. Excessive air flow rate may damage the hollow fiber membrane.
  HFU-2020: 4.8 – 9.0 Nm^3/h, normally 6.0 Nm^3/h
  (2.8 – 5.3 scfm, normally 3.5 scfm)
  HFU-2008: 0.7 – 1.2 Nm^3/h, normally 0.8 Nm^3/h
  (0.4 – 0.7 scfm, normally 0.5 scfm)
  HFU-1020: 4.8 – 9.0 Nm^3/h, normally 6.0 Nm^3/h
  (2.8 – 5.3 scfm, normally 3.5 scfm)
  HFU-1010: 1.2 – 2.2 Nm^3/h, normally 1.5 Nm^3/h
  (0.7 – 1.3 scfm, normally 0.9 scfm)

(6) Close the air-scrubbing valve (V-2) and open the drainage valve (V-3).
(7) Close the drainage valve (V-3) after the water is all drained out.
(8) Run the feed water pump and open the feed water valve (V-1).
(9) Close the air exhaust valve (V-4) after the air is purged from the module.

⚠ CAUTION

- Always monitor filtrate water quality during filtration, and stop the operation if abnormal water quality is detected. If abnormal water quality is detected, check the integrity of the module with PDT (Pressure Decay Test) or DAF (Diffusive Air Flow Test). The recommended test procedure is provided as the technical information by Toray.

3. Toray Maintenance Cleaning

Instead of chemical dosing for every backwash, soaking the membrane to chemical solution several tens of minutes a day is also effective for membrane performance retention. This process is called Toray Maintenance Cleaning (TMC). The TMC is usually held following the backwash and air-scrubbing which does not contain the chemical dosing. The frequency and soaking time of the TMC mainly depends on the raw water quality. (Normally once a day and each soaking time are 20 minutes. Please contact us if you need technical support.) Fig. 8 shows a typical example of flow diagram for the TMC.

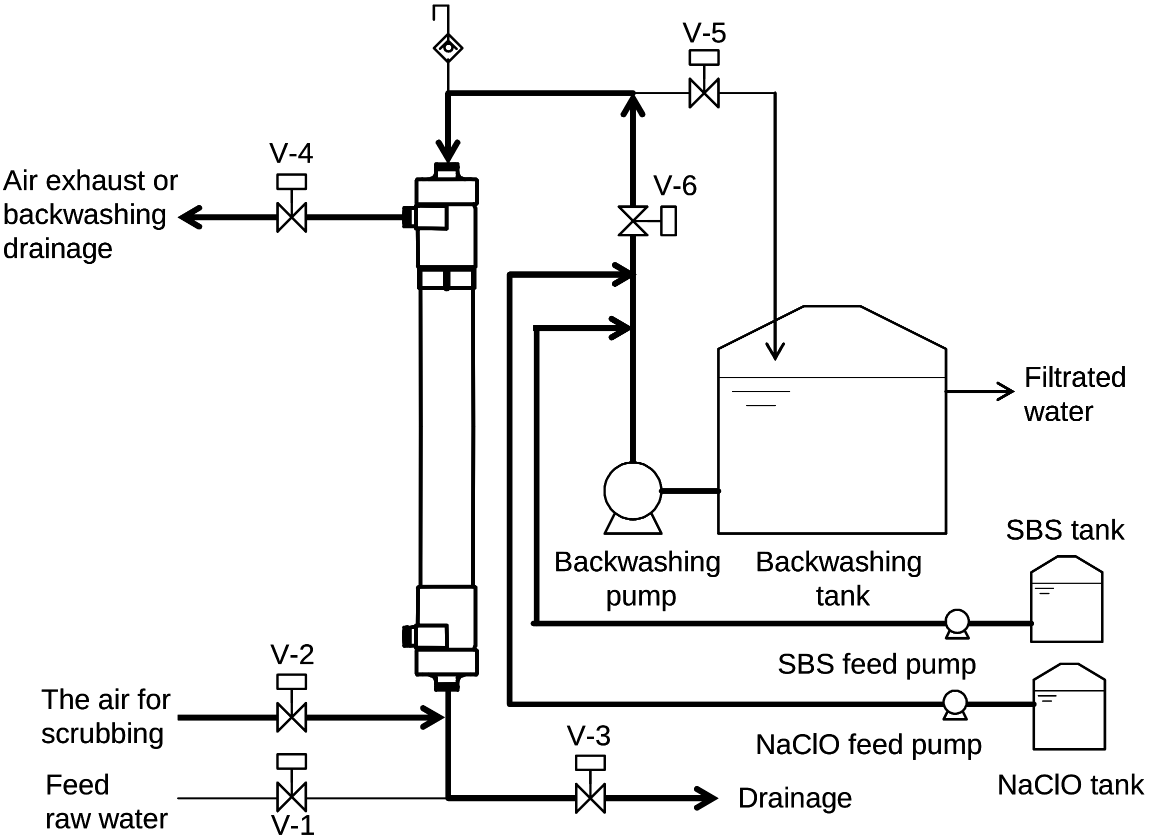


Fig. 8 Flow diagram for the TMC

(1) Open the air exhaust valve (V-4) and the drainage valve (V-3).

(2) Open the backwashing valve (V-6), run the NaClO feed pump and the backwashing pump to feed the chemical enhanced backwash water to the membrane module.

The flow rate of backwash water is set up in advance for 1.0 to 1.5 times filtrate water flow rate (don't exceed Max. Backwash Flow described in Table 4).

(3) As soon as the NaClO is detected in the drainage water, close the drainage valve (V-3).

(4) After making sure water comes out from upper part of the side nozzle of the membrane module, stop the NaClO feed pump, close the backwashing valve (V-6) and stop the backwashing pump.

(5) Soak the membrane in the chemical for a fixed time (normally 20minutes). During the soak, open the air-scrubbing valve (V-2) a few times (normally every 5 minutes and each scrubbing time are 30 seconds).

(6) Open the backwashing valve (V-6), run the sodium bi-sulfite (SBS) feed pump and the backwashing pump to deactivate the chlorine residue for a fixed time (normally 30 seconds).

(7) Stop the SBS feed pump and the backwashing pump and close the backwashing valve (V-6), and then open the air-scrubbing valve for a fixed time (normally 30 seconds).

⚠ **CAUTION**

- The air flow rate for air-scrubbing should be within the range below. Excessive air flow rate may damage the hollow fiber membrane.

  HFU-2020: 4.8 – 9.0 Nm^3/h, normally 6.0 Nm^3/h
  (2.8 – 5.3 scfm, normally 3.5 scfm)

  HFU-2008: 0.7 – 1.2 Nm^3/h, normally 0.8 Nm^3/h
  (0.4 – 0.7 scfm, normally 0.5 scfm)

  HFU-1020: 4.8 – 9.0 Nm^3/h, normally 6.0 Nm^3/h
  (2.8 – 5.3 scfm, normally 3.5 scfm)

  HFU-1010: 1.2 – 2.2 Nm^3/h, normally 1.5 Nm^3/h
  (0.7 – 1.3 scfm, normally 0.9 scfm)

(8) Close the air-scrubbing valve (V-2), open the drainage valve (V-3) to drain the chemical from the membrane module.

(9) Close the drainage valve (V-3), and then open the backwashing valve (V-6) and run the backwashing pump (normally 30 seconds). Stop the backwashing pump and close the backwashing valve (V-6), and then open the air-scrubbing valve (V-2) (normally 30 seconds). Repeat this procedure until the overflow water meets the required water quality.

(10) Make sure the air-scrubbing valve (V-2) and the backwashing valve (V-6) are “closed” and the backwashing pump is “stopped”.

CAUTION	- Always monitor filtrate water quality during filtration, and stop the operation if abnormal water quality is detected. If abnormal water quality is detected, check the integrity of the element with PDT (Pressure Decay Test) or DAF (Diffusive Air Flow) Test. The test procedure is provided as the technical information by Toray.

4. Temperature Correction Factor

The permeability of the membrane is influenced by temperature mainly because the water viscosity changes with temperature. When you evaluate the permeability correctly, you need to eliminate the temperature effect with the temperature correction factor (TCF) shown in Fig. 9.

A Trans-Membrane Pressure (TMP) measured at some real temperature can be converted to 25 degree C corrected TMP with multiplying by TCF at real temperature shown in Fig. 9.

A filtrate flow rate measured at some real temperature can be converted to 25 degree C corrected filtrate flow rate with divided by TCF at real temperature shown in Fig. 9.

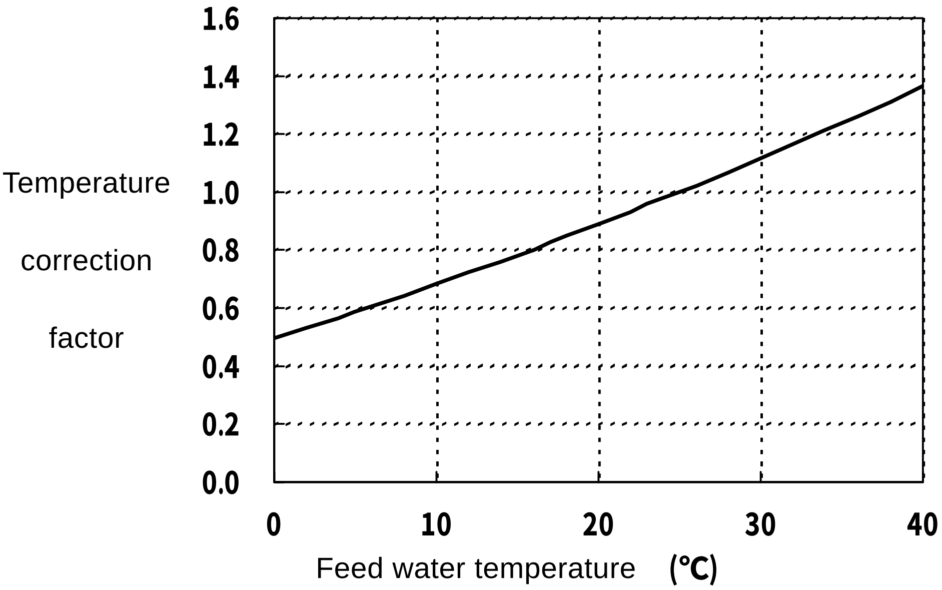


Fig. 9　Temperature correction factor (TCF) for HFU series

The equation for calculating TCF at a temperature (T degree C) is as follows.

TCF

= 0.0008902 / (0.01257187 x EXP((1－0.005806436 x (273.15 + T)) / (0.001130911 x (273.15 + T) - 0.000005723952 x (273.15 + T) x (273.15 + T))) / 1000)

VII. Chemical Cleaning

The chemical cleaning should be carried out to remove foulants accumulated in the membrane pores or sticking to the membrane surface.

⚠ CAUTION	- Carry out the chemical cleaning before the trans-membrane pressure rises up to 200 kPa (29.0 PSI), or the module filtration performance could be reduced significantly. - Follow the instruction described in this manual when you carry out the chemical cleaning. If you use the unacceptable chemicals or perform the cleaning altered from the recommended procedure, the membrane could be seriously damaged.

⚠ DANGER	- Pay full attention when handling chemicals and be sure to wear the safety gear such as glasses and gloves. The chemicals used for the chemical cleaning are harmful to people. If chemicals directly contact your skin, your eyes or other body parts, take the appropriate treatment as stated in its MSDS. - Do not mix sodium hypochlorite with acid. Such mixture generates toxic chlorine gas. - Stop operations when any instrumental anomalies occur or any sign of anomalies are observed.

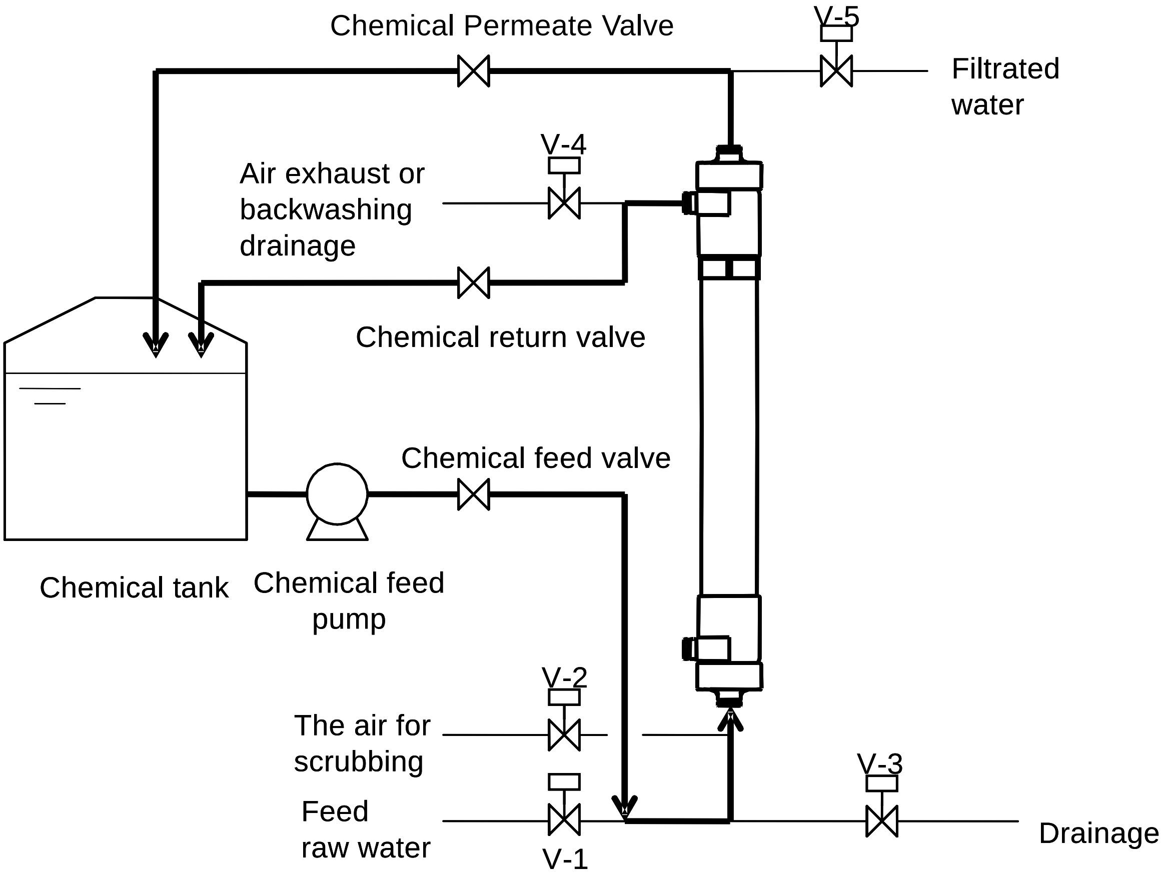


Fig. 10 Flow diagram for chemical cleaning

(1) The flow diagram for cleaning simultaneously both outer surface and inside of hollow fiber membranes is shown in Fig. 10. The flow diagram can be changed case by case. Please contact us if you need the information in detail.

(2) Open the chemical return valve and then open the chemical feed valve.

(3) Run the chemical feed pump to start the circulation of chemical and then open the chemical permeate valve to have the chemical permeate through the membrane.

(4) Circulate the chemical for a fixed time.

(5) Stop the chemical feed pump.

(6) Drain the chemical and rinse the cleaning line and the module thoroughly with product water.

⚠ **CAUTION**

- Take appropriate measures to prevent the mis-operation or accidents that could cause the chemicals to get into the product water. Check the piping and correctly position of each valve before starting the chemical cleaning.

(7) The standard conditions for chemical cleaning are shown in Table 5.

- The concentration and the circulation time shown in Table 5 should be observed. Otherwise the membrane module may get damaged and/or the life of membrane may be shortened.
- To get enough cleaning effect, the cleaning temperature should be higher than 20 degree C.
- The circulation flow rate for each type of the module is as follows.

HFU-2020:	50 L/min (13 gpm)
HFU-2008:	8 L/min (2.1 gpm)
HFU-1020:	20 L/min (5.3 gpm)
HFU-1010:	5 L/min (1.3 gpm)

Table 5. Standard conditions for chemical cleaning

Pollutants	Chemicals	Maximum Concentration	Circulation Time (hr)
Inorganic substances	Citric acid *1	3.0 wt%	1 - 3
Organic substances	Sodium hypochlorite	3,000 mg/l as chlorine	1 - 3

*1: Besides citric acid, hydrochloric acid (with the maximum concentration of 1.0 mol/l), oxalic acid (with 1.0 wt%), sulfuric acid (with 0.05 mol/l) and nitric acid (with 0.1 mol/l) are acceptable.

⚠ **CAUTION**	- In the case of cleaning with acid and with sodium hypochlorite alternately, rinse the cleaning line and the module with clean water thoroughly after each cleaning. Use product water for rinsing and make sure that pH of the water in the module is in the range between pH 6.5 and 7.5 after rinsing.

⚠ **DANGER**	- Do not use any other chemicals than those indicated above. - Do not mix sodium hypochlorite with acid. Such mixture generates toxic chlorine gas.

VIII. Storage of Membrane Module

Follow the instruction below when you store the modules.

⚠ **CAUTION**

- Be careful not to freeze the modules.

1. Storage of New Membrane Modules

Keep the modules in the original packing in a dark and cool place.
Avoid direct sunlight and moisture.

2. Storage of Membrane Modules after use

(1) Short term, or temporary, shutdown or storage

In the case of the suspension of operation for less than four days, stop the feed water and keep modules full of water.

If the suspension lasts for four days to less than eight days, fill the module with the chemical described in Table 6. Use filtrate quality water.

Table 6. Conditions for storing membrane modules for less than eight days

Maximum Storage period	Chemical	Concentration of the chemical
7 days	sodium hypochlorite	20 mg/l as chlorine

(2) Long term storage

First carry out a chemical cleaning with sodium hypochlorite. Fill the module with the chemical described in Table 7. Use filtrate quality water. Follow the instructions shown in the table 7.

Keep the modules sealed with the aqueous chemical solution shown in Table 6 or Table 7. If removing modules from the system, seal them and store out of direct sunlight.

Table 7. Conditions for storing membrane modules for more than seven days

Storage period	Preservative Chemical	Concentration of the chemical
more than 7 days	sodium bisulfite	1,000 mg/l

⚠ **DANGER**

- Rinse the module thoroughly with clean water after the chemical cleaning with sodium hypochlorite, and fill the module with sodium bisulfite solution. Toxic chlorine gas is generated in the case of mixing sodium hypochlorite with sodium bisulfite without first flushing with water.

3. Replace Preservative Chemical

Check the pH value of sodium bisulfite solution as the preservative and replace the chemical if the pH is below three (3.0). Sodium bisulfite solution with a pH of 3 - 6 is active for the preservation. Sodium bisulfite reacts with oxygen and forms sulfuric acid which results in a lower pH.

'TORAY'

Toray Membrane USA, Inc.
Cleaning Procedures for Composite Polyamide RO Membrane Elements

This bulletin provides general information about the most typical foulants which may affect the performance of Composite Polyamide Reverse Osmosis (RO) membrane elements, and procedures for the removal of these foulants. The information in this bulletin applies to both 4-inch and 8-inch diameter RO membrane elements.

The surface of the RO membrane is subject to fouling by foreign materials which may be present in the feed water. Examples are:

- Calcium carbonate scale
- Sulfate scale of calcium, barium or strontium
- hydrates of metal oxides (iron, manganese, copper, nickel, aluminum, etc.)
- Polymerized silica scale
- Inorganic colloidal deposits
- Mixed inorganic/organic colloidal deposits
- NOM organic material (Natural Organic Matter)
- Man-made organic compounds (e.g. antiscalant/dispersants, cationic polyelectrolytes)
- Biological (bacterial bioslime, algae, mold, or fungi)

The term fouling used here includes the build up/ deposition of all kinds of layers on the surface of the membrane, including scale formation.

Note: The Composite Polyamide type of RO membrane elements may not be exposed to chlorinated water under any circumstances. Any such exposure may cause irreparable damage to the membrane. Absolute care must be taken following any disinfection of piping or equipment or the preparation of cleaning or storage solutions to ensure that no trace of chlorine is present in the feedwater to the RO membrane elements. If there is any doubt about the presence of chlorine, perform chemical testing. Neutralize any chlorine residual with a sodium bisulfite solution, and ensure adequate mixing and contact time to accomplish complete dechlorination. Dosing rate is 1.8 to 3.0 ppm sodium bisulfite per 1.0 ppm of free chlorine.

Note: It is recommended that all RO membrane cleaning operations should be closely coordinated with Toray Membrane USA during the RO membrane element warranty period. TMUS field service personnel are available to be on site for cleaning assistance, should the need arise. Please contact TMUS for current charges for this service.

Note: The use of cationic surfactant should be avoided in cleaning solutions, since irreversible fouling of the membrane elements may occur.

The nature and rapidity of fouling depends on a number of factors, including:

- quality of the feedwater
- system recovery rate
- element flux

Type of Foulant/ Problem	**Probable** Location	**Pressure** Drop	**Feed** Pressure	**Salt** Passage
Metal Oxide Fouling (e.g. Fe,Mn,Cu,Ni,Zn)	1st stage lead elements	Rapid increase	Rapid increase	Rapid Increase
Colloidal Fouling (organic and/or inorganic complexes)	1st stage/ lead elements	Gradual increase	Gradual increase	Slight increase
Mineral Scaling (e.g. Ca, Mg, Ba, Sr)	Last stage/ tail elements	Moderate increase	Slight increase	Marked increase
Polymerized Silica	Last stage/ tail elements	Normal to increased	Increased	Normal to increased
Biological Fouling	Any stage, usually lead	Marked increase	Marked increase	Normal to increased
Organic Fouling (dissolved NOM)	All stages	Gradual Increase	Increased	Decreased
Antiscalant Fouling	2nd stage most severe	Normal to increased	Increased	Normal to increased
Oxidant damage (e.g Cl2, Ozone,KmnO4)	1st stage most severe	Normal to decreased	Decreased	Increased
Hydrolysis damage (out of range pH)	All stages	Normal to decreased	Decreased	Increased
Abrasion damage (carbon fines, etc)	1st stage most severe	Normal to decreased	Decreased	Increased
O-ring leaks (at interconnectors or adapters)	Random (typically at feed adapter)	Normal to decreased	Normal to decreased	Increased
Glue line leaks (due to perm pressure > feed pressure in service or standby)	1st stage most severe	Normal to decreased	Normal to decreased	Increassed
Glue line leaks (due to closed permeate valve while cleaning or flushing)	Tail element of a stage	Increased (based on prior fouling and high delta P	Increased (based on prior fouling and high delta P	Increased

Note: Pressure Drop is defined as the Feed pressure minus the Concentrate pressure

Table 1 Types of foulant, and their usual symptoms

Foulant types and effective cleaners

Calcium Carbonate Scale: Calcium carbonate is a mineral scale that may be deposited from almost any feedwater if there is a failure in the antiscalant/dispersant addition system or in the acid injection pH control system. An early detection of calcium carbonate scaling is essential to prevent damage caused by the crystals on the active membrane layers. Calcium carbonate scale detected early can be removed by lowering the feedwater pH to between 3.0 and 5.0 for one or two hours. Longer resident accumulations of calcium carbonate scale can be removed by a low pH cleaning with a citric acid solution.

Calcium, Barium & Strontium Sulfate Scale: Sulfate scale is a much "harder" mineral scale than calcium carbonate and is therefore more difficult to remove. Sulfate scale may be deposited if there is a failure in the antiscalant/dispersant feed system or if there is an over feed of sulfuric acid in pH adjustment. Early detection of the resulting sulfate scaling is essential to prevent damage caused by the crystals on the active membrane layers. Barium and strontium sulfate scales are particularly difficult to remove as they are insoluble in almost all cleaning solutions. Special care should be taken to prevent their formation.

Calcium Phosphate Scale: This scale is particularly common in municipal wastewaters and water supplies which may contain high levels of phosphate. This scale can generally be removed with acidic pH cleaners.

Metal Oxide/Hydroxide Foulants: Typical metal oxide and metal hydroxide foulants are iron, zinc, manganese, copper, aluminum, etc. They can be the result of corrosion products from unlined pipes and tanks; from oxidation of the soluble metal ion with air, chlorine, ozone, potassium permanganate; or from a pretreatment filter system upset that utilizes iron or aluminum based coagulant aids. Can generally be removed with low pH cleaners

Polymerized Silica Coating: A silica gel coating resulting from the super-saturation and polymerization of soluble silica can be very difficult to remove. It should be noted that this type of silica fouling is different from silica-based colloidal foulants, which may be associated with either metal hydroxides or organic matter. Polymerized silica scale can be very difficult to remove by traditional chemical cleaning methods.

Colloidal Foulants: Colloids are inorganic or mixed inorganic/organic based particles that are suspended in water and will not settle out due to gravity. Colloidal matter typically contains one or more of the following major components: iron, aluminum, silica, sulfur, or organic matter. High pH cleaners are generally more effective against this type of foulant

Dissolved NOM/ Organic Foulants: The sources of dissolved NOM (Natural Organic Matter) foulants are typically derived from the decomposition of vegetative material into surface waters or shallow wells. The chemistry of organic foulants is very complex, with the major organic components being either humic acid or fulvic acid. Dissolved NOMs can quickly foul RO membranes by being absorbed onto the membrane surface. Once absorption has occurred, then a slower fouling process of gel or cake formation begins. It should be noted that the mechanism of fouling with dissolved NOM should not be confused with the mechanism of fouling created by NOM organic material that is bound with colloidal particles. High pH cleaners are generally more effective against this type of foulant. Please note that wastewaters may contain a range of naturally occurring and man-made organic compounds. Should any of these compounds chemically bond to the membrane, cleaning regimes may be ineffective in removing the foulant.

Microbiological Deposits: Organic-based deposits resulting from bacterial slimes, fungi, molds, etc. can be difficult to remove, particularly if the feed path is plugged. Plugging of the feed path makes it difficult to introduce and distribute the cleaning solutions. To inhibit additional growth, it is important to clean and sanitize not only the RO system, but also the pretreatment, piping, dead-legs, etc. High pH cleaners in association with biocide treatments are most effective against this type of problem.

Selection and Use of Cleaning Chemicals

There are a number of factors involved in the selection of a suitable cleaning chemical (or chemicals) and proper cleaning protocol. At the time of the first cleaning, it is recommended to contact:

- Manufacturer of the equipment,
- RO element manufacturer,
- RO specialty chemical and service supplier.

Proper identification of the foulant is essential to prescibe the correct cleaners to most effectively remove the foulant.

Once the suspected foulant(s) are identified, one or more cleaning chemicals will be recommended.
These cleaning chemical(s) can be:

- Generic (typically technical grade, available from local chemical supply companies)
- Private-labeled proprietary chemicals.

Independent RO service companies are available who can determine the proper chemicals and cleaning protocol for your situation by testing a fouled element at their facility. For difficult situations, this is a recommended option.

It is not unusual to use a number of different cleaning chemicals in a specific sequence to achieve the optimum cleaning. As foulants may be laid down in discrete “layers”, the sequence of cleaning can be important.

Typically, a low pH cleaning is first used to remove foulants (such as mineral scale), followed by a high pH cleaning to remove organic material. This is not always the case - there are instances where a high pH cleaning may used first to remove foulants like oil or biological matter, followed by a low pH cleaning. The optimum sequence can usually only be determined by conducting tests.

Some cleaning solutions are “combination” agents, and may have detergents added to aid in the removal of heavy biological and organic debris, while others have a chelating agent like EDTA added to aid in the removal of colloidal, organic and biological material, as well as sulfate scale. Advice on the best use of such cleaners is best obtained directly from the manufacturer of the speciality cleaners.

TMUS has no objection to the use of speciality cleaners, providing it has been adequately demonstrated that the cleaner will not damage the Toray membrane.

General Precautions in Cleaning Chemical Selection and Usage

- If using a proprietary chemical, be sure the chemical has been qualified for use with the membrane by the chemical supplier. The chemical supplier’s instructions should not be in conflict with TMUS’s recommended cleaning parameters and limits.
- Use the mildest cleaning regimen. This includes the cleaning parameters of pH, temperature, and contact time. This will optimize the useful life of the membrane.
- Clean at the recommended target temperatures to optimize cleaning efficiency and membrane life.
- Use the minimal amount of chemical contact time to optimize membrane life.

- Be prudent in the adjustment of pH at the low and high pH range to extend the useful life of the membrane. A “gentle” pH range is 4 to 10, while the harshest is 2 to 12.
- Typically, the most effective cleaning sequence is low pH followed by high pH solutions. One known exception is oil-fouled membranes should not use a low pH clean first as the oil will coagulate.
- Cleaning and flushing flows should be in the same direction as the normal feed flow to avoid potential telescoping and element damage.
- When cleaning a multi-stage RO, the most effective cleaning plan is to clean one bank/stage at a time so cleaning flow velocities can be optimized and foulants from upstream stages will not pass through to downstream stages.
- Flushing detergents with higher pH permeate can reduce any foaming problems.
- Verify that proper disposal requirements for the cleaning solution are followed.
- If the system has been fouled biologically, consider the extra step of introducing a sanitizing biocide chemical after a successful cleaning. Biocides can be introduced
    - immediately after cleaning,
    - periodically (e.g. once a week),
    - continuously during service.
- Ensure that the biocide is compatible with the membrane, does not create any health risks, is effective in controlling biological activity, and is not cost prohibitive before going this route.
- Safety Considerations
    - Be sure all hoses and piping can handle the temperatures, pressures and pH which will be encountered during a cleaning.
    - Always add chemicals slowly to an agitated batch of make-up water.
    - Always wear safety glasses and appropriate protective gear when working with chemicals.
    - Don’t mix concentrated acids with caustic solutions.
    - Thoroughly rinse the 1st cleaning solution from the RO system before introducing the next solution.

pH and Temperature Limits for Cleaning Toray

Membrane Type	**45 C (113 F)**	**35 C (95 F)**	**30 C (86 F)**
Brackish (“7 “and “L”)	2-10	2-11.5	2-12
Low Pressure Brackish (“G” And “H”)	2-10	2-11.5	2-12
Seawater	2-10	2-11	2-12

Note: The above cleaning parameters denote the maximum temperature limits for a corresponding range of pH. Cleaning operations performed at the extremes may result in a more effective cleaning, but can shorten the useful life of the membrane due to hydrolysis.effects. To optimize the useful life of a membrane, it is recommended to use the least harsh cleaning solutions necessary and to minimize the contact time whenever possible.

Cleaning and Flushing Flow Rates per RO Pressure Tube
(differential Pressures are not to exceed 60 psi (4 bar) across any tube.)

Element Diameter	**GPM**	**LPM**
4-inches	6 to 10	23 to 38
8-inches	24 to 40	91 to 151

Elements should be cleaned at the highest flow rate possible without exceeding 60 psi differential pressure limit. Exceeding the limit can result in mechanical damage to the elements.

Cleaning Solution Volume Requirement per RO Element
(This volume does not include additional volumes required for piping, filters, etc. or the initial 20% of volume dumped to drain.)

Element Size	**Normal Fouling** (Gallons)	**Heavy Fouling** (Gallons)	**Normal Fouling** (Liters)	**Heavy Fouling** (Liters)
4 x 40 inches	2.5	5	9.5	19
8 x 40 inches	9	18	34	68

Cleaning Tank sizing

Required volume of cleaning solution can be estimated as follows:

1. Cleaning solution requirement per element (see above) x number of elements to be cleaned

Plus

2. Swept volume of connecting pipework to and from cleaning skid

Plus

3. Extra 20% of (1+2) above for first part of cleaning solution sent to drain

RO Cleaning Skid

The successful cleaning of an RO on-site requires a well designed RO cleaning skid. See Figure 1 for a typical arrangement. The skid may or may not be hard piped to the RO skid and may use flexible hose for connections to the RO skid.
For a multi-stage RO, it is recommended that each bank/array be cleaned one stage at a time to optimize cross-flow cleaning velocity.
The source water for chemical solution make-up and rinsing should be clean RO permeate or DI water and be free of hardness, transition metals (e.g. iron), and chlorine..

RO Cleaning Tank:
This tank needs to be sized properly to accommodate the displacement of water in the hose, piping, and RO elements. (see above).The tank should be designed to:

- Allow 100 % drainage
- easy access for chemical introduction and mixing
- recirculation line from the RO Cleaning Pump,
- proper venting,
- overflow,
- return line located near the bottom to minimize foam formation when using a surfactant.

RO Cleaning Pump:
This pump needs to be sized to develop the proper cross-flow velocity to scrub the membrane clean. The maximum recommended pressure is 60 psi (4 bar) at the inlet to the pressure vessels to minimize the production of permeate during cleaning and so reduce the convective re-deposition of foulant back on the membrane surface. The table above gives the recommended flow rate ranges for each pressure tube.

RO Cleaning Cartridge Filter:

Normally 5 to 10-micron and is designed to remove foulants that have been displaced from the cleaning process. Filter must be located upstream of the RO elements.

RO Tank Heater or Cooler:
The maximum design temperature for cleaning is 113° F (45° C). It should be noted that heat is generated and imparted by the RO Cleaning Pump during recirculation which can act as a heater,

RO Tank Mixer: This component is recommended for optimal mixing of chemical, though some designers rely solely on the slow introduction of chemical while maintaining a recirculation through the RO Cleaning Pump back to the tank.

Instrumentation: Cleaning system instrumentation should be included to monitor flow, temperature, pressure, and tank level.

Sample Points:
Sample valves should be located to allow pH and TDS measurements off the RO Cleaning Pump discharge and the concentrate side recirculation return line.

Permeate Return Line:
A small amount of the cleaning solution can permeate through the membranes, therefore a permeate-side return line back to the RO Cleaning Tank is required.
Important: The permeate line and any permeate valves must always be open to atmospheric pressure during the cleaning and flushing steps or damage to RO elements can occur. If the permeate line is closed, the permeate pressure can build up and become higher than the feed-side pressure of the tail elements. This can result in excessive permeate back-pressure which can damage the membrane glue lines in the tail elements.

RO Membrane Element Cleaning and Flushing Procedures

The RO membrane elements can be cleaned in place in the pressure tubes by recirculating the cleaning solution across the high-pressure side of the membrane at low pressure and relatively high flow. A cleaning unit is needed to accomplish this task. See fig 1 for general arrangement.

RO cleaning procedures may vary dependent on the situation. The time required to clean a stage is from 4 to 8 hours. A general procedure for cleaning the RO membrane elements is as follows:

1. Perform a low pressure flush at 60 psi (4 bar) or less of the pressure tubes by pumping clean water from the cleaning tank (or equivalent source) through the pressure tubes to drain for several minutes. Flush water should be clean water of RO permeate or DI quality and be free of hardness, transition metals, and chlorine.
2. Mix a fresh batch of the selected cleaning solution in the cleaning tank. The dilution water should be clean water of RO permeate or DI quality and be free of hardness, transition metals, and chlorine. The temperature and pH should be adjusted to their target levels.
3. Start recirculation. Initially send the displaced water from the system to drain so y cleaning chemical is not diluted. Then divert the first 20%of the returned cleaning solution (the most highly fouled cleaning solution) to drain before allowing the remaining cleaning solution to recirculate back into the RO Cleaning Tank. For the first 5 minutes, slowly throttle the flow rate to 1/3 of the maximum design flow rate. This is to minimize the potential plugging of the feed path with a large amount of dislodged foulant. For the second 5 minutes, increase the flow rate to 2/3 of the maximum design flow rate, and then increase the flow rate to the maximum design flow rate. If required, readjust the pH back to the target when it changes more than 0.5 pH units. Circulate the cleaning solution through the pressure tubes for approximately one hour or as required.
4. An optional soak and recirculation sequence can be used, if required. The soak time can be from 1 to 8 hours depending on the manufacturer’s recommendations. Caution should be used to maintain the proper temperature and pH.
5. Upon completion of the chemical cleaning step, a low pressure cleaning rinse with clean water (RO permeate or DI quality and free of hardness, transition metals, and chlorine) is required to remove all traces of chemical from the Cleaning Skid and the RO Skid. Drain and flush the cleaning tank; then completely refill the Cleaning Tank with clean water for the Cleaning Rinse. Rinse the pressure tubes by pumping all of the rinse water from the Cleaning Tank through the pressure tubes to drain. A second cleaning can be started at this point, if required.
6. Once the RO system is fully rinsed of cleaning chemical with clean water from the Cleaning Tank, a final low pressure clean-up flush can be performed using pretreated feedwater.The permeate line should remain open to drain. Feed pressure should be less than 60 psi (4bar). This final flush continues until the flush water flows clean and is free of any foam or residues of cleaning agents. This usually takes 15 to 60 minutes. The operator should sample the flush water going to the drain for detergent removal and lack of foaming by using a clear flask and shaking it. A conductivity meter can be used to test for removal of cleaning chemicals. The flush water to drain should be within 10-20% of the feedwater conductivity.A pH meter can also be used to compare the flush water to drain to the feed pH.

7. Once all the stages of a train are cleaned and the chemicals flushed out, the RO can be restarted and placed into a Service Rinse. The RO permeate should be diverted to drain until it meets the quality requirements of the process (e.g. conductivity, pH, etc.). It is not unusual to take a period from a few hours to a few days for the RO permeate quality to fully stabilize, especially after high pH or very low pH cleanings..

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Technical Service Bulletin

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Foulants and Cleaning Procedures for composite polyamide RO Membrane Elements (ESPA, ESNA, CPA, LFC, NANO and SWC)

This bulletin provides general information about the usual foulants affecting the performance of Hydranautics' Composite Polyamide Reverse Osmosis (RO) membrane elements and the removal of these foulants. The information in this bulletin applies to 4-inch, 6-inch, 8-inch, 8.5-inch, and 16-inch diameter RO membrane elements.

Note: The Composite Polyamide type of RO membrane elements may not be exposed to chlorinated water under any circumstances. Any such exposure will cause irreparable damage to the membrane. Absolute care must be taken following any disinfection of piping or equipment or the preparation of cleaning or storage solutions to ensure that no trace of chlorine is present in the feedwater to the RO membrane elements. If there is any doubt about the presence of chlorine, perform chemical testing to make sure. Neutralize any chlorine residual with a sodium bisulfite solution, and ensure adequate mixing and contact time to accomplish complete dechlorination. Dosing rate is 1.8 to 3.0 ppm sodium bisulfite per 1.0 ppm of free chlorine.

Note: It is recommended that all RO membrane cleaning operations should be closely coordinated with Hydranautics during the RO membrane element warranty period. Hydranautics field service personnel are available to be on site for cleaning assistance, should the need arise. Please contact Hydranautics for current charges for this service.

Note: The use of cationic surfactant should be avoided in cleaning solutions, since irreversible fouling of the membrane elements may occur.

If additional information is needed, please contact the Technical Services Department at:

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RO Membrane Fouling and Cleaning

During normal operation over a period of time, RO membrane elements are subject to fouling by suspended or sparingly soluble materials that may be present in the feedwater. Common examples of foulants are:

- Calcium carbonate scale
- Sulfate scale of calcium, barium or strontium
- Metal oxides (iron, manganese, copper, nickel, aluminum, etc.)
- Polymerized silica scale
- Inorganic colloidal deposits
- Mixed inorganic/organic colloidal deposits
- NOM organic material (Natural Organic Matter)
- Man-made organic material (e.g. antiscalant/dispersants, cationic polyelectrolytes)
- Biological (bacterial bioslime, algae, mold, or fungi)

The nature and rapidity of fouling depends on a number of factors, such as the quality of the feedwater and the system recovery rate. Typically, fouling is progressive, and if not controlled early, will impair the RO membrane element performance in a relatively short time. Cleaning is should accur when the RO shows evidence of fouling, just prior to a long-term shutdown, or as a matter of scheduled routine maintenance. The elements shall be maintained in a clean or “nearly clean” condition to prevent excessive fouling by the foulants listed above. Some fouling is allowed as long as:

- normalized permeate flow decrease is less than 10%

- normalized permeate quality decrease is less than 10%
.
- normalized pressure drop, as measured between the feed and concentrate headers, increase is less than 15%.

Cleaning should be carried out before these values are exceeded to maintain the elements in a clean or “nearly clean” condition. Effective cleaning is evidenced by the return of the normalized parameters to their initial, Start-up, value. In the event you do not normalize your operating data, the above values still apply if you do not have major changes in critical operating parameters. The operating parameters that have to stay constant are permeate flow, permeate back-pressure, recovery, temperature, and feed TDS. If these operating parameters fluctuate, then it is highly recommended that you normalize the data to determine if fouling is occurring or if the RO is actually operating normally based on the change in a critical operating parameter. Hydranautics offers a free normalization software program called ROData, which can be downloaded from our web site at www.membranes.com.

Monitoring overall plant performance on a regular basis is an essential step in recognizing when membrane elements are becoming fouled. Performance is affected progressively and in varying degrees, depending on the nature of the foulants. Table 1 “RO Troubleshooting Matrix” provides a summary of the expected effects that common foulants have on performance.

RO cleaning frequency due to fouling will vary by site. A rough rule of thumb as to an acceptable cleaning frequency is once every 3 to 12 months. If you have to clean more than once a month, you should be able to justify further capital expenditures for improved RO pretreatment or a re-design of the RO operation. If the cleaning frequency is every one to three months, you may want to focus on improving the operation of your existing equipment but further capital expenditure may be harder to justify.

It is important to clean the membranes when they are only lightly fouled, not heavily fouled. Heavy fouling can impair the effectiveness of the cleaning chemical by impeding the penetration of the chemical deep into the foulant and in the flushing of the foulant out of the elements. If normalized membrane performance drops 30 to 50%, it may be impossible to fully restore the performance back to baseline conditions.

When inorganic or polyelectrolyte coagulants are used in the pretreatment process, there can often be incomplete reaction of the coagulant and thus insufficient formation of a filterable floc. The user should ensure that excessive amounts of coagulant are not fed to the RO system, as it can lead to fouling. Polyelectrolyte fouling can often be very difficult to remove and result in higher than expected feed pressure. Excessive amounts of inorganic coagulant can be measured by using SDI filter equipment. In the case of iron, the iron on the SDI filter pad should typically be 3 µg/pad and never above 5 µg/pad. In regards to polymer coagulants, the user should discuss the concern with their chemical supplier and have them ensure that the chemical will not adversely affect the membrane.

In addition to the use of turbidity and SDI, particle counters are also very effective to accurately measure the suitability of the feedwater for NF/RO elements. The measure of particles greater than 2 microns in size should be < 100 particles per millilitre.

One RO design feature that is commonly over-looked in reducing RO cleaning frequency is the use of RO permeate water for flushing foulants from the system. Soaking the RO elements during standby with permeate can help dissolve scale and loosen precipitates, reducing the frequency of chemical cleaning.

What you clean for can vary site by site depending on the foulant. Complicating the situation frequently is that more than one foulant can be present, which explains why cleanings frequently require a low pH and high pH cleaning regiment.

Note: The membrane elements shall not be exposed to feed water containing oil, grease, or other foreign matter which proves to chemically or physically damage the integrity of the membrane.

Table 1: RO Troubleshooting Matrix

(Pressure Drop is defined as the Feed pressure minus the Concentrate pressure)

Possible Cause	Possible Location	Pressure Drop	Feed Pressure	Salt Passage
Metal Oxide Fouling (e.g. Fe,Mn,Cu,Ni,Zn)	1st stage lead elements	Rapid increase	Rapid increase	Rapid increase
Colloidal Fouling (organic and/or inorganic complexes)	1st stage lead elements	Gradual increase	Gradual increase	Slight increase
Mineral Scaling (e.g. Ca, Mg, Ba, Sr)	Last stage tail elements	Moderate Increase	Slight increase	Marked increase
Polymerized Silica	Last stage tail elements	Normal to increased	Increased	Normal to increased
Biological Fouling	Any stage, usually lead elements	Marked increase	Marked increase	Normal to increased
Organic Fouling (dissolved NOM)	All stages	Gradual increase	Increased	Decreased
Antiscalant Fouling	2nd stage most severe	Normal to increased	Increased	Normal to increased
Oxidant damage (e.g Cl_2, ozone,$KMnO_4$)	1st stage most severe	Normal to decreased	Decreased	Increased
Hydrolysis damage (out of range pH)	All stages	Normal to decreased	Decreased	Increased
Abrasion damage (carbon fines, etc)	1st stage most severe	Normal to decreased	Decreased	Increased
O-ring leaks (at interconnectors or adapters)	Random (typically at feed adapter)	Normal to decreased	Normal to decreased	Increased
Glue line leaks (due to permeate back-pressure in service or standby)	1st stage most severe	Normal to decreased	Normal to decreased	Increased
Glue line leaks (due to closed permeate valve while cleaning or flushing)	Tail element of a stage	Increased (based on prior fouling & high delta P)	Increased (based on prior fouling & and high delta P)	Increased

Discussion on Foulants

Calcium Carbonate Scale: Calcium carbonate is a mineral scale and may be deposited from almost any feedwater if there is a failure in the antiscalant/dispersant addition system or in the acid injection pH control system that results in a high feedwater pH. An early detection of the resulting calcium carbonate scaling is absolutely essential to prevent the damage that crystals can cause on the active membrane layers. Calcium carbonate scale that has been detected early can be removed by lowering the feedwater pH to between 3.0 and 5.0 for one or two hours. Longer resident accumulations of calcium carbonate scale can be removed by a low pH cleaning with a citric acid solution.

Calcium, Barium & Strontium Sulfate Scale: Sulfate scale is a much “harder” mineral scale than calcium carbonate and is harder to remove. Sulfate scale may be deposited if there is a failure in the antiscalant/dispersant feed system or if there is an over feed of sulfuric acid in pH adjustment. Early detection of the resulting sulfate scaling is absolutely essential to prevent the damage that crystals can cause on the active membrane layers. Barium and strontium sulfate scales are particularly difficult to remove as they are insoluble in almost all cleaning solutions, so special care should be taken to prevent their formation.

Calcium Phosphate Scale: This scale is particularly common in municipal waste waters and polluted water supplies which may contain high levels of phosphate. This scale can generally be removed with acidic pH cleaners. At this time, phosphate scaling calculations are not performed by the Hydranautics RO Design software. As a rule of thumb, contact Hydranautics technical department if phosphate levels in the feed are 5 ppm or higher.

Metal Oxide/Hydroxide Foulants: Typical metal oxide and metal hydroxide foulants are iron, zinc, manganese, copper, aluminum, etc. They can be the result of corrosion products from unlined pipes and tanks, or result from the oxidation of the soluble metal ion with air, chlorine, ozone, potassium permanganate, or they can be the result of a pretreatment filter system upset that utilizes iron or aluminum-based coagulant aids.

Polymerized Silica Coating: A silica gel coating resulting from the super-saturation and polymerization of soluble silica can be very difficult to remove. It should be noted that this type of silica fouling is different from silica-based colloidal foulants, which may be associated with either metal hydroxides or organic matter. Silica scale can be very difficult to remove by traditional chemical cleaning methods. Contact Hydranautics technical department if the traditional methods are unsuccessful. There does exist harsher cleaning chemicals, like ammonium biflouride, that have been used successfully at some sites but are considered rather hazardous to handle and can damage equipment.

Colloidal Foulants: Colloids are inorganic or mixed inorganic/organic based particles that are suspended in water and will not settle out due to gravity. Colloidal matter typically contains one or more of the following major components: iron, aluminum, silica, sulfur, or organic matter.

Dissolved NOM Organic Foulants: The sources of dissolved NOM (Natural Organic Matter) foulants are typically derived from the decomposition of vegetative material into surface waters or shallow wells. The chemistry of organic foulants is very complex, with the major organic components being either humic acid or fulvic acid. Dissolved NOMs can quickly foul RO membranes by being absorbed onto the membrane surface. Once absorption has occurred, then a slower fouling process of gel or cake formation starts. It should be noted that the mechanism of fouling with dissolved NOM should not be confused with the mechanism of fouling created by NOM organic material that is bound up with colloidal particles.

Microbiological Deposits: Organic-based deposits resulting from bacterial slimes, fungi, molds, etc. can be difficult to remove, particularly if the feed path is plugged. Plugging of the feed path makes it difficult to introduce and distribute the cleaning solutions. To inhibit additional growth, it is important to clean and sanitize not only the RO system, but also the pretreatment, piping, dead-legs, etc. The membranes, once chemically cleaned, will require the use of a Hydranautics approved biocide and an extended exposure requirement to be effective. For further information on biocides, refer to Hydranautics Technical Service Bulletin TSB-110 “Biocides for Disinfection and Storage of Hydranautics Membrane Elements”.

Selection and Use of Cleaning Chemicals

There are a number of factors involved in the selection of a suitable cleaning chemical (or chemicals) and proper cleaning protocol. The first time you have to perform a cleaning, it is recommended to contact the manufacturer of the equipment, the RO element manufacturer, or a RO specialty chemical and service supplier. Once the suspected foulant(s) are identified, one or more cleaning chemicals will be recommended. These cleaning chemical(s) can be generic or can be private-labeled proprietary chemicals. Typically, the generic chemicals can be of technical grades and are available from local chemical supply companies. The proprietary RO cleaning chemicals can be more expensive, but may be easier to use and you cannot rule out the advantage of the intellectual knowledge supplied by these companies. Some independent RO service companies can determine the proper chemicals and cleaning protocol for your situation by testing at their facility a fouled element pulled from your system.

It is not unusual to use a number of different cleaning chemicals in a specific sequence to achieve the optimum cleaning. Typically, a high pH cleaning is used first to remove foulants like oil or biological matter, followed by a low pH cleaning to remove foulants like mineral scale or metal oxides/hydroxides fouling. There are times that order of high and low pH cleaning solutions is reversed or one solution only is required to clean the membranes. Some cleaning solutions have detergents added to aid in the removal of heavy biological and organic debris, while others have a chelating agent like EDTA added to aid in the removal of colloidal material, organic and biological material, and sulfate scale. An important thing to remember is that the improper selection of a cleaning chemical, or the sequence of chemical introduction, can make the foulant worse.

Hydranautics recommends that the membrane system operator thoroughly investigate the signs of fouling before they select a cleaning chemical and a cleaning protocol. Some forms of fouling (iron deposits and scaling commonly associated with well waters) may require only a simple low pH cleaning. However, for most complex fouling phenomena, Hydranautics recommends the following sequence:

1. Flushing with permeate with addition of non oxidizing biocide (DBNPA or similar type) at the end of the flushing.
2. High pH CIP – Temperature versus pH as per recommendations in this TSB
3. Flushing with permeate until pH on the brine side is below pH 8.5
4. Low pH CIP
5. Acid flushing with permeate and non oxidizing biocide (DBNPA or similar type)

General Precautions in Cleaning Chemical Selection and Usage

- If you are using a proprietary chemical, make sure the chemical has been qualified for use with your Hydranautics membrane by the chemical supplier. The chemical supplier’s instructions should not be in conflict with Hydranautics recommended cleaning parameters and limits listed in this Technical Service Bulletin.
- If you are using generic chemicals, make sure the chemical has been qualified for use with your Hydranautics membrane in this Technical Service Bulletin.
- Use the least harshest cleaning regiment to get the job done. This includes the cleaning parameters of pH, temperature, and contact time. This will optimize the useful life of the membrane.
- Clean at the recommended target temperatures to optimize cleaning efficiency and membrane life.
- Use the minimal amount of chemical contact time to optimize membrane life.

- Be prudent in the adjustment of pH at the low and high pH range to extend the useful life of the membrane. A “gentle” pH range is 4 to 10, while the harshest is 2 to 12.
- Oil and biologically -fouled membranes should not use a low pH clean-up first as the oil and biological matter will congeal.
- Cleaning and flushing flows should be in the same direction as the normal feed flow to avoid potential telescoping and element damage.
- When cleaning a multi-stage RO, the most effective cleaning is one stage at a time so cleaning flow velocities can be optimized and foulants from upstream stages don’t have to pass through down-stream stages.
- Flushing out detergents with higher pH permeate can reduce foaming problems.
- Verify that proper disposal requirements for the cleaning solution are followed.
- If your system has been fouled biologically, you may want to consider the extra step of introducing a sanitizing biocide chemical before and after a successful cleaning. Biocides can be introduced before and immediately after cleaning, periodically (e.g. once a week), or continuously during service. You must be sure that the biocide is compatible with the membrane, does not create any health risks, is effective in controlling biological activity, and is not cost prohibitive.
- For safety reasons, make sure all hoses and piping can handle the temperatures, pressures and pH’s encountered during a cleaning.
- For safety reasons, always add chemicals slowly to an agitated batch of make-up water.
- For safety reason, always wear safety glasses and protective gear when working with chemicals.
- For safety reasons, don’t mix acids with caustics. Thoroughly rinse the 1st cleaning solution from the RO system before introducing the next solution.

Selecting a Cleaning Solution

Table 2 lists the recommended generic chemical solutions for cleaning an RO membrane element based on the foulant to be removed.

> **Important: It is recommended that the MSDS of the cleaning chemicals be procured from the chemical supplier and that all safety precautions be utilized in the handling and storage of all chemicals.**

Table 2: Hydranautics Recommended Chemical Cleaning Solutions

Foulant	**Gentle Cleaning Solution**	**Harsher Cleaning Solution**
Calcium carbonate scale	1	4
Calcium, barium or strontium sulfate scale	2	4
Metal oxides/hydroxides (Fe, Mn, Zn, Cu, Al)	1	5
Inorganic colloidal foulants	1	4
Mixed Inorganic/organic colloidal foulants	2	6
Polymerized silica coating	None	7
Biological matter	2 or 3	6
NOM organic matter (naturally occurring)	2 or 3	6

Table 3 “Hydranautics Recipes for Cleaning Solutions” offers instructions on the volumes of bulk chemical to be added to 100 U.S. gallons (379 liters) of make-up water. Prepare the solutions by proportioning the amount of chemicals to the amount of make-up water to be used. Make-up water quality should be of RO permeate or deionized (DI) quality, and be free of chlorine and hardness. Before forwarding the cleaning solution to the membranes, it is important to thoroughly mix it, adjust the pH according to the target pH, and stabilize the temperature at the target temperature. Unless otherwise instructed, the cleaning design parameters are based on a chemical recirculation flow period of one hour and an optional chemical soak period of one hour.

Table 4 “Hydranautics Maximum pH and Temperature Limits for Cleaning” highlights the maximum pH and temperature limits for specific membranes, after which irreparable membrane damage can occur. A suggested minimum temperature limit is 70 F (21 C), but cleaning effectiveness and the solubility of the cleaning chemical is significantly improved at higher temperatures.

Description of Cleaning Solutions

Note: The notation (w) denotes that the diluted chemical solution strength is based on the actual weight of the 100% pure chemical or active ingredient.

Solution 1: This is a low pH cleaning solution of 2.0% (w) citric acid ($C_6H_8O_7$). It is useful in removing inorganic scale (e.g. calcium carbonate, calcium sulfate, barium sulfate, strontium sulfate) and metal oxides/hydroxides (e.g. iron, manganese, nickel, copper, zinc), and inorganic-based colloidal material. Note: Citric acid is available as a powder.

Solution 2: This is a high pH cleaning solution (target pH of 10.0) of 2.0% (w) of STPP (sodium tripolyphosphate) ($Na_5P_3O_{10}$) and 0.8% (w) of Na-EDTA (sodium salt of ethylaminediaminetetraacetic acid). It is specifically recommended for removing calcium sulfate scale and light to moderate levels of organic foulants of natural origin. STPP functions as an inorganic-based chelating agent and detergent. Na-EDTA is an organic-based chelating cleaning agent that aids in the sequestering and removal of divalent and trivalent cations and metal ions. STPP and Na-EDTA are available as powders.

Solution 3: This is a high pH cleaning solution (target pH of 10.0) of 2.0% % (w) of STPP (sodium tripolyphosphate) ($Na_5P_3O_{10}$) and 0.025% (w) Na-DDBS ($C_6H_5(CH_2)_{12}\text{-}SO_3Na$) (sodium salt of dodecylbenzene sulfonate). It is specifically recommended for removing heavier levels of organic foulants of natural origin. STPP functions as an inorganic-based chelating agent and detergent. Na-DDBS functions as an anionic detergent.

Solution 4: This is a low pH cleaning solution (target pH of 2.5) of 0.5% (w) of HCL (hydrochloric) acid. It is useful in removing inorganic scale (e.g. calcium carbonate, calcium sulfate, barium sulfate, strontium sulfate and metal oxides/hydroxides (e.g. iron, manganese, nickel, copper, zinc) and inorganic-based colloidal material. This cleaning solution is considered to be harsher than Solution 1. HCL acid, a strong mineral acid, is also known as muriatic acid. HCL acid is available in a number of concentrations: (18 ^{0} Baume = 27.9%), (20 ^{0} Baume = 31.4%), (22 ^{0} Baume = 36.0%).

Solution 5: This is a lower pH cleaning solution (natural pH is between pH 4 and 6. No pH adjustment is required) 1.0% (w) of $Na_2S_2O_4$ (sodium hydrosulfite). It is useful in the removal of metal oxides and hydroxides (especially iron fouling), and to a lesser extent calcium sulfate, barium sulfate and strontium sulfate. Sodium hydrosulfite is strong reducing agent and is also known as sodium dithionite. The solution will have a very strong odor so proper ventilation is required. Sodium hydrosulfite is available as a powder.

Solution 6: This is a high pH cleaning solution (target pH of 11.5) of 0.1% (w) of NaOH (sodium hydroxide) and 0.03% (w) of SDS (sodium dodecylsulfate). It is useful in the removal of organic foulants of natural origin, colloidal foulants of mixed organic/inorganic origin, and biological material (fungi, mold, slimes and biofilm). SDS is a detergent that is an anionic surfactant that will cause some foaming. This is considered to be a harsh cleaning regiment. ***Note: Do not exceed maximum pH and temp limits for specific elements. See Table4.***

Solution 7: This is a high pH cleaning solution (target pH of 11.5) of 0.1% (w) of NaOH (sodium hydroxide). It is useful in the removal of polymerized silica. This is considered to be a harsh cleaning regiment. *Note: Do not exceed maximum pH and temp limits for specific elements. See Table4.*

> **Important: It is recommended that the MSDS of the cleaning chemicals be procured from the chemical supplier and that all safety precautions be utilized in the handling and storage of all chemicals.**

Table 3: Hydranautics Recipes for Cleaning Solutions

The quantities listed below are to be added to 100 U.S.gallons (379 liters) of dilution water.

Cleaning Solution	**Bulk Ingredients**	**Quantity**	**Target[1] pH Adjustment**	**Target[1] Temp.**
1	**Citric acid** (as 100% powder)	17.0 pounds (7.7 kg)	No pH adjustment is Required.	104 F (40 C)
2	**STPP** (sodium tripolyphosphate) (as 100% powder) **Na-EDTA** (Versene 220 or equal) (as 100% powder)	17.0 pounds (7.7 kg) 7.0 pounds (3.18 kg)	Adjust to pH 10.0 with sulfuric or hydrochloric acid.	104 F (40 C)
3	**STPP** (sodium tripolyphosphate) (as 100% powder) **Na-DDBS** Na-dodecylbenzene sulfonate	17 pounds (7.7 kg) 0.21 pounds (0.1 kg)	Adjust down to pH 10.0 with sulfuric or hydrochloric acid.	104 F (40 C)
4	**HCl acid** (hydrochloric acid (as 22^0 Baume or 36% HCL)	0.47 gallons (1.78 liters)	Slowly adjust pH down to 2.5 with HCL acid. Adjust pH up with sodium hydroxide.	95 F (35 C)
5	**Sodium hydrosulfite** (as 100% powder)	8.5 pounds (3.86 kg)	No pH adjustment is required.	95 F (35 C)
6	**NaOH** (sodium hydroxide**)** (as 100% powder) (or as 50% liquid) **SDS** (sodium dodecylsulfate)	0.83 pounds (0.38 kg) 0.13 gallons (0.49 liters) 0.25 pounds (0.11 kg)	Slowly adjust pH up to 11.5 with sodium hydroxide. Adjust pH down to 11.5 by adding HCL acid.	86 F (30 C)
7	**NaOH** (sodium hydroxide) (as 100% powder) (or as 50% liquid)	0.83 pounds (0.38 kg) 0.13 gallons (0.49 liters)	Slowly adjust pH up to 11.5 with sodium hydroxide. Adjust pH down to 11.5 by adding HCL acid.	86 F (30 C)

[1] *- Note: These pH and temperature targets are recommendations only. For maximum pH and temperature limits for specific elements. See Table 4.*

Table 4: Hydranautics pH and Temperature Limits for Cleaning

(See Table 3 for target pH and temperatures)

	Continuous Operation		Maximum Cleaning Temp			
Membrane	**<45 C**	**≤ 36 C**	**50 C**	**≤45 C**	**≤35 C**	**≤25 C**
NANO-SW, NANO-BW	3 to 8.5	3 to 9	Contact Hydranautics Technical Department	Contact Hyd Tech Dept	1 to 10.5	1 to 11.5
ESNA1-LF, ESNA1-LF2, ESNA1-K1	3 to 9.5	2 to 10	Contact Hydranautics Technical Department	2 to 10.5	1 to 11	1 to 12
ESPA1, ESPA3, ESPA4	3 to 9.5	2 to 10	Contact Hydranautics Technical Department	2 to 10.5	1 to 11	1 to 12
ESPA2	3 to 10	2 to 10.6	Contact Hydranautics Technical Department	2 to 10.5	1 to 11	1 to 12
ESPAB	3 to 10.5	2 to 11	Contact Hydranautics Technical Department	2 to 11	1 to 11.5	1 to 12.5
LFC3, LFC3-LD	3 to 9.5	2 to 10	Contact Hydranautics Technical Department	2 to 10.5	1 to 11	1 to 12
CPA3	3 to 10	2 to 10.8	Contact Hydranautics Technical Department	2 to 11	1 to 11.5	1 to 12.5
CPA5-LD, ESPA2-LD	3 to 10.5	2 to 11	Contact Hydranautics Technical Department	2 to 11.5	1 to 12	1 to 13
SWC4+, SWC5, SWC5-LD, SWC6	3 to 10.5	2 to 11	Contact Hydranautics Technical Department	2 to 11	1 to 12	1 to 13

Note: The above cleaning parameters denote the maximum temperature limits for a corresponding range of pH. Cleaning operations performed at the extremes may result in a more effective cleaning, but can shorten the useful life of the membrane due to hydrolysis. To optimize the useful life of a membrane, it is recommended to use the least harsh cleaning solutions and minimize the contact time whenever possible. The pH of the feed stream or cleaning solution should be closely monitored and controlled. The pH meters used to measure and control pH should be regularly calibrated to ensure accuracy. It is typical to re-circulate cleaning chemicals through the RO for 1 hour. At the pH limits shown above, cleaning exposure at temperatures less than 40 C is limited to 60 minutes, at temperatures greater than 40 C exposure is limited to 30 minutes. Extended soaking is possible, but at less aggressive pH levels. See page 14 for more information on cleaning and flushing procedures.

Table 5: Cleaning and Flushing Flow Rates per RO Pressure Tube

(Pressures are not to exceed 60 psi (4 bar) at inlet to tubes.)

Element Diameter	**GPM**	**LPM**
4-inches	6 to 10	23 to 38
6-inches	12 to 20	46 to 76
8-inches	24 to 40	91 to 151
8.5-inches	27 to 45	102 to 170
16-inches	96 to 160	360 to 600

Table 6: Cleaning Solution Volume Requirement per RO Element

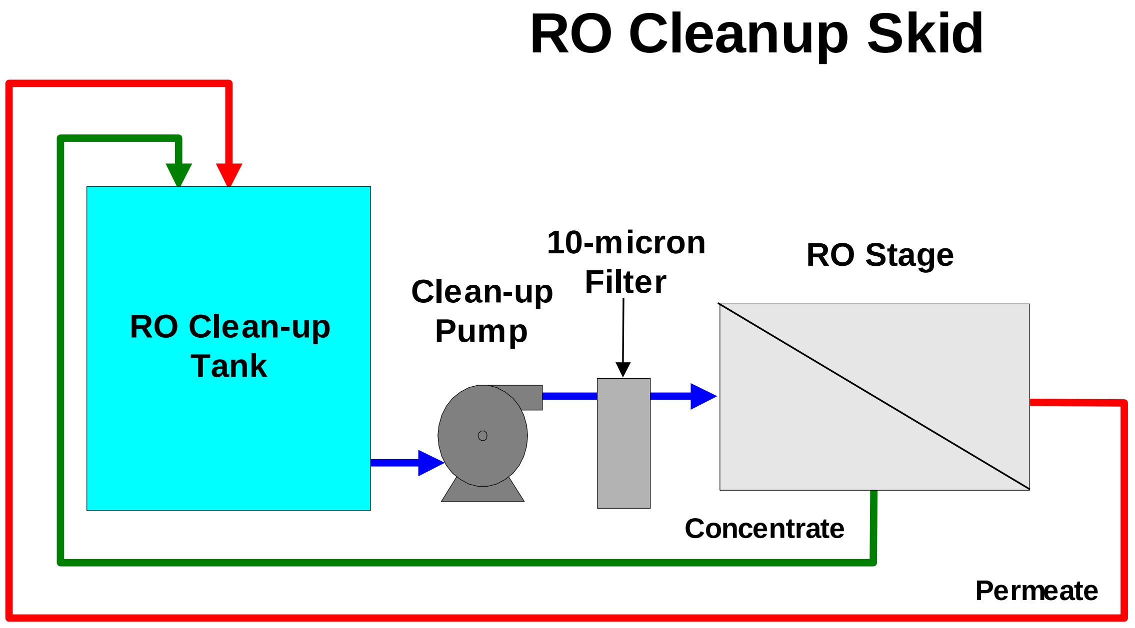
(these volumes do not include volumes required for piping, filters, etc)

(these volumes do not include initial 20% of volume dumped to drain)

Element Size	**Normal Fouling** (Gallons)	**Heavy Fouling** (Gallons)	**Normal Fouling** (Liters)	**Heavy Fouling** (Liters)
4 x 40 inches	2.5	5	9.5	19
6 x 40 inches	5	10	19	38
8 x 40 inches	9	18	34	68
8.5 x 40 inches	10	20	38	76
16 x 40 inches	36	72	136	272

RO Cleaning Skid

The successful cleaning of an RO on-site requires a well designed RO cleaning skid. Normally this skid is not hard piped to the RO skid and uses temporary hosing for connections. It is recommended to clean a multi-stage RO one stage at a time to optimize cross-flow cleaning velocity. The source water for chemical solution make-up and rinsing should be clean RO permeate or DI water and be free of hardness, transition metals (e.g. iron), and chlorine. Components must be corrosion proof. Major cleaning system components are:



- RO Cleaning Tank: This tank needs to be sized properly to accommodate the displacement of water in the hose, piping, and RO elements. The table below denotes the amount of chemical solution that needs to be made for a single RO element. The tank should be designed to allow 100 % drainage, easy access for chemical introduction and mixing, a recirculation line from the RO Cleaning Pump, proper venting, overflow, and a return line located near the bottom to minimize foam formation when using a surfactant.
- RO Cleaning Pump: This pump needs to be sized to develop the proper cross-flow velocity to scrub the membrane clean. The maximum recommended pressure is 60 psi (4 bar) at the inlet to the pressure vessels to minimize the production of permeate during cleaning and reduce the convective redeposition of foulant back on to the membrane surface. The table below denotes the flow rate ranges for each pressure tube.
- RO Cleaning Cartridge Filter: Normally 5 to 10-micron and is designed to remove foulants that have been displaced from the cleaning process.
- RO Tank Heater or Cooler: The maximum design temperature for cleaning is 113^0 F (45^0 C). It should be noted that heat is generated and imparted by the RO Cleaning Pump during recirculation.
- RO Tank Mixer: This is recommended to get optimal mixing of chemical, though some designers rely solely on the slow introduction of chemical while maintaining a recirculation through the RO Cleaning Pump back to the tank.
- Instrumentation: Cleaning system instrumentation should be included to monitor flow, temperature, pressure, and tank level.
- Sample Points: Sample valves should be located to allow pH and TDS measurements off the RO Cleaning Pump discharge and the concentrate side recirculation return line.

- Permeate Return Line: A small amount of the cleaning solution can permeate through the membranes and so a permeate-side return line back to the RO Cleaning Tank is required.

  Important: The permeate line and any permeate valves must always be open to atmospheric pressure during the cleaning and flushing steps or damage to RO elements can occur. If the permeate line is closed, the permeate pressure can build up and become higher than the feed-side pressure of the tail elements. This can result in excessive permeate back-pressure which can damage the membrane glue lines in the tail elements.

RO Membrane Element Cleaning and Flushing Procedures

The RO membrane elements can be cleaned in place in the pressure tubes by recirculating the cleaning solution across the high-pressure side of the membrane at low pressure and relatively high flow. A cleaning unit is needed to do this. RO cleaning procedures may vary dependent on the situation. The time required to clean a stage can take from 4 to 8 hours.

A general procedure for cleaning the RO membrane elements is as follows:

1. Perform a low pressure flush at 60 psi (4 bar) or less of the pressure tubes by pumping clean water from the cleaning tank (or equivalent source) through the pressure tubes to drain for several minutes. Flush water should be clean water of RO permeate or DI quality and be free of hardness, transition metals, and chlorine.

2. Mix a fresh batch of the selected cleaning solution in the cleaning tank. The dilution water should be clean water of RO permeate or DI quality and be free of hardness, transition metals, and chlorine. The temperature and pH should be adjusted to their target levels.

3. Circulate the cleaning solution through the pressure tubes for approximately one hour or the desired period of time. At the start, send the displaced water to drain so you don’t dilute the cleaning chemical and then divert up to 20% of the most highly fouled cleaning solution to drain before returning the cleaning solution back to the RO Cleaning Tank. For the first 5 minutes, slowly throttle the flow rate to 1/3 of the maximum design flow rate. This is to minimize the potential plugging of the feed path with a large amount of dislodged foulant.. For the second 5 minutes, increase the flow rate to 2/3 of the maximum design flow rate, and then increase the flow rate to the maximum design flow rate. If required, readjust the pH back to the target when it changes more than 0.5 pH units.

4. An optional soak and recirculation sequence can be used, if required. The soak time can be from 1 to 8 hours depending on the manufacturer’s recommendations. Caution should be used to maintain the proper temperature and pH. *Do not exceed maximum pH and temperature limits for specific elements. See Table 4.* Also note that this does increase the chemical exposure time of the membrane.

5. Upon completion of the chemical cleaning steps, a low pressure Cleaning Rinse with clean water (RO permeate or DI quality and free of hardness, transition metals, and chlorine) is required to remove all traces of chemical from the Cleaning Skid and the RO Skid. Drain and flush the cleaning tank; then completely refill the Cleaning Tank with clean water for the Cleaning Rinse. Rinse the pressure tubes by pumping all of the rinse water from the Cleaning Tank through the pressure tubes to drain. A second cleaning can be started at this point, if required.

5. Once the RO system is fully rinsed of cleaning chemical with clean water from the Cleaning Tank, a Final Low Pressure Clean-up Flush can be performed using pretreated feed water. The permeate line should remain open to drain. Feed pressure should be less than 60 psi (4 bar). This final flush continues until the flush water flows clean and is free of any foam or residues of cleaning agents. This usually takes 15 to 60 minutes. The operator can sample the flush water going to the drain for detergent removal and lack of foaming by using a clear flask and shaking it. A conductivity meter can be used to test for removal of cleaning chemicals, such that the flush water to drain is within 10-20% of the feed water conductivity. A pH meter can also be used to compare the flush water to drain to the feed pH.

7. Once all the stages of a train are cleaned, and the chemicals flushed out, the RO can be restarted and placed into a Service Rinse. The RO permeate should be diverted to drain until it meets the quality requirements of the process (e.g. conductivity, pH, etc.). It is not unusual for it to take from a few hours to a few days for the RO permeate quality to stabilize, especially after high pH cleanings.

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APPENDIX F – EXAMPLE DATA COLLECTION SHEETS

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City of San Diego IPR/RA Demostration Project

MF/UF SYSTEM

DRAFT OPERATIONAL DATA COLLECTION SHEET

Run Number: ______________

Date (mm/dd/yy)	Time (hh:mm)	Operator	PLC Temp-erature (degC)	Filtrate Flow		Pressure					Time since Backwash (min)	Backwash Flow (gpm)	Turbidity (NTU)		Notes
				PLC Screen (gpm)	Rota-meter (gpm)	PLC Feed (psi)		PLC Filtrate (psi)		TMP (psi)			Online Feed (NTU)	Online Filtrate (NTU)	
						Left	Right	Left	Right						

Note: Minimum of two readings per day

Comments: ____

City of San Diego IPR/RA Demostration Project

MF/UF SYSTEM

DRAFT EVALUATION OF CLEANING EFFICIENCY

Run Number: ___________

Date (mm/dd/yy)	Time (hh:mm)	Operator	Feed Temp-erature (degC)	Filtrate Flow (gpm)		Feed Pressure (psi)	Filtrate Pressure (psi)	TMP (psi)	

BEFORE CLEANING

Chemical 1: ____________ pH ___________ Turbidity ___________ TDS ______________________

Visual Color: ____________ Flow (gpm): ___________ Residual (before): ___________ Residual (after): ___________

Pressure (psi): ___________ Temperature (before): ___________ Temperature (after): ___________

Describe Chemical Cleaning Procedure (including flows and pressures during cleaning if possible):

AFTER CHEMICAL 1

Chemical 2: ____________ pH ___________ Turbidity ___________ TDS ______________________

Visual Color: ____________ Flow (gpm): ___________ Residual (before): ___________ Residual (after): ___________

Pressure (psi): ___________ Temperature (before): ___________ Temperature (after): ___________

Describe Chemical Cleaning Procedure (including flows and pressures during cleaning if possible):

AFTER CHEMICAL 2

Chemical 3: ____________ pH ___________ Turbidity ___________ TDS ______________________

Visual Color: ____________ Flow (gpm): ___________ Residual (before): ___________ Residual (after): ___________

Pressure (psi): ___________ Temperature (before): ___________ Temperature (after): ___________

Describe Chemical Cleaning Procedure (including flows and pressures during cleaning if possible):

AFTER CHEMICAL 3

Comments:

City of San Diego IPR/RA Demonstration Project
On-Site Lab
DRAFT pH Data Log Sheet

Date	Time	Sampler	NC Tert Feed	RO Feed	Combined Permeate

City of San Diego IPR/RA Demonstration Project
On-Site Lab
DRAFT Conductivity/Temperature Data Log Sheet

Date	**Time**	**Sampler**	**NC Tert Feed**		**RO Feed**		**Combined Permeate**	
			Temperature (C)	Conductivity (S)	Temperature (C)	Conductivity (S)	Temperature (C)	Conductivity (S)

City of San Diego IPR/RA Demonstration Project
On-Site Lab
DRAFT UV Data Log Sheet

Date	Time	Sampler	NC Tert Feed (S1)	RO Feed (S2)	Combined Permeate

City of San Diego IPR/RA Demonstration Project

DRAFT Long Term RO Performance Testing

DRAFT Operational Data Collection Sheet

Date (mm:dd:yy)	***Time*** (hh:mm)	***Run Hours***	***Operator Initials***	***Feed Chlorine*** Free/Total	***Feed pH***	***Feed Temp.*** (deg F)	***Pressure***						***Flow***				***Conductivity***				
							Feed (psi)	Stage 1 Interstage (psi)	Stage 2 Interstage (psi)	Conc. (psi)	Stage 1 Permeate (psi)	Stage 2 Permeate (psi)	Stage 1 Permeate (gpm)	Stage 2 Permeate (gpm)	[1]Conc. (gpm)	Recycle (gpm)	Feed (µmhos)	Feed (on line) (µmhos)	Combined Permeate (on line) (µmhos)	Stage 1 Permeate (µmhos)	Stage 2 Permeate (µmhos)

Comments: [1] Measured before recycle, actual concentrate flow leaving the system = "Conc." - "Recycle".

City of San Diego IPR/RA Demonstration Project

RO system

Shutdown Log

Operator Initials	***Begin***		***End***		***Shutdown Reason***
	Date (mm:dd:yy)	***Time*** (hh:mm)	***Date*** (mm:dd:yy)	***Time*** (hh:mm)	

Comments:

City of San Diego IPR/RA Demonstration Project

DRAFT UV Performance Testing

DRAFT UV Operational Data Collection Sheet

Date (mm:dd:yy)	Time (hh:mm)	Run Hours	Operator Initials	Flow		H_2O_2 dose (mg/l)	Power Setting (%)	UV Adsorbance cm^{-1}	UVT (%)	Intensity (mW/cm^2)	EEO
				PLC readout (gpm)	Flow meter (gpm)						

Comments: [1] Measured before recycle, actual concentrate flow leaving the system = "Conc." - "Recycle".

APPENDIX G – WATER QUALITY REGULATORY REQUIREMENTS AND GUIDANCE

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Table G-1

Primary Drinking Water Standards for Measured Organic Parameters

		Primary Drinking Water Standard, MCL	
Parameter	**Units**	**Federal**	**CA**
Volatile Organic Compounds			
Benzene	mg/L	0.005	0.001
Carbon tetrachloride	mg/L	0.005	0.0005
1,2 Dichlorobenzene	mg/L	0.6	0.6
1,4 Dichlorobenzene	mg/L	0.075	0.005
1,1 Dichloroethane	mg/L	0	0.005
1,2 Dichloroethane	mg/L	0.005	0.0005
1,1 Dichloroethylene	mg/L	0.007	0.006
cis-1,2 Dichloroethylene	mg/L	0.07	0.006
trans-1,2 Dichloroethylene	mg/L	0.1	0.01
Dichloromethane	mg/L	0.005	0.005
1,3 Dichloropropene	mg/L	NR	0.0005
1,2 Dichloropropane	mg/L	0.005	0.005
Ethylbenzene	mg/L	0.7	0.3
Methyl-tert-butyl ether (MTBE)	mg/L	0	0.013
Monochlorobenzene	mg/L	0.1	0.07
Styrene	mg/L	0.1	0.1
1,1,2,2 Tetrachloroethane	mg/L	0	0.001
Tetrachloroethylene	mg/L	0.005	0.005
Toluene	mg/L	1	0.15
1,2,4 Trichlorobenzene	mg/L	0.07	0.07
1,1,1-Trichloroethane	mg/L	0.2	0.2
1,1,2-Trichloroethane	mg/L	0.005	0.005
Trichloroethylene	mg/L	0.005	0.005
Trichlorofluoromethane	mg/L	0	0.15
1,12Trichloro1,2,2Trifluoroethane	mg/L	0	1.2
Vinyl chloride	mg/L	0.002	0.0005
Xylenes	mg/L	10	1.75
SOCs			
Alachlor	mg/L	0.002	0.002
Atrazine	mg/L	0.003	0.001
Bentazon	mg/L	0	0.018
Benzo(a)pyrene	mg/L	0.0002	0.0002
Carbofuran	mg/L	0.04	0.018
Chlordane	mg/L	0.002	0.0001
Dalapon	mg/L	0.2	0.2
Dibromochloropropane	mg/L	0.0002	0.0002
Di(2ethylhexyl)adipate	mg/L	0.4	0.4
Di(2ethylhexyl)phthalate	mg/L	0.006	0.004
2,4-D	mg/L	0.07	0.07
Dinoseb	mg/L	0.007	0.007
Diquat	mg/L	0.02	0.02
Endothall	mg/L	0.1	0.1
Endrin	mg/L	0.002	0.002
Ethylene dibromide	mg/L	0.00005	0.00005
Glyphosate	mg/L	0.7	0.7
Heptachlor	mg/L	0.0004	0.00001
Heptachlor epoxide	mg/L	0.0002	0.00001
Hexachlorobenzene	mg/L	0.001	0.001
Hexachlorocyclopentadiene	mg/L	0.05	0.05
Lindane	mg/L	0.0002	0.0002
Methoxychlor	mg/L	0.04	0.03
Molinate	mg/L	0	0.02
Oxamyl (Vydate)	mg/L	0.2	0.05
Pentachlorophenol	mg/L	0.001	0.001
Picloram	mg/L	0.5	0.5
Polychlorinated Biphenyls	mg/L	0.0005	0.0005
Simazine	mg/L	0.004	0.004
Thiobencarb	mg/L	0	0.07
Toxaphene	mg/L	0.003	0.003
2,3,7,8_TCDD (Dioxin)	mg/L	3.00E-08	3exp-8
2,4,5-TP (Silvex)	mg/L	0.05	0.05
DBPs			
Total Trihalomethanes	mg/L	0.08	0.1
Total haloacetic acids	mg/L	0.06	0.06
Bromate	mg/L	0.01	0.01
Chlorite	mg/L	1	1

Notes:

-Subsequent to the establishment of the above table maximum residual disinfectant levels (MRDLs) for chloramines, chlorine, and chlorine dioxide have been established at 4.0, 4.0, and 0.8 mg/L, respectively.

Table G-2

Primary Drinking Water Standards for Measured Inorganic Parameters

Parameter	Units	Primary Drinking Water Standard, MCL	
		Federal	CA
Inorganics			
Antimony	mg/L	0.006	0.006
Arsenic	mg/L	0.01	0.01
Asbestos	MFL/L	7	7
Barium	mg/L	2	1
Beryllium	mg/L	0.004	0.004
Cadmium	mg/L	0.005	0.005
Chromium	mg/L	0.1	0.05
Copper	mg/L	1.3	1.3
Cyanide	mg/L	0.2	0.2
Fluoride	mg/L	4	2
Lead	mg/L	0.015	0.015
Mercury	mg/L	0.002	0.002
Nickel	mg/L	0	0.1
Nitrate	mg/L	10 (as N)	45 (as NO_3)
Nitrite as N	mg/L	1	1
Selenium	mg/L	0.05	0.05
Thallium	mg/L	0.002	0.002
Microbial			
Total Coliforms	P/A	Absent	Absent
Radionuclides			
Uranium	ug/L	30	0
Uranium	pCi/L	0	20
Radium 226+228	pCi/L	5	5
Gross Alpha Part.	pCi/L	15	15
Gross Beta Part.	mrem/yr	4	0
Gross Beta Part.	pCi/L	0	50
Strontium 90	pCi/L	8	8
Tritium	pCi/L	20000	20000

Notes:

-As of 6/11/2006 the California gross beta MCL is 4 millirem/year annual dose equivalent to the total body or any internal organ.

-Strontium-90 and tritium are now covered under the gross beta MCL; Stronium-90 MCL = 4 millirem/year to bone marrow; tritium MCL = 4 millirem/year to total body.

-As of 10/18/2007, California has established a MCL for perchlorate at 0.006 mg/L.

-The State and Federal established MCL for nitrate-N + nitrite-N is 10 mg/L.

Table G-3

Secondary Drinking Water Standards for Measured Parameters

Parameter	Units	Secondary, MCL	
		Federal	CA
Aluminum	mg/L	0.2	0.2
Color	Units	15	15
Copper	mg/L	1	1
Corrosivity		Non Corr.	Non Corr.
Foaming Agents (MBAS)	mg/L	0.5	0.5
Iron	mg/L	0.3	0.3
Manganese	mg/L	0.05	0.05
MTBE	mg/L	NR	0.005
Odor Threshold	TON	3	3
Silver	mg/L	0.1	0.1
Thiobencarb	mg/L	NR	0.001
Turbidity	NTU	5	5
Zinc	mg/L	5	5
pH		6.5-8.5	NR
Specific Conductance	micromhos	NR	900
Sulfate	mg/L	250	250
Fluoride	mg/L	2	NR
Chloride	mg/L	250	250
TDS	mg/L	500	500

Table G-4
CDPH Drinking Water Notification Levels

Chemical	Notification Level(mg/L)
Boron	1
n-Butylbenzene	0.26
sec-Butylbenzene	0.26
tert-Butylbenzene	0.26
Carbon Disulfide	0.16
Chlorate	0.8
2-Chlorotoluene	0.14
4-Chlorotoluene	0.14
Dichlorodifluoromethane (Freon 12)	1
1,4-Dioxane	0.003
Ethylene Glycol	14
Formaldehyde	0.1
HMX	0.35
Isopropylbenzene	0.77
Manganese	0.5
Methyl isobutyl ketone (MIBK)	0.12
Naphthalene	0.017
N-Nitrosodiethylamine (NDEA)	0.00001
N-Nitrosodimethylamine (NDMA)	0.00001
N-Nitrosodi-n-propylamine (NDPA)	0.00001
Propachlor	0.09
n-Propylbenzene	0.26
RDX	0.0003
Tertiary butyl alcohol (TBA)	0.012
1,2,3-Trichloropropane (1,2,3-TCP)	0.000005
1,2,4-Trimethylbenzene	0.33
1,3,5-Trimethylbenzene	0.33
2, 4, 6-Trinitrotoluene (TNT)	0.001
Vanadium	0.05

Information obtained from http://www.cdph.ca.gov/certlic/drinkingwater/Pages/NotificationLevels.aspx
Last Updated Dec 14, 2007, for complete list of current notifications levels visit the CDPH website listed above.

UCMR3 ANALYTES

Entry Point	CAS Registry	MRL
17-b-estradiol	50–28–2	0.0004 µg/L
17-a-ethynylestradiol	57–63–6	0.0009 µg/L
estriol	50–27–1	0.0008 µg/L
equilin	474–86–2	0.004 µg/L
estrone	53–16–7	0.002 µg/L
testosterone	58–22–0	0.0001 µg/L
4-androstene-3,17-dione	63–05–8	0.0003 µg/L
1,2,3-trichloropropane	96–18–4	0.03 µg/L
1,3-butadiene	106–99–0	0.1 µg/L
chloromethane	74–87–3	0.2 µg/L
1,1-dichloroethane	75–34–3	0.03 µg/L
n-propylbenzene	103–65–1	0.03 µg/L
bromomethane	74–83–9	0.2 µg/L
sec-butylbenzene	135–98–8	0.04 µg/L
chlorodifluoromethane (HCFC–22)	75–45–6	0.08 µg/L
bromochloromethane (halon 1011)	74–97–5	0.06 µg/L
1,4-Dioxane	123–91–1	0.07 µg/L
Perfluorooctane sulfonic acid (PFOS)	1763–23–1	0.04 µg/L
Perfluorooctanoic acid (PFOA)	335–67–1	0.02 µg/L
Perfluorononanoic acid (PFNA)	375–95–1	0.02 µg/L
Perfluorohexane sulfonic acid (PFHxS)	355–46–4	0.03 µg/L
Perfluoroheptanoic acid (PFHpA)	375–85–9	0.01 µg/L
Perfluorobutanesulfonic acid (PFBS)	375–73–5	0.09 µg/L

Entry Point and Distribution System Maximum Residence Time		
Vanadium	7440–62–2	0.2 µg/L
Molybdenum	7439–98–7	1.0 µg/L
Cobalt	7440–48–4	1.0 µg/L
Strontium	7440–24–6	0.3 µg/L
Chlorate	14866–68–3	20 µg/L

Analyte	**MWH Method**	**MWH Analytical Mode**	**MRL ng/L**
1,7-Dimethylxanthine	LC-MS-MS	Positive	5
2,4-D	LC-MS-MS	Negative	5
4-nonylphenol - semi quantitative	LC-MS-MS	Negative	100
4-tert-octylphenol	LC-MS-MS	Negative	50
Acesulfame-K	LC-MS-MS	Negative	20
Acetaminophen	LC-MS-MS	Positive	5
Albuterol	LC-MS-MS	Positive	5
Amoxicillin (semi-quantitative)	LC-MS-MS	Positive	20
Andorostenedione	LC-MS-MS	Positive	5
Atenolol	LC-MS-MS	Positive	5
Atrazine	LC-MS-MS	Positive	5
Bendroflumethiazide	LC-MS-MS	Negative	5
Bezafibrate	LC-MS-MS	Positive	5
BPA	LC-MS-MS	Negative	10
Bromacil	LC-MS-MS	Positive	5
Butalbital	LC-MS-MS	Negative	5
Butylparben	LC-MS-MS	Negative	5
Caffeine	LC-MS-MS	Positive	5
Carbadox	LC-MS-MS	Positive	5
Carbamazepine	LC-MS-MS	Positive	5
Carisoprodol	LC-MS-MS	Positive	5
Chloramphenicol	LC-MS-MS	Negative	10
Chloridazon	LC-MS-MS	Positive	5
Chlorotoluron	LC-MS-MS	Positive	5
Cimetidine	LC-MS-MS	Positive	5
Clofibric Acid	LC-MS-MS	Negative	5
Cotinine	LC-MS-MS	Positive	10
Cyanazine	LC-MS-MS	Positive	5
DACT	LC-MS-MS	Positive	5
DEA	LC-MS-MS	Positive	5
DEET	LC-MS-MS	Positive	2
Dehydronifedipine	LC-MS-MS	Positive	5
DIA	LC-MS-MS	Positive	5
Diazepam	LC-MS-MS	Positive	5
Diclofenac	LC-MS-MS	Negative	5
Dilantin	LC-MS-MS	Positive	20
Diuron	LC-MS-MS	Positive	5
Erythromycin	LC-MS-MS	Positive	10
Estradiol	LC-MS-MS	Negative	5
Estrone	LC-MS-MS	Negative	5
Ethinyl Estradiol - 17 alpha	LC-MS-MS	Negative	5
Ethylparaben	LC-MS-MS	Negative	20
Flumeqine	LC-MS-MS	Positive	10
Fluoxetine	LC-MS-MS	Positive	10
Gemfibrozil	LC-MS-MS	Negative	5

Analyte	**MWH Method**	**MWH Analytical Mode**	**MRL ng/L**
Ibuprofen	LC-MS-MS	Negative	10
Iohexal	LC-MS-MS	Negative	10
Iopromide	LC-MS-MS	Negative	5
Isobutylparaben	LC-MS-MS	Negative	5
Isoproturon	LC-MS-MS	Positive	100
Ketoprofen	LC-MS-MS	Positive	5
Ketorolac	LC-MS-MS	Positive	5
Lidocaine	LC-MS-MS	Positive	5
Lincomycin	LC-MS-MS	Positive	10
Linuron	LC-MS-MS	Positive	5
Lopressor	LC-MS-MS	Positive	20
Meclofenamic Acid	LC-MS-MS	Positive	5
Meprobamate	LC-MS-MS	Positive	5
Metazachlor	LC-MS-MS	Positive	5
Methylparaben	LC-MS-MS	Negative	20
Naproxen	LC-MS-MS	Negative	10
Nifedipine	LC-MS-MS	Positive	20
Norethisterone	LC-MS-MS	Positive	5
Oxolinic acid	LC-MS-MS	Positive	5
Pentoxifylline	LC-MS-MS	Positive	5
Phenazone	LC-MS-MS	Positive	5
Primidone	LC-MS-MS	Positive	5
Progesterone	LC-MS-MS	Positive	5
Propazine	LC-MS-MS	Positive	5
Propylparaben	LC-MS-MS	Negative	5
Quinoline	LC-MS-MS	Positive	5
Simazine	LC-MS-MS	Positive	5
Sucralose	LC-MS-MS	Negative	100
Sulfachloropyridazine	LC-MS-MS	Positive	5
Sulfadiazine	LC-MS-MS	Positive	5
Sulfadimethoxine	LC-MS-MS	Positive	5
Sulfamerazine	LC-MS-MS	Positive	5
Sulfamethazine	LC-MS-MS	Positive	5
Sulfamethizole	LC-MS-MS	Positive	5
Sulfamethoxazole	LC-MS-MS	Positive	5
Sulfathiazole	LC-MS-MS	Positive	5
TCEP	LC-MS-MS	Positive	5
TCPP	LC-MS-MS	Positive	5
TDCPP	LC-MS-MS	Positive	5
Testosterone	LC-MS-MS	Positive	10
Theobromine	LC-MS-MS	Positive	5
Theophylline	LC-MS-MS	Positive	10
Triclosan	LC-MS-MS	Negative	10
Trimethoprim	LC-MS-MS	Positive	5
Warfarin	LC-MS-MS	Negative	5

TABLE G-5

PRIORITY POLLUTANT NUMERIC CRITERIA AND GUIDANCE

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A		B Freshwater		C Saltwater		D Human Health (10^{-6} risk for carcinogens) For consumption of:	
# Compound	CAS Number	Criterion Maximum Conc. [d] B1	Criterion Continuous Conc. [d] B2	Criterion Maximum Conc. [d] C1	Criterion Continuous Conc. [d] C2	Water & Organisms (µg/L) D1	Organisms Only (µg/L) D2
1. Antimony	7440360					14 a,s	4300 a,t
2. Arsenic [b]	7440382	340 i,m,w	150 i,m,w	69 i,m	36 i,m		
3. Beryllium	7440417					n	n
4. Cadmium [b]	7440439	4.3 e,i,m,w,x	2.2 e,i,m,w	42 i,m	9.3 i,m	n	n
5a. Chromium (III)	16065831	550 e,i,m,o	180 e,i,m,o			n	n
5b. Chromium (VI) [b]	18540299	16 i,m,w	11 i,m,w	1100 i,m	50 i,m	n	n
6. Copper [b]	7440508	13 e,i,m,w,x	9.0 e,i,m,w	4.8 i,m	3.1 i,m	1300	
7. Lead [b]	7439921	65 e,i,m	2.5 e,i,m	210 i,m	8.1 i,m	n	n
8. Mercury [b]	7439976	[Reserved]	[Reserved]	[Reserved]	[Reserved]	0.050 a	0.051 a
9. Nickel [b]	7440020	470 e,i,m,w	52 e,i,m,w	74 i,m	8.2 i,m	610 a	4600 a
10. Selenium [b]	7782492	[Reserved] p	5.0 q	290 i,m	71 i,m	n	n
11. Silver [b]	7440224	3.4 e,i,m		1.9 i,m			
12. Thallium	7440280					1.7 a,s	6.3 a,t
13. Zinc [b]	7440666	120 e,i,m,w,x	120 e,i,m,w	90 i,m	81 i,m		
14. Cyanide [b]	57125	22 o	5.2 o	1 r	1 r	700 a	220,000 a,j
15. Asbestos	1332214					7,000,000 fibers/L k,s	
16. 2,3,7,8-TCDD (Dioxin)	1746016					0.000000013 c	0.000000014 c
17. Acrolein	107028					320 s	780 t
18. Acrylonitrile	107131					0.059 a,c,s	0.66 a,c,t
19. Benzene	71432					1.2 a,c	71 a,c
20. Bromoform	75252					4.3 a,c	360 a,c
21. Carbon Tetrachloride	56235					0.25 a,c,s	4.4 a,c,t
22. Chlorobenzene	108907					680 a,s	21,000 a,j,t
23. Chlorodibromomethane	124481					0.401 a,c	34 a,c
24. Chloroethane	75003						
25. 2-Chloroethylvinyl Ether	110758						

26. Chloroform	67663					[Reserved]	[Reserved]
27. Dichlorobromomethane	75274					0.56 a,c	46 a,c
28. 1,1-Dichloroethane	75343						
29. 1,2-Dichloroethane	107062					0.38 a,c,s	99 a,c,t
30. 1,1-Dichloroethylene	75354					0.057 a,c,s	3.2 a,c,t
31. 1,2-Dichloropropane	78875					0.52 a	39 a
32. 1,3-Dichloropropylene	542756					10 a,s	1,700 a,t
33. Ethylbenzene	100414					3,100 a,s	29,000 a,t
34. Methyl Bromide	74839					48 a	4,000 a
35. Methyl Chloride	74873					n	n
36. Methylene Chloride	75092					4.7 a,c	1,600 a,c
37. 1,1,2,2-Tetrachloroethane	79345					0.17 a,c,s	11 a,c,t
38. Tetrachloroethylene	127184					0.8 c,s	8.85 c,t
39. Toluene	108883					6,800 a	200,000 a
40. 1,2-Trans-Dichloroethylene	156605					700 a	140,000 a
41. 1,1,1-Trichloroethane	71556					n	n
42. 1,1,2-Trichloroethane	79005					0.60 a,c,s	42 a,c,t
43. Trichloroethylene	79016					2.7 c,s	81 c,t
44. Vinyl Chloride	75014					2 c,s	525 c,t
45. 2-Chlorophenol	95578					120 a	400 a
46. 2,4-Dichlorophenol	120832					93 a,s	790 a,t
47. 2,4-Dimethylphenol	105679					540 a	2,300 a
48. 2-Methyl-4,6-Dinitrophenol	534521					13.4 s	765 t
49. 2,4-Dinitrophenol	51285					70 a,s	14,000 a,t
50. 2-Nitrophenol	88755						
51. 4-Nitrophenol	100027						
52. 3-Methyl-4-Chlorophenol	59507						
53. Pentachlorophenol	87865	19 f,w	15 f,w	13	7.9	0.28 a,c	8.2 a,c,j
54. Phenol	108952					21,000 a	4,600,000 a,j,t
55. 2,4,6-Trichlorophenol	88062					2.1 a,c	6.5 a,c
56. Acenaphthene	83329					1,200 a	2,700 a
57. Acenaphthylene	208968						
58. Anthracene	120127					9,600 a	110,000 a

59. Benzidine	92875					0.00012 a,c,s	0.00054 a,c,t
60. Benzo(a)Anthracene	56553					0.0044 a,c	0.049 a,c
61. Benzo(a)Pyrene	50328					0.0044 a,c	0.049 a,c
62. Benzo(b)Fluoranthene	205992					0.0044 a,c	0.049 a,c
63. Benzo(ghi)Perylene	191242						
64. Benzo(k)Fluoranthene	207089					0.0044 a,c	0.049 a,c
65. Bis(2-Chloroethoxy)Methane	111911						
66. Bis(2-Chloroethyl)Ether	111444					0.031 a,c,s	1.4 a,c,t
67. Bis(2-Chloroisopropyl)Ether	39638329					1,400 a	170,000 a,t
68. Bis(2-Ethylhexyl)Phthalate	117817					1.8 a,c,s	5.9 a,c,t
69. 4-Bromophenyl Phenyl Ether	101553						
70. Butylbenzyl Phthalate	85687					3,000 a	5,200 a
71. 2-Chloronaphthalene	91587					1,700 a	4,300 a
72. 4-Chlorophenyl Phenyl Ether	7005723						
73. Chrysene	218019					0.0044 a,c	0.049 a,c
74. Dibenzo(a,h)Anthracene	53703					0.0044 a,c	0.049 a,c
75. 1,2 Dichlorobenzene	95501					2,700 a	17,000 a
76. 1,3 Dichlorobenzene	541731					400	2,600
77. 1,4 Dichlorobenzene	106467					400	2,600
78. 3,3'-Dichlorobenzidine	91941					0.04 a,c,s	0.077 a,c,t
79. Diethyl Phthalate	84662					23,000 a,s	120,000 a,t
80. Dimethyl Phthalate	131113					313,000 s	2,900,000 t
81. Di-n-Butyl Phthalate	84742					2,700 a,s	12,000 a,t
82. 2,4-Dinitrotoluene	121142					0.11 c,s	9.1 c,t
83. 2,6-Dinitrotoluene	606202						
84 Di-n-Octyl Phthalate	117840						
85. 1,2-Diphenylhydrazine	122667					0.040 a,c,s	0.54 a,c,t
86. Fluoranthene	206440					300 a	370 a
87. Fluorene	86737					1,300 a	14,000 a
88. Hexachlorobenzene	118741					0.00075 a,c	0.00077 a,c
89. Hexachlorobutadiene	87683					0.44 a,c,s	50 a,c,t
90. Hexachlorocyclopentadiene	77474					240 a,s	17,000 a,j,t
91. Hexachloroethane	67721					1.9 a,c,s	8.9 a,c,t

92. Indeno(1,2,3-cd) Pyrene	193395					0.0044 a,c	0.049 a,c
93. Isophorone	78591					8.4 c,s	600 c,t
94. Naphthalene	91203						
95. Nitrobenzene	98953					17 a,s	1,900 a,j,t
96. N-Nitrosodimethylamine	62759					0.00069 a,c,s	8.1 a,c,t
97. N-Nitrosodi-n-Propylamine	621647					0.005 a	1.4 a
98. N-Nitrosodiphenylamine	86306					5.0 a,c,s	16 a,c,t
99. Phenanthrene	85018						
100. Pyrene	129000					960 a	11,000 a
101. 1,2,4-Trichlorobenzene	120821						
102. Aldrin	309002	3 g		1.3 g		0.00013 a,c	0.00014 a,c
103. alpha-BHC	319846					0.0039 a,c	0.013 a,c
104. beta-BHC	319857					0.014 a,c	0.046 a,c
105. gamma-BHC	58899	0.95 w		0.16 g		0.019 c	0.063 c
106. delta-BHC	319868						
107. Chlordane	57749	2.4 g	0.0043 g	0.09 g	0.004 g	0.00057 a,c	0.00059 a,c
108. 4,4'-DDT	50293	1.1 g	0.001 g	0.13 g	0.001 g	0.00059 a,c	0.00059 a,c
109. 4,4'-DDE	72559					0.00059 a,c	0.00059 a,c
110. 4,4'-DDD	72548					0.00083 a,c	0.00084 a,c
111. Dieldrin	60571	0.24 w	0.056 w	0.71 g	0.0019 g	0.00014 a,c	0.00014 a,c
112. alpha-Endosulfan	959988	0.22 g	0.056 g	0.034 g	0.0087 g	110 a	240 a
113. beta-Endosulfan	33213659	0.22 g	0.056 g	0.034 g	0.0087 g	110 a	240 a
114. Endosulfan Sulfate	1031078					110 a	240 a
115. Endrin	72208	0.086 w	0.036 w	0.037 g	0.0023 g	0.76 a	0.81 a,j
116. Endrin Aldehyde	7421934					0.76 a	0.81 a,j
117. Heptachlor	76448	0.52 g	0.0038 g	0.053 g	0.0036 g	0.00021 a,c	0.00021 a,c
118. Heptachlor Epoxide	1024573	0.52 g	0.0038 g	0.053 g	0.0036 g	0.00010 a,c	0.00011 a,c
119-125. Polychlorinated biphenyls (PCBs)			0.014 u		0.03 u	0.00017 c,v	0.00017 c,v
126. Toxaphene	8001352	0.73	0.0002	0.21	0.0002	0.00073 a,c	0.00075 a,c
Total Number of Criteria [h]		22	21	22	20	92	90

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Footnotes to Table in Parargraph (b)(1):

a. Criteria revised to reflect the Agency q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of October 1, 1996. The fish tissue bioconcentration factor (BCF) from the 1980 documents was retained in each case.

b. Criteria apply to California waters except for those waters subject to objectives in Tables III–2A and III–2B of the San Francisco Regional Water Quality Control Board's (SFRWQCB) 1986 Basin Plan, that were adopted by the SFRWQCB and the State Water Resources Control Board, approved by EPA, and which continue to apply.

c. Criteria are based on carcinogenicity of 10 (-6) risk.

d. Criteria Maximum Concentration (CMC) equals the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects. Criteria Continuous Concentration (CCC) equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects. ug/L equals micrograms per liter.

e. Freshwater aquatic life criteria for metals are expressed as a function of total hardness (mg/L) in the water body. The equations are provided in matrix at paragraph (b)(2) of this section. Values displayed above in the matrix correspond to a total hardness of 100 mg/l.

f. Freshwater aquatic life criteria for pentachlorophenol are expressed as a function of pH, and are calculated as follows: Values displayed above in the matrix correspond to a pH of 7.8. CMC = exp(1.005(pH) − 4.869). CCC = exp(1.005(pH) − 5.134).

g. This criterion is based on 304(a) aquatic life criterion issued in 1980, and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5–80–019), Chlordane (EPA 440/5–80–027), DDT (EPA 440/5–80–038), Endosulfan (EPA 440/5–80–046), Endrin (EPA 440/5–80–047), Heptachlor (440/5–80–052), Hexachlorocyclohexane (EPA 440/5–80–054), Silver (EPA 440/5–80–071). The Minimum Data Requirements and derivation procedures were different in the 1980 Guidelines than in the 1985 Guidelines. For example, a ''CMC'' derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

h. These totals simply sum the criteria in each column. For aquatic life, there are 23 priority toxic pollutants with some type of freshwater or saltwater, acute or chronic criteria. For human health, there are 92 priority toxic pollutants with either ''water + organism'' or ''organism only'' criteria. Note that these totals count chromium as one pollutant even though EPA has developed criteria based on two valence states. In the matrix, EPA has assigned numbers 5a and 5b to the criteria for chromium to reflect the fact that the list of 126 priority pollutants includes only a single listing for chromium.

i. Criteria for these metals are expressed as a function of the water-effect ratio, WER, as defined in paragraph (c) of this section. CMC = column B1 or C1 value x WER; CCC = column B2 or C2 value x WER.

j. No criterion for protection of human health from consumption of aquatic organisms (excluding water) was presented in the 1980 criteria document or in the 1986 Quality Criteria for Water. Nevertheless, sufficient information was presented in the 1980 document to allow a calculation of a criterion, even though the results of such a calculation were not shown in the document.

k. The CWA 304(a) criterion for asbestos is the MCL.

l. [Reserved]

m. These freshwater and saltwater criteria for metals are expressed in terms of the dissolved fraction of the metal in the water column. Criterion values were calculated by using EPA's Clean Water Act 304(a) guidance values (described in the total recoverable fraction) and then applying the conversion factors in § 131.36(b)(1) and (2).

n. EPA is not promulgating human health criteria for these contaminants. However, permit authorities should address these contaminants in NPDES permit actions using the State's existing narrative criteria for toxics.

o. These criteria were promulgated for specific waters in California in the National Toxics Rule (''NTR''), at § 131.36. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays or estuaries and waters of the State defined as inland, i.e., all surface waters of the State not ocean waters. These waters specifically include the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta. This section does not apply instead of the NTR for this criterion.

p. A criterion of 20 ug/l was promulgated for specific waters in California in the NTR and was promulgated in the total recoverable form. The specific waters to which the NTR criterion applies include: Waters of the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of Salt Slough, Mud Slough (north) and the San Joaquin River, Sack Dam to the mouth of the Merced River. This section does not apply instead of the NTR for this criterion. The State of California adopted and EPA approved a site specific criterion for the San Joaquin River, mouth of Merced to Vernalis; therefore, this section does not apply to these waters.

q. This criterion is expressed in the total recoverable form. This criterion was promulgated for specific waters in California in the NTR and was promulgated in the total recoverable form. The specific waters to which the NTR criterion applies include: Waters of the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of Salt Slough, Mud Slough (north) and the San Joaquin River, Sack Dam to Vernalis. This criterion does not apply instead of the NTR for these waters. This criterion applies to additional waters of the United States in the State of California pursuant to 40 CFR 131.38(c). The State of California adopted and EPA approved a site-specific criterion for the Grassland Water District, San Luis National Wildlife Refuge, and the Los Banos State Wildlife Refuge; therefore, this criterion does not apply to these waters.

r. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays or estuaries including the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta. This section does not apply instead of the NTR for these criteria.

s. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the Sacramento-San Joaquin Delta and waters of the State defined as inland (*i.e.,* all surface waters of the State not bays or estuaries or ocean) that include a MUN use designation. This section does not apply instead of the NTR for these criteria.

t. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays and estuaries including San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of the State defined as inland (i.e., all surface waters of the State not bays or estuaries or ocean) without a MUN use designation. This section does not apply instead of the NTR for these criteria.

u. PCBs are a class of chemicals which include aroclors 1242, 1254, 1221, 1232, 1248, 1260, and 1016, CAS numbers 53469219, 11097691, 11104282, 11141165, 12672296, 11096825, and 12674112, respectively. The aquatic life criteria apply to the sum of this set of seven aroclors.

v. This criterion applies to total PCBs, e.g., the sum of all congener or isomer or homolog or aroclor analyses.

w. This criterion has been recalculated pursuant to the 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water, Office of Water, EPA–820–B–96–001, September 1996. See also Great Lakes Water Quality Initiative Criteria Documents for the Protection of Aquatic Life in Ambient Water, Office of Water, EPA–80–B–95–004, March 1995.

x. The State of California has adopted and EPA has approved site specific criteria for the Sacramento River (and tributaries) above Hamilton City; therefore, these criteria do not apply to these waters.

General Notes to Table in Paragraph (b)(1)

1. The table in this paragraph (b)(1) lists all of EPA's priority toxic pollutants whether or not criteria guidance are available. Blank spaces indicate the absence of national section 304(a) criteria guidance. Because of variations in chemical nomenclature systems, this listing of toxic pollutants does not duplicate the listing in Appendix A to 40 CFR Part 423–126 Priority Pollutants. EPA has added the Chemical Abstracts Service (CAS) registry numbers, which provide a unique identification for each chemical.

2. The following chemicals have organoleptic-based criteria recommendations that are not included on this chart: zinc, 3-methyl-4-chlorophenol.

3. Freshwater and saltwater aquatic life criteria apply as specified in paragraph (c)(3) of this section.

(2) Factors for Calculating Metals Criteria. Final CMC and CCC values should be rounded to two significant figures.

(i) $CMC = WER \times (Acute\ Conversion\ Factor) \times (\mathrm{exp}\{m_A[1n(hardness)]+b_A\})$

(ii) $CCC = WER \times (Acute\ Conversion\ Factor) \times (\mathrm{exp}\{m_C[1n(hardness)]+b_C\})$

(iii) Table 1 to paragraph (b)(2) of this section:

Metal	m_A	b_A	m_C	b_C
Cadmium	1.128	−3.6867	0.7852	−2.715
Copper	0.9422	−1.700	0.8545	−1.702
Chromium (III)	0.8190	3.688	0.8190	1.561
Lead	1.273	−1.460	1.273	−4.705
Nickel	0.8460	2.255	0.8460	0.0584
Silver	1.72	−6.52		
Zinc	0.8473	0.884	0.8473	0.884

Note to Table 1: The term ''exp'' represents the base e exponential function.

(iv) Table 2 to paragraph (b)(2) of this section:

Metal	Conversion factor (CF) for freshwater acute criteria	CF for freshwater chronic criteria	CF for saltwater acute criteria	CF [a] for saltwater chronic criteria
Antimony	(d)	(d)	(d)	(d)
Arsenic	1.000	1.000	1.000	1.000
Beryllium	(d)	(d)	(d)	(d)
Cadmium	[b] 0.944	[b] 0.909	0.994	0.994
Chromium (III)	0.316	0.860	(d)	(d)
Chromium (VI)	0.982	0.962	0.993	0.993
Copper	0.960	0.960	0.83	0.83
Lead	[b] 0.791	[b] 0.791	0.951	0.951
Mercury				
Nickel	0.998	0.997	0.990	0.990
Selenium		(c)	0.998	0.998
Silver	0.85	(d)	0.85	(d)
Thallium	(d)	(d)	(d)	(d)
Zinc	0.978	0.986	0.946	0.946

Footnotes to Table 2 of Paragraph (b)(2):

[a] Conversion Factors for chronic marine criteria are not currently available. Conversion Factors for acute marine criteria have been used for both acute and chronic marine criteria.

[b] Conversion Factors for these pollutants in freshwater are hardness dependent. CFs are based on a hardness of 100 mg/l as calcium carbonate ($CaCO_3$). Other hardness can be used; CFs should be recalculated using the equations in table 3 to paragraph (b)(2) of this section.

[c] Bioaccumulative compound and inappropriate to adjust to percent dissolved.

[d] EPA has not published an aquatic life criterion value.

Note to Table 2 of Paragraph (b)(2): The term ''Conversion Factor'' represents the recommended conversion factor for converting a metal criterion expressed as the total recoverable fraction in the water column to a criterion expressed as the dissolved fraction in the water column. See ''Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria'', October 1, 1993, by Martha G. Prothro, Acting Assistant Administrator for Water available from Water Resource Center, USEPA, Mailcode RC4100, M Street SW, Washington, DC, 20460 and the note to § 131.36(b)(1).

(v) Table 3 to paragraph (b)(2) of this section:

	Acute	Chronic
Cadmium	CF=1.136672—[(ln {hardness}) (0.041838)]	CF = 1.101672—[(ln {hardness})(0.041838)]
Lead	CF=1.46203—[(ln {hardness})(0.145712)]	CF = 1.46203—[(ln {hardness})(0.145712)]

(c) *Applicability.* (1) The criteria in paragraph (b) of this section apply to the State's designated uses cited in paragraph (d) of this section and apply concurrently with any criteria adopted by the State, except when State regulations contain criteria which are more stringent for a particular parameter and use, or except as provided in footnotes p, q, and x to the table in paragraph (b)(1) of this section.

(2) The criteria established in this section are subject to the State's general rules of applicability in the same way and to the same extent as are other Federally-adopted and State-adopted numeric toxics criteria when applied to the same use classifications including mixing zones, and low flow values below which numeric standards can be exceeded in flowing fresh waters.

(i) For all waters with mixing zone regulations or implementation procedures, the criteria apply at the appropriate locations within or at the boundary of the mixing zones; otherwise the criteria apply throughout the water body including at the point of discharge into the water body.

(ii) The State shall not use a low flow value below which numeric standards can be exceeded that is less stringent than the flows in Table 4 to paragraph (c)(2) of this section for streams and rivers.

(iii) Table 4 to paragraph (c)(2) of this section:

Criteria	Design flow
Aquatic Life Acute Criteria (CMC).	1 Q 10 or 1 B 3
Aquatic Life Chronic Criteria (CCC).	7 Q 10 or 4 B 3
Human Health Criteria.	Harmonic Mean Flow

Note to Table 4 of Paragraph (c)(2): 1. CMC (Criteria Maximum Concentration) is the water quality criteria to protect against acute effects in aquatic life and is the highest instream concentration of a priority toxic pollutant consisting of a short-term average not to be exceeded more than once every three years on the average.

2. CCC (Continuous Criteria Concentration) is the water quality criteria to protect against chronic effects in aquatic life and is the highest in stream concentration of a priority toxic pollutant consisting of a 4-day average not to be exceeded more than once every three years on the average.

3. 1 Q 10 is the lowest one day flow with an average recurrence frequency of once in 10 years determined hydrologically.

4. 1 B 3 is biologically based and indicates an allowable exceedence of once every 3 years. It is determined by EPA's computerized method (DFLOW model).

5. 7 Q 10 is the lowest average 7 consecutive day low flow with an average recurrence frequency of once in 10 years determined hydrologically.

6. 4 B 3 is biologically based and indicates an allowable exceedence for 4 consecutive days once every 3 years. It is determined by EPA's computerized method (DFLOW model).

(iv) If the State does not have such a low flow value below which numeric standards do not apply, then the criteria included in paragraph (d) of this section apply at all flows.

(v) If the CMC short-term averaging period, the CCC four-day averaging period, or once in three-year frequency is inappropriate for a criterion or the site to which a criterion applies, the State may apply to EPA for approval of an alternative averaging period, frequency, and related design flow. The State must submit to EPA the bases for any alternative averaging period, frequency, and related design flow. Before approving any change, EPA will publish for public comment, a document proposing the change.

(3) The freshwater and saltwater aquatic life criteria in the matrix in paragraph (b)(1) of this section apply as follows:

(i) For waters in which the salinity is equal to or less than 1 part per thousand 95% or more of the time, the applicable criteria are the freshwater criteria in Column B;

(ii) For waters in which the salinity is equal to or greater than 10 parts per thousand 95% or more of the time, the applicable criteria are the saltwater criteria in Column C except for selenium in the San Francisco Bay estuary where the applicable criteria are the freshwater criteria in Column B (refer to footnotes p and q to the table in paragraph (b)(1) of this section); and

(iii) For waters in which the salinity is between 1 and 10 parts per thousand as defined in paragraphs (c)(3)(i) and (ii) of this section, the applicable criteria are the more stringent of the freshwater or saltwater criteria. However, the Regional Administrator may approve the use of the alternative freshwater or saltwater criteria if scientifically defensible information and data demonstrate that on a site-specific basis the biology of the water body is dominated by freshwater aquatic life and that freshwater criteria are more appropriate; or conversely, the biology of the water body is dominated by saltwater aquatic life and that saltwater criteria are more appropriate. Before approving any change, EPA will publish for public comment a document proposing the change.

(4) *Application of metals criteria.* (i) For purposes of calculating freshwater aquatic life criteria for metals from the equations in paragraph (b)(2) of this section, for waters with a hardness of 400 mg/l or less as calcium carbonate, the actual ambient hardness of the surface water shall be used in those equations. For waters with a hardness of over 400 mg/l as calcium carbonate, a hardness of 400 mg/l as calcium carbonate shall be used with a default Water-Effect Ratio (WER) of 1, or the actual hardness of the ambient surface water shall be used with a WER. The same provisions apply for calculating the metals criteria for the comparisons provided for in paragraph (c)(3)(iii) of this section.

(ii) The hardness values used shall be consistent with the design discharge conditions established in paragraph (c)(2) of this section for design flows and mixing zones.

(iii) The criteria for metals (compounds #1—#13 in the table in paragraph (b)(1) of this section) are expressed as dissolved except where otherwise noted. For purposes of calculating aquatic life criteria for metals from the equations in footnote i to the table in paragraph (b)(1) of this section and the equations in paragraph (b)(2) of this section, the water effect ratio is generally computed as a specific pollutant's acute or chronic toxicity value measured in water from the site covered by the standard, divided by the respective acute or chronic toxicity value in laboratory dilution water. To use a water effect ratio other than the default of 1, the WER must be determined as set forth in Interim Guidance on Determination and Use of Water Effect Ratios, U.S. EPA Office of Water, EPA–823–B–94–001, February 1994, or alternatively, other scientifically defensible methods adopted by the State as part of its water quality standards program and approved by EPA. For calculation of criteria using site-specific values for both the hardness and the water effect ratio, the hardness used in the equations in paragraph (b)(2) of this section must be determined as required in paragraph (c)(4)(ii) of this section. Water hardness must be calculated from the measured calcium and magnesium ions present, and the ratio of calcium to magnesium should be approximately the same in standard laboratory toxicity testing water as in the site water.

(d)(1) Except as specified in paragraph (d)(3) of this section, all waters assigned any aquatic life or human health use classifications in the Water Quality Control Plans for the various Basins of the State (''Basin Plans'') adopted by the California State Water Resources Control Board (''SWRCB''), except for ocean waters covered by the Water Quality Control Plan for Ocean Waters of California (''Ocean Plan'') adopted by the SWRCB with resolution Number 90–27 on March 22, 1990, are subject to the criteria in paragraph (d)(2) of this section, without exception. These criteria apply to waters identified in the Basin Plans. More particularly, these criteria apply to waters identified in the Basin Plan chapters designating beneficial uses for waters within the region. Although the State has adopted several use designations for each of these waters, for purposes of this action, the specific standards to be applied in paragraph (d)(2) of this section are based on the presence in all waters of some aquatic life designation and the presence or absence of the MUN use designation (municipal and domestic supply). (See Basin Plans for more detailed use definitions.)

(2) The criteria from the table in paragraph (b)(1) of this section apply to the water and use classifications defined in paragraph (d)(1) of this section as follows:

Water and use classification	Applicable criteria
(i) All inland waters of the United States or enclosed bays and estuaries that are waters of the United States that include a MUN use designation.	(A) Columns B1 and B2—all pollutants (B) Columns C1 and C2—all pollutants (C) Column D1—all pollutants
(ii) All inland waters of the United States or enclosed bays and estuaries that are waters of the United States that do not include a MUN use designation.	(A) Columns B1 and B2—all pollutants (B) Columns C1 and C2—all pollutants (C) Column D2—all pollutants

(3) Nothing in this section is intended to apply instead of specific criteria, including specific criteria for the San Francisco Bay estuary, promulgated for California in the National Toxics Rule at § 131.36.

(4) The human health criteria shall be applied at the State-adopted 10 (−6) risk level.

(5) Nothing in this section applies to waters located in Indian Country.

(e)*Schedules of compliance.* (1) It is presumed that new and existing point source dischargers will promptly comply with any new or more restrictive water quality-based effluent limitations (''WQBELs'') based on the water quality criteria set forth in this section.

(2) When a permit issued on or after May 18, 2000 to a new discharger contains a WQBEL based on water quality criteria set forth in paragraph (b) of this section, the permittee shall comply with such WQBEL upon the commencement of the discharge. A new discharger is defined as any building, structure, facility, or installation from which there is or may be a ''discharge of pollutants'' (as defined in 40 CFR 122.2) to the State of California's inland surface waters or enclosed bays and estuaries, the construction of which commences after May 18, 2000.

(3) Where an existing discharger reasonably believes that it will be infeasible to promptly comply with a new or more restrictive WQBEL based on the water quality criteria set forth in this section, the discharger may request approval from the permit issuing authority for a schedule of compliance.

(4) A compliance schedule shall require compliance with WQBELs based on water quality criteria set forth in paragraph (b) of this section as soon as possible, taking into account the dischargers' technical ability to achieve compliance with such WQBEL.

(5) If the schedule of compliance exceeds one year from the date of permit issuance, reissuance or modification, the schedule shall set forth interim requirements and dates for their achievement. The dates of completion between each requirement may not exceed one year. If the time necessary for completion of any requirement is more than one year and is not readily divisible into stages for completion, the permit shall require, at a minimum, specified dates for annual submission of progress reports on the status of interim requirements.

(6) In no event shall the permit issuing authority approve a schedule of compliance for a point source discharge which exceeds five years from the date of permit issuance, reissuance, or modification, whichever is sooner. Where shorter schedules of compliance are prescribed or schedules of compliance are prohibited by law, those provisions shall govern.

(7) If a schedule of compliance exceeds the term of a permit, interim permit limits effective during the permit shall be included in the permit and addressed in the permit's fact sheet or statement of basis. The administrative record for the permit shall reflect final permit limits and final compliance dates. Final compliance dates for final permit limits, which do not occur during the term of the permit, must occur within five years from the date of issuance, reissuance or modification of the permit which initiates the compliance schedule. Where shorter schedules of compliance are prescribed or schedules of compliance are prohibited by law, those provisions shall govern.

(8) The provisions in this paragraph (e), Schedules of compliance, shall expire on May 18, 2005.

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Table G-6

Basin Plan Numeric Water Quality Objectives

Constituent	Water Quality Objective
Total Dissolved Solids	300 mg/L
Chloride	50 mg/L
Sulfate	65 mg/L
Percent Sodium	60%
Iron	0.3 mg/L
Manganese	0.05 mg/L
Boron	1.0 mg/L
Turbidity	20 NTU
Color	20 color units
Fluoride	1.0 mg/L
Nutrients	-Total Phosphorus less than 0.025 mg/L -Natural ratios of total nitrogen to total phosphorus are to be upheld, if no data is available a ratio (N:P) of 10:1 is to be used.
Ammonia (as N)	0.025 mg/L
Fecal Coliform	-Not less than 5 samples every 30 days -Sampling shall not exceed a log mean of 200/100mL -No more than 10% of samples during any 30 day period shall exceed 400/100mL
Dissolved Oxygen	- not less than 6.0 mg/L -annual mean DO shall not be less than 7.0 mg/L more than 10% of the time
pH	-change in pH level shall not exceed 0.5 units -pH shall not be depressed below 6.5 nor raised above 8.5
Phenolic Compounds	1.0 µg/L

APPENDIX H – COMPARISON OF CEC DATA MEASURED IN NCWRP TERTIARY WATER TO MEC/MTL DATA PRESENTED IN THE SWRCB 2010 FINAL REPORT

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Table H-1 Comparison of CEC Concentrations measured in the NCWRP Tertiary Effluent to MEC/MTL Ratio's Established in the SWRCB Final Report

CEC	Units	MDL	MTL[4]	MEC[4]	Average Detected Concentration[1,2]	MEC/MTL	Average/MTL	Comments	Use
Hydrocodone	ng/L	1	NA	NA	83.0				Pain killer
Trimethoprim	ng/L	1	61,000	112	387.0	0.00	0.01		Anti-biotic
Acetaminophen	ng/L	1	350,000	550	2.2	0.00	0.00		Analgesic
Caffeine	ng/L	10	350	900	20.0	2.57	0.06		Stimulant
Erythromycin-H_2O	ng/L	1	4,900	113	318.3	0.02	0.06		Anti-biotic
Sulfamethoxazole	ng/L	1	35,000	1,400	857.3	0.04	0.02		Anti-biotic
Fluoxetine	ng/L	1	10,000	31	36.7	0.00	0.00		Anti-depressant
Pentoxifylline	ng/L	1	NA	NA	4.3				Blood thinner
Meprobamate	ng/L	1	260,000	430	283.3	0.00	0.00		Anti-anxiety
Dilantin	ng/L	1	NA	217	141.3				Anti-convulsant
TCEP	ng/L	10	2,500	688	300.3	0.28	0.12		Fire retardent
Carbamazepine	ng/L	1	1,000	400	266.3	0.40	0.27		Anti-seizure/analgesic
DEET[5]	ng/L	1	2,500	1,520	250.0	0.61	0.10		Insect repellant
Atrazine	ng/L	1	NA	NA	2.3				Herbicide
Diazepam	ng/L	1	NA	NA	3.6				Anti-anxiety/muscle relaxant
Oxybenzone	ng/L	1	NA	NA	14.3				Sunscreen
Estriol	ng/L	5	350	NA	6.3		0.02		Steroid
Ethynylestradiol	ng/L	1	350	1	0.5	0.00	0.00		Synthetic birth control
Estrone	ng/L	1	350	73	68.8	0.21	0.20		Steroid
Estradiol	ng/L	1	0.9	8.4	6.3	9.33	7.04		Steroid
Testosterone	ng/L	1			0.5				Steroid
Progesterone	ng/L	1	110,000	18	0.5	0.00	0.00		Steroid
Androstenedione	ng/L	1	NA	NA	5.2				Steroid
Iopromide[5]	ng/L	1	750,000	2,174	556.3	0.00	0.00		X-ray contrast reagent
Naproxen	ng/L	1	220,000	851	183.3	0.00	0.00		Analgesic
Ibuprofen	ng/L	1	34,000	500	57.3	0.01	0.00		Pain killer
Diclofenac	ng/L	1	1,800	230	65.7	0.13	0.04		Arthritis treatment
Triclosan	ng/L	1	350	485	199.7	1.39	0.57		Anti-biotic
Gemfibrozil[5]	ng/L	1	45,000	3,550	689.3	0.08	0.02		Anti-cholesterol
NDMA	ng/L	2	10	68	42.3[3]	6.80	4.23		Industrial (e.g. rocket fuel production)
1,2,3-Trichloropropane	ng/L	5	5	NA	250[6]			Never detected. 500 ng/L MDL	
Hydrazine	ng/L	1	10						
Quinoline	ng/L	1	10						
3-Hydroxycarbofuran	ng/L	400	420	NA	250[6]		0.60	Never detected. 500 ng/L MDL	
Sucralose[5]	ng/L	--	NA	26,390	NA				food sweetener

Notes:

[1] Average and high detected concentrations from tertiary treatment effluent samples collected on 3/23/2005, 4/13/2005, and 12/30/2005.

[2] Non-detections calculated in at half the MDL.

[3] Average and high detected concentrations from tertiary treatment effluent samples collected on 3/23/2005, 4/13/2005, and 12/12/2005.

[4] MTL and MEC as developed in SWRCB, 2010. MTL=Monitor triggering limit; MEC=Measured Environmental Concentration. Compounds with MEC/MTL > 1 recommended for monitoring.

[5] Identified for surface spreading and direct injection operations as a viable performance indicator compound along with certain surrogate parameters (SWRCB, 2010).

[6] Average and high detected concentrations from tertiary treatment effluent samples collected on 3/23/2005, 4/13/2005, and 12/12/2005.

Acronyms:

CEC - Chemical of Emerging Concern
DEET - N, N-Diethyl-meta-Toluamide
MDL - method detection limit
MEC - Measured Environmental Concentration
MTL - Monitoring Trigger Level
NA - not available
ND - not detected
NDMA - N-nitrosodimethylamine
SWRCB - State Water Resources Control Board
TCEP - Tris (2-chloroethyl) phosphate

APPENDIX I – ANALYTICAL TESTING METHODS, MDLS, TATS

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Table I-1
Compounds to be Monitored Quarterly (non-CEC)

Analyte/Contaminant Group	**Method**	**Turn Around Time**	**MDL**	**Units**	**Rationale**
Volatile Organic Compounds (VOCs)					
Benzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Bromoform	EPA 524.2		0.5	µg/L	Priority pollutant
Bromomethane	EPA 524.2		0.5	µg/L	Priority pollutant
tert-Butyl alcohol	EPA 524.2		2	µg/L	CDPH drinking water notification level
n-Butylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
sec-Butylbenzen	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
tert-Butylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
Carbon Tetrachloride	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Chlorobenzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Chlorodibromomethane	EPA 524.2		0.5	µg/L	Priority pollutant
Chloroethane	EPA 524.2		0.5	µg/L	Priority pollutant
Chloromethane	EPA 524.2		0.5	µg/L	Priority pollutant
Chloroform	EPA 524.2		0.5	µg/L	Priority pollutant
2-Chlorotoluene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
4-Chlorotoluene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
1, 2-Dichlorobenzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 3-Dichlorobenzene	EPA 524.2		0.5	µg/L	Priority pollutant
1, 4-Dichlorobenzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Dichlorobromomethane	EPA 524.2		0.5	µg/L	Priority pollutant
Dichlorodifluoromethane (Freon-12)	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
1, 1-Dichloroethane	EPA 524.2		0.5	µg/L	State primary drinking water standards, priority pollutant
1, 2-Dichloroethane	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 1-Dichloroethylene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
cis-1, 2-Dichloroethylene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards
trans-1, 2-Dichloroethylene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 2-Dichloropropane	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 2-Dichloropropene	EPA 524.2		0.5-5	µg/L	Priority pollutant
1, 3-Dichloropropene	EPA 524.2		0.5	µg/L	State primary drinking water standards
Ethylbenzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Hexachlorobutadiene	EPA 524.2		0.5	µg/L	Priority pollutant
Hexachloroethane	EPA 524.2		0.5-5	µg/L	Priority pollutant
Isopropylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
Methyl-tert-butyl ether (MTBE)	EPA 524.2		0.5	µg/L	Federal and state primary and secondary drinking water standards
Methylene Chloride (Dichloromethane)	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Methyl isobutyl ketone (MIKB)	EPA 524.2		5	µg/L	CDPH drinking water notification level
n-Propylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
Styrene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards
1, 1, 2, 2-Tetrachloroethane	EPA 524.2		0.5	µg/L	State primary drinking water standards, priority pollutant
Tetrachloroethylene (PCE)	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Toluene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 2, 4-Trichlorobenzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 1, 1-Trichloroethane	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 1, 2-Trichloroethane	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Trichloroehtylene (TCE)	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Trichlorofluoromethane (Freon-11)	EPA 524.2		0.5	µg/L	State primary drinking water standards
1, 2, 3-Trichloropropane	EPA 524.2 MOD		0.005	µg/L	CDPH drinking water notification level
1, 1, 2-Trichloro-1, 2, 2-Trifluoroethane (Freon-113)	EPA 524.2		0.5	µg/L	State primary drinking water standards
1, 2, 4-Trimethylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
1, 3, 5-Trimethylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
Vinyl Chloride	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Xylenes, total	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards
Synthetic Organic Compounds (SOCs)					
Acenapthene	EPA 525.2		0.5	µg/L	Priority pollutant
Acenapthylene	EPA 525.2		0.5	µg/L	Priority pollutant
Acetochlor	EPA 525.2		0.02-5	µg/L	Unregulated comtaminant monitoring program
Acrolein	EPA 556		1-5	µg/L	Priority pollutant
Acrylonitrile					Priority pollutant
Alachlor	EPA 525.2		0.5	µg/L	Federal and state primary drinking water standards, Unregulated comtaminant monitoring program
Aldrin	EPA 505		0.075	µg/L	Priority pollutant
Anthracene	EPA 525.2		0.5	µg/L	Priority pollutant
Atrazine	EPA 525.2		0.4	µg/L	Federal and state primary drinking water standards, IAP recommended
Bentazon	EPA 555		2	µg/L	State primary drinking water standards
Benzidine	EPA 605			µg/L	Priority pollutant
Benzo(a)anthracene	EPA 525.2		0.5	µg/L	Priority pollutant
Benzo(a)pyrene	EPA 525.2		0.1	µg/L	Federal and state primary drinking water standards, priority pollutant
Benzo(g, h, i)perylene	EPA 525.2		0.5	µg/L	Priority pollutant
Benzo(b)fluoranthene	EPA 525.2		0.5	µg/L	Priority pollutant
Benzo(k)fluoranthene	EPA 525.2		0.5	µg/L	Priority pollutant
alpha-BHC	EPA 505		0.01-0.5	µg/L	Priority pollutant
beta-BHC	EPA 505		0.01-0.5	µg/L	Priority pollutant
delta-BHC	EPA 505		0.01-0.5	µg/L	Priority pollutant
Bis(2-chloroethoxy) methane					Priority pollutant
Bis(2-chloroethyl) ether					Priority pollutant
Bis(2-chloroisopropyl) ether					Priority pollutant
Bis(2-ethylhexyl) adipate	EPA 525.2		2	µg/L	Federal and state primary drinking water standards
Bis(2-ethylhexyl) phthalate (DEHP)	EPA 525.2		3	µg/L	Federal and state primary drinking water standards, priority pollutant
4-Bromophenyl phenyl ether					Priority pollutant
Butyl benzyl phthalate	EPA 525.2		0.02-5	µg/L	Priority pollutant
Carbofuran	EPA 531.2		0.4	µg/L	Federal and state primary drinking water standards
Chlordane	EPA 505		0.1	µg/L	Federal and state primary drinking water standards, priority pollutant
2-Chloroethyl vinyl ethers					Priority pollutant
2-Chloronapthalene					Priority pollutant
4-Chlorophenyl phenyl ether					Priority pollutant
Chrysene	EPA 525.2		0.5	µg/L	Priority pollutant
Dalapon	EPA 549		2	µg/L	Federal and state primary drinking water standards
Di-n-butyl phthalate	EPA 525.2		2	µg/L	Priority pollutant
Di-n-octyl phthalate	EPA 525.2		0.02-5	µg/L	Priority pollutant
Dibenzo(g, h)anthracene	EPA 525.2		0.02-5	µg/L	Priority pollutant
Dibromochloropropane	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards
3, 3-Dichlorobenzidine	EPA 605			µg/L	Priority pollutant
2, 4-Dichlorophenol	EPA 528		0.1-1	µg/L	Priority pollutant
2, 4-Dichlorophenoxy acetic acid (2, 4-D)	EPA 555		3	µg/L	Federal and state primary drinking water standards
4, 4-DDT	EPA 680			µg/L	Priority pollutant
4, 4-DDE	EPA 680			µg/L	Priority pollutant
4, 4-DDD	EPA 680			µg/L	Priority pollutant
Dieldrin	EPA 505		0.02	µg/L	Priority pollutant
Diethyl phthalate	EPA 525.2		0.5	µg/L	Priority pollutant
Dimethyl phthalate	EPA 525.2		0.5	µg/L	Priority pollutant
Dimethoate	EPA 527		0.025	µg/L	Unregulated comtaminant monitoring program
2, 4-Dimethylphenol	EPA 528		0.1-1	µg/L	Priority pollutant
4, 6-Dinitro-o-cresol	EPA 528		0.1-1	µg/L	Priority pollutant
2, 4-Dinitrophenol	EPA 528		0.1-1	µg/L	Priority pollutant
Dinoseb	EPA 555		2	µg/L	Federal and state primary drinking water standards
Diquat	EPA 549.2		0.4	µg/L	Federal and state primary drinking water standards
alpha-Endosulfan	EPA 608			µg/L	Priority pollutant
beta-Endosulfan	EPA 608			µg/L	Priority pollutant

Table I-1
Compounds to be Monitored Quarterly (non-CEC)

Analyte/Contaminant Group	Method	Turn Around Time	MDL	Units	Rationale
Endosulfan sulfate	EPA 608			µg/L	Priority pollutant
Endothall	EPA 548.1		8	µg/L	Federal and state primary drinking water standards
Endrin	EPA 505		0.1	µg/L	Federal and state primary drinking water standards, priority pollutant
Endrin aldehyde	EPA 505		0.01-0.5	µg/L	Priority pollutant
Ethylene Dibromide	EPA 504.1		0.01	µg/L	Federal and state primary drinking water standards
Fluoranthene	EPA 525.2		0.02-5	µg/L	Priority pollutant
Fluorene	EPA 525.2		0.5	µg/L	Priority pollutant
Glyphosate	EPA 547		6	µg/L	Federal and state primary drinking water standards
Heptachlor	EPA 505		0.01	µg/L	Federal and state primary drinking water standards, priority pollutant
Heptachlor epoxide	EPA 505		0.01	µg/L	Federal and state primary drinking water standards, priority pollutant
Hexachlorobenzene	EPA 525.2		0.4	µg/L	Federal and state primary drinking water standards, priority pollutant
Hexachlorocyclopentadiene	EPA 525.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Indeno(1, 2, 3-cd)pyrene	EPA 525.2		0.5	µg/L	Priority pollutant
Isophorone	EPA 525.2		0.02-5	µg/L	Priority pollutant
Lindane (gamma-BHC)	EPA 505		0.2	µg/L	Federal and state primary drinking water standards, priority pollutant
Methoxychlor	EPA 505		0.5	µg/L	Federal and state primary drinking water standards
Metolachlor	EPA 525.2		0.02-5	µg/L	Unregulated comtaminant monitoring program
Molinate	EPA 525.2		0.5	µg/L	State primary drinking water standards
Napthalene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level, priority pollutant
2-Nitrophenol	EPA 528		0.1-1	µg/L	Priority pollutant
4-Nitrophenol	EPA 528		0.1-1	µg/L	Priority pollutant
n-Nitrosodiethylamine (NDEA)	EPA 521		2	ng/L	Unregulated comtaminant monitoring program
n-Nitrosodimethylamine (NDMA)	EPA 521		2	ng/L	CDPH drinking water notification level, Unregulated comtaminant monitoring program, priority pollutant, process performance, IAP recommended, SWRCB CEC advisory panel
n-Nitrosodiphenylamine	EPA 521		2	ng/L	Other nitrosamine compound (non-UCMR/Notification Limit), priority pollutant
n-Nitroso-di-n-butylamine (NDBA)	EPA 521		2	ng/L	Unregulated comtaminant monitoring program
n-Nitroso-di-n-propylamine (NDPA)	EPA 521		2	ng/L	Unregulated comtaminant monitoring program, priority pollutant
n-Nitrosomethylethylamine (NMEA)	EPA 521		2	ng/L	Unregulated comtaminant monitoring program
n-Nitrosomorpholine	EPA 521		2	ng/L	Other nitrosamine compound (non-UCMR/Notification Limit)
N-nitrosopiperidine (NPIP)	EPA 521		2	ng/L	Other nitrosamine compound (non-UCMR/Notification Limit)
n-Nitrosopyrrolidine (NYPR)	EPA 521		2	ng/L	Unregulated comtaminant monitoring program
Oxamyl (Vydate)	EPA 531.2		0.4	µg/L	Federal and state primary drinking water standards
Parachlorometa Cresol	EPA 528		0.1-1	µg/L	Priority pollutant
Pentachlorophenol (PCP)	EPA 528		0.1-1	µg/L	Federal and state primary drinking water standards, priority pollutant
Phenanthrene	EPA 525.2		0.5	µg/L	Priority pollutant
Phenol	EPA 528		0.1-1	µg/L	Priority pollutant
Picloram	EPA 555		1	µg/L	Federal and state primary drinking water standards
Polychlorinated Biphenyls (PCBs)	EPA 505		0.5	µg/L	Federal and state primary drinking water standards
PCB-1016 (Aroclor 1016)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1221 (Aroclor 1221)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1232 (Aroclor 1232)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1242 (Aroclor 1242)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1248 (Aroclor 1248)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1254 (Aroclor 1254)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1260 (Aroclor 1260)	EPA 505		0.5	µg/L	Priority pollutant
Propachlor	EPA 505		0.5	µg/L	CDPH drinking water notification level
Pyrene	EPA 525.2		0.5	µg/L	Priority pollutant
Simazine	EPA 525.2		0.5	µg/L	Federal and state primary drinking water standards
Surfactants (MBAS)	SM5540C/E425.1		0.05	mg/L	Federal and state secondary drinking water standards
Terbufos Sulfone	EPA 527		0.04	µg/L	Unregulated comtaminant monitoring program
Thiobencarb	EPA 555		1	µg/L	Federal and state primary and secondary drinking water standards
Toxaphene	EPA 505		1	µg/L	Federal and state primary drinking water standards
2, 3, 7, 8-Tetrachlorodibenzo-p-dioxin (2, 3, 7, 8-TCDD)	EPA 1613B		5	pg/L	Federal and state primary drinking water standards, priority pollutant
2, 4, 5-TP (Silvex)	EPA 555		1	µg/L	Federal and state primary drinking water standards
2, 4, 6-Trichlorophenol	EPA 528		0.1-1	µg/L	Priority pollutant
Disinfection by Products (DBPs)					
Total Trihalomethanes	EPA 551.1		0.5	µg/L	Federal and state primary drinking water standards
Total Haloacetic acids	SM6251B		4	µg/L	Federal and state primary drinking water standards
Bromate	EPA 317		1	µg/L	Federal and state primary drinking water standards
Chlorite	EPA 300.1B		10	µg/L	Federal and state primary drinking water standards
Chlorate	EPA 300.1B		20	µg/L	Water treatment disinfection byproduct
Inorganics					
Aluminum	EPA 200.7		25	µg/L	Federal and state secondary drinking water standards
Antimony	EPA 200.7		1	µg/L	Federal and state primary drinking water standards, priority pollutant
Arsenic	EPA 200.7		1	µg/L	Federal and state primary drinking water standards, priority pollutant
Asbestos	EPA 100.2		0.2	MFL	Federal and state primary drinking water standards, priority pollutant
Barium	EPA 200.7		2	µg/L	Federal and state primary drinking water standards
Beryllium	EPA 200.7		1	µg/L	Federal and state primary drinking water standards, priority pollutant
Boron	EPA 200.7		25	µg/L	CDPH drinking water notification level, IAP recommended
Cadmium	EPA 200.7		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Calcium	EPA 200.7		1	mg/L	San Diego Basin Plan inland surface water monitoring
Chloride	EPA 300.0		10	mg/L	Federal and state secondary drinking water standards
Chromium	EPA 200.7		1	µg/L	Federal and state primary drinking water standards, priority pollutant
Copper	EPA 200.7		2	µg/L	Federal and state primary and secondary drinking water standards, priority pollutant
Cyanide	SM4500CN-F		0.005	mg/L	Federal and state primary drinking water standards, priority pollutant
Fluoride	EPA 300.0		0.05	mg/L	Federal and state primary drinking water standards
Iron	EPA 200.7		0.02	mg/L	Federal and state secondary drinking water standards
Lead	EPA 200.7		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Magnesium	EPA 200.7		0.1	mg/L	San Diego Basin Plan inland surface water monitoring
Manganese	EPA 200.7		2	µg/L	Federal and state secondary drinking water standards, CDPH drinking water notification level
Mercury	EPA 245.1		0.2	µg/L	Federal and state primary drinking water standards, priority pollutant
Nickel	EPA 200.7		5	µg/L	State primary drinking water standards, priority pollutant
Perchlorate	EPA 314		2	µg/L	CDPH drinking water notification level
Potassium	EPA 200.7		1	mg/L	San Diego Basin Plan inland surface water monitoring
Selenium	EPA 200.7		5	µg/L	Federal and state primary drinking water standards, priority pollutant
Silver	EPA 200.7		0.5	µg/L	Federal and state secondary drinking water standards, priority pollutant
Sodium	EPA 200.7		1	mg/L	San Diego Basin Plan inland surface water monitoring
Sulfate	EPA 300.0		2	mg/L	Federal and state secondary drinking water standards
Thallium	EPA 200.7		1	µg/L	Federal and state primary drinking water standards, priority pollutant
Vanadium	EPA 200.7		0.5	µg/L	CDPH drinking water notification level
Zinc	EPA 200.7		5	µg/L	Federal and state secondary drinking water standards, priority pollutant
Nutrients					
Ammonia	EPA 350.1		0.05	mg/L	San Diego Basin Plan inland surface water monitoring, process performance
Nitrate-NO3	EPA 300.0		1.8	mg/L	State primary drinking water standards
Nitrate-N	EPA 300.0		0.4	mg/L	Federal primary drinking water standards
Nitrite-N	EPA 300.0		0.4	mg/L	Federal and state primary drinking water standards, process performance
Nitrogen, total	EPA 300.0/351.2		0.5	mg/L	Process performance monitoring
Orthophosphate	SM4500P-E		0.05	mg/L	Process performance monitoring
Phosphorus, total	E365.1/365.2		0.05	mg/L	Process performance monitoring
Microbial					
Total Coliform	SM9223		2	MPL/100mL	Federal and state primary drinking water standards, process performance
Hetertrophic plate count	SM9215		1	CFU/mL	Process performance monitoring

Table I-1

Compounds to be Monitored Quarterly (non-CEC)

Analyte/Contaminant Group	**Method**	**Turn Around Time**	**MDL**	**Units**	**Rationale**
Coliphage	EPA 1601/1602		varies	PFU/mL	Process performance monitoring
Radionuclides					
Uranium	EPA 200.8		1	µg/L	Federal and state primary drinking water standards
Radium-226+228	EPA 903.1 / 904.0		1	pCi/L	Federal and state primary drinking water standards
Gross Alpha particualtes	EPA 900.0		3	pCi/L	Federal and state primary drinking water standards
Gross Beta particulates	EPA 900.0		3	pCi/L	Federal and state primary drinking water standards
Strontium-90	EPA 905.0		1	pCi/L	Federal and state primary drinking water standards
Tritium	EPA 906.0		1,000	pCi/L	Federal and state primary drinking water standards
Explosives					
1, 3-Dinitrobenzene	EPA 529		UCMR	µg/L	Unregulated comtaminant monitoring program
2, 4-Dinitrotoluene	EPA 529		UCMR	µg/L	Priority pollutant
2, 6-Dinitrotoluene	EPA 529		UCMR	µg/L	Priority pollutant
Hexahydro-1, 3, 5-trinitro-1, 3, 5-triazine (RDX)	EPA 529		UCMR	µg/L	Unregulated comtaminant monitoring program
Nitrobenzene	EPA 529		UCMR	µg/L	Priority pollutant
2, 4, 6-Trinitrotoluene	EPA 529		UCMR	µg/L	Unregulated comtaminant monitoring program
Acetanilide Degredates					
Acetochlor ethane sulfonic acid (ESA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
Acetochlor oxanilic acid (OA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
Alachlor ethane sulfonic acid (ESA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
Alachlor oxanilic acid (OA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
Metolachlor ethane sulfonic acid(ESA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
Metolachlor oxanilic acid (OA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
General Water Qualtiy Monitoring Parameters					
Biochemical oxygen demand (BOD)	SM5210B		3	mg/L	Process performance monitoring
Color	S2120B		3	ACU	Federal and state secondary drinking water standards
Corrosivity					Federal and state secondary drinking water standards
Odor threshold	S2150B		1	TON	Federal and state secondary drinking water standards
pH	4500HB/E150		0.001	pH units	Process performance monitoring
Specific conductance	ML/S2510B		2	umho/cm	Federal and state secondary drinking water standards
Temperature					Process performance monitoring
Total anion / cation	SM1030E		0.001	meg/L	Process performance monitoring
Total dissolved solids (TDS)	SM2540C		10	mg/L	Federal and state secondary drinking water standards, Process performance
Total organic carbon (TOC)	SM5310C		0.25	mg/L	Process performance monitoring
Turbidity	EPA 180.1		0.05	NTU	Federal and state secondary drinking water standards, Process performance
Other Compounds					
Acetaminiphen	LC-MS-MS		1	ng/L	Other potential AOP byproduct
n-Acetyl-p-benzoquione					Other potential AOP byproduct
1, 4-Dioxane	EPA 522 MOD		0.5	µg/L	CDPH drinking water notification level, process performance monitoring, IAP recommended
1, 2-dipheylhydrazine					Priority pollutant
Formaldehyde					Other potential AOP byproduct
2, 2', 4, 4', 5, 5'-Hexabromobiphenyl (HBB)	EPA 527		UCMR	µg/L	Unregulated comtaminant monitoring program
2, 2', 4, 4', 5, 5'-Hexabromobiphenyl ether (BDE-153)	EPA 527		UCMR	µg/L	Unregulated comtaminant monitoring program
2, 2', 4, 4', 5-Pentabromodiphenyl ether (BDE-99)	EPA 527		UCMR	µg/L	Unregulated comtaminant monitoring program
2, 2', 4, 4', 6-Pentabromodiphenyl ether (BDE-100)	EPA 527		UCMR	µg/L	Unregulated comtaminant monitoring program
2, 2', 4, 4'-Tetrabromodiphenyl ether (BDE-47)	EPA 527		UCMR	µg/L	Unregulated comtaminant monitoring program

Table I-2
CECs to be Monitored Quarterly

Analyte/Contaminant Group	Method [1]	Turn Around Time	MDL	Units	Rationale
Hormones					
EE2 (17 Alpha-ethynylestradiol)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
E2 (17 Beta-Estradiol)	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC, SWRCB CEC advisory panel
Andorostenedione	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Estrone	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC, IAP recommended
Norethisterone	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Progesterone	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Testosterone	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Pesticides / Herbicides					
2,4-D	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Atrazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Bromacil	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Chlorotoluron	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Cyanazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
DACT (Diaminochlorotriazine)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
DEA (Deethylatrazine)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
DIA (Deisopropylatrazine)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Diuron	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Isoproturon	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Linuron	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Metazachlor	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Propazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Simazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Pharmaceuticals					
Acetaminophen	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Albuterol	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Amoxicillin (semi quantitative)	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Atenolol	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Bendroflumethiazide	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Bezafibrate	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Butalbital	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Carbadox	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Carbamazepine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC, IAP recommended
Carisoprodol	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Chloramphenicol	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Chloridazon	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Cimetidine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Dehydronifedipine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Diazepam	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Diclofenac	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Dilantin (Phenytoin)	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC, IAP recommended
Erythromycin (semiquantitative)	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Flumeqine	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Fluoxetine (semiquantitative)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Furosemide	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Gemfibrozil	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC, IAP recommended, SWRCB CEC advisory panel
Ibuprofen	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Ketoprofen	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Ketorolac	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Lidocaine (Semiquantitative)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Lincomycin	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Lopressor	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Meclofenamic	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Meprobamate	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC, IAP recommended
Naproxen	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Nifedipine	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Oxolinic acid	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Pentoxifylline	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Primidone	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfachloropyridazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfadiazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfadimethoxine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfamerazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfamethazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfamethizole	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfamethoxazole	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC, IAP recommended
Sulfathiazole	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Theophylline	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Trimethoprim	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Warfarin	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Preservative					
Butylparben	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Ethylparaben	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Isobuylparaben	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Methylparaben	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Propylparaben	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Stimulants					
1,7-dimethylxanthine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Caffeine	API SCIEX 5000 LC-MS-MS		3	ng/L	Identified CEC, SWRCB CEC advisory panel
Cotinine	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Theobromine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Wastewater Indicators					
4-nonylphenol (qualitative)	API SCIEX 5000 LC-MS-MS		100	ng/L	Identified CEC
4-tert-octylphenol	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
BPA (Bis Phenol A)	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Iohexol	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Iopromide	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC, IAP recommended, SWRCB CEC advisory panel
PFOS (Perfluoro octanesulfonate)	API SCIEX 5000 LC-MS-MS		0.2	ng/L	Identified CEC
Sucralose	API SCIEX 5000 LC-MS-MS		100	ng/L	Identified CEC, SWRCB CEC advisory panel
TCEP (Tris(2-chloroethyl) phosphate)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC, IAP recommended
Other Identified CECs					
DEET (N,N-Diethyl-meta-toluamide)	API SCIEX 5000 LC-MS-MS		2	ng/L	Identified CEC, IAP recommended, SWRCB CEC advisory panel
1, 4-Dioxane	EPA 522 MOD		0.5	µg/L	Identified CEC, IAP recommended, process performance
n-Nitrosodimethylamine (NDMA)	EPA 521		2	ng/L	Identified CEC, IAP recommended, process performance, SWRCB CEC advisory panel
Triclosan	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC, SWRCB CEC advisory panel
1, 2, 3-Trichloropropane	EPA 524.2 MOD		0.005	µg/L	IAP recommended
Hydrazine					IAP recommended
Quinoline					IAP recommended

Notes:
1. API SCIEX 5000 LC-MS-MS analytical method represents the most current, peer-reviewed methodology available.

APPENDIX J – SAMPLING PROCEDURES FOR MICROBIAL PARAMETERS

BIOVIR LABORATORIES, INC.

EXAMPLE PROCEDURE FOR COLLECTING FILTERED WATER SAMPLES (Using HV Envirochek Capsule Filters)
FOR
METHOD 1622/23 ANALYSIS

NOTE! The EPA method 1623: Cryptosporidium and Giardia in Water by Filtration/IMS/FA December 2005
Sample arrival temperature requirement is 0° C to < 20°C *
EPA target arrival temperature <10°C

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* Adapted from EPA Document. See http;/www.epa.gov/microbes

Example Procedure for Collecting Filtered Water Samples for Method 1622/1623 Analysis

1.0 Required Materials

Have the following materials available prior to sampling:

- Several pair of new latex gloves*
- Sample Data sheet*
- HV Envirochek capsule Filter and Filer Sampling Equipment w/ 10L cubitainer*
- Small Return cooler w/ 250 mL Temperature blank
- Waterproof Sample label*
- Waterproof Pen
- Cooler / vessel for chilling of sample prior to shipment
- Ice for chilling of sample prior to shipping
- 2 plastic liners (bags)*
- 4-5 Gel Pacs (Frozen)* or
- Ice (cubes or crushed) for shipping
- 5 large ziplocks bags*
- Strapping or duct tape to seal cooler prior to shipping
- Shipping air bill (completed by utilities)

2.0 Collecting the Sample from a Pressurized Source

- Put on a pair of latex gloves.
- Flush the system for 2 to 3 minutes until any accumulated stagnant water or debris has cleared, or temperature and turbidity has become visibly uniform before connecting the sampling unit to the tap.
- While system is flushing record following information on the sample data sheet:
  - Public Water System (PWS)Name and Address
  - Sampler Name
  - PWS ID Number
  - Facility Name and PWS facility ID number
  - Sample collection point name and ID number
  - Sample collection date
  - Source water type (required for E. Coli sample forms)
  - Assay Requested (indicate if Regular or Matrix sample)
- After system has flushed, measure and enter water quality parameters such as temperature, turbidity, pH.
- Connect assembled sampling unit to the sample tap **(without capsule filter)** to sample tap, flush sampling unit for 2-3 minutes and test for leaks, and slowly adjust up an adequate flow. **(maximum** values 100 psi w/ flow restrictor).
- Turn off sample tap, install filter capsule **(retain blue vinyl caps)**, insert three (3) foot length tubing into effluent 10L cubitainer .
- Record start time on sample data sheet. Slowly turn on sample tap. When 10L cubitainer has reached fill mark, turn off sample tap. Record stop time
- **If taking a Matrix spike sample with this sample the two volumes must be the same (within 10%)**
- Hold Capsule filter (inlet pointing up), remove tubing allowing water to drain through the “out port” of the filter. Open bleed valve to speed draining process, and disconnect tubing from capsule filter.
- Seal capsule filter ends with blue caps, close bleed valve, and place into gallon ziplock bag. Seal and place into a second ziplock bag (ie. Double bag)

3.0 Pre-Chilling of Filter

*Supplied if Requested

- Place bagged filter and temperature blank into an ice bath. The filter will float semi- submerged in the ice water.
- A 25˚C filter and temperature blank will chill to approximately 6˚C in 1.5 hours
- Filter and temperature blank should be stored between 0 - 8˚C from time of filtration**.**
- Sample testing must be completed within 96 hours of sample collection**.**

4.0 Packing and Shipping the Sample Using Ice Cubes/Crushed Ice

- Create a double liner by inserting one plastic liner into the other. Line the cooler with the liners
- Divide 8-lbs of ice(cubes or crushed) into the ziplock bags, expel as much air as possible then seal. Secure the ends with tape.˚
- Place the chilled filter and temperature blank into the sample cooler, cover with a layer of bubble wrap or similar material. Place an ice pack on top of the insulating material.
- Seal each liner by twisting the top of each bag, and secure with tape.
- Place the completed sample data sheet (chain of custody) into a ziplock bag, seal and tape to the inside cooler lid.
- Close and seal the cooler lid.
- Attach your completed air bill to the cooler, retain sender copy. Send to processing lab
- Alert BioVir at least 24 hours prior to sample shipment date. Indicate courier used and request BioVir contact client if sample not received.
- If problems are encountered with the shipment, communicate with the shipping company and BioVir to resolve.

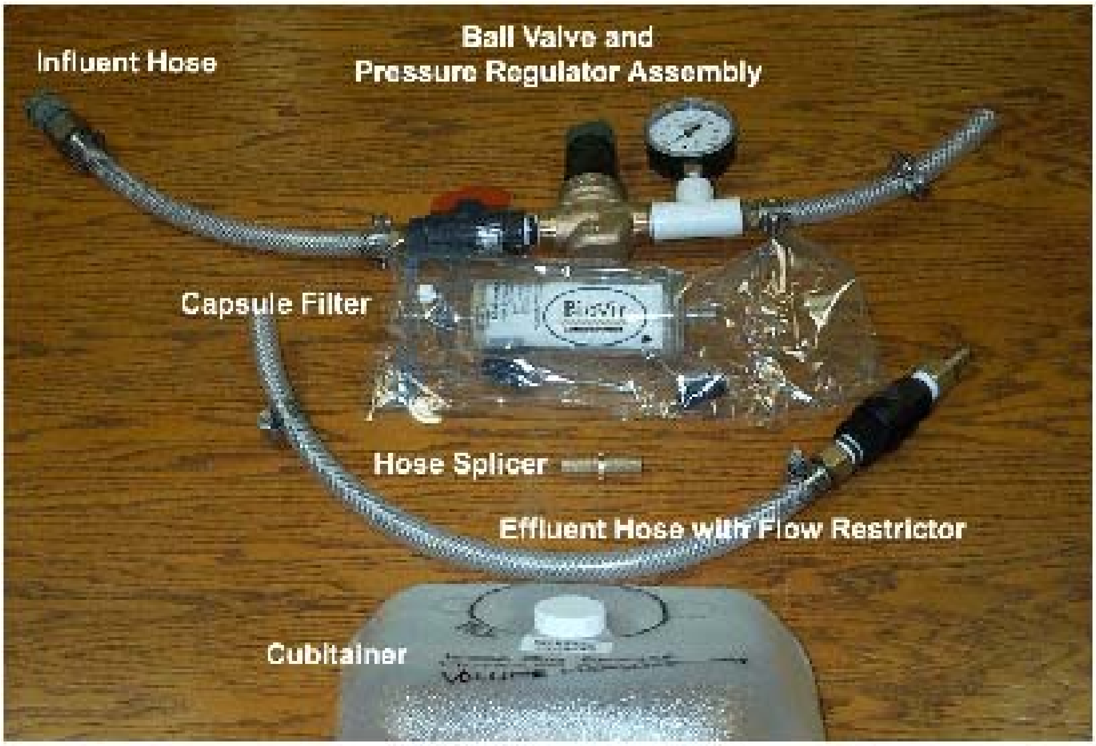
5.0 Packing and Shipping Sample Using Frozen Gel Pacs

- Create a double liner by inserting one bag liner into the other. Line cooler with the liners.
- Place each **FROZEN** gel pac into a ziplock.
- Place the pre-chilled filter and temperature blank into cooler, cover with a layer of bubble wrap or similar material. Place a frozen gel pac on each side and on top of the filter and temperature blank.
- Seal each liner by twisting the top of each bag, and securing with tape.
- Place the completed sample data sheet (chain of custody) into a ziplock, seal and tape to the inside cooler lid.
- Close and seal the cooler lid.
- Attach your completed air bill to the cooler, retain sender copy. Send to processing lab
- Alert BioVir at least 24 hours prior to sample shipment date. Indicate courier used and request BioVir contact client if sample not received.
- If problems are encountered with the shipment, communicate with the shipping company and BioVir to resolve.

NOTE ! It is very important to use the double liners and ziplocks to prevent leakage from the sample cooler. Shipping companies may delay shipment if leakage occurs.

*Supplied if Requested

EPA Method 1623 Field Concentrating Apparatus



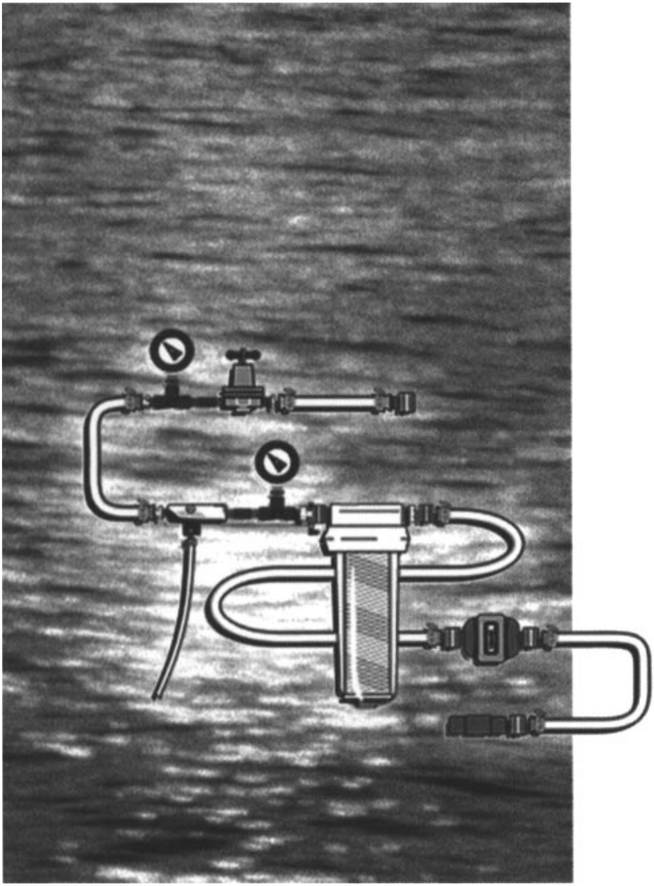
United States
Environmental
Protection Agency

Office of Ground Water
and Drinking Water
Washington, DC 20460

EPA/814-B-95-001
June 1995

EPA

Information Collection Requirements Rule— Protozoa and Enteric Virus Sample Collection Procedures



ABOUT THIS MANUAL

This manual is designed to be brought into the field by drinking water utility personnel when collecting source and finished water samples for protozoa and viruses. The sample collection steps in this manual are consistent with those demonstrated in the accompanying video. To further associate the steps in this manual with the sampling demonstration on the video, the photos for each step are taken directly from the video.

Several graphic conventions are used throughout the manual to differentiate steps or denote special actions:

2 A step icon is used at the beginning of each step. These steps are parallel to those in the accompanying video.

! Actions denoted by this icon are critical to ensuring that the sample will be valid and uncontaminated, such as putting on fresh latex gloves before handling the filter.

Text denoted by this icon provides additional information to the samplers, but may not be part of the actual collection procedure.

Collecting protozoan and virus samples correctly under the Information Collection Requirements Rule can be challenging. Please watch the demonstration video before collecting the samples, and be sure to follow each step in this manual when in the field.

CONTENTS

PROTOZOAN AND ENTERIC VIRUS SAMPLE COLLECTION PROCEDURES AS DEFINED BY THE INFORMATION COLLECTION REQUIREMENTS RULE

This manual describes the procedures for collecting source water and finished water samples for protozoan and enteric virus monitoring under the Information Collection Requirements (ICR) rule. This manual and the accompanying video comprise a two-part set of instructional materials that provide public water supply systems with the information needed to properly collect samples for protozoan and virus monitoring. All water utility personnel involved with ICR monitoring should watch the video and review this manual before collecting any samples.

The protozoan collection procedures described in this manual and in the video are based on the procedures in the ICR Protozoan Method for Detecting *Giardia* cysts and *Cryptosporidium* Oocysts in Water by a Fluorescent Antibody Procedure. The total culturable virus collection procedures described in this manual and in the video are based on the procedures in the Virus Monitoring Protocol for the Information Collection Rule. Both of these methods can be requested by calling the Safe Drinking Water Hotline, at (800) 426-4791.

QUESTIONS COMMONLY ASKED BY DRINKING WATER UTILITIES

What is the purpose of the ICR rule?

The ICR rule was developed by EPA to collect occurrence, exposure, and treatment data on drinking water pathogens and disinfectant by-products. The pathogen data are needed to determine whether current Surface Water Treatment Regulations should be revised to include new or more stringent treatment levels for some microbes. The disinfectant by-product data are needed to determine whether to regulate the chemical by-products that form when disinfectants react with organic chemicals in source water.

Although drinking water utilities will be involved in collecting both disinfectant by-product and waterborne pathogen data under the ICR rule, this manual describes the utility's role in collecting data on drinking water pathogen occurrence.

What pathogens are monitored under the ICR rule?

The ICR rule requires public water supply systems to monitor source water (and finished water in some cases) for the following pathogens:

- *Giardia* cysts
- *Cryptosporidium* oocysts
- Total culturable viruses
- Fecal coliform or *Escherichia coli* bacteria
- Total coliform bacteria

EPA is considering revising the current Surface Water Treatment Regulations because existing treatment levels for *Giardia* and viruses may not be adequate to protect public health for systems supplied by poor-quality source water and because of the new threat posed by *Cryptosporidium.*

Giardia cysts in drinking water cause more reported waterborne disease outbreaks than any other single known pathogen. They also are more resistant to environmental stresses and disinfection than almost all other known waterborne pathogens.

Cryptosporidium oocysts in drinking water have caused major waterborne disease outbreaks in the U.S. and other countries and are even more resistant to disinfection than *Giardia.*

Several enteric viruses have caused waterborne disease and may be responsible for many, if not most, of the outbreaks where a causative agent was not identified (about half of all reported outbreaks). Adequate analytical methodology is not yet available for routine analysis for many enteric viruses, so EPA has required monitoring of total culturable viruses. Total culturable viruses are a group of enteric viruses commonly found in poor-quality waters and which EPA believes are at least somewhat representative of other pathogenic viruses. Monitoring for total culturable viruses is useful because this group contains pathogens and is a potential indicator of other viral pathogens.

Fecal coliforms, *E. coli*, and total coliforms have been used for decades to assess source water quality. Coliform bacteria are much more susceptible to environmental stress and disinfection than protozoa and viruses, and would be eliminated by any system that eliminated more resistant pathogens. However, the ICR rule requires drinking water utilities to submit coliform monitoring data as general indicators of water quality. Monitoring procedures for fecal coliform, *E. coli*, and total coliform densities have been established and are not addressed by this manual.

Which drinking water utilities have to collect protozoan and virus samples?

Public water supply systems that serve between 10,000 and 100,000 people and use surface water (or groundwater under the influence of surface water) are required to monitor their source water for *Giardia* cysts and *Cryptosporidium* oocysts.

Public water supply systems that serve more than 100,000 people and use surface water (or groundwater under the influence of surface water) are required to monitor their source water for *Giardia* cysts, *Cryptosporidium* oocysts, and total culturable viruses. If pathogen densities in the source water exceed 1 pathogen per liter during the first 12 months of monitoring, then public water supply systems also must sample finished water for the remaining months.

How often must samples be taken?

Public water supply systems that serve between 10,000 and 100,000 people must collect samples every two months for 12 months.

Systems that serve more than 100,000 people must take samples every month for 18 months.

However, these systems may discontinue monitoring if:

- Viruses are not detected in the source water during the first 12 months of monitoring, or
- Source water has been tested for either total coliforms or fecal coliforms at least five times per week for four months before and two months after the effective date of the ICR and the total coliform density is less than 100 colonies/100 mL or the fecal coliform density in 90 percent of all samples is less than 20 colonies/100 mL.

Where should samples be collected?

Samples must be taken at the intake of each treatment plant. If a plant has several sources of water, the system must sample the blended water from all sources. If this is not possible, the source with the highest expected pathogen concentration should be sampled.

Who will analyze the samples?

EPA has approved several laboratories to analyze the protozoan and virus samples. Before collecting samples, you must arrange to have them analyzed by an EPA-approved laboratory.

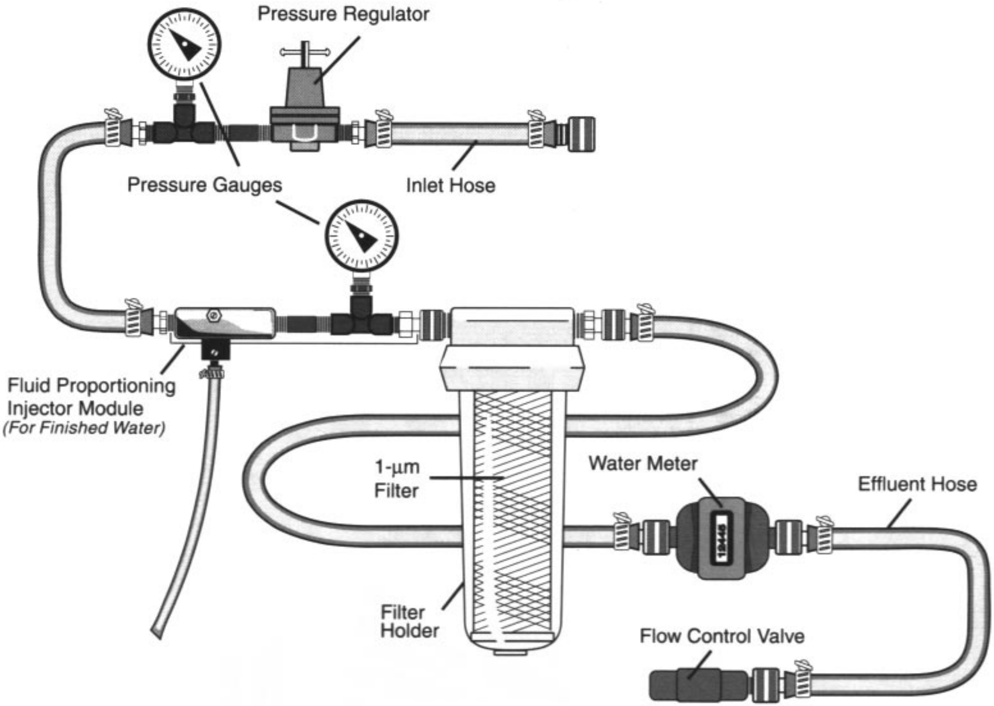
If you have not already located an approved laboratory, notify:

ICR Laboratory Coordinator
EPA Office of Ground Water & Drinking Water
26 West Martin Luther King Drive
Cincinnati, Ohio 45268.

EPA will provide you with a list of approved laboratories or other appropriate guidance.

SAMPLE COLLECTION PROCEDURES FOR DETECTING PROTOZOA IN WATER

Sampling Train for Collecting Protozoa



STEP 1 Each month, your laboratory will send you all of the equipment needed to collect samples for *Giardia* cyst and *Cryptosporidium* oocyst analyses. When you receive the sampling kit, check the contents of the carton. The sampling kit should contain the following items:

☐ Sampling train for collecting protozoa (left):

- Inlet hose
- Pressure regulator with pressure gauge
- Fluid proportioning injector module, including an injector and pressure gauge*
- 1-μm nominal porosity filter and holder made by Parker Hannifan or Filterite
- Water meter
- Effluent hose and flow control valve

*Needed for finished water sample collection only

- ☐ Plastic sample bags
- ☐ Ice packs for shipping the collected samples
- ☐ Sample labels

If you are missing any items, contact your laboratory immediately. Do not attempt to collect the samples without a complete sampling kit.

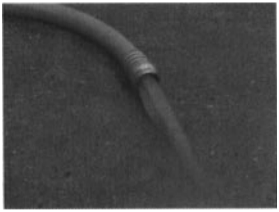
STEP 2 Once you have verified the contents of the sampling kit, place the ice packs in the freezer and repack the box for later use.

COLLECTING SOURCE WATER SAMPLES

When you are ready to collect your protozoa sample, bring the following items with you to the sampling location:

☐ Shipping container sent by the laboratory
☐ Sampling apparatus
☐ Plastic sample bags
☐ Sample labels
☐ Frozen ice packs
☐ Several pairs of new latex gloves
☐ pH meter
☐ Thermometer
☐ Turbidimeter

! If you will be collecting samples from both source water and finished water on the same day, perform the finished water sampling first. Using the sampling apparatus on source water first may cause false positives for finished water sample analyses.

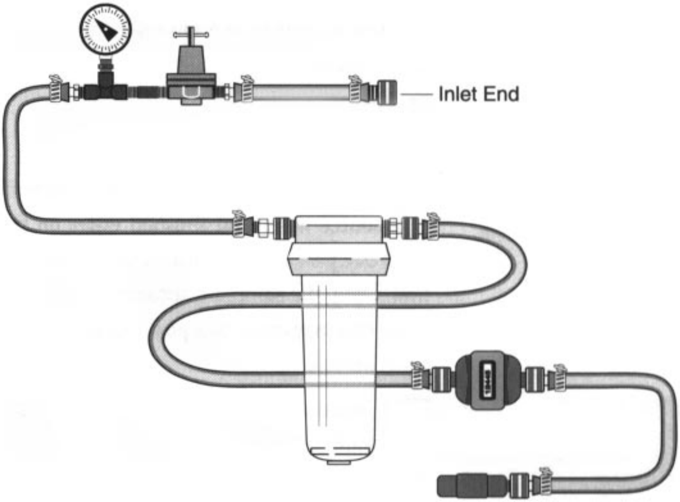


STEP 3 Turn on the water at the tap and allow the water to flow for 2 to 3 minutes or until any debris that has accumulated in the sampling line has cleared or the turbidity in the water becomes uniform.

Turn off the water at the tap.

STEP 4 Put on new latex gloves to prevent contamination from outside sources. Sterile technique must be used when sampling for *Giardia* and *Cryptosporidium*. Any contamination of the sampling apparatus may bias the final results.

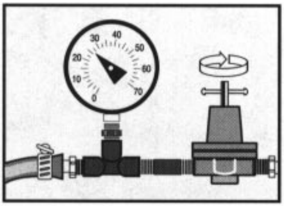
Assemble the sampling apparatus as shown below and connect the inlet end of the sampling apparatus to the sampling tap or to an extension hose connected to the tap.



! Be sure that the filter housing does *not* contain the filter.

Note the water meter reading, then slowly turn on the water.

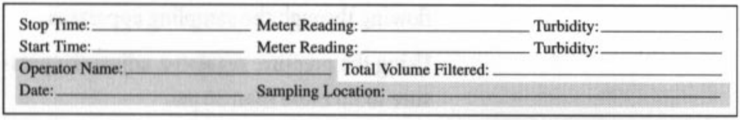
5 Using the pressure regulator, adjust the water pressure to no more than 30 psi. Flush the sampling apparatus with 20 gallons/ 76 liters of water by allowing the water to flow through the system and out the effluent hose.



Sampling Step	Volume In GALLONS	Volume In LITERS	Volume In FT^3
System Flush	20	76	2.7

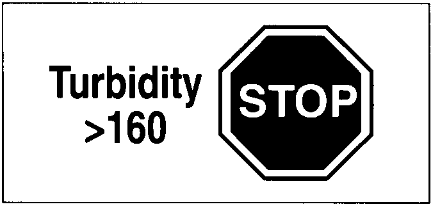
While the water is flushing the sampling apparatus, begin completing your sample label. Record the following information:

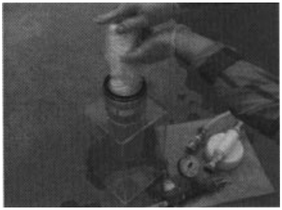
- Sampler's name
- Date
- Sample location



Stop Time: ________ Meter Reading: ________ Turbidity: ________
Start Time: ________ Meter Reading: ________ Turbidity: ________
Operator Name: ________ Total Volume Filtered: ________
Date: ________ Sampling Location: ________

6 Measure the turbidity of the source water flowing from the effluent hose. Record the readings on the sample label. If the turbidity is greater than 160 Nephelometric Turbidity Units (NTU), sampling should be rescheduled for a day when the turbidity is lower.





STEP 7 After the system has been flushed with 20 gallons / 76 liters of water, turn off the tap and disconnect the inlet and outlet hoses from the filter housing.

Using the filter wrench, open and drain the filter housing.

Open the filter packaging as aseptically as possible and carefully drop the filter into the filter housing.

! Be sure to hold the loose gasket in place using aseptic technique.

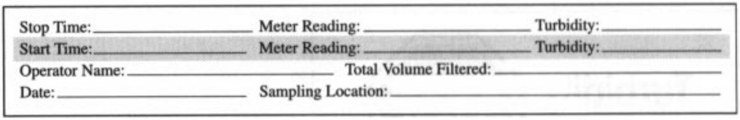
Reassemble the filter housing, and reconnect the inlet and outlet hoses. Place the filter housing in an upright position.

Slowly, turn on the tap and start the water flowing through the sampling apparatus.

Using the pressure regulator, adjust the pressure to no more than 30 psi.

Record the following information on the sample label:

- Time sampling started
- Initial water meter reading (including units)
- Turbidity



Stop Time: ______ Meter Reading: ______ Turbidity: ______
Start Time: ______ Meter Reading: ______ Turbidity: ______
Operator Name: ______ Total Volume Filtered: ______
Date: ______ Sampling Location: ______

Monitor the water meter to ensure that the flow rate does not exceed 1 gallon/min (approximately 4 liters/min).

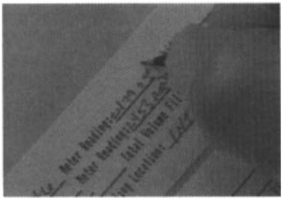
8 Allow at least 26 gallons/100 liters of water to pass through the filter. At a flow rate of approximately 1 gallon/minute, this will require about 30 minutes.

Sampling Step	Volume In GALLONS	Volume In LITERS	Volume In FT^3
Protozoa Flow Rate	1 per minute	4 per minute	.13 per minute
Protozoa Source Water Sample	26	100	3.5

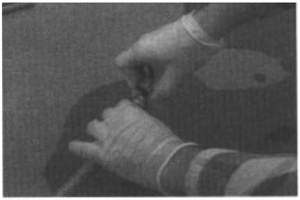
9 When the water meter indicates that 26 gallons/100 liters of water have passed through the filter, turn off the water at the tap.

Record the following information on the sample label:

- Time sampling stopped
- Final water meter reading (including units)
- Final turbidity
- Total volume filtered



Stop Time: ____ Meter Reading: ____ Turbidity: ____
Start Time: ____ Meter Reading: ____ Turbidity: ____
Operator Name: ____ Total Volume Filtered: ____
Date: ____ Sampling Location: ____

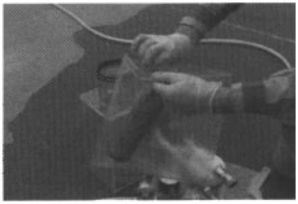


STEP 10 Disconnect the sampling apparatus from the water tap.

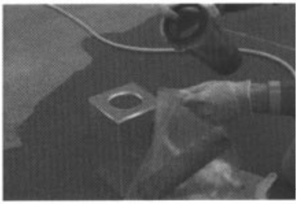
! Be sure to hold the inlet hose *above the level of the outlet hose opening* while the water drains from the housing. This will prevent backwash and loss of particulate matter from the filter.

Disconnect the inlet and outlet hoses from the filter housing.

! Put on fresh latex gloves.



STEP 11 As aseptically as possible, remove the filter from the housing and put it into a plastic sample bag.



STEP 12 Pour all of the water remaining in the filter housing into the same plastic bag.

STEP 13 Seal the plastic sample bag and place it inside the second plastic sample bag. Transfer the label or label information to the outside of the outer bag.

STEP 14 Put the bags containing the filter into the shipping container. Place the ice packs around, but not on, the sample bag to prevent freezing the sample. You may want to insert several inflated, empty sample bags between the sample and the ice packs.

STEP 15 Seal the container and follow the laboratory's instructions related to the cleaning, storage, and return of sampling equipment.

STEP 16 Ship the container by overnight courier to the laboratory. Call the laboratory and notify them of the sample shipment.

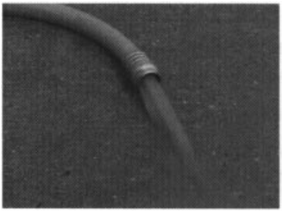
COLLECTING FINISHED WATER SAMPLES

If *Giardia* or *Cryptosporidium* concentrations in your source water samples exceed 1 per liter during the first 12 months of sampling, then you must monitor finished water as well as source water. If you are required to collect samples from both, collect the finished water sample first, then the source water sample.

Receiving and verifying the contents of your sampling kit are addressed in **STEPS 1** and **2** of the source water sampling section.

When you are ready to collect your finished water protozoa sample, bring the following items with you to the sampling location:

☐ Shipping container sent by the laboratory
☐ Sampling apparatus
☐ Fluid proportioning injector (for adding 2% thiosulfate solution to neutralize effects of chlorination or other disinfectant treatments)
☐ Plastic sample bags
☐ Sample labels
☐ Frozen ice packs
☐ Several pairs of new latex gloves
☐ Approximately 2 gal (4 L) of 2% sodium thiosulfate solution
☐ Sterile, 250- or 500-mL graduated cylinder
☐ Thermometer

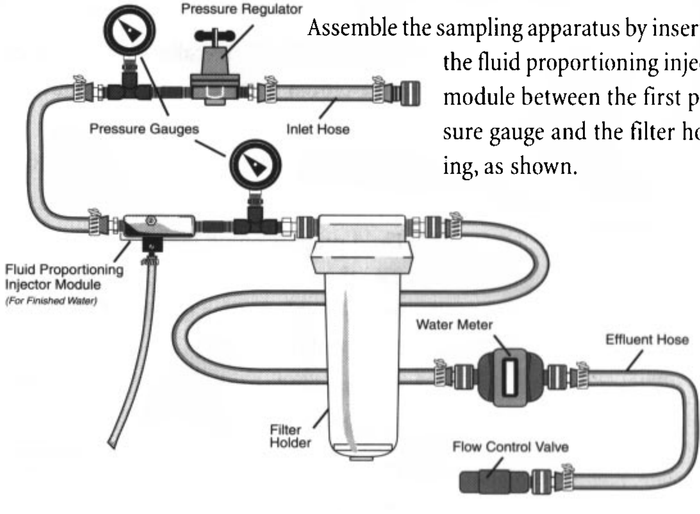


STEP 3 Turn on the water at the tap and allow the water to flow for 2 to 3 minutes or until any debris that has accumulated in the sampling line has cleared or the turbidity in the water becomes uniform.

Turn the water off at the tap

STEP 4 Put on new latex gloves to prevent contamination from outside sources. Sterile technique must be used when sampling for *Giardia* and *Cryptosporidium.* Any contamination of the sampling apparatus may bias the final results.

Assemble the sampling apparatus by inserting the fluid proportioning injector module between the first pressure gauge and the filter housing, as shown.

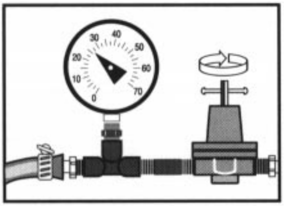


Connect the inlet end of the sampling apparatus to the sampling tap or to an extension hose connected to the tap.

Be sure that the filter housing does NOT contain the filter.

Note the water meter reading, then slowly turn on the water.

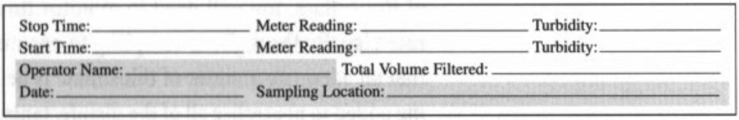
5 Using the pressure regulator, adjust the water pressure on the first pressure gauge to no more than 30 psi.



Flush the sampling apparatus with 20 gallons/76 liters of water by allowing the water to flow through the system and out the effluent hose.

While the water is flushing the sampling apparatus, begin completing your sample label. Record the following information:

- Sampler's name
- Date
- Sample location



Stop Time:________ Meter Reading:________ Turbidity:________

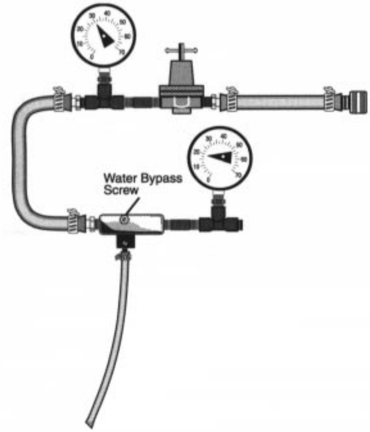
Start Time:________ Meter Reading:________ Turbidity:________

Operator Name:________ Total Volume Filtered:________

Date:________ Sampling Location:________

6 Now, you must adjust the thiosulf injector.

First, using the water bypass screw, the larger top screw in the injector, adjust the pressure on the downstream pressure gauge to be at least 35% less than the pressure shown on the upstream gauge. For ample, if the upstream gauge reads 30 then the second gauge should read no m than 19psi.



Pour the 2% sodium thiosulfate solution into a graduated cylinder. Place the injector tube in the thiosulfate solution, and adjust the smaller injector screw, located on the bottom of the injector, so that the flow rate of the 2% thiosulfate solution is approximately 10 milliliters per minute.

! If there is no suction visibly drawing down the thiosulfate solution, or if too much is flowing, adjust the water bypass screw further to increase or decrease the pressure differential between the two gauges. A greater differential between the upstream and downstream gauges increases the flow rate; a smaller differential decreases the flow rate.

After the thiosulfate flow rate is adjusted properly, transfer the injector tube to a carboy of thiosulfate. You will need to monitor this rate visually throughout sampling to ensure that an adequate amount of thiosulfate is being added to neutralize all of the disinfectants.

Turn off the water at the tap and empty the water in the filter housing.

7 Open the filter packaging as aseptically as possible and carefully drop the filter into the filter housing.

! Hold the loose gasket in place.

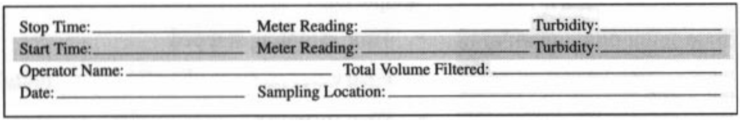
Reassemble the filter housing, and reconnect the inlet and outlet hoses.

Slowly, start the water flowing through the sampling apparatus.

Using the pressure regulator, adjust the pressure on the upstream pressure gauge to no more than 30 psi. Using the water bypass screw, readjust the downstream pressure gauge to read 35% less than the upstream gauge, if necessary.

Record the following information on the sample label:

- Time sampling started
- Initial water meter reading (including units)
- Turbidity



Stop Time: ____________ Meter Reading: ____________ Turbidity: ____________

Start Time: ____________ Meter Reading: ____________ Turbidity: ____________

Operator Name: ____________ Total Volume Filtered: ____________

Date: ____________ Sampling Location: ____________

Place the filter housing in an upright position.

Monitor the water meter to ensure that the flow rate does not exceed 1 gallon/min (approximately 4 liters/min).

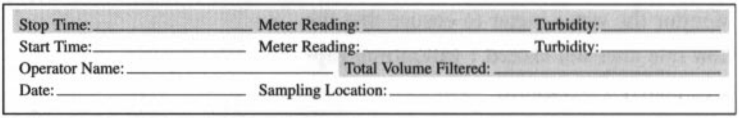
STEP 8 Allow at least 264 gallons/1000 liters of water to pass through the filter. At a flow rate of approximately 1 gallon/minute, this will require about 4 hours and 45 minutes.

Sampling Step	Volume In GALLONS	Volume In LITERS	Volume In FT^3
Protozoa Flow Rate	1 per minute	4 per minute	.13 per minute
Protozoa Finished Water Sample	264	1000	36

STEP 9 When the water meter indicates that 264 gallons/1000 liters of water have passed through the filter, turn off the water at the tap.

Record the following information on the sample label:

- Time sampling stopped
- Final water meter reading (including units)
- Final turbidity
- Total volume filtered



Stop Time: ____ Meter Reading: ____ Turbidity: ____
Start Time: ____ Meter Reading: ____ Turbidity: ____
Operator Name: ____ Total Volume Filtered: ____
Date: ____ Sampling Location: ____

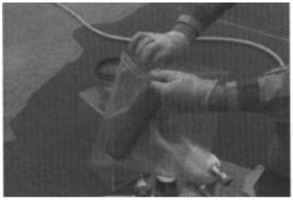
STEP 10 Disconnect the sampling apparatus from the water tap.

! Be sure to hold the inlet hose *above the level of the outlet hose opening* while the water drains from the housing. This will prevent backwash and loss of particulate matter from the filter.

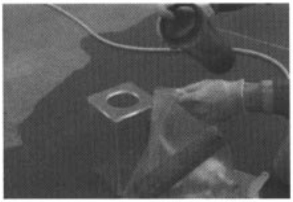
Disconnect the inlet and outlet hoses from the filter housing.

! Put on fresh latex gloves.

11 As aseptically as possible, remove the filter from the housing and put it into a plastic sample bag.



12 Pour all of the water remaining in the filter housing into the same plastic bag.

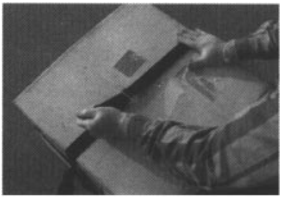


13 Seal the plastic sample bag and place it inside the second plastic sample bag.

Transfer the label or label information to the outside of the outer bag.

14 Put the bags containing the filter into the shipping container.

Place the ice packs around, but not on, the sample bag to prevent freezing the sample. You may want to insert several inflated, empty sample bags between the sample and the ice packs.



STEP 15 Seal the container and follow the laboratory's instructions related to the cleaning, storage, and return of sampling equipment.

STEP 16 Ship the container by overnight courier to the laboratory.

Call the laboratory and notify them of the sample shipment.

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SAMPLE COLLECTION PROCEDURES FOR DETECTING ENTERIC VIRUSES IN WATER

STEP 1 Each month, your laboratory will send you all of the equipment needed to collect samples for enteric virus analyses. When you receive the sampling kit, immediately check the contents of the carton. The sampling kit will be shipped as three modules, and should contain the following items:

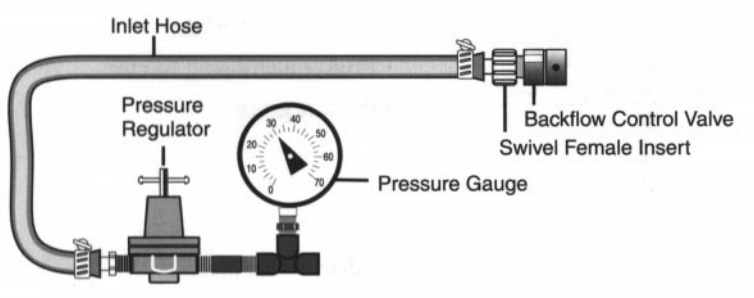
☐ Plastic sample bags

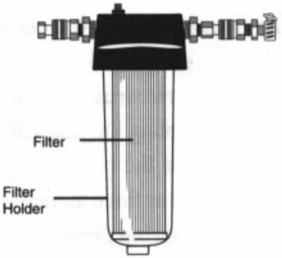
☐ Ice packs for shipping the collected samples

☐ Sample data sheet

☐ Regulator Module (below):

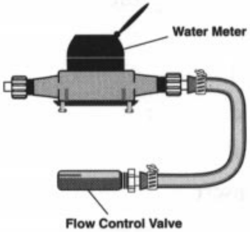
- Backflow control valve
- Swivel female insert
- Inlet hose
- Pressure regulator with pressure gauge





☐ Cartridge Housing Module:

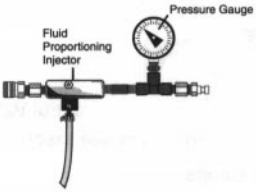
- 1-MDS Zetapor Virosorb filter inside a filter holder



☐ Discharge Module:

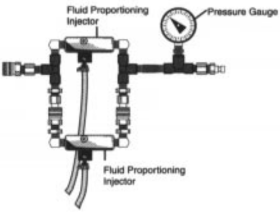
- Water meter
- Flow control valve

The laboratory will also ship three additional modular sections, as required by your facility. These may include:



☐ Single Injector Module:

- Fluid proportioning injector
- Pressure gauge

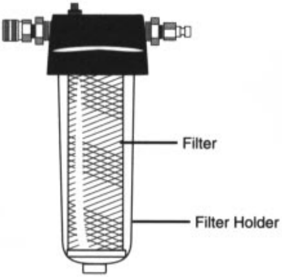


☐ Double Injector Module:

- Two fluid proportioning injectors, in parallel
- Pressure gauge

☐ Prefilter Module:

- 10 µm polypropylene filter inside a filter holder



❗ The ends of each module should be wrapped in foil to ensure that the equipment remains free of contamination. If your modules are unprotected or compromised, please contact your laboratory immediately for further instructions.

If you are missing any items, contact your laboratory immediately. Do not attempt to collect the samples without a complete sampling kit.

Once you have verified the contents of the sampling kit, place the ice packs in the freezer and repack the box.

COLLECTING SOURCE WATER SAMPLES

When you are ready to collect your virus sample, bring the following items with you to the sampling location:

☐ Shipping container sent by the laboratory
☐ Regulator Module
☐ Cartridge Housing Module
☐ Discharge Module
☐ Single Injector Module (for adding 0.1-molar hydrochloric acid to adjust pH, if necessary)
☐ Prefilter Module (for filtering sediment from highly turbid water, if necessary)
☐ Approximately 2 gal (4 L) of 0.1-molar hydrochloric acid solution (for adjusting pH, if necessary)
☐ Sterile, 250- or 500-mL graduated cylinder
☐ Plastic sample bags
☐ Sample data sheet
☐ Frozen ice packs
☐ Several pairs of new latex gloves
☐ pH meter
☐ Thermometer
☐ Turbidimeter

2 Turn on the water at the tap and allow the water to flow for 2 to 3 minutes or until any debris that has accumulated in the sampling line has cleared or the turbidity in the water becomes uniform.

3 Put on new latex gloves to prevent contamination from outside sources. Sterile technique must be used when sampling for enteric viruses. Any contamination of the sampling apparatus may bias the final results.

Turn off the water at the tap.

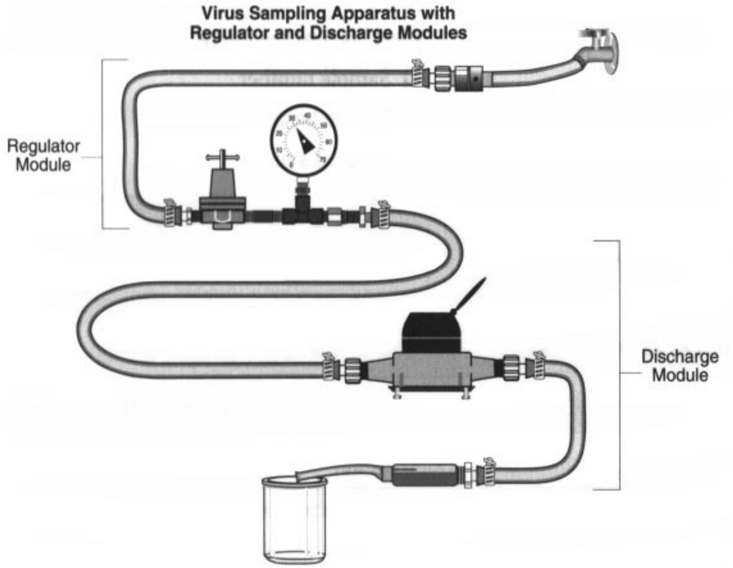
Remove the foil from the backflow regulator on the Regulator Module and connect it to the water tap or to an extension hose connected to the tap.

Remove the foil from the other end of the Regulator Module and from the Discharge Module. Connect the Discharge Module to the Regulator Module.

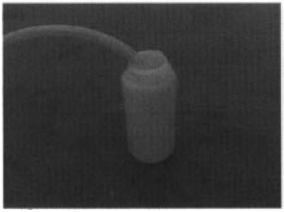
Place the end of the Discharge Module, or an extension hose connected to the Discharge Module, into a 1-liter plastic bottle.

Note the water meter reading, then slowly turn on the water.

Using the pressure regulator, adjust the water pressure to no more than 30 psi.


Virus Sampling Apparatus with Regulator and Discharge Modules

4 Flush the sampling apparatus with 20 gallons / 76 liters of water by allowing the water to flow through the system, out the effluent hose into the 1-liter plastic bottle.



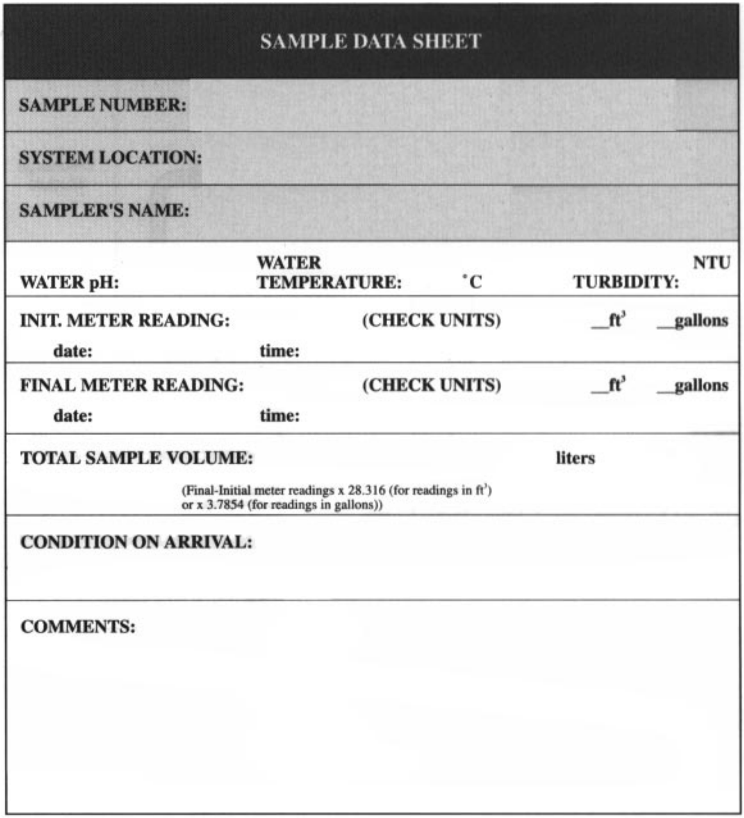
Sampling Step	Volume In GALLONS	Volume In LITERS	Volume In FT^3
System Flush	20	76	2.7

While the water is flushing the sampling apparatus, begin completing your sample data sheet. Record the following information:

☐ Sample number

☐ System location

☐ Sampler's name



SAMPLE DATA SHEET

SAMPLE NUMBER:

SYSTEM LOCATION:

SAMPLER'S NAME:

WATER pH: **WATER TEMPERATURE:** °C **TURBIDITY:** NTU

INIT. METER READING: (CHECK UNITS) __ft³ __gallons
date: **time:**

FINAL METER READING: (CHECK UNITS) __ft³ __gallons
date: **time:**

TOTAL SAMPLE VOLUME: liters
(Final-Initial meter readings x 28.316 (for readings in ft³)
or x 3.7854 (for readings in gallons))

CONDITION ON ARRIVAL:

COMMENTS:

5 Measure the pH, temperature, and turbidity of the source water flowing from the effluent hose. Record the readings on the sample data sheet.

SAMPLE DATA SHEET

SAMPLE NUMBER:

SYSTEM LOCATION:

SAMPLER'S NAME:

WATER pH: **WATER TEMPERATURE:** °C **TURBIDITY:** NTU

INIT. METER READING: **(CHECK UNITS)** __ft^3 __gallons
date: **time:**

FINAL METER READING: **(CHECK UNITS)** __ft^3 __gallons
date: **time:**

TOTAL SAMPLE VOLUME: **liters**
(Final-Initial meter readings x 28.316 (for readings in ft^3) or x 3.7854 (for readings in gallons))

CONDITION ON ARRIVAL:

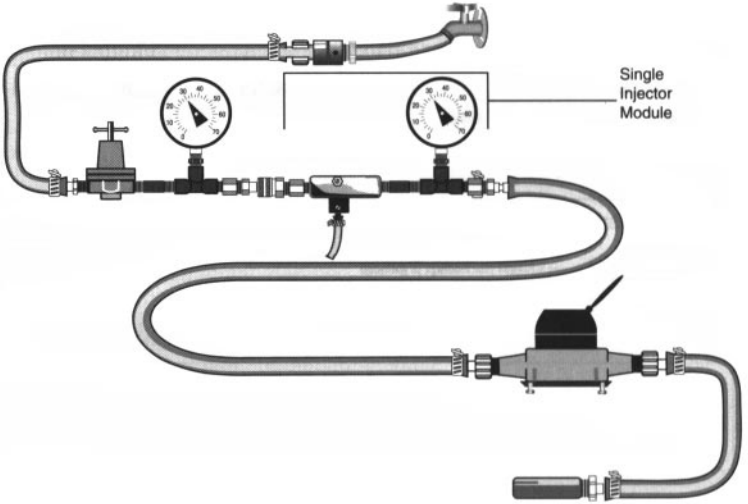
COMMENTS:

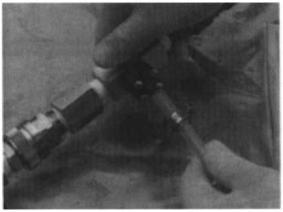
6 Turn off the water at the tap and decide whether you need to insert additional modules into the sampling train.

For source water sampling, you may need to use the Single Injector Module and/or the Prefilter Module.

First, determine if you need to use the Single Injector Module.

If your pH value is greater than 8.0, you need to insert the Single Injector Module between the Regulator and Discharge Modules before proceeding.

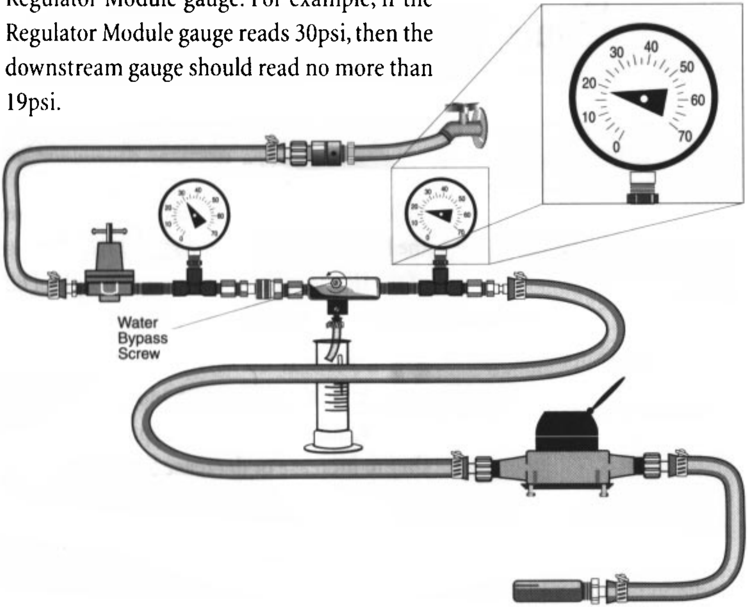


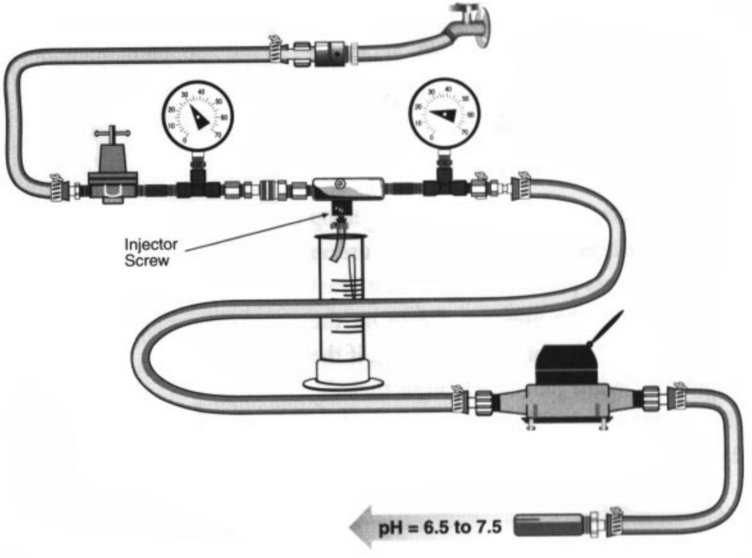


Using aseptic technique, connect the sterile tubing to the injector. Fill the sterile graduated cylinder with 0.1-molar HCl and place the tube in the graduated cylinder.

Turn on the water at the tap.

Using the water bypass screw—the larger top screw in the injector—adjust the pressure on the downstream pressure gauge to be at least 35% less than the pressure shown on the Regulator Module gauge. For example, if the Regulator Module gauge reads 30psi, then the downstream gauge should read no more than 19psi.





Adjust the smaller injector screw, located on the bottom of the injector, so that the flow rate of the HCl is sufficient to maintain a pH of 6.5 to 7.5.

❗ If there is no suction visibly drawing down the HCl, or if too much HCl is flowing, adjust the water bypass screw further to increase or decrease the pressure differential between the two gauges. A greater differential between the upstream gauges increases the flow rate; a smaller differential decreases the flow rate.

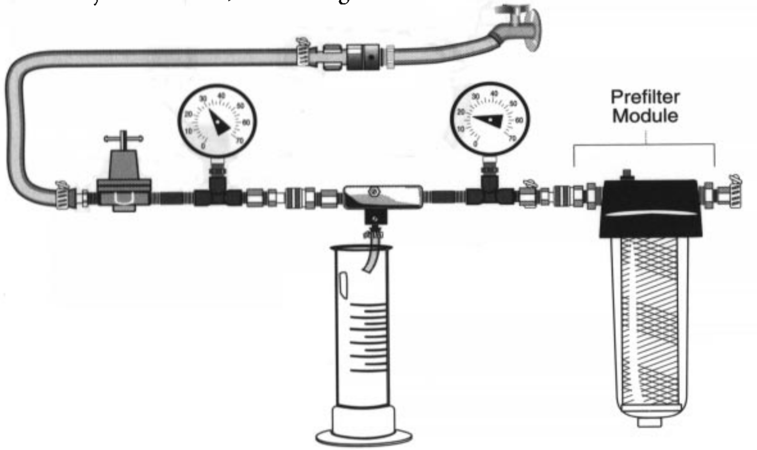
After the HCl flow rate is adjusted properly, transfer the injector tube to a carboy of HCl. Periodically check the pH to ensure that sufficient HCl is being added to maintain a pH of 6.5 to 7.5.

Record the adjusted pH on the Sample Data Sheet.

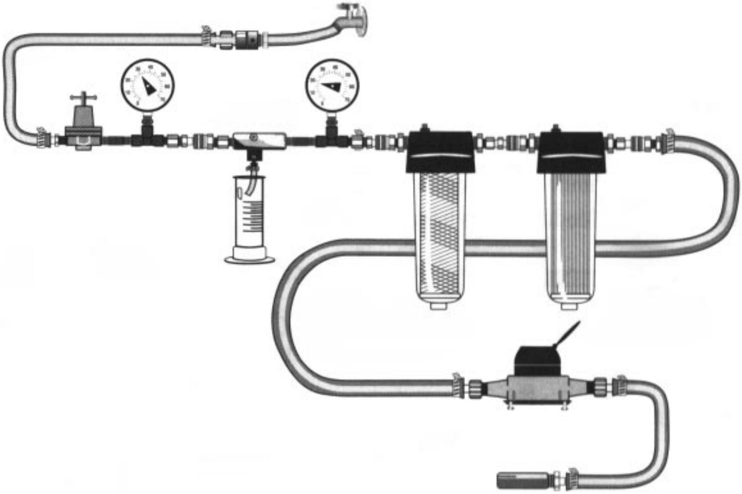
Next, determine if you need to use the Prefilter Module.

Turn off the water at the tap, and note the turbidity. If the turbidity is greater than 75 NTU, or for conditions where the 1-MDS filter is expected to clog before sampling is completed, you will need to use the Prefilter Module.

Disconnect the Discharge Module and connect the Prefilter Module to the Regulator Module or the Injector Module, if it is being used.



7 Connect the Cartridge Housing Module containing the 1-MDS filter to the Prefilter Module. Then, reconnect the Discharge Module to the outlet end of the Cartridge Housing Module.



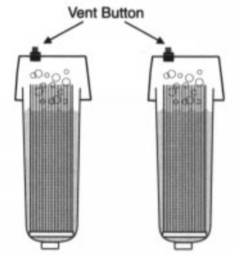
Record the following information on the Sample Data Sheet:

☐ Date sampling started

☐ Time sampling started

☐ Initial water meter reading (including units)

SAMPLE DATA SHEET			
SAMPLE NUMBER:			
SYSTEM LOCATION:			
SAMPLER'S NAME:			
WATER pH:	**WATER TEMPERATURE: °C**		**TURBIDITY: NTU**
INIT. METER READING: **date:**	**time:**	**(CHECK UNITS)**	**__ft³ __gallons**
FINAL METER READING: **date:**	**time:**	**(CHECK UNITS)**	**__ft³ __gallons**
TOTAL SAMPLE VOLUME:	(Final-Initial meter readings x 28.316 (for readings in ft³) or x 3.7854 (for readings in gallons))	**liters**	
CONDITION ON ARRIVAL:			
COMMENTS:			



STEP 8

Slowly, start the water flowing through the sampling apparatus.

Push the red vent buttons on top of the filter housings to expel air in the filters. When the air is totally expelled from the filters, release the button and open the water tap completely.

Using the pressure regulator on the Regulator Module, adjust the pressure regulator to no more than 30 psi.

Using the water bypass screw on the injector, adjust the pressure regulator on the Single Injector Module to be at least 35% less than the pressure shown on the Regulator Module gauge.

Allow 53 - 80 gallons / 200 - 300 liters of water to pass through the filter.

Sampling Step	**Volume In GALLONS**	**Volume In LITERS**	**Volume In FT^3**
Sampling Source Water	53 - 80	200 - 300	7 - 11

!

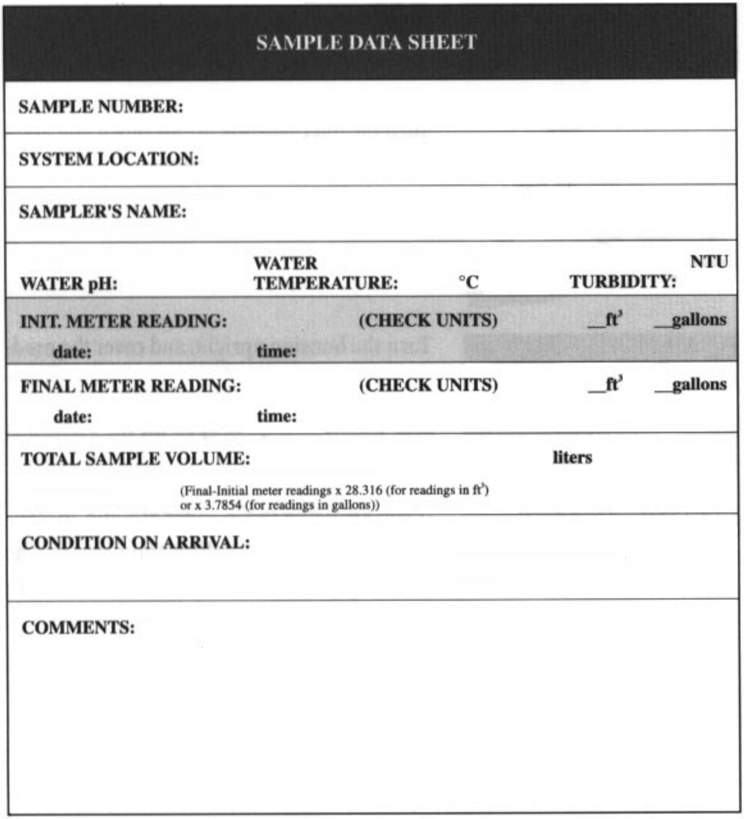
If the virus filter clogs before 53 gallons/ 100 liters are collected, contact the approved analyst at your laboratory for further instructions.

STEP 9

When the water meter indicates that 53 - 80 gallons / 200 - 300 liters of water have passed through the filter, turn off the water at the tap.

Record the following information on the Sample Data Sheet:

- ☐ Date sampling ended
- ☐ Time sampling ended
- ☐ Final water meter reading (including units)



SAMPLE DATA SHEET

SAMPLE NUMBER:

SYSTEM LOCATION:

SAMPLER'S NAME:

WATER pH: **WATER TEMPERATURE:** **°C** **TURBIDITY:** **NTU**

INIT. METER READING: **(CHECK UNITS)** **_ft^3** **_gallons**
date: **time:**

FINAL METER READING: **(CHECK UNITS)** **_ft^3** **_gallons**
date: **time:**

TOTAL SAMPLE VOLUME: **liters**
(Final-Initial meter readings x 28.316 (for readings in ft^3) or x 3.7854 (for readings in gallons))

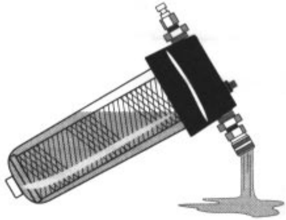
CONDITION ON ARRIVAL:

COMMENTS:

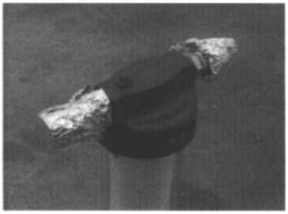
Put on fresh latex gloves.

Carefully, disconnect the sampling apparatus from the water tap.

Disconnect the Cartridge Housing Module from the sampling train.



Turn the filter housing upside down and allow excess water to flow out as waste water.



Turn the housing upright, and cover the module ends with sterile foil.

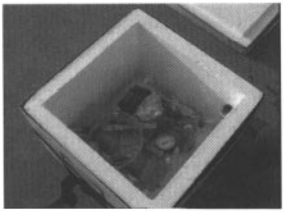
Do not attempt to open the filter housing.

If you are using the Prefilter Module, disconnect it from the sampling train, repeat the draining procedure, and cover the module ends with sterile foil.

The filters and filter housings are shipped to the laboratory intact. The Discharge Module may be retained at the utility and reused.

Place the filter housings into an insulated shipping box.

Set the ice packs around the housings.



Return the Regulator Module and the Injector Module to the laboratory for cleaning and sterilization.

Place the Sample Data Sheet in a plastic bag and pack it on top of the sampling apparatus.

You may need to use additional packing material to ensure that the contents of the box will not shift during transport.

11 Seal the container and ship it by overnight courier to the laboratory. Call the laboratory and notify them of the sample shipment.

COLLECTING FINISHED WATER SAMPLES

1 If the concentration of any pathogen in your source water samples exceeds 1 per liter during the first 12 months of sampling, then you must monitor finished water as well as source water.

Sampling of finished water begins in the same manner as sampling of source water described previously, as follows:

When you are ready to collect your finished water virus sample, bring the following items with you to the sampling location:

☐ Shipping container sent by the laboratory

☐ Regulator Module

☐ Cartridge Housing Module

☐ Discharge Module

☐ Single Injector Module (for adding 2% thiosulfate solution to neutralize effects of chlorination or other disinfectant treatments)

☐ Double Injector Module (for adding 2% thiosulfate solution to neutralize effects of chlorination or other disinfectant treatments while adding 0.1-molar hydrochloric acid to adjust pH, if necessary)

☐ Approximately 2 gal (4 L) of 2% sodium thiosulfate solution

☐ Approximately 2 gal (4 L) of 0.1-molar hydrochloric acid solution (for adjusting pH, if necessary)

☐ 2 sterile, 250- or 500-mL graduated cylinders

☐ Plastic sample bags

☐ Sample data sheet

☐ Frozen ice packs

☐ Several pairs of new latex gloves

☐ pH meter

☐ Thermometer

2 Turn on the water at the tap and allow the water to flow for 2 to 3 minutes or until any debris that has accumulated in the sampling line has cleared or the turbidity in the water becomes uniform.

Turn off the water at the tap.

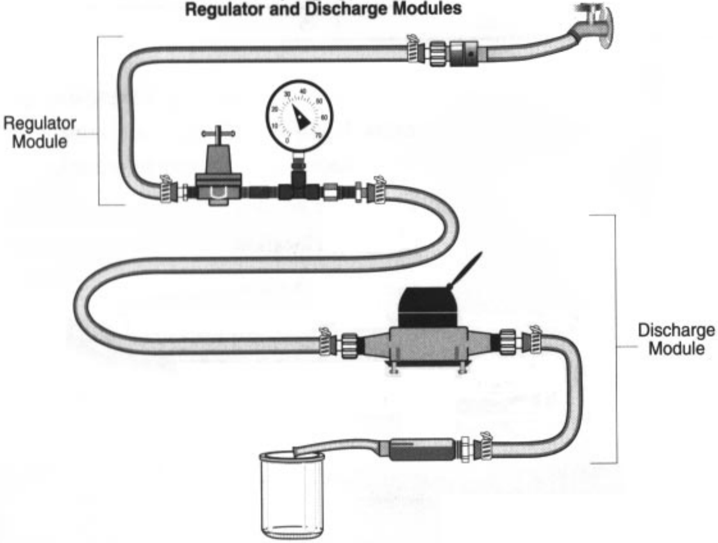
3 Put on new latex gloves to prevent contamination from outside sources. Sterile technique must be used when sampling for enteric viruses. Any contamination of the sampling apparatus may bias the final results.

Remove the foil from the backflow regulator on the Regulator Module and connect the module to the water tap or to an extension hose connected to the tap.

Remove the foil from the other end of the Regulator Module and from the Discharge Module and connect the Discharge Module to the Regulator Module.

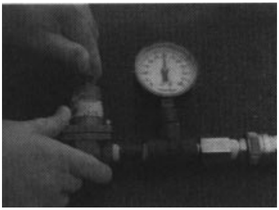
Place the end of the Discharge Module, or an extension hose connected to the Discharge Module, into a 1-liter plastic bottle.

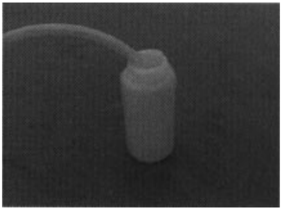
Virus Sampling Apparatus with Regulator and Discharge Modules



Note the water meter reading, then slowly turn on the water.

Using the pressure regulator, adjust the water pressure to no more than 30 psi.



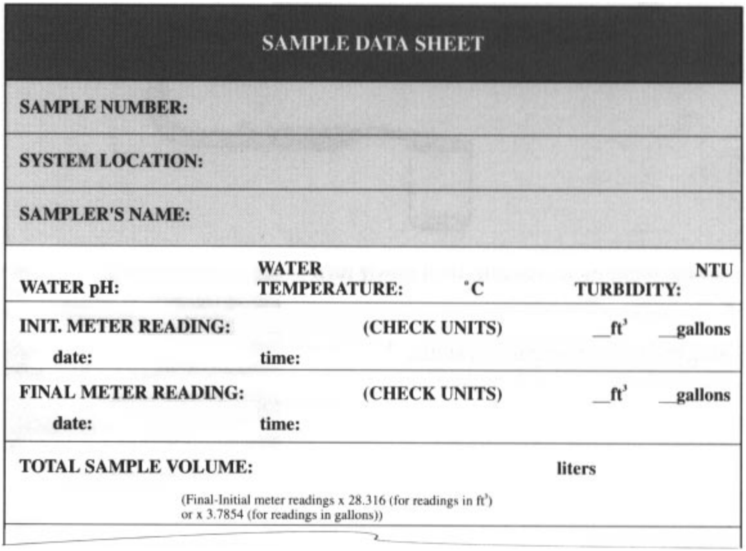


STEP 4 Flush the sampling apparatus with 20 gallons / 76 liters of water by allowing the water to flow through the system, out the effluent hose into the 1-liter plastic bottle.

Sampling Step	Volume In GALLONS	Volume In LITERS	Volume In FT^3
System Flush	20	76	2.7

While the water is flushing the sampling apparatus, begin completing your sample data sheet. Record the following information:

☐ Sample number
☐ System location
☐ Sampler's name



SAMPLE DATA SHEET

SAMPLE NUMBER:

SYSTEM LOCATION:

SAMPLER'S NAME:

WATER pH: **WATER TEMPERATURE:** °C **TURBIDITY:** NTU

INIT. METER READING: (CHECK UNITS) _ft^3 _gallons
date: time:

FINAL METER READING: (CHECK UNITS) _ft^3 _gallons
date: time:

TOTAL SAMPLE VOLUME: liters
(Final-Initial meter readings x 28.316 (for readings in ft^3) or x 3.7854 (for readings in gallons))

5 Measure the pH, temperature, and turbidity of the source water flowing from the effluent hose. Record the readings on the sample data sheet.

SAMPLE DATA SHEET

SAMPLE NUMBER:

SYSTEM LOCATION:

SAMPLER'S NAME:

WATER pH: **WATER TEMPERATURE:** °C **TURBIDITY:** NTU

INIT. METER READING: **(CHECK UNITS)** __ft³ __gallons
date: **time:**

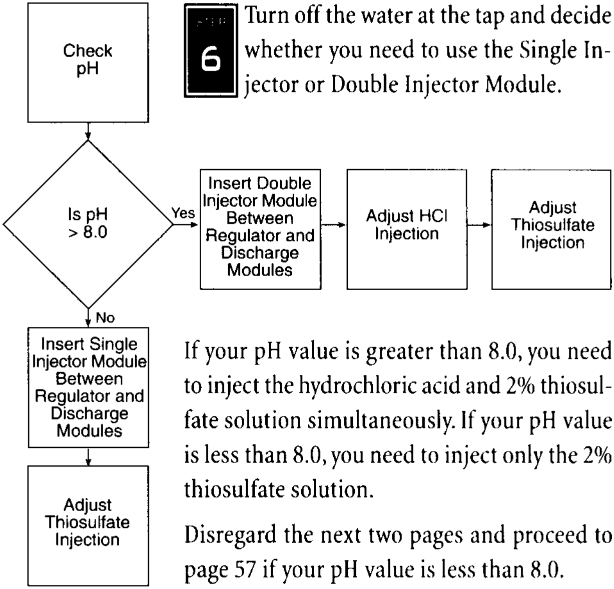
FINAL METER READING: **(CHECK UNITS)** __ft³ __gallons
date: **time:**

TOTAL SAMPLE VOLUME: **liters**
(Final-Initial meter readings x 28.316 (for readings in ft³)
or x 3.7854 (for readings in gallons))

CONDITION ON ARRIVAL:

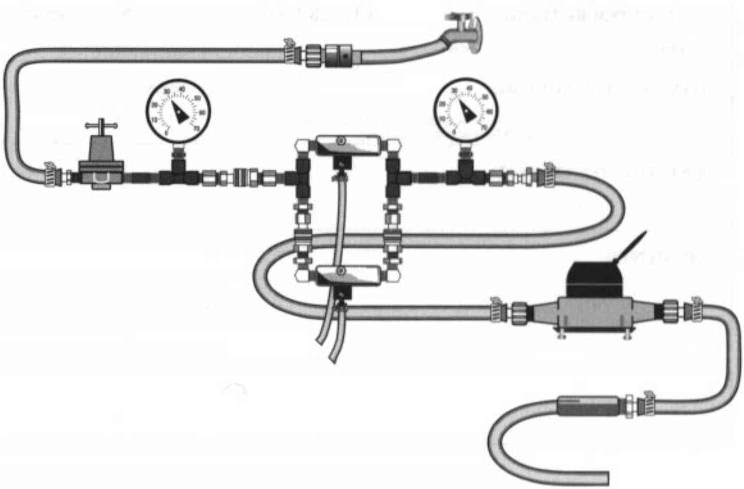
COMMENTS:

STEP 6 Turn off the water at the tap and decide whether you need to use the Single Injector or Double Injector Module.



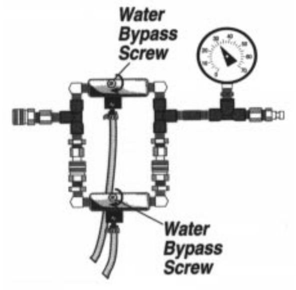
If your pH value is greater than 8.0, you need to inject the hydrochloric acid and 2% thiosulfate solution simultaneously. If your pH value is less than 8.0, you need to inject only the 2% thiosulfate solution.

Disregard the next two pages and proceed to page 57 if your pH value is less than 8.0.



pH > 8.0 Insert the Double Injector Module between the Regulator and Discharge Modules before proceeding.

! Ensure that both injectors are completely closed before proceeding.

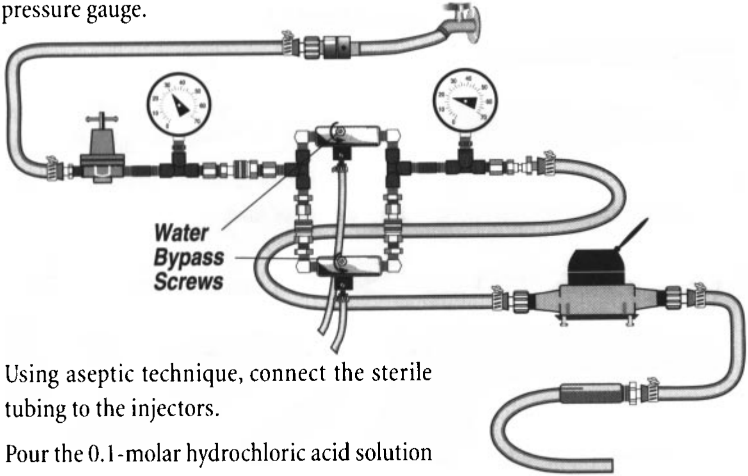


Adjust the water bypass screws on each injector clockwise as far as possible.

Turn on the water.

Next, turn each of the screws one half turn counterclockwise.

Continue opening the water bypass screws in half-turn increments until the reading on the second pressure gauge is approximately 35% less than that shown on the Regulator Module pressure gauge.



Using aseptic technique, connect the sterile tubing to the injectors.

Pour the 0.1-molar hydrochloric acid solution into a sterile graduated cylinder and place one of the injector tubes into it.

Pour the 2% thiosulfate solution into a second, sterile graduated container. Place the tube from the second injector into the thiosulfate solution.

❗ If there is no suction visibly drawing down the 2% thiosulfate or the HCl, or if too much is flowing, adjust the water bypass screws further to increase or decrease the pressure differential between the two gauges, until the flow is regulated properly.

Adjust the smaller injector screw on the hydrochloric acid injector to add sufficient hydrochloric acid to maintain a pH of 6.5 to 7.5.

After adjusting the injector, transfer the injector tube to the carboy of 0.1-molar hydrochloric acid. As sampling proceeds, periodically check the pH to ensure that it remains between 6.5 and 7.5.

Record the adjusted pH on the Sample Data Sheet.

Next, using the formula below, calculate the rate of thiosulfate injection and adjust the thiosulfate injector to deliver 10 mL of thiosulfate per gallon of flow.

$$\begin{pmatrix}\text{Water}\\ \text{Flow}\\ \text{Rate}\end{pmatrix}\frac{\text{gallons}}{\text{minute}} \times \frac{\text{10 ml Thiosulfate}}{\text{1 gallon water}} = \begin{pmatrix}\text{Thiosulfate}\\ \text{Injection Rate}\end{pmatrix}\frac{\text{ml}}{\text{minute}}$$

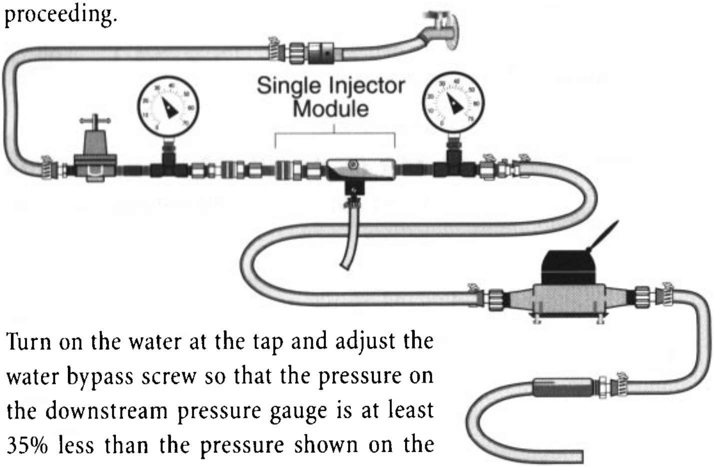
After the thiosulfate flow rate is adjusted, transfer the injector tube to the carboy of thiosulfate.

Monitor the thiosulfate flow rate visually throughout sampling.

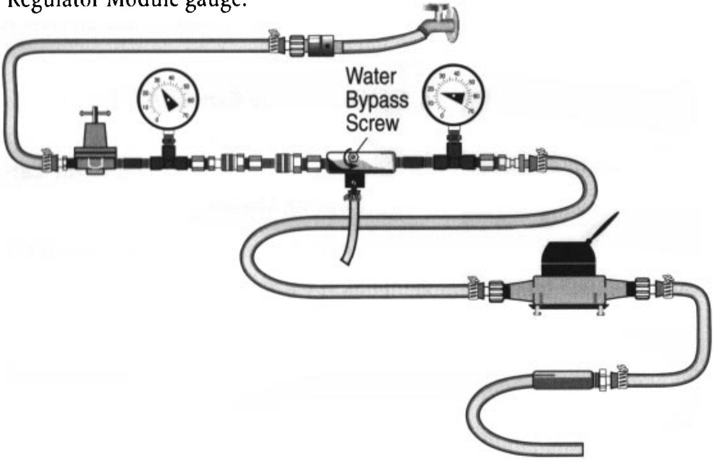
Disregard the next section and proceed to step 7 (page 58).

pH < 8.0 If your pH value is less than 8.0, it does not need to be adjusted, and you can use the Single Injector Module to inject the 2% sodium thiosulfate solution.

Insert the Single Injector Module between the Regulator and Discharge Modules before proceeding.



Turn on the water at the tap and adjust the water bypass screw so that the pressure on the downstream pressure gauge is at least 35% less than the pressure shown on the Regulator Module gauge.



Pour the 2% thiosulfate into a graduated cylinder.

Next, using the formula below, calculate the rate of thiosulfate injection and adjust the thiosulfate injector to deliver 10 mL of thiosulfate per gallon of flow.

$$\left(\begin{array}{c}\text{Water}\\ \text{Flow}\\ \text{Rate}\end{array}\right)\frac{\text{gallons}}{\text{minute}} \times \frac{\text{10 ml Thiosulfate}}{\text{1 gallon water}} = \left(\begin{array}{c}\text{Thiosulfate}\\ \text{Injection Rate}\end{array}\right)\frac{\text{ml}}{\text{minute}}$$

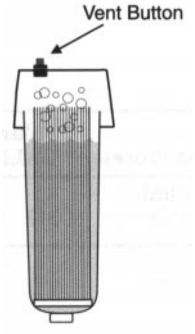
After the thiosulfate flow rate is adjusted, transfer the injector tube to the carboy of thiosulfate.

Monitor the thiosulfate flow rate visually throughout sampling.

! If there is no suction visibly drawing down the thiosulfate, or if too much is flowing, adjust the water bypass screw further to increase or decrease the pressure differential between the two gauges, until the flow is regulated properly.

STEP 7 Connect the Cartridge Housing Module. Then reconnect the Discharge Module to the outlet end of the Cartridge Housing Module.

Slowly, start the water flowing through the sampling apparatus.



Push the red vent button on top of the filter housing to expel air in the filter. When the air is totally expelled from the filter, release the button and open the water tap completely.

Using the pressure regulator on the Regulator Module, adjust the pressure to no more than 30 psi.

Using the water bypass screw on the injector, adjust the pressure gauge on the Single Injector Module to be at least 35% less than the pressure shown on the Regulator Module gauge .

Record the following information on the Sample Data Sheet:

☐ Date sampling started
☐ Time sampling started
☐ Initial water meter reading (including units)

SAMPLE DATA SHEET			
SAMPLE NUMBER:			
SYSTEM LOCATION:			
SAMPLER'S NAME:			
WATER pH:	**WATER TEMPERATURE:** °C	**TURBIDITY:**	**NTU**
INIT. METER READING: **date:**	**(CHECK UNITS)** **time:**	__ft^3	__**gallons**
FINAL METER READING: **date:**	**(CHECK UNITS)** **time:**	__ft^3	__**gallons**
TOTAL SAMPLE VOLUME:	(Final-Initial meter readings x 28.316 (for readings in ft^3) or x 3.7854 (for readings in gallons))	**liters**	
CONDITION ON ARRIVAL:			

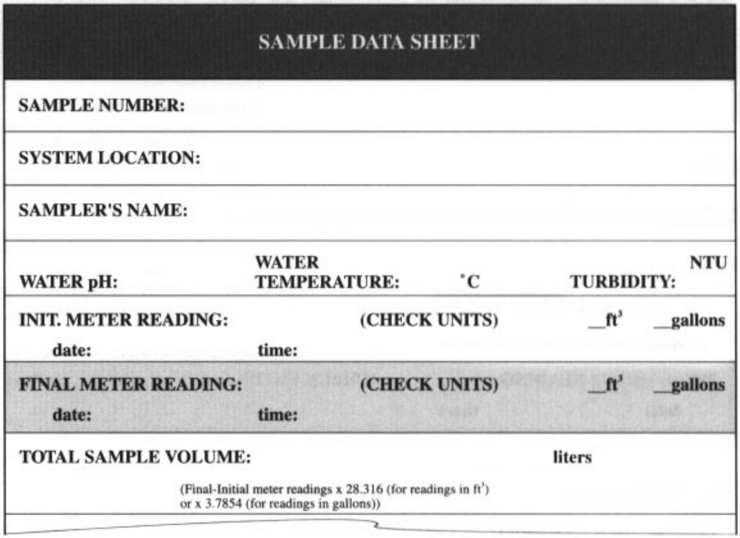
STEP 8 Collect 317 - 396 gallons or 1200 to 1500 liters of finished water.

Sampling Process	Volume In GALLONS	Volume In LITERS	Volume In FT^3
Virus Finished Water Sample	317 - 396	1200 - 1500	43 - 53

STEP 9 When the water meter indicates that 317 - 396 gallons / 1200 - 1500 liters of water have passed through the filter, turn off the water at the tap.

Record the following information on the Sample Data Sheet:

- ☐ Date sampling ended
- ☐ Time sampling ended
- ☐ Final water meter reading (including units)



SAMPLE DATA SHEET

SAMPLE NUMBER:

SYSTEM LOCATION:

SAMPLER'S NAME:

WATER pH: WATER TEMPERATURE: °C TURBIDITY: NTU

INIT. METER READING: (CHECK UNITS) __ft³ __gallons
date: time:

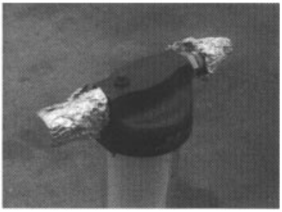
FINAL METER READING: (CHECK UNITS) __ft³ __gallons
date: time:

TOTAL SAMPLE VOLUME: liters
(Final-Initial meter readings x 28.316 (for readings in ft³) or x 3.7854 (for readings in gallons))

Put on fresh latex gloves.

Carefully, disconnect the sampling apparatus from the water tap.

Disconnect the Cartridge Housing Module from the sampling train. Turn the filter housing upside down and allow excess water to flow out as waste water.



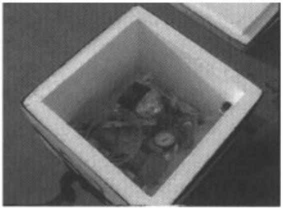
Turn the housing upright, and cover the module ends with sterile foil.

Do not attempt to open the filter housing.

The filter and filter housing are shipped to the laboratory intact. The Discharge Module may be retained at the utility and reused.

STEP 10

Place the filter housing into an insulated shipping box.



Set the ice packs around the housing.

Return the Regulator Module and the Injector Module to the laboratory for cleaning and sterilization.

Place the Sample Data Sheet in a plastic bag and pack it on top of the sampling apparatus. Seal the container.

You may need to use additional packing material to ensure that the contents of the box will not shift during transport.

STEP 11 Ship the container by overnight courier to the laboratory. Call the laboratory and notify them of the sample shipment.

CREDITS AND ACKNOWLEDGMENTS

The use of Manufacturer Trade Names in the production does not constitute endorsement by the U.S. Environmental Protection Agency.

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Special thanks to the management and staff of the Fairfax County Water Authority.

APPENDIX K – Memorandum: *Findings and Recommendations of the Advanced Water Purification Facility Subcommittee Meeting,* November 15, 2010, NWRI

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NWRI National Water Research Institute

Joint Powers Agreement Members

Inland Empire Utilities Agency

Irvine Ranch Water District

Los Angeles Department of Water and Power

Orange County Sanitation District

Orange County Water District

West Basin Municipal Water District

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To: Ms**.** Marsi Steirer
Deputy Water Department Director
Public Utilities Department
City of San Diego
600 B Street, Suite 600
San Diego, CA 92101

From: James Crook, Ph.D., P.E.
Vice Chair, NWRI Independent Advisory Panel for the City of San Diego's Indirect Potable Reuse/Reservoir Augmentation Demonstration Project

Jeff Mosher
Executive Director
National Water Research Institute

Subject: Findings and Recommendations of the Advanced Water Purification Facility Subcommittee Meeting

Date: November 15, 2010

The NWRI Independent Advisory Panel (IAP) for the City of San Diego's Indirect Potable Reuse/Reservoir Augmentation Demonstration Project held an Advanced Water Purification Facility (AWPF) Subcommittee meeting on October 21, 2010, at the City of San Diego's Ocean Monitoring Laboratory in San Diego, California.

Specifically, the Subcommittee of the IAP was charged with the following:

- Review the Draft Testing and Monitoring (T&M) Plan for the Advanced Water Purification Demonstration Facility.
- Resolve key comments on the IAP Report (dated September 17, 2009) as related to the T&M Plan.
- Review key items requiring input from the IAP and California Department of Public Health (CDPH) on the Draft T&M Plan.
- Review the schedule for the approval of the T&M Plan.

Members of the Advanced Water Purification Facility Subcommittee include:

- *Subcommittee Chair:* James Crook, Ph.D., P.E., Water Reuse Consultant (Boston, MA)
- Joseph A. Cotruvo, Ph.D., Joseph Cotruvo Associates (Washington, D.C.)
- Richard Gersberg, Ph.D., San Diego State University (San Diego, CA)
- Audrey D. Levine, Ph.D., P.E., DEE, U.S. Environmental Protection Agency (Washington, D.C.)
- David R. Schubert, Ph.D., The Salk Institute for Biological Studies (La Jolla, CA)

Attendees of the subcommittee meeting are listed in Appendix A. The subcommittee meeting agenda is provided in Appendix B.

The subcommittee findings and recommendations, provided below, will be presented to the full IAP for approval and/or revisions at the next IAP meeting and may be modified prior to inclusion in the next IAP report.

FINDINGS AND RECOMMENDATIONS

The IAP Subcommittee would like to commend the City of San Diego for its efforts in developing a comprehensive T&M Plan for the AWPF and for organizing the Subcommittee to review this effort.

Treatment Process

- To ensure that the pilot testing provides robust data, it is important to integrate potential upstream changes into the overall testing program. It would be worthwhile to identify possible process upgrades that might impact water quality, such as changes in nutrient removal, disinfection, or filtration. Changes to the tertiary wastewater treatment process should be integrated into the testing program now to evaluate the complete range of water quality conditions that might impact the performance and operation of the AWPF. For example:
    - Changes in the type and dose of coagulant should be tested to evaluate water quality impacts, such as pH, conductivity, and mineral composition. As a minimum, the effects of ferric chloride coagulation, currently shown as optional, should be assessed along with other potential treatment modifications.
    - The technical and economic feasibility of conducting partial demineralization by electrodialysis reversal (EDR) should be assessed to optimize the use of reverse osmosis (RO) or identify opportunities to use it as a back-up or supplementary system. Since RO has the capacity to handle some increased total dissolved solids (TDS) loading, it is not clear whether upstream EDR provides enough additional benefits to plant operations to justify the additional expense.
    - The status of the existing filtration process should be evaluated in the context of projected upgrades or modifications. Since filtration will now be functioning as pretreatment for the microfiltration/ultrafiltration (MF/UF) process, its performance should be optimized in conjunction with the pilot testing.

- In recognition of the fact that the UV reactor in the pilot plant is not representative of the UV system to be used in the full-scale AWFP, the IAP recommends that verification of the log removal requirements for NDMA and 1,4-dioxane by the advanced oxidation process (AOP), as specified in the August 4, 2008 California Department of Public Health draft groundwater recharge regulations, be performed on the full-scale facility prior to implementation of the project.

- The IAP Subcommittee was presented with some pilot plant data relating to NDMA removal. This data set was very limited and should not be considered definitive at this time. The IAP would appreciate the opportunity to review additional data related to NDMA removal as it becomes available.

Water Stabilization

The stability of the product water is important to ensure the integrity of the pipeline from a microbial and corrosion perspective. It would be worthwhile to consider evaluating the options for controlling biofilm growth and corrosion. Using a pipe-loop study or annular reactor to evaluate microbial growth and the effectiveness of alternative control strategies could be a valuable complement to the pilot study once the system is operating at steady-state. These tests could be used to determine the extent to which a secondary disinfectant and/or corrosion control in addition to lime treatment is needed.

Water Quality

The IAP suggests that, except for water quality monitoring needed at startup of the AWPF to optimize the unit processes, water quality monitoring of the full-scale AWPF not begin until the system has been stabilized and is operating at steady-state conditions to obtain representative data.

Microbial

- The draft routine bacteria and virus surrogate monitoring plan proposes direct bacteria and virus monitoring using epifluorescence microscopy (with SYBR-green ATP measurements), which is not an approved method. Further, the analysis is expensive and does not determine organism viability. The IAP recommends that the use of epifluorescence microscopy for direct monitoring of bacteria and viruses not be included in the routine surrogate monitoring plan.

- For the component that calls for the direct monitoring of pathogens, the IAP concluded that, due to the well-known performance of the treatment train for pathogen removal and the substantial indicators analyses, monitoring for bacterial and viral pathogens may not necessary. However, the IAP recognizes the value of such monitoring from a public confidence perspective, and suggests that the proposed pathogen monitoring component be reevaluated at the next IAP meeting.

- The IAP suggests that it may be possible to reduce the monitoring frequency for *Cryptosporidium* (before and after MF/UF) by sampling for aerobic spores like *B. subtilis* as potential surrogates for *Cryptosporidium*. *B. subtilis* are much smaller than *Cryptosporidium* and, thus, would be a conservative indicator that can be analyzed quickly and inexpensively. *B. subtilis* analyses could be performed in conjunction with the *Cryptosporidium* studies, and more frequently as potential MF/UF process performance indicators. The use of aerobic spores would be appropriate if the spores survive the prior disinfection process. This would need to be evaluated.

Constituents of Emerging Concern (CECs)

- The major purpose for the design of the monitoring strategy should be to: 1) determine which constituents are likely to either break-through or not be removed; and 2) use the information obtained as a basis to identify surrogates for operational tracking purposes at different stages of treatment. Experience at Orange County Water District's Groundwater Replenishment System and other similar projects demonstrates that many chemicals (e.g., metals and other priority pollutants) are easily handled by the treatment train if any are in the treated wastewater influent to the advanced treatment plant. In addition, breakthroughs of some chemicals such as NDMA and 1,4-dioxane (and a few others) at ng/L levels are expected, and do not *per se* indicate significant health risks. The IAP recommends that San Diego design a monitoring strategy for the pilot program that collects sufficient numbers of samples to determine appropriate surrogates for managing the processes and also provides public confidence on the effectiveness of the treatment system.

- The IAP recommends that the draft strategy include an approach for selecting appropriate surrogate constituents. Initially, screening tests should be conducted for a suite of CECs that may be present in the influent wastewater. Based on the results of the screening studies, a set of surrogate parameters can be selected that could be linked back to the constituents in the wastewater. This study should be initiated after the treatment system has been running for perhaps a minimum of 4 months and is operating at steady-state conditions. The analytical list may be drawn from the City's currently proposed monitoring list of 90 CECs, as well as other sources. The parallel analyses of chemicals and surrogate candidates would include the feed water, before and after RO, and potentially, some chemicals that survive after the advanced oxidation process (AOP). This assessment is important since it will serve as the basis for process operating decisions in the full-scale plant.

- It is doubtful that contaminants will routinely break through at concentrations that have health significance, which is one of the reasons for focusing on surrogate analyses. The IAP disagrees with the SWRCB-sponsored report entitled "Final Report: Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water" that caffeine and triclosan should be considered as health-related; however, it may be advisable to include them for monitoring process performance. That report also included NDMA and 17 β-estradiol (although it is unlikely to survive the process). They, as well as many other chemicals, would represent potential health concerns if they occurred at higher than expected levels. Therefore, it is appropriate to have health advisory levels available in the event that any were detected.

- The IAP has some suggestions related to the monitoring strategy. DEET, carbamazepine, and primidone could be analyzed because they are ubiquitous in domestic wastewaters and refractory in nature. Among the other suggested chemicals, PFAAs might be candidates, even though their removal by RO has been well documented. 1,4-dioxane is also a good choice due to its known inefficient removal by RO. Chemicals included in the third Unregulated Contaminant Monitoring Rule, Cycle 3 (UCMR3) would best be addressed selectively, unless there is a regulatory requirement to analyze them. Chemicals like triclosan, caffeine, and sucralose and other artificial sweeteners are of no toxicological interest, but may be able to serve as surrogates. Hydrazine and quinoline are of little interest unless they are ubiquitous in the tertiary-treated wastewater and not readily removed by RO and/or AOP; hydrazine would likely not be well removed by RO, if present. Nicotine and cotinine could be considered for inclusion since they are cigarette-related and likely to be in sewage and of toxicity interest if at high enough levels in the finished water, although this is unlikely. They also are relatively low molecular weight molecules that could challenge RO, but not likely AOP. Extensive monitoring for the priority pollutants is of little value. Our understanding is that the Orange County Water District has had no detections in their extensive monitoring over several years. Perhaps a few samples could be analyzed for that group for verification and if the regulatory agencies require it. These types of analyses could also play a role in demonstrating the overall quality of the finished water to the public.

- The characteristics of wastewater can vary depending on the time of day and the loading to the wastewater treatment plant. For parameters that will be monitored using grab-samples, it is important to time sample collection to reflect the range of conditions that are likely (e.g., peak-flow, peak-loading, etc.). It is also important to ensure that the sampling program can yield statistically defensible results. Prior to initiating the routine sampling program, initial quality assurance studies should be conducted to determine the appropriate sample volumes (relates to detection limits), sampling frequency and timing, and which parameters should be monitored using grab-samples versus composite samples. The City should confer with San Diego Regional Water Quality Control Board (RWQCB) to get input on the parameters that should be measured using composite samples and whether the composites should be generated using a flow-weighted or time-based approach.

- Trihalomethanes (THMs) are a grouping of disinfection byproducts (DBPs) that are formed when chlorine is added to water containing organics. It is likely that DBPs are present in the wastewater at μg/L levels, and they may not be entirely removed by RO or AOP. THMs are currently regulated as a group at 80 μg/L in drinking water, and it is our understanding that the RWQCB may impose more stringent requirements. It is important to have a clear understanding of any current and proposed RWQCB requirements and incorporate these considerations into the testing program.

- The Orange County Water District has experienced inconsistencies in comparing the monitoring results from grab samples versus online measurements for TOC. Thus, the City should consider relying entirely on online TOC measurements as they would be more informative – and likely more accurate – than using grab samples.

- The IAP finds that although definitive nutrient requirements for phosphorus and nitrogen have not been determined by the RWQCB, narrative and numeric nutrient requirements already included in the Basin Plan for discharges to surface water (such as San Vicente Reservoir) may allow the use of a 0.1 mg/L total phosphorus goal to determine compliance. Using the nominal N:P ratio of 10:1 to determine compliance for total nitrogen, it is possible that a 1.0 mg/L goal may be promulgated for total nitrogen to prevent eutrophication of the reservoir. The presentations to the IAP by the City of San Diego and their consultants suggests that modifications of the existing treatment process to date at the North City Water Reclamation Plant enhance denitrification and lower nitrate levels has had some success, but nitrate levels are still somewhat above 10 mg/L in the tertiary effluent. Using an 80- to 90-percent removal value for nitrate (provided at the meeting by the City's consultants) as that potentially-achieved by the RO system may yield an effluent nitrate level above the potential compliance limit for discharge to the reservoir. Therefore, the IAP suggests that more attention be paid to the operation of the existing tertiary treatment plant at the North City Water Reclamation Plant (NCWRP) to try to maximize denitrification to achieve lower the nitrate levels in the tertiary-treated water (to well below 10 mg/L) in order to demonstrate that such compliance may be achieved by the AWPF under future effluent limitation scenarios.

Source Control

- The IAP acknowledges the City's efforts to identify potential contaminants of concern in the NCWRP watershed from industries, including pharmaceutical and research facilities.

- Because the opportunity exists for the discharge of (probably small) amounts of chemical, radioactive, and biological material into the wastewater stream, it is advisable to contact each industry, particularly pharmaceutical manufacturers, hospitals, and laboratories, to raise awareness in those industries that their discharges will be feed water to the AWPF that will process the wastewater to be used for potable reuse.

- The IAP is interested in hearing more about the City's source control program. The IAP requests that a presentation on the source control program be provided at the next IAP meeting.

Appendix A: Subcommittee Meeting Attendees

Subcommittee:

- *Subcommittee Chair:* James Crook, Ph.D., P.E., Water Reuse Consultant (Boston, MA)
- Joseph A. Cotruvo, Ph.D., Joseph Cotruvo Associates (Washington, D.C.)
- Richard Gersberg, Ph.D., San Diego State University (San Diego, CA)
- Audrey D. Levine, Ph.D., P.E., DEE, U.S. Environmental Protection Agency (Washington, D.C.)
- David R. Schubert, Ph.D., The Salk Institute for Biological Studies (La Jolla, CA)

National Water Research Institute:

- Jeff Mosher, Executive Director
- Gina Melin Vartanian, Outreach and Communications Manager

City of San Diego:

- Amy Dorman
- Jeffrey Pasek
- William Pearce
- Joseph Quicho
- Marsi Steirer
- Anthony Van

City of San Diego Consultants

- Greg Bradshaw, RMC Water and Environment
- Debra Burris, DDB Engineering, Inc.
- Jay DeCarolis, Operations and Testing Manager, MWH
- Randy Hill, P.E., Project Manager, CDM
- Tom Richardson, RMC Water and Environment
- Greg Watterau, Team Leader for Membranes and Desalination, CDM

California Department of Public Health

- Brian Bernados, P.E., Recycled Water and Treatment Technology Specialist
- Heather Collins, P.E., Section Chief, Drinking Water Program, Region V (San Bernardino)
- Cindy A. Forbes, P.E., Chief, Southern California Branch
- Bob Hultquist, P.E., Chief, Drinking Water Technical Operations Section (retired)
- Sean Sterchi, Division of Drinking Water and Environmental Management

California Regional Water Quality Control Board, San Diego Region

- Brian Kelley

Appendix B: Subcommittee Meeting Agenda

City of San Diego
Water Purification Demonstration Project
Advanced Water Purification Facility (AWP)
Independent Advisory Panel (IAP)/AWP Subcommittee Meeting

Proposed Meeting Agenda
October 21, 2010
(8:30 a.m. – 5:00 p.m.)

Meeting Location	**On-Site Contacts:**
City of San Diego's Environmental Monitoring & Technical Services (EMTS) Laboratory	Anthony Van (City) Cell: (619) 980-9512 Tom Richardson (RMC) Cell: (408) 239-6164

Goals of the Meeting

- Review the Draft Testing and Monitoring (T&M) Plan for the AWP Demonstration Facility.
- Resolve Comments on IAP Report related to the T&M Plan.
- Review Key Items Requiring input from IAP/CDPH on the Draft T&M Plan.
- Review schedule for approval of the T&M Plan.

Program		**Presenters**
8:30 am – 9:00 am	Welcome and Introduction	
	• Meeting Objectives	Marsi Steirer
	• T&M Plan Critical Path Schedule	Anthony Van
	• IAP's Role on T&M Plan	Jim Crook
	• Regulatory Context	Tom Richardson
9:00 am – 10:00 am	Overview of the Draft T&M Plan • Objectives • Materials and Methods • Process Operations, Activities and Schedule • AWP Facility Process Evaluation • Specialty Testing • QA/QC	Jay DeCarolis
10:00 am - 10:15 am	BREAK	
10:15 am - 1:00 pm	CDPH T&M Related Comments on IAP Final Report	

	• Overview of Comments/Proposed Solutions	Greg Wetterau
	• Open Discussion	All
Noon - 12:30 pm	WORKING LUNCH	
1:00 pm - 1:15 pm	BREAK	
1:15 pm – 2:30 pm	T&M Plan Approach Key Items Requiring IAP/CDPH Input	
	• AWP Facility Treated Water Quality Goals	Jay DeCarolis
	• Monitoring of Local Contaminants based on NCWRP Collection System Catchment Investigation	Tom Richardson
	• Proposed Framework for defining criteria that will drive sampling frequency requirements to achieved statistical certainty	Jay DeCarolis
2:30 pm - 2:40 pm	Wrap up Schedule Completion and Final Approval of T&M Plan	Anthony Van
2:40 pm – 5:00 pm	IAP Subcommittee Convene	Closed Session

THE CITY OF SAN DIEGO

April 4, 2011

Ms. Heather L. Collins, P.E.
California Department of Public Health
South Coast Regional Engineer
464 West 4th Street, Suite 437
San Bernardino, CA 92401

Dear Ms. Collins:

Subject: Water Purification Demonstration Project (WPDP) - Revised Draft Testing and Monitoring Plan (TMP) for the Advanced Water Purification (AWP) Facility

The City of San Diego Public Utilities Department (City) would like to thank the Department of Public Health (CDPH), Division of Drinking Water and Environmental Management team for assisting with the review of the subject Testing and Monitoring Plan submitted on December 2, 2010. Enclosed with this letter are the City's responses to CDPH comments, which were conveyed in your letter dated January 31, 2011.

Please contact me at (619) 533-4112 if you have any questions regarding our responses, or if you need additional information on our overall WPDP effort.

Sincerely,

Marsi A. Steirer
Deputy Director, Public Utilities Department

AV/ctc

Enclosures: 1. CDPH Letter dated January 31, 2011 – Detailed comments Water Purification Demonstration Project – Revised Draft Testing and Monitoring Plan for the Advanced Water Purification Facility.

2. City's responses to comments from CDPH letter dated January 31, 2011, regarding the Draft TMP of the AWP Facility.

DIVERSITY
BRINGS US ALL TOGETHER

Public Utilities Department
600 B Street, Suite 600, MS 906 • San Diego, CA 92101
Tel (619) 533-7595 Fax (619) 533-5325

cc: Cindy Forbes, Southern California Branch Chief, California Department of Public Health
Sean Sterchi, San Diego District Engineer, California Department of Public Health
Brian Bernados, Senior Sanitary Engineer - Technical Specialist, California Department of Public Health
Randy Barnard, Senior Sanitary Engineer - Technical Specialist, California Department of Public Health
Bob Hultquist, Annuitant - California Department of Public Health
David W. Gibson, Executive Officer, California Regional Water Quality Control Board
Jeff Mosher, Executive Director, National Water Research Institute
Amy Dorman, Senior Civil Engineer, City of San Diego, Public Utilities Department

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification (AWP) Facility
Draft Testing and Monitoring Plan (12/2/10)

Responses to comments from the California Department of Public Health, Division of Drinking Water and Environmental Management (letter dated January 31, 2011) regarding the Draft Testing and Monitoring (T&M) Plan of the AWP Facility are listed below.

Comment No. 1: Peroxide Dose

Comment Response.

The project team agrees with the CDPH recommendation. To clarify the peroxide doses (1 and 5 mg/L) presented on page 6-4 refer to doses proposed to be tested during the proposed NDMA / 1,4 dioxane spiking experiments only. The baseline peroxide dose proposed for normal operational will be 3 mg/L, based on the dose currently approved by CDPH for the OCWD Groundwater Replenishment System. The T&M plan will be revised accordingly. Response to Comment 6 is also relevant.

Comment No. 2: CEC Overview

Comment Response.

The project team agrees and will add sucralose and cotinine to the current 91 compound CEC list to be analyzed at all sampling locations as part of the initial feed water characterization monthly for the first four months (Table 5-5). Based on occurrence and removal data gained during the initial characterization period the list of compounds shown in Table 5-5 to be measured quarterly may be modified.

Comment Number 3: Trojan Phox UV System

Comment Response

As discussed during the IAP Sub-committee meeting on 10/21/10, the project team recognizes the UV/AOP system proposed for use in the Demonstration Facility will not provide the same electric power efficiency as a full scale system to produce a given product water quality. We anticipate the demonstration unit to be more conservative in determining the EEO, electrical energy per order reduction. Regardless, the City's goals do not include developing the design criteria for the full scale UV/AOP system. However one goal is to operate the Demo scale UV/AOP system to demonstrate that it is effective for achieving 1.2 log removal of NDMA and 0.5 log removal 1,4 dioxane on these source waters. In addition, data collected from the spiking experiments will be used to compare the EEO values from the demonstration unit with the EEO values from permitted / operating full scale systems.

Comment No. 4: Effectiveness of Advanced Oxidation Process

The project team agrees a targeted chemical indicator removal demonstration of the AOP to develop a relevant surrogate parameter should be included in the test plan. See Comment Response 5 for more information.

Comment No. 5: Surrogate Indicator Framework to establish efficacy in AOP
Comment Response
In general, the project team agrees with CDPH's recommendation to develop and implement the Surrogate/Indicator approach with some validation at full-scale. The steps recommended by CDPH to demonstrate efficacy of the advanced oxidation process along with the project team's response provided in italic follow:

1. Validation monitoring during start-up. ***Response:*** *Agreed.*

2. Compliance monitoring during full-scale operation for the first twelve months of operation. ***Response:*** *Agreed.*

3. On-going compliance monitoring after the first twelve months of operation ***Response:*** *Agreed.*

4. Identification of operational parameters that is suitable to demonstrate a measurable change of a viable continuous online surrogate parameter under normal operating conditions. ***Response:*** *See comment response 8.*

5. Conduct challenge (spiking) tests with select indicator compounds to determine removal differentials under normal operating conditions using ten compounds as listed in footnote 3. Response: ***Response:*** *The UV/AOP technology being demonstrated has been proven at many facilities to be a reliable technology for reducing NDMA and 1, 4 dioxane. The City has collected useful data in 2005 on the efficacy of UV/AOP on many of the indicators listed in the CDPH letter including the target compound of NDMA. The intent of the demonstration study is to collect more information on removal efficiencies of different membrane configurations and operation data for consideration for the potential full scale AWPF.*

   However, the project team understands the concept of using the indicator/surrogate approach for compliance monitoring is new and needs some validation. As such, the project team proposes to conduct one spiking experiment after the first quarter of testing is complete to demonstrate the removal of several indicator compounds with the removal of surrogate parameters (UVA, chloramines), which can be easily measured on a frequent basis. The indicator compounds to be included in the spiking experiment will be based on occurrence data collected in the feed and product water of the AOP process with the overall goal of selecting compounds that will serve as good indicator compounds representative of wide range of characteristics for ongoing monitoring. The project team will work closely with the project advisory team including Dr. Jorg Drewes and Dr. Shane Snyder to develop the list of compounds to be included in the CEC spiking experiment. Note: The

CEC spiking experiment will be conducted under the UV/AOP conditions determined from the NDMA, 1,4 dioxane spiking experiment that provide 1.2 log removal of NDMA and 0.5 log removal of 1,4 dioxane.

6. The identified performance indicators are then monitored during start up to determine removal efficiencies under normal operating conditions. ***Response:*** *Agreed.*

7. Differentials of surrogates and indicators should be developed according to the table presented on p. 3. ***Response:*** *Agreed.*

Response to additional comments on page 4:

- CDPH Comment: add S10 as an additional sampling location for initial characterization.

  Response: *The project team accepts this recommendation.*

- CDPH Comment: add triclosan, gemfibrozil, carbamazepine, dilantin, erymthromycin, iopromide, meprobamate, naproxen, primidone, sulfamethoxazole, TCEP and trimethroprim to the monitoring plan in Table 5-6 for weekly samples over four weeks, including S10.

  Response: *The team has evaluated past monitoring results and believes it is likely to detect compounds currently listed in Table 5-6. Adding additional compounds as suggested by CDPH is defeating the purpose of using a limited list of suitable indicator compounds, a concept that CDPH endorses. However, we do propose to monitor the compounds suggested by CDPH at the same locations (S1, S6, S9, S10) monthly for the first four months, which will provide insight on their occurrence level.*

- CDPH Comment: add clofibric acid, musk ketone, TCPP and TDCPP to compounds listed in Table I-2.

  Response: *Table I-2 was intended to include clofibric acid, TCPP and TDCPP and will be modified accordingly. Additional information on the occurrence and analytical methods for the CDPH recommended compounds for monitoring follow:*

  - ***Clofibric acid*** *is a metabolite of a blood-lipid regulator that is not administered in the U.S. anymore and therefore occurrence levels are very low. It is not expected that this compound is present in recycled water.*
  - ***Musk ketone*** *is a compound that is well amendable to oxidation. Since we have other compounds with similar properties project team recommend NOT adding this compound to Table I-2.*

- ***TCPP and TCDPP** are chlorinated flame retardants. We have the chlorinated flame retardant TCEP in our target list as a representative of this class of compounds. Since analytical (isotope) standards are not readily available for TCPP and TDCPP, accurate determination of these compounds in recycled water can be questioned.*

- CDPH Comment: requesting to develop a list of ten UV/AOP performance indicator compounds and monitor them monthly instead of quarterly.

  ***Response:** Based on results of the initial characterization sampling (Table 5-5) and CEC spiking experiment, the project team will select several indicator compounds for AOP performance monitoring that are present at quantifiable levels in the RO product water. The removal of these compounds will be correlated with surrogate removal including UVA and chloramines. The surrogates will be monitored daily. The project team recommends sampling the selected indicator compounds every other month and that this frequency of sampling provides a sufficient data set to assess performance.*

- CDPH is suggesting 3D TRASAR at location S10.
  Response: See comment response 11.

Comment No. 6: NDMA and 1,4 dioxane Spiking Experiment

Comment Response

As outlined in the Section 6.2.3, the main purpose of the spiking experiment to is to confirm the flow, power and peroxide dose settings of the UV/AOP system to achieve 1.2 log NDMA removal and 0.5 log removal of 1,4 dioxane. As the RO product water will not contain concentrations sufficient to demonstrate these log removals, spiking would be required. The project team recommends the experiments be conducted as it will establish the operating conditions under which all sampling events will be conducted. The results from the spiking experiments will also be used to calculate the EEO (electrical energy per order) removal for NDMA, for comparison to measured EEO values from full scale permitted UV/AOP systems including Orange County and West Basin.

The project team will conduct the spiking experiment using the baseline dose of 3 mg/L to demonstrate the AWPF achieves the same log reduction values of permitted and operating full scale AWT facilities including Orange County and West Basin. Data will also be collected at lower doses (1 or 2 mg/L) for informational purposes only. This will provide the City preliminary data that may serve as the basis future studies to determine optimal peroxide dose. It is believed the lower doses of peroxide even at low conversion efficiency might be sufficient for destruction of trace organic chemicals given the low demand in the RO permeate.

Comment No. 7: Grab-samples versus composite samples

Comment Response

CDPH is suggesting collecting sequential grab samples for certain analytes to assess diurnal variations. The team acknowledges that certain compounds are subject to diurnal variations however the diurnal variation at NCWRP may be less significant than the Tillman Plant due to differences in hydraulic detention time and other operating conditions. In response to the CDPH comment, the project team recommends conducting two 24 hour sampling events during the 12 month operating period to collect grab samples of the RO feed every 4 hours for the following <u>*preliminary list*</u> *of compounds:*

1. *Caffeine*
2. *Sucralose*
3. *Total nitrogen*
4. *Nitrate*
5. *1,4 dioxane*
6. *NDMA*
7. *Total phosphorus*

The above list may be modified based on occurrence data collected during the first 4 months.

Note: the project team recommends off-setting the increased analytical requirements related to the above sampling events by reducing the sample locations shown in Table 5-4 for parameters to be collected as 24 hour composite samples to only include locations S6 (RO Feed), S7 (RO 1 permeate), S8 (RO 2 permeate). In addition, the number of NDMA and sister compound samples proposed for measurement in Table 6-3 may be reduced.

The sampling frequency of "bi-weekly" refers to once every two weeks.

Comment No. 8: Grab Samples versus on-line

Comment Response

The current UV/AOP design incorporates 1 on-line UVA-254 analyzer to be located at the UV/AOP inlet (S9) for UV process control similar to the AOP system used at OCWD GWRS. While the project team agrees on-line monitoring of UVA in the feed and effluent may be useful there are several concerns:

- *Changes in UVA removal across the UV/AOP may fluctuate and be inconsistent over the course of operation;*
- *The unique calibration of each on-line unit may mask the actual UVA removal.*

Instead of adding an online UVA meter to the UV/AOP outlet, the project team recommends during the demonstration period to collect grab samples from UV/AOP feed and effluent and measuring UVA and total chloramines using desktop meters daily (using a 10 cm cell for more accuracy). This will allow a data set to be established to assess the viability of both surrogates for UV/AOP process performance validation and make recommendations for online measurements for the potential full scale AWPF.

Comment No. 9: NCWRP Operational Changes to Reduce Effluent Total Nitrogen
Comment Response
Trussell Technologies is currently working on the North City Water Reclamation Plant Denitrification Optimization Study to assess operational changes to reduce effluent nitrogen of the NCWRP. The City will address this item under separate correspondence by early May 2011.

Comment No. 10: Testing of RO Membranes
Comment Response
The intention of Section 3.6.1 is to require that all membranes used for the demonstration project undergo direct integrity testing by the manufacturer (via vacuum decay or pressure hold testing) prior to delivery to the site. The project team will be requesting the RO suppliers to provide a statement that membranes were selected randomly from a standard production lot. The requirement that membranes used for IPR projects achieve a specified pressure decay or pressure hold rate prior to installation is something the project team would like to further discuss with CDPH.

Comment No. 11: TRASAR Challenge Testing
Comment Response
The project team agrees challenge testing of the RO membranes using the TRASAR system may provide valuable insight to the potential use of this technology to provide assurance of RO membrane integrity and possibly AOP performance. However, at this time it is NOT intended to conduct this testing as part of the current demonstration project. The City may decide to conduct TRASAR testing as part of future evaluations outside the current scope of the demonstration project.

Comment No. 12: MS2 Virus Challenge Testing
Comment Response
The project team agrees challenge testing of the RO membranes using the MS2 in conjunction with TRASAR testing could provide valuable research for the water reuse industry. However, at this time it is not planned to request from CDPH virus removal credits for the RO system and therefore it is currently not planned to conduct MS2 challenge testing. This requirement may change during the 3rd Quarter once the regulatory requirements for the full scale project become more defined. At this time the City will re-assess the possibility of such testing.

CDPH

State of California—Health and Human Services Agency
California Department of Public Health

MARK B HORTON, MD, MSPH
Director

EDMUND G. BROWN JR.
Governor

January 31, 2011

Ms. Marsi Steirer
Deputy Director
City of San Diego Water Department
600 B Street, Suite 600
San Diego, CA 92101

Subject: Water Purification Demonstration Project - Revised Draft Testing and Monitoring Plan for the Advanced Water Purification (AWP) Facility

Dear Ms. Steirer:

The Department of Public Health, Division of Drinking Water and Environmental Management (Department) has reviewed the subject Testing and Monitoring Plan (TMP) submitted on December 2, 2010. Enclosed with this letter are comments on the TMP which was reviewed by our program staff.

The Department would like to thank you for allowing us additional time for our review and to provide comments on this plan. We look forward to working with your project team as this project develops.

If you have you have any comments regarding the content of this letter, please feel free to contact Brian Bernados at (619) 525-4497, Randy Barnard at (619) 525-4022, Sean Sterchi at (619) 525-4159, or myself at (909) 383-4328.

Very truly yours,

Heather L. Collins, P.E.
South Coast Regional Engineer
CDPH-DDWEM

Southern California Drinking Water Field Operations Branch, San Bernardino Region
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Internet Address: www.cdph.ca.gov

Enclosure - CDPH Detailed Comments Water Purification Demonstration Project - Revised Draft Testing and Monitoring Plan for the Advanced Water Purification (AWP) Facility

cc: David W. Gibson
Executive Officer
California Regional Water Quality Control Board
San Diego Region
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San Diego, CA 92123-4353

Mr. Jeffrey J. Mosher
National Water Research Institute
18700 Ward Street
P.O. Box 8096
Fountain Valley, CA 92728-8096

SUBJECT: City of San Diego - Water Purification Demonstration Project Revised Draft Testing and Monitoring Plan for the Advanced Water Purification (AWP) Facility

CDPH Drinking Water Program field and technical staff have reviewed the report referenced above and make the following comments:

Peroxide Dose

On Page 6-4, two doses are proposed for the AOP demonstration testing – one mg/L and five mg/L. On other pages other peroxide doses are mentioned. Please clarify. A dose target of one mg/L will be too low because the resultant creation of hydroxyl radicals will likely be too low to oxidize organic chemicals effectively. OCWD reports that approximately 13% of peroxide is converted to hydroxyl radicals; therefore, a higher dose should be used. CDPH recommends a dose level between 1-5 mg/L. We also would recommend that along with doses of 5 mg/l and 1 mg/l that you evaluate an additional dose between that range such as 2 or 3 mg/l. A dose of 3 mg/L is the target for current AOP projects. A strategy to develop the optimum operation of AOP and the proper dose of peroxide is important to meet the goals of the demonstration project. This will be especially important in order to address the issues regarding the AOP demonstration delineated below.

Constituents of Emerging Concern (CECs) - Overview

Findings and Recommendations of the Advanced Water Purification Facility Subcommittee Meeting, November 15, 2010 made the following comment,

> "The IAP has some suggestions related to the monitoring strategy. DEET, carbamazepine, and primidone could be analyzed because they are ubiquitous in domestic wastewaters and refractory in nature. Among the other suggested chemicals, PFAAs might be candidates, ... Chemicals like triclosan, caffeine, and sucralose and other artificial sweeteners are of no toxicological interest, but may be able to serve as surrogates. Hydrazine and quinoline are of little interest unless they are ubiquitous in the tertiary-treated wastewater and not readily removed by RO and/or AOP; hydrazine would likely not be well removed by RO, if present. Nicotine and cotinine could be considered for inclusion since they are cigarette-related and likely to be in sewage and of toxicity interest if at high enough levels in the finished water, although this is unlikely. They also are relatively low molecular weight molecules that could challenge RO, but not likely AOP."

Quarterly monitoring is proposed for these compounds in Table 5-5, except for sucralose and cotinine. CDPH recommends that they be added to Table 5-5. While sucralose is included in Table 5-6, it is to be sampled at different locations.

Trojan Phox UV system

November 30, 2010 Final Draft Testing and Monitoring Plan, Page 2-1 states the following:

> "Section 2.1 Testing and Monitoring Objectives The ultimate goal of testing and monitoring the AWP Facility is to generate the necessary data to support the regulatory approval and permitting of the proposed full-scale IPR/RA project. Specific objectives of the testing and monitoring component are provided in the following paragraphs." On Page 2-3, it states, "Validate the performance of AWP Facility unit processes using full-scale treatment equipment. . . The proposed UV/AOP demonstration system is the UV Phox Model 72AL75, which is a single chamber version of the

> reactors used at OCWD. During the initial phase of testing, the ability of the unit to achieve 1.2-log (93.7%) removal of N-Nitrosodimethylamine (NDMA) at a flow of 1 MGD will be verified. Results obtained during initial testing will establish the power setting at which to operate the system for the remainder of the operations period."

As noted previously, the Trojan Phox UV system at OCWD consists of three reactors (six chambers) per treatment train (8.75 MGD capacity). Essentially the demonstration project consists of one 72-lamp chamber that will have a lower flow, longer residence time and very different hydraulics than the full-scale; all of which affects AOP performance and efficiency. The issue of whether the results from a one-MGD demo can be used to predict actual full-scale performance, in regard to AOP, was noted in the *Final Report of the May 11-12, 2009, Meeting of the IAP,* which made the important point,

> "It is important that the unit provide treatment that will simulate the full-scale system and ensure that the UV dose is proportional to the flow. As full-scale units like the Trojan UV Phox system do not scale well"

Closed-vessel UV reactor systems are not designed to be scalable. *Final Report of the May 11-12, 2009, Meeting of the IAP* stated,

> "The scaling of the UV reactor design will require consulting with UV manufacturers. It may be possible to provide the same UV dose, but given reactor flow dynamics at different velocities, assuring the scalability of the UV system could be critical."

Since, the demonstration work will use a smaller reactor and the flow will be less than full-scale, the test plan must address flow dynamics and different velocities. While the test plan attempts to address these issues, CDPH has sufficient concerns to recommend a more targeted chemical indicator removal demonstration of the AOP to develop relevant surrogate parameters. Therefore, CDPH recommends the following Surrogate / Indicator Framework:[1]

Effectiveness of Advanced Oxidation Process

Based upon comments CDPH received from the public regarding the August 5, 2008 version of the *Groundwater Recharge Reuse DRAFT Regulation*, CDPH has been evaluating recent studies to assess the effectiveness of treatment technologies. Accordingly, CDPH is willing to consider alternative approaches to determine the efficacy of the AOP treatment train. While not necessarily the only alternative, a Surrogate / Indicator Framework should applied to this demonstration project.

Surrogate / Indicator Framework to establish efficacy in AOP

The relationship between process performance, online surrogates, and indicator chemical reduction shall be validated for advanced oxidation process. Initially, an occurrence study shall confirm detection of viable indicator compounds in the feed water to the unit process. Performance of the process shall be determined during three phases:

1. validation monitoring during piloting/start-up,
2. compliance monitoring during full-scale operation for the first twelve months of operation,
3. on-going compliance monitoring after the first twelve months of operation.

Operational parameters shall be proposed that demonstrate a measurable change of a viable continuous online surrogate parameter under normal operating conditions (i.e., UVA_{254}, fluorescence or ozone exposure)[2]. Challenge or spiking tests shall be conducted with select

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[1] Similar in concept to the San Diego IAP recommendations and the SWRCB-sponsored report entitled "*Final Report: Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water*":

[2] For example, a 50% removal of UVA_{254} measured pre-AOP and post AOP; a 50% reduction in fluorescence intensity, or an ozone CT = 10 mg/l-min.

indicator compounds to determine the removal differential under normal operating conditions. A minimum of ten indicator chemicals[3] shall be examined, during piloting/start-up, that exhibit both "good" and "intermediate" removal expected based upon research detailed in the categories below. An operational correlation shall be developed between the surrogate and the indicator. Operational parameters shall be evaluated that demonstrate a measurable change in the surrogate parameter (X_i) under normal operating conditions. In parallel, an occurrence study needs to be performed confirming detection ratios of viable indicator compounds in the feed water to the AOP. During piloting or start-up, challenge or spiking tests can be conducted with select indicator compounds (Y_i) to determine the removal differential ΔY_i under normal operating conditions.

Surrogate / indicator framework to establish efficacy in AOP		
	Surrogate Parameters	**Indicator Compounds**
Piloting and / or Start-up		
Step 1	Establish anticipated operational conditions of process; i.e., typical flow range, dosage application range, seasonal variation in critical water quality parameters, etc.	
Step 2	Select surrogate parameters that demonstrate a measurable change under normal operating conditions and quantify this differential $\Delta X_i = \lvert (X_{i,in}-X_{i,out}) \rvert$	Conduct occurrence study to confirm detection ratio of viable indicator compounds is in the feed water of unit process
Step 3		Conduct challenge or spiking study with ten representative indicator compounds during pilot- or start-up to determine the removal differentials under normal operating conditions $\Delta Y_i = (Y_{i,in}-Y_{i,out})/Y_{i,in}$
Step 4	Select viable surrogate and operational parameters for unit process	Select 3-5 indicator compounds from representative chemical structure categories with expected removal rates of 90% via AOP AND Select 3-5 indicator compounds from representative chemical structure categories with expected removal rates of 50-90% via AOP

Operational parameters shall be evaluated that demonstrate a measurable change surrogate parameter (X_i) under normal operating conditions. In parallel, an occurrence study needs to be performed confirming detection ratios of viable indicator compounds in the feed water to the unit process. During piloting or start-up of a new treatment process, challenge or spiking tests can be conducted with select indicator compounds (Y_i) to determine the removal differential ΔY_i under normal operating conditions.

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[3] If present, example indicators include caffeine, estradiol, NDMA, triclosan, DEET, gemfibrozil, iopromide, sucralose, BPA, carbamazepine, atenolol, clofibric acid, dilantin, ibuprofen, meprobamate, musk ketone, naproxen, primidone, sulfamethoxazole, TCEP, TCPP, TDCPP, and trimethroprim.

Example advanced oxidation treatment removal categories for indicator compounds And Structure
Typical Expected Good Removal > 90%[4]

Hydroxy Aromatic:	*Amino / Acylamino Aromatic:*	*Nonaromatic C=C:*	*Deprotonated Amine:*	*Alkoxy Polyaromatic:*	*Alkyl Aromatic:*
Acetominophen	Sulfamethoxazole	Acetyl cedrene	Atenolol	Naproxen	Benzophenone
Atorvastatin (o-hydroxy)	Atorvastatin	Carbamazepine	Caffeine	Propranolol	Benzyl acetate
Atorvastatin (p-hydroxy)	Triclocarban	Codeine	Diclofenac		Bucinal
Benzyl salicylate		Hexylcinnamaldehyde	EDTA	*Alkoxy Aromatic:*	DEET
Bisphenol A		Methyl ionine	Erythromycin-H_2O	Gemfibrozil	Dilantin
Estrone		OTNE	Fluoxetine	Hydrocodone	Dibutyl Phthalate
Hexyl salicylate		Simvastatin hydroxy	Metoprolol		Diphenhydramine
Isobutylparaben		Terpineol	Nicotine		Galaxolide
Methyl salicylate			Norfluoxetine		Ibuprofen
Nonylphenol			Ofloxacin		Indolebutyric acid
Oxybenzone			Paraxanthine		Primidone
Propylparaben			Pentoxifylline		Tonalide
Salicyclic acid			Trimethoprim		
Triclosan					
Clorfibric Acid					

Example advanced oxidation treatment removal categories for indicator compounds And Structure <90%

Typical Expected Intermediate Removal		Typical Expected Poor Removal	
90-50%		50-25%	< 25%
Saturated Aliphatic:	*Nitro Aromatic:*	*Nitrosamine:*	*Halogenated Aliphatic:*
Iopromide	Musk ketone	NDMA	Chloroform
Isobornyl acetate	Musk xylene		TCEP (Tris (2-chloroethyl) phosphate)
Meprobamate			TCPP (Tris (chloroisopropyl) phosphate)
Methyl dihydrojasmonate			TDCPP (Tris (1, 3-dichloropropyl) Phosphate)

November 30, 2010 Final Draft Testing and Monitoring Plan, Section 5.2.3 is generally in agreement with this approach; however, some modifications should be made as follows:

1. Add S10 in Table 5-6, sampling locations, under initial characterization (weekly for four weeks) for DEET, sucralose, NDMA, and caffeine.
2. Based upon IAP Sub-committee recommendations, chemical structures, and occurrence data from 2005 (Table 3-2), add triclosan, gemfibrozil, carbamazepine, dilantin, Erythromycin-H_2O, iopromide, meprobamate, naproxen, primidone, sulfamethoxazole,

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[4] Dickenson, Drewes, Sedlak, Wert, & Snyder. Applying Surrogates and Indicators to Assess Removal Efficiency of Trace Organic Chemicals during Chemical Oxidation of Wastewaters. *Environ. Sci. & Tech.* 2009, 43, 6242-6247.

TCEP (Tris (2-chloroethyl) phosphate), and trimethroprim to Table 5-6, initial characterization (weekly for four weeks), including sampling at S10.
3. Add clofibric acid, musk ketone, TCPP, and TDCPP to Table I-2.
4. Modify Table 5-6, On-going Monitoring to Assure UV/AOP Performance by adding monthly monitoring for approximately ten chemical indicators chosen based upon the initial four weeks of sampling in Table 5-6 and the initial four months of sampling in Table 5-5. Additionally, monitor UVA (or UVT) frequently, online if possible, at the time that the indicator monitoring is conducted.
5. Consider online monitoring using the 3D TRASAR at sample location S10 to evaluate fluorescence as a potential surrogate compared to UVA_{254}.

NDMA and 1,4-Dioxane Spiking Experiment
While the special monitoring proposed in Section 6.2 "NDMA and 1,4-Dioxane Spiking Experiment" may have some value, CDPH considers it of limited application to the full-scale project. As noted above, the UV system and AOP will not be tested under relevant flow and hydraulic conditions during the demonstration project. The results will not provide sufficient demonstration of the full-scale performance. Therefore, this special testing would need to be repeated at full-scale start-up. CDPH would consider deletion of this spiking experiment in favor of the "**Surrogate / indicator framework to establish efficacy in AOP**" detailed previously. One of the stated goals of the demonstration project is to develop applicable surrogates and indicators for full-scale application. If done properly, surrogates and indicators can be identified for this project that are known to occur and in which removal can indicate efficacy of the process performance.

NDMA and 1,4-Dioxane can be monitored on a frequent basis at full-scale to ensure that the effluent levels are below the Notification Levels. Additionally, NDMA formation can be reduced either via a source control program or via modification of upstream processes to decrease NDMA formation or precursors.

Grab-Samples Versus Composite Samples
Findings and Recommendations of the Advanced Water Purification Facility Subcommittee Meeting, November 15, 2010 made the following comment,

> "The characteristics of wastewater can vary depending on the time of day and the loading to the wastewater treatment plant. For parameters that will be monitored using grab-samples, it is important to time sample collection to reflect the range of conditions that are likely (e.g., peak-flow, peak-loading, etc.). . . .Prior to initiating the routine sampling program, initial quality assurance studies should be conducted to determine the appropriate sample volumes (relates to detection limits), sampling frequency and timing, and which parameters should be monitored using grab-samples versus composite samples."

While Table 5-4 specifies some composite samples (TOC, ammonia, nitrate, total nitrogen, and total phosphorus), other compounds should be considered, such as caffeine and sucralose, which could vary significantly based upon different times of the day. Since it has been shown via diurnal monitoring at the Tillman plant in LA that NDMA can vary widely throughout the day, NDMA grab-samples may not adequately characterize the diurnal effect. Therefore, CDPH recommends that additional focused sampling be performed to capture the diurnal effect. For NDMA, this may mean picking a 24-hour period in which to collect grab samples once every four hours. This should be repeated to confirm the diurnal effect. In general, CDPH recommends a similar 24-hour monitoring period for other important chemicals, such as nitrogen, nitrate, 1,4-dioxane, etc. With this data, a standard deviation or whisker plot can be developed to indicate the variability.

Additionally, Table 5-4 specifies "Bi-weekly" as the monitoring frequency for some constituents. Please clarify whether this means twice a week or once every two weeks.

Grab-Samples Versus Online
In Table 5-6, daily monitoring for UVA-254 nm is proposed. CDPH recommends online monitoring via a standard UVT analyzer as is commonly used in UV disinfection systems. This could serve as an online surrogate for AOP performance. Table 5-1 monitors UVT twice per day at the feed, but not at sample locations S9 and S10. Table 5-3 is confusing as both grab and online are noted for some surrogate parameters that are normally online.

NCWRP Operational Changes to Reduce Effluent Total Nitrogen
Page 3-5 to 3-6, Section 3.1.3.1 mentions the study to "assess improving the NCWRP recycled water quality by enhancing the plant's denitrification process (Trussell et al., 2010)." Please provide an update on this study and conclusions reached. CDPH is interested in which of the Trussell recommendations have been implemented or will be in the future. As stated in previous correspondence, CDPH recommends optimization of the treatment process. Additionally, the San Diego Regional Water Quality Control Board should be consulted.

Testing of RO Membranes Prior to Installation
Section 3.6 discusses the manufacturer testing prior to delivery. The RO suppliers should not hand pick the best membrane cartridges of the lot. Instead they should be randomly selected in order to indicate the performance of the average RO cartridge of the particular model. Therefore, manufacturers should supply a statement to that effect.

TRASAR Challenge Testing
Section 3.6.4 describes this potential monitoring tool. Previous piloting work in 2005 performed for the City of San Diego gave a reasonable indication that TRASAR® would provide a method to determine integrity of the RO membranes. CDPH is in favor of TRASAR® Challenge Testing, since direct integrity testing methods for RO have not been developed yet. If successful, the TRASAR® unit could provide assurance of membrane integrity, similar to the pressure decay tests used as a standard test for microfiltration and ultrafiltration type membranes.

TRASAR® is composed of fluorescent molecules. The trace leak detection (TLD) system detects TRASAR® by measuring fluorescence. Therefore, it may have potential application in monitoring other processes, including AOP.

MS2 Virus Challenge Testing
Page 3-19, Section 3.6.3 states,

> "Though it is not an objective of the testing plan to demonstrate the ability of the RO membranes to remove viruses, conducting virus challenge experiments is a powerful means of monitoring RO system integrity. Accordingly, an optional service for consideration, challenge experiments can be performed on each RO system during start up and upon completion of the target 5,000 hour test period."

While not necessarily required, CDPH would appreciate seeing and evaluating the outcome of any MS2 virus challenge testing performed on the RO processes. If this testing is performed, it could provide valuable research for the water reuse industry, especially in conjunction with membrane integrity testing such as the proposed TRASAR testing. It should be noted that if the City of San Diego would like to obtain credit for the virus removal capability of the RO process, such a MS2 virus challenge testing scheme may provide justification. It should be noted that CDPH is in the preliminary stages of developing new regulations for surface water augmentation with recycled water and new research is encouraged.

Since there is currently no accepted integrity test for RO, awarding credit for pathogen removal may not be feasible; however, CDPH is open to new demonstration work. Referring to the EPA Membrane Filtration Guidance Manual, integrity testing must meet requirements for resolution, sensitivity, and frequency. The sensitivity of a membrane module is defined as the maximum Log Removal Value that can be reliably verified by an integrity test, which must be equal to or greater than the Cryptosporidium removal credit awarded to the module via challenge testing. The feasibility of performing a daily integrity test for RO would be of interest to CDPH.

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California Regional Water Quality Control Board
San Diego Region
Over 50 Years Serving San Diego, Orange, and Riverside Counties
Recipient of the 2004 Environmental Award for Outstanding Achievement from U.S. EPA

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February 28, 2011

In reply refer to:
244506:JCOFRANCESCO

Ms. Marsi A. Steirer
Deputy Director, Public Utilities Department
City of San Diego
600 B Street, Suite 600, MS 906
San Diego, CA, 92101

Dear: Ms. Steirer

SUBJECT: WATER PURIFICATION DEMONSTRATION PROJECT, NOVEMBER 30, 2010 DRAFT TESTING AND MONIOTRING PLAN, AND REGULATION OF PROJECT UNDER ORDER NO. 97-03

The California Regional Water Quality Control Board, San Diego Region (San Diego Water Board) appreciates having the opportunity to review the *Final Draft Testing and Monitoring Plan, November 30, 2010* (Draft Plan). The Draft Plan provides a comprehensive approach to generating the data necessary for addressing numerous and varied concerns regarding indirect potable reuse and the quality of the product produced by an Advanced Water Purification Facility. The following comments on the Draft Plan are being provided for the City's consideration with the purpose of facilitating the NPDES permitting process.

Comments Regarding the Draft Plan

1. The monitoring that will be conducted provides an opportunity to develop data for establishing applicability of water quality-based effluent limitations for priority pollutant criteria/ objectives in a National Pollutant Discharge Elimination System (NPDES) permit. Specifically, sufficient data of the discharge is necessary to perform a reasonable potential analysis (RPA) for each of priority pollutant. The monitoring location must be representative of the quality of the product water and the monitoring be conducted according to the U.S. Environmental Protection Agency test procedures approved at 40 CFR Part 136, *Guidelines Establishing Test Procedures for Analysis of Pollutants Under the Clean Water Act* as amended.

   In general, the monitoring parameters should include all constituents having water quality objectives listed in the *Water Quality Control Plan for the San Diego Basin* (Basin Plan) for the San Vicente Reservoir.

2. The Draft Plan should include provisions for addressing the State Water Resources Control Board's (State Water Board) draft Policy for Toxicity Assessment and Control (Policy). The Policy includes a new method to determine the toxicity of effluents, statewide numeric objectives, and further standardization of toxicity provisions for National Pollutant Discharge Elimination System (NPDES) permittees. A copy of the Policy may be obtained at:

http://www.waterboards.ca.gov/water_issues/programs/state_implementation_policy/index.shtml.

3. Although as stated in the Draft Plan, the Basin Plan sets a threshold limit for total phosphorus concentration for any streams at the point of entering inland standing body surface waters, such as San Vicente Reservoir, of 0.05 milligrams phosphorus per liter (mg-P/L). San Vicente Reservoir, however, is considered a "standing body of water", not "flowing waters". Therefore, the threshold total phosphorus concentrations shall not exceed 0.025 mg/l in the Reservoir.

4. The Draft Plan should continue to be updated when necessary to implement new monitoring strategies for chemicals of emerging concern in recycled water as decided by the State Water Resource Control Board and California Department of Public Health.

Comments Regarding Order No. 97-03

As discussed in the City of San Diego's December 16, 2010 letter, the City proposes distribute a blend the effluent from the Advanced Water Purification Facility and the North City Water Reclamation Plant to reuse customers in accordance with the requirements of Order No. 97-03. The San Diego Water Board does not require a modification of Order No. 97-03 for the City's proposal because the Advanced Water Purification Facility will provide supplemental treatment to the tertiary effluent produced by the North City Water Reclamation Plant.

For questions pertaining to the above comments, please contact Joann Cofrancesco by email at jcofrancesco@waterboards.ca.gov, or by phone at 858-637-5589.

PLEASE INCLUDE "244506:JCOFRANCESCO" IN THE SUBJECT LINE OF FUTURE CORRESPONDENCE.

Sincerely,

Robert Morris

ROBERT W. MORRIS
Senior Water Resource Control Engineer
San Diego Regional Water Quality Control Board

cc: (by email):
Amy Dorman, Senior Civil Engineer, Long-Range Planning & Water Resource, ADorman@sandiego.gov
Anthony Van, Associate Engineer-Civil, Long-Range Planning & Water Resource, AVan@sandiego.gov

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility

Draft Testing and Monitoring Plan (10/8/10) IAP Subcommittee Comments received letter Dated 11/15/10

Comment 1 Treatment Process

Changes in the type and dose of coagulant should be tested to evaluate water quality impacts, such as pH, conductivity, and mineral composition. As a minimum, the effects of ferric chloride coagulation, currently shown as optional, should be assessed along with other potential treatment modifications.

Comment Response

Based on consultation with the NCWRP operations, coagulant and polymers will either not be used during the AWP testing period or would be used at constant concentrations. Currently, NCWRP only uses cation polymer during plant upsets which occur on a very limited basis (i.e. 1 or 2 per year). However, coagulant dosing will be tested upstream of the UF membranes to enhance membrane productivity. The need for coagulant (type and dose) upstream of the UF system will be established by assessing baseline (i.e. no coagulant addition) fouling performance data and recommendations from the UF membrane manufacturer.

Comment 2 Treatment Process

The technical and economic feasibility of conducting partial demineralization by electrodialysis reversal (EDR) should be assessed to optimize the use of reverse osmosis (RO) or identify opportunities to use it as a back-up or supplementary system. Since RO has the capacity to handle some increased total dissolved solids (TDS) loading, it is not clear whether upstream EDR provides enough additional benefits to plant operations to justify the additional expense.

Comment Response

The AWP Demonstration Facility is designed to receive feedwater from the tertiary effluent of the NCWRP upstream of EDR. While the team agrees conducting partial demineralization using EDR upfront of the AWP treatment train may provide benefits (i.e. lower TDS and nitrate) this is not in the scope of the current demonstration testing. Should the baseline train being used at the demonstration scale not meet the nitrogen objectives, the option of using EDR for the full scale AWPF could be considered for nitrate removal, however this option would need to be compared to other possible treatment processes such as ion exchange (IX). Also, further analysis on whether the current EDR system at NCWRP would provide enough capacity for the full scale AWPF would need to be evaluated.

Comment 3 Treatment Process

The status of the existing filtration process should be evaluated in the context of projected upgrades or modifications. Since filtration will now be functioning as pretreatment for the microfiltration/ultrafiltration (MF/UF) process, its performance should be optimized in conjunction with the pilot testing.

Comment Response

The 2009 annual monitoring data from the NCWRP showed Average Daily Turbidity (NTU) from Jan. to Dec. ranged from 0.41 to 0.75 with average a yearly value of 0.56. This data indicates the plant is producing fairly consistent and good quality filter *effluent. It is our understanding that the filter process at NCWRP has been optimized over the years to achieve the current performance and that no further changes / optimization of the process will be made during the operational period of the AWP Demonstration Facility.*

Comment 4 Treatment Process

In recognition of the fact that the UV reactor in the pilot plant is not representative of the UV system to be used in the full-scale AWFP, the IAP recommends that verification of the log removal requirements for NDMA and 1,4-dioxane by the advanced oxidation process (AOP), as specified in the August 4, 2008 California Department of Public Health draft groundwater recharge regulations, be performed on the full-scale facility prior to implementation of the project.

Comment Response

The project team is in agreement.

Comment 5 Treatment Process

The IAP Subcommittee was presented with some pilot plant data relating to NDMA removal. This data set was very limited and should not be considered definitive at this time. The IAP would appreciate the opportunity to review additional data related to NDMA removal as it becomes available.

Comment Response

The AWT pilot testing conducted at NCWRP in 2005 showed NDMA measured in the product water to be below the current CDPH notification limit (10 ng/L) in all samples with only 1 detection above the MDL (2 ng/L). Testing and monitoring of the AWP Demonstration facility will generate a greater number of NDMA removal results than the pilot. This information will be included in quarterly progress reports, which will be provided to the IAP to review.

Comment 6 Water Quality

The IAP suggests that, except for water quality monitoring needed at startup of the AWPF to optimize the unit processes, water quality monitoring of the full-scale AWPF not begin until the system has been stabilized and is operating at steady-state conditions to obtain representative data.

Comment Response

Please clarify the comment is referring to water quality monitoring of the demonstration scale AWPF and not the full- scale AWPF. The project team agrees it is important that the demonstration facility operation is stabilized prior to beginning extensive water quality monitoring (i.e. complete list of parameters identified for quarterly sampling). The sampling plan will be executed accordingly.

Draft Testing and Monitoring Plan (10/8/10) IAP Subcommittee Comments
received letter Dated 11/15/10

Comment 7 Microbial

The draft routine bacteria and virus surrogate monitoring plan proposes direct bacteria and virus monitoring using epifluorescence microscopy (with SYBR-green ATP measurements), which is not an approved method. Further, the analysis is expensive and does not determine organism viability. The IAP recommends that the use of epifluorescence microscopy for direct monitoring of bacteria and viruses not be included in the routine surrogate monitoring plan.

Comment Response

The project team appreciates the IAPs input and will remove direct monitoring of bacteria and viruses using epifluorescence microscopy (with SYBR-green ATP measurements).

Comment 8 Microbial

For the component that calls for the direct monitoring of pathogens, the IAP concluded that, due to the well-known performance of the treatment train for pathogen removal and the substantial indicators analyses, monitoring for bacterial and viral pathogens may not necessary. However, the IAP recognizes the value of such monitoring from a public confidence perspective, and suggests that the proposed pathogen monitoring component be reevaluated at the next IAP meeting.

Comment Response

The project team appreciates the IAP's feedback and will hold off on revising the draft plan for direct monitoring of pathogens until further feedback is provided.

Comment 9 Microbial

The IAP suggests that it may be possible to reduce the monitoring frequency for Cryptosporidium (before MF/UF) by sampling for aerobic spores like B. subtilis as potential surrogates for Cryptosporidium. B subtilis are much smaller than Cryptosporidium and thus would be a conservative indicator that can be analyzed quickly and inexpensively. B. subtilis analyses could be performed in conjunction with Cryptosporidium studies and more frequently as potential MF/UF process performance indicators. The use of aerobic spores would be appropriate if the spores service the prior disinfection process. This would need to be evaluated.

Comment Response

The project team agrees B. subtilis may serve a good surrogate for Cryptosporidium as it is smaller and should be removed by sieving. However, it is unknown if the spores will survive the addition of chloramines upstream of the MF/UF systems to have substantial levels. Also, it may be difficult to differentiate whether observations of reduced concentrations in the MF/UF filtrate is due to disinfectant contact time during filtration, or actual removal. In order to answer these questions, the project team would recommend conducting conventional microbial inactivation bench scale experiments using B. subtilis under various conditions including chloramines concentration, pH and contact time. At this time, such testing is not in the scope of the current demonstration testing.

*The project team would also like to point out that the type of UF and MF membranes being used at the demonstration facility have been tested under the **Drinking Water Membrane Testing Protocol For California Department of Public Health (CDPH) Conditional Acceptance** (April 2007) and received CDPH conditional approval for membrane filtration products and log removal credits. This testing includes direct challenge testing experiments with an approved Cryptosporidium and Giardia surrogate. Additionally, during the demonstration testing period daily pressure decay testing will be performed to assess membrane integrity of both UF and MF systems in accordance to the **EPA Membrane Filtration Guidance Manual** (November 2005).*

Comment 10 Constituents of Emerging Concern
The major purpose for the design of the monitoring strategy should be to: 1) determine which constituents are likely to either break-through or not be removed; and 2) use the information obtained as a basis to identify surrogates for operational tracking purposes at different stages of treatment. Experience at Orange County Water District's Groundwater Replenishment System and other similar projects demonstrates that many chemicals (e.g., metals and other priority pollutants) are easily handled by the treatment train if any are in the treated wastewater influent to the advanced treatment plant. In addition, breakthroughs of some chemicals such as NDMA and 1,4-dioxane (and a few others) at ng/L levels are expected, and do not *per se* indicate significant health risks. The IAP recommends that San Diego design a monitoring strategy for the pilot program that collects sufficient numbers of samples to determine appropriate surrogates for managing the processes and also provides public confidence on the effectiveness of the treatment system.

Comment Response
The project team agrees with the goals the IAP has provided with regards to the CEC monitoring plan and will incorporate these into the test plan. The project team has revised the CEC monitoring plan to increase the initial sampling of surrogate / indicators, and increase the list of compounds and sampling locations to be monitored on a quarterly basis based on past performance seen at the City of San Diego AWT pilot and CDPH Recommendations.

Comment 11 Constituents of Emerging Concern
The IAP recommends that the draft strategy include an approach for selecting appropriate surrogate constituents. Initially, screening tests should be conducted for a suite of CECs that may be present in the influent wastewater. Based on the results of the screening studies, a set of surrogate parameters can be selected that could be linked back to the constituents in the wastewater. This study should be initiated after the treatment system has been running for perhaps a minimum of 4 months and is operating at steady-state conditions. The analytical list may be drawn from the City's currently proposed monitoring list of 90 CECs, as well as other sources. The parallel analyses of chemicals and surrogate candidates would include the feed water, before and after RO, and potentially, some chemicals that survive after the advanced

oxidation process (AOP). This assessment is important since it will serve as the basis for process operating decisions in the full-scale plant.

Comment Response
This comment is noted and the recommendations will be implemented in the execution of the CEC monitoring plan.

Comment 12 Constituents of Emerging Concern
It is doubtful that contaminants will routinely break through at concentrations that have health significance, which is one of the reasons for focusing on surrogate analyses. The IAP disagrees with the SWRCB-sponsored report entitled “Final Report: Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water” that caffeine and triclosan should be considered as health-related; however, it may be advisable to include them for monitoring process performance. That report also included NDMA and 17 estradiol (although it is unlikely to survive the process). They, as well as many other chemicals, would represent potential health concerns if they occurred at higher than expected levels. Therefore, it is appropriate to have health advisory levels available in the event that any were detected.

Comment Response
The project team appreciates the comment and it is noted.

Comment 13 Constituents of Emerging Concern
The IAP has some suggestions related to the monitoring strategy. DEET, carbamazepine, and primidone could be analyzed because they are ubiquitous in domestic wastewaters and refractory in nature. Among the other suggested chemicals, PFAAs might be candidates, even though their removal by RO has been well documented. 1,4-dioxane is also a good choice due to its known inefficient removal by RO. Chemicals included in the third Unregulated Contaminant Monitoring Rule, Cycle 3 (UCMR3) would best be addressed selectively, unless there is a regulatory requirement to analyze them. Chemicals like triclosan, caffeine, and sucralose and other artificial sweeteners are of no toxicological interest, but may be able to serve as surrogates. Hydrazine and quinoline are of little interest unless they are ubiquitous in the tertiary-treated wastewater and not readily removed by RO and/or AOP; hydrazine would likely not be well removed by RO, if present. Nicotine and cotinine could be considered for inclusion since they are cigarette-related and likely to be in sewage and of toxicity interest if at high enough levels in the finished water, although this is unlikely. They also are relatively low molecular weight molecules that could challenge RO, but not likely AOP. Extensive monitoring for the priority pollutants is of little value. Our understanding is that the Orange County Water District has had no detections in their extensive monitoring over several years. Perhaps a few samples could be analyzed for that group for verification and if the regulatory agencies require it. These types of analyses could also play a role in demonstrating the overall quality of the finished water to the public.

Comment Response

This comment is noted and the recommendations will be implemented in the execution of the CEC and quarterly water quality monitoring plan.

Comment 14 Constituents of Emerging Concern

The characteristics of wastewater can vary depending on the time of day and the loading to the wastewater treatment plant. For parameters that will be monitored using grab-samples, it is important to time sample collection to reflect the range of conditions that are likely (e.g., peak-flow, peak-loading, etc.). It is also important to ensure that the sampling program can yield statistically defensible results. Prior to initiating the routine sampling program, initial quality assurance studies should be conducted to determine the appropriate sample volumes (relates to detection limits), sampling frequency and timing, and which parameters should be monitored using grab-samples versus composite samples. The City should confer with San Diego Regional Water Quality Control Board (RWQCB) to get input on the parameters that should be measured using composite samples and whether the composites should be generated using a flow-weighted or time-based approach.

Comment Response

The project team appreciates the IAPs suggestions with regards to water quality sampling plan. The Testing and Monitoring Plan has been updated to include a revised routine monitoring plan including the basis of the parameter selection, sampling frequency, sample collection type (grab vs. composite) and target demonstration goals. ***This information has been included in Table 5-2 and Table 5-4 located on pages 10 and 11, respectfully of this document.*** *The project team also confirmed with the NCWRP operations that the tertiary flow is constant therefore justifying the use of time weighted (as opposed to flow paced) composite sample collection. In addition, the sampling plan has been updated based on CDPH comments to assess diurnal variations, which will include conducting two 24 hour sampling events during the 12 month operating period to collect grab samples of the RO feed every 4 hours for the following preliminary list of compounds:*

- *Caffeine*
- *Sucralose*
- *Total nitrogen*
- *Nitrate*
- *1,4 dioxane*
- *NDMA*
- *Total phosphorus*

Prior to initiating the sampling plan, the project team will coordinate closely with all laboratories to ensure appropriate samples volumes are collected for each parameter to achieve method detection limits (MDLs) and reporting limits (RLs). The project team feels the revised changes to the sampling plan described above will provide statistically defensible results

Comment 15 Constituents of Emerging Concern

The Orange County Water District has experienced inconsistencies in comparing the monitoring results from grab samples versus online measurements for TOC. Thus, the City should consider relying entirely on online TOC measurements as they would be more informative – and likely more accurate – than using grab samples.

Comment Response

The project team agrees on-line TOC measurements have been reported to be more accurate and provide greater sensitivity than grab samples. The general consensus during the IAP subcommittee meeting with regards to TOC monitoring at the AWP Demonstration Facility was to have (1) one online portable TOC monitor on the combined RO product for each 24 hour period except when it is used to take grab samples from other locations (i.e. RO feed, RO 1 product, RO 2 product, UV/AOP product). During the operation period, the team will access differences (if any) between samples taken online vs. grab samples using the portable TOC monitor for a given sample location.

Comment 16 Constituents of Emerging Concern

The IAP finds that although definitive nutrient requirements for phosphorus and nitrogen have not been determined by the RWQCB, narrative and numeric nutrient requirements already included in the Basin Plan for discharges to surface water (such as San Vicente Reservoir) may allow the use of a 0.1 mg/L total phosphorus goal to determine compliance. Using the nominal N:P ratio of 10:1 to determine compliance for total nitrogen, it is possible that a 1.0 mg/L goal may be promulgated for total nitrogen to prevent eutrophication of the reservoir. The presentations to the IAP by the City of San Diego and their consultants suggests that modifications of the existing treatment process to date at the North City Water Reclamation Plant enhance denitrification and lower nitrate levels has had some success, but nitrate levels are still somewhat above 10 mg/L in the tertiary effluent. Using an 80- to 90-percent removal value for nitrate (provided at the meeting by the City's consultants) as that potentially-achieved by the RO system may yield an effluent nitrate level above the potential compliance limit for discharge to the reservoir. Therefore, the IAP suggests that more attention be paid to the operation of the existing tertiary treatment plant at the North City Water Reclamation Plant (NCWRP) to try to maximize denitrification to achieve lower the nitrate levels in the tertiary-treated water (to well below 10 mg/L) in order to demonstrate that such compliance may be achieved by the AWPF under future effluent limitation scenarios.

Comment Response

As mentioned in the Testing and Monitoring Plan Section 3.1.3.1 the City began a study in January 2008 to assess possible improvements to the NCWRP recycled water quality by enhancing the plants denitrification process. Over the course of the demonstration period, further refinements to the implemented changes are planned to occur with a focus to increase automation of the oxygen system to further reduce the plants effluent nitrate concentration. The project team will coordinate closely with

NCWRP operations staff to be sure data collected at the demonstration plant reflects these changes.

Comment 17 Source Control
The IAP acknowledges the City's efforts to identify potential contaminants of concern in the NCWRP watershed from industries, including pharmaceutical and research facilities.

Comment Response
Noted.

Comment 18 Source Control
Because the opportunity exists for the discharge of (probably small) amounts of chemical, radioactive, and biological material into the wastewater stream, it is advisable to contact each industry, particularly pharmaceutical manufacturers, hospitals, and laboratories, to raise awareness in those industries that their discharges will be feed water to the AWPF that will process the wastewater to be used for potable reuse.

Comment Response
The project team appreciates this advice. The team is preparing a workplan to address source control and will take this concept into consideration.

Comment 19 Source Control
The IAP is interested in hearing more about the City's source control program. The IAP requests that a presentation on the source control program be provided at the next IAP meeting.
Comment Response
Findings related to source control will be presented at a future IAP meeting.

Comment 20 Water Stabilization
The stability of the product water is important to ensure the integrity of the pipeline from a microbial and corrosion perspective. It would be worthwhile to consider evaluating the options for controlling biofilm growth and corrosion. Using a pipe-loop study or annular reactor to evaluate microbial growth and the effectiveness of alternative control strategies could be a valuable complement to the pilot study once the system is operating at steady-state. These tests could be used to determine the extent to which a secondary disinfectant and/or corrosion control in addition to lime treatment is needed.

Comment Response
The project team appreciates the IAP subcommittees recommendations related to water stabilization. At this time, the details of the pump station and pipeline design (pipe material, detention time, etc.) and requirements (including the need for secondary chlorination / dechlorination) for the full scale AWPF conveyance system

have not been determined. Accordingly, as part of the current demonstration testing the project team will only focus on the requirements to stabilize the AOP product water in terms of pH adjustment and lime addition for alkalinity recovery. To achieve this goal, the project team will conduct desktop modeling and bench scale testing using AOP product water collected at the demonstration facility. The City may consider additional testing as recommended by the IAP at a later stage in the demonstration project and / or during the pre-design phase of the possible full-scale AWPF.

Table 5-2 Anticipated Water Quality Goals for Regulated Constituents: San Diego AWP Facility

Constituent	Units	Proposed Demonstration Goal (average)	Anticipated Regulatory Limit (maximum)	Basis	Critical Beneficial Use/Issue
Total organic carbon (TOC)	mg/L	0.5	[1]0.5	CDPH	MUN
Ammonia (unionized as N)	ug/L	25	25 or Ce=25+Dm(25)	Basin Plan	Habitat
Nitrate (as N)	mg/L	[2]1	10 or Ce=10+Dm(10)	CDPH & Basin Plan	MUN
Total nitrogen	ug/L	[2]1000	[1]5000	CDPH	MUN
			[1,2]1000	Basin Plan	Biostimulation
Total phosphorus	ug/L	[2]100	[1,2]100	Basin Plan	Biostimulation
N-nitrodisodimethylamine (NDMA)	Log reduction	> 1.2-log	[1]1.2- log	CDPH	MUN
	ng/L	Not detected	[3]0.69 or Ce=0.69+Dm(0.69)	CTR/SIP	
1,4-Dioxane	Log reduction	> 0.5-log	[1]0.5- log	CDPH	MUN
1,2-Dichloroethane	ug/L	< 0.38	[3]0.38 or Ce=0.38+Dm(0.38)	California Toxics Rule	MUN
Total trihalomethanes	ug/L	< 80	[1]80	CDPH	MUN
Bromoform	ug/L	Not detected	[3]4.3 or Ce=4.3+Dm(4.3)	California Toxics Rule	MUN
Chlorodibromomethane	ug/L	Not detected	[3]0.401 or Ce=0.401+Dm(0.401)	California Toxics Rule	MUN
Dichlorobromomethane	ug/L	Not detected	[3]0.56 or Ce=0.56+Dm(0.56)	California Toxics Rule	MUN
Halo acetic acid (HAA)	ug/L	< 60	[1]60	CDPH	MUN
Methylene chloride	ug/L	< 4.7	[3]4.7 or Ce=4.7+Dm(4.7)	California Toxics Rule	MUN
Turbidity	NTU	< 0.2	[1]0.2	CDPH	MUN
Chloride	mg/L	50	[3]50 or Ce=50+Dm(50)	Basin Plan	MUN
Total dissolved solids (TDS)	mg/L	300	[3]300 or Ce=300+Dm(300)	Basin Plan	MUN

1. Potential limit based on best available information developed to date. Value subject to change.
2. Tentative goals based on providing best available treatment economically achievable and achieving Basin Plan total nitrogen and total phosphorus objectives for flowing waters.
3. Based on simplified version for determining California Toxics Rule (CTR) permit limits for priority pollutants. Section 1.4 of the State Implementation Plan contains specific steps and procedures that take into consideration ambient background concentration, the coefficient of variation of measured concentration data, and dilution credit. In some cases, the calculated effluent limitation can be lower than the CTR criterion. Ce - effluent concentration; Dm – dilution factor.

Table 5-4
Certified Laboratory Routine Water Quality Monitoring Plan for the San Diego AWP Facility

Constituent	[1] Sample Location	[2] Type of Sample	[3] Analytical Method	Monitoring Frequency	[4] Total Number of Samples per location
Total organic carbon (TOC)	S6, S7, S8	24-Hour Composite	SM2540C	[5] Monthly	12
Ammonia (unionized as N)	S6, S7, S8,	24-Hour Composite	EPA 300.0	[5] Bi-weekly (once per 2 weeks	26
Nitrate (as N)	S6, S7, S8	24-Hour Composite	EPA 300/351.2	[5] Bi-weekly (once per 2 weeks	26
Total nitrogen	S6, S7, S8	24-Hour Composite	SM4500P-E	[5] Bi-weekly (once per 2 weeks)	26
Total phosphorus	S6, S7, S8	24-Hour Composite	EPA 521	Bi-weekly (once per 2 weeks	26
N-nitrodisodimethylamine (NDMA)	S6, S7, S8, S9, S10	24-Hour Composite	EPA 522 MOD	Monthly	12
1,4-Dioxane	S6, S9, S10	Grab	ML/SW 8270 mod	Monthly	12
1,2-Dichloroethane	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Total trihalomethanes	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Bromoform	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Chlorodibromomethane	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Dichlorobromomethane	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Trichloromethane	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Halo acetic acid (HAA)	S6, S9, S10	Grab	EPA 552.2	Monthly	12
Methylene chloride	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Turbidity	S4, S5	24-Hour Composite		Daily	365
Chloride	S6, S7, S8	24-Hour Composite	ML/EPA 300.0	Bi-weekly (once per 2 weeks	26
Total dissolved solids (TDS)	S6, S7, S8	24-Hour Composite	SM 2540C	Bi-weekly (once per 2 weeks	26
Microbial	See endnote 5	See endnote 5	See endnote 6	See endnote 6	See endnote 6

[1]. Sampling locations: S4 = MF product; S5 = UF product; S6 = RO feed; S7 = RO 1 product; S8 = RO 2 product; S9 = UV/AOP feed; S10 = UV/AOP product.

[2]. Composite samples to be collected on a time weighted basis. NCWRP is operated to provide constant tertiary flow.

[3]. MDLs, RLs, TATs, sample hold times for each method are provided in Appendix E.

[4]. Based on a 12 month testing period.

[5]. Additional samples to be analyzed 2 per week collected 3 days apart at S10 in accordance to CDPH Groundwater Recharge Reuse Draft Regulations (2008).

[6]. See Section 5.2.4, Table 5-8 for microbial sampling plan.

Note: two 24 hour sampling events during the 12 month operating period will also be conducted to assess diurnal variations by collecting grab samples of the RO feed every 4 hours for the following preliminary list of compounds: Caffeine; Sucralose; Total nitrogen, Nitrate; 1,4 dioxane; NDMA; Total phosphorus.

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Final Testing and Monitoring Plan

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Appendix B

Quarterly Testing Report No.4

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Quarterly Testing Report No. 4

January 2013

CITY OF SAN DIEGO

Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility

THE CITY OF SAN DIEGO

City of San Diego
PUBLIC UTILITIES
Water & Wastewater

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Abbreviations and Acronyms

Ace-K	acesulfame potassium
ADI	acceptable daily intake
ALCR	air liquid conversion ratio
ANSI	American National Standards Institute
AWP	advanced water purification
AWP Facility	advanced water purification facility
Basin Plan	Water Quality Control Plan for the San Diego Basin
Bay- Delta	Sacramento San Joaquin Bay Delta
BCM	bromochloromethane
BDCM	bromodichloromethane
C	Celsius
CAL	critical alert level
CCL3	Contaminant Candidate List 3
CCP	critical control point
CB	chlorinated backwashes
CDPH	California Department of Public Health
CEC	constituent of emerging concern
CIP	clean in place
City	City of San Diego
CLP	Contract Laboratory Program
CLP's	critical limit parameters
cm	centimeter
CSM	Colorado School of Mines
CTR	California Toxic Rule
CWA	Clean Water Act
DBCM	dibromochloromethane
DCS	distributed control system
DEET	N,N-diethyl-meta-toluamide
DBP	disinfection byproduct
DEA	Deethylatrazine
Demonstration Project	Water Purification Demonstration Project
DL	method detection limit
DLR	CDPH detection limit for reporting
DO	dissolved oxygen
DP	distribution panel
DP	differential pressure
DWEL	Drinking Water Equivalent Level
DWR	California Department of Water Resources
EDR	electrodialysis reversal
EED	electrical energy dose
EEO	electrical energy per order
EG	ethylene glycol
ENR	Engineering News Record
EPA	U. S. Environmental Protection Agency
ERD	energy recovery device

ERI	Energy Recovery, Inc.
ft^2	square feet
FWR	feedwater recovery
gfd	gallons per square foot per day
gpm	gallons per minute
H_2O_2	hydrogen peroxide
HAAs	Haloacetic Acids
HMI	human machine interface
HP	horsepower
HVAC	heating, ventilating, and air conditioning
I&C	instrumentation and controls
IAP	Independent Advisory Panel
IAW	imported raw aqueduct water
in^2	square inches
IPR	indirect potable reuse
IPR/RA	indirect potable reuse/reservoir augmentation
IRWM	Integrated Regional Water Management
KV	kilovolts
KVA	kilovolts amperes
kW	kilowatt
kWh	kilowatt hours
kWh/d	kilowatt hours per day
kWh/yr	kilowatt hours per year
L	liter
LDC	Laboratory Data Consultants, Inc.
LPHO	low pressure high output
LRV	log removal value
LRL	laboratory reporting level
LSI	Langelier Saturation Index
m	meter
MC	maintenance cleans
MCC	motor control center
MCL	maximum contaminant level
MDA	minimum detectable activity
MDL	method detection limit
MF	microfiltration
MG	million gallons
mg/L	milligrams per liter
mg/L-N	milligrams per liter as nitrogen
mg/L-P	milligrams per liter as phosphorus
mgd	million gallons per day
mL	milliliters
mL/min	milliliters per minute
min	minute
mJ/cm^2	millijoules per square centimeter
MPN	most probable number
mV	millivolt
µg/L	micrograms per liter

µg/L-P	P micrograms per liter as phosphorus
µS/cm	microsiemens per centimeter
N/A	not applicable
NE	Nautilus Environmental Laboratories
North City	North City Water Reclamation Plant
ND	not detectable or not quantifiable
NDBA	N-Nitrosodi-n-butylamine
NDEA	N-Nitrosodiethylamine
NDMA	N-Nitrosodimethylamine
NDPA	N-Nitrosodi-n-propylamine
ng/L	nanograms per liter
NL	notification level
NMEA	N-Nitrosomethylethylamine
NMOR	N-Nitrosomorpholine
NOP	net operating pressure
NPDES	National Pollution Discharge Elimination System
NPIP	N-Nitrosopiperidine
NPYR	N-Nitrosopyrrolidine
NR	not reported
NR&C	Natural Resources and Culture Committee
NTU	Nephelometric Turbidity Units
OCWD	Orange County Water District
O&M	operation and maintenance
ORP	oxidation reduction potential
PDC	power distribution cabinet
PDT	Pressure Decay Testing
PLC	programmable logic controller
Point Loma	Point Loma Wastewater Treatment Plant
ppb	parts per billion
PPCPs	pharmaceuticals and personal care products
ppm	parts per million
ppt	parts per trillion
psi	pounds per square inch
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
Q1	Quarter 1
Q2	Quarter 2
Q3	Quarter 3
Q4	Quarter 4
QA/QC	quality assurance/quality control
RA	Reservoir Augmentation
RA	re-analyzed
Regional Board	San Diego Regional Water Quality Control Board
RL	reporting level
RO	reverse osmosis
RPD	relative percent difference
RWQCB	Regional Water Quality Control Board
SDG&E	San Diego Gas & Electric

SDI	silt density index
SDWA	Safe Drinking Water Act
SIP	State Board Policy for Implementation of Toxics Standards for Inland Surface Water, Enclosed Bays, and Estuaries of California
South Bay	South Bay Water Reclamation Plant
State Board/SWRCB	State Water Resources Control Board
STD	standard deviation
T&M Plan	Plan Testing and Monitoring Plan
TCEP	tris (2-chloroethyl) phosphate
TCPP	tris (1-chlor 2 propyl) phosphate
TDI	tolerable daily intake
TDS	total dissolved solids
THMs	trihalomethanes
Title 22	Title 22 of California Code of Regulations
TKN	Total Kjeldahl Nitrogen
TMP	transmembrane pressure
TOC	total organic carbon
TU	toxic unit
UCMR	Unregulated Contaminant Monitoring Rule
UF	ultrafiltration
UV	ultraviolet
UV/AOP	ultraviolet light disinfection and advanced oxidation
UV254	UV 254 Absorbance
UVT	ultraviolet light transmittance
VOC	volatile organic compound
Water Authority	San Diego County Water Authority
WET	Whole Effluent Toxicity
WSE	water surface elevation

Glossary

Advanced Oxidation: A set of chemical treatment processes designed to destroy organic material through the breakdown of their molecular structure. The advanced oxidation process used at the AWP Facility employs ultraviolet light and hydrogen peroxide, which break down into natural elements, such as carbon, hydrogen and nitrogen.

Advanced Water Purification Facility (AWP Facility): A facility that produces purified water by utilizing advanced treatment technologies: membrane filtration (microfiltration [MF] or ultrafiltration [UF]), reverse osmosis (RO), disinfection, and advanced oxidation.

Advanced Water Purification (AWP) Facility Study: One element of the multi-faceted Demonstration Project. The AWP Facility Study included two primary elements: (1) the design, installation, and operation of a one million gallon per day (mgd) Demonstration Facility located at North City and (2) a conceptual design and cost estimate for a potential Full-Scale Facility.

Advanced Water Purification (AWP) Facility Study Report: Final report documenting the observations and findings of the AWP Facility Study.

Analyte: a chemical substance that is the subject of chemical analysis.

Backwash: The process of reversing the direction of flow through a filtration system in order to remove contaminants that had been filtered out in a water purification process, e.g. membrane filtration. The backwash process is necessary in order to maintain the treatment capacity of membrane filtration.

Bacteriophage: Viruses present among coliform bacteria. Have a high presence in wastewater.

Ballast: An electronic device on the UV system designed to generate a constant UV intensity and maximize UV lamp life.

Blending: Mixing or combining one water source with another such as purified water with raw water sources.

California Groundwater Recharge Reuse Draft Regulations: The November 21, 2011 Groundwater Recharge Reuse Draft Regulations, which are used as a guidance document for the conceptual design of the Full-scale Facility since regulations for reservoir augmentation with purified water do not yet exist. Also referred to as the draft groundwater recharge regulations.

Clean in place: The in situ chemical cleaning of membranes that consists of soaking membranes in one or more chemical solutions (typically acid and caustic solutions) to remove accumulated foulants and restore permeability.

Concentrate: A continuous waste stream, typically containing concentrated dissolved solids, from the membrane process.

Constituent: In water, a constituent is a dissolved chemical element or compound or a suspended material that is carried in the water.

Constituents of Emerging Concerns (CECs): CECs are not regulated and include commonly used pharmaceuticals, personal care products, flame retardants and unregulated pesticides.

Contaminant: An organic or inorganic substance found in the water. Some contaminants have a health effect in people consuming the water, and thus is regulated in drinking water. Not all contaminants are unsafe. Iron and manganese are contaminants, but in excess simply causing staining. See Maximum Contaminant Level.

Critical alert limit: Measurement of a critical limit parameter that requires urgent corrective action in order for the corresponding critical control point to function as intended.

Critical control point: A point or step within the AWP Facility process train at which critical limit parameters can be monitored in order for corrective actions to be taken should critical alert limits be exceeded.

Critical limit parameter: A parameter that indicates whether or not a control measure is within the alert limit or critical alert limit for the corresponding critical control point.

Demonstration Facility: The one-mgd advanced water purification facility that was designed, installed, and operated as part of the City's Water Purification Demonstration Project.

Detection limit for the purposes of reporting (DLR): The DLR is a parameter that is set by regulation for each reportable analyte. It is not laboratory specific and it is independent of the analytical method used (in cases where several methods are approved). The DLR cannot be changed by the laboratory. It is expected that a laboratory can achieve a reporting limit (RL) that is lower than or equal to the DLR set by the California Department of Public Health (CDPH).

Disinfection: The removal, deactivation or destroying of microorganisms present in a water supply that may be harmful to humans. Commonly used disinfectants include chlorine (and its derivatives), ultraviolet (UV) light, and ozone. Chlorine and its derivatives are used to disinfect drinking water because they provide residual disinfection that protects the water as it goes through the pipes to homes and businesses.

Disinfection byproduct: A compound that is formed through the reaction of a disinfectant (chlorine, ozone, chlorine dioxide) with organic or inorganic material present in the water. Some disinfection byproducts have been found to be harmful to human health and are regulated by the EPA or under consideration for future regulation.

1, 4- Dioxane: A chemical contaminant primarily used as an industrial stabilizer to enhance performance of solvents in manufacturing processes. Commonly used in food and food additives or in personal care products such as cosmetics, deodorants, soaps and shampoos. Currently there is not a federal or state MCL; however, the CDPH has established a notification level of 1 ppb. CDPH also specifies in the 2011 Draft Groundwater Recharge Reuse Regulations that AOP systems required for direct injection applications can be designed to achieve 0.5 log removal of 1,4-Dioxane. Alternatively, AOP sizing can be based on demonstrated log removals of select indicator compounds from different functional groups.

Drinking water: Water that meets federal drinking water standards as well as state and local water quality standards so that it is safe for human consumption. Water treatment facilities that produce drinking water require a state permit. Also referred to as potable water.

Drought: A defined period of time when rainfall and runoff in a geographic area are much less than average.

EEO-electrical energy per order: The amount of energy required to destroy 1 log order (i.e. 90%) of a given contaminant per 1000 gallons of water treated. EEO values are both reactor and water quality specific and used to baseline differences in reactor configurations and UV lamp intensities to establish comparative removals of a given constituent such as NDMA and 1,4-Dioxane.

EED -electrical energy dose: The amount of energy (kWh) dosed per 1000 gallons of water treated.

Effluent: The water leaving a water or wastewater treatment process or facility. If effluent has been treated to a high enough standard, it may be considered to be recycled water and can be used for beneficial purposes.

Endocrine disrupting compounds (EDCs): A chemical substance or mixture that alters the normal hormone functions in humans and animals. These chemicals can come from pharmaceuticals and personal care products such as detergent and synthetic hormones. They may also come from some industrial wastes and pesticides. EDCs are also contained in natural agricultural products such as soybeans, alfalfa, and natural hormones in animals.

Environmental Impact Statement / Environmental Impact Report (EIS/EIR): Detailed analysis of impacts of a project on all aspects of the natural and human environment. An EIS is required by the federal National Environmental Policy Act (NEPA) for federal permitting or use of federal funds. An EIR is required by the California Environmental Quality Act (CEQA) for local projects.

Filtrate: A continuous stream of water that passes through a filter.

Filtration: A process that separates small particles from water by using a porous barrier to trap the particles and allow the water to pass through.

Flux: The unit rate at which water passes through the membrane expressed as flow per unit of membrane area (e.g., gallons per square foot per day (gfd)).

Fouling: The accumulation of contaminants on the membrane surface, within membrane pores, or media surface that inhibits the passage of water.

Full-Scale Facility: The proposed AWP Facility for the full scale IPR/RA project. The Full Scale

Facility will have a capacity of 18 mgd and annual average purified water production of 15 mgd.

Groundwater recharge: Naturally or artificially adding water back into a groundwater basin.

Hydrogen peroxide: Chemical added in the UV disinfection/advanced oxidation step.

Imported water: A water source that originates in one hydrologic region and is transferred to another hydrologic region. In San Diego's case, water is imported from Northern California or the Colorado River and travels to this region in large above ground aqueducts or underground pipelines.

Imported raw aqueduct water: The imported raw water conveyed to the City's three Drinking Water Treatment Plants. For the AWP Facility Project, imported raw aqueduct water specifically refers to the imported water that was sampled per the Testing and Monitoring Plan. Imported raw aqueduct water was sampled at the Miramar Water Treatment Plant.

Indicator Compounds or Indicator Organisms: A common method to evaluate water or wastewater quality using representative chemicals or organisms that are characteristic of a larger group of related chemicals or organisms. Coliform bacteria are common indicator organisms, and trihalomethanes, benzene, and NDMA are examples of indicator compounds.

Indirect potable reuse (IPR): The process of blending purified water into a natural water source (groundwater basin or reservoir) that can be used as a source of drinking water.

Influent: Flow entering a process.

Inorganic chemicals: Inorganic chemicals are substances that do not contain both carbon and hydrogen. Generally, inorganic chemicals are minerals. Most minerals are not a cause for concern in water. Water contains many natural minerals from the rocks the water has come into contact with on its journey to the water treatment plant. Nutrients, such as phosphorus and nitrogen, and metals, such as calcium, iron, sodium, potassium, and zinc, are inorganic chemicals. Some inorganic chemicals, when they are too abundant, are considered contaminants in water.

Integrity monitoring: Performance evaluation of a treatment process in order to verify that the process meets its intended treatment performance on a continuous basis.

Laboratory reporting level (LRL) or Reporting Level (RL): The lowest concentration at which an analyte can be quantified and reported with an acceptable degree of accuracy. Laboratory reporting levels can vary based on the analytical method used, the laboratory, and the concentration being tested.

Maximum Contaminant Level (MCL): The highest allowable amount of a contaminant in water, established by the U.S. Environmental Protection Agency as a regulatory standard.

Membrane filtration: A type of filter used to separate particles from the water. Membrane filters are characterized by the pore openings size from the largest to the smallest pore size:

microfiltration, ultrafiltration, and nanofiltration. Membrane filters remove suspended solids, bacteria, protozoa, and other material from water.

Method detection limit (MDL) or Detection Limit (DL): The lowest concentration at which an analyte can be detected in a sample and reported with greater than 99 percent certainty using a particular analytical method.

Microfiltration (MF): A low pressure membrane filtration process where tiny, hollow straw like membranes separate small suspended particles, bacteria and other materials out of the water. MF provides the most efficient preparation of water for reverse osmosis. MF is used in commercial industries to process food, fruit juices and soda beverages; in computer chip manufacturing; and to sterilize medicines that cannot be heated.

Micron: Equal to one millionth of a meter or 1/25,400 of one inch. The eye can see particles only to about 40 microns. Used to describe the size of bacteria.

National Pollutant Discharge Elimination System (NPDES): A federal permit authorized by the Clean Water Act, Title IV, which is required for discharge of pollutants to navigable waters of the United States, and includes any discharge to surface waters: lakes, streams, rivers, bays, the ocean, wetlands, storm sewer, or tributary to any surface water body.

NDMA-N-Nitrosodimethylamine: A semi-volatile, yellow, oily liquid of low viscosity that has been extensively used in industry for several decades (USEPA, 2001). NDMA is found at low levels in numerous items of human consumption including cured meat, fish, beer, and tobacco smoke. Currently there is not a federal or state MCL; however, the CDPH has established a notification level of 10 ng/L. Until revision of the Draft Groundwater Recharge Reuse Regulations in 2011 CDPH required that AOP systems required for direct injection applications be designed to achieve 0.5 log removal of 1,4-Dioxane and 1.2 log removal of NDMA.

Non detectable and non quantifiable (ND): Laboratory sample results of a constituent reported as less than the reporting limit (RL) and detection limit (DL).

Non-potable water: Water that is not suitable for drinking because it has not been treated to drinking water standards.

North City Water Reclamation Plant (North City): Wastewater treatment plant that produces recycled water through a series of processes: primary treatment (screening and sedimentation), secondary treatment (aeration and clarification), and tertiary treatment (filtration and disinfection).

Organic chemicals: Chemicals that contain both carbon and hydrogen. There are millions of organic compounds, both naturally occurring and man-made. Naturally occurring organic compounds include amino acids (the building blocks of proteins), sugars, fats, hormones, and vitamins. All living matter is made up of natural organic chemicals. Synthetic (manmade) organic chemicals have been developed because they exhibit features that are valuable to us. These synthetic organic chemicals include herbicides, insecticides, pharmaceuticals, food coloring and flavors, personal care products, dyes, paints, adhesives, detergents, polymers, and plastics.

Osmotic pressure: The amount of pressure that must be applied to stop the natural osmosis driven flow of water across a semi-permeable membrane.

Oxidation: A treatment step often used in disinfection, where chlorine, hydrogen peroxide, ozone, or another oxidizing agent is added to water to produce a chemical reaction that removes or aids in removal of harmful substances.

Pathogens: Disease causing organisms. The general groupings of pathogens are viruses, bacteria, protozoa, and fungi.

Permeate: A continuous stream of water that passes through membrane. Typically used for water that passes through a reverse osmosis membrane (i.e., reverse osmosis permeate). Also referred to as filtrate or product.

Personal care product: Products that can be found in wastewater such as shampoos, fragrances, soap, and deodorant.

Pharmaceutically active compound: Hormone based compounds found within EDC's. Examples of these compounds include antibiotics, anti epileptic medications, heart medications, pain medications, and cancer medications, along with veterinary drugs and feed additives used for livestock.

Phenolic Compounds: A class of aromatic organic compounds commonly used in the manufacture of plastics, cosmetics, and antiseptics, and as preservatives for wood and rubber. Several of these compounds are regulated for surface water (11 compounds), drinking water (1 compound), and air (5 compounds), based on observed toxicity. Phenolic compounds are commonly found in bottled water and are sometimes classified as endocrine disrupting compounds.

Point Loma Wastewater Treatment Plant (Point Loma): Advanced primary wastewater treatment plant that discharges treated wastewater into the Pacific Ocean.

Potable water: See drinking water.

Purified water: Recycled water that has been treated to an advanced level beyond tertiary treatment, so that it can be added to water supplies ultimately used for drinking water. The treatment includes membrane filtration with microfiltration (MF) or ultrafiltration (UF), reverse osmosis (RO), and advanced oxidation that consists of disinfection with ultraviolet light (UV) and hydrogen peroxide (H2O2). Purified water may be discharged into a groundwater basin or surface water reservoir that supplies water to a drinking water treatment facility.

Quarterly Testing Reports: Four quarterly testing reports were prepared to summarize the testing data collected at the Demonstration Facility. Quarterly Testing Report No. 4 includes all of the data collected at the Demonstration Facility and is included as an appendix to the AWP Facility Project Report.

Raw water: Water that has not been treated for use. Examples of raw water are water in the Colorado River aqueduct, the State Water Project aqueduct, open reservoirs (whether filled with imported water or runoff), rivers, naturally occurring lakes and some well water.

Reactor: A vessel or tank where physical or chemical treatment processes occur**.**

Reclaimed water: See recycled water.

Recovery: Also called Feedwater Recovery is the volumetric percent of feed water that is converted to filtrate or permeate.

Recycled water: Treatment of wastewater beyond secondary treatment using tertiary filtration and chlorination. Water treated to this tertiary level is considered to be recycled water, which is suitable for many beneficial uses including irrigation or industrial processes. Recycled water meets treatment and reliability criteria established by Title 22, Chapter 4, of the California Code of Regulations.

Reservoir: A manmade lake or tank used to collect and store water.

Reservoir augmentation (RA): The process of adding purified water to a surface water reservoir. The purified water undergoes advanced treatment (membrane filtration, reverse osmosis and UV disinfection/advanced oxidation). The purified water is then blended with untreated water in a reservoir. The blended water is then treated and disinfected at a conventional drinking water treatment plant and is distributed into the drinking water delivery system. Also known as surface water augmentation.

Reverse osmosis (RO): A high pressure membrane process that forces water through the molecular structure of several sheets of thin plastic membranes to filter out minerals and contaminants, including salts, viruses, pesticides, and other materials. The RO membranes are like microscopic strainers bacteria and viruses as well as inorganic and most organic molecules cannot pass through the membranes.

Scaling: The precipitation or crystallization of salts on a surface (e.g., on the feed side of a membrane).

Specific flux: Flux per unit pressure (gfd/psi). This value is temperature corrected due to the impact of temperature on viscosity. (See definition of flux).

Spiking: A process in which a known quantity of a given constituent is added to the feed of a treatment system to test the robustness of the treatment process when ambient concentrations of the target constituent(s) is very low.

Stage: A group of membrane units operating in series. In a two stage configuration, concentrate from the first stage travels to the second where more water is produced.

Storage: Water held in a reservoir for later use.

Surface water: Water located on the Earth's surface, in a river, stream, lake, pond or surface water reservoir.

Surrogate Compounds or Surrogate Parameters: A common method used to evaluate water quality using a compound or parameter viewed as representative of a non-related class of chemicals or organisms. Surrogates are used when the analytes of interest are more difficult to quantify and measure through standard laboratory practices. Examples of surrogate parameters include turbidity, conductivity, UV254, and total organic carbon.

Tertiary effluent prior to chlorination: Tertiary effluent prior to chlorination is wastewater that has undergone primary treatment, secondary treatment, and tertiary filtration, but has not been disinfected with chlorine. This is the feed water to the AWP Facility. Sometimes referred to as recycled water even though it has not been disinfected.

Testing and Monitoring Plan (T&M Plan): This plan was prepared as part of the AWP Facility Project to outline the testing and monitoring that was conducted at the Demonstration Facility. The plan was reviewed and commented on by the Independent Advisory Panel (IAP), the California Department of Public Health (CDPH), and the San Diego Regional Water Quality Control Board (Regional Board).

Total dissolved solids (TDS): The concentration of mineral salts dissolved in water. Salinity may be measured by weight (TDS) or by electrical conductivity. Salinity and TDS are both measures of the amount of salt dissolved in water, and the terms are often used interchangeably. Generally, salinity is used when referring to water with a lot of salt (e.g., seawater), whereas TDS is used to refer to water with little salt (e.g., freshwater).

Total Organic Carbon (TOC): TOC has no health effects. However, TOC provides a medium for the formation of disinfection by-products. These by-products include trihalomethanes (THMs) and haloacetic acids (HAAS). Drinking water containing these by-products in excess of the MCL may lead to adverse health effects, liver or kidney problems, or nervous system effects, and may lead to an increased risk of cancer.

Transmembrane pressure: The difference in pressure from the feed (or feed concentrate average) to the permeate across the membrane.

Turbidity: A measure of suspended solids in water; cloudiness.

Ultrafiltration (UF): A membrane filtration process with pore openings that fall between reverse osmosis (RO) and microfiltration (MF). Also used to characterize the size of particles removed.

Ultraviolet (UV) disinfection and advanced oxidation: During ultraviolet disinfection, water is exposed to ultraviolet (UV) light, just like instruments in medical and dental offices, to provide disinfection. Additionally, ultraviolet light combined with hydrogen peroxide creates an advanced oxidation reaction that eliminates any remaining compounds in water by breaking them down into harmless compounds.

Vessel Array: Physical arrangement of pressure vessels in a reverse osmosis (RO) system. For example, a 10 by 5 by 3 vessel array indicates a three stage RO system with 18 total vessels: stage one has 10 vessels, stage two has 5 vessels, and stage three has 3 vessels.

Wastewater: Untreated water collected in the sewer system from residences and businesses (e.g., from bathtubs, showers, bathroom sinks, clothes washers, toilets, kitchen sinks, dishwashers, and industrial processes). It consists of mostly water with some impurities. Also known as sewage.

Water Purification Demonstration Project (Demonstration Project): The second phase of the City of San Diego's Water Reuse Program. During this phase the Demonstration Facility will operate for approximately one year and will produce one million gallons of purified water per day. A study of the San Vicente Reservoir is being conducted to test the key functions of reservoir augmentation and to determine the viability of a full-scale project. No purified water was sent to the reservoir during the demonstration phase.

Water Purification Demonstration Project (Demonstration Project) Report: Final report documenting the findings of the Demonstration Project.

Water purification process: The process of using water purification technology on recycled water to produce a water supply that can be used for reservoir augmentation and ultimately for drinking water purposes. The process of water purification starts with recycled water, which has already been treated to produce a supply of water safe enough for irrigation and industrial purposes. This recycled water is further treated with water purification technology. The resulting purified water can be used to augment local reservoir supplies, which would be treated once more at a potable water treatment plant to produce drinking water.

Water purification technology: The technology used for purifying treated wastewater, including membrane filtration with microfiltration (MF) or ultrafiltration (UF), reverse osmosis (RO), and ultraviolet (UV) disinfection and advanced oxidation.

Water reuse: The planned use of recycled water that would otherwise return to the natural hydrologic (water) system for a specific beneficial purpose.

Water Quality Sampling Terminology

Field Duplicate: A portion of the collected sample volume is analyzed identically to evaluate laboratory precision, reproducibility of sample handling and analytical procedures, sample heterogeneity, and analytical procedures.

Blind Duplicate: Same as field duplicate, however the laboratory is not provided the sample location prior to analysis.

Split Sample: A portion of the collected sample volume is analyzed by a separate laboratory with overlapping capabilities utilizing identical analytical methods to evaluate laboratory accuracy, reproducibility of sample handling and analytical procedures, sample heterogeneity, and analytical procedures.

Field Blank: A sample of analyte free water (laboratory provided) is poured into the container in the field, preserved and shipped to the laboratory with field samples. The purpose is to assess contamination from field conditions during sampling.

Travel Blank: A clean sample of a matrix that is transported from the laboratory to the sampling site and transported back to the laboratory without having been exposed to sampling procedures. Typically, analyzed only for volatile compounds. The purpose is to aassess contamination introduced during shipping and field handling procedures.

Grab Sample: An individual sample collected at a selected time.

Composite Sample: Consists of grab samples of the same volume, taken from one source over a specific period at regulated times (i.e. time weighted) or at irregular intervals in irregular volumes that proportion the flow (i.e. flow weighted).

Water Measurement Terms

Milligrams per liter (mg/L) also known as parts per million (ppm): A measurement describing the amount of a substance (such as a mineral, chemical or contaminant) in a liter of water; a unit used to measure water concentrations (parts of something per million parts of water). One part per million is equal to one milligram per liter. (This term is becoming obsolete as instruments measure smaller particles.) This is equivalent to one drop of water diluted into 50 liters (roughly the fuel tank capacity of a compact car) or about thirty seconds out of a year.

Micrograms per liter (ug/L) also known as parts per billion (ppb): A frequently used measurement for water concentration (parts of something per billion parts of water). One part per billion is equivalent to one second of time in 32 years or one drop of water in a typical backyard swimming pool (a typical residential swimming pool is 30 feet by 15 feet with an average depth of 6 feet or 60 cubic meters). One thousand parts per billion is equal to one part per million.

Nanograms per liter (ng/L) also known as parts per trillion (ppt): A very high level of measurement for water concentration (parts of a constituent per trillion parts of water). This is equivalent to one drop of water diluted into 20 London Olympics swimming pools (2,500 cubic meters times 20 = 50,000 cubic meters) or about three seconds out of every 100,000 years.

Million gallons per day (mgd): This term is used to describe the flow of water treated and distributed from a treatment plant.

Acre foot (AF): A unit of water commonly used in the water industry to measure large volumes of water. It equals the volume of water required to cover one acre to a depth of one foot. An acre foot is 325,851 gallons and is considered enough water to meet the needs of two families of four with a house and yard for one year.

Executive Summary

In June 2011, the City of San Diego began operation of a three-step Advanced Water Purification (AWP) Facility to produce water suitable for indirect potable reuse from tertiary effluent (pre-chlorination) produced at the North City Water Reclamation Plant (North City). The Demonstration Facility is located at 4949 Eastgate Mall Road San Diego, CA 92121. A flow diagram of the Demonstration Facility processes and sampling locations (designated as S1 through S10) is provided in **Figure ES-1**. The Demonstration Facility was designed with a 1 million gallon per day (mgd) production capacity and consists of the following unit processes: parallel membrane filtration processes (microfiltration [MF] and ultrafiltration [UF]); parallel-two stage and three-stage reverse osmosis (RO) processes; and ultraviolet (UV) light disinfection and advanced oxidation (UV/AOP).

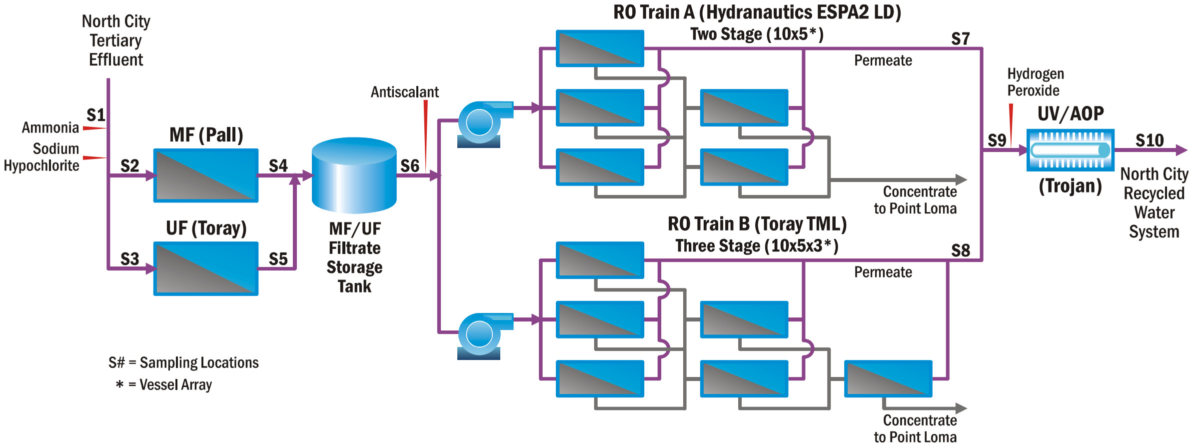

Figure ES-1 Demonstration Facility Processes

Specific objectives of the testing and monitoring program for the Demonstration Facility included:

- Demonstrate to the California Department of Public Health (CDPH) and the Regional Water Quality Control Board (RWQCB) that the proposed water purification processes will produce a final product water that meets public health and surface water augmentation criteria.
- Implement a monitoring plan for Constituents of Emerging Concern (CECs) tailored to the North City tertiary water characteristics and current recommendations of the State Water Resources Control Board (State Board).
- Demonstrate integrity monitoring techniques and performance reliability measures for the water purification processes, which can be implemented at the potential Full-Scale Facility.
- Monitor and collect operational performance and maintenance requirements of the Demonstration Facility equipment.

- Evaluate the degradation and by-product formation of nitrosamines and 1,4-dioxane by UV/AOP and compare alternative chloramines application conditions to mitigate N-Nitrosodimethlyamine (NDMA) formation.

The above objectives were met by operating the Demonstration Facility on a continuous basis for a 13.5-month period beginning in mid-June 2011 through the end of July 2012. During this time a testing and monitoring plan was implemented that specified water quality goals, materials and methods, process evaluation procedures and quality control measures. The Final Testing and Monitoring Plan (CDM Smith / MWH 2011) was reviewed and commented on by the Demonstration Project's Independent Advisory Panel (IAP), the CDPH, and the San Diego RWQCB. The operation and testing results associated with the Demonstration Facility were reported on a quarterly basis. The start and completion date for each testing period are shown in **Table ES-1**.

Table ES-1 Summary of Demonstration Facility Testing Periods

Testing Period	Testing Quarter	Test Period Start	Test Period End	Report Date
Testing Period 1	Q1	6/16/2011	10/31/2011	December 2011
Testing Period 2	Q2	11/1/2011	2/10/2012	March 2012
Testing Period 3	Q3	2/11/2012	5/14/2012	June 2012
Testing Period 4	Q4	5/15/2012	7/31/2012	September 2012

Operational Performance Monitoring

The subsections below summarize the cumulative operational performance results collected for each water purification process.

Microfiltration and Ultrafiltration Systems

Based on the similarities in operational performance and water quality performance, both MF and UF are suitable systems for membrane filtration in a Full-Scale Facility. The results of the testing showed the following:

- **Recovery:** The MF system operated at a recovery of 93 percent and experienced minimal fouling (reduction in performance). The UF system operated at 95 percent recovery and minimal fouling was observed during the Testing Periods 1 and 2; however, an increased rate of fouling was observed during the Testing Period 3. The UF system's higher recovery (i.e., less backwash waste) of 95 percent may have contributed to the increased rate of fouling.

- **Chemical Cleaning:** Two chemical cleanings were conducted on both the MF and UF systems during Testing Periods 1 through 3. These were effective at restoring the performance to the level observed when the membranes were new, which maintains efficient operations. Increased fouling of the UF system was observed during Testing Period 4.. The shorter cleaning cycle observed on the UF compared to the MF system may be due to smaller membrane pore size, which could result in more fouling by trace organic constituent or differences in membrane cleaning procedures based on manufacturers' recommendations.

- **Energy Use:** The MF and UF system pressures and resulting energy consumption were essentially equal.

- **Water Quality:** Both the MF and UF systems consistently produced water with similar concentrations for key water quality parameters including turbidity (<0.1 NTU), total organic carbon (6.5 mg/L), and UV 254 absorbance (0.17 cm-1). Pathogen testing showed that both the MF and UF as the first step in the purification process removed bacteria to undetectable concentrations, demonstrating greater than 99.9 percent removal of coliform bacteria. Removal of measured viruses (bacteriophage) was greater for the UF system as attributed to the smaller pore size of the UF membranes compared to the MF membranes. The MF and UF systems achieved composite virus removals (Somatic plus Male Specific) greater than 99.8 percent and 99.97 percent, respectively. **Section 2.2** of this report provides additional information regarding bacteriophage removal performance of the MF and UF systems.

Reverse Osmosis Systems

Two reverse osmosis configurations were tested: Train A, a two-stage configuration; and Train B, a three-stage configuration. The different configurations were tested to compare hydraulic conditions and potential operating advantages of one configuration over the other.

- **Recovery:** During Testing Periods 1 and 2 both Trains A and B were operated at 80 percent recovery. During this time both systems operated with little to no fouling with membrane cleaning cycles (time between required cleaning) exceeding six months. Due to the successful operation at 80 percent recovery, the recovery of both systems was increased to 85 percent during Testing Period 3, which is desirable to maximize water production at the Full-Scale Facility. Train A operated for three months with little fouling under 85 percent recovery conditions; however, due to an issue with the concentrate flow meter Train B was operated at a higher recovery than anticipated (i.e. 87 to 89 percent), which lead to scaling and the need to clean after 0.6 months of operation. Upon resolving the issue, Train B was operated for a short period of time prior to the end of the testing period at 85 percent recovery with moderate fouling/scaling observed .

- **Chemical Cleanings:** Two chemical cleanings were performed for Trains A and B during Testing Periods 1 and 2. For Train A, the cleanings had little effect on the operating conditions as buildup was likely not present in significant quantities. Assessment of the Train B membrane performance before and after the cleanings showed that they were partially effective at restoring the operation to that observed when the membranes were new. Train B was cleaned (third stage only) successfully during Testing Period 3.

- **Energy Use:** The power monitors on the RO system Train A (two-stage) and Train B (three stage) showed that the three-stage configuration required on average 10 percent more energy than the two-stage configuration under similar operating conditions. The overall average energy reduction resulting from the energy recovery devices was determined to be 8 percent for Train A and 5 percent for Train B during operation at 80 percent recovery. However, the boost pressure was observed to decrease significantly when the recovery was increased to 85 percent due to the reduction of concentrate flow available. The ERD performance observed at the Demonstration Facility under the 85% FWR condition does not represent what could be achieved at the potential Full-Scale Facility.

- **Water Quality:** Both systems consistently produced water with nearly identical water quality characteristics. Nitrate rejection was better than expected for Train A, and lower than expected in Train B, resulting in identical total nitrogen concentrations from both trains.

UV/AOP System

The UV disinfection and advanced oxidation system, which includes ultraviolet light and hydrogen peroxide, was operated to achieve a target 1.2- log (94 percent) removal of NDMA as defined in the 2008 CDPH Groundwater Replenishment Reuse Draft Regulations, and 0.5-log (68 percent) removal of 1,4-Dioxane as defined in the 2008 and 2011 CDPH Groundwater Replenishment Reuse Draft Regulations. The average power level required to achieve the target NDMA removal, was approximately 68 percent, which corresponded to an average power of 12.5 kW. The target power required to achieve the target removal increased as runtime increased, attributed to a decrease in temperature during winter operation, as well a correction factor in the control system that accommodates for reduced efficiency with lamp age. The target power also increased slightly when the target chloramine dose to prevent bio-fouling on the RO membranes was increased (i.e. 1.5 mg/L to 3 mg/L) as this caused the ultraviolet light transmittance (UVT) of the RO permeate to decrease.

The average electrical energy per order (EEO) value was 0.19 kWh/1000 gallons/log removal. For the Full-Scale Facility, multiple UV vessels in series will likely be used, which may improve efficiency and further reduce the EEO. The UV intensity values measured in the Testing Period 1 were very close to values measured in Testing Period 4 at 100 percent reactor power, which indicates that lamp aging was not significant over this time period.

Water Quality Monitoring

In general two categories of parameters were monitored over the testing period: (1) contaminants selected based on regulatory considerations for the potential Full-Scale Facility and (2) non-regulated contaminants.

Regulatory Relevance of Water Quality Results

Table ES-2 provides a summary of water quality monitoring results for all contaminants monitored based on regulatory considerations for the potential Full-

Scale Facility. Overall the results showed the purified water quality consistently met or exceeded the specified requirements for guidelines. As indicated all microbial constituents (coliform and viruses) measured in the purified water were non-detect in all samples analyzed over the testing period.

Table ES- 2 Water Quality Monitoring Results of Regulated Constituents

Regulation and Guideline Group	Number of Constituents / Parameters	Total Number of Tests[1]	Purified Water Results
Primary Drinking Water MCL [2]	90	1781	√ Meets all
Secondary Drinking Water MCL [3]	18	1290	√ Meets all
Microbial [4]	4	1547	√ Non-Detect
CDPH Notification Level [5]	30	716	√ Below all
CDPH Groundwater Replenishment [6]	142	2244	√ Meets all
Reservoir Limits [7]	143	4404	√ Meets all
Total Number of Constituents / Parameters[8]	231[8]	7,523[8]	-----------------

Notes:

[1] The total number of tests represents the approximate number of tests conducted at all sample locations shown in Figure ES-1 and the Imported Raw Aqueduct Water.

[2] Maximum Contaminant Levels and Regulatory Dates for Drinking Water U.S. EPA VS. California November 2008.

[3] California Code of Regulation: Title 22, Division 4, Environmental Health Chapter 15. Domestic Water Quality and Monitoring Regulations Article 16. Secondary Water Standards. Purified water met all Federal and State Secondary MCLs with the exception of pH and corrosivity. The potential Full Scale Facility would include post treatment to meet these requirements.

[4] EPA Total Coliform Rule (published 29 June 1989/effective 31 December 1990). Samples from the Demonstration Facility were analyzed for the following microbial contaminants: Total coliform, Fecal Coliform, and Viruses (Somatic and Male Specific Bacteriophage).

[5] Drinking Water Notification Levels and Response Levels: An Overview. California Department of Public Health Drinking Water Program Last Update: December 14, 2010.

[6] CDPH Groundwater Replenishment Reuse DRAFT Regulation 2011. Purified water meets all numerical water quality requirements for indirect potable reuse via groundwater replenishment.

[7] EPA Numeric Criteria for Priority Pollutants Toxic Pollutants for the State of California Rule. San Diego Regional Water Quality Control Board San Diego Basin Plan Numeric objectives; note some objectives have not been defined.

[8] Because some contaminants and parameters are in multiple regulations / guidelines the total of unique parameters is less than the sum.

Non-Regulated Water Quality Results

These constituents are grouped into two main categories: those included in the 2012 EPA Unregulated Contaminant Monitoring Rule (UCMR3) and other CECs, such as pharmaceutical compounds and personal care products. Of the 111 non-regulated constituents sampled for at the Demonstration Facility, only six were found to be quantifiably detected at low levels in the purified water at any time, including three constituents from the UCMR3 list and three CECs.

Three UCMR3 list constituents, bromochloromethane, hexavalent chromium, and strontium, were quantifiable detected in the purified water. The first two of these constituents can be considered disinfection byproducts and may have been formed at low levels within the treatment processes. The third constituent is a naturally occurring metal used as a dietary supplement and in manufacturing.

Only three CECs were detected at quantifiable concentrations in the purified water. These compounds were iohexal (contrasting agent used in x-ray), acesulfame-k (widely used artificial sweetener), and triclosan (antibacterial agent).

Section 3.6.2 and **Table 45** of this report provide a detailed discussion and summary of the results for these six constituents.

Quality Control

Several quality control (QC) procedures related to data analysis, lab testing, field sampling, sample handling and storage, and data validation were employed during the testing period. The results of this program showed the data set generated during the testing program is of high quality in terms of accuracy, precision, completeness, representativeness, and comparability.

Integrity & Critical Control Point Monitoring

The integrity and reliability of the individual water purification processes were evaluated closely during the testing period. Overall the results of the integrity monitoring plan showed the methods, frequency of testing, and response procedures were useful in verifying the integrity and reliability of the water purification processes. The findings indicate that the development of a similar monitoring and response plan during the design phase of the potential Full-Scale Facility that provides sufficient features and assurances that a foreseeable malfunction could be promptly identified and an appropriate response can be applied that would aid in assuring continuous production of high quality purified water. Results of integrity monitoring at Demonstration Facility are discussed below.

- **MF and UF.** Online continuous filtrate turbidity monitoring and daily pressure decay testing (PDT) were used. Turbidity monitoring results showed both systems achieve filtrate turbidities of less than 0.1 NTU on a consistent basis. The pressure decay rates were less than 0.1 pounds per square inch (psi) / 5 minutes. The fact that the pressure decay rates did not change over the testing period indicates no fibers were broken and the systems remained intact.

- **RO.** Prior to membrane installation, pressure or vacuum decay testing confirmed there were no defects in the membranes or membrane glue lines of each element that would inhibit performance. Post installation of the elements into the pressure vessels, conductivity probing was used to determine that there were no leaks in the interconnectors or end-caps and that the RO systems were intact and ready for operation. Lastly, during the operation the integrity of the RO systems were verified to be intact by conducting online continuous monitoring of permeate conductivity and total organic carbon.

- **UV/AOP.** Online power monitoring was done on a continuous basis. Verification and confirmation of the hydrogen peroxide dosing was also conducted. Results of the testing detected several occurrences of changes in power resulting from ballast failures. The UV/AOP control system automatically responded by increasing the reactor power level to prevent a loss in treatment performance. The system alarms also notified the operations staff allowing them to identify and replace the faulty ballasts in a timely manner. Additionally, during a short period of the testing period air entrapment in the hydrogen peroxide dosing system resulted in the loss of peroxide dose. Again, the automatic control systems detected and signaled the operations staff via alarm. Lessons learned from the Demonstration Facility were used to identify design features for consideration at the potential Full-Scale Facility to prevent or reduce such occurrences.

UV/AOP Challenge Testing

The overall water quality goals established for the Demonstration Facility included the assessment of the ability of the UV/AOP system to achieve target removal values of two specific contaminants (NDMA and 1,4 Dioxane) based on the 2008 and 2011 Groundwater Replenishment Reuse Draft Regulations, respectively. Because these contaminants were not present in the Demonstration Facility influent or RO permeate it was necessary to dose laboratory prepared solutions of these contaminants to the influent of the UV/AOP system in order to demonstrate the target removals. The major conclusions associated with the testing follow:

- The UV/AOP system achieved 1.5-log removal (96.8 percent) of NDMA under the design flow (1 mgd), UVT (97 percent) and peroxide dose (3 mg/L) conditions. This exceeded the log-removal goal of 1.2-log removal (93.7 percent) based on the 2008 Groundwater Recharge Reuse Draft Regulations.

- The average EEO for NDMA was determined to be 0.19 kW-h/1000 gallons/order.

- The UV/AOP system achieved 0.6-log removal (74.9 percent) of 1,4-Dioxane under the design conditions. This exceeded the log-removal goal of 0.5 (68.7 percent) based on 2011 Groundwater Recharge Reuse Draft Regulations.

Chemical and Power Usage

Chemical and power usage of the Demonstration Facility was tracked closely to assess ways to to improve operational efficiency and provide a basis for estimating operation and maintenance (O&M) costs for the potential Full-Scale Facility.

Chemical usage included chemicals used on a continuous basis as part of the purification process as well as chemicals required for periodic cleaning of the membrane systems. The amount of process chemicals required during the testing period was in close agreement with what was anticipated based on the design conditions. In general, the MF and UF systems required a greater volume of cleaning chemicals per cleaning event than that required for the RO systems mainly due to differences in the configuration of the cleaning systems, and the type and concentration of chemicals used based recommendations from the membrane manufacturers.

Power usage of the AWP equipment was also closely monitored. **Figure ES-2** provides the breakdown of power usage for the individual AWP equipment based on typical daily power totals taken when the Demonstration Facility was operating at full production capacity over a 24 hour period. The breakdown includes power required for the feed pump, which was used to supply tertiary effluent prior to chlorination to the MF and UF systems.

The power required for the feed pump is higher than what would be required for a full-scale facility due to specific operational requirements associated with the Demonstration Facility as further discussed in this report. The higher use of power required for the UF system, compared to the MF system, was largely attributed to differences in the size and efficiency of the air compressors equipped on the systems.

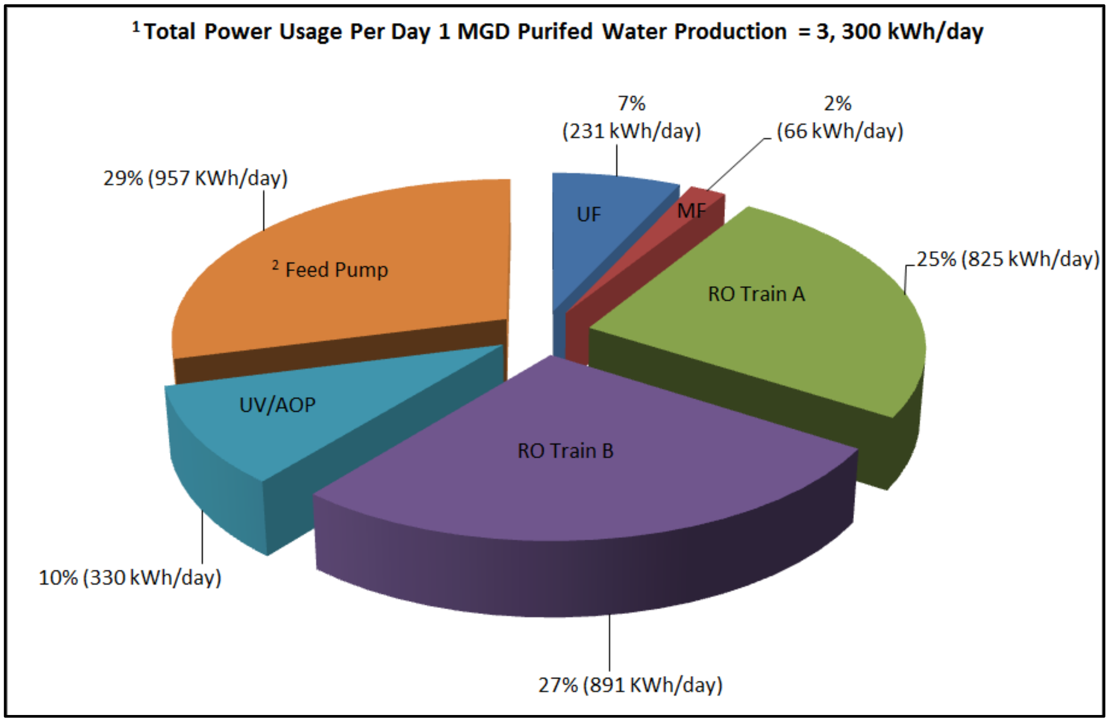

Figure ES-2 Demonstration Facility Process Power Usage

It seems the UF system air compressor was oversized and the design could be optimized for the Full-Scale Facility. The higher power use of RO Train B compared to RO Train A is largely attributed to difference in the membrane configuration (i.e. 3 Stage vs. 2 Stage) and membrane characteristics of the two systems. Train B was equipped with membranes designed for high rejection and low fouling requiring higher feed pressure, while Train A was equipped with membranes designed for energy savings, requiring lower feed pressure.

Note: [1] The total power usage per day is equivalent to 3.3 kWh/1000 gallons of purified water produced and 1,100 kWh per acre-foot of purified water produced. [2] The amount of power required for the Feed Pump is not representative (higher) of a full-scale facility due to specific operational requirements of the Demonstration Facility. Typically, the power usage for feed pumps used at full-scale facilities is accounted for in the MF or UF system power usage. Daily power usage shown does not include parasitic loads (e.g. lights, air conditioning, and ancillary equipment), which were measured to be between 3 to 5% of the equipment power usage.

Section 1
Introduction

1.1 Summary of Progress to Date

The following report provides the final progress update on the operations, testing, and monitoring component of the City of San Diego Demonstration Advanced Water Purification Facility (AWP Facility) located at 4949 Eastgate Mall Road San Diego, CA 92121. Full time operation of the AWP Facility began on June 16, 2011 which coincided with the beginning of the testing and monitoring period. Testing and monitoring was completed on July 31, 2012, representing a duration of approximately 13.5 months. Results were presented in quarterly reports over this period as summarized below. **Tables 1 and 2** respectively, provide a detailed summary of the overall AWP Facility operation schedule and quarterly monitoring periods.

- **Testing Period 1 Quarter 1 (Q1)** began on 6/16/2011 and was completed on 10/31/2011. The testing report was prepared in December 2011.
- **Testing Period 2 Quarter 2 (Q2)** began on 11/1/2011 with completion on 2/10/2012. The testing report was prepared in March 2012
- **Testing Period 3 Quarter 3 (Q3)** began on 2/11/2012 with completion on 5/14/2012. The testing report was prepared in June 2012.
- **Testing Period 4 Quarter 4 (Q4)** began on 5/15/2012 with completion on 7/31/2012. Progress for Q4 is the main focus of the current report.

During each testing period operational and water quality performance information was collected on each AWP unit process including the:

- Pall Microfiltration (MF) System,
- Toray Ultrafiltration (UF) System,
- Hydranautics ESPA2 LD Reverse Osmosis (RO) System (Train A),
- Toray TML RO System (Train B), and
- Trojan Phox Ultraviolet (UV) disinfection and advanced oxidation system (UV/AOP).

Each testing report presented the cumulative results of specific quarterly testing events, as well as routine water quality and operational data, plus the data from previous quarters. Observations included in each quarterly report focused on the most recent quarter. This current testing report (Q4) includes data collected for the entire 13.5 month start-up and testing period.

The collection of operational and water quality data of various constituents groups reported in the Q1, Q2 and Q3 Testing Reports continued during the Q4 Testing Period. The previous Testing Reports also presented the initial monthly sampling events for constituents of emerging concern (CECs), which were conducted in August, September, October and November 2011. Based on the results of the initial characterization, a select group of CECs were monitored weekly for four weeks during the Q3 testing period. A final set of CEC samples were collected conducted in tandem with the fourth quarterly sampling event conducted on 5/1/12. Results of all sampling events for the previous and current testing period are summarized in this report.

As reported in the Q1 Testing Report, prior to the initial quarterly sampling event a spiking experiment was conducted on the UV/AOP system to confirm the system was achieving the target log removal of N-Nitrosodimethylamine (NDMA). During this testing period a second spiking experiment was conducted to demonstrate the UV/AOP system achieved the target log removal of 1,4-dioxane and assess the impact of peroxide dose and electrical energy dose on removal. Results for both spiking experiments are presented and discussed in detail in this report.

During the current testing period, integrity monitoring of the various unit processes continued. This included daily pressure decay testing of the MF and UF membranes, along with online monitoring of MF/UF turbidity, RO conductivity, Total Organic Carbon (TOC), and UV/AOP power draw. Critical limit parameters and acceptable values were identified and monitored for each unit process to ensure the systems were meeting their designed treatment goals on a consistent basis. If any of the integrity monitoring indicated that unit processes were not meeting their designed treatment goals, then they were shut down for troubleshooting and repair.

Third party validation of water quality results was performed during the previous testing period. The purpose of the validation was to assess the quality of the data and review laboratory procedures to identify possible procedural alterations to be implemented for subsequent sampling events. A technical memorandum summarizing the extensive reports provided by the third party laboratory that conducted the data validation is provided in this report. Results of quality control (QC) sampling for all testing periods are summarized and assessed in this report.

1.2 Report Organization

The progress report is organized as follows:

- Executive Summary
- Section 1 Introduction
- Section 2 Operational Performance Monitoring of AWP Facility Unit Processes
- Section 3 Water Quality Monitoring Results

- Section 4 Integrity Monitoring
- Section 5 AWP Facility Chemical and Power Consumption
- Section 6 Maintenance and Equipment Issues
- Section 7 Summary and Conclusions
- Tables and Figures
- Appendix A: Final Report: Toxicity Testing Results for the City of San Diego Water Purification Demonstration Project.
- Appendix B: Quality Control Sample Results and CEC Data Review Letter prepared by Andy Eaton, Ph.D.
- Appendix C: Technical Memorandum: Summary of Third Party Data Validation of AWP Facility Quarterly Sampling Event Results.
- Appendix D: Expert Report: In review of Data for City of San Diego AWP Facility prepared by Shane Snyder, Ph.D.

Section 2
Operational Performance Monitoring of Water Purification Processes

2.1 Summary of Operations

The subsections below summarize the operational performance results collected between 6/16/11 through 7/31/12 for each water purification process. The feedwater for the purification processes was North City Water Reclamation Plant (North City) tertiary effluent (prior to chlorination). In general, the feedwater quality observed throughout the testing period was high quality in terms of general parameters that can impact operational performance of the purification processes including: turbidity, TOC, nutrients (nitrogen and phosphorus), and scale forming species. During the testing period, each process was operated continuously with minimal offline time due to routine maintenance, cleaning (membrane systems) and unscheduled minor repairs. Based on comparison of actual time to run hours (i.e. online time) the AWP Facility produced purified water greater than 87% of the time during this period.

Sections 2.2 and 2.3, respectively, compare microfiltration (MF) to ultrafiltration (UF) system performance and RO Train A to RO Train B performance.

2.1.1 Microfiltration System

The Pall Aria MF system was operated for over 8700 run hours (12 months) during the Q1 through Q4 testing periods. Membrane fouling was assessed by monitoring the temperature corrected specific flux under constant flux operation. **Figure 1** presents operational performance data including specific flux, flux, transmembrane pressure (TMP) and temperature based on daily operational readings. These parameters are plotted versus run hours; the plot also includes dates at each 1,000 run hour interval. The MF system was operated under the same steady state operating conditions throughout the testing periods. This included: target instantaneous flux = 29 gallons per square foot-day (gfd); average feedwater recovery = 93%; backwash interval = 19 minutes or production interval of 10,000 gallons; backwash duration = 96 seconds and target feedwater chloramine dose of 3 mg/L. Performance results collected during each testing period are discussed below.

Q1 Testing Period. Operational data collected on the MF system during the first testing period showed an initial overall fouling rate (percent decline in temperature corrected specific flux per month) of approximately 14% with the majority of the decline occurring between run hours 750 to 1300. A full clean in place (CIP) was conducted at run hour 2227 and was effective at restoring the temperature corrected (20 Deg C) specific flux to ~8 gallons per square foot of membrane per day (gfd)/pounds per square inch (psi). Post cleaning, the specific flux dropped steadily during the initial 120 run hours becoming steady at a value of ~5.8 gfd/psi for the remainder of the testing period.

Q2 Testing Period. During the Q2 testing period the temperature corrected specific flux remained steady at ~5.5 gfd/psi with little to no decline for approximately 2,175 hours (3.2 months) of operation.

Q3 Testing Period. During the Q3 testing period the MF system was operated for approximately 2,069 hours (Run hour 4996 to 7065) with minimal downtime. The only non-scheduled downtime occurred at run hour 6998 when the AWP Facility was shut down due to a pipe break which occurred on the downstream RO system. The AWP Facility was offline for approximately 3.5 days to make necessary repairs.

Beginning at run hour 4996 the temperature corrected specific flux remained steady at ~5.2 gfd/psi for approximately 580 hours of operation. At this time, the specific flux began to decline steadily reaching a value of 3.3 gfd/psi after 663 hours of operation. A full CIP was conducted at run hour 6239 and was effective at restoring the temperature corrected (20 Deg C) specific flux to a value close (~7.5 gfd/psi) to that achieved after the initial CIP conducted during Q1. Post cleaning, the specific flux dropped steadily as expected becoming steady at a value of ~5.6 gfd/psi for the remainder of the testing period.

Q4 Testing Period. During the Q4 testing period the MF system was operated for approximately 1643 hours (Run hour 7066 to 8709) with minimal downtime. Over this time period the temperature corrected specific flux dropped from a value of ~5.3 gfd/psi to ~4.3 gfd/psi, representing a decrease in specific flux of about 19%. A CIP was not necessary during this testing period. The overall fouling rate (% decrease in specific flux per month) starting after the completion of the last CIP (conducted during Q3) through the end of the Q4 testing period was about 12% per month. Assuming a linear fouling rate, it is projected the MF system could operate approximately 6 months before cleaning (i.e. specific flux reaches 2-3 gfd/psi) under the current operating conditions .

2.1.2 Ultrafiltration System

The Toray UF system was operated for over 8600 run hours (11.9 months) during the Q1 to Q4 testing periods. Membrane fouling was assessed by monitoring the temperature corrected specific flux under constant flux operation. **Figure 2** presents operational performance data including specific flux, flux, TMP and temperature based on daily operational readings. These parameters are plotted versus run hours; the plot also includes dates at each 1,000 run hour interval. The UF system was operated under the same steady state operating conditions throughout the testing periods. This included: target instantaneous flux = 30 gfd; average feedwater recovery = 95%; backwash frequency = 30 minutes; backwash duration = 195 seconds and target feedwater chloramine dose of 3 mg/L. Performance results collected during each testing period are discussed below.

Q1 Testing Period. Operational data collected on the UF system during the first testing period showed an initial overall fouling rate (% decline in temperature corrected specific flux per month) of approximately 25% with the majority of the decline occurring during run hours 750 to 1400. A full CIP conducted at run hour 1729 effectively restored the specific flux to ~8.8 gfd/psi. Post cleaning the specific flux decline was gradual (~1 gfd/psi) over 1,158 run hours.

Q2 Testing Period. During the Q2 testing period the temperature corrected specific flux declined gradually to a value of ~5.5 gfd/psi between run hours 2872 to 4984 hours, representing an overall fouling rate of ~8% per month following the CIP conducted during the Q1 testing period. However, it was observed that the rate of specific flux decline increased during the latter part of the testing period starting at around run hour 4504.

During the Q2 testing period, the North City operations staff reported the introduction of a continuous low dose of ferric chloride in the influent of the tertiary filters beginning on 12/8/11 to meet the California Department of Public Health (CDPH) requirement for recycled water used in cooling towers. On 2/6/12 the North City operations staff reported the short-term use of polymer addition at the aeration basin effluent prior to secondary clarification to reduce tertiary filter effluent turbidity. Based on operational data collected to date it does not appear the use of these chemicals impacted the MF or UF system performance.

Q3 Testing Period. During the Q3 testing period the UF system was operated for approximately 2,004 hours (Run hour 4984 to 6989) with minimal downtime. The only non-scheduled downtime occurred at run hour 6923 due to the aforementioned AWP Facility shut down to repair the damaged RO permeate piping.

The steady decline in specific flux observed towards the end of the Q2 testing period continued from run hour 4984 to 5585 to a value of ~2.8 gfd/psi. At this time, a full CIP was conducted and was effective at restoring the temperature corrected (20 Deg C) specific flux to a value close (~8.3 gfd/psi) to that achieved after the initial CIP conducted during Q1. Post cleaning, the specific flux dropped steadily at a rate faster than expected for the next 716 hours of operation to a value of ~3.9 gfd/psi at run hour 6301. At this time the decline in specific flux was observed to be steady with a slight increase for ~593 hours of operation. However, for the remainder of the testing period the decline was steady to a final value of 3.5 gfd/psi at run hour 6989.

Q4 Testing period. During the current testing period the UF system was operated for approximately 1618 hours (Run hour 6990 to 8608) with minimal downtime.

The steady decline in specific flux observed towards the end of the Q3 testing period continued from run hour 6990 to 7360 to a value of ~1.9 gfd/psi. At this time, a full CIP was conducted. Based on discussions with Toray the cleaning protocol was modified from that used previously. During the previous cleanings the target pH during the citric acid step was 3, however a target of 1.5 was recommended by Toray as a possible way to extend time between cleanings. It is expected the lower pH would dissolve a larger amount of inorganic material that may have precipitated on the membranes therefore extending the time between cleanings. The CIP was effective at restoring the temperature corrected (20 Deg C) specific flux to a value (~9.6 gfd/psi), which was higher than that achieved from previous cleanings. Post cleaning, the specific flux dropped consistently for the remainder of the testing period to a value of~5.4 gfd/psi at run hour 6806. The overall fouling rate starting after the completion of the CIP through the end of the testing period was about 26% per month. Assuming a linear fouling rate, it is projected the UF system could operate approximately 3 months between cleaning events (i.e. specific flux reaches 2-3 gfd/psi) under the current operating conditions.

2.1.3 Reverse Osmosis System

During the Q1 through Q4 testing period the RO systems (Trains A and B) were operated using combined filtrate from the membrane filtration systems for approximately 8,500 hours (11.8 months) of runtime. The RO trains were operated under similar operating conditions for the entire testing period as shown in **Table 3**. Each RO train was also equipped with an energy recovery device (ERD) by Energy Recovery, Inc. (ERI) that was designed to transfer pressure from the concentrate to the feed of the last stage. The RO trains were designed without the use of cartridge filtration as pre-treatment. RO Train A was configured as a two-stage system and utilized model ESPA2 LD membranes manufactured by Hydranautics. Likewise, RO Train B was configured as a three stage system and utilized model TML membranes manufactured by Toray. Operational performance data collected for both RO Trains during each testing period is discussed in the subsections below.

2.1.3.1 RO Train A

Operational performance parameters including net operating pressure (NOP), flux, specific flux and feedwater temperature for the RO Train A are illustrated in **Figure 3**. Membrane fouling was assessed by monitoring the decline in temperature corrected specific flux, or permeability, under constant flux operation. These parameters are plotted versus run hours; the plot also includes dates at each 1,000 run hour interval. Operational performance observed during each testing period is summarized below.

Q1 Testing Period. During the initial operation period, a decrease in the specific flux was observed prior to becoming level around run hour 900 (5 weeks). Since this decrease was predominantly in the first stage elements, it was believed that it may have been related to organic fouling or to biological regrowth. To prevent further fouling, the target feedwater concentration of chloramines was increased from 1.5 to 3.0 mg/L. Following this adjustment, the membranes operated with little to no decrease in specific flux for around 1,345 hours of operation. A full Chemical cleaning was performed on Train A on 10/14/11 (run hour 2,245). The membranes were cleaned in accordance to the manufacturer's protocol using caustic soda followed by citric acid. A summary of cleaning results for both RO Systems is provided in **Table 4**. Comparison of the specific flux measured pre and post cleaning for the 10/14/11 Train A cleaning indicates the cleaning had no effect on restoring the average membrane specific flux. These results suggest that the decrease in specific flux observed during the initial operation may have been related to conditioning of the membranes rather than entirely from membrane fouling. It is also possible that the cleaning procedures chosen were not sufficient to entirely remove the foulant layers.

Q2 Testing Period. The corresponding run hours for the Q2 Testing period began at 2,618 and ended at 4,764 hours. During this time the temperature corrected specific flux remained steady at ~0.13 gfd/psi with little decline for approximately 2,146 hours of operation. The overall fouling rate from the previous CIP to the end of the Q3 testing period was less than 2% per month. The net operating pressure increased over the testing period due to the decrease in feedwater temperature.

The calculated efficiency of the RO Train A Turbocharger from Q1 and Q2 operation was determined to be far below optimal conditions. After several discussions with the manufacturer, a representative from the RO skid supplier (Enaqua) installed a complete set of new bearings on the device on 12/5/11 (run hour ~3,512). Upon review of performance pre and post replacement of the bearings technicians from ERI confirmed there was a hydraulic issue with the ERD and agreed to repair the unit. On 1/10/12 (run hour ~4097), a representative from Enaqua removed the device for return to ERI and installed necessary piping to allow the RO system to be operated while the device was being repaired.

Q3 Testing Period. The corresponding run hours for the Q3 Testing period began at run hour 4764 and ended at run hour 6805. The only unscheduled downtime occurred at run hour 6737 due to the aforementioned AWP Facility shut down required to repair the damaged RO permeate piping.

During the first 1,500 hours of Q3 operation the system was operated under the same target operating conditions as the previous testing periods, which were: average flux = 11.8 gfd; feedwater recovery = 80%, antiscalant dose = 3 mg/L; and chloramines dose = 3 mg/L. During this period, the temperature corrected specific flux remained steady at ~0.13 gfd/psi with little to no decline. A goal during this testing period was to assess the performance of the RO systems at an increased feedwater recovery (FWR). Prior to increasing the FWR, a full CIP was conducted to try and restore the specific flux so an accurate assessment of the impact of FWR on fouling/scaling could be made.

Due to the ineffectiveness of the CIP conducted during the Q1 testing period the cleaning protocol was modified to change the order of cleaning chemicals. During Q1 caustic was followed by citric acid. However, during this testing period citric acid was followed by caustic. In addition, the chemical soak and recirculation times were extended. Data collected before and after the cleaning showed the specific flux was restored by about 15% with all of the increase observed after the caustic cleaning, suggesting that the majority of the fouling was related to organic material. Though there was no observed increase in specific flux after the acid cleaning it is believed the acid may have removed inorganic foulants which may have coated or complexed with organic foulants allowing for effective removal of the organic foulants by the caustic.

Following completion of the CIP, the system was operated under the same target operating conditions as stated above with the exception that the FWR was increased to 85% at run hour 6314. The FWR was increased by manually adjusting the valve located on the concentrate piping to reduce the concentrate flow. The permeate flow set point was held constant to the design flow rate and not impacted by increasing the FWR. The system operated with little to no fouling as measured by the decline in overall specific flux for the remainder of the testing period.

Performance monitoring of the TurboCharger (Energy Recovery Inc. - ERI) energy recovery device (ERD) continued during the testing period. **Figure 6** presents values of Stage 1 concentrate pressure before and after the TurboCharger along with the calculated boost pressure. The unit was repaired and reinstalled at run hour 5015. Comparison of performance data pre and post repair showed that the average boost pressure increased from 8.9 to 22.9 psi as a result of the repair. It was also observed during this testing period that the average boost pressure dropped significantly (22.9 psi to 11.8 psi) when the recovery FWR increased to 85%. The drop in boost pressure would be expected with an increase in FWR as the concentrate flow into the Turbocharger is reduced.

Q4 Testing Period. The corresponding run hours for the Q4 Testing period began at run hour 6805 and ended at run hour 8458, representing 1653 hours (2.3 months) of online time. During this time system operation continued at a target feedwater recovery of 85%. The system operated for 2144 hours (3 months) during the period following the previous cleaning (conducted during Q3) to the end of the current reporting period The average fouling rate was about 2% per month as measured by the decline in temperature corrected specific flux.

Figure 4 presents values of specific flux for Stage 1 and Stage 2, respectively. As shown the values for Stage 1 were consistent over the testing period with little to no decline after the initial conditioning period, indicating minimal fouling occurred. The values for Stage 2 show a downward trend suggesting some scaling occurred. **Figure 5** shows values of differential pressure (DP) measured across Stage 1 and Stage 2. It was observed during the Q2 testing period that Stage 1 DP values were increasing slightly with runtime. During the current and previous testing periods the values remained fairly consistent indicating that membrane element feed channels are not plugging.

Performance monitoring of the TurboCharger (Energy Recovery Inc. - ERI) energy recovery device (ERD) continued during the testing period. **Figure 6** presents values of Stage 1 concentrate pressure before and after the TurboCharger along with the calculated boost pressure. The average boost pressure observed during the current reporting period was similar (~12 psi) to that observed during the Q3 testing period during operation at 85% recovery.

2.1.3.2 RO Train B

Operational performance parameters including net operating pressure (NOP), flux, specific flux and feedwater temperature for the RO Train A are illustrated in **Figure 7.** Membrane fouling was assessed by monitoring the decline in temperature corrected specific flux, or permeability, under constant flux operation. These parameters are plotted versus run hours, the plot also includes dates at each 1,000 run hour interval. Operational performance observed during each testing period is summarized below.

Q1 Testing Period. The target operating conditions for the Q1 Testing period were: average flux = 11.6 gfd; feedwater recovery= 80%, antiscalant dose = 3 mg/L; chloramines dose = 1.5 to 3 mg/L. During the initial 160 hours (1 week) of operation, the specific flux (gfd/psi @25 °C) of the new Toray TML membranes declined steadily from an initial value of 0.15 to 0.13. The specific flux further declined slightly over the next 740 run hours to ~0.12 gfd/psi. The target feed concentration of chloramines was increased from 1.5 to 3.0 mg/L (same modification as Train A) at run hour 941. The specific flux remained steady with little or no decline for the next 1,126 hours (1.6 months) of operation.

A full chemical cleaning was performed on Train B at run hour 2,027. The membranes were cleaned in accordance with the manufacturer's protocol using both caustic soda and citric acid. Assessment of the membrane performance before and after the cleaning showed the cleaning restored the specific flux by about 18% signifying the cleaning was effective. Post cleaning, the specific flux remained steady with little to no decline for the remaining 551 run hours of the testing period.

Q2 Testing Period. The corresponding run hours for the Q2 Testing period began at 2595 and ended at 4772 hours. During this time the system was operated with the same target operating conditions as the previous testing period. The temperature corrected specific flux remained steady at ~0.12 gfd/psi with little decline for approximately 2,177 hours (3 months) of operation. The overall fouling rate from the previous CIP to the end of the Q2 testing period was less than ~3% per month. As shown the net operating pressure increased over the testing period due to the decrease in feedwater temperature.

Monitoring of the TurboCharger (Energy Recovery Inc.) energy recovery device during Q2 showed the average pressure boost was 25.4 psi, which was similar to the average boost pressure observed during the previous testing period (e.g. 22.6 psi).

Q3 Testing Period. The corresponding run hours for the Q3 Testing period began at run hour 4772 and ended at run hour 6787. The only unscheduled downtime occurred at run hour 6721 due to the aforementioned AWP Facility shut down required to repair the damaged RO permeate piping.

During the first 1,525 hours of Q3 operation the system was operated under the same target operating conditions as the previous testing periods. The temperature corrected specific flux remained steady at ~0.11 gfd/psi with little to no decline. At this time a full CIP was conducted. Due to the ineffectiveness of the CIP conducted on the RO systems during the Q1 testing period the cleaning protocol was modified as described above for RO Train A. Data collected before and after the cleaning showed the specific flux was restored by about 17%. The specific flux increased by 8% after the acid cleaning and an additional 9% after the caustic cleaning.

Following completion of the CIP the system was operated under the same target operating conditions as above with the exception that the FWR was increased to 85% at run hour 6391. During the initial 396 hours (2.3 weeks) of operation, little to no fouling was observed as measured by the decline in overall specific flux.

However, comparison of values of normalized specific flux for Stage 1, Stage 2 and Stage 3 indicated increasing the FWR to 85% resulted in the Stage 3 normalized specific flux to decline at a much faster rate than Stage 1 and Stage 2. In addition, over this time the permeate conductivity of Stage 3 increased by about 158%. These observations signify that scaling of the Stage 3 membranes occurred.

Monitoring of the TurboCharger (Energy Recovery, Inc.) energy recovery device on the Train B RO system continued during this testing period. The average boost pressure during operation at a target FWR of 80% was 23.3 psi with a noticeable decrease at run hour 5022. The decrease is due to a manual adjustment made on the concentrate valve to decrease the concentrate flow in order to maintain the target FWR. Further adjustment was made to the concentrate valve at run hour 6391 to increase the target FWR to 85%. The average boost pressure measured during operation at 85% over the remainder of the testing period was only 6.4 psi. The reduced boost pressure at 85% FWR is attributed to the lower concentrate flow.

While the ERD could have been adapted to the higher FWR conditions using a nozzle valves, the City elected not to proceed with this modification during the testing period. If it is decided to incorporate ERD's into the design of the potential Full Scale Facility consideration should be given to the use of automatic control valves and auxiliary nozzle valves to optimize the performance of the ERD's over the expected range of concentrate flow, pressure and temperature.

Q4 Testing Period. The corresponding run hours for the Q4 Testing period began at run hour 6787 and ended at run hour 8435, representing 1648 (2.3 months) of online time. During this time system operation continued at a target FWR of 85%. The decrease in the third stage specific flux observed at the end of the previous reporting period continued for the initial 938 hours (1.3 months) of operation. At run hour 7311 the third stage specific flux had dropped by 40% of the initial value observed at the start of 85% FWR operation. This drastic drop in specific flux indicated the third stage had undergone significant scaling. At this time a CIP was conducted on the third stage membranes. Results of the cleaning show the cleaning was effective at restoring the specific flux. Following the CIP the Train B was restarted at a target FWR of 80%.

Because Train B scaled at a much faster rate than Train A during operation at 85%, an investigation was undertaken to identify the possible cause. The investigation included verification of the accuracy of the flow transmitters equipped on the RO skids as well as verifying the FWR of the systems based on sulfate values measured in the feed, permeate and concentrate. The flow transmitters equipped on both RO skids were checked against measurements using an ultrasonic flow meter provided by Toray. Comparing results showed the flow transmitters were within acceptable agreement with the ultrasonic flow meter with the exception of the concentrate flow transmitter on Train B, which read 22% higher than the flow measured by the ultrasonic meter. Based on this information, recovery calculations were revised to use the permeate and feed flowmeters rather than the concentrate. In addition, sulfate mass balance calculations were performed, confirming the accuracy of the revised recovery calculations. It was therefore determined that Train B had operated at FWR between 87 and 89% instead of the targeted 85% FWR during the time the scaling was observed. In order to rectify the issue the scale factor on the concentrate flow meter was adjusted to accommodate for the measured discrepancy. The FWR was returned to 85% FWR at run hour 7942. During the following 493 hours (3 weeks) the overall specific flux declined by about 9.9% and the third stage by 25%. Because a limited amount of run time was conducted on Train B at 85% recovery it is recommended further operation be conducted to further assess the fouling rate at this recovery.

Lastly, it was confirmed that prior to changing the FWR to 85%, Train B operated at a FWR between 79 to 81% (target 80%) based on flow measurements recorded from the magmeter located on the feed pump and permeate flow transmitters equipped on the RO skid.

Figure 8 presents values of specific flux for Stage 1, Stage 2 and Stage 3, respectively. As shown the specific flux of the third stage declined much faster than Stage 1 and Stage 2 during the initial 85% FWR operating period. This decline is attributed to the aforementioned scaling event. During operation following the completion of the CIP the specific flux for Stage 1, Stage 2 and Stage 3 remained fairly constant with no significant decline observed. **Figure 9** presents values of differential pressure (DP) measured for each Stage. Overall the DP values were consistent with that expected due to hydraulic losses and indicate no plugging of the membrane feed channels occurred over the previous or current testing period. The lower DP values observed in Stage 3 during the operation at 87 to 89% FWR (Run hour 6391) is attributed to a reduction in flow to the stage as the membranes scaled.

Monitoring of the TurboCharger (Energy Recovery Inc.) energy recovery device on the Train B RO system continued during this testing period. **Figure 10** presents values of Stage 2 concentrate pressure before and after the TurboCharger along with the calculated boost pressure. As the FWR is increased the concentrate flow from Stage 2 is decreased therefore providing less flow through the ERD resulting in lower boost pressure. The average boost pressure measured during the testing period changed during operation at different FWR conditions as provided below.

- Run hour 6391 to 7311 – The average boost pressure measured during this time period was 7 psi, FWR 87 to 89%.

- Run hour 7329 to 7920 – The average boost pressure measured during this time period was 16 psi, FWR 80%.

- Run hour 7942 to 8435 – The average boost pressure measured during this time period was 12 psi, FWR 85%.

2.1.4 UV Disinfection and Advanced Oxidation

During the Q1 through Q4 testing period the UV/AOP system was operated using permeate from the RO systems for approximately 8,500 hours (11.8 months) of runtime. During normal operation, the system was operated to achieve a target log removal of NDMA and 1,4-dioxane of 1.2 (93.7%) and 0.5 (68.4%), respectively. The target hydrogen peroxide dose applied to the UV/AOP feedwater was held constant at 3 mg/L. The ultraviolet light transmittance (UVT) at the 254 nanometer wavelength measured in the feed ranged from approximately 97 % to 98.5 %, which was determined to be impacted by the chloramine residual concentration. The Trojan control system adjusted the reactor power to maintain the target log removals using an algorithm, which takes into account feed flow, temperature, UVT, and lamp age**.** **Section 2.1.4.1** presents operational UV/AOP performance results collected during each testing period. **Sections 2.1.4.2 and 2.1.4.4**, respectively, provide results from an evaluation of potential UV/AOP by-products and challenge experiments conducted on the UV/AOP system to demonstrate target removals of NDMA and 1,4-dioxane.

2.1.4.1 Operational Performance Results

Operational data for the UV/AOP system collected during the Q1 through Q4 testing period are presented in **Figures 11 and 12.**

Q1 Testing Period. Operational data collection on the UV/AOP system during the Q1 Testing period showed the ultraviolet transmittance (UVT) measured at the 254 nanometer wavelength in the feedwater decreased from 98.5% to 97.7% (run hour 916) due to the increased chloramines dose required to reduce biofouling of the RO membranes. The Trojan algorithm changes the applied power required to achieve a target log removal based on changes in inlet flow, temperature, and UVT. Therefore, when the UVT decreased the required power increased. The average reactor power level required to achieve the target NDMA removal following the drop in UVT was 67% of the maximum reactor power level (i.e. 100%) corresponding to an average present power of 12.5 kW. Based on the average inlet flow the electrical energy dose (EED) was 0.303 kWh/1000 gallons. On four occasions the reactor power increased to 100% due to ballast failures. The faulty ballasts were sent to Trojan for autopsy to determine the cause(s) of failure. Upon analysis Trojan reported three of the failures were due to blown primary fuses, which commonly result from power surges, and the fourth was due to an output failure. It is also not uncommon in the ballast industry to have a bad batch of ballasts due to defective components. Trojan noted that installation of a transient voltage surge suppressor (TVSS) on the system may be a good idea if ballasts continue to fail in the future due to blown fuses.

The average electrical energy per order (EEO) value recorded at the Trojan HMI over the operating period was 0.260 kilowatt-hours (kW-h)/1000 gallons/ log removal. The EEO values and NDMA performance of the UV/AOP were confirmed by conducting a spiking experiment as described in **Section 2.1.4.4** which showed the unit was performing more efficiently than predicted (e.g. Average EEO was determined to be 0.188 kW-h/1000 gallons/log removal).

Q2 Testing Period. Operational data collected on the UV/AOP system during the Q2 testing period started at run hour 2,595. Overall the performance of the UV/AOP system during this testing period was similar to the previous testing period. However, a slight trend of increasing reactor power level required to achieve the target 1.2-log removal of NDMA was observed. The increase in power is likely due to the lower feedwater temperature of ~4 degrees Celsius (C) observed during the this testing period. In addition to the aforementioned factors that impact the applied power level (i.e. inlet flow, temperature and UVT) the Trojan control system also increases power with time to accommodate for lamp aging. The average reactor power level required to achieve the target NDMA removal was 71% of the maximum power level, which corresponds to an average present power of 13.0 kilowatts (kW). Based on the average inlet flow the EED was 0.317 kWh/1000 gallons. In addition, no ballast failures occurred during this testing period.

Q3 Testing Period. Operational data collected on the UV/AOP system during the Q3 testing period started at run hour 4793 and ended 6841. The reactor operated for ~2,048 hours. There were two periods of unscheduled downtime. The first occurred around run hour 6602 when the reactor was taken offline for approximately 1 to 2 hours to replace a single faulty ballast and lamp. The operations team immediately contacted Trojan to send replacement parts. The faulty parts were sent back to Trojan for autopsy (ballast only) to determine the cause of failure. The second shutdown occurred at run hour 6775 due to the aforementioned AWP Facility shut down required to repair the damaged RO permeate piping.

Starting around run hour 6263 the UVT analyzer alarmed on a frequent basis due to low flow. When these alarms occurred the UV control system automatically increased the UV power to 100%. It was determined the cause of the low flow was air entrapped in the UV inlet piping. After several attempts to remove the air by adjusting the air relief valves located upstream and downstream of the UV reactor the problem was resolved by partially closing the butterfly valve located on the UV outlet pipe to increase the backpressure in the line and installing a bubble trap upfront of the UVT analyzer.

Q4 Testing Period. Operational data collected on the UV/AOP system during the current testing period started at run hour 6841 and ended at 8549. The reactor operated for ~1,708 hours. Overall the performance of the UV/AOP system during this testing period was similar to the previous testing periods. However, a slight trend of decreasing reactor power level required to achieve the target 1.2-log removal of NDMA was observed. As previously mentioned, the Trojan control system adjusts power based on feed temperature. The average feedwater temperature during the current testing period was ~3.3 degrees Celsius (C) higher than that observed during Q2 and Q3, which would account for the reduction in the reactor power requirement. The average reactor power level required to achieve the target NDMA removal during this testing period under normal operating conditions was 68% of the maximum power level which corresponds to an average present power of 12.5 kilowatts (kW). The EED based on the average inlet flow was of 0.303 kWh/1000 gallons. These values are in close agreement with those measured during the Q1 Testing Period suggesting the lamp ageing factor built into the Trojan control system did not have a significant impact on the EED during the Q1 to Q4 Test Period.

The UV intensity sensor equipped on the system was checked against a reference sensor during each testing period. This was done by stopping flow to the system and increasing the power to 100%. Readings of UV intensity were taken with the duty sensor. The system was then shutoff and the reference sensor was installed and the procedure was repeated. Comparison of UV intensity measurements from both sensors are provided in **Table 5**. Results showed close agreement (i.e. < 5% difference) throughout the testing period. Also, the UV intensity values measured in the Q1 testing period were very close to values measured in the Q4 testing period giving a gross indication that lamp aging was not significant over this time period. However, it is important to keep in mind the intensity sensor is only positioned at one lamp. A comprehensive assessment of lamp aging would require several lamps be sent to Trojan for analysis.

During the current testing period there were several occurrences of peroxide pump failures caused by air entrained in the dosing pumps. The first occurrence happened around run hour 7052 when the duty pump lost flow confirmation and auto switched to the standby pump. After the switch over occurred, the second pump lost flow confirmation causing the system to go into critical alarm and shut off. The system was re-started, however the pumps continued to lose flow confirmation on several occasions over the next few days. At this time, the operations team contacted Trojan to trouble shoot the issue. Several adjustments were made to the peroxide dosing system which seemed to remedy the issue. First, the degasification interval and duration (user set points) were adjusted to allow the dosing system to purge air on a more frequent basis and for a longer time period per purge. Second, a valve on the discharge side of the peroxide pumps which allows air to return to the peroxide storage tank was opened. It should also be noted that on several of the pump failure occurrences the feed flow to the UV was at reduced flow as only one RO system was in operation. Because the peroxide dose is flow paced the dose rate would be lowered automatically which may have increased the likelihood of air entrapment.

A ballast failure also occurred during this testing period, which makes a total of six ballast failures during the Q1 through Q4 testing period. Based on discussions with

Trojan, it was suggested a power monitoring study be employed to assess if the failures could be a result of power surges. In addition, it was recommended the air filters on the power distribution cabinet (PDC), which houses the ballasts, be changed on a monthly basis to prevent the cabinet temperature from getting to a level that could damage the ballasts. At the time of this report the power study was underway. In addition, the operations team initially began changing the PDC filters on a monthly basis. However, due to the amount of debris discovered on the filters over this time period, a more frequent maintenance schedule was implemented (i.e. every 2 weeks). Lastly, Trojan also sent the failed ballasts to the ballast manufacturer to determine the possible cause (s) of the failures. The initial findings were that there does not seem to be a common cause for the ballast failures. It is expected the manufacturer will provide further details as they become available.

2.1.4.2 UV/AOP By-product Evaluation

The T&M Plan takes into consideration input from the IAP, CDPH, and the RWQCB. CDPH reviewed the 2010 IAP report and suggested that the demonstration program evaluate by-products from advanced oxidation of NDMA, 1,4-dioxane, and other organic constituents present in the RO permeate. Based on information found in peer reviewed literature and past pilot testing conducted at North City, the project team recommended taking grab samples from the RO permeate (UV/AOP influent) and UV/AOP product water and measuring formaldehyde on a weekly basis during the initial eight weeks of the routine sampling period. Three additional sample sets were taken later in the testing period.

Results of the formaldehyde analyses are provided in **Table 6**. The average concentration (µg/L) in the influent (n=11) was 4.1 ± 2.5 while the product (n=11) was 9.7±2.9. While the results showed an apparent increase in concentration across the UV/AOP process, the relative change in concentration does not appear to be of health concern. The concentration measured in the UV/AOP product is nearly 10 times lower than the CDPH Notification Level (NL) of 100 µg/L. Interestingly, the concentrations of NDMA and 1,4-dioxane measured in RO permeate, which can serve as pre-cursors to formaldehyde formation, were below or near below their RL of 2 ng/L and 0.5 µg/L, respectively. During subsequent testing periods additional samples of formaldehyde were taken and analyzed as part of the overall water quality QC plan. Results from analysis conducted by a second commercial lab showed the concentration of formaldehyde in the UV/AOP product to be higher than those reported by the original lab that conducted the analysis but still lower than the NL. This is further discussed in **Section 3.5.1.2.**

2.1.4.3 Chloramine and Nitrosamines Investigation

The T&M Plan outlined specific measures to evaluate different chloramine dosing alternatives during the testing period. While chloramine dosing is required to control organic and biological fouling of the membrane components (i.e. MF, UF, and RO membranes) of the overall purification process, past studies have shown the combination of chloramines and organic pre-cursors present in wastewater are common pathways for the formation of nitrogenous disinfection by products (DBPs) such as nitrosamines. Chloramines can be created by either sequential addition of ammonia (aqueous ammonia) or chlorine (sodium hypochlorite) directly into the feedwater or by a side stream process that pre-forms chloramines prior to application to the feedwater. The latter method has been shown to reduce the formation of some DBPs.

The T&M Plan was designed to evaluate both chloramine dosing methods with the initial condition to be sequential addition. As discussed in **Section 3.1,** routine water quality monitoring included sampling of nitrosamines on a monthly basis from various locations in the purification process including tertiary effluent (prior to chlorination), RO feed, RO permeate and UV/AOP product water. Results of nitrosamine monitoring presented in **Table 18** showed the average concentration (n=10) of NDMA measured in the tertiary effluent was 4.2 ng/L and ranged from <RL (RL=2 ng/L) to 20 ng/L. Slightly lower concentrations were measured in the RO feed with the average concentration (n=14) of 3.5 ng/L ranging from <2 ng/L to 17 ng/L. These results show that NDMA formation was not occurring under the sequential addition of chloramines.

Results also showed the RO system achieved greater 43% removal of NDMA based on average concentration in the RO permeate of <2 ng/L. All NDMA results in the UV/AOP product water were < 2 ng/L with the exception of the sample collected on 1/3/12, for which the reported result was 5.5 ng/L. Results for other nitrosamines (i.e. NDEA, NDBA, NDPA, NMEA, NMOR, NPIP, NPYR) were similar in concentration in the tertiary water and RO feed throughout the testing period further indicating nitrogenous DBP formation was not occurring. These results did not warrant the need for testing the pre-formed chloramine application and therefore sequential chloramination was continued for the remainder of the testing period.

It should be noted routine sampling results showed that both NDMA and NDEA had occasional positive hits at locations downstream of locations where no detectable levels had been observed. For NDEA, this occurred on 12/1/11, 1/3/12, and 4/23/12, where low levels of NDEA were measured in the UV/AOP product (levels were 2.5, 2.9, and 4.9 ng/L, respectively), but had been below quantifiable levels in the upstream RO product. Similarly, a 6.1 ng/L NDEA level was measured in the Train B RO permeate on 11/2/11 when no NDEA was detected in either the upstream RO feed or the downstream combined RO permeate. For NDMA, a 5.5 ng/L result was found in the UV/AOP product on 1/3/12 when concentrations had been below quantifiable levels in both the RO product and RO feed. These positive results represent the challenge of reliably monitoring nitrosamine concentrations at such low concentrations with an analytical reporting level of only 2 ng/L. It is unlikely that these results suggest that either NDMA or NDEA was formed or introduced downstream of the RO membranes or within the UV/AOP, and the vast majority of the 15 NDEA and NDMA samples were below quantifiable levels in the UV/AOP product. Similarly, all results were below the CDPH notification level of 10 ng/L for both constituents.

2.1.4.4 UV/AOP Challenge Experiments

During the course of the Q1 through Q4 testing period several challenge experiments were conducted to demonstrate the performance and efficiency of the UV/AOP system to reduce NDMA and 1, 4-Dioxane. The design criterion for the UV/AOP was based on a 1.2 log removal of NDMA and 0.5 log removal of 1,4-dioxane at a system flow rate of 1 MGD. Because the concentration of the target compounds in the North City tertiary effluent and subsequently the RO permeate were too low (i.e. <RL) to demonstrate the required log removals it was necessary to spike laboratory prepared solutions containing adequate concentrations of these compounds spiked into the UV inlet. During all spiking experiments the UV/AOP product water was sent to sewer to avoid possible contamination of the recycled water. During Q1 a spiking experiment was conducted to assess the removal of NDMA, during Q3 (and repeated during Q4) spiking experiments were conducted to assess the removal of 1,4-dioxane. Details and results of each experiment are discussed in the subsections below.

2.1.4.4.1 NDMA Spiking Experiment

Objectives and Test Procedure. NDMA was spiked upstream of the UV/AOP to demonstrate the system could achieve the target removal under the aforementioned design conditions. During this experiment the reactor power was varied between the minimum and maximum settings. The reactor was operated at the design flow rate of 1 MGD and UV transmittance (UVT) of approximately 97%. In addition, the chloramines residual present in the UV/AOP feedwater was ~ 3 mg/L. The log removal of NDMA was determined for each set point. In addition 1,4-dioxane was measured in the UV/AOP feed and product to assess removal of inherent concentrations present.

The testing equipment required to conduct the spiking experiments, shown in **Figure 13**, was comprised of the following:

- Chemical Storage tank and cover– 30 gallon black polyethylene
- Chemical Storage tank mixing rod
- Chemical dosing pump
- Hydrogen Peroxide monitoring kit
- Piping and valving to make the connections between the components

1 L of NDMA stock spiking solution prepared by a certified laboratory experienced with preparing spiking solutions.

For each sample run, three individual 1.0 L influent grab samples were taken from the influent sample port and three product grab samples were taken from the product sample port. Samples were collected in UV proof (amber glass) bottles with preservative. Samples were sent to MWH Labs for analyses using EPA method 521 (NDMA) and 525 (1,4-dioxane). All samples were analyzed for NDMA and one (1) influent and one (1) product were analyzed from each run for 1,4-dioxane.

Concurrent to sampling, the feed UVT, product H_2O_2 concentration, feed flow, temperature, target reactor power, actual reactor power, target LRV, actual LRV EEO, and lamp hours were recorded. Documentation of the number of lamps in service was also recorded.

Control – The test plan included two runs in which the UV unit was in the off position. Samples were collected from the influent and product with and without peroxide.

- Test 1 consisted of operating the UV unit at the manufacturer's recommended power setting (approximately 64%) to achieve 1.2 log removal of NDMA at 695 gpm. The H_2O_2 was dosed at 3 mg/L. Three sets of influent and product samples were collected approximately 5 minutes apart.

- Test 2 increased the UV power setting to a target of 80% of the maximum output of the UV unit and the H_2O_2 was dosed at 3 mg/L. Three influent and three product samples were collected approximately 5 minutes apart.

- In Test 3 the UV power setting was approximately 60% (minimum power setting). Three influent and three product samples were collected approximately 5 minutes apart.

- Test 4 increased the UV power settings to 100% (maximum power setting). Three influent and three product samples were collected approximately 5 minutes apart.

A total of twenty-nine (29) NDMA and eight (8) 1,4-dioxane samples were collected and analyzed as part of this spiking experiment including samples measured in the UV/AOP influent, UV/AOP product and control samples. The spiking experiment lasted approximately four (4) hours. The first hour was used to set-up and verify that the testing and dosing apparatus were operating correctly and to give the system time to reach equilibrium. During the spiking experiment the UV/AOP product was directed to sewer. Any remaining volume in the mixing tank at the conclusion of the experiment was run through the UV unit to completely destroy any remaining chemical. Following completion of the experiment the UV/AOP product was diverted to sewer for another hour to ensure the system was completely flushed before putting the product back into the North City recycled water system.

Results. Table 7 provides analytical results of NDMA and 1,4-dioxane of samples collected during the spiking experiment. Results include measurements of the batch, control samples and three (3) influent and three (3) product samples for each power set point condition. The average influent and product concentration of NDMA (ng/L) based on results from all test conditions ranged from 737 to 847 and 5.3 to 29, respectively. The analytical data also show that the inherent feed concentration and product concentration of 1,4-dioxane sampled during each run was non-detect (ND). Control samples yielded results as expected showing similar values of influent and product NDMA concentrations with lamps off and peroxide dosing of 0 mg/L (Control 1) and lamps off and target peroxide dose of 3 mg/L (Control 2).

The analytical lab data was used to calculate the average NDMA log removal for each reactor power set point as presented in **Figure 14**. Results indicate the Trojan system achieved between 1.5 to 2.1 log removal of NDMA over the span of power settings (minimum 60% to maximum 100%) tested. The figure also presents the average target NDMA log removal recorded from the Trojan HMI for each test condition. For each power set point (100% power setting the exception) the NDMA log removal based on measured values was higher than that predicted by the Trojan algorithm.

Using the calculated NDMA log removal values, feed flow, and power measured during each test condition, values of electrical energy per order (kWh/1000 gallons/log removal) were calculated for each test condition as presented in **Table 8**. The calculated EEO values ranged from 0.176 to 0.205 over the range of power settings tested. Results showed the calculated EEO for the 64% power set point (0.188) was lower than the average EE/0 value (0.26) displayed on the Trojan system during the operating period as presented in **Section 2.1.4.1**. The data suggest the Trojan system is operating more efficiently than predicted.

The project team consulted with Trojan regarding the discrepancy of the EEO values calculated based on spiking results compared to the values calculated by the UV/AOP system algorithm. In response, Trojan compared the EEO models of the AWPF system to the UV/AOP system used at the Orange County Water District (OCWD) Groundwater Replenishment System. Trojan reported the AWP Facility system control algorithms are more complicated than OCWD's because the program structure allows for model parameters to be modified to control the system based on alternate contaminants. Furthermore, the OCWD system model does not have peroxide control so it only determines the UV dose needed for NDMA removal.

Trojan concluded that because the AWP Facility system calculates higher EEO values than the OCWD system the AWP Facility system may achieve higher than intended NDMA log reductions. Lastly, Trojan compared the two models based on a 95% feedwater UVT and showed the AWP Facility model calculated an EEO of 0.31 while the OCWD model predicted an EEO of 0.22.

2.1.4.4.2 1,4-Dioxane Spiking Experiment

Objectives and Test Procedure. During the Q3 Testing Period a second spiking experiment was conducted on the UV/AOP. The objectives of this experiment included:

1. Demonstrate the UV/AOP reactor is achieving minimum 0.5-log removal of 1,4-dioxane under the target reactor conditions to achieve 1.2-log removal of NDMA.

2. Determine EEO of the UV/AOP reactor with respect to 1,4-dioxane.
3. Assess the impact of hydrogen peroxide dose on 1,4-dioxane removal by the UV/AOP.
4. Assess the removal of 1,4-dioxane under UV dose conditions lower than the target conditions demonstrated to achieve >1.2-log removal of NDMA.
5. Gather information on the removal of select surrogate compounds by the UV/AOP process.

The experiment included four different operating conditions (Run 1 to 4) which varied in terms of target peroxide concentration, influent flow and UV reactor power. Details are provided in **Table 9**. A summary of the test conditions follow.

- Test 1 consisted of operating the UV unit at the manufacturer's recommended power setting (approximately 64%) to achieve 1.2 log removal of NDMA at 695 gpm. The H_2O_2 was dosed at 1.5 mg/L. One influent and three product samples were collected for both NDMA and 1,4-dioxane at approximately 5 minute intervals.
- Test 2 increased the H_2O_2 dose to 3 mg/L with the same flow and UV settings as Run 1. One influent and three product samples (1,4-dioxane only) were collected at approximately 5 minute intervals.
- Test 3 increased the H_2O_2 dose to 6 mg/L with the same flow and UV settings as Run 1 and Run 2. One influent and three product samples (1,4-dioxane only) were collected at approximately 5 minute intervals.
- Test 4 decreased the UV power settings to 60% (minimum power setting). The influent flow was increased by approximately 20% to further lower the UV dose. The H_2O_2 dose was set to 3 mg/L. One influent and three product samples were collected for both NDMA and 1,4-dioxane at approximately 5 minute intervals.

The target feedwater concentrations for NDMA and 1,4-dioxane were 1,000 ng/L and 20 µg/L, respectively. It was necessary to repeat the experiment during the current testing period because it was discovered that the solvent (methanol) originally used by the lab to prepare the spiking solution significantly increased the free radical demand and therefore would reduce the removal of 1,4-dioxane. Specifically, during the original experiment 1 L of methanol was used to prepare the stock solution resulting in a much greater concentration (>60X) than the spiked amount of 1,4-dioxane. During the repeated experiment the spiking solution was prepared with a solvent of DI water mixed with only 5 mL of methanol per 1 L. Though the target compounds are highly soluble in distilled water alone, the small volume of methanol was used to serve as a wetting agent and prevent the compounds from sticking to the surface of the glass container used to prepare the spiking solution.

Results. **Table 10** summarizes the results for 1,4-dioxane and NDMA measured in the batch samples, control samples, and the UV/AOP influent and product samples for the four test conditions. **Figure 15** plots average log removal values of 1,4-dioxane and NDMA versus target peroxide dose (mg/L) for Test 2 and Test 4, in which the peroxide dose was held constant at 3 mg/L but the EED was reduced (Test 4) by lowering the reactor power level and increasing the feed flow rate. As expected, the log removal of 1,4-dioxane was reduced under the lower EED conditions due to the reduced amount of free hydroxyl radical production. The average log removal of 1,4-dioxane and NDMA were 0.6 and 1.6, respectively for Test 2 but reduced to 0.39 and 1.3, respectively for Test 4.

Average values of 1,4-dioxane EEO (kWh/1000 gallons/log reduction) were 0.50 (range=0.45 to 0.58) to 0.57 (range=0.34 to 0.70) for Test 2 and Test 4, respectively. Such results are in general agreement with EEO values determined from spiking studies conducted on the full-scale AOP system located the OCWD's Groundwater Replenishment System which ranged from 0.27 to 0.58 kWh/1000 gallons/ log removal of 1,4 Dioxane (2009 WaterReuse California Section meeting, San Diego CA). **Table 11** provides calculated values of EED (kWh/1000 gallon) for the four test conditions. EED values for Tests 1, 2, and 3 were similar (i.e. 0.302 to 0.312) but approximately 27% lower for Test 4 (i.e. 0.225).

Figure 16 plots log removal of 1,4-dioxane versus target peroxide dose for Tests 1 to 3. The results show a linear relationship between log removal and peroxide dose ($R^2 = 0.99$). Based on this relationship, a predicted target dose of 2.3 mg/L would be required to achieve 0.5 log removal of 1,4-dioxane. The significance of these results is that it may be possible to optimize the peroxide dose to reduce O&M costs of the UV/AOP, however the overall results show it is a balance between electrical energy and peroxide dose to determine the optimal operating conditions to meet the target removal.

2.2 Comparison of MF and UF System Performance

The MF and UF systems were operated side by side for similar runtimes to compare operational and water quality performance.

A summary of operational performance of the membrane filtration systems is provided in **Table 12**.

Operating Period 1 is defined as the operational time period between the completion of the first and second chemical cleanings. During this time, the MF system operated for 5.5 months and the UF system for 5.7 months with similar fouling rates of 11 % (average decline in specific flux per month). During this time the UF system operated with a slightly lower average TMP (4.6 psi vs. 5.0 psi); however, the UF system required a higher average feed pressure (16 psi vs. 15 psi), due to a higher permeate backpressure from the longer discharge piping between the UF system and the break tank. Backpressure on the UF averaged 11.3 psi, but averaged 8.5 psi for the MF system, located immediately adjacent to the break tank. The differences in feed pressure should therefore not be considered representative of the two systems, but are rather the result of the unique flow configuration of the intermediate piping downstream of each system.

Operational Period 2 is defined as the operational period following the completion of the second chemical cleaning. The MF system operated for over 3.4 months with a calculated fouling rate of 12% and did not require a third cleaning through the end of the current testing period. In comparison, the UF system only operated for 2 months before requiring cleaning. During this time the fouling rate for the UF was 38%, which was significantly greater (> 3 times) than that observed on the MF system over a similar time period.

Operational Period 3 (UF only) is defined as the operational period following the completion of the third chemical cleaning. The UF system operated for 1.7 months with a lower fouling rate (26% vs. 38%) and much lower average TMP (2.7 vs. 6.8) than observed during Operational Period 2. The decrease in fouling is attributed to the lower target pH (1.5 vs. 3) used during the third cleaning as opposed to the target pH of the second cleaning.

On-site water quality monitoring of the membrane filtration systems showed that both consistently produced filtrate with similar average concentrations for turbidity (<0.1 NTU), Total Organic Carbon (6.5 mg/L), and UV 254 Absorbance (0.17 cm-1). Pathogen testing showed that both the MF and UF as the first step in the purification process removed bacteria to undetectable concentrations, demonstrating greater than 3-log (99.9 percent) removal of coliform bacteria. Removal of measured viruses (bacteriophage) was greater for the UF system, but exceeded 97 percent for both the MF and UF.

The MF and UF systems achieved concentrations of Total and Fecal Coliforms that were consistently non-detect (ND) in the filtrate from both systems; however, it was observed that the UF system achieved a slightly higher log removal of bacteriophage than the MF system, which is attributable to the smaller pore size in the UF membranes. The average log removal for Somatic (n=21) and Male Specific (n=20) Bacteriophage for the MF system were greater than 3.0 and 1.1, respectively. The average log removal of Somatic (n=21) and Male Specific Bacteriophage (n=20) for the UF system were calculated as greater than 3.7 and 2.2, respectively. No quantifiable hits of either Somatic or Male Specific Bacteriophage were recorded in the UF product, suggesting that higher log removal values may have been observed had concentrations in the feed been higher. **Section 3.15** provides further discussion of microbial monitoring results based on samples collected before and after each purification process.

2.3 Comparison of RO System Train A and Train B Operation

A comparison of operational performance of RO System Trains A and B is provided in **Table 13**. The Table is organized by operational periods as discussed below.

Operating Period 1: is defined as the operational time period between the completion of the first and second chemical cleaning. During this time the systems operated for 5.6 months (Train A) and 5.9 months (Train B) with similar fouling rates of 1.4 % and 1.6 % (average decline in specific flux per month), respectively at a target feedwater recovery of 80%. During this time, Train B operated with a higher feed pressure (e.g., 139 psi vs. 133 psi) and NOP (e.g., 104 psi vs. 98 psi). The higher pressure required for Train B is attributed to the difference in membrane type and configuration (three stages vs. two stages), as the permeabilities (specific flux) were found to be similar for both membranes and were nearly identical for the first stage elements **(see Table 13).**

Operational Period 2: is defined as the operational period following the completion of the second chemical cleaning, which was conducted at run hour 6,265 for Train A and run hour 6,297 for Train B. During this time the target feedwater recovery for both systems was 85%. Following the second cleaning Train A operated for 2,144 run hours (3 months) with little fouling (2.1 % per month). However, Train B only operated for 920 run hours (1.3 months) due to the aforementioned issue with the concentrate flow meter which led to the system being operated above the target recovery (i.e. .87 to 89%). During this time fouling rate was 15% based on the decline in the overall specific flux, however the Stage 3 fouling rate was 40%. At this time the third stage was cleaned.

Operational Period 3 (Train B only): is defined as the operational period following the cleaning of the third stage membranes. During this period the system was operated with a target recovery of 80% during which time the issue with the concentrate flow meter was investigated and resolved. During this period the system operated for 591 run hours with a modest fouling rate of 2.1%.

Operational Period 4 (Train B only): is defined as the operational period during which the system was operated at 85% recovery upon resolving the aforementioned issue with the concentrate flow meter. During this time the system operated for 493 run hours (0.7 months) with a measured fouling rate of 9.9%. Because a limited amount of run time was conducted on Train B at 85% recovery it is recommended further operation be conducted to further assess the fouling rate at this recovery.

Comparison of the power consumption monitored from RO Train A (2-Stage configuration) and Train B (3-Stage configuration) during operation at 85 percent recovery shows that the RO Train B required on average 19% more energy than RO Train A. The basis for this determination follows:

- Train A – Based on the average power consumption (67,000 kWh) and permeate flow (344 gpm) monitored over 2,144 hours of operation at 85% recovery, the average power consumption per treated flow (kWh/MG) was calculated as 1,514.

- Train B – Based on power consumption (18,500 kWh) and permeate flow (347 gpm) monitored over 493 hours of operation at 85% recovery, the average power consumption per treated flow (kWh/MG) was calculated as 1,802.

Table 14 presents water quality data of the RO System Trains A and B for several key water quality parameters. The two types of membranes were projected to differ on some water quality parameters, but both systems consistently produced permeate with similar water quality characteristics. Software projections for both membranes under-predicted the Total Dissolved Solids (TDS) and chloride rejection, with the Hydranautics ESPA2 elements (Train A) closer to projections for TDS and the Toray TML20 elements (Train B) closer for chlorides. Nitrate rejection was significantly under-predicted for the ESPA2 elements, projecting a nitrate concentration of 1.4 mg/L-N in the product, but the measured average concentration was much lower, at 0.41 mg/L-N. In contrast, the TML20 software over projected the nitrate rejection, predicting a nitrate of 0.22 mg/L-N, but the measured average concentration was 0.45 mg/L-N. Overall, there was very little difference between the permeate produced by the two RO membranes tested, in spite of the initial projections that had suggested much higher nitrogen removal with the TML20 elements.

Section 3
Water Quality Monitoring Results

An extensive water quality monitoring plan was implemented for the Water Purification Demonstration Project. The detailed water quality monitoring plan including sample locations, laboratory methods, and sampling frequencies is provided in the Final T&M Plan. For thorough water quality analysis, several different laboratories were selected to conduct analysis of samples collected during the testing. The labs utilized over the testing period were: MWH Laboratories, Weck Laboratories, Biovir Laboratories, and the AQWATEC, Laboratory at the Colorado School of Mines. In addition, Laboratory Data Consultants, Inc. (LDC) was selected to perform data validation of the laboratory analyses. Multiple laboratories were selected for specific analysis performed by labs that specialize in that area, increasing accuracy and lowering detection levels. The Final T&M Plan provides specific information on the credentials and the types of analysis each lab conducted over the testing period as well as information on an Onsite Lab used during the testing period to analyze general process parameters. The overall water quality monitoring plan included the following seven categories.

- *Routine Water Quality Monitoring*. This category included nutrients (nitrogen and phosphorus); volatile organic compounds (Trihalomethanes, Methylene Chloride, 1,2-Dichloroethane); nitrosamines; 1,4-Dioxane; and TOC. Sampling frequencies ranged from bi-weekly to monthly depending on the specific parameter.

- *Microbial Monitoring*. This category included initial daily followed by weekly sampling for Total Coliform and Fecal Coliform and initial weekly followed by monthly sampling for Somatic and Male Specific Bacteriophage.

- *Basin Plan Objectives Monitoring*. This category consisted of parameters with Basin Plan numeric objectives not addressed in other sampling categories: Total Dissolved Solids (TDS), Chloride, Sulfate, Sodium, Iron, Manganese, Boron, Color, Fluoride, Phenolic compounds, pH, Temperature, Dissolved Oxygen, and Turbidity. Sampling frequencies ranged from daily to bi-monthly.

- *Quarterly Monitoring*. This category consisted of (1) compounds with Federal and State drinking water maximum contaminant levels (MCLs); (2) compounds included on U.S. EPA's priority pollutant list; (3) compounds with current CDPH Notification Levels (NLs); (4) compounds on the US EPA's current Unregulated Contaminant Monitoring Rule (UCMR3) list; (5) compounds recommended by the IAP (lithium, benzo(k)fluoranthene, and hexavalent chromium). Samples were collected quarterly.

- *Constituents of Emerging Concern (CECs).* During the Q1 and Q2 Testing Periods, an initial characterization study was conducted based on four monthly sampling events for 92 CECs, including pesticides, herbicides, pharmaceuticals, and ingredients in personal care products representing a wide range of chemical and physical properties. The initial characterization study included monitoring of health-based and performance-based indicators recommended by the State Water Resources Control Board's (SWRCB) expert panel on CEC monitoring for groundwater recharge projects that utilize RO/AOP. The complete report produced by the expert panel can be found online at the following website: **http://www.waterboards.ca.gov/water_issues/programs/water_recycling_policy/recycledwater_cec.shtml.** Thirty CECs were selected for monitoring as potential treatment performance indicators based on occurrence in the RO feed water as measured during the initial characterization study or CECs recommended by the IAP. Weekly samples were collected over a period of four weeks.

- *Whole Effluent Toxicity Testing*. This program, conducted during the Q2 Testing Period, consisted of acute and chronic toxicity assays for a blend of UV/AOP product and Lake Murray water (local reservoir primarily holding imported water) and a control sample. The chronic test organisms were Ceriodaphnia dubia (water flea), Pimephales promelas (fathead minnow) and Selenastrum capricornutum (green algae). The test organisms used for the acute testing were Ceriodaphnia dubia and Pimephales promelas.

- *Quality Assurance/Quality Control (QA/QC) Testing*. A QA/QC Plan was developed for the project consisting of the collection and analysis of field duplicates, blind duplicates, travel blanks, field blanks, and split samples. In addition, third-party validations were performed by Laboratory Data Consultants, Inc. (LDC) using United States Environmental Protection Agency USEPA Level IV guidelines to assess data quality and review laboratory and sample handling procedures by WECK and MWH Labs.

There was some overlap for parameters in the different categories. For example, some of the constituents included in the routine monitoring category were also assessed as part of the quarterly monitoring category. The subsections below present the results for each constituent category. **Section 3.6** summarizes the water quality results for both regulatory relevant and non-regulated constituents measured of the purified water and compares the results to the proposed demonstration goals as outlined in the Final T&M Plan. As noted in the Final T&M Plan, the goals for each parameter were established based on the anticipated regulatory requirements using the best available information at that time and may be subject to change.

3.1 Routine Water Quality Monitoring

This section provides the cumulative results of routine sampling and analysis, conducted from 8/1/11 to 7/31/12. Samples were collected at various locations throughout the purification process as identified in the general AWP Facility Process Schematic provided in **Figure 17.** As shown, ammonia hydroxide and sodium hypochlorite were added upstream of the MF and UF system to achieve a target residual of 3 mg/L chloramines as a means of controlling biological fouling of the membrane systems.

During the Q1 Testing period, all samples were collected as grab samples; however beginning with the Q2 Testing period, 24-hour composite samples were collected (when appropriate or feasible) or by grab samples. In general, composite samples are more representative than grab samples as they capture changes in feed water quality and/or treatment performance over a given time period. The tables referenced in this section are organized by parameter, sample date, sample type (grab or composite), sample location and include statistical parameters (i.e. average, number of samples (n), maximum, minimum and standard deviation). Sample results reported as equal to or greater than the laboratory reporting level (RL) are considered to be measured concentrations. Sample results less than the RL but greater than the method detection limit (DL) were detected but not quantifiable and are noted as less than the RL value (i.e., <RL). Sample results reported as less than the DL are considered to be below levels of detection and are noted as <DL. For purposes of calculating statistical parameters, results reported below the RL were considered as 50% of the RL value and for values reported below the DL a value of 50% of the DL was used.

Based on comments from the Project's Independent Advisory Panel (IAP) as outlined in the February 2, 2012 memorandum: *Recommendation from IAP: Draft Memorandum: Findings and Recommendations of the Advanced Water Purification Facility Subcommittee, February 2, 2012*, efforts were made during the Q3 and current testing period to time sequence all sample collection. The purpose was to allow tracking of process performance in parallel with the hydraulic detention time of each reactor to monitor changes in approximately the same slug of water (i.e., plug flow) as it passes through each treatment processes.

A brief summary of the results is provided below for each constituent or constituent group monitored routinely.

3.1.1 Nitrogen and Phosphorus

Table 15 provides the results for various forms of nitrogen and Total Phosphorus from samples collected at various locations throughout the purification process during the previous and current testing periods. The majority of samples collected were 24 hour composites. The specific parameters evaluated are: Ammonia, Total Kjeldahl Nitrogen (TKN), Nitrate+Nitrite, Nitrite, Total Nitrogen, and Total Phosphorus. Total Nitrogen values were calculated by summing the concentrations of nitrate-N + nitrite-N and TKN (organically bound nitrogen + ammonia). Individual nitrate concentrations were calculated by subtracting measured concentrations of nitrite-N from measured concentrations of (nitrate-+nitrite as N). The following convention was followed for the calculations:

- If nitrite as N was below the DL of 0.010 mg/L no subtraction was done. In this case, nitrate-N was determined to be the same value as the nitrate-N + nitrite concentration.

- If nitrite as N was between the DL and the RL (0.10 mg/L) and was 10% or greater of the nitrate-N + nitrite concentration, the result was subtracted from the nitrate-N + nitrite to calculate a value for nitrate-N.

A discussion of the nutrient results to date for different parameters is provided below.

- **Ammonia** – During the previous testing periods, the average ammonia concentration (n=71) in the UV/AOP product water using grab and composite samples was 0.20 ±0.09 mg/L-N. Similar values were measured during the current testing period using composite samples with the average ammonia concentration (n=22) measured in the UV/AOP product of 0.23 ±0.04 mg/L-N. Results of ammonia samples collected during the testing period before and after each purification process indicate the RO and the UV/AOP achieved an average (n=23) removal of 77% and 50%, respectively. It should be noted that the test method for ammonia does not distinguish between free ammonia and ammonia complexes, such as monochloramine and dichloramine, which have different removal rates in both the RO and UV/AOP.

- **Total Nitrogen** - The average value of total nitrogen (n=74) reported during the previous testing periods for the UV/AOP product water using grab and composite samples was 0.80 ±0.17 mg/L-N. Slightly higher values were reported for the current testing period using composite samples with the average value of total nitrogen (n=22) of 1.10 ±0.28 mg/L-N. The total nitrogen concentration in the sample collected on 5/31/12 was 2.2 mg/L-N (predominantly TKN). The cumulative average (n=96) total nitrogen concentration from all testing periods in the UV/AOP product water was 0.87 ±0.23 mg/L-N. The demonstration goal for total nitrogen based on anticipated CDPH requirements is 5 mg/L-N.

- **Nitrate** – During the previous testing periods the average nitrate concentration (n=74) in the UV/AOP product was 0.65 ±0.11 mg/L-N. Slightly higher values were reported for the current testing period with the average nitrate concentration (n=22) of 0.99 ±0.14 mg/L-N. The average concentration (n=96) of nitrate based on cumulative results of all testing periods was 0.73 ± 0.19 mg/L-N. It was also observed over all testing periods that both RO systems achieved similar rejection of nitrate even though the Toray membranes were projected to reject more nitrate than the Hydranautics membranes The average nitrate rejection (%) for Hydranautics ESPA 2 and Toray TML (n=23) based on the total number of results from all testing periods is 96.6% and 96.3%, respectively. It was also observed that the concentration of nitrate in the RO permeate is consistently slightly lower (average 26% lower) than values measured in the UV/AOP product water. This is attributed to the oxidization of ammonia to nitrate that occurs across the UV/AOP process.

- **Total Phosphorus –** During the previous testing periods, the average value of total phosphorus (n=66) measured in the UV/AOP product water based on grab and composite samples was 19 µg/L-P (0.019 mg/L-P). During the previous testing period, four results reported in the UV/AOP product water were higher than expected: 3/8/12, (420 µg/L-P); 3/15/12 (140 µg/L-P); 3/22/12 (140 µg/L-P); and 4/16/12 (120 µg/L-P). These results were from sampling events when samples were only taken from the UV/AOP product water. Therefore, during the current reporting period additional samples were taken at sample locations upstream (i.e. tertiary effluent prior to chlorination and RO permeate) of the UV/AOP product water. Results showed the average (n=10) concentration of total phosphorus in the tertiary effluent and RO permeate was 1,385 µg/L and <10 µg/L, respectively. These results represent an average removal of total phosphorus by the RO system of > 99.3 %. During the current testing period the average concentration (n=22) of total phosphorus measured in the UV/AOP product water was <10 µg/L-P (0.010 mg/L-P). The average concentration (n=88) of total phosphorus based on cumulative results of all testing periods based on grab and composite samples was 16 ±50 µg/L-P (0.016±0.050 mg/L-P).

3.1.2 Disinfection By-products, Methylene Chloride, 1,2-Dichloroethane, and Naphthalene

Table 16 presents results for volatile organic compounds (VOCs) including Trihalomethanes (THMs), Methylene Chloride, 1,2-Dichlorethane and Napthalene. Results for THMs include Total THMs along with individual compounds (*Dibromochloromethane, Chloroform, Bromoform and Bromodichloromethane,*). **Table 17** presents results for Haloacetic Acids (HAAs). Results for HAAs include Total HAA5, along with individual compounds (*Dibromoacetic acid, Trichloroacetic acid, Dichloroacetic acid, Monobromoacetic acid, Monochloroacetic acid*).

A discussion of the results for the various parameters listed above is provided below.

- **Total THMs –** The average (n=9) concentration of Total THMs (TTHMs) measured in the UV/AOP product water during the previous testing periods was below the RL (2 µg/L). All samples (n=3) analyzed during the current testing period were below the RL or DL (0.6 µg/L) in the UV/AOP product water making the cumulative average of all testing periods <2 µg/L. Note: Because THMs are volatile and require a short holding time, all samples were collected as grab samples. The demonstration goal for TTHM's is <80 µg/L based on the drinking water maximum contaminant level (MCL) which is anticipated to be the CDPH limit for surface water augmentation using purified water.

- **Bromoform –** All samples (n=12) analyzed in the RO permeate and UV/AOP product during the previous t testing periods and the current testing period were less than the DL (0.19 µg/L). The anticipated regulatory limit presented in the Final T&M Plan is based on the California Toxic Rule (CTR) criterion of 4.3 µg/L.

- **Dibromochloromethane (DBCM) -** All samples (n=9) analyzed in the UV/AOP product water during the previous testing periods were less than the DL=0.2 µg/L. During the current reporting period three additional monthly samples were analyzed from the UV/AOP product. The calculated average concentration for the current reporting period is 0.14 µg/L. Two of the sample results were less than the DL. However, the third result from the 6/4/12 sampling was 0.6 µg/L. This result is questionable because results for samples collected on the same day in the tertiary effluent and RO permeate were 0.6 µg/L and <RL (0.5 µg/L), respectively. The cumulative average for this compound for all testing periods is less than the RL (0.5 µg/L), which meets the demonstration goal for DBCM of <RL (0.5 µg/L). The anticipated regulatory limit presented in the Final T&M Plan is based on the CTR criterion of 0.401 µg/L.

- **Bromodichloromethane (BDCM)** – All samples (n=9) analyzed in the UV/AOP product water during previous testing periods were less than the RL (0.5 µg/L) with the exception of samples collected on 8/1/11 (0.71 µg/L) and 3/6/12 (0.56 µg/L). During the current testing period three additional monthly samples were collected from the UV/AOP product water. Two of the sample results were less than the RL. However, the third result (sampling date 6/4/12) was 0.85 µg/L. This result is questionable because results for samples collected on the same day in the tertiary effluent and RO permeate were both lower in concentration (i.e. 0.78 µg/L and 0.66 µg/L, respectively) than the UV/AOP product water). The cumulative average of 0.33 µg/L (n=12) for this compound for all testing periods is less than the RL (0.5 µg/L), which meets the demonstration goal of less than 0.56 µg/L. The anticipated regulatory limit presented in the Final T&M Plan is based on the CTR criterion of 0.56 µg/L.

- **Methylene Chloride –** All monthly samples (n=3) analyzed during the current testing period from the UV/AOP product were below the RL (0.5 µg/L) or DL (0.14). The average (n=12) concentration in the UV/AOP product water based on cumulative results from all testing periods is less than the RL, which is below the demonstration goal of <4.7 µg/L. The anticipated regulatory limit presented in the Final T&M Plan is based on the CTR criterion of 4.7 µg/L.

- **1,2-Dichloroethane -** All monthly samples (n=12) analyzed in the UV/AOP product during all testing periods were below the DL of 0.12 µg/L, which is below the demonstration goal for this parameter of <0.38 µg/L. The anticipated regulatory limit presented in the Final T&M Plan is based on the CTR criterion of 0.38 µg/L.

- **Naphthalene –** All samples (n=3) analyzed in the RO feed and RO permeate during the previous and current reporting period were below the DL. This compound was monitored based on recommendation from the IAP for the purpose of assessing removal by the RO system. Because all samples were below the DL, removal rate by RO could not be determined.

- **HAA5, Total -** All monthly samples (n=12) analyzed in the UV/AOP product during all testing periods were below the DL (1 µg/L) in both the RO permeate and UV/AOP product water, which is below the demonstration goal for HAA5, Total of <60 µg/L. The anticipated regulatory limit (60 µg/L) presented in the Final T&M Plan is based on the drinking water MCL which is anticipated to be the CDPH limit for surface water augmentation using recycled water.

3.1.3 Nitrosamines & 1,4-Dioxane

Tables 18 and 19 provide results for nitrosamines and 1,4-Dioxane, respectively, sampled at various locations throughout the AWP Facility. Because nitrosamines form in the presence of chloramines, all samples were collected as grab samples. All samples of 1,4-Dioxane during the previous and current testing period were collected as composites. Results are presented for NDMA and the seven other nitrosamine compounds listed below:

- N-Nitrosodiethylamine (NDEA)
- N-Nitrosodi-n-butylamine (NDBA)
- N-Nitrosodi-n-propylamine (NDPA)
- N-Nitrosomethylethylamine (NMEA)
- N-Nitrosomorpholine (NMOR)
- N-Nitrosopiperidine (NPIP)
- N-Nitrosopyrrolidine (NPYR)

A discussion of the results to date compared to the proposed demonstration goals is provided below.

- **Nitrosamines -** All routine samples (n=15) collected during all testing periods show that the concentrations of all the nitrosamines in the RO permeate were below the RL or DL. The majority of samples analyzed in the UV/AOP product water were also below the RL or DL with the exception of one sample with NDMA reported at a value of 5.5 ng/L (sample date 1/3/12). It was observed that the concentration of NDMA in the RO permeate on the same day was reported at the RL of 2 ng/L. The lab reanalyzed the UV/AOP product sample and reported the result as ND; however, the result is considered inconclusive as the sample was past the holding time required for the analytical method. On three occasions (12/1/11, 1/3/12, 4/23/12), the concentration of NDEA was also reported to be above the RL in the UV/AOP product water with concentrations measured in the RO permeate on the same day below the RL. All results for NDMA, NDEA, and NDPA measured in the UV/AOP product water were below the current CDPH drinking water Notification Levels (NL) of 10 ng/L for each chemical. It is not clear how NL-based requirements might be applied in permits for surface water augmentation projects at this time. The treatment performance goal for NDMA was 1.2 log removal across AOP. Additional information on removal of nitrosamines is provided in **Section 2.1.4**.

- **1,4-Dioxane -** All monthly samples (n=12) collected in the RO permeate during all testing periods were below the RL of 0.5 µg/L. All samples (n=12) collected in the UV/AOP product water were below the DL of 0.040 µg/L. The average (n=11) concentration of 1,4 Dioxane measured in the RO feed water based on cumulative results from all testing periods was less than 2 µg/L. The treatment performance goal was to achieve 0.5-log removal across the AOP. This goal was demonstrated during the current reporting period by conducting challenge testing on the UV/AOP system as presented in **Section 2.1**. While CDPH has established a NL of 1 µg/L for 1,4-Dioxane, it is not clear how NL based requirements might be applied in permits for surface water augmentation projects at this time.

3.1.4 Total Organic Carbon (TOC)

Table 20 provides the results for TOC sampled at various sample locations throughout the purification process. The majority of samples collected during the current testing periods were collected as composites. Results from all testing periods (n=97) show the average TOC concentration measured in the UV/AOP product water is below the RL of 0.3 mg/L. The demonstration goal for TOC is 0.5 mg/L based on the anticipated CDPH requirement for use of recycled water for surface augmentation. The results of TOC measured before and after the RO systems show an average (n=12) removal of greater than 97.4%.

It should be noted on one occasion during the Q2 testing period (1/12/12), the TOC result for the sample collected in the UV/AOP product was reported at 1.4 mg/L. The laboratory reanalyzed the sample and confirmed the original result. However, the online TOC measured in the RO product (**see Section 4.2.1.**2) was consistently below 0.07 mg/L on the day of the sampling event, and the lab reported values in the UV/AOP product water before and after this result were consistently below the RL. Statistical analysis of the entire set of lab results for TOC measured in the UV/AOP product identified the result of 1.4 mg/L to be an outlier and is not considered representative of the TOC concentration consistently reported in the UV/AOP product water. It is likely that the high TOC value is the result of a contaminated sample or mislabeled sample bottle.

It should be noted TOC values measured online in the RO permeate throughout the testing period were much lower (**i.e. ranged from 0.02 to 0.08 mg/L**) than lab results, which were reported below the labs quantifiable limit of 0.3 mg/L. Based on discussion with the manufacturer of the online TOC analyzer, GE Power and Water, online analyzers can detect lower amounts of organics due to the fact there are no organic interferences in the measurement system. In addition, during the collection of field samples for laboratory analysis, samples can be contaminated with organics from the several sources including the sample vials themselves and carbon dioxide from the atmosphere. The operating specifications for the online analyzer used during the demonstration project had an operating range of 0.03 µg/L to 50 mg/L with accuracy of ±2% or 0.5 µg/L, whichever is greater.

3.1.5 Microbial Monitoring

Tables 21 and 22 present results for Coliform (Total and Fecal) and naturally occurring Bacteriophage (Somatic and Male Specific), respectively, measured before and after each AWP Facility unit process. Results for total and fecal coliform samples (n=12) collected weekly during this testing period were <DL for all samples collected in the MF filtrate, UF filtrate, RO feed, RO permeate (Trains A and B) and UV/AOP product water. The cumulative number of samples collected during all testing periods from each sampling location was 85. Of these, all results were ≤DL for total and fecal coliform with the exception of 3 total coliform results reported at low concentrations: UF filtrate (2.2 MPN/100 mL, 3.6 MPN/100 mL) and RO feed (5.1 MPN/100 mL). These results are attributed to bacterial growth which occurred in the sample lines located on the filtrate/permeate side of the membranes. Upon flushing and disinfection of the lines no further detections occurred. Overall the results showed that both the MF and UF, as the first step in the purification process, removed bacteria to undetectable concentrations, demonstrating greater than 3 log (99.9 percent) removal of coliform bacteria.

The results of monthly sampling for Somatic (n=21) and Male Specific Bacteriophage (n=20) collected for each sample location for the current and previous testing periods are discussed below. EPA Method 1602 (DL=1 pfu/100 mL) was used to analyze all tertiary effluent samples while a more sensitive method, EPA Method 1601 (Present or Absent per L), was used for MF filtrate, UF filtrate, RO Permeate, and UV/AOP product. Duplicate samples were collected for these locations so that in the event detection occurred using EPA Method 1601, the laboratory could perform the analysis using EPA Method 1602. As noted in **Table 22** the samples for Somatic Bacteriophage using EPA 1601 on 5/29/12 were analyzed past the recommended hold time due to laboratory issues and therefore no bacteriophage results are presented for this sampling date. A follow up sampling was conducted on 6/18/12, however because this reduced the overall number of sample results collected during the testing period an additional sampling was conducted on 9/10/12.

Overall the results showed that both the MF and UF, as the first step in the purification process, achieved high removal of bacteriophage. The MF and UF systems achieved composite virus removals (Somatic plus Male Specific) greater than 99.8 percent and 99.97 percent, respectively. The higher removal by the UF is attributed to the smaller pore size. All bacteriophage results for the purified water were Absent. A summary of results measured over the testing period for each sampling location is below.

- **Tertiary Effluent –** During this testing period, Somatic Bacteriophage concentrations ranged from 578 to 1500 pfu/100 mL; and Male Specific Bacteriophage concentrations ranged from 4 to 9 pfu/100 mL. These results are comparable to data collected during the prior testing periods. Somatic Bacteriophage ranged from 99 to > 3000 pfu/100 mL and Male Specific Bacteriophage ranged from > 1 to 67 pfu/100 mL.

- **UF Filtrate –** All samples of Somatic and Male Specific Bacteriophage collected during the current testing period were reported as Absence per L using EPA Method 1601 with the exception of the sample collected on 6/18/12 where the Somatic Bacteriophage was reported as Present per L. The sample was then run using EPA Method 1602 and the result was <1 pfu/100 mL. During the prior testing periods all Male Specific Bacteriophage were reported as Absence per L. For Somatic Bacteriophage, 2 samples were reported as Present per L. The samples were then run using EPA Method 1602 and the results were <1 pfu/100 mL.

- **MF Filtrate –** Somatic and Male Specific Bacteriophage collected during this testing period ranged from Absence per L to <1 pfu/100 mL. During the prior testing periods, Somatic Bacteriophage ranged from Absence per L to 10 pfu/100 mL and Male Specific Bacteriophage ranged from Absence per L to 11 pfu/100 mL. Note the higher concentration of bacteriophage in the MF filtrate compared to the UF filtrate is attributed to the difference in membrane pore size.

- **RO Permeate Trains A & B –** All samples of Somatic and Male Specific Bacteriophage during the current testing period were reported as Absence per L. During the prior testing periods, all bacteriophage samples were reported as Absence per L with the exception of the sample collected on 12/12/11 from Train A permeate. For this sample, the Male Specific Bacteriophage was reported as Present per L. The sample was then run using EPA Method 1602 and the result was <1 pfu/100 mL.

- **UV/AOP Product –** During the current and prior testing periods, all sample results for Somatic and Male Specific Bacteriophage were Absent per L.

- **Overall Log Removal Value (LRV) –** Based on sampling results , the average concentrations of Somatic (n=21) and Male Specific (20) Bacteriophage in the tertiary effluent compared to the UV/AOP product indicate the AWP Facility purification process achieved log reduction values (LRV's) greater than 4.2 and 2.2, respectively for removal of naturally occurring phage.

Overall the microbial monitoring results to date demonstrate the ability of the AWP Facility to provide a barrier to bacteria and pathogens.

3.1.6 Basin Plan Numeric Objectives

The Basin Plan Numeric Objectives are provided in **Table 23**. It should be noted that the nutrient requirements (including phosphorus and nitrogen) for the potential Full-Scale Facility have not been established at the time of this report. **Table 24** provides results for general parameters with Basin Plan Numeric Objectives not presented elsewhere in this report, including: total dissolved solids (TDS), chloride, sulfate, sodium, iron, manganese, boron, color, fluoride and phenolic compounds. In general each of these parameters present in the RO feedwater were shown to be highly removed (>95%) by the RO systems with the exception of boron for which the average removal was only approximately 42% (similar rejection by both Train A and Train B membranes). The average concentration (229 μg/L) of boron measured in the purified water was 4 times lower than the Basin Plan Objective of 1,000 μg/L (1 mg/L).

All results collected during the Q1 through Q4 Testing Periods showed the purified water met the Basin Plan objectives with the exception of three occasions when phenolic compounds were reported above the Basin Plan Objective of 1 μg/L. The sample dates and reported results for the three occasions follow: 9/1/2011 (22 μg/L), 10/24/11 (1.9 μg/L) and 11/21/11 (2.6 μg/L). The 9/1/2011 (first sample analyzed during the Q1 Testing Period) result is considered an outlier as the sample was analyzed using method EPA 420.4 (RL=10 μg/L), which only measures total phenolics thereby making analyses prone to interferences. Subsequent samples were analyzed using method EPA 8270 which quantifies individual (14 total) phenolic compounds, with a RL of 1 μg/L. The 10/24/11 and 11/21/11 results for the purified water are also questionable as RO permeate composite samples collected on the same day were lower in concentration. The laboratory reanalyzed the samples and confirmed the results. It should also be noted, based on discussions with the laboratory that conducted the analysis, the 12/19/11 samples were re-extracted and reanalyzed past hold time due to the likelihood of lab contamination. All other results showed phenolic compounds (14 total) measured in the RO permeate and UV/AOP product during the previous and current testing periods were <1 μg/L in both the RO permeate and UV/AOP product water.

Table 25 presents on-site water quality measured in the UV/AOP product water for other constituents with Basin Plan numeric objectives including: pH, Dissolved Oxygen (DO), and Turbidity. To date, the results for DO and Turbidity meet Basin Plan objectives; the pH ranged from 5.2 to 6.5, which was within the expected range without chemical stabilization.

3.2 Quarterly Monitoring

During the current and previous testing periods, quarterly monitoring of various compound groups was conducted by collecting grab samples of the North City tertiary effluent, UV/AOP product water and imported raw aqueduct water (IAW). The specific compound groups evaluated on a quarterly basis are:

- Compounds with Federal and State Primary and Secondary Drinking Water Maximum Contaminant Levels;
- Compounds included on EPA's Priority Pollutant List as defined by the California Toxic Rule;
- Compounds with current CDPH NLs;

- Proposed Contaminants from EPA's Unregulated Contaminant Monitoring Rule (UCMR3) Assessment Monitoring (List 1 and List 2);
- Other Radionuclides (Cesium-137, Iodine-129, Iodine-131);
- Other Compounds: Lithium, benzo(k)fluoranthene, hexavalent chromium.

The results of the fourth quarter sampling event (5/1/12) for each compound group are summarized below. Note: Several compounds appear in multiple compound groups. The summary tables presented below also include data from the previous testing periods.

3.2.1 Federal and State Drinking Water MCLs

Tables 26 and 27, respectively, present results for compounds regulated under Federal and State Primary and Secondary drinking water standards. Consistent with results from the Q1, Q2, and Q3 Testing periods, the concentrations of constituents measured in the UV/AOP product water were all below MCLs for Federal and State Drinking Water Standards with the exception of pH (Federal Secondary MCL=6.5 to 8.5; there is no State MCL for pH) and corrosivity (Federal MCL= Non Corrosive; there is no State MCL for corrosivity). The AWP Facility does not include chemical stabilization as the product water is blended with tertiary recycled water for non-potable uses. Chemical stabilization at the potential Full Scale Facility would address pH and corrosivity.

3.2.2 EPA California Toxic Rule Priority Pollutants

Tables 28, 29 and 30 present results of compounds included on the EPA's Priority Pollutant list that were detected in samples collected in the NCWRP tertiary water, UV/AOP product water and IAW, respectively, during the testing periods. The EPA Priority Pollutant list (126 compounds) is provided in **Table 31** for reference. A summary of the results for each sample location follows:

- **Tertiary Effluent –** Samples analyzed showed only eight ccompounds were reported above the RL all of which were below their respective CTR criterion. During the previous testing periods a similar number of compounds were reported above the RL. A total of four results were reported above their respective CTR criterion during all testing periods. These results follow: BDCM at 1 µg/L (Q1) and 0.58 µg/L (Q2), DBCM at 0.65 µg/L (Q1), and NDMA at 2.9 ng/L (Q1).
- **UV/AOP Product Water –**Samples analyzed during the current testing period showed all compounds reported in the UV/AOP product water were at concentrations less than their RL or DL. Similar results were reported for the Q1, Q2 and Q3 Testing periods. Only one result was reported above the CTR criterion. The result was BDCM at 0.78 µg/L (CTR criterion of 0.56 µg/L) reported during the Q1 Testing period. All subsequent quarterly results for BDCM were reported as less than RL (0.5 µg/L). It was also observed the di-n-butyl phthalate results were

<DL (DL=0.24 µg/L) for all testing periods with the exception of the Q1 Testing Period with a reported results of 2.2. µg/L, which was still well below CTR criterion of 2700 µg/L. The higher value reported for Q1 may have resulted from UV light exposure to the PVC (polyvinyl chloride) piping located just downstream of the UV reactor. In general, phthalates are typically used as plasticizers and are primarily used as softening agents for PVC.

- **IAW –** Samples analyzed showed eight compounds were reported in the imported raw aqueduct water above their RLs. Of these, three compounds were reported above their CTR criterion: BDCM (19, 14, 10, and 10 µg/L), DBCM (21, 14, 14, and 15 µg/L), and bromoform (3.5, 2.9, 3.8, and 6.2 µg/L). BDCM and DBCM were reported above their criterion during all testing periods.

3.2.3 CDPH Notification Levels

Table 32 presents results of the 30 compounds with current CDPH notification levels (NLs). Overall similar results were seen for the previous testing periods. Results from the current testing period show all sample locations were below the NL's for all compounds with the exception of 1,4-Dioxane at 1.6 µg/L in the tertiary effluent, which was just above the NL of 1 µg/L. Ethylene glycol (EG) was also reported <RL (50 mg/L) in the tertiary effluent and UV/AOP product water. As noted, because the RL for EG was above the NL (14 mg/L) additional samples were collected (samples dates 8/13/12 and 8/15/12) in both the tertiary effluent and UV/AOP product water. The samples were analyzed using a more sensitive method (RL=1 mg/L). All results were <DL (DL=0.5 mg/L). The NL results also showed slightly higher concentrations of formaldehyde (Q1, Q2, Q3, Q4) were measured in the UV/AOP product water as compared to the tertiary effluent. All results were below the respective NL. Similar results were observed from analysis done as part of the routine sampling as discussed in **Section 2.1.4.3** and **Section 3.1.3**.

3.2.4 UCMR3 Compounds

Table 33 presents results of the 30 compounds proposed for the EPA's Unregulated Contaminant Monitoring Rule (UCMR3) Assessment Monitoring (List 1and List 2). EPA uses the UCMR Monitoring program to collect data for contaminants suspected to be present in drinking water, but that do not have health-based standards set under the Safe Drinking Water Act (SDWA). As shown, the reporting levels for many of these compounds are extremely low. Results from the current testing period show 27 of the compounds were <RL or <DL in the UV/AOP product water. The remaining three compounds that were found at concentrations above their RLs were bromochloromethane, hexavalent chromium and strontium. Similar results were seen for the previous testing periods with the exception of strontium which was reported <RL (0.3 µg/L) for the previous testing periods. The concentration of strontium reported in the UV/AOP product water during this testing period was 0.37 µg/L, which is just above the RL. Based on average the average concentration of quarterly sampling results values (n=4) measured in the tertiary water (443 µg/L) and the UV/AOP product water (<0.3 µg/L) the AWP achieved a high level and consistent removal (>99.9%) of strontium during all testing periods. The average concentration of strontium measured in the IAW water was 403 μg/L. Additional information on strontium, bromochloromethane, and hexavalent chromium results is provided in **Section 3.6.2**.

3.2.5 Other Radionuclides

Radiation sources provide critical capabilities in the oil and gas, electrical power (utilities) construction, manufacturing, and food industries. They are used to treat millions of patients each year in diagnostic and therapeutic procedures and also are used in a variety of military applications. Radionuclides are commonly used for pharmaceutical research, fluorescent fixtures, wall tiles, luminous devices like exit signs, gauges and watches, electric arc welding for aircraft, petrochemical and food processing industries, test the integrity of pipe welds, nuclear power plants and propulsion systems, lighting rods, electric blanket thermostats, indicator lights in household appliances, sterilization of surgical instruments, treating cancerous tumors, biological and agricultural research, inspect airline luggage for explosives, gauge moisture content in soils, smoke detectors, analyze metal alloys, providing coloring and fluorescence in colored glazes and glassware, and more.

Radionuclides are regulated in drinking water to protect public health from potential harmful effects of radiation. Radionuclides are naturally occurring and thus commonly found in natural water supplies, particularly groundwater. Most radioactive contaminants are at levels that are low enough to not be considered a public health concern, but at higher levels long-term exposure to radionuclides in drinking water could increase the chances of developing cancer or cause toxic effects to the kidney. Radionuclides are unstable isotopes and elements that give off various types of radiation as they decay into more stable forms. Drinking water regulations are established for both Gross Alpha and Gross Beta, which represent the total measured quantity of alpha and beta radiation emitted by any radionuclides present in the water. Gross Alpha measures alpha radiation or alpha particles, which are released by large molecular weight unstable elements, such as Uranium and Radium isotopes. Gross Beta measures beta radiation or beta particles, released by numerous unstable isotopes, such as Cesium-137, Strontium-90, Tritium, and Iodine isotopes. In addition, maximum contaminant levels (MCLs) have been established for specific radionuclides, including Radium-226 and 228, Tritium, Strontium-90, and Uranium.

Measurements of radionuclides are presented in units different than other drinking water parameters. Radionuclides are commonly expressed in terms of radiation output (picocuries per liter or pCi/L) or millirems per year (a unit of ionizing radiation dose), rather than as a weight concentration, such as milligrams per liter (mg/L). In addition, sample results can often be negative and have ranges of values rather than definitive numbers, making the interpretation of the reported results seemingly more complex than other contaminants measured in water supplies. Because ambient radiation exists throughout the environment, sample values are reported in the positive when measured values are above, or negative when below the ambient radiation in the location where testing is conducted. Radiochemical analyses of drinking water, as part of their methods, also include the determination of counting errors (CEs). CEs reflect the randomness of the natural decay of radionuclides and are a statistical expression of the variability in analytical procedures.

The California Department of Public Health (CDPH) requires measurement of Gross Beta and two specific beta emitters, Tritium and Strontium-90, in drinking water. In the event that the Gross Beta results exceed the federal standard of 4 millirems per year or the equivalent CDPH standard of 50 pCi/L, additional sampling is required for individual beta emitters, such as Cesium-137, Iodine-129, and Iodine-131. Although it was anticipated that the Gross Beta level of the purified water would be less than the Gross Beta MCL, the Testing & Monitoring Plan included quarterly monitoring of Cesium-137, Iodine-129, and Iodine-131 in the tertiary effluent, purified water, and raw imported aqueduct water to provide additional information about the purified water quality. **Table 34** presents the results for Cesium-137, Iodine-129, and Iodine-131 for Quarter 1 (Q1), Quarter 2 (Q2), Quarter 3 (Q3), Quarter 4 (Q4), and an additional sampling event on 7/9/12.

As shown in **Table 34**, the results are shown with the associated minimum detectable activity (MDA) and CEs reported by the laboratory that conducted the analysis. The MDA is defined as the smallest concentration of radioactivity in a sample that can be detected with a 5 percent probability of erroneously detecting radioactivity, when in fact none is present (Type I error) and also, a 5 percent probability of not detecting radioactivity, when in fact some is present (Type II error). Per American National Standards Institute (ANSI) Standard 13.30 (Performance Criteria for Radiobioassay), several factors affect the MDA, including the duration of the sample count, the volume of sample counted, the efficiency of the detector used, the background of the detector used, the decay during sample hold time and counting (for short-lived isotopes), and the measured radiation from the analysis. The MDA is a calculated value, which will vary for each analysis depending on the values of these factors.

Gross Beta measurements were conducted quarterly in the purified water and were less than 50 pCi/L. Consequently, individual measurements of Cesium-137, Iodine-129 and Iodine-131 were not required by regulation, but were measured anyway in accordance with the Testing & Monitoring Plan. Results from Q1, Q2, Q3 and Q4 show that Cesium-137, Iodine-129, and Iodine-131 were measured at or lower than the MDA in the purified water. If the Gross Beta did exceed 50 pCi/L, the EPA has published limits for individual beta emitting radionuclides:

http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/att_d-clean.pdf

These limits are based on concentrations equivalent to an exposure of 4 millirem per year, which is the federal MCL for Gross Beta. The limits for Cesium-137, Iodine-129, and Iodine-131 are:

- Cesium-137 less than 200 pCi/L

- Iodine-129 less than 1 pCi/L
- Iodine-131 less than 3 pCi/L

The results from the quarterly sampling show that Cesium-137 was consistently below this limit in the purified water. However, the laboratory selected MDAs for Iodine-129 and Iodine-131 that were too high to confirm that the samples met the limits cited above. A fifth sampling event was conducted on 7/9/12 during which the lab targeted an MDA of less than 1 pCi/L for both Iodine-129 and Iodine-131. The results presented in Table 33 show the concentration of Iodine-129 in the purified water was below the 1 pCi/L limit and Iodine-131 was below the 3 pCi/L limit.

The Q1 and Q2 results for Cesium-137, Iodine-129, and Iodine I-131 were originally presented in Draft Quarterly Testing Report No. 2 and subsequently posted by the City on a public website. However, incorrect results were presented. The Q1 and Q2 results for Cesium-137, Iodine-129, and Iodine-131 presented in the Draft Quarterly Testing Report No. 2 (submitted to the City on 3/3/12) reflected a discrepancy that was discovered shortly after the City posted the Q1 and Q2 water quality results on the City's project website.

An example of the discrepancy between the correct data and the previously reported data is that the laboratory result of "U" reported for Iodine-131 was incorrectly converted to a value of 16 pCi/L. A result of "U" indicates that the radionuclide was not detected at a value greater than the MDA. In this example, the MDA was 16 pCi/L, meaning that if the radionuclide was present it would be at a value between 0 to less than 16 pCi/L (or negative due to background), but was not quantifiable based on the sensitivity of the test procedure. The correct Q1 and Q2 results are presented in **Table 34**, along with results from additional sampling.

3.2.6 Other Compounds

Table 35 presents results of the three other compounds included as part of the quarterly monitoring program: benzo(k)fluoranthene, hexavalent chromium, and lithium. Results from the current and previous testing periods show all the results were <RL or <DL for all compound and sample locations with the exception of lithium. Lithium was reported <RL or < DL in all UV/AOP four quarterly samples but ranged from 20 - 28 µg/L in the tertiary water and <RL to 21 µg/L in the IAW with two samples above the RL. Hexavalent chromium was also sampled as part of UCMR3 (see Section 3.2.4) and benzo(k)fluoranthene was sampled as part of the priority pollutants (Section 3.2.2).

3.3 Constituents of Emerging Concern (CEC)

3.3.1 Summary of Initial Characterization CEC Results

Table 36 presents the results of CEC samples collected monthly as part of an initial characterization period beginning in August 2011. Analyses were performed by MWH Laboratories using a liquid chromatography followed by tandem mass spectrometry (LC-MS-MS) method. The table provides the common use for each compound, sample location, sample date and reported result. Sample locations included: tertiary effluent (prior to chlorination), various locations in the AWP Facility (i.e. RO feed, RO permeate, and UV/AOP product), and imported raw aqueduct water. During this time, samples were collected for a target list of ninety-two (92) compounds, including those used in pesticides, herbicides, and pharmaceuticals and personal care products (PPCPs) representing a wide range of chemical and physical properties. Information used from the initial characterization period was intended to be used to 1) characterize the tertiary effluent, 2) identify appropriate AWP Facility performance indicator compounds to be monitored on an on-going basis, 3) assess AWP Facility unit process CEC removal performance and 4) compare AWP Facility product water quality to the City's imported raw drinking water.

Results shown in **Table 36** include three samples collected monthly during the Q1 testing period and the one monthly sample collected during the Q2 testing period. Results that were reported below the RL but above the DL are shown as <RL; for some analytes, the table indicates not reported (NR) due to QC concerns reported by the laboratory for two (2) of the 92 target compounds reducing the list to 90 compounds. Further information is provided in a brief letter provided by Dr. Andy Eaton from Eurofins Eaton Analytical Labs (formerly MWH Labs) that is located in **Appendix B**.

Results for six compounds that were re-analyzed (RA) due to discrepancies in results between several different dilutions in the original analytical runs are highlighted in yellow. The re-analyzed compounds were all from samples collected in the RO feed water on 8/15/11. Although the samples were past internal holding time, they were held refrigerated and most of the target analytes are stable for extended periods under these conditions. During the Q3 testing period the lab also investigated the results reported for the compound Deethylatrazine (DEA) from samples collected on 9/14/11. The original results of 160 ng/L and 78 ng/L, respectively reported in the UV/AOP product water and IAW were determined to be false positives and therefore the results were revised in **Table 36** as <DL (1.5 ng/L).

The results from the four month initial characterization period showed on average 41 of the 90 compounds analyzed in the tertiary water were above their RL. As expected, a similar number of compounds (average count above the RL per sampling event = 36) and concentrations were reported in the RO feed water. Of these, the majority were removed by the RO system (average count above the RL per sampling event = 3). All CECs were less than their RL or DL in the UV/AOP product water with the exception of three results reported from the 9/14/11 sampling event. The compound name, common use, reported concentration and respective RL for each follow:

- Acesulfame-K (sugar substitute) reported at 50 ng/L (RL= 20 ng/L)
- Iohexal (contrasting agent) reported at 19 ng/L (RL= 10 ng/L)
- Triclosan (anti-microbial) reported at 19 ng/L (RL=10 ng/L).

Additional information on these three compounds is provided in **Section 3.6**. When assessing low level CEC results such as these it is important to keep in mind that analytical variability and influence of false positive / negative results become a more significant issue at minute levels. Technologies were not available to measure compounds at these low concentrations a decade ago, and there is still considerable debate about the significance of such low concentrations. As such, it is important that CEC monitoring be accompanied with robust QC sampling. The overall water quality QC sampling plan implemented during the testing periods is discussed in **Section 3.5**. As part of the CEC monitoring QC procedures several samples from each sampling location were sent to a second lab (Colorado School of Mines - CSM) for analysis during the initial characterization period. These samples were collected on the same date and time frame as samples analyzed by MWH laboratories. Results from the 41 compounds analyzed by CSM for samples collected during the initial characterization (sample date 8/15/11 and 11/8/11) are included in **Table 37**. The results showed all compounds measured in the RO permeate and UV/AOP product water were <DL with the exception of sulfamethoxazole, which was reported at the DL (1 ng/L). This compound is an antibiotic and was shown to be highly removed (99.9%) by the RO system. Overall the results from MWH and CSM laboratories were in agreement. Further discussion is provided in **Section 3.5.1.2**.

3.3.2 On-going CEC Characterization & Performance Indicators

3.3.2.1 Revised CEC Monitoring Plan

As presented in the Q2 Testing Report, the project team revised the CEC monitoring plan following completion of the four month initial characterization period presented in **Section 3.4.1**. Implementation of the revised CEC monitoring plan presented in **Table 38** began in concert with the third quarterly sampling event, which was conducted on 2/1/12. The compounds selected for monitoring were based on one or more of the following rationale:

- Toxicologically relevant and treatment performance indicator compounds recommended for monitoring by the State Water Resources Control Board (SWRCB) Expert Panel (*Monitoring Strategies for CECs in Recycled Water: Recommendations of a Science Advisory Panel, June 2010*).
- Potential treatment performance indicator compounds presented in **Table 39** that were selected based on occurrence in the RO feed water as measured during the initial characterization period.

- Additional potential treatment performance indicator compounds based on comments received from the IAP (NWRI Draft Memorandum: *Findings and Recommendations of the Advanced Water Purification Facility Subcommittee*, February 2, 2012).

3.3.2.2 Summary of Results

Results for CEC compounds measured by MWH Labs during the previous and current reporting period are presented in **Tables 40 and 41.** The tables are organized as Group A and Group B compounds, respectively.

Group A. This group contains a total of five compounds, four of which (Caffeine, 17 β-estradiol, NDMA and Triclosan) were the CECs recommended by the SWRCB expert panel based on toxicological relevance for monitoring groundwater recharge projects that use RO/AOP. This group also includes 1,4-Dioxane, which is currently presented as an option for evaluating AOP performance in the November 2011 Draft CDPH Groundwater Recharge Regulations. The Group A compounds were measured as part of the third and fourth quarterly sampling event at five sample locations: S1 (tertiary effluent), S6 (RO feed), S9 (RO permeate), S10 (UV/AOP product water) and imported raw aqueduct water.

Q3 results showed all compounds were below the RL or DL in the RO permeate and UV/AOP product water with the exception of Triclosan reported at 13 ng/L and 17 ng/L, respectively. It should be noted split samples taken from these locations and analyzed by the Colorado School of Mines (CSM) showed Tricolsan to be below the DL of 5 ng/L. Information regarding an investigation of discrepancies between CEC results reported by MWH Labs and CSM is discussed in **Section 3.5**. Triclosan is an antibacterial and antifungal agent used in a variety of consumer products, including toothpastes, deodorants, and soaps. Different DWELs have been developed for Triclosan ranging from 0.35 μg/L (350 ng/L)[1] to 2,600 μg/L (2,600,000 ng/L)[2], which are all significantly higher than the MWH Labs reported values in the RO permeate and UV/AOP product water. Note: DWELs are developed from tolerable daily intakes (TDIs) or acceptable daily intakes (ADIs), which describe a daily dose below which risks to public health are judged to be minimal, assuming repeated daily exposure over a lifetime through consumption of drinking water.

Q4 results for Group A compounds were below the RL or DL in the RO permeate and UV/AOP product water.

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[1] Environment Protection and Heritage Council, the National Health and Medical Research Council and the Natural Resource Management Ministerial Council, 2008, *Australian guidelines for water recycling augmentation of drinking water supplies*, March.

[2] Bruce, G. M.; Pleus, R. C.; Snyder, S. A. Toxicological relevance of pharmaceuticals in drinking water. *Environ. Sci. Technol.* **2010,** *44*, 5619–5626.

Group B. This group contains 37 compounds selected as potential performance indicator compounds for the RO and UV/AOP processes. Three of these compounds (Sucralose, NDMA, and DEET) were the CECs recommended by the SWRCB expert panel for performance of RO/AOP systems for groundwater recharge projects. These compounds were consistently detected in the RO feed of the AWP Facility water during the initial characterization period. Thirty additional compounds were also included in Group B based on their occurrence in pre RO/AOP waters during the initial characterization period. The four remaining compounds (Caffeine, Theobromine, Linuron and Estrone) were included based on recommendations from the IAP. The Group B compounds were measured weekly for four weeks at three sampling locations: S6 (RO feed), S9 (RO permeate), and S10 (UV/AOP product water). Results showed the average number of compounds (per sampling event) detected per location at concentrations above the RL to be: RO feed (33), RO permeate (3), UV/AOP product water (1).

3.3.3 Differential Removal of CEC Performance Indicator and Surrogate Compounds

Based on the results of the four weeks of CEC monitoring of the 37 compounds presented in **Table 41** a smaller group of CEC's were identified to serve as performance indicator compounds. The primary selection criterion was the consistency in the concentration detected in the RO feed water over the four week period. Comparison of weekly results for each of the 37 compounds showed 15 compounds had a relative percent difference (RPD) ≤ 35%. The RPD was calculated for each compound as the standard deviation divided by the average of the 4 results. The lower the RPD the less spread between the results. For example, if the results were all the same, the RPD would be zero.

Table 42 provides average (n=5) values measured in the RO feed, RO permeate and UV/AOP product water along with calculated values of differential removal (Δ Removal) of 16 selected performance indicator compounds for the RO and UV/AOP process. It should be noted that even though the NDMA results did not meet the RPD criteria (e.g. 47% vs. ≤ 35%) it has been recommended by the SWRCB expert panel as a performance indicator for RO/AOP for groundwater recharge projects and for CEC monitoring based on toxicological relevance. Furthermore, the concentration of NDMA in the RO feed was typically 10 X the DL (2 ng/L vs. 0.28 ng/L). Differential removal was calculated based on the average (n=5) concentrations measured in the feed and product of each unit process as follows:

- RO Removal = [RO Feed – RO Permeate] / [RO Feed]
- UV/AOP Removal = [UV/AOP Influent – UV/AOP Product] / [UV/AOP Influent]

For calculation purposes, for results reported below the RL, the value of the RL was used. For results reported below the DL, the value of the DL was used. The RO process effectively removed all 16 compounds with differential removal (%) ranging from >65.5% to >99.9%. Differential removal values shown as greater than (>) indicate the average RO permeate or UV/AOP product concentrations were near or less than the RL or DL. As shown the average RO feed concentration of the various compounds ranged from 3 to 33,000 ng/L with only one compound (Acesulfame-K) with an average concentration above the RL in the RO permeate. Therefore, Acesulfame-K was the only selected performance indicator compound for which differential removal across the UV/AOP could be determined.

During the initial two weeks of the performance indicator sampling period, surrogate compounds including TOC, Conductivity, Monochloramines, and UV 254 Absorbance (UV 254) were monitored daily. **Table 43** provides the differential removal of surrogates measured for the RO and UV/AOP process. The average value of differential removal for surrogates measured for the RO and UV/AOP follow:

- RO Removal: TOC = 99.6%; UV 254 =88.8%; and Conductivity =99.0%
- UV/AOP Removal: UV 254 = 68.7%; Monochloramines = 72.8%.

It should be noted removal of UV 254 Absorbance and Monochloramines removal by the UV/AOP was observed to be similar irrespective of whether hydrogen peroxide was dosed or not. This suggests that removal of these surrogates was due to photolysis, particularly of the chloramines present in the RO permeate. This finding indicates that while removal of these surrogates is a good indication that photolysis is occurring; the results suggest they are not appropriate surrogates for AOP performance. As discussed in **Section 3.1.1**, nitrate results measured in the RO permeate and UV/AOP product water indicated that ammonia was oxidized to nitrate across the UV/AOP process. These results suggest ammonia may serve as a good UV/AOP surrogate for performance monitoring. Though lab results of ammonia measured in the RO permeate and UV/AOP during the testing period did not show consistent reduction across the UV/AOP an online ammonia analyzer may provide additional information about the possibility of ammonia as an AOP surrogate. Also, per IAP recommendation, UV Absorbance at the 228 nm wavelength was also measured in samples collected before and after the UV/AOP. Though the 228 nm wavelength is expected to provide a more sensitive measure of NDMA absorption results from field measurements showed a slight increase in UV 228 absorbance across the UV/AOP. It should be noted the NDMA concentrations in the RO permeate measured during the testing period was consistently <RL (2 ng/L).

During the current testing period the 37 Group B compounds were sampled again in concert with the Quarterly 4 sampling event conducted on 5/1/12. Results are included in **Table 40**. In addition to sampling the RO feed, RO permeate and UV/AOP, separate samples were also collected from the permeate of each RO system. The results showed both RO membranes achieved similar rejection of CECs (i.e. >99%).

3.4 Whole Effluent Toxicity (WET) Testing

3.4.1 Sampling and Test Procedure

WET testing was performed during the previous testing period utilizing both acute and chronic freshwater bioassays. All tests were performed by Nautilus Environmental (NE) Laboratories (San Diego, CA). Tests were conducted per EPA protocols: EPA/821/R-02/013 (2002) Chronic Manual and EPA/821/R-02/012 (2002) Acute Manual. The chronic test organisms included: *Ceriodaphnia dubia* (water flea), *Pimephales promelas* (fathead minnow) and *Selenastrum capricornutum* (green algae). The test organisms used for the acute testing included water flea and fathead minnow. A complete report provided by NE is provided in **Appendix A**.

The sample water was comprised of a blend of UV/AOP product water collected from the AWP Facility and raw aqueduct water collected from Lake Murray. The target total hardness of the blend was 50 mg/L resulting in a final blend of UV/AOP product water (67%) plus raw aqueduct water (33%). Prior to testing, the pH of the blended sample was raised to approximately 8.5 using sodium hydroxide. In addition, sodium thiosulfate was added to the sample to remove residual chlorine and hydrogen peroxide. Laboratory control water was EPA moderately hard mineral water (20% diluted). A reference control consisting of deionized water (67%) mixed with raw aqueduct water (33%) was also utilized.

3.4.2 Summary of Results

Overall, the results showed there was no toxicity observed in the sample for any of the acute and chronic tests performed. The laboratory did observe a statistically significant decrease (~7%) in the chronic fathead minnow growth endpoint for the sample as compared to the control sample. However, this observation was not deemed biologically relevant as it was outside of the acceptable range of sensitivity per the laboratory's Quality Control procedures. The statistical results of the UV/AOP sample follow:

- NOEC (No Observed Effect Concentration) values (% effluent) for all species and endpoints tested were reported as 100%.

- LOEC (Lowest Observed Effect Concentration) values (% effluent) for all species and endpoints tested were reported as >100%.

- Toxic Units (TU) were reported as 1.0 for all species and end points tested with the exception of the Water Flea 96-hr Acute survival TU = 0.41 and the Fathead minnow 96- hr acute survival TU=0.

3.5 Quality Assurance / Quality Control

As outlined in the Final T&M Plan, several QA/QC procedures were employed during the Q1 through Q4 testing period including data analysis, lab testing, field sampling procedures, sample handling and storage, and data validation. The overall purpose of the QA/QC program was to ensure that the water quality data are accurate and useful. Due to the significant number of variables which can impact water quality data, even the best water quality data will have errors, and it is the goal of the QA/QC program to measure and minimize these errors. Data quality is described by its accuracy, precision, completeness, representative ness, and comparability. The subsections below discuss the results of three main components of the overall QA/QC water quality program implemented during the Q1 through Q4 testing period including:

- QC Sample Collection
- Data Validation
- Sampling Procedures

3.5.1 QC Sample Collection

Field and laboratory QC samples were collected and analyzed as a quality check of sampling and analytical procedures throughout the testing period. QC sample types included:

- Field Duplicate. A portion of the collected sample volume is analyzed identically to evaluate laboratory precision, reproducibility of sample handling and analytical procedures, sample heterogeneity, and analytical procedures.
- Blind Duplicate. Same as field duplicate, however the laboratory is not provided the sample location prior to analysis.
- Split Sample. A portion of the collected sample volume is analyzed by a separate laboratory with overlapping capabilities utilizing identical analytical methods to evaluate laboratory accuracy, reproducibility of sample handling and analytical procedures, sample heterogeneity, and analytical procedures.
- Field Blank. A sample of analyte free water (laboratory provided) is poured into the container in the field, preserved and shipped to the laboratory with field samples. The purpose is to assess contamination from field conditions during sampling.
- Travel Blank: A clean sample of a matrix that is transported from the laboratory to the sampling site and transported back to the laboratory without having been exposed to sampling procedures. Typically, analyzed only for volatile compounds. The purpose is to assess contamination introduced during shipping and field handling procedures.

A summary of the QC samples collected during the Q1 through Q4 testing period is provided in **Table B-1 (Appendix B)**. For each entry, the following information is provided: sample date, QC sample type, the laboratory conducting the analysis, sample location and compounds analyzed. The results associated with QC samples are provided in **Appendix B**. A description of the results for each QC samples group is provided below.

3.5.1.1 Blind Duplicate Sample Results

During each testing period, quarterly blind duplicate samples were sent to WECK Labs for analysis for all compound groups (with the exception of CECs and UCMR3 compounds). Blind duplicate samples were sent to MWH Labs during each CEC sampling event. The specific sampling location associated with all blind duplicate samples was rotated quarterly. **Tables B-2** through **B-5 (Appendix B)** provides results for compounds detected in the original and duplicate samples for all quarterly sampling events. When comparing results the following general criteria were used to assess if the differences in results were acceptable.

1. If the result of the original sample was within two times the RL, then the difference in results between the two samples should be ± 0.5 RL or b) the relative percent difference (RPD) should be 50%, whichever is higher. For purposes of this report, RPD is defined as the difference in results divided by the average times 100%.

2. If the result of the original sample was less than two times the RL, then the difference in results between the two samples should be ± 0.5 RL or b) RPD of 20%, whichever higher.

Quarter 1 Sampling Event. Table B-2 compares the results of the original and blind duplicate (UV/AOP product water) samples collected during the Q1 quarterly sampling event conducted on 8/24/11. As shown, of the 40 compounds detected in both samples the results were in good agreement with the exception of six compounds for which the difference in results was outside the acceptance criteria. The table provides notes for each of the six compounds based on discussions with the laboratories. As indicated, the only compound that was recommended for further QC sampling was TOC. Results related to additional TOC sampling are discussed in **Section 3.5.1.2.**

Quarter 2 Sampling Event. Table B-3 compares the results of the original and blind duplicate samples (tertiary effluent) collected during the Q2 quarterly sampling event conducted on 11/8/11. As shown, of the 48 compounds detected in both samples the results were in good agreement with the exception of some of the radionuclides for which the acceptance criteria are considered not applicable because the results were analyzed with different MDAs and counting errors. QC samples for radionuclides were deemed acceptable if the difference in results was within the range of the counting errors. The table provides other notes for each compound that were just outside the acceptable criteria based on discussions with the laboratories. As indicated, no compounds were recommended for further QC sampling.

Quarter 3 Sampling Event. Table B-4 compares the results of the original and blind duplicate samples (imported raw aqueduct water) collected during the Q3 quarterly sampling event conducted on 2/1/12. . As shown, the results for the 40 compounds reported above the RL in one or both samples were in good agreement. Comparison of radionuclide results included the counting errors as previously noted. The table provides other notes for each compound that were just outside the acceptable criteria based on discussions with the laboratories. As indicated, no compounds were recommended for further QC sampling.

Quarter 4 Sampling Event. Table B-5 compares the results of the original and blind duplicate samples (UV/AOP product water) collected during the Q4 quarterly sampling event conducted on 5/1/12. As shown, the results for the 19 compounds reported above the RL in one or both samples were in good agreement. The table provides other notes for each compound that was just outside the acceptable criteria based on discussions with the laboratories. As indicated, no compounds were recommended for further QC sampling.

CEC Sampling Events. Table B-6 compares the results of the original and blind duplicate samples collected during the four CEC sampling events (i.e. 9/14/11, 10/17/11, 11/8/11, 2/1/12, and 5/1/12). When comparing QC sample results, the general criteria presented above were slightly modified to make the maximum RPD for the Criteria 2 acceptance to be 40%. The higher degree of acceptable difference is justified based on the extremely low RLs, DLs and concentrations of CECs reported. Overall there was very good agreement between sample results for original and blind duplicate CEC samples. A summary of the results for each sampling event is provided below.

- Sampling Event 9/14/11. Of the 90 compounds for which results were reported in the RO permeate, only five were reported above the RL in the original or blind duplicate samples. Of these only two (Triclosan and Acesulfame-k) did not meet the general acceptance criteria (RPD of 106 to 109%). As noted in the table the difference warrants further QC sampling.

- Sampling Event 10/17/11. Of the 90 compounds for which results were reported in the tertiary effluent, 36 were reported above the RL in the original or blind duplicate samples. Of these, only two did not meet the general acceptance criteria (RPD's were below 90%); however, as noted in the table because the results were near the RL in one or more of the samples the difference was deemed acceptable.

- Sampling Event 11/08/11. Of the 90 compounds for which results were reported in the tertiary effluent, 37 were reported above the RL in the original or blind duplicate samples. Of these only two did not meet the general acceptance criteria (RPD's ≤70%); however, as noted in the table, the difference in results for

Acetaminophen was considered acceptable because the results were near the RL. However, the difference in results for Iopromide was just outside the acceptance criteria which did not warrant further QC sampling. A possible reason for the observed discrepancies is potential differences in the homogeneity of the samples.

- Sampling Event 2/1/12. Of the 38 compounds for which results were reported in the RO feed, 34 were reported above the RL in the original or blind duplicate samples. Of these only four did not meet the general acceptance criteria. The RPDs for these results ranged from 57% to 164%. Table B-6 provides additional information for each set of results that was outside the general acceptance criteria.
- Sampling Event 5/1/12. Of the 38 compounds for which results were reported in the UV/AOP product water, no results were reported above the RL in the original or blind duplicate samples.

3.5.1.2 Split Sample Results

Compounds Monitored Quarterly. During the Q1 Testing period, split samples of the UV/AOP product water were sent to MWH Labs for analysis for all compound groups being monitored by WECK Labs on a quarterly basis. **Table B-7 (Appendix B)** provides results for compounds that were detected in the original samples analyzed by WECK and the split samples analyzed by MWH. When comparing results the general criteria previously presented were used to assess if the difference in results were considered acceptable. As shown, of the 42 compounds detected in both samples, the results were in good agreement with the exception of 12 compounds for which the difference in results was outside the acceptance criteria. Of these, ten were reported by both laboratories to be below their RL or DL and were therefore deemed acceptable. In the Q2 Testing Report it was noted that these reported that differences suggest further QC sampling is required for TOC and Formaldehyde.

Results from split samples analyzed for TOC in the UV/AOP product water by both labs during the Q3 testing period were in agreement as <0.3 mg/L. However, the results differed for three sets of split samples analyzed for Formaldehyde (Method EPA 556) in the RO permeate and UV/AOP product water by both labs. WECK reported average (n=3) concentration of 2.7 µg/L in the RO permeate and 5.6 µg/L in the UV/AOP product water. However, MWH reported average (n=3) concentrations of 9.5 µg/L in the RO permeate and 70 µg/L in the UV/AOP product water. During the current reporting period both labs purchased and analyzed stock solutions of formaldehyde obtained from the same supplier and lot number to further investigate the discrepancies. Results of spiked stock solution at concentrations of 5 µg/L and 25 µg/L from analysis by both labs were within close agreement.

The variability observed by WECK labs in RO permeate over time is consistent with the difference in the results of the split samples, but the variability in the UV/AOP results is well outside of the variability observed by either lab in repeat analyses. It is therefore likely there is a matrix effect on the formaldehyde analysis due to the peroxide that one of the two labs is not dealing with properly. Additional analysis by a different method might help to resolve the discrepancy. Finding these levels of formaldehyde in an AOP product is not unexpected because of the potential formation of aldehydes. Even if one uses the MWH results, they are below the CDPH notification level.

CECs: During the current and prior testing periods, split samples were sent to MWH Labs and CSM. Of the 90 CECs analyzed by MWH labs (results **shown in Table 36**), CSM analyzed 30 compounds in the split samples. **Table B-8 (Appendix B)** provides results from each lab along with RPD's. Results were compared for each compound and assigned one of the following QC categories.

- **Category 1** - comparison of lab results for the given compound showed consistent agreement (i.e., RPD's < 40% or ND);

- **Category 2** - comparison of lab results for the given compound showed consistent agreement for some results and discrepancies for others; possibly due to non-homogeneity in the samples and/or sample contamination.

- **Category 3** - comparison of lab results for the given compound showed consistent disagreement possibly due to systematic differences between laboratory analysis procedures.

- **Category 4** - Results could not be compared due to insufficient data.

Based on discussion with the labs a possible cause of the Category 2 discrepancies is the result of differences in the sample volumes used by labs. MWH Labs provides 40 mL vials for CEC collection compared to CSM, which provides 1 L bottles. Sample collection using 40 mL vials are much more sensitive to low level contamination. This may explain differences in results reported by the two labs for compounds such as DEET and Triclosan. To test this hypothesis, during the current reporting period UV/AOP product water samples and field blanks were collected in both 40 mL and 1 L bottles and analyzed by MWH Labs for a target list of 38 CECs (field blanks) and 27 CECs (UV/AOP product water). Results for the field blanks showed all compounds to be <RL in both the 1 L and 40 mL samples with 37 results <DL in the 1 L sample and 33 results less than the DL in the 40 mL sample. Results for the UV/AOP samples showed all compounds to be <RL in both the 1 L and 40 mL samples with all results also <DL in the 1 L sample and 24 results less than the DL in the 40 mL sample. While these results showed a higher number of detected compounds in the smaller sample size it was not conclusive. As a result additional field blank and UV/AOP samples were collected and analyzed during the current reporting period including samples collected in samples volumes 40 mL, 250 mL, 500 mL and 1 L. Samples were analyzed for only Triclosan and DEET and results were all <DL.

Therefore while earlier data suggest the possibility of field contamination impacting the samples due to the low sample volume, the subsequent test, which found no detects in field blanks is inconclusive. Both DEET and Triclosan are ubiquitous in the environment and there is insufficient data to rule out possible field blank or laboratory contamination during one of the sampling periods.

To further investigate Category 3 discrepancies, MWH and CSM labs exchanged and analyzed standards for compounds analyzed using the same method by both labs. Of the standards analyzed results were in good agreement suggesting that differences in standards used by the labs are not the cause of discrepancies in results. As part of the QC for a separate research project not related to the demonstration project, both MWH and CSM labs also analyzed blind CEC samples prepared by a specialty laboratory (ERA Laboratories, Inc.) and split samples from the Santa Ana River. Each of these was also analyzed by 3 other laboratories, although not all for the same suite of analytes. Results from this study showed results from both labs were in good agreement. A brief letter provided by Dr. Andy Eaton from Eurofins Eaton Analytical Labs (formerly MWH Labs) addressing the agreement in results between MWH Labs and CSM is is provided in **Appendix B**.

Comparison of CEC results from the 5/1/12 sampling show very close agreement between the labs for RO permeate and UV/AOP product water results with all results below the RL or DL.

3.5.1.3 Travel / Field Blank Results

Due to the extremely low RLs and DLs (ng/L) of CEC compounds, travel or field banks were provided for all associated sampling events. For the initial three monthly CEC sampling events, MWH Labs provided travel blanks. The analysis of the travel blanks for the 8/24/11 sampling showed five compounds were detected at concentrations between 3.8 to 340 ng/L. Three compounds were also detected in the travel blank associated with the 9/14/11 sampling with concentrations between 4.7 to 6.2 ng/L. Subsequent to these findings, the MWH Labs investigated the potential cause of the detected compounds in the travel blanks and discovered an issue with the quality of the water used to prepare the travel blanks. Because of these findings and the fact that travel blanks provide limited information regarding contamination that may happen in the field, the travel blanks were replaced with field blanks made of highly purified deionized water starting on 2/1/12. Results of all subsequent CEC field blanks (sample dates: 2/1/12, 2/8/12, 2/15/12, 2/22/12, 5/1/12, 7/30/12) analyzed by MWH Labs during the previous and current testing period were <DL for the majority of the compounds and the rest were reported below the RL. For the split CEC samples sent to CSM, field blanks were utilized with all results to date reported below the DL for all compounds analyzed.

3.5.2 Data Validation

Third-party validation was performed on the water quality data produced from WECK Laboratory and MWH Labs for a sampling event conducted on 8/24/11 during the first testing period. The purpose of the validation was to assess data quality and review laboratory and sample handling procedures in order to identify possible procedural alterations to be implemented for subsequent sampling events.

Data validation was performed on results from samples collected from the UV/AOP product water (S10). This included the original and blind duplicate samples analyzed by WECK Labs and the split samples analyzed by MWH Labs for all compounds monitored quarterly (CEC's and UCMR3 compounds excluded). Data validation was also performed for S10 samples analyzed for CECs by MWH Labs (8/15/11 sampling event only).

Laboratory Data Consultants, Inc. (LDC) performed all data validation analyses under EPA Level IV guidelines. Level IV review is the most rigorous and is characterized by QA/QC protocols and documentation resulting in a complete qualitative and quantitative analysis of the analytical data. Data that fulfills the requirements of this level of third party validation fulfills the minimum data quality standards needed to allow the data to be used for its intended objective. The analyses were validated using the following documents applicable to each method:

- USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008.

- USEPA, CLP National Functional Guidelines for Inorganic Superfund Data Review, January 2010.

- USEPA, CLP National Functional Guidelines for Polychlorinated Dioxins / Dibenzofurans Data Review, Review, September 2005.

- Multiple Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual, July 2004.

The third party validation process showed all the data validated to be acceptable. It was also confirmed that the majority of the data met the strict analytical standards of the USEPA CLP. Given the large number of parameters and control statistics analyzed, it is always likely that a handful of parameters will not quite fulfill all of the validation criteria. The project team notified the laboratories of data that did not fulfill all validation criteria and requested they make any necessary procedural changes for future analysis. A technical memorandum summarizing the extensive data validation reports prepared by LDC for analysis conducted by WECK and MWH Labs is provided in **Appendix C**.

3.5.3 Field Sampling Procedures

The following section describes the equipment and procedures utilized to collect water quality samples during the testing periods as well as components of the CEC monitoring plans incorporated to provide robust data set.

- **General Sampling Procedures.** All sampling personnel utilized clean handling techniques when processing samples such that only new powder- and phthalate-free vinyl gloves (nitrile) were worn when handling the sample bottles. Personnel wore gloves during all sample retrieval operations and changed gloves frequently, with each change in task. After opening stainless steel sample valves and allowing water to flow for two to three minutes, personnel collected water samples from appropriate sample locations. Prior to sampling operators verified that purification processes (i.e. MF/UF/RO/UV/AOP) were operating normally under design conditions. Efforts were also made to time sequence sample collection to assess treatment performance. Samples were labeled appropriately, and placed into coolers packed with ice packs/blue ice at the conclusion of the sampling event or stored in the onsite fridge dedicated to sample storage. Personnel then shipped the sealed coolers under chain-of-custody to the contracted laboratory. The laboratory processed and analyzed the samples in accordance with their standard operating procedures. Strict adherence with the sample volume quantities, preservation methods and hold times provided by the certified laboratories for each analytical method were followed in order to meet reporting levels.

- **CEC Sampling Procedures**. Due to the common use of pharmaceuticals, the ubiquitous nature of personal care products, common use of target compounds in commercial products and the extremely low levels of detection related to CEC analysis, a number of procedures were followed and pre-cautions taken to avoid field sample contamination. Strict sampling protocols including sample collection, storage and handling procedures provided by the laboratories were reviewed and followed prior to and during all CEC sampling events. This included:

1. Certified one time use bottles provided by the MWH and CSM Labs and used for all samples collected.

2. Samples were only collected by trained AWP Facility operators familiar with the strict sampling protocols. Due to schedules and the number of sample locations and required timing it was not possible to have one person collect all samples, however the number of samplers used during the testing periods was limited to three.

Use of gloves at all times during sampling. Gloves were made of 100% nitrile powder free per recommendation by State Board CEC Expert Panel. The gloves do not contain triclosan or any other CEC compounds.

1. Based on "lessons learned" from previous CEC monitoring programs several components were incorporated into the monitoring program for the AWP Facility. These included: 1) increased number of samples 2) increased number of QC samples including: field blanks, blind duplicates, and split samples 3) use of multiple laboratories to compare results 4) frequent communication with labs to discuss any results that were not current with expectations based on anticipated treatment performance.

2. On the day of sampling, AWP Facility operations staff avoided contact with or consumption of the products listed below.

a. Soaps, detergents, including antibacterial cleansers

b. DEET

c. Fragrances

d. Sunscreen

e. Caffeine

f. Tobacco

g. Pharmaceutical

h. Antibiotics

Microbiological Sampling Procedures. Additional procedures were taken when collecting water samples for analysis microbiological parameters including:

1. Sterilization of sample valves using a hand-held propane torch prior to collecting the grab samples.

2. Samples were stored with blue or wet ice and at a target temperature of 3-8 °C.

3. Sample collection and handling procedures were followed as specified in USEPA Methods 1602 (F- and somatic coliphage), 1682 (salmonella), and SAP 2009 Draft (E. coli O157), and method SM 9221 (coliform).

3.6 Summary of Water Quality Monitoring Results for Regulated and Non-Regulated Constituents

3.6.1 Regulated Constituents

Water quality monitoring was conducted in compliance with the Final T&M Plan to demonstrate the feasibility of an AWP Facility to reliably produce purified water that is consistently in compliance with all drinking water quality standards. Water quality goals were established for the Demonstration Facility based on existing recycled water regulations, as well as anticipated future regulatory requirements specific to the City’s proposed Full Scale Facility. The overall approach to water quality monitoring was to collect water quality data at different locations throughout the Demonstration Facility water purification process to analyze process performance, and to compare purified water quality to project objectives, screening levels, and existing water supplies. A comparison of key water quality results and the Demonstration Facility goals is presented in **Table 44.** The table shows that the average concentration of all constituents measured in the purified water is below the established Demonstration Facility goals. Note results shown as ND were reported below the RL (i.e. non quantifiable) or below the DL.

3.6.2 Non-Regulated Constituents

Non-regulated constituent monitoring was conducted at various locations in the purification process and the imported raw aqueduct water. These constituents are grouped as follows:

- 30 constituents included in the original 2012 EPA Unregulated Contaminant Monitoring Rule (UCMR3) List 1 and List 2. *Note: on May 2 2012 the EPA issued the Final Rule Promulgation, which removed two constituents from the original List 1;*

- 90 other constituents of emerging concern (CECs), such as pharmaceutical compounds and personal care products;

- 1 additional constituent (lithium) as recommended for testing by the IAP;

- 5 nitrosamines beyond the three which have current NLs (i.e. NDMA, NDEA, and NDPA) as tested as part of the routine water sampling.

- 3 individual beta emitters including: Cesium-137, Iodine-129, and Iodine-131. As described in **Section 3.2.5** these compounds have CDPH drinking water regulatory requirements should Gross Beta exceed a concentration of 50 pCi/L.

The monitoring results of the above 129 constituents conducted at the Demonstration Facility, showed only six were found to be quantifiably detected in the purified water at any time, including three constituents from the UCMR3 list and three CECs. The six constituents, discussed in further detail below, are:

1. Bromochloromethane (BCM)
2. Hexavalent Chromium (Chromium-6)
3. Acesulfame Potassium (Ace-K)
4. Iohexal
5. 2,4,4′ –trichloro-2′-hydroxydiphenyl ether (triclosan)
6. Strontium

Table 45, on page 105 of the Tables and Figures, provides a summary of the six constituents, including average and maximum values measured in both the purified water and imported raw aqueduct water. It should be noted of the 129 constituents contained in the groups listed above some overlap with the 231 regulated constituents shown in **Table ES-2**. Constituents that overlap among the two groups were tested with more sensitive test methods as part of the non-regulated constituent monitoring allowing for lower levels of quantification. Accounting for overlaps, 111 discrete constituents were monitored as part of the non-regulated constituent monitoring.

Additional information on the six constituents and the potential significance of the measured concentrations are discussed below. As part of the Project Advisory Team, Dr. Shane Snyder (Co-Director of the Arizona Laboratory for Emerging Contaminants located the University of Arizona) also reviewed the results associated with these unregulated constituents. A technical memorandum prepared by Dr. Snyder which summarizes his findings is located in **Appendix D**.

- **Bromochloromethane (BCM).** Also called Halon 1011, is used as a fire-extinguishing fluid and to suppress explosions, as well as a solvent in the manufacturing of pesticides. It may also occur as a disinfection by-product in drinking water, when chlorine used for disinfection reacts with organic material in the water. BCM was detected four times out of four samples in the purified water, with an average value of 0.225 µg/L and a maximum value of 0.250 µg/L. The Drinking Water Equivalent level (DWEL) for bromochloromethane is 40 µg/L (40,000 ng/L) (SWRCB, June 2010), which is more than 170 times higher than the concentration measured in the purified water, suggesting that the concentrations measured in the purified water do not pose a health risk for human consumption.

- **Hexavalent Chromium(Chromium-6)** Chromium is an odorless, tasteless metallic element found naturally in rocks, plants, soil and volcanic dust, and animals. Chromium is commonly found in two forms: trivalent chromium (chromium-3) and hexavalent chromium (chromium-6). Chromium is a heavy metal that occurs throughout the environment. The trivalent form is a required nutrient and has very low toxicity. The hexavalent form, also commonly known as chromium-6, is more toxic and has been known to cause cancer when inhaled. In recent scientific studies in laboratory animals, chromium-6 has also been linked to cancer when ingested.

In 2008, EPA began a rigorous and comprehensive review of chromium-6 health effects based on new scientific information. When this human health assessment is finalized, the EPA will carefully review the conclusions and consider all relevant information to determine if the current chromium standard should be revised. Currently, there is no federal or state MCL specific to the hexavalent form of chromium. Chromium-6 is regulated in drinking water through the establishment of a total chromium MCL. In California, the total chromium MCL is 50 µg/L, while the federal MCL is 100 µg/L.

Additional information on hexavalent chromium can be found at:
http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chromium6.aspx .

CDPH is in the process of developing an MCL for chromium-6. Currently CDPH is collecting data associated with the risks and prevalence of chromium-6 and has established a detection limit for purposes of reporting (DLR) of 1 µg/L. This detection limit for purposes of reporting is 33 to 50 times higher than the method reporting level (RL) used by the primary laboratory where chromium-6 samples were taken during the Demonstration Facility operation. As a result, data from the

Demonstration Facility includes concentrations that are currently considered undetectable based on CDPH guidelines.

During the Demonstration Facility operation, chromium-6 samples were sent for analysis to two separate labs MWH Lab (Lab 1) and WECK Lab (Lab 2). Information about the sampling of chromium-6 is provided below:

1. For Lab 1 , the method used was EPA 218.6 (RL= 0.02 µg/L, DL=0.009 µg/L) /EPA 218.7 (RL= 0.03 µg/L, DL=0.0083 µg/L). Chromium-6 was found at quantifiable concentrations in the purified water four times out of four samples, with an average value of 0.09 µg/L and a maximum value of 0.16 µg/L. The RL (0.03 µg/L) used by the lab, using EPA 218.7, is in accordance with current UCMR3's RL. The concentration of Chromium-6 in purified water were at or below the results of UCMR monitoring from over 7,000 drinking water sources, from between 2000 to 2011, which showed Chromium-6 at or above the 1-µg/L DLR in about one-third of them. (http://www.cdph.ca.gov/certlic/drinkingwater/pages/chromium6sampling.aspx)
2. Chromium 6 was <RL or <DL in the tertiary effluent by Lab 1, suggesting that chromium-3 may have been oxidized by the advanced oxidation process to form the low levels of chromium-6 measured in the purified water.
3. Lab 2 analyzed chromium-6 using method EPA 218.6 with all results in purified water reported below detectable levels (DL=0.0059 µg/L). The Lab 2 method reporting level was 0.3 µg/L, which is higher than Lab 1. Also the Lab 2 detection limit is lower than Lab 1.
4. All results from both labs were below the CDPH detection limit (DLR) of 1 µg/L.

- **Ace-K: Acesulfame Potassium (Ace-K):** is a widely used artificial sweetener. Ace-K is used in a variety of consumables, including soft drinks, sports drinks, chewable and liquid medications, and other foods. During the testing period, Ace-K was below quantifiable levels in the purified water in seven of nine samples analyzed, with an average concentration below quantifiable levels and maximum concentration of 50 ng/L (RL=20 ng/L). Ace-K was below detectable levels in the RO permeate or RO permeate duplicate in samples collected on the same day that results in the purified water (after advanced oxidation) were reported above the RL, suggesting that even the low levels measured on these days may have resulted from sampling or analytical error. It should be noted based on concentrations measured in the RO feed and RO permeate the AWP process consistently achieved greater than 99.9% removal of Ace-K.

  The Food and Drug Administration has established an Acceptable Daily Intake for Ace-K of 50 mg/kg. Based on this, the calculated DWEL for Ace-K is 525 mg/L, which is a concentration 10 million times greater than the maximum value reported in the purified water. This suggests that the concentrations of Ace-K measured in the purified water (and in the tertiary water before purification) do not pose a threat to public health.

- **Iohexal:** This compound is a contrasting agent used in x-ray procedures, such as coronary angiographs. Iohexal is typically injected into the body, allowing organic iodine compounds to block x-rays as they pass through the body. This allows for delineation between body structures containing iodine and structures that do not contain iodine. This compound was below quantifiably detectable levels in the purified water for eight of nine samples analyzed, with an average value of below quantifiable levels and a maximum value of 19 ng/L (RL=10 ng/L). RO permeate and RO permeate duplicate QC samples collected during the same sampling event as the single positive result were below quantifiable levels, suggesting that the single positive result may have been the result of analytical imprecision at levels near the MRL. Iohexal is not analyzed by isotope dilution due to lack of an available isotope, so this adds the potential for signal suppression or enhancement in the LC-MS-MS and may make measurements near the MRL less precise therefore he single positive result may have been the result of analytical error.

  The DWEL for this compound is 720,000 ng/L (SWRCB, June 2010), which is nearly 38,000 times higher than the maximum concentration reported in the purified water, suggesting that the concentrations measured do not pose a threat to public health.

- **Triclosan : 2,4,4′ –trichloro-2′-hydroxydiphenyl ether (triclosan):** is used as a synthetic broad-spectrum antimicrobial agent. Triclosan is used in a variety of consumer products , such as antimicrobial hand soaps, toothpaste, and over-the-counter drugs. It also functions as a material preservative in adhesives, fabrics, vinyl, plastics (toys, toothbrushes), polyethylene, polyurethane, polypropylene, floor wax emulsions, textiles (footwear, clothing), caulking compounds, sealants, rubber, carpeting, and a wide variety of other products. In commercial, institutional, and industrial equipment, triclosan is used to prevent microbial growth in conveyor belts, fire hoses, dye bath vats, HVAC coils, and ice-making equipment. Split samples collected in the RO permeate and Purified Water at the same time as one of the two positive results were found to be below detectable limits by a second lab that performed the analysis.

  Seven of nine samples analyzed for triclosan in the purified water were below the RL. A number of factors suggest that the two results (19 ng/L and 17 ng/L) above the RL in the purified water may have resulted from sample contamination. The first factor is the wide spread use of this compound in personal care products. Though careful measures (use of gloves, avoidance of products that contain tricolsan, etc.) were taken during all sampling events to minimize the possibility of field contamination, such contamination cannot be ruled out. All sample bottles used were one time use USEPA certified bottles, however, the laboratory conducting the analysis reported that because there are no commercially available preserved containers for the CECs, bottles are preserved by lab staff prior to shipping to clients for collection. This introduces the risk of contamination. Another important factor is that duplicate quality control samples taken from both the RO permeate and Purified water (collected on the same day as one of the two samples reported above the RL) were analyzed by a second lab and reported non-detectable values (less than 2.5 ng/L). Additionally, when the first lab analyzed field blanks using two different sample volumes, no triclosan was measured in the larger volume sample. Because of the small sample volume even trace amounts of triclosan in the air could have been enough to lead to measureable values.

It should be noted that the Science Advisory Panel (State Board, 2010) recommended a more practical reporting level of 50 ng/L for Triclosan, which would suggest that all of the samples measured in the purified water should be considered below quantifiably detectable levels. Based on input received from the chair of the SAP (Jörg E. Drewes, Ph.D.) the driver for this recommendation was to avoid the issues encountered in reporting ultra-low levels of this compound. Furthermore, Dr. Drewes stated that avoiding triclosan hits in blanks is almost impossible in practical applications.

The DWEL for triclosan ranges between 350 to 2,600,000 ng/L (SWRCB, June 2010), which is 18 to nearly 137,000 times higher than the maximum concentration reported in the purified water, suggesting that no public health concerns are associated with the low levels of triclosan which may or may not have been present in the purified water.

- **Strontium:** is a naturally-occurring element and is used as a dietary supplement and in various industrial applications, such as pyrotechnics and automobile manufacturing. During the testing period strontium was < RL (0.3 µg/L) in three of the four quarterly samples analyzed from the purified water. The purified water sample taken during Q4 Testing Period was reported at 0.37 µg/L and the result was confirmed with a blind duplicate sample which was reported at 0.41 µg/L. These results are over 10,000 times lower than the EPA's Contaminant Candidate List 3 (CCL3) Health Reference Level for strontium of 4.2 mg/L. The average results from samples collected in the tertiary water during the quarterly sampling was 518 µg/L indicating the AWP process achieved greater than 99.9% removal of strontium. The average concentration in the IAW from samples collected quarterly was 405 µg/L. It should also be noted strontium-90 (the most common radioisotope of strontium), which emits beta particles during radioactive decay, was below the federal and state primary drinking water MCL in all purified water samples analyzed during the previous and current testing period.

Section 4
Integrity Monitoring

4.1 MF and UF Systems Integrity Testing

4.1.1 Pressure Decay Testing (PDT)

During the previous testing periods, monitoring of the integrity of the MF and UF systems was done by conducting daily pressure decay tests (PDT). Results indicated both membrane systems were intact (i.e. no particles larger than the membrane pore size can pass through the membrane) throughout the testing periods. Pressure decay rates measured daily over a 5 minute period for both systems were consistently below 0.1 psi/5 minutes.

PDT testing was continued at the same frequency during the current testing period. **Figures 18 and 19** present cumulative results of the PDTs performed on the MF and UF systems, respectively for all testing periods. Approximately, three hundred and fifty (350) individual PDT tests were performed on the MF and UF systems during the Q1 through Q4 testing period, the pressure decay rates were consistently below 0.1 psi/5 minutes indicating the membranes were intact with no fiber breakage over the entire testing period.

Estimates of the log removal value (LRV) of Cryptosporidium achieved by the MF and UF systems were performed based on the measured values of pressure decay. The predicted log removal values were determined using the Darcy Pipe Flow Model equation for air liquid conversion ratio (ALCR) as presented in the *EPA Membrane Filtration Guidance Manual*, 2005. This equation requires several inputs categorized as operating parameters, direct integrity test parameters, and unit and membrane characteristics. Values for these parameters were obtained from the membrane manufacturers and/or by field verification.

Based on the average pressure decay rates (psi/5 minutes) measured daily from the MF and UF systems during the previous and current testing periods the average predicted log removals were determined to be 4.69 and 5.45, respectively. Utilizing the referenced equation, the calculated pressure decay rate (psi/5 minute) corresponding to 4 LRV of Cryptosporidium for the MF and UF systems was estimated to be 0.4. Based on this estimate and the average PDT measured on both systems the predicted removal of Cryptosporidium by both the MF and UF exceeded 4 LRV.

4.1.2 Online Turbidity Monitoring

During the previous and current testing periods, the integrity of the MF and UF systems were also monitored by measuring online filtrate turbidity. Though this method does not provide the same level of sensitivity as pressure decay testing, it does provide the benefit of being an online measurement which provides continuous feedback on membrane performance.

Turbidity profiles measured for the MF and UF systems during the previous and current testing periods are provided in **Figures 20 and 21**, respectively. Average filtrate turbidities (NTU) based on readings taken twice per day from the online analyzer displays during the Q1 through Q4 testing periods were 0.05 for the MF system and 0.015 for the UF system. The lower turbidity values measured on the UF system are attributed to the fact that this system uses a laser turbidimeter (HACH Model Filter Trak 660 SC) which uses advanced incident light as opposed to the MF system which uses a conventional incandescent light turbidmeter (HACH 1720 E). The specifications on the laser turbidmeter claim the unit can detect changes in turbidity as low as 0.0003 NTU. Based on results from the demonstration testing both types (incandescent light and laser) of online turbidimeters would be appropriate for the potential Full-Scale Facility. It was also observed during testing that taking frequent routine measurements of filtrate turbidity using a desktop turbdimenter (HACH sensION156 Portable Meter) was useful to check the accuracy of the online meters and provided similar turbidity values (i.e. 0.03 to 0.06 NTU) as the HACH 1720E online turbidmeter.

The average value of the online MF/UF feed turbidity during the previous and current testing periods was 0.4 NTU. The scatter shown in the turbidity profiles is attributed to changes in the flow rate entering the turbidimeter. Around run hour 1750, the operations team began checking and adjusting (if needed) the flow resulting in more stable values (~0.2 to 0.4 NTU) for the remainder of the testing period. These values are consistent with that reported in the tertiary effluent by the North City operations team.

4.2 RO Systems Integrity Testing

Pre-Installation. Prior to delivering the RO elements to the AWP Facility the membrane manufacturers were requested to conduct pressure or vacuum decay testing on each element. Such testing is the only direct integrity method available to detect defects or damaged membranes and/or faulty glue lines. The results of the test results provided by the manufacturers are summarized in **Figure 22**. Of the 119 elements provided by Hydranautics the average vacuum decay rate was 0.37 inches Hg/min. Toray reported the 120 elements they tested had a pressure decay <0.29 inches Hg/min. By comparison, the acceptable RO element vacuum decay rate per ASTM D3923 is 6 inches Hg/min. Though the results cannot be directly compared due to differences in the test methods used by each manufacturer and that outlined in the ASTM standard, the low and precise decay rates are a good indication that the elements received for testing were free of any major defects which would inhibit performance. Lastly, in order to not skew the results generated in the AWP Facility demonstration, manufacturers were requested to provide elements that were randomly selected from a standard production lot. Each supplier confirmed this by providing letters to this affect.

Post Installation. Upon installation of the RO membranes the operations team conducted conductivity vessel probing of all vessels on the Train A and Train B systems. The purpose of this testing was to ensure that each membrane element was installed properly with no leaks at the element interconnection or end-caps, and that they were not damaged during shipping. Conductivity was measured along each vessel at 15 locations spaced approximately 20 inches apart. These locations allowed for conductivity measurements at the end-cap connectors, element interconnections and midway of each element. The trend of conductivity measured from both Train A and Train B were indicative of intact systems. The general trend of intact RO systems being that vessel conductivity should gradually increase in the direction of flow as the feed water becomes more concentrated. In addition, conductivity should also increase from stage to stage as the concentrate from the upstream stage provides feedwater to the downstream stage. Breaches of integrity would also be signified by sharp spikes in conductivity, which were not observed during the testing.

Operation. During operation, conductivity and total organic carbon (TOC) were monitored online to provide continuous assessment of system integrity. All integrity monitoring results indicated the membrane elements and membrane systems for both Train A and Train B were intact through the all testing periods. Results of the online monitoring results of these two parameters to date are discussed below.

4.2.1 Online Monitoring

4.2.1.1 Conductivity

Figures 23 and 24 provide conductivity profiles for the Hydranautics ESPA2 LD and Toray TML RO systems, respectively. The profiles were developed from values recorded twice per day from the online analyzer displays. It should be noted the online analyzer takes continuous measurements of conductivity and the control system on the RO systems was set to shut the systems off automatically if the online permeate conductivity reached a high alarm set point of 150 uS/cm. As shown, the permeate conductivity of both systems remained well below the alarm set point during the entire Q1 through Q4 testing period. The average permeate conductivity (uS/cm) of the Hydranautics and Toray RO systems during at 80% feedwater recovery (FWR) were 18 and 21, respectively.

The permeate conductivity of both RO systems increased notably as expected when the FWR was increased from 80 to 85% corresponding to run hour 6314 (Hydranautics) and run hour 6391 (Toray). As discussed in Section 2, the Toray RO system exhibited scaling after increasing the FWR due to a faulty flow meter which resulted in operation at an even higher FWR than intended (i.e. 87-89%). **Figure 24** shows the permeate conductivity increased over this time period as expected due to concentration polarization. The average permeate conductivity (uS/cm) of the Hydranautics and Toray RO systems during the current testing period while operating at a target 85% FWR were 26 and 30, respectively. Based on the average measured feed conductivity measured over the entire Q1 through Q4 testing periods, the Hydranautics membranes achieved an average conductivity rejection (%) of 98.8 at a FWR of 80% and 98.4 at FWR of 85%. The average calculated conductivity rejection for the Toray membranes is 98.6 % during operation at 80% FWR and 98.1% at a FWR of 85%.

4.2.1.2 Total Organic Carbon (TOC)

During the Q1 testing period, TOC measured online in the combined permeate from the two RO systems during September and October 2011 was consistently between 40 to 80 ppb. The TOC analyzer (GE Sievers Model 5310) was also used to characterize the concentration and diurnal variation of TOC in the RO feedwater. **Figure 25** provides results from an eight day monitoring period conducted in August 2011; it shows the RO feed TOC concentration follows a fairly consistent diurnal pattern with values between approximately 7.5 to 8.5 ppm (7,500 to 8,500 ppb). Over a typical 24 hour period, peak TOC concentrations occurred around 6 AM and low concentrations occurred around 6 PM.

Online TOC monitoring of the combined RO permeate was conducted during the Q1, Q2, Q3 and current testing periods. **Figure 26** provides online values measured every 4 minutes and downloaded directly from the online TOC analyzer. The figure provides cumulative online data measured from 9/1/11 through 7/31/12. Overall results from the previous and current testing period have been consistently between 20 to 80 ppb. The lower concentrations may be due to lower feedwater temperatures which could result in higher rejection by the RO membranes.

As noted on **Figure 26,** during the latter part of December 2011 the location of the online analyzer was switched to the RO feedwater. The purpose of this was to confirm the diurnal characterization observed during the previous testing period. Results collected over a 15 day monitoring period (not shown) indicated the TOC ranged from between 2.0 to 7.0 ppm (2,000 to 7,000 ppb). In addition, an opposite diurnal trend was observed as compared to the Q1 testing period.

Based on follow up discussions with GE the cause of the discrepancy is speculated to have resulted from large swings in the internal cell and ambient temperature that occurred during the December monitoring period. The cell temperature measured by the instrument ranged from 12 to 28 degrees Celsius. The cell temperature measured by the instrument is generally 4-8 degrees Celsius higher than ambient temperature due to heating that occurs within the instrument. The low end of the cell temperatures recorded by the instrument in December indicates that the ambient temperature was lower than 10 Celsius, which is outside the instruments ambient temperature specification of 10 to 40 degrees Celsius. Overall results from the demonstration testing showed the instrument worked properly when operated in the operating specifications.

During the previous testing period, the operations team worked with GE to perform a series of tests and calibrations to ensure the analyzer is working properly within specifications. GE recommended replacing the tubing on the inorganic carbon removal (ICR) component of the analyzer. Upon replacing the tube, the unit passed the 10 ppm (10,000 ppb) TOC single point verification. The unit was then operated on RO feed water for a 1-week period beginning on 2/24/12. The results of the online TOC monitoring of the RO feed are presented in **Figure 27**. As shown, the concentration of TOC ranged from 6.5 to 7.5 ppm (6,500 to 7,500 ppb) and the diurnal variation was observed to be similar to that measured during the Q1 Testing Period. The range of TOC measured in the RO feed was expected based on the typical concentrations reported in the tertiary effluent by the North City operations staff. On 3/1/12 the analyzer was operated on RO permeate for the remainder of the testing period. The concentration of TOC in the RO permeate was similar to what was measured during previous testing periods.

During the current testing period the unit was operated on RO feed water for an eight day period beginning on 7/5/12. The results of the online TOC monitoring of the RO feed are presented in Figure 28. The concentrations and diurnal variation of TOC in the RO feed water were consistent with results from previous testing periods. Prior to performing the RO feed water characterization the accuracy of the unit was confirmed by running a 10 ppm (10,000 ppb) TOC single point verification standard.

Based on the range of feed TOC concentrations (6,500 to 8500 ppb) measured during short term diurnal testing done on the RO feedwater during each testing period (when the instrument was operated within specification) and the range of TOC concentrations (20 to 80 ppb) recorded from continuous monitoring of the RO permeate, the TOC rejection by the RO membranes ranged from 98.8% to 99.8%.

4.3 Summary of Critical Control Point Monitoring Results

As outlined in the Final T&M Plan a key component of the integrity monitoring plan was to conduct critical control point (CCP) monitoring to identify any change in the performance of the treatment processes that can adversely impact the final water quality. **Table 46** provides a summary of the initial CCP monitoring plan implemented during the Demonstration Facility testing period. The specific parameters, limits, and corrective actions shown were used for the Demonstration Facility; it is expected a comparable plan would be established for the potential Full Scale Facility at a later date. The plan identified CCPs (e.g. MF/UF, RO and UV/AOP system) as well as critical limit parameters (CLP), limits and corrective actions. The values of limits and corrective actions were refined and further defined throughout the testing period. During the design phase of the potential Full-Scale Facility, the City would develop a similar monitoring and response plan that provides sufficient features and assurances that any foreseeable malfunction could be promptly identified and appropriate responses applied.

Table 47 summarizes the CCP monitoring results from the previous and current monitoring periods. During the Q1 testing period one exceedance of the established critical alert limit (CAL) for pressure decay occurred on the UF system. After further investigation, it was determined the high pressure decay rate resulted from a leak in the air piping not the actual membrane(s). Upon repair of the leak, the measured PDT results were well below the CAL for the remainder of the testing period. During the Q1 testing period, the CAL for the UV/AOP reactor power level was not met on four separate occasions each due to the ballast failures. When a single ballast failure occurs, only two of 72 total lamps are out of service, representing a ~3% decrease in reactor present power. In response, the reactor power automatically increases to 100%. Based on the reactor performance to date it has been determined a reactor power level of approximately 70% is required to achieve the target log removal of NDMA. As a result, the occurrences of ballast failures are highly unlikely to have jeopardized the treatment performance and UV/AOP product. No exceedances of CALs were identified for any of the CLP's during the Q2 testing period.

During the Q3 Testing Period, two CAL exceedances occurred. The first incident was due to the loss of flow confirmation on the hydrogen peroxide dosing pump of the UV/AOP system. Once this occurred, the system auto switched to the stand-by pump. However, the stand-by pump also shut off due to low flow resulting from air lock, thereby causing the system to automatically shut down. The Demonstration Facility operations staff was present when the event occurred and quickly restarted the system with no issues for the remainder of the testing period. The second incident was due to a single ballast failure on the UV/AOP system. The system automatically increased power to 100 percent to accommodate power loss thereby maintaining treatment performance. An alarm notified the operations team of this occurrence, shortly after the system was taken offline and the ballast was replaced.

During the Q4 Testing Period, six CAL exceedances occurred. Five of these were due to the loss of flow confirmation on the hydrogen peroxide dosing pump of the UV/AOP system. Once this occurred, the system auto switched to the stand-by pump. On two occasions the switch to duty pump was successful and the system operated without interruption. However, on the other three occasions, the stand-by pump also shut off due to low flow resulting from air lock, thereby causing the UV/AOP system to automatically shut down. The operations staff were notified by alarms when the unit was shut down, shortly after the system was restarted after operating both pumps in manual to remove entrained air. As described in **Section 2.1.4.1**, the issue was resolved by making adjustments to the degassing interval and pulse length on the peroxide dosing skid and opening a valve on the pump skid to allow off gas to return to the peroxide storage tank.

The sixth CAL exceedance occurred due to a single ballast failure on the UV/AOP system. The system automatically increased power to 100 percent to accommodate power loss thereby maintaining treatment performance. An alarm notified the operations team of this occurrence, shortly after the system was taken offline and the ballast was replaced. As described in **Section 2.1.4.1** at the time this report was prepared a power study was underway to assess if the ballast failures experienced during the testing period are due to power surges. Also, the ballast manufacturer was in the processes of inspecting ballasts that failed during the current and previous testing periods to identify the potential cause(s) of the failures. It should be noted ballast failures are common at other UV facilities and the lessons learned at the Demonstration Facility should be considered in the design of the potential Full-Scale Facility.

Overall the CCP monitoring conducted at the Demonstration Facility proved to be a useful tool for identifying and responding to potential interruptions in treatment performance of the AWP processes. Based on the experience at the Demonstration Facility a similar plan is recommended for the potential Full Scale Facility.

Section 5

AWP Facility Chemical and Power Consumption

5.1 Chemical Consumption of AWP Facility Unit Processes

5.1.1 Process Chemicals

The AWP Facility uses four chemicals during routine operations: ammonium hydroxide, sodium hypochlorite, antiscalant, and hydrogen peroxide. Chemicals are fed into the process stream using diaphragm metering pumps. The speeds of the pumps are flow paced to maintain a constant dose when changes in flow occur. The most notable flow change throughout the AWP Facility process is the feed flow when the MF or UF system goes into backwash or PDT mode. A cylinder drawdown is done each day to make sure that each chemical is being fed accurately and in the proper quantity.

Monitoring of the chemical consumption of the AWP Facility unit processes began during the Q1 testing period and continued over the current testing period. **Table 48** provides information related to chemical usage for the MF, UF, RO and UV/AOP systems. The table provides the following information for each chemical: injection location, target feed concentration, target dose rate, estimated total amount delivered per testing period, and estimated daily consumption.

The typical daily consumption of each chemical was estimated based on full capacity production for a 24 hour day using data from the Q1 Testing period. No changes were made to the chemical dose rates during the subsequent testing periods. During the Q2, Q3, and Q4 testing periods the actual average daily usage of each chemical was determined by monitoring the level of each chemical storage tank before and after each delivery. The volume of each chemical used over the testing period was then calculated based on the difference in tank levels recorded at the beginning and end of the testing period, the total volume delivered over the testing period and the estimated storage capacity per foot of each chemical tank. The total calculated usage over the testing period was then divided by the total number of days in the testing period to estimate the average daily usage. No chemical usage above what was expected was required during any of the testing periods.

5.1.2 Membrane Cleaning Chemicals

During cleaning of the membrane systems, two additional chemicals were used: sodium hydroxide (25% w/w) and citric acid (50% w/w). These chemicals are stored in 55 gallon drums, fed into RO permeate water, and mixed in the CIP system. Based on tracking of membrane cleaning chemicals used over the testing periods it is estimated the RO systems required on average 2-3 gallons of sodium hydroxide and citric acid per cleaning event. However, the MF and UF systems required a much larger volume of chemicals per cleaning. The MF required approximately 45 gallons of both sodium hydroxide and citric acid and 9 gallons of sodium hypochlorite per CIP. The UF system required approximately 40 gallons and 68 gallons of sodium hypochlorite and citric acid, respectively. The amount of citric acid for the UF system is based on the CIP conducted during the current testing period for which the target pH was reduced from 3 to 1.5. The amount required for previous CIPs was about 60% less.

The UF system was equipped with an additional sodium hypochlorite dosing system to allow dosing in the backwash cycle to maintain a free chlorine residual in the backwash waste stream. This chlorine is fed from a separate 55 gallon drum by a pump mounted on the UF skid. Due to persistent air locking problems, this chlorination system was disabled. Based on the performance of the UF system during the Q3 and current testing period, it was not deemed necessary to perform chlorinated backwashes under the current operating conditions.

5.2 Power Consumption of AWP Unit Processes

The power consumption of each AWP unit process was monitored during all testing periods by taking daily readings of power totals displayed on the main SCADA system. The totals are based on daily power logged by the individual power monitors (Electro Industries model Shark 200) installed in each individual unit process including the MF, UF, RO and UV/AOP systems. An additional power meter was installed during the Q2 testing period to monitor the total main power being used by the AWP Facility. The purpose of the main power meter is to capture the power usage of the various AWP Facility unit processes as well as parasitic loads such as lights, air conditioning and ancillary equipment (i.e. auto-samplers, TOC analyzer, etc.) plugged into the 120 v receptacles, which were not previously recorded.

Table 49 provides daily power totals logged from the main SCADA screen for each unit process from 8/1/11 through 7/31/12 as well as the total power reading. For days that power totals were not recorded from the meters, power usage was estimated based on the estimated runtime and typical power usage over a 24 hour period. The total kW-h per month including daily totals from all systems for the current testing period is as follows: May (partial) = 32,773 kW-h; June 55,002 kW-h; and July 57,558 kW-h. Comparison of the sum of values from the power meters for the individual unit processes to values recorded on the main power meter show the parasitic load to be approximately 3 to 5% of the total power. The average monthly power usage of the AWP equipment (not including the feed pump) based on monthly totals from 8/1/11 through 7/31/12 was 60,701 kW-h per month. The monthly usage varied based on the amount of time the AWP Facility was in operation. The monthly power consumption of the AWP equipment including the feed water pump based on 24 hour per day 7 day per week online time is estimated to be 99,000 kWh-month.

During the testing periods several other areas of power usage related to the AWP Facility were investigated as described below:

- **Power monitoring of the North City Feed pump:** The AWP Facility operations team worked with the City's independent consultant to perform short term power monitoring of the external pump that supplied feedwater to the MF and UF systems. An external power meter was connected to the feed pump for nearly nine days. Based on the total power recorded over this time period the power usage of the feed pump per day was determined to be approximately 960 kW-h / day, representing approximately 30% of the total power recorded from the power monitors on the AWP Facility unit processes for a typical 24 hour operating period. The relatively high power use of the feed pump was attributed to the fact that the pump was programmed to maintain a constant feed pressure which required the motor to ramp up and down each time the MF or UF system went offline (i.e. for backwashing or to perform a PDT). The feed pump was also designed for other high pressure equipment operated at 60 psi which required pressure reducing valves on the MF and UF inlet piping.

- **Investigation of UF Power:** Comparison of the UF and MF power meters showed the MF power total (not including raw water pump) to be approximately 70% lower than the power total of the UF system. The operations team worked with the City's independent consultant to investigate the higher power usage required by the UF system. First, the power requirement of the UF system was confirmed using an external power meter which was connected to the main supply for approximately 14 days. Based on the total power recorded over this time period, the power usage of the UF system was determined to be approximately 200 kW-h/day, which matched closely to the values logged from the power monitor equipped on the system. Next, the power usage of the air compressor on the UF system was monitored for nearly 14 days using the external power meter. Based on the total power recorded over this time period the power usage of the air compressor was determined to be 105 kW-h/day which is about 50% of the total UF power. It is expected that differences in the size and efficiency of the compressors equipped on the UF and MF may account for the discrepancy in power totals. The UF compressor is 40 HP and requires 50 amps while the MF compressor is ~8 HP and requires 7.9 amps. It should be noted both systems operated with similar values of the transmembrane pressure (TMP) and target filtrate flow rates. It was also observed that the daily UF power totals increased notably starting on 1/18/12 after the replacement of the actuator on the inlet valve. After further discussion with the manufacturer it was discovered that the new actuator is designed to bleed air on a continuous basis which would require the system's air compressor to operate more frequently. The increase in observed power total is attributed to the increased operation of the compressor.

- **RO Power Requirements –**The power demand of the RO systems was compared under different operating conditions. After startup a bypass was required on the

Train A energy recovery device (ERD) in order to accommodate the designed recovery rate of 80%. Because of this, the train used more power than it would have with a fully functioning ERD. In January 2012, the ERD was removed and bypass piping was installed. A new, fully functioning ERD was installed in February 2012. In April 2012, the recovery for both trains was adjusted to 85%. Based on comparison of typical power usage data gathered during these time periods, the following observations were made:

1. At 80% recovery, Train B (a 3 stage system) used approximately 8% more power than Train A (a 2 stage system).

2. At 80% recovery, Train A used approximately 7% more power with no ERD installed versus a fully functioning ERD. Note: Calculated values of energy reduction based on average boost pressure values measured during 80% recovery operation were 8% for Train A and 5% for Train B.

3. At 80% recovery, Train A used approximately 4% more power with a partially functioning ERD than with a fully functioning ERD.

4. At 85% recovery, Train B used approximately 19% more power than Train A.

- **Distribution of Power Requirements for AWP Facility Unit Processes:** The percent of total power attributed to each unit process was estimated based on average power measurements made on a typical 24 hour continuous operating period during the Q1 through Q4 testing periods. The average daily power use was estimated to be 3,300 kWh/day, which includes the estimated power for the raw water pump (based on a nine day monitoring period). This equates to a power usage of 3.3 kWh per 1000 gallons of purified water produced and 1,100 kWh per acre-foot of purified water produced. **Figure ES-1** (located in the Executive Summary) provides the breakdown of equipment power.

Section 6
Summary of Maintenance and Equipment Issues

6.1 Equipment Failures

In general, the AWP Facility unit processes and ancillary equipment operated without any major failures that required the AWP Facility to be offline for an extended period of time over the course of the previous and current reporting periods. **Table 50** provides a log of key equipment failures organized by month from August 2011 through July 2012. The log contains items identified during the Q4 testing period including open items identified during the Q1, Q2, and Q3 reporting periods. Each entry in the log identifies the effected equipment, brief description of the issue, action taken to resolve the issue and current status. Of the items identified, the only remaining issue is that the UF system backwash chlorine dosing pump does not hold prime due to off gassing. As previously mentioned, during the current reporting period, chlorinated backwashes (CBs) or daily maintenance cleans (MCs) were not required on the UF system. However, should the UF system be operated under more aggressive operating conditions in the future these fouling prevention measures may be required and the issue with the pump would need to be resolved. Items shown in the log designated with a "monitoring "status are items that have either been reoccurring or require routine maintenance to prevent.

6.2 Routine Maintenance

The operations team has conducted routine maintenance of the AWP Facility process equipment and site over the course of the testing periods. The routine maintenance items associated with the current reporting period follow:

- Replenishment of reagents on the online chlorine and TOC analyzer.
- Replacement of the faulty ballast and UV lamp on the UV/AOP system.
- Recalibration of the online turbidimeter located on the MF/UF feedwater and filtrate.
- Recalibration of the online pH meter located on the MF/UF feedwater.
- Accuracy, precision and linearity verification of the online TOC analyzer.
- Verification check on the TOC analyzer.
- Quarterly comparison of the UV intensity duty sensor to a reference sensor.

- General weekly cleaning of the AWP Facility site including: removal of debris and dust from the tour path, equipment and piping and display sink.
- Tightening of leaky air line fittings on the UF and MF systems.
- Tightening of minor leaks at valves, pipe fittings, dosing pump tubing, etc.
- Changing of air filters on the power distribution cabinet of the UV/AOP system.

The above items are indicative of routine maintenance conducted by the AWP Facility Operations staff during the testing periods. However, the O&M manuals for each major piece of AWP Facility equipment (i.e. MF, UF, RO systems and UV/AOP system) as well as ancillary equipment (e.g. compressors, pumps, etc.), have manufacturer-recommended maintenance schedules that should be followed to maintain the design service life of the equipment.

Section 7
Summary and Conclusions

The testing and monitoring objectives of the Demonstration Facility were met by operating the AWP processes on the North City tertiary effluent (pre-chlorination) over a 13.5 month period beginning in mid-June 2011 through the end of July 2012. The Demonstration Facility was designed to provide multiple barriers to contaminants and consisted of MF, UF, RO, and UV/AOP. Purified water was returned to the North City recycled water upstream of the chlorine contact chamber prior to distribution for use in irrigation and industry. The main components of the testing and monitoring program implemented at the Demonstration Facility follow:

- Operational Performance Monitoring
- Water Quality Monitoring
- Integrity and Critical Control Point Monitoring
- UV/AOP Challenge Testing
- Chemical and Power Usage

The following subsections summarize the major conclusions for each of the above components based on results collected over the testing and monitoring period.

7.1 Operational Performance Monitoring

Operational performance monitoring of the MF, UF, RO, and UV/AOP systems was conducted to assess the overall operation and maintenance (O&M) requirements of the systems during operation at design conditions. The major conclusions for each system follow:

- The MF system operated with cleaning cycles (production time before cleaning is required) exceeding 6 months under target average flux and recovery conditions of 29 gfd and 93%, respectively.
- The UF system operated with cleaning cycles between 3 to 6 months under target flux and recovery conditions of 30 gfd and 95%, respectively. The slightly shorter cleaning cycles associated with the UF, compared to MF, may be attributable to the smaller membrane pore size, which may be more susceptible to organic fouling, to the higher operating recovery (i.e. less frequent backwashing), or possibly to differences in membrane cleaning protocols or membrane chemistry.
- Chemical pretreatment for the MF and UF systems during production consisted of sodium hypochlorite and ammonium hydroxide to achieve target does of 3 mg/L chloramines. No chemicals were used during backwashing. No maintenance cleans (e.g. daily or weekly) were performed.

- Membrane cleanings of the MF and UF systems, performed in accordance with manufacturer's protocols, utilized three chemicals: sodium hypochlorite, sodium hydroxide (MF only) and citric acid. Cleanings were effective at restoring productivity close to values measured when the membranes were new with no indications that irreversible membrane fouling occurred over the testing period.

- The average measured power requirement for the MF and UF systems (not including feed pump energy) each operating at net filtrate production capacities of 0.72 MGD was 66 kW-h/day and 229 kW-h/day, respectively. The higher power required by the UF system was largely attributed to differences in air compressor efficiencies.

- RO Train A and RO Train B operated with cleaning cycles exceeding 6 months under design average flux (Train A = 11.9 gfd, Train B = 11.6 gfd) and feedwater recovery (FWR) of 80%.

- RO Train A operated with a 2 percent fouling rate (average decrease in normalized specific flux per month) over a 3 month period at increased FWR conditions (85%).

- RO Train B operated with a 10 percent fouling rate over a 1 month period at FWR of 85%; additional operation is required to fully assess the impact of FWR on cleaning frequency.

- Operation of the RO Trains at increased FWR is beneficial for the potential Full-Scale Facility in terms of footprint and the amount purified water production capacity (for a fixed amount of feedwater); however, the downside is the likelihood of increased O&M (including energy, pretreatment chemicals and cleaning chemicals). Testing results indicate that the 2-stage system (Train A) operated reliably at this increased FWR, however, further testing is recommended before determining whether or not an 85% FWR could be reliably maintained with a 3-stage configuration.

- The overall average energy reduction resulting from the energy recovery devices was determined to be 8 percent for Train A and 5 percent for Train B during operation at 80 percent recovery. However, the boost pressure was observed to decrease significantly when the recovery was increased to 85 percent due to the reduction of concentrate flow available. The ERD performance observed at the Demonstration Facility under the 85% FWR condition does not represent what could be achieved at the potential Full-Scale Facility. Careful consideration should be made in deciding the economic pay back of these systems for the Full-Scale Facility.

- If ERDs are deemed economical for the potential Full-Scale Facility, the design should consider the use of automatic control valves and auxiliary nozzle valves (not tested at the Demonstration Facility) to optimize the performance of the ERD's over the expected range of recovery rates, concentrate flow, pressure and temperature.

- The chemical pretreatment requirement for the RO systems included a target dose of antiscalant (Product Name Y2K manufactured by King Lee Technologies). No pH suppression was used upstream of the RO system over the testing period.
- The UV/AOP system operated with an average applied present power of 12.5 kW and EED of 0.303 kWh/1000 gallons at the design conditions over the testing period. The average power was observed to increase slightly due to decreases in UVT resulting from increasing the chloramines dose in the RO feed water and with decreased temperature.
- Comparison of UV intensity measurement readings using both the duty and reference sensor (which measure intensity from 1 lamp only) provided a gross indication that lamp aging was not significant on the UV/AOP system over the testing period. A more detailed assessment of lamp aging would require several lamps to be returned to Trojan for analysis.
- During the testing period six ballast failures occurred on the UV/AOP system. The cause is under investigation via a power study and an assessment of the failed components by the manufacturer. These failures emphasis the importance of redundancy and other measures for use in the design of the potential Full Scale Facility.

7.2 Water Quality Monitoring

A comprehensive water quality monitoring plan was implemented during the testing and monitoring period. The overall approach of the monitoring plan was to collect water quality data at different locations throughout the Demonstration Facility to analyze process performance, and to compare the quality of the purified water to demonstration goals, screening levels, and existing water supplies. The major conclusions follow:

- Results of routine water quality sampling (i.e. sample collection frequency parameter specific including: daily, weekly, bi-weekly or monthly) showed the purified water met all parameter specific numerical water quality goals established for the Demonstration Facility. Such objectives were based on potential regulatory requirements for the Full Scale Facility.
- Results of quarterly monitoring (i.e. samples collected on 8/14/11, 11/8/11 2/1/12, and 5/1/12) for regulated contaminant groups showed the purified water quality met Federal and State Primary and Secondary MCLs, CDPH Notification Levels, and Priority Pollutant Criteria.

- Results of quarterly monitoring of 129 unregulated constituents (including 92 CECs and 30 UCMR3 compounds, resulting in a total of 111 unique constituents not included in previous testing) showed the average measured concentration for all but two contaminants in the purified water were below the RL or DL. The exceptions were Chromium VI (average concentration =0.09 µg/L, maximum 0.016 µg/L, RL=0.03 µg/L) and Bromochoromethane (average concentration of 0.225 µg/L, maximum 0.250 µg/L, RL=0.06 µg/L). Both compounds are associated with disinfection byproducts, and are commonly reported at similar (or higher) concentrations in most drinking water sources.

- Monitoring of a target list of 92 CECs monthly for 4 months upstream and downstream of each purification process showed the RO system effectively removed the majority of CECs detected in tertiary effluent. Only three of these CECs (triclosan, ACE-K, and Iohexal) were reported above the RL in the purified water (concentrations ≤20 ng/L) one or more times during the entire testing period.

- CECs that have been identified by the SWRCB's "Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water (2010)" for groundwater recharge projects, may be used as indicator compounds based on toxicological reliance (i.e. NDMA, 17 beta-estradiol, caffeine and triclosan). The concentrations of these compounds, in all RO permeate and purified water samples analyzed, were less than the recommended health-based practical MRLs.

- Microbial monitoring conducted in the purified water showed measured microbial parameters (i.e. total coliform, fecal coliform, male specific and somatic coliphage) were either not-detected or absent in samples collected during the testing period.

- Based on results of microbial monitoring conducted upstream and downstream of the MF and UF systems, the average log removal of coliforms was determined to be >3.3 (99.95%) for total coliform and >3.8 (99.98%) for fecal coliform. As no detections were found downstream of the MF or UF, higher removals may have been demonstrated had higher concentrations been present in the feed water.

- The UF system achieved a slightly higher log removal of bacteriophage than the MF system, which is attributable to the smaller pore size in the UF membranes. The log removal for Somatic and Male Specific Bacteriophage for the MF system were greater than 3.0 and 1.1, respectively. The log removal of Somatic and Male Specific Bacteriophage for the UF system were calculated as greater than 3.7 and 2.2, respectively.

- Results of microbial monitoring conducted in the tertiary effluent and purified water indicate the purification process achieved log removal values (LRV's) greater than 4.2 (99.99%) for somatic coliphage and 2.2 (99.4%) for male-specific coliphage. As no quantifiable detections were observed for either type of virus in the purified water, higher removals may have been demonstrated had higher concentrations been present in the feed water.

- On-site water quality monitoring of the MF and UF membrane systems, showed that both systems consistently produced filtrate with similar average concentrations for turbidity (<0.1 NTU), Total Organic Carbon (6.5 mg/L), and UV 254 Absorbance (0.17 cm-1).

- Comparison of feed and permeate concentrations of measured organic, inorganic and microbial constituents from both RO systems showed similar rejection and permeate water quality over the testing period.

7.3 Integrity Monitoring

The integrity and reliability of the AWP processes was evaluated closely during the testing period. Integrity monitoring was conducted using several direct and indirect methods employed at various stages in the testing period. A critical control point (CCP) monitoring plan was also implemented to identify changes in the performance of the AWP processes that could have an adverse impact on the purified water quality.

The major conclusions follow:

- Results of daily pressure decay test conducted on the MF and UF systems showed the average pressure decay rates were consistently below 0.128 psi/5 min. indicating the membranes were intact with no fiber breakage over the entire testing period.

- Predicted log removal of Cryptosporidium values for the MF and UF systems based on the pressure decay rates were 4.7 and 5.5, respectively.

- Direct pressure / vacuum decay tests conducted on each RO element prior to delivery indicated the elements were intact with no defects prior to installation.

- Vessel probing conducted on the RO systems post element installation showed the RO systems were intact with no leaks at end caps or inter connections.

- Continuous online monitoring of conductivity and TOC showed the RO membranes were intact during operation over the testing period.

- Critical control point monitoring for the Demonstration Facility included the identification of CCPs (e.g. MF/UF, RO and UV/AOP system) as well as critical limit parameter (CLP) limits and corrective actions.

- CCP monitoring results showed all CLPs were below their limits during the testing period with the exception of reactor power level (due to occurrences of ballast failures) and peroxide dose (due to air entrained in the dosing system) associated with the UV/AOP system. When the limits were exceeded they were detected and corrected in a timely fashion mainly via automatic controls thereby preventing a loss in purification performance.

- Overall CCP monitoring was useful to identify and respond to changes in treatment performance at the Demonstration Facility and it is recommended a similar plan be implemented at the potential Full Scale Facility.

- Based on occurrence/consistency 16 CECs were selected as performance indicator compounds. Results showed the rejection of the indicators by the RO system ranged from greater than 65.5% to greater than 99.9%. The demonstration of higher percent removals was limited by non-quantifiable concentrations in the product water and levels in the source water that were too low to demonstrate higher levels of removal.

- Only one compound (acesulfame-K) was present in the RO permeate at a quantifiable concentration to assess removal by the UV/AOP. Monitoring of easily measured bulk surrogate parameters (i.e. conductivity, TOC, Mono-chloramines, UV absorbance) showed consistent removal as expected based on the mechanisms of each process.

7.4 UV/AOP Challenge Testing

The overall water quality demonstration goals included the assessment of the ability of the UV/AOP system to achieve target removal values of two specific contaminants (NDMA and 1,4 Dioxane) based on the August 2008 and November 2011 Draft CPDH Groundwater Replenishment Regulations. Because these contaminants were not present in the Demonstration Facility influent or RO permeate it was necessary to dose laboratory prepared solutions of these contaminants to the influent of the UV/AOP system in order to demonstrate the target removals. The major conclusions associated with the testing follow:

- Results of challenge testing demonstrated the UV/AOP system achieved 1.5 log removal (96.8%) of NDMA under the design flow (1 MGD), UVT (97%) and peroxide dose (3 mg/L) conditions. This exceeded the log removal Demonstration goal of 1.2 log removal (93.7%) based on the 2008 Draft Groundwater Recharge Regulations.

- The average EEO for NDMA was determined to be 0.19 kW-h/1000 gallons/order.

- Results of challenge testing demonstrated the UV/AOP system achieved 0.6 log removal (74.9 %) of 1,4-Dioxane under the design conditions. This exceeded the log removal Demonstration goal of 0.5 (68.7%) based on the 2011 Draft Groundwater Recharge Regulations.

- Results of challenge testing showed a linear correlation between 1,4-Dioxane removal and peroxide dose (1 to 6 mg/L) under constant EED conditions (average 0.3 kWh/1000 gallons). The correlation of these parameters predicts a peroxide dose of 2.3 mg/L would achieve 0.5 log removal (68.7%) under the test conditions. These preliminary results show it may be possible to reduce peroxide dose at the potential Full Scale Facility however further investigation, testing, and discussion with CDPH would be required.

7.5 Chemical and Power Usage

Chemical and power usage of the Demonstration Facility were tracked closely during the testing and monitoring period. This information was evaluated to assess ways to to improve operational efficiency and provide a basis for estimating O&M costs for the Full Scale Facility. The conclusions follow:

- The estimated daily use of AWP process chemicals including sodium hypochlorite (13%), ammonium hydroxide (19%), antiscalant (100%), and hydrogen peroxide (30%) under design conditions were: 39 gallons, 11 gallons, 4 gallons and 8 gallons, respectively.

- The actual chemical consumption of AWP process chemicals over the testing period was consistent with estimated values; average daily usage was slightly lower due to downtime and flow paced dosing control.

- Three membrane cleaning chemicals were used. The chemicals and their concentrations were: sodium hypochlorite (13%), citric acid (50%), and sodium hydroxide (30%).

- The RO systems required on average 2 to 3 gallons of both sodium hydroxide and citric acid per cleaning event.

- The MF system required approximately 45 gallons of both sodium hydroxide and citric acid and 9 gallons of sodium hypochlorite per cleaning.

- The UF system required approximately 40 gallons and 68 gallons of sodium hypochlorite and citric acid, respectively.

- The North City feed pump used to supply the MF and UF systems used about 960 kWh/day; however the relatively high energy requirement for this pump was due to the specific operational control strategy required for the Demonstration Facility and is not representative of what would be required for the Full-Scale Facility.

- The average daily AWP equipment (including feed pump) power use measured during a typical 24 hour operating period at design conditions and 1 MGD purified water production was 3,300 kWh/day. This corresponds to 3.3 kWh/1000 gallons of purified water produced and 1,100 kWh/acre-foot of purified water produced. Approximately, 3 to 5% additional power was measured for parasitic loads associated with the Demonstration Facility.

- The breakdown (% total daily power) of power values measured during a typical 24 hour operating period at design conditions and 1 MGD purified water production follows: UF System = 7%, MF System = 2%, RO Train A = 25%, RO Train B = 27%, UV/AOP = 10%, Feed Pump = 29%.
- The higher use of power required for the UF system, compared to the MF system, was largely attributed to differences in the size and efficiency of the air compressors equipped on the systems. It seems the UF system air compressor was oversized and the design could be optimized for the Full-Scale Facility.
- The higher power use of RO Train B compared to RO Train A is largely attributed to difference in the membrane configuration (i.e. 3 Stage vs. 2 Stage) and membrane characteristics of the two systems. Train B was equipped with membranes designed for high rejection and low fouling requiring higher feed pressure, while Train A was equipped with membranes designed for energy savings, requiring lower feed pressure.

Tables and Figures

Table 1 Summary of Demonstration Plant Schedule

Milestone	Start Date	End Date	Approximate Number of Months
Start-up Period[1]	Thursday 6/16/11	Thursday 7/15/11	1
Testing Period[2,3]	Friday 7/18/11	Tuesday 6/20/12	11
Operational Period[4]	Wednesday 6/21/12	Monday 12/18/12	6
Total	Thursday 6/16/11	Monday 12/18/12	18

Notes:

[1] 125 working days after NTP (concurrent with Substantial Completion) – Start-Up and Operation Begins

[2] 145 working days after NTP (20 working days after Substantial Completion) – Testing Starts (and Start-Up ends)

[3] 375 working days after NTP (230 working days after Substantial Completion) – Testing Period Complete

[4] 500 working days after NTP (375 working days after Substantial Completion) – Operational Period Complete

Table 2 Summary of Quarterly Monitoring Periods

Quarterly Monitoring Periods		Target Data Period Included in Quarterly Report
No.	Dates	
1	6/16/11 – 9/15/11	6/16/11 – 10/31/11
2	9/16/11 – 12/15/11	11/1/11 – 2/10/12[1]
3	12/16/11 – 3/15/12	2/11/12 – 5/14/12[1]
4	3/16/12 – 6/19/12	5/15/12 – 7/31/12[1,2]

Notes:

[1] The end date of the target data period is based on both the expected dates laboratory data will be received and the established due dates for each quarterly report. Q2 report due 3/3/12; Q3 report due 6/7/12; Q4 report due 9/12/12.

[2] Routine water quality data will continue to be collected twice a week for 6 weeks beyond the end of the Testing Period, from 6/19/12 through 7/31/12, in accordance with the Testing and Monitoring Plan.

Table 3: Summary of the RO System Operating Conditions

Parameter	Units	Value
RO Train A		
Anti-scalant dose	mg/L	3
Average flux	gfd	11.9
Feedwater recovery	%	80 to 85
RO Train B		
Anti-scalant dose	mg/L	3
Average flux	gfd	11.6
Feedwater recovery	%	80 to 85

Table 4 Summary of RO Membrane Cleaning Results

RO System	Date of Cleaning	Pre-Clean Temperature Corrected Specific Flux (gfd/psi@ 25 Deg C)	Post Clean Temperature Corrected Specific Flux (gfd/psi @ 25 Deg C)	Cleaning Effectiveness (% change in specific flux pre to post clean)	Cleaning Chemicals
Train A	10/14/11	0.14	0.14	0 %	Caustic followed by citric acid
Train A	4/26/12	0.13	0.15	15%	Citric acid followed by caustic
Train B	10/7/11	0.11	0.13	18%	Caustic followed by citric acid
Train B	4/18/12	0.12	0.14	17%	Citric acid followed by caustic
Train B (3rd Stage Only)	6/7/12	0.05	0.11	120%	Citric acid followed by caustic

Table 5 - UV Intensity Measurements Duty Sensor and Reference Sensor for the Trojan UV/AOP System

Testing Period	Date	Reactor Power (%)	Average (n=3) UV Intensity (mW/cm2) Duty Sensor	Average (n=3) UV Intensity (mW/cm2) Reference Sensor	UVT (%)	Temperature (Deg C)
Q1	9/16/2011	100	30.6	29.3	98.1	29.4
Q2	1/6/2012	100	31.0	29.8	97.1	22.9
Q3	4/24/2012	100	30.2	28.2	96.9	25.7
Q4	6/22/2012	100	28.9	28.6	97.4	28.3

Table 6 Certified Laboratory Results of Potential AOP By-products

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Formaldehyde	8/1/2011	grab	EPA 556	µg/L	0.26	2	6.4	9.6
Formaldehyde	8/8/2011	grab	EPA 556	µg/L	0.26	2	4.4	11
Formaldehyde	8/15/2011	grab	EPA 556	µg/L	0.26	2	9.7	11
Formaldehyde	8/22/2011	grab	EPA 556	µg/L	0.26	2		11
Formaldehyde	8/29/2011	grab	EPA 556	µg/L	0.26	2	<2	12
Formaldehyde	9/6/2011	grab	EPA 556	µg/L	0.26	2	3.4	13
Formaldehyde	9/12/2011	grab	EPA 556	µg/L	0.26	2	4.5	13
Formaldehyde	9/19/2011	grab	EPA 556	µg/L	0.26	2	3.3	9.9
Formaldehyde	2/1/2012	grab	EPA 556	µg/L	0.26	2	4	
Formaldehyde	2/8/2012	grab	EPA 556	µg/L	0.26	2	<2	4.6
Formaldehyde	2/15/2012	grab	EPA 556	µg/L	0.26	2	4.9	6.9
Formaldehyde	2/22/2012	grab	EPA 556	µg/L	0.26	2	2.3	5.2
n =							11	11
Average							4.2	9.7
Maximum							9.7	13
Minimum							1.0	4.6
STDev							2.4	2.9

Table 7 Spiking Experiment No. 1 UV/AOP Summary of NDMA Results

Sample Number	Sample ID	NDMA (ng/L)	1,4 Dioxane (µg/L)
1	**Batch**	6300000	
2	**Control IN - 1**	930	
3	**Control Out- 1**	870	
4	**Control IN - 2**	830	
5	**Control Out -2**	910	
	TEST 1 (64% power)		
6	**Test 1a IN**	790	
7	**Test 1 a Out**	23	
8	**Test1 b IN**	960	ND (<1)
9	**Test 1b OUT**	25	ND (<1)
10	**Test 1 c IN**	760	
11	**Test 1 C Out**	23	
	AVG IN	**837**	
	AVG OUT	**24**	
	TEST 2 (78% power)		
12	**Test 2a IN**	760	
13	**Test 2 a Out**	8.1	
14	**Test2 b IN**	800	ND (<1)
15	**Test 2b OUT**	10	ND (<1)
16	**Test 2 c IN**	750	
17	**Test 2 C Out**	8.5	
	AVG IN	**770**	
	AVG OUT	**8.9**	
	TEST 3 (60% power)		
18	**Test 3A IN**	740	
19	**Test 3A OUT**	29	
20	**Test 3B IN**	980	ND (<1)
21	**Test 3B OUT**	29	ND (<1)
22	**Test 3C IN**	820	
23	**Test 3C Out**	29	
	AVG IN	**847**	
	AVG OUT	**29**	
	TEST 4 (100% power)		
24	**Test 4A IN**	750	
25	**Test 4A OUT**	5.8	
26	**Test 4B IN**	750	ND (<1)
27	**Test 4B OUT**	5.4	ND (<1)
28	**Test 4C IN**	710	
29	**Test 4C OUT**	4.8	
	AVG IN	**737**	
	AVG OUT	**5.3**	

Table 8 Spiking Experiment No. 1 Calculated EE/O Values of the Trojan UV/AOP System

Test #	Reactor Power	UV Power (kW)	UV Feed Flow (gpm)	Time to treat 1000 gallon (min.)	[1]Measured NDMA LRV Average (n=3)	[2]EE/O Calculated (kW-h/1000 gallons/log removal)
1	60%	11.1	699	1.4	1.5	0.176
2	64%	11.8	699	1.4	1.5	0.188
3	78%	14.4	700	1.4	1.9	0.181
4	100%	17.9	694	1.4	2.1	0.205

Note:

1. Measured NDMA LRV Average values show for each test were calculated from results of 3 IN and 3 OUT samples X 4 tests = 24 total samples. An additional 5 samples were analyzed during the experiment including: (1) batch and (4) control samples for a total of 29 samples. Results for all samples are provided in Table 7.

2. EE/O (kW-h/1000 gallons/log removal) was calculated as [UV Power(kW) * (Time to treat 1000 gallons(min/1000 gallons))/60(min/hr))]/Log Removal

Table 9 Spiking Experiment 2 UV/AOP 1,4-Dioxane Test Plan

Sample ID	Target NDMA / 1,4-Dioxane LRV	Target Flowrate (gpm)	Target UVT (%)	Target spike NDMA Feed Concentration (ng/l)	Target spike 1,4-Dioxane Feed Concentration (µg/L)	Target Reactor Power (%)	Peroxide Dose (mg/L)	1,4-Dioxane Samples	NDMA Samples	Peroxide Samples (titanium oxalate method)
Batch	NA	NA	NA	NA	NA	NA	NA	1	1	
Control IN	0	695	97	1000	20	0	0	1	1	
Control OUT	0	695	97	1000	20	0	0	1	1	
Control IN	0	695	97	1000	20	0	3	1	1	1
Control OUT	0	695	97	1000	20	0	3	1	1	1
TEST 1	1.2 / 0.5	695	97	1000	20	~70	1.5	1 in, 3 out	0 in, 0 out	1 out
TEST 2	1.2 / 0.5	695	97	1000	20	~70	3	1 in, 3 out	1 in, 3 out	1 in, 1 out
TEST 3	1.2 / 0.5	695	97	1000	20	~70	6	1 in, 3 out	0 in, 0 out	1 out
TEST 4	TBD / 0.5	695+20%	97	1000	20	60	3	1 in, 3 out	1 in, 3 out	1 in, 1 out
Total number of Samples								**21**	**13**	**8**

Note:

1. Results from spiking experiment number 1 showed the reactor achieved 1.5 log removal (predicted 1.2 log removal) NDMA under the target power 60%, UVT 97% and flow conditions 695 gpm. Due to lamp aging and decrease in water temperature the reactor power level for 1.2 log removal (predicted) is now ~ 70-74%.
2. Surrogates including UV 254/UV228; and mono-chloramine will be measured on site during each run from the inlet and outlet.
3. Note the chloramines concentration in the UV/AOP inlet is typically 3 mg/L.

Table 10 Summary of Spiking Experiment 2 1,4-Dioxane Spiking Results

Sample ID	NDMA (ng/L)	1,4 Dioxane (µg/L)
Batch (mg/L)	8500000	220000
Control In - 1 (System off)	1500	27
Control Out- 1 (System off)	1600	28
Control In - 2 (UV off, 3 mg/L peroxide)	1800	27
Control Out -2 (UV off, 3 mg/L peroxide)	1800	26
TEST 1 (1.5 mg/L peroxide)		
Test 1 IN	----------	31
Test 1 a Out	----------	12
Test 1 b Out	----------	12
Test 1 c Out	----------	11
Average Out (n=3)	-----------	12
TEST 2 (3 mg/L peroxide)		
Test 2 IN	2000	28
Test 2 a Out	54	6.6
Test 2 b Out	47	7.8
Test 2 c Out	55	6.9
Average Out (n=3)	52	7.1
TEST 3 (6 mg/L peroxide)		
Test 3 IN	----------	26
Test 3 a Out	----------	3
Test 3 b Out	----------	3.7
Test 3 c Out	----------	3.7
Average Out (n=3)	-----------	3.5
TEST 4 (3 mg/L peroxide - lower UV dose)		
Test 4 IN	1900	21
Test 4 a Out	82	6.6
Test 4 b Out	96	8.8
Test 4 c Out	98	10
Average Out (n=3)	92.0	8.5

Table 11 Summary of Calculated EED Values Spiking Experiment 2: Test Conditions 1 to 4

Test	Target Peroxide Dose (mg/L)	Measured Peroxide Dose (mg/L)	1,4 Dioxane LRV (n=3)	NDMA LRV (N=3)	EED Calculated (Kw-h/1000 gallons)
1	1.5	1.3	0.36	-	0.307
2	3.0	2.6	0.57	1.6	0.302
3	6.0	4.9	0.88	-	0.312
4	3.0	2.5	0.39	1.3	0.225

Note:

1. Measured 1,4 Dioxane LRV Average values show for each test were calculated from results of 4 IN and 3 OUT/test samples X 4 tests = 16 total samples. An additional 5 samples were analyzed during the experiment including: (1) batch and (4) control samples for a total of 21 samples. Results for all samples are provided in Table 10.

Table 12: Summary of Membrane Filtration Operation

Operational Period following chemical cleanings	Run Time Hours (Months)	Average Feed Pressure (psi)	Average Filtrate Pressure (psi)	Total Delta H between Feed & Filtrate Pressure Transmitters (psi)	Average TMP[1] (psi)	Fouling Rate (% decrease temp. corrected specific flux per month)
MF System						
Operating Period 1 (10/6/11 to 4/5/12)	3,962 (5.5)	15.0	8.5	1.5	5.0	11
Operating Period 2 (4/6/12 to 7/31/12)	2,444 (3.4)	15.2	8.6	1.5	5.1	12
UF System						
Operating Period 1 (9/8/11 to 3/22/12)	4,138 (5.7)	16.0	11.3	1.3	3.4	11
(Operating Period 2 (3/23/12 to 5/31/12)	1,472 (2)	19.4	11.3	1.3	6.8	38
Operating Period 3 (6/2/12 to 7/31/12)	1,225 (1.7)	15.3	11.3	1.3	2.7	26

Notes:

1. TMP was calculated as Average Feed Pressure minus Average Filtrate Pressure minus total Delta H (difference in elevation between feed and filtrate pressure transmitters).
2. chemical cleanings performed on the MF system on 10/5/11 and 4/5/12.
3. chemical cleanings performed on the UF system on 9/7/11, 3/22/12, 5/31/12.

Table13: Summary of the RO System Trains A and B Operation

Operational Period following chemical cleanings	Run Time Hours (Months)	Target Feed Water Recovery (%)	Average Feed Pressure (psi)	Net operating pressure(psi)	Average Specific Flux or Permeability (gfd/psi@25 °C)	Fouling Rate (% decrease temperature corrected specific flux per month)
Train A (Two-stage)						
Operating Period 1 (10/16/11 to 4/16/12)	4,020 (5.6)	80	133	98	1st Stage: 0.12 2nd Stage: 0.14	1.4
Operating Period 2 (4/19/12 to 7/31/12)	2,144 (3)	85	124	87	1st Stage: 0.13 2nd Stage: 0.16	2.1
Train B (Three-stage)						
Operating Period 1 (10/6/11 to 4/17/12)	4,254 (5.9)	80	139	104	1st Stage: 0.12 2nd Stage: 0.13 3rd Stage: 0.10	1.6
(Operating Period 2 (4/23/12 to 6/7/12)	920 (1.3)	[1]85	138	97	1st Stage: 0.13 2nd Stage: 0.14 3rd Stage: 0.08	15 (Stage 3 =40)
[2] Operating Period 3 (6/8/12 to 7/9/12)	591 (0.8)	80	130	91	1st Stage: 0.12 2nd Stage: 0.13 3rd Stage: 0.10	2.1
Operating Period 4 (7/10/12 to 7/31/12)	493 (0.7)	85	130	88	1st Stage: 0.12 2nd Stage: 0.13 3rd Stage: 0.10	9.9

Note:

1. The actual feed water recovery during Operating Period 2 was determined to be between 87 to 89%.
2. No cleaning was performed between Operating Period 3 and Operating Period 4.

Table 14: Comparison of RO System Trains A and B Permeate Water Quality

Contaminant	Units	Number of Samples (n)	Train A Permeate (Hydranautics ESPA2) (Average ±STD)	Train B Permeate (Toray TML) (Average ±STD)
Nutrients				
Ammonia, Total	mg/L-N	20	0.39 ±0.13	0.40 ±0.14
Nitrate	mg/L-N	20	0.38 ±0.09	0.40 ±0.09
Nitrite	mg/L-N	14	0.01 ±0.03	0.01 ±0.03
Nitrogen, Total	mg/L-N	20	0.82 ±0.15	0.82 ±0.13
Phosphorus, Total	µg/L-P	21	4 ±2	4 ±3
Inorganic				
TDS	mg/L	17	14 ±2	14 ±2
Sodium	mg/L	15	3.1 ±0.7	3.1 ±0.8
Chloride	mg/L	18	2.5 ±0.5	2.4 ±0.6
Boron	mg/L	15	0.23 ±0.02	0.23 ±0.02
Manganese	mg/L	15	0.002 ±0.001	0.002 ±0.001
Fluoride	mg/L	17	0.02 ±0.01	0.02 ±0.02
Organics				
TOC	mg/L	9	0.18 ±0.01	0.18 ±0.01
UV 254	cm-1	41	0.016 ±0.00	0.016 ±0.00
Microbial				
Total / Fecal Coliform	MPN/100 mL	73	<1	<1

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Ammonia as N	8/1/2011	grab	EPA 350.1	mg/L	0.048	0.1	1.2	0.19	0.21		0.12
Ammonia as N	8/4/2011	grab	EPA 350.1	mg/L	0.048	0.1					<0.1
Ammonia as N	8/8/2011	grab	EPA 350.1	mg/L	0.048	0.1					<0.1
Ammonia as N	8/11/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.15
Ammonia as N	8/15/2011	grab	EPA 350.1	mg/L	0.048	0.1	1.4	0.28	0.27		0.15
Ammonia as N	8/18/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.16
Ammonia as N	8/22/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.2
Ammonia as N	8/25/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.16
Ammonia as N	8/29/2011	grab	EPA 350.1	mg/L	0.048	0.1	1.8	0.7	0.72	0.74	0.36
Ammonia as N	9/1/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.79
Ammonia as N	9/6/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.16
Ammonia as N	9/8/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.14
Ammonia as N	9/12/2011	grab	EPA 350.1	mg/L	0.048	0.1	1.4	0.24	0.24	0.26	0.18
Ammonia as N	9/15/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.18
Ammonia as N	9/19/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.17
Ammonia as N	9/22/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.16
Ammonia as N	9/26/2011	grab	EPA 350.1	mg/L	0.048	0.1	1.3	0.28	0.28	0.28	0.15
Ammonia as N	9/29/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.12
Ammonia as N	10/3/2011	grab	EPA 350.1	mg/L	0.048	0.1					<0.1
Ammonia as N	10/6/2011	grab	EPA 350.1	mg/L	0.048	0.1					0.18
Ammonia as N	10/10/2011	grab	EPA 350.1	mg/L	0.048	0.1	1.4	0.31	0.32	0.31	0.2
Ammonia as N	10/13/2011	grab	EPA 350.1	mg/L	0.048	0.1					<0.1
Ammonia as N	10/17/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.18
Ammonia as N	10/20/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.2
Ammonia as N	10/24/2011	composite	EPA 350.1	mg/L	0.048	0.1	1.4	0.33	0.46	0.37	0.25
Ammonia as N	10/31/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.17
Ammonia as N	11/3/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.19
Ammonia as N	11/7/2011	composite	EPA 350.1	mg/L	0.048	0.1	1.5	0.55	0.52	0.36	0.22
Ammonia as N	11/10/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.19
Ammonia as N	11/14/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.21
Ammonia as N	11/17/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.19
Ammonia as N	11/21/2011	composite	EPA 350.1	mg/L	0.048	0.1	1.3	0.48	0.5	0.46	0.2
Ammonia as N	11/29/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.2
Ammonia as N	12/1/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.23
Ammonia as N	12/5/2011	composite	EPA 350.1	mg/L	0.048	0.1	1.4	0.32	0.33	0.36	0.17

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Ammonia as N	12/8/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.24
Ammonia as N	12/12/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.18
Ammonia as N	12/15/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.2
Ammonia as N	12/19/2011	composite	EPA 350.1	mg/L	0.048	0.1	1.4	0.57	0.62	0.37	0.19
Ammonia as N	12/22/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.22
Ammonia as N	12/27/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.2
Ammonia as N	12/29/2011	composite	EPA 350.1	mg/L	0.048	0.1					0.19
Ammonia as N	1/3/2012	composite	EPA 350.1	mg/L	0.048	0.1	1.5	0.31	0.34	0.34	0.22
Ammonia as N	1/5/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.31
Ammonia as N	1/9/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.15
Ammonia as N	1/12/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.25
Ammonia as N	1/17/2012	composite	EPA 350.1	mg/L	0.048	0.1	1.40	0.33	0.31	0.34	0.2
Ammonia as N	1/19/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.21
Ammonia as N	1/23/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.16
Ammonia as N	1/26/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.20
Ammonia as N	1/30/2012	composite	EPA 350.1	mg/L	0.048	0.1	1.40	0.3	0.32	0.32	0.20
Ammonia as N	2/2/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.33
Ammonia as N	2/9/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.19
Ammonia as N	2/14/2012	composite	EPA 350.1	mg/L	0.048	0.1	1.40	0.56	0.6	0.57	0.19
Ammonia as N	2/23/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.17
Ammonia as N	2/27/2012	composite	EPA 350.1	mg/L	0.048	0.1	1.40	0.34	0.31	0.32	
Ammonia as N	3/1/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.19
Ammonia as N	3/6/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.19
Ammonia as N	3/8/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.22
Ammonia as N	3/12/2012	composite	EPA 350.1	mg/L	0.048	0.1	1.40	0.32	0.32	0.34	0.21
Ammonia as N	3/15/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.17
Ammonia as N	3/19/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.18
Ammonia as N	3/22/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.28
Ammonia as N	3/26/2012	composite	EPA 350.1	mg/L	0.048	0.1	1.40	0.49	0.52	0.48	0.36
Ammonia as N	3/29/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.29
Ammonia as N	4/2/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.26
Ammonia as N	4/5/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.34
Ammonia as N	4/9/2012	composite	EPA 350.1	mg/L	0.048	0.1	4.40	0.41	0.33	0.34	0.24
Ammonia as N	4/12/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.15
Ammonia as N	4/16/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.14
Ammonia as N	4/23/2012	composite	EPA 350.1	mg/L	0.048	0.1	1.50			0.48	0.20
Ammonia as N	4/26/2012	composite	EPA 350.1	mg/L	0.048	0.1		0.52	0.52		0.26

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Ammonia as N	4/30/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.26
Ammonia as N	5/3/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.36
Ammonia as N	5/7/2012	composite	EPA 350.1	mg/L	0.048	0.1	1.50	0.48	0.49	0.39	0.20
Ammonia as N	5/14/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.29
Ammonia as N	5/21/2012	composite	EPA 350.1	mg/L	0.048	0.1	1.70	0.50	0.56	0.54	0.25
Ammonia as N	5/24/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.21
Ammonia as N	5/29/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.19
Ammonia as N	5/31/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.20
Ammonia as N	6/4/2012	composite	EPA 350.1	mg/L	0.048	0.1	1.40	0.49	0.53	0.52	0.24
Ammonia as N	6/7/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.25
Ammonia as N	6/11/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.23
Ammonia as N	6/21/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.18
Ammonia as N	6/28/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.20
Ammonia as N	7/2/2012	composite	EPA 350.1	mg/L	0.048	0.1				0.52	0.18
Ammonia as N	7/5/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.23
Ammonia as N	7/9/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.21
Ammonia as N	7/12/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.23
Ammonia as N	7/16/2012	composite	EPA 350.1	mg/L	0.048	0.1				0.36	0.23
Ammonia as N	7/19/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.27
Ammonia as N	7/23/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.23
Ammonia as N	7/26/2012	composite	EPA 350.1	mg/L	0.048	0.1					0.21
Ammonia as N	7/30/2012	composite	EPA 350.1	mg/L	0.048	0.1				0.47	0.22
n =							23	23	23	24	93
Average							1.78	0.40	0.42	0.41	0.21
Maximum							6.00	0.70	0.72	0.74	0.79
Minimum							1.20	0.20	0.20	0.30	0.10
STDev							1.11	0.13	0.14	0.11	0.08

Note: For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported <DL were considered the 0.5 X DL.

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
TKN	08/01/11	grab	EPA 351.2	mg/L	0.074	0.10	0.93	0.43	0.27		0.2
TKN	08/04/11	grab	EPA 351.2	mg/L	0.074	0.10					<0.1
TKN	08/08/11	grab	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	08/15/11	grab	EPA 351.2	mg/L	0.074	0.10	<0.074	0.37	0.33		0.13
TKN	08/18/11	grab	EPA 351.2	mg/L	0.074	0.10					0.2
TKN	08/22/11	grab	EPA 351.2	mg/L	0.074	0.10					0.11
TKN	08/25/11	grab	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	08/29/11	grab	EPA 351.2	mg/L	0.074	0.10	3.9	0.45	0.4	0.46	0.13
TKN	09/01/11	grab	EPA 351.2	mg/L	0.074	0.10					0.8
TKN	09/08/11	grab	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	09/12/11	grab	EPA 351.2	mg/L	0.074	0.10	1.1	0.29	0.28	0.32	0.13
TKN	09/19/11	grab	EPA 351.2	mg/L	0.074	0.10					0.23
TKN	09/22/11	grab	EPA 351.2	mg/L	0.074	0.10					0.25
TKN	09/26/11	grab	EPA 351.2	mg/L	0.074	0.10	<0.074	0.39	0.32	0.3	0.16
TKN	09/29/11	grab	EPA 351.2	mg/L	0.074	0.10					0.15
TKN	10/03/11	grab	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	10/06/11	grab	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	10/10/11	grab	EPA 351.2	mg/L	0.074	0.10	1.6	0.31	0.18	0.48	0.38
TKN	10/13/11	grab	EPA 351.2	mg/L	0.074	0.10					0.13
TKN	10/17/11	grab	EPA 351.2	mg/L	0.074	0.10					0.28
TKN	10/20/11	composite	EPA 351.2	mg/L	0.074	0.10					0.16
TKN	10/24/11	composite	EPA 351.2	mg/L	0.074	0.10	<0.1	0.35	0.33	0.37	0.22
TKN	10/31/11	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	11/03/11	composite	EPA 351.2	mg/L	0.074	0.10					0.17
TKN	11/07/11	composite	EPA 351.2	mg/L	0.074	0.10	0.16	0.42	0.39	0.34	0.13
TKN	11/10/11	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	11/14/11	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	11/17/11	composite	EPA 351.2	mg/L	0.074	0.10					0.16
TKN	11/21/11	composite	EPA 351.2	mg/L	0.074	0.10	0.13	0.43	0.52	0.42	<0.1
TKN	11/29/11	composite	EPA 351.2	mg/L	0.074	0.10					0.12
TKN	12/01/11	composite	EPA 351.2	mg/L	0.074	0.10					<0.1
TKN	12/05/11	composite	EPA 351.2	mg/L	0.074	0.10	0.43	0.4	0.42	0.46	0.18
TKN	12/08/11	composite	EPA 351.2	mg/L	0.074	0.10					0.14
TKN	12/12/11	composite	EPA 351.2	mg/L	0.074	0.10					0.19
TKN	12/15/11	composite	EPA 351.2	mg/L	0.074	0.10					<0.074

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
TKN	12/19/11	composite	EPA 351.2	mg/L	0.074	0.10	<0.074	0.37	0.38	0.4	0.13
TKN	12/22/11	composite	EPA 351.2	mg/L	0.074	0.10					0.17
TKN	12/27/11	composite	EPA 351.2	mg/L	0.074	0.10					0.12
TKN	12/29/11	composite	EPA 351.2	mg/L	0.074	0.10					<0.1
TKN	01/03/12	composite	EPA 351.2	mg/L	0.074	0.10	0.31	0.56	0.44	0.45	0.14
TKN	01/05/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.1
TKN	01/09/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	01/12/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	01/17/12	composite	EPA 351.2	mg/L	0.074	0.10	1.20	0.35	0.32	0.41	0.18
TKN	01/19/12	composite	EPA 351.2	mg/L	0.074	0.10					0.19
TKN	01/23/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	01/26/12	composite	EPA 351.2	mg/L	0.074	0.10					0.2
TKN	01/30/12	composite	EPA 351.2	mg/L	0.074	0.10	<0.074	0.43	0.39	0.48	0.12
TKN	02/02/12	composite	EPA 351.2	mg/L	0.074	0.10					0.18
TKN	02/06/12	composite	EPA 351.2	mg/L	0.074	0.10					0.21
TKN	02/09/12	composite	EPA 351.2	mg/L	0.074	0.10					0.14
TKN	02/14/12	composite	EPA 351.2	mg/L	0.074	0.10	0.16	0.26	0.29	0.33	<0.1
TKN	02/16/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	02/20/12	composite	EPA 351.2	mg/L	0.074	0.10					0.12
TKN	02/23/12	composite	EPA 351.2	mg/L	0.074	0.10					0.12
TKN	02/27/12	composite	EPA 351.2	mg/L	0.074	0.10	0.35	0.37	0.35	0.38	
TKN	03/01/12	composite	EPA 351.2	mg/L	0.074	0.10					0.49
TKN	03/06/12	composite	EPA 351.2	mg/L	0.074	0.10					0.48
TKN	03/08/12	composite	EPA 351.2	mg/L	0.074	0.10					0.11
TKN	03/12/12	composite	EPA 351.2	mg/L	0.074	0.10	0.39	0.35	0.44	0.28	<0.074
TKN	03/15/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.1
TKN	03/19/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	03/22/12	composite	EPA 351.2	mg/L	0.074	0.10					0.26
TKN	03/26/12	composite	EPA 351.2	mg/L	0.074	0.10	4.40	0.54	0.6	0.51	0.27
TKN	03/29/12	composite	EPA 351.2	mg/L	0.074	0.10					0.42
TKN	04/02/12	composite	EPA 351.2	mg/L	0.074	0.10					0.32
TKN	04/05/12	composite	EPA 351.2	mg/L	0.074	0.10					0.32
TKN	04/09/12	composite	EPA 351.2	mg/L	0.074	0.10	2.80	0.41	0.38	0.38	0.31
TKN	04/12/12	composite	EPA 351.2	mg/L	0.074	0.10					0.14
TKN	04/16/12	composite	EPA 351.2	mg/L	0.074	0.10					0.36
TKN	04/23/12	composite	EPA 351.2	mg/L	0.074	0.10	0.34	0.49	0.2	0.41	<0.074
TKN	04/26/12	composite	EPA 351.2	mg/L	0.074	0.10					0.12

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
TKN	04/30/12	composite	EPA 351.2	mg/L	0.074	0.10					0.13
TKN	05/03/12	composite	EPA 351.2	mg/L	0.074	0.10					0.12
TKN	05/07/12	composite	EPA 351.2	mg/L	0.074	0.10	1.10	0.45	0.44	0.36	0.11
TKN	05/14/12	composite	EPA 351.2	mg/L	0.074	0.10					0.21
TKN	05/21/12	composite	EPA 351.2	mg/L	0.074	0.10	0.25	0.44	0.37	0.30	<0.074
TKN	05/24/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	05/29/12	composite	EPA 351.2	mg/L	0.074	0.10					0.21
TKN	05/31/12	composite	EPA 351.2	mg/L	0.074	0.10					1.20
TKN	06/04/12	composite	EPA 351.2	mg/L	0.074	0.10	0.89	0.51	0.26	0.16	0.11
TKN	06/07/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	06/11/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	06/21/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.1
TKN	06/28/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	07/02/12	composite	EPA 351.2	mg/L	0.074	0.10				0.11	<0.074
TKN	07/05/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	07/09/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	07/12/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	07/16/12	composite	EPA 351.2	mg/L	0.074	0.10				0.34	<0.1
TKN	07/19/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	07/23/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	07/26/12	composite	EPA 351.2	mg/L	0.074	0.10					<0.074
TKN	07/30/12	composite	EPA 351.2	mg/L	0.074	0.10				<0.074	<0.074
n =							23	23	23	24	93
Average							0.90	0.41	0.36	0.35	0.15
Maximum							4.4	0.56	0.60	0.51	1.2
Minimum							0.0	0.30	0.20	0.0	0.0
STDev							1.2	0.08	0.10	0.12	0.17

Note: For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported <DL were considered the 0.5 X DL.

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrate + Nitrite as N	08/01/11	grab	EPA 353.2	mg/L	0.01	0.10	12	0.42	0.44		0.55
Nitrate + Nitrite as N	08/04/11	grab	EPA 353.2	mg/L	0.01	0.10					0.73
Nitrate + Nitrite as N	08/08/11	grab	EPA 353.2	mg/L	0.01	0.10					0.72
Nitrate + Nitrite as N	08/11/11	grab	EPA 353.2	mg/L	0.01	0.10					0.72
Nitrate + Nitrite as N	08/15/11	grab	EPA 353.2	mg/L	0.01	0.10	12	0.47	0.43		0.57
Nitrate + Nitrite as N	08/18/11	grab	EPA 353.2	mg/L	0.01	0.10					0.69
Nitrate + Nitrite as N	08/22/11	grab	EPA 353.2	mg/L	0.01	0.10					0.63
Nitrate + Nitrite as N	08/25/11	grab	EPA 353.2	mg/L	0.01	0.10					0.7
Nitrate + Nitrite as N	08/29/11	grab	EPA 353.2	mg/L	0.01	0.10	9.5	0.35	0.33	0.31	0.5
Nitrate + Nitrite as N	09/01/11	grab	EPA 353.2	mg/L	0.01	0.10					0.46
Nitrate + Nitrite as N	09/01/11	grab	EPA 353.2	mg/L	0.01	0.10					0.46
Nitrate + Nitrite as N	09/06/11	grab	EPA 353.2	mg/L	0.01	0.10					0.71
Nitrate + Nitrite as N	09/08/11	grab	EPA 353.2	mg/L	0.01	0.10					0.85
Nitrate + Nitrite as N	09/12/11	grab	EPA 353.2	mg/L	0.01	0.10	9.7	0.32	0.4	0.36	0.52
Nitrate + Nitrite as N	09/15/11	grab	EPA 353.2	mg/L	0.01	0.10					0.82
Nitrate + Nitrite as N	09/19/11	grab	EPA 353.2	mg/L	0.01	0.10					0.62
Nitrate + Nitrite as N	09/22/11	grab	EPA 353.2	mg/L	0.01	0.10					0.72
Nitrate + Nitrite as N	09/26/11	grab	EPA 353.2	mg/L	0.01	0.10	14	0.46	0.52	0.5	0.68
Nitrate + Nitrite as N	09/29/11	grab	EPA 353.2	mg/L	0.01	0.10					0.79
Nitrate + Nitrite as N	10/03/11	grab	EPA 353.2	mg/L	0.01	0.10					0.58
Nitrate + Nitrite as N	10/06/11	grab	EPA 353.2	mg/L	0.01	0.10					0.62
Nitrate + Nitrite as N	10/10/11	grab	EPA 353.2	mg/L	0.01	0.10	11	0.32	0.45	0.38	0.57
Nitrate + Nitrite as N	10/13/11	grab	EPA 353.2	mg/L	0.01	0.10					0.6
Nitrate + Nitrite as N	10/17/11	grab	EPA 353.2	mg/L	0.01	0.10					0.7
Nitrate + Nitrite as N	10/20/11	composite	EPA 353.2	mg/L	0.01	0.10					0.75
Nitrate + Nitrite as N	10/24/11	composite	EPA 353.2	mg/L	0.01	0.10	13	0.42	0.4	0.47	0.66
Nitrate + Nitrite as N	10/31/11	composite	EPA 353.2	mg/L	0.01	0.10					0.53
Nitrate + Nitrite as N	11/03/11	composite	EPA 353.2	mg/L	0.01	0.10					0.8
Nitrate + Nitrite as N	11/07/11	composite	EPA 353.2	mg/L	0.01	0.10	13	0.3	0.35	0.43	0.63
Nitrate + Nitrite as N	11/10/11	composite	EPA 353.2	mg/L	0.01	0.10					0.79
Nitrate + Nitrite as N	11/14/11	composite	EPA 353.2	mg/L	0.02	0.20					0.64
Nitrate + Nitrite as N	11/17/11	composite	EPA 353.2	mg/L	0.01	0.10					0.7
Nitrate + Nitrite as N	11/21/11	composite	EPA 353.2	mg/L	0.01	0.10	13	0.29	0.36	0.31	0.64
Nitrate + Nitrite as N	11/29/11	composite	EPA 353.2	mg/L	0.01	0.10					0.56
Nitrate + Nitrite as N	12/01/11	composite	EPA 353.2	mg/L	0.01	0.10					0.59

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrate + Nitrite as N	12/05/11	composite	EPA 353.2	mg/L	0.01	0.10	11	0.27	0.31	0.41	0.6
Nitrate + Nitrite as N	12/08/11	composite	EPA 353.2	mg/L	0.01	0.10					0.66
Nitrate + Nitrite as N	12/12/11	composite	EPA 353.2	mg/L	0.01	0.10					0.62
Nitrate + Nitrite as N	12/15/11	composite	EPA 353.2	mg/L	0.01	0.10					0.62
Nitrate + Nitrite as N	12/19/11	composite	EPA 353.2	mg/L	0.01	0.10	13	0.32	0.37	0.39	0.74
Nitrate + Nitrite as N	12/22/11	composite	EPA 353.2	mg/L	0.01	0.10					0.6
Nitrate + Nitrite as N	12/27/11	composite	EPA 353.2	mg/L	0.01	0.10					0.56
Nitrate + Nitrite as N	12/29/11	composite	EPA 353.2	mg/L	0.01	0.10					0.51
Nitrate + Nitrite as N	01/03/12	composite	EPA 353.2	mg/L	0.01	0.10	12	0.33	0.33	0.36	0.5
Nitrate + Nitrite as N	01/05/12	composite	EPA 353.2	mg/L	0.01	0.10					0.61
Nitrate + Nitrite as N	01/09/12	composite	EPA 353.2	mg/L	0.01	0.10					0.57
Nitrate + Nitrite as N	01/12/12	composite	EPA 353.2	mg/L	0.01	0.10					0.67
Nitrate + Nitrite as N	01/17/12	composite	EPA 353.2	mg/L	0.01	0.10	15	0.43	0.43	0.47	0.63
Nitrate + Nitrite as N	01/19/12	composite	EPA 353.2	mg/L	0.01	0.10					0.71
Nitrate + Nitrite as N	01/23/12	composite	EPA 353.2	mg/L	0.01	0.10					0.54
Nitrate + Nitrite as N	01/26/12	composite	EPA 353.2	mg/L	0.01	0.10					0.67
Nitrate + Nitrite as N	01/30/12	composite	EPA 353.2	mg/L	0.01	0.10	12	0.34	0.34	0.36	0.52
Nitrate + Nitrite as N	02/02/12	composite	EPA 353.2	mg/L	0.01	0.10					0.64
Nitrate + Nitrite as N	02/06/12	composite	EPA 353.2	mg/L	0.01	0.10					0.52
Nitrate + Nitrite as N	02/09/12	composite	EPA 353.2	mg/L	0.01	0.10					0.59
Nitrate + Nitrite as N	02/14/12	composite	EPA 353.2	mg/L	0.01	0.10	14.00	0.47	0.46	0.47	0.59
Nitrate + Nitrite as N	02/16/12	composite	EPA 353.2	mg/L	0.01	0.10					0.64
Nitrate + Nitrite as N	02/20/12	composite	EPA 353.2	mg/L	0.01	0.10					0.54
Nitrate + Nitrite as N	02/23/12	composite	EPA 353.2	mg/L	0.01	0.10					0.6
Nitrate + Nitrite as N	02/27/12	composite	EPA 353.2	mg/L	0.01	0.10	13	0.38	0.38	0.44	
Nitrate + Nitrite as N	03/01/12	composite	EPA 353.2	mg/L	0.01	0.10					0.72
Nitrate + Nitrite as N	03/06/12	composite	EPA 353.2	mg/L	0.01	0.10					0.58
Nitrate + Nitrite as N	03/08/12	composite	EPA 353.2	mg/L	0.01	0.10					0.65
Nitrate + Nitrite as N	03/12/12	composite	EPA 353.2	mg/L	0.01	0.10	12	0.32	0.44	0.79	0.57
Nitrate + Nitrite as N	03/15/12	composite	EPA 353.2	mg/L	0.01	0.10					0.78
Nitrate + Nitrite as N	03/19/12	composite	EPA 353.2	mg/L	0.01	0.10					0.58
Nitrate + Nitrite as N	03/22/12	composite	EPA 353.2	mg/L	0.01	0.10					0.66
Nitrate + Nitrite as N	03/26/12	composite	EPA 353.2	mg/L	0.01	0.10	12	0.36	0.39	0.68	0.81
Nitrate + Nitrite as N	03/29/12	composite	EPA 353.2	mg/L	0.01	0.10					0.63
Nitrate + Nitrite as N	04/02/12	composite	EPA 353.2	mg/L	0.01	0.10					0.6
Nitrate + Nitrite as N	04/05/12	composite	EPA 353.2	mg/L	0.01	0.10					0.66
Nitrate + Nitrite as N	04/09/12	composite	EPA 353.2	mg/L	0.01	0.10	6.80	0.43	0.48	0.54	0.67

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrate + Nitrite as N	04/12/12	composite	EPA 353.2	mg/L	0.01	0.10					0.74
Nitrate + Nitrite as N	04/16/12	composite	EPA 353.2	mg/L	0.01	0.10					0.66
Nitrate + Nitrite as N	04/23/12	composite	EPA 353.2	mg/L	0.01	0.10	13.00	0.63	0.64	0.74	0.91
Nitrate + Nitrite as N	04/26/12	composite	EPA 353.2	mg/L	0.01	0.10					1.20
Nitrate + Nitrite as N	04/30/12	composite	EPA 353.2	mg/L	0.01	0.10					0.83
Nitrate + Nitrite as N	05/03/12	composite	EPA 353.2	mg/L	0.01	0.10					1.00
Nitrate + Nitrite as N	05/07/12	composite	EPA 353.2	mg/L	0.01	0.10	11.00	0.53	0.65	0.61	0.77
Nitrate + Nitrite as N	05/14/12	composite	EPA 353.2	mg/L	0.01	0.10					0.93
Nitrate + Nitrite as N	05/21/12	composite	EPA 353.2	mg/L	0.01	0.10	13.00	0.56	0.68	0.88	0.96
Nitrate + Nitrite as N	05/24/12	composite	EPA 353.2	mg/L	0.01	0.10					1.30
Nitrate + Nitrite as N	05/29/12	composite	EPA 353.2	mg/L	0.01	0.10					1.00
Nitrate + Nitrite as N	05/31/12	composite	EPA 353.2	mg/L	0.01	0.10					1.00
Nitrate + Nitrite as N	06/04/12	composite	EPA 353.2	mg/L	0.01	0.10	13.00	0.67	0.80	0.88	1.00
Nitrate + Nitrite as N	06/07/12	composite	EPA 353.2	mg/L	0.01	0.10					0.88
Nitrate + Nitrite as N	06/11/12	composite	EPA 353.2	mg/L	0.01	0.10					0.93
Nitrate + Nitrite as N	06/21/12	composite	EPA 353.2	mg/L	0.01	0.10					0.98
Nitrate + Nitrite as N	06/28/12	composite	EPA 353.2	mg/L	0.01	0.10					1.00
Nitrate + Nitrite as N	07/02/12	composite	EPA 353.2	mg/L	0.01	0.10				0.77	0.94
Nitrate + Nitrite as N	07/05/12	composite	EPA 353.2	mg/L	0.01	0.10					0.92
Nitrate + Nitrite as N	07/09/12	composite	EPA 353.2	mg/L	0.01	0.10					1.40
Nitrate + Nitrite as N	07/12/12	composite	EPA 353.2	mg/L	0.01	0.10					1.00
Nitrate + Nitrite as N	07/16/12	composite	EPA 353.2	mg/L	0.01	0.10				0.73	0.90
Nitrate + Nitrite as N	07/19/12	composite	EPA 353.2	mg/L	0.01	0.10					1.10
Nitrate + Nitrite as N	07/23/12	composite	EPA 353.2	mg/L	0.01	0.10					0.95
Nitrate + Nitrite as N	07/26/12	composite	EPA 353.2	mg/L	0.01	0.10					1.10
Nitrate + Nitrite as N	07/30/12	composite	EPA 353.2	mg/L	0.01	0.10				0.67	0.91
n =							23	23	23	24	97
Average							12	0.41	0.45	0.54	0.73
Maximum							15	0.67	0.80	0.88	1.4
Minimum							6.8	0.30	0.30	0.30	0.50
STDev							1.7	0.11	0.13	0.18	0.19

Note: For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported <DL were considered the 0.5 X DL.

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrate as N	8/1/2011	grab	EPA 353.2	mg/L	0.04	0.11	11.97	0.41	0.43		0.54
Nitrate as N	8/4/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.72
Nitrate as N	8/8/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.72
Nitrate as N	8/11/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.72
Nitrate as N	8/15/2011	grab	EPA 353.2	mg/L	0.04	0.11	11.52	0.47	0.43		0.56
Nitrate as N	8/18/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.70
Nitrate as N	8/22/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.63
Nitrate as N	8/25/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.70
Nitrate as N	8/29/2011	grab	EPA 353.2	mg/L	0.04	0.11	9.48	0.36	0.32	0.32	0.50
Nitrate as N	9/1/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.47
Nitrate as N	9/6/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.72
Nitrate as N	9/8/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.86
Nitrate as N	9/12/2011	grab	EPA 353.2	mg/L	0.04	0.11	9.71	0.32	0.41	0.36	0.52
Nitrate as N	9/15/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.81
Nitrate as N	9/19/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.63
Nitrate as N	9/22/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.72
Nitrate as N	9/26/2011	grab	EPA 353.2	mg/L	0.04	0.11	14.45	0.45	0.52	0.50	0.68
Nitrate as N	9/29/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.79
Nitrate as N	10/6/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.61
Nitrate as N	10/10/2011	grab	EPA 353.2	mg/L	0.04	0.11	11.29	0.32	0.45	0.38	0.56
Nitrate as N	10/13/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.61
Nitrate as N	10/17/2011	grab	EPA 353.2	mg/L	0.04	0.11					0.70
Nitrate as N	10/20/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.75
Nitrate as N	10/24/2011	composite	EPA 353.2	mg/L	0.04	0.11	12.65	0.43	0.41	0.47	0.65
Nitrate as N	10/31/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.52
Nitrate as N	11/3/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.79
Nitrate as N	11/7/2011	composite	EPA 353.2	mg/L	0.04	0.11	12.87	0.29	0.34	0.43	0.63
Nitrate as N	11/10/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.79
Nitrate as N	11/14/2011	composite	EPA 353.2	mg/L	0.08	0.23					0.63
Nitrate as N	11/17/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.70
Nitrate as N	11/21/2011	composite	EPA 353.2	mg/L	0.04	0.11	13.10	0.29	0.36	0.32	0.63
Nitrate as N	11/29/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.56
Nitrate as N	12/1/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.59
Nitrate as N	12/5/2011	composite	EPA 353.2	mg/L	0.04	0.11	11.29	0.27	0.32	0.41	0.59
Nitrate as N	12/8/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.65
Nitrate as N	12/12/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.61

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrate as N	12/15/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.63
Nitrate as N	12/19/2011	composite	EPA 353.2	mg/L	0.04	0.11	13.10	0.32	0.38	0.38	0.75
Nitrate as N	12/22/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.59
Nitrate as N	12/27/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.56
Nitrate as N	12/29/2011	composite	EPA 353.2	mg/L	0.04	0.11					0.50
Nitrate as N	1/3/2012	composite	EPA 353.2	mg/L	0.04	0.11	11.97	0.34	0.32	0.36	0.50
Nitrate as N	1/5/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.61
Nitrate as N	1/9/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.56
Nitrate as N	1/12/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.68
Nitrate as N	1/17/2012	composite	EPA 353.2	mg/L	0.04	0.11	15.35	0.43	0.43	0.47	0.63
Nitrate as N	1/19/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.79
Nitrate as N	1/23/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.54
Nitrate as N	1/26/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.68
Nitrate as N	1/30/2012	composite	EPA 353.2	mg/L	0.04	0.11	12.19	0.34	0.34	0.36	0.52
Nitrate as N	2/2/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.63
Nitrate as N	2/6/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.52
Nitrate as N	2/9/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.59
Nitrate as N	2/14/2012	composite	EPA 353.2	mg/L	0.04	0.11	14.45	0.47	0.45	0.47	0.59
Nitrate as N	2/16/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.63
Nitrate as N	2/20/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.54
Nitrate as N	2/23/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.61
Nitrate as N	2/27/2012	composite	EPA 353.2	mg/L	0.04	0.11	13.00	0.38	0.38	0.44	0.59
Nitrate as N	3/1/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.72
Nitrate as N	3/6/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.58
Nitrate as N	3/8/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.65
Nitrate as N	3/12/2012	composite	EPA 353.2	mg/L	0.04	0.11	12.00	0.32	0.44	0.79	0.57
Nitrate as N	3/15/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.78
Nitrate as N	3/19/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.58
Nitrate as N	3/22/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.66
Nitrate as N	3/26/2012	composite	EPA 353.2	mg/L	0.04	0.11	12.00	0.36	0.38	0.68	0.81
Nitrate as N	3/29/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.63
Nitrate as N	4/2/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.60
Nitrate as N	4/5/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.66
Nitrate as N	4/9/2012	composite	EPA 353.2	mg/L	0.04	0.11	6.60	0.43	0.48	0.54	0.67
Nitrate as N	4/12/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.74
Nitrate as N	4/16/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.66
Nitrate as N	4/23/2012	composite	EPA 353.2	mg/L	0.04	0.11	13.00	0.63	0.64	0.74	0.91

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrate as N	4/26/2012	composite	EPA 353.2	mg/L	0.04	0.11					1.20
Nitrate as N	4/30/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.83
Nitrate as N	5/3/2012	composite	EPA 353.2	mg/L	0.04	0.11					1.00
Nitrate as N	5/7/2012	composite	EPA 353.2	mg/L	0.04	0.11	11.00	0.53	0.65	0.61	0.77
Nitrate as N	5/14/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.93
Nitrate as N	5/21/2012	composite	EPA 353.2	mg/L	0.04	0.11	13.00	0.56	0.68	0.88	0.96
Nitrate as N	5/24/2012	composite	EPA 353.2	mg/L	0.04	0.11					1.30
Nitrate as N	5/29/2012	composite	EPA 353.2	mg/L	0.04	0.11					1.00
Nitrate as N	5/31/2012	composite	EPA 353.2	mg/L	0.04	0.11					1.00
Nitrate as N	6/4/2012	composite	EPA 353.2	mg/L	0.04	0.11	13.00	0.67	0.80	0.88	1.00
Nitrate as N	6/7/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.88
Nitrate as N	6/11/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.93
Nitrate as N	6/21/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.98
Nitrate as N	6/28/2012	composite	EPA 353.2	mg/L	0.04	0.11					1.00
Nitrate as N	7/2/2012	composite	EPA 353.2	mg/L	0.04	0.11				0.77	0.94
Nitrate as N	7/5/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.92
Nitrate as N	7/9/2012	composite	EPA 353.2	mg/L	0.04	0.11					1.40
Nitrate as N	7/12/2012	composite	EPA 353.2	mg/L	0.04	0.11					1.00
Nitrate as N	7/16/2012	composite	EPA 353.2	mg/L	0.04	0.11				0.73	0.90
Nitrate as N	7/19/2012	composite	EPA 353.2	mg/L	0.04	0.11					1.10
Nitrate as N	7/23/2012	composite	EPA 353.2	mg/L	0.04	0.11					0.95
Nitrate as N	7/26/2012	composite	EPA 353.2	mg/L	0.04	0.11					1.10
Nitrate as N	7/30/2012	composite	EPA 353.2	mg/L	0.04	0.11				0.67	0.91
n =							23	23	23	24	96
Average							12.1	0.41	0.45	0.54	0.73
Maximum							15.4	0.67	0.80	0.88	1.4
Minimum							6.60	0.30	0.30	0.30	0.50
STDev							1.83	0.11	0.13	0.18	0.19

Note: For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported <DL were considered the 0.5 X DL. Nitrate concentrations were calculated by subtracting measured concentrations of nitrite-N from measured concentrations of (nitrate-+nitrite as N).

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrite as N	8/15/2011	grab	EPA 353.2	mg/L	0.01	0.09	<0.09	<0.01	<0.01		<0.01
Nitrite as N	8/18/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	8/22/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	8/25/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	8/29/2011	grab	EPA 353.2	mg/L	0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite as N	9/1/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	9/1/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	9/6/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	9/8/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	9/12/2011	grab	EPA 353.2	mg/L	0.01	0.09	<0.09	<0.01	<0.01	<0.01	<0.01
Nitrite as N	9/15/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	9/19/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	9/22/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	9/26/2011	grab	EPA 353.2	mg/L	0.01	0.09	<0.09	<0.01	<0.01	<0.01	<0.01
Nitrite as N	9/29/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	10/6/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	10/10/2011	grab	EPA 353.2	mg/L	0.01	0.09	<0.09	<0.01	<0.01	<0.01	<0.01
Nitrite as N	10/13/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	10/17/2011	grab	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	10/20/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	10/24/2011	composite	EPA 353.2	mg/L	0.01	0.09	<0.09	<0.01	<0.01	<0.01	<0.01
Nitrite as N	10/31/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	11/3/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	11/7/2011	composite	EPA 353.2	mg/L	0.01	0.09	<0.09	<0.01	<0.01	<0.01	<0.01
Nitrite as N	11/10/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	11/14/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	11/17/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	11/21/2011	composite	EPA 353.2	mg/L	0.01	0.09	0.13	<0.01	<0.01	<0.01	<0.01
Nitrite as N	11/29/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	12/1/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	12/5/2011	composite	EPA 353.2	mg/L	0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.09
Nitrite as N	12/8/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	12/12/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	12/15/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	12/19/2011	composite	EPA 353.2	mg/L	0.01	0.09	<0.09	<0.01	<0.01	<0.01	<0.01
Nitrite as N	12/22/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrite as N	12/27/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	12/29/2011	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	1/3/2012	composite	EPA 353.2	mg/L	0.01	0.09	<0.09	<0.01	<0.01	<0.01	<0.01
Nitrite as N	1/5/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	1/9/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	1/12/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	1/17/2012	composite	EPA 353.2	mg/L	0.01	0.09	<0.09	<0.01	<0.01	<0.01	<0.01
Nitrite as N	1/19/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	1/23/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	1/26/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	1/30/2012	composite	EPA 353.2	mg/L	0.01	0.09	<0.09	<0.01	<0.01	<0.01	<0.01
Nitrite as N	2/2/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	2/6/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	2/9/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	2/14/2012	composite	EPA 353.2	mg/L	0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite as N	2/16/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	2/20/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	2/23/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	2/27/2012	composite	EPA 353.2	mg/L	0.01	0.09	<0.1	<0.1	<0.1	<0.01	<0.1
Nitrite as N	3/1/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.1
Nitrite as N	3/6/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	3/8/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	3/12/2012	composite	EPA 353.2	mg/L	0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite as N	3/15/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	3/19/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	3/22/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	3/26/2012	composite	EPA 353.2	mg/L	0.01	0.09	0.31	<0.01	<0.01	<0.01	<0.01
Nitrite as N	3/29/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	4/2/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	4/5/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	4/9/2012	composite	EPA 353.2	mg/L	0.01	0.09	0.48	<0.01	<0.01	<0.01	<0.01
Nitrite as N	4/12/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	4/16/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	4/23/2012	composite	EPA 353.2	mg/L	0.01	0.09	<0.1	<0.01	<0.01	<0.01	<0.01
Nitrite as N	4/26/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	4/30/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	5/3/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrite as N	5/7/2012	composite	EPA 353.2	mg/L	0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite as N	5/14/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	5/21/2012	composite	EPA 353.2	mg/L	0.01	0.09	<0.1	<0.01	<0.01	<0.01	<0.01
Nitrite as N	5/24/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	5/29/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	5/31/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	6/4/2012	composite	EPA 353.2	mg/L	0.01	0.09	<0.1	<0.01	<0.01	<0.01	<0.01
Nitrite as N	6/7/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	6/11/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	6/21/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	6/28/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	7/2/2012	composite	EPA 353.2	mg/L	0.01	0.09				<0.01	<0.01
Nitrite as N	7/5/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	7/9/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	7/12/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	7/16/2012	composite	EPA 353.2	mg/L	0.01	0.09				<0.01	<0.01
Nitrite as N	7/19/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	7/23/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	7/26/2012	composite	EPA 353.2	mg/L	0.01	0.09					<0.01
Nitrite as N	7/30/2012	composite	EPA 353.2	mg/L	0.01	0.09				<0.01	<0.01
n =							22	22	22	24	93
Average							<0.09	<0.01	<0.01	<0.01	<0.01
Maximum							0.48	0.10	0.10	0.09	0.10
Minimum							0.0	0.0	0.0	0.0	0.0
STDev							0.1	0.0	0.0	0.0	0.0

Note: For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported <DL were considered the 0.5 X DL.

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrogen, Total - N	8/1/2011	grab	Various	mg/L	0.074	0.1	13	0.85	0.71		0.75
Nitrogen, Total - N	8/4/2011	grab	Various	mg/L	0.074	0.1					0.8
Nitrogen, Total - N	8/8/2011	grab	Various	mg/L	0.074	0.1					0.8
Nitrogen, Total - N	8/11/2011	grab	Various	mg/L	0.074	0.1					0.98
Nitrogen, Total - N	8/15/2011	grab	Various	mg/L	0.074	0.1	12	0.85	0.76		0.7
Nitrogen, Total - N	8/18/2011	grab	Various	mg/L	0.074	0.1					0.88
Nitrogen, Total - N	8/22/2011	grab	Various	mg/L	0.074	0.1					0.74
Nitrogen, Total - N	8/25/2011	grab	Various	mg/L	0.074	0.1					0.7
Nitrogen, Total - N	8/29/2011	grab	Various	mg/L	0.074	0.1	13	0.81	0.73	0.77	0.63
Nitrogen, Total - N	9/1/2011	grab	Various	mg/L	0.074	0.1					1.3
Nitrogen, Total - N	9/6/2011	grab	Various	mg/L	0.074	0.1					0.71
Nitrogen, Total - N	9/8/2011	grab	Various	mg/L	0.074	0.1					0.85
Nitrogen, Total - N	9/12/2011	grab	Various	mg/L	0.074	0.1	11	0.62	0.68	0.68	0.65
Nitrogen, Total - N	9/15/2011	grab	Various	mg/L	0.074	0.1					0.82
Nitrogen, Total - N	9/19/2011	grab	Various	mg/L	0.074	0.1					0.85
Nitrogen, Total - N	9/22/2011	grab	Various	mg/L	0.074	0.1					0.97
Nitrogen, Total - N	9/26/2011	grab	Various	mg/L	0.074	0.1	14	0.84	0.84	0.8	0.84
Nitrogen, Total - N	9/29/2011	grab	Various	mg/L	0.074	0.1					0.94
Nitrogen, Total - N	10/3/2011	grab	Various	mg/L	0.074	0.1					0.58
Nitrogen, Total - N	10/6/2011	grab	Various	mg/L	0.074	0.1					0.62
Nitrogen, Total - N	10/10/2011	grab	Various	mg/L	0.074	0.1	13	0.63	0.63	0.86	0.95
Nitrogen, Total - N	10/13/2011	grab	Various	mg/L	0.074	0.1					0.73
Nitrogen, Total - N	10/17/2011	grab	Various	mg/L	0.074	0.1					0.98
Nitrogen, Total - N	10/20/2011	composite	Various	mg/L	0.074	0.1					0.91
Nitrogen, Total - N	10/24/2011	composite	Various	mg/L	0.074	0.1	13	0.84	0.79	0.84	0.87
Nitrogen, Total - N	10/31/2011	composite	Various	mg/L	0.074	0.1					0.53
Nitrogen, Total - N	11/3/2011	composite	Various	mg/L	0.074	0.1					0.97
Nitrogen, Total - N	11/7/2011	composite	Various	mg/L	0.074	0.1	13	0.65	0.67	0.77	0.76
Nitrogen, Total - N	11/10/2011	composite	Various	mg/L	0.074	0.1					0.79
Nitrogen, Total - N	11/14/2011	composite	Various	mg/L	0.074	0.2					0.64
Nitrogen, Total - N	11/17/2011	composite	Various	mg/L	0.074	0.1					0.86
Nitrogen, Total - N	11/21/2011	composite	Various	mg/L	0.074	0.1	13	0.72	0.88	0.73	0.74
Nitrogen, Total - N	11/29/2011	composite	Various	mg/L	0.074	0.1					0.68
Nitrogen, Total - N	12/1/2011	composite	Various	mg/L	0.074	0.1					0.68
Nitrogen, Total - N	12/5/2011	composite	Various	mg/L	0.074	0.1	12	0.66	0.73	0.87	0.77

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrogen, Total - N	12/8/2011	composite	Various	mg/L	0.074	0.1					0.8
Nitrogen, Total - N	12/12/2011	composite	Various	mg/L	0.074	0.1					0.8
Nitrogen, Total - N	12/15/2011	composite	Various	mg/L	0.074	0.1					0.62
Nitrogen, Total - N	12/19/2011	composite	Various	mg/L	0.074	0.2	13	0.69	0.76	0.78	0.87
Nitrogen, Total - N	12/22/2011	composite	Various	mg/L	0.074	0.2					0.76
Nitrogen, Total - N	12/27/2011	composite	Various	mg/L	0.074	0.2					0.68
Nitrogen, Total - N	12/29/2011	composite	Various	mg/L	0.074	0.2					0.6
Nitrogen, Total - N	1/3/2012	composite	Various	mg/L	0.074	0.2	12	0.9	0.77	0.8	0.65
Nitrogen, Total - N	1/5/2012	composite	Various	mg/L	0.074	0.2					0.71
Nitrogen, Total - N	1/9/2012	composite	Various	mg/L	0.074	0.2					0.57
Nitrogen, Total - N	1/12/2012	composite	Various	mg/L	0.074	0.2					0.67
Nitrogen, Total - N	1/17/2012	composite	Various	mg/L	0.074	0.2	17	0.78	0.76	0.88	0.82
Nitrogen, Total - N	1/19/2012	composite	Various	mg/L	0.074	0.2					0.9
Nitrogen, Total - N	1/23/2012	composite	Various	mg/L	0.074	0.2					0.54
Nitrogen, Total - N	1/26/2012	composite	Various	mg/L	0.074	0.2					0.87
Nitrogen, Total - N	1/30/2012	composite	Various	mg/L	0.074	0.2	12	0.77	0.74	0.84	0.63
Nitrogen, Total - N	2/2/2012	composite	Various	mg/L	0.074	0.2					0.82
Nitrogen, Total - N	2/6/2012	composite	Various	mg/L	0.074	0.2					0.72
Nitrogen, Total - N	2/9/2012	composite	Various	mg/L	0.074	0.2					0.73
Nitrogen, Total - N	2/14/2012	composite	Various	mg/L	0.074	0.2	15	0.74	0.74	0.8	0.67
Nitrogen, Total - N	2/16/2012	composite	Various	mg/L	0.074	0.2					0.64
Nitrogen, Total - N	2/20/2012	composite	Various	mg/L	0.074	0.2					0.65
Nitrogen, Total - N	2/23/2012	composite	Various	mg/L	0.074	0.2					0.72
Nitrogen, Total - N	2/27/2012	composite	Various	mg/L	0.074	0.2	13	0.74	0.73	0.82	
Nitrogen, Total - N	3/1/2012	composite	Various	mg/L	0.074	0.2					1.2
Nitrogen, Total - N	3/6/2012	composite	Various	mg/L	0.074	0.2					1.1
Nitrogen, Total - N	3/8/2012	composite	Various	mg/L	0.074	0.2					0.76
Nitrogen, Total - N	3/12/2012	composite	Various	mg/L	0.074	0.2	13	0.66	0.88	1.1	0.57
Nitrogen, Total - N	3/15/2012	composite	Various	mg/L	0.074	0.2					0.88
Nitrogen, Total - N	3/19/2012	composite	Various	mg/L	0.074	0.2					0.58
Nitrogen, Total - N	3/22/2012	composite	Various	mg/L	0.074	0.2					0.92
Nitrogen, Total - N	3/26/2012	composite	Various	mg/L	0.074	0.2	16	0.9	0.99	1.2	1.1
Nitrogen, Total - N	3/29/2012	composite	Various	mg/L	0.074	0.2					1
Nitrogen, Total - N	4/2/2012	composite	Various	mg/L	0.074	0.2					0.92
Nitrogen, Total - N	4/5/2012	composite	Various	mg/L	0.074	0.2					0.98
Nitrogen, Total - N	4/9/2012	composite	Various	mg/L	0.074	0.2	9.6	0.84	0.86	0.92	0.98
Nitrogen, Total - N	4/12/2012	composite	Various	mg/L	0.074	0.2					0.88

Table 15 Certified Laboratory Results of Nitrogen Parameters Sampled from Various Locations in the AWPF (Cont.)

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Nitrogen, Total - N	4/16/2012	composite	Various	mg/L	0.074	0.2					1
Nitrogen, Total - N	4/23/2012	composite	Various	mg/L	0.074	0.2	14	1.1	0.84	1.2	0.91
Nitrogen, Total - N	4/26/2012	composite	Various	mg/L	0.074	0.2					1.30
Nitrogen, Total - N	4/30/2012	composite	Various	mg/L	0.074	0.2					0.96
Nitrogen, Total - N	5/3/2012	composite	Various	mg/L	0.075	1.2					1.20
Nitrogen, Total - N	5/7/2012	composite	Various	mg/L	0.074	0.2	12.00	0.98	1.10	0.97	0.88
Nitrogen, Total - N	5/14/2012	composite	Various	mg/L	0.074	0.2					1.10
Nitrogen, Total - N	5/21/2012	composite	Various	mg/L	0.074	0.2	13.00	1.00	1.00	1.20	0.96
Nitrogen, Total - N	5/24/2012	composite	Various	mg/L	0.074	0.2					1.30
Nitrogen, Total - N	5/29/2012	composite	Various	mg/L	0.074	0.2					1.20
Nitrogen, Total - N	5/31/2012	composite	Various	mg/L	0.074	0.2					2.20
Nitrogen, Total - N	6/4/2012	composite	Various	mg/L	0.074	0.2	14.00	1.20	1.10	1.00	1.20
Nitrogen, Total - N	6/7/2012	composite	Various	mg/L	0.074	0.2					0.88
Nitrogen, Total - N	6/11/2012	composite	Various	mg/L	0.074	0.2					0.93
Nitrogen, Total - N	6/21/2012	composite	Various	mg/L	0.074	0.2					1.10
Nitrogen, Total - N	6/28/2012	composite	Various	mg/L	0.074	0.2					1.00
Nitrogen, Total - N	7/2/2012	composite	Various	mg/L	0.074	0.2				0.89	0.94
Nitrogen, Total - N	7/5/2012	composite	Various	mg/L	0.074	0.2					0.92
Nitrogen, Total - N	7/9/2012	composite	Various	mg/L	0.074	0.2					1.40
Nitrogen, Total - N	7/12/2012	composite	Various	mg/L	0.074	0.2					1.00
Nitrogen, Total - N	7/16/2012	composite	Various	mg/L	0.074	0.2				1.10	0.98
Nitrogen, Total - N	7/19/2012	composite	Various	mg/L	0.074	0.2					1.10
Nitrogen, Total - N	7/23/2012	composite	Various	mg/L	0.074	0.2					0.95
Nitrogen, Total - N	7/26/2012	composite	Various	mg/L	0.074	0.2					1.10
Nitrogen, Total - N	7/30/2012	composite	Various	mg/L	0.074	0.2				0.67	0.91
n =							23	23	23	24	96
Average							13	0.82	0.81	0.90	0.87
Maximum							17	1.2	1.1	1.2	2.2
Minimum							9.6	0.60	0.60	0.70	0.50
STDev							1.5	0.15	0.13	0.16	0.23

Note: For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported <DL were considered the 0.5 X DL.

Table 15 Certified Laboratory Results of Total Phosphorus Sampled from Various Locations in the AWPF

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Total Phosphorus-P	8/1/2011	grab	EPA 365.1	µg/L	35	250	2200	11	11		
Total Phosphorus-P	8/15/2011	grab	EPA 365.1	µg/L	1.4	10	1100	<10	<10		<10
Total Phosphorus-P	8/18/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	8/22/2011	grab	EPA 365.1	µg/L	1.4	10					<1.4
Total Phosphorus-P	8/25/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	8/29/2011	grab	EPA 365.1	µg/L	1.4	10	1100	<10	<10	<10	<10
Total Phosphorus-P	9/1/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	9/6/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	9/8/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	9/12/2011	grab	EPA 365.1	µg/L	1.4	10	320	<1.4	<1.4	<10	<1.4
Total Phosphorus-P	9/15/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	9/19/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	9/22/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	9/26/2011	grab	EPA 365.1	µg/L	1.4	10	2100	<10	<10	<10	<10
Total Phosphorus-P	9/29/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	10/3/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	10/6/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	10/10/2011	grab	EPA 365.1	µg/L	1.4	10	2500	<10	<10	<10	<10
Total Phosphorus-P	10/10/2011	grab	EPA 365.1	µg/L	1.4	10	2000	<10	<10		
Total Phosphorus-P	10/13/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	10/17/2011	grab	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	10/20/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	10/24/2011	composite	EPA 365.1	µg/L	1.4	10	1800	<10	<10	<10	<10
Total Phosphorus-P	10/31/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	11/3/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	11/7/2011	composite	EPA 365.1	µg/L	1.4	10	1200	<1.4	<1.4	<10	<10
Total Phosphorus-P	11/10/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	11/14/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	11/17/2011	composite	EPA 365.1	µg/L	1.4	10					<1.4
Total Phosphorus-P	11/21/2011	composite	EPA 365.1	µg/L	1.4	10	1600	<1.4	<1.4	<1.4	<1.4
Total Phosphorus-P	11/29/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	12/5/2011	composite	EPA 365.1	µg/L	1.4	10	1200	<10	<10	<10	<10
Total Phosphorus-P	12/01/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	12/8/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	12/12/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	12/15/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	12/19/2011	composite	EPA 365.1	µg/L	1.4	10	1700	<10	<10	14	<10
Total Phosphorus-P	12/22/2011	composite	EPA 365.1	µg/L	1.4	10					<10

Table 15 Certified Laboratory Results of Total Phosphorus Sampled from Various Locations in the AWPF

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Total Phosphorus-P	12/27/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	12/29/2011	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	1/3/2012	composite	EPA 365.1	µg/L	1.4	10	300	<10	<10	<10	<10
Total Phosphorus-P	1/5/2012	composite	EPA 365.1	µg/L	70	500					940
Total Phosphorus-P	1/9/2012	composite	EPA 365.1	µg/L	1.4	10					14
Total Phosphorus-P	1/12/2012	composite	EPA 365.1	µg/L	1.4	10					<1.4
Total Phosphorus-P	1/17/2012	composite	EPA 365.1	µg/L	1.4	10	430.00	<1.4	<1.4	<10	20
Total Phosphorus-P	1/19/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	1/23/2012	composite	EPA 365.1	µg/L	1.4	10					45
Total Phosphorus-P	1/26/2012	composite	EPA 365.1	µg/L	1.4	10					18
Total Phosphorus-P	1/30/2012	composite	EPA 365.1	µg/L	1.4	10	430	<10	<10	280	21
Total Phosphorus-P	2/2/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	2/9/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	2/14/2012	composite	EPA 365.1	µg/L	1.4	10	560	<10	<1.4	<10	<10
Total Phosphorus-P	2/23/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	2/27/2012	composite	EPA 365.1	µg/L	1.4	10	1800	<10	<1.4	<10	
Total Phosphorus-P	3/1/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	3/6/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	3/8/2012	composite	EPA 365.1	µg/L	1.4	10					420
Total Phosphorus-P	3/12/2012	composite	EPA 365.1	µg/L	1.4	10	1900	<10	<1.4	<10	<10
Total Phosphorus-P	3/15/2012	composite	EPA 365.1	µg/L	1.4	10					140
Total Phosphorus-P	3/19/2012	composite	EPA 365.1	µg/L	1.4	10					26
Total Phosphorus-P	3/22/2012	composite	EPA 365.1	µg/L	1.4	10					140
Total Phosphorus-P	3/26/2012	composite	EPA 365.1	µg/L	1.4	10	1400	<10	<10	<10	11
Total Phosphorus-P	3/29/2012	composite	EPA 365.1	µg/L	1.4	10					22
Total Phosphorus-P	4/2/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	4/5/2012	composite	EPA 365.1	µg/L	1.4	10					15
Total Phosphorus-P	4/9/2012	composite	EPA 365.1	µg/L	1.4	10	490	<10	<1.4	<10	<10
Total Phosphorus-P	4/12/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	4/16/2012	composite	EPA 365.1	µg/L	1.4	10					120
Total Phosphorus-P	4/23/2012	composite	EPA 365.1	µg/L	1.4	10	910	<10	<10	<10	<10
Total Phosphorus-P	4/26/2012	composite	EPA 365.1	µg/L	1.4	10					11
Total Phosphorus-P	4/30/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	5/3/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	5/7/2012	composite	EPA 365.1	µg/L	1.4	10	1000.00	<1.4	<10	<10	<10
Total Phosphorus-P	5/14/2012	composite	EPA 365.1	µg/L	1.4	10					29.00
Total Phosphorus-P	5/21/2012	composite	EPA 365.1	µg/L	1.4	10	680.00	<1.4	<1.4	<10	<10

Table 15 Certified Laboratory Results of Total Phosphorus Sampled from Various Locations in the AWPF

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Total Phosphorus-P	5/24/2012	composite	EPA 365.1	µg/L	1.4	10	1100.00			<10	<10
Total Phosphorus-P	5/29/2012	composite	EPA 365.1	µg/L	1.4	10	870.00			<10	<10
Total Phosphorus-P	5/31/2012	composite	EPA 365.1	µg/L	1.4	10	1100.00			23.00	<10
Total Phosphorus-P	6/4/2012	composite	EPA 365.1	µg/L	1.4	10	1400.00	<10	<10	<10	<10
Total Phosphorus-P	6/7/2012	composite	EPA 365.1	µg/L	1.4	10	1900.00			<10	14.00
Total Phosphorus-P	6/11/2012	composite	EPA 365.1	µg/L	1.4	10	1600.00			<10	<10
Total Phosphorus-P	6/21/2012	composite	EPA 365.1	µg/L	1.4	10	2100.00			<10	<10
Total Phosphorus-P	6/28/2012	composite	EPA 365.1	µg/L	1.4	10	2100.00			<10	<10
Total Phosphorus-P	7/2/2012	composite	EPA 365.1	µg/L	1.4	10				<10	<10
Total Phosphorus-P	7/5/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	7/9/2012	composite	EPA 365.1	µg/L	1.4	10					<1.4
Total Phosphorus-P	7/12/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	7/16/2012	composite	EPA 365.1	µg/L	1.4	10				<10	<10
Total Phosphorus-P	7/19/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	7/23/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	7/26/2012	composite	EPA 365.1	µg/L	1.4	10					<10
Total Phosphorus-P	7/30/2012	composite	EPA 365.1	µg/L	1.4	10				<10	<10
n =							31	24	24	31	88
Average							1320	<10	<10	15	16
Maximum							2500	11	11	280	420
Minimum							300	0.70	0.70	0.70	0.70
STDev							630	2.4	2.6	49	50

Note: For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported <DL were considered the 0.5 X DL. . The result shown for S10 (940 µg/L) on 1/5/2012 is considered an outlier and ommitted for determination of statistical parameters. Data flags provided in the original laboratory reports are not shown.

Table 16 Certified Laboratory Results of Trihalomethanes, Methylene Chloride, 1, 2 Dichloroethane, and Napthalene

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
THMs, Total	8/1/2011	grab	EPA 524.2	µg/L	0.60	2.0		3.7	2.1	<2
THMs, Total	9/1/2011	grab	EPA 524.2	µg/L	0.60	2.0	<0.6		<0.6	<0.6
THMs, Total	10/3/2011	grab	EPA 524.2	µg/L	0.60	2.0	<2		<0.6	<0.6
THMs, Total	11/2/2011	grab	EPA 524.2	µg/L	0.60	2.0	<2		<0.6	<0.6
THMs, Total	12/1/2011	grab	EPA 524.2	µg/L	0.60	2.0	<0.6	<2	<0.6	<0.6
THMs, Total	1/3/2012	grab	EPA 524.2	µg/L	0.60	2.0	<0.6	<2	<0.6	<0.6
THMs, Total	2/1/2012	grab	EPA 524.2	µg/L	0.60	2.0	<0.6	<0.6	<0.6	<0.6
THMs, Total	3/6/2012	grab	EPA 524.2	µg/L	0.60	2.0	3	3.1	<2	<2
THMs, Total	4/2/2012	grab	EPA 524.2	µg/L	0.60	2.0	<0.6	<0.6	<0.6	<0.6
THMs, Total	5/1/2012	grab	EPA 524.2	µg/L	0.60	2.0	<2	<2	<0.6	<0.6
THMs, Total	6/4/2012	grab	EPA 524.2	µg/L	0.60	2.0	<2	<2		<2
THMs, Total	7/2/2012	grab	EPA 524.2	µg/L	0.60	2.0	<2			<0.6
n =							11	8	10	12
Average							<2	<2	<2	<0.6
Maximum							3	4	2	1
Minimum							0.3	0.3	0.3	0.3
STDev							0.8	1	0.6	0.3
Methylene chloride	8/1/2011	grab	EPA 524.2	µg/L	0.14	0.50		<0.14	<0.5	<0.5
Methylene chloride	9/1/2011	grab	EPA 524.2	µg/L	0.14	0.50	0.72		0.62	0.59
Methylene chloride	10/3/2011	grab	EPA 524.2	µg/L	0.14	0.50	<0.5		<0.5	<0.5
Methylene chloride	11/2/2011	grab	EPA 524.2	µg/L	0.14	0.50	<0.14		<0.14	<0.14
Methylene chloride	12/1/2011	grab	EPA 524.2	µg/L	0.14	0.50	<0.5	<0.5	<0.5	<0.5
Methylene chloride	1/3/2012	grab	EPA 524.2	µg/L	0.14	0.50	<0.5	<0.5	<0.5	<0.5
Methylene chloride	2/1/2012	grab	EPA 524.2	µg/L	0.14	0.50	<0.5	<0.5	<0.5	<0.5
Methylene chloride	3/6/2012	grab	EPA 524.2	µg/L	0.14	0.50	<0.5	<0.5	<0.14	<0.14
Methylene chloride	4/2/2012	grab	EPA 524.2	µg/L	0.14	0.50	<0.5	<0.5	<0.5	<0.5
Methylene chloride	5/1/2012	grab	EPA 524.2	µg/L	0.14	0.50	<0.5	<0.5	<0.5	<0.5
Methylene chloride	6/4/2012	grab	EPA 524.2	µg/L	0.14	0.50	<0.14	<0.14		<0.14
Methylene chloride	7/2/2012	grab	EPA 524.2	µg/L	0.14	0.50	<0.14			<0.14
n =							11.0	8.0	10.0	12.0
Average							<0.5	<0.5	<0.5	<0.5
Maximum							0.7	0.3	0.6	0.6
Minimum							0.1	0.1	0.1	0.1
STDev							0.2	0.1	0.1	0.1

Table 16 Certified Laboratory Results of Trihalomethanes, Methylene Chloride, 1, 2 Dichloroethane, and Napthalene

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Dibromochloromethane	8/1/2011	grab	EPA 524.2	µg/L	0.20	0.50		1	<0.5	<0.20
Dibromochloromethane	9/1/2011	grab	EPA 524.2	µg/L	0.20	0.50	<0.20		<0.20	<0.20
Dibromochloromethane	10/3/2011	grab	EPA 524.2	µg/L	0.20	0.50	<0.5		<0.5	<0.20
Dibromochloromethane	11/2/2011	grab	EPA 524.2	µg/L	0.20	0.50	0.51		<0.5	<0.20
Dibromochloromethane	12/1/2011	grab	EPA 524.2	µg/L	0.20	0.50	<0.5	<0.5	<0.20	<0.20
Dibromochloromethane	1/3/2012	grab	EPA 524.2	µg/L	0.20	0.50	<0.5	<0.5	<0.5	<0.20
Dibromochloromethane	2/1/2012	grab	EPA 524.2	µg/L	0.20	0.50	<0.5	<0.5	<0.20	<0.20
Dibromochloromethane	3/6/2012	grab	EPA 524.2	µg/L	0.20	0.50	0.8	0.84	<0.5	<0.20
Dibromochloromethane	4/2/2012	grab	EPA 524.2	µg/L	0.20	0.50	<0.5	<0.20	<0.20	<0.20
Dibromochloromethane	5/1/2012	grab	EPA 524.2	µg/L	0.20	0.50	0.53	<0.5	<0.2	<0.2
Dibromochloromethane	6/4/2012	grab	EPA 524.2	µg/L	0.20	0.50	0.6	<0.5		0.6
Dibromochloromethane	7/2/2012	grab	EPA 524.2	µg/L	0.20	0.50	<0.5			<0.2
n =							11	8	10	12
Average							<0.5	<0.5	<0.2	<0.2
Maximum							0.8	1.0	0.3	0.6
Minimum							0.1	0.1	0.1	0.1
STDev							0.2	0.3	0.1	0.1
Chloroform	8/1/2011	grab	EPA 524.2	µg/L	0.12	0.5		1.3	1.3	1.1
Chloroform	9/1/2011	grab	EPA 524.2	µg/L	0.12	0.5	<0.12		<0.12	<0.12
Chloroform	10/3/2011	grab	EPA 524.2	µg/L	0.12	0.5	0.89		0.52	<0.5
Chloroform	11/2/2011	grab	EPA 524.2	µg/L	0.12	0.5	<0.5		<0.12	<0.12
Chloroform	12/1/2011	grab	EPA 524.2	µg/L	0.12	0.5	<0.5	0.61	<0.12	<0.12
Chloroform	1/3/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.5	0.71	<0.5	<0.12
Chloroform	2/1/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.5	<0.5	<0.12	<0.12
Chloroform	3/6/2012	grab	EPA 524.2	µg/L	0.12	0.5	1.1	1.1	1	0.97
Chloroform	4/2/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.5	<0.5	<0.12	<0.12
Chloroform	5/1/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.5	0.67	<0.12	<0.12
Chloroform	6/4/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.5	<0.5		<0.5
Chloroform	7/2/2012	grab	EPA 524.2	µg/L	0.12	0.5	0.68			<0.5
n =							11	8	10	12
Average							<0.5	0.6	<0.5	<0.5
Maximum							1	1	1	1
Minimum							0.1	0.3	0.1	0.1
STDev							0.3	0.4	0.5	0.4

Table 16 Certified Laboratory Results of Trihalomethanes, Methylene Chloride, 1, 2 Dichloroethane, and Napthalene

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Bromoform	8/1/2011	grab	EPA 524.2	µg/L	0.19	0.5		<0.19	<0.19	<0.19
Bromoform	9/1/2011	grab	EPA 524.2	µg/L	0.19	0.5	<0.19		<0.19	<0.19
Bromoform	10/3/2011	grab	EPA 524.2	µg/L	0.19	0.5	<0.19		<0.19	<0.19
Bromoform	11/2/2011	grab	EPA 524.2	µg/L	0.19	0.5	<0.19		<0.19	<0.19
Bromoform	12/1/2011	grab	EPA 524.2	µg/L	0.19	0.5	<0.19	<0.19	<0.19	<0.19
Bromoform	1/3/2012	grab	EPA 524.2	µg/L	0.19	0.5	<0.19	<0.19	<0.19	<0.19
Bromoform	2/1/2012	grab	EPA 524.2	µg/L	0.19	0.5	<0.19	<0.19	<0.19	<0.19
Bromoform	3/6/2012	grab	EPA 524.2	µg/L	0.19	0.5	<0.19	<0.19	<0.19	<0.19
Bromoform	4/2/2012	grab	EPA 524.2	µg/L	0.19	0.5	<0.19	<0.19	<0.19	<0.19
Bromoform	5/1/2012	grab	EPA 524.2	µg/L	0.19	0.5	<0.19	<0.19	<0.19	<0.19
Bromoform	6/4/2012	grab	EPA 524.2	µg/L	0.19	0.5	<0.19	<0.19		<0.19
Bromoform	7/2/2012	grab	EPA 524.2	µg/L	0.19	0.5	<0.19			<0.19
n =							11	8	10	12
Average							<0.19	<0.19	<0.19	<0.19
Maximum							0.10	0.10	0.10	0.10
Minimum							0.10	0.10	0.10	0.10
STDev							0.0	0.0	0.0	0.0
Bromodichloromethane	8/1/2011	grab	EPA 524.2	µg/L	0.090	0.5		1.4	0.84	0.71
Bromodichloromethane	9/1/2011	grab	EPA 524.2	µg/L	0.090	0.5	<0.090		<0.090	<0.090
Bromodichloromethane	10/3/2011	grab	EPA 524.2	µg/L	0.090	0.5	0.71		<0.5	<0.5
Bromodichloromethane	11/2/2011	grab	EPA 524.2	µg/L	0.090	0.5	0.71		<0.5	<0.5
Bromodichloromethane	12/1/2011	grab	EPA 524.2	µg/L	0.090	0.5	<0.5	0.52	<0.5	<0.5
Bromodichloromethane	1/3/2012	grab	EPA 524.2	µg/L	0.090	0.5	<0.5	0.59	<0.5	<0.5
Bromodichloromethane	2/1/2012	grab	EPA 524.2	µg/L	0.090	0.5	<0.5	0.57	<0.5	<0.5
Bromodichloromethane	3/6/2012	grab	EPA 524.2	µg/L	0.090	0.5	1.1	1.2	0.71	0.56
Bromodichloromethane	4/2/2012	grab	EPA 524.2	µg/L	0.090	0.5	<0.5	<0.5	<0.090	<0.090
Bromodichloromethane	5/1/2012	grab	EPA 524.2	µg/L	0.090	0.5	0.53	0.59	<0.5	<0.5
Bromodichloromethane	6/4/2012	grab	EPA 524.2	µg/L	0.090	0.5	0.78	0.66		0.85
Bromodichloromethane	7/2/2012	grab	EPA 524.2	µg/L	0.090	0.5	0.61			<0.5
n =							11	8	10	12
Average							<0.5	0.7	<0.5	<0.5
Maximum							1.1	1.4	0.8	0.9
Minimum							0.0	0.3	0.0	0.0
STDev							0.3	0.4	0.3	0.2

Table 16 Certified Laboratory Results of Trihalomethanes, Methylene Chloride, 1, 2 Dichloroethane, and Napthalene

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
1,2-Dichloroethane	8/1/2011	grab	EPA 524.2	µg/L	0.12	0.5		<0.12	<0.12	<0.12
1,2-Dichloroethane	9/1/2011	grab	EPA 524.2	µg/L	0.12	0.5	<0.12		<0.12	<0.12
1,2-Dichloroethane	10/3/2011	grab	EPA 524.2	µg/L	0.12	0.5	<0.12		<0.12	<0.12
1,2-Dichloroethane	11/2/2011	grab	EPA 524.2	µg/L	0.12	0.5	<0.12		<0.12	<0.12
1,2-Dichloroethane	12/1/2011	grab	EPA 524.2	µg/L	0.12	0.5	<0.12	<0.12	<0.12	<0.12
1,2-Dichloroethane	1/3/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.12	<0.12	<0.12	<0.12
1,2-Dichloroethane	2/1/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.12	<0.12	<0.12	<0.12
1,2-Dichloroethane	3/6/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.12	<0.12	<0.12	<0.12
1,2-Dichloroethane	4/2/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.12	<0.12	<0.12	<0.12
1,2-Dichloroethane	5/1/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.12	<0.12	<0.12	<0.12
1,2-Dichloroethane	6/4/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.12	<0.12		<0.12
1,2-Dichloroethane	7/2/2012	grab	EPA 524.2	µg/L	0.12	0.5	<0.12			<0.12
n =							11	8	10	12
Average							<0.12	<0.12	<0.12	<0.12
Maximum							0.1	0.1	0.1	0.1
Minimum							0.1	0.1	0.1	0.1
STDev							0.0	0.0	0.0	0.0
Naphthalene	4/2/2012	Grab	EPA 524.2	µg/L	0.42	0.5	<0.42	<0.42	<0.42	<0.42
Naphthalene	5/1/2012	Grab	EPA 524.2	µg/L	0.42	0.5	<0.42	<0.42	<0.42	<0.42
Naphthalene	6/4/2012	Grab	EPA 524.2	µg/L	0.42	0.5	<0.42	<0.42		<0.42
Naphthalene	7/2/2012	Grab	EPA 524.2	µg/L	0.42	0.5	<0.42			<0.42
n =							4	3	2	4
Average							<0.42	<0.42	<0.42	<0.42
Maximum							0.2	0.2	0.2	0.2
Minimum							0.2	0.2	0.2	0.2
STDev							0.0	0.0	0.0	0.0

Note: For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported <DL were considered the 0.5 X DL.

Table 17 Certified Laboratory Results of Haloacetic Acids

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Monochloroacetic acid (mcaa)	8/4/2011	grab	EPA 552.2	µg/L	0.32	2.0		<0.32				<0.32
Monochloroacetic acid (mcaa)	9/1/2011	grab	EPA 552.2	µg/L	0.32	2.0	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
Monochloroacetic acid (mcaa)	10/3/2011	grab	EPA 552.2	µg/L	0.32	2.0	<0.32		<0.32	<0.32	<0.32	<0.32
Monochloroacetic acid (mcaa)	10/4/2011	grab	EPA 552.2	µg/L	0.32	2.0		<0.32				
Monochloroacetic acid (mcaa)	11/2/2011	composite	EPA 552.2	µg/L	0.32	2.0	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
Monochloroacetic acid (mcaa)	12/1/2011	composite	EPA 552.2	µg/L	0.32	2.0	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
Monochloroacetic acid (mcaa)	1/3/2012	composite	EPA 552.2	µg/L	0.32	2.0	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
Monochloroacetic acid (mcaa)	2/1/2012	composite	EPA 552.2	µg/L	0.32	2.0	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
Monochloroacetic acid (mcaa)	3/6/2012	composite	EPA 552.2	µg/L	0.32	2.0	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
Monochloroacetic acid (mcaa)	4/2/2012	composite	EPA 552.2	µg/L	0.32	2.0	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
Monochloroacetic acid (mcaa)	5/1/2012	composite	EPA 552.2	µg/L	0.32	2.0	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
Monochloroacetic acid (mcaa)	6/4/2012	composite	EPA 552.2	µg/L	0.32	2.0	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
Monochloroacetic acid (mcaa)	7/2/2012	composite	EPA 552.2	µg/L	0.32	2.0	<0.32	<0.32			<0.32	<0.32
n =							11	12	10	10	11	12
Average							<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
Maximum							0.3	0.3	0.3	0.3	0.3	0.2
Minimum							0.2	0.2	0.2	0.2	0.2	0.2
STDev							0.1	0.1	0.1	0.1	0.1	0.0
Monobromoacetic acid (mbaa)	8/4/2011	grab	EPA 552.2	µg/L	0.21	1.0		<0.21				<0.21
Monobromoacetic acid (mbaa)	9/1/2011	grab	EPA 552.2	µg/L	0.21	1.0	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Monobromoacetic acid (mbaa)	10/3/2011	grab	EPA 552.2	µg/L	0.21	1.0	<0.21		<0.21	<0.21	<0.21	<0.21
Monobromoacetic acid (mbaa)	10/4/2011	grab	EPA 552.2	µg/L	0.21	1.0		<0.21				
Monobromoacetic acid (mbaa)	11/2/2011	composite	EPA 552.2	µg/L	0.21	1.0	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Monobromoacetic acid (mbaa)	12/1/2011	composite	EPA 552.2	µg/L	0.21	1.0	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Monobromoacetic acid (mbaa)	1/3/2012	composite	EPA 552.2	µg/L	0.21	1.0	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Monobromoacetic acid (mbaa)	2/1/2012	composite	EPA 552.2	µg/L	0.21	1.0	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Monobromoacetic acid (mbaa)	3/6/2012	composite	EPA 552.2	µg/L	0.21	1.0	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Monobromoacetic acid (mbaa)	4/2/2012	composite	EPA 552.2	µg/L	0.21	1.0	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Monobromoacetic acid (mbaa)	5/1/2012	composite	EPA 552.2	µg/L	0.21	1.0	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Monobromoacetic acid (mbaa)	6/4/2012	composite	EPA 552.2	µg/L	0.21	1.0	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Monobromoacetic acid (mbaa)	7/2/2012	composite	EPA 552.2	µg/L	0.21	1.0	<0.21	<0.21			<0.21	<0.21
n =							11	12	10	10	11	12
Average							<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
Maximum							0.2	0.2	0.2	0.2	0.2	0.2
Minimum							0.1	0.1	0.1	0.1	0.1	0.1
STDev							0.0	0.0	0.0	0.0	0.0	0.0

Table 17 Certified Laboratory Results of Haloacetic Acids

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Dichloroacetic acid (dcaa)	8/4/2011	grab	EPA 552.2	µg/L	0.41	1		5.8				<0.41
Dichloroacetic acid (dcaa)	9/1/2011	grab	EPA 552.2	µg/L	0.41	1	<0.41	<0.41	<0.41	<1	<0.41	<0.41
Dichloroacetic acid (dcaa)	10/3/2011	grab	EPA 552.2	µg/L	0.41	1	<0.41		<0.41	<0.41	<0.41	<0.41
Dichloroacetic acid (dcaa)	10/4/2011	grab	EPA 552.2	µg/L	0.41	1		7.1				
Dichloroacetic acid (dcaa)	11/2/2011	composite	EPA 552.2	µg/L	0.41	1	<0.41	8.1	<0.41	<0.41	<0.41	<0.41
Dichloroacetic acid (dcaa)	12/1/2011	composite	EPA 552.2	µg/L	0.41	1	<0.41	5.7	<0.41	<0.41	<0.41	<0.41
Dichloroacetic acid (dcaa)	1/3/2012	composite	EPA 552.2	µg/L	0.41	1	<0.41	5.4	<0.41	<0.41	<0.41	<0.41
Dichloroacetic acid (dcaa)	2/1/2012	composite	EPA 552.2	µg/L	0.41	1	<0.41	6.9	<0.41	<0.41	<0.41	<0.41
Dichloroacetic acid (dcaa)	3/6/2012	composite	EPA 552.2	µg/L	0.41	1	<0.41	7.3	<0.41	<0.41	<0.41	<0.41
Dichloroacetic acid (dcaa)	4/2/2012	composite	EPA 552.2	µg/L	0.41	1	<0.41	6.9	<0.41	<0.41	<0.41	<0.41
Dichloroacetic acid (dcaa)	5/1/2012	composite	EPA 552.2	µg/L	0.41	1	<0.41	5	<0.41	<0.41	<0.41	<0.41
Dichloroacetic acid (dcaa)	6/4/2012	composite	EPA 552.2	µg/L	0.41	1	<0.41	6.6	<0.41	<0.41	<0.41	<0.41
Dichloroacetic acid (dcaa)	7/2/2012	composite	EPA 552.2	µg/L	0.41	1	<0.41	6.4			<0.41	<0.41
n =							11	12	10	10	11	12
Average							<0.41	6	<0.41	<0.41	<0.41	<0.41
Maximum							0.2	8	0.2	0.5	0.2	0.2
Minimum							0.2	0.2	0.2	0.2	0.2	0.2
STDev							0.0	2	0.0	0.1	0.0	0.0
Trichloroacetic acid (tcaa)	8/4/2011	grab	EPA 552.2	µg/L	0.22	1.0		6.9				<0.22
Trichloroacetic acid (tcaa)	9/1/2011	grab	EPA 552.2	µg/L	0.22	1.0	1.2	1.7	<0.22	<0.22	<0.22	<0.22
Trichloroacetic acid (tcaa)	10/3/2011	grab	EPA 552.2	µg/L	0.22	1.0	1.6		<0.22	<0.22	<0.22	<0.22
Trichloroacetic acid (tcaa)	10/4/2011	grab	EPA 552.2	µg/L	0.22	1.0		2				
Trichloroacetic acid (tcaa)	11/2/2011	composite	EPA 552.2	µg/L	0.22	1.0	1.4	1.6	<0.22	<0.22	<0.22	<0.22
Trichloroacetic acid (tcaa)	12/1/2011	composite	EPA 552.2	µg/L	0.22	1.0	2.1	2.9	<0.22	<0.22	<0.22	<0.22
Trichloroacetic acid (tcaa)	1/3/2012	composite	EPA 552.2	µg/L	0.22	1.0	3.5	4.4	<0.22	<0.22	<0.22	<0.22
Trichloroacetic acid (tcaa)	2/1/2012	composite	EPA 552.2	µg/L	0.22	1.0	4.6	4.1	<0.22	<0.22	<0.22	<0.22
Trichloroacetic acid (tcaa)	3/6/2012	composite	EPA 552.2	µg/L	0.22	1.0	4.2	5.1	<0.22	<0.22	<0.22	<0.22
Trichloroacetic acid (tcaa)	4/2/2012	composite	EPA 552.2	µg/L	0.22	1.0	<0.22	3.4	<0.22	<0.22	<0.22	<0.22
Trichloroacetic acid (tcaa)	5/1/2012	composite	EPA 552.2	µg/L	0.22	1.0	2.3	2.9	<0.22	<0.22	<0.22	<0.22
Trichloroacetic acid (tcaa)	6/4/2012	composite	EPA 552.2	µg/L	0.22	1.0	1.4	3.2	<0.22	<0.22	<0.22	<0.22
Trichloroacetic acid (tcaa)	7/2/2012	composite	EPA 552.2	µg/L	0.22	1.0	2.5	3.4			<0.22	<0.22
n =							11	12	10	10	11	12
Average							2.3	3.5	<0.22	<0.22	<0.22	<0.22
Maximum							4.6	6.9	0.1	0.1	0.1	0.1
Minimum							0.1	1.6	0.1	0.1	0.1	0.1
STDev							1.4	1.5	0.0	0.0	0.0	0.0
Dibromoacetic acid (dbaa)	8/4/2011	grab	EPA 552.2	µg/L	0.13	1.0		<1				<0.13

Table 17 Certified Laboratory Results of Haloacetic Acids

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Dibromoacetic acid (dbaa)	9/1/2011	grab	EPA 552.2	µg/L	0.13	1.0	<0.13	<1	<0.13	<0.13	<0.13	<0.13
Dibromoacetic acid (dbaa)	10/3/2011	grab	EPA 552.2	µg/L	0.13	1.0	<0.13		<0.13	<0.13	<0.13	<0.13
Dibromoacetic acid (dbaa)	10/4/2011	grab	EPA 552.2	µg/L	0.13	1.0		<1				
Dibromoacetic acid (dbaa)	11/2/2011	composite	EPA 552.2	µg/L	0.13	1.0	<0.13	<1	<0.13	<0.13	<0.13	<0.13
Dibromoacetic acid (dbaa)	12/1/2011	composite	EPA 552.2	µg/L	0.13	1.0	<0.13	<1	<0.13	<0.13	<0.13	<0.13
Dibromoacetic acid (dbaa)	1/3/2012	composite	EPA 552.2	µg/L	0.13	1.0	<0.13	<1	<0.13	<0.13	<0.13	<0.13
Dibromoacetic acid (dbaa)	2/1/2012	composite	EPA 552.2	µg/L	0.13	1.0	<0.13	<1	<0.13	<0.13	<0.13	<0.13
Dibromoacetic acid (dbaa)	3/6/2012	composite	EPA 552.2	µg/L	0.13	1.0	<0.13	<1	<0.13	<0.13	<0.13	<0.13
Dibromoacetic acid (dbaa)	4/2/2012	composite	EPA 552.2	µg/L	0.13	1.0	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13
Dibromoacetic acid (dbaa)	5/1/2012	composite	EPA 552.2	µg/L	0.13	1.0	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13
Dibromoacetic acid (dbaa)	6/4/2012	composite	EPA 552.2	µg/L	0.13	1.0	<0.13	1.3	<0.13	<0.13	<0.13	<0.13
Dibromoacetic acid (dbaa)	7/2/2012	composite	EPA 552.2	µg/L	0.13	1.0	<0.13	1.1			<0.13	<0.13
n =							11	12	10	10	11	12
Average							<0.13	<1	<0.13	<0.13	<0.13	<0.13
Maximum							0.1	1	0.1	0.1	0.1	0.1
Minimum							0.1	0.1	0.1	0.1	0.1	0.1
STDev							0.0	0.3	0.0	0.0	0.0	0.0
HAA5, Total	8/4/2011	grab	EPA 552.2	µg/L	NA	1.0		13				<1
HAA5, Total	9/1/2011	grab	EPA 552.2	µg/L	NA	1.0	1.2	1.7	<1	<1	<1	<1
HAA5, Total	10/3/2011	Grab	EPA 552.2	µg/L	NA	1.0	1.6		<1	<1	<1	<1
HAA5, Total	10/4/2011	Grab	EPA 552.2	µg/L	NA	1.0		9.1				
HAA5, Total	11/2/2011	composite	EPA 552.2	µg/L	NA	1.0	1.4	9.7	<1	<1	<1	<1
HAA5, Total	12/1/2011	composite	EPA 552.2	µg/L	NA	1.0	2.1	8.6	<1	<1	<1	<1
HAA5, Total	1/3/2012	composite	EPA 552.2	µg/L	NA	1.0	3.5	9.8	<1	<1	<1	<1
HAA5, Total	2/1/2012	composite	EPA 552.2	µg/L	NA	1.0	4.6	11	<1	<1	<1	<1
HAA5, Total	3/6/2012	composite	EPA 552.2	µg/L	NA	1.0	4.2	12	<1	<1	<1	<1
HAA5, Total	4/2/2012	composite	EPA 552.2	µg/L	NA	1.0	<1	10	<1	<1	<1	<1
HAA5, Total	5/1/2012	composite	EPA 552.2	µg/L	NA	1.0	2.3	7.8	<1	<1	<1	<1
HAA5, Total	6/4/2012	composite	EPA 552.2	µg/L	NA	1.0		11	<1	<1	<1	<1
HAA5, Total	7/2/2012	composite	EPA 552.2	µg/L	NA	1.0	2.5	11			<1	<1
n =							11	12	10	10	11	12
Average							2.3	9.6	<1	<1	<1	<1
Maximum							4.6	13	0.5	0.5	0.5	0.5
Minimum							0.0	1.7	0.0	0.0	0.0	0.0
STDev							1.4	2.9	0.0	0.0	0.0	0.0

Note: For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported below the DL were considered the 0.5 X DL.

Table 18 Certified Laboratory Results of Nitrosamines

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
N-Nitrosodiethylamine (NDEA)	8/1/2011	grab	EPA 521	ng/L	0.72	2.0		<0.72	<0.72	<0.72	<0.72	<0.72
N-Nitrosodiethylamine (NDEA)	9/1/2011	grab	EPA 521	ng/L	0.72	2.0	<2	<2	<2	<0.72	<2	<0.72
N-Nitrosodiethylamine (NDEA)	10/3/2011	grab	EPA 521	ng/L	0.72	2.0	<0.72	<2	<0.72	<0.72	<0.72	<0.72
N-Nitrosodiethylamine (NDEA)	11/2/2011	grab	EPA 521	ng/L	0.72	2.0	<2.3	<0.72	<0.72	6.1	<0.72	<0.72
N-Nitrosodiethylamine (NDEA)	12/1/2011	grab	EPA 521	ng/L	0.72	2.0	<2	2.6	<0.72	<0.72	<0.72	2.5
N-Nitrosodiethylamine (NDEA)	1/3/2012	grab	EPA 521	ng/L	0.72	2.0	11	7.9	<2	<0.72	<2	2.9
N-Nitrosodiethylamine (NDEA)	2/1/2012	grab	EPA 521	ng/L	0.72	2.0	<2	<2	<0.72	<2	<2	<2
N-Nitrosodiethylamine (NDEA)	2/8/2012	grab	EPA 521	ng/L	0.72	2.0	<2	<0.72			<2	<2
N-Nitrosodiethylamine (NDEA)	2/15/2012	grab	EPA 521	ng/L	0.72	2.0	<0.72	<2			<0.72	<0.72
N-Nitrosodiethylamine (NDEA)	2/22/2012	grab	EPA 521	ng/L	0.72	2.0	<0.72	3.4			<2	<0.72
N-Nitrosodiethylamine (NDEA)	3/6/2012	grab	EPA 521	ng/L	0.72	2.0	<0.72	<2		<0.72	<0.72	<0.72
N-Nitrosodiethylamine (NDEA)	4/2/2012	grab	EPA 521	ng/L	0.72	2.0	<2	<2	<0.72	<0.72		
N-Nitrosodiethylamine (NDEA)	4/23/2012	grab	EPA 521	ng/L	0.72	2.0					<2	4.9
N-Nitrosodiethylamine (NDEA)	5/1/2012	grab	EPA 521	ng/L	0.72	2.0	<2	<0.72	<0.72	<0.72	<0.72	<0.72
N-Nitrosodiethylamine (NDEA)	6/4/2012	grab	EPA 521	ng/L	0.72	2.0	<0.72	<0.8	<0.72	<0.72	<0.72	<0.72
N-Nitrosodiethylamine (NDEA)	7/2/2012	grab	EPA 521	ng/L	0.72	2.0	<0.72	<0.72			<0.72	<0.72
n =							14	15	11	11	15	15
Average							<2	<2	<0.72	<2	<0.72	<2
Maximum							11	7.9	1.0	6.1	1.0	4.9
Minimum							0.40	0.40	0.1	0.40	0.40	0.40
STDev							2.8	2.0	0.30	1.7	0.30	1.3
N-Nitrosodimethylamine (NDMA)	8/1/2011	grab	EPA 521	ng/L	0.28	2.0		3.8	<2	<2	<2	<0.28
N-Nitrosodimethylamine (NDMA)	9/1/2011	grab	EPA 521	ng/L	0.28	2.0	3.6	6.3	<2	2.6	<2	<2
N-Nitrosodimethylamine (NDMA)	10/3/2011	grab	EPA 521	ng/L	0.28	2.0	<2	6.1	<2	<2	<2	<2
N-Nitrosodimethylamine (NDMA)	10/18/2011	grab	EPA 521	ng/L	0.28	2.0						
N-Nitrosodimethylamine (NDMA)	11/2/2011	grab	EPA 521	ng/L	0.28	2.0	3.2	2.3	ND	<2	ND	<0.28
N-Nitrosodimethylamine (NDMA)	12/1/2011	grab	EPA 521	ng/L	0.28	2.0	2.1	2.1	<2	2.3	<2	<0.28
N-Nitrosodimethylamine (NDMA)	1/3/2012	grab	EPA 521	ng/L	0.28	2.0	7.6	<2	<2	<2	<2	5.5
N-Nitrosodimethylamine (NDMA)	2/1/2012	grab	EPA 521	ng/L	0.28	2.0	<2	2.9	<2	<2	ND	<2
N-Nitrosodimethylamine (NDMA)	2/8/2012	grab	EPA 521	ng/L	0.28	2.0		<2			<2	<0.28
N-Nitrosodimethylamine (NDMA)	2/15/2012	grab	EPA 521	ng/L	0.28	2.0		<2			<2	<2
N-Nitrosodimethylamine (NDMA)	2/22/2012	grab	EPA 521	ng/L	0.28	2.0		<2			<2	<2
N-Nitrosodimethylamine (NDMA)	3/6/2012	grab	EPA 521	ng/L	0.28	2.0	<2	<2		<2	<2	<0.28
N-Nitrosodimethylamine (NDMA)	4/2/2012	grab	EPA 521	ng/L	0.28	2.0	20	17	7.9	8.7		
N-Nitrosodimethylamine (NDMA)	4/23/2012	grab	EPA 521	ng/L	0.28	2.0					ND	<0.28
N-Nitrosodimethylamine (NDMA)	5/1/2012	grab	EPA 521	ng/L	0.28	2.0						<2

Table 18 Certified Laboratory Results of Nitrosamines

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
N-Nitrosodimethylamine (NDMA)	6/4/2012	grab	EPA 521	ng/L	0.28	2.0	<2	<2.2	<0.28	<2	<0.28	<0.28
N-Nitrosodimethylamine (NDMA)	7/2/2012	grab	EPA 521	ng/L	0.28	2.0	<2	<2			<2	<2
n =							10	14	9	10	14	15
Average							4.2	3.5	<2.0	2.1	<2.0	<2.0
Maximum							20	17	7.9	8.7	2.0	5.5
Minimum							1.0	1.0	0.10	1.0	0.10	0.10
STDev							5.9	4.3	2.4	2.4	0.60	1.3
N-Nitrosodi-n-butylamine (NDBA)	8/1/2011	grab	EPA 521	ng/L	0.59	2.0		<2	<0.59	<0.59	<0.59	<0.59
N-Nitrosodi-n-butylamine (NDBA)	9/1/2011	grab	EPA 521	ng/L	0.59	2.0	<0.59	<2	<0.59	<0.59	<0.59	<0.59
N-Nitrosodi-n-butylamine (NDBA)	10/3/2011	grab	EPA 521	ng/L	0.59	2.0	<0.59	<2	<0.59	<0.59	<0.59	<0.59
N-Nitrosodi-n-butylamine (NDBA)	11/2/2011	grab	EPA 521	ng/L	0.59	2.0	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
N-Nitrosodi-n-butylamine (NDBA)	12/1/2011	grab	EPA 521	ng/L	0.59	2.0	<2	<0.59	<0.59	<0.59	<2	<0.59
N-Nitrosodi-n-butylamine (NDBA)	1/3/2012	grab	EPA 521	ng/L	0.59	2.0	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
N-Nitrosodi-n-butylamine (NDBA)	2/1/2012	grab	EPA 521	ng/L	0.59	2.0	<0.59	<0.59	<2	<0.59	<0.59	<2
N-Nitrosodi-n-butylamine (NDBA)	2/8/2012	grab	EPA 521	ng/L	0.59	2.0		<0.59			<2	<0.59
N-Nitrosodi-n-butylamine (NDBA)	2/15/2012	grab	EPA 521	ng/L	0.59	2.0		<0.59			<0.59	<0.59
N-Nitrosodi-n-butylamine (NDBA)	2/22/2012	grab	EPA 521	ng/L	0.59	2.0		<0.59			<0.59	<0.59
N-Nitrosodi-n-butylamine (NDBA)	3/6/2012	grab	EPA 521	ng/L	0.59	2.0	<0.59	<0.59		<0.59	<0.59	<0.59
N-Nitrosodi-n-butylamine (NDBA)	4/2/2012	grab	EPA 521	ng/L	0.59	2.0	<0.59	<0.59	<0.59	<0.59		
N-Nitrosodi-n-butylamine (NDBA)	4/23/2012	grab	EPA 521	ng/L	0.59	2.0					<0.59	<0.59
N-Nitrosodi-n-butylamine (NDBA)	5/1/2012	grab	EPA 521	ng/L	0.59	2.0	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
N-Nitrosodi-n-butylamine (NDBA)	6/4/2012	grab	EPA 521	ng/L	0.59	2.0	<0.59	<2.2	<0.59	<2	<0.59	<2
N-Nitrosodi-n-butylamine (NDBA)	7/2/2012	grab	EPA 521	ng/L	0.59	2.0	<0.59	<0.59			<0.59	<0.59
n =							11	15	10	11	15	15
Average							<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
Maximum							1.0	1.1	1.0	1.0	1.0	1.0
Minimum							0.3	0.3	0.3	0.3	0.3	0.3
STDev							0.2	0.3	0.2	0.2	0.2	0.2

Table 18 Certified Laboratory Results of Nitrosamines

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
N-Nitrosodi-n-propylamine (NDPA)	8/1/2011	grab	EPA 521	ng/L	0.35	2.0		<0.35	<0.35	<0.35	<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	9/1/2011	grab	EPA 521	ng/L	0.35	2.0	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	10/3/2011	grab	EPA 521	ng/L	0.35	2.0	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	11/2/2011	grab	EPA 521	ng/L	0.35	2.0	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	12/1/2011	grab	EPA 521	ng/L	0.35	2.0	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	1/3/2012	grab	EPA 521	ng/L	0.35	2.0	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	2/1/2012	grab	EPA 521	ng/L	0.35	2.0	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	2/8/2012	grab	EPA 521	ng/L	0.35	2.0		<0.35			<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	2/15/2012	grab	EPA 521	ng/L	0.35	2.0		<0.35			<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	2/22/2012	grab	EPA 521	ng/L	0.35	2.0		<0.35			<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	3/6/2012	grab	EPA 521	ng/L	0.35	2.0	<0.35	<0.35		<0.35	<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	4/2/2012	grab	EPA 521	ng/L	0.35	2.0	<0.35	<0.35	<0.35	<0.35		
N-Nitrosodi-n-propylamine (NDPA)	4/23/2012	grab	EPA 521	ng/L	0.35	2.0					<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	5/1/2012	grab	EPA 521	ng/L	0.35	2.0	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	6/4/2012	grab	EPA 521	ng/L	0.35	2.0	<0.35	<0.39	<0.35	<0.35	<0.35	<0.35
N-Nitrosodi-n-propylamine (NDPA)	7/2/2012	grab	EPA 521	ng/L	0.35	2.0	<0.35	<0.35			<0.35	<0.35
n =							11	15	10	11	15	15
Average							<0.35	<0.35	<0.35	<0.35	<0.35	<0.35
Maximum							0.2	0.2	0.2	0.2	0.2	0.2
Minimum							0.2	0.2	0.2	0.2	0.2	0.2
STDev							0.0	0.0	0.0	0.0	0.0	0.0
N-Nitrosomethylethylamine (NMEA)	8/1/2011	grab	EPA 521	ng/L	0.28	2.0		<0.28	<0.28	<0.28	<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	9/1/2011	grab	EPA 521	ng/L	0.28	2.0	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	10/3/2011	grab	EPA 521	ng/L	0.28	2.0	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	11/2/2011	grab	EPA 521	ng/L	0.28	2.0	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	12/1/2011	grab	EPA 521	ng/L	0.28	2.0	<2	<0.28	<0.28	<2	<0.28	<2
N-Nitrosomethylethylamine (NMEA)	1/3/2012	grab	EPA 521	ng/L	0.28	2.0	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	2/1/2012	grab	EPA 521	ng/L	0.28	2.0	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	2/8/2012	grab	EPA 521	ng/L	0.28	2.0		<0.28			<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	2/15/2012	grab	EPA 521	ng/L	0.28	2.0		<0.28			<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	2/22/2012	grab	EPA 521	ng/L	0.28	2.0		<0.28			<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	3/6/2012	grab	EPA 521	ng/L	0.28	2.0	<0.28	<0.28		<0.28	<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	4/2/2012	grab	EPA 521	ng/L	0.28	2.0	<0.28	<0.28	<0.28	<0.28		
N-Nitrosomethylethylamine (NMEA)	4/23/2012	grab	EPA 521	ng/L	0.28	2.0					<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	5/1/2012	grab	EPA 521	ng/L	0.28	2.0	<0.28	<0.28	<0.28	<0.28	<0.28	<0.28
N-Nitrosomethylethylamine (NMEA)	6/4/2012	grab	EPA 521	ng/L	0.28	2.0	<0.28	<0.31	<0.28	<0.28	<0.28	<0.28

Table 18 Certified Laboratory Results of Nitrosamines

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
N-Nitrosomethylethylamine (NMEA)	7/2/2012	grab	EPA 521	ng/L	0.28	2.0	<0.28	<0.28			<0.28	<0.28
n =							11	15	10	11	15	15
Average							<0.28	<0.28	<0.28	<0.28	<0.28	<0.28
Maximum							1.0	0.2	0.2	1.0	0.2	1.0
Minimum							0.1	0.1	0.1	0.1	0.1	0.1
STDev							0.3	0.0	0.0	0.3	0.0	0.2
N-Nitrosomorpholine (NMOR)	8/1/2011	grab	EPA 521	ng/L	0.47	2.0		20	<0.47	<2	<2	<0.47
N-Nitrosomorpholine (NMOR)	9/1/2011	grab	EPA 521	ng/L	0.47	2.0	25	23	<0.47	<0.47	<2	<0.47
N-Nitrosomorpholine (NMOR)	10/3/2011	grab	EPA 521	ng/L	0.47	2.0	17	21	<0.47	<2	<2	<0.47
N-Nitrosomorpholine (NMOR)	11/2/2011	grab	EPA 521	ng/L	0.47	2.0	25	25	<2.2	<2	<2.3	<0.47
N-Nitrosomorpholine (NMOR)	12/1/2011	grab	EPA 521	ng/L	0.47	2.0	23	19	<2	<2	<2	<0.47
N-Nitrosomorpholine (NMOR)	1/3/2012	grab	EPA 521	ng/L	0.47	2.0	17	14	<0.47	<0.47	<0.47	<0.47
N-Nitrosomorpholine (NMOR)	2/1/2012	grab	EPA 521	ng/L	0.47	2.0	28	28	<2	<2	<2	<2
N-Nitrosomorpholine (NMOR)	2/8/2012	grab	EPA 521	ng/L	0.47	2.0		34			<2	<0.47
N-Nitrosomorpholine (NMOR)	2/15/2012	grab	EPA 521	ng/L	0.47	2.0		17			<0.47	<0.47
N-Nitrosomorpholine (NMOR)	2/22/2012	grab	EPA 521	ng/L	0.47	2.0		22			<0.47	<0.47
N-Nitrosomorpholine (NMOR)	3/6/2012	grab	EPA 521	ng/L	0.47	2.0	26	30		<2	<2	<0.47
N-Nitrosomorpholine (NMOR)	4/2/2012	grab	EPA 521	ng/L	0.47	2.0	8.8	7.7	<2	<2		
N-Nitrosomorpholine (NMOR)	4/23/2012	grab	EPA 521	ng/L	0.47	2.0					<2	<0.47
N-Nitrosomorpholine (NMOR)	5/1/2012	grab	EPA 521	ng/L	0.47	2.0	15	13	<2	<0.47	<2	<0.47
N-Nitrosomorpholine (NMOR)	6/4/2012	grab	EPA 521	ng/L	0.47	2.0	19	23	<2	<2	<2	<0.47
N-Nitrosomorpholine (NMOR)	7/2/2012	grab	EPA 521	ng/L	0.47	2.0	12	14			<2	<0.47
n =							11	15	10	11	15	15
Average							20	21	<2.0	<2.0	<2.0	<0.47
Maximum							28	34	1.1	1.0	1.2	1.0
Minimum							8.8	7.7	0.2	0.2	0.2	0.2
STDev							6.3	7.0	0.4	0.4	0.3	0.2
N-Nitrosopiperidine (NPIP)	8/1/2011	grab	EPA 521	ng/L	0.71	2.0		<0.71	<0.71	<0.71	<0.71	<0.71
N-Nitrosopiperidine (NPIP)	9/1/2011	grab	EPA 521	ng/L	0.71	2.0	<0.71	<0.71	<0.71	<0.71	<0.71	<0.71
N-Nitrosopiperidine (NPIP)	10/3/2011	grab	EPA 521	ng/L	0.71	2.0	<0.71	<0.71	<0.71	<0.71	<0.71	<0.71
N-Nitrosopiperidine (NPIP)	11/2/2011	grab	EPA 521	ng/L	0.71	2.0	<0.71	<0.71	<0.71	<0.71	<0.71	<0.71
N-Nitrosopiperidine (NPIP)	12/1/2011	grab	EPA 521	ng/L	0.71	2.0	<0.71	<0.71	<0.71	<0.71	<0.71	<0.71
N-Nitrosopiperidine (NPIP)	1/3/2012	grab	EPA 521	ng/L	0.71	2.0	<0.71	<0.71	<0.71	<0.71	<0.71	<0.71
N-Nitrosopiperidine (NPIP)	2/1/2012	grab	EPA 521	ng/L	0.71	2.0	<0.71	<0.71	<0.71	<0.71	<0.71	<0.71
N-Nitrosopiperidine (NPIP)	2/8/2012	grab	EPA 521	ng/L	0.71	2.0		<0.71			<0.71	<0.71
N-Nitrosopiperidine (NPIP)	2/15/2012	grab	EPA 521	ng/L	0.71	2.0		<0.71			<0.71	<0.71
N-Nitrosopiperidine (NPIP)	2/22/2012	grab	EPA 521	ng/L	0.71	2.0		<0.71			<0.71	<0.71

Table 18 Certified Laboratory Results of Nitrosamines

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
N-Nitrosopiperidine (NPIP)	3/6/2012	grab	EPA 521	ng/L	0.71	2.0	<0.71	<0.71		<0.71	<0.71	<0.71
N-Nitrosopiperidine (NPIP)	4/2/2012	grab	EPA 521	ng/L	0.71	2.0	<0.71	<0.71	<0.71	<0.71		
N-Nitrosopiperidine (NPIP)	4/23/2012	grab	EPA 521	ng/L	0.71	2.0					<0.71	<0.71
N-Nitrosopiperidine (NPIP)	5/1/2012	grab	EPA 521	ng/L	0.71	2.0	<0.71	<0.71	<0.71	<0.71	<0.71	<0.71
N-Nitrosopiperidine (NPIP)	6/4/2012	grab	EPA 521	ng/L	0.71	2.0	<0.71	<0.79	<0.71	<0.71	<0.71	<0.71
N-Nitrosopiperidine (NPIP)	7/2/2012	grab	EPA 521	ng/L	0.71	2.0	<0.71	<0.71			<0.71	<0.71
n =							11	15	10	11	15	15
Average							<0.71	<0.71	<0.71	<0.71	<0.71	<0.71
Maximum							0.4	0.4	0.4	0.4	0.4	0.4
Minimum							0.4	0.4	0.4	0.4	0.4	0.4
STDev							0.0	0.0	0.0	0.0	0.0	0.0
N-Nitrosopyrrolidine (NPYR)	8/1/2011	grab	EPA 521	ng/L	0.66	2.0		<0.66	<0.66	<0.66	<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	9/1/2011	grab	EPA 521	ng/L	0.66	2.0	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	10/3/2011	grab	EPA 521	ng/L	0.66	2.0	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	11/2/2011	grab	EPA 521	ng/L	0.66	2.0	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	12/1/2011	grab	EPA 521	ng/L	0.66	2.0	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	1/3/2012	grab	EPA 521	ng/L	0.66	2.0	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	2/1/2012	grab	EPA 521	ng/L	0.66	2.0	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	2/8/2012	grab	EPA 521	ng/L	0.66	2.0		<0.66			<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	2/15/2012	grab	EPA 521	ng/L	0.66	2.0		<0.66			<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	2/22/2012	grab	EPA 521	ng/L	0.66	2.0		<0.66			<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	3/6/2012	grab	EPA 521	ng/L	0.66	2.0	<0.66	<0.66		<0.66	<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	4/2/2012	grab	EPA 521	ng/L	0.66	2.0	<2	<0.66	<0.66	<0.66		
N-Nitrosopyrrolidine (NPYR)	4/23/2012	grab	EPA 521	ng/L	0.66	2.0					<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	5/1/2012	grab	EPA 521	ng/L	0.66	2.0	<0.66	<0.66	<0.66	<0.66	<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	6/4/2012	grab	EPA 521	ng/L	0.66	2.0	<2	<2.2	<0.66	<0.66	<0.66	<0.66
N-Nitrosopyrrolidine (NPYR)	7/2/2012	grab	EPA 521	ng/L	0.66	2.0	<0.66	<0.66			<0.66	<0.66
n =							11	15	10	11	15	15
Average							<0.66	<0.66	<0.66	<0.66	<0.66	<0.66
Maximum							1.0	1.1	0.4	0.3	0.4	0.3
Minimum							0.3	0.3	0.3	0.3	0.3	0.3
STDev							0.3	0.2	0.0	0.0	0.0	0.0

Note: For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported <DL were considered the 0.5 X DL.

Table 19 Certified Laboratory Results of 1,4-Dioxane

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
1,4-Dioxane	8/1/2011	grab	EPA 8270M	µg/L	0.040	0.50	1.9			<0.040	<0.040
1,4-Dioxane	9/1/2011	grab	EPA 8270M	µg/L	0.040	0.50	1.6	<0.040	<0.040	<0.040	<0.040
1,4-Dioxane	10/3/2011	grab	EPA 8270M	µg/L	0.040	0.50	1.8	<0.040	<0.040	<0.040	<0.040
1,4-Dioxane	11/2/2011	composite	EPA 8270M	µg/L	0.040	0.50	1.0	<0.040	<0.040	<0.040	<0.040
1,4-Dioxane	12/1/2011	composite	EPA 8270M	µg/L	0.040	0.50	1.2	<0.040	<0.5	<0.5	<0.040
1,4-Dioxane	1/3/2012	composite	EPA 8270M	µg/L	0.040	0.50	1.3	<0.040	<0.5	<0.040	<0.040
1,4-Dioxane	2/1/2012	composite	EPA 8270M	µg/L	0.040	0.50	1.2	<0.040	<0.040	<0.5	<0.040
1,4-Dioxane	3/6/2012	composite	EPA 8270M	µg/L	0.040	0.50	1.4	<0.040	<0.040	<0.040	<0.040
1,4-Dioxane	4/2/2012	composite	EPA 8270M	µg/L	0.040	0.50	1.4	<0.040	<0.040	<0.040	<0.046
1,4-Dioxane	5/1/2012	composite	EPA 8270M	µg/L	0.040	0.50	1.5	<0.04	<0.04	<0.04	<0.04
1,4-Dioxane	6/4/2012	composite	EPA 8270M	µg/L	0.040	0.50	1.3			<0.04	<0.04
1,4-Dioxane	7/2/2012	composite	EPA 8270M	µg/L	0.040	0.50				<0.04	<0.04
n =							11	9	9	12	12
Average							1.4	<0.040	<0.50	<0.50	<0.040
Maximum							1.9	0.02	0.25	0.25	0.03
Minimum							1.0	0.02	0.02	0.02	0.02
STDev							0.27	0.00	0.10	0.09	0.00

Note: For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported <DL were considered the 0.5 X DL.

Table 20 Certified Laboratory Results of Total Organic Carbon (TOC)

Parameter	Sample Date	[1] Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Total Organic Carbon (TOC)	8/1/2011	grab	SM5310C	mg/l	0.009	0.3	6		0.31		0.35
Total Organic Carbon (TOC)	8/4/2011	grab	SM5310C	mg/l	0.009	0.3		0.46		<0.3	<0.3
Total Organic Carbon (TOC)	8/8/2011	grab	SM5310C	mg/l	0.009	0.3					0.45
Total Organic Carbon (TOC)	8/11/2011	grab	SM5310C	mg/l	0.009	0.3					0.45
Total Organic Carbon (TOC)	8/15/2011	grab	SM5310C	mg/l	0.009	0.3					0.9
Total Organic Carbon (TOC)	8/18/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	8/22/2011	grab	SM5310C	mg/l	0.009	0.3					0.66
Total Organic Carbon (TOC)	8/25/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	8/29/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	9/1/2011	grab	SM5310C	mg/l	0.009	0.3	7.2	<0.3	0.34	0.31	0.32
Total Organic Carbon (TOC)	9/6/2011	grab	SM5310C	mg/l	0.009	0.3					0.41
Total Organic Carbon (TOC)	9/8/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	9/12/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	9/15/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	9/19/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	9/22/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	9/26/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	9/29/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	10/3/2011	grab	SM5310C	mg/l	0.009	0.3		<0.3	<0.3	<0.009	<0.3
Total Organic Carbon (TOC)	10/4/2011	grab	SM5310C	mg/l	0.009	0.3	5				
Total Organic Carbon (TOC)	10/6/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	10/10/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	10/13/2011	grab	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	10/17/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	10/20/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	10/24/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	10/31/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	11/2/2011	composite	SM5310C	mg/l	0.009	0.3	4.3	<0.3	<0.3	<0.3	
Total Organic Carbon (TOC)	11/3/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	11/7/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	11/10/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	11/14/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3

Table 20 Certified Laboratory Results of Total Organic Carbon (TOC)

Parameter	Sample Date	[1] Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Total Organic Carbon (TOC)	11/17/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	11/21/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	11/29/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	12/1/2011	composite	SM5310C	mg/l	0.009	0.3	5.8	<0.3	<0.3	<0.3	<0.3
Total Organic Carbon (TOC)	12/5/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	12/8/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	12/12/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	12/15/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	12/19/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	12/22/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	12/27/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	12/29/2011	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	1/3/2012	composite	SM5310C	mg/l	0.009	0.3	6.5	<0.3	<0.3	<0.3	<0.3
Total Organic Carbon (TOC)	1/5/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	1/9/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	1/12/2012	composite	SM5310C	mg/l	0.009	0.3					[2] 1.4
Total Organic Carbon (TOC)	1/17/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	1/19/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	1/23/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	1/26/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	1/30/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	2/1/2012	composite	SM5310C	mg/l	0.018	0.6	5.8	<0.3	<0.3	<0.3	
Total Organic Carbon (TOC)	2/2/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	2/6/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	2/9/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	2/14/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	2/16/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	2/20/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	2/22/2012	composite	SM5310C	mg/l	0.009	0.3	6.4			<0.3	<0.3
Total Organic Carbon (TOC)	2/23/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	2/27/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	3/1/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3

Table 20 Certified Laboratory Results of Total Organic Carbon (TOC)

Parameter	Sample Date	[1] Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Total Organic Carbon (TOC)	3/6/2012	composite	SM5310C	mg/l	0.009	0.3	6	<0.3	<0.3	<0.3	<0.3
Total Organic Carbon (TOC)	3/8/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	3/12/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	3/15/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	3/19/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	3/22/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	3/26/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	3/29/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	4/2/2012	composite	SM5310C	mg/l	0.009	0.3	7	<0.3	<0.3	<0.3	<0.3
Total Organic Carbon (TOC)	4/5/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	4/9/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	4/12/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	4/16/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	4/23/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	4/26/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	5/1/2012	composite	SM5310C	mg/l	0.009	0.3	5.3	<0.3	<0.3	<0.3	<0.3
Total Organic Carbon (TOC)	5/3/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	5/7/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	5/14/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	5/21/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	5/24/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	5/29/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	5/31/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	6/4/2012	composite	SM5310C	mg/l	0.009	0.3	4.3	<0.3	<0.3	<0.3	<0.3
Total Organic Carbon (TOC)	6/11/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	6/21/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	6/28/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	7/2/2012	composite	SM5310C	mg/l	0.009	0.3				<0.3	<0.3
Total Organic Carbon (TOC)	7/5/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	7/9/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	7/12/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	7/16/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3

Table 20 Certified Laboratory Results of Total Organic Carbon (TOC)

Parameter	Sample Date	[1] Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Total Organic Carbon (TOC)	7/19/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	7/23/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	7/26/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
Total Organic Carbon (TOC)	7/30/2012	composite	SM5310C	mg/l	0.009	0.3					<0.3
n =							12	11	11	16	97
[3] Average							6	<0.3	<0.3	<0.3	<0.3
Maximum							7	0.5	0.3	0.3	1
Minimum							4	0.2	0.2	0.0	0.2
STDev							0.9	0.1	0.1	0.1	0.2

Note:

1. The result of 1.4 mg/L was determined to be an outlier and is not representative of the TOC concentration consistently measured in the UV/AOP product water. TOC measured online upstream of the UV/AOP system on the day of the sampling event was below 0.07 mg/L.

2. All S7 and S8 samples were grab samples.

3. For purposes of calculating statistical parameters, results reported below the RL were considered 0.5 X RL and results reported ND were considered the DL.

Table 21 Certified Laboratory Results of Total and Fecal Coliform

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S4 (MF Filtrate)	S5 (UF Filtrate)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S10 (UV/AOP Product)
Total Coliform	8/2/2011	grab	[1]SM 9223B	NA	1	1	Present	<1	<1	<1	<1	<1	<1
E. coli	8/2/2011	grab	[1]SM 9223B	NA	1	1	Present	<1	<1	<1	<1	<1	<1
Total Coliform	8/3/2011	grab	[1]SM 9223B	NA	1	1	Present	<1	<1	<1	<1	<1	<1
E. coli	8/3/2011	grab	[1]SM 9223B	NA	1	1	Present	<1	<1	<1	<1	<1	<1
Total Coliform	8/4/2011	grab	[1]SM 9223B	NA	1	1	Present	<1	<1	<1	<1	<1	<1
E. coli	8/4/2011	grab	[1]SM 9223B	NA	1	1	Present	<1	<1	<1	<1	<1	<1
Total Coliform	8/8/2011	grab	[1]SM 9223B	NA	1	1	Present	<1	<1	<1	<1	<1	<1
E. coli	8/8/2011	grab	[1]SM 9223B	NA	1	1	Present	<1	<1	<1	<1	<1	<1
Total Coliform	8/9/2011	grab	[1]SM 9223B	NA	1	1	Present	<1	<1	<1	<1	<1	<1
E. coli	8/9/2011	grab	[1]SM 9223B	NA	1	1	Present	<1	<1	<1	<1	<1	<1
Total Coliform	8/10/2011	grab	[1]SM 9223B	NA	1	1	>2419.6	<1	<1	<1	<1	1	<1
E. coli	8/10/2011	grab	[1]SM 9223B	NA	1	1	>2419.6	<1	<1	<1	<1	<1	<1
Total Coliform	8/11/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/11/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/12/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	5.1	<1.1	<1.1	<1.1
Fecal Coliform	8/12/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/15/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	9000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/15/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1700	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/16/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	17000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/16/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/17/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	11000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/17/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1700	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/18/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/18/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/19/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/19/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/22/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/22/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	900	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/23/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2200	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/23/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2200	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/24/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	9000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1

Table 21 Certified Laboratory Results of Total and Fecal Coliform

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S4 (MF Filtrate)	S5 (UF Filtrate)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S10 (UV/AOP Product)
Fecal Coliform	8/24/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/25/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/25/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1600	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/26/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	30000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/26/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	530	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/30/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/30/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/31/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	50000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/31/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/29/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	17000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/29/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	7000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	8/31/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	50000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	8/31/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/1/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	2.2	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/1/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/2/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/2/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/6/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1600	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/6/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	900	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/8/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/8/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/12/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	1.1	<1.1	<1.1	1.1	<1.1
Fecal Coliform	9/12/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1100	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/13/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	3.6	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/13/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/14/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	22000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/14/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/15/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/15/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	11000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/16/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/16/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	9000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/19/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1

Table 21 Certified Laboratory Results of Total and Fecal Coliform

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S4 (MF Filtrate)	S5 (UF Filtrate)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S10 (UV/AOP Product)
Fecal Coliform	9/19/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	900	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/20/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	9000	<1.1	<1.1	<1.1	<1.1	1.1	<1.1
Fecal Coliform	9/20/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2200	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/21/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/21/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/22/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/22/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	900	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/23/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/23/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1600	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/26/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1700	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/26/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	900	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	10/3/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1600	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	10/3/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	240	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	10/10/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1100	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	10/10/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	700	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	10/17/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	10/17/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	10/24/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	10/24/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	10/31/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1600	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	10/31/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	11/7/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	11/7/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	240	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	11/15/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	11/15/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	700	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	11/21/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	11/21/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	11/29/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	330	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	11/29/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	80	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	12/6/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1700	<1.1	<1.1	<1.1	<1.1	1.1	<1.1
Fecal Coliform	12/6/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	170	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	12/12/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2200	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1

Table 21 Certified Laboratory Results of Total and Fecal Coliform

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S4 (MF Filtrate)	S5 (UF Filtrate)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S10 (UV/AOP Product)
Fecal Coliform	12/12/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	12/19/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	12/19/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	80	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	12/27/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	12/27/2011	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1600	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	1/3/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	1/3/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	1/9/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	1/9/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	1/18/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	1/18/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	300	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	1/23/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	700	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	1/23/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	240	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	1/30/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	1/30/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	2/2/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	2/2/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	2/6/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	2/6/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	300	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	2/9/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	2/9/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	2/14/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	2/14/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	300	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	2/16/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	2/16/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	2/20/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1600	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	2/20/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	300	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	2/23/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	2/23/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	2/27/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1700	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	2/27/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	900	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	3/1/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1

Table 21 Certified Laboratory Results of Total and Fecal Coliform

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S4 (MF Filtrate)	S5 (UF Filtrate)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S10 (UV/AOP Product)
Fecal Coliform	3/1/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	3/6/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1700	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	3/6/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	3/8/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	3/8/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	3/12/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2800	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	3/12/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	700	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	3/15/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	3/15/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	3/19/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	3/19/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2200	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	3/22/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	3/22/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	3/26/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	3/26/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	3/29/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	3/29/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	4/2/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1100	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	4/2/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	11000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	4/5/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	4/5/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	4/9/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	3000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	4/9/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	300	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	4/12/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	4/12/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	4/16/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	4/16/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	4/23/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	4/23/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	4/26/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	4/26/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	ND	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	4/30/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	900	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1

Table 21 Certified Laboratory Results of Total and Fecal Coliform

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S4 (MF Filtrate)	S5 (UF Filtrate)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S10 (UV/AOP Product)
Fecal Coliform	4/30/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	300	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	5/7/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	220	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	5/7/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1700	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	5/21/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	5/21/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	30000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	5/29/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	5/29/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	30000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	6/4/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2200	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	6/4/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	7000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	6/11/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	6/11/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	6/18/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	900	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	6/18/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	7/2/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	7/2/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2200	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	7/9/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	5000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	7/9/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	2400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	7/16/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	60000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	7/16/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	16000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	7/23/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	48000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	7/23/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	10000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	7/30/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	48000	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	7/30/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	500	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Total Coliform	9/17/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	4400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Fecal Coliform	9/17/2012	grab	SM 9221B/E	MPN/100 ml	1.1	1.1	1400	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1

Note:

1. SM 9223B analyses were performed as present or absent from 8/2/2011 to 8/9/2011 and quantifiable on 8/10/2011.

Table 22 Certified Laboratory Results of Somatic & Male Specific Bacteriophage

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S4 (MF Filtrate)	S5 (UF Filtrate)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S10 (UV/AOP Product)
Bacteriophage, Somatic	8/8/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	3000	<1	NP	NP	NP	NP	NP
Bacteriophage, Somatic	8/8/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	A	A	A	A
Bacteriophage, Male Specific	8/8/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	30	NP	NP	NP	NP	NP	NP
Bacteriophage, Male Specific	8/8/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Somatic	8/15/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	3000	NP	NP	NP	NP	NP	NP
Bacteriophage, Somatic	8/15/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Male Specific	8/15/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	67	NP	NP	NP	NP	NP	NP
Bacteriophage, Male Specific	8/15/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Somatic	8/22/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	3000	NP	NP	NP	NP	NP	NP
Bacteriophage, Somatic	8/22/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Male Specific	8/22/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	15	<1	NP	NP	NP	NP	NP
Bacteriophage, Male Specific	8/22/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	A	A	A	A
Bacteriophage, Somatic	8/29/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	630	NP	NP	NP	NP	NP	NP
Bacteriophage, Somatic	8/29/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Male Specific	8/29/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	<1	NP	NP	<1	NP	NP	NP
Bacteriophage, Male Specific	8/29/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	P	A	A	A
Bacteriophage, Somatic	9/12/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	840	NP	<1	<1	NP	NP	NP
Bacteriophage, Somatic	9/12/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	P	P	A	A	A
Bacteriophage, Male Specific	9/12/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	7	NP	NP	NP	NP	NP	NP
Bacteriophage, Male Specific	9/12/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Somatic	9/19/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	99	NP	NP	NP	NP	NP	NP
Bacteriophage, Somatic	9/19/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Somatic	9/26/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	720	NP	NP	NP	NP	NP	NP
Bacteriophage, Somatic	9/26/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Male Specific	9/26/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	32	NP	NP	NP	NP	NP	NP
Bacteriophage, Male Specific	9/26/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Somatic	10/10/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	1090	1	NP	<1	NP	NP	NP
Bacteriophage, Somatic	10/10/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	P	A	A	A
Bacteriophage, Male Specific	10/10/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	19	<1	NP	1	NP	NP	NP
Bacteriophage, Male Specific	10/10/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	P	A	A	A
Bacteriophage, Somatic	10/17/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	300	10	NP	4	NP	NP	NP
Bacteriophage, Somatic	10/17/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	P	A	A	A
Bacteriophage, Male Specific	10/17/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	12	11	NP	NP	NP	NP	NP
Bacteriophage, Male Specific	10/17/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	A	A	A	A
Bacteriophage, Somatic	10/25/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	629	3	NP	<1	NP	NP	NP

Table 22 Certified Laboratory Results of Somatic & Male Specific Bacteriophage

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S4 (MF Filtrate)	S5 (UF Filtrate)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S10 (UV/AOP Product)
Bacteriophage, Somatic	10/25/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	P	A	A	A
Bacteriophage, Male Specific	10/25/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	23	NP	NP	NP	NP	NP	NP
Bacteriophage, Male Specific	10/25/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Somatic	11/7/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	1200	2	<1	<1	NP	NP	NP
Bacteriophage, Somatic	11/7/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	P	P	A	A	A
Bacteriophage, Male Specific	11/7/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	7	5	NP	<1	NP	NP	NP
Bacteriophage, Male Specific	11/7/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	P	A	A	A
Bacteriophage, Male Specific	11/15/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	17	<1	NP	<1	NP	NP	NP
Bacteriophage, Male Specific	11/15/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	P	A	A	A
Bacteriophage, Somatic	11/15/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	3000	<1	<1	1	NP	NP	NP
Bacteriophage, Somatic	11/15/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	P	P	A	A	A
Bacteriophage, Male Specific	12/12/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	20	4	NP	2	<1	NP	NP
Bacteriophage, Male Specific	12/12/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	P	P	A	A
Bacteriophage, Somatic	12/12/2011	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	2100	2	NP	<1	NP	NP	NP
Bacteriophage, Somatic	12/12/2011	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	P	A	A	A
Bacteriophage, Male Specific	1/9/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	10	3	NP	<1	NP	NP	NP
Bacteriophage, Male Specific	1/9/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	P	A	A	A
Bacteriophage, Somatic	1/9/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	3000	<1	NP	NP	NP	NP	NP
Bacteriophage, Somatic	1/9/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	A	A	A	A
Bacteriophage, Male Specific	2/13/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	9	<1	NP	NP	NP	NP	NP
Bacteriophage, Male Specific	2/13/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	A	A	A	A
Bacteriophage, Somatic	2/13/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	810	2	<1	NP	NP	NP	NP
Bacteriophage, Somatic	2/13/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	P	A	A	A	A
Bacteriophage, Male Specific	3/12/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	<1	NP	NP	NP	NP	NP	NP
Bacteriophage, Male Specific	3/12/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Somatic	3/12/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	>3000	NP	NP	NP	NP	NP	NP
Bacteriophage, Somatic	3/12/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Male Specific	4/9/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	12	1	NP	<1	NP	NP	NP
Bacteriophage, Male Specific	4/9/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	P	A	A	A
Bacteriophage, Somatic	4/9/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	630	2	NP	28	NP	NP	NP
Bacteriophage, Somatic	4/9/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	A	P	A	A	A
Bacteriophage, Male Specific	6/18/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	4	NP	NP	NP	NP	NP	NP
Bacteriophage, Male Specific	6/18/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A
Bacteriophage, Somatic	6/18/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	578	<1	<1	NP	NP	NP	NP
Bacteriophage, Somatic	6/18/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	P	P	A	A	A	A

Table 22 Certified Laboratory Results of Somatic & Male Specific Bacteriophage

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S1 (tertiary effluent)	S4 (MF Filtrate)	S5 (UF Filtrate)	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S10 (UV/AOP Product)
Bacteriophage, Male Specific	7/9/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	6	NP	NP	25	NP	NP	NP
Bacteriophage, Male Specific	7/9/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	P	A	A	A
Bacteriophage, Somatic	7/9/2012	grab	EPA 1602 (821-R-01-029)	pfu/100 ml	1/100 mL	1/100 mL	1500	NP	NP	NP	NP	NP	NP
Bacteriophage, Somatic	7/9/2012	grab	EPA 1601 (821-R-01-030)	P/A per L	P/A per L	P/A per L	NP	A	A	A	A	A	A

Note:

1. NP=not performed. A=absent. P= present.
2. A sample set was collected on 5/29/12 however results are not valid because EPA 1601 Somatic Coliphage Phage analysis were made past the recommended holdtime due to a lab issue.

Table 23 Basin Plan Number Water Quality Objectives

Constituent	Water Quality Objective
Total Dissolved Solids	300 mg/L
Chloride	50 mg/L
Sulfate	65 mg/L
Percent Sodium	60%
Iron	0.3 mg/L
Manganese	0.05 mg/L
Boron	1.0 mg/L
Turbidity	20 NTU
Color	20 color units
Fluoride	1.0 mg/L
Nutrients	-Total Phosphorus less than 0.025 mg/L -Natural ratios of total nitrogen to total phosphorus are to be upheld, if no data is available a ratio (N:P) of 10:1 is to be used.
Ammonia (unionized as N)	0.025 mg/L
Fecal Coliform	-Not less than 5 samples every 30 days -Sampling shall not exceed a log mean of 200/100mL -No more than 10% of samples during any 30 day period shall exceed 400/100mL
Dissolved Oxygen	- not less than 6.0 mg/L -annual mean DO shall not be less than 7.0 mg/L more than 10% of the time
pH	-change in pH level shall not exceed 0.5 units -pH shall not be depressed below 6.5 nor raised above 8.5
Phenolic Compounds	1.0 µg/L

Note:

1. Water Quality Control Plan for the San Diego Basin California Regional Water Quality Control Board San Diego Region September 8, 1994. http://www.waterboards.ca.gov/sandiego/water_issues/programs/basin_plan/

Table 24 Certified Laboratory Results of Select General Inorganic Parameters with Basin Plan Numeric Objectives

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Total Dissolved Solids	8/15/2011	grab	SM2540C	mg/l	4	10	810	13	15		14
Total Dissolved Solids	8/29/2011	grab	SM2540C	mg/l	4	10	770	13	12	11	14
Total Dissolved Solids	9/12/2011	grab	SM2540C	mg/l	4	10	820	17	15	13	19
Total Dissolved Solids	9/26/2011	grab	SM2540C	mg/l	4	10	750	12	11		15
Total Dissolved Solids	9/29/2011	grab	SM2540C	mg/l	4	10					11
Total Dissolved Solids	10/10/2011	grab	SM2540C	mg/l	4	10	740	15	13		11
Total Dissolved Solids	10/24/2011	composite	SM2540C	mg/l	4	10	680	13	18		15
Total Dissolved Solids	11/7/2011	composite	SM2540C	mg/l	4	10	700	18	13		17
Total Dissolved Solids	11/21/2011	composite	SM2540C	mg/l	4	10	600	16	11		13
Total Dissolved Solids	12/5/2011	composite	SM2540C	mg/l	4	10	890	13	17		19
Total Dissolved Solids	12/19/2011	composite	SM2540C	mg/l	4	10	540	14	17		13
Total Dissolved Solids	1/3/2012	composite	SM2540C	mg/l	4	10	660	11	14		11
Total Dissolved Solids	1/17/2012	composite	SM2540C	mg/l	4	10	800	11	12		13
Total Dissolved Solids	2/14/2012	composite	SM2540C	mg/l	4	10	770	12	15		15
Total Dissolved Solids	2/27/2012	composite	SM2540C	mg/l	4	10					17
Total Dissolved Solids	3/12/2012	composite	SM2540C	mg/l	4	10	800	17	12		15
Total Dissolved Solids	3/26/2012	composite	SM2540C	mg/l	4	10	690	13	14		11
Total Dissolved Solids	4/9/2012	composite	SM2540C	mg/l	4	10	750	11	15		16
Total Dissolved Solids	4/23/2012	composite	SM2540C	mg/l	4	10	800	11	12		<10
Total Dissolved Solids	5/7/2012	composite	SM2540C	mg/l	4	10	790	15	16		11
Total Dissolved Solids	5/21/2012	composite	SM2540C	mg/l	4	10	770	17	11		13
Total Dissolved Solids	6/4/2012	composite	SM2540C	mg/l	4	10	800	11	15		13
Total Dissolved Solids	7/2/2012	composite	SM2540C	mg/l	4	10					11
Total Dissolved Solids	7/16/2012	composite	SM2540C	mg/l	4	10	930	13	12		11
Total Dissolved Solids	7/30/2012	composite	SM2540C	mg/l	4	10					14
n =							21	21	21	2	25
Average							760	14	14	12	14
Maximum							930	18	18	13	19
Minimum							540	11	11	11	10
STDev							89	2.3	2.1	1.4	2.6

Table 24 Certified Laboratory Results of Select General Inorganic Parameters with Basin Plan Numeric Objectives

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Chloride, Total	8/15/2011	Composite	300.0_Cl Water	mg/l	0.1	0.5	250	2.5	2.2		2.8
Chloride, Total	8/29/2011	Composite	300.0_Cl Water	mg/l	0.1	0.5	240	2.1	2	2.1	2.9
Chloride, Total	9/12/2011	Composite	300.0_Cl Water	mg/l	0.1	0.5	260	2.2	2	2.2	2.7
Chloride, Total	9/26/2011	Composite	300.0_Cl Water	mg/l	0.1	0.5	260	2.4	2.3		2.9
Chloride, Total	10/10/2011	Composite	300.0_Cl Water	mg/l	0.1	0.5	240	2.2	2.1		2.8
Chloride, Total	10/24/2011	Composite	300.0_Cl Water	mg/l	0.1	0.5	270	2	1.8		3.3
Chloride, Total	11/7/2011	Composite	300.0_Cl Water	mg/l	0.1	0.5	240	2.6	2.5		2.9
Chloride, Total	11/21/2011	Composite	300.0_Cl Water	mg/l	0.1	0.5	260	2.3	1.9		2.8
Chloride, Total	12/5/2011	Composite	300.0_Cl Water	mg/l	0.1	0.5	240	2.2	2.2		2.7
Chloride, Total	12/19/2011	Composite	300.0_Cl Water	mg/l	0.1	0.5	270	2.5	2.4		2.8
Chloride, Total	1/3/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5	260	2.4	2.1		2.6
Chloride, Total	1/17/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5	280	1.9	1.7		2.8
Chloride, Total	1/30/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5	250	2.1	2		2.6
Chloride, Total	2/14/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5	270	2.3	2		2.8
Chloride, Total	2/27/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5					2.9
Chloride, Total	3/12/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5	280	2.3	2.2		3.1
Chloride, Total	3/26/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5	270	2.2	2.2		3.1
Chloride, Total	4/9/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5	270	2.5	2.3		3
Chloride, Total	4/23/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5	280	3.4	3.1		3.7
Chloride, Total	5/7/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5	270	3.6	3.6		4.1
Chloride, Total	5/21/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5	270	3.3	3.4		3.9
Chloride, Total	6/4/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5	290	3.4	3.6		4.3
Chloride, Total	7/2/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5					4.1
Chloride, Total	7/16/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5					3.9
Chloride, Total	7/30/2012	Composite	300.0_Cl Water	mg/l	0.1	0.5					4
n =							21	21	21	2	25
Average							260	2.5	2.4	2.2	3.2
Maximum							290	3.6	3.6	2.2	4.3
Minimum							240	1.9	1.7	2.1	2.6
STDev							15	0.50	0.60	0.10	0.60

Table 24 Certified Laboratory Results of Select General Inorganic Parameters with Basin Plan Numeric Objectives

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Sulfate as SO4	8/15/2011	grab	EPA 300.0	mg/l	0.1	0.5	170	<0.5	<0.5		<0.1
Sulfate as SO4	8/29/2011	grab	EPA 300.0	mg/l	0.1	0.5	140	<0.5	<0.1	<0.5	<0.5
Sulfate as SO4	9/12/2011	grab	EPA 300.0	mg/l	0.1	0.5	160	<0.1	<0.1	<0.1	<0.5
Sulfate as SO4	9/26/2011	grab	EPA 300.0	mg/l	0.1	0.5	150	<0.1	<0.5		<0.5
Sulfate as SO4	10/10/2011	grab	EPA 300.0	mg/l	0.1	0.5	130	<0.5	<0.5		<0.1
Sulfate as SO4	10/24/2011	composite	EPA 300.0	mg/l	0.1	0.5	140	<0.5	<0.1		<0.5
Sulfate as SO4	11/7/2011	composite	EPA 300.0	mg/l	0.1	0.5	130	<0.5	<0.1		0.58
Sulfate as SO4	11/21/2011	composite	EPA 300.0	mg/l	0.1	0.5	150	<0.5	<0.5		<0.5
Sulfate as SO4	12/5/2011	composite	EPA 300.0	mg/l	0.1	0.5	130	<0.1	<0.5		<0.5
Sulfate as SO4	12/19/2011	composite	EPA 300.0	mg/l	0.1	0.5	140	<0.5	<0.1		<0.5
Sulfate as SO4	1/3/2012	composite	EPA 300.0	mg/l	0.1	0.5	130	<0.1	<0.1		<0.1
Sulfate as SO4	1/17/2012	composite	EPA 300.0	mg/l	0.1	0.5	170	<0.1	<0.1		<0.5
Sulfate as SO4	2/14/2012	composite	EPA 300.0	mg/l	0.1	0.5	150	<0.1	<0.5		<0.5
Sulfate as SO4	2/27/2012	composite	EPA 300.0	mg/l	0.1	0.5					<0.5
Sulfate as SO4	3/12/2012	composite	EPA 300.0	mg/l	0.1	0.5	170	<0.1	<0.5		<0.5
Sulfate as SO4	3/26/2012	composite	EPA 300.0	mg/l	0.1	0.5	170	<0.5	<0.1		<0.5
Sulfate as SO4	4/9/2012	composite	EPA 300.0	mg/l	0.1	0.5	160	<0.5	<0.1		1.1
Sulfate as SO4	4/23/2012	composite	EPA 300.0	mg/l	0.1	0.5	180	<0.5	<0.1		<0.5
Sulfate as SO4	5/7/2012	composite	EPA 300.0	mg/l	0.1	0.5	180	<0.5	<0.5		<0.5
Sulfate as SO4	5/21/2012	composite	EPA 300.0	mg/l	0.1	0.5	170	<0.5	<0.1		<0.5
Sulfate as SO4	6/4/2012	composite	EPA 300.0	mg/l	0.1	0.5	200	<0.5	<0.1		<0.5
Sulfate as SO4	7/2/2012	composite	EPA 300.0	mg/l	0.1	0.5					<0.5
Sulfate as SO4	7/9/2012	composite	EPA 300.0	mg/l	0.1	0.5	190	<0.5	<0.5		
Sulfate as SO4	7/16/2012	composite	EPA 300.0	mg/l	0.1	0.5	180	<0.5	<0.5		<0.5
Sulfate as SO4	7/23/2012	composite	EPA 300.0	mg/l	0.1	0.5	200	<0.5	<0.5		
Sulfate as SO4	7/30/2012	composite	EPA 300.0	mg/l	0.1	0.5	170	<0.5	<0.5		<0.5
n =							24	24	24	2	24
Average							160	<0.5	<0.5	<0.5	<0.5
Maximum							200	0.3	0.3	0.3	1.1
Minimum							130	0.1	0.1	0.1	0.1
STDev							22	0.1	0.1	0.1	0.2

Table 24 Certified Laboratory Results of Select General Inorganic Parameters with Basin Plan Numeric Objectives

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Sodium, Total	8/15/2011	grab	EPA 200.7	mg/l	0.015	0.5	170	3.3	3.1		3.3
Sodium, Total	8/29/2011	grab	EPA 200.7	mg/l	0.015	0.5				3.8	3.8
Sodium, Total	9/12/2011	grab	EPA 200.7	mg/l	0.015	0.5				3.3	3.3
Sodium, Total	9/26/2011	grab	EPA 200.7	mg/l	0.015	0.5					3.1
Sodium, Total	10/10/2011	grab	EPA 200.7	mg/l	0.015	0.5	170	3.2	3.4		3.2
Sodium, Total	10/24/2011	composite	EPA 200.7	mg/l	0.015	0.5	160	3.1	3.1		3.3
Sodium, Total	11/7/2011	composite	EPA 200.7	mg/l	0.015	0.5	150	2.7	2.7		2.8
Sodium, Total	11/21/2011	composite	EPA 200.7	mg/l	0.015	0.5	160	2.6	2.6		2.8
Sodium, Total	12/5/2011	composite	EPA 200.7	mg/l	0.015	0.5	160	2.4	2.4		2.6
Sodium, Total	12/19/2011	composite	EPA 200.7	mg/l	0.015	0.5	170	2.6	2.7		2.8
Sodium, Total	1/3/2012	composite	EPA 200.7	mg/l	0.015	0.5	160	2.4	2.4		2.4
Sodium, Total	1/17/2012	composite	EPA 200.7	mg/l	0.015	0.5	170	2.8	2.6		2.8
Sodium, Total	2/14/2012	composite	EPA 200.7	mg/l	0.015	0.5	160	2.4	2.4		2.4
Sodium, Total	2/27/2012	composite	EPA 200.7	mg/l	0.015	0.5	160	2.4	2.4		2.6
Sodium, Total	3/12/2012	composite	EPA 200.7	mg/l	0.015	0.5	180	3	3		3
Sodium, Total	3/26/2012	composite	EPA 200.7	mg/l	0.015	0.5	160	2.9	3.1		3.1
Sodium, Total	4/9/2012	composite	EPA 200.7	mg/l	0.015	0.5	180	3.1	3.1		3.3
Sodium, Total	4/23/2012	composite	EPA 200.7	mg/l	0.015	0.5	180	3.7	3.4		3.9
Sodium, Total	5/7/2012	composite	EPA 200.7	mg/l	0.015	0.5	170	3.7	4		4
Sodium, Total	5/21/2012	composite	EPA 200.7	mg/l	0.015	0.5	180	4.3	4.5		4.6
Sodium, Total	6/4/2012	composite	EPA 200.7	mg/l	0.015	0.5	190	4.6	5.1		5.3
Sodium, Total	7/2/2012	composite	EPA 200.7	mg/l	0.015	0.5					4.5
Sodium, Total	7/16/2012	composite	EPA 200.7	mg/l	0.015	0.5					4.6
Sodium, Total	7/30/2012	composite	EPA 200.7	mg/l	0.015	0.5					4.8
n =							18	18	18	2	24
Average							170	3.1	3.1	3.6	3.4
Maximum							190	4.6	5.1	3.8	5.3
Minimum							150	2.4	2.4	3.3	2.4
STDev							10	0.70	0.80	0.40	0.80

Table 24 Certified Laboratory Results of Select General Inorganic Parameters with Basin Plan Numeric Objectives

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Iron, Total	8/15/2011	grab	EPA 200.7	µg/L	1.1	10	55	<1.1	<1.1		<1.1
Iron, Total	8/29/2011	grab	EPA 200.7	mg/l	0.001	0.01				<0.001	<0.001
Iron, Total	9/12/2011	grab	EPA 200.7	µg/L	1.1	10				<1.1	<1.1
Iron, Total	9/26/2011	grab	EPA 200.7	mg/l	0.001	0.01					<0.001
Iron, Total	10/10/2011	grab	EPA 200.7	mg/l	0.001	0.01	54	<0.001	<0.001		<0.001
Iron, Total	10/24/2011	composite	EPA 200.7	µg/L	1.1	10	66	<1.1	<1.1		<10
Iron, Total	11/7/2011	composite	EPA 200.7	µg/L	1.1	10	50	<10	<10		<10
Iron, Total	11/21/2011	composite	EPA 200.7	µg/L	1.1	10	85	<1.1	<1.1		<10
Iron, Total	12/5/2011	composite	EPA 200.7	µg/L	1.1	10	72	0.018	<10		<10
Iron, Total	12/19/2011	composite	EPA 200.7	µg/L	1.1	10	68	<10	<10		<10
Iron, Total	1/3/2012	composite	EPA 200.7	µg/L	1.1	10	59	<10	<1.1		<1.1
Iron, Total	1/17/2012	composite	EPA 200.7	µg/L	1.1	10	67	<10	<1.1		<10
Iron, Total	2/14/2012	composite	EPA 200.7	µg/L	1.1	10	63	<10	<10		<1.1
Iron, Total	2/27/2012	composite	EPA 200.7	µg/L	1.1	10	53	<10	<10		<10
Iron, Total	3/12/2012	composite	EPA 200.7	µg/L	1.1	10	70	<1.1	<1.1		<10
Iron, Total	3/26/2012	composite	EPA 200.7	µg/L	1.1	10	73	<10	<1.1		<10
Iron, Total	4/9/2012	composite	EPA 200.7	µg/L	1.1	10	75	<1.1	<1.1		<1.1
Iron, Total	4/23/2012	composite	EPA 200.7	µg/L	1.1	10	47	<1.1	<1.1		<1.1
Iron, Total	5/7/2012	composite	EPA 200.7	µg/L	1.1	10	54	<1.1	<1.1		<10
Iron, Total	5/21/2012	composite	EPA 200.7	µg/L	1.1	10	68	<1.1	<10		<1.1
Iron, Total	6/4/2012	composite	EPA 200.7	µg/L	1.1	10	57	<0.0011	<0.0011		<0.0011
Iron, Total	7/2/2012	composite	EPA 200.7	µg/L	1.1	10					<0.01
Iron, Total	7/16/2012	composite	EPA 200.7	µg/L	1.1	10					<0.0011
Iron, Total	7/30/2012	composite	EPA 200.7	µg/L	1.1	10					<1.1
n =							18	18	18	2	24
Average							63	<10	<10	<1.1	<10
Maximum							85	10	10	0.60	10
Minimum							47	0.0	0.0	0.0	0.0
STDev							10	2.9	2.8	0.40	2.8

Table 24 Certified Laboratory Results of Select General Inorganic Parameters with Basin Plan Numeric Objectives

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Manganese, Total	8/15/2011	grab	EPA 200.7	µg/L	2.6	5	87	<2.6	<2.6		<2.6
Manganese, Total	8/29/2011	grab	EPA 200.7	mg/l	0.003	0.01				<0.003	<0.003
Manganese, Total	9/12/2011	grab	EPA 200.7	µg/L	2.6	5				<2.6	<2.6
Manganese, Total	9/26/2011	grab	EPA 200.7	mg/l	0.003	0.01					<0.003
Manganese, Total	10/10/2011	grab	EPA 200.7	mg/l	0.003	0.01	0.081	<0.003	<0.003		<0.003
Manganese, Total	10/24/2011	composite	EPA 200.7	µg/L	2.6	5	95	<2.6	<2.6		<2.6
Manganese, Total	11/7/2011	composite	EPA 200.7	µg/L	2.6	5	77	<2.6	<2.6		<2.6
Manganese, Total	11/21/2011	composite	EPA 200.7	µg/L	2.6	5	69	<2.6	<2.6		<2.6
Manganese, Total	12/5/2011	composite	EPA 200.7	µg/L	2.6	5	0.085	<2.6	<2.6		<2.6
Manganese, Total	12/19/2011	composite	EPA 200.7	µg/L	2.6	5	66	<2.6	<2.6		<2.6
Manganese, Total	1/3/2012	composite	EPA 200.7	µg/L	2.6	5	94	<2.6	<2.6		<2.6
Manganese, Total	1/17/2012	composite	EPA 200.7	µg/L	2.6	5	98	<2.6	<2.6		<2.6
Manganese, Total	2/14/2012	composite	EPA 200.7	µg/L	2.6	5	72	<2.6	<2.6		<2.6
Manganese, Total	2/27/2012	composite	EPA 200.7	µg/L	2.6	5	76	<5	<5		<5
Manganese, Total	3/12/2012	composite	EPA 200.7	µg/L	2.6	5	85	<2.6	<2.6		<2.6
Manganese, Total	3/26/2012	composite	EPA 200.7	µg/L	2.6	5	0.091	<0.0026	<0.0026		<0.0026
Manganese, Total	4/9/2012	composite	EPA 200.7	µg/L	2.6	5	120	<2.6	<2.6		<2.6
Manganese, Total	4/23/2012	composite	EPA 200.7	µg/L	2.6	5	0.09	<2.6	<2.6		<0.0026
Manganese, Total	5/7/2012	composite	EPA 200.7	µg/L	2.6	5	83	<2.6	<2.6		<2.6
Manganese, Total	5/21/2012	composite	EPA 200.7	µg/L	2.6	5	96	<2.6	<2.6		<2.6
Manganese, Total	6/4/2012	composite	EPA 200.7	µg/L	2.6	5	0.1	<0.0026	<0.0026		<0.0026
Manganese, Total	7/2/2012	composite	EPA 200.7	µg/L	2.6	5					<0.0026
Manganese, Total	7/16/2012	composite	EPA 200.7	µg/L	2.6	5					<2.6
Manganese, Total	7/30/2012	composite	EPA 200.7	µg/L	2.6	5					<2.6
n =							18	18	18	2	24
Average							62	<2.6	<2.6	<2.6	<2.6
Maximum							120	5.0	5.0	1.3	5.0
Minimum							0.10	0.0	0.0	0.0	0.0
STDev							42	1.1	1.1	0.90	1.0

Table 24 Certified Laboratory Results of Select General Inorganic Parameters with Basin Plan Numeric Objectives

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Boron, Total	8/1/2011	grab	EPA 200.7	µg/L	1	10	410				
Boron, Total	8/15/2011	grab	EPA 200.7	µg/L	1	10	410	230	220		220
Boron, Total	8/29/2011	grab	EPA 200.7	µg/L	1	10				230	240
Boron, Total	9/12/2011	grab	EPA 200.7	µg/L	1	10				280	280
Boron, Total	9/26/2011	grab	EPA 200.7	µg/L	1	10					230
Boron, Total	10/10/2011	grab	EPA 200.7	µg/L	1	10	390	210	220		220
Boron, Total	10/24/2011	composite	EPA 200.7	µg/L	1	10	430	260	260		240
Boron, Total	11/7/2011	composite	EPA 200.7	µg/L	1	10	370	230	230		200
Boron, Total	11/21/2011	composite	EPA 200.7	µg/L	1	10	380	220	210		200
Boron, Total	12/5/2011	composite	EPA 200.7	µg/L	1	10	360	190	180		180
Boron, Total	12/19/2011	composite	EPA 200.7	µg/L	1	10	400	210	200		200
Boron, Total	1/3/2012	composite	EPA 200.7	µg/L	1	10	390	220	210		220
Boron, Total	1/17/2012	composite	EPA 200.7	µg/L	1	10	400	220	210		210
Boron, Total	2/14/2012	composite	EPA 200.7	µg/L	1	10	400	200	190		200
Boron, Total	2/27/2012	composite	EPA 200.7	µg/L	1	10	400	210	220		200
Boron, Total	3/12/2012	composite	EPA 200.7	µg/L	1	10	410	230	230		210
Boron, Total	3/26/2012	composite	EPA 200.7	µg/L	1	10	390	230	230		210
Boron, Total	4/9/2012	composite	EPA 200.7	µg/L	1	10	400	220	210		210
Boron, Total	4/23/2012	composite	EPA 200.7	µg/L	1	10	390	260	250		240
Boron, Total	5/7/2012	composite	EPA 200.7	µg/L	1	10	440	270	270		290
Boron, Total	5/21/2012	composite	EPA 200.7	µg/L	1	10	400	260	260		250
Boron, Total	6/4/2012	composite	EPA 200.7	µg/L	1	10	410	280	270		260
Boron, Total	7/2/2012	composite	EPA 200.7	µg/L	1	10					260
Boron, Total	7/16/2012	composite	EPA 200.7	µg/L	1	10					280
Boron, Total	7/30/2012	composite	EPA 200.7	µg/L	1	10					250
n =							19	18	18	2	24
Average							400	230	230	255	230
Maximum							440	280	270	280	290
Minimum							360	190	180	230	180
STDev							19	25	27	35	30

Table 24 Certified Laboratory Results of Select General Inorganic Parameters with Basin Plan Numeric Objectives

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Color	8/15/2011	grab	SM2120B	CU		3	20	<3	<3		<3
Color	8/29/2011	grab	SM2120B	CU		3				<3	<3
Color	9/12/2011	grab	SM2120B	CU		3				<3	<3
Color	9/26/2011	grab	SM2120B	CU		3				<3	<3
Color	10/10/2011	grab	SM2120B	CU		3				<3	<3
Color	10/24/2011	composite	SM2120B	CU		3				<3	<3
Color	11/7/2011	composite	SM2120B	CU		3				<3	<3
Color	11/21/2011	composite	SM2120B	CU		3				<3	<3
Color	12/5/2011	composite	SM2120B	CU		3				<3	<3
Color	12/19/2011	composite	SM2120B	CU		3				<3	<3
Color	1/3/2012	composite	SM2120B	CU		3				<3	<3
Color	1/17/2012	composite	SM2120B	CU		3				<3	<3
Color	2/14/2012	composite	SM2120B	CU		3				<3	<3
Color	2/27/2012	composite	SM2120B	CU		3				<3	<3
Color	3/12/2012	composite	SM2120B	CU		3				<3	<3
Color	3/26/2012	composite	SM2120B	CU		3				<3	<3
Color	4/9/2012	composite	SM2120B	CU		3				<3	<3
Color	4/23/2012	composite	SM2120B	CU		3				<3	<3
Color	5/7/2012	composite	SM2120B	CU		3				<3	<3
Color	5/21/2012	composite	SM2120B	CU		3				<3	<3
Color	6/4/2012	composite	SM2120B	CU		3				<3	<3
Color	7/2/2012	composite	SM2120B	CU		3					<3
Color	7/16/2012	composite	SM2120B	CU		3					<3
Color	7/30/2012	composite	SM2120B	CU		3					<3
n =							1	1	1	20	24
Average							20	<3	<3	<3	<3
Maximum							20	3	3	3	3
Minimum							20	0	0	0	0
STDev										0	0

Table 24 Certified Laboratory Results of Select General Inorganic Parameters with Basin Plan Numeric Objectives

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S6 (RO Feed)	S7 (RO Perm. Train A)	S8 (RO Perm. Train B)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Fluoride, Total	8/15/2011	grab	EPA 300.0	mg/l	0.02	0.1	0.67	<0.02	<0.02		<0.02
Fluoride, Total	8/29/2011	grab	EPA 300.0	mg/l	0.02	0.1	0.58	<0.02	<0.02	<0.02	<0.1
Fluoride, Total	9/12/2011	grab	EPA 300.0	mg/l	0.02	0.1	0.61	<0.02	<0.02	<0.02	<0.02
Fluoride, Total	9/26/2011	grab	EPA 300.0	mg/l	0.02	0.1	0.65	<0.1	<0.1		<0.1
Fluoride, Total	10/10/2011	grab	EPA 300.0	mg/l	0.02	0.1	0.61	<0.02	<0.02		<0.1
Fluoride, Total	10/24/2011	composite	EPA 300.0	mg/l	0.02	0.1	0.56	<0.1	<0.1		<0.1
Fluoride, Total	11/7/2011	composite	EPA 300.0	mg/l	0.02	0.1	0.64	<0.02	<0.02		<0.02
Fluoride, Total	11/21/2011	composite	EPA 300.0	mg/l	0.02	0.1	0.61	<0.02	<0.02		<0.02
Fluoride, Total	12/5/2011	composite	EPA 300.0	mg/l	0.02	0.1	0.55	<0.02	<0.02		<0.02
Fluoride, Total	12/19/2011	composite	EPA 300.0	mg/l	0.02	0.1	0.59	<0.02	<0.02		<0.02
Fluoride, Total	1/3/2012	composite	EPA 300.0	mg/l	0.02	0.1	0.52	<0.02	<0.02		<0.02
Fluoride, Total	1/17/2012	composite	EPA 300.0	mg/l	0.02	0.1	0.56	<0.02	<0.1		<0.1
Fluoride, Total	2/14/2012	composite	EPA 300.0	mg/l	0.02	0.1	0.56	<0.1	<0.1		<0.02
Fluoride, Total	2/27/2012	composite	EPA 300.0	mg/l	0.02	0.1					<0.1
Fluoride, Total	3/12/2012	composite	EPA 300.0	mg/l	0.02	0.1	0.6	<0.02	<0.1		<0.1
Fluoride, Total	3/26/2012	composite	EPA 300.0	mg/l	0.02	0.1	0.72	<0.02	<0.02		<0.02
Fluoride, Total	4/9/2012	composite	EPA 300.0	mg/l	0.02	0.1	0.68	<0.02	<0.02		<0.02
Fluoride, Total	4/23/2012	composite	EPA 300.0	mg/l	0.02	0.1	0.69	<0.02	<0.02		<0.02
Fluoride, Total	5/7/2012	composite	EPA 300.0	mg/l	0.02	0.1	0.76	<0.02	<0.02		<0.02
Fluoride, Total	5/21/2012	composite	EPA 300.0	mg/l	0.02	0.1	0.63	<0.02	<0.02		<0.02
Fluoride, Total	6/4/2012	composite	EPA 300.0	mg/l	0.02	0.1	0.67	<0.02	<0.02		<0.02
Fluoride, Total	7/2/2012	composite	EPA 300.0	mg/l	0.02	0.1					<0.02
Fluoride, Total	7/16/2012	composite	EPA 300.0	mg/l	0.02	0.1					<0.1
Fluoride, Total	7/30/2012	composite	EPA 300.0	mg/l	0.02	0.1					<0.02
n =							20	20	20	2	24
Average							0.6	<0.02	<0.02	<0.02	<0.02
Maximum							0.8	0.1	0.1	0.0	0.1
Minimum							0.5	0.0	0.0	0.0	0.0
STDev							0.1	0.0	0.0	0.0	0.0

Table 24 Certified Laboratory Results of Select General Inorganic Parameters with Basin Plan Numeric Objectives

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Phenolics (Total)	9/1/2011	grab	EPA 420.4	mg/l	0.004	0.01		0.022
Phenolics (14 compounds)	10/10/2011	grab	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (13 compounds)	10/24/2011	composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenol	10/24/2011	composite	EPA 8270C-SIM	µg/L	0.35	1	1.4	1.9
Phenolics (13 compounds)	11/17/2011	composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenol	11/7/2011	composite	EPA 8270C-SIM	µg/L	0.35	1	<1	<1
Phenolics (13 compounds)	11/21/2011	composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenol	11/21/2011	composite	EPA 8270C-SIM	µg/L	0.35	1	<1	2.6
Phenolics (13 compounds)	12/5/2011	composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenol	12/5/2011	composite	EPA 8270C-SIM	µg/L	0.35	1	<1	<1
Phenolics[1] (14 compounds)	12/19/2011	composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (14 compounds)	1/3/2012	composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (12 compounds)	1/17/2012	composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
2,4-Dichlorophenol	1/17/2012	composite	EPA 8270C-SIM	µg/L	0.51	1	<1	<1
4,6-Dinitro-2-methylphenol	1/17/2012	composite	EPA 8270C-SIM	µg/L	0.14	1	<1	<1
Phenolics (14 compounds)	1/23/2012	composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (14 compounds)	2/14/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (14 compounds)	2/27/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (14 compounds)	3/12/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (14 compounds)	3/26/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (14 compounds)	4/9/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1

Table 24 Certified Laboratory Results of Select General Inorganic Parameters with Basin Plan Numeric Objectives

Parameter	Sample Date	Sample Type	Method	Units	DL	RL	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
Phenolics (14 compounds)	4/23/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (14 compounds)	5/7/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (14 compounds)	5/21/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (14 compounds)	6/4/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies	<1	<1
Phenolics (14 compounds)	7/2/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies		<1
Phenolics (14 compounds)	7/16/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies		<1
Phenolics (14 compounds)	7/30/2012	Composite	EPA 8270C-SIM	µg/L	varies	varies		<1

1. Samples were re-extracted and reanalyzed past hold time due reported lab contamination

Table 25 On-site Laboratory UV/AOP Product Water Results of General Parameters with Basin Plan Numeric Objectives

Sample Date	Method	Parameter Measured @ S10 UV/AOP Product			
		pH	Temperature, Deg C	DO, mg/L	Turbidity, NTU
8/11/2011	HACH sensION156 Portable Meter	5.79	26.8		0.04
8/12/2011	HACH sensION156 Portable Meter	5.77	26		0.05
8/13/2011	HACH sensION156 Portable Meter	5.8	26.9		0.07
8/14/2011	HACH sensION156 Portable Meter	5.88	26.7		0.04
8/15/2011	HACH sensION156 Portable Meter	5.86	23.6		0.05
8/16/2011	HACH sensION156 Portable Meter	5.88	22.4		0.04
8/17/2011	HACH sensION156 Portable Meter	5.72	21		0.04
8/18/2011	HACH sensION156 Portable Meter	5.75	21.5		0.04
8/19/2011	HACH sensION156 Portable Meter	5.71	25.7		0.04
8/21/2011	HACH sensION156 Portable Meter				0.04
8/22/2011	HACH sensION156 Portable Meter	5.79	27		0.05
8/23/2011	HACH sensION156 Portable Meter	5.87	27.2		0.04
8/24/2011	HACH sensION156 Portable Meter	5.7	24.7		0.08
8/25/2011	HACH sensION156 Portable Meter	5.74	26		0.05
8/26/2011	HACH sensION156 Portable Meter	5.82	26.4		0.06
8/27/2011	HACH sensION156 Portable Meter	5.85	27.8		0.05
8/28/2011	HACH sensION156 Portable Meter	5.86	27.7		0.06
8/29/2011	HACH sensION156 Portable Meter	5.92	25.4		0.03
8/30/2011	HACH sensION156 Portable Meter	6.15	25.6		0.06
8/31/2011	HACH sensION156 Portable Meter	6.32	23.7		0.05
9/1/2011	HACH sensION156 Portable Meter	6.45	21.6		0.04
9/2/2011	HACH sensION156 Portable Meter	6.31	21.9		0.05
9/3/2011	HACH sensION156 Portable Meter	5.86	25.6		0.04
9/4/2011	HACH sensION156 Portable Meter	5.76	27.2		0.03
9/6/2011	HACH sensION156 Portable Meter	5.87	27.8		0.05
9/7/2011	HACH sensION156 Portable Meter	5.68	30		0.04
9/8/2011	HACH sensION156 Portable Meter	5.76	28.8		0.05
9/12/2011	HACH sensION156 Portable Meter	5.91	24.7		0.06
9/13/2011	HACH sensION156 Portable Meter	5.73	27.9	7.34	0.03
9/14/2011	HACH sensION156 Portable Meter	5.67	25.7		0.04
9/15/2011	HACH sensION156 Portable Meter	5.76	22.1	7.55	0.04
9/16/2011	HACH sensION156 Portable Meter	5.77	23.9		0.05
9/17/2011	HACH sensION156 Portable Meter	6.4	25.6		0.05
9/18/2011	HACH sensION156 Portable Meter	5.89	23.1	7.07	0.03
9/19/2011	HACH sensION156 Portable Meter	5.82	23.7		0.05
9/20/2011	HACH sensION156 Portable Meter	5.75	25.5	7.3	0.03

Table 25 On-site Laboratory UV/AOP Product Water Results of General Parameters with Basin Plan Numeric Objectives

Sample Date	Method	Parameter Measured @ S10 UV/AOP Product			
		pH	Temperature, Deg C	DO, mg/L	Turbidity, NTU
9/21/2011	HACH sensION156 Portable Meter	5.92	27.4		0.03
9/22/2011	HACH sensION156 Portable Meter	5.78	21.3	7.41	0.04
9/23/2011	HACH sensION156 Portable Meter	5.74	24.6		0.04
9/24/2011	HACH sensION156 Portable Meter	5.88	26.6		0.05
9/26/2011	HACH sensION156 Portable Meter	5.73	24.1		0.06
9/27/2011	HACH sensION156 Portable Meter	5.69	21.8	6.96	0.06
9/28/2011	HACH sensION156 Portable Meter	5.65	20.4		0.05
9/29/2011	HACH sensION156 Portable Meter	5.91	20.3	6.77	0.05
9/30/2011	HACH sensION156 Portable Meter	5.86	22		0.05
10/1/2011	HACH sensION156 Portable Meter	6.15	27.1		0.07
10/2/2011	HACH sensION156 Portable Meter	6.27	27.8	6.39	0.07
10/3/2011	HACH sensION156 Portable Meter	5.83	27.9		0.04
10/4/2011	HACH sensION156 Portable Meter	5.63	20.8	7.1	0.07
10/5/2011	HACH sensION156 Portable Meter	5.61	20.3		0.06
10/6/2011	HACH sensION156 Portable Meter	5.5	22.1	7.12	0.03
10/9/2011	HACH sensION156 Portable Meter	5.54	26.4	6.72	0.04
10/10/2011	HACH sensION156 Portable Meter	5.63	26.7		0.03
10/11/2011	HACH sensION156 Portable Meter	5.79	27.1		0.05
10/12/2011	HACH sensION156 Portable Meter	5.53	24.3	7.03	0.05
10/13/2011	HACH sensION156 Portable Meter	5.47	26.8	7.47	0.06
10/14/2011	HACH sensION156 Portable Meter	5.45	26.7		0.06
10/15/2011	HACH sensION156 Portable Meter	5.91	26.7		0.05
10/16/2011	HACH sensION156 Portable Meter	5.95	26.5	7.15	0.06
10/17/2011	HACH sensION156 Portable Meter	6.39	27.5		0.06
10/19/2011	HACH sensION156 Portable Meter	5.6	26.6	9.54	0.04
10/20/2011	HACH sensION156 Portable Meter	5.43	26.6	6.58	0.07
10/21/2011	HACH sensION156 Portable Meter	5.48	26.6		0.06
10/22/2011	HACH sensION156 Portable Meter	5.52	26.5		0.04
10/23/2011	HACH sensION156 Portable Meter	5.46	25.7		0.06
10/24/2011	HACH sensION156 Portable Meter	5.65	26.3		0.04
10/25/2011	HACH sensION156 Portable Meter	5.54	26.3		0.05
10/26/2011	HACH sensION156 Portable Meter	5.5	26.3		0.05
10/27/2011	HACH sensION156 Portable Meter	5.46	26.3		0.06
10/28/2011	HACH sensION156 Portable Meter	5.43	26.4		0.05
10/29/2011	HACH sensION156 Portable Meter	5.63	26.3		0.04
10/30/2011	HACH sensION156 Portable Meter	5.77	26	7.89	0.04
10/31/2011	HACH sensION156 Portable Meter	5.51	26		0.04

Table 25 On-site Laboratory UV/AOP Product Water Results of General Parameters with Basin Plan Numeric Objectives

Sample Date	Method	Parameter Measured @ S10 UV/AOP Product			
		pH	Temperature, Deg C	DO, mg/L	Turbidity, NTU
11/1/2011	HACH sensION156 Portable Meter	5.46	26.3	6.85	0.06
11/2/2011	HACH sensION156 Portable Meter	5.46	26.4		0.04
11/3/2011	HACH sensION156 Portable Meter	5.53	25.6	7.3	0.05
11/4/2011	HACH sensION156 Portable Meter	5.64	19.1		0.04
11/5/2011	HACH sensION156 Portable Meter	5.58	25.5		0.05
11/6/2011	HACH sensION156 Portable Meter	5.72	24.7	7.79	0.10
11/7/2011	HACH sensION156 Portable Meter	6.28	26		0.04
11/8/2011	HACH sensION156 Portable Meter	5.41	24.9	7.63	0.04
11/9/2011	HACH sensION156 Portable Meter	5.50	22		0.05
11/10/2011	HACH sensION156 Portable Meter	5.51	21.6	7.68	0.05
11/11/2011	HACH sensION156 Portable Meter	5.82	21.1		0.04
11/12/2011	HACH sensION156 Portable Meter	5.37	21.3		0.05
11/13/2011	HACH sensION156 Portable Meter	5.58	25.2	7.67	0.06
11/16/2011	HACH sensION156 Portable Meter	5.32	21.5		0.06
11/17/2011	HACH sensION156 Portable Meter	5.40	24.8	7.55	0.05
11/18/2011	HACH sensION156 Portable Meter	5.49	19.6		0.05
11/19/2011	HACH sensION156 Portable Meter	5.42	22.2		0.05
11/20/2011	HACH sensION156 Portable Meter	5.50	23.5	7.47	0.05
11/21/2011	HACH sensION156 Portable Meter	5.49	24.5		0.05
11/22/2011	HACH sensION156 Portable Meter	5.26	18.8	7.54	0.05
11/23/2011	HACH sensION156 Portable Meter	5.42	18.4		0.04
11/25/2011	HACH sensION156 Portable Meter	5.48	24.1		0.05
11/26/2011	HACH sensION156 Portable Meter	5.40	24.7		0.04
11/27/2011	HACH sensION156 Portable Meter	5.43	24.8	7.59	0.05
11/28/2011	HACH sensION156 Portable Meter	5.42	24.8		0.04
11/29/2011	HACH sensION156 Portable Meter	5.44	24	7.44	0.05
11/30/2011	HACH sensION156 Portable Meter	5.37	24.1		0.05
12/1/2011	HACH sensION156 Portable Meter	5.48	21.7	7.19	0.04
12/2/2011	HACH sensION156 Portable Meter	5.41	17.9		0.05
12/3/2011	HACH sensION156 Portable Meter	5.33	23.5		0.04
12/4/2011	HACH sensION156 Portable Meter	5.39	23.5	7.25	0.05
12/5/2011	HACH sensION156 Portable Meter	5.53	19.2		0.05
12/6/2011	HACH sensION156 Portable Meter	5.35	15.9	7.31	0.05
12/7/2011	HACH sensION156 Portable Meter	5.36	22.7		0.04
12/8/2011	HACH sensION156 Portable Meter	5.42	23.4	7.3	0.04
12/9/2011	HACH sensION156 Portable Meter	5.25	19		0.05
12/10/2011	HACH sensION156 Portable Meter	5.47	23.4		

Table 25 On-site Laboratory UV/AOP Product Water Results of General Parameters with Basin Plan Numeric Objectives

Sample Date	Method	Parameter Measured @ S10 UV/AOP Product			
		pH	Temperature, Deg C	DO, mg/L	Turbidity, NTU
12/11/2011	HACH sensION156 Portable Meter	5.43	23.1	7.38	
12/12/2011	HACH sensION156 Portable Meter	5.38	23.1		
12/13/2011	HACH sensION156 Portable Meter	5.47		7.28	0.05
12/14/2011	HACH sensION156 Portable Meter	5.38	21.9		0.04
12/15/2011	HACH sensION156 Portable Meter	5.24	22.7	7.78	0.05
12/16/2011	HACH sensION156 Portable Meter	5.46	17.1		0.04
12/17/2011	HACH sensION156 Portable Meter	5.39	23.4		0.04
12/18/2011	HACH sensION156 Portable Meter	5.42	22.3	7.91	0.04
12/19/2011	HACH sensION156 Portable Meter	5.39	22.9		0.05
12/20/2011	HACH sensION156 Portable Meter	5.48	16.3	7.67	0.04
12/21/2011	HACH sensION156 Portable Meter	5.39	22.2		0.05
12/22/2011	HACH sensION156 Portable Meter	5.39	22.8	7.58	0.04
12/23/2011	HACH sensION156 Portable Meter	5.41	22		0.04
12/26/2011	HACH sensION156 Portable Meter	5.35	23.2		0.04
12/27/2011	HACH sensION156 Portable Meter	5.32	23.3	7.83	0.05
12/28/2011	HACH sensION156 Portable Meter	5.38	23.1		0.05
12/29/2011	HACH sensION156 Portable Meter	5.52	23.1	7.92	0.05
12/30/2011	HACH sensION156 Portable Meter	5.52	20.8		0.04
12/31/2011	HACH sensION156 Portable Meter	5.29	23		0.04
1/2/2012	HACH sensION156 Portable Meter	5.36	23.1		0.04
1/3/2012	HACH sensION156 Portable Meter	5.37	21.1	7.96	0.04
1/4/2012	HACH sensION156 Portable Meter	5.43	22.2		0.04
1/5/2012	HACH sensION156 Portable Meter	5.35	22.9	8	0.04
1/6/2012	HACH sensION156 Portable Meter	5.43	21.3		0.04
1/7/2012	HACH sensION156 Portable Meter	5.33	23.1		0.04
1/8/2012	HACH sensION156 Portable Meter	5.35	23	7.9	0.04
1/9/2012	HACH sensION156 Portable Meter	5.47	23		0.04
1/10/2012	HACH sensION156 Portable Meter	5.27	20.5	7.81	0.05
1/12/2012	HACH sensION156 Portable Meter	5.28	20.9	7.77	0.05
1/13/2012	HACH sensION156 Portable Meter	5.40	22.2		0.05
1/14/2012	HACH sensION156 Portable Meter	5.42	22.7		0.05
1/15/2012	HACH sensION156 Portable Meter	5.46	22.6	7.47	0.04
1/16/2012	HACH sensION156 Portable Meter	5.56	21.7		0.05
1/17/2012	HACH sensION156 Portable Meter	5.58	21.4	7.76	0.04
1/18/2012	HACH sensION156 Portable Meter	5.46	22.2		0.05
1/19/2012	HACH sensION156 Portable Meter	5.44	18	7.82	0.04
1/20/2012	HACH sensION156 Portable Meter	5.50			0.04

Table 25 On-site Laboratory UV/AOP Product Water Results of General Parameters with Basin Plan Numeric Objectives

Sample Date	Method	Parameter Measured @ S10 UV/AOP Product			
		pH	Temperature, Deg C	DO, mg/L	Turbidity, NTU
1/21/2012	HACH sensION156 Portable Meter	5.50	22.4		0.03
1/22/2012	HACH sensION156 Portable Meter	5.81	22.7	7.58	0.04
1/23/2012	HACH sensION156 Portable Meter	5.57	22		0.04
1/24/2012	HACH sensION156 Portable Meter	5.27	18.8	7.97	0.04
1/25/2012	HACH sensION156 Portable Meter	5.37	22.6		0.06
1/26/2012	HACH sensION156 Portable Meter	5.31	21.7	8.09	0.04
1/27/2012	HACH sensION156 Portable Meter	5.31	19.4		0.05
1/28/2012	HACH sensION156 Portable Meter	5.37	22.9		0.06
1/29/2012	HACH sensION156 Portable Meter	5.27	23	7.8	0.05
1/30/2012	HACH sensION156 Portable Meter	5.61	22.4		0.05
1/31/2012	HACH sensION156 Portable Meter	5.25	21.8	7.53	0.04
2/1/2012	HACH sensION156 Portable Meter	5.25	22.2		0.05
2/2/2012	HACH sensION156 Portable Meter	5.26	21.5	7.78	0.04
2/3/2012	HACH sensION156 Portable Meter	5.31			0.05
2/4/2012	HACH sensION156 Portable Meter	5.43	22.4		0.05
2/5/2012	HACH sensION156 Portable Meter	5.36	22.1	7.92	0.05
2/6/2012	HACH sensION156 Portable Meter	5.59	22.8		0.05
2/7/2012	HACH sensION156 Portable Meter	5.39	22.4	7.99	0.05
2/8/2012	HACH sensION156 Portable Meter	5.55	22.6		0.04
2/9/2012	HACH sensION156 Portable Meter	5.95	22.4		0.06
2/10/2012	HACH sensION156 Portable Meter	5.75	21.5		0.04
2/11/2012	HACH sensION156 Portable Meter				
2/12/2012	HACH sensION156 Portable Meter				
2/13/2012	HACH sensION156 Portable Meter	5.95	21.3		
2/14/2012	HACH sensION156 Portable Meter	5.53	22.2	7.72	0.05
2/15/2012	HACH sensION156 Portable Meter	5.31	22.5		0.05
2/16/2012	HACH sensION156 Portable Meter	5.47	21.7		0.04
2/18/2012	HACH sensION156 Portable Meter	5.46	22.1		0.05
2/19/2012	HACH sensION156 Portable Meter	5.45	22.1	7.93	0.04
2/20/2012	HACH sensION156 Portable Meter				0.04
2/22/2012	HACH sensION156 Portable Meter	5.40	22.4		0.04
2/23/2012	HACH sensION156 Portable Meter	5.91	22.8	7.93	0.03
2/24/2012	HACH sensION156 Portable Meter	5.60	21.5		0.03
2/25/2012	HACH sensION156 Portable Meter	5.41	22.2		0.04
2/26/2012	HACH sensION156 Portable Meter	5.43	22.4	7.91	0.04
2/27/2012	HACH sensION156 Portable Meter	5.57	22.3		0.04
2/28/2012	HACH sensION156 Portable Meter	5.23	17.1		

Table 25 On-site Laboratory UV/AOP Product Water Results of General Parameters with Basin Plan Numeric Objectives

Sample Date	Method	Parameter Measured @ S10 UV/AOP Product			
		pH	Temperature, Deg C	DO, mg/L	Turbidity, NTU
2/29/2012	HACH sensION156 Portable Meter	5.25	21.7		0.03
3/1/2012	HACH sensION156 Portable Meter	5.28	21.8	7.9	0.05
3/2/2012	HACH sensION156 Portable Meter	5.43	22.1		0.03
3/3/2012	HACH sensION156 Portable Meter	5.66	22.3		0.03
3/5/2012	HACH sensION156 Portable Meter	5.93	22.5		0.04
3/6/2012	HACH sensION156 Portable Meter	5.32	22	7.87	0.04
3/7/2012	HACH sensION156 Portable Meter	5.52	22.3		0.04
3/8/2012	HACH sensION156 Portable Meter	5.77	22.2	8.13	0.04
3/9/2012	HACH sensION156 Portable Meter	5.51	22.8		0.05
3/10/2012	HACH sensION156 Portable Meter	6.11	23		0.04
3/11/2012	HACH sensION156 Portable Meter	5.56	22.7	7.99	0.03
3/12/2012	HACH sensION156 Portable Meter	5.58	22.6		0.04
3/13/2012	HACH sensION156 Portable Meter	5.47	22.3	7.91	0.04
3/14/2012	HACH sensION156 Portable Meter	5.51	22.1		0.04
3/15/2012	HACH sensION156 Portable Meter	5.53	21.2	7.84	0.04
3/16/2012	HACH sensION156 Portable Meter	5.48	22.2		0.04
3/17/2012	HACH sensION156 Portable Meter	5.55	22.8		0.05
3/18/2012	HACH sensION156 Portable Meter	5.54	21.7	7.92	0.04
3/19/2012	HACH sensION156 Portable Meter	5.84	20.6		0.04
3/20/2012	HACH sensION156 Portable Meter	6.13	21.6	7.84	0.04
3/21/2012	HACH sensION156 Portable Meter	5.69	21.7		0.03
3/22/2012	HACH sensION156 Portable Meter	5.92	22	7.92	0.04
3/23/2012	HACH sensION156 Portable Meter	5.73	22		0.04
3/24/2012	HACH sensION156 Portable Meter	5.63	22		0.03
3/25/2012	HACH sensION156 Portable Meter	5.80	22.6	8.09	0.04
3/26/2012	HACH sensION156 Portable Meter	5.85	22.2		0.05
3/27/2012	HACH sensION156 Portable Meter	6.01	20.5	7.91	0.05
3/28/2012	HACH sensION156 Portable Meter	5.86	20.3		0.04
3/29/2012	HACH sensION156 Portable Meter	5.76	21.9	7.7	0.04
3/30/2012	HACH sensION156 Portable Meter	5.71	22		0.04
3/31/2012	HACH sensION156 Portable Meter	5.80	22.6		0.04
4/1/2012	HACH sensION156 Portable Meter	5.79	20.9	7.82	0.04
4/2/2012	HACH sensION156 Portable Meter	6.05	22.2		0.04
4/3/2012	HACH sensION156 Portable Meter	5.86	22.8	7.7	0.05
4/4/2012	HACH sensION156 Portable Meter	5.92	22.7		0.04
4/5/2012	HACH sensION156 Portable Meter	5.99	21.8	7.59	0.05
4/6/2012	HACH sensION156 Portable Meter	5.62	22.5		0.04

Table 25 On-site Laboratory UV/AOP Product Water Results of General Parameters with Basin Plan Numeric Objectives

Sample Date	Method	Parameter Measured @ S10 UV/AOP Product			
		pH	Temperature, Deg C	DO, mg/L	Turbidity, NTU
4/7/2012	HACH sensION156 Portable Meter	5.87	22.7		0.04
4/8/2012	HACH sensION156 Portable Meter	5.38	23.4	7.86	0.04
4/9/2012	HACH sensION156 Portable Meter	5.62	23.5		0.04
4/10/2012	HACH sensION156 Portable Meter	5.57	23	7.88	0.04
4/11/2012	HACH sensION156 Portable Meter	5.53	22.8		0.04
4/12/2012	HACH sensION156 Portable Meter	5.41	22.7	7.65	0.05
4/13/2012	HACH sensION156 Portable Meter	5.44	22.3		0.04
4/14/2012	HACH sensION156 Portable Meter	5.51	22.7		0.05
4/15/2012	HACH sensION156 Portable Meter	5.55	22.8	7.95	0.03
4/16/2012	HACH sensION156 Portable Meter	5.53	23.4		0.05
4/17/2012	HACH sensION156 Portable Meter	5.25	23.2	7.45	0.05
4/19/2012	HACH sensION156 Portable Meter	5.43	23.3		0.04
4/20/2012	HACH sensION156 Portable Meter	5.44	23.4	7.81	0.04
4/21/2012	HACH sensION156 Portable Meter	5.49	23.7		0.05
4/22/2012	HACH sensION156 Portable Meter	5.43	23.2	7.83	0.04
4/23/2012	HACH sensION156 Portable Meter	5.65	23.8		0.03
4/24/2012	HACH sensION156 Portable Meter	5.93	22.9	7.88	0.04
4/25/2012	HACH sensION156 Portable Meter	5.57	23.3		0.04
4/26/2012	HACH sensION156 Portable Meter	5.52	23.8	7.98	0.04
4/27/2012	HACH sensION156 Portable Meter	5.49	23.3		0.04
4/28/2012	HACH sensION156 Portable Meter	5.46	23.9		0.03
4/29/2012	HACH sensION156 Portable Meter	5.44	23.3	7.92	0.04
4/30/2012	HACH sensION156 Portable Meter	5.63	23.9		0.05
5/1/2012	HACH sensION156 Portable Meter	5.62	24.2	7.52	0.08
5/2/2012	HACH sensION156 Portable Meter	5.56	23.6		0.04
5/3/2012	HACH sensION156 Portable Meter	5.54	23.6	7.37	0.04
5/4/2012	HACH sensION156 Portable Meter	5.61	23.7		0.04
5/5/2012	HACH sensION156 Portable Meter	5.70	24.1		0.05
5/6/2012	HACH sensION156 Portable Meter	5.63	23.9	7.45	0.04
5/7/2012	HACH sensION156 Portable Meter	5.64	24		0.04
5/12/2012	HACH sensION156 Portable Meter	5.62	24.6		0.05
5/13/2012	HACH sensION156 Portable Meter	5.75	24.8	7.69	0.04
5/14/2012	HACH sensION156 Portable Meter	5.56	25		0.04
5/15/2012	HACH sensION156 Portable Meter	5.49	24.6	7.46	0.04
5/16/2012	HACH sensION156 Portable Meter	5.57	24.9		0.04
5/17/2012	HACH sensION156 Portable Meter	5.56	24.7	7.5	0.04
5/18/2012	HACH sensION156 Portable Meter	5.62	24.7		0.04

Table 25 On-site Laboratory UV/AOP Product Water Results of General Parameters with Basin Plan Numeric Objectives

Sample Date	Method	Parameter Measured @ S10 UV/AOP Product			
		pH	Temperature, Deg C	DO, mg/L	Turbidity, NTU
5/19/2012	HACH sensION156 Portable Meter	5.70	25.2		0.04
5/20/2012	HACH sensION156 Portable Meter	5.68	25.1	7.6	0.04
5/21/2012	HACH sensION156 Portable Meter	5.66	25.3		0.04
5/23/2012	HACH sensION156 Portable Meter	5.63	25.1		0.04
5/25/2012	HACH sensION156 Portable Meter	5.66	24.7		0.04
5/28/2012	HACH sensION156 Portable Meter	5.64	25.4		0.04
5/29/2012	HACH sensION156 Portable Meter	5.70	25.8	7.51	0.04
5/30/2012	HACH sensION156 Portable Meter	5.65	24.7		0.04
6/2/2012	HACH sensION156 Portable Meter	5.69	25.8		0.04
6/3/2012	HACH sensION156 Portable Meter	5.75	25.9	6.87	0.05
6/4/2012	HACH sensION156 Portable Meter	5.66	25.9		0.05
6/5/2012	HACH sensION156 Portable Meter	5.66	25.4	7.87	0.06
6/6/2012	HACH sensION156 Portable Meter	5.63	25.7		0.05
6/7/2012	HACH sensION156 Portable Meter	5.52	26.1		0.05
6/9/2012	HACH sensION156 Portable Meter	5.62	26.1		0.05
6/10/2012	HACH sensION156 Portable Meter	5.79	26	7.28	0.04
6/11/2012	HACH sensION156 Portable Meter	5.86	25.7		0.05
6/12/2012	HACH sensION156 Portable Meter	5.76	25.6	7.58	0.05
6/13/2012	HACH sensION156 Portable Meter	5.57	25.4		0.05
6/14/2012	HACH sensION156 Portable Meter	5.60	25.5	7.43	0.05
6/16/2012	HACH sensION156 Portable Meter	5.70	25.8		0.04
6/17/2012	HACH sensION156 Portable Meter	5.66	25.6	7.37	0.04
6/18/2012	HACH sensION156 Portable Meter	5.73	26		0.06
6/20/2012	HACH sensION156 Portable Meter	5.62	26.2		0.04
6/21/2012	HACH sensION156 Portable Meter	5.64	26.3	7.27	0.06
6/22/2012	HACH sensION156 Portable Meter	5.65	26.4		0.04
6/26/2012	HACH sensION156 Portable Meter	5.60	26.5	7.36	0.05
6/27/2012	HACH sensION156 Portable Meter	5.55	26.6		0.05
6/28/2012	HACH sensION156 Portable Meter	5.82	25.2	6.74	0.06
7/2/2012	HACH sensION156 Portable Meter	5.72	26.8		0.05
7/3/2012	HACH sensION156 Portable Meter	6.05	26	7.26	0.05
7/5/2012	HACH sensION156 Portable Meter	6.02	26	7.32	0.05
7/6/2012	HACH sensION156 Portable Meter	5.68	26.5		0.04
7/10/2012	HACH sensION156 Portable Meter	5.72	27.2	6.93	0.04
7/11/2012	HACH sensION156 Portable Meter	5.65	27.4		0.04
7/12/2012	HACH sensION156 Portable Meter	5.69	27.3		0.04
7/13/2012	HACH sensION156 Portable Meter	5.68	27.2		0.04

Table 25 On-site Laboratory UV/AOP Product Water Results of General Parameters with Basin Plan Numeric Objectives

Sample Date	Method	Parameter Measured @ S10 UV/AOP Product			
		pH	Temperature, Deg C	DO, mg/L	Turbidity, NTU
7/16/2012	HACH sensION156 Portable Meter	5.85	27.2		0.05
7/17/2012	HACH sensION156 Portable Meter	5.74	27.4	7.05	0.04
7/18/2012	HACH sensION156 Portable Meter	5.83	27.5		0.05
7/19/2012	HACH sensION156 Portable Meter	5.78	27.8		0.04
7/20/2012	HACH sensION156 Portable Meter	5.78	27.7		0.05
7/23/2012	HACH sensION156 Portable Meter	5.82	27.7		0.04
7/24/2012	HACH sensION156 Portable Meter	5.81	27.5	7.42	0.05
7/25/2012	HACH sensION156 Portable Meter	5.75	27.5		0.04
7/26/2012	HACH sensION156 Portable Meter	5.65	27.6	7.26	0.04
7/27/2012	HACH sensION156 Portable Meter	5.69	27.5		0.06
7/31/2012	HACH sensION156 Portable Meter	6.04	27.9	7.32	0.05
n =		301	298	109	298
Average		5.6	24	7.6	0.05
Maximum		6.5	30	9.5	0.10
Minimum		5.2	16	6.4	0.03
STDev		0.2	2.4	0.4	0.01

Table 26 Summary of Compounds with Federal and State Primary Drinking Water Standards Results

Parameter	Method	Units	DL	RL	Quarter 1: 08/24/2011			Quarter 2: 11/08/2011			Quarter 3: 2/1/2012			Quarter 4: 5/1/2012			[1] Federal Drinking Water MCL	[1] CDPH Drinking Water MCL
					S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water		
1,1,1-Trichloroethane	EPA 524.2	µg/L	0.11	0.5	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	200	200
1,1,2,2-Tetrachloroethane	EPA 524.2	µg/L	0.2	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	1
1,1,2-Trichloroethane	EPA 524.2	µg/L	0.19	0.5	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	5	5
1,1-Dichloroethane	EPA 524.2	µg/L	0.12	0.5	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	-	5
1,1-Dichloroethene	EPA 524.2	µg/L	0.16	0.5	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	7	6
1,2,4-Trichlorobenzene	EPA 524.2	µg/L	0.17	0.5	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	70	5
1,2-Dibromo-3-chloropropane	EPA 504.1	µg/L	0.0034	0.01	<0.0034	<0.0034	<0.0034	<0.0034	<0.0034	<0.0034	<0.0034	<0.0034	<0.0034	<0.0034	<0.0034	<0.0034	0.2	0.2
1,2-Dibromoethane (EDB)	EPA 504.1	µg/L	0.0054	0.02	<0.0054	<0.0054	<0.0054	<0.0054	<0.0054	<0.0054	<0.0054	<0.0054	<0.02	<0.0054	<0.0054	<0.0054	0.05	0.05
1,2-Dichloroethane	EPA 524.2	µg/L	0.12	0.5	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	5	0.5
1,2-Dichloropropane	EPA 524.2	µg/L	0.13	0.5	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	5	5
1,3-Dichloropropene, Total	EPA 524.2	µg/L	0.15	0.5	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	-	0.5
2,3,7,8-Tetra CDD	EPA 1613B mod.	pg/L	1.9	10	<10	<9.5	<9.3	<10	<10	<9.8	<9.7	<9.5	<9.5	<5.2	<5.2	<5.2	30	30
2,4,5-TP (Silvex)	EPA 515.3	µg/L	0.09	0.2	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	50	50
2,4-D	EPA 515.3	µg/L	0.07	0.4	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	70	70
Alachlor	EPA 525.2	µg/L	0.022	0.1	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	<0.022	2	2
Aluminum, Total	EPA 200.8	µg/L	0.61	5	11	<5	37	8.8	<5	26	16	<5	29	6.1	<5	16	-	1000
Antimony, Total	EPA 200.8	µg/L	0.04	0.5	0.58	<0.04	<0.5	0.53	<0.5	<0.5	<0.5	<0.04	<0.5	<0.5	<0.04	<0.5	6	6
Arsenic, Total	EPA 200.8	µg/L	0.036	0.4	0.97	<0.036	2.5	0.98	<0.036	2.3	0.62	<0.036	2	0.77	<0.4	2.2	10	10
Asbestos	EPA 100.2	MFL	NA	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	7	7
Atrazine	EPA 525.2	µg/L	0.034	0.1	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	<0.034	3	1
Barium, Total	EPA 200.8	µg/L	0.03	0.5	22	<0.03	39	18	<0.03	39	21	<0.03	47	20	<0.5	70	2000	1000
Bentazon	EPA 515.3	µg/L	0.11	2	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	-	18
Benzene	EPA 524.2	µg/L	0.15	0.5	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	5	1
Benzo (a) pyrene	EPA 525.2	µg/L	0.07	0.1	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	0.2	0.2
Beryllium, Total	EPA 200.8	µg/L	0.088	0.1	<0.088	<0.088	<0.088	<0.088	<0.088	<0.088	<0.088	<0.088	<0.088	<0.088	<0.088	<0.088	4	4
Bis(2-ethylhexyl)adipate	EPA 525.2	µg/L	0.1	5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	400	400
Bis(2-ethylhexyl)phthalate	EPA 525.2	µg/L	1.1	3	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<3	<1.1	6	4
Bromate	EPA 326.0	µg/L	1.2	2.5	<1.2	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.5	<0.5	<0.25	<0.25	<0.25	10	10
Cadmium, Total	EPA 200.8	µg/L	0.02	0.1	<0.02	<0.02	<0.02	<0.1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	5	5
Carbofuran	EPA 531.1	µg/L	0.59	2	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	40	18
Carbon tetrachloride	EPA 524.2	µg/L	0.12	0.5	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	5	0.5
Chlordane (tech)	EPA 508	µg/L	0.066	0.1	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	2	0.1
Chlorite	EPA 300.1	µg/L	0.7	10	<0.7	<0.7	<0.7	<0.7	<10	<0.7	<0.7	<0.7	<0.7	<1.4	<0.7	<0.7	1000	1000
Chlorobenzene	EPA 524.2	µg/L	0.15	0.5	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	100	70
Chromium, Total	EPA 200.8	µg/L	0.074	0.2	0.25	<0.074	<0.2	0.56	<0.074	<0.2	0.52	<0.074	<0.2	0.28	<0.074	<0.2	100	50
cis-1,2-Dichloroethene	EPA 524.2	µg/L	0.11	0.5	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	70	6
Copper, Total	EPA 200.8	µg/L	0.27	0.5	1.6	<0.27	2.6	1.8	<0.27	4.1	1.7	<0.27	3	1.6	<0.27	3.1	1300a	1300a
Cyanide, Total	EPA 335.4	µg/L	2.7	5	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	200	150
Dalapon	EPA 515.3	µg/L	0.1	0.4	<0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.4	<0.1	<0.1	<0.1	<0.1	<0.1	200	200
Dinoseb	EPA 515.3	µg/L	0.14	0.4	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	7	7
Diquat	EPA 549.2	µg/L	0.9	4	<0.9	<0.9	<0.9	<4	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	20	20
Endothall	EPA 548.1	µg/L	3.5	45	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	100	100
Endrin	EPA 508	µg/L	0.002	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	2	2
Ethylbenzene	EPA 524.2	µg/L	0.21	0.5	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	700	300

Table 26 Summary of Compounds with Federal and State Primary Drinking Water Standards Results

Parameter	Method	Units	DL	RL	Quarter 1: 08/24/2011			Quarter 2: 11/08/2011			Quarter 3: 2/1/2012			Quarter 4: 5/1/2012			[1] Federal Drinking Water MCL	[1] CDPH Drinking Water MCL
					S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water		
Fluoride, Total	EPA 300.0	mg/l	0.02	0.1	0.61	<0.1	0.14	0.63	<0.02	0.16	0.54	<0.02	0.13	0.71	<0.02	0.25	4	2
Freon 113	EPA 524.2	µg/L	0.27	5	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	-	1200
gamma-BHC (Lindane)	EPA 508	µg/L	0.0015	0.01	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	0.2	0.2
Glyphosate	EPA 547	µg/L	1.8	5	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	700	700
[2] **Gross Alpha**	EPA 900.0	pCi/L	NA	NA	0.016+/-0.16 (MDA=0.016)	0.94+/-0.404 (MDA=0.601)	2.1+/-0.77 (MDA=1.089)	5.78+/-0.393 (MDA=0.016)	-2.0+/-0.582 (MDA=0.886)	0.31+/-0.584 (MDA=1)	0.016+/-0.15 (MDA=0.016)	-0.30+/-0.47 (MDA=0.801)	2.3+/-0.68 (MDA=1)	0.016+/-0.164 (MDA=0.016)	0.16+/-0.529 (MDA=0.927)	1.02+/-0.222 (MDA=0.016)	15 pCi/L	15 pCi/L
[3] **Gross Beta**	EPA 900.0	pCi/L	NA	NA	21+/-1.096 (MDA=1.117)	-0.59+/-0.578 (MDA=0.968)	1.7+/-0.626 (MDA=0.991)	24+/-1.329 (MDA=1.365)	-1.4+/-0.575 (MDA=0.922)	2.8+/-0.75 (MDA=1.191)	7.6+/-0.84 (MDA=1.1096)	0.28+/-0.532 (MDA=0.902)	3.2+/-0.537 (MDA=0.808)	3.4+/-0.829 (MDA=1.25)	0.62+/-0.531 (MDA=0.884)	5+/-0.83 (MDA=1.215)	4 mrem/ yr	50 pCi/L 4 mrem/ yr
HAA5, Total	EPA 552.2	µg/L		1	2.6	<1	2.5	1.5	<1	2.7	4	<1	5.7	2.1	<1	3.6	60	60
Heptachlor	EPA 508	µg/L	0.0009	0.01	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	<0.0009	0.4	0.01
Heptachlor epoxide	EPA 508	µg/L	0.0011	0.01	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011	0.2	0.01
Hexachlorobenzene	EPA 508	µg/L	0.003	0.01	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.01	<0.003	<0.003	<0.003	<0.003	<0.003	1	1
Hexachlorocyclopentadiene	EPA 508	µg/L	0.014	0.05	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	50	50
Lead, Total	EPA 200.8	µg/L	0.011	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.011	<0.2	<0.2	<0.011	<0.2	15a	15a
Mercury, Total	EPA 245.1	µg/L	0.0039	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.0039	<0.0039	<0.0039	2	2
Methoxychlor	EPA 508	µg/L	0.0044	0.01	<0.0044	<0.0044	<0.0044	<0.0044	<0.0044	<0.0044	<0.0044	<0.0044	<0.0044	<0.0044	<0.0044	<0.0044	40	30
Methyl tert-butyl ether (MTBE)	EPA 524.2	µg/L	0.19	2	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	-	13
Methylene chloride	EPA 524.2	µg/L	0.14	0.5	<0.5	<0.5	<0.14	<0.14	<0.14	<0.14	<0.5	<0.5	<0.14	<0.5	<0.5	<0.14	5	5
Molinate	EPA 525.2	µg/L	0.039	0.1	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	<0.039	-	20
Nickel, Total	EPA 200.8	µg/L	0.13	0.8	3.6	<0.13	1.2	3.5	<0.13	1.5	4.4	<0.13	1.1	3.2	<0.13	1.2	-	100
Nitrate as NO3	EPA 353.2	mg/l	0.36	1	73	3.1	1.6	70	2.9	1.5	69	3	1.3	66	4.3	<1	(as N) 10	(as NO3) 45
Nitrite as N	EPA 353.2	µg/L	10	100	<100	<10	<10	<100	<10	<10	<100	<10	<100	<100	<10	<10	1000	1000
NO2+NO3 as N	EPA 353.2	µg/L	20	200	17000	700	370	16000	660	350	16000	670	300	15000	970	200	10000	10000
o-Dichlorobenzene	EPA 524.2	µg/L	0.19	0.5	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	600	600
Oxamyl	EPA 531.1	µg/L	0.48	2	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	<0.48	200	50
PCBs, Total	EPA 508	µg/L	0.049	0.5	<0.049	<0.049	<0.049	<0.049	<0.049	<0.049	<0.049	<0.049	<0.049	<0.049	<0.049	<0.049	0.5	0.5
p-Dichlorobenzene	EPA 524.2	µg/L	0.18	0.5	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	75	5
Pentachlorophenol	EPA 515.3	µg/L	0.04	0.2	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	1	1
Perchlorate	EPA 314.0	µg/L	0.95	2	5.8	<0.95	<0.95	4.9	<0.95	<0.95	12	<0.95	<0.95	9.8	<0.95	<0.95	-	6
Picloram	EPA 515.3	µg/L	0.05	0.6	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	500	500
[4]**Radium 226**	EPA 903.1	pCi/L	NA	NA	0.433+/-0.278 (MDA=0.439)	0.118+/-0.172 (MDA=0.439)	0.078+/-0.153 (MDA=0.439)	0.108+/-0.259 (MDA=0.439)	0.000+/-0.21 (MDA=0.439)	0.053+/-0.233 (MDA=0.439)	0.241+/-0.341 (MDA=0.439)	0.048+/-0.282 (MDA=0.439)	0.00+/-0.265 (MDA=0.439)	0.265+/-0.267 (MDA=0.354)	0.22+/-0.259 (MDA=0.354)	0.572+/-0.311 (MDA=0.354)	5	5
[4]**Radium 228**	EPA Ra-05	pCi/L	NA	NA	0.00+/-0.631 (MDA=0.322)	0.207+/-0.707 (MDA=0.277)	0.00+/-0.563 (MDA=0.205)	0.000+/-0.562 (MDA=0.276)	0.000+/-0.484 (MDA=0.204)	0.000+/-0.625 (MDA=0.322)	0.00+/-0.453 (MDA=0.205)	0.00+/-0.418 (MDA=0.203)	0.00+/-0.702 (MDA=0.261)	0.25+/-0.431 (MDA=0.25)	0.2+/-0.495 (MDA=0.2)	0.203+/-0.464 (MDA=0.203)	5	5
Selenium, Total	EPA 200.8	µg/L	0.28	0.4	0.56	<0.28	<0.4	0.57	<0.28	<0.4	0.48	<0.28	0.43	1.1	<0.28	0.87	50	50
Simazine	EPA 525.2	µg/L	0.015	0.1	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	4	4
Strontium 90	EPA 905.0	pCi/L		NA	0.00+/-0.471 (MDA=0.676)	0.00+/-0.411 (MDA=0.675)	0.00+/-0.435 (MDA=0.675)	0.183+/-0.223 (MDA=0.675)	0.152+/-0.215 (MDA=0.675)	0.579+/-0.31 (MDA=0.676)	0.00+/-0.267 (MDA=0.636)	0.062+/-0.287 (MDA=0.636)	0.218+/-0.283 (MDA=0.636)	0.636+/-0.508 (MDA=0.636)	0.636+/-0.546 (MDA=0.636)	0.636+/-0.469 (MDA=0.636)	8	8
Styrene	EPA 524.2	µg/L	0.19	0.5	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	100	100
Tetrachloroethene	EPA 524.2	µg/L	0.18	0.5	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	5	5
Thallium, Total	EPA 200.8	µg/L	0.009	0.2	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.2	<0.2	<0.2	<0.2	<0.009	<0.009	2	2
Thiobencarb	EPA 525.2	µg/L	0.025	0.1	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	-	70
THMs, Total	EPA 524.2	µg/L	0.6	2	3	2.2	54	<2	<0.6	38	<0.6	<0.6	33	<2	<0.6	36	80	80

Table 26 Summary of Compounds with Federal and State Primary Drinking Water Standards Results

Parameter	Method	Units	DL	RL	Quarter 1: 08/24/2011			Quarter 2: 11/08/2011			Quarter 3: 2/1/2012			Quarter 4: 5/1/2012			[1] Federal Drinking Water MCL	[1] CDPH Drinking Water MCL
					S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water		
Toluene	EPA 524.2	µg/L	0.14	0.5	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.5	<0.14	<0.14	1000	150
Toxaphene	EPA 508	µg/L	0.066	1	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	<0.066	3	3
trans-1,2-Dichloroethene	EPA 524.2	µg/L	0.11	0.5	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	100	10
Trichloroethene	EPA 524.2	µg/L	0.18	0.5	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	5	5
Trichlorofluoromethane	EPA 524.2	µg/L	0.18	0.5	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	-	150
Tritium[5]	EPA 906.0	pCi/L	NA	NA	0.00+/-246 (MDA=423)	0.00+/-242 (MDA=423)	0.00+/-244 (MDA=423)	0.000+/-417 (MDA=714)	0.00+/-421 (MDA=714)	0.00+/-422 (MDA=714)	126+/-268 (MDA=437)	0+/-267 (MDA=437)	0.00+/-261 (MDA=437)	505+/-303 (MDA=505)	25.7+/-305 (MDA=505)	505+/-301 (MDA=505)	20000	20000
Uranium Rad[5]	EPA 200.8	pCi/L	0.019	0.13	0.17	<0.019	0.92	<0.13	<0.019	0.96	0.16	<0.019	1.3	0.31	<0.019	2.2	20.1	20
Vinyl chloride	EPA 524.2	µg/L	0.18	0.5	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	2	0.5
Xylenes, Total	EPA 524.2	µg/L	0.33	0.5	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	<0.33	10000	1750

Note:

1. California Department of Public Health, *Maximum Contaminant Levels and Regulatory Dates for Drinking Water U.S. EPA Vs California*, November 2008. http://www.cdph.ca.gov/certlic/drinkingwater/pages/chemicalcontaminants.aspx
2. Gross Alpha Radioactivity is simply a measurement of all alpha activity present, regardless of specific radionuclide source. Gross measurements are used as a method to screen samples for relative levels of radioactivity.
3. Gross Beta Radioactivity is simply a measurement of all beta activity present, regardless of specific radionuclide source. Gross measurements are used as a method to screen samples for relative levels of radioactivity.
4. MCL for Radium 226 and Radium 228 is expressed as Combined Radium (226+228)
5. Refer to **Section 3.2.5 URs** for how to interpret MDAs and Counting Errors.
6. Results shown as less than (<VALUE) indicate the reported result was less than the RL or DL. In some instances, the RL and/or DL varied during the testing period due to laboratory QC procedures or changes in method procedures.

Table 27 Summary of Compounds with Federal and State Secondary Drinking Water Standards Results

Parameter	Method	Units	DL	RL	Quarter 1: 08/24/2011			Quarter 2: 11/08/2011			Quarter 3: 2/1/2012			Quarter 4: 5/1/2012			Federal Drinking Water MCL	CDPH Drinking Water MCL
					S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water		
Aluminum, Total	EPA 200.8	µg/L	0.61	5	11	<5	37	8.8	<5	26	16	<5	29	6.1	<5	16	50 to 200	200
Chloride, Total	EPA 300.0	mg/l	1	5	250	<5	61	240	<5	54	260	<5	63	270	<5	71	250	250
Color	SM2120B	Color Units	NA	3	20	<3	<3	20	<3	<3	15	<3	<3	15	<3	<3	15	15
Copper, Total	EPA 200.8	µg/L	0.27	0.5	1.6	<0.27	2.6	1.8	<0.27	4.1	1.7	<0.27	3	1.6	<0.27	3.1	1000	1000
Iron, Total	EPA 200.7	µg/L	1.1	10	93	<1.1	22	73	<1.1	33	110	<1.1	35	69	<1.1	18	300	300
Langelier Index @ 20 C	EPA 200.2	N/A	-10.0	-10.0	<-10	-6.64	<-10	<-10	-6.69	<-10	-0.832	-6.59	-0.483	-0.784	-6.15	-0.112	Non Corrosive	----------
Manganese, Total	EPA 200.8	µg/L	0.11	0.2	110	<0.11	23	70	<0.11	5.7	93	0.37	4.3	72	<0.2	2.8	50	50
MBAS	SM 5540 C	mg/l	0.019	0.05	0.063	<0.019	<0.05	<0.05	<0.019	<0.019	0.054	<0.019	<0.019	0.07	<0.019	<0.019	0.5	0.5
Methyl tert-butyl ether (MTBE)	EPA 524.2	µg/L	0.19	2	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	----------	5
pH water	General Preparation	Units	0.1	0.1	7.08	5.82	7.48	7.04	5.99	7.4	6.99	5.75	7.52	6.91	5.89	7.62	6.5-8.5	----------
Silver, Total	EPA 200.8	µg/L	0.027	0.2	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	0.21	<0.2	<0.2	100	100
Specific Conductance (EC)	SM2510B	umhos/cm	0.47	4	1500	22	470	1100	16	370	1400	20	520	1500	26	670	NR	900
Sulfate as SO4	EPA 300.0	mg/l	0.1	0.5	170	<0.1	61	130	<0.5	56	150	<0.1	73	180	<0.5	130	250	250
Thiobencarb	EPA 525.2	µg/L	0.025	0.1	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	----------	1
Threshold Odor Number	EPA 140.1	T.O.N.	NA	1	10	<1	<1	2	<1	2	20	<1	<1	10	<1	<1	3	3
Total Dissolved Solids	SM2540C	mg/l	4	10	850	16	280	760	16	380	710	13	270	650	11	290	500	500
Turbidity	EPA 180.1	NTU	0.024	0.1	0.35	<0.024	0.61	<0.024	<0.024	<0.024	0.17	<0.024	0.35	<0.024	<0.024	<0.024	5	5
Zinc, Total	EPA 200.8	µg/L	1.1	5	66	<1.1	5.5	48	<1.1	<5	100	<1.1	<5	36	<1.1	<5	5000	5000

Note:

1. NR=not regulated. California Code of Regulation Title 22. Division 4. Environmental Health Chapter 15. Domestic Water Quality and Monitoring Regulations Article 16.
2. Results shown as less than (<VALUE) indicate the reported result was less than the RL or DL. In some instances, the RL and/or DL varied during the testing period due to laboratory QC procedures or changes in method procedures.

Table 28 Summary of Detected Priority Pollutant Results North City Tertiary Effluent (Pre-chlorination)

Parameter	Method	Units	DL	RL	Quarter 1: 08/24/2011	Quarter 2: 11/08/2011	Quarter 3: 02/01/2012	Quarter 4: 05/01/2012	Fresh Water Criterion Continuous Conc. Aquatic (µg/L)	Human Health (10-6) risk for carcinogens) For the Consumption of: Water & Organisms (µg/L)
2,3,7,8-Tetra CDD	EPA 1613B mod.	pg/L	varies	10	<10	<10	<9.7	<5.2		0.000000013 c
Antimony, Total	EPA 200.8	µg/L	0.04	0.5	0.58	0.53	<0.5	<0.5		14 a,s
Arsenic, Total	EPA 200.8	µg/L	0.036	0.4	0.97	0.98	0.62	0.77	150 i,m,w	
Asbestos	EPA 100.2	MFL	0	0.2	<0.2	<0.2	<0.2	<0.2		7,000,000 fibers/L k,s
Bromodichloromethane	EPA 524.2	µg/L	0.09	0.5	1	0.58	<0.5	0.51		0.56 a,c
Cadmium, Total	EPA 200.8	µg/L	0.02	0.1	<0.02	<0.1	<0.02	<0.02	2.2 e,i,m,w	n
Chloroform	EPA 524.2	µg/L	0.12	0.5	1.4	0.8	<0.5	0.52	Reserved	Reserved
Chromium, Total (Cr (III) + Cr(VI))	EPA 200.8	µg/L	0.074	0.2	0.25	0.56	0.52	0.28	11 i,m,w (Cr(VI))/180 e,i,m,o(Cr(III))	n
Copper, Total	EPA 200.8	µg/L	0.27	0.5	1.6	1.8	1.7	1.6	9.0 e,i,m,w	1300
Dibromochloromethane	EPA 524.2	µg/L	0.2	0.5	0.65	<0.5	<0.5	<0.5		0.401 a,c
Lead, Total	EPA 200.8	µg/L	0.011	0.2	<0.2	<0.2	<0.2	<0.2	2.5 e,i,m	n
Mercury, Total	EPA 245.1	µg/L	0.0039	0.05	<0.05	<0.05	<0.05	<0.0039	[Reserved]	0.050 a
Methylene chloride	EPA 524.2	µg/L	0.14	0.5	<0.5	<0.14	<0.5	<0.5		4.7 a,c
Nickel, Total	EPA 200.8	µg/L	0.13	0.8	3.6	3.5	4.4	3.2	52 e,i,m,w	610 a
Selenium, Total	EPA 200.8	µg/L	0.28	0.4	0.56	0.57	0.48	1.1	5.0 q	n
Thallium, Total	EPA 200.2	µg/L	0.009	0.2	<0.009	<0.009	<0.2	<0.2		
Zinc, Total	EPA 200.8	µg/L	1.1	5	66	48	100	36	120 e,i,m,w	
N-Nitrosodimethylamine	EPA 521	ng/l	0.14	2	2.9	<2	<0.14	<0.14		0.00069 a,c,s

Note:

1. Footnotes are defined in Federal Register / Vol. 65, No. 97/Thursday, May 18, 2000/Rules and Regulations. The complete list of priority pollutants analyzed is provided in Table 31.
2. Results shown as less than (<VALUE) indicate the reported result was less than the RL or DL. In some instances, the RL and/or DL varied during the testing period due to laboratory QC procedures or changes in method procedures.

Table 29 Summary of Detected Priority Pollutant Results UV/AOP Product Water

Parameter	Method	Units	DL	RL	Quarter 1: 08/24/2011	Quarter 2: 11/08/2011	Quarter 3: 02/01/2012	Quarter 4: 05/01/2012	Fresh Water Criterion Continuous Conc. Aquatic (μg/L)	Human Health (10-6) risk for carcinogens) For the Consumption of: Water & Organisms (μg/L)
2,3,7,8-Tetra CDD	EPA 1613B mod.	pg/L	varies	10	<9.5	<10	<9.5	<5.2		0.000000013 c
Antimony, Total	EPA 200.8	μg/L	0.04	0.5	<0.04	<0.5	<0.04	<0.04		14 a,s
Arsenic, Total	EPA 200.8	μg/L	0.036	0.4	<0.036	<0.036	<0.036	<0.4	150 i,m,w	
Asbestos	EPA 100.2	MFL	0	0.2	<0.2	<0.2	<0.2	<0.2		7,000,000 fibers/L k,s
Bromodichloromethane	EPA 524.2	μg/L	0.09	0.5	0.78	<0.5	<0.5	<0.5		0.56 a,c
Chloroform	EPA 524.2	μg/L	0.12	0.5	1.4	<0.5	<0.12	<0.5	Reserved	Reserved
Diethyl phthalate	EPA 625	μg/L	0.15	1	<1	<0.15	<0.15	<0.15		23000 a,s
Dimethyl phthalate	EPA 625	μg/L	0.18	1	<1	<0.18	<0.18	<0.18		313000 s
Di-n-butyl phthalate	EPA 625	μg/l	0.24	1	2.2	<0.24	<0.24	<0.24		2700 a,s
Lead, Total	EPA 200.8	μg/L	0.011	0.2	<0.2	<0.2	<0.011	<0.011	2.5 e,i,m	n
Mercury, Total	EPA 245.1	μg/L	0.0039	0.05	<0.05	<0.05	<0.05	<0.0039	[Reserved]	0.050 a
Methylene chloride	EPA 524.2	μg/L	0.14	0.5	<0.5	<0.14	<0.5	<0.5		4.7 a,c
N-Nitrosodimethylamine	EPA 521	ng/l	0.14	2	<0.14	<0.14	<0.14	<0.14		0.00069 a,c,s
Silver, Total	EPA 200.8	μg/L	0.027	0.2	<0.027	<0.027	<0.027	<0.2		

Note:

1. Footnotes are defined in Federal Register / Vol. 65, No. 97/Thursday, May 18, 2000/Rules and Regulations. The complete list of priority pollutants analyzed is provided in Table 31.
2. Results shown as less than (<VALUE) indicate the reported result was less than the RL or DL. In some instances, the RL and/or DL varied during the testing period due to laboratory QC procedures or changes in method procedures.

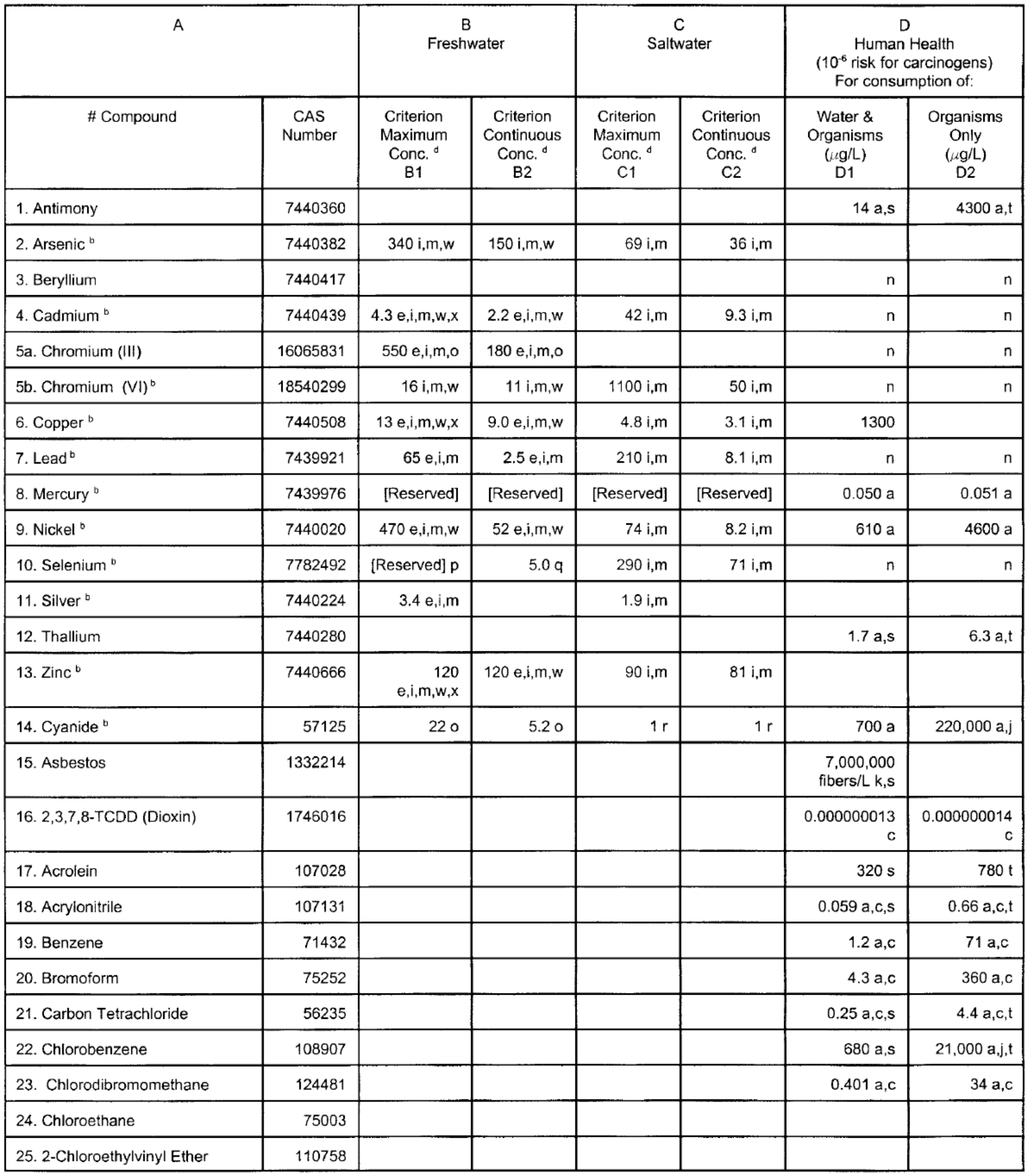
Table 30 Summary of Detected Priority Pollutant Results Imported Raw Aqueduct Water

Parameter	Method	Units	DL	RL	Quarter 1: 08/24/2011	Quarter 2: 11/08/2011	Quarter 3: 02/01/2012	Quarter 4: 05/01/2012	[1] Fresh Water Criterion Continuous Conc. Aquatic (µg/L)	[1] Human Health (10-6) risk for carcinogens) For the Consumption of: Water & Organisms (µg/L)
2,3,7,8-Tetra CDD	EPA 1613B mod.	pg/L	varies	10	<9.3	<9.8	<9.5	<5.2		0.000000013 c
Antimony, Total	EPA 200.8	µg/L	0.04	0.5	<0.5	<0.5	<0.5	<0.5		14 a,s
Arsenic, Total	EPA 200.8	µg/L	0.036	0.4	2.5	2.3	2	2.2	150 i,m,w	
Asbestos	EPA 100.2	MFL	0	0.2	<0.2	<0.2	<0.2	<0.2		7,000,000 fibers/L k,s
Bis(2-ethylhexyl)phthalate	EPA 625	µg/L	2.3	5	<2.3	<2.3	<2.3	<5		
Bromodichloromethane	EPA 524.2	µg/L	0.09	0.5	19	14	10	10		0.56 a,c
Bromoform	EPA 524.2	µg/L	0.19	0.5	3.5	2.9	3.8	6.2		4.3 a,c
Chloroform	EPA 524.2	µg/L	0.12	0.5	11	6.6	4.8	4.8	Reserved	Reserved
[2] **Chromium, Total (Cr (III) + Cr(VI))**	EPA 200.8	µg/L	0.074	0.2	<0.2	<0.2	<0.2	<0.2	11 i,m,w (Cr(VI))/180 e,i,m,o(Cr(III))	n
Copper, Total	EPA 200.8	µg/L	0.27	0.5	2.6	4.1	3	3.1	9.0 e,i,m,w	1300
Dibromochloromethane	EPA 524.2	µg/L	0.2	0.5	21	14	14	15		0.401 a,c
Heptachlor epoxide	EPA 508	µg/L	0.0011	0.01	<0.0011	<0.0011	<0.0011	<0.0011	0.0038 g	0.0001 a,c
Lead, Total	EPA 200.8	µg/L	0.011	0.2	<0.2	<0.2	<0.2	<0.2	2.5 e,i,m	n
Mercury, Total	EPA 245.1	µg/L	0.0039	0.05	<0.05	<0.05	<0.05	<0.0039	[Reserved]	0.050 a
Nickel, Total	EPA 200.8	µg/L	0.13	0.8	1.2	1.5	1.1	1.2	52 e,i,m,w	610 a
Nitrobenzene	EPA 625	µg/L	0.36	1	<0.36	<0.36	<0.36	<0.36		17 a,s
Phenanthrene	EPA 625	µg/L	0.32	1	<0.32	<0.32	<0.32	<0.32		
Pyrene	EPA 625	µg/L	0.25	1	<0.25	<0.25	<0.25	<0.25		960 a
Selenium, Total	EPA 200.8	µg/L	0.28	0.4	<0.4	<0.4	0.43	0.87	5.0 q	n
Silver, Total	EPA 200.8	µg/L	0.027	0.2	<0.027	<0.027	<0.027	<0.2		
Vinyl chloride	EPA 524.2	µg/L	0.18	0.5	<0.18	<0.18	<0.18	<0.18		2 c,s
Zinc, Total	EPA 200.8	µg/L	1.1	5	5.5	<5	<5	<5	120 e,i,m,w	

Note:

1. Footnotes are defined in Federal Register / Vol. 65, No. 97/Thursday, May 18, 2000/Rules and Regulations. Data flags provided in the original laboratory reports are not shown. The complete list of priority pollutants analyzed is provided in Table 31.
2. Lab 2 condcuted these analysis. Hexavalent Chromium results are presented in Table 33 (Lab 1) and Table 33 (Lab 2). Cr (III) = Trivalent chromium is determined based on calculation of Total Chromium minus Cr VI (hexavalent chromium).
3. Results shown as less than (<VALUE) indicate the reported result was less than the RL or DL. In some instances, the RL and/or DL varied during the testing period due to laboratory QC procedures or changes in method procedures.

Table 31 Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule



A		B Freshwater		C Saltwater		D Human Health (10^{-6} risk for carcinogens) For consumption of:	
# Compound	CAS Number	Criterion Maximum Conc. [d] B1	Criterion Continuous Conc. [d] B2	Criterion Maximum Conc. [d] C1	Criterion Continuous Conc. [d] C2	Water & Organisms (μg/L) D1	Organisms Only (μg/L) D2
1. Antimony	7440360					14 a,s	4300 a,t
2. Arsenic [b]	7440382	340 i,m,w	150 i,m,w	69 i,m	36 i,m		
3. Beryllium	7440417					n	n
4. Cadmium [b]	7440439	4.3 e,i,m,w,x	2.2 e,i,m,w	42 i,m	9.3 i,m	n	n
5a. Chromium (III)	16065831	550 e,i,m,o	180 e,i,m,o			n	n
5b. Chromium (VI) [b]	18540299	16 i,m,w	11 i,m,w	1100 i,m	50 i,m	n	n
6. Copper [b]	7440508	13 e,i,m,w,x	9.0 e,i,m,w	4.8 i,m	3.1 i,m	1300	
7. Lead [b]	7439921	65 e,i,m	2.5 e,i,m	210 i,m	8.1 i,m	n	n
8. Mercury [b]	7439976	[Reserved]	[Reserved]	[Reserved]	[Reserved]	0.050 a	0.051 a
9. Nickel [b]	7440020	470 e,i,m,w	52 e,i,m,w	74 i,m	8.2 i,m	610 a	4600 a
10. Selenium [b]	7782492	[Reserved] p	5.0 q	290 i,m	71 i,m	n	n
11. Silver [b]	7440224	3.4 e,i,m		1.9 i,m			
12. Thallium	7440280					1.7 a,s	6.3 a,t
13. Zinc [b]	7440666	120 e,i,m,w,x	120 e,i,m,w	90 i,m	81 i,m		
14. Cyanide [b]	57125	22 o	5.2 o	1 r	1 r	700 a	220,000 a,j
15. Asbestos	1332214					7,000,000 fibers/L k,s	
16. 2,3,7,8-TCDD (Dioxin)	1746016					0.000000013 c	0.000000014 c
17. Acrolein	107028					320 s	780 t
18. Acrylonitrile	107131					0.059 a,c,s	0.66 a,c,t
19. Benzene	71432					1.2 a,c	71 a,c
20. Bromoform	75252					4.3 a,c	360 a,c
21. Carbon Tetrachloride	56235					0.25 a,c,s	4.4 a,c,t
22. Chlorobenzene	108907					680 a,s	21,000 a,j,t
23. Chlorodibromomethane	124481					0.401 a,c	34 a,c
24. Chloroethane	75003						
25. 2-Chloroethylvinyl Ether	110758						

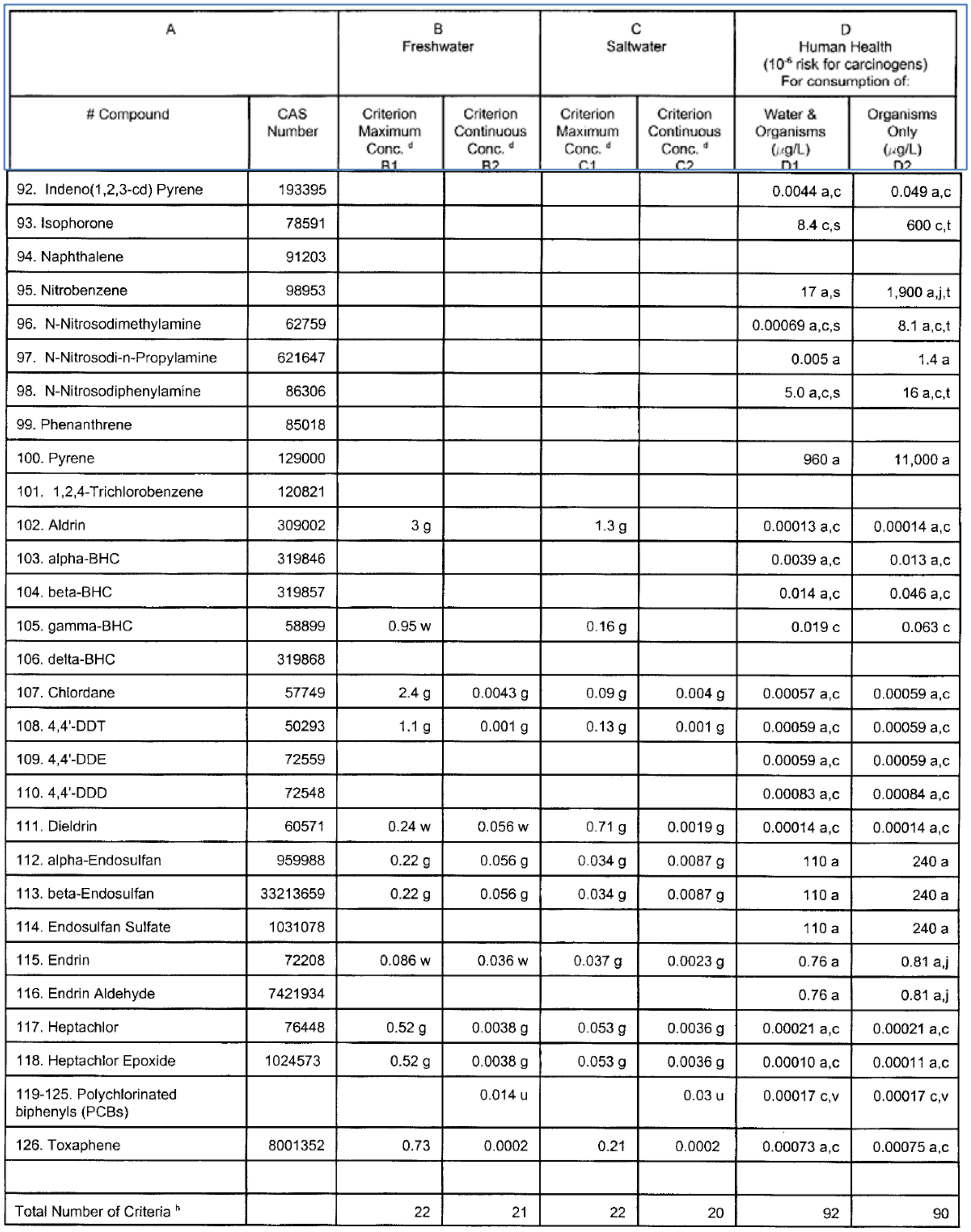
Table 31 Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule (Cont.)

A		B Freshwater		C Saltwater		D Human Health (10^{-6} risk for carcinogens) For consumption of:	
# Compound	CAS Number	Criterion Maximum Conc. [d] B1	Criterion Continuous Conc. [d] B2	Criterion Maximum Conc. [d] C1	Criterion Continuous Conc. [d] C2	Water & Organisms (µg/L) D1	Organisms Only (µg/L) D2
26. Chloroform	67663					[Reserved]	[Reserved]
27. Dichlorobromomethane	75274					0.56 a,c	46 a,c
28. 1,1-Dichloroethane	75343						
29. 1,2-Dichloroethane	107062					0.38 a,c,s	99 a,c,t
30. 1,1-Dichloroethylene	75354					0.057 a,c,s	3.2 a,c,t
31. 1,2-Dichloropropane	78875					0.52 a	39 a
32. 1,3-Dichloropropylene	542756					10 a,s	1,700 a,t
33. Ethylbenzene	100414					3,100 a,s	29,000 a,t
34. Methyl Bromide	74839					48 a	4,000 a
35. Methyl Chloride	74873					n	n
36. Methylene Chloride	75092					4.7 a,c	1,600 a,c
37. 1,1,2,2-Tetrachloroethane	79345					0.17 a,c,s	11 a,c,t
38. Tetrachloroethylene	127184					0.8 c,s	8.85 c,t
39. Toluene	108883					6,800 a	200,000 a
40. 1,2-Trans-Dichloroethylene	156605					700 a	140,000 a
41. 1,1,1-Trichloroethane	71556					n	n
42. 1,1,2-Trichloroethane	79005					0.60 a,c,s	42 a,c,t
43. Trichloroethylene	79016					2.7 c,s	81 c,t
44. Vinyl Chloride	75014					2 c,s	525 c,t
45. 2-Chlorophenol	95578					120 a	400 a
46. 2,4-Dichlorophenol	120832					93 a,s	790 a,t
47. 2,4-Dimethylphenol	105679					540 a	2,300 a
48. 2-Methyl-4,6-Dinitrophenol	534521					13.4 s	765 t
49. 2,4-Dinitrophenol	51285					70 a,s	14,000 a,t
50. 2-Nitrophenol	88755						
51. 4-Nitrophenol	100027						
52. 3-Methyl-4-Chlorophenol	59507						
53. Pentachlorophenol	87865	19 f,w	15 f,w	13	7.9	0.28 a,c	8.2 a,c,j
54. Phenol	108952					21,000 a	4,600,000 a,j,t
55. 2,4,6-Trichlorophenol	88062					2.1 a,c	6.5 a,c
56. Acenaphthene	83329					1,200 a	2,700 a
57. Acenaphthylene	208968						
58. Anthracene	120127					9,600 a	110,000 a

Table 31 Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule (Cont.)

A		B Freshwater		C Saltwater		D Human Health (10^{-6} risk for carcinogens) For consumption of:	
# Compound	CAS Number	Criterion Maximum Conc. [d] B1	Criterion Continuous Conc. [d] B2	Criterion Maximum Conc. [d] C1	Criterion Continuous Conc. [d] C2	Water & Organisms (μg/L) D1	Organisms Only (μg/L) D2
59. Benzidine	92875					0.00012 a,c,s	0.00054 a,c,t
60. Benzo(a)Anthracene	56553					0.0044 a,c	0.049 a,c
61. Benzo(a)Pyrene	50328					0.0044 a,c	0.049 a,c
62. Benzo(b)Fluoranthene	205992					0.0044 a,c	0.049 a,c
63. Benzo(ghi)Perylene	191242						
64. Benzo(k)Fluoranthene	207089					0.0044 a,c	0.049 a,c
65. Bis(2-Chloroethoxy)Methane	111911						
66. Bis(2-Chloroethyl)Ether	111444					0.031 a,c,s	1.4 a,c,t
67. Bis(2-Chloroisopropyl)Ether	39638329					1,400 a	170,000 a,t
68. Bis(2-Ethylhexyl)Phthalate	117817					1.8 a,c,s	5.9 a,c,t
69. 4-Bromophenyl Phenyl Ether	101553						
70. Butylbenzyl Phthalate	85687					3,000 a	5,200 a
71. 2-Chloronaphthalene	91587					1,700 a	4,300 a
72. 4-Chlorophenyl Phenyl Ether	7005723						
73. Chrysene	218019					0.0044 a,c	0.049 a,c
74. Dibenzo(a,h)Anthracene	53703					0.0044 a,c	0.049 a,c
75. 1,2 Dichlorobenzene	95501					2,700 a	17,000 a
76. 1,3 Dichlorobenzene	541731					400	2,600
77. 1,4 Dichlorobenzene	106467					400	2,600
78. 3,3'-Dichlorobenzidine	91941					0.04 a,c,s	0.077 a,c,t
79. Diethyl Phthalate	84662					23,000 a,s	120,000 a,t
80. Dimethyl Phthalate	131113					313,000 s	2,900,000 t
81. Di-n-Butyl Phthalate	84742					2,700 a,s	12,000 a,t
82. 2,4-Dinitrotoluene	121142					0.11 c,s	9.1 c,t
83. 2,6-Dinitrotoluene	606202						
84 Di-n-Octyl Phthalate	117840						
85. 1,2-Diphenylhydrazine	122667					0.040 a,c,s	0.54 a,c,t
86. Fluoranthene	206440					300 a	370 a
87. Fluorene	86737					1,300 a	14,000 a
88. Hexachlorobenzene	118741					0.00075 a,c	0.00077 a,c
89. Hexachlorobutadiene	87683					0.44 a,c,s	50 a,c,t
90. Hexachlorocyclopentadiene	77474					240 a,s	17,000 a,j,t
91. Hexachloroethane	67721					1.9 a,c,s	8.9 a,c,t

Table 31 Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule (Cont.)



A		B Freshwater		C Saltwater		D Human Health (10^{-6} risk for carcinogens) For consumption of:	
# Compound	CAS Number	Criterion Maximum Conc. [d] B1	Criterion Continuous Conc. [d] B2	Criterion Maximum Conc. [d] C1	Criterion Continuous Conc. [d] C2	Water & Organisms (µg/L) D1	Organisms Only (µg/L) D2
92. Indeno(1,2,3-cd) Pyrene	193395					0.0044 a,c	0.049 a,c
93. Isophorone	78591					8.4 c,s	600 c,t
94. Naphthalene	91203						
95. Nitrobenzene	98953					17 a,s	1,900 a,j,t
96. N-Nitrosodimethylamine	62759					0.00069 a,c,s	8.1 a,c,t
97. N-Nitrosodi-n-Propylamine	621647					0.005 a	1.4 a
98. N-Nitrosodiphenylamine	86306					5.0 a,c,s	16 a,c,t
99. Phenanthrene	85018						
100. Pyrene	129000					960 a	11,000 a
101. 1,2,4-Trichlorobenzene	120821						
102. Aldrin	309002	3 g		1.3 g		0.00013 a,c	0.00014 a,c
103. alpha-BHC	319846					0.0039 a,c	0.013 a,c
104. beta-BHC	319857					0.014 a,c	0.046 a,c
105. gamma-BHC	58899	0.95 w		0.16 g		0.019 c	0.063 c
106. delta-BHC	319868						
107. Chlordane	57749	2.4 g	0.0043 g	0.09 g	0.004 g	0.00057 a,c	0.00059 a,c
108. 4,4'-DDT	50293	1.1 g	0.001 g	0.13 g	0.001 g	0.00059 a,c	0.00059 a,c
109. 4,4'-DDE	72559					0.00059 a,c	0.00059 a,c
110. 4,4'-DDD	72548					0.00083 a,c	0.00084 a,c
111. Dieldrin	60571	0.24 w	0.056 w	0.71 g	0.0019 g	0.00014 a,c	0.00014 a,c
112. alpha-Endosulfan	959988	0.22 g	0.056 g	0.034 g	0.0087 g	110 a	240 a
113. beta-Endosulfan	33213659	0.22 g	0.056 g	0.034 g	0.0087 g	110 a	240 a
114. Endosulfan Sulfate	1031078					110 a	240 a
115. Endrin	72208	0.086 w	0.036 w	0.037 g	0.0023 g	0.76 a	0.81 a,j
116. Endrin Aldehyde	7421934					0.76 a	0.81 a,j
117. Heptachlor	76448	0.52 g	0.0038 g	0.053 g	0.0036 g	0.00021 a,c	0.00021 a,c
118. Heptachlor Epoxide	1024573	0.52 g	0.0038 g	0.053 g	0.0036 g	0.00010 a,c	0.00011 a,c
119-125. Polychlorinated biphenyls (PCBs)			0.014 u		0.03 u	0.00017 c,v	0.00017 c,v
126. Toxaphene	8001352	0.73	0.0002	0.21	0.0002	0.00073 a,c	0.00075 a,c
Total Number of Criteria [h]		22	21	22	20	92	90

Note: Footnotes are defined in Federal Register / Vol. 65, No. 97/Thursday, May 18, 2000/Rules and Regulations.

Table 32 Summary of Compounds with CDPH Drinking Water Notification Levels Results

Parameter	Method	Units	DL	RL	Quarter 1: 08/24/2011			Quarter 2: 11/08/2011			Quarter 3: 02/01/2012			Quarter 4: 05/01/2012			CDPH Drinking Water Notification Level [1]
					S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	
1,2,3-Trichloropropane	SRL 524M-TCP	µg/L	0.0012	0.005	<0.0012	<0.0012	<0.0012	<0.0012	<0.0012	<0.0012	<0.0012	<0.0012	<0.0012	<0.0012	<0.0012	<0.0012	0.005
1,2,4-Trimethylbenzene	EPA 524.2	µg/L	0.2	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	330
1,3,5-Trimethylbenzene	EPA 524.2	µg/L	0.17	0.5	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	330
1,4-Dioxane	EPA 8270M	µg/L	0.04	0.5	1.8	<0.04	<0.04	5.6	<0.04	<0.04	1.2	<0.04	<0.04	1.6	<0.04	<0.04	1
2,4,6-Trinitrotoluene	EPA 8330A	µg/L	0.2	2	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	1
2-Chlorotoluene	EPA 524.2	µg/L	0.15	0.5	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	140
4-Chlorotoluene	EPA 524.2	µg/L	0.15	0.5	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	140
Methyl isobutyl Ketone (MIBK)	EPA 524.2	µg/L	0.56	5	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	<0.56	120
Boron, Total	EPA 200.8	µg/L	0.28	1	400	240	160	340	210	130	360	200	140	370	290	150	1000
Carbon Disulfide	EPA 524.2	µg/L	0.13	0.5	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	160
Chlorate	EPA 300.1	µg/L	0.95	10	16	<0.95	<0.95	580	<10	<10	88	<0.95	<10	14	<0.95	13	800
Diazinon	EPA 525.2	µg/L	0.096	0.1	<0.096	<0.096	<0.096	<0.096	<0.096	<0.096	<0.096	<0.096	<0.096	<0.096	<0.096	<0.096	1.2
Dichlorodifluoromethane (Freon 12)	EPA 524.2	µg/L	0.12	0.5	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	1000
[2]Ethylene glycol	EPA 8015B	mg/l	11	50	<11	<11	<11	<11	<11	<11	<11	<11	<11	<50	<50	<50	14
Formaldehyde	EPA 556	µg/L	0.26	2	6.8	8.9	5	6	11	2.8	8.2	5.7	2.7	8.5	6.5	2.5	100
HMX	EPA 8330A	µg/L	3	10	<3	<0.59	<0.59	<1.5	<0.3	<0.3	<1.5	<0.3	<0.3	<1.5	<0.3	<0.3	350
Isopropylbenzene	EPA 524.2	µg/L	0.18	0.5	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	770
Manganese, Total	EPA 200.8	µg/L	0.11	0.2	110	<0.11	23	70	<0.11	5.7	93	0.37	4.3	72	<0.2	2.8	500
Naphthalene	EPA 524.2	µg/L	0.42	0.5	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	<0.42	17
n-Butylbenzene	EPA 524.2	µg/L	0.29	0.5	<0.29	<0.29	<0.29	<0.29	<0.29	<0.29	<0.29	<0.29	<0.29	<0.29	<0.29	<0.29	260
N-Nitrosodiethylamine	EPA 521	ng/l	0.72	2	<2	<0.72	<0.72	<0.72	<0.72	3.3	<2	5.7	<0.72	<2	4.9	<0.72	10
N-Nitrosodimethylamine	EPA 521	ng/l	0.28	2.2	2.9	<2	<0.28	<2	<0.28	<0.28	<2	<2	<0.28	5.2	<2.2	<2	10
N-Nitrosodi-n-propylamine	EPA 521	ng/l	0.35	2.2	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<0.35	<2.2	<0.35	10
n-Propylbenzene	EPA 524.2	µg/L	0.18	0.5	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	260
Propachlor	EPA 508	µg/L	0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	90
RDX	EPA 8330A	µg/L	0.32	2	<0.32	<0.32	<0.32	<0.16	<0.16	<0.16	<0.8	<0.16	<0.16	<0.8	<0.16	<0.16	0.3
sec-Butylbenzene	EPA 524.2	µg/L	0.24	0.5	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	<0.24	260
Tert-butyl alcohol	EPA 524.2	µg/L	0.45	2	<0.45	<0.45	<0.45	<2	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	<0.45	12
tert-Butylbenzene	EPA 524.2	µg/L	0.18	0.5	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	260
Vanadium, Total	EPA 200.8	µg/L	0.047	0.5	1.1	<0.5	2.6	<0.047	<0.047	1.3	0.8	<0.5	2.7	0.81	<0.047	2.8	50

Note:

1. CDPH Drinking Water Notification Levels Last Update: December 14, 2010. For notes on toxicological enpoints, references, history, and other information visit: http://www.cdph.ca.gov/certlic/drinkingwater/Pages/default.aspx.

2. Additonal testing was conducted for ethylene glycol at sample locations S1 and S10 using a more sensitive method (EPA 8270 C DL=0.5 mg/L; RL= 1 mg/L). Samples from each location were collected on 8/13/12 and 8/15/12. All results were <0.5 mg/L.

3. Results shown as less than (<VALUE) indicate the reported result was less than the RL or DL. In some instances, the RL and/or DL varied during the testing period due to laboratory QC procedures or changes in method procedures.

Table 33 Summary of Proposed Contaminants EPA's Unregulated Contaminant Monitoring Rule (UCMR 3) Assessment Monitoring (List 1and List 2) Results

Parameter	Method	Units	DL	RL	Quarter 1: 08/24/2011			Quarter 2: 11/08/2011			Quarter 3: 03/08/2012			Quarter 4: 05/01/2012		
					S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water
1,1-Dichloroethane	EPA 524.3	ng/L	10	30	<10	<10	<10	**<10**	**<10**	**<10**	<10	<10	<10	<10	<10	<10
1,2,3-Trichloropropane	EPA 524.3	ng/L	4.6	30	<4.6	<4.6	<4.6	**<4.6**	**<4.6**	**<4.6**	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
1,3-butadiene	EPA 524.3	ng/L	37	100	<37	<37	<37	**<37**	**<37**	**<37**	<37	<100	<37	<37	<37	<37
1,4-Dioxane	EPA 522	µg/L	0.035	0.070	0.95	<0.035	<0.035	4.2	<0.070	<0.035	0.97	<0.035	<0.035	1.2	<0.035	<0.070
17 alpha-ethynylestradiol	EPA 539	µg/L	0.00010	0.00040	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
17-beta-Estradiol	EPA 539	µg/L	0.00010	0.00090	<0.00090	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00090	<0.00010	<0.00010	<0.00090	<0.00010	<0.00010
4-androstene-3,17-dione	EPA 539	µg/L	0.000040	0.00030	0.0012	<0.000040	<0.00030	0.0018	<0.00030	<0.00030	0.0032	<0.000040	<0.00030	0.0032	<0.000040	<0.00030
Bromochloromethane (BCM)	EPA 524.3	ng/L	5.5	60	220	230	<60	**260**	**190**	**<5.5**	230	230	78	170	250	79
Bromomethane	EPA 524.3	ng/L	35	200	<35	<35	<35	**<35**	**<35**	**<200**	<35	<35	<35	<35	<35	<35
Chlorate	UCMR 300.1	µg/L	2.0	20	<20	<2.0	<2.0	580	<20	<2.0	28	<2.0	<20	<20	<2.0	<20
Chlorodifluoromethane	EPA 524.3	ng/L	6.8	80	<80	<80	<80	**<80**	**<80**	**<80**	<80	<80	<80	<6.8	<6.8	<6.8
Chloromethane	EPA 524.3	ng/L	6.0	200	<200	<6.0	<200	**<6.0**	**<200**	**<200**	<6.0	<6.0	<6.0	<200	<200	<6.0
Chromium	UCMR 200.8	µg/L	0.021	0.30	1.1	<0.021	0.37	<0.3	**<0.021**	<0.021	<0.30	<0.30	**<0.021**	0.35	<0.021	<0.15
Cobalt	UCMR 200.8	µg/L	0.28	1.0	<1.0	<0.28	<0.28	<1.0	**<0.28**	<0.28	<1.0	<0.28	**<0.28**	<1.0	<0.28	<0.28
Equilin	EPA 539	µg/L	0.00040	0.0040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Estriol	EPA 539	µg/L	0.00020	0.00080	<0.00080	<0.00020	<0.00020	<0.00020	<0.00020	<0.00080	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Estrone	EPA 539	µg/L	0.00020	0.0020	0.0047	<0.00020	<0.0020	<0.0020	<0.00020	<0.00020	0.0043	<0.00020	<0.00020	0.0038	<0.00020	0.87
Hexavalent chromium(Dissolved)	EPA 218.6/218.7	µg/L	0.0090	0.020	<0.0090	0.090	0.052	<0.0090	0.083	0.045	<0.030	0.040	0.048	<0.030	0.16	<0.030
Molybdenum	UCMR 200.8	µg/L	0.057	1.0	8.0	<0.057	2.1	7.5	**<0.057**	2.1	5.6	<0.057	**<0.057**	6.2	<0.50	3.6
n-Propylbenzene	EPA 524.3	ng/L	5.4	30	<5.4	<5.4	<5.4	**<5.4**	**<5.4**	**<5.4**	<5.4	<5.4	<5.4	<5.4	<5.4	<5.4
Perfluoro octanesulfonic acid - PFOS	EPA 537	µg/L	0.0023	0.040	<0.040	<0.0023	<0.0023	<0.040	<0.0023	<0.0023	<0.040	<0.0023	<0.0023	<0.040	<0.0023	<0.0023
Perfluoro-1-butanesulfonic acid -PFBS	EPA 537	µg/L	0.0018	0.090	<0.090	<0.0018	<0.090	<0.090	<0.0018	<0.0018	<0.090	<0.0018	<0.0018	<0.090	<0.0018	<0.0018
Perfluoro-1-hexanesulfonic acid - PFHxS	EPA 537	µg/L	0.0020	0.030	<0.030	<0.0020	<0.0020	<0.030	<0.0020	<0.0020	<0.030	<0.0020	<0.0020	<0.030	<0.0020	<0.0020
Perfluoroheptanoic acid - PFHpA	EPA 537	µg/L	0.0031	0.010	0.032	<0.0031	<0.0031	0.036	<0.010	<0.0031	0.023	<0.0031	<0.0031	0.026	<0.0031	<0.0031
Perfluoro-n-nonanoic acid -PFNA	EPA 537	µg/L	0.0022	0.020	<0.020	<0.0022	<0.0022	0.020	<0.0022	<0.0022	<0.020	<0.0022	<0.0022	<0.020	<0.0022	<0.0022
Perfluorooctanoic acid - PFOA	EPA 537	µg/L	0.0035	0.020	0.17	<0.0022	<0.0022	0.29	<0.0035	<0.0022	0.21	<0.0035	<0.0035	0.23	<0.0035	<0.0035
sec-Butylbenzene	EPA 524.3	ng/L	1.5	40	<1.5	<1.5	<1.5	**<1.5**	**<1.5**	**<1.5**	<40	<40	<40	<1.5	<1.5	<1.5
Strontium	UCMR 200.8	µg/L	0.016	0.30	580	<0.30	280	400	**<0.30**	290	480	<0.30	430	310	0.37	610
Testosterone	EPA 539	µg/L	0.000020	0.00010	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.00010	<0.00010	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Vanadium	UCMR 200.8	µg/L	0.011	0.20	1.2	<0.011	2.3	<0.20	<0.011	2.6	<0.20	<0.011	**<0.011**	0.79	<0.011	2.4

Note: Shaded results are from resamples collected on 1/18/2012 and 3/14/2012. Resampling was required due to lab error and /or QC failures that occurred during analyses of original samples. Data flags provided in the original laboratory reports are not shown. On May 2, 2012, the EPA issued the Final Rule Promulgation, which removed two compounds from the original List 1. These compounds are n-Propylbenzene and sec-Butylbenzene. Results shown as less than (<VALUE) indicate the reported result was less than the RL or DL. In some instances, the RL and/or DL varied during the testing period due to laboratory QC procedures or changes in method procedures.

Table 34 Summary of Other Radionuclides Results

Parameter	Method	Units	Sample Date: 08/24/2011			Sample Date: 11/08/2011			Sample Date: 02/01/2012			Sample Date: 05/01/2012			Sample Date: 7/9/2012		
			S1 Tertiary Effluent	S10 AWPF Product	Imported Raw Aqueduct Water	S1 Tertiary Effluent	S10 AWPF Product	Imported Raw Aqueduct Water	S1 Tertiary Effluent	S10 AWPF Product	Imported Raw Aqueduct Water	S1 Tertiary Effluent	S10 AWPF Product	Imported Raw Aqueduct Water	S1 Tertiary Effluent	S10 AWPF Product	Imported Raw Aqueduct Water
Cesium - 137	Gamma Ray Spectrometry	pCi/L	-5.05+/-8.2 (MDA=11.1)	0.900+/-7.9 (MDA=10.2)	-3.88+/-6.7 (MDA=13.4)	-6.60+/-16 (MDA=16.7)	-3.33+/-5.8 (MDA=16.0)	-3.88+/-13 (MDA=13.1)	-0.840+/-13 (MDA=23.1)	-9.60+/-14 (MDA=23.7)	2.32+/-13 (MDA=18.5)	-1.46+/-10 (MDA=20.3)	-2.18+/-11 (MDA=15.0)	0.180+/-0.64 (MDA=1.25)	not sampled	not sampled	not sampled
Iodine - 129	X-Ray Spectrometry	pCi/L	0.834+/-3.1 (MDA=3.86)	0.087+/-2.4 (MDA=3.25)	-1.20+/-2.5 (MDA=3.38)	-0.415+/-1.1 (MDA=2.40)	-1.63+/-3.6 (MDA=4.17)	-0.031+/-0.93 (MDA=2.10)	3.31+/-3.0 (MDA=3.86)	-2.17+/-2.4 (MDA=3.47)	-1.54+/-3.0 (MDA=4.10)	-0.783+/-0.95 (MDA=2.16)	-0.990+/-1.9 (MDA=3.73)	-1.30+/-1.9 (MDA=3.61)	0.046+/-0.25 (MDA=0.572)	0.092+/-0.28 (MDA=0.636)	0.110+/-0.21 (MDA=0.462)
Iodine - 131	Gamma Ray Spectrometry	pCi/L	46.6+/-16 (MDA=18.2)	1.79+/-12 (MDA=16.0)	0.720+/-9.9 (MDA=26.4)	15.6+/-27 (MDA=27.9)	-15.6+/-20 (MDA=21.6)	-7.28+/-16 (MDA=18.5)	-2.08+/-5.7 (MDA=11.3)	-1.99+/-25 (MDA=23.0)	-4.10+/-7.0 (MDA=11.2)	-6.45+/-21 (MDA=38.7)	-5.97+/-16 (MDA=24.6)	0.610+/-1.2 (MDA=2.48)	3.03+/-1.4 (MDA=1.64)	-0.044+/-0.11 (MDA=0.154)	-0.001+/-0.12 (MDA=0.162)

Note:

1. MDA is the Minimum Detectable Activity @ 95% confidence interval. Table 26 provides results for nuclide parameters regulated in drinking water including: Gross Beta (Examples of beta emitters include: Cesium 137, Iodine 129 and Iodine 131), Gross Alpha, Radium 226, Radium 228, Tritium, Strontium 90, and Uranium
2. Refer to **Section 3.2.5 URs** for how to interpret MDAs and Counting Errors.

Table 35 Summary of Other Measured Compounds Results

Parameter	Method	Units	DL	RL	Quarter 1: 08/24/2011			Quarter 2: 11/08/2011			Quarter 3: 02/01/2012			Quarter 4: 05/01/2012		
					S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water
Benzo (k) fluoranthene	EPA 525.2	µg/L	0.09	0.5	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09
Hexavalent chromium(Dissolved)	EPA 218.6	µg/L	0.0059	0.3	<0.0059	<0.0059	<0.3	<0.0059	<0.0059	<0.0059	<0.0059	<0.0059	<0.3	<0.0059	<0.0059	<0.3
Lithium, Total	EPA 200.7	µg/L	1.4	10	26	<1.4	<10	20	<1.4	<10	23	<10	14	28	<10	21

Note: Results shown as less than (<VALUE) indicate the reported result was less than the RL or DL. In some instances, the RL and/or DL varied during the testing period due to laboratory QC procedures or changes in method procedures.

Table 36 Summary of Initial Characterization Results of Chemical of Emerging Concern (CECs) Analyzed by MWH Laboratories 4 X Monthly Samples

Compound Name	Common Use	Method	Units	DL	RL	8/15/2011					9/14/2011					10/17/2011					11/8/2011				
						S1 (tertiary effluent) 9/1/11	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water (10/18/11)	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water
1,7-Dimethylxanthine	Caffeine Degradant	LC-MS-MS	ng/L	3.4	10	<10	5.4	<3.4	<3.4	<3.4	<3.4	<10	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4
2,4-D	Herbicide	LC-MS-MS	ng/L	5	5	49	<5	<5	<5	9.8	2000	2200	6.4	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
4-nonylphenol - semi quantitative	Surfactant	LC-MS-MS	ng/L	50	100	1400	780	<50	<50	280	410	480	<100	<100	<100	200	260	<50	<50	<50	330	470	<50	<50	<50
4-tert-Octylphenol	Surfactant	LC-MS-MS	ng/L	6.9	50	<50	<50	<6.9	<6.9	<6.9	<50	<50	<6.9	<6.9	<6.9	<50	<50	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9	<6.9
Acesulfame-K	Sugar Substitute	LC-MS-MS	ng/L	20	20	27000	26000	40	<20	370	29000	29000	65	50	360	33000	33000	66	<20	360	28000	27000	<20	<20	280
Acetaminophen	Analgesic	LC-MS-MS	ng/L	3	5	<3	<3	<3	<3	<3	<5	<3	<3	<3	<3	<3	<3	<3	<3	<3	10	8.3	<3	<3	<3
Albuterol	Anti Asthmatic	LC-MS-MS	ng/L	2.4	5	9.6	6.6	<2.4	<5	<5	8.1	6.5	<2.4	<2.4	<2.4	9.9	7.6	<2.4	<2.4	<2.4	10	<2.4	<2.4	<2.4	<2.4
Amoxicillin (semi-quantitative)	Antibiotic	LC-MS-MS	ng/L	6.4	20	1400	90	<6.4	<6.4	<6.4	470	220	<6.4	<6.4	<6.4	960	61	24	<20	<6.4	320	48	<6.4	<6.4	<6.4
Andorostenedione	Steroid Hormone	LC-MS-MS	ng/L	1.7	5	<1.7	5.1	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Atenolol	Beta Blocker	LC-MS-MS	ng/L	3.9	5	670	210	<3.9	<3.9	<3.9	250	250	7.7	<3.9	<3.9	59	74	<3.9	<3.9	<3.9	150	150	<3.9	<3.9	<3.9
Atrazine	Triazine Herbicide	LC-MS-MS	ng/L	2.3	5	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3
Azithromycin	Antibiotic	LC-MS-MS	ng/L	10	20	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Bendroflumethiazide	Triazide	LC-MS-MS	ng/L	4.4	5	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4
Bezafibrate	Lipid Regulator	LC-MS-MS	ng/L	3.5	5	6	<3.5	<3.5	<3.5	<3.5	7.6	6	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5	<3.5
BPA	Plasticizer	LC-MS-MS	ng/L	7.2	10	<7.2	<7.2	<7.2	<7.2	<7.2	74	81	<7.2	<7.2	<7.2	<7.2	<7.2	<7.2	<7.2	<7.2	<7.2	<7.2	<7.2	<7.2	<7.2
Bromacil	Herbicide	LC-MS-MS	ng/L	3.2	5	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<5	<3.2	<3.2	<3.2	<3.2	<3.2
Butalbital	Analgesic-NSAID	LC-MS-MS	ng/L	2.9	5	16	16	<2.9	<2.9	<5	39	29	<2.9	<2.9	<2.9	25	28	<2.9	<2.9	<2.9	21	15	<2.9	<2.9	<2.9
Butylparaben	Preservative	LC-MS-MS	ng/L	3.3	5	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3
Caffeine	Stimulant	LC-MS-MS	ng/L	4.3	5	77	28	<4.3	<4.3	22	61	<5	<4.3	<4.3	<4.3	36	6.5	<4.3	<4.3	<4.3	20	6.7	<4.3	<4.3	<4.3
Carbadox	Antibiotic	LC-MS-MS	ng/L	4.2	5	8.6	<4.2	<4.2	<4.2	<4.2	13	30	<4.2	<4.2	<4.2	5.7	8.8	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2
Carbamazepine	Anti Seizure	LC-MS-MS	ng/L	1.2	5	300	170	<1.2	<1.2	<5	190	190	<5	<1.2	<5	190	180	<5	<1.2	<5	170	160	<1.2	<1.2	<5
Carisoprodol	Muscle Relaxant	LC-MS-MS	ng/L	1.2	5	150	200	<1.2	<1.2	<5	42	43	<1.2	<1.2	<1.2	62	69	<1.2	<1.2	<1.2	52	60	<1.2	<1.2	<1.2
Chloramphenicol	Antibiotic	LC-MS-MS	ng/L	3.1	10	<3.1	<3.1	<3.1	<3.1	<3.1	<10	12	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1
Chloridazon	Enzyme	LC-MS-MS	ng/L	1.6	5	<5	<1.6	<1.6	<1.6	<1.6	<1.6	<5	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6
Chlorotoluron	Herbicide	LC-MS-MS	ng/L	0.89	5	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89	<0.89
Cimetidine	H2 Blocker	LC-MS-MS	ng/L	2.7	5	62	<5	<2.7	<2.7	<2.7	22	<5	<2.7	<2.7	<2.7	12	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7
Clofibric Acid	Anti Cholesterol	LC-MS-MS	ng/L	5	5	<5	7.9	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cotinine	Nicotine Degradate	LC-MS-MS	ng/L	4.8	10	44	33	<10	<10	<10	<10	20	<4.8	<4.8	<4.8	25	11	<4.8	<4.8	<4.8	31	18	<4.8	<4.8	<4.8
Cyanazine	Triazine Herbicide	LC-MS-MS	ng/L	1.7	5	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
DACT	Triazine Degradate	LC-MS-MS	ng/L	3.9	5	36	27	<3.9	<3.9	<3.9	32	21	<3.9	<3.9	<3.9	26	13	<3.9	<3.9	<3.9	21	<3.9	<3.9	<3.9	<5
Deethylatrazine	Triazine Degradate	LC-MS-MS	ng/L	1.5	5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
DEET	Mosquito Repellant	LC-MS-MS	ng/L	1.1	10	30	180	<1.1	<1.1	<10	63	40	<10	<1.1	<10	180	170	<1.1	<1.1	<10	160	170	<10	<10	12

Table 36 Summary of Initial Characterization Results of Chemical of Emerging Concern (CECs) Analyzed by MWH Laboratories 4 X Monthly Samples

Compound Name	Common Use	Method	Units	DL	RL	8/15/2011					9/14/2011					10/17/2011					11/8/2011				
						S1 (tertiary effluent) 9/1/11	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water (10/18/11)	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water
Dehydronifedipine	Heart Medication	LC-MS-MS	ng/L	1.4	5	160	280	<5	<5	6	120	120	<1.4	<5	<5	360	400	<1.4	<1.4	<5	40	47	<1.4	<1.4	<1.4
DIA	Triazine Degradate	LC-MS-MS	ng/L	2.4	5	5.5	<5	<2.4	<2.4	<2.4	<5	<5	<2.4	<2.4	<2.4	<5	6.7	<2.4	<2.4	<2.4	<5	<5	<2.4	<2.4	<5
Diazepam	Valium - Antianxiety	LC-MS-MS	ng/L	2.1	5	<5	<5	<2.1	<2.1	<2.1	<5	<5	<2.1	<2.1	<2.1	<2.1	<5	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1
Diclofenac	Anti Inflammatory	LC-MS-MS	ng/L	3.3	5	60	58	<3.3	<3.3	<3.3	59	63	<3.3	<3.3	<3.3	59	67	<3.3	<3.3	<3.3	95	70	<3.3	<3.3	<3.3
Dilantin	Anti Seizure	LC-MS-MS	ng/L	13	20	86	82	<13	<13	<13	79	70	<13	<13	<13	110	82	<13	<13	<13	130	110	<13	<13	<13
Diuron	Herbicide	LC-MS-MS	ng/L	1.8	5	42	75	<5	<5	52	60	47	<1.8	<1.8	60	74	70	<5	<5	66	61	68	<1.8	<1.8	110
Erythromycin	Antibiotic	LC-MS-MS	ng/L	4	10	45	23	<4	<4	<4	58	48	<4	<4	<4	25	28	<4	<4	<4	45	57	<4	<4	<4
Estradiol	Estrogenic Hormone	LC-MS-MS	ng/L	4.4	5	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4	<4.4
Estrone	Estrogenic Hormone	LC-MS-MS	ng/L	3.9	5	16	21	<3.9	<3.9	<3.9	10	9.2	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9
Ethinyl Estradiol - 17 alpha	Contraceptive Hormone	LC-MS-MS	ng/L	3.3	5	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3
Ethylparaben	Preservative	LC-MS-MS	ng/L	11	20	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11
Flumeqine	Antibiotic	LC-MS-MS	ng/L	7.1	10	<7.1	<10	<10	<7.1	<10	<7.1	<7.1	<7.1	<7.1	<7.1	<7.1	<7.1	<7.1	<7.1	<7.1	<7.1	<7.1	<7.1	<7.1	<7.1
Fluoxetine	Antidepressant	LC-MS-MS	ng/L	10	10	34	59	<10	<10	<10	50	43	<10	<10	<10	39	28	<10	<10	<10	28	21	<10	<10	<10
Gemfibrozil	Lipid Regulator	LC-MS-MS	ng/L	2.5	5	68	62	<2.5	<2.5	<2.5	73	64	<2.5	<2.5	<2.5	34	33	<2.5	<2.5	<2.5	28	24	<2.5	<2.5	<2.5
Hydrazine	Anti Depressant	LC-MS-MS	ng/L	2.5	5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Ibuprofen	Analgesic-NSAID	LC-MS-MS	ng/L	8.6	15	<8.6	<8.6	<8.6	<8.6	<8.6	20	<15	<15	<8.6	<8.6	<8.6	<8.6	<8.6	<15	<8.6	<8.6	<8.6	<8.6	<8.6	<8.6
Iohexal	X-ray Contrast Agent	LC-MS-MS	ng/L	7.7	10	3100	4500	<7.7	<7.7	41	9500	8700	<10	19	55	4500	3900	<7.7	<7.7	41	4100	6000	<7.7	<7.7	34
Iopromide	X-ray Contrast Agent	LC-MS-MS	ng/L	1.6	5	140	<5	<1.6	<1.6	<5	93	100	<1.6	<1.6	<1.6	<5	<1.6	<1.6	<1.6	<1.6	27	33	<1.6	<1.6	<1.6
Isobutylparaben	Preservative	LC-MS-MS	ng/L	4.2	5	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2
Isoproturon	Herbicide	LC-MS-MS	ng/L	12	100	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<12	<100	<100	<12	<12	<12
Ketoprofen	Anti Inflammatory	LC-MS-MS	ng/L	2.6	5	10	15	<2.6	<2.6	<2.6	11	15	<2.6	<2.6	<2.6	38	24	<2.6	<2.6	<2.6	<5	<2.6	<2.6	<2.6	<2.6
Ketorolac	Anti Inflammatory	LC-MS-MS	ng/L	2.1	5	16	<5	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<5	<5	<2.1	<2.1	<2.1	<5	<2.1	<2.1	<2.1	<2.1
Lidocaine	Analgesic	LC-MS-MS	ng/L	1.1	5	78	310	<1.1	<1.1	<1.1	100	110	<1.1	<1.1	<1.1	90	95	<5	<1.1	<1.1	120	130	<1.1	<1.1	<1.1
Lincomycin	Antibiotic	LC-MS-MS	ng/L	1.7	10	<10	<10	<1.7	<1.7	<1.7	<10	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<10	<1.7	<1.7	<1.7	<1.7
Linuron	Herbicide	LC-MS-MS	ng/L	2.8	5	<5	9.2	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	6.3	<2.8	<2.8	<2.8	<2.8
Lopressor	Beta Blocker	LC-MS-MS	ng/L	5.1	20	400	300	<5.1	<5.1	<5.1	280	300	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	<5.1	270	270	<5.1	<5.1	<5.1
Meclofenamic Acid	Anti Inflammatory	LC-MS-MS	ng/L	4.7	5	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7	<4.7
Meprobamate	Anti Anxiety	LC-MS-MS	ng/L	2	5	110	200	<5	<5	<5	130	130	<2	<2	<2	92	99	<2	<2	<2	120	120	<2	<2	<5
Metazachlor	Herbicide	LC-MS-MS	ng/L	1.3	5	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
Methylparaben	Preservative	LC-MS-MS	ng/L	11	20	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<11	<20	<20	<11	<11	<11	<11	<11	<11
Naproxen	Analgesic-NSAID	LC-MS-MS	ng/L	8.5	10	<8.5	23	<8.5	<8.5	<8.5	<8.5	<8.5	<8.5	<8.5	<8.5	13	12	<8.5	<8.5	<8.5	19	21	<8.5	<8.5	<8.5
Nifedipine	Calcium Blocker	LC-MS-MS	ng/L	12	20	48	<12	<12	<12	<12	<12	<12	<12	<12	<12	40	<20	<12	<12	<12	57	<20	<12	<12	<12
Norethisterone	Steroid Hormone	LC-MS-MS	ng/L	2.3	5	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<2.3	<5	<2.3	<2.3	<2.3	<2.3
Oxolinic acid	Antibiotic	LC-MS-MS	ng/L	2.5	10	19	<2.5	<2.5	<10	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<10	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Pentoxifylline	Blood Thinner	LC-MS-MS	ng/L	1.5	5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Phenazone	Analgesic	LC-MS-MS	ng/L	5	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

Table 36 Summary of Initial Characterization Results of Chemical of Emerging Concern (CECs) Analyzed by MWH Laboratories 4 X Monthly Samples

Compound Name	Common Use	Method	Units	DL	RL	8/15/2011					9/14/2011					10/17/2011					11/8/2011				
						S1 (tertiary effluent) 9/1/11	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water (10/18/11)	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water
Primidone	Anti Convulsant	LC-MS-MS	ng/L	4.8	5	110	96	<4.8	<4.8	<4.8	83	88	<4.8	<4.8	<4.8	76	86	<4.8	<4.8	<4.8	65	62	<4.8	<4.8	<4.8
Progesterone	Steroid Hormone	LC-MS-MS	ng/L	2.9	5	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9
Propazine	Triazine Herbicide	LC-MS-MS	ng/L	1.8	5	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
Propylparaben	Preservative	LC-MS-MS	ng/L	2.9	5	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9	<2.9
Quinoline	Organophosphate Pesticide	LC-MS-MS	ng/L	2.5	5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Simazine	Triazine Herbicide	LC-MS-MS	ng/L	1.2	5	7.6	5.1	<1.2	<1.2	10	8.4	8	<1.2	<1.2	15	11	9	<1.2	<1.2	14	7.4	7.7	<1.2	<1.2	11
Sucralose	Sugar Substitute	LC-MS-MS	ng/L	42	100	48000	20000	<42	<42	410	34000	31000	<42	<42	300	50000	55000	200	<42	310	26000	22000	<100	<100	380
Sulfachloropyridazine	Sulfa Antibiotic	LC-MS-MS	ng/L	2.1	5	<2.1	<5	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<5	<2.1	<2.1	<2.1	<2.1
Sulfadiazine	Sulfa Antibiotic	LC-MS-MS	ng/L	3.9	5	<3.9	9.6	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<5	<5	<3.9	<3.9	<3.9
Sulfadimethoxine	Sulfa Antibiotic	LC-MS-MS	ng/L	1.6	5	<1.6	<1.6	<5	<5	<5	<1.6	<1.6	<1.6	<5	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6
Sulfamerazine	Sulfa Antibiotic	LC-MS-MS	ng/L	4.6	5	16	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
Sulfamethazine	Sulfa Antibiotic	LC-MS-MS	ng/L	1.5	5	<5	<1.5	<5	<5	<5	<1.5	<1.5	<1.5	<1.5	<1.5	<5	<5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Sulfamethizole	Sulfa Antibiotic	LC-MS-MS	ng/L	3.2	5	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2
Sulfamethoxazole	Sulfa Antibiotic	LC-MS-MS	ng/L	2.8	5	820	870	<2.8	<2.8	<2.8	480	410	<2.8	<2.8	<2.8	470	580	<2.8	<2.8	<2.8	780	740	<2.8	<2.8	<5
Sulfathiazole	Sulfa Antibiotic	LC-MS-MS	ng/L	2.4	5	<2.4	<5	<5	<5	<5	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4
TCEP	Flame Retardant	LC-MS-MS	ng/L	3.2	10	160	180	<5	<5	5.5	380	380	<3.2	<3.2	<3.2	520	550	<3.2	<10	13	410	370	<3.2	<3.2	<3.2
TCPP	Flame Retardant	LC-MS-MS	ng/L	20	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
TDCPP	Flame Retardant	LC-MS-MS	ng/L	20	100	500	NR	<20	<20	<20	650	710	<20	<20	<20	710	600	<20	<20	<20	320	130	<20	<20	<20
Testosterone	Steroid Hormone	LC-MS-MS	ng/L	2.5	5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Theobromine	Caffeine Degradant	LC-MS-MS	ng/L	3.2	10	<3.2	400	19	<10	54	25	42	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	<3.2	31	<3.2	<3.2	<3.2	<3.2	<3.2
Theophylline	Anti Asthmatic	LC-MS-MS	ng/L	4.8	10	<4.8	<4.8	<4.8	<4.8	<4.8	57	48	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8	<4.8
Triclosan	Antibacterial	LC-MS-MS	ng/L	6.3	10	120	68	20	<6.3	<10	44	37	34	19	<6.3	140	120	29	<6.3	<6.3	84	60	12	<6.3	<6.3
Trimethoprim	Antibiotic	LC-MS-MS	ng/L	1.8	5	150	200	<1.8	<1.8	<1.8	100	120	<5	<1.8	<1.8	200	220	<5	<1.8	<1.8	120	120	<1.8	<1.8	<1.8
Warfarin	Anticoagulant	LC-MS-MS	ng/L	4.1	5	<5	<5	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1	<4.1
Count						43	39	3	0	11	41	40	4	3	5	35	34	4	0	7	36	32	1	0	6
Maximum						48000	26000	40	0	410	34000	31000	65	50	360	50000	55000	200	0	360	28000	27000	12	0	380
Minimum						5.5	5.1	19	0	5.5	7.6	6	6.4	19	15	5.7	6.5	24	0	13	6.3	6.7	12	0	11

Notes:

1. NR (not reported) due to batch lab QC concerns. QC indicates the method was not reliable for these compounds duirng the testing period.
2. Results in yellow highlight were from re-analysis conducted due to issues with original analysis.
3. Results shown as less than (<VALUE) indicate the reported result was less than the RL or DL. In some instances, the RL and/or DL varied during the testing period due to laboratory QC procedures or changes in method procedures.

Table 37 Colorado School of Mines CEC Summary Results

			8/15/2011					11/8/2011					
Compound	**Units**	**Method**	**Detection Limit (S6)**	**S6**	**Detection Limit (S9 and S10)**	**S9**	**S10**	**DL**	**S1**	**S6**	**S9**	**S10**	**IAW**
Acetaminophen	ng/L	ESI Positive	20	BDL	1	BDL	BDL	1	BDL	BDL	BDL	BDL	BDL
Amitriptyline	ng/L	ESI Positive	20	26.8	1	BDL	BDL	1	30	23.8	BDL	BDL	BDL
Atenolol	ng/L	ESI Positive	20	455	1	BDL	BDL	1	172	174	BDL	BDL	BDL
Atrazine	ng/L	ESI Positive	20	BDL	1	BDL	BDL	1	BDL	BDL	BDL	BDL	BDL
Benzophenone	ng/L	ESI Positive	200	260	10	BDL	BDL	25	BDL	BDL	BDL	BDL	BDL
Caffeine	ng/L	ESI Positive	50	BDL	2.5	BDL	BDL	2.5	23.1	17.1	BDL	BDL	6.4
Carbamazepine	ng/L	ESI Positive	20	243	2.5	BDL	BDL	1	244	241	BDL	BDL	2
Cimetidine[3]	ng/L	ESI Positive	20	BDL	1	BDL	BDL	1	BDL	BDL	BDL	BDL	BDL
DEET	ng/L	ESI Positive	20	327	2.5	BDL	BDL	2.5	248	255	BDL	BDL	BDL
Diazepam	ng/L	ESI Positive	20	BDL	1	BDL	BDL	1	3	3	BDL	BDL	BDL
Dilantin	ng/L	ESI Positive	20	156	5	BDL	BDL	5	112	113	BDL	BDL	BDL
Diphenhydramine	ng/L	ESI Positive	20	509	0	BDL	BDL	1	374	361	BDL	BDL	BDL
Fluoexetine	ng/L	ESI Positive	20	32.1	1	BDL	BDL	1	43.4	28	BDL	BDL	BDL
Hydrocodone	ng/L	ESI Positive	20	75.6	2.5	BDL	BDL	2.5	69.3	65.5	BDL	BDL	BDL
Meprobamate	ng/L	ESI Positive	20	295	1	BDL	BDL	1	290	287	BDL	BDL	4
Norfluoxetine	ng/L	ESI Positive	20	BDL	2.5	BDL	BDL	2.5	16.8	17	BDL	BDL	BDL
Oxybenzone	ng/L	ESI Positive	20	35.6	5	BDL	BDL	5	8.5	7.5	BDL	BDL	BDL
Primidone	ng/L	ESI Positive	20	110	1	BDL	BDL	1	85.9	88.8	BDL	BDL	2
Sulfamethoxazole	ng/L	ESI Positive	20	1563	1	BDL	BDL	1	1630	1310	1	BDL	BDL
Trimethoprim	ng/L	ESI Positive	20	248	1	BDL	BDL	1	153	160	BDL	BDL	BDL
TCEP	ng/L	ESI Positive	20	683	2.5	BDL	BDL	5	401	403	BDL	BDL	BDL
TCPP	ng/L	ESI Positive	20	3750	2.5	BDL	BDL	10	2840	2640	BDL	BDL	BDL
TDCPP	ng/L	ESI Positive	20	1338	10	BDL	BDL	10	1250	1080	BDL	BDL	BDL

Note: BDL = Below Detection Limit

Table 37 Colorado School of Mines CEC Summary Result (cont.)

			8/15/2011				11/8/2011					
Compound	**Units**	**Method**	**Detection Limit**	**S6**	**S9**	**S10**	**DL**	**S1**	**S6**	**S9**	**S10**	**IAW**
Bisphenol A	ng/L	ESI Negative	5	BDL	BDL	BDL	10	BDL	BDL	BDL	BDL	BDL
Diclofenac	ng/L	ESI Negative	1	184	BDL	BDL	1	138	139	BDL	BDL	BDL
Gemfibrizol	ng/L	ESI Negative	2.5	73.9	BDL	BDL	5	37.6	36.1	BDL	BDL	BDL
Ibuprofen	ng/L	ESI Negative	5	BDL	BDL	BDL	10	BDL	BDL	BDL	BDL	BDL
Ketoprofen	ng/L	ESI Negative	25	BDL	BDL	BDL	25	BDL	BDL	BDL	BDL	BDL
Methylparaben	ng/L	ESI Negative	5	15.2	BDL	BDL	5	8.3	5.9	BDL	BDL	BDL
Naproxen	ng/L	ESI Negative	2.5	27.7	BDL	BDL	1	23.5	24.2	BDL	BDL	BDL
4-n-Nonylphenol	ng/L	ESI Negative	25	BDL	BDL	BDL	25	BDL	BDL	BDL	BDL	BDL
Propylparaben	ng/L	ESI Negative	2.5	BDL	BDL	BDL	1	BDL	BDL	BDL	BDL	BDL
Sucralose[1]	ng/L	ESI Negative	50	NA	NA	NA	NA	NA	NA	NA	NA	NA
Triclocarban	ng/L	ESI Negative	2.5	81.5	BDL	BDL	5	113	106	BDL	BDL	BDL
Triclosan	ng/L	ESI Negative	1	96.1	BDL	BDL	5	79.3	69	BDL	BDL	BDL
Estradiol 17B	ng/L	APCI (steroids)	5	BDL	BDL	BDL	5	BDL	BDL	BDL	BDL	BDL
Estriol	ng/L	APCI (steroids)	5	BDL	BDL	BDL	5	BDL	BDL	BDL	BDL	BDL
Estrone	ng/L	APCI (steroids)	5	BDL[2]	BDL	BDL	5	BDL	BDL	BDL	BDL	BDL
Ethynylestradiol	ng/L	APCI (steroids)	2.5	BDL	BDL	BDL	5	BDL	BDL	BDL	BDL	BDL
Progesterone	ng/L	APCI (steroids)	2.5	BDL	BDL	BDL	2.5	BDL	BDL	BDL	BDL	BDL
Testosterone	ng/L	APCI (steroids)	1	BDL	BDL	BDL	1	BDL	BDL	BDL	BDL	BDL

Notes (provided by lab):

1. Results for 8/15/11 sucralose not reported due to lab issue
2. Estrone signal in the 8/15/11 S6 sample marginally failed the QC criteria due to high background noise in the sample. Calculated concentration was at 23 ppt.
3. presence in the 2/1/12 S1 sample is likely due to contamination
4. BDL = Below Detection Limit

Table 38 Revised CEC Monitoring Plan

CEC Contaminant Group	[1] Sampling Locations	Rationale for Monitoring
Initial Feed Water Characterization (sample monthly for the first four months) – COMPLETE.		
List of 91 CECs analyzed by MWH Laboratories	S1, S6, S9, S10 Imported Aqueduct Water	1. Characterize NCWRP tertiary water. 2. Identify appropriate indicator constituents. 3. Assess AWP unit process CEC removal performance. 4. Compare water quality of AWP to imported water.
1, 4-Dioxane	S1, S6, S9, S10 Imported Aqueduct Water	
NDMA	S1, S6, S9, S10 Imported Aqueduct Water	
List for On-going Characterization (Quarters 3 and 4)		
Caffeine	S1, S6, S9, S10 Imported Aqueduct Water	• Compounds prioritized based on toxicological evidence. Measured environmental concentration (MEC) greater than monitoring trigger level (MTL), as developed in SWRCB, 2010. • Ongoing characterization of NCWRP tertiary water. 5. Assess AWP unit process CEC removal performance. • Compare water quality of AWP to imported water.
E2 (17β-Estradiol)	S1, S6, S9, S10 Imported Aqueduct Water	
NDMA	S1, S6, S9, S10 Imported Aqueduct Water	
Triclosan	S1, S6, S9, S10 Imported Aqueduct Water	
1,4-Dioxane	S1, S6, S9, S10 Imported Aqueduct Water	• Revised Draft CDPH Groundwater Recharge Regulations specify the AOP be sized to achieve 0.5 log removal of 1,4-Dioxane for direction injection applications. Alternatively, AOP sizing can be based on demonstrated log removals of select indicator compounds from different functional groups.
Potential Performance Indicator Compounds (sample weekly for 4 weeks to assess differential removal along with surrogate parameters)		
Sucralose	S6, S9, S10	• Identified for surface spreading and direct injection operations as viable performance indicator compounds along with certain surrogate parameters (SWRCB, 2010). These compounds were also detected in the RO feed consistently during the initial feed water characterization period with low variability (Relative Standard Deviation <100 %.)
NDMA	S6, S9, S10	
DEET	S6, S9, S10	
Additional 30 CEC compounds (See Table 39)	S6, S9,S10	• These compounds were also consistently present in the RO feed during the initial feed water characterization period with low variability. Based on the 4 weeks of sample results a shorter list of RO and UV/AOP performance indicator compounds will be recommended for continued monitoring. The 30 compound list may also serve useful for periodic monitoring of source water quality.
Caffeine	S6, S9, S10	• Recommendation from IAP: Draft Memorandum: Findings and Recommendations of the Advanced Water Purification Facility Subcommittee, February 2, 2012.
Theobromine	S6, S9, S10	
Linuron	S6, S9, S10	
Estrone	S6, S9, S10	

Note: S1 = tertiary effluent; S6 = RO feed; S9=RO permeate; S10=UV/AOP product.

Table 39 Potential performance indicator compounds to be monitored weekly for 4 weeks

Compound Name	
Butalbital	**TDCPP**
Erythromycin	**Diclofenac**
Simazine	Albuterol
Primidone	Ketoprofen
Lidocaine	Naproxen
4-nonylphenol - semi quantitative	DACT
Gemfibrozil	**Lopressor**
Amoxicillin (semi-quantitative)	Fluoxetine
Atenolol	**Acesulfame-K**
Carbamazepine	Dilantin
Diuron	**Meprobamate**
Triclosan	**Iohexal**
Cotinine	**Dehydronifedipine**
TCEP	**Sulfamethoxazole**
Carisoprodol	**Trimethoprim**

Note: compounds in bold were detected in the RO feed at concentrations greater than 10 times the detection limit in 50% or more of the samples measured during the initial characterization period.

Table 40 Summary of Results for Group A (on-going characterization) CECs for Quarter 3 and Quarter 4

Parameter	Method	Units	DL	RL	Quarter 3: 2/1/2012					Quarter 4: 5/1/2012				
					S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water	S1 (tertiary effluent)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	Imported Raw Aqueduct Water
Triclosan	LC-MS-MS	ng/L	6.3	10	79	74	13	17	ND	35	28	<6.3	<6.3	<6.3
Estradiol	LC-MS-MS	ng/L	4	5	ND	ND	ND	ND	11	<4.4	<5	<4.4	<4.4	<4.4
Caffeine	LC-MS-MS	ng/L	4	5	59	9.8	ND	ND	ND	53	<4.3	<4.3	<4.3	<4.3
N-Nitroso-dimethylamine (NDMA)	EPA 521	ng/L	0.28	2	<2	3.2	ND	<2	ND	11	<2	<2	<2	<2
1,4 dioxane	EPA 8270M	ng/L	0.04	0.5	1.2	1.2	<0.5	ND	ND	1.6	1.5	<0.04	<0.04	<0.04

Note: Detections of triclosan at S9 and S10 are based on results from analysis conducted by MWH Labs. Results of split samples analyzed by Colorado School of Mines Lab reported triclosan to be ND (DL=5 ng/L) for both S9 and S10. Results shown as less than (<VALUE) indicate the reported result was less than the RL or DL. In some instances, the RL and/or DL varied during the testing period due to laboratory QC procedures or changes in method procedures.

Table 41 Summary of Results for Group B (Potential Performance Indicators) CECs 4X Weekly Samples

Parameter	Method	Units	DL	RL	2/1/2012			2/8/2012			2/15/2012			2/22/2012			5/1/2012				
					S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	S6 (RO Feed)	S9 (RO Perm. Combined)	S10 (UV/AOP Product)	S6 (RO Feed)	S7	S8	S9 (RO Perm. Combined)	S10 (UV/AOP Product)
4-nonylphenol - semi quantitative	LC-MS-MS	ng/L	50	100	<50	<50	<50	<100	<50	<50	<50	<50	<50	1800	<100	<100	520	<50	<100	<50	<50
Acesulfame-K	LC-MS-MS	ng/L	20	20	48000	31	<20	31000	<20	<20	44000	<20	31	37000	42	<20	6400	<20	<20	<20	<20
Albuterol	LC-MS-MS	ng/L	2.4	5	12	<2.4	<2.4	24	<2.4	<2.4	16	<2.4	<2.4	<2.4	<2.4	<2.4	18	<2.4	<2.4	<5	<2.4
Amoxicillin (semi-quantitative)	LC-MS-MS	ng/L	6.4	20	270	<6.4	<6.4	280	<6.4	<6.4	120	<6.4	<6.4	260	<6.4	<6.4	150	<6.4	<6.4	<6.4	<6.4
Atenolol	LC-MS-MS	ng/L	3.9	5	42	<3.9	<3.9	110	<3.9	<3.9	60	<3.9	<3.9	89	<3.9	<3.9	43	<3.9	<3.9	<3.9	<3.9
Butalbital	LC-MS-MS	ng/L	2.9	5	<2.9	<2.9	<2.9	<2.9	<2.9	<5	<2.9	<2.9	<2.9	180	<2.9	<2.9	9.9	<2.9	<2.9	<2.9	<2.9
Caffeine	LC-MS-MS	ng/L	4.3	5	9.8	<4.3	<5	19	8.5	<4.3	7.9	<4.3	<4.3	25	<4.3	<4.3	<4.3	<5	<4.3	<4.3	<4.3
Carbamazepine	LC-MS-MS	ng/L	1.2	5	190	<5	<1.2	200	<1.2	<1.2	190	<1.2	<1.2	180	<1.2	<1.2	210	<1.2	<1.2	<1.2	<1.2
Carisoprodol	LC-MS-MS	ng/L	1.2	5	780	<1.2	<1.2	79	<1.2	<1.2	48	<1.2	<1.2	30	<1.2	<1.2	60	<1.2	<1.2	<1.2	<1.2
Cotinine	LC-MS-MS	ng/L	4.8	10	15	<4.8	<4.8	49	<4.8	<4.8	34	<4.8	<4.8	83	72	<10	60	<4.8	<4.8	<4.8	<4.8
DACT	LC-MS-MS	ng/L	3.9	5	11	<3.9	<3.9	19	<3.9	<3.9	27	<3.9	<3.9	<3.9	<3.9	<3.9	58	<3.9	<5	<5	<3.9
DEET	LC-MS-MS	ng/L	1.1	10	260	<10	<10	67	<10	<10	70	<10	<10	100	<10	<10	210	<10	<10	<10	<10
Dehydronifedipine	LC-MS-MS	ng/L	1.4	5	140	<5	<1.4	62	<1.4	<1.4	49	<1.4	<1.4	240	<5	<1.4	210	<5	<1.4	<1.4	<1.4
Diclofenac	LC-MS-MS	ng/L	3.3	5	18	<3.3	<3.3	35	<3.3	<3.3	<5	<3.3	<3.3	120	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3
Dilantin	LC-MS-MS	ng/L	13	20	110	<13	<13	130	<13	<13	120	<13	<13	82	<13	<13	140	<13	<13	<13	<13
Diuron	LC-MS-MS	ng/L	1.8	5	92	<1.8	<1.8	57	<1.8	<1.8	68	<1.8	<5	89	<1.8	<1.8	80	<1.8	<1.8	<1.8	<1.8
Erythromycin	LC-MS-MS	ng/L	4	10	90	<4	<4	210	<4	<4	120	<4	<4	<10	<4	<4	61	<4	<4	<4	<4
Estrone	LC-MS-MS	ng/L	3.9	5	15	<3.9	<5	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9	<3.9
Fluoxetine	LC-MS-MS	ng/L	10	10	100	<10	<10	120	<10	<10	100	<10	<10	67	<10	<10	31	<10	<10	<10	<10
Gemfibrozil	LC-MS-MS	ng/L	2.5	5	79	<2.5	<5	100	<2.5	<2.5	39	<2.5	<2.5	130	<2.5	<2.5	52	<2.5	<2.5	<2.5	<2.5
Iohexal	LC-MS-MS	ng/L	7.7	10	40000	24	<7.7	18000	<7.7	<7.7	2300	<7.7	<7.7	15000	<10	<7.7	6700	<7.7	<7.7	<7.7	<7.7
Ketoprofen	LC-MS-MS	ng/L	2.6	5	75	<2.6	<2.6	31	<2.6	<2.6	13	<2.6	<2.6	28	<2.6	<2.6	17	<2.6	<2.6	<2.6	<2.6
Lidocaine	LC-MS-MS	ng/L	1.1	5	220	<1.1	<1.1	150	<1.1	<1.1	120	<1.1	<1.1	220	<1.1	<1.1	120	<1.1	<1.1	<1.1	<1.1
Linuron	LC-MS-MS	ng/L	2.8	5	210	<2.8	<2.8	<5	<2.8	<2.8	<5	<2.8	<2.8	<2.8	<2.8	<2.8	6.5	<2.8	<2.8	<2.8	<2.8
Lopressor	LC-MS-MS	ng/L	5.1	20	200	<5.1	<5.1	480	<5.1	<5.1	390	<5.1	<5.1	400	<20	<5.1	210	<5.1	<5.1	<5.1	<5.1
Meprobamate	LC-MS-MS	ng/L	2	5	550	<2	<2	140	<2	<2	96	<2	<2	220	<2	<2	160	<2	<2	<2	<2
Naproxen	LC-MS-MS	ng/L	8.5	10	<8.5	<8.5	<8.5	<8.5	<8.5	<8.5	<8.5	<8.5	<8.5	11	<8.5	<8.5	<8.5	<8.5	<8.5	<8.5	<8.5
N-Nitroso-dimethylamine (NDMA)	EPA 521	ng/L	0.96	2	3.2	<0.96	<0.96	<2	<0.96	<0.96	1.9	0.58	0.4	1.4	0.53	0.36	6.1	-	-	<2	2.1
Primidone	LC-MS-MS	ng/L	4.8	5	93	<4.8	<4.8	100	<4.8	<4.8	110	<4.8	<4.8	120	<4.8	<4.8	97	<4.8	<4.8	<4.8	<4.8
Simazine	LC-MS-MS	ng/L	1.2	5	15	<1.2	<1.2	8.5	<1.2	<1.2	9.1	<1.2	<1.2	24	<1.2	<1.2	<5	<1.2	<1.2	<1.2	<1.2
Sucralose	LC-MS-MS	ng/L	42	100	45000	<100	<42	81000	<100	<42	62000	<42	<42	37000	<42	<42	48000	<42	<42	<42	<42
Sulfamethoxazole	LC-MS-MS	ng/L	2.8	5	1200	<2.8	<2.8	1100	<2.8	<2.8	700	<2.8	<2.8	860	<2.8	<2.8	870	<2.8	<2.8	<2.8	<2.8
TCEP	LC-MS-MS	ng/L	3.2	10	400	<3.2	<3.2	290	<3.2	<3.2	280	<3.2	<3.2	220	12	<3.2	270	<10	<3.2	<3.2	<10
TCPP	LC-MS-MS	ng/L	20	100	1600	<20	<20	2600	<20	<100	1400	<20	<20	2000	160	<100	2300	<20	<20	<20	<20
TDCPP	LC-MS-MS	ng/L	20	100	270	<20	<20	1100	<20	<20	910	<20	<20	930	<100	<20	780	<20	<20	<20	<100
Theobromine	LC-MS-MS	ng/L	3.2	10	<3.2	<3.2	<3.2	86	<3.2	<10	25	<10	<10	<3.2	<3.2	<3.2	<3.2	<10	<10	<3.2	<10
Triclosan	LC-MS-MS	ng/L	6.3	10	74	13	17	47	<6.3	<10	44	<6.3	<6.3	47	<6.3	<6.3	28	<6.3	<6.3	<6.3	<6.3
Trimethoprim	LC-MS-MS	ng/L	1.8	5	450	<5	<5	410	<5	<1.8	210	<1.8	<1.8	280	<1.8	<1.8	280	<1.8	<1.8	<1.8	<1.8

Note: Results shown as less than (<VALUE) indicate the reported result was less than the RL or DL. In some instances, the RL and/or DL varied during the testing period due to laboratory QC procedures or changes in method procedures.

Table 42 Summary of Differential Removal of Performance Indicator Compounds

No.	Compound	Method	Units	DL	RL				RO	UV/AOP
						Avg RO Feed (n = 5)	Avg RO Perm. (n = 5)	Avg UV/AOP (n = 5)	Δ Removal	Δ Removal
1	Acesulfame-K	LC-MS-MS	ng/L	20	20	33000	<27	<22	>99.9%	>16.5%
2	Amoxicillin (semi-quantitative)	LC-MS-MS	ng/L	6.4	20	220	<6.4	<6.4	>97%	-
3	Carbamazepine	LC-MS-MS	ng/L	1.2	5	190	<5	<1.2	>99%	-
4	Dilantin	LC-MS-MS	ng/L	13	20	120	<13	<13	>88.8%	-
5	Diuron	LC-MS-MS	ng/L	1.8	5	77	<1.8	<5	>97.7%	-
6	Fluoxetine	LC-MS-MS	ng/L	10	10	84	<10	<10	>88%	-
7	Lidocaine	LC-MS-MS	ng/L	1.1	5	170	<1.1	<1.1	>99.3%	-
8	Lopressor	LC-MS-MS	ng/L	5.1	20	340	<20	<5.1	>97.6%	-
9	N-Nitroso-dimethylamine (NDMA)	EPA 521	ng/L	0.96	2	3	<2	<0.96	>65.5%	-
10	Primidone	LC-MS-MS	ng/L	4.8	5	100	<4.8	<4.8	>95.4%	-
11	Sucralose	LC-MS-MS	ng/L	42	100	55000	<100	<42	>99.9%	-
12	Sulfamethoxazole	LC-MS-MS	ng/L	2.8	5	950	<2.8	<2.8	>99.7%	-
13	TCEP	LC-MS-MS	ng/L	3.2	10	300	<10	<10	>98.3%	-
14	TCPP	LC-MS-MS	ng/L	20	100	2000	<100	<100	>97.6%	-
15	Triclosan	LC-MS-MS	ng/L	6.3	10	48	<10	<10	>84.1%	-
16	Trimethoprim	LC-MS-MS	ng/L	1.8	5	330	<5	<5	>99.1%	-

Note: For calculating average concentrations, results reported below the RL were considered the value of the RL and for values reported below the DL the value of the DL was used. Dashes shown for the UV/AOP Differential Removal indicate the average concentration in the RO permeate and UV/AOP product were below the RL or DL and therefore removal could not be quantified.

Table 43 Summary of Differential Removal of Surrogate Compounds

No.	Surrogate	RO	UV/AOP
		Δ Removal (%)	Δ Removal (%)
1	TOC	99.6%	NA
2	UV 254	88.8%	68.7%
3	Monochloramines	----------	72.8%
4	Conductivity	99.0%	NA

Table 44 Comparison of Key Water Quality Results and Demonstration Goals

Constituent	Units	RL	[d]Purified Water Results			Water Quality Goal[b]
			Number of Samples	Average Concentration[a]	Maximum Concentration	
Nitrate as N	mg/L	0.11	100	0.73	1.4	1
Nitrite as N	mg/L	0.09	97	ND	ND	1
Ammonia as N (unionized)	mg/L	varies[c]	93	ND	0.021	0.025
Phosphorus, Total	mg/L	0.01	88	0.016	0.420	0.10
Nitrogen, Total	mg/L	0.1	96	0.87	2.2	1
Bromoform	µg/L	0.5	16	ND	0.1	0.5
Methylene Chloride	µg/L	0.50	16	ND	0.59	4.7
Trihalomethanes, Total	µg/L	2.0	16	ND	ND	80
Bromodichloromethane	µg/L	0.5	16	ND	0.85	0.56
Dibromochloromethane	µg/L	0.5	16	ND	0.6	0.5
Haloacetic Acids (HAA5)	µg/L	1	16	ND	ND	60
N-Nitrosodiethylamine	ng/L	2	19	ND	5.7	10
N-Nitrosodimethylamine (NDMA)	ng/L	2	19	ND	5.5	2
1,4-Dioxane	µg/L	0.5	16	ND	ND	1
1,2-Dichloroethane	µg/L	0.5	16	ND	ND	0.5
Total Organic Carbon	mg/L	0.3	97	ND	1.4	0.5
Total Dissolved Solids	mg/L	10	29	13.7	19	300
Chloride	mg/L	0.5	29	3.10	4.3	50
Sulfate	mg/L	0.5	28	ND	1.10	65
Boron	mg/L	0.01	28	0.230	0.290	1.0
Turbidity	NTU	-	298	0.05	0.10	0.2

Notes:

a. Average concentration calculation assumes non-quantifiable results are half of the reporting level and non-detectable results are half of the detection limit.

b. See Testing and Monitoring Plan, Table 5-2 (Appendix A).

c. Unionized values of ammonia were estimated based on USEPA's *Aqueous Ammonia Equilibrium – Tabulation of Percent Un-ionized Ammonia (EPA-600/3-79-091)* using average values of temperature and pH measured on-site.

d. Results shown as ND are non-quantifiable or non-detectable.

Acronyms:
RL – Method reporting level
ND – Not detectable or not quantifiable, shown for all values below method reporting level
mg/L – milligrams per liter, equivalent to parts per million (ppm)
µg/L – micrograms per liter, equivalent to parts per billion (ppb)
ng/L – nanograms per liter, equivalent to parts per trillion (ppt)
NTU – Nephelometric Turbidity Units

Table 45: Other Non-Regulated Constituents Detected in Purified Water and Imported Raw Aqueduct Water

Note: ***Of the 111 additional non-regulated constituents measured at the Demonstration Facility, only six were found to be quantifiably detected at any time in the purified water.***

Constituent	Classification/ Common Use	Units	RL	[c]Purified Water			[c]Imported Raw Aqueduct Water		
				Number of Samples	Average Concentration[a]	Maximum Concentration	Number of Samples	Average Concentration[a]	Maximum Concentration
Bromochloromethane	UCMR3 Disinfection byproduct	µg/L	0.06	4	0.225	0.250	4	ND	0.08
Chromium (VI)[b]	UCMR3 Disinfection byproduct, industrial byproduct	µg/L	0.02	4	0.09	0.16	4	0.047	0.052
Acesulfame-K	CEC Sugar Substitute	ng/L	20	9	ND	50	4	343	370
Iohexal	CEC X-ray contrast agent	ng/L	10	9	ND	19	4	43	55
Triclosan	CEC Antibacterial	ng/L	10	9	ND	19	5	ND	ND
Strontium	UCMR3 Alkaline earth Metal	µg/L	0.3	4	ND	0.37	4	405	610

Notes:

a. Average concentration calculation assumes non-quantifiable results are half of the reporting level and non-detectable results are half of the detection limit.

b. Three Chromium (VI) samples were sent to another lab and all results were ND (DL = 0.0059 µg/L). The CDPH Detection Limit for purposes of Reporting (DLR) is 1 µg/L.

c. Results shown as ND are non-quantifiable or non-detectable.

Acronyms:
RL – Method reporting level
ND – Not detectable or not quantifiable, shown for all values below method reporting level
µg/L – micrograms per liter, equivalent to parts per billion (ppb)
ng/L – nanograms per liter, equivalent to parts per trillion (ppt)

Table 46 Summary of Critical Control Point Monitoring Plan for the San Diego AWPF

Critical Control Point	Critical Limit Parameter	Monitoring Frequency	[1]Alert Limit	[1]Critical Limit	[1]Example Corrective Actions
MF/UF	Pressure Decay	1 per day	Value above baseline that approaches Critical limit.	0.4 psi / 5 min. based on the maximum decay predicted to achieve 4 log removal Cryptosporidium.	Confirm Results. Assess fiber breakage. Isolate/ repair/replace damaged membrane.
RO	TOC, Conductivity	Continuous	% change of measured concentration in combined RO permeate.	Online permeate conductivity = 150 µs/cm. Online permeate TOC = 100 ppb or greater for five consecutive measurements.	Automatic shutdown (conductivity). Monitor individual RO trains. Verify analyzer accuracy. Conduct vessel probing.
UV/AOP	Reactor Power Level	Continuous	100% (2 to 7 lamp failures or 1 to 3 ballast failures).	0% (8 or more lamp failures or 4 ballast failures).	System alarm. Automatic increase of reactor power to 100% or system shutdown. Check / replace lamps and/or ballasts.
UV/AOP	Hydrogen peroxide dose rate Continuous (flow confirmation)	1 per day by draw down Continuous flow confirmation	minimum dose (~22 ml/min.) to provide 3 mg/L peroxide	0 ml/min. indicating pump failure or loss of flow confirmation,	Check dosing system. Recalibrate pump. Auto switch to standby pump.

Note:

1. Specific limit values are based on baseline performance observed at the Demonstration Facility. During the design phase of the potential Full-Scale Facility, it is anticipated that the City would develop a similar monitoring and response plan that provides sufficient features and assurances that any foreseeable malfunction could be promptly identified and appropriate response applied.

Table 47 Summary of Critical Control Point Monitoring Results for the San Diego AWPF

Critical Control Point	Critical Limit Parameter	Monitoring Frequency	Number of Exceedances Above Limits				Notes
			Q1	Q2	Q3	Q4	
MF/UF	Pressure Decay	1 per day	1 (UF)	0	0	0	Pressure decay above limit due to leak in air piping not membrane integrity. Repair made, PDT repeated and passed.
RO	TOC, Conductivity	Continuous	0	0	0	0	None.
UV/AOP	Reactor Power Level	Continuous	4	0	1	1	Exceedances due to occurrences of single failed ballasts. System automatically increased power to 100% to accommodate power loss.
UV/AOP	Hydrogen peroxide dose	1 per day (draw down) Continuous (flow confirmation)	0	0	1	5	Q3 -Duty pump auto switched to standby pump and standby pump shutoff, due to low flow (air lock). System automatic shutdown. Restarted shortly after issue self-resolved. Q4 - Pump failures due to air locking. Adjustments made to degas interval and return off gas piping.

Table 48 Chemical Consumption of the Various AWP Unit Processes

Chemical	Concentration (w/w)	Injection Location	Target Dose (mg/L)	Dose Rate (mL/min)	Total Amount Delivered Quarter 1: 5/3/11 to 10/31/11 (gal)	Total Amount Delivered Quarter 2: 11/1/11 to 2/10/12 (gal)	Total Amount Delivered Quarter 3: 2/11/12 to 5/14/12 (gal)	Total Amount Delivered Quarter 4: 5/15/12 to 7/31/12 (gal)
Ammonium Hydroxide	19%	MF/UF Feed	1.5	38	1593	1007	1208	865
Sodium Hypochlorite	13%	MF/UF Feed	3.8	110	4229	2932	3464	2455
Antiscalant	100%	RO Feed	3	10	440	275	220	212
Hydrogen Peroxide	30%	UV Feed	3	22	1784	869	550	550

Chemical	Estimated Daily Consumption Quarter 1 based on 24 hour runtime (gal)	Estimated Average Daily Consumption Quarter 2 (gal)	Estimated Average Daily Consumption Quarter 3 (gal)	Estimated Average Daily Consumption Quarter 4 (gal)	Delivery Interval (Weeks)
Ammonium Hydroxide	11	10	12.4	11.9	3
Sodium Hypochlorite	24 (@ 2 mg/L target dose 7-1-11 to 8-9-11); 39 (@3 mg/L target dose 8-10-11 to 10-31-11)	30	34.7	33.8	1.5
Antiscalant	4	2.7	3.2	2.1	5
Hydrogen Peroxide	8	5.8	7.8	7	6

Note: Target dose rate is based on feed flow (MGD): MF+UF = 1.58; RO=1.25; UV=1. The total amount of chemical delivered for each quarter is based the measured volume delivered as reported by the Brenntag represenative at the time of delivery with the exception of hydrogen peroxide which was calcuated based the difference in tank level before and after each delivery. The estimated Average Daily Consumption for Q2, Q3 and Q4 was determined from differences in chemical tank levels recorded at the start and end of the testing period and the total amount delivered over the testing period.

Table 49 Power Totals of the Various AWP Unit Processes

Date	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
8/1/11	177175	69382	154749	785020	275289	1461615	NA	RO A power meter reading low.
8/2/11	174969	71411	270270	820177	273271	1610098	NA	RO A power meter reading low.
8/3/11	164713	62367	207498	642896	214921	1292395	NA	RO A power meter reading low.
8/4/11	0	0	0	0	0	0	NA	Offline for North City filter mudball chlorination
8/5/11		0	0	0	0	0	NA	Offline for North City filter mudball chlorination
8/6/11	0	0	0	0	0	0	NA	Offline for North City filter mudball chlorination
8/7/11	105975	3197	0	0	21600	130772	NA	RO systems offline.
8/8/11	153239	50077	190139	260084	199665	853204	NA	RO A power meter reading low.
8/9/11	166572	76340	268418	827364	280904	1619598	NA	RO A power meter reading low.
8/10/11	168510	76306	285679	802415	281882	1614792	NA	RO A power meter reading low.
8/11/11	158422	73287	507055	761544	270528	1770836	NA	Electrician swapped 2 wires on RO A power meter.
8/12/11	172002	72739	786253	840360	286875	2158229	NA	
8/13/11	164452	70661	769482	820144	264656	2089395	NA	
8/14/11	144236	47229	507716	540324	243933	1483438	NA	
8/15/11	154829	67876	743783	791380	274836	2032704	NA	
8/16/11	157357	71481	784927	835420	302400	2151585	NA	
8/17/11	146844	71754	783901	833325	300013	2135837	NA	
8/18/11	144077	71502	794484	838166	302465	2150694	NA	
8/19/11						0	NA	Totals not recorded.
8/20/11	124587	29478	290233	309204	109878	863380	NA	
8/21/11	118133	17433	173358	160102	67017	536043	NA	
8/22/11	133286	50326	551012	569555	208435	1512614	NA	
8/23/11	148203	74411	811023	829978	301956	2165571	NA	
8/24/11	154231	72283	805821	856534	302195	2191064	NA	
8/25/11	149646	72297	806455	858888	310680	2197966	NA	
8/26/11	148074	58773	647053	675318	244696	1773914	NA	
8/27/11						0	NA	Totals not recorded.
8/28/11	154274	72920	799079	854588	311392	2192253	NA	
8/29/11	160316	72549	805315	848794	302346	2189320	NA	
8/30/11	155077	72399	816466	861770	302412	2208124	NA	
8/31/11	153396	72574	819239	862184	298566	2205959	NA	
TOTAL (kW-h)	**3953**	**1621**	**14379**	**18086**	**6553**	**44591**	NA	
9/1/11	150591	71884	822969	849608	268390	2163442	NA	
9/2/11	141659	66237	741020	755582	237032	1941530	NA	

Table 49 Power Totals of the Various AWP Unit Processes

	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
Date	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
9/3/11	137444	53834	591336	612258	184835	1579707	NA	
9/4/11						0	NA	Totals not available.
9/5/11	107038	3089	0	0	0	110127	NA	RO and UV/AOP offline.
9/6/11	128629	88037	562688	580606	186182	1546142	NA	
9/7/11	178902	191669	796060	542594	274407	1983632	NA	UF cleaning.
9/8/11						0	NA	Blackout occurred at 3:30 p.m. Offline for weekend
9/9/11						0	NA	Offline due to blackout
9/10/11						0	NA	Offline due to blackout
9/11/11	43260	0	0	0	0	43260	NA	Offline due to blackout
9/12/11	121213	50852	525600	458486	178267	1334418	NA	Back online at ~8 A.M.
9/13/11	174005	72443	814238	859576	263788	2184050	NA	
9/14/11	170557	72086	826192	862508	262035	2193378	NA	
9/15/11	175543	71458	834726	863430	261465	2206622	NA	
9/16/11	163775	62254	726872	743700	238493	1935094	NA	
9/17/11	171963	72249	840096	863858	267446	2215612	NA	
9/18/11	176938	70673	839302	863892	265498	2216303	NA	
9/19/11	171889	71472	835564	846810	271549	2197284	NA	
9/20/11	167910	71943	837178	814944	269463	2161438	NA	
9/21/11	173320	71865	840548	826312	268666	2180711	NA	
9/22/11	173608	70729	828866	832392	264021	2169616	NA	
9/23/11						0	NA	Totals not available.
9/24/11	194134	71068	838174	811920	201340	2116636	NA	
9/25/11	195343	70878	832254	804412	4	1902891	NA	UV/AOP offline.
9/26/11	193885	71214	804784	767424	194237	2031544	NA	
9/27/11	190600	71366	835984	805804	282694	2186448	NA	
9/28/11	169839	40928	462392	451376	173747	1298282	NA	
9/29/11	174505	51536	520864	561296	209871	1518072	NA	
9/30/11	180890	58670	622260	672508	237928	1772256	NA	
TOTAL (kW-h)	**4027**	**1668**	**17180**	**17051**	**5261**	**45188**	NA	
10/1/11	172270	71720	816800	849632	300201	2210623	NA	
10/2/11	174610	71950	813808	846920	337770	2245058	NA	
10/3/11	181130	71260	810744	844152	331570	2238856	NA	
10/4/11						0	NA	Totals not available.
10/5/11	180010	77960	810744	3612	318560	1390886	NA	MF cleaning. RO B offline.

Table 49 Power Totals of the Various AWP Unit Processes

	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
Date	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
10/6/11	179870	163170	823136	607880	306130	2080186	NA	RO B Cleaning.
10/7/11	181190	328000	812024	263412	314110	1898736	NA	RO B Cleaning.
10/8/11						0	NA	Totals not available.
10/9/11	195070	64620	830600	824432	337490	2252212	NA	
10/10/11	198260	62610	815200	814184	352790	2243044	NA	
10/11/11	200490	64100	824320	828432	350530	2267872	NA	
10/12/11	201950	64070	802168	835616	294820	2198624	NA	
10/13/11	209210	43200	650692	719760	261660	1884522	NA	
10/14/11	203640	216800	243188	822336	227770	1713734	NA	RO A Cleaning. (MF/RO A/UV offline)
10/15/11	205610	154040	296972	829672	118420	1604714	NA	RO A Cleaning. (MF/RO A/UV offline)
10/16/11	199630	64350	814980	838960	304300	2222220	NA	
10/17/11	198400	64560	814832	837464	302420	2217676	NA	
10/18/11	190220	56580	719648	739600	265780	1971828	NA	All systems offline for ~ 4 hours.
10/19/11	200870	63840	822300	844800	302340	2234150	NA	
10/20/11	200650	63440	823960	846064	303800	2237914	NA	
10/21/11	185450	54270	674788	700952	276240	1891700	NA	All systems offline for ~ 3 hours.
10/22/11	197810	63930	809192	846880	362210	2280022	NA	
10/23/11	194730	63460	807568	845760	311430	2222948	NA	
10/24/11	191690	63070	806584	844008	304990	2210342	NA	
10/25/11	194180	62810	812520	850880	302610	2223000	NA	
10/26/11	190480	63000	806728	845136	301720	2207064	NA	
10/27/11	190810	63720	817688	859104	304480	2235802	NA	
10/28/11	182170	57490	746472	783920	276400	2046452	NA	
10/29/11	188780	63140	824152	866568	305230	2247870	NA	
10/30/11	177060	53160	678688	711600	244740	1865248	NA	
10/31/11	194310	63670	820288	859520	298030	2235818	NA	
TOTAL (kW-h)	**5561**	**2438**	**21951**	**22211**	**8619**	**60779**	NA	
11/1/11	199080	63260	826400	865336	333772	2287848	NA	
11/2/11	192000	58030	746280	781184	275416	2052910	NA	All systems offline for ~2 hours.
11/3/11	197890	64040	832344	872424	306584	2273282	NA	
11/4/11	171680	44060	567168	593936	212868	1589712	NA	All systems offline for ~8 hours.
11/5/11	140795	35850	498769	548883	181349	1405647	NA	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/6/11	196160	62360	847048	886792	313860	2306220	NA	

Table 49 Power Totals of the Various AWP Unit Processes

	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
Date	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
11/7/11	199020	63570	844960	884672	313200	2305422	NA	
11/8/11	202120	63170	855552	897256	311212	2329310	NA	
11/9/11	165105	42040	584887	643654	212661	1648348	NA	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/10/11	157930	32750	393912	405496	146784	1136872	NA	All systems offline for ~13 hours.
11/11/11	158623	40390	561923	618382	204311	1583628	NA	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/12/11	158623	40390	561923	618382	204311	1583628	NA	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/13/11	158623	40390	561923	618382	204311	1583628	NA	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/14/11	181330	51400	693800	715344	251344	1893218	NA	All systems offline for ~5 hours.
11/15/11	148660	41940	498892	502728	189416	1381636	NA	All systems offline for ~10 hours.
11/16/11	144240	26980	319268	332760	119920	943168	NA	All systems offline for ~15 hours.
11/17/11	145890	22590	260308	260608	97560	786956	NA	All systems offline for ~17 hours.
11/18/11	156820	32730	384012	442840	154840	1171242	NA	All systems offline for ~12 hours. Total AWPF Power Meter Installed.
11/19/11	205690	62320	858300	897944	300852	2325106	2452280	
11/20/11	207820	62030	860536	900576	300212	2331174	2461540	
11/21/11	206470	61900	867816	907632	325200	2369018	2496990	
11/22/11	204720	61630	875704	914952	356040	2413046	2542740	
11/23/11	244113	62158	864772	951661	314425	2437129	2556849	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/24/11	203850	61730	870944	911264	436920	2484708	2616290	
11/25/11	207110	61560	863920	904248	432752	2469590	2597210	
11/26/11	202060	60890	875064	914760	434248	2487022	2618050	
11/27/11	207050	61430	868504	909288	434740	2481012	2614940	
11/28/11	211570	61620	869200	909864	361280	2413534	2545380	
11/29/11	217290	61350	875540	916688	299892	2370760	2501650	
11/30/11	200170	61410	875704	914832	298068	2350184	2477260	
TOTAL (kW-h)	**5593**	**1566**	**21265**	**22443**	**8328**	**59195**	**NA**	

Table 49 Power Totals of the Various AWP Unit Processes

	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
Date	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
12/1/11	206210	55830	778264	813840	267052	2121196	2236112	All systems offline for ~3 hours.
12/2/11	213390	61100	884864	922928	302068	2384350	2500536	
12/3/11	223180	61030	801808	838088	275480	2199586	2319144	RO Trains and UV offline for ~3 hours.
12/4/11	202450	61360	884432	925496	304252	2377990	2501068	
12/5/11	188950	59890	741376	901856	294760	2186832	2305920	UF and ROA offline for ~4 hours.
12/6/11	201290	60770	869408	932992	301568	2366028	2487720	
12/7/11	190510	60740	833504	937712	301208	2323674	2441092	
12/8/11	189320	57720	832880	890296	285392	2255608	2375200	All systems offline for ~1 hour.
12/9/11	186670	55670	810336	862792	277440	2192908	2310536	All systems offline for ~2 hours.
12/10/11	217020	61210	883824	943168	302728	2407950	2532384	
12/11/11	217970	60970	883656	941936	302272	2406804	2529368	
12/12/11	210410	60530	872808	930560	298128	2372436	2499232	
12/13/11	212540	62050	887680	943360	302292	2407922	2512840	
12/14/11	207080	61420	892152	946424	304612	2411688	2536696	
12/15/11	197880	61090	890200	939256	301088	2389514	2511720	
12/16/11	190080	51480	726960	769512	246752	1984784	2099864	All systems offline for ~4 hours.
12/17/11	206570	54770	778768	825224	263280	2128612	2245824	All systems offline for ~3 hours.
12/18/11	216410	61240	890968	946408	303608	2418634	2545344	
12/19/11	213990	61960	891232	946616	303672	2417470	2545072	
12/20/11	185170	43490	619712	657592	211568	1717532	1826304	All systems offline for ~7 hours.
12/21/11	180810	41970	589264	623336	205400	1640780	1746208	All systems offline for ~8 hours.
12/22/11	211690	63130	888896	943952	306792	2414460	2542416	
12/23/11	165550	49620	705440	746528	241656	1908794	2016672	All systems offline for ~5 hours.
12/24/11	236010	60095	836066	920070	303987	2356228	2471975	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
12/25/11	196540	61820	892312	946744	305200	2402616	2521992	
12/26/11	200860	61030	899616	949472	303092	2414070	2536656	
12/27/11	193100	61420	902928	950336	303492	2411276	2530784	
12/28/11	193660	60800	909304	952520	303328	2419612	2546936	
12/29/11	239048	60868	846831	931917	307901	2386566	2503803	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
12/30/11	199720	53800	775680	818560	263852	2111612	2227360	All systems offline for ~3 hours.
12/31/11	243100	61900	861184	947712	313120	2427016	2546240	Power totals not available. Values estimated

Table 49 Power Totals of the Various AWP Unit Processes

Date	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
								based on runtime and typical power usage for 24 hour period.
TOTAL (kW-h)	**6337**	**1811**	**25762**	**27547**	**8907**	**70365**	**74053**	
1/1/12	210870	61330	895440	948720	306432	2422792	2550712	
1/2/12	210870	61290	896248	949424	305388	2423220	2551456	
1/3/12	213840	61390	877672	937760	301620	2392282	2522992	
1/4/12	216520	61700	892608	947888	303592	2422308	2553648	
1/5/12	212100	61120	895768	950368	304776	2424132	2558856	
1/6/12	194900	51820	731960	772304	257224	2008208	2125112	All systems offline for ~5 hours.
1/7/12	212300	61270	898584	950192	309028	2431374	2557264	
1/8/12	204230	62110	904952	951936	309060	2432288	2554896	
1/9/12	206940	62970	905584	951920	311232	2438646	2559944	
1/10/12	162030	34190	484688	551376	182136	1414420	1515768	All systems offline for ~10 hours. Energy recovery device removed from RO Train A.
1/11/12	113400	6440	9816	8816	11760	150232	221592	Systems offline for ERD maintenance.
1/12/12	173412	39350	569488	576752	193640	1552642	1661320	All systems offline for ~9 hours.
1/13/12	192656	59470	921472	946208	302172	2421978	2546944	
1/14/12	188904	60000	926504	954512	301300	2431220	2549808	
1/15/12	204708	60510	931680	953824	305900	2456622	2576352	
1/16/12	204260	60540	931304	955136	305188	2456428	2580400	
1/17/12	208672	57900	886480	867776	290744	2311572	2429648	
1/18/12	254888	60450	937496	955200	309408	2517442	2634832	Positioner on UF feed valve controller replaced.
1/19/12	267432	60530	939224	955184	311592	2533962	2654848	
1/20/12	245968	18620	733080	747696	246976	1992340	2133616	All systems offline for ~5 hours.
1/21/12	266550	60760	931936	954112	311632	2524990	2662048	
1/22/12	265340	60760	932880	954976	312408	2526364	2647504	
1/23/12	259820	60470	937256	954304	315760	2527610	2653248	
1/24/12	262020	60660	934400	954656	310440	2522176	2643376	
1/25/12	266040	60830	936960	954464	310112	2528406	2654512	
1/26/12	266120	59940	923280	935840	304992	2490172	2619808	
1/27/12	231260	57980	496280	886368	276240	1948128	2063248	
1/28/12	226840	62610	489360	956368	295920	2031098	2145840	
1/29/12	250920	60890	928616	956448	315176	2512050	2633104	
1/30/12	240400	51150	762712	785056	261240	2100558	2213680	All systems offline for ~4 hours.
1/31/12	267348	61400	928240	958528	314384	2529900	2657568	

Table 49 Power Totals of the Various AWP Unit Processes

Date	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
TOTAL (kW-h)	**6902**	**1720**	**25372**	**27084**	**8797**	**69876**	**73634**	
2/1/12	266864	60190	928600	957712	312388	2525754	2651936	
2/2/12	263280	60270	928904	956528	315240	2524222	2642992	
2/3/12	254416	54520	823528	849328	280628	2262420	2378288	
2/4/12	239048	60868	846831	931917	307901	2386566	2503803	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
2/5/12	262320	60350	934344	957632	316420	2531066	2650592	
2/6/12	262860	60860	929640	956864	316440	2526664	2649680	
2/7/12	268440	60950	929352	956784	313320	2528846	2666944	
2/8/12	269060	60710	933360	958640	313460	2535230	2666080	
2/9/12	269928	60890	937600	958688	309220	2536326	2667232	
2/10/12	256532	51780	775936	794768	261300	2140316	2251232	All systems offline for ~4 hours.
2/11/12	264612	61390	936064	958000	317392	2537458	2657888	
2/12/12	264840	60790	930496	956896	318028	2531050	2652992	
2/13/12	262928	60830	928032	956208	317988	2525986	2649296	
2/14/12	267688	60410	932080	956720	318532	2535430	2657200	
2/15/12	261852	60540	931392	943600	311508	2508892	2630880	
2/16/12	260680	58030	898768	909872	298160	2425510	2544224	
2/17/12	246440	59870	747568	755584	249584	2059046	2156112	
2/18/12	266020	61100	940368	954688	315560	2537736	2659424	
2/19/12	267780	61100	938592	954832	320120	2542424	2665120	
2/20/12	251612	52490	774320	809904	271856	2160182	2273808	
2/21/12	262056	61390	862000	957728	318960	2462134	2581136	
2/22/12	258832	60550	861552	958992	316652	2456578	2586976	
2/23/12	260840	60400	847072	873648	290900	2332860	2455520	
2/24/12	261432	61620	872352	955680	316760	2467844	2592416	
2/25/12	260268	61190	872128	955264	316352	2465202	2587824	
2/26/12	259040	61320	868592	952840	320344	2462136	2585280	
2/27/12	243759	61416	788134	885108	320021	2298439	2405254	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
2/28/12	259536	60390	867296	948624	315296	2451142	2574256	
2/29/12	261112	61250	878144	957024	317632	2475162	2597808	
TOTAL (kW-h)	**7554**	**1737**	**25643**	**26880**	**8918**	**70733**	**74242**	

Table 49 Power Totals of the Various AWP Unit Processes

Date	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
3/1/12	259900	61360	875760	956400	318176	2471596	2598560	
3/2/12	249700	55080	758144	828960	278464	2170348	2284544	
3/3/12	252680	55850	794624	869456	293600	2266210	2382416	
3/4/12	172448	5370	4672	4560	11632	198682	267184	UF Critical alarm shut down plant (Bray air valve)
3/5/12	199532	32940	414061	456848	15728	1119109	1360848	
3/6/12	241612	61210	844544	899632	315536	2362534	2484128	
3/7/12	226948	49930	670400	738000	250872	1936150	2044992	
3/8/12	239300	61740	866112	952640	322672	2442464	2561504	
3/9/12	236740	56410	776480	858944	287360	2215934	2333472	
3/10/12	246132	61820	851368	948416	313560	2421296	2546304	
3/11/12	244640	61580	851360	948496	318648	2424724	2548736	
3/12/12	244760	61990	844560	948816	318400	2418526	2541856	
3/13/12	244868	62100	848800	948160	309296	2413224	2535264	
3/14/12	245740	61900	848480	949376	309992	2415488	2539468	
3/15/12	244940	62130	846576	948432	313048	2415126	2537312	
3/16/12	245280	61500	843552	948960	313328	2412620	2533920	
3/17/12	243300	62010	844192	946080	313504	2409086	2530240	
3/18/12	243760	61680	853632	948928	316272	2424272	2543168	
3/19/12	242700	61750	854640	948352	315488	2422930	2542720	
3/20/12	240360	60470	851952	937152	307568	2397502	2518336	
3/21/12	243100	61900	861184	947712	313120	2427016	2546240	
3/22/12	204528	342470	857712	481664	288640	2175014	2312320	
3/23/12	199472	290286	838352	418128	281344	2027582	2167104	
3/24/12	244072	61870	863200	951312	316248	2436702	2558432	
3/25/12	240536	62270	862176	951456	314352	2430790	2550944	
3/26/12	243652	61270	861856	950256	317288	2434322	2554752	
3/27/12	239012	58050	832736	935792	297136	2362726	2476608	
3/28/12	244640	52700	871072	1024640	314856	2507908	2639616	
3/29/12	243768	52310	870432	1019616	319552	2505678	2636480	
3/30/12	233552	56210	779840	914912	286456	2270970	2386720	
3/31/12	240368	59140	863152	1024384	304200	2491244	2607456	
TOTAL (kW-h)	**7342**	**2277**	**24706**	**26606**	**8896**	**69828**	**73672**	
4/1/12	244100	62050	863680	1085504	317360	2572694	2695872	
4/2/12	243040	61870	860768	1043136	316728	2525542	2651552	

Table 49 Power Totals of the Various AWP Unit Processes

	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
Date	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
4/3/12	240892	61770	860272	1057616	315192	2535742	2662400	
4/4/12	238968	238810	836208	1028688	307040	2649714	2770432	
4/5/12	244872	182990	685936	981968	306192	2401958	2520320	
4/6/12	236208	105050	772480	893552	286088	2293378	2408160	
4/7/12	242280	62060	849232	1036224	312176	2501972	2626080	
4/8/12	245368	62600	846288	1037232	311976	2503464	2625760	
4/9/12	243840	62090	839232	1023536	312296	2480994	2604960	
4/10/12	243192	62340	840304	1009312	308448	2463596	2583712	
4/11/12	245632	62040	842048	1007008	305584	2462312	2584512	
4/12/12	245256	62850	839728	1002528	306104	2456466	2574592	
4/13/12	235712	56920	753232	900544	272400	2218808	2331616	
4/14/12	243560	61990	847840	1010224	307696	2471310	2590432	
4/15/12	246060	61800	846368	1006304	315624	2476156	2597248	
4/16/12	245692	598720	441216	991952	301160	2578740	2741728	RO A offline for approximately 12 hours for cleaning; Extra power usage at MF due to heating CIP water
4/17/12	244200	462370	286368	990336	303840	2287114	2436064	RO A offline for approximately 15 hours for cleaning; Extra power usage at MF due to heating CIP water
4/18/12	230128	297120	293888	349072	110408	1280616	1992000	All systems offline for approx. 3 hours; RO B offline for approximately 16 hours for cleaning; Extra power usage at MF due to heating CIP water
4/19/12	243808	125610	840291	445648	303684	1959041	2043456	RO B offline for approximately 12 hours for cleaning; Extra power usage at MF due to heating CIP water. Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/20/12	234452	55680	735254	832384	283008	2140778	2215936	All systems offline for approximately 3 hours. Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/21/12	243932	61880	840291	939776	319488	2405367	2468192	Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/22/12	239948	58080	770267	882080	300768	2251143	2332896	All systems offline for approximately 2 hours.

Table 49 Power Totals of the Various AWP Unit Processes

	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
Date	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
								Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/23/12	244188	61180	840291	907808	316152	2369619	2426752	Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/24/12	233512	56560	735254	779120	275896	2080342	2150784	All systems offline for approximately 3 hours. Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/25/12	243392	62030	778624	874640	302256	2260942	2376704	Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/26/12	243048	61520	778928	876576	300992	2261064	2378816	
4/27/12	213289	53739	689618	774470	280018	2011134	2104597	All systems offline for approximately 3 hours. Power totals not available. Usage estimated based on runtime and typical power usage.
4/28/12	243428	61540	780128	876480	315912	2277488	2393600	
4/29/12	242632	60930	780528	877488	345992	2307570	2426432	
4/30/12	240312	56930	745024	823552	327069	2192887	2311680	All systems offline for approximately 1 hour
TOTAL (kW-h)	**7225**	**3401**	**22720**	**27345**	**8988**	**69678**	**73627**	
5/1/12	244000	61470	775296	874272	318192	2273230	2391488	
5/2/12	242880	61360	777760	879024	359032	2320056	2438208	
5/3/12	244888	61380	773072	874992	357496	2311828	2429216	
5/4/12	237040	56910	686048	794784	314104	2088886	2199936	All systems offline for approxmiately 2 hours
5/5/12	243480	60830	771648	875664	293872	2245494	2361664	
5/6/12	245480	61460	772912	879472	290848	2250172	2366720	
5/7/12	142193	35826	459745	516313	186679	1340756	1403065	All sytems offline for approximately 10 hours. Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
5/8/12	0	0	0	0	0	0	0	All systems offline all day
5/9/12	0	0	0	0	0	0	0	All systems offline all day
5/10/12	0	0	0	0	0	0	0	All systems offline all day
5/11/12	152349	38385	492584	553193	200013	1436524	1503284	All systems offline for approximately 9 hours. Power totals not available. Values estimated

Table 49 Power Totals of the Various AWP Unit Processes

Date	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
								based on runtime and typical power usage for 24 hour period.
5/12/12	198680	62740	766224	872080	296536	2196260	2313600	
5/13/12	198380	62110	764800	873264	295544	2194098	2310528	
5/14/12	197780	61930	759328	871808	295680	2186526	2302976	
5/15/12	192988	62560	762288	876864	296528	2191228	2308544	
5/16/12	193944	62900	762416	873760	293104	2186124	2304960	
5/17/12	190600	55960	719248	789808	264656	2020272	2133408	
5/18/12	172125.3	55823.8	676644.2	775462.0	260129.8	1940185	2045652.0	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
5/19/12	197904	62310	817312	875584	293264	2246374	2360800	
5/20/12	193216	62170	814192	868608	292896	2231082	2347040	
5/21/12	200144	61940	811200	864240	297432	2234956	2351456	
5/22/12	196416	62300	818912	867536	296936	2242100	2360000	
5/23/12	196772	62270	820032	872080	280304	2231458	2345376	
5/24/12	195588	61720	819472	871952	292352	2241084	2358016	
5/25/12	197612	54280	710544	679152	237944	1879532	1982592	All systems offline for ~3 hours; ROB and UV offline for ~5 hours
5/26/12								
5/27/12	180680	35810	442816	479568	164312	1303186	1395424	All systems offline for ~11 hours
5/28/12	154347	50058	606756	695367	233262	1739790	1834364	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~ 5 hours.
5/29/12	154347	50058	606756	695367	233262	1739790	1834364	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~ 5 hours.
5/30/12	188780	231900	786720	872080	306656	2386136	2502624	Extra power usage on MF due to heating of water for UF CIP
5/31/12	177068	285150	364800	853488	279184	1959690	2113184	UF and ROA offline for ~13 hours due to UF cleaning; Extra power usage on MF due to heating of water for UF CIP
TOTAL (kW-h)	**5330**	**1942**	**19140**	**21676**	**7530**	**55617**	**58598**	
6/1/12	171593	199139	692067	844410	270463	2177671	2279565	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.

Table 49 Power Totals of the Various AWP Unit Processes

Date	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
6/2/12	195472	61680	789280	882624	306784	2235840	2351936	
6/3/12	192328	61660	784432	888944	307104	2234468	2357280	
6/4/12	191472	62040	780416	887264	306912	2228104	2339360	
6/5/12	192840	61440	780752	924640	306632	2266304	2382848	
6/6/12	194256	225440	783472	955936	306184	2465288	2580640	Extra power usage on MF due to heating water for ROB CIP
6/7/12	193672	206870	771984	287168	178672	1638366	1745888	MF and ROB offline for ~17 hours, UV offline for ~9 hours; Extra power usage on MF due to heating water for ROB CIP
6/8/12	81749	94873	329711	402290	128852	1037475	1086019	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~ 14 hours.
6/9/12	195800	61360	768512	914272	289416	2229360	2346176	
6/10/12	192720	62080	760928	906752	297752	2220232	2336832	
6/11/12	192160	57680	709040	847584	278160	2084624	2198144	All systems offline for ~2 hours
6/12/12	186976	44900	538336	643904	193656	1607772	1707936	All systems offline for ~7 hours
6/13/12	195144	62400	760880	911040	293600	2223064	2338880	
6/14/12	197608	61500	765648	918464	294976	2238196	2353696	
6/15/12	140856	43190	530512	637696	203840	1556094	1648640	All systems offline for ~7 hours
6/16/12	194096	63030	762384	915008	289344	2223862	2341888	
6/17/12	198912	63070	758896	912224	290128	2223230	2342144	
6/18/12	195512	62910	743760	869216	286992	2158390	2278560	
6/19/12	175960	27660	311440	370368	125976	1011404	1099520	All systems offline for ~14 hours due to leak at chlorine pump
6/20/12	185944	44850	540592	639200	212632	1623218	1728032	All systems offline for ~7 hours due to leak at chlorine pump
6/21/12	198024	62110	758400	902496	293648	2214678	2336000	
6/22/12	191312	52960	632768	748832	254056	1879928	1991200	All systems offline for ~4 hours
6/23/12	168320	52794	644640	767122	249601	1882476	1985600	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~4 hours.
6/24/12	161752	4710	4320	3904	11736	186422	254592	All systems offline all day
6/25/12	173080	26080	272048	317600	114584	903392	990816	All systems offline for ~15 hours
6/26/12	0	0	0	0	0	0	0	Power Outage plant shutdown
6/27/12	195016	61690	754192	888736	299000	2198634	2318880	
6/28/12	196408	61270	753328	888032	298856	2197894	2315232	

Table 49 Power Totals of the Various AWP Unit Processes

	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
Date	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
6/29/12	172266	53739	660731	778878	262122	1927736	2030651	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~3 hours for maintenance.
6/30/12	172266	53739	660731	778878	262122	1927736	2030651	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~3 hours for maintenance.
TOTAL (kW-h)	**5294**	**2057**	**18804**	**21633**	**7214**	**55002**	**58098**	
7/1/12	196080	61530	748160	890592	305432	2201794	2321408	Shutdown for ~2hrs due to pump failure.
7/2/12	201600	61110	745968	887264	303472	2199414	2321472	
7/3/12	180859	56419	693690	817729	275197	2023894	2131943	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~2 hours.
7/4/12	193360	61200	751520	894976	894976	2796032	2318080	
7/5/12	0	0	0	0	0	0	0	Plant shutdown due to pump failures & EDR exercises
7/6/12	0	0	0	0	0	0	0	Plant shutdown all weekend due to comm. Failures
7/7/12	0	0	0	0	0	0	0	Plant shutdown all weekend due to comm. Failures
7/8/12	0	0	0	0	0	0	0	Plant shutdown all weekend due to comm. Failures
7/9/12	185136	39430	457504	540192	540192	1762454	1512256	Plant shutdown all weekend due to comm. Failures
7/10/12	193720	55610	665296	774976	774976	2464578	2076416	
7/11/12	197656	61120	738112	861312	296784	2154984	2276032	
7/12/12	196784	61480	739328	866816	294720	2159128	2281344	
7/13/12	179975.4	56228.6	676177.1	792775.5	269546.0	1974702	2086479	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
7/14/12	179975.4	56228.6	676177.1	792775.5	269546.0	1974702	2086479	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
7/15/12	198480	60740	736368	858240	293688	2147516	2265600	
7/16/12	197352	60350	738448	860032	292096	2148278	2264768	

Table 49 Power Totals of the Various AWP Unit Processes

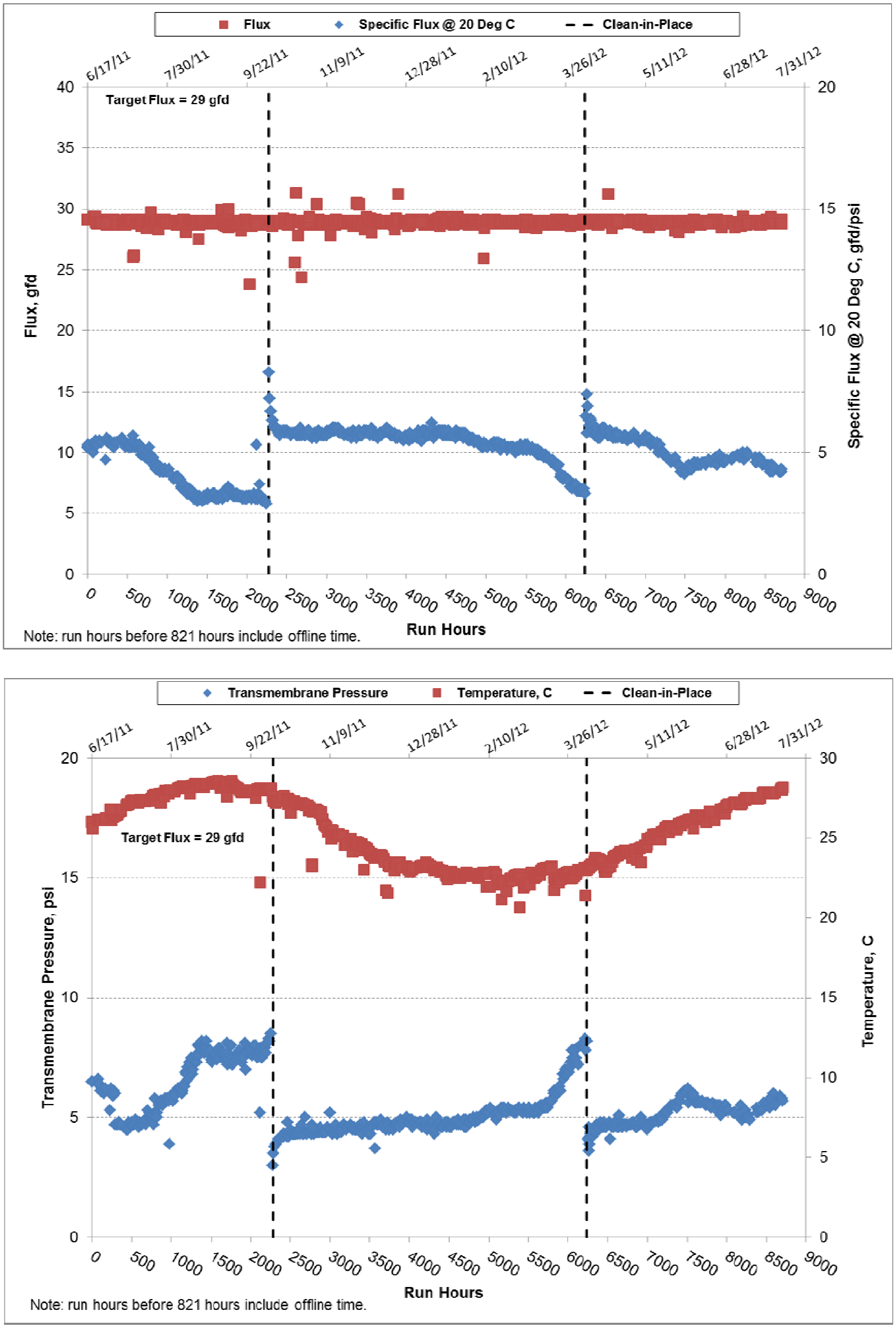
Date	Daily Power Totals (wH) from Power Meters (August 2011-July 2012)							Comments
	UF	MF	RO Train A	RO Train B	UV/AOP	Total Power Usage for AWPF Process Skids (wH)	Total AWPF Main Power Usage (wH)	
7/17/12	196960	61350	746112	870400	294984	2169806	2286592	
7/18/12	193464	60480	748800	874368	296856	2173968	2295936	
7/19/12	189304	55550	675040	786144	268320	1974358	2093056	
7/20/12	193320	60900	743360	865920	294632	2158132	2277568	
7/21/12	193320	60900	743360	865920	294632	2158132	2277568	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
7/22/12	197592	61300	743776	876040	293424	2172132	2283264	
7/23/12	194792	60420	743328	869120	291856	2159516	2279936	
7/24/12	190976	48760	588160	688096	231080	1747072	1858176	Plant shutdown ~5 hrs due to pump failure while operator not present
7/25/12	194464	60700	745968	878144	294824	2174100	2291264	
7/26/12	198288	60480	742096	871552	295184	2167600	2286208	
7/27/12	185069	56448	692623	813449	275505	2023093	2133794	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
7/28/12	185069	56448	692623	813449	275505	2023093	2133794	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
7/29/12	196928	60620	737920	863840	293712	2153020	2270208	
7/30/12	198392	60270	735520	862400	291488	2148070	2265408	
7/31/12	201760	60780	734832	861920	289488	2148780	2265728	
TOTAL (kW-h)	**5211**	**1577**	**19180**	**22498**	**9092**	**57558**	**59241**	

Table 50 Equipment Maintenance / Failure Log Q4 Testing Period

Month / Year	Equipment	Description of Issue	Action	Status
August 2011 – July 2012	UF System	Backwash chlorine pump loose prime.	Tubing has been rerouted and foot valve replaced. H2O Innovations looking at installing a recirculation line to prevent air locking of chemical.	open
May 2012	UVT analyzer	Lamp failed.	Replaced lamp.	closed
May 2012	Hydrogen Peroxide Pumps	Multiple no flow alarms on peroxide pumps causing a latched alarm and reactor shutdown.	Changed degas interval and length of time; Opened vent valve on peroxide pump skid.	monitoring
June 2012	Antiscalant Pump	Crack found in pump skid piping.	Replaced cracked pipe section.	closed
June 2012	Sodium Hypochlorite Pump	Pressure relief valve on pump skid steadily dripping due to a crack in the plug.	Cracked plug removed and replaced.	closed
June 2012	RO Train B	Discovered concentrate flow meter to be reading ~20 gpm higher than actual flow based on comparison to strap on flow meter and concentrate conductivity readings; This caused the calculated recovery to be lower than the actual recovery.	Scaled flow transmitter equipped on RO skid to display correct flows. Confirmed FWR based on sulfate rejection.	closed
June 2012	UV/AOP System	Ballast failure.	Replaced ballast.	Power study and failure diagnostic in progress.
July 2012	Feed Pumps	Feed pumps faulted.	Reset alarms.	closed
July 2012	Programmable Logic Controller Fault (PLC-101)	Plant continued to shut-down due to PLC communication failures.	Data transferred from PLC-101 to AWP operations computer to increase hard drive capacity. Also cleared communication ports.	closed
July 2012	Feed Pumps	No flow from Penasquitos pump station caused low flow in the North City feed pump wet wells which caused AWP feed pump to shut down.	Reset alarms.	closed
July 2012	Feed Pumps	Pumps faulted on a low wet well level alarm. North City operators discovered this caused by a PLC issue and not actual low levels.	Reset alarms.	closed

Note:

1. The table includes items from previous Testing Periods that remained open during the Q4 Reporting Period.



Note: run hours before 821 hours include offline time.

Note: run hours before 821 hours include offline time.

Figure 1 Pall Microfiltration System Operating Data

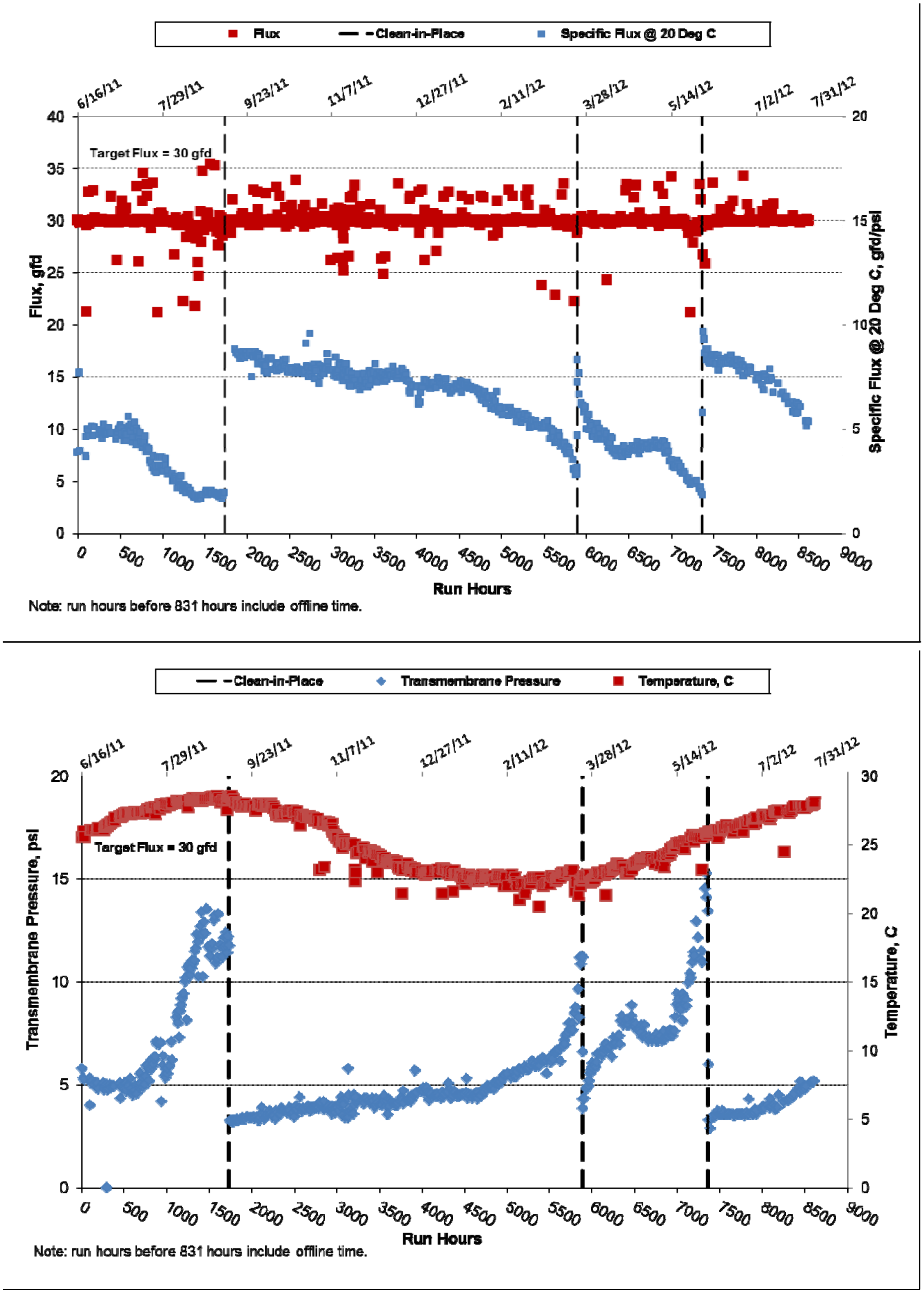
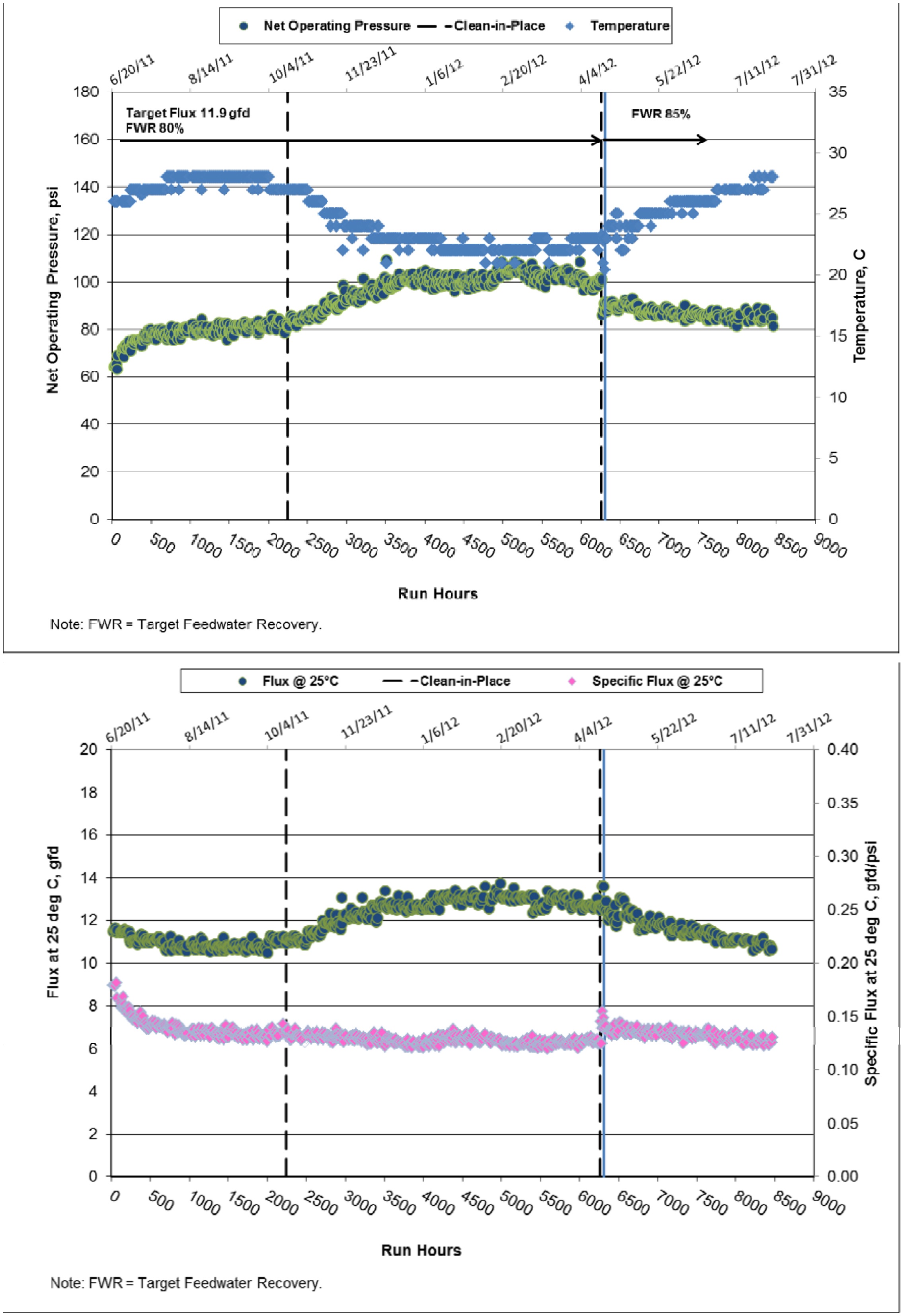


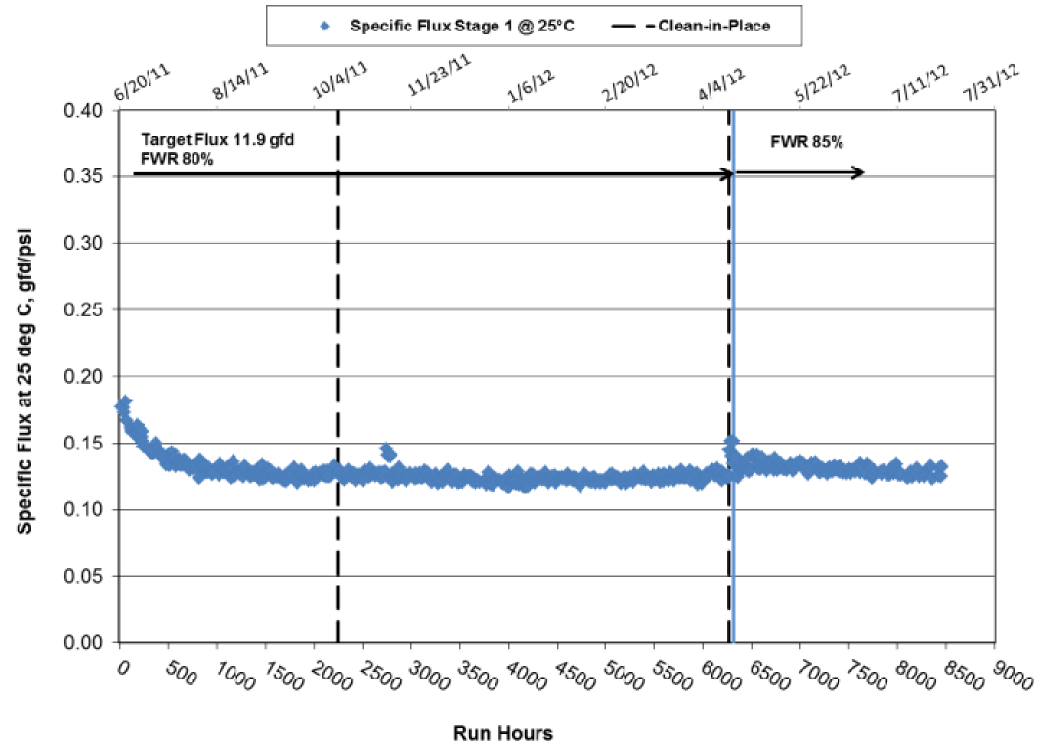
Figure 2 Toray Ultrafiltration Operating Data



Note: FWR = Target Feedwater Recovery.

Note: FWR = Target Feedwater Recovery.

Figure 3 Membrane Performance of the Hydranautics ESPA 2 LD RO Membrane Systrem



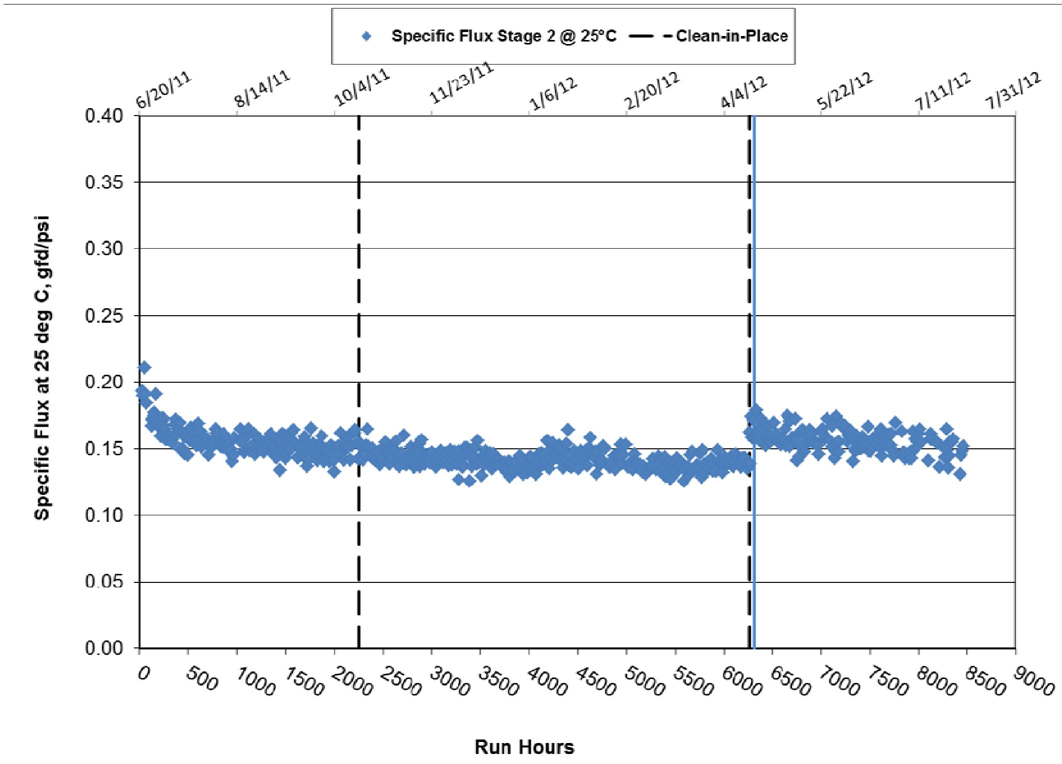


Figure 4 Comparison of Temperature Corrected Specific Flux Stage 1 (Top) and Stage 2 (Bottom) of the Hydranautics ESPA2 LD RO Membrane System

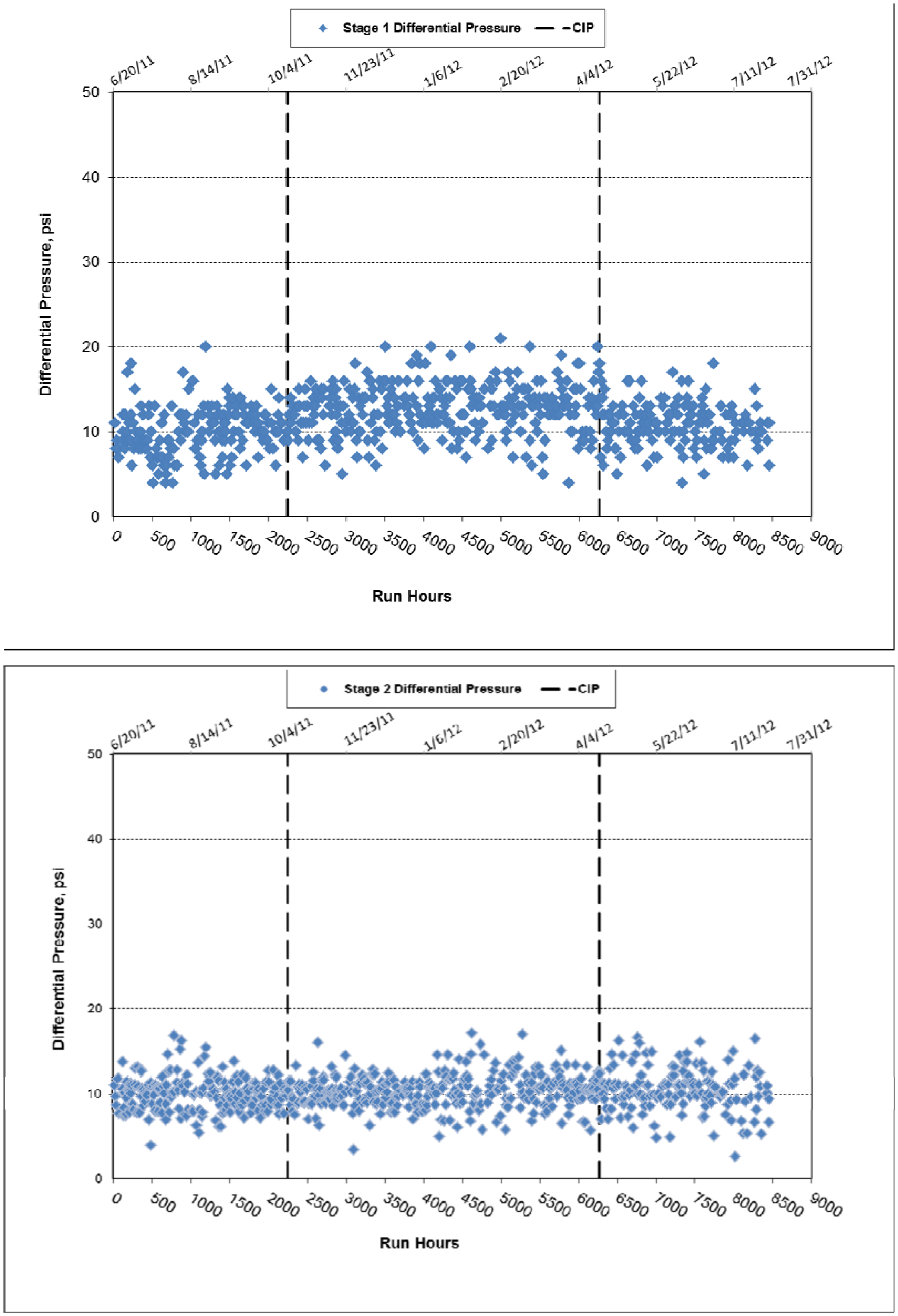
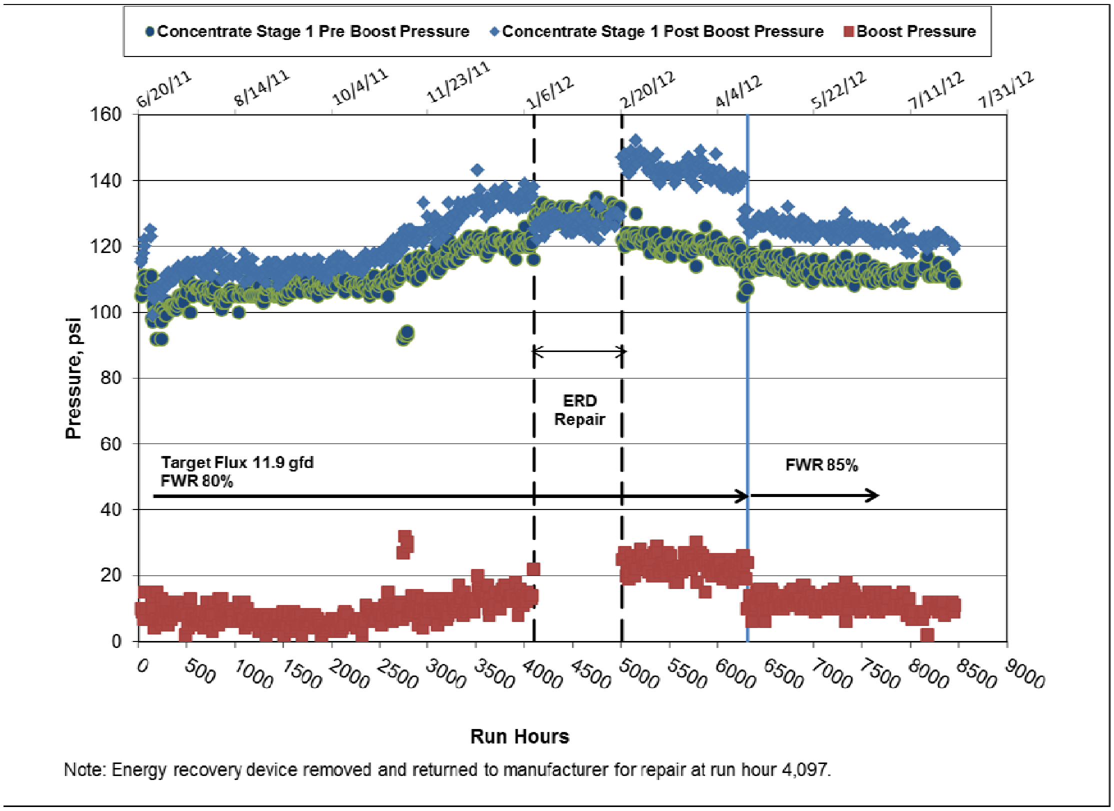


Figure 5 Differntial Pressure (DP) of the Hydranautics ESPA2 LD RO Membrane System



Note: Energy recovery device removed and returned to manufacturer for repair at run hour 4,097.

Figure 6 Energy Recovery Performance of the Hydranautics ESPA2 LD RO Membrane System

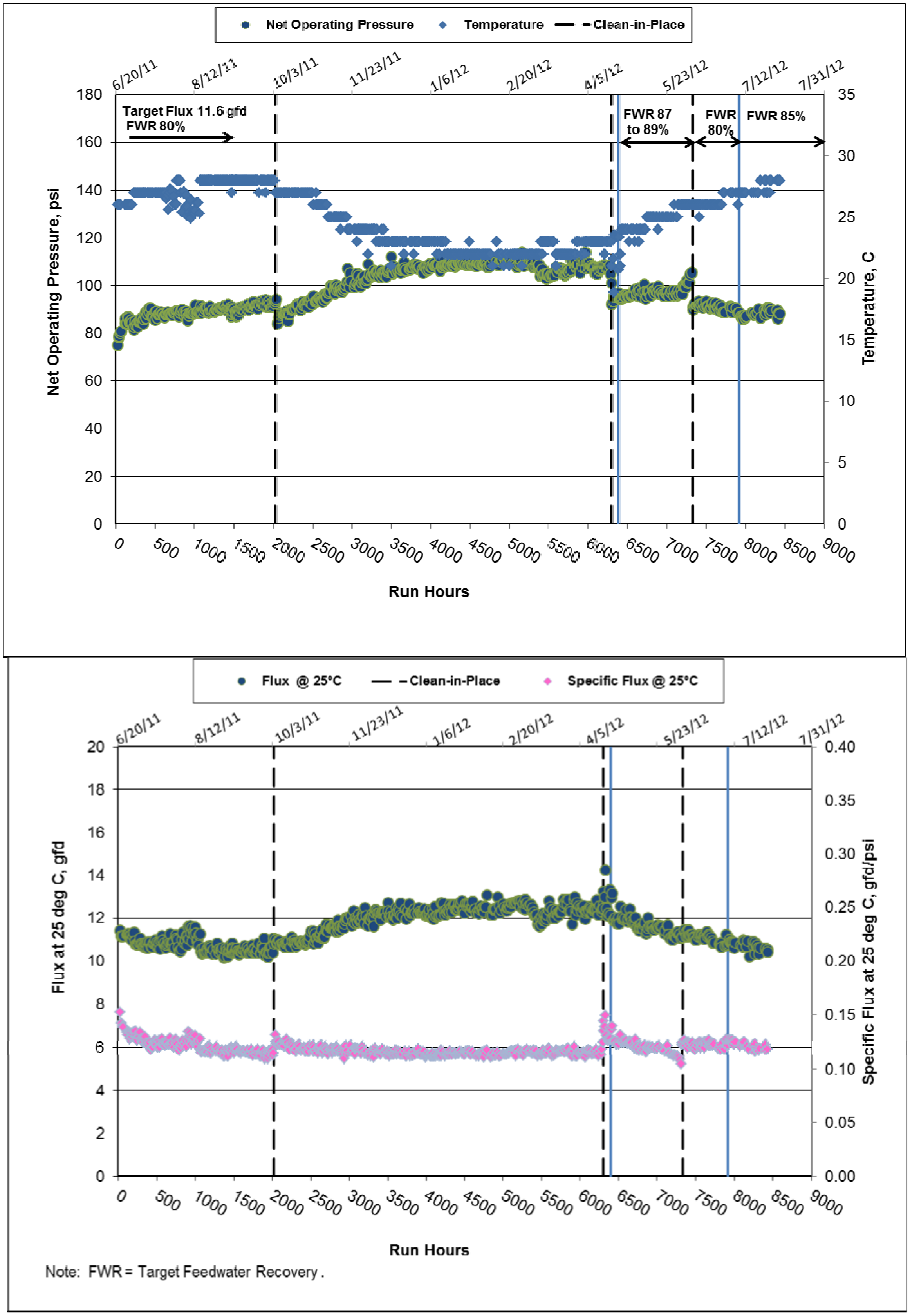


Figure 7 Membrane Performance of the Toray TML RO Membrane System

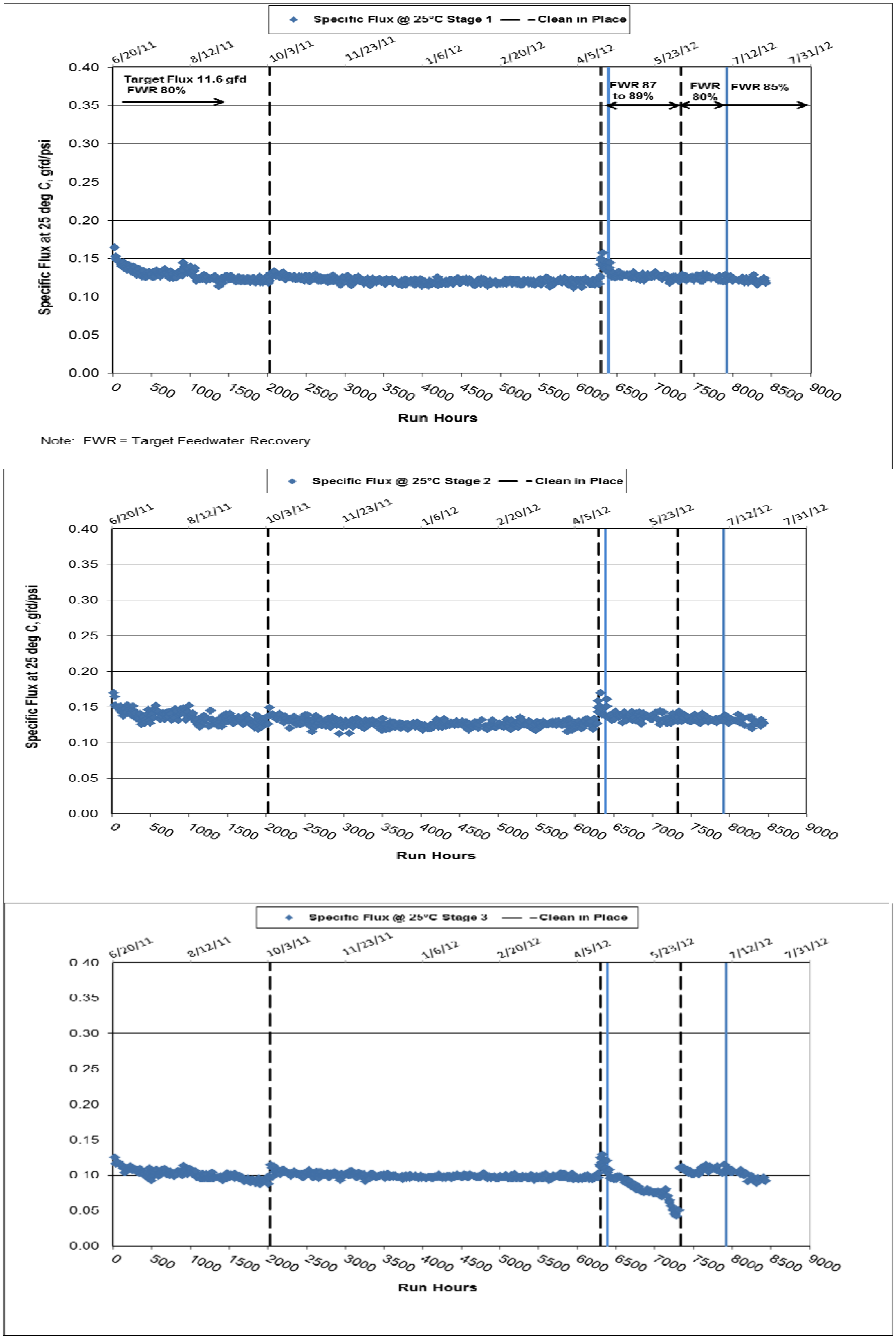


Figure 8 Comparison of Temperature Corrected Specific Flux by Stage 1 (Top), Stage 2 (Mid), Stage 3 (Bottom) of the TML RO Membrane System

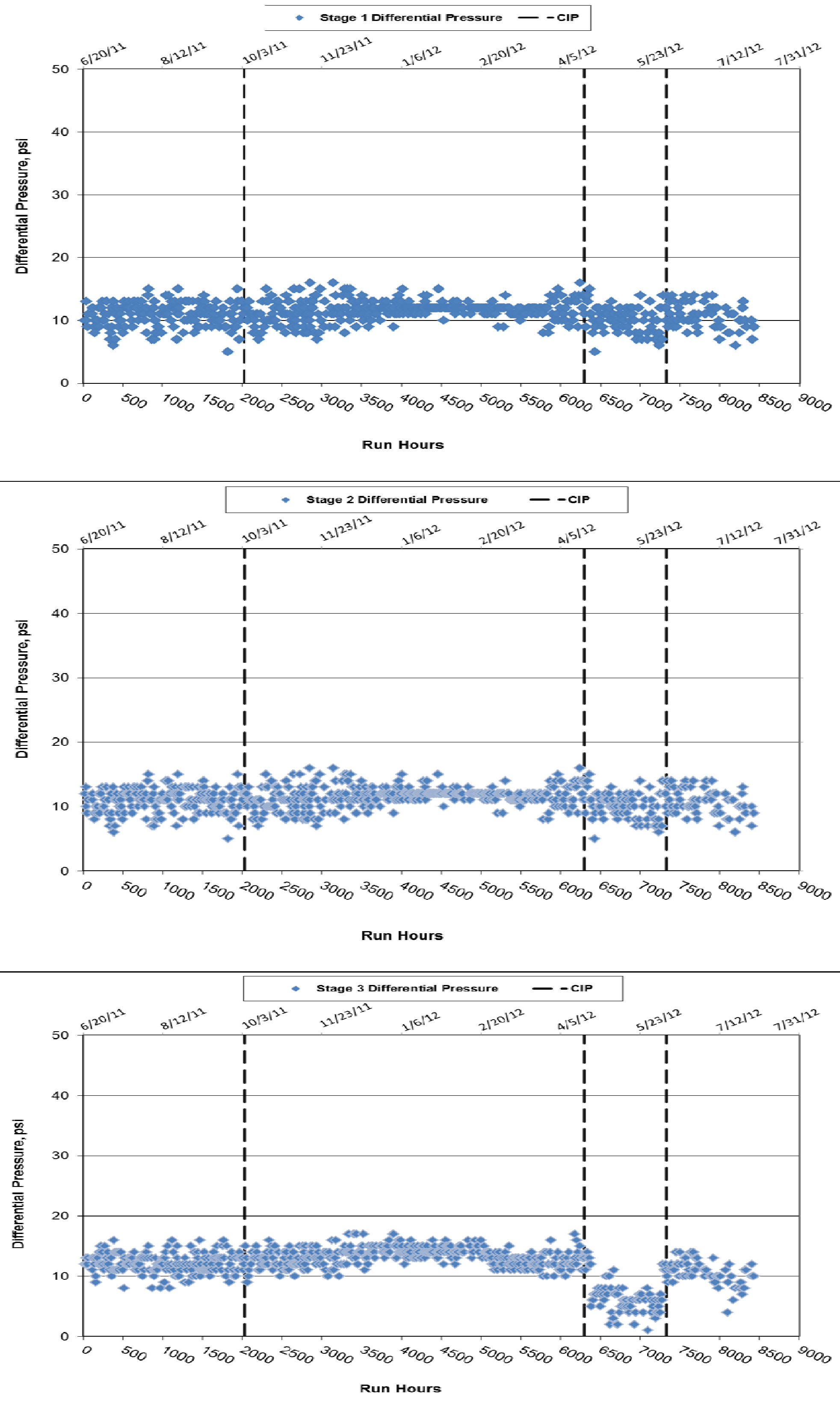


Figure 9 Differential Pressure (DP) of the Toray TML RO Membrane System

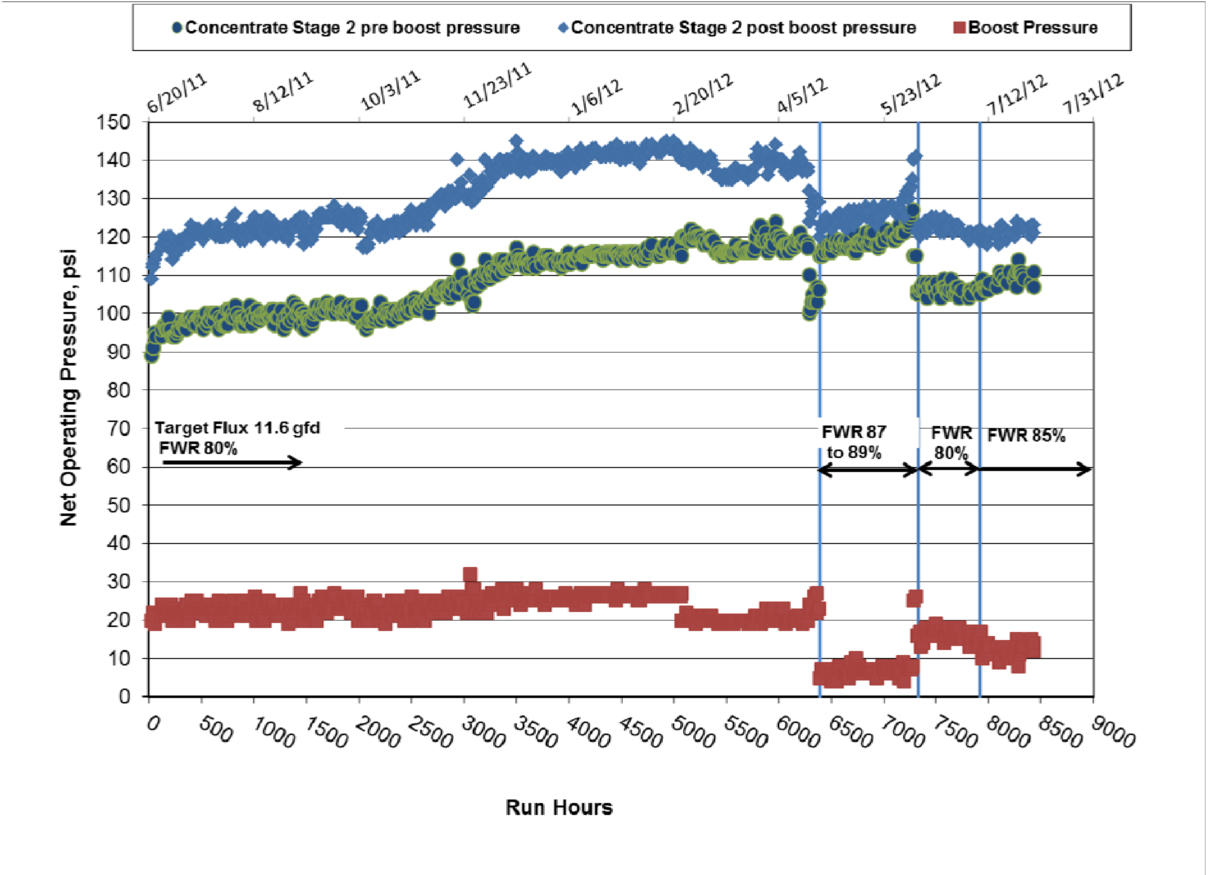


Figure 10 Energy Recovery Performance of the Toray TML RO Membrane System

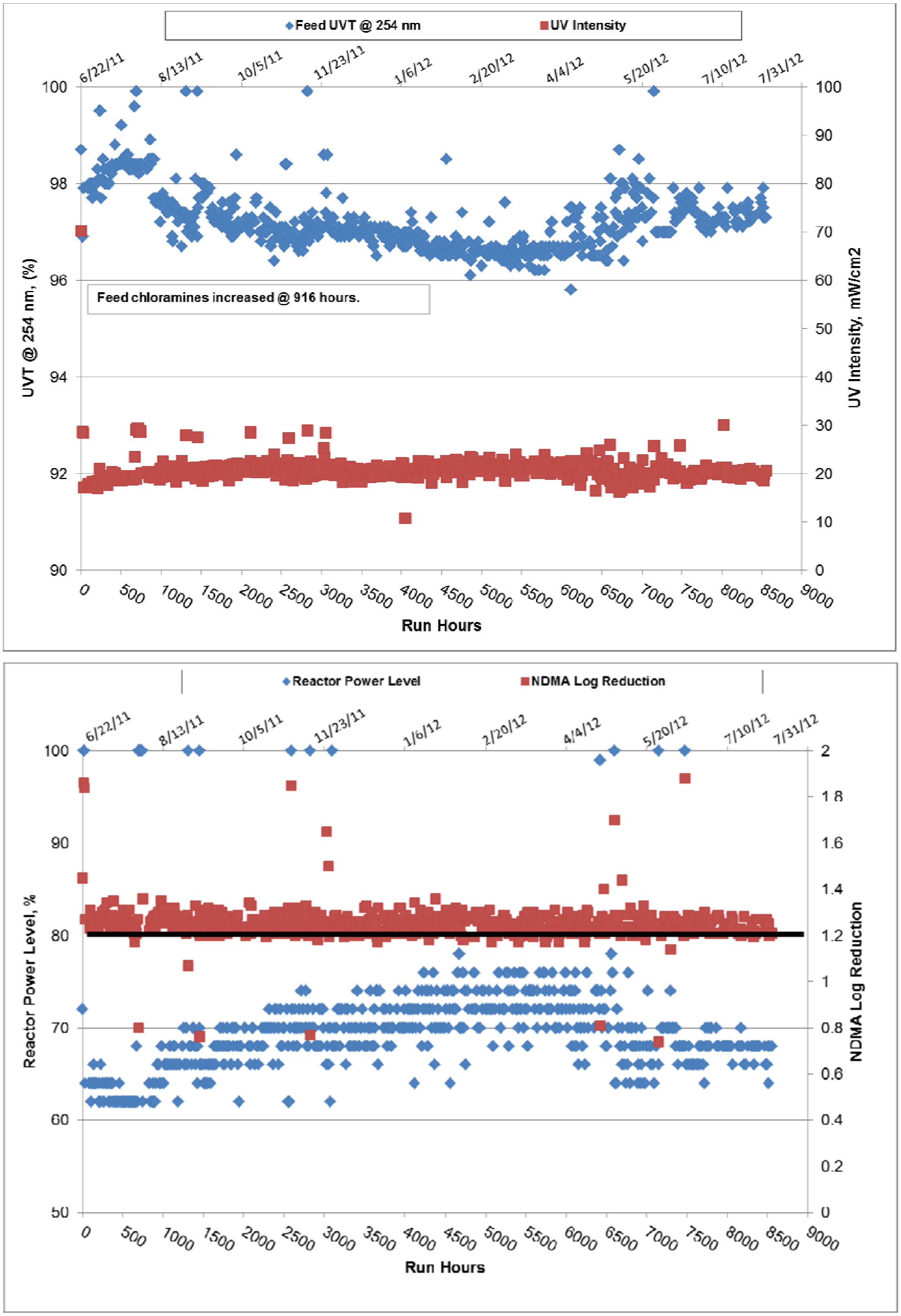


Figure 11 Trojan UV/AOP Operating Data

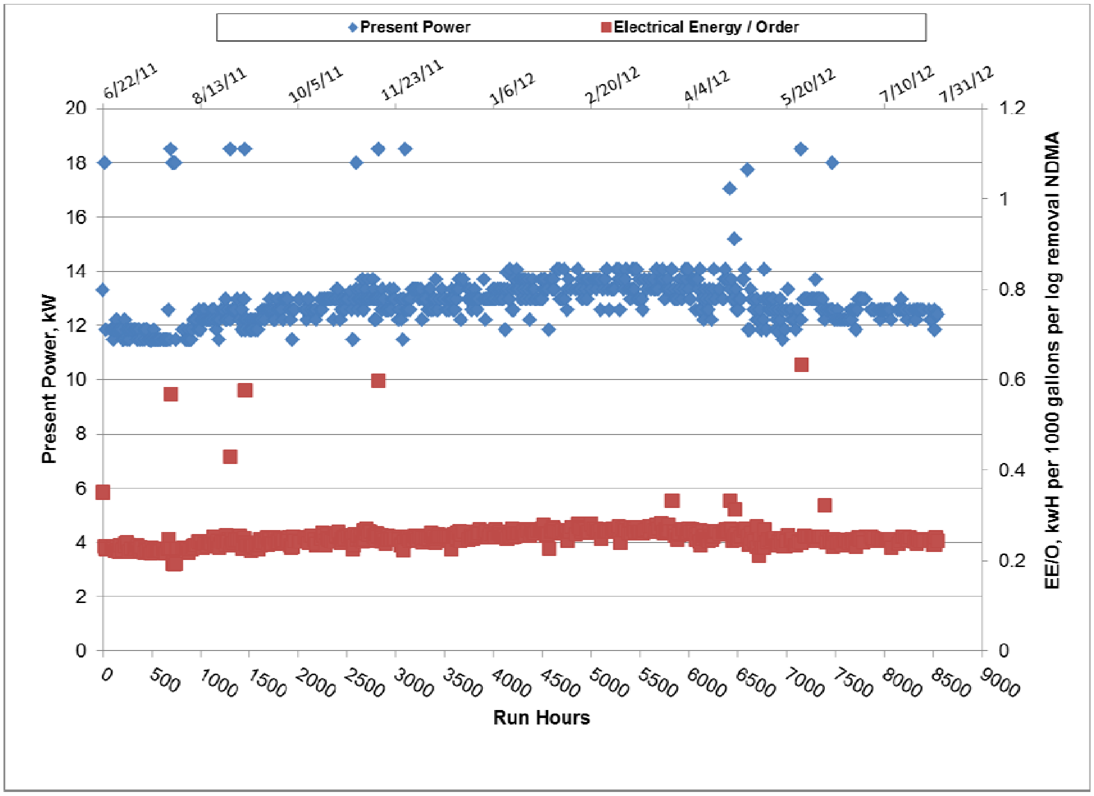


Figure 12 UV/AOP Electrical Energy per Order based on Trojan Algorithm

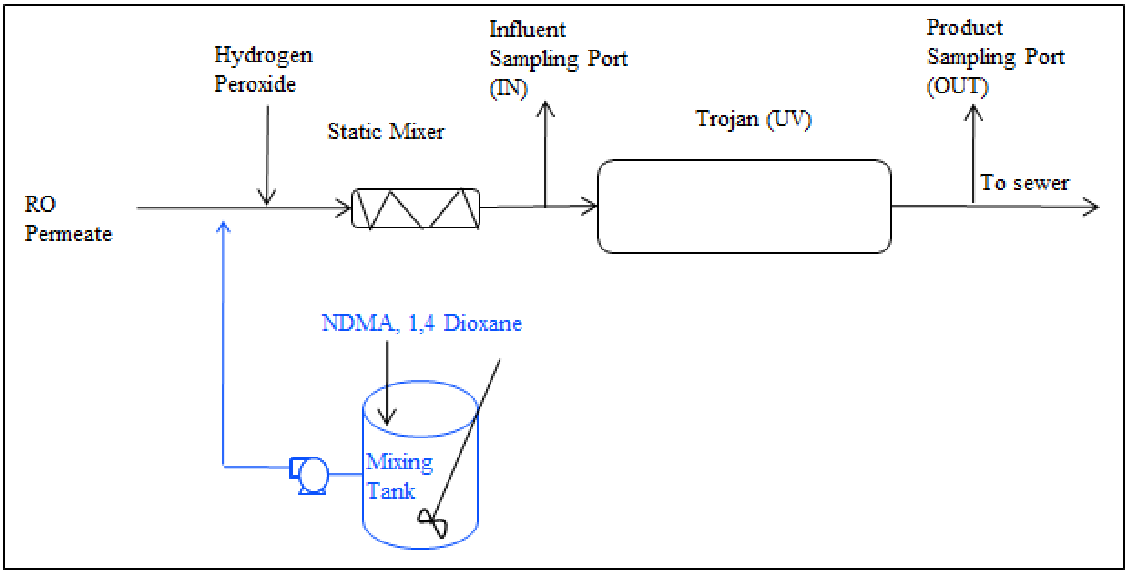
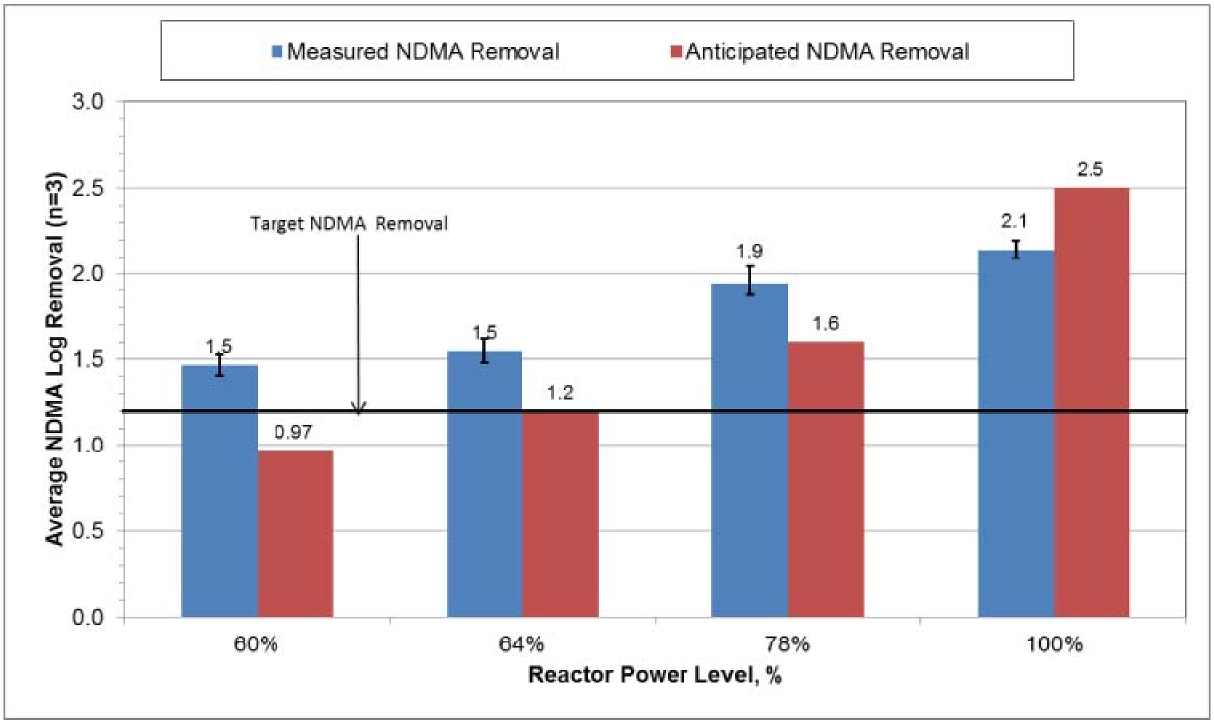
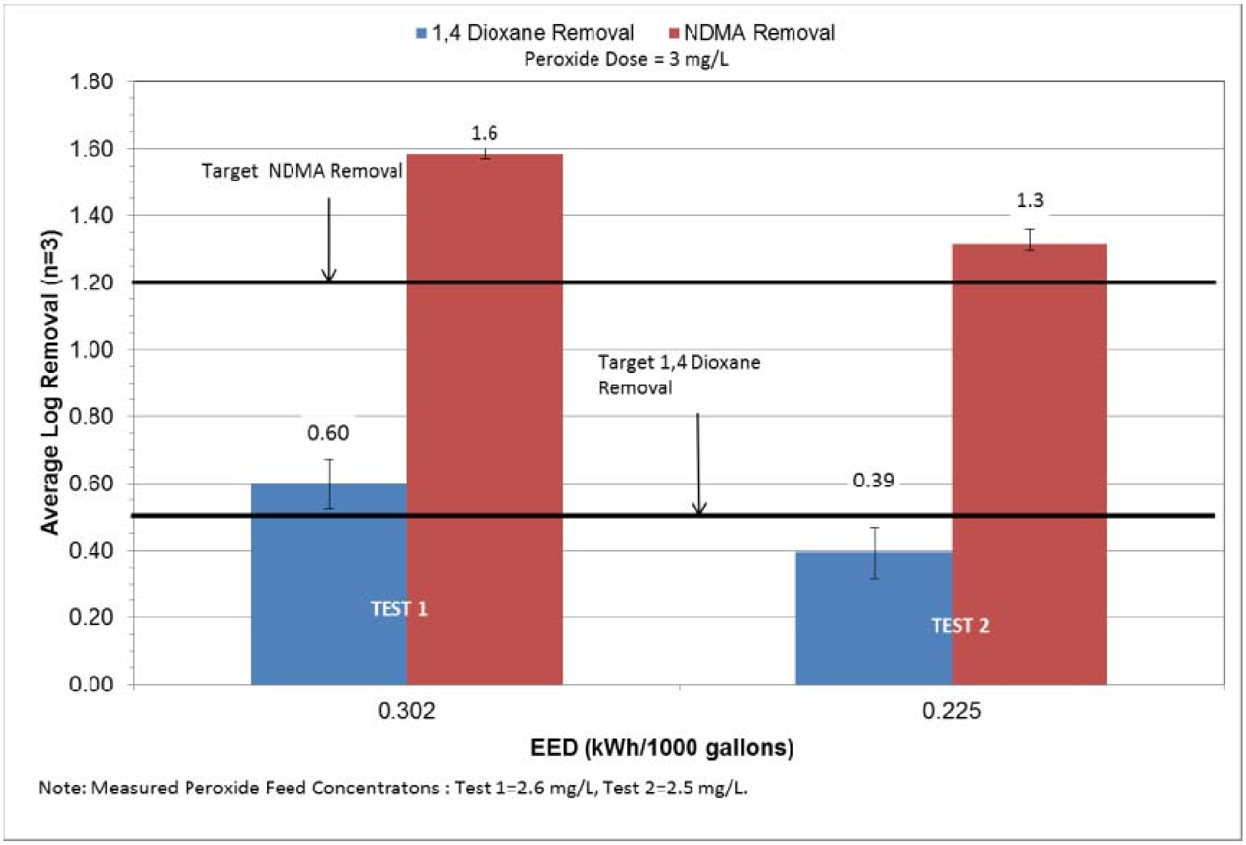


Figure 13 Spiking Experiment Set Up



Note: Log removal values were calculated as (-LOG_{10}(OUT/IN)) based on concentrations of IN and OUT samples provided in Table 7.

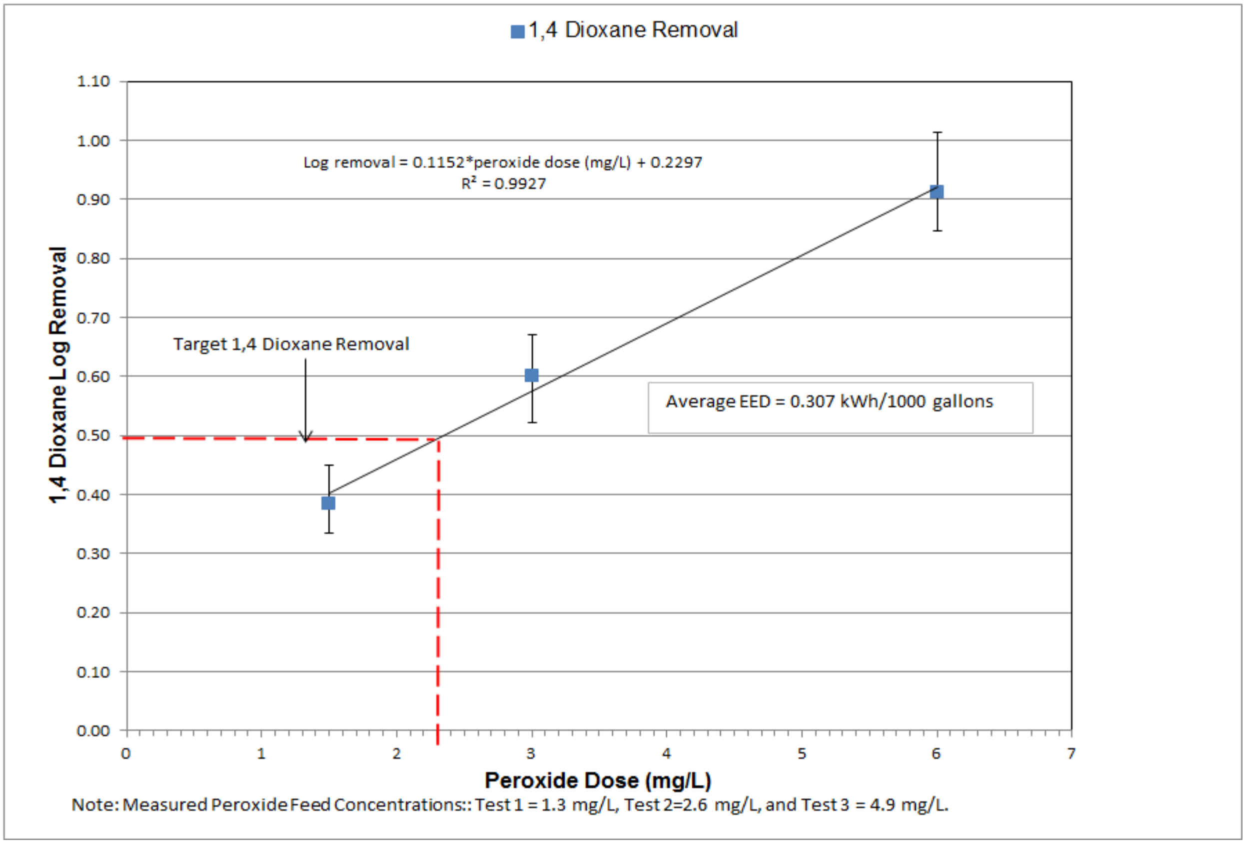
Figure 14 Trojan UV/AOP NDMA Spiking Experiment No. 1Results



Note: Measured Peroxide Feed Concentratons : Test 1=2.6 mg/L, Test 2=2.5 mg/L.

Note: Log removal values were calculated as (-LOG_{10}(OUT/IN)) based on concentrations of IN and OUT samples provided in Table 10.

Figure 15 Trojan UV/AOP 1,4 Dioxane Spiking Experiment No. 2Results



Note: Measured Peroxide Feed Concentrations:: Test 1 = 1.3 mg/L, Test 2=2.6 mg/L, and Test 3 = 4.9 mg/L.

Figure 16 Trojan UV/AOP 1,4 Dioxane Spiking Experiment 2 LRV vs. Target Peroxide Dose

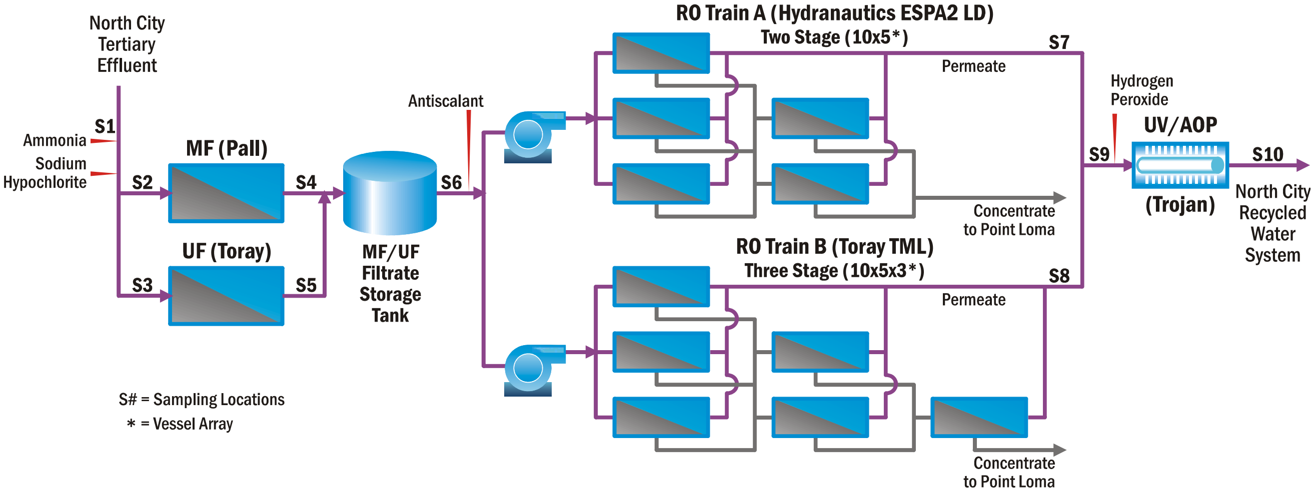


Figure 17 AWP Facility Process Schematic (S# indicates sampling location)

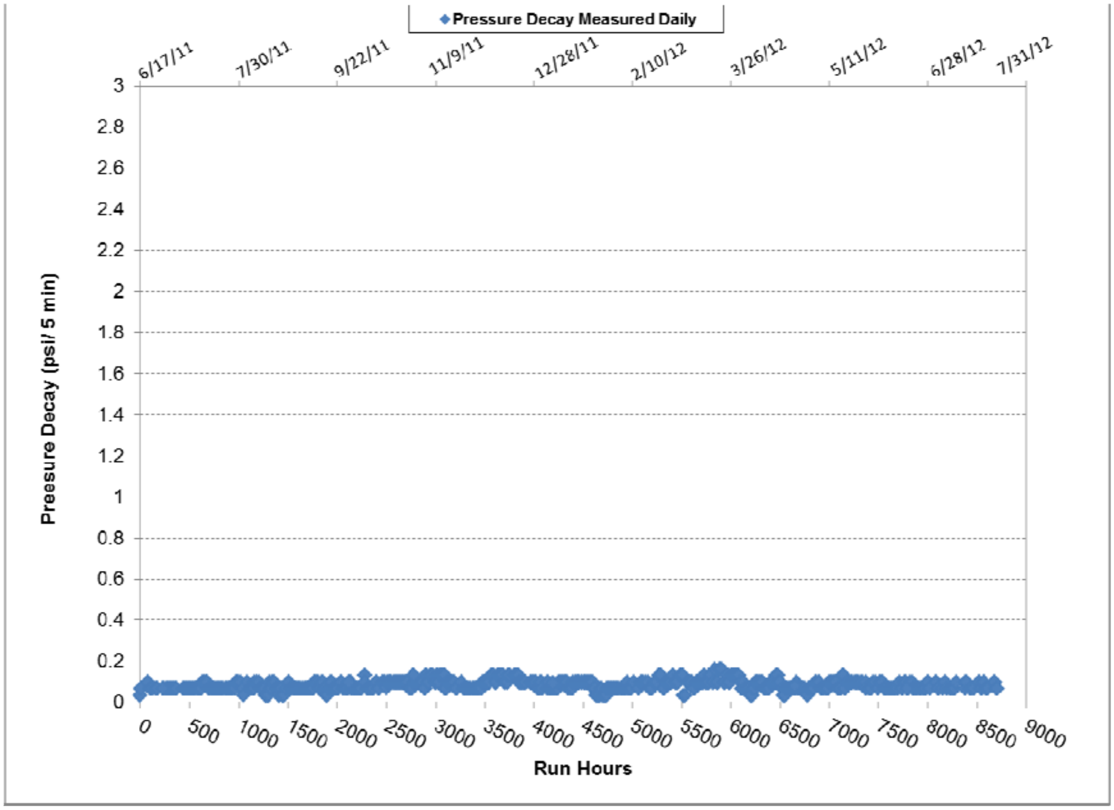


Figure 18 Pressure Decay Test (PDT) Values of the Pall Microfiltration System

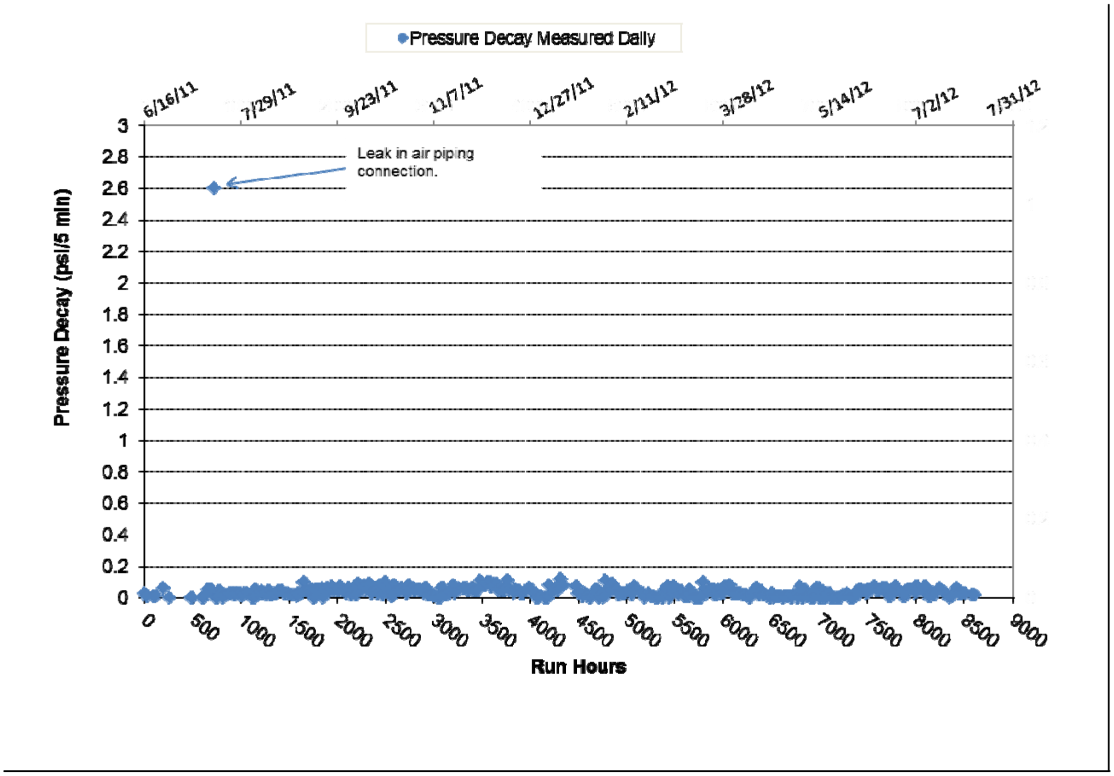


Figure 19 Pressure Decay Test (PDT) Values of the Toray Ultrafiltration System

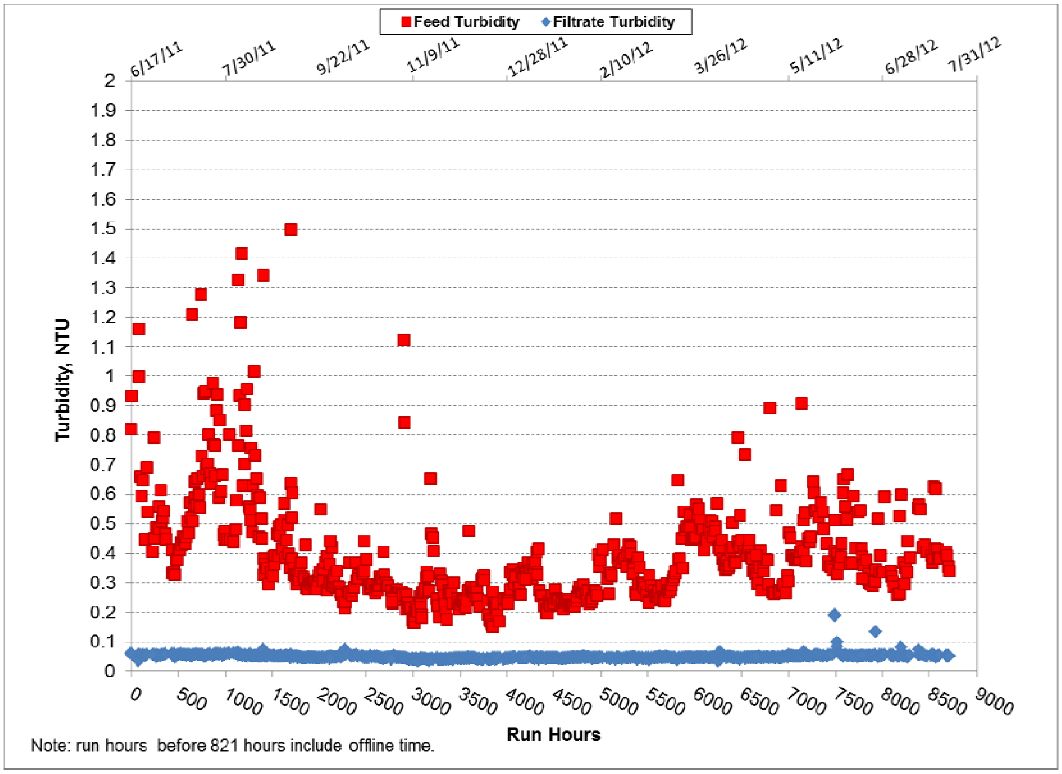


Figure 20 Turbidity Profile of the Pall Microfiltration System

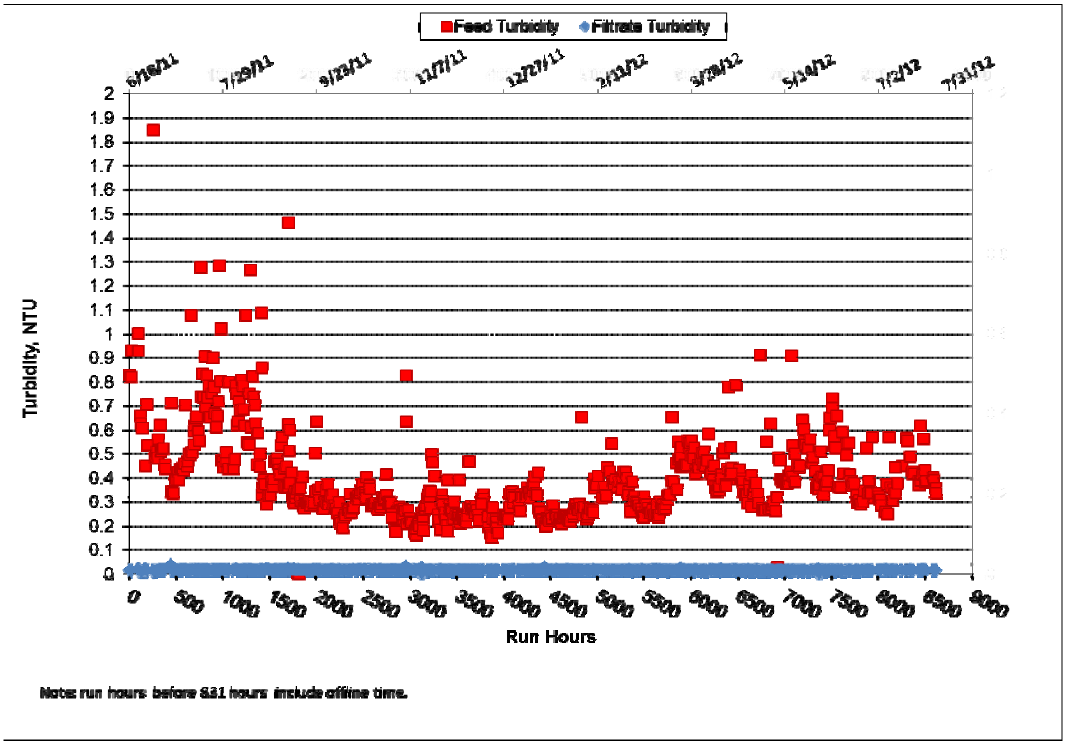


Figure 21 Turbidity Profile of the Toray Ultrafiltration System

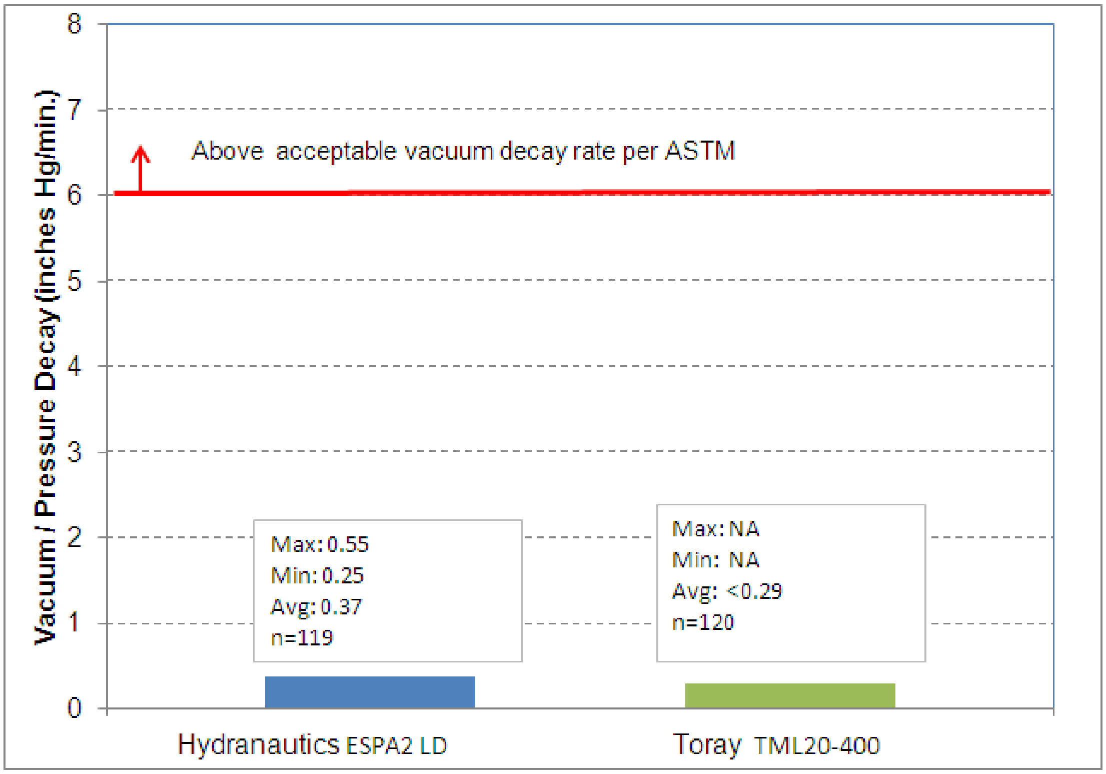


Figure 22 Pre-delivery RO Element Pressure / Vacuum Decay Test Results

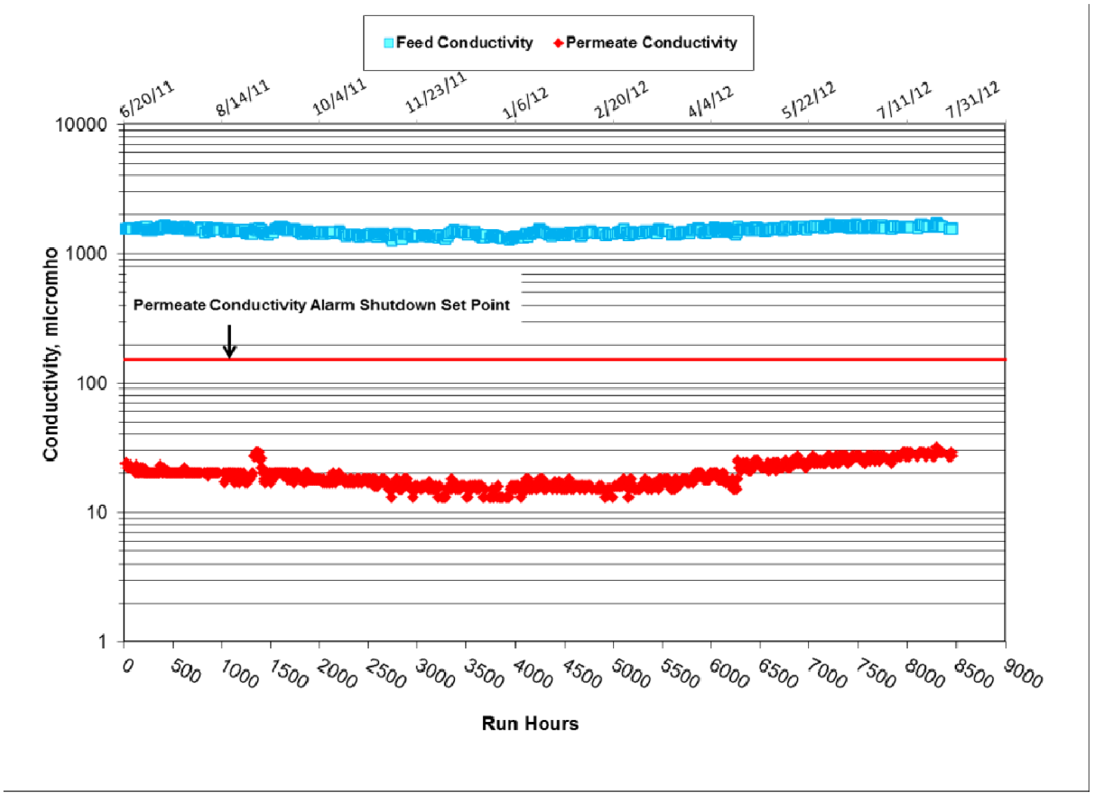


Figure 23 Conductivity Profile of the Hydranautics ESPA2 LD RO Membrane System

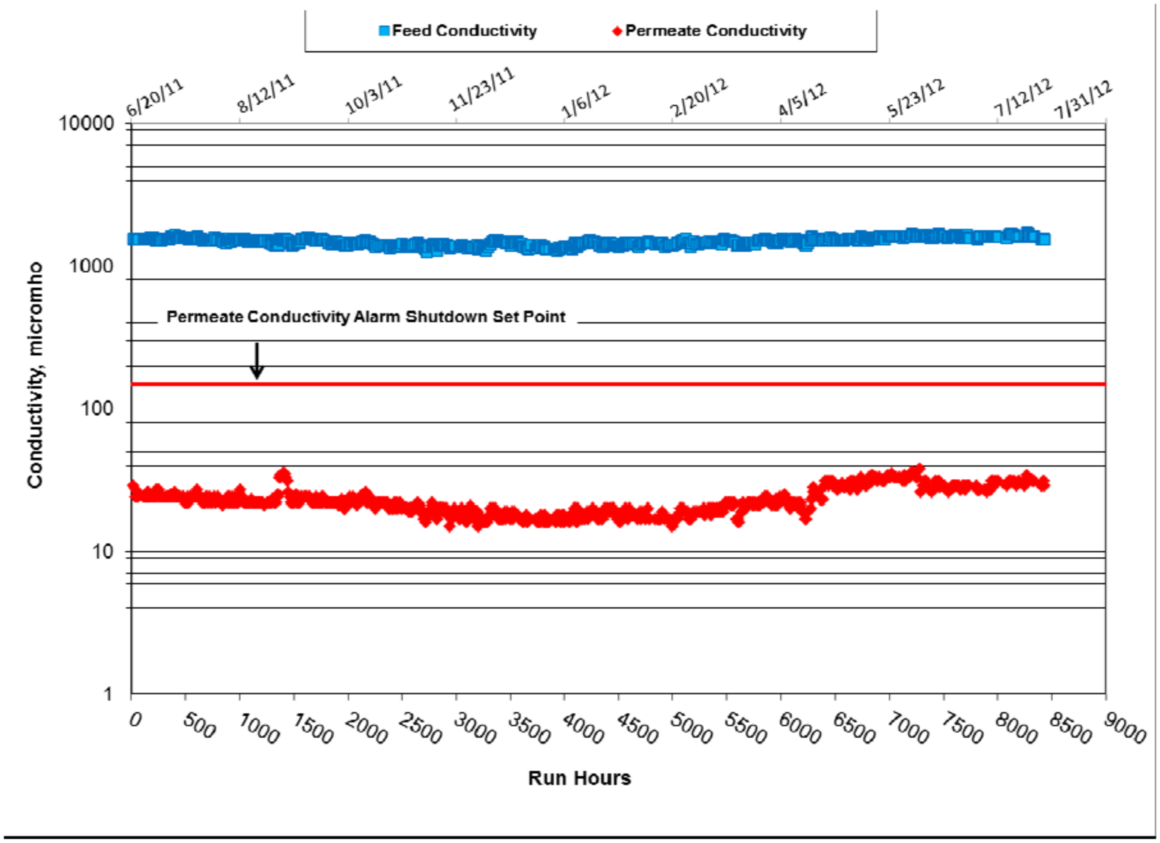


Figure 24 Conductivity Profile of the Toray TML RO Membrane System

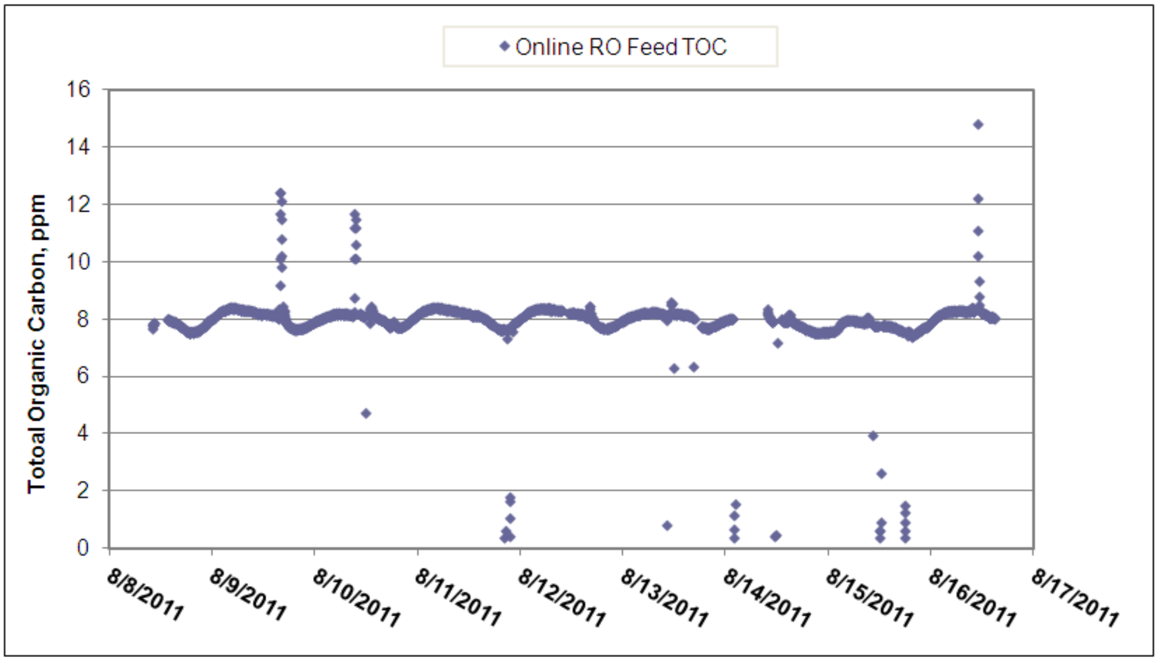


Figure 25 Online TOC Monitoring Results of RO Feed during Q1 Testing Period

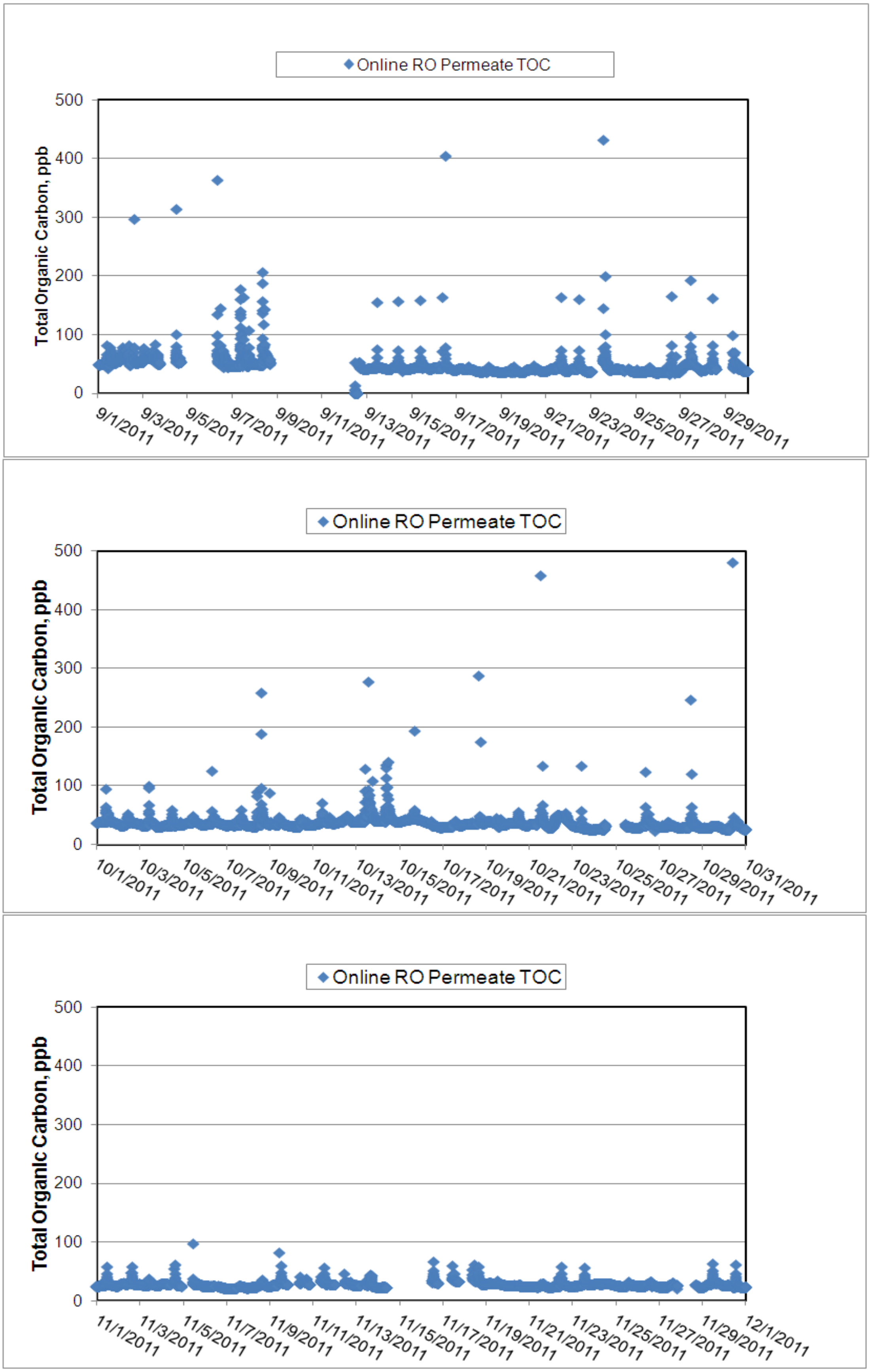
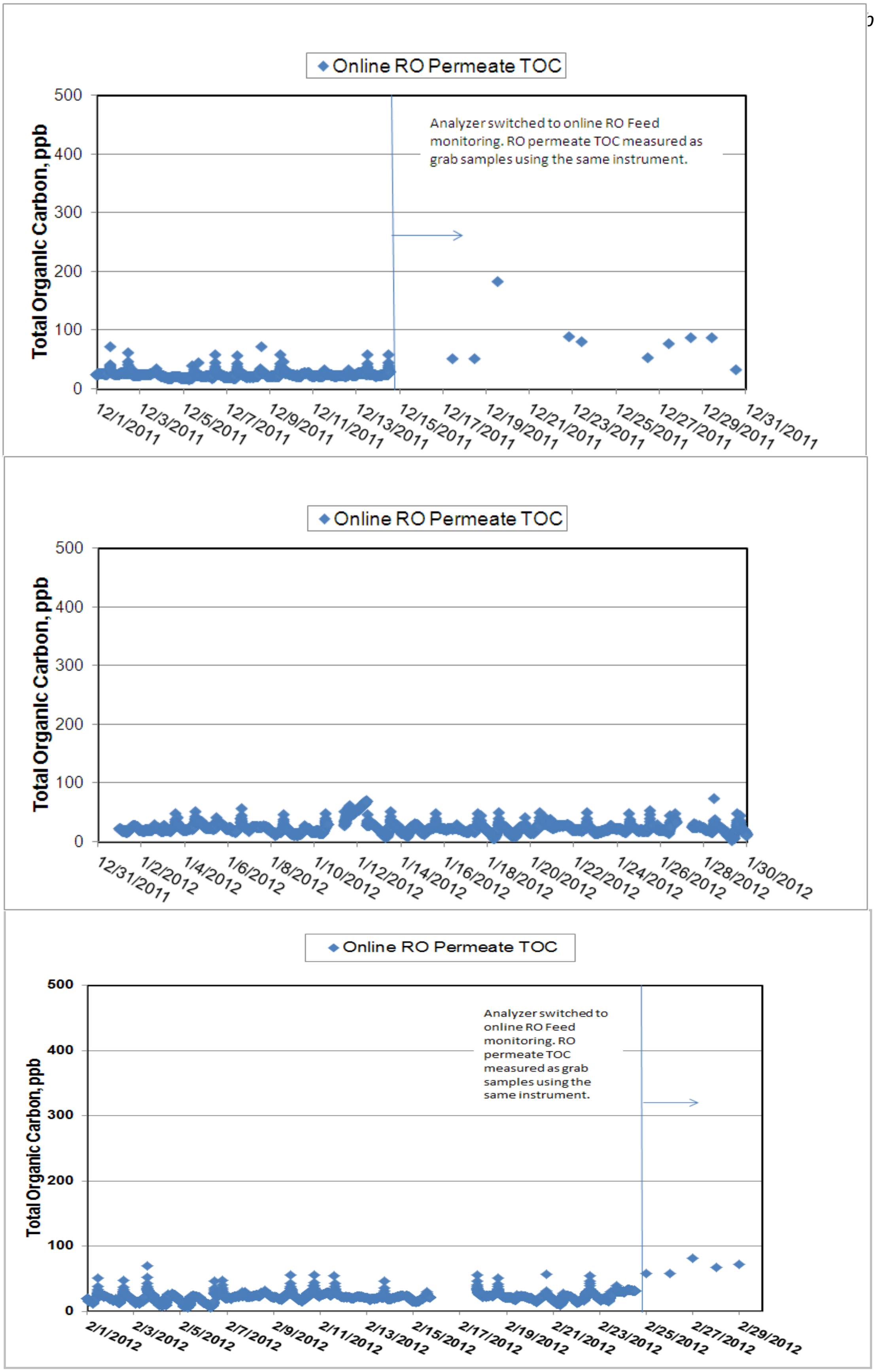


Figure 26 Online TOC Monitoring Results of RO Permeate



Analyzer switched to online RO Feed monitoring. RO permeate TOC measured as grab samples using the same instrument.

Analyzer switched to online RO Feed monitoring. RO permeate TOC measured as grab samples using the same instrument.

Figure 26 Online TOC Monitoring Results of RO Permeate (Cont.)

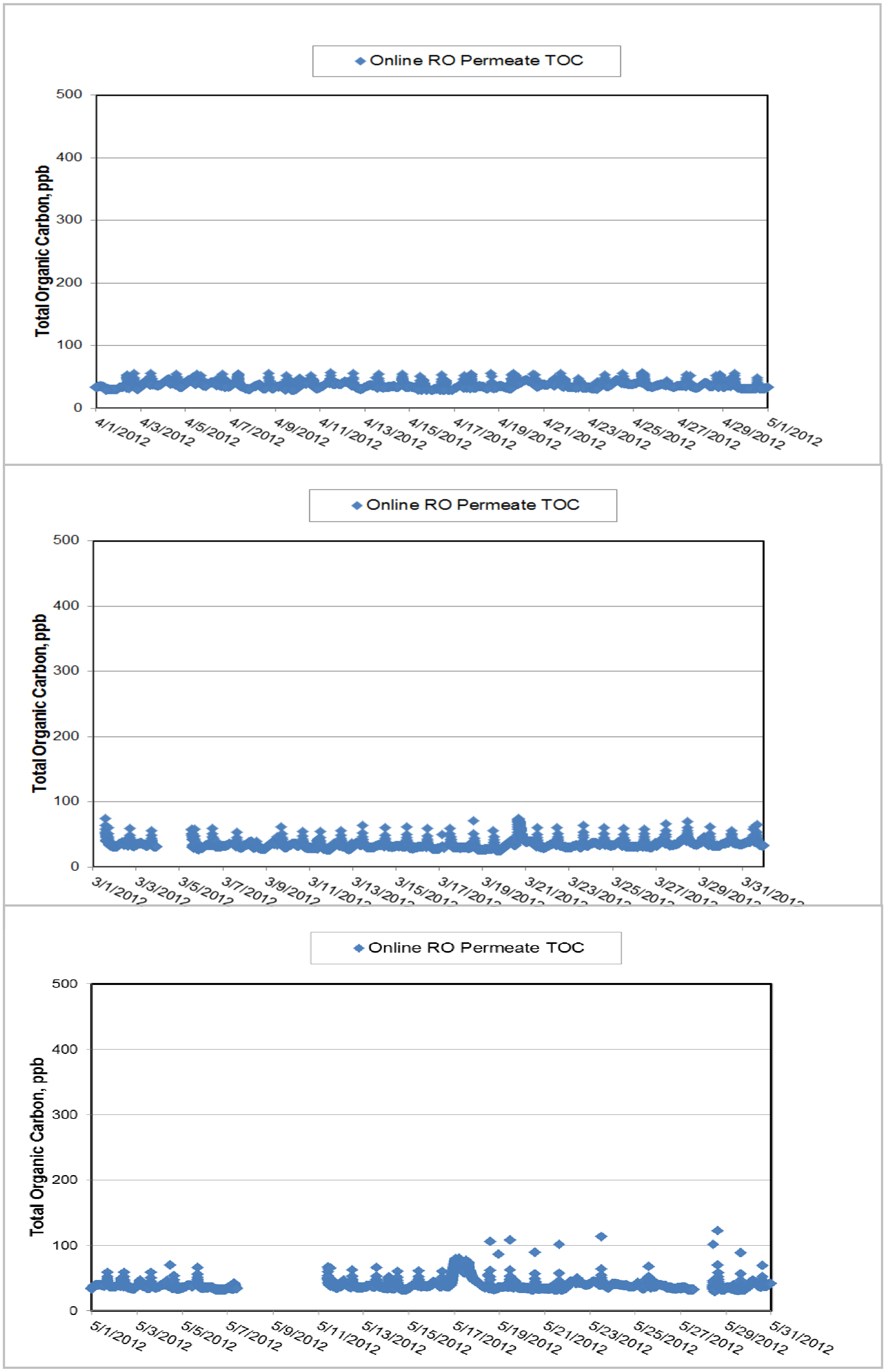
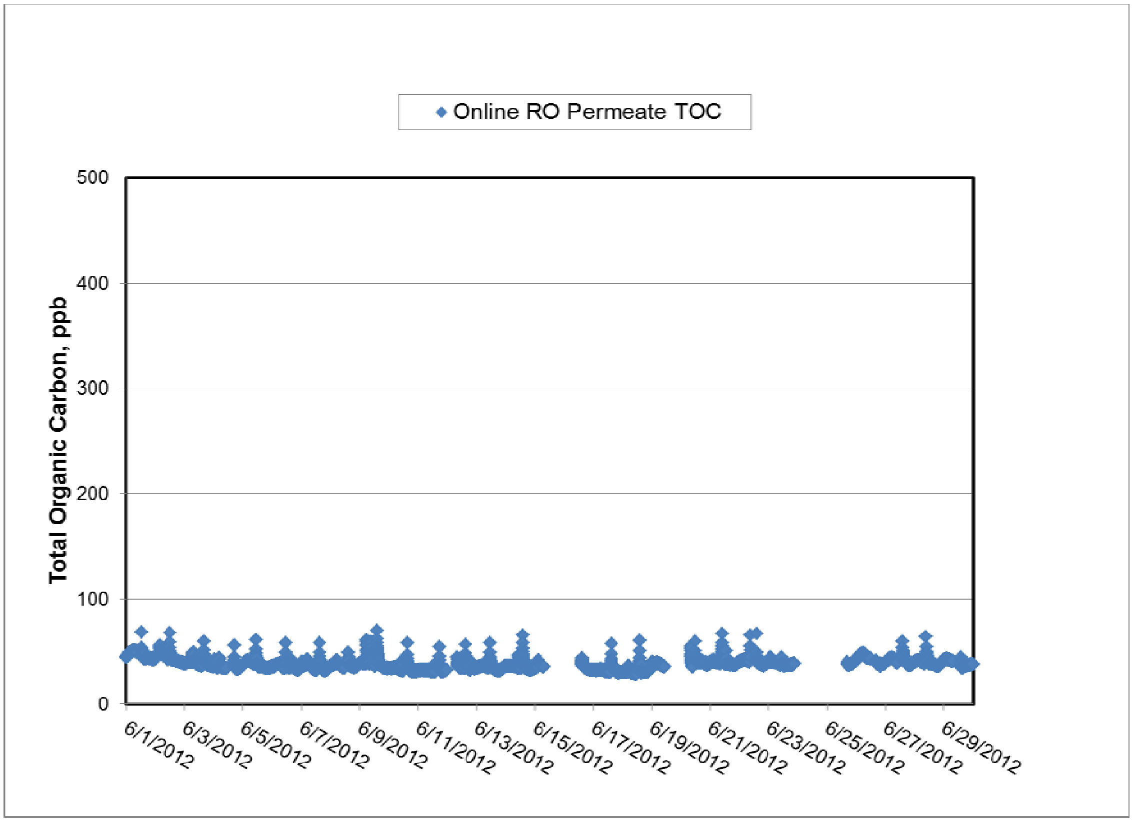


Figure 26 Online TOC Monitoring Results of RO Permeate (Cont.)



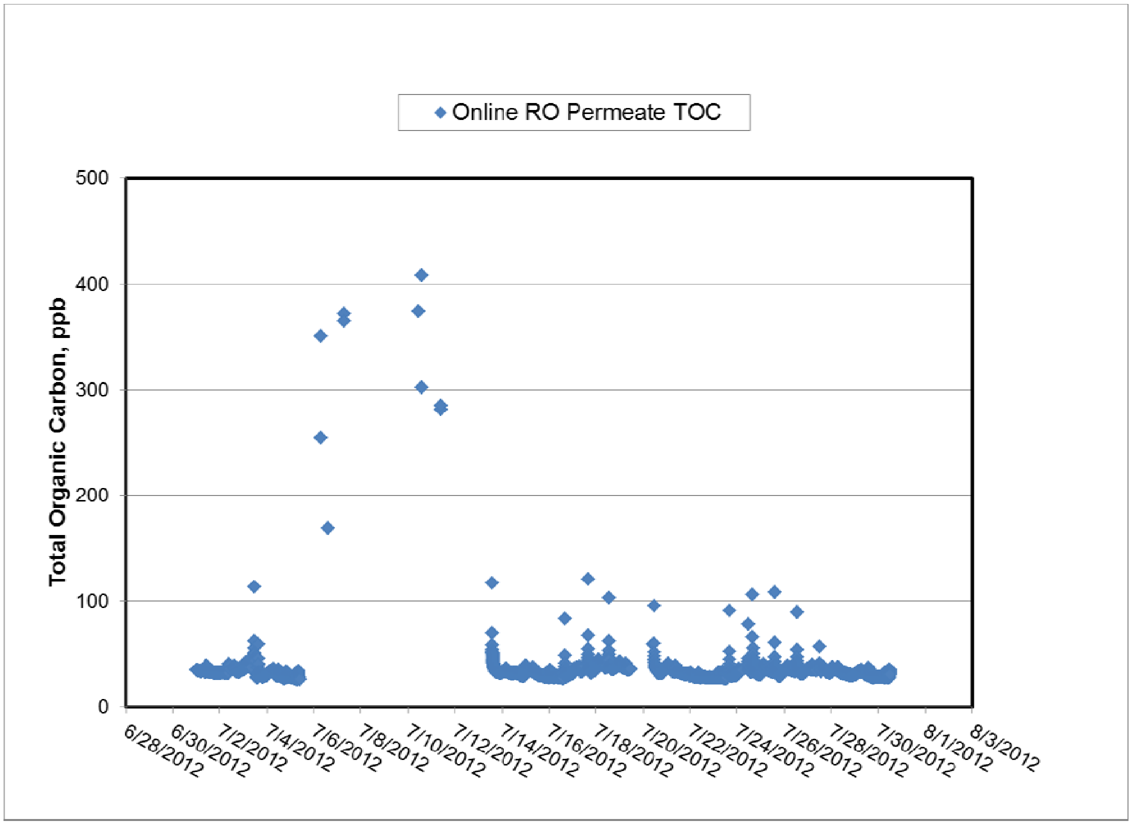


Figure 26 Online TOC Monitoring Results of RO Permeate (Cont.)

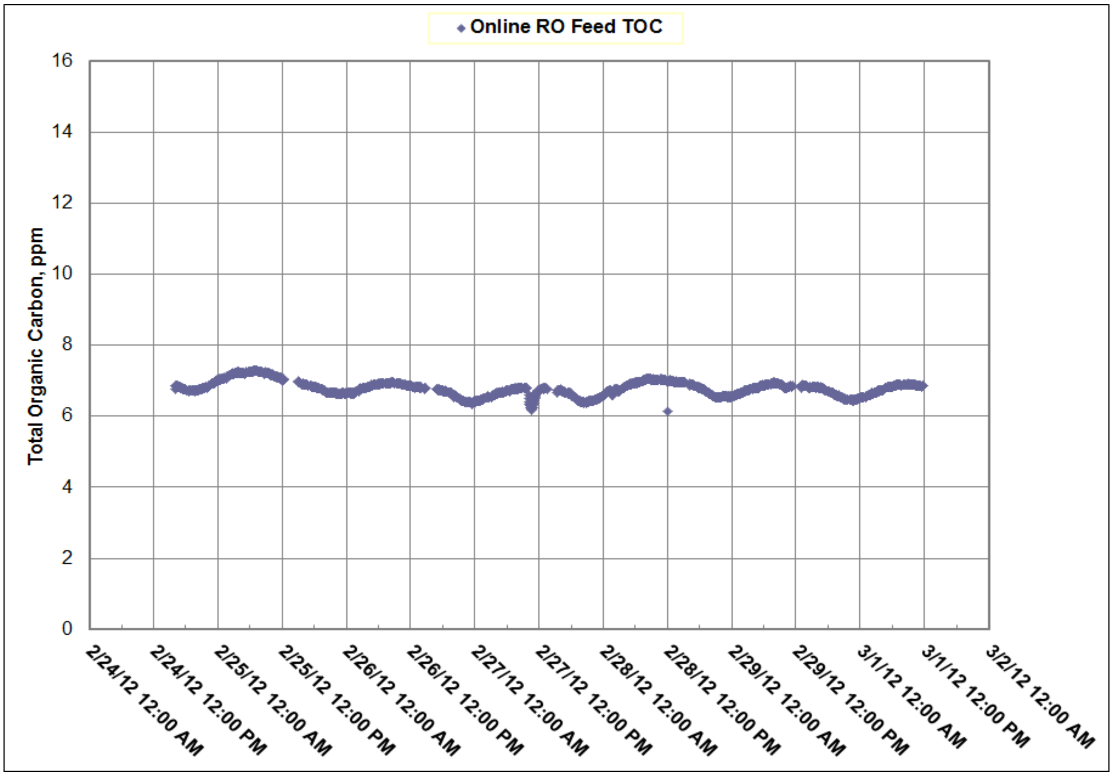


Figure 27 Online TOC Monitoring Results of RO Feed during Q3 Testing Period

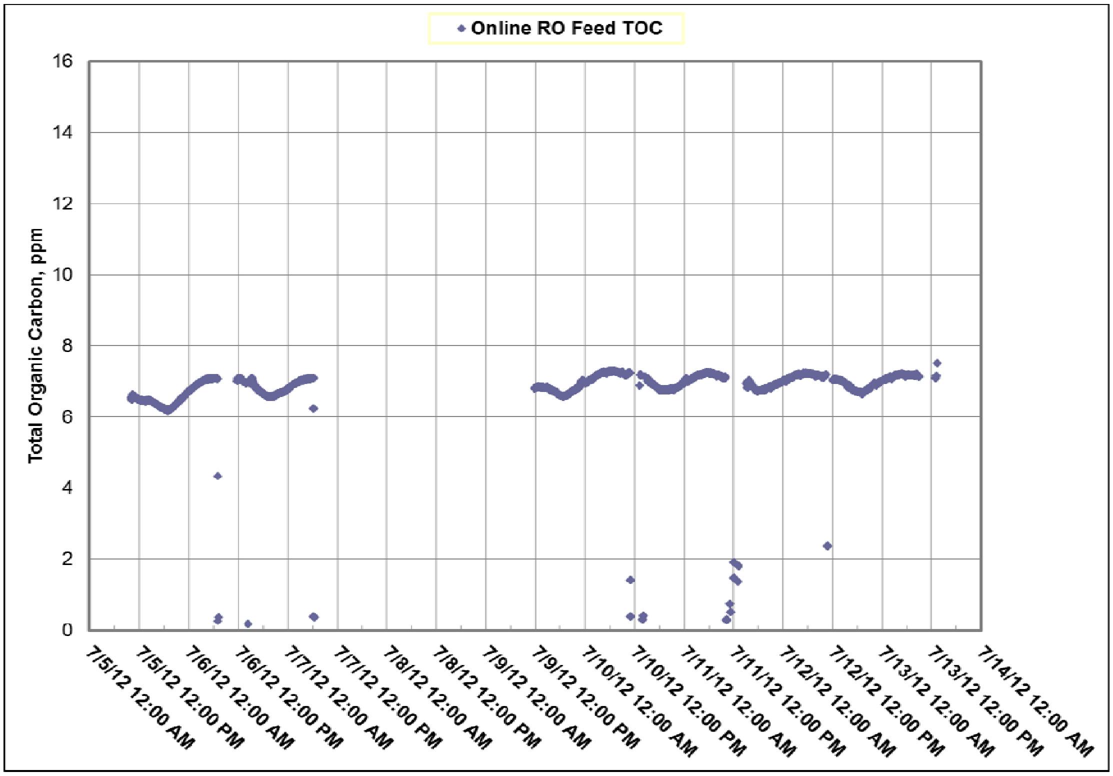


Figure 28 Online TOC Monitoring Results of RO Feed during Q4 Testing Period

Appendix A

Final Report: Toxicity Testing Results for the City of San Diego Water Purification Demonstration Project.

Nautilus Environmental

Toxicity Testing Results for the City of San Diego Water Purification Demonstration Project – Advanced Water Purification Facility (AWPF)

Monitoring Period: November 2011

Prepared for: MWH Americas, Inc.
9444 Farnham Street, Ste. 300
San Diego, CA 92117

Test Laboratory: Nautilus Environmental
4340 Vandever Avenue
San Diego, CA 92120

Submitted: December 16, 2011

Data Quality Assurance:

- **Nautilus Environmental is a state certified laboratory under the California Department of Health Services – Environmental Laboratory Accreditation Program (ELAP), Certificate No. 1802.**
- **All test results included in this report have met internal Quality Assurance requirements, as well as all minimum acceptability criteria required by the EPA protocols. Any deviations have been noted in the report.**
- **All data have been reviewed and verified.**

Results Verified By: Steve Carlson **Date:** 12-16-11

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4340 Vandever Ave.
San Diego, CA 92120
858-587-7333
fax: 858-587-3961

British Columbia
8664 Commerce Court
Burnaby, British Columbia
V5A 4N7
604-603-9381
fax: 604-603-9381

nautilusenvironmental.com

Sample Information

Client:	MWH Americas, Inc.
Project Name:	City of San Diego Water Purification Demonstration Project – Advanced Water Purification Facility (AWPF)
Sample Collection Dates:	11/14/11, 07:20; 11/16/11, 08:50; and 11/18/11, 07:19
Sample Receipt Dates:	11/14/11, 10:55; 11/16/11, 09:25; and 11/18/11, 09:00
Sample/Test Material:	UV/advanced oxidized product (UV/AOP) water
Aqueduct/Dilution Water:	Grab sample from Lake Murray water
Sample Mixture:	The UV/AOP water was mixed with the aqueduct water to achieve a hardness of 50 mg/L. This mixture ended up being a ratio of 67% UV/AOP and 33% Aqueduct. This mixture represented the 100% sample tested.
Sample Treatment:	Prior to testing, the pH of the sample mixture was raised to approximately 8.5 by adding Sodium Hydroxide (NaOH). Then, Sodium Thiosulfate (STS) was added to remove any residual chlorine or peroxide.
Sample Receipt WQ Parameters:	Summarized in Table 1 (see Appendix C for details).
Mixture/Treatment Process:	Summarized in Table 2 (see Appendix C for details).

Table 1. Water Quality Parameters Measured upon Sample Receipt

WQ Parameters	Lake Murray Aqueduct	Sample A (11/14/11)	Sample B (11/16/11)	Sample C (11/18/11)
Nautilus Log No.	11-0952	11-0951	11-0960	11-0976
Receipt Temperature (°C)	13.8	13.5	20.6	15.6
Dissolved Oxygen (mg/L)	9.3	9.8	6.5	8.9
pH	8.00	5.68	5.61	5.27
Conductivity (µS/cm)	684	19	20	23
Alkalinity (mg/L $CaCO_3$)	95	<1	3	3
Hardness (mg/L $CaCO_3$)	170	<1	1	7
Total Chlorine (mg/L)*	0.06	0.57	0.70	0.53

* Total chlorine was measured with a HACH colorimetric meter. Therefore, readings could have picked up peroxide or other interferences, in addition to true chlorine measurements. Information provided by the client suggests that each of the A, B, and C samples contained approximately 3.0 mg/L peroxide.

Table 2. Mixture and Sample Treatment WQ Measurements

Mixing & WQ Parameters	**Sample A (10/31/11)**	**Sample B (11/2/11)**	**Sample C (11/4/11)**
Mixture Percentage of Aqueduct Water	33%	33%	33%
Mixture Percentage of UV/AOP Water	67%	67%	67%
Final Hardness of Mixture (mg/L)	51	52	53
Initial pH of Mixture	7.07	7.04	7.12
Final pH (after adjusting with NaOH)	8.48	8.40	8.47
Dissolved Oxygen (mg/L)	8.9	9.0	8.7
Conductivity (µS/cm)	302	294	283
Alkalinity (mg/L)	39	38	43
Total Dissolved Solids (mg/L)	145	141	131
Initial Free Chlorine (mg/L)	0.18	0.04	0.14
Final Free Chlorine (after treating with STS)*	0.02	0.02	0.03

* The STS added to the sample should have removed any residual chlorine or peroxide.

All Test Procedures

Test Concentrations:	Sample Water, Lab Control, and Reference Control
Sample Water:	Final mixture of UV/AOP water (67%) + Aqueduct water (33%)
Lab Control Water:	EPA moderately hard mineral water (20% diluted)
Reference Control Water:	Deionized water (67%) mixed with Aqueduct water (33%)
Protocols Used:	EPA/821/R-02/013 (2002) Chronic Manual EPA/821/R-02/012 (2002) Acute Manual
Statistical Analysis Software:	CETIS, version 1.8.0.12

Chronic Water Flea Test Specifications

Test Start Date, Time:	11/15/11, 15:25
Test End Date, Time:	11/22/11, 14:45
Test Organism:	*Ceriodaphnia dubia* (water flea)
Test Organism Source; Age:	In-house culture; < 24 hr
Test Acceptability Criteria:	Mean control survival ≥ 80%; mean number of offspring ≥ 15 per surviving adult female; and 60% or more of the surviving control females must produce three broods.

Chronic Larval Fish Test Specifications

Test Start Date, Time:	11/15/11, 15:25
Test End Date, Time:	11/22/11, 15:15
Test Organism:	*Pimephales promelas* (fathead minnow)
Test Organism Source; Age:	Aquatic Biosystems (Fort Collins, CO); 1 day
Test Acceptability Criteria:	Mean control survival ≥ 80% Mean control biomass ≥ 0.25 mg

Chronic Green Algae Test Specifications

Test Start Date, Time:	11/17/11, 16:35
Test End Date, Time:	11/21/11, 14:50
Test Organism:	*Selenastrum capricornutum* (green algae)
Test Organism Source; Age:	In-house Culture; 7 days old
Nutrient Addition:	A macro- and micronutrient solution was added to all sample concentrations to ensure any observed decreases in algal growth was due to toxic constituents present in the sample rather than a nutrient deficiency.
Sample Filtering:	The sample was 0.45- µm filtered prior to testing, per protocol. This is done to remove any native algae that might compete for lighting and nutrients. The unfiltered sample is also tested concurrently for comparison purposes.
Test Acceptability Criteria:	Mean control density of ≥ 1 x 10^6 cells/ml, and ≤ 20% variability among control replicates (CV)

Acute Water Flea Test Specifications

Test Start Date, Time:	11/15/11, 15:20
Test End Date, Time:	11/19/11, 13:45
Test Organism:	*Ceriodaphnia dubia* (water flea)
Test Organism Source; Age:	In-house culture; < 24 hr
Test Acceptability Criteria:	Mean control survival ≥ 90%

Acute Larval Fish Test Specifications

Test Start Date, Time:	11/15/11, 15:20
Test End Date, Time:	11/19/11, 14:00
Test Organism:	*Pimephales promelas* (fathead minnow)
Test Organism Source; Age:	Aquatic Biosystems (Fort Collins, CO); 10 days old
Test Acceptability Criteria:	Mean control survival ≥ 90%

Results

A summary of the statistical results are presented in Table 3, while the test data are summarized in Tables 4 and 5. In general, there was no toxicity observed in the sample with any of the acute or chronic tests performed. However, there was a statistically significant 7% decrease in the chronic fathead minnow growth endpoint, when compared to the lab control. This was not deemed as biologically relevant since it was outside the acceptable range of sensitivity (see QA section). Moreover, there was no significant difference in growth compared to the reference control (DI and Aqueduct water). Thus, there is no evidence that the sample was associated with any adverse effects.

Interestingly, the only significant effect observed during this round of testing was between the reference control and the lab control with the chronic water flea reproduction endpoint. There was a 33% decrease in reproduction found in the reference control when compared to the lab control. It is not clear whether this decrease is the result of an interaction between the deionized water and the aqueduct water, a contamination issue with the deionized water or the dilution cup used in preparing this concentration, or an intrinsic response to the aqueduct water itself. However, no adverse effects were observed with the actual sample (i.e. mixture of UV/AOP and Aqueduct water) being tested. Thus, the no observed effect concentration (NOEC) is reported as 100% sample for all acute and chronic tests performed. Raw data and statistical analyses for the chronic toxicity tests are presented in Appendix A, and the acute toxicity tests are presented in Appendix B. Sample receipt information and chain-of-custody forms can be found in Appendices C and D, respectively.

Table 3. Summary of Statistical Results for the UV/AOP Sample

Species & Endpoint	NOEC (% effluent)	LOEC (% effluent)	Toxic Units
Water Flea:			
96-hr Acute Survival	100	>100	0.41
Chronic Survival	100	>100	1.0
Chronic Reproduction	100	>100	1.0
Fathead minnow:			
96-hr Acute Survival	100	>100	0.0
Chronic Survival	100	>100	1.0
Chronic Growth (biomass)	100	>100	1.0
Green algae:			
Chronic Growth (cell density)	100	>100	1.0

NOEC = the highest Concentration tested that results in No Observed Effect
LOEC = the Lowest Observed Effect Concentration (the next concentration higher than the NOEC)
Acute Toxic Units (TU_a) = Log (100 - %survival) ÷ 1.7
Chronic Toxic Units (TU_c) = 100 ÷ NOEC

Table 4. Summary of Chronic Toxicity Test Results

Test Concentration (%)	Fathead Minnow		Water flea		Green algae
	Chronic Survival (%)	Chronic Biomass (mg)	Chronic Survival (%)	Mean No. of Offspring	Chronic Cell Density (10^6 cells/ml)
Lab Control	95.0	0.307	100	27.3	3.26
Reference	97.5	0.287 *	90	18.4 *	3.32
Sample	92.5	0.285 *	100	26.7	3.23 [a]

* An asterisk indicates a statistically significant difference compared to the lab control (see QA section)
[a] The results for the filtered sample is reported above. The cell density in the unfiltered sample was 3.26 x 10^6 cells/ml.

Table 5. Summary of Acute Toxicity Test Results

Test Concentration (%)	Fathead Minnow	Water flea
	Chronic Survival (%)	Chronic Survival (%)
Lab Control	95	100
Reference	100	100
Sample	100	95

Quality Assurance/Quality Control

All samples were received the same day as collected, and were immediately placed in cold storage until used in testing. All tests were initiated within the required 36-hour holding time. There were no deviations to the test protocol procedures, and the lab control for each test performed met the minimum acceptability criteria. Therefore, all test results were deemed valid for reporting purposes.

The chronic fathead minnow test had some unusual statistical results. The survival and mean growth data met test acceptability criteria. However, the percent minimum significant difference (PMSD) value was only 5.0%, which is below the test acceptability criteria. Due to low replicate variability, the power to detect a statistical difference for this test was greater than typical. The PMSD value, which is a measure of test sensitivity, was less than the lower 10th percentile value determined by EPA for the fathead minnow test during a nationwide inter-laboratory variability study (EPA 2000 and 2002). This lower bound is used as guidance to appropriately address small differences not likely to be biologically meaningful when statistical power is greater than typical. If the PMSD for a test is below the lower limit, and the difference in biological response in a sample concentration relative to that in the control is less than the PMSD lower bound, then this difference is not considered statistically significant. The difference between fathead growth in the lab control and UV/AOP sample was only 7.0%, which is below the lower PMSD bound of 12%. Thus, this difference is not considered statistically significant according to EPA (2002), and this is deemed a false-positive test result. Therefore, this test result is being reported as no observed effect in the sample (NOEC = 100%).

A similar result occurred in the chronic *Selenastrum* algae test. The PMSD value for the test was only 5.0%, and the acceptable range is between 9.1% and 29%. Thus, we had very tight data again with the *Selenastrum* test. However, with this set of data there was less than a 3.0% difference between the sample and the lab control, and it did not result in being statistically significant. Therefore, the PMSD value does not apply in this case.

References

USEPA. 2000. Understanding and Accounting for Method Variability in Whole Effluent Toxicity Applications Under the National Pollutant Discharge Elimination System. United States Environmental Protection Agency Office of Wastewater Management (EPA-833-R-00-003).

USEPA. 2002. Methods for Measuring the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. Pages 51-52, section 10.2.8.2.5. Fourth Edition. United States Environmental Protection Agency Office of Water, Washington DC (EPA-821-R-02-013).

Appendix A

Chronic Test Data & Statistical Analyses

Chronic Water Flea

CETIS Summary Report

Report Date:	02 Dec-11 14:00 (p 1 of 1)
Test Code:	1111-S169 | 05-3100-9565

Ceriodaphnia 7-d Survival and Reproduction Test **Nautilus Environmental (CA)**

Batch ID:	01-5082-4520	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	
Start Date:	15 Nov-11 15:25	**Protocol:**	EPA/821/R-02-013 (2002)	Control: ~~**Diluent:**~~ KL	Diluted Mineral Water (8:2)
Ending Date:	22 Nov-11 14:45	**Species:**	Ceriodaphnia dubia	**Brine:**	Not Applicable
Duration:	6d 23h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	13-3622-2924	**Code:**	11-0951	**Client:**	MWH Labs
Sample Date:	14 Nov-11 07:20	**Material:**	~~POTW~~ Effluent Sample	**Project:**	
Receive Date:	14 Nov-11 10:55	**Source:**	MWH Labs KL		
Sample Age:	32h	**Station:**	SD AWPF		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
16-0378-0972	7d Survival Rate	100	>100	N/A	N/A	1	Fisher Exact Test
12-5459-5171	Reproduction	100	>100	N/A	14.9%	1	Wilcoxon Rank Sum Two-Sample Test

Test Acceptability

Analysis ID	Endpoint	Attribute	Test Stat	TAC Limits	Overlap	Decision
16-0378-0972	7d Survival Rate	Control Resp	1	0.8 - NL	Yes	Passes Acceptability Criteria
12-5459-5171	Reproduction	Control Resp	27.3	15 - NL	Yes	Passes Acceptability Criteria
12-5459-5171	Reproduction	PMSD	0.1493	0.13 - 0.47	Yes	Passes Acceptability Criteria

7d Survival Rate Summary

Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Rec. Water	10	0.9	0.7819	1	0	1	0.1	0.3162	35.14%	0.0%
0	Lab Control	10	1	1	1	1	1	0	0	0.0%	-11.11%
100		9	1	1	1	1	1	0	0	0.0%	-11.11%

Reproduction Summary

Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Rec. Water	10	18.4	14.27	22.53	0	34	3.493	11.05	60.04%	0.0%
0	Lab Control	10	27.3	25.49	29.11	15	32	1.535	4.855	17.78%	-48.37%
100		9	26.67	24.66	28.67	14	33	1.787	5.362	20.11%	-44.93%

7d Survival Rate Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Rec. Water	1	1	1	1	0	1	1	1	1	1
0	Lab Control	1	1	1	1	1	1	1	1	1	1
100		1	1	1	1	1		1	1	1	1

Reproduction Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Rec. Water	24	33	34	19	0	16	8	26	9	15
0	Lab Control	31	31	28	15	29	29	32	26	26	26
100		26	30	28	24	28		29	33	14	28

Analyst: SC QA: KL 12/14/11

CETIS Analytical Report

Report Date: 02 Dec-11 14:00 (p 1 of 1)
Test Code: 1111-S169 | 05-3100-9565

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental (CA)**

Analysis ID:	16-0378-0972	**Endpoint:**	7d Survival Rate	**CETIS Version:**	CETISv1.8.0
Analyzed:	02 Dec-11 13:58	**Analysis:**	Single 2x2 Contingency Table	**Official Results:**	Yes

Data Transform	Zeta	Alt Hyp	MC Trials	Test Result
Untransformed		C > T	Not Run	Sample passes 7d survival rate endpoint

Fisher Exact Test

Control	vs	Conc-%	Test Stat	P-Value	Decision(0.05)
Lab Control		100	1	1.0000	Non-Significant Effect

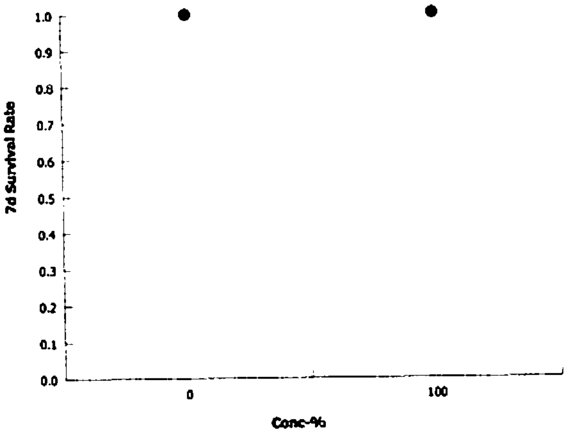
Data Summary

Conc-%	Control Type	No-Resp	Resp	Total
0	Lab Control	10	0	10
100		9	0	9

7d Survival Rate Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Lab Control	1	1	1	1	1	1	1	1	1	1
100		1	1	1	1	1	1	1	1	1	

Graphics



Analyst: SC QA: KL 12/14/11

CETIS Analytical Report

Report Date: 02 Dec-11 13:59 (p 1 of 1)
Test Code: 1111-S169 | 05-3100-9565

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental (CA)**

Analysis ID:	12-5459-5171	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.0
Analyzed:	02 Dec-11 13:58	**Analysis:**	Nonparametric-Two Sample	**Official Results:**	Yes

Data Transform	Zeta	Alt Hyp	MC Trials	Test Result	PMSD
Untransformed	0	C > T	Not Run	Sample passes reproduction endpoint	14.9%

Wilcoxon Rank Sum Two-Sample Test

Control	vs	Conc-%	Test Stat	Critical	DF	Ties	P-Value	Decision(α:5%)
Lab Control		100	85		17	3	0.3598	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	1.9	1.9	1	0.07306	0.7902	Non-Significant Effect
Error	442.1	26.00588	17			
Total	444	27.90588	18			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	1.22	6.693	0.7681	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.7993	0.8605	0.0011	Non-normal Distribution

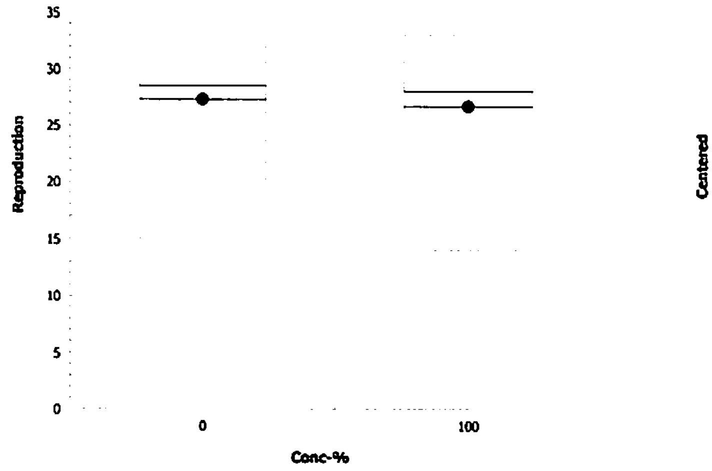
Reproduction Summary

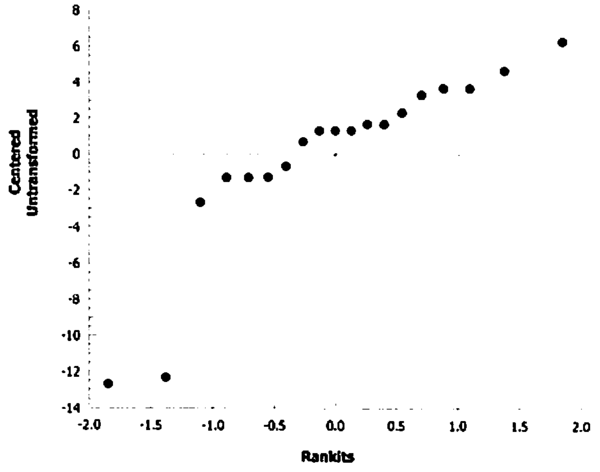
Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Lab Control	10	27.3	25.45	29.15	15	32	1.535	4.855	17.78%	0.0%
100		9	26.67	24.63	28.71	14	33	1.787	5.362	20.11%	2.32%

Reproduction Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Lab Control	31	31	28	15	29	29	32	26	26	26
100		26	30	28	24	28	29	33	14	28	

Graphics





Analyst: SC QA: KL 12/14/11

CETIS Analytical Report (Lab Control vs Reference Control)

Report Date: 02 Dec-11 14:00 (p 1 of 1)
Test Code: 1111-S169 | 05-3100-9565

Nautilus Environmental (CA)

Ceriodaphnia 7-d Survival and Reproduction Test

Analysis ID:	10-6389-5593	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.0
Analyzed:	02 Dec-11 13:59	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Data Transform	Zeta	Alt Hyp	MC Trials	Test Result	PMSD
Untransformed	0	C > T	Not Run	Sample fails reproduction endpoint	24.2%

Equal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	DF	MSD	P-Value	Decision(α:5%)
Lab Control		Rec. Water	2.332	1.734	18	6.617	0.0157	Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	396.05	396.05	1	5.44	0.0315	Significant Effect
Error	1310.5	72.80556	18			
Total	1706.55	468.8555	19			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	5.179	6.541	0.0223	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.962	0.866	0.5845	Normal Distribution

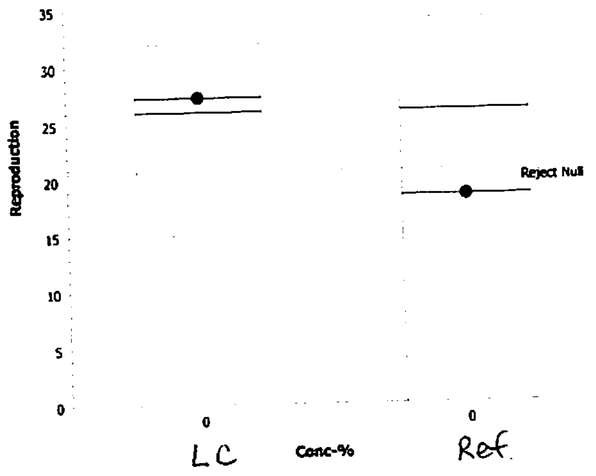
Reproduction Summary

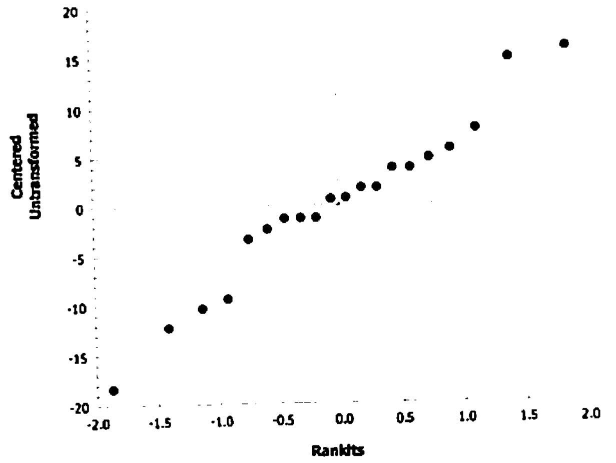
Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Rec. Water	10	18.4	14.2	22.6	0	34	3.493	11.05	60.04%	0.0%
0	Lab Control	10	27.3	25.45	29.15	15	32	1.535	4.855	17.78%	-48.37%

Reproduction Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Lab Control	31	31	28	15	29	29	32	26	26	26
0	Rec. Water	24	33	34	19	0	16	8	26	9	15

Graphics





Analyst: SC QA: KL 12/14/11

Freshwater Chronic Bioassay

Daphnid Survival and Reproduction Datasheet

Test Species: ***C. dubia***

Client/Sample ID: MWH / Effluent

Test Number: 1111-5169

Start Date/Time: 11/15/2011 1525

End Date/Time: 11/22/2011 1445

Conc.	Rep	Rand #	Daily Reproduction/ Survival								Total	QC
			1	2	3	4	5	6	7	8		
LC	1	8	0	0	5	0	11	15	0		31	
	2	29	0	0	4	0	11	110	16/B		31	
	3	26	0	0	0	4	9	0	15		28	
	4	14	0	0	0	4	11	0	0		15	
	5	5	0	0	0	6	10	0	13		29	
	6	27	0	0	0	3	10	0	16		29	
	7	21	0	0	4	0	10	0	18		32	
	8	6	0	0	0	4	7	0	15		26	
	9	11	0	0	0	4	11	0	11		26	11
	10	3	0	0	0	3	9	0	14		26	
		Tech:	JF	JF	AD	AD	JG	AD	JWW			AD

Conc.	Rep	Rand #	Daily Reproduction/ Survival								Total	QC
			1	2	3	4	5	6	7	8		
100 ~~10000%~~	1	25	0	0	0	5	8	0	13		26	
	2	15	0	0	5	0	11	14	0		30	
	3	10	0	0	6	0	10	12	12/B		28	12
	4	24	0	0	0	0	11	13	0		24	
	5	2	0	0	0	4	11	0	13		28	
	6	20	0	0	LIP	—	—	—	–		LIP	ES
	7	1	0	0	2	0	8	19	0		29	
	8	19	0	0	0	6	11	16	0		33	
	9	4	0	0	0	0	4	0	10		14	
	10	17	0	0	0	3	10	0	15		28	

Conc.	Rep	Rand #	Daily Reproduction/ Survival								Total	QC
			1	2	3	4	5	6	7	8		
RC	1	12	0	0	0	0	4	4	16		24	
	2	16	0	0	5	0	12	16	0		33	
	3	23	0	0	0	6	11	17	0		34	
	4	13	0	0	0	3	3	13	0		19	
	5	22	0/d	–	–	–	–	–	–		0/d	
	6	28	0	0	0	0	5	0	11		16	
	7	9	0	0	6	0	2	0	0		8	
	8	7	0	0	0	6	9	11	0		26	
	9	18	0	0	0	5	0	0	4		9	
	10	30	0	0	0	0	6	0	9		15	8

Neonates for each replicate were blocked across concentrations at test initiation

Rep:	1	2	3	4	5	6	7	8	9	10
Board:	57									→
Cup:	43	44	47	48	50	53	54	57	58	60

Initiated By: JF **Verified By:** JP

Time Fed/Test Solution Renewed (day):
(0) 1525 **(1)** 1400 **(2)** 1245 **(3)** 1230 **(4)** 1335 **(5)** 1350 **(6)** 1225 **(7)** ______

Notes: d = dead; M = male; LIP = lost in progress; B = 4th brood (only the first 3 broods are included in total)

QC Check: 12-1-11

Final Review: KL 12-14-11

Nautilus Environmental, LLC. 4340 Vandever Avenue. San Diego, CA 92120.

Freshwater Chronic Bioassay **Water Quality Measurements**

Client: MWH
Test Species: *C. dubia*
Sample ID: ~~RO Treated~~ Effluent KL
Start Date/Time: 11/15/2011 1525
Test No: 1111-S169
End Date/Time: 11/22/2011 1445

Concentration	**Lab Control**							
Day	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
				Initial				
pH	8.27	8.23	8.04	8.29	8.22	8.26	8.26	
DO (mg/L)	7.4	8.3	8.5	8.0	7.7	8.3	7.6	
Cond. (µmhos/cm)	193	190	195	194	193	200	196	
Temp (°C)	25.2	24.8	24.7	24.4	25.2	25.8	24.8	
				Final				
pH		8.08	8.15	8.22	8.23	8.20	8.25	8.12
DO (mg/L)		8.0	8.0	8.3	78	8.3	8.7	8.0
Temp (°C)		25.0	24.7	24.1	24.0	25.1	24.2	24.3

Concentration	**100%**							
Day	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
				Initial				
pH	8.56	8.54	8.40	8.48	8.51	8.90	8.45	
DO (mg/L)	8.8	8.0	9.0	8.0	8.5	8.9	8.9	
Cond. (µmhos/cm)	303	302	294	301	255	221	283	
Temp (°C)	25.2	25.7	26.0	25.8	25.4	25.9	25.0	
				Final				
pH		8.00	8.00	8.00	7.90	7.96	~~8.01~~ 7.97 AG	7.87
DO (mg/L)		7.9	7.9	8.3	7.7	8.2	8.8	8.0
Temp (°C)		25.0	24.7	24.1	24.0	25.1	24.2	24.3

Concentration	**Reference Control**							
Day	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
				Initial				
pH	8.41	8.56	~~8.27~~ 8.43	8.52	8.48	8.40	8.52	
DO (mg/L)	7.7	8.1	~~8.8~~ 8.6	8.1	8.4	8.9	9.0	
Cond. (µmhos/cm)	260	248	~~257~~ 251	251	303	247	259	
Temp (°C)	25.7	24.9	24.9	24.5	25.4	25.8	25.3	
				Final				
pH		7.89	7.90	7.90	7.98	7.86	7.93	7.82
DO (mg/L)		8.0	8.0	8.3	7.9	8.0	8.7	8.2
Temp (°C)		25.0	24.7	24.1	24.0	25.1	24.2	24.3

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Analysts: Initial:	JVV	JF	ES/JF	ES	ES	SL	ES	
Final:		JVV	JF	AD	AD	SL	AG	LN
Dilutions made by:	JF/PA	JW/JP	JF/PA	AD/ES	JF	JG	JP	
Sample Used (A, B, C):	A	A	B	B	B	C	C	

Comments:

Animal Source/Date Received: Internal / NA
Animal Age at Initiation: <24 hours
Sample Log-in Numbers: A: 11-0951 **B:** 11-0960 **C:** 11-0976
QC Check: 12-1-11
Final Review: KL 12-14-11

Chronic Fathead minnow

CETIS Summary Report

Report Date: 02 Dec-11 14:20 (p 1 of 1)
Test Code: 1111-S170 | 09-6925-3834

Fathead Minnow 7-d Larval Survival and Growth Test

Nautilus Environmental (CA)

Batch ID:	08-5879-3857	**Test Type:**	Growth-Survival (7d)	**Analyst:**	
Start Date:	15 Nov-11 15:25	**Protocol:**	EPA/821/R-02-013 (2002)	~~**Diluent:**~~ Control KL	Diluted Mineral Water (8:2)
Ending Date:	22 Nov-11 15:15	**Species:**	Pimephales promelas	**Brine:**	Not Applicable
Duration:	7d	**Source:**	Aquatic Biosystems, CO	**Age:**	1d

Sample ID:	07-7437-1488	**Code:**	11-0951	**Client:**	MWH Labs
Sample Date:	14 Nov-11 07:20	**Material:**	~~Groundwater~~ Effluent Sample KL	**Project:**	
Receive Date:	14 Nov-11 10:55	**Source:**	MWH Labs		
Sample Age:	32h	**Station:**	SD AWPF		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
06-6625-6678	7d Survival Rate	100	>100	N/A	13.9%	1	Equal Variance t Two-Sample Test
16-3753-6868	Mean Dry Biomass-mg	100 ~~<100~~ KL	>100	N/A	4.97%	~~>1~~ 1 KL	Equal Variance t Two-Sample Test

Test Acceptability

Analysis ID	Endpoint	Attribute	Test Stat	TAC Limits	Overlap	Decision
06-6625-6678	7d Survival Rate	Control Resp	0.95	0.8 - NL	Yes	Passes Acceptability Criteria
16-3753-6868	Mean Dry Biomass-mg	Control Resp	0.3065	0.25 - NL	Yes	Passes Acceptability Criteria
16-3753-6868	Mean Dry Biomass-mg	PMSD	0.04971	0.12 - 0.3	Yes	Below Acceptability Criteria *

7d Survival Rate Summary

Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Rec. Water	4	0.975	0.9563	0.9937	0.9	1	0.025	0.05	5.13%	0.0%
0	Lab Control	4	0.95	0.9127	0.9873	0.8	1	0.05	0.1	10.53%	2.56%
100		4	0.925	0.8892	0.9608	0.8	1	0.04787	0.09574	10.35%	5.13%

Mean Dry Biomass-mg Summary

Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Rec. Water	4	0.287	0.2839	0.2901	0.276	0.296	0.004123	0.008246	2.87%	0.0%
0	Lab Control	4	0.3065	0.3013	0.3117	0.294	0.323	0.006958	0.01392	4.54%	-6.79%
100		4	0.2852	0.2826	0.2879	0.279	0.292	0.003614	0.007228	2.53%	0.61%

7d Survival Rate Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Rec. Water	0.9	1	1	1
0	Lab Control	1	1	0.8	1
100		1	1	0.8	0.9

Mean Dry Biomass-mg Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Rec. Water	0.288	0.276	0.288	0.296
0	Lab Control	0.323	0.296	0.313	0.294
100		0.292	0.279	0.291	0.279

* See QA section of report.

The PMSD value was only 5.0%, which is below the test acceptability range of 12-30%. This result indicates the data was very tight with low variability. This usually results in over-sensitive statistical results and leads to False Positive readings. If we look at the low bar of the PMSD acceptable range, which is 12%, we would need to see at least a 12% difference in growth to deem a result as being biologically relevant. In this case, there was less than a 7.0% difference, which we believe to be a False Positive result. Therefore, we are reporting this as no effect in the 100% sample.

Analyst: SC QA: KL 12-14-11

CETIS Analytical Report

Report Date: 02 Dec-11 14:20 (p 1 of 2)
Test Code: 1111-S170 | 09-6925-3834

Fathead Minnow 7-d Larval Survival and Growth Test — **Nautilus Environmental (CA)**

Analysis ID:	16-3753-6868	**Endpoint:**	Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.8.0
Analyzed:	02 Dec-11 14:18	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Data Transform	Zeta	Alt Hyp	MC Trials	Test Result	PMSD
Untransformed	0	C > T	Not Run	Sample fails mean dry biomass-mg endpoint	4.97%

Equal Variance t Two-Sample Test

Control	vs	Conc-%	Test Stat	Critical	DF	MSD	P-Value	Decision(α:5%)
Lab Control		100*	2.71	1.943	6	0.01524	0.0175	Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.0009031296	0.0009031296	1	7.345	0.0351	Significant Effect
Error	0.0007377589	0.0001229598	6			
Total	0.001640889	0.001026089	7			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	3.707	47.47	0.3104	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9102	0.6451	0.3556	Normal Distribution

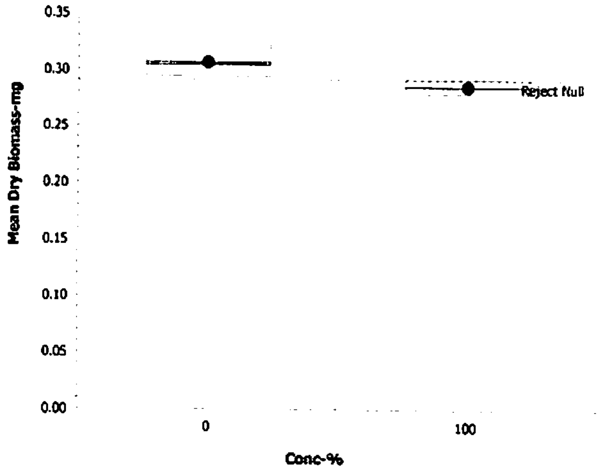
Mean Dry Biomass-mg Summary

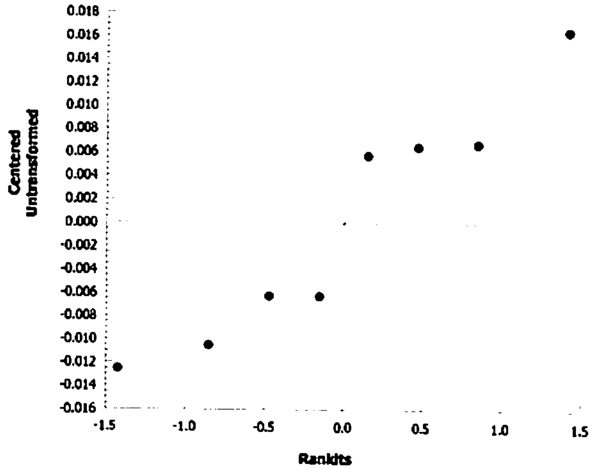
Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Lab Control	4	0.3065	0.3012	0.3118	0.294	0.323	0.006958	0.01392	4.54%	0.0%
100		4	0.2852	0.2825	0.288	0.279	0.292	0.003614	0.007228	2.53%	6.93%

Mean Dry Biomass-mg Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Lab Control	0.323	0.296	0.313	0.294
100		0.292	0.279	0.291	0.279

Graphics





Analyst: SC QA: KL 12-14-11

Fathead Minnow 7-d Larval Survival and Growth Test **Nautilus Environmental (CA)**

Analysis ID:	06-6625-6678	**Endpoint:**	7d Survival Rate	**CETIS Version:**	CETISv1.8.0
Analyzed:	02 Dec-11 14:17	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Data Transform	Zeta	Alt Hyp	MC Trials	Test Result	PMSD
Angular (Corrected)	0	C > T	Not Run	Sample passes 7d survival rate endpoint	13.9%

Equal Variance t Two-Sample Test

Control	vs	Conc-%	Test Stat	Critical	DF	MSD	P-Value	Decision(α:5%)
Lab Control		100	0.3848	1.943	6	0.2057	0.3568	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.003319917	0.003319917	1	0.1481	0.7136	Non-Significant Effect
Error	0.1344935	0.02241559	6			
Total	0.1378134	0.0257355	7			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	1.076	47.47	0.9534	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.7948	0.6451	0.0252	Normal Distribution

7d Survival Rate Summary

Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Lab Control	4	0.95	0.912	0.988	0.8	1	0.05	0.1	10.53%	0.0%
100		4	0.925	0.8886	0.9614	0.8	1	0.04787	0.09574	10.35%	2.63%

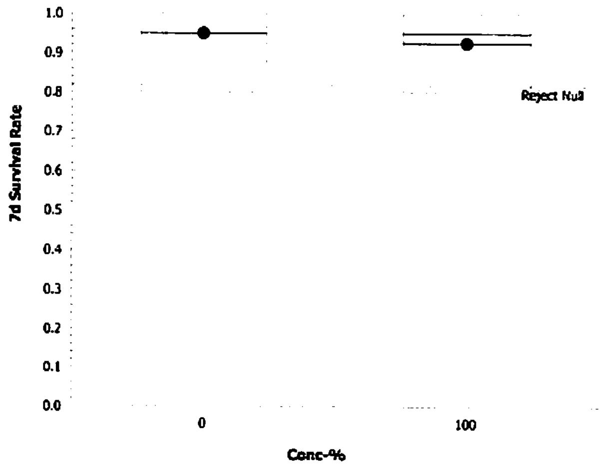
Angular (Corrected) Transformed Summary

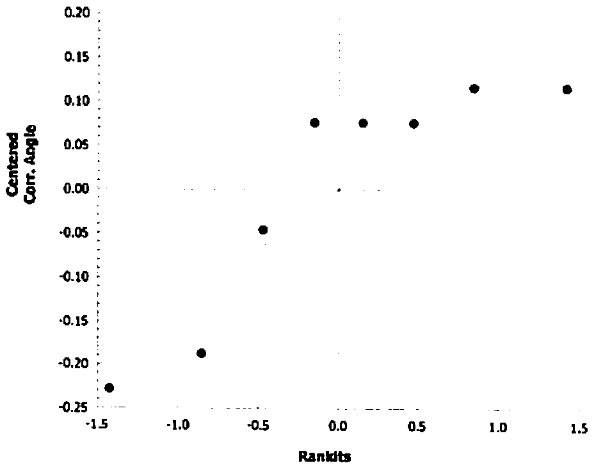
Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Lab Control	4	1.336	1.278	1.394	1.107	1.412	0.07622	0.1524	11.41%	0.0%
100		4	1.295	1.239	1.351	1.107	1.412	0.07348	0.147	11.35%	3.05%

7d Survival Rate Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Lab Control	1	1	0.8	1
100		1	1	0.8	0.9

Graphics





Analyst: Sc QA: KL 12-14-11

CETIS Analytical Report

(Lab Control vs Reference Control)

Report Date:	02 Dec-11 14:20 (p 2 of 2)
Test Code:	1111-S170 | 09-6925-3834

Fathead Minnow 7-d Larval Survival and Growth Test — **Nautilus Environmental (CA)**

Analysis ID:	05-1519-7731	**Endpoint:**	Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.8.0
Analyzed:	02 Dec-11 14:19	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Data Transform	Zeta	Alt Hyp	MC Trials	Test Result	PMSD
Untransformed	0	C > T	Not Run	Sample fails mean dry biomass-mg endpoint	5.13%

Equal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	DF	MSD	P-Value	Decision(α:5%)
Lab Control		Rec. Water	2.411	1.943	6	0.01572	0.0263	Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.0007604932	0.0007604932	1	5.813	0.0525	Non-Significant Effect
Error	0.0007850142	0.0001308357	6			
Total	0.001545507	0.0008913289	7			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	2.848	47.47	0.4129	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9184	0.6451	0.4166	Normal Distribution

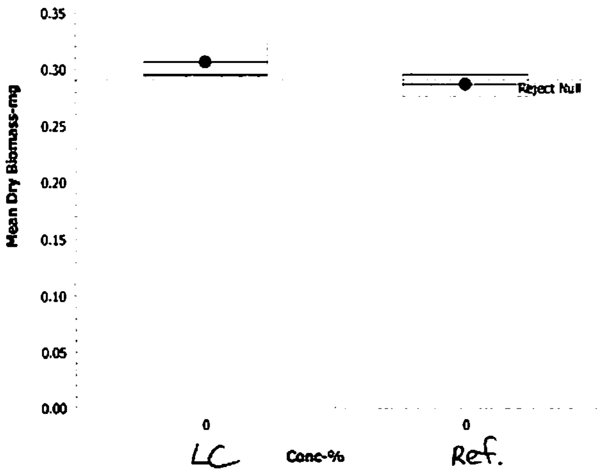
Mean Dry Biomass-mg Summary

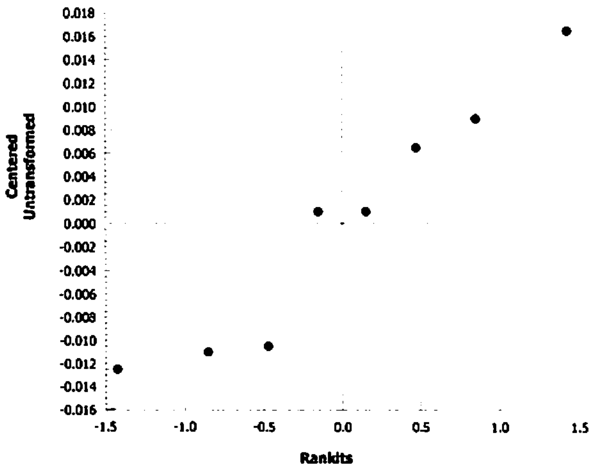
Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Rec. Water	4	0.287	0.2839	0.2901	0.276	0.296	0.004123	0.008246	2.87%	0.0%
0	Lab Control	4	0.3065	0.3012	0.3118	0.294	0.323	0.006958	0.01392	4.54%	-6.79%

Mean Dry Biomass-mg Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Lab Control	0.323	0.296	0.313	0.294
0	Rec. Water	0.288	0.276	0.288	0.296

Graphics





Analyst: SC QA: KL 12-14-11

CETIS Analytical Report (Reference Control vs 100% Sample)

Report Date: 02 Dec-11 14:20 (p 1 of 2)
Test Code: 1111-S170 | 09-6925-3834

Fathead Minnow 7-d Larval Survival and Growth Test

Nautilus Environmental (CA)

Analysis ID:	00-7707-0425	**Endpoint:**	Mean Dry Biomass-mg	**CETIS Version:**	CETISv1.8.0
Analyzed:	02 Dec-11 14:19	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Data Transform	Zeta	Alt Hyp	MC Trials	Test Result	PMSD
Untransformed	0	C > T	Not Run	Sample passes mean dry biomass-mg endpoin	8.71%

Equal Variance t Two-Sample Test

Control	vs	Conc-%	Test Stat	Critical	DF	MSD	P-Value	Decision(α:5%)
Rec. Water		100	0.3192	1.943	6	0.01065	0.3802	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	6.12599E-06	6.12599E-06	1	0.1019	0.7604	Non-Significant Effect
Error	0.0003607558	6.012597E-05	6			
Total	0.0003668818	6.625196E-05	7			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	1.301	47.47	0.8337	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9298	0.6451	0.5141	Normal Distribution

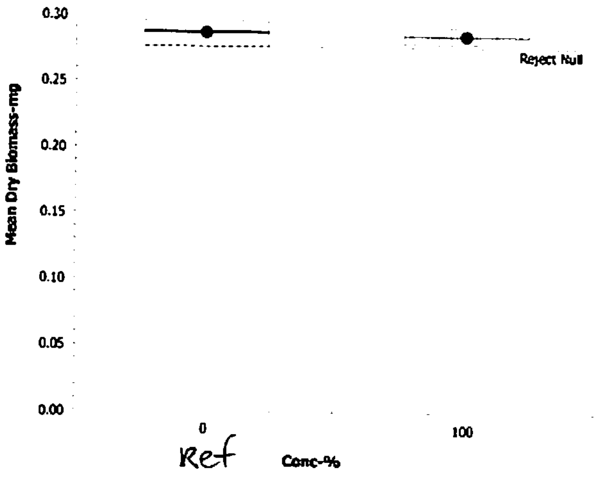
Mean Dry Biomass-mg Summary

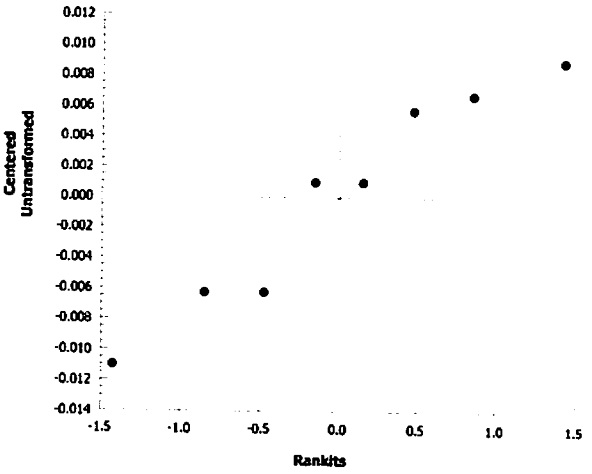
Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Rec. Water	4	0.287	0.2839	0.2901	0.276	0.296	0.004123	0.008246	2.87%	0.0%
100		4	0.2852	0.2825	0.288	0.279	0.292	0.003614	0.007228	2.53%	0.61%

Mean Dry Biomass-mg Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Rec. Water	0.288	0.276	0.288	0.296
100		0.292	0.279	0.291	0.279

Graphics





Analyst: SC QA: KL 12-14-11

Freshwater Chronic Bioassay

Larval Fish Survival

Client: MWH

Sample ID: ~~RO Treated~~ Effluent EL

Test No.: 1111-5170

Test Species: *P. promelas*

Start Date/Time: 11/15/2011 1525

End Date/Time: 11/22/2011 1515

Conc. (%)	Rep.	Rand #	Test Day / No. Organisms Alive 0	1	2	3	4	5	6	7	Percent Survival
Lab Control	a	6	10	10	10	10	10	10	10	10	100
	b	5	10	10	10	10	10	10	10	10	100
	c	12	10	10	10	8	8	8	8	8	80
	d	7	10	10	10	10	10	10	10	10	100
100	a	4	10	10	10	10	10	10	10	10	100
	b	3	10	10	10	10	10	10	10	10	100
	c	10	10	10	10	8	8	8	8	8	80
	d	11	10	10	10	10	9	9	9	9	90
	a	2	10	JP ~~9~~ 10	10	10	10	10	9	9	90
Reference Control	b	8	10	10	10	10	10	10	10	10	100
	c	9	10	10	10	10	10	10	10	10	100
	d	1	10	10	10	10	10	10	10	10	100

Initial Counts QC'd by: JF

	0	1	2	3	4	5	6	7
Tech Initials	JG	JP	JP	JP	JF	SL	JP	KF
Time	1525	1400	1210	1030	1335	1320	1200	1515

Time Fed (day):	0	1	2	3	4	5	6
morning:	–	0815	0830	0830	0930	0850	0830
midday:	–	1210	1220	1220	1145	1205	1215
evening:	–	1450	1710	1500	1515	1530	1450

Comments:

Drying Oven Info

Tare wt. Initials/Date: AD 11/22/11

Date/Time in: 11/22/11 1530

Date/Time out: ~~11/23/11~~ 11/28/11 1415

Temp (°C): ~~25°~~ AD ~~68~~ 66

QC Check: JC 12-1-11

Final Review: KL 12-14-11

Nautilus Environmental, LLC. 4340 Vandever Avenue. San Diego, CA 92120.

Freshwater Chronic Bioassay

Larval Fish Weights

Client: MWH

Sample ID: ~~Re-treated~~ KL Effluent

Test No.: 1111-5170

Test Species: *Pimephales promelas*

Start Date/Time: ####### 11/15/11 1525

End Date/Time: 11/22/11 1515

Conc. (%)	Rep.	pan weight (mg)	pan + fish weight (mg)	organism weight (mg)
LC	a	30.08	33.31	3.23
	b	29.11	32.07	2.96
	c	29.44	32.57	3.13
	d	29.70	32.64	2.94
RC	a	29.61	32.49	2.88
	b	28.79	31.55	2.76
	c	29.77	32.65	2.88
	d	30.35	33.31	2.96
100	a	30.63	33.55	2.92
	b	28.95	31.74	2.79
	c	30.85	33.76	2.91
	d	31.38	34.17	2.79
	a			0
	b			0
	c			0
	d			0
	a			0
	b			0
	c			0
	d			0
	a			0
	b			0
	c			0
	d			0
	a			0
	b			0
	c			0
	d			0
	Tech Initials:	AD	AG	
	Date/Time:	11/22/2011 1010	11/28/2011 1415	

QC Check: JC 12-1-11

Final Review: KL 12-14-11

Freshwater Chronic Bioassay **Water Quality Measurements**

Client: MWH
Test Species: *P. promelas*
Sample ID: ~~RO Treated~~ TCC Effluent
Start Date/Time: 11/15/2011 1525
Test No: 1111-5170
End Date/Time: 11/22/2011 1515

Concentration	**Lab Control**							
Day	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
					Initial			
pH	8.28	8.23	8.05	8.28	8.16 ~~7.87~~ ES	8.26	8.26	
DO (mg/L)	7.3	8.3	8.5	7.4	7.6	8.3	7.6	
Cond. (µmhos/cm)	194	190	194	194	199	200	196	
Temp (°C)	25.8	24.8	24.0	25.4	25.4	25.8	24.8	
					Final			
pH		8.18	8.19	7.93	7.87	8.04	7.97	7.91
DO (mg/L)		7.5	6.4	6.5	6.6	7.6	7.5	7.1
Temp (°C)		25.8	25.6	25.6	25.4	25.0	24.4	25.4

Concentration	**100%**							
Day	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
					Initial			
pH	8.45	8.54	8.40	8.40	8.44	8.40	8.45	
DO (mg/L)	8.9	8.0	9.0	8.9	8.9	8.9	8.9	
Cond. (µmhos/cm)	305 ~~345~~ JF	302	294	294 JVV	~~25~~ 295	221	283	
Temp (°C)	25.1	25.7	26.0	25.1	24.6	25.9	25.0	
					Final			
pH		8.06	7.87	7.10	7.45	7.84	7.64	7.64
DO (mg/L)		7.9	6.5	4.8	6.4	7.5	7.1	6.8
Temp (°C)		25.6	24.7	25.1	25.3	25.1	24.4	25.2

Concentration	**Reference Control**							
Day	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
					Initial			
pH	8.41	8.56	8.43	8.41	8.44	8.40	8.52	
DO (mg/L)	8.3	8.1	8.6	8.3	8.2	8.9	9.0	
Cond. (µmhos/cm)	248	248	251	250	295	247	259	
Temp (°C)	24.7	24.9	26.0	25.9	25.5	25.8	25.3	
					Final			
pH		7.91	7.90	7.56	7.56	7.81	7.42	7.67
DO (mg/L)		8.0	6.6	6.5	6.2	7.1	6.5	6.7
Temp (°C)		25.5	25.1	25.5	25.5	25.0	24.6	25.4

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Analysts: Initial:	JVV	JF	JF	ES	~~ES~~ ES	SL	ES	
Final:		JF	JF	ES	ES	SL	ES	JP
Dilutions made by:	PA	JVV/JP	AD	AD	JVV	SG	JP	
Sample Used (A, B, C):	A	A	B	B	B	C	C	

Comments:

Animal Source/Date Received: ABS 11/15/11
Animal Age at Initiation: 1 Day
Sample Log-In Numbers: A: 11-0951 **B:** 11-0960 **C:** 11-0976
QC Check: Jc 12-1-11
Final Review: KC 12-14-11

Chronic Green Algae

CETIS Summary Report

Report Date: 02 Dec-11 13:43 (p 1 of 1)
Test Code: 1111-S171 | 17-8340-7840

Selenastrum Growth Test **Nautilus Environmental (CA)**

Batch ID:	20-8375-1066	**Test Type:**	Cell Growth	**Analyst:**	
Start Date:	17 Nov-11 16:35	**Protocol:**	EPA/821/R-02-013 (2002)	~~**Diluent**~~ Control KL **:**	Very Hard Water
Ending Date:	21 Nov-11 14:50	**Species:**	Selenastrum capricornutum	**Brine:**	Not Applicable
Duration:	94h	**Source:**	In-House Culture	**Age:**	7d

Sample ID:	18-5518-5944	**Code:**	11-0960	**Client:**	MWH Labs
Sample Date:	16 Nov-11 08:50	**Material:**	Effluent Sample	**Project:**	
Receive Date:	16 Nov-11 09:25	**Source:**	MWH Labs		
Sample Age:	32h	**Station:**	MWH		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
13-8700-5396	Cell Density	100	>100	N/A	5.05%	1	Equal Variance t Two-Sample Test

Test Acceptability

Analysis ID	Endpoint	Attribute	Test Stat	TAC Limits	Overlap	Decision
13-8700-5396	Cell Density	Control CV	0.0511	NL - 0.2	Yes	Passes Acceptability Criteria
13-8700-5396	Cell Density	Control Resp	3.26E+6	1.00E+6 - NL	Yes	Passes Acceptability Criteria
13-8700-5396	Cell Density	PMSD	0.05049	0.091 - 0.29	Yes	Below Acceptability Criteria *

Cell Density Summary

Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Rec. Water	4	3.317E+6	3.301E+6	3.333E+6	3.280E+6	3.379E+6	2.151E+4	4.301E+4	1.3%	0.0%
0	Lab Control	4	3.260E+6	3.198E+6	3.322E+6	3.116E+6	3.494E+6	8.329E+4	1.666E+5	5.11%	1.72%
100		4	3.231E+6	3.219E+6	3.243E+6	3.206E+6	3.275E+6	1.542E+4	3.084E+4	0.95%	2.59%
101		4	3.259E+6	3.249E+6	3.268E+6	3.229E+6	3.289E+6	1.279E+4	2.558E+4	0.79%	1.76%

Cell Density Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Rec. Water	3.308E+6	3.301E+6	3.280E+6	3.379E+6
0	Lab Control	3.494E+6	3.172E+6	3.116E+6	3.258E+6
100		3.206E+6	3.275E+6	3.229E+6	3.214E+6
101		3.267E+6	3.229E+6	3.249E+6	3.289E+6

101 = 100% sample unfiltered

* See QA section of report.

Analyst: SC QA: KL 12-14-11

CETIS Analytical Report

Report Date:	02 Dec-11 13:43 (p 1 of 1)
Test Code:	1111-S171 | 17-8340-7840

Selenastrum Growth Test **Nautilus Environmental (CA)**

Analysis ID:	13-8700-5396	**Endpoint:**	Cell Density	**CETIS Version:**	CETISv1.8.0
Analyzed:	02 Dec-11 13:41	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Data Transform	Zeta	Alt Hyp	MC Trials	Test Result	PMSD
Untransformed	0	C > T	Not Run	Sample passes cell density endpoint	5.05%

Equal Variance t Two-Sample Test

Control	vs	Conc-%	Test Stat	Critical	DF	MSD	P-Value	Decision(α:5%)
Lab Control		100	0.3424	1.943	6	164600	0.3719	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	1682000000	1682000000	1	0.1172	0.7437	Non-Significant Effect
Error	86094000000	14349000000	6			
Total	87775990000	16031000000	7			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	29.17	47.47	0.0203	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.8806	0.6451	0.1907	Normal Distribution

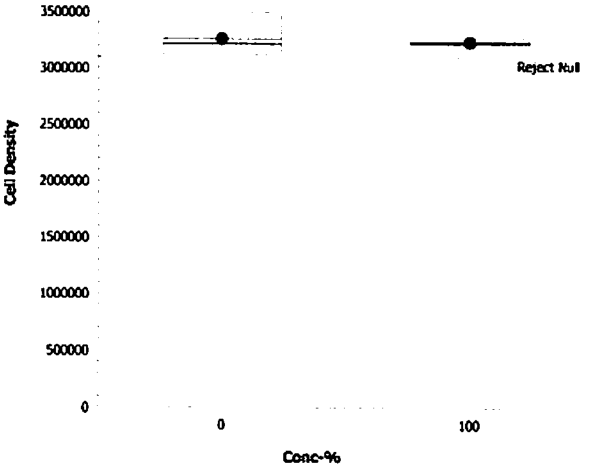
Cell Density Summary

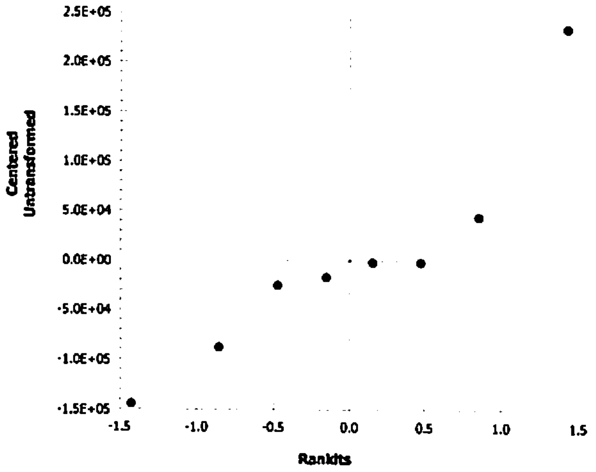
Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Lab Control	4	3.260E+6	3.197E+6	3.323E+6	3.116E+6	3.494E+6	8.329E+4	1.666E+5	5.11%	0.0%
100		4	3.231E+6	3.219E+6	3.243E+6	3.206E+6	3.275E+6	1.542E+4	3.084E+4	0.95%	0.89%

Cell Density Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Lab Control	3.494E+6	3.172E+6	3.116E+6	3.258E+6
100		3.206E+6	3.275E+6	3.229E+6	3.214E+6

Graphics





Analyst: SC QA: KL 12-14-11

Fluorometric & Microscopic Determination of Cell Density
Turner Fluorometer Model TD-700

Test Species: *S. capricornutum*

Client : MWH

Start Date/Time: 11/17/2011 1635

Sample ID: ~~Ro-Treated~~ Effluent KL

End Date/Time: 11/21/2011 1450

Test No: 1111-5171

Analyst: VG

Random Number	Cell Density (fluorometric) (cells/ml *10^5)	Dilution	Cell Density (microscopic) (cells/ml *10^4)
Blank		NA	
Cal Check 1 (NEW, Solid)	0.00/~~2.84~~ 2.83 JG		
69	32.06		
70	32.75		
71	32.14		
72	32 58		
73	33.08		
74	32.29		
75	32.29		
76	32.89		
77	32.80		
78	33.79		
79	32.67		
80	31.72		
81	34.94		
82	32.49		
Cal Check 2 (NEW, Solid)	0.00/2.80		
100% filtered blank	0.00		
100% unfiltered blank	1.62		
83	31.16		
84	33.07		
UNFILTERED A	41.63		
UNFILT. B	42.34		
UNFILT. C	42.16		
UNFILT. D	41.13		

Comments: ALL REPS WERE SCOPED FOR ATTACHED ALGAE PRIOR TO READINGS

QC Check: SL 12-1-11

Final Review: KL 12/14/11

CETIS Test Data Worksheet

Report Date: 17 Nov-11 09:37 (p 1 of 1)
Test Code: 17-8340-7840/~~6A4CA4E0~~ 1111-
KL S171

Selenastrum Growth Test **Nautilus Environmental (CA)**

Start Date:	17 Nov-11	**Species:**	Selenastrum capricornutum	**Sample Code:**	~~6E93E418~~ 11-0960
End Date:	21 Nov-11	**Protocol:**	EPA/821/R-02-013 (2002)	**Sample Source:**	MWH Labs KL
Sample Date:	16 Nov-11	**Material:**	Effluent Sample	**Sample Station:**	MWH

Conc-%	Code	Rep	Pos *	Cell Density	Absorbance	Biomass	Chlorophyll a	Notes
0	LC	1	81					* Random # Positions
0	LC	2	80					
0	LC	3	83					
0	LC	4	72					
0	R	1	73					
0	R	2	84					
0	R	3	77					
0	R	4	78					
100		1	69					
100		2	70					
100		3	74					
100		4	71					
101		1	79					
101		2	75					
101		3	82					
101		4	76					

combined sample outfall

QC: JW

000-089-170-3 CETIS™ v1.8.0.12 Analyst: JW QA: 12-1-11

Freshwater Chronic Bioassay **Algal Growth Inhibition Worksheet**

Client/Sample ID : MWH/RO-Treated Eff.

Test Species: ***S. capricornutum***

Test No: 1111-5171

Start Date/Time: 11/17/2011 1635

Analyst: AD/JVV

End Date/Time: 11/21/2011 1450

Culture Used (circle one): Nutrient Enriched DI Water (NEW) / [✓ Very Hard Water (VHW)]

Date Stock Culture Started: 11/10/11 Culture Age: 7d

Culture subsample inspected for algal cell health? AD/JVV (initials) bacteria/invasive algal species present? Y / N

Stock Cell Density Measurements: AD ~~40.01~~ 44.86

45.53

45.65

45.94

45.53

Mean: 45.50

(mean no. * 100,000)/(500,000) = x (dilution factor): 9.1

Prepare inoculum according to the dilution factor. This yields a solution with the desired cell density of 500,000 cells/ml.

dil. factor 9.1

-1.0 part Sele stock = 20 ml

8.1 part(s) NEW = 162 ml

Inoculate 1 ml into 3 initial count flasks containing 50 ml of NEW, stir and count on the hemacytometer. Flasks should contain a final density of 10,000 cells/ml ± 10%.

Inoculum Cell Density Confirmation Counts:

2

1

0

Mean: 1

Location in Environmental Chamber (All replicates in each test must be on the same shelf; do not split up tests among shelves):

Shelf Number	Measured Light Intensity Range (must be between 360 and 440 ft-c)	Random Number Range
1	360 - 437	41-68
2		
3	363- 438	25-32, 68-84
4		
5		
AD ~~6~~ 8	361 - 438	1-~~40~~ AD 24 33-40

Are lights on 24 hour cycle? [✓ Y] / N

Comments:

QC Check: 12-1-11

Final Review: KL 12-14-11

Nautilus Environmental, LLC. 4340 Vandever Avenue. San Diego, CA 92120.

Freshwater Chronic Bioassay

Water Quality Measurements
Algal Growth Inhibition

Client : MWH Labs
Sample ID: ~~RO Treated~~ KL Effluent
Sample Log No.: 11- 0960
Dilutions made by: JVV

Test Species: *S. capricornutum*
Start Date/Time: 11/17/2011 1635
End Date/Time: 11/21/2011 1450
Test No: 1111-5171

	Initial Readings				Final Readings	
Concentration (%)	**D.O. (mg/L)**	**Conductivity (umhos-cm)**	**Alkalinity (mg/L)**	**Hardness (mg/L)**	**D.O. (mg/L)**	**Conductivity (umhos-cm)**
Lab Control	7.1	275	98	100	8.6	165
Reference Control	6.7	325	43	70	8.6	336
Combined Sample filt	6.6	370	54	72	8.6	382
Combined Sample unfilt	8.1	372	53	72	8.6	384

		0 Hour	**24 Hour** Q1	Q1 **48 Hour**	**72 Hour**	**96 Hour**
pH/Temperature (°C):	**LC**	8.10 /24.1	8.39 /28.4	8.75/26.9	9.04 / 24.8	9.33 /24.6
pH/Temperature (°C):	**RC**	8.42 / 24.4	8.15 /28.6	8.73/26.3	9.12 / 25.6	9.53/24.8
pH/Temperature (°C):	**Combined Sample filt**	8.45 / 24.5	8.15 /28.9	8.69 /27.4	9.26 /25.3	9.58 / 25.0
pH/Temperature (°C):	**Combined Sample unfilt**	8.44 / 24.7	8.19 /28.9	8.71/27.7	9.25 /25.4	9.62/25.1
pH/Temperature (°C):		/	/	/	/	/
pH/Temperature (°C):		/	/	/	/	/
pH/Temperature (°C):		/	/	/	/	/
	Technician:	JVV	JP	JF	SL	JG

Comments:

QC Check: SC 12-1-11

Final Review: KL 12-14-11

Nautilus Environmental, LLC. 4340 Vandever Avenue. San Diego, CA 92120.

Appendix B

Acute Test Data & Statistical Analyses

Acute Water Flea

CETIS Summary Report

Report Date: 02 Dec-11 14:32 (p 1 of 1)
Test Code: 1111-S172 | 11-6228-7568

Ceriodaphnia 96-h Acute Survival Test — **Nautilus Environmental (CA)**

Batch ID:	02-9009-2692	**Test Type:**	Survival (96h)	**Analyst:**	
Start Date:	15 Nov-11 15:20	**Protocol:**	EPA/821/R-02-012 (2002)	Control: **~~Diluent:~~** KL	Diluted Mineral Water (8:2)
Ending Date:	19 Nov-11 13:45	**Species:**	Ceriodaphnia dubia	**Brine:**	Not Applicable
Duration:	94h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	16-9114-1243	**Code:**	11-0951	**Client:**	MWH Labs
Sample Date:	14 Nov-11 07:20	**Material:**	~~Stormwater~~ KL Effluent Sample	**Project:**	
Receive Date:	14 Nov-11 10:55	**Source:**	MWH Labs		
Sample Age:	32h	**Station:**	SD AWPF		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
12-6272-1334	96h Survival Rate	100	>100	N/A	11.2%	~~>~~0.41 KL	Wilcoxon Rank Sum Two-Sample Test

Test Acceptability

Analysis ID	Endpoint	Attribute	Test Stat	TAC Limits	Overlap	Decision
12-6272-1334	96h Survival Rate	Control Resp	1	0.9 - NL	Yes	Passes Acceptability Criteria

96h Survival Rate Summary

Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Rec. Water	4	1	1	1	1	1	0	0	0.0%	0.0%
0	Lab Control	4	1	1	1	1	1	0	0	0.0%	0.0%
100		4	0.95	0.9127	0.9873	0.8	1	0.05	0.1	10.53%	5.0%

96h Survival Rate Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Rec. Water	1	1	1	1
0	Lab Control	1	1	1	1
100		1	0.8	1	1

Analyst: SC QA: KL 12/14/11

CETIS Analytical Report

Report Date: 02 Dec-11 14:32 (p 1 of 1)
Test Code: 1111-S172 | 11-6228-7568

Ceriodaphnia 96-h Acute Survival Test — **Nautilus Environmental (CA)**

Analysis ID:	12-6272-1334	**Endpoint:**	96h Survival Rate	**CETIS Version:**	CETISv1.8.0
Analyzed:	02 Dec-11 14:32	**Analysis:**	Nonparametric-Two Sample	**Official Results:**	Yes

Data Transform	Zeta	Alt Hyp	MC Trials	Test Result	PMSD
Angular (Corrected)	0	C > T	Not Run	Sample passes 96h survival rate endpoint	11.2%

Wilcoxon Rank Sum Two-Sample Test

Control	vs	Conc-%	Test Stat	Critical	DF	Ties	P-Value	Decision(α:5%)
Lab Control		100	16		6	1	0.3429	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.007088488	0.007088488	1	1	0.3559	Non-Significant Effect
Error	0.04253092	0.007088488	6			
Total	0.04961941	0.01417698	7			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Mod Levene Equality of Variance	1	13.75	0.3559	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.7065	0.6451	0.0027	Non-normal Distribution

96h Survival Rate Summary

Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Lab Control	4	1	1	1	1	1	0	0	0.0%	0.0%
100		4	0.95	0.912	0.988	0.8	1	0.05	0.1	10.53%	5.0%

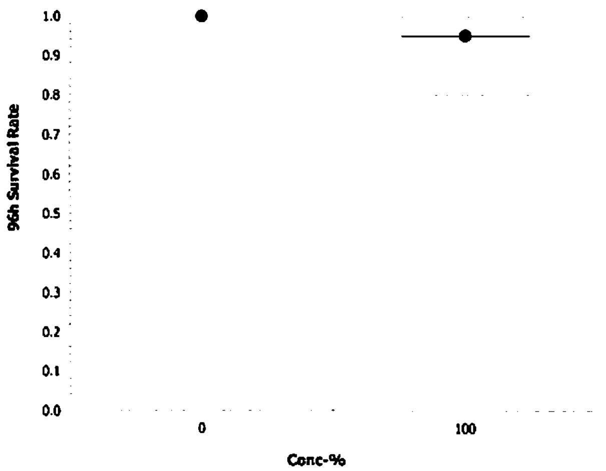
Angular (Corrected) Transformed Summary

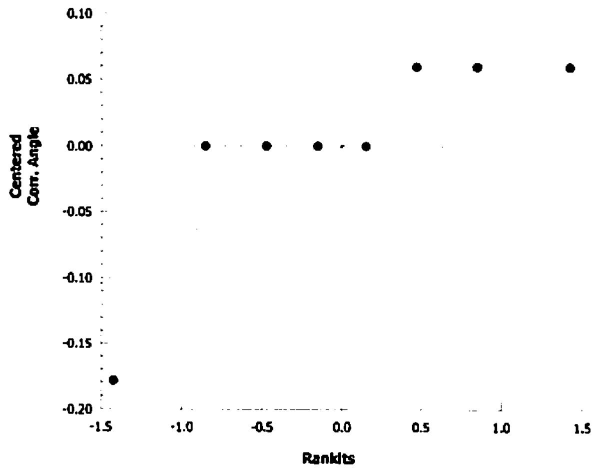
Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Lab Control	4	1.345	1.345	1.345	1.345	1.345	0	0	0.0%	0.0%
100		4	1.286	1.24	1.331	1.107	1.345	0.05953	0.1191	9.26%	4.43%

96h Survival Rate Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Lab Control	1	1	1	1
100		1	0.8	1	1

Graphics





Analyst: Sc   QA: KL 12/14/11

96-hour Freshwater Acute Bioassay
Static-Renewal Conditions

Water Quality Measurements
& Test Organism Survival

Client: MWH
Sample ID: ~~RO-treated~~ Effluent
Test No.: 1111-5172

Test Species: *C. dubia*
Start Date/Time: 11/15/2011 1520
End Date/Time: 11/19/2011 1345

Tech Initials	0	24	48	72	96
Counts:	JP	JP	JP	ES	JV
Readings:	JV	JF	JF	ES	ES
Dilutions made by:	PA		AD		

Concentration (%)	Rep	Number of Live Organisms					Conductivity (µmhos/cm)					Temperature (°C)					Dissolved Oxygen (mg/L)					pH (units)				
		0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96
	A	5	5	5	5	5	194	195	i 193	196	197	25.1	26.0	i 24.0	25.1	25.1	7.8	7.9	i 7.5	7.5	7.4	8.25	8.33	i 8.00	8.23	8.27
Lab Control	B	5	5	5	5	5			f 219					f 24.3					f 8.1					f 8.29		
	C	5	5	5	5	5																				
	D	5	5	~~4~~5	5	5																				
	A	5	5	5	5	5	302	306	i 298	320	325	25.0	26.0	i 24.2	24.9	25.1	8.9	8.0	i 8.3	7.8	7.9	8.45	8.19	i 8.60	8.02	8.65
100%	B	5	~~5~~4	4	4	4			f 344					f 24.3					f 8.2					f 8.20		
	C	5	5	5	5	5																				
	D	5	5	5	5	5																				
	A	5	5	5	5	5	249	248	i 246	258	258	25.9	26.0	i 24.8	25.3	25.4	8.0	8.0	i 8.4	7.6	7.6	8.41	8.04	i 8.46	8.01	8.06
Reference	B	5	5	5	5	5			f 283					f 24.3					f 8.2					f 8.10		
Control	C	5	5	5	5	5																				
	D	5	5	5	5	5																				
	A	~~5~~ JP							i					i					i					i		
	B	~~5~~							f					f					f					f		
	C	~~5~~																								
	D	~~5~~																								

Initial Counts QC'd by:

Animal Source/Date Received: Internal / NA

Age at Initiation: < 24 hours

Feeding Times	0	24	48	72	96
AM:	-	-	1235	-	-
PM:	-	-	-	-	-

Comments: i = initial reading in fresh test solution, f = final reading in test chamber prior to renewal

Organisms fed prior to initiation, circle one ([✓ y] / n)

QC Check: JC 12-1-11

Final Review: KL 12-14-11

Nautilus Environmental, LLC. 4340 Vandever Avenue. San Diego, CA 92120.

Acute Fathead Minnow

CETIS Summary Report

Report Date: 02 Dec-11 14:45 (p 1 of 1)
Test Code: 1111-S173 | 18-0461-7389

Fathead Minnow 96-h Acute Survival Test	**Nautilus Environmental (CA)**

Batch ID:	10-6545-1767	**Test Type:**	Survival (96h)	**Analyst:**	
Start Date:	15 Nov-11 15:20	**Protocol:**	EPA/821/R-02-012 (2002)	**Diluent:**	Not Applicable
Ending Date:	19 Nov-11 14:00	**Species:**	Pimephales promelas	**Brine:**	Not Applicable
Duration:	95h	**Source:**	Aquatic Biosystems, CO	**Age:**	10d

Sample ID:	01-3036-2812	**Code:**	11-0951	**Client:**	MWH Labs
Sample Date:	14 Nov-11 07:20	**Material:**	~~POTW~~ SC Effluent Sample	**Project:**	
Receive Date:	14 Nov-11 10:55	**Source:**	MWH Labs		
Sample Age:	32h	**Station:**	SD AWPF		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
06-3388-2429	96h Survival Rate	100	>100	N/A	10.8%	10.0 SC	Wilcoxon Rank Sum Two-Sample Test

Test Acceptability

Analysis ID	Endpoint	Attribute	Test Stat	TAC Limits	Overlap	Decision
06-3388-2429	96h Survival Rate	Control Resp	0.95	0.9 - NL	Yes	Passes Acceptability Criteria

96h Survival Rate Summary

Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Rec. Water	4	1	1	1	1	1	0	0	0.0%	0.0%
0	Lab Control	4	0.95	0.9127	0.9873	0.8	1	0.05	0.1	10.53%	5.0%
100		4	1	1	1	1	1	0	0	0.0%	0.0%

96h Survival Rate Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Rec. Water	1	1	1	1
0	Lab Control	1	1	0.8	1
100		1	1	1	1

Analyst: SC QA: KL 12/14/11

CETIS Analytical Report

Report Date: 02 Dec-11 14:45 (p 1 of 1)
Test Code: 1111-S173 | 18-0461-7389

Fathead Minnow 96-h Acute Survival Test — **Nautilus Environmental (CA)**

Analysis ID:	06-3388-2429	**Endpoint:**	96h Survival Rate	**CETIS Version:**	CETISv1.8.0
Analyzed:	02 Dec-11 14:43	**Analysis:**	Nonparametric-Two Sample	**Official Results:**	Yes

Data Transform	Zeta	Alt Hyp	MC Trials	Test Result	PMSD
Angular (Corrected)	0	C > T	Not Run	Sample passes 96h survival rate endpoint	10.8%

Wilcoxon Rank Sum Two-Sample Test

Control	vs	Conc-%	Test Stat	Critical	DF	Ties	P-Value	Decision(α:5%)
Lab Control		100	20		6	1	0.6571	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.007088488	0.007088488	1	1	0.3559	Non-Significant Effect
Error	0.04253092	0.007088488	6			
Total	0.04961941	0.01417698	7			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Mod Levene Equality of Variance	1	13.75	0.3559	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.7065	0.6451	0.0027	Non-normal Distribution

96h Survival Rate Summary

Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Lab Control	4	0.95	0.912	0.988	0.8	1	0.05	0.1	10.53%	0.0%
100		4	1	1	1	1	1	0	0	0.0%	-5.26%

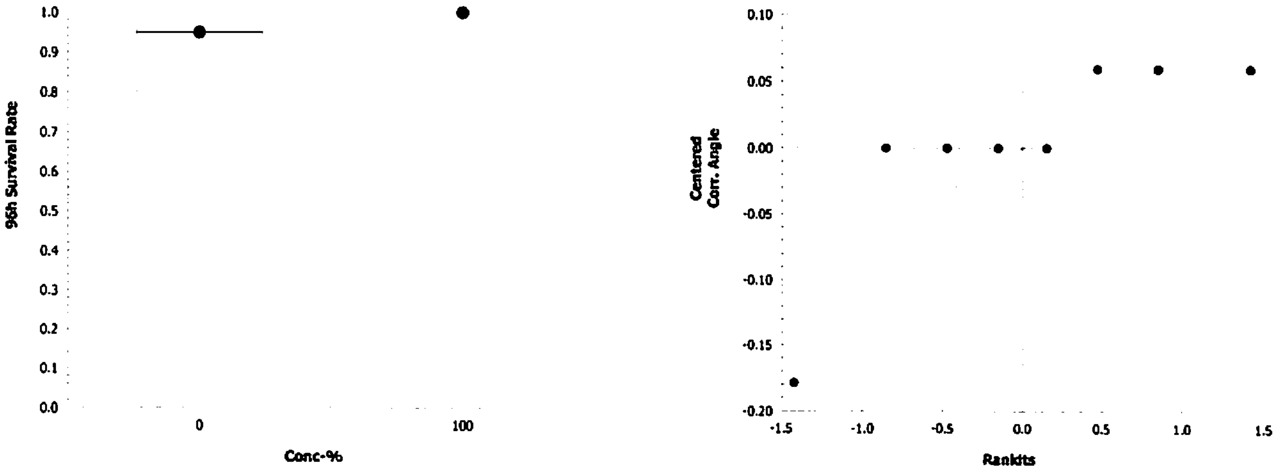
Angular (Corrected) Transformed Summary

Conc-%	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Lab Control	4	1.286	1.24	1.331	1.107	1.345	0.05953	0.1191	9.26%	0.0%
100		4	1.345	1.345	1.345	1.345	1.345	0	0	0.0%	-4.63%

96h Survival Rate Detail

Conc-%	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0	Lab Control	1	1	0.8	1
100		1	1	1	1

Graphics



Analyst: SC QA: KL 12/14/11

96-hour Freshwater Acute Bioassay
Static-Renewal Conditions

Water Quality Measurements
& Test Organism Survival

Client: MWH
Sample ID: ~~R.O. treated Effluent~~
Test No.: 1111-S173

Test Species: *P. promelas*
Start Date/Time: 11/15/2011 1520
End Date/Time: 11/19/2011 1400

Tech Initials	0	24	48	72	96
Counts:	JG	JP	JF	JP	JF
Readings:	JW	JF	JF	ES	ES
Dilutions made by:	PA		AD		

Concentration (%)	**Rep**	**Number of Live Organisms**					**Conductivity (µmhos/cm)**					**Temperature (°C)**					**Dissolved Oxygen (mg/L)**					**pH (units)**				
		0	**24**	**48**	**72**	**96**	**0**	**24**	**48**	**72**	**96**	**0**	**24**	**48**	**72**	**96** Q2	**0**	**24**	**48**	**72**	**96**	**0**	**24**	**48**	**72**	**96**
	A	5	5	5	5	5	195	204	i 195	198	206	25.6	25.9	i 24.2	25.4	24.0	7.2	7.5	i 6.9	7.4	7.7	8.25	8.11	i 8.07	8.07	8.16
Lab Control	**B**	5	5	5	5	5			f 207					f 25.1					f 6.5					f 8.01		
	C	5	5	5	5	4																				
	D	5	5	5	5	5																				
	A	5	5	5	5	5	305	313	i 303	321	343	25.2	25.7	i 26.0	25.3	23.8	9.0	7.7	i 8.1	6.7	8.0	8.60	7.97	i 8.60	7.56	7.94
100%	**B**	5	5	5	5	5			f 317					f 25.1					f 6.4					f 7.84		
	C	5	5	5	5	5																				
	D	5	5	5	5	5																				
	A	5	5	5	5	5	247	260	i 248	265	279	25.1	25.3	i 25.3	24.9	23.8	8.2	7.8	i 8.5	7.3	7.9	8.43	7.83	i 8.46	7.79	8.03
Reference	**B**	5	5	5	5	5			f 217					f 25.0					f 6.6					f 7.76		
Control	**C**	5	5	5	5	5																				
	D	5	5	5	5	5																				
	A	~~5~~							i					i					i					i		
	B	~~5~~	JW						f					f					f					f		
	C	~~5~~																								
	D	~~5~~																								

Initial Counts QC'd by: AG

Animal Source/Date Received: ABS 11/15/11

Age at Initiation: 10 days

Feeding Times	0	24	48	72	96
AM:	–	–	0830	–	–
PM:	–	–	–	–	–

Comments: i = initial reading in fresh test solution, f = final reading in test chamber prior to renewal

Organisms fed prior to initiation, circle one ([✓ y] / n)

QC Check: CZ 11/21/11

Final Review: SC 12-1-11

Nautilus Environmental, LLC. 4340 Vandever Avenue. San Diego, CA 92120.

Appendix C

Sample Receipt Information

& Mixing Worksheet

Nautilus Environmental
4340 Vandever Avenue
San Diego, CA 92120

Sample Check-In Information

Client: MWH
Sample ID: San Diego AWPF
Test ID No(s).: 1111-S169 to 174

	Lake Murray	SIO ~~Effluent~~	SIO Eff.	SIO Eff.
Sample (A, B, C):	Aquaduct	A	B	C
Log-in No. (11-xxxx):	0952	0951	0960	0976
Sample Collection Date & Time:	11/14/11 0928	11/14/11 0720	11/16/11 0850	11/18/11 0719
Sample Receipt Date & Time:	11/14/11 1055 →		11/16/11 0925	11/18/11 0900
Number of Containers & Container Type:	2-10L cubis	1-4L cubi	1-4L cubi	1~4L cubi
Approx. Total Volume Received (L):	~20 L	~4 L	≃3.5 L	~4L
Check-in Temperature (°C)	13.8	13.5	20.6	15.6
Temperature OK? [1]	[✓ Y] N	[✓ Y] N	[✓ Y] N	[✓ Y] N
DO (mg/L)	ES ~~6.84~~ 9.3	9.8	6.5	8.9
pH (units)	8.00	~~6~~ ES 5.68	5.61	5.27
Conductivity (µS/cm)	684	18.6	20	22.6
TDS (mg/L)	329	8.0	9.6	11.0
Alkalinity (mg/L)*	95	0.0	3	3
Hardness (mg/L)* [a]	170	0.0	1	7
Total Chlorine (mg/L)	0.06	0.57	0.70	0.53
Technician Initials	ES	ES	[illegible]	LN

Sample Description:
Lake Murray: colorless, clear, odorless, no debris
SIO A: colorless, clear, odorless, no debris
SIO B: Clear, colorless, odorless, no debris
SIO C: colorless, clear, odorless, no debris

COC Complete ([✓ Y]/N)?
A ✓ B ✓ C ✓

Filtration? Y [✓ N]
Pore Size:
Organisms or **Debris**

Salinity Adjustment? Y [✓ N]
Artificial Salts: target ppt:
Hypersaline Brine: target ppt:
Tests:
pH Adjustment? Y N (see worksheet)

	A	B	C
Initial pH:			
Amount of HCl added:			
Final pH:			

Cl₂ Adjustment? Y N (see worksheet)

	SIO Eff A	SIO Eff B	C
Initial Free Cl$_2$:	0.32	~~0.700~~ 0.14	0.28
STS added:			
Final Free Cl$_2$:			

Additional Comments:

Test Performed: Cerio Acute & Chronic
Laboratory Control: 20% diluted mineral water (8:2) Alkalinity: 80 Hardness: 86
Reference Control: DI water + Aquaduct water Alkalinity: 41-48 Hardness: 52-54

Test Performed: Fathead Acute & Chronic
Laboratory Control: 20% diluted mineral water (8:2) Alkalinity: 80 Hardness: 86
Reference Control: DI water + Aquaduct water Alkalinity: 41-40 Hardness: 52-54

Notes: [1] Temperature of sample should be 0-6°C, if received more than 24 hours past collection time.
* = mg/L as CaCO3, a = Measured for freshwater samples only, NA = Not Applicable

QC Check: 12-1-11
Final Review: KL 12-4-11

Nautilus Environmental
4340 Vandever Avenue
San Diego, CA 92120

Client: MWH - SD AWPF
Sample ID: MIXING WORKSHEET
Test ID No(s).: 1111-5169 to 174

Sample Check-In Information

Sample Mixtures (A, B, C):	**Aquaduct + "A" Sample**	**Aquaduct + "B" Sample**	**Aquaduct + "C" Sample**	Reference Control A	Reference Control B	Reference Control C
Percent Aquaduct Water (%):	33	33	33	34	34	34
Percent ~~RO-treated~~ UV/AOP SC Sample (%):	67	67	67	66	66	66
Final Hardness of Mixture (aim for 50 mg/L):	51 mg/L	52 mg/L	53 mg/L	52 mg/L	53 mg/L	54 mg/L
Initial pH (units):	7.07	7.04	7.12	7.87	7.94	8.02
Adjust to pH 8.5 with NaOH	11 drops 1.0N NaOH	13drops 1.0N NaOH	14drops 1.0N NaOH	5 drops 1.0N NaOH	3drops 1.0 NaOH	4 drops 1.0N NaOH
Final pH (units):	8.48	8.40	8.47	8.54	8.43	8.54
DO (mg/L)	8.9	9.0	8.7	8.0	8.6	8.5
Conductivity (µS/cm)	302	294	283	249	251	246
TDS (mg/L)	145	141	131	119	121	117
Alkalinity (mg/L)	39	JF ⇒ ~~1000~~ 38	43	41	JF ~~[illegible]~~ 46	48
Initial Free Chlorine (mg/L)	0.18	0.04	0.14	<0.02	<0.02	0.03
Add STS* to dechlorinate:	100mg → 4.5L	100mg → 4.5L	100mg → 4.5L	—	—	—
Final Free Chlorine (mg/L)	0.02	0.02	0.03	—	—	—
Technician Initials		PA/JF			PA/JF	

Test Performed: Cerio and Fathead (Acute + Chronic)

Laboratory Control: 20% diluted mineral water (8:2) Alkalinity: 80 Hardness: 86
Reference Control: DI water + Aquaduct water Alkalinity: 41-48 Hardness: 52-54

Additional Comments:

Test Performed:

Laboratory Control: 20% diluted mineral water (8:2) Alkalinity: Hardness:
Reference Control: DI water + Aquaduct water Alkalinity: Hardness:

Notes:

* Sodium Thiosulfate (STS) should remove both chlorine and peroxide.

QC Check: SC 12-1-11
Final Review: KL 12-14-11

Appendix D

Chain-of-Custody Forms And Data Qualifier Codes

Nautilus Environmental
4340 Vandever Avenue
San Diego, CA 92120
Phone 858.587.7333
Fax 858.587.3961

Chain of Custody

Date 11/14/11 Page 1 of 1

Sample Collection By: Michelle Berens / James Wright

Report to:

Company MWH
Address 9444 Farnham St, Suite 300
City/State/Zip San Diego, CA 92123
Contact Jay DeCarolis
Phone 619-204-2537
Email james.decarolis@mwhglobal.com

Invoice To:

Company
Address
City/State/Zip
Contact
Phone
Email

ANALYSES REQUIRED

	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	NO. OF CONTAINERS	COMMENTS		[illegible]	WET Toxicity								Receipt Temperature (°C)
1	S10_11-14-11	11/14/11	7:20	water	1 gal	1	peroxide = 3 mg/L ; pH = 5.51			X								13.5
2					plastic		temp = 22.5°C ; free Cl_2 = 0.05 mg/L											
3							tot Cl_2 = 1.04 mg/L ; cond = 16.89 uS/cm											
4	Lake Murray_11-14-11	11/14/11	9:28	water	~~3~~	2				X								13.8
5					2.5 gal													
6					plastic													
7																		
8																		
9																		
10																		

PROJECT INFORMATION		SAMPLE RECEIPT	
Client:	MWH	Total No. of Containers	3
PO No.:		Received Good Condition?	✓
Shipped Via:		Matches Test Schedule?	✓

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY (CLIENT)

(Signature) (Time) 10:55
(Printed Name) James Wright (Date) 11/14/11
(Company) MWH

RECEIVED BY (COURIER)

(Signature) (Time)
(Printed Name) (Date)
(Company)

RELINQUISHED BY (COURIER)

(Signature) (Time)
(Printed Name) (Date)
(Company)

RECEIVED BY (LABORATORY)

(Signature) (Time) 1055
(Printed Name) Elli Slaughter (Date) 11/14/11
(Company) Nautilus Log In No. 11-0951 -0952

Additional costs maybe required for sample disposal or storage.
Payment Net 30 unless otherwise contracted.

DISTRIBUTION: WHITE - Nautilus Environmental, COLOR - Originator

www.nautilusenvironmental.com

Nautilus Environmental
4340 Vandever Avenue
San Diego, CA 92120
Phone 858.587.7333
Fax 858.587.3961

Chain of Custody

Date 11/16/11 Page 1 of 1

Sample Collection By: Michelle Brnano / James Wright

Report to:
Company MNH
Address 9444 Farnham St Ste 300
City/State/Zip San Diego, CA 92123
Contact Jay DeCarolis
Phone 619-204-2537
Email James.decarolis@mnhglobal.com

Invoice To:
Company
Address
City/State/Zip
Contact
Phone
Email

	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	NO. OF CONTAINERS	COMMENTS	ANALYSES REQUIRED										Receipt Temperature (°C)
									WET TOXICITY									
1	S10-11-16-11	11/16/2011	8:50	W	1 gal plastic	1	free Cl 0.02 mg/L		X									20.6
2							total Cl 0.89 mg/L											
3							pH 5.38											
4							conductivity 18.98 µS/cm											
5							H₂O 3 mg/L											
6																		
7																		
8																		
9																		
10																		

PROJECT INFORMATION

Client:	MNH
PO No.:	
Shipped Via:	

SAMPLE RECEIPT

Total No. of Containers	1
Received Good Condition?	Y
Matches Test Schedule?	Y

SPECIAL INSTRUCTIONS/COMMENTS:

RELINQUISHED BY (CLIENT)
(Signature) (Time) 0925
(Printed Name) James Wright (Date) 11/16/11
(Company) MNH

RECEIVED BY (COURIER)
(Signature) (Time)
(Printed Name) (Date)
(Company)

RELINQUISHED BY (COURIER)
(Signature) (Time)
(Printed Name) (Date)
(Company)

RECEIVED BY (LABORATORY)
(Signature) Jessica Anderson (Time) 0925
(Printed Name) Jessica Andersen (Date) 11/16/11
(Company) 11-0960

Additional costs maybe required for sample disposal or storage.
Payment Net 30 unless otherwise contracted.

www.nautilusenvironmental.com

DISTRIBUTION: WHITE - Nautilus Environmental, COLOR - Originator

Nautilus Environmental
4340 Vandever Avenue
San Diego, CA 92120
Phone 858.587.7333
Fax 858.587.3961

Chain of Custody

Date 11/18/11 Page 1 of 1

Sample Collection By: Michelle Berens

Report to:

Company MWH
Address 9444 FARNHAM St Ste 300
City/State/Zip SAN DIEGO, CA 92123
Contact Jay DeCarolis
Phone 619-204-2557
Email james.decarolis@mwhglobal.com

Invoice To:

Company
Address
City/State/Zip
Contact
Phone
Email

ANALYSES REQUIRED

	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	NO. OF CONTAINERS	COMMENTS	WET Tox	Receipt Temperature (°C)
1	S10-11-18-11	11/18/11	0719	W	1 gal poly	1	pH = 5.60 temp = 21.1°C	X	5.6
2							free Cl_2 = 0.04 mg/L		
3							tot Cl_2 = 0.72 mg/L		
4							peroxide = 3.0 mg/L		
5							conductivity = ~~[illegible]~~ µS/cm		
6							18.44		
7									
8									
9									
10									

PROJECT INFORMATION

Client:	MWH
PO No.:	
Shipped Via:	

SAMPLE RECEIPT

Total No. of Containers	1
Received Good Condition?	✓
Matches Test Schedule?	✓

RELINQUISHED BY (CLIENT)

(Signature) (Time) 0900
(Printed Name) James Wright (Date) 11/18/11
(Company) MWH

RECEIVED BY (COURIER)

(Signature) (Time)
(Printed Name) (Date)
(Company)

RELINQUISHED BY (COURIER)

(Signature) (Time)
(Printed Name) (Date)
(Company)

RECEIVED BY (LABORATORY)

(Signature) Ashley Donohue (Time) 0900
(Printed Name) Ashley Donohue (Date) 11/18/11
(Company) Nautilus 11-0976

SPECIAL INSTRUCTIONS/COMMENTS:

**Additional costs maybe required for sample disposal or storage.
Payment Net 30 unless otherwise contracted.**

DISTRIBUTION: WHITE - Nautilus Environmental, COLOR - Originator

Glossary of Qualifier Codes:

Q1 - Temperatures out of recommended range; corrective action taken and recorded in Test Temperature Correction Log

Q2 - Temperatures out of recommended range; no action taken, test terminated same day

Q3 - Sample aerated prior to initiation or renewal due to dissolved oxygen (D.O.) levels below 6.0 mg/L

Q4 - Test aerated; D.O. levels dropped below 4.0 mg/L

Q5 - Test initiated with aeration due to an anticipated drop in D.O.

Q6 - Airline obstructed or fell out of replicate and replaced; drop in D.O. occurred

Q7 - Salinity out of recommended range; refer to QA section of report

Q8 - Spilled test chamber/ Unable to recover test organism(s)

Q9 - Inadequate sample volume remaining, 50% renewal performed

Q10 - Inadequate sample volume remaining, no renewal performed

Q11 -Sample out of holding time; refer to QA section of report

Q12 -Replicate(s) not initiated; excluded from data analysis

Q13 -Survival counts not recorded due to poor visibility or heavy debris

Updated: 3/31/2011

Appendix B

Quality Control Sample Results & Project Advisory Team Expert Review Memorandum Dr. Andy Eaton

Table B-1 Summary of QC Samples Collected Q1, Q2, Q3, and Q4 Testing Periods

Date	Laboratory	QC Sample Type	Sample Location (s)	Compounds
8/15/2011	CSM / MWH	split	S6, S9, S10	CEC's
8/15/2011	CSM	field blank	NA	CEC's
8/24/2011	WECK	blind duplicate	S10	Compounds monitored quarterly
8/24/2011	MWH / WECK	split	S10	Compounds monitored quarterly
9/1/2011	MWH	travel blank	NA	CEC's
9/14/2011	MWH	blind duplicate	S9	CEC's
9/14/2011	MWH	travel blank	NA	CEC's
10/17/2011	MWH	blind duplicate	S1	CEC's
10/17/2011	MWH	travel blank	NA	CEC's
11/2/2011	MWH /WECK	split	S1, S6, S7, S8, S9, S10	1,4 dioxane, NDMA
11/8/2011	WECK	blind duplicate	S1	Compounds monitored quarterly
11/8/2011	MWH	blind duplicate	S1	CEC's
11/8/3011	MWH	travel blank	NA	CEC's
11/8/2011	CSM / MWH	split	S1, S6, S9, S10, Imported	CEC's
11/8/2011	CSM	field blank	NA	CEC's
2/1/2012	CSM	field blank	NA	CEC's
2/1/2012	MWH	field blank	NA	CEC's
2/1/2012	CSM / MWH	split	S1, S6, S9, S10, Imported	CEC's
2/1/2012	MWH	blind duplicate	S6	CEC's
2/1/2012	WECK	blind duplicate	Imported Water	Compounds monitored quarterly
2/1/2012	MWH / WECK	spilt	S6, S9, S10	NDMA
2/8/2012	MWH / WECK	split	S9, S10	Formaldehyde
2/8/2012	MWH / WECK	spilt	S6, S9, S10	NDMA
2/8/2012	MWH	field blank	NA	CEC's
2/15/2012	MWH	field blank	NA	CEC's
2/15/2012	MWH / WECK	split	(S9, 10) / (S6, S9, S10)	Formaldehyde, TOC
2/22/2012	MWH	field blank	NA	CEC's
2/22/2012	MWH / WECK	split	(S9, 10) / (S10)	Formaldehyde, TOC
5/1/2012	WECK	blind duplicate	S10	Compounds monitored quarterly
5/1/2012	CSM	field blank	NA	CEC's
5/1/2012	MWH	field blank	NA	
5/1/2012	MWH	blind duplicate	S10	CEC's
5/1/2012	CSM / MWH	split	S6, S9, S10	CEC's
5/1/2012	MWH	field blank (1 L and 40 mL)	NA	CEC's
5/1/2012	MWH	duplicate (1 L and 40 mL)	S10	CEC's
7/30/2012	MWH	field blank (40 mL, 250 mL, 500 mL, 1 L)	NA	Triclosan, DEET
7/30/2012	MWH	duplicate (40 mL, 250 mL, 500 mL, 1 L)	S10	Triclosan, DEET

Table B-2 Summary of Blind Duplicate Samples from Quarterly Sampling Event Number 1 Results (8/24/11)

No.	Compound	MDL	RL	S10 Grab	Blind Duplicate	Difference	RPD (Actual)	RPD (Acceptance Criteria 1a & 2a)	RPD (Acceptance Criteria 2a & 2b)	Governing RPD	PASS / FAIL	NOTES
1	Bromodichloromethane	0.09	0.5	0.78	0.76	0.02	3%	32%	50%	50%	PASS	
2	Chloroform	0.12	0.5	1.4	1.5	0.1	7%	17%	20%	20%	PASS	
3	Methylene chloride	0.14	0.5	0.2	0.21	0.01	5%	122%	50%	122%	PASS	
4	THM's, Total	0.6	2	2.2	2.3	0.1	4%	44%	50%	50%	PASS	
5	2-Butanone	0.72	5	0.72	0.96	0.24	29%	298%	50%	298%	PASS	
6	Diethylphthalate	0.15	1	0.98	0.15	0.83	147%	88%	50%	88%	FAIL	Deemed acceptable as both results were below the RL.
7	Dimethylphthalate	0.07	2	0.21	0.07	0.14	100%	714%	50%	714%	PASS	
8	Di-n-butylphthalate	0.24	1	2.2	0.24	1.96	161%	41%	20%	41%	FAIL	Phthalates are prone to field and lab contamination and possible cause for poor precision.
9	Diethylphthalate	0.22	2	0.31	0.22	0.09	34%	377%	50%	377%	PASS	
10	Aluminum	0.61	5	3.6	7.5	3.9	70%	45%	50%	50%	FAIL	Original sample below the RL. Follow up with lab required.
11	Boron	0.28	1	240	240	0	0%	0%	20%	20%	PASS	
12	Calcium	0.016	0.1	0.025	0.033	0.008	28%	172%	50%	172%	PASS	
13	Lithium	1.4	10	1.4	1.4	0	0%	357%	50%	357%	PASS	
14	Lead	0.011	0.2	0.03	0.05	0.02	50%	250%	50%	250%	PASS	
15	Mercury	0.0039	0.05	0.016	0.014	0.002	13%	167%	50%	167%	PASS	
16	Potassium	0.081	0.1	0.31	0.47	0.16	41%	13%	20%	20%	FAIL	Poor precision, but difference is reasonable for the method at the low concentrations.
17	Sodium	0.015	0.5	3.2	3.3	0.1	3%	8%	20%	20%	PASS	
18	Vanadium	0.047	0.5	0.05	0.22	0.17	126%	185%	50%	185%	PASS	
19	Chloride	0.1	0.5	2.8	2.8	0	0%	9%	20%	20%	PASS	
20	Fluoride	0.02	0.1	0.025	0.02	0.005	22%	222%	50%	222%	PASS	
21	Sulfate	0.1	0.5	0.1	0.16	0.06	46%	192%	50%	192%	PASS	
22	Total anions	0.02	0.078	0.18	0.19	0.01	5%	21%	20%	21%	PASS	
23	Total cations	0.0045	0.038	0.15	0.16	0.01	6%	12%	20%	20%	PASS	
24	pH (units)	0.1	0.1	5.82	5.96	0.14	2%	1%	20%	20%	PASS	
25	Odor	1	1	1	1	0	0%	50%	50%	50%	PASS	
26	Nitrate	0.18	0.5	3.1	3.1	0	0%	8%	20%	20%	PASS	
27	Nitrite/Nitrate as N	10	100	700	700	0	0%	7%	20%	20%	PASS	
28	Total dissolved solids	4	10	16	14	2	13%	33%	50%	50%	PASS	
29	Specific Conductance	0.23	2	22	22	0	0%	5%	20%	20%	PASS	
30	Total organic carbon	0.009	0.3	0.86	0.48	0.38	57%	22%	20%	22%	FAIL	Suggests either inhomogeneity or a problem with the method at these methods. Additional split samples collected. Issue resolved.
31	Total alkalinity	0.56	2	2.6	3	0.4	14%	36%	50%	50%	PASS	
32	Bicarbonate alkalinity	0.56	2	3.2	3.6	0.4	12%	29%	50%	50%	PASS	
33	Langelier Index @20C	-10	-10	-6.64	-6.32	0.32	-5%	77%	20%	77%	PASS	
34	Langelier Index @60C	-10	-10	-6.1	-5.79	0.31	-5%	84%	20%	84%	PASS	
35	Acetaldehyde	0.34	2	0.8	0.37	0.43	74%	171%	50%	171%	PASS	
36	Cyclohexanone	0.38	2	0.72	1.1	0.38	42%	110%	50%	110%	PASS	
37	Formaldehyde	0.26	2	8.9	9.4	0.5	5%	11%	20%	20%	PASS	
38	N-Nitrosodimethylamine	0.28	2	0.35	0.28	0.07	22%	317%	50%	317%	PASS	

Note: Criteria 1 = a) If the result of the original sample was within 2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) the relative percent difference (RPD) should be 50%), whichever is higher. Criteria 2 = a) If the result of the original sample was >2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) RPD of 20%, whichever higher.

Table B-3 Summary of Blind Duplicate Samples from Quarterly Sampling Event Number 2 Results (11/8/11)

No.	Compound	MDL	RL	Units	S1 Sample	Blind Duplicate	Difference	RPD (Actual)	RPD (Acceptance Criteria 1a & 2a)	RPD (Acceptance Criteria 2a & 2b)	Governing RPD	PASS / FAIL	NOTES
1	Aluminum, Total	0.61	5	ug/l	8.8	9	0.2	2%	28%	50%	50%	PASS	
2	Antimony, Total	0.04	0.5	ug/l	0.53	0.52	0.01	2%	48%	50%	50%	PASS	
3	Arsenic, Total	0.036	0.4	ug/l	0.98	0.96	0.02	2%	21%	20%	21%	PASS	
4	Barium, Total	0.03	0.5	ug/l	18	18	0	0%	1%	20%	20%	PASS	
5	Chromium, Total	0.074	0.2	ug/l	0.56	0.58	0.02	4%	18%	20%	20%	PASS	
6	Copper, Total	0.27	0.5	ug/l	1.8	1.8	0	0%	14%	20%	20%	PASS	
7	Fluoride, Total	0.04	0.2	mg/l	0.63	0.63	0	0%	16%	20%	20%	PASS	
8	Gross Alpha	0	0	pCi/L	5.78+/-0.393 MDA=0.016	3.74+/-0.32 MDA=0.016	2.04	43%	0%	20%	20%	NA	Criteria not applicable results provided with different counting errors and MDAs.
9	HAA5, Total		1	ug/l	1.5	1.6	0.1	6%	32%	50%	50%	PASS	
10	Nickel, Total	0.13	0.8	ug/l	3.5	3.6	0.1	3%	11%	20%	20%	PASS	
11	Nitrate as NO3	0.36	1	mg/l	70	70	0	0%	1%	20%	20%	PASS	
12	NO2+NO3 as N	20	200	ug/l	16000	16000	0	0%	1%	20%	20%	PASS	
13	Perchlorate	0.95	2	ug/l	4.9	5.2	0.3	6%	20%	20%	20%	PASS	
14	Selenium, Total	0.28	0.4	ug/l	0.57	0.5	0.07	13%	37%	50%	50%	PASS	
15	Aluminum, Total	0.61	5	ug/l	8.8	9	0.2	2%	28%	50%	50%	PASS	
16	Chloride, Total	1	5	mg/l	240	240	0	0%	1%	20%	20%	PASS	
17	Color		3	Color Units	20	20	0	0%	8%	20%	20%	PASS	
18	Copper, Total	0.27	0.5	ug/l	1.8	1.8	0	0%	14%	20%	20%	PASS	
19	Iron, Total	1.1	10	ug/l	73	72	1	1%	7%	20%	20%	PASS	
20	Manganese, Total	0.11	0.2	ug/l	70	71	1	1%	0%	20%	20%	PASS	
21	Specific Conductance (EC)	0.23	2	umhos/cm	1100	1100	0	0%	0%	20%	20%	PASS	
22	Sulfate as SO4	1	5	mg/l	130	130	0	0%	2%	20%	20%	PASS	
23	Threshold Odor Number		1	T.O.N.	2	1	1	67%	33%	50%	50%	FAIL	Poor precision, but difference is reasonable for the method at the low concentrations.
24	Total Dissolved Solids	4	10	mg/l	760	680	80	11%	1%	20%	20%	PASS	
25	Zinc, Total	1.1	5	ug/l	48	49	1	2%	5%	20%	20%	PASS	
26	Antimony, Total	0.04	0.5	ug/l	0.53	0.52	0.01	2%	48%	50%	50%	PASS	
27	Arsenic, Total	0.036	0.4	ug/l	0.98	0.96	0.02	2%	21%	20%	21%	PASS	
28	Bromodichloromethane	0.09	0.5	ug/l	0.58	0.59	0.01	2%	43%	50%	50%	PASS	
29	Chloroform	0.12	0.5	ug/l	0.8	0.83	0.03	4%	31%	50%	50%	PASS	
30	Chromium, Total	0.074	0.2	ug/l	0.56	0.58	0.02	4%	18%	20%	20%	PASS	
31	Copper, Total	0.27	0.5	ug/l	1.8	1.8	0	0%	14%	20%	20%	PASS	
32	Nickel, Total	0.13	0.8	ug/l	3.5	3.6	0.1	3%	11%	20%	20%	PASS	
33	Selenium, Total	0.28	0.4	ug/l	0.57	0.5	0.07	13%	37%	50%	50%	PASS	
34	Zinc, Total	1.1	5	ug/l	48	49	1	2%	5%	20%	20%	PASS	
35	1,4-Dioxane	0.04	0.5	ug/l	5.6	5.8	0.2	4%	4%	20%	20%	PASS	
36	Boron, Total	0.28	1	ug/l	340	350	10	3%	0%	20%	20%	PASS	
37	Chlorate	1.9	20	ug/l	580	650	70	11%	2%	20%	20%	PASS	
38	Formaldehyde	0.26	2	ug/l	6	6.4	0.4	6%	16%	20%	20%	PASS	
39	Manganese, Total	0.11	0.2	ug/l	70	71	1	1%	0%	20%	20%	PASS	
40	N-Nitrosodiethylamine	0.72	2	ng/l	2	2.4	0.4	18%	45%	50%	50%	PASS	
41	N-Nitrosodimethylamine	0.28	2	ng/l	2	2.1	0.1	5%	49%	50%	50%	PASS	
42	N-Nitrosodi-n-propylamine	0.35	2	ng/l	2	3.4	1.4	52%	37%	50%	50%	FAIL	Sample result at RL, RPD close to criteria.
43	Lithium, Total	1.4	10	ug/l	20	22	2	10%	24%	50%	50%	PASS	

Note: Criteria 1 = a) If the result of the original sample was within 2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) the relative percent difference (RPD) should be 50%), whichever is higher. Criteria 2 = a) If the result of the original sample was >2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) RPD of 20%, whichever higher.

Table B-4 Summary of Blind Duplicate Samples from Quarterly Sampling Event Number 3 Results (2/1/12)

No.	Compound	MDL	RL	Units	Imported Aquifer Water	Blind Duplicate	Difference	RPD (Actual)	RPD (Criteria 1)	RPD (Criteria 2)	Governing RPD	PASS / FAIL	NOTES
1	Aluminum, Total	0.61	5	ug/l	29	29	0	0%	9%	20%	20%	PASS	
2	Arsenic, Total	0.036	0.4	ug/l	2	2	0	0%	10%	20%	20%	PASS	
3	Barium, Total	0.03	0.5	ug/l	47	48	1	2%	1%	20%	20%	PASS	
4	Copper, Total	0.27	0.5	ug/l	3	3.1	0.1	3%	8%	20%	20%	PASS	
5	Fluoride, Total	0.02	0.1	mg/l	0.13	0.12	0.01	8%	40%	50%	50%	PASS	
6	Gross Alpha			pCi/L	2.3+/-0.68 MDA=1	1.5+/-0.642 MDA=1	0.8	42%	0%	20%	20%	NA	Criteria not applicable results provided with different counting errors and MDAs. Results deemed acceptable.
8	HAA5, Total		1	ug/l	5.7	5.4	0.3	5%	9%	20%	20%	PASS	
9	Nickel, Total	0.13	0.8	ug/l	1.1	1.1	0	0%	36%	50%	50%	PASS	
10	Nitrate as NO3	0.18	0.5	mg/l	1.3	1.3	0	0%	19%	20%	20%	PASS	
11	NO2+NO3 as N	0.01	0.1	mg/l	0.3	0.29	0.01	3%	17%	20%	20%	PASS	
14	Selenium, Total	0.28	0.4	ug/l	0.43	0.4	0.03	7%	48%	50%	50%	PASS	
16	THMs, Total	0.6	2	ug/l	33	35	2	6%	3%	20%	20%	PASS	
18	Uranium Rad	0.019	0.13	pCi/L	1.3	1.3	0	0%	5%	20%	20%	PASS	
19	Aluminum, Total	0.61	5	ug/l	29	29	0	0%	9%	20%	20%	PASS	
20	Chloride, Total	1	5	mg/l	63	63	0	0%	4%	20%	20%	PASS	
21	Copper, Total	0.27	0.5	ug/l	3	3.1	0.1	3%	8%	20%	20%	PASS	
22	Iron, Total	1.1	10	ug/l	35	37	2	6%	14%	20%	20%	PASS	
23	Manganese, Total	0.11	0.2	ug/l	4.3	4.4	0.1	2%	2%	20%	20%	PASS	
24	Specific Conductance (EC)	0.47	4	umhos/cm	520	520	0	0%	0%	20%	20%	PASS	
25	Sulfate as SO4	1	5	mg/l	73	73	0	0%	3%	20%	20%	PASS	
26	Total Dissolved Solids	4	10	mg/l	270	270	0	0%	2%	20%	20%	PASS	
27	Turbidity	0.024	0.1	NTU	0.35	0.47	0.12	29%	12%	20%	20%	FAIL	Poor precision, but difference is reasonable for the method at the low concentrations.
28	Arsenic, Total	0.036	0.4	ug/l	2	2	0	0%	10%	20%	20%	PASS	
29	Bromodichloromethane	0.09	0.5	ug/l	11	10	1	10%	2%	20%	20%	PASS	
30	Bromoform	0.19	0.5	ug/l	4	3.8	0.2	5%	6%	20%	20%	PASS	
31	Chloroform	0.12	0.5	ug/l	4.8	4.8	0	0%	5%	20%	20%	PASS	
32	Copper, Total	0.27	0.5	ug/l	3.1	3	0.1	3%	8%	20%	20%	PASS	
33	Dibromochloromethane	0.2	0.5	ug/l	15	14	1	7%	2%	20%	20%	PASS	
34	Nickel, Total	0.13	0.8	ug/l	1.1	1.1	0	0%	36%	50%	50%	PASS	
35	Selenium, Total	0.28	0.4	ug/l	0.4	0.43	0.03	7%	48%	50%	50%	PASS	
36	Boron, Total	0.28	1	ug/l	140	140	0	0%	0%	20%	20%	PASS	
37	Formaldehyde	0.26	2	ug/l	2.7	2.4	0.3	12%	39%	50%	50%	PASS	
38	Manganese, Total	0.11	0.2	ug/l	4.3	4.4	0.1	2%	2%	20%	20%	PASS	
39	Vanadium, Total	0.047	0.5	ug/l	2.7	2.8	0.1	4%	9%	20%	20%	PASS	
40	Lithium, Total	1.4	10	ug/l	14	13	1	7%	37%	50%	50%	PASS	

Note: Criteria 1 = a) If the result of the original sample was within 2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) the relative percent difference (RPD) should be 50%), whichever is higher. Criteria 2 = a) If the result of the original sample was >2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) RPD of 20%, whichever higher.

Table B-5 Summary of Blind Duplicate Samples from Quarterly Sampling Event Number 4 Results (5/1/12)

No.	Compound	MDL	RL	Units	S10 Sample	Blind Duplicate	Difference	RPD (Actual)	RPD (Criteria 1)	RPD (Criteria 2)	Governing RPD	PASS / FAIL	NOTES
1	Aluminum, Total	0.61	5	ug/l	5	9.1	4.1	58%	35%	50%	50%	FAIL	S10 Result at RL. RPD close to acceptance criteria.
2	Alkalinity as CaCO3	0.56	2	mg/l	3.4	2	1.4	52%	37%	50%	50%	FAIL	Blind Dupe at RL. RPD close to acceptance criteria.
3	Barium, Total	0.03	0.5	ug/l	0.5	0.7	0.2	33%	42%	50%	50%	PASS	
4	Bicarbonate Alkalinity as HCO3	0.56	2	mg/l	4.1	2.4	1.7	52%	31%	20%	31%	FAIL	RPD governing criteria 2 deemed applicable
5	Boron, Total	0.28	1	ug/l	290	290	0	0%	0%	20%	20%	PASS	
6	Chloride, Total	0.1	0.5	mg/l	3.9	3.8	0.1	3%	6%	20%	20%	PASS	
7	Formaldehyde	0.26	2	ug/l	6.5	6.5	0	0%	15%	20%	20%	PASS	
8	Manganese, Total	0.11	0.2	ug/l	0.2	0.22	0.02	10%	48%	50%	50%	PASS	
9	Nitrate as NO3	0.18	0.5	mg/l	4.3	4.3	0	0%	6%	20%	20%	PASS	
11	N-Nitrosodiethylamine	0.8	2.2	ng/l	4.9	2.2	2.7	76%	31%	20%	31%	FAIL	Follow up with lab required. UV/AOP should have removed NDEA.
12	NO2+NO3 as N	0.01	0.1	mg/l	0.97	0.98	0.01	1%	5%	20%	20%	PASS	
13	pH	0.1	0.1	Units	5.89	6.09	0.2	3%	1%	20%	20%	PASS	
14	Potassium, Total	0.081	0.1	mg/l	0.5	0.47	0.03	6%	10%	20%	20%	PASS	
15	Sodium, Total	0.015	0.5	mg/l	4.1	4.1	0	0%	6%	20%	20%	PASS	
16	Specific Conductance (EC)	0.23	2	umhos/cm	26	27	1	4%	4%	20%	20%	PASS	
17	Total Anions	0.02	0.078	meq/l	0.25	0.22	0.03	13%	17%	20%	20%	PASS	
18	Total Cations	0.0045	0.038	meq/l	0.2	0.2	0	0%	10%	20%	20%	PASS	
19	Total Dissolved Solids	4	10	mg/l	11	13	2	17%	42%	50%	50%	PASS	

Note: Criteria 1 = a) If the result of the original sample was within 2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) the relative percent difference (RPD) should be 50%), whichever is higher. Criteria 2 = a) If the result of the original sample was >2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) RPD of 20%, whichever higher.

Table B-6 Summary of Blind Duplicate Samples from Monthly CEC Sampling Results

				Sample Date: 9/14/2011							
No.	Compound	MDL	RL	S9 (RO Perm. Combined)	S9 (Dupe)	RPD	RPD (Acceptance Criteria 1a & 2a)	RPD (Acceptance Criteria 1b & 2b)	Governing RPD	PASS / FAIL	NOTES
1	Oxolinic acid	2.46	5	5	7.1	35%	41%	50%	50%	PASS	
2	Atenolol	3.88	5	7.7	5	43%	39%	50%	50%	PASS	
3	Triclosan	6.32	10	34	10	109%	23%	40%	40%	FAIL	Additional QC sampling conducted.
4	Acesulfame-K	20	20	65	20	106%	24%	40%	40%	FAIL	Additional QC sampling conducted.
5	2,4-D	4.98	5	6.4	5	25%	44%	50%	50%	PASS	

				Sample Date: 10/17/2011							
No.	Compound	MDL	RL	S1 (tertiary effluent)	S1 (tertiary effluent DUPE)	RPD	RPD (Acceptance Criteria 1a & 2a)	RPD (Acceptance Criteria 1b & 2b)	Governing RPD	PASS / FAIL	NOTES
1	Butalbital	2.9	5	25	27	8%	10%	40%	40%	PASS	
2	DIA	2.45	5	5	5.7	13%	47%	50%	50%	PASS	
3	Erythromycin	4.03	10	25	32	25%	18%	40%	40%	PASS	
4	Simazine	1.23	5	11	10	10%	24%	40%	40%	PASS	
5	Primidone	5.66	5	76	70	8%	3%	40%	40%	PASS	
6	DEET	1.08	2	180	160	12%	1%	40%	40%	PASS	
7	TDCPP	5	100	710	880	21%	6%	40%	40%	PASS	
8	Lidocaine	1.11	5	90	90	0%	3%	40%	40%	PASS	
9	Diclofenac	3.3	5	59	71	18%	4%	40%	40%	PASS	
10	Albuterol	2.45	5	9.9	8.7	13%	27%	50%	50%	PASS	
11	Nifedipine	12.4	20	40	37	8%	26%	50%	50%	PASS	
12	Ketoprofen	2.59	5	38	33	14%	7%	40%	40%	PASS	
13	Naproxen	8.51	10	13	14	7%	37%	50%	50%	PASS	
14	4-nonylphenol - semi quantitative	50	100	200	230	14%	23%	50%	50%	PASS	
15	Gemfibrozil	2.47	5	34	33	3%	7%	40%	40%	PASS	
16	Amoxicillin (semi-quantitative)	6.39	20	960	800	18%	1%	40%	40%	PASS	
17	Atenolol	3.88	5	59	71	18%	4%	40%	40%	PASS	
18	Carbamazepine	1.21	5	190	200	5%	1%	40%	40%	PASS	
19	Diuron	1.8	5	74	77	4%	3%	40%	40%	PASS	
20	Triclosan	6.32	10	140	150	7%	3%	40%	40%	PASS	
21	DACT	3.92	5	26	10	89%	14%	40%	40%	FAIL	Results below or close to RL deemed acceptable.
22	Cotinine	4.85	10	25	10	86%	29%	40%	40%	FAIL	Results below or close to RL deemed acceptable.
23	Cimetidine	2.71	5	12	14	15%	19%	40%	40%	PASS	
24	TCEP	3.18	5	520	520	0%	0%	40%	40%	PASS	
25	Fluoxetine	10	10	39	43	10%	12%	40%	40%	PASS	
26	Acesulfame-K	20	20	33000	33000	0%	0%	40%	40%	PASS	
27	Sucralose	42.2	100	50000	52000	4%	0%	40%	40%	PASS	
28	Dilantin	12.6	20	110	96	14%	10%	40%	40%	PASS	
29	Meprobamate	2.03	5	92	88	4%	3%	40%	40%	PASS	
30	Caffeine	4.31	5	36	28	25%	8%	40%	40%	PASS	
31	Iohexal	7.74	10	4500	4100	9%	0%	40%	40%	PASS	
32	Dehydronifedipine	1.35	5	360	380	5%	1%	40%	40%	PASS	
33	Carbadox	4.19	5	5.7	5.7	0%	44%	50%	50%	PASS	
34	Sulfamethoxazole	2.82	5	470	490	4%	1%	40%	40%	PASS	
35	Trimethoprim	1.81	5	200	260	26%	1%	40%	40%	PASS	
36	Carisoprodol	1.19	5	62	67	8%	4%	40%	40%	PASS	

Table B-6 Summary of Blind Duplicate Samples from Monthly CEC Sampling Results (Cont.)

				Sample Date: 11/8/2011							
No.	Compound	MDL	RL	S1 (tertiary effluent)	S1 (dupe)	RPD	RPD (Acceptance Criteria 1a & 2a)	RPD (Acceptance Criteria 1b & 2b)	Governing RPD	PASS / FAIL	NOTES
1	Butalbital	2.9	5	21	17	21%	13%	40%	40%	PASS	
2	Acetaminophen	3.01	5	10	5	67%	33%	50%	50%	FAIL	Results below or close to RL deemed acceptable.
3	Erythromycin	4.03	10	45	55	20%	10%	40%	40%	PASS	
4	Simazine	1.23	5	7.4	8	8%	32%	50%	50%	PASS	
5	Primidone	5.66	5	65	66	2%	4%	40%	40%	PASS	
6	DEET	1.08	2	160	180	12%	1%	40%	40%	PASS	
7	TDCPP	5	100	320	260	21%	17%	40%	40%	PASS	
8	Lidocaine	1.11	5	120	140	15%	2%	40%	40%	PASS	
9	Diclofenac	3.3	5	95	65	38%	3%	40%	40%	PASS	
10	Albuterol	2.45	5	10	12	18%	23%	50%	50%	PASS	
11	Nifedipine	12.4	20	57	51	11%	19%	40%	40%	PASS	
12	Naproxen	8.51	10	19	22	15%	24%	50%	50%	PASS	
13	4-nonylphenol - semi quantitative	50	100	330	440	29%	13%	40%	40%	PASS	
14	Gemfibrozil	2.47	5	28	23	20%	10%	40%	40%	PASS	
15	Amoxicillin (semi-quantitative)	6.39	20	320	400	22%	3%	40%	40%	PASS	
16	Atenolol	3.88	5	150	140	7%	2%	40%	40%	PASS	
17	Carbamazepine	1.21	5	170	180	6%	1%	40%	40%	PASS	
18	Diuron	1.8	5	61	64	5%	4%	40%	40%	PASS	
19	Linuron	2.84	5	6.3	5.6	12%	42%	50%	50%	PASS	
20	Triclosan	6.32	10	84	78	7%	6%	40%	40%	PASS	
21	DACT	3.92	5	21	22	5%	12%	40%	40%	PASS	
22	Cotinine	4.85	10	31	37	18%	15%	40%	40%	PASS	
23	Lopressor	5.14	20	270	280	4%	4%	40%	40%	PASS	
24	TCEP	3.18	5	410	340	19%	1%	40%	40%	PASS	
25	Fluoxetine	10	10	28	35	22%	16%	40%	40%	PASS	
26	Acesulfame-K	20	20	28000	35000	22%	0%	40%	40%	PASS	
27	Sucralose	42.2	100	26000	29000	11%	0%	40%	40%	PASS	
28	Dilantin	12.6	20	130	120	8%	8%	40%	40%	PASS	
29	Meprobamate	2.03	5	120	120	0%	2%	40%	40%	PASS	
30	Caffeine	4.31	5	20	21	5%	12%	40%	40%	PASS	
31	Meclofenamic Acid	4.66	5	5	5.5	10%	48%	50%	50%	PASS	
32	Iohexal	7.74	10	4100	4700	14%	0%	40%	40%	PASS	
33	Dehydronifedipine	1.35	5	40	41	2%	6%	40%	40%	PASS	
34	Sulfamethoxazole	2.82	5	780	690	12%	0%	40%	40%	PASS	
35	Iopromide	1.59	5	27	56	70%	6%	40%	40%	FAIL	Results below or close to RL deemed acceptable.
36	Trimethoprim	1.81	5	120	120	0%	2%	40%	40%	PASS	
37	Carisoprodol	1.19	5	52	56	7%	5%	40%	40%	PASS	

Table B-6 Summary of Blind Duplicate Samples from Monthly CEC Sampling Results (Cont.)

				Sample Date: 2/1/2012							
No.	Compound	MDL	RL	S6	S6 Duplicate	RPD	RPD (Acceptance Criteria 1a & 2a)	RPD (Acceptance Criteria 1b & 2b)	Governing RPD	PASS / FAIL	NOTES
1	Acesulfame-K	20	20	48000	52000	8%	0%	40%	40%	PASS	
2	Albuterol	2.4	5	12	14	15%	19%	40%	40%	PASS	
3	Amoxicillin (semi-quantitative)	6.4	20	270	250	8%	4%	40%	40%	PASS	
4	Atenolol	3.9	5	42	33	24%	7%	40%	40%	PASS	
5	Butalbital	2.9	5	5	51	164%	9%	50%	50%	FAIL	Low value is suspect – not consistent with historical data.
6	Caffeine	4.3	5	9.8	10	2%	25%	50%	50%	PASS	
7	Carbamazepine	1.2	5	190	200	5%	1%	40%	40%	PASS	
8	Carisoprodol	1.2	5	780	1400	57%	0%	40%	40%	FAIL	May reflect heterogeneity between samples for this compound or possible dilution.
9	Cotinine	4.8	10	15	15	0%	33%	50%	50%	PASS	
10	DACT	3.9	5	11	8.2	29%	26%	40%	40%	PASS	
11	DEET	1.1	10	260	200	26%	2%	40%	40%	PASS	
12	Dehydronifedipine	1.4	5	140	160	13%	2%	40%	40%	PASS	
13	Diclofenac	3.3	5	18	16	12%	15%	40%	40%	PASS	
14	Dilantin	13	20	110	78	34%	11%	40%	40%	PASS	
15	Diuron	1.8	5	92	96	4%	3%	40%	40%	PASS	
16	Erythromycin	4	10	90	90	0%	6%	40%	40%	PASS	
17	Estrone	3.9	5	15	27	57%	12%	40%	40%	FAIL	No obvious reason for difference. May be inhomogeneity in sample.
18	Fluoxetine	10	10	100	92	8%	5%	40%	40%	PASS	
19	Gemfibrozil	2.5	5	79	86	8%	3%	40%	40%	PASS	
20	Iohexal	7.7	10	40000	46000	14%	0%	40%	40%	PASS	
21	Ketoprofen	2.6	5	75	60	22%	4%	40%	40%	PASS	
22	Lidocaine	1.1	5	220	260	17%	1%	40%	40%	PASS	
23	Linuron	2.8	5	210	170	21%	1%	40%	40%	PASS	
24	Lopressor	5.1	20	200	200	0%	5%	40%	40%	PASS	
25	Meprobamate	2	5	550	380	37%	1%	40%	40%	PASS	
26	Primidone	4.8	5	93	98	5%	3%	40%	40%	PASS	
27	Simazine	1.2	5	15	14	7%	17%	40%	40%	PASS	
28	Sucralose	42	100	45000	55000	20%	0%	40%	40%	PASS	
29	Sulfamethoxazole	2.8	5	1200	1200	0%	0%	40%	40%	PASS	
30	TCEP	3.2	10	400	390	3%	1%	40%	40%	PASS	
31	TCPP	20	100	1600	1900	17%	3%	40%	40%	PASS	
32	TDCPP	20	100	270	100	92%	27%	40%	40%	FAIL	Many of the flame retardants are semi-quantitative due to poor chromatographic resolutions.
33	Triclosan	6.3	10	74	69	7%	7%	40%	40%	PASS	
34	Trimethoprim	1.8	5	450	400	12%	1%	40%	40%	PASS	

Table B-6 Summary of Blind Duplicate Samples from Monthly CEC Sampling Results (Cont.)

				Sample Date: 5/1/2012							
No.	Compound	MDL	RL	S10	S10 Duplicate	RPD	RPD (Acceptance Criteria 1a & 2a)	RPD (Acceptance Criteria 1b & 2b)	Governing RPD	PASS / FAIL	NOTES
1	4-nonylphenol - semi quantitative	50	100	<50	<50	0%	NA	40%	NA	PASS	
2	Acesulfame-K	20	20	<20	<20	0%	NA	40%	NA	PASS	
3	Albuterol	2.4	5	<2.4	<5	0%	NA	40%	NA	PASS	
4	Amoxicillin (semi-quantitative)	6.4	20	<6.4	<6.4	0%	NA	40%	NA	PASS	
5	Atenolol	3.9	5	<3.9	<3.9	0%	NA	40%	NA	PASS	
6	Butalbital	2.9	5	<2.9	<2.9	0%	NA	40%	NA	PASS	
7	Caffeine	4.3	5	<4.3	<4.3	0%	NA	40%	NA	PASS	
8	Carbamazepine	1.2	5	<1.2	<1.2	0%	NA	40%	NA	PASS	
9	Carisoprodol	1.2	5	<1.2	<1.2	0%	NA	40%	NA	PASS	
10	Cotinine	4.8	10	<4.8	<4.8	0%	NA	40%	NA	PASS	
11	DACT	3.9	5	<3.9	<3.9	0%	NA	40%	NA	PASS	
12	DEET	1.1	10	<10	<10	0%	NA	40%	NA	PASS	
13	Dehydronifedipine	1.4	5	<1.4	<1.4	0%	NA	40%	NA	PASS	
14	Diclofenac	3.3	5	<3.3	<3.3	0%	NA	40%	NA	PASS	
15	Dilantin	13	20	<13	<13	0%	NA	40%	NA	PASS	
16	Diuron	1.8	5	<1.8	<1.8	0%	NA	40%	NA	PASS	
17	Erythromycin	4	10	<4	<4	0%	NA	40%	NA	PASS	
18	Estradiol	4.4	5	<4.4	<4.4	0%	NA	40%	NA	PASS	
19	Estrone	3.9	5	<3.9	<3.9	0%	NA	40%	NA	PASS	
20	Fluoxetine	10	10	<10	<10	0%	NA	40%	NA	PASS	
21	Gemfibrozil	2.5	5	<2.5	<2.5	0%	NA	40%	NA	PASS	
22	Iohexal	7.7	10	<7.7	<7.7	0%	NA	40%	NA	PASS	
23	Ketoprofen	2.6	5	<2.6	<2.6	0%	NA	40%	NA	PASS	
24	Lidocaine	1.1	5	<1.1	<1.1	0%	NA	40%	NA	PASS	
25	Linuron	2.8	5	<2.8	<2.8	0%	NA	40%	NA	PASS	
26	Lopressor	5.1	20	<5.1	<5.1	0%	NA	40%	NA	PASS	
27	Meprobamate	2	5	<2	<2	0%	NA	40%	NA	PASS	
28	Naproxen	8.5	10	<8.5	<8.5	0%	NA	40%	NA	PASS	
29	Primidone	4.8	5	<4.8	<4.8	0%	NA	40%	NA	PASS	
30	Simazine	1.2	5	<1.2	<1.2	0%	NA	40%	NA	PASS	
31	Sucralose	42	100	<42	<42	0%	NA	40%	NA	PASS	
32	Sulfamethoxazole	2.8	5	<2.8	<2.8	0%	NA	40%	NA	PASS	
33	TCEP	3.2	10	<10	<3.2	0%	NA	40%	NA	PASS	
34	TCPP	20	100	<20	<20	0%	NA	40%	NA	PASS	
35	TDCPP	20	100	<100	<20	0%	NA	40%	NA	PASS	
36	Theobromine	3.2	10	<10	<3.2	0%	NA	40%	NA	PASS	
37	Triclosan	6.3	10	<6.3	<6.3	0%	NA	40%	NA	PASS	
38	Trimethoprim	1.8	5	<1.8	<1.8	0%	NA	40%	NA	PASS	

Note: Criteria 1 = a) If the result of the original sample was within 2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) the relative percent difference (RPD) should be 50%), whichever is higher. Criteria 2 = a) If the result of the original sample was >2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) RPD of 40%, whichever higher. A total of 89 compounds were analyzed per sampling event. Results are only provided for compounds in which a value was reported above the ≥RL in the original or blind duplicate sample.

Table B-7 Summary of Split Samples from Quarterly Sampling Event Number 1 Results WECK and MWH Lab (8/24/11)

No.	Compound	MDL	RL	S10 Grab Result	DL	S10 Split Result	Difference	RPD (Actual)	RPD (Criteria 1)	RPD (Criteria 2)	Governing RPD	PASS / FAIL	NOTES
1	Bromodichloromethane	0.09	0.5	0.78	0.5	0.76	0.02	3%	32%	50%	50%	PASS	
2	Chloroform	0.12	0.5	1.4	0.5	1.3	0.1	7%	19%	20%	20%	PASS	
3	Methylene chloride	0.14	0.5	0.2	0.5	0.5	0.3	86%	71%	50%	71%	FAIL	Acceptable both results at below the RL or DL.
4	THM's, Total	0.6	2	2.2	0.5	2	0.2	10%	48%	50%	50%	PASS	
8	Diethylphthalate	0.22	2	0.31	0.5	0.5	0.19	47%	247%	50%	247%	PASS	
12	Aluminum	0.61	5	3.6	20	20	16.4	139%	21%	50%	50%	FAIL	Acceptable both results at below the RL or DL.
13	Boron	0.28	1	240	0.28	210	30	13%	0%	20%	20%	PASS	
14	Calcium	0.016	0.1	0.025	1	1	0.975	190%	10%	50%	50%	FAIL	Acceptable both results at below the RL or DL.
15	Lead	0.011	0.2	0.03	0.5	0.5	0.47	177%	38%	50%	50%	FAIL	Acceptable both results at below the RL or DL.
16	Mercury	0.0039	0.05	0.016	0.2	0.2	0.184	170%	23%	50%	50%	FAIL	Acceptable both results at below the RL or DL.
17	Potassium	0.081	0.1	0.31	1	1	0.69	105%	8%	20%	20%	FAIL	Acceptable both results at below the RL or DL.
18	Sodium	0.015	0.5	3.2	1	3.4	0.2	6%	8%	20%	20%	PASS	
21	Chloride	0.1	0.5	2.8	1	20	17.2	151%	2%	20%	20%	FAIL	Acceptable both results at below the RL or DL.
22	Fluoride	0.02	0.1	0.025	0.05	0.05	0.025	67%	133%	50%	133%	PASS	
24	Total anions	0.02	0.078	0.18	0.001	0.16	0.02	12%	23%	20%	23%	PASS	
25	Total cations	0.0045	0.038	0.15	0.001	0.15	0	0%	13%	20%	20%	PASS	
26	pH (units)	0.1	0.1	5.82	0.1	5.8	0.02	0%	1%	20%	20%	PASS	
27	Odor	1	1	1	1	1	0	0%	50%	50%	50%	PASS	
28	Nitrate	0.18	0.5	3.1	0.44	2.8	0.3	10%	8%	20%	20%	PASS	
29	Nitrite/Nitrate as N	10	100	700	100	650	50	7%	7%	20%	20%	PASS	
30	Total dissolved solids	4	10	16	10	14	2	13%	33%	50%	50%	PASS	
31	Specific Conductance	0.23	2	22	2	20	2	10%	5%	20%	20%	PASS	
32	Total organic carbon	0.009	0.3	0.86	0.3	0.3	0.56	97%	26%	20%	26%	FAIL	Difference in results warrants additional QC sampling. Completed.
33	Total alkalinity	0.56	2	2.6	2	2.3	0.3	12%	41%	50%	50%	PASS	
34	Bicarbonate alkalinity	0.56	2	3.2	2	2.9	0.3	10%	33%	50%	50%	PASS	
36	Langelier Index @60C	-10	-10	-6.1	-14	-5	1.1	-20%	90%	20%	90%	PASS	
37	Turbidity	0.024	0.1	0.024	0.05	0.068	0.044	96%	109%	50%	109%	PASS	
38	Gross Alpha	0.38	0.601	0.94	3	3	2.06	105%	15%	50%	50%	FAIL	Acceptable both results at below the RL or DL.
39	HAA5 Total		1	1	2	2	1	67%	33%	50%	50%	FAIL	Acceptable both results at below the RL or DL.
40	Acetaldehyde	0.34	2	0.8	1	1	0.2	22%	111%	50%	111%	PASS	
41	Formaldehyde	0.26	2	8.9	5	51	42.1	141%	3%	20%	20%	FAIL	Difference in results warrants additional QC sampling. Completed.
42	N-Nitrosodimethylamine	0.28	2	0.35	2	2	1.65	140%	85%	50%	85%	FAIL	Acceptable both results at below the RL or DL.

Note: Criteria 1 = a) If the result of the original sample was within 2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) the relative percent difference (RPD) should be 50%), whichever is higher. Criteria 2 = a) If the result of the original sample was >2 X RL then the difference in results between the two samples should be ± 1/2 RL or b) RPD of 20%, whichever higher.

Table B-8 Summary of Split Samples Results for CEC's (Samples Dates: 8/15/11, 11/8/11, 2/1/12, 5/1/12)

			Sample Date												
			8/15/2011				11/8/2011								
No.	Compound	Units	MWH Lab (RO Feed)	CSM Lab (RO Feed)	MWH-CSM S6	RPD (%)	MWH Lab (Tertiary Effluent)	CSM (Tertiary Effluent	MWH-CSM S1	RPD (%)	MWH Lab (RO Feed)	CSM Lab (RO Feed)	MWH-CSM S6	RPD	Assigned QC Assessment Category (1, 2 or 3)
1	4-n-Nonylphenol	ng/L	780	25	755	**188%**	330	25	305	**172%**	470	25	445	**180%**	3
2	Acetaminophen	ng/L	ND	ND		**-------**	10	1	9	**164%**	8.3	1	7.3	**157%**	3
3	Atenolol	ng/L	210	455	245	**74%**	150	172	22	**14%**	150	174	24	**15%**	2
4	Atrazine	ng/L	ND	ND		**------**	ND	ND		**------**	ND	ND		**------**	1
5	Caffeine	ng/L	28	50	22	**56%**	20	23.1	3.1	**14%**	6.7	17.1	10.4	**87%**	2
6	Carbamazepine	ng/L	170	243	73	**35%**	170	244	74	**36%**	160	241	81	**40%**	1
7	Cimetidine	ng/L	ND	ND		**------**	ND	ND		**------**	ND	ND		**------**	1
8	DEET	ng/L	180	327	147	**58%**	160	248	88	**43%**	170	255	85	**40%**	3
9	Diazepam	ng/L	ND	ND		**------**	2.06	3	0.94	**37%**	2.06	3	0.94	**37%**	1
10	Diclofenac	ng/L	58	184	126	**104%**	95	138	43	**37%**	70	139	69	**66%**	3
11	Dilantin	ng/L	82	156	74	**62%**	130	112	18	**15%**	110	113	3	**3%**	1
12	Estradiol 17B	ng/L	ND	ND		**------**	ND	ND		**------**	ND	ND		**------**	1
13	Estrone	ng/L	21	5	16	**123%**	ND	ND		**------**	ND	ND		**------**	2
14	Fluoexetine	ng/L	59	32.1	26.9	**59%**	28	43.4	15.4	**43%**	21	28	7	**29%**	2
15	Gemfibrizol	ng/L	62	73.9	11.9	**18%**	28	37.6	9.6	**29%**	24	36.1	12.1	**40%**	1
16	Ibuprofen	ng/L	ND	ND		**------**	ND	ND		**------**	ND	ND		**------**	1
17	Ketoprofen	ng/L	15	25	10	**50%**	ND	ND		**------**	ND	ND		**------**	2
18	Meprobamate	ng/L	200	295	95	**38%**	120	290	170	**83%**	120	287	167	**82%**	3
19	Methylparaben	ng/L	11.4	15.2	3.8	**29%**	11.4	8.3	3.1	**31%**	11.4	5.9	5.5	**64%**	1
20	Naproxen	ng/L	23	27.7	4.7	**19%**	19	23.5	4.5	**21%**	21	24.2	3.2	**14%**	1
21	Primidone	ng/L	96	110	14	**14%**	65	85.9	20.9	**28%**	62	88.8	26.8	**36%**	1
22	Progesterone	ng/L	ND	ND		**------**	ND	ND		**------**	ND	ND		**-------**	1
23	Propylparaben	ng/L	ND	ND		**------**	ND	ND		**------**	ND	ND		**------**	1
24	Sucralose	ng/L	20000	**------**		**------**	26000	**------**		**------**	22000	**------**		**------**	4
25	Sulfamethoxazole	ng/L	870	1563	693	**57%**	780	1630	850	**71%**	740	1310	570	**56%**	3
26	TCEP	ng/L	180	683	503	**117%**	410	401	9	**2%**	370	403	33	**9%**	1
27	TCPP	ng/L	------	------	------	**------**	------	------	------	**------**	------	------	------	**------**	4
28	TDCPP	ng/L	5	1338	1333	**199%**	320	1250	930	**118%**	130	1080	950	**157%**	3
29	Testosterone	ng/L	ND	ND		**------**	ND	ND		**------**	ND	ND		**-------**	1
30	Triclosan	ng/L	68	96.1	28.1	**34%**	84	79.3	4.7	**6%**	60	69	9	**14%**	2
31	Trimethoprim	ng/L	200	248	48	**21%**	120	153	33	**24%**	120	160	40	**29%**	1

Note: Assigned QC Assessment Categories: 1 =comparison of lab results for the given compound showed consistent agreement (i.e. RPD's < 40% or ND); 2 = comparison of lab results for the given compound showed consistent agreement for some results and discrepancies for others; possibly due to inhomogeneity in the samples and / or sample contamination. 3=comparison of lab results for the given compound showed consistent disagreement possibly due to systematic differences between laboratory analysis procedures 4) Results could not be compared due to insufficient data. 3. The potential for systematic analytical differences was evaluated by having CSM participate in a project for SAWPA that involved a total of 5 labs. Memorandum from Dr. Andy Eaton.

Table B-8 Summary of Split Samples Results for CEC's (Samples Dates: 8/15/11, 11/8/11, 2/1/12, 5/1/12) (continued)

No.	Compound	Units	2/1/2012															Assigned QC Assessment Category (1, 2 or 3)
			MWH Lab (RO Feed)	CSM Lab (RO Feed)	CSM Lab (RO Feed)	MWH-CSM	MWH Dupe-CSM	RPD (%)	RPD Dupe	MWH Lab (RO Permeate Combined)	CSM Lab (RO Permeate Combined)	MWH-CSM	RPD (%)	MWH Lab (UV/AOP Product)	CSM Lab (UV/AOP Product)	MWH-CSM	RPD (%)	
1	4-n-Nonylphenol	ng/L	ND	<100	ND			**------**		ND	ND		------	ND	ND		------	3
2	Acetaminophen	ng/L																3
3	Atenolol	ng/L	42	33	101	5900%	68	**83%**	1.014925373	ND	ND		------	ND	ND		------	2
4	Atrazine	ng/L	------	------	------	------	------	**------**	------	------	------		------				------	1
5	Caffeine	ng/L	9.8	10	24.9	1510%	14.9	**87%**	0.853868195	ND	ND		------	<5	ND		------	2
6	Carbamazepine	ng/L	190	200	242	5200%	42	**24%**	0.190045249	<5	ND		------	ND	ND		------	1
7	Cimetidine	ng/L	------	------	------	------	------	**------**	------	------	------		------	**------**	**------**		------	1
8	DEET	ng/L	260	200	58.7	20130%	141.3	**126%**	1.092385002	<6	ND		------	<6	ND		------	3
9	Diazepam	ng/L	------	------	------	------	------	**------**	------	------	------		------				------	1
10	Diclofenac	ng/L	18	16	145	12700%	129	**156%**	1.602484472	ND	ND		------	ND	ND		------	3
11	Dilantin	ng/L	110	78	127	1700%	49	**14%**	0.47804878	ND	ND		------	ND	ND		------	1
12	Estradiol 17B	ng/L	------	------	------	------	------	**------**	------	------	------		------	**------**	**------**		------	1
13	Estrone	ng/L	15	27	ND			**------**		ND	ND		------	<5	ND		------	2
14	Fluoexetine	ng/L	100	92	46.8	5320%	45.2	**72%**	0.65129683	ND	ND		------	ND	ND		------	2
15	Gemfibrizol	ng/L	79	86	70.1	890%	15.9	**12%**	0.203715567	ND	ND		------	<5	ND		------	1
16	Ibuprofen	ng/L	------	------	------	------	------	**------**	------	------	------		------				------	1
17	Ketoprofen	ng/L	75	60	ND			**------**		ND	ND		------	ND	ND		------	2
18	Meprobamate	ng/L	550	380	308	24200%	72	**56%**	0.209302326	ND	ND		------	ND	ND		------	3
19	Methylparaben	ng/L	------	------	------	------	------	**------**	------	------	------		------				------	1
20	Naproxen	ng/L	ND	ND	8.72			**------**		ND	ND		------	ND	ND		------	1
21	Primidone	ng/L	93	98	122	2900%	24	**27%**	0.218181818	ND	ND		------	ND	ND		------	1
22	Progesterone	ng/L	------	------	------	------	------	**------**	------	------	------		------				------	1
23	Propylparaben	ng/L	------	------	------	------	------	**------**	------	------	------		------				------	1
24	Sucralose	ng/L	45000	55000	-------			**------**	#VALUE!	<100			------	ND			------	4
25	Sulfamethoxazole	ng/L	1200	1200	1770	57000%	570	**38%**	0.383838384	ND	ND		------	ND	ND		------	3
26	TCEP	ng/L	400	390	456	5600%	66	**13%**	0.156028369	ND	ND		------	ND	ND		------	1
27	TCPP	ng/L	1600	1900	291	1309	1609	**138%**	1.468735737	ND	ND		------	ND	ND		------	4
28	TDCPP	ng/L	270	<100	156	11400%	#VALUE!	**54%**	#VALUE!	ND	ND		------	ND	ND		------	3
29	Testosterone	ng/L	------	------	------	------	------	**------**	------	------	------		------				------	1
30	Triclosan	ng/L	74	69	42.3	3170%	26.7	**55%**	0.479784367	13	ND		------	17	ND		------	2
31	Trimethoprim	ng/L	450	400	510	6000%	110	**13%**	0.241758242	<5	ND		------	<5	ND		------	1

Note: Assigned QC Assessment Categories: 1 =comparison of lab results for the given compound showed consistent agreement (i.e. RPD's < 40% or ND); 2 = comparison of lab results for the given compound showed consistent agreement for some results and discrepancies for others; possibly due to inhomogeneity in the samples and / or sample contamination. 3=comparison of lab results for the given compound showed consistent disagreement possibly due to systematic differences between laboratory analysis procedures 4) Results could not be compared due to insufficient data. 3. The potential for systematic analytical differences was evaluated by having CSM participate in a project for SAWPA that involved a total of 5 labs. Memorandum from Dr. Andy Eaton.

Table B-8 Summary of Split Samples Results for CEC's (Samples Dates: 8/15/11, 11/8/11, 2/1/12, 5/1/12) (continued)

No.	Compound	Units	5/1/2012												Assigned QC Assessment Category (1, 2 or 3)
			MWH Lab (RO Feed)	CSM Lab (RO Feed)	MWH-CSM	RPD (%)	MWH Lab (RO Permeate Combined)	CSM Lab (RO Permeate Combined)	MWH-CSM	RPD (%)	MWH Lab (UV/AOP Product)	CSM Lab (UV/AOP Product)	MWH-CSM	RPD (%)	
1	4-n-Nonylphenol	ng/L	520	25	495	**182%**	ND	BDL	------	**------**	ND	BDL	------	**------**	3
2	Acetaminophen	ng/L	-	BDL	------	**------**	ND	BDL	------	**------**	ND	BDL	------	**------**	3
3	Atenolol	ng/L	43	74.1	31	**53%**	ND	BDL	------	**------**	ND	BDL	------	**------**	2
4	Atrazine	ng/L	-	BDL	------	**------**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
5	Caffeine	ng/L	4.3	24.5	20	**140%**	ND	BDL	------	**------**	ND	BDL	------	**------**	2
6	Carbamazepine	ng/L	210	192	18	**9%**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
7	Cimetidine	ng/L	-	BDL	------	**------**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
8	DEET	ng/L	210	222	12	**6%**	<10	BDL	------	**------**	<10	BDL	------	**------**	3
9	Diazepam	ng/L	-	BDL	------	**------**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
10	Diclofenac	ng/L	3.3	129	126	**190%**	ND	BDL	------	**------**	ND	BDL	------	**------**	3
11	Dilantin	ng/L	140	133	7	**5%**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
12	Estradiol 17B	ng/L	<5	BDL	------	**------**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
13	Estrone	ng/L	<3.9	BDL	------	**------**	ND	BDL	------	**------**	ND	BDL	------	**------**	2
14	Fluoexetine	ng/L	31	27.1	4	**13%**	ND	BDL	------	**------**	ND	BDL	------	**------**	2
15	Gemfibrizol	ng/L	52	42.6	9	**20%**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
16	Ibuprofen	ng/L	-	BDL	------	**------**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
17	Ketoprofen	ng/L	17	5	12	**109%**	ND	BDL	------	**------**	ND	BDL	------	**------**	2
18	Meprobamate	ng/L	160	285	125	**56%**	ND	BDL	------	**------**	ND	BDL	------	**------**	3
19	Methylparaben	ng/L	-	BDL	------	**------**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
20	Naproxen	ng/L	8.5	12.8	4	**40%**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
21	Primidone	ng/L	97	112	15	**14%**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
22	Progesterone	ng/L	-	BDL	------	**------**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
23	Propylparaben	ng/L	-	BDL	------	**------**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
24	Sucralose	ng/L	48000	-	------	**------**	ND	-	------	**------**	ND	-	------	**------**	4
25	Sulfamethoxazole	ng/L	870	1130	260	**26%**	2.8	1.28	152%	**75%**	ND	BDL	------	**------**	3
26	TCEP	ng/L	270	451	181	**50%**	ND	BDL	------	**------**	<10	BDL	------	**------**	1
27	TCPP	ng/L	2300	357	1943	**146%**	ND	BDL	------	**------**	ND	BDL	------	**------**	4
28	TDCPP	ng/L	780	178	602	**126%**	ND	BDL	------	**------**	<100	BDL	------	**------**	3
29	Testosterone	ng/L	-	BDL	------	**------**	ND	BDL	------	**------**	ND	BDL	------	**------**	1
30	Triclosan	ng/L	28	36.8	9	**27%**	ND	BDL	------	**------**	ND	BDL	------	**------**	2
31	Trimethoprim	ng/L	280	298	18	**6%**	ND	BDL	------	**------**	ND	BDL	------	**------**	1

Note: Assigned QC Assessment Categories: 1 =comparison of lab results for the given compound showed consistent agreement (i.e. RPD's < 40% or ND); 2 = comparison of lab results for the given compound showed consistent agreement for some results and discrepancies for others; possibly due to inhomogeneity in the samples and / or sample contamination. 3=comparison of lab results for the given compound showed consistent disagreement possibly due to systematic differences between laboratory analysis procedures 4) Results could not be compared due to insufficient data. 3. The potential for systematic analytical differences was evaluated by having CSM participate in a project for SAWPA that involved a total of 5 labs. Memorandum from Dr. Andy Eaton.

eurofins | Eaton Analytical

Jennifer Thompson, PE
CDM-Smith
1925 Palomar Oaks Way, Suite 300
Carlsbad, CA 92008

September 10, 2012

Dear Ms. Thompson;

As part of the San Diego AWP Facility testing program, MWH Labs (now Eurofins Eaton Analytical, Inc.) tested a target list of ninety two (92) constituents of emerging concern (CEC) including those used in pesticides, herbicides, and pharmaceuticals and personal care products (PPCP) representing a wide variety of physical and chemical properties. Analysis were conducted monthly for the initial 4 months of testing on samples collected throughout the purification processes including tertiary effluent prior to chlorination, RO feed, RO permeate and UV/AOP product water and imported raw aqueduct water. Though 92 constituents were initially targeted results were only provided for 90 constituents due to poor precision on two constituents (Azithromycin and TCPP). Analysis of this many compounds in a single method requires optimization of the column and instrumentation to get consistent resolution. Azithromycin and TCPP were both added to the method after it was optimized for the other analytes however, the chromatographic performance for these compounds was determined to be inadequate to generate quantitative data and therefore removed from the target list.

Following the initial 4 months of testing a subset of constituents were selected for additional sampling due to their consistent presence in the RO feed, making them candidates to serve as performance indicators for the RO and/or UV/AOP. The subset of compounds also included CECs identified by the State Board Science Advisory Panel (SAP) prioritized for monitoring based on toxicological relevance and those identified as viable performance indicators along with surrogate parameters for surface spreading and direct injection of recycled water for groundwater recharge operations.

Overall the results of the CEC testing, including QC samples, showed the number and concentration of constituents detected at each sample location to be consistent and the overall data set is considered to be of high quality in terms of consistency, accuracy, and reproducibility. In nearly every case, where there were detections in the RO feed, there were significant decreases through the RO and into the UV/AOP influent and UV/AOP product. Of the 545 individual CEC compound measurements (i.e. 90 constituents tested monthly X 4 months + 37 constituents tested weekly X 4 weeks + 1 quarterly sampling event) for the UV/AOP product water generated during the testing period, only 5 results were reported above the associated reporting limit (RL). The results of these individual detections are summarized below, along with the concentrations measured in the RO feed and RO permeate at the same time. Additional information as well as scientific interpretation of the results for each constituent is also provided below.

Sample Date	Compound	RL (ng/L)	RO feed (ng/L)	RO permeate (ng/L)	UV/AOP product (ng/L)
9/14/11	Triclosan	10	37	34	19
9/14/11	Iohexal	10	8700	<10	19
9/14/11	Acesulfame-k	20	29000	65	50
2/1/12	Triclosan	10	74	13	17
2/15/12	Acesulfame-k	20	44000	<20	31

- **Triclosan** is used as a synthetic broad-spectrum antimicrobial agent. Triclosan is used in a variety of consumer products, such as antimicrobial hand soaps, toothpaste, and over-the-counter drugs. It also functions as a material preservative in adhesives, fabrics, vinyl, plastics (toys, toothbrushes), polyethylene, polyurethane, polypropylene, floor wax emulsions, textiles (footwear, clothing), caulking compounds, sealants, rubber, carpeting, and a wide variety of other products. While MWH Labs has not historically seen extensive issues with method blank or field blank contamination for this compound, there have been sporadic cases where it has shown up unexpectedly, which is most likely due to ambient field or lab contamination. Although it was not possible to identify specific sources of triclosan in the laboratory, the lab did determine that blanks were somewhat higher than normal on the days with two of the positive hits. It is worth noting that the SAP recommended using an RL of 50 ng/L for compliance monitoring because of the ubiquitous occurrence of triclosan. In the WateResearch Foundation (WaterRF) sponsored Project 4167, triclosan was one of only 6 compounds (out of 22) with false positive rates of >10% with RLs that ranged from 1 to 20 ng/L. In that project, MWH was not one of the labs that had false positives for triclosan, and there was also no issue with either field blanks or method blanks on another large wastewater effluent project conducted in June of 2011 and again in June of 2012. However the high blanks on several of the days associated with hits make these hits suspect.

- **Acesulfame-k** is a widely used artificial sweetener. Ace-K is used in a variety of consumables, including baked goods, soft drinks, sports drinks, chewable and liquid medications, and other foods. Ace-K was present at very high levels in the RO Feed (6400 ng/L to 48,000 ng/L). Thus the detections of 18-65 ng/L in the permeate represent an RO rejection rate exceeding 99.5%. If one also considers the other sample events where it was not detected, the rejection rate is likely even higher. The expected analytical precision of Ace-K at these levels is +/-50% (e.g. ~10 ng/L), so the values in the AOP product are very similar to those in the RO. Buerge (2009) had suggested in Germany that Ace-K was an ideal tracer of wastewater presence in groundwaters in part because of the high source concentrations and also due to its conservative behavior and lack of reactivity. Eurofins Eaton Analytical has analyzed over 2,000 samples for Ace-K (Eaton, WateReuse 2012) and found that in the U.S. concentrations in wastewater effluents are somewhat more variable than sucralose (proposed by the SAP as an indicator compound) but generally of the same order of magnitude in wastewater effluent concentration. The increased analytical sensitivity for this compound compared to sucralose makes it more likely to be detected even with high rejection rates.

- **Iohexal** This compound is used widely as an X-ray contrasting agent in a variety of hospital radiological tests, such as coronary angiographs. It is used much more frequently than iopromide, which was suggested by the SAP as a good performance indicator compound. Ioxhexal was only detected in 1 of 9 purified water samples, even though the typical RO feed water had between 5,000 and 40,000 ng/L. On the day that it was detected in the AOP product water, the RO permeate and a blind duplicate of the RO permeate had trace level detects below the RL of 10 ng/L. This suggests that the positive value in the AOP was likely impacted by analytical imprecision at that level. There is no stable isotope analog available for iohexal so it is potentially subject to signal enhancement or suppression, although there should be minimal matrix impact in RO permeate or AOP product. Again the very high influent values suggest that the removal efficiency, even if there were iohexal in the AOP product is greater than 99%.

During the testing program, RL's were adjusted for three CECs as described below.

DEET – The RL for this compound was originally 2 ng/L however, because the RL for this compound is subject to change based on concentrations detected in blanks in a given analysis batch, the RL was increased to 10 ng/L for all samples to ensure consistency and the ability to compare data.

Oxolinic Acid – The RL for this compound was originally 5 ng/L, however because this compound does not have a reliable secondary isotope for quantification, and is prone to baseline noise, increasing uncertainty in quantitation) the RL for all samples was increased to 10 ng/L.

Theobromine – The RL for this compound was originally 5 ng/L, however, because this compound does not have a reliable secondary isotope for quantification and is sensitive to matrix impacts on the signal response, the RL for all samples was increased to 10 ng/L.

As part of the overall testing program, split samples of CECs collected at various sampling locations were also analyzed by Colorado School of Mines. Comparison of results of MWH Labs and CSM Labs showed overall good agreement between results however there were some results with higher than expected discrepancies (i.e. relative percent difference > 50%). In order to investigate the potential cause of these discrepancies several steps were taken as discussed below.

- **Exchange of Standards** Both labs reviewed their raw data and exchanged and analyzed standards prepared by each other for compounds analyzed for the project. Of the standards analyzed, results were in close agreement for both labs, generally within 20%. This included those compounds where there were significant differences between the labs. CSM did determine that their sensitivity for acetaminophen might not be as good as initially through. This suggested that the cause of any discrepancy was not due to obvious calibration differences, but there could be some impact from method sensitivity.

- **Investigation of Sample Volume –** Some of the discrepancies between the lab results were associated with possible sample contamination**.** Because the labs used two different sample volumes (MWH Labs = 40 mL; CSM = 1000 mL) an investigation was undertaken to determine if the smaller sample volume was more prone to sample contamination. Results of the investigation targeting DEET and triclosan showed no conclusive evidence that sample volume impacted detections, although one round of initial testing did suggest that smaller sample volumes were more likely to be impacted by any ambient field contamination.

- **Third Part Study Participation -** In tandem with the San Diego AWP Facility testing, both MWH Labs and and CSM participated in a multi lab study conducted on behalf of the Santa Ana Watershed Project Authority (SAWPA). This study is now in its third year of sampling over twenty wastewater dischargers to the SAWPA watershed. For purposes of the San Diego IPR project however, the more important part of the study is the QC samples that are an integral part of it. Each laboratory analyzes two blind samples prepared by Environmental Resources Associates (ERA) for a set of 11 SAWPA designated contaminants of emerging concern (CECs) and also analyzes a split sample of water from the Santa Ana River collected below Prado dam (representative of a receiving water) for whatever CECs they can report with their analytical method. In 2010 and 2011, only 4 laboratories were involved in the study, but in 2012, SAWPA agreed to let CSM also analyze the ERA samples and the Prado Dam sample as a way of evaluating any systematic bias between MWH Labs and CSM that might explain some of the discrepancies in the San Diego results. Also note that the Prado Dam sample included a field blank. Detailed results from this study, including tables comparing lab performance, are available from SAWPA in their annual report on CECs (2012 report still in preparation).

  For the ERA sample, results generally agreed well among all four labs with only a few exceptions. One of these was acetaminophen, where CSM had unusually low recovery on a low level spike sample. In the San Diego split samples there were three compounds: Acetaminophen, DEET, and sulfamethoxazole, that had significant differences on one or more of the split samples. Thus the low bias from CSM may at least partially explain the San Diego differences, although one PT sample is insufficient to demonstrate a systematic issue and could instead indicate a one-time error. Since acetaminophen was not detected by either lab in the Prado Dam sample, it is not possible to determine if there was also a matrix issue. Results for DEET and Sulfamethoxazole generally agreed amongst all labs. This indicates that there are no obvious differences in analytical methods in clean matrices such as proficiency testing samples or river water, but because CSM did not test any of the effluent samples from the SAWPA project we cannot use these data to determine if there are possible method differences on more complex matrices such as the RO feed water.

Based on the investigation measures described above it seems that the most likely cause for the differences in results between MWH and CSM on some of the San Diego splits may well be sample inhomogeneity for the RO feedwater (S6), where there are solids present that might impact either the analytical methods themselves or the representativeness of the split itself.

There is no obvious explanation for the differences at purified water sites as both labs have demonstrated the ability to produce accurate results. It is worth noting that PPCP studies occasionally have apparent outliers on individual samples, particularly when measurements are near the reporting limit. This is likely because measurements are being made in the low ng/L level, where there are a myriad of potential sources for lab or field contamination. One of the reasons the SAP recommended reporting limits as high as 50 ng/L for triclosan was just that reason.

If you have any questions about these data do not hesitate to contact me.

Sincerely yours,

Andrew Eaton

Andrew Eaton, PhD
Vice President/Technical Director

Appendix C

Technical Memorandum: Summary of Third Party Data Validation of AWP Facility Quarterly Sampling Event Results.

· TECHNICAL MEMORANDUM

To:	Anthony Van	**Date:**	7/31/12
From:	Jay DeCarolis, PE	**CC:**	Marsi Steirer Bill Pearce

Subject: Summary of AWPF Third Party Data Validation of Quarterly Sampling Event Number 1 Results

Background.

Per the QA/QC plan outlined in the Final T&M Plan third-party validation was performed on the water quality data produced from WECK Laboratories, Inc. (WECK) and MWH Laboratories, Inc. (MWH) for samples collected during the first Quarterly sampling event conducted on 8/24/11. The purpose of the validation was to determine the data quality and review laboratory procedures in order to identify possible procedural alterations to be implemented for subsequent sampling events.

Data validation was performed was on results from samples collected from the UV/AOP product water (S10). These included original samples analyzed by WECK and split samples analyzed by MWH along with blind duplicate samples analyzed by WECK labs only. The specific fractions analyzed by each lab are provided in Appendix A and Appendix B, respectively.

Benefits of Third Party Validation

Third party validation is beneficial whenever analytical data may be subject to intense scrutiny that could result in the accuracy of the reported data being challenged in a court of law. The USEPA issued guidance documents1,2 detailing analytical data evaluation and review processes for inorganic and organic data produced under the EPA Contract Lab Program (CLP). The CLP supports a major portion of the sample analysis needs of the EPA Superfund Program. Due to the potential for legal challenges, samples submitted under this program must be analyzed in conformance with specified analytical protocols and the assembled data package must go through a technical quality assurance review (validation) prepared by an independent third party. In 1986, the Director of the Office of Emergency and Remedial Response proposed several levels of data validation.

Commercial third party specialists performing water quality data validation utilize the guidance issued under the EPA CLP program. Level IV review is the most rigorous and is characterized by quality assurance / quality control (QA/QC) protocols and documentation resulting in a complete qualitative and quantitative analysis of the

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[1] www.epa.gov/superfund/programs/clp/download.fgorg.pdf
[2] www.epa.gov/superfund/programs/clp/download/fginor.pdf

analytical data3. Data that fulfills the requirements of this level of third party validation fulfills the minimum data quality standards needed to allow the data to be used for its intended objective.

Selection and Credentials of Third Party Validation Firm

Many commercial firms are available to perform third party validations. Laboratory Data Consultants, Inc. (LDC) was selected to review the City's water quality data because they fulfill the following criteria:

- located locally in Carlsbad, CA
- disadvantaged business, 8(a) certified under Small Business Administration
- staffing capacity to meet rapid turn-around-time request
- previous experience validating WECK & MWH data
- wealth of prior water/wastewater laboratory experience in California firm
- subcontractor for EPA, Army Corps, AFCEE, Navy, DOE, DOD, and private consultants.

Protocols.

Laboratory Data Consultants, Inc. (LDC) performed all data validation analysis under EPA Level IV guidelines. Level IV review is the most rigorous and is characterized by QA/QC protocols and documentation resulting in a complete qualitative and quantitative analysis of the analytical data. Data that fulfills the requirements of this level of third party validation fulfills the minimum data quality standards needed to allow the data to be used for its intended objective. The analyses were validated using the following documents applicable to each method

- USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008.
- USEPA, CLP National Functional Guidelines for Inorganic Superfund Data Review, January 2010.
- USEPA, CLP National Functional Guidelines for Polychlorinated Dioxins / Dibenzofurans Data Review, Review, September 2005.
- Multiple Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual, July 2004.

Summary of Results

The third party validation process confirmed that the majority of the data met the strict analytical standards of the USEPA CLP. Given the large number of parameters and control statistics analyzed, it is always likely that a handful of parameters will not quite fulfill all of the validation criteria. Since split samples were collected for analysis by each of the laboratories, this summary section only calls out the sample

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[3] EPA 540/G 87/003A, Data Quality Objectives For Remedial Response Activities, March 1987)

parameter results that ended up being flagged and qualified for both laboratories or were flagged and only analyzed by one of the laboratories. Flagging of data is performed to denote lack of fulfillment with one or more of the CLP review criteria that could impact data detection or quantization. Flags are classified as P (protocol) or A (advisory) to indicate whether the flag is due to a laboratory deviation from a specified protocol or is of technical advisory nature. Flagged data is qualified to provide information on how the finding impacted the results. The following are definitions of the data qualifiers:

U	Indicates the compound or analyte was analyzed for but not detected at or above the stated limit.
J	Indicates an estimated value.
R	Quality control indicates the data is not usable.
NJ	Presumptive evidence of presence of the compound at an estimated quantity.
UJ	Indicates the compound or analyte was analyzed for but not detected. The sample detection limit is an estimated value.
None	Indicates the data was not significantly impacted by the finding, therefore qualification was not required.

All of the exceptions for either laboratory are detailed in the subsequent section. The project team contacted each laboratory to discuss the findings of the data validation and requested that any necessary procedural changes be implemented for analysis conducted In future sampling events.

Presentation and Interpretation of Third Party Validation Findings

WECK analyzed samples two sample sets utilizing 45 analytical methods as detailed in **Table A-1.** MWH analyzed samples from one sample location utilizing 56 analytical methods as detailed in **Table A-2**. Brief summaries of the items reviewed for each analytical methodology and description of the samples not fully meeting the analytical method requirements are provided below.

EPA Method 524.2 (Volatiles)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Instrument performance check met
4. Initial calibration performed with required standard concentrations

5. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
6. Method blanks contained no volatile contaminants
7. Surrogate spikes were within acceptable surrogate recoveries
8. Laboratory control samples (LCS) were within acceptable percent recoveries
9. Internal standards were within QC limits
10. Target compound identification were within validation criteria
11. Compound quantification and Reporting Limits were within validation criteria
12. System performance was acceptable
13. Overall assessment data
14. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The two (2) samples fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008.

The exceptions include:

- **Method Blanks –** No volatile contaminants were detected in the method blanks with the exception of bromodichloromethane (BDCM). As a result, the reported concentrations of BDCM were flagged as not detected at or above the stated values.
- **Laboratory Control Samples (LCS) –** All LCS's were within QC limits with the exception of dichlorofluoromethane. As a result the reported concentrations were flagged as estimates.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA SRL 524.2 M (1,2,3 Trichloropropane)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations

4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no volatile contaminants
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The two (2) samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified

EPA 625 (Semi-volatiles)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Instrument performance check met
4. Initial calibration performed with required standard concentrations
5. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
6. Method blanks contained no volatile contaminants
7. Surrogate spikes were within acceptable surrogate recoveries
8. Laboratory control samples (LCS) were within acceptable percent recoveries
9. Internal standards were within QC limits
10. Target compound identification were within validation criteria
11. Compound quantification and Reporting Limits were within validation criteria
12. System performance was acceptable
13. Overall assessment data
14. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The two (2) samples fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. The only exception was that the continuing calibration differences (%D) for the following compounds: **hexachlorocyclopentadiene, ideno (1,2,3 –cd) pyrene, dibenzoa (a,h) anthracene, and benzo (g,h,i) perylene** were above the acceptable value of 20%. Therefore, all reported results for these compounds were flagged as estimated values (all detects) or with estimated detection limits (all non detects).

MWH Laboratories

The sample fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008.

The exceptions include:

- **Continuing Calibration –** All continued calibration was performed at the required frequencies. However, the difference (%D) for one compound (benzidine) was greater than 20% on two occasions. Therefore, the result for this parameter was flagged with an estimated detection limit.
- **Laboratory Control Samples (LCS) –** All LCS's were within QC limits with the exception of one compound (**benzidine**). Therefore, the result for this parameter was flagged with an estimated detection limit.

EPA 525.2 (Semi-volatiles)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Instrument performance check met
4. Initial calibration performed with required standard concentrations
5. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
6. Method blanks contained no volatile contaminants
7. Surrogate spikes were within acceptable surrogate recoveries
8. Laboratory control samples (LCS) were within acceptable percent recoveries
9. Internal standards were within QC limits

10. Target compound identification were within validation criteria
11. Compound quantification and Reporting Limits were within validation criteria
12. System performance was acceptable
13. Overall assessment data
14. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The two (2) samples fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. The only exception was that the acceptable percent recovery (%R) and relative percent difference (RPD), respectively for LCS's of two compounds were not met. The compounds included **disulfoton** and **diazinon**. Therefore, all reported results for these compounds were flagged as estimated values (all detects) or with estimated detection limits (all non detects).

MWH Laboratories

The sample fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008.
The exception follows:

- **Continuing Calibration –** All continued calibration was performed at the required frequencies. However, the values of the difference (%D) between calibrations for three compounds (**aldrin, endrin aldehyde and permitrin)** were greater than 30% on one occasion. Therefore, all reported results for these compounds were flagged as estimated values (all detects) or with estimated detection limits (all non-detects).

EPA SW 486 Method 8270M (1,4 Dioxane)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Instrument performance check met
4. Initial calibration performed with required standard concentrations
5. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
6. Method blanks contained no trace of the target compound

7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Internal standards were within QC limits
9. Target compound identification were within validation criteria
10. Compound quantification and Reporting Limits were within validation criteria
11. System performance was acceptable
12. Overall assessment data
13. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The S10 sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. The Blind Duplicate sample also fulfilled all of the stated requirements within the exception that one of the internal standards **(1,4 Dioxane-d8)** was outside the QC requirements. Therefore, the reported result for this sample location had to be flagged with an estimated detection limit.

MWH Laboratories

This analysis was not performed by the MWH Laboratories. Instead 1,4 dioxane was analyzed using EPA Method 522.

EPA 522 (1,4 Dioxane)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Instrument performance check met
4. Initial calibration performed with required standard concentrations
5. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
6. Method blanks contained no trace of the target compound
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Internal standards were within QC limits
9. Target compound identification were within validation criteria
10. Compound quantification and Reporting Limits were within validation criteria
11. System performance was acceptable
12. Overall assessment data
13. Field duplicate relative percent difference for detected compounds

WECK Laboratories

This analysis was not performed by the WECK Laboratories. Instead 1,4 dioxane was analyzed using EPA SW 486 Method 8270M.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 508 (Chlorinated Pesticides and PCBs)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Instrument performance check met
4. Initial calibration performed with required standard concentrations
5. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
6. Method blanks contained no trace of the target compound(s)
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Internal standards were within QC limits
9. Target compound identification were within validation criteria
10. Compound quantification and Reporting Limits were within validation criteria
11. System performance was acceptable
12. Overall assessment data
13. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The two (2) samples fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008.

The exceptions include:

- **Continuing Calibration –** All continued calibration was performed at the required frequencies. However, the values of the difference (%D) between calibrations for two compounds (**alpha-BHC, hexachlorocyclopentadiene)** were greater than 20% and results for both sample locations were flagged as estimated values (all detects) or with estimated detection limits (all non-detects).

- **Surrogate Spikes –** The recovery (%R) of surrogate spikes for all compounds were within the QC limits for the S10 sample. However, the %R for the surrogate compound **decachlorobipheny**l was just outside the QC limits making it necessary to flag results as estimates.

MWH Laboratories

This analysis was not performed by the MWH Laboratories. Instead chlorinated pesticides and PCBs were analyzed using EPA Method 508 and 608.

EPA 505&608 (Chlorinated Pesticides and PCBs)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Instrument performance check met
4. Initial calibration performed with required standard concentrations
5. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
6. Method blanks contained no trace of the target compound(s)
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Internal standards were within QC limits
9. Target compound identification were within validation criteria
10. Compound quantification and Reporting Limits were within validation criteria
11. System performance was acceptable
12. Overall assessment data
13. Field duplicate relative percent difference for detected compounds

WECK Laboratories

This analysis was not performed by the WECK Laboratories. Instead chlorinated pesticides and PCBs were analyzed using EPA Method 508.

MWH Laboratories

The sample fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008.
The exception follows:

- **Initial Calibration** **–** Relative standard deviations associated with the initial calibration of the column for all required compounds were less than or equal to 10% with the exception of **delta-BHC and 4,4 DDT**. . Therefore, all reported results for these compounds were flagged as estimated values (all detects) or with estimated detection limits (all non-detects).

EPA 200.7, 200.8, and 245.1 (Metals)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Instrument performance check met
4. Initial calibration performed with required standard concentrations
5. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
6. Method blanks contained no trace of the target compound(s)
7. Matrix spikes %R and RPD were within QC limits
8. Laboratory control samples (LCS) were within acceptable percent recoveries
9. Internal standards were within QC limits
10. Target compound identification were within validation criteria
11. Compound quantification and Reporting Limits were within validation criteria
12. System performance was acceptable
13. Overall assessment data
14. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The two samples fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. The first exception was the detection of **aluminum and mercury** in the S10 sample method blank where concentrations in the samples were detected at values less than 5 X the concentration measured in the method blank. The second exception was the detection of **mercury** in the Blind duplicate sample method blank where concentrations in the samples were detected at values less than 5 X the concentration measured in the method blank. For both occurrences results were flagged as being analyzed but not detected at or above the stated limit.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 515.3 / 515.4 (Herbicides)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Matrix spikes %R and RPD were within QC limits
7. Duplicate samples analyses were reviewed for each matrix as applicable to assess if QC limits were met
8. Laboratory control samples (LCS) were within acceptable percent recoveries
9. Internal standards were within QC limits
10. Target compound identification were within validation criteria
11. Compound quantification and Reporting Limits were within validation criteria
12. System performance was acceptable
13. Overall assessment data
14. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The two samples fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

SM 2320 B (Alkalinity)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The two samples fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. The exceptions were the detection of alkalinity and bicarbonate alkalinity in both the S10 and Blind Duplicate samples method blanks where concentrations in the sample were detected at concentration less than 5 X the concentration measured in the method blank. Therefore these results had to be flagged as being analyzed but not detected at or above the stated limit.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 100.2 (Asbestos)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations

4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

EPA 326.0 / 317.0 (Bromate)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable

11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

Bromate analysis was performed using EPA 326.0. The samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

MWH Laboratories

Bromate analysis was performed using EPA 317.0. The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 300.1 (Chlorate and Chlorite)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

MWH Laboratories

Chlorate analysis of the sample using EPA 300.1 fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified. MWH Laboratories analyzed chlorite using EPA Method 300.0.

EPA 300.0 (Chloride, Chlorite, Nitrate, Nitrite, Fluoride, Sulfate)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

WECK Laboratories used EPA 300.0 to analyze chloride, fluoride and sulfate. The two samples fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. The only exception was the detection of fluoride in the S10 sample method blank where concentrations in the sample were detected at concentration less than 5 X the concentration measured in the method blank. Therefore these result had to be flagged as being analyzed but not detected at or above the stated limit.

MWH Laboratories

MWH Laboratories used EPA 300.0 to analyze chloride, chlorite, nitrate, nitrite and sulfate. The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

SM 2120 B (Color)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

SM 2150 B (Conductivity)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

EPA 335.4 / SM 4500 CN-F (Total Cyanide)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

Calculation for Hardness, Total Nitrogen, Total Anions, Total Cations)

EPA 218.6 (Hexavalent Chromium)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

SM 2330 B (Langlier Index)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

EPA 353.2 (Nitrate, Nitrite as Nitrogen, Nitrate/Nitrite as Nitrogen)
Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.
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MWH Laboratories

MWH Laboratories used EPA 300.0 to analyze nitrate and nitrite.

EPA 140.1 / SM 2150 B (Odor)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

Odor analysis was performed using EPA 140.1. The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010). No sample data was qualified.

MWH Laboratories

Odor analysis was performed using SM-2150 B. The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010). No sample data was qualified.

EPA 314.0 (Perchlorate)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

SM 4500 B (pH)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

EPA 365.1 (Total Phosphorus)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled most of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
The only exception was the detection of phosphorus in the Blind Duplicate sample method blank where concentrations in the sample were detected at concentration less than 5 X the concentration measured in the method blank. Therefore these result had to be flagged as being analyzed but not detected at or above the stated limit.

MWH Laboratories

The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

SM 5540 C / EPA 425.1 (Surfactants)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

Surfactant analysis was performed using SM 5540C. The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010). No sample data was qualified.

MWH Laboratories

Surfactant analysis was performed using SM 5540C & EPA 425.1. The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010). No sample data was qualified.

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SM 2540 C / EPA 160.1 (Total Dissolved Solids)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

SM 5310 C / EPA 415.3 (Total Organic Carbon)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

EPA 351.2 (Total Kjeldahl Nitrogen)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

EPA 180.1 (Turbidity)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The samples fulfilled all of the review requirements of the modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified

EPA 504.1 (1,2 Dibromoethane, 1,2-Dibromo-3-chloropropane)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. Internal standards were within QC limits
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA SW 836 Method 1613B (2,3,7,8-TCDD)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. HRGC/HRMS Instrument Performance Checked at required frequency
4. Initial calibration performed with required standard concentrations
5. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
6. Method blanks contained no trace of the target compound(s)
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Internal standards were within QC limits
9. Target compound identification were within validation criteria
10. Compound quantification and Reporting Limits were within validation criteria
11. System performance was acceptable
12. Overall assessment data
13. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Polychlorinated 2, 3, 7, 8-TCDD Data Review, (September 2005). No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Polychlorinated 2, 3, 7, 8-TCDD Data Review, (September 2005). No sample data was qualified.

EPA 900.0 (Gross Alpha and Beta Radioactivity)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. All minimum detectable activities met required detection limits.
8. Internal standards were within QC limits
9. Target compound identification were within validation criteria
10. Compound quantification and Reporting Limits were within validation criteria
11. System performance was acceptable
12. Overall assessment data
13. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
. No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

EPA 903.0 (Radium 226)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. All minimum detectable activities met required detection limits.
8. Sample result verifications were acceptable
9. System performance was acceptable
10. Overall assessment data
11. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

MWH Laboratories

The sample fulfilled most of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
The only exception was that the acceptable percent recovery (%R) and relative percent difference (RPD), respectively for LCS was not met. Therefore, the reported result for this parameter was flagged with an estimated detection limit.

EPA Ra-05 / EPA 904.0 (Radium 228)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. All carrier recoveries were within validation criteria.
8. All minimum detectable activities met required detection limits.
9. Sample result verifications were acceptable
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

WECK analyzed Radium 228 using EPA Method Ra-05. The samples fulfilled all of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010). No sample data was qualified.

MWH Laboratories

MWH analyzed Radium 228 using EPA Method 904.0. The sample fulfilled all of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010). No sample data was qualified.

EPA 906.0 (Tritium)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. All carrier recoveries were within validation criteria.
8. All minimum detectable activities met required detection limits.
9. Sample result verifications were acceptable
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled most of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
The only exception was that the acceptable percent recovery (%R) and relative percent difference (RPD), respectively for the LCS was not met. Therefore, the reported results were flagged to indicate the isotope was analyzed but not detected and the detection limit is estimated.

MWH Laboratories

The sample fulfilled all of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

EPA 901.1 (Gamma Spectroscopy)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. All carrier recoveries were within validation criteria.
8. All minimum detectable activities met required detection limits.
9. Sample result verifications were acceptable
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).

MWH Laboratories

MWH Laboratories did not perform this analysis.

EPA SW 846 Method 8330 (Explosives)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Surrogate recoveries were added to samples and blanks as required by the method.
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

MWH Laboratories

MWH Laboratories analyzed explosives using LCMS.

LCMS (Explosives)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Surrogate recoveries were added to samples and blanks as required by the method.
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

WECK Laboratories analyzed explosives using EPA SW 846 Method 8330.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA SW 846 Method 8015 B / 8270C (Ethylene Glycol)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Surrogate recoveries were added to samples and blanks as required by the method.
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

WECK Laboratories analyzed Ethylene Glycol using EPA SW 846 Method 8015B. The samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

MWH Laboratories

MWH Laboratories analyzed Ethylene Glycol using EPA SW 846 Method 8270C. The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 552.2 / 6251B (Haloacetic Acids)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Surrogate recoveries were added to samples and blanks as required by the method.
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

WECK Laboratories analyzed Haloacetic Acids using EPA Method 552.2. The samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

MWH Laboratories

MWH Laboratories analyzed Haloacetic Acids using EPA Method 6251 B. The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 905.0 (Strontium-90)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. All carrier recoveries were within validation criteria.
8. All minimum detectable activities met required detection limits.
9. Sample result verifications were acceptable
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled most of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
The only exception was that the acceptable percent recovery (%R) and relative percent difference (RPD), respectively for the LCS's were not met. Therefore, the reported results were flagged to indicate the isotope was analyzed but not detected and the detection limit is estimated.

MWH Laboratories

The sample fulfilled all of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).
No sample data was qualified.

EPA 556 (Aldehydes)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Surrogate recoveries were added to samples and blanks as required by the method.
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008.
The only exception was the detection of acetaldehyde in both the S10 and Blind Duplicate sample method blank where concentrations in the sample were detected at concentration less than 5 X the concentration measured in the method blank. Therefore, the reported result had to be flagged and was modified as being analyzed but not detected at or above 2.0 ug/L.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 521 (Nitrosamines)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Surrogate recoveries were added to samples and blanks as required by the method.
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled most of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008.
The only exception was the detection of N-nitrosdimethylamine (NDMA) in the S10 sample method blank where the concentration in the sample was detected at a concentration less than 5 X the concentration measured in the method blank. Therefore the reported result had to be flagged and modified as being analyzed but not detected at or above 2.0 ug/L.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 531.1 / 531.2 (Carbamate & Urea Pesticides)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Surrogate recoveries were added to samples and blanks as required by the method.
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

WECK Laboratories analyzed Carbamate & Urea pesticides using EPA Method 531.1. The samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

MWH Laboratories

MWH Laboratories analyzed Carbamate & Urea pesticides using EPA Method 531.2. The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 549.2 (Diquat)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Surrogate recoveries were added to samples and blanks as required by the method.
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 547 (Glyphosphate)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Surrogate recoveries were added to samples and blanks as required by the method.
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 548.1 (Endothall)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained no trace of the target compound(s)
6. Surrogate recoveries were added to samples and blanks as required by the method.
7. Laboratory control samples (LCS) were within acceptable percent recoveries
8. Target compound identification were within validation criteria
9. Compound quantification and Reporting Limits were within validation criteria
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

The samples fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

MWH Laboratories

The sample fulfilled all of the review requirements in the USEPA, Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, June 2008. No sample data was qualified.

EPA 901.1 (Gamma Emitting Radionuclides / Cesium 137)

Data review verified the following items:

1. Technical holding time requirements met
2. Cooler temperature requirements met
3. Initial calibration performed with required standard concentrations
4. Continuing calibration (CC) was performed at the required frequency and the difference between the initial and repeated calibrations were within QC limits.
5. Method blanks contained less than the minimum detectable activity (MDA)
6. Laboratory control samples (LCS) were within acceptable percent recoveries
7. All carrier recoveries were within validation criteria.
8. All minimum detectable activities met required detection limits.
9. Sample result verifications were acceptable
10. System performance was acceptable
11. Overall assessment data
12. Field duplicate relative percent difference for detected compounds

WECK Laboratories

WECK lab utilized Eberline Services to analyze for gamma emitting radionuclides using EPA 901.1. The samples fulfilled all of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).

MWH Laboratories

MWH lab utilized GEL Laboratories to analyze for Cesium 137 using EPA 901.1. The samples fulfilled all of the review requirements of the Multi Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual (July 2004) and a modified outline of the USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Review (January 2010).

Table A-1: Sample Analyses Performed by WECK Laboratories, Inc.

Sample Location	Collection Date	Method
UV/AOP Product Water (S10) Blind Duplicate (S10)	8/24/2011	EPA 524.2 (Volatiles) EPA SRL 524.2 M (1,2,3 Trichloropropane) EPA 625 (Semi-volatiles) EPA 525.2 (Semi-volatiles) EPA SW 486 Method 8270M (1,4 Dioxane) EPA 508 (Chlorinated Pesticides and PCBs) EPA 200.7, 200.8, and 245.1 (Metals) EPA 515.3 (Herbicides) SM 2320 B (Alkalinity) EPA 100.2 (Asbestos) EPA 326.0 (Bromate) EPA 300.1 (Chlorate and Chlorite) EPA 300 (Chloride, Fluoride and Sulfate) SM 2120 B (Color) SM 2150 B (Conductivity) EPA 335.4 (Total Cyanide,) Calculation for Hardness, Total Nitrogen, Total Anions, Total Cations) EPA 218.6 (Hexavalent Chromium) SM 2330 B (Langlier Index) EPA 353.2 (Nitrate, Nitrite as Nitrogen, Nitrate/Nitrite as Nitrogen) EPA 140.1 (Odor) EPA 314.0 (Perchlorate) SM 4500 B (pH) EPA 365.1 (Total Phosphorus) SM 5540 C (Surfactants) SM 2540 C (Total Dissolved Solids) SM 5310 C (Total Organic Carbon) EPA 351.2 (Total Kjeldahl Nitrogen) EPA 180.1 (Turbidity) EPA 504.1 (1,2 Dibromoethane, 1,2-Dibromo-3-chloropropane) EPA SW 836 Method 1613B (2,3,7,8-TCDD) EPA 900.0 (Gross Alpha and Beta Radioactivity) EPA 903.0 (Radium 226) Method Ra-05 (Radium 228) EPA 906.0 (Tritium)

Table A-1: Sample Analyses Performed by WECK Laboratories, Inc. (cont'd)

Sample Location	Collection Date	Method
UV/AOP Product Water (S10) Blind Duplicate (S10)	8/24/2011	EPA 901.1 (Gamma Spectroscopy) EPA SW 846 Method 8330 (Explosives) EPA SW 846 Method 8015 B (Ethylene Glycol) EPA 552.2 (Haloacetic Acids) EPA 905.0 (Strontium-90) EPA 556 (Aldehydes) EPA 521 (Nitrosamines) EPA 531.1 (Carbamate & Urea Pesticides) EPA 549.2 (Diquat) EPA 547 (Glyphosphate) EPA 548.1 (Endothall)

Table A-2: Sample Analyses Performed by MWH Laboratories, Inc.

Sample Location	Collection Date	Method
UV/AOP Product Water (S10)	8/24/2011	EPA 524.3 (Volatiles) EPA SRL 524.2 M (1,2,3 Trichloropropane) EPA 524.2 (Volatiles) EPA 524.2 using Selected Ion Monitoring (t-Butyl Alcohol) EPA 624 (Volatiles) EPA 624 (2-Chloroethylvinyl ether) EPA 625 (Semi-volatiles) EPA 525.2 (Semi-volatiles) EPA 522 (1,4 Dioxane) EPA SW 846 Method 8270 C (Ethylene Glycol) EPA 505 (Chlorinated Pesticides and PCBs) EPA 608 (Chlorinated Pesticides and PCBs) EPA 200.7, 200.8, and 245.1 (Metals) EPA 515.4 (Herbicides) SM 2320 B (Alkalinity) EPA 100.2 (Asbestos) EPA 317.0 (Bromate) EPA 300.1 (Chlorate) EPA 300 (Chloride, Chlorite, Nitrate, Nitrite, and Sulfate) SM 9223 (Coliform SM 2120 B (Color) SM 2150 B (Conductivity) SM 4500 CN-F (Cyanide) SM 4500 C02-D (Free Carbon Dioxide) SM 2340B (Hardness) EPA 218.6 (Dissolved Hexavalent Chromium) SM 2330 B (Langlier Index & pH) Calculation Method Nitrate, Nitrite/Nitrate, Total Nitrogen) EPA 2150B (Odor) EPA 314.0 (Perchlorate) SM 4500-PE & EPA 365.1 (Total Phosphorus and Phosphorus) SM 5540 C & EPA 425.1 (Surfactants) EPA 160.1 & SM 2540 C (Total Dissolved Solids) SM 5310 C & EPA 415.3 (Total Organic Carbon) EPA 351.2 (Total Kjeldahl Nitrogen) SM 1030 E (Total Anions, Total Cations, and Cation/Anion Difference)

Table A-2: Sample Analyses Performed by MWH Laboratories, Inc. (cont'd)

Sample Location	Collection Date	Method
UV/AOP Product Water (S10)	8/24/2011	EPA 180.1 (Turbidity) Calculation Method (Aggressiveness Index) SM 4500F-C (Fluoride) EPA 551.1 (Dibromochloropropane & Ethylene Dibromide) EPA SW 836 Method 1613B (2,3,7,8-TCDD) EPA 900.0 (Gross Alpha and Beta Radioactivity) EPA 903.0 (Radium 226) EPA 904.0 (Radium 228) EPA 906.0 (Tritium) LCMS (Explosives: 2,4,6-Trinitrotoluene, HMX and RDX) SM 6251 B (Haloacetic Acids) EPA 905.0 (Strontium-90) EPA 902 & SM 7500-IB (Iodine-131) EPA 556 (Acetaldehyde & Formaldehyde) LC-MS-MS (Hydrazines) EPA 521 (Nitrosoamines) EPA 531.2 (Carbamate & Urea Pesticides) EPA 549.2 (Diquat & Paraquat) EPA 547 (Glyphosphate) EPA 548.1 (Endothall) EPA 901.1 (Cesium 137) EPA 537 (Perfluorinated Chemicals) EPA 539 (Hormones) DX_ABI_NEG & POS (Pharmaceutical and Personal Care Products and Endocrine Disrupting Compounds)

Appendix D

Expert Report: In review of Data for City of San Diego AWP Facility prepared by Shane Snyder, PhD

EXPERT REPORT

OF

SHANE A. SNYDER, Ph.D.

In review of data for City of San Diego AWPF
provided by CDM-Smith / MWH consultants

13th October 2012

Shane A. Snyder, Ph.D.
2810 W Desert Splendor Ct
Oro Valley, Arizona 85742
Phone (520) 609-0586

13th October 2012

1.0 INTRODUCTION

During a telephone discussion with CDM-Smith/MWH (consultant team) including Jennifer Thompson, Greg Wetterau and James DeCarolis, I became aware of detectable substances in the finished water of the AWPF in San Diego. I have discussed some of these "anomalies" previously with the consultant team; however, on the 21st of June call (taken by me in Singapore) I became aware of additional information relevant to the project. On the 24th of July, the consultant team provided me data and a specific list of issues to be addressed in my expert report. The data I reviewed in preparing my report is included in the Quarterly Testing Report No. 4 (Q4 Testing Report) as referenced in subsequent sections of this report.

The consultant team specifically asked me to provide expert opinions on:

1. The statistical significance of the detection of certain unregulated contaminants in product water and likelihood of being true occurrence values rather than false positives (Type 1 error),

2. Comparison of the results of the unregulated detected contaminants compounds in product water to those occurrences reported in the blanks of other studies (i.e., USGS),

3. Public health relevance of occurrence of the unregulated contaminants at the concentrations reported in product water,

4. Compare/contrast the analytical values provided by the three laboratories involved in the study,

5. Opinion on role of sample volume on method report limits between MWH Labs and Colorado School of Mines.

Data has been provided to me indicated the presence of said unregulated contaminants in advanced treated water. I understand that my evaluation includes those data provided along with peer-reviewed data from other studies and my expert opinion.

While I have been asked to provide opinions regarding sampling techniques, quality assurance, quality control, and representativeness of analytical measurements related to the detections reported, it is important to state upfront that I have had no direct (hands on) experience with the sampling that took place in San Diego. Therefore, my expert opinion is based on the facts provided to me and limits the scope of my expert opinion. In order to develop my expert opinion, I have relied upon water quality monitoring data by the consultant team, peer-reviewed published literature, federal and state government documents, electronic media, and my own academic and professional experience.

1.1 QUALIFICATIONS

A current curriculum vitae (CV) containing publications and research projects is provided in Attachment A. I am the Vice-President and Director of Total Environmental Solutions, Inc. (TES), in Boulder City, Nevada. I am also a Professor of Chemical and Environmental Engineering at the University of Arizona and the Co-Director of the Arizona Laboratory for Emerging Contaminants also at the University of Arizona. I have conducted environmental research for more than 15 years and have acted as an environmental consultant for over a decade. My career has focused on understanding the occurrence, fate, and transport of contaminants in water. I am the Principal Investigator for several projects related to emerging contaminants in water and serve on several expert panels and committees related to water quality in the United States (US). I was a member of the recent National Academy of Science's National Research Council expert panel on water reuse. I have served on two US EPA advisory committees on endocrine disrupting chemicals and was a member of two US EPA expert panels for the Contaminant Candidate List 3. I have conducted extensive research related to trace contaminants in water supplies and have authored or co-authored over 100 manuscripts, reports, and book chapters during my career. I am a well-established expert on contaminant occurrence, treatment, and distribution in municipal drinking and waste water. In 2011 alone, I delivered more than a dozen invited presentations in five countries. The US Senate Committee on Environment and Public Works invited me to testify in April of 2008 as one of six national experts on the occurrence and relevance of trace pharmaceuticals in US drinking water. I have provided briefings for the US Congress three additional times. I was appointed twice to the California State Water Resources Control Board's Blue Ribbon Panels on emerging water quality issues.

Prior to my current employment, I was the Research and Development Project Manager for the Southern Nevada Water Authority (SNWA) in Las Vegas, Nevada from 2000 through 2010. The SNWA provides public water services for nearly 2,000,000 permanent residents and up to 40,000,000 visitors per year. My primary role at SNWA is to lead a group of researchers to determine occurrence and treatment efficacy of emerging environmental contaminants. The SNWA relies on both surface and groundwater to supply water within Clark County, Nevada. With over ten years of experience at the SNWA, I became proficient in the issues surrounding the federal and state regulations that govern the supply, treatment, and delivery of municipal water.

For the purposes of this report, I am acting solely on behalf of TES.

1.1.1 **Academic Credentials**

I have received the following degrees from accredited colleges and universities:

1. Bachelor of Arts (B.A.) degree in Chemistry with a minor in Medical Biology from Thiel College in Greenville, Pennsylvania

2. Doctor of Philosophy (Ph.D.) in Zoology and Environmental Toxicology from Michigan State University in East Lansing, Michigan

2.0 BACKGROUND AND SUMMARY

Water Quality Constituents and Influences

Water inherently contains a variety of organic, inorganic, and biological constituents. In fact, pure water, being two hydrogen atoms covalently bonded to an oxygen atom, does not naturally exist as a liquid on earth. All water contains some degree of dissolved and solid materials that comprise the complex aqueous mixture. In fact, all water systems will endogenously contain various salts, elements, and organic constituents. Beyond endogenous/natural constituents, a diversity of contaminants, including pharmaceuticals, have been reported in drinking water (Benotti, Trenholm et al. 2009), municipal wastewater (Nelson, Do et al. 2011), and in septic systems (Conn, Barber et al. 2006). Fortunately, essentially all public water systems in the United States regularly monitor water quality and perform extensive maintenance procedures to ensure regulatory compliance and reliability.

Accuracy and Precision of Water Quality Data

In environmental monitoring, there are seven key steps (Figure 1) to consider, namely: problem definition, sample program design, field sampling, sample preparation, chemical analysis, data analysis, and reporting (Batley 1999). If these seven steps are not considered, data collected may lead to erroneous conclusions. Problem definition involves defining the purpose of the monitoring program and questions to be answered by the acquired data. For San Diego, this is most likely a question of is the advanced treatment process being piloted tested robust and reliable for the production of exemplary water quality. Sample program design involves establishment of a testing plan that allows the problem definition to be adequately addressed. This will involve consideration of diurnal, spacial, and temporal variability as well as providing the necessary statistical power to demonstrate trends and to have confidence in representativeness of data to estimate the true population. Of critical importance are field sampling protocols and blanks. How a sample is collected and stored can have a dramatic impact on the resulting data. Blanks provide a measure of knowledge as to the trueness of an analytical measurement. For environmental measurements, field blanks, method blanks, and instruments blanks are of paramount importance. For aqueous sampling, a field blank requires the transporting ultrapure, previously characterized, water to the field site and passing this water through all sampling devices and collecting in a sample bottle exactly in the same way that an actual sample is collected and handled, and ultimate analyzed. A method blank evaluates the cleanliness of the analytical procedure and thus involves ultrapure water processed in the laboratory in exactly the same manner as a sample. The final type of blank that is critical for environmental analysis is an instrument blank, which involves the analysis of a blank matrix (water or solvent depending on analysis) which provides a measure of instrument cleanliness. These are just three types of blanks that should be included in any environmental sampling event. Failure to include these types of blanks will draw the resulting data into serious question. For instance, the issue of blanks is paramount when analyzing for ubiquitous substances such as bis(2-ethylhexyl)phthalate (DEHP). As a ubiquitous contaminant in laboratory and field sampling settings, DEHP sampling and analysis requires that the amount of DEHP contributed by sampling equipment, laboratory facilities, and other routes of contamination be accurately accounted for through blanks (Connelly ; Tienpont, David et al. 2005; Fankhauser-Noti and Grob 2007). The use of plastics and polymers, for instance the plastic bucket and polymeric tubing must be avoided when sampling for trace levels of DEHP in water. The issue with personal care products is similar in that people handling aqueous samples should avoid using products such as sunscreen, antimicrobial soaps, and insect repellent.

In 2002, the USGS published one of the most impactful reports on pharmaceuticals in US water systems (Kolpin, Furlong et al. 2002). However, later review of this report indicated that many of the steroid hormone data were at concentrations that were far higher than any other studies in the world. For instance, Kolpin purported a maximum ethynylestradiol (birthcontrol) concentration of 831 ng/L, yet another study from the USA published earlier showed a maximum concentration of just 0.759 ng/L. Later, the USGS issued an errata on their website (http://toxics.usgs.gov/regional/est_errata.html) lowering the maximum concentration by one order of magnitude. Regardless, the corrections were not made to the published article and the US EPA used those data in the development of the CCL3 and later the UCMR3. Had it not been for the faulty USGS data used by the EPA in the dossier for the CCL3, it is highly unlikely that steroid hormones would have made the CCL3 and perhaps would not have also appeared on the UMCR3. In addition, the USGS provided no QA/QC data within Kolpin 2002, yet on the USGS website it is obvious that there were problems in achieving clean blanks. For instance, the USGS reports that acetaminophen occurred in 59% of all blanks in the Kolpin study, while diethyl phthalate occurred at concentrations up to 74,000 ng/L. Thus these sage examples shows how inaccurate analytical data can influence public policy.

Acesulfame K

Acesulfame is an artificial sweetener with the “K” standing for potassium. Acesulfame K is around 200x sweeter than sucrose (table sugar) and is often blended with other artificial sweeteners which has been reported to have a synergistic effect on the sweetness. It is a bit unique compared to other artificial sweeteners as it is stable under elevated temperatures and can be used in baking. Acesulfame K is approved as a food additive in the US, Europe, and other countries, thus, health relevance at ng/L in water is assumed to be *de minimis*.

According to Table 41 of the Q4 Testing Report , Acesulfame K was detected two times in the UV-AOP product. On the 15th of February 2012, Acesulfame K demonstrated a concentration of 31 ng/L, yet, was undetectable (<20 ng/L) in the RO permeate. My guess is that the sample was miss-labeled and switched with the post-RO sample, since in all other events, the post-RO sample had between 30-40 ng/L. These post-RO values for Acesulfame K are expected, as rejection of organic constituents should not exceed the rejection for TDS. In other words, 99% rejection of Acesulfame K would still result in detectable concentrations considering the feed concentration. Acesulfame K also was detected in product water on 9/14/2011 at 50 ng/L as shown in Table 36 of the Q4 Testing Report. In this sampling event, Acesulfame K was present at 65 ng/L in the RO permeate, this the 50 ng/L in the UV-AOP effluent would indicate a low degree of oxidation. Indeed, Acesulfame K is only moderately removed by UV-AOP, which would be relatively consistent with this finding. However, as mentioned above, in all other samples Acesulfame K is removed to less than detection. However, the 65 ng/L RO permeate is one of the higher feed concentrations entering the UV-AOP. Thus, there is no clear reason for the detection in the product water, but it is not entirely surprising to me.

Bromochloromethane (BCM)

Bromochloromethane was used in fire extinguishers (Halon 1011), but has not been widely used since the 1960's. Passage through RO is expected due to low molecular weight and neutral charge. The US EPA has calculated a reference dose for bromochloromethane of 0.01 mg/kg-day, thus for a 70 Kg human drinking 2L of water per day, an estimated drinking water equivalent level (DWEL) would be around 35 ug/L. As shown in Table 45 of the Q4 Testing Report, the maximum concentration of BCM reported in the purified water was 0.25 ug/L, which is >100 X lower than the DWEL. Considering the detected concentration of BCM is two orders of magnitude lower than the DWEL calculated from an EPA reference dose, I would not expect any relevance to public health from this concentration.

IOHEXAL

Iohexal is an iodinated contrast media applied intravenously before certain medical procedures. Since it is approved for intravenous application in high-doses, it is not a highly toxic agent and not likely to have any meaningful health relevance at ng/L. However, recent studies have shown that iohexal can contribute to iodinated disinfection byproducts when oxidized during water treatment. The detection of iohexal at 19 ng/L in the product water on the 14th of September (Table 36 of the Q4 Testing Report) seems to be an analytical artifact. There is no detection of iohexal in the RO permeate that feeds the UV-AOP reactor, yet it is detectable post UV-AOP. I do not believe this is accurate and I am strongly of the opinion that this singe detection is an artifact and can be discarded due to lack of detection in the RO permeate and lack of other detections in UV-AOP product water.

Triclosan

Triclosan is a commonly used anti-microbial agent that is used in a variety of household and personal care products. For instance, triclosan is approved as an additive for toothpaste at %triclosan by product weight. Obviously triclosan is not considered to be relevant to human health at nanograms when it is approved as an additive in toothpaste in milligrams. Additionally, triclosan is often used in hand soaps also at percent by weight, thus, hand washing provides another significant source to humans. These common uses also lead to higher propensity in blanks. In the USGS study by Kolpin in 2002, triclosan was detected in blanks up to 560 ng/L. Triclosan has been shown to be highly rejected by RO and extremely susceptible to UV oxidation (Snyder, Adham et al. 2006; Snyder, Wert et al. 2007). Thus, the two detections of triclosan (sample date 9/14/11 = 19 ng/L and sample date 2/1/12 = 17 ug/L) in UV-AOP product water are highly unlikely due to rejection by RO and oxidation by UV-AOP. Moreover, triclosan is very common in laboratory blanks. At the laboratory at SNWA, we have established a reporting limit of 50 ng/L due to challenges of achieving consistently clean blanks below 30 ng/L.

Formaldehyde

Formaldehyde is a naturally occurring compound that is a gas at room temperature. Formaldehyde also is formed during oxidative processes and is considered the last transformation product of carboneous molecules before mineralization to carbon dioxide. Because it is volatile and relatively soluble in water, it is difficult to remove during water treatment. It will pass through RO membranes to some extent and is formed by UV and ozone AOPs (Trenholm, Rosario-Ortiz et al. 2008). At other reuse facilities using UV-AOP, I have observed formation of formaldehyde, at times with concentrations exceeding 100 ug/L. Thus, I am not surprised to see formaldehyde in the produce water here. On the contrary, if formaldehyde were not observed, it would indicate either over or under dosing of the UV-AOP system. However, I find the analytical data provided to be concerning since one laboratory differs from another by one order of magnitude. From the information provided, it appears both laboratories used the same method (EPA 556) and that both laboratories achieved spiked recoveries well within the acceptable range. Therefore, I can find no plausible explanation for the large discrepancy between the two laboratories. Regardless, formaldehyde is not considered to be highly toxic to human health by ingestion. The US EPA (IRIS) determined the NOAEL in rats to be 82 mg/kg-day, which equates to 5.7 g/day for an adult. Even if the uncertainty factor would be 1000, this equates to levels far above those levels detectable in product water here, regardless of laboratory providing analysis.

OPINION OF ROLE OF SAMPLE VOLUME ON METHOD REPORTING LIMITS AND BLANKS BETWEEN MWH LABS AND COLORADO SCHOOL OF MINES LAB.

I was asked to provide expert opinion regarding the impact of a 40 mL sample volume versus 1 L sample volume in the laboratories performing analyses for this study. In theory, the sample volume is critical depending on instrument sensitivity, operating conditions, and instrument/method blanks. In other words, one cannot judge a methods reporting limits or robustness simply on sample volume. Indeed, on-line solid-phase extraction methods have allowed trace organic analysis in very low volumes of water (Trenholm, Vanderford et al. 2009). In the cases here, I do not have sufficient information to thoroughly evaluate the two methods in dispute. However, I do believe the MWH method using 40 mL is an on-line SPE method. Again, we can assume that the concentration of analytes in water samples are the sample regardless of sample volume.

However, in analytical chemistry, the mass injected on-column is usually the most critical parameter in the method sensitivity on a given instrument. Thus, on-line SPE can accomplish a similar on-column mass by "injecting" the complete mass extracted in a small water volume while a 1 L sample would be extracted conventionally off-line, then usually 5-50 uL injected out of the resulting 1 mL extract. Thus, the 1000x concentration factor with off-line SPE actually results in a relatively small mass injected since only a few uL of the 1 mL extract are actually used. Thus, MRLs involve more than just the sample volume. In terms of blanks; however, there can be large differences between on-line and off-line SPE methods. For instance, we recently discovered that bisphenol A cannot reliably be analyzed using off-line SPE since the SPE cartridges are made of plastic that results in significant blank contamination. This contamination is not observed with on-line SPE since no plastic cartridges are used. On the contrary, if there are any issues with instrument blanks, such as carry over, solvent contamination, or leaching from instrument parts, the concentration calculated to the field blanks will be exaggerated. This is because the instrument reports a mass. This mass is then back calculated to the injection volume and later to the volume of water. Therefore, a systematic issue with blanks within the instrument system will calculate to a much higher concentration in a lower sample volume as compared to a large sample volume. Thus, instrumental blanks are even more important with on-line SPE techniques.

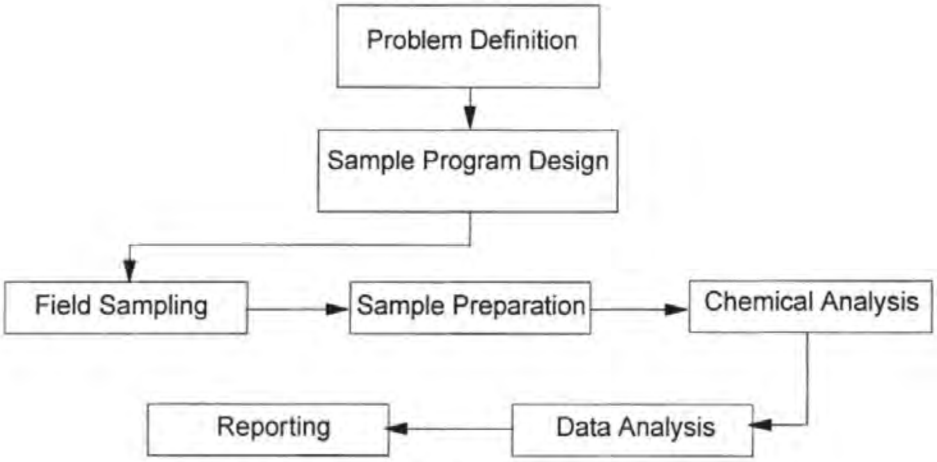

Figure 1. Seven Key Steps in Environmental Monitoring (from Batley, G. E. (1999). "Quality assurance in environmental monitoring." Marine Pollution Bulletin 39(1-12): 23-31.)

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Education

1994-2000 **Michigan State University, East Lansing, Michigan**
Doctorate of Philosophy
Environmental Toxicology and Zoology
Dissertation Title: ***Instrumental and Bioanalytical Measures of Endocrine Disruptors in Water***
Advisor: Dr. John P. Giesy (Distinguished Professor)

1990-1994 **Thiel College, Greenville, Pennsylvania**
Department of Chemistry
Bachelor of Arts: *Magna Cum Laude*
Major: Chemistry
Minor: Medical Biology

Funded Research Projects

2011-2013 **Co-Principal Investigator – WateReuse Research Foundation:** "Development of Bio-Analytical Techniques to Assess the Potential Human Health Impacts of Recycled Water" – Project# 10-07

2010-2011 **Principal Investigator – WateReuse Research Foundation:** "Use of UV and Fluorescence Spectra as Surrogate Measures for Contaminant Oxidation and Disinfection in the Ozone/H2O2 Advanced Oxidation Process" – Project# 09-10

2010-2011 **Co-Principal Investigator – WateReuse Research Foundation:** "Effect of Prior Knowledge of Unplanned Potable Reuse on the Acceptance of Planned Potable Reuse" – Project# 09-01

2009-2011 **Principal Investigator – WateReuse Research Foundation: "**Use of Ozone in Water Reclamation for Contaminant Oxidation" – Project# 08-05

2009-2011 **Co-Principal Investigator – Water Environment Research Foundation:** "Trace Organic Compounds Removal during Wastewater Treatment – Categorizing Wastewater Treatment Processes by their Efficacy in Reduction of a Suite of Indicator TOrCs" – Project# CEC4R08

2009-2011 **Principal Investigator (with Brett Vanderford – SNWA Research Chemist) – Water Research Foundation:** "Evaluation of Analytical Methods for EDCs and PPCPs via Interlaboratory Comparison" – Project# 4167

2009-2011 **Principal Investigator (with Benjamin Stanford – SNWA Post-Doctoral Researcher) – WateReuse Foundation:** "Pilot-Scale Oxidative Technologies for Reducing Fouling Potential in Water Reuse and Drinking Water Treatment Membrane Systems" – Project# 08-008

2008-2009 **Principal Investigator – American Water Works Association/American Water Works Association Research Foundation:** "Hypochlorite – An Assessment of Factors That Influence the Formation of Perchlorate and Other Contaminants" – Project# 712/4147

2008-2010 **Principal Investigator – American Water Works Association Research Foundation:** "Role of bromamines on disinfection byproduct formation and impact on application of chloramination and

	ozonation" – Project# 4159
2007-2009	**Principal Investigator – WateReuse Foundation:** "Comparisons of Chemical Composition of Reclaimed and Conventional Waters" Project# 06-006
2007-2008	**Principal Investigator – WateReuse Foundation:** "Identifying Hormonally Active Compounds, Pharmaceutical Ingredients, and Personal Care Product Ingredients of Most Health Concern From Their Potential Presence in Water Intended for Indirect Potable Reuse" Project# 05-005
2007-2009	**Principal Investigator (with Fernando Rosario – SNWA Post-Doctoral Researcher) – WateReuse Foundation:** "Optimization of Advanced Water Treatment Processes for Water Reuse" Project# 06-012
2006-2009	**Co-Principal Investigator – WateReuse Foundation:** "Development of Surrogates To Determine The Efficacy Of Groundwater Recharge Systems For The Removal Of Trace Organic Chemicals" Project# 05-004
2007-2009	**Co-Principal Investigator – American Water Works Association Research Foundation:** "Low Dose Risks from Bromate: The Relationship between Drinking Water Concentrations and the Actual Dose to Susceptible Organs in Rats and Humans" Project#4042
2005-2007	**Co-Principal Investigator – WateReuse Foundation:** "Reaction Rates and Mechanisms of Advanced Oxidation Processes for Water Reuse" Project# 04-017
2005-2006	**Principal Investigator – American Water Works Association Research Foundation:** "Comprehensive Utility Guide for Endocrine Disruptors and Pharmaceuticals in Drinking Water" Project# 3033
2004-2006	**Principal Investigator – American Water Works Association Research Foundation and WateReuse Foundation:** "Toxicological Relevance of EDC and Pharmaceuticals in Drinking Water" AwwaRF # 3085 & WRF 04-003
2004-2006	**Co-Principal Investigator – WateReuse Foundation:** *Colorado School of Mines as PI* "Development of Indicators and Surrogates for Chemical Contaminant Removal during Wastewater Treatment and Reclamation" Project# WRF-03-014
2004-2006	**Co-Principal Investigator – WateReuse Foundation:** *Carollo Engineers as PI* "Reclaimed Water Aquifer Storage and Recovery: Potential Changes in Water Quality" Project# WRF-03-009
2004-2006	**Co-Principal Investigator – Water Environment Research Foundation:** *Colorado School of Mines as PI.* "Contributions of Household Chemicals to Sewage and their Relevance to Municipal Wastewater Systems and the Environment" Project# 03-CTS-21UR
2002-2005	**Principal Investigator - American Water Works Association Research Foundation:** "Evaluation of Conventional and Advanced Treatment Processes to Remove Endocrine Disruptors and Pharmaceutically Active Compounds" Project #2758
2001-2004	**Principal Investigator - Strategic Environmental Research and Development Program (for Department of Defense):** "Toxicological Impact of Ammonium Perchlorate on Fish" Project# 1222
1998-2000	**Principal Investigator - Southern Nevada Water Authority/U.S. Bureau of Reclamation/National Park Service:** "Toxicity Identification and Evaluation of Xenobiotic Compounds in Lake Mead, Nevada"
1998-2000	**Principal Author - Chemical Manufacturers Association:** "Identification and Quantitation of Alkylphenols from Fish Tissues"
1997	**Principal Author - Las Vegas Valley Water District:** "Screening of Drinking Water for Possible Endocrine Disrupting Compounds"
1997	**Principal Author - Chemical Manufacturers Association:** Instrument grant for alkylphenol analyses

Recent Volunteer Efforts

2008-2011	**National Academy of Science – National Research Council**: Member of Water Reuse expert panel
2010-Present	**WateReuse Association:** Member of the Board of Directors
2009-2010	**National Association of Clean Water Agencies and Association of Metropolitan Water Agencies**: Co-chair of expert panel to author ***Pharmaceuticals in the Water Environment***
2008-2011	**Water Research Foundation**: Member of EDC Strategic Initiative Expert Panel
2008-2011	**American Water Works Association:** Appointed Trustee of the Water Science & Research Division
2008-Present	**WateReuse Research Foundation:** Research Advisory Council (RAC) member
2008-2010	**United Nations University & Gwangju Institute of Science and Technology:** Science Advisory Committee member.
2008-2009	**American Water Works Association**: Chair of the Planning Committee for the Organic Contaminants Research Symposium – Austin Texas February 2009
2006	**Expert Panel Member:** US EPA Contaminant Candidate List Classification Process Meeting
2004-2006	**Federal Advisory Committee Member:** Endocrine Disruptor Methods Validation Advisory Committee (EDMVAC)
2004-Present	**American Water Works Association:** Source Water Protection Committee – (Vice-Chair 2004-2006)
2002-Present	**American Water Works Association:** Organic Contaminants Research Committee – (Chair 2005-2008)
2002-2005	**Henderson Blue Ribbon Commission:** Member of special committee to promote educational excellence in Southern Nevada
2001-2004	**National Advisory Council for Environmental Policy and Technology:** Member of the US EPA Federal Advisory Committee "*Endocrine Disruptor Methods Validation Subcommittee* (EDMVS)"
2000-2001	**American Water Works Association:** Endocrine Disruptor & the Water Industry Symposium planning committee

Employment Experience

2010-Present	**University of Arizona – Professor of Chemical and Environmental Engineering.** Provide leadership and teaching in the areas of water treatment, contaminant fate and transport, and public/environmental health implications of water pollution.
2010-Present	**Arizona Laboratory for Emerging Contaminants (ALEC) – Co-Director.** State-of-the-art analytical facility at University of Arizona with a focus on identification and quantification of emerging contaminants, such as pharmaceutical, endocrine disrupting compounds, and nanoparticles.
2000-2010	**Research and Development – Project Manager.** Southern Nevada Water Authority, Las Vegas, Nevada. Develop and manage diversity of drinking and wastewater projects related to emerging contaminants, conventional and advanced treatment technologies, and modern analytical method development. Achieve external research funding to support team of chemists, engineers, graduate students, and post-doctoral researchers.
1998 – Present	**Owner/Consultant.** Total Environmental Solutions Inc., Boulder City, Nevada. Provide professional consultation, expert witness services, and build teams of experts capable of solving a diversity of challenging environmental issues.
1994-2000	**Graduate Student.** Michigan State University, East Lansing, Michigan. Department of Zoology

	and Institute of Environmental Toxicology. Developed novel analytical and bioanalytical approaches to identify and quantitate endocrine disrupting compounds and pharmaceuticals in the aquatic environment.
Summer 1995	**Research Internship.** Bayer Corp., Biotechnology Division, Leverkuesen, Germany. Synthesized and analyzed DNA and PNA strains for pharmaceutical discovery. Utilized DNA/PNA synthesizers and sequences. Purified strains using HPLC and verified molecular weights using Time of Flight Mass Spectrometry.
Summer 1994	**Research Internship.** Bayer Corp., New Martinsville, West Virginia. Developed spectral library using newly developed open-path FTIR instrumentation used to monitor potential leaks at industrial sites.

Additional Relevant Experience

2011-Present	**Chair.** National Water Research Institute. Expert Panel on Water Reuse in Tucson, Arizona
2011-2015	**Visiting Professor.** National University of Singapore – National Environmental Research Institute.
2010-Present	**Science Advisory Panel Member.** King Abdullah University of Science and Technology, Saudi Arabia.
2010-Present	**Science Advisory Panel Member.** Southern California Coastal Water Research Program. *Constituents of Emerging Concern in Coastal and Marine Ecosystems*
2010-Present	**Adjunct Professor.** Environmental Science & Engineering, Gwangju Institute of Science and Technology, South Korea
2009-2010	**Science Advisory Panel Member.** California Water Resources Control Board. *Constituents/Contaminants of Emerging Concern in Recycled Water*
2009	**Effective Media Communications.** Professional training for communicating with news media. *The Ammerman Experience.* Houston, Texas
2009	**Advanced Presentations Training.** Professional training in presentation of data in public forums
2008-Present	**Fellow.** University of California, Santa Cruz. Center for Integrated Water Research
2007-2008	**West Basin Water District Expert Panel**. Provide expert advice regarding water quality and technology issues related to water reuse operations at West Basin, California
2006-2011	**Pepsi Corporation Water Quality Advisory Council.** Provide expert advice and scientific opinion regarding global water quality and treatment technology issues
2000 – 2010	**Adjunct Faculty.** University of Nevada, Las Vegas. Act as a committee member for various graduate research programs. Aid in research efforts of faculty and students. Instruct classes and serve as a visiting lecturer
2000 – 2007	**Adjunct Faculty.** State College of Southern Nevada, Las Vegas, Nevada. Instruct undergraduate science classes. Work with other faculty on local environmental issues
1997 – Present	**Peer Reviewer.** Peer reviewer for several journals including: *Analytical Chemistry, Environmental Science and Technology, Water Research, Journal of the American Water Works Association, Chemosphere, and others*
2000 & 2008	**Invited Speaker.** National Public Radio (NPR) recorded in Las Vegas, Nevada. Interview regarding pharmaceuticals and personal care products in Lake Mead, Nevada

Invited Presentations and Seminars (Previous Years Available on Request)

December 2011	**Las Vegas, Nevada –** Invited speaker at Agilent Technologies Annual Meeting
December 2011	**Flagstaff, Arizona –** Invited speaker and panel member for public meeting on water reuse
November 2011	**Genoa, Italy –** Invited speaker for symposium on EDCs in water supplies
November 2011	**Santa Clara, California –** Invited seminar for Agilent Technologies

November 2011	**Phoenix, Arizona –** Invited speaker for Water Quality Technology Conference (WQTC) – reuse special session
October 2011	**Phoenix, Arizona –** Invited speaker for Western Coalition of Arid States (WESTCAS)
September 2011	**Barcelona, Spain** – Invited keynote presentation at International Water Association Water Reclamation and Reuse Conference
August 2011	**Dallas, Texas** – Invited presentation for EPA Region 9 Workshop
July 2011	**Singapore** – Invited presentation at the Singapore International Water Week
June 2011	**Amsterdam Netherlands** – IWA Leading Edge Technology meeting – Invited Keynote on Water Reuse and Emerging Water Quality Issues
May 2011	**Beijing China –** Peking University – Invited Presentation on Water Reuse
May 2011	**Beijing China –** Tsinghua University – Invited Plenary Presentation at Symposium EDCs, PPCPs, and DBPs in Water
April 2011	**Cambridge MA –** Harvard University – Invited Presentation at Symposium on R&D and Technology for Water
February 2011	**Northridge CA –** University of California, Northridge – Invited Presentation on PPCPs iN Water Supplies: Sustainable Solutions
November 2010	**Raleigh NC –** US EPA Research Triangle Park – Invited Presentation on Emerging Contaminants and Water Reuse
September 2010	**Washington DC –** Congressional Briefing on Pharmaceuticals in the Environment
July 2010	**Singapore – Singapore International Water Week.** Invited Session Chair and Speaker
June 2010	**Holderness, NH –** Gordon Research Conference: Water – Invited Presentation regarding Water Reuse and Emerging Water Quality Challenges
May 2010	**Racine, WI –** Wingspread Meeting on Environmental Estrogens – Invited Panelist
May 2010	**Cape Cod, MA –** Waquoit Bay Reserve – Invited Presentation regarding Emerging Contaminants in Septic Systems and Groundwater
March 2010	**Boston, MA** – Tufts University – Invited Presentation for the National Academy of Engineering
November 2009	**Gwangju, S. Korea –** United Nations University – Science Advisory Board
November 2009	**Boston, MA –** Harvard School of Public Health – Invited Presentation on DBPs
October 2009	**Princeton, NJ** – FASTRAC Meeting – Invited Presentation
September 2009	**Brisbane, Australia –** International Water Association WRRS – Invited Keynote
September 2009	**Tokyo, Japan –** International Ozone Association – Invited Keynote
August 2009	**Washington, DC** – ACS National Conference – Invited Keynote
August 2009	**Mount Holyeoke, MA** – Gordon Research Conference on Disinfection Byproducts
June 2009	**Singapore –** IWA Leading Edge Technology Meeting – Invited Keynote
June 2009	**San Francisco, CA –** IWA Micropol Meeting – Invited Keynote Presentation
June 2009	**Toronto, Canada –** Ontario Ministry of the Environment – Invited Presentation
May 2009	**Boise, ID –** Idaho Water Reuse Symposium – Invited Presentation
May 2009	**Salem, OR –** Pacific Northwest Awwa meeting – Invited Presentation
April 2009	**Costa Mesa, CA –** So. Cal. Coastal Water Research Program – Invited Presentation
March 2009	**Boston, MA –** Harvard University's School of Public Health – Invited Seminar

March 2009	**Washington, DC –** US Senate – Invited Briefing
March 2009	**New York, NY –** Hazen & Sawyer – Invited Seminar
March 2009	**San Diego, CA –** Association of Environmental Health Sciences – Invited Keynote
March 2009	**Las Vegas, NV –** US/Japan Joint Water Conference – Invited Presentation
February 2009	**Washington DC –** US House of Representatives – Invited Briefing
February 2009	**Phoenix, Arizona –** Arizona Water Association – Invited Seminar
February 2009	**Austin, Texas** – Awwa Emerging Contaminant Symposium – Conference Chair
January 2009	**Delft, The Netherlands –** Vakantiecursus in Drinkwatervoorziening – Invited Presentation
January 2009	**Greenville, South Carolina –** Southeastern Regional Water Technology Transfer Conference – Invited Presentation
November 2008	**East Lansing, Michigan** – Michigan State University – Invited Seminar
November 2008	**Cincinnati, Ohio –** Water Quality Technology Conference – Invited Presentation
October 2008	**Monterey, California** – WateReuse Foundation – Invited Presentation on agricultural water reuse
October 2008	**Gwangju, S. Korea** – United Nations University – Science Advisory Board Meeting
September 2008	**Tucson, Arizona** – University of Arizona – Invited Seminar
August 2008	**Orlando, Florida** – International Ozone Association – Invited Plenary Presentation
June 2008	**Singapore –** Invited delegate for World Water Leaders Summit
March 2008	**Long Beach, California –** California Water Environment Association – Invited Presentation
March 2008	**Cork, Ireland –** Invited presentation on emerging water quality issues
March 2008	**Zurich, Switzerland –** Invited Seminar for EAWAG on emerging contaminants
March 2008	**Lyon, France –** Invited speaker for EU NORMAN meeting on bioassay techniques
February 2008	**Mumbai, India –** Invited expert panel member for Pepsi Corporation FEMA meeting
December 2007	**University of California, Berkeley** – Invited Seminar for Department of Engineering
November 2007	**Canberra, Australia**: EDC/PPCPs in Australia – Invited Keynote Presentation
November 2007	**Brisbane, Australia** – Invited Seminar for Queensland Water
November 2007	**Gwangju, South Korea** – Invited Presentation at Opening of National Desalination Program (SeaHERO)
October 2007	**Costa Mesa, California**: National Groundwater Association – Keynote Presentation
October 2007	**Seattle, Washington**: Association of Metropolitan Water Agencies – Invited Presentation
September 2007	**University of Massachusetts, Amherst** – Invited Seminar in Water Sustainability Lecture Series
September 2007	**Tampa, Florida**: WateReuse Association – Invited Panelist in Closing Plenary Session
August 2007	**Los Angeles, California**: International Ozone Association – Invited Keynote Presentation
August 2007	**Carson City, Nevada**: Nevada Water Resources Association – Invited Keynote Presentation
August 2007	**Water Environment Federation** – Webcast on Emerging Issues – Invited Presentation
July 2007	**Flagstaff, Arizona**: Arizona Water Reuse Association – Invited Presentation
July 2007	**Los Angeles, California**: California Urban Water Association – Invited Seminar
May 2007	**Sacramento, California**: California EPA DTSC – Invited Presentation
May 2007	**Tampa, Florida**: World Environmental & Water Resources Congress – Keynote Presentation
April 2007	**Santa Rosa, California –** Invited Seminar for the Public Utilities Board

April 2007	**Greensboro, North Carolina** – Syngenta's Distinguished Speaker Series
April 2007	**Athens, Georgia**: Society for Environmental Toxicology and Chemistry – Invited Lecturer
February 2007	**Sacramento, California**: California DHS Meeting – Invited Seminar
February 2007	**New York, New York**: AwwaRF/KIWA CEO Conference – Invited Presentation
January 2007	**Okinawa, Japan**: Japanese-U.S. Conference on Water Quality and Wastewater Control – Invited Presentation

Publications

114.	2011	Stanford BD, Pisarenko AN, Holbrook RD, **Snyder SA.** *Preozonation Effects on the Reduction of Reverse Osmosis Membrane Fouling in Water Reuse.* Ozone: Science & Engineering. **33**(5):379-388.
113.	2011	Holbrook RD, Motabar D, Quinones O, Stanford BD, **Snyder SA**. *Titanium distribution in a swimming pool - The case for dissolution*. Geochimica et Cosmochimica Acta. **74**(12): A410-A410.
112.	2011	Gerrity D, Gamage S, Holady JC, Mawhinney DB, Quinones O, Trenholm RA, **Snyder SA.** *Pilot-scale evaluation of ozone and biological activated carbon for trace organic contaminant mitigation and disinfection.* Water Research 45(5):2155-2165.
111.	2011	Laws BV, Dickenson ERV, Johnson TA, **Snyder SA**, Drewes JE. *Attenuation of contaminants of emerging concern during surface-spreading aquifer recharge*. Science of the Total Environment. 409:1087-1094.
110.	2011	Gerrity D and **Snyder SA.** *Review of Ozone for Water Reuse Applications: Toxicity, Regulations, and Trace Organic Contaminant Oxidation.* Ozone Science and Engineering. 33:253-266.
109.	2011	Mawhinney DB, Young RB, Vanderford BJ, Borch T, **Snyder SA**. *The Artificial Sweetener Sucralose in U.S. Drinking Water Systems.* Environmental Science and Technology. *In press*
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107.	2011	Gerrity D, Trenholm RA, **Snyder SA**. *Temporal variations in pharmaceuticals and illicit drugs in wastewater during a major sporting event.* Water Research. 45(17):5399-5411.
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103.	2011	Dickenson ERV, **Snyder SA,** Sedlak DL, Drewes JE. *Indicator Compounds for Assessment of Wastewater Effluent Contributions to Flow and Water Quality.* Water Research 45:1199-1212.
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101.	2010	Bruce GM, Pleus RC, **Snyder SA.** *Toxicological Relevance of Pharmaceuticals in Drinking Water*. Environmental Science & Technology. 41(14):5619-5626.
100.	2010	Stanford BD, Trenholm RA, Holady JC, Vanderford BJ, **Snyder SA**. *Estrogenic Activity of US Drinking Waters: A Relative Exposure Comparison*. Journal of the American Water Works Association. 110(11):55-65.
99.	2010	Stanford BD, Benotti MJ, **Snyder SA**. *"Impact of Endocrine Disruptors on the Water Industry"* In Endocrine Toxicology. J.T. Stevens and J.C. Eldridge (Editors). In Press.
98.	2010	Gerrity D, Benotti MJ, Reckhow DA, **Snyder SA**. *Pharmaceuticals and Potential Endocrine*

Disrupting Compounds in Drinking Water. In Biophysio-Chemical Processes of Anthropogenic Compounds in Environmental Systems, Volume 3. B. Ying (eds.), IUPAC-Wiley. Accepted for Publication.

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94. 2010 Gerrity D, Stanford BD, Trenholm RA, **Snyder SA**. *An Evaluation of a Pilot-Scale Nonthermal Plasma Advanced Oxidation Process for Trace Organic Compound Degradation*. Water Research. 44(2):493-504.

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		Chromatography A 1216(9):1319-1324.
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80.	2009	Benotti MJ, Trenholm RA, Vanderford BJ, Holady JC, Stanford BD, **Snyder SA**. *Pharmaceuticals and Endocrine Disrupting Compounds in U.S. Drinking Water*. Environmental Science & Technology. 43(3):597-603.
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74.	2009	Wert EC, Rosario FL, **Snyder SA.** *Using UV Absorbance and Color to Assess Pharmaceutical Oxidation during Ozonation of Wastewater*. Environmental Science & Technology. 43(13):4858-4863.
73.	2008	**Snyder SA,** Trenholm RA, Snyder EM, Bruce GM, Pleus RC, and Hemming JDC. *Toxicological Relevance of EDCs and Pharmaceuticals in Drinking Water.* American Water Works Association Research Foundation. Project 3085.
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70.	2008	Trenholm RA, Rosario FL, **Snyder SA**. *Analysis of Formaldehyde Formation in Wastewater using On Fiber Derivatization Solid Phase Microextraction Gas Chromatography Mass Spectrometry.* Journal of Chromatography A. 1210:25-29.
69.	2008	**Snyder SA**. *Occurrence, Treatment, and Toxicological Relevance of EDCs and Pharmaceuticals in Water*. Ozone Science & Engineering. 30:65-69
68.	2008	**Snyder SA**, Vanderford BJ, Drewes J, Dickenson E, Snyder EM, Bruce GM, Pleus RC. *State of Knowledge of Endocrine Disruptors and Pharmaceuticals in Drinking Water*. American Water Works Association Research Foundation Report #91228
67.	2008	Ikehata K, El-Din MG, **Snyder SA**. *Ozonation and Advanced Oxidation Treatment of Emerging Organic Pollutants in Water and Wastewater*. Ozone Science & Engineering. 30(1):21-26.
66.	2008	Rosario-Ortiz FL, Mezyk SP, Doud DFR, Wert EC, **Snyder SA**. *Effect of Ozone Oxidation on the Molecular and Kinetic Properties of Effluent Organic Matter.* Journal of Applied Oxidation Technologies. 11(3):529-535
65.	2008	Trenholm RA, Vanderford BJ, Drewes JE, **Snyder SA.** *Analysis of Household Chemicals Using Gas Chromatography and Liquid Chromatography with Tandem Mass Spectrometry*. Journal of Chromatography A. 1190(1-2):253-262.

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63. 2008 **Snyder SA**, Lei H, Wert EC. *"Removal of Endocrine Disruptors and Pharmaceuticals during Water Treatment"* In <u>Fate of Pharmaceuticals in the Environment and in Water Treatment Systems.</u> Diane S. Aga (Editor), CRC Press, Taylor & Francis Books, FL, USA. Chapter 11:229-259

62. 2007 Lei H and **Snyder SA**. *3D QSPR models for the removal of trace organic contaminants by ozone and free chlorine*. Water Research 41:3271-3280

61. 2007 **Snyder SA**, Lei H, Wert EC, Yoon Y, Westerhoff P. *Removal of EDCs and Pharmaceuticals in Drinking and Reuse Treatment Processes*. American Water Works Association Research Foundation Report #91188

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57. 2007 Yoon Y, Westerhoff P, **Snyder SA**, Wert EC, Yoon J. *Removal of endocrine disrupting compounds and pharmaceuticals by nanofiltration and ultrafiltration membranes.* Desalination 202(1-3):16-23

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54. 2007 Quiñones O, Oh JE, Vanderford BJ, Kim JH, Cho J. **Snyder SA**. *Perchlorate in the Nakdong and Yeongsan Watersheds, South Korea*. Environmental Toxicology and Chemistry. 26(7):1349-1354.

53. 2007 Wert EC, Rosario-Ortiz FL, Drury DD, **Snyder SA**. *Formation of Oxidation Byproducts from Ozonation of Wastewater*. Water Research. 41:1481-1490

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Deposition, Testimony, and Briefings

2010 *United States House of Representatives – Science and Technology Committee.* Invited briefing entitled "*Pharmaceuticals in Our Water: Concerns and Responses.*" Sponsored by the American Chemical Society

2009	*United States Senate – Committee on Environment and Public Works.* Invited briefing entitled *"Pharmaceuticals and Endocrine Disruptors in US Drinking Water: Occurrence, Treatment, & Relevance."* Sponsored by the Water Research Foundation.
2009	*Richard A. Rowe, et al. vs. E.I. du Pont de Nemours.* US District Court – District of New Jersey.
2009	*United States House of Representatives.* Invited briefing entitled *"Pharmaceuticals in Drinking Water."* Sponsored by the Water Research Foundation.
2009	*William R. Rhodes, et al. vs. E.I. du Pont de Nemours.* US District Court – Southern District of West Virginia.
2008	*United States Senate – Committee on Environment and Public Works.* Invited testimony at hearing entitled *"Pharmaceuticals in the Nation's Water: Assessing Potential Risks and Actions to Address the Issue."*
2005	*Jayne Palmisano and Richard Palmisano vs. Olin Corporation and Standard Fusee Corporation.* US District Court – San Jose California.

Professional Affiliations

2003 - Present	Water Environment Federation
2000 – Present	American Water Works Association
2000 – Present	International Ozone Association
2000 – Present	International Water Association
1997 – Present	American Association for the Advancement of Science
1996 – Present	Sigma Xi
1995 – Present	Society of Environmental Toxicology and Chemistry
1991 – Present	American Chemical Society

Students Mentored

2011-Current	**Shimin Wu – University of Arizona** – Current enrolled in Ph.D. program.
2011-Current	**Christopher Deason – University of Arizona** – Currently enrolled in M.Sc. program.
2011-Current	**Xu Li – University of Arizona** – Currently enrolled in Ph.D. program.
2010-Current	**Tarun Anumol - University of Arizona –** Currently enrolled in Ph.D. program.
2010-Current	**Darryl Jones – University of Arizona –** Currently enrolled in Ph.D. program.
2010	**Sujanie Gamage – University of Nevada, Las Vegas** – Currently enrolled in Ph.D. program in Vern Hodge's research group.
2010	**Dongxu Yan – University of Arizona** – Currently enrolled in Ph.D. program in Wendell Ella's research group.
2009	**Ludwig Kim – Texas A&M University** – Currently enrolled in Ph.D. program in Robin Autenreith's research group.
2009-2010	**Robert Young – Colorado State University** – Currently enrolled in Ph.D. program in Thomas Borch's research group.
2008-2009	**Sarper Sarp – Gwangju Institute of Science & Technology, Korea** – Currently enrolled in Ph.D. program in Jaeweon Cho's research group.
2008-2009	**Aleks Pisarenko – Miami University of Ohio** – Currently enrolled in Ph.D. program in Gilbert Pacey's research group.
2008-2010	**Susanna Blunt – University of Nevada, Las Vegas & Desert Research Institute** – Currently enrolled in M.S. program in Duane Mosher's research group.
2008-2009	**Deborah Dryer – University of Washington** - Currently enrolled in Ph.D. program in Gregory Korshin's research group.

2007-2008	**Seungyun Baik – State University of New York, Buffalo –** Currently enrolled in Ph.D. program in Diana Aga's research group.
2006-2008	**Mei Xin – University of Nevada, Reno –** Ph.D. granted in 2008; currently employed by Norit Carbon, Dallas Texas.
2005-2010	**Christy Meza – University of Nevada, Las Vegas** – Undergraduate research intern, B.S. awarded in 2008.
2005-2009	**Elaine Go – University of Nevada, Las Vegas** – Undergraduate research intern, B.S. expected in 2009.
2004-2006	**Fernando Rosario-Ortiz – University of California, Los Angeles –** D.Env. granted in 2006..
2003-2006	**Yixin Wei – University of Nevada, Las Vegas** – Ph.D. granted in 2006.
2000-2004	**Elisa Nemr – University of Nevada, Las Vegas** – M.S. granted in 2004**.**

Post-Doctoral Researchers Mentored

2010-Current	**Ai Jia** – Ph.D. from Peking University, China, with Professor Jianying Hu.
2010-2012	**Bradley Clarke** – Ph.D. from RMIT, Australia, with Professor Judy Blackbeard.
2010-Current	**Sylvain Merel –** Ph.D. from University of Rennes, France, with Professor Oliver Thomas
2009-2010	**Aleks Pisarenko** – Ph.D. from Miami University of Ohio with Professor Gilbert Gordon.
2008-2010	**Daniel Gerrity –** Ph.D. from Arizona State University with Professors John Crittenden and Morteza Abbaszadegan as advisors.
2008-2010	**Yongui Tan –** Ph.D. from Rensselaer Polytechnic Institute with Professor James Kilduff as primary advisor.
2007-2009	**Benjamin Stanford –** Ph.D. from University of North Carolina, Chapel Hill with Professor Howard Weinberg as primary advisor. Currently employed as Director of R&D, Hazen and Sawyer, New York.
2007-2009	**Mark Benotti –** Ph.D. from State University of New York, Stoney Brook with Professor Bruce Brownawell as primary advisor. Currently employed as private consultant.
2006-2008	**Fernando Rosario-Ortiz –** D.Env. from University of California, Los Angeles with Professor Mel Suffet as primary advisor. Currently employed as Assistant Professor at the University of Colorado, Boulder.
2005-2007	**Hongxia Lei –** Ph.D. from University of Illinois with Professor Benito J. Mariñas as primary advisor. Currently employed by Golden State Water, California.

Quarterly Testing Report No. 4

Appendix C

Full-Scale Reservoir Augmentation Capacity Analysis Technical Memorandum

Technical Memorandum

City of San Diego Water Purification Demonstration Project
Task 2 Conveyance Pipeline Concept Design Report

Subject:	**Full-scale Reservoir Augmentation Capacity Analysis**
Prepared For:	Amy Dorman and Anthony Van, Public Utilities Department
Prepared by:	Mabel Uyeda, & Richard Bichette, RMC
Reviewed by:	Greg Bradshaw, Tom Richardson, RMC
Date:	December 27, 2011
Reference:	0104-004.00

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1 Purpose

The purpose of this Technical Memorandum (TM) is to determine an optimal capacity for a proposed full scale Advanced Water Purification project being served by excess recycled water from the North City Water Reclamation Plant (NCWRP). For the purpose of this analysis, optimum capacity is the capacity that adheres to the regulatory strategy developed as part of the Water Purification Demonstration Project (WPDP) while minimizing annual cost. This analysis does not consider the wastewater-related benefit of maximizing diversion from the Point Loma Wastewater Treatment Plant, which will also need to be considered when making a final decision on sizing the full-scale project. Based on the results of this TM, and the findings of the Recycled Water Study (to be completed in 2012), the City of San Diego (City) will choose a preliminary capacity for both the advanced water purification facility (AWPF) and the conveyance system, consisting of purified water pump station and conveyance pipeline to San Vicente Reservoir (SVR). This preliminary capacity will be the basis for facilities layout and cost estimation.

2 Findings

The following are findings for the AWPF and conveyance system facilities.

2.1 AWPF

This analysis was performed using two different wastewater plant flow concepts and an optimal AWPF capacity was determined for each concept. The first flow concept assumes available flow to the AWPF is comprised of tertiary effluent after subtracting utility water and recycled water demand and assuming tertiary filter and membrane filter (MF) backwash is wasted to Point Loma Wastewater Treatment Plant. The second flow concept assumes tertiary filter and MF backwash is recycled to the head of the NCWRP plant, thereby increasing available flow to the AWPF.

*Without returning Backwash Flows:*The results of this analysis determined an apparent optimal AWPF capacity when not recycling the backwash waters from tertiary or MF of 14 million gallons per day (mgd) for the full-scale project, yielding 14,270 AFY of purified water. The size of the AWPF is limited by the NCWRP capacity and the amount of water available after serving the recycled water demands. The AWPF plant capacity can be as high as 18 mgd with a product water yield of 15,730 AFY based on the projected recycled water demands and assumptions used in this analysis.

*With returning Backwash Flows:*An increase in AWPF production could be achieved if tertiary filter backwash and MF backwash is recycled to the front of the NCWRP rather than wasted to Point Loma Wastewater Treatment Plant. Under this operation, an optimal AWPF capacity of 18 mgd for a full-scale project would yield approximately 16,876 AFY of purified water. To maximize yield, the AWPF capacity could be up to 20 MGD. However the projected available flows to the AWPF after satisfying the recycled water demands would result in operation at 19 mgd for three months and operation at 20 mgd for one month out of the year.

Recycling of these flows is currently not part of the demonstration testing at NCWRP. The potential impacts to NCWRP and AWPF treatment processes are not anticipated to impact to the overall process but may have a slight increase in nitrogen as the return flows include chloraminated waters. The return flows could have an impact to the NCWRP operations however. Thus the point of re-entry and challenges to the operations as well as nitrogen limits should be evaluated further during the next phase of the project.

The cost analysis in Section 9 is presented for both flow scenarios: 1) assuming tertiary filter and MF backwash is not recycled to the head of the plant, and 2) assuming tertiary filter and MF backwash is recycled to the front of NCWRP.

2.2 Pump Station

Capacity will be sized to convey purified water from the AWPF to the SVR, and is directly dependent upon the AWPF capacity. To provide flexibility for future changes to planning decisions and flow projections; the footprint, power requirements, equipment space should be sized to house the number of pumps required to convey the maximum potential product water flow. This would allow the City to potentially increase the station capacity in stages without paying significant capital costs with each increase.

2.3 Pipeline

At the City's request, the pipeline diameter in this analysis was sized for the ultimate conveyance flow from the AWPF. The optimum product water that can be produced is projected to be approximately 18 mgd. Based on discussions with the City, the conveyance pipeline will be sized for the ultimate condition to avoid construction of a parallel pipeline to accommodate a phased capacity approach. Using City design guidelines and assumed flow projections, a 30-inch pipe was determined to be an appropriate diameter for ultimate condition in 2030. A 30-inch pipeline would have a velocity of approximately 5.7 ft/s, which is higher than the goal of 5 ft/s. Note that the energy analysis will confirm the pipeline diameter. The following economic analyses use a 30-inch conveyance pipeline size regardless of the AWPF capacity. This pipe size provides flexibility to address the range of flows under consideration while maintaining relatively low energy costs for pumping. Pipe diameter should be re-assessed as part of an energy/capital cost analysis under the conceptual design report when flow and pipeline alignment are more defined.

3 Sources of Information

In the City of San Diego Water Reuse Study (March 2006), approximately 10,500 acre-ft per year (AFY) was identified as being offset via a 16 mgd AWPF. The latest Recycled Water Study increased this recycled water use to 16,800 AFY. In addition to these studies, the WPDP team met with NCWRP staff to gain insight into current operations in order to verify the results of these previous studies.

The conveyance facilities used in this analysis are based on previous studies prepared for the City. The conveyance pipeline alignment is based on the South Corridor alignment that traverses along SR-52. This was originally identified in the *1996 Repurification Project Report, Volume 3 - Repurified Water Conveyance System* (1996 Project Report). The study recommended a 42-inch pipeline to carry up to 27 mgd of purified water to the SVR and suggested two potential alignments, Sycamore Canyon or Mast Boulevard Alignments. The Mast Boulevard alignment was selected and refined with the intent to progress to 30% design in the *1997 Repurified Water Conveyance System Technical Memorandum Final, Pipeline Alignment - Mast Boulevard* (30% Design Report). Additional studies including geotechnical investigation, corrosivity reports, transient analysis, environmental assessment, and preliminary construction cost estimates were prepared for the proposed alignment. The 27-mgd design flow and single pump station concept initially proposed in the 1996 Project Report were retained and included in the 30% Design Report.

For the purpose of this TM, the proposed Mast Boulevard South Corridor alignment that is approximately 28-miles in length (5 miles of which is already built) and the single pump station concept at the AWPF will be used in developing the life cycle costs for the conveyance facilities. An optimum AWPF flow rate will be determined in this evaluation, and associated conveyance facility sizes (pipeline diameter and pump station capacity) will be updated and used for capital and operations and maintenance costs.

The following is a list of previous studies referenced in this TM:

1. *Repurification Project Report, Volume 3 - Repurified Water Conveyance System, April 2006* (1996 Project Report) prepared by Montgomery Watson and Woodward-Clyde.

2. *Repurified Water Conveyance System (RWCS) Technical Memorandum (Final), Pipeline Alignment - Mast Boulevard, May 1997* (30% Design Report) prepared by Boyle Engineering Corporation.

3. *City of San Diego Water Reuse Study, Final Draft Report, March 2006* prepared by PBS&J.

4. *City of San Diego Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)* prepared by PBS&J.

5. *City of San Diego* Recycled Water Study, prepared by Brown and Caldwell.

4 Project Components

The project components that will be analyzed in this TM include the AWPF, pump station facility at the AWPF to pump purified water to the San Vicente Reservoir, and the conveyance pipeline. Preliminary sizes and life cycle costs were determined for each of the components at varying capacities and flow rates. Costs developed for this analysis are intended for comparison purposes; not for the City's budgeting of capital improvement program for construction costs. The dechlorination facility (included in the 1990's evaluations), discharge structure, bike path improvements, and surge control facilities are not included in this analysis.

5 Methodology

The methodology employed for this analysis included the following activities:

- Preliminarily size pipeline and pump station for varying AWPF capacities
- Account for monthly irrigation demands in flows available for AWPF
- Determine life cycled costs for proposed facilities
- Conduct cost analysis to illustrate optimum capacity (yielding lowest unit cost per acre-ft)
- Use analysis to provide City with options and tradeoffs (cost implications of maximizing yield)

The optimal capacity analysis included an economic evaluation and a seasonal flow balance evaluation. The economic evaluation involved a comparison of the total project life cycle cost on an annual unit cost per acre-foot basis for AWPF capacities from 1 to 20 mgd and associated conveyance facilities. These project costs were further evaluated on an incremental basis to determine the increased cost of purified water produced by increasing the AWPF capacity by 1 mgd. This analysis was performed to identify when there is a diminishing return with increasing AWPF capacity. As the facility capacity increases it is oversized for a longer span of time throughout the year, particularly during the summer months when less flow is available to the plant due to irrigation demands. Therefore, there will be a breakpoint where the gain in product water yield starts to decrease with increasing incremental cost.

The seasonal flow balance evaluation involved balancing available flows to the AWPF capacity. This analysis was performed to strike a balance between having a plant sized for available flow once peak summer irrigation demands are met resulting in less product water to Point Loma Wastewater Treatment Plant during off peak demands and a facility that is oversized and unable to be fully utilized for many months. The ideal capacity is believed to be slightly larger or in excess of what is needed during peak demands but not too large such that a portion of the asset is rarely used. For this flow balance analysis, the balanced AWPF capacity is assumed to be achieved when the excess recycled water to the facility is the same as the deficit in available recycled water for the year.

6 Projected Flows to the AWPF and Recommended Capacity

The amount of purified water that may be produced by the proposed AWPF is estimated by deducting the waste streams and recycled water demands from the projected wastewater inflow of 30 mgd for the year 2030. It is assumed that the NCWRP's design capacity would remain at 30 mgd during that time. At the outset of this TM, the planning year is 2030. The flow projections, plant capacity and recycled water demands are consistent with the Recycled Water Study. The flows that impact the product water volume are identified as follows:

- Sludge waste
- Filter Backwash
- Utility Water
- Recycled Water Demands from the Distribution System
- MF/ RO Waste

In addition, the ultimate yield of the project will be impacted by the AWPF on-line factor. The calculations for the Projected Flows based on Max Month Recycled Water Demands can be found in **Appendix A.**

6.1 Sludge

Sludge waste is comprised of primary sludge, secondary sludge and scum. Its concentration averages approximately 4,000 mg/L of total solids. Approximately 1.4 mgd of sludge is estimated to be removed from the NCWRP influent flow and pumped to the Metro Biosolids Center (MBC). This is based on actual plant data and recommended value provided by Lynn Chou (former Senior Civil Engineer who oversaw the daily plant operation at NCWRP).

6.2 Filter Backwash

Filter backwash at the NCWRP is estimated by assuming 0.2 mgd per backwash per day for 10 mgd of tertiary flow (or 2, according to Lynn Chou. To project for 28.6 mgd of tertiary flow, triple the backwash flow for an estimated 0.6 mgd of flow lost due to filter backwash.

Utility water for processing cooling, sealant, and wash down will flow to the plant drain and is approximately 0.8 mgd. An additional 0.5 mgd is used for on-site irrigation. The total utility water demand is approximate 1.3 mgd. However, this is already included in recycled water demand from the distribution system described below.

6.3 Recycled Water Demands

Recycled water demands from the distribution system that are primarily for irrigation purposes are seasonal. According to the latest Recycled Water Study, the average annual recycled demand projected between the years 2015 and 2030 is 9.1 mgd. Monthly factors that correlate the average annual demand to the average monthly demand are provided in **Table 1** and depicted in **Figure 1**.

As previously mentioned, the projected recycled water demand includes utility water at NCWRP. Since utility water flows to the plant drain are not seasonal, they are not subject to the monthly peaking factors and are subtracted before the monthly factors are applied.

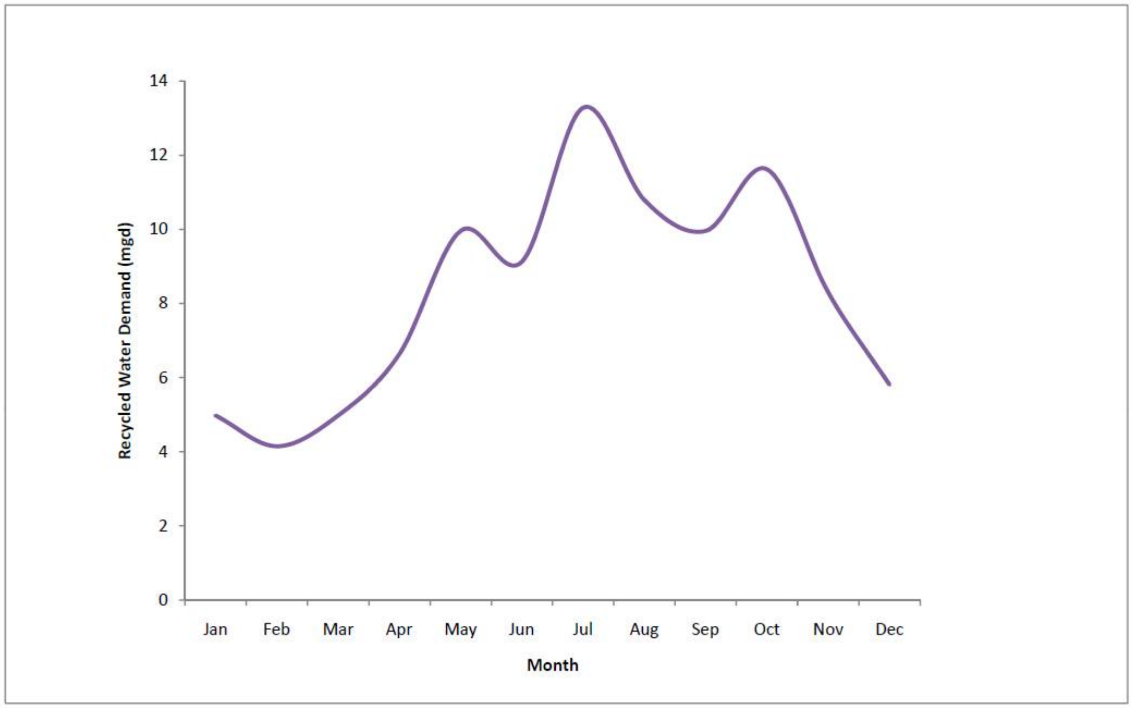
Table 1: Average Daily Recycled Water (RW) Demands by Month

Month	Avg Annual RW Demand (mgd)	Utility Water without Irrigation (mgd)	Irrigation RW Demands (mgd)	NCWRP RW Monthly Factor	Avg Daily Irrigation Demand by Month (mgd)
Jan	9.1	0.8	8.3	0.6	5.0
Feb	9.1	0.8	8.3	0.5	4.2
Mar	9.1	0.8	8.3	0.6	5.0
Apr	9.1	0.8	8.3	0.8	6.6
May	9.1	0.8	8.3	1.2	10.0
Jun	9.1	0.8	8.3	1.1	9.1
Jul	9.1	0.8	8.3	1.6	13.2
Aug	9.1	0.8	8.3	1.3	10.8
Sep	9.1	0.8	8.3	1.2	10.0
Oct	9.1	0.8	8.3	1.4	11.6
Nov	9.1	0.8	8.3	1.0	8.3
Dec	9.1	0.8	8.3	0.7	5.8

Note: NCWRP Recycled Water Monthly Factor obtained from Amy Dorman via email of Wed, June 8, 2011, 2:48:33PM. City referenced from latest Recycled Water Study.

After factoring in the above waste streams and recycled water demands, the remaining tertiary flow is available for the AWPF.

Figure 1: Average Daily Recycled Water Demands Curve



6.4 MF/ RO Waste

The available water will undergo membrane filtration (either micro- or ultra-filtration), and reverse osmosis (RO) at the AWPF. Each of these treatment processes will generate waste streams that would be transported to the Point Loma Waste Water Treatment Plant. Recycling of backwash, also referred to as washwater, flows from MF is considered under this study as a potential scenario. The Independent Advisory Panel (IAP) discouraged recycling these flows, as expressed at the June 6, 2011 full IAP meeting.

Approximately 21.8% of the available flow supplying the AWPF is assumed to be wasted if MF backwash flows are not recycled. This waste percentage is consistent with the demonstration project currently underway at the NCWRP and represents 92% recovery for MF and 85% recovery for RO. Based on information collected from other AWPFs in southern California this is a reasonable assumption. The Los Angeles Water Replenishment District operates the Leo Van der Lans AWPF which has a biological treatment strategy that is closest to how the NCWRP operates utilizing nitrification and denitrification and operates with an overall 80% recovery.

6.5 On-line AWPF Operation

The AWPF is anticipated to operate continuously throughout the year. However, shutdown of the facility for maintenance and repairs for the AWPF throughout the year could occasionally interrupt or stop operation. An on-line percentage of 95% is assumed and factored into the amount of purified water produced annually when determining the unit cost per acre-foot of yield. In estimating the on-line percentage for the City, the operation of the Orange County Water District's (OCWD's) Ground Water Replenishment System in Fountain Valley, CA was investigated. The groundwater replenishment system treats secondary effluent and operates with 92% of the rated capacity on-line each year. Diurnal flow conditions limit the operation of the facility. OCWD anticipates increasing its on-line operation to 95% with the construction of equalization basins to attenuate the flow fluctuations. Since the NCWRP is equipped with flow equalization, an on-line percentage of 95% is assumed. This on-line operation is also used to estimate the pump station power usage for the year. The pump station is assumed to operate 24 hours per day, seven days a week with the exception of the annual shutdown resulting in an operation of approximately 347 days out of the year.

Figure 2 shows a schematic of the projected 2030 wastewater flow progression from the NCWRP through the AWPF to the final purified water product, and **Figure 3** shows a schematic of the flow progression with recycling of tertiary filter and MF backwash to the front of the plant. Example calculations of the estimated purified water product based on the apparent optimum AWPF capacity of 18 mgd with tertiary filter and MF backwash flows recycled to the front of the plant are provided as **Appendix A.**

Figure 2: Flow Progression from NCWRP to AWPF Purified Water Product (no recycle flows)

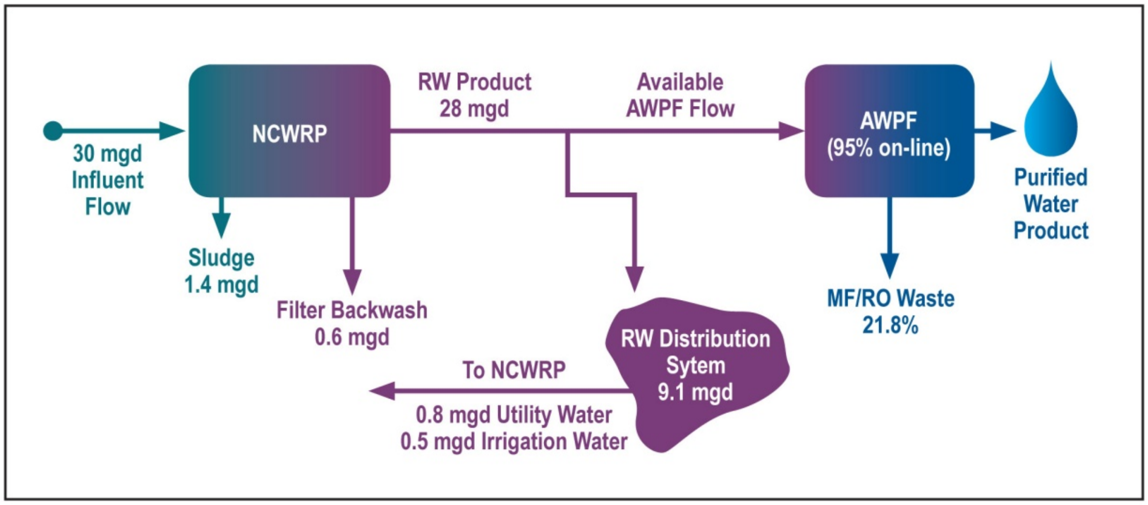
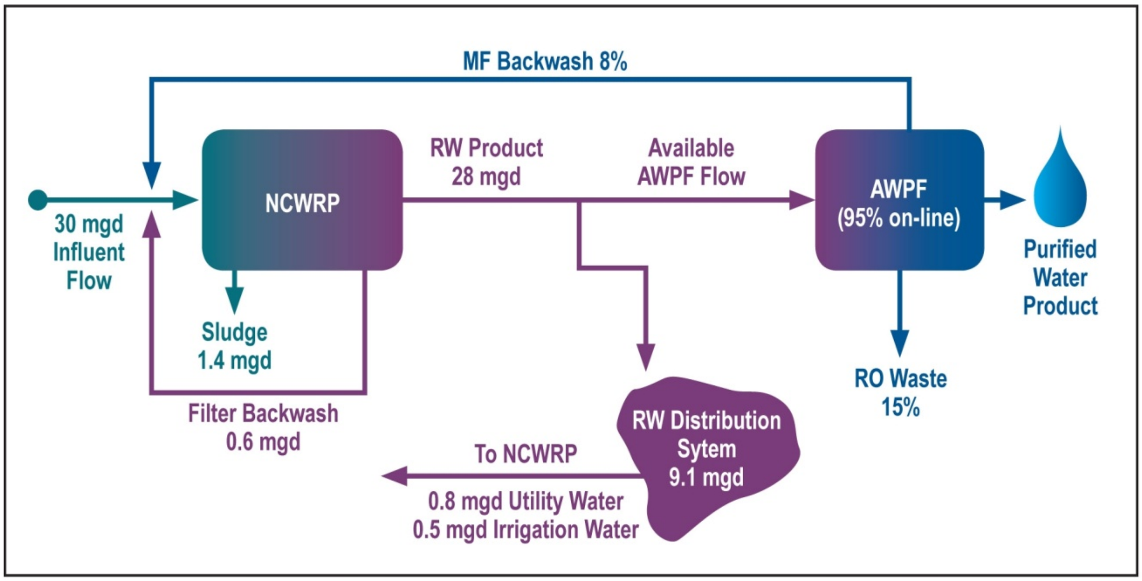


Figure 3: Flow Progression from NCWRP to AWPF Purified Water Product (with tertiary and MF backwash recycle)



7 Preliminary Design Criteria for Sizing Conveyance System

The design criteria and assumptions used in this analysis to preliminarily size the project components and determine the optimal AWPF capacity is provided in **Table 2**.

Table 2: Preliminary Facility Design Criteria

Facility	Criteria	Reference
Pipeline	Max Velocity = 5 ft/s Min Diameter = 8-inch Minor Losses = 10% of Friction Losses Hazen-Williams Coefficient = 135	*City of San Diego Water Department Capital Improvements Program Guidelines and Standards, Book 2*, November 2002 (City Guidelines and Standards).
Pump Station	Capacity = APWF Product Water Flow	Planned operation of AWPF at capacity
APWF	MF/ /RO Waste = 21.8% (8% MF Waste and 15% RO Waste)	Based on Water Purification Demonstration Project performed by CDM
	Online Factor = 95%	Based on OCWD's Ground Water Replenishment System

For the purposes of this analysis, the 1996 Project Report recommendation of a single pump station at the AWPF to pump all of the purified water flows to the SVR will be used.

As previously mentioned, the selected pipeline alignment for this analysis is the South Corridor Mast Boulevard Alignment. The alignment is approximately 28-miles in length (5 miles of which is built) and extends from the AWPF to the SVR. The proposed alignment for this cost analysis assumes that the pipeline will connect to the existing recycled waterline that extends from the NCWRP to the MBC. The point of connection for the proposed conveyance pipeline would be to the existing 36-inch recycled water line at MBC. This would eliminate the construction of approximately 5 miles of pipeline.

8 Preliminary Project Life Cycle Costs

To help select the optimal capacity, preliminary costs in 2011 dollars have been developed. While these costs are not to be considered the programmatic costs, they are useful in comparing the relative and incremental costs or a given yield. The preliminary costs for the project components in this analysis were determined using the following cost assumptions summarized in **Table 3**. Sources for these assumptions include the 2005 Water Reuse Study, latest Recycled Water Study, data provided by the City, and assumed values based on typical industry standards.

Table 3: Facility Cost Assumptions

Facility	Cost Assumptions	Source
Capital Cost Pipeline	$20/in-dia/ft	Planning level unit cost includes some limited tunneling
Pump Station	PS Cost [1]= (440,000*(Q_{cfs})^0.75 * (H_{ft}/300)^0.66)	*Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)*
AWPF	MF: $1,410,000/mgd RO: $1,750,000/mgd AOP: $310,000/mgd	Provided by City and rounded to nearest $10,000
O&M Cost Pipeline	1% of Construction Cost[2]	*Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)*
Pump Station	2.5% of Construction Cost[2] Pump Hrs per Day = 24 hrs Days per Year = 95% of 365 days = 347 days Wire to Water Pumping Efficiency = 75% Energy Cost = $0.15/kWh	*Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)* Assumed Based on AWPF on-line factor Assumed Assumed
AWPF	MF/RO/AOP: $600,000/mgd	Latest Recycled Water Study and rounded to nearest $10,000
Soft Costs		
Life Cycle	50 years	Apply to all facilities. Provided by City
Interest Rate	6%	*Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)*
Contingency	40%	Provided by City
Engineering/Admin	20%	Provided by City
Environmental Doc	20%	Provided by City
Land Acquisition	4%	Provided by City
Construction Mgmt	10%	Provided by City

Notes:

1. The original pump station capital cost equation from *Water Reuse Study, Cost Analysis, Technical Memorandum 7 (September 2005)* included 30% administrative & engineering fees and 20% construction management fees. These were removed as soft costs provided by the City would be factored in later.
2. Pump station and pipeline O&M Costs is percentage of construction cost with 40% soft cost contingency factored into construction cost.

3. AWPF O&M costs for microfiltration, reverse osmosis, and advanced oxidation process provided by City was compared to OCSD's AWPF that produces 49 mgd of product water. OCWD in November 2008 had operating costs of $573k/mgd which includes $10k/mgd of OCSD credits. The difference of $17k/mgd can be attributed to data being 3 years ago and economies of scale.

9 Cost Analysis

As part of the cost analysis, the total project cost was estimated for varying AWPF capacities to determine an optimal unit cost per acre-foot of purified water produced annually. This analysis was done first assuming tertiary filter and MF backwash flows are wasted to Point Loma Wastewater Treatment Plant (Section 9.1), and next assuming tertiary filter and MF backwash flows are recycled to the head of the NCWRP (Section 9.2).

9.1 Cost Analysis Assuming No Recycle Flows

Table 4 summarizes the unit costs for the preliminarily sized pump station, ultimate conveyance pipeline diameter of 30-inch, and purified product water yield for AWPF capacities varying from 0 to 20 mgd. A complete detailed cost breakdown showing costs for each project component is provided as **Appendix B**.

Table 4: Purified Water Yields and Project Unit Costs by AWPF Capacity (no recycle flows)

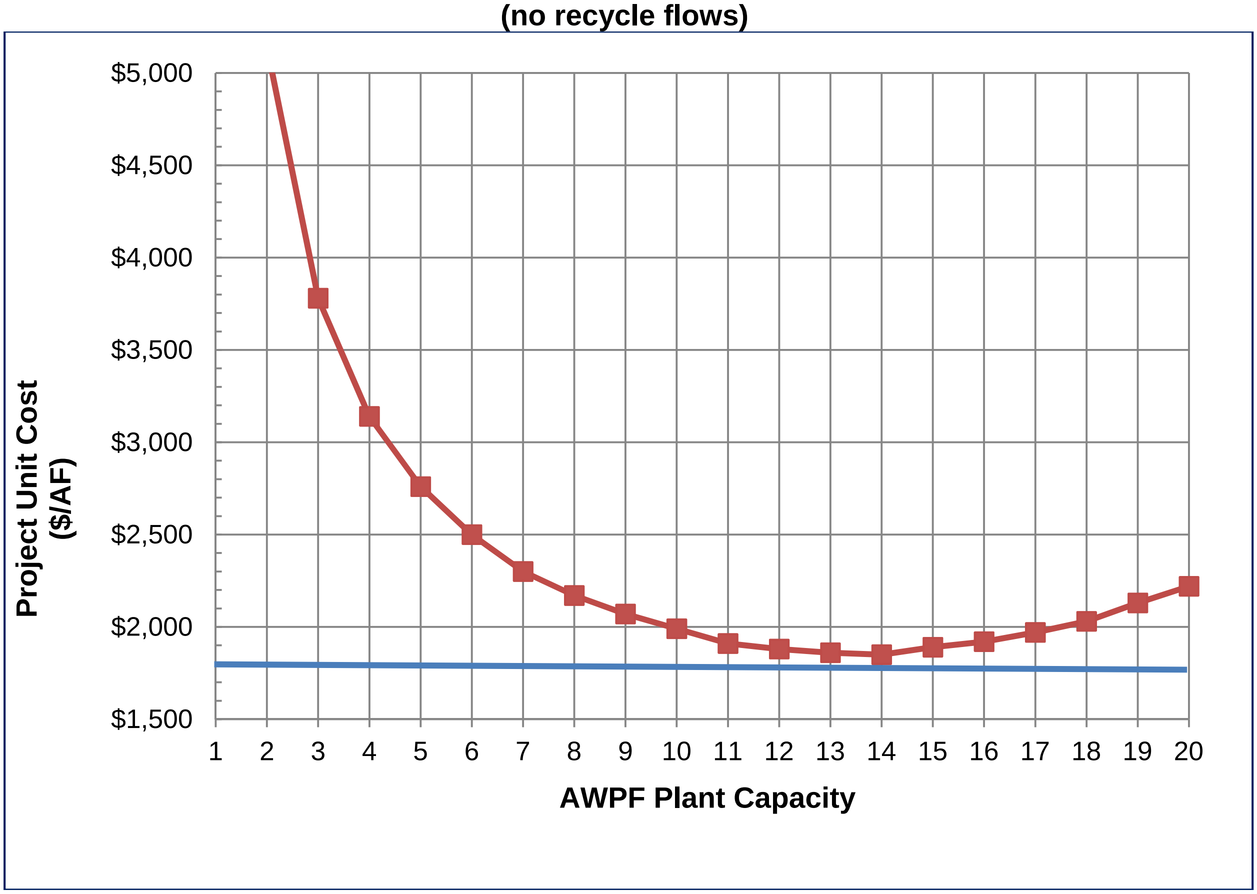
AWPF Plant Capacity (mgd)	Projected AWPF Product Water Yield (95% on-line) (AFY)	Conveyance Pipe Diameter (in)	Pump Flow (gpm)	TDH (ft)	Pump Power (Hp)	Unit Cost ($/AFY)
1	1,070	30	700	450	110	$8,970
2	2,130	30	1,400	450	220	$5,140
3	3,210	30	2,100	460	330	$3,780
4	4,270	30	2,800	460	440	$3,140
5	5,330	30	3,500	470	560	$2,760
6	6,400	30	4,200	480	680	$2,500
7	7,460	30	4,900	500	830	$2,300
8	8,530	30	5,600	510	970	$2,170
9	9,590	30	6,300	530	1130	$2,070
10	10,650	30	7,000	550	1300	$1,990
11	11,710	30	7,700	560	1460	$1,910
12	12,680	30	8,400	590	1670	$1,880
13	13,570	30	9,100	610	1870	$1,860
14	**14,270**	**30**	**9,800**	**630**	**2080**	**$1,850**
15	14,800	30	10,500	660	2340	$1,890
16	15,240	30	11,200	680	2570	$1,920
17	15,580	30	11,900	710	2850	$1,970
18	15,740	30	12,500	740	3120	$2,030
19	15,740	30	13,200	770	3430	$2,130
20	15,740	30	13,900	810	3800	$2,220

Notes:
1. Pipeline diameter sizes are based on a maximum velocity of 5 feet per second per *City of San Diego CIP Guidelines and Standards* for transmission mains less than 60-inch in diameter.
2. Estimated Projected AWPF Water Yield includes the 5% off-line factor.

Based on the unit cost per acre-foot cost analysis, Table 4 and **Figure 4** illustrate the apparent optimal price point is at an AWPF capacity of 14 mgd with an estimated unit cost of $1,850 per acre-feet of purified water produced annually. However, this analysis is based on the projected recycled water demands for 2030 (which may vary over the next 19 years) and concept level costs. Because of the potential variations in the assumptions, an optimum range would be reasonable as the differences in unit costs are within a narrow margin. Therefore, AWPF feed rates within the lower and flatter segment of the curve (from 11 to 16 mgd) are within an optimal range with 14 mgd estimated as having the lowest unit cost per acre-foot of product water yield. This range provides the City some flexibility in capturing the flows when the irrigation demands are less, thus avoiding lost product water to Point Loma Wastewater Treatment Plant.

Per the City's request, a separate analysis was performed assuming an ultimate 36-inch pipe diameter would be constructed. Similar to evaluating the economic analysis with a constant 30-inch pipe, this was performed to determine the cost implications the pipe capital cost would have on the project unit cost, as well as the overall project costs. The results of this analysis are included in **Appendix C**.

Figure 4: Project Unit Cost by AWPF Plant Capacity for 30-inch Pipe (no recycle flows)

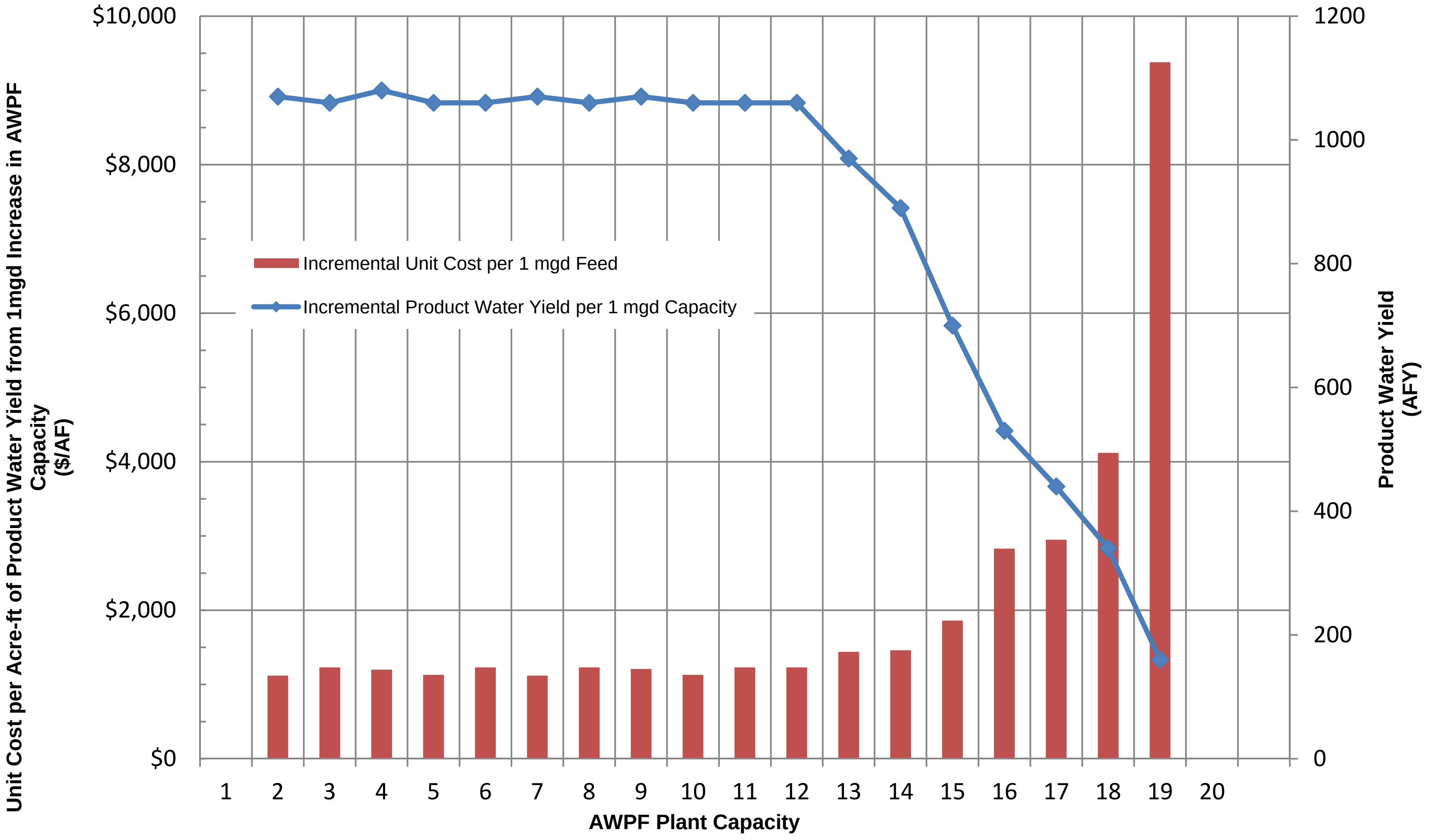


Another way to analyze the capacity is to look at the incremental costs for each additional 1 mgd of flow. **Table 5** below shows the incremental product water yield and total project costs for each additional increase in 1-mgd of AWPF feed rate. The incremental cost per 1mgd of capacity starts to increase at an increasing rate at 14 mgd and above.

Figure 5 shows the purified water yield for each additional 1 mgd of AWPF feed along with the "incremental" unit cost per acre-foot. The amount of product water yield from the AWPF begins to decrease for feed rates greater than 14 mgd because seasonal recycled water demands impact the amount of tertiary water available for advanced treatment. As the AWPF capacity increases, the product water yield diminishes because the facility is oversized for longer periods of time during the summer months when available tertiary flows to the purification facility are lowest. This incremental unit cost should not be confused with the overall project unit cost where annualized project costs are divided by the average annual purified water yield.

Based on the incremental unit cost analysis, the product water yield starts to decline for AWPF capacities that are greater than 11 mgd. Even for capacities from 12 to 14 mgd, it appears that the incremental costs are relatively comparable in cost despite the decline in product water yield. An AWPF capacity of 14 mgd is the breakpoint where the benefit to cost ratio starts to decline more dramatically.

Figure 5: Incremental Unit Cost of Purified Water Yield Per 1 MGD Increase of AWPF Capacity (no recycle flows)



NOTE: THE ABOVE UNIT COSTS ARE INCREMENTAL. THEY SHOULD NOT BE COMPARED TO TOTAL PROJECT UNIT COSTS OR SDCWA YR 2030 PROJECTED IMPORTED WATER COSTS OF $2000/AF. PRODUCT WATER YIELD ASSUMES AWPF IS 95% ON-LINE ANNUALLY.

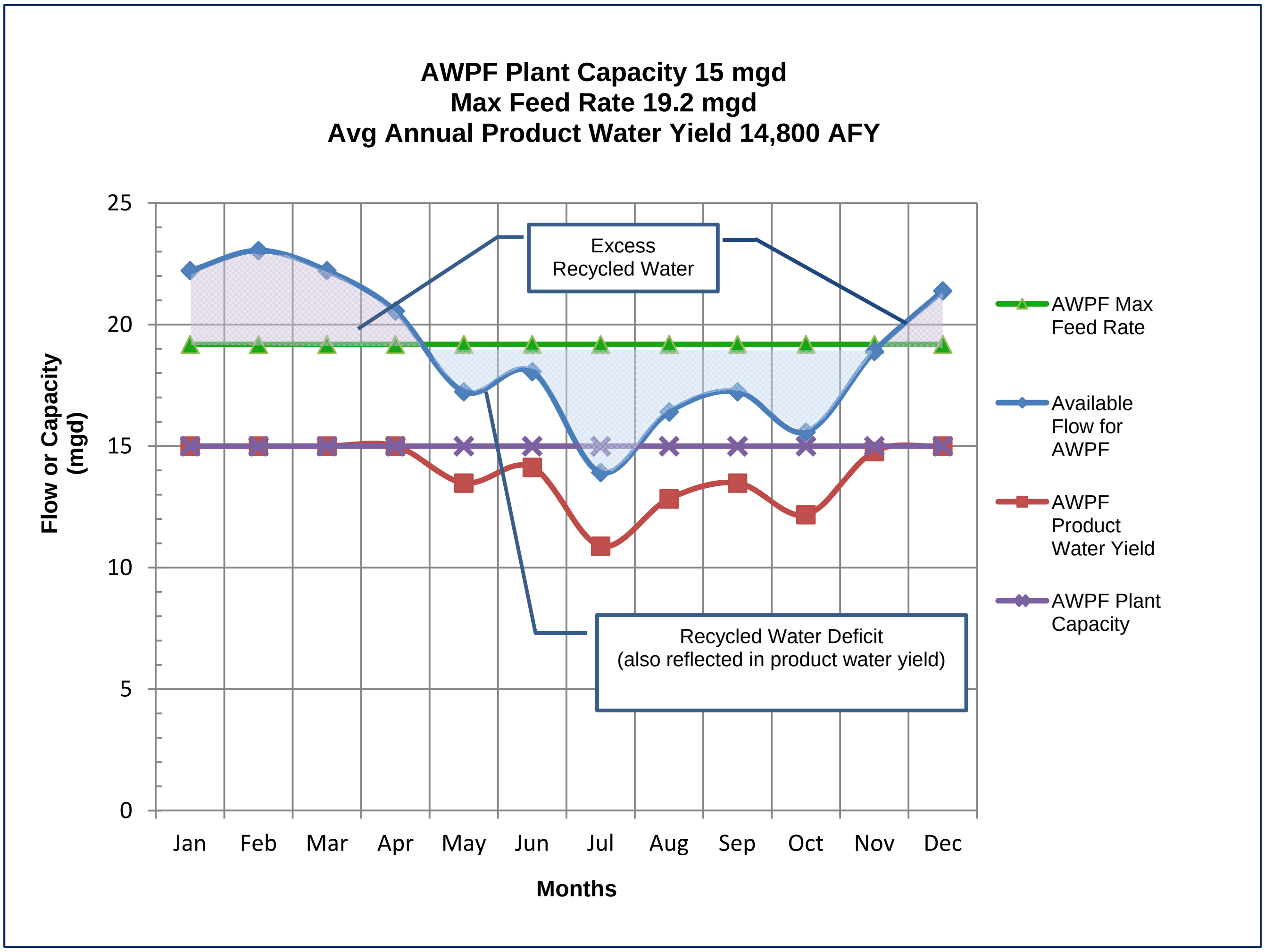
Table 5: Incremental Unit Cost by AWPF Capacity
(no recycle flows)

AWPF Capacity (mgd)	Conveyance Pipe Diameter (in)	AWPF Product Water Yield (95% on-line) (AFY)	Incremental AWPF Capacity (AFY)	Incremental Capital Cost ($)	Incremental Annual O&M Cost ($)	Incremental Total Annual Cost ($)	Incremental Unit Cost ($/AF)
1	30	1,070	1,070	$8,300,000	$600,000	$1,200,000	$1,120
2	30	2,130	1,060	$7,900,000	$700,000	$1,300,000	$1,230
3	30	3,210	1,080	$7,900,000	$600,000	$1,300,000	$1,200
4	30	4,270	1,060	$7,800,000	$700,000	$1,200,000	$1,130
5	30	5,330	1,060	$7,800,000	$700,000	$1,300,000	$1,230
6	30	6,400	1,070	$7,800,000	$600,000	$1,200,000	$1,120
7	30	7,460	1,060	$7,800,000	$600,000	$1,300,000	$1,230
8	30	8,530	1,070	$7,800,000	$700,000	$1,300,000	$1,210
9	30	9,590	1,060	$7,900,000	$600,000	$1,200,000	$1,130
10	30	10,650	1,060	$7,800,000	$600,000	$1,300,000	$1,230
11	30	11,710	1,060	$7,800,000	$600,000	$1,300,000	$1,230
12	30	12,680	970	$8,000,000	$700,000	$1,400,000	$1,440
13	30	13,570	890	$7,900,000	$700,000	$1,300,000	$1,460
14	**30**	**14,270**	**700**	**$7,900,000**	**$600,000**	**$1,300,000**	**$1,860**
15	30	14,800	530	$8,000,000	$700,000	$1,500,000	$2,830
16	30	15,240	440	$7,900,000	$600,000	$1,300,000	$2,950
17	30	15,580	340	$8,100,000	$600,000	$1,400,000	$4,120
18	30	15,740	160	$8,000,000	$700,000	$1,500,000	$9,380
19	30	15,740	0	$8,100,000	$600,000	$1,400,000	---
20	30	15,740	0	$8,200,000	$700,000	$1,500,000	---

Note: The above flow data and costs are based on 30-inch pipe.

From an economic analysis, the optimum value appears to occur from an AWPF capacity of 14 mgd which produces a projected product yield of 14,270 AFY at a required feed flow of 17.9 mgd. Although it would treat less recycled water during the winter months than the balanced scenario, it would potentially operate at its design capacity for 9 months out of a given year depending upon recycled water demands.

**Figure 6: Flow Balance Analysis
(no recycle flows)**



9.2 Cost Analysis with Tertiary/MF Recycle Flows

Table 6 summarizes the unit costs for the preliminarily sized pump station, ultimate conveyance pipeline diameter of 30-inch, and purified product water yield for AWPF capacities varying from 0 to 20 mgd assuming tertiary filter and MF backwash flows are recycled to the front of the NCWRP. Recycling flows to the front of the plant will increase flow to the AWPF, increasing monthly yield when plant capacity exceeds the flow available. A complete detailed cost breakdown showing costs for each project component is provided as **Appendix B**.

Table 6: Purified Water Yields and Project Unit Costs by AWPF Capacity (with tertiary and MF backwash recycle)

AWPF Plant Capacity (mgd)	Projected AWPF Product Water Yield (95% on-line) (AFY)	Conveyance Pipe Diameter (in)	Pump Flow (gpm)	TDH (ft)	Pump Power (Hp)	Unit Cost ($/AFY)
1	1,070	30	700	450	110	$8,970
2	2,130	30	1,400	450	220	$5,140
3	3,210	30	2,100	460	330	$3,780
4	4,270	30	2,800	460	440	$3,140
5	5,330	30	3,500	470	560	$2,760
6	6,400	30	4,200	480	680	$2,500
7	7,460	30	4,900	500	830	$2,300
8	8,530	30	5,600	510	970	$2,170
9	9,590	30	6,300	530	1130	$2,070
10	10,650	30	7,000	550	1300	$1,990
11	11,720	30	7,700	560	1460	$1,910
12	12,780	30	8,400	590	1670	$1,870
13	13,770	30	9,100	610	1870	$1,820
14	14,700	30	9,800	630	2080	$1,800
15	15,510	30	10,500	660	2340	$1,800
16	16,100	30	11,200	680	2570	$1,820
17	16,570	30	11,900	710	2850	$1,850
18	**16,990**	**30**	**12,500**	**740**	**3120**	**$1,900**
19	17,290	30	13,200	770	3430	$1,940
20	17,370	30	13,900	810	3800	$2,030

Notes:

3. Pipeline diameter sizes are based on a maximum velocity of 5 feet per second per *City of San Diego CIP Guidelines and Standards* for transmission mains less than 60-inch in diameter.
4. Estimated Projected AWPF Water Yield includes the 5% off-line factor.

Based on the unit cost per acre-foot cost analysis, **Table 6** and **Figure 7,** AWPF feed rates within the lower and flatter segment of the curve (from 11 to 18 mgd) are within an optimal range with 14 to 15 mgd estimated as having the lowest unit cost per acre-foot of product water yield. This is because at 14 to 15 MGD the plant would operate at full capacity nearly year round. However, at a capacity of approximately 18 MGD, the City would be able to meet the stated IPR goals.

Figure 7: Project Unit Cost by AWPF Plant Capacity for 30-inch Pipeline (with tertiary and MF backwash recycle)

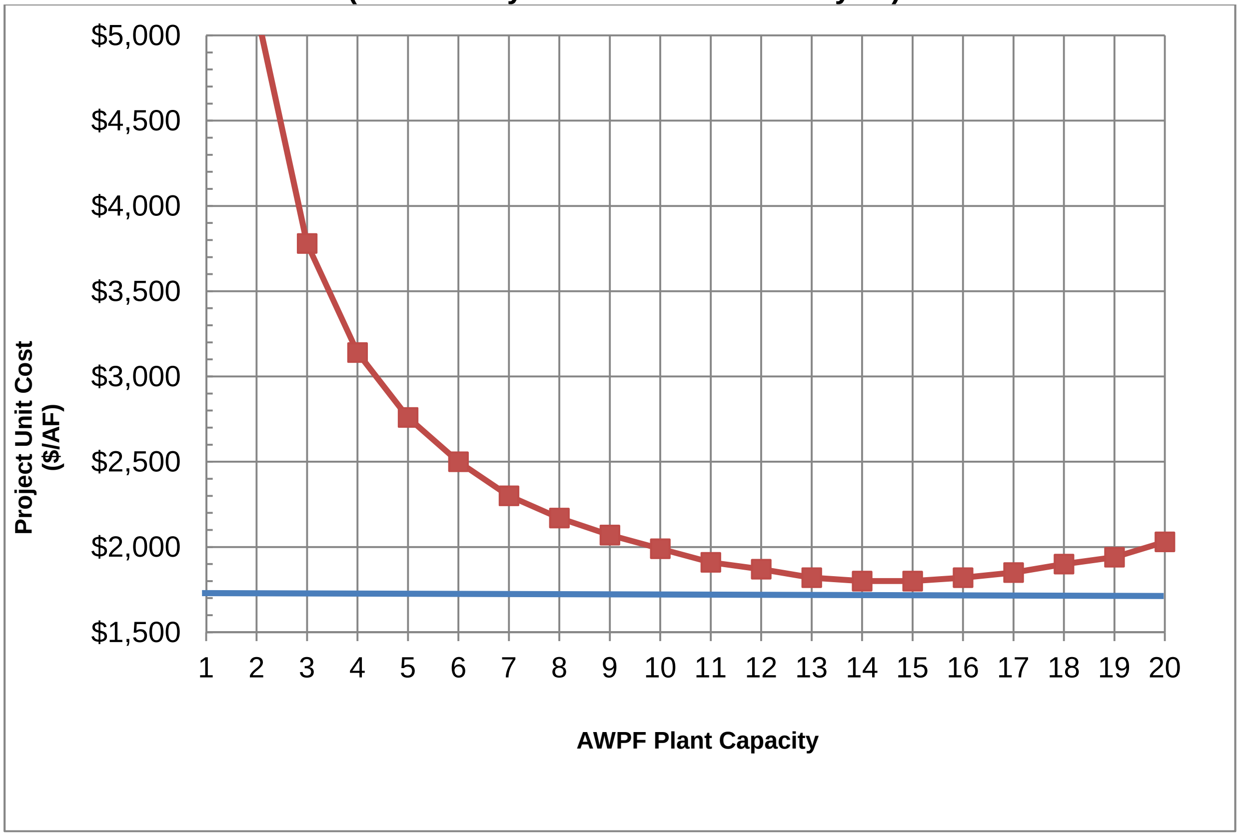
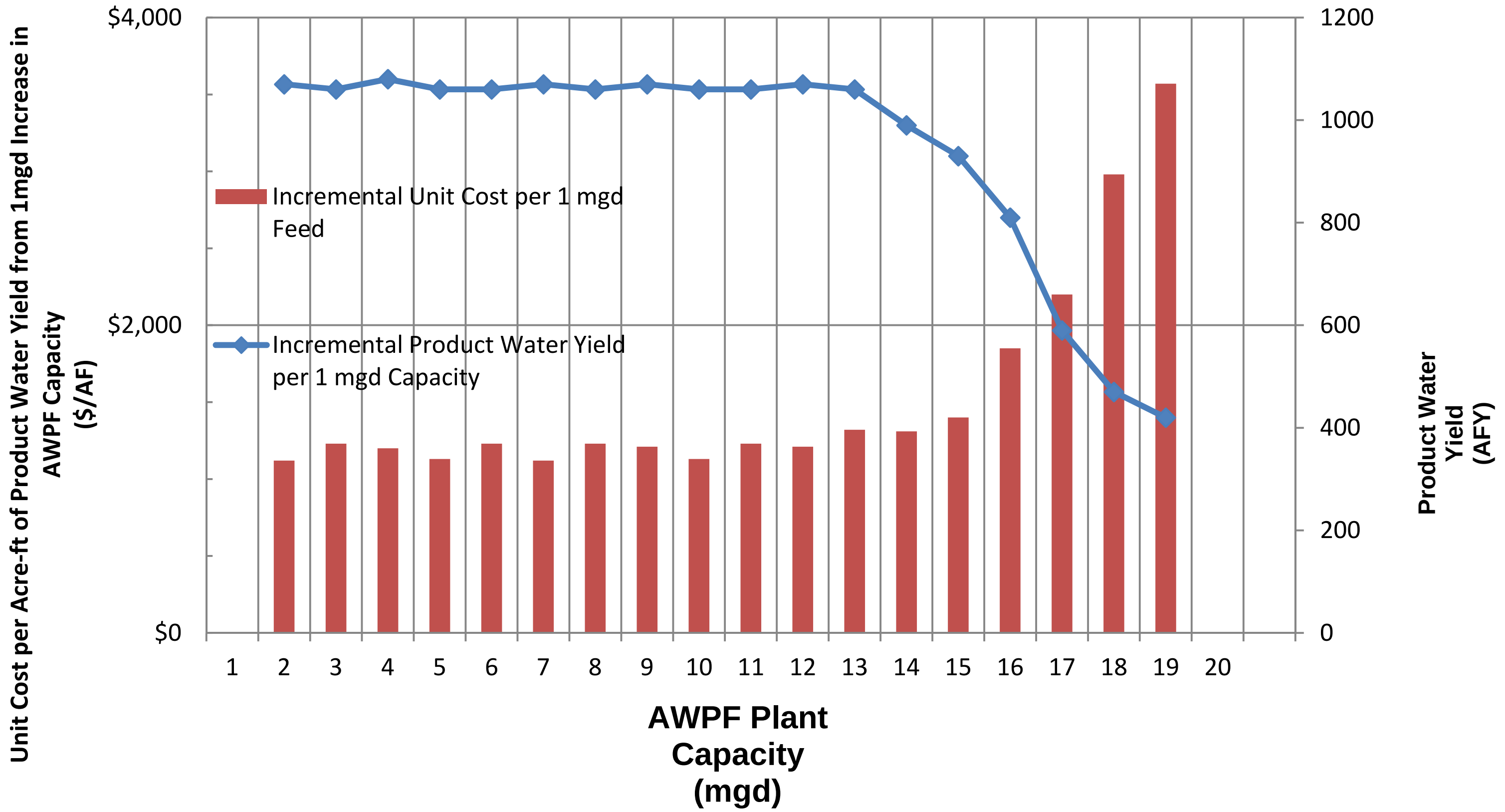


Table 7 shows the incremental product water yield and total project costs for each additional increase in 1-mgd of AWPF feed rate with recycle flows. The incremental cost per 1 mgd of capacity starts to increase at an increasing rate at 16 mgd and above.

Figure 8 shows the purified water yield for each additional 1 mgd of AWPF feed along with the "incremental" unit cost per acre-foot. The amount of product water yield from the AWPF begins to decrease for feed rates greater than 14 mgd because seasonal recycled water demands impact the amount of tertiary water available for advanced treatment. As the AWPF capacity increases, the product water yield diminishes because the facility is oversized for longer periods of time during the summer months when available tertiary flows to the purification facility are lowest.

Figure 8: Incremental Unit Cost and Purified Water Yield per 1 MGD Increase of AWPF Capacity (with tertiary and MF backwash recycle)



NOTE: THE ABOVE UNIT COSTS ARE INCREMENTAL. THEY SHOULD NOT BE COMPARED TO TOTAL PROJECT UNIT COSTS OR SDCWA YR 2030 PROJECTED IMPORTED WATER COSTS OF $2000/AF. PRODUCT WATER YIELD ASSUMES AWPF IS 95% ON-LINE ANNUALLY.

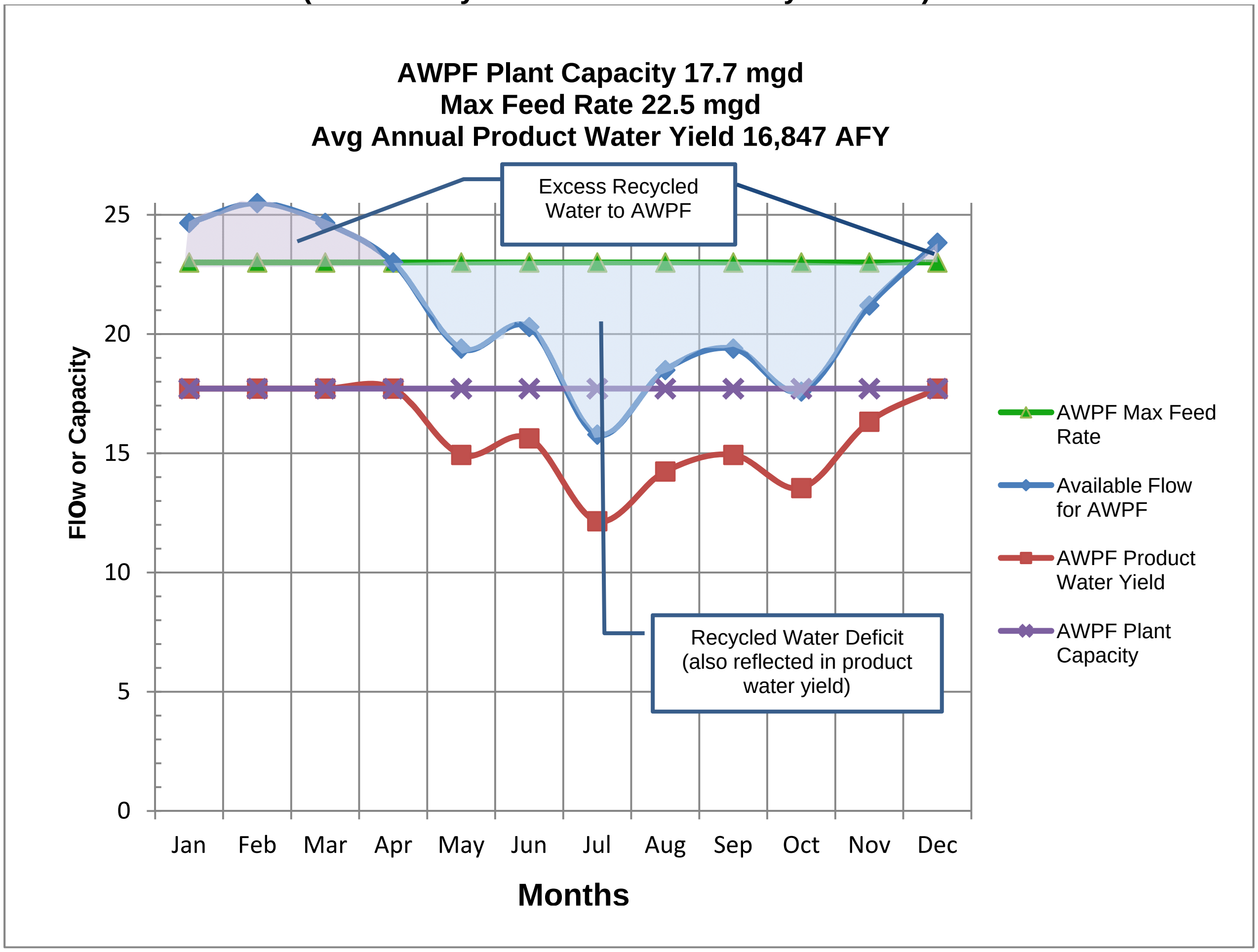
Table 7: Incremental Unit Cost by AWPF Capacity (with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	Conveyance Pipe Diameter (in)	AWPF Product Water Yield (95% on-line) (AFY)	Incremental AWPF Capacity (AFY)	Incremental Capital Cost ($)	Incremental Annual O&M Cost ($)	Incremental Total Annual Cost ($)	Incremental Unit Cost ($/AF)
1	30	1,070	1,070	$8,300,000	$600,000	$1,200,000	$1,120
2	30	2,130	1,060	$7,900,000	$700,000	$1,300,000	$1,230
3	30	3,210	1,080	$7,900,000	$600,000	$1,300,000	$1,200
4	30	4,270	1,060	$7,800,000	$700,000	$1,200,000	$1,130
5	30	5,330	1,060	$7,800,000	$700,000	$1,300,000	$1,230
6	30	6,400	1,070	$7,800,000	$600,000	$1,200,000	$1,120
7	30	7,460	1,060	$7,800,000	$600,000	$1,300,000	$1,230
8	30	8,530	1,070	$7,800,000	$700,000	$1,300,000	$1,210
9	30	9,590	1,060	$7,900,000	$600,000	$1,200,000	$1,130
10	30	10,650	1,060	$7,800,000	$600,000	$1,300,000	$1,230
11	30	11,720	1,070	$7,800,000	$600,000	$1,300,000	$1,210
12	30	12,780	1,060	$8,000,000	$700,000	$1,400,000	$1,320
13	30	13,770	990	$7,900,000	$700,000	$1,300,000	$1,310
14	30	14,700	930	$7,900,000	$600,000	$1,300,000	$1,400
15	30	15,510	810	$8,000,000	$700,000	$1,500,000	$1,850
16	30	16,100	590	$7,900,000	$600,000	$1,300,000	$2,200
17	30	16,570	470	$8,100,000	$600,000	$1,400,000	$2,980
18	**30**	**16,990**	**420**	**$8,000,000**	**$700,000**	**$1,500,000**	**$3,570**
19	30	17,290		$8,100,000	$600,000	$1,400,000	
20	30	17,370		$8,200,000	$700,000	$1,500,000	

Note: The above flow data and costs are based on 30-inch pipe.

Calculations of treatment capacity and AWPF yield show that a 17.7 MGD plant can meet the City's goal of 16,800 AFY IPR reuse. **Figure 9** shows the amount of recycled water above and below the AWPF capacity by month for a 17.7 MGD AWPF, including excess recycled water available to the AWPF and deficit recycled water (excess AWPF capacity). For approximately 7 months out of the year, the flow available is less than required for the plant to run at full capacity. However, this is the minimum size plant that would meet the City's IPR goals.

Figure 9: Flow Balance Analysis
(with tertiary and MF backwash recycle flows)



10 Conclusion

As discussed earlier, flows available to the AWPF vary by season throughout the year. After on-site and irrigation demands are met, the maximum month available flow would be 25 mgd with recycling tertiary filter and MF backwash flows. Without recycling the tertiary filter and MF backwash flows the AWPF and pumping facilities should be sized for 14 mgd of capacity initially and 18 mgd for ultimate. **Table 8** summarizes the project costs by component and highlights the two recommended AWPF capacities. However, an increase in AWPF production could be achieved if tertiary filter backwash and membrane filtration (MF) backwash is recycled back to the front of the plant rather than wasted to Point Loma Wastewater Treatment Plant. If this scenario is implemented, an optimal AWPF capacity of 18 mgd for a full-scale project would yield approximately 16,876 AFY of purified water, which meets the City’s goal of maximizing reuse. **Table 9** summarizes the project costs by component and highlights the recommended AWPF capacity.

Recycling of these flows is not part of the current operations at the NCWRP or at the pilot demonstration tests facility. The NCWRP plant staff believes that they can process more flow than the rated capacity but is actually operating well below the rated capacity and does not have a track record of performance above 30 mgd. In the future and with recycling the tertiary and MF backwash flows, the NCWRP could see flows greater than 10% above the rated capacity on a continuous basis. Note that this analysis did not evaluate the hydraulics or process design capabilities and limitations. The MF backwash water contains chloramines and thus would add more nitrogen back into the NCWRP from recycling this water. While the load may be relatively small, total nitrogen is a key regulatory parameter for reservoir augmentation. Therefore, potential water quality impacts and mitigation measures should be evaluated in the next phase of the design. In addition, recycling of these flows would deliver more flow to the front of the NCWRP, and potential impacts to NCWRP operations, including available process capacity must be evaluated.

Table 8: Project Cost Summary by AWPF Capacity
(no recycle flows)

AWPF Capacity (mgd)	AWPF Product Water Yield (95% online) (AFY)	Construction Costs Total ($)	Soft Costs Total ($)	Capital Costs				Annualized Capital Costs Total ($)	Annualized O&M Costs Total ($)	Total Annualized Cost Total ($)	Annual Unit Cost Total ($/AF)
				AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)				
1	1,070	$65,100,000	$61,200,000	$7,220,000	$118,000,000	$1,032,000	$126,300,000	$8,100,000	$1,500,000	$9,600,000	$8,970
2	2,130	$69,200,000	$65,100,000	$14,430,000	$118,000,000	$1,734,000	$134,200,000	$8,600,000	$2,200,000	$10,900,000	$5,140
3	3,210	$73,300,000	$68,900,000	$21,650,000	$118,000,000	$2,386,000	$142,100,000	$9,100,000	$2,800,000	$12,200,000	$3,780
4	4,270	$77,300,000	$72,700,000	$28,860,000	$118,000,000	$2,960,000	$149,900,000	$9,600,000	$3,500,000	$13,400,000	$3,140
5	5,330	$81,300,000	$76,400,000	$36,080,000	$118,000,000	$3,550,000	$157,700,000	$10,000,000	$4,200,000	$14,700,000	$2,760
6	6,400	$85,300,000	$80,200,000	$43,290,000	$118,000,000	$4,128,000	$165,500,000	$10,500,000	$4,800,000	$15,900,000	$2,500
7	7,460	$89,400,000	$84,000,000	$50,510,000	$118,000,000	$4,761,000	$173,300,000	$11,000,000	$5,400,000	$17,200,000	$2,300
8	8,530	$93,400,000	$87,800,000	$57,720,000	$118,000,000	$5,331,000	$181,100,000	$11,500,000	$6,100,000	$18,500,000	$2,170
9	9,590	$97,400,000	$91,600,000	$64,930,000	$118,000,000	$5,973,000	$189,000,000	$12,000,000	$6,700,000	$19,700,000	$2,070
10	10,650	$101,500,000	$95,400,000	$72,150,000	$118,000,000	$6,623,000	$196,800,000	$12,500,000	$7,300,000	$21,000,000	$1,990
11	11,710	$105,500,000	$99,200,000	$79,360,000	$118,000,000	$7,199,000	$204,600,000	$13,000,000	$7,900,000	$22,300,000	$1,910
12	12,680	$109,600,000	$103,000,000	$86,580,000	$118,000,000	$7,954,000	$212,600,000	$13,500,000	$8,600,000	$23,700,000	$1,880
13	13,570	$113,700,000	$106,900,000	$93,790,000	$118,000,000	$8,635,000	$220,500,000	$14,000,000	$9,300,000	$25,000,000	$1,860
14	**14,270**	**$117,800,000**	**$110,700,000**	**$101,010,000**	**$118,000,000**	**$9,324,000**	**$228,400,000**	**$14,500,000**	**$9,900,000**	**$26,300,000**	**$1,850**
15	14,800	$121,900,000	$114,600,000	$108,220,000	$118,000,000	$10,125,000	$236,400,000	$15,000,000	$10,600,000	$27,800,000	$1,890
16	15,240	$126,000,000	$118,400,000	$115,440,000	$118,000,000	$10,839,000	$244,300,000	$15,500,000	$11,200,000	$29,100,000	$1,920
17	15,580	$130,100,000	$122,300,000	$122,650,000	$118,000,000	$11,671,000	$252,400,000	$16,100,000	$11,800,000	$30,500,000	$1,970
18	**15,740**	**$134,300,000**	**$126,200,000**	**$129,870,000**	**$118,000,000**	**$12,521,000**	**$260,400,000**	**$16,600,000**	**$12,500,000**	**$32,000,000**	**$2,030**
19	15,740	$138,400,000	$130,100,000	$137,080,000	$118,000,000	$13,384,000	$268,500,000	$17,100,000	$13,100,000	$33,400,000	$2,130
20	15,740	$142,700,000	$134,100,000	$144,290,000	$118,000,000	$14,381,000	$276,700,000	$17,600,000	$13,800,000	$34,900,000	$2,220

Table 9: Project Cost Summary by AWPF Capacity
(with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	AWPF Product Water Yield (95% online) (AFY)	Construction Costs Total ($)	Soft Costs Total ($)	Capital Costs				Annualized Capital Costs Total ($)	Annualized O&M Costs Total ($)	Total Annualized Cost Total ($)	Annual Unit Cost Total ($/AF)
				AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)				
1	1,070	$65,100,000	$61,200,000	$7,220,000	$118,000,000	$1,032,000	$126,300,000	$8,100,000	$1,500,000	$9,600,000	$8,970
2	2,130	$69,200,000	$65,100,000	$14,430,000	$118,000,000	$1,734,000	$134,200,000	$8,600,000	$2,200,000	$10,900,000	$5,140
3	3,210	$73,300,000	$68,900,000	$21,650,000	$118,000,000	$2,386,000	$142,100,000	$9,100,000	$2,800,000	$12,200,000	$3,780
4	4,270	$77,300,000	$72,700,000	$28,860,000	$118,000,000	$2,960,000	$149,900,000	$9,600,000	$3,500,000	$13,400,000	$3,140
5	5,330	$81,300,000	$76,400,000	$36,080,000	$118,000,000	$3,550,000	$157,700,000	$10,000,000	$4,200,000	$14,700,000	$2,760
6	6,400	$85,300,000	$80,200,000	$43,290,000	$118,000,000	$4,128,000	$165,500,000	$10,500,000	$4,800,000	$15,900,000	$2,500
7	7,460	$89,400,000	$84,000,000	$50,510,000	$118,000,000	$4,761,000	$173,300,000	$11,000,000	$5,400,000	$17,200,000	$2,300
8	8,530	$93,400,000	$87,800,000	$57,720,000	$118,000,000	$5,331,000	$181,100,000	$11,500,000	$6,100,000	$18,500,000	$2,170
9	9,590	$97,400,000	$91,600,000	$64,930,000	$118,000,000	$5,973,000	$189,000,000	$12,000,000	$6,700,000	$19,700,000	$2,070
10	10,650	$101,500,000	$95,400,000	$72,150,000	$118,000,000	$6,623,000	$196,800,000	$12,500,000	$7,300,000	$21,000,000	$1,990
11	11,720	$105,500,000	$99,200,000	$79,360,000	$118,000,000	$7,199,000	$204,600,000	$13,000,000	$7,900,000	$22,300,000	$1,910
12	12,780	$109,600,000	$103,000,000	$86,580,000	$118,000,000	$7,954,000	$212,600,000	$13,500,000	$8,600,000	$23,700,000	$1,870
13	13,770	$113,700,000	$106,900,000	$93,790,000	$118,000,000	$8,635,000	$220,500,000	$14,000,000	$9,300,000	$25,000,000	$1,820
14	14,700	**$117,800,000**	**$110,700,000**	**$101,010,000**	**$118,000,000**	**$9,324,000**	**$228,400,000**	**$14,500,000**	**$9,900,000**	**$26,300,000**	$1,800
15	15,510	$121,900,000	$114,600,000	$108,220,000	$118,000,000	$10,125,000	$236,400,000	$15,000,000	$10,600,000	$27,800,000	$1,800
16	16,100	$126,000,000	$118,400,000	$115,440,000	$118,000,000	$10,839,000	$244,300,000	$15,500,000	$11,200,000	$29,100,000	$1,820
17	16,570	$130,100,000	$122,300,000	$122,650,000	$118,000,000	$11,671,000	$252,400,000	$16,100,000	$11,800,000	$30,500,000	$1,850
18	16,990	**$134,300,000**	**$126,200,000**	**$129,870,000**	**$118,000,000**	**$12,521,000**	**$260,400,000**	**$16,600,000**	**$12,500,000**	**$32,000,000**	$1,900
19	17,290	$138,400,000	$130,100,000	$137,080,000	$118,000,000	$13,384,000	$268,500,000	$17,100,000	$13,100,000	$33,400,000	$1,940
20	17,370	$142,700,000	$134,100,000	$144,290,000	$118,000,000	$14,381,000	$276,700,000	$17,600,000	$13,800,000	$34,900,000	$2,030

APPENDIX A

City of San Diego IPR/PMPO

Concept Design Report - Conveyance System

Table: Projected Flows Based on Max Month RW Demands and Fixed AWPF Capacity

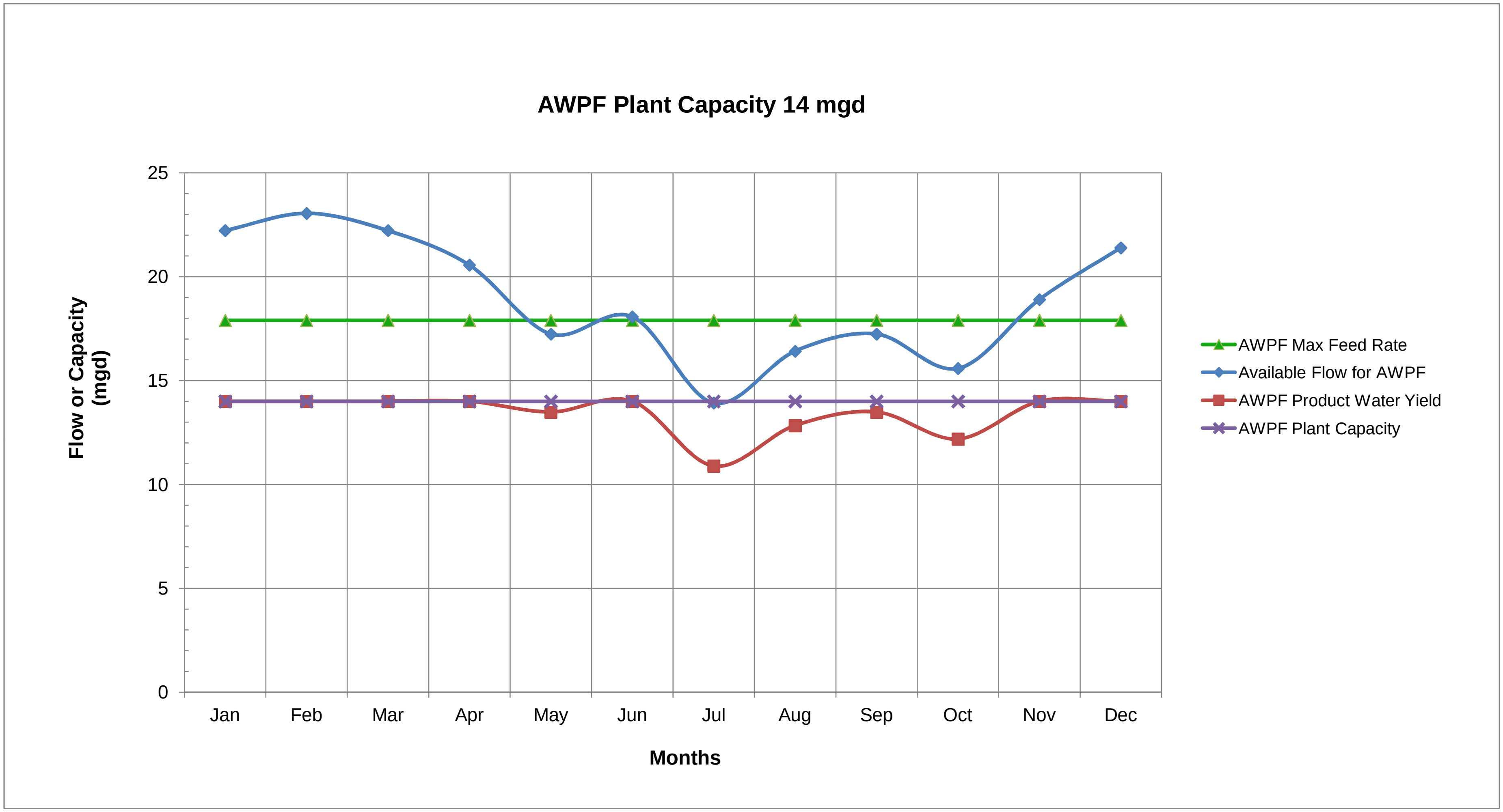
Month	**NCWRP Capacity (mgd)**	**Sludge (mgd)**	**Available for Tertiary Flow (mgd)**	**Tertiary Filter Backwash (mgd)**	**Tertiary Flow Product (mgd)**	**Utility Water (mgd)**	**RW Demand by Month (mgd)**	**Available Flow for AWPF (mgd)**	**AWPF Feed Rate (mgd)**	**AWPF Waste Streams (mgd)**	**AWPF Product Yield (mgd)**	**Total Flow to PLWWTP (mgd)**		**AWPF Max Feed Rate (mgd)**	**Excess RW (mgd)**	**RW Deficit Capacity (mgd)**
Jan	30	1.4	28.6	0.6	28.00	0.80	4.98	22.22	17.90	3.90	14.00	9.62		17.90	4.32	0
Feb	30	1.4	28.6	0.6	28.00	0.80	4.15	23.05	17.90	3.90	14.00	10.45		17.90	5.15	0
Mar	30	1.4	28.6	0.6	28.00	0.80	4.98	22.22	17.90	3.90	14.00	9.62		17.90	4.32	0
Apr	30	1.4	28.6	0.6	28.00	0.80	6.64	20.56	17.90	3.90	14.00	7.96		17.90	2.66	0
May	30	1.4	28.6	**0.6**	28.00	0.80	9.96	17.24	17.24	3.76	13.48	5.16		17.90	0	0.66
Jun	30	1.4	28.6	0.6	28.00	0.80	9.13	18.07	17.90	3.90	14.00	5.47		17.90	0.17	0
Jul	30	1.4	28.6	0.6	28.00	0.80	13.28	13.92	13.92	3.03	10.89	4.43		17.90	0	3.98
Aug	30	1.4	28.6	0.6	28.00	0.80	10.79	16.41	16.41	3.58	12.83	4.98		17.90	0	1.49
Sep	30	1.4	28.6	0.6	28.00	0.80	9.96	17.24	17.24	3.76	13.48	5.16		17.90	0	0.66
Oct	30	1.4	28.6	0.6	28.00	0.80	11.62	15.58	15.58	3.40	12.18	4.80		17.90	0	2.32
Nov	30	1.4	28.6	0.6	28.00	0.80	8.30	18.90	17.90	3.90	14.00	6.30		17.90	1	0.00
Dec	30	1.4	28.6	0.6	28.00	0.80	5.81	21.39	17.90	3.90	14.00	8.79		17.90	3.49	0
															21.11	9.11
			Volume (MG/Yr)				3030	6899	6256	1364	4893	2517			633	273
			Volume (AFY)					21,172	19,202	4,186	15,016	7,725			1,944	839
			AWPF Annual Offline Percentage	5%					**960**	**209**	**751**	**386**			97	42
			Adjusted Volume (AFY)					21,172	18,241	3,977	14,265	7,339			1,846	797
			Adjusted Avg Annual Flow (mgd)				**8.30**	**18.90**	**16.3**	**3.5**	**12.7**	**6.6**			**1.6**	**0.7**

NCWRF RW Produced	**30 mgd**
Sludge	**1.4 mgd**
Filter Backwash	**0.6 mgd**
MF/RO Waste	**21.8%**
Utility Water	**0.80 mgd**

Max	**14.00**
Min	10.89

AWPF Max Feed Rate	**17.90 mgd**

AWPF Capacity	**14 mgd**


AWPF Plant Capacity 14 mgd
Flow or Capacity (mgd)
0
5
10
15
20
25
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Months
AWPF Max Feed Rate
Available Flow for AWPF
AWPF Product Water Yield
AWPF Plant Capacity

City of San Diego IPR/PMPO
Concept Design Report - Conveyance System

Table: Projected Flows Based on Max Month RW Demands and Fixed AWPF Capacity (EDR Brine to PL)

Month	Raw WW Influent (mgd)	Tertiary Filter Backwash Return (mgd)	MF Backwash Return (mgd)	Total NCWRP Primary/ Secondary Influent (mgd)	Sludge sent to MBC (mgd)	Secondary Effluent (mgd)	Tertiary Filter Backwash (mgd)	Tertiary Product (mgd)	Utility Water (mgd)	EDR Feed (mgd)	EDR Product (Based on demands for RW, UW and TF BW water) (mgd)	EDR Brine (mgd)	RW Demand by Month (mgd)	Available Flow After NPR Demand (mgd)	Projected Flow to AWPF (mgd)	AWPF MF Backwash Water (mgd)	AWPF Brine (mgd)	AWPF Product Water Yield (mgd)	Total Flow to PLWWTP (Brine flows and surplus water)
Jan	30	0.6	1.61	32.21	1.4	30.81	0.6	30.21	0.80	2.48	2.11	0.37	4.98	24.06	23.00	1.61	3.2	18.2	4.88
Feb	30	0.6	1.61	32.21	1.4	30.81	0.6	30.21	0.80	2.15	1.83	0.32	4.15	24.94	23.00	1.61	3.2	18.2	5.71
Mar	30	0.6	1.61	32.21	1.4	30.81	0.6	30.21	0.80	2.48	2.11	0.37	4.98	24.06	23.00	1.61	3.2	18.2	4.88
Apr	30	0.6	1.56	32.16	1.4	30.76	0.6	30.16	0.80	3.12	2.65	0.47	6.64	22.25	22.26	1.56	3.1	17.6	3.81
May	30	0.6	1.29	31.89	1.4	30.49	0.6	29.89	0.80	4.41	3.75	0.66	9.96	18.47	18.48	1.29	2.6	14.6	3.43
Jun	30	0.6	1.36	31.96	1.4	30.56	0.6	29.96	0.80	4.09	3.47	0.61	9.13	19.42	19.42	1.36	2.7	15.4	3.53
Jul	30	0.6	1.03	31.63	1.4	30.23	0.6	29.63	0.80	5.70	4.84	0.85	13.28	14.69	14.70	1.03	2.1	11.6	3.06
Aug	30	0.6	1.23	31.83	1.4	30.43	0.6	29.83	0.80	4.73	4.02	0.71	10.79	17.53	17.53	1.23	2.4	13.9	3.34
Sep	30	0.6	1.29	31.89	1.4	30.49	0.6	29.89	0.80	4.41	3.75	0.66	9.96	18.47	18.48	1.29	2.6	14.6	3.43
Oct	30	0.6	1.16	31.76	1.4	30.36	0.6	29.76	0.80	5.05	4.30	0.76	11.62	16.58	16.59	1.16	2.3	13.1	3.25
Nov	30	0.6	1.43	32.03	1.4	30.63	0.6	30.03	0.80	3.77	3.20	0.56	8.30	20.36	20.36	1.43	2.8	16.1	3.62
Dec	30	0.6	1.61	32.21	1.4	30.81	0.6	30.21	0.80	2.80	2.38	0.42	5.81	23.18	23.00	1.61	3.2	18.2	4.05

Annual Volume (MG)		10950	5766	
Annual Volume (AF)		33,605	17,697	
AWPF Annual Offline Percentage	5%		885	
Adjusted Annual Volume (AF)			16,813	
Adjusted Avg Annual AWPF Product Water Yield (mgd)		30.00	**15.01**	

AWPF Max Feed Rate (mgd)	Surplus Water after NPR and AWPF Demands (mgd)	AWPF Capacity Not Used (mgd)
23.00	1.06	0
23.00	1.94	0
23.00	1.06	0
23.00	0	0.75
23.00	0	4.53
23.00	0	3.58
23.00	0	8.31
23.00	0	5.47
23.00	0	4.53
23.00	0	6.42
23.00	0	2.64
23.00	0.18	0
	4.23	36.23

129	1102	Annual Volume (MG)
395	3,382	Annual Volume (AF)
20	169	AWPF Annual Offline Percentage
375	3,213	Adjusted Annual Volume (AF)
0.34	**2.87**	**Adjusted Avg Annual RW Flows (mgd)**

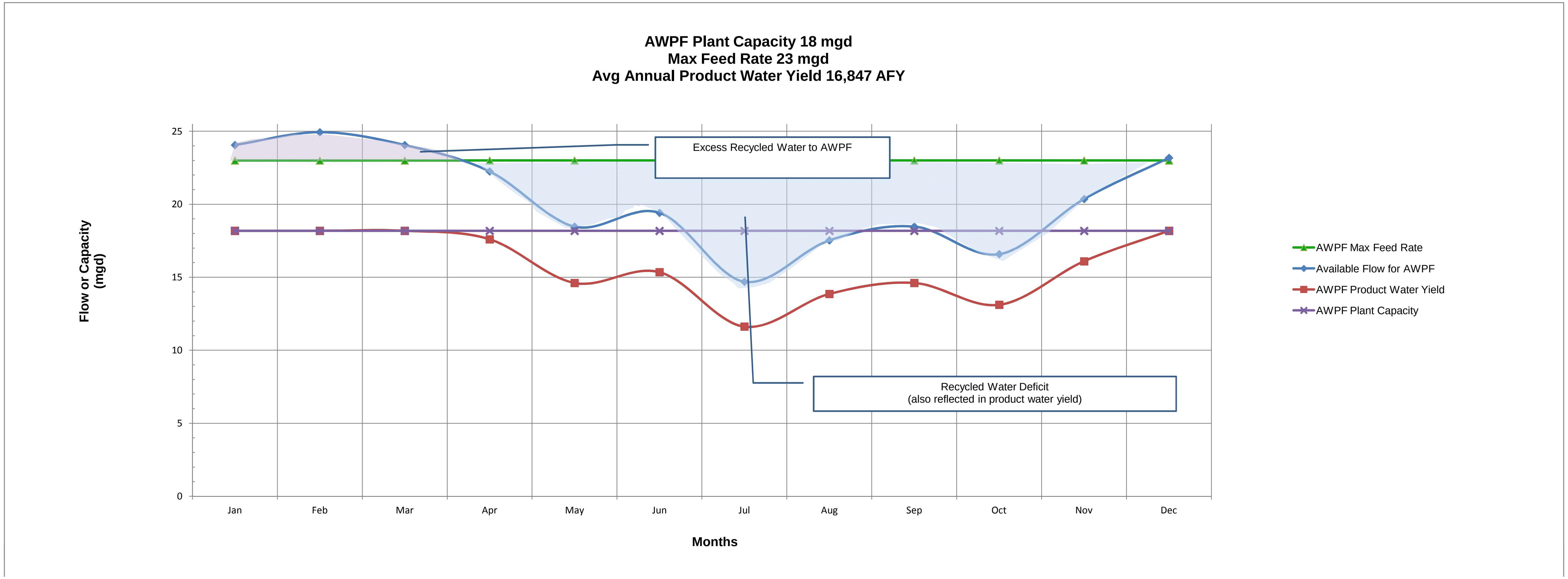
122.340199

	NCWRF RW Produced	**30 mgd**
1.57500	Sludge	**1.4 mgd**
0.07	Filter Backwash (Recycled)	**0.6 mgd**
	RO Waste	**15%**
	MF Backwash Recycled	**7.0%**
	Utility Water (excludes 0.5 mgd irr wtr)	**0.80 mgd**

Max Monthly Yield	18.2
Min Monthly Yield	11.6

AWPF Max Feed Rate **23.0 mgd**

AWPF Capacity **18 mgd**



AWPF Plant Capacity 18 mgd
Max Feed Rate 23 mgd
Avg Annual Product Water Yield 16,847 AFY

APPENDIX B

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)

							Construction Costs				Soft Costs			
AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Pump Power (Hp)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	110	$3,719,000	$60,840,000	$532,000	$65,100,000	$3,495,860	$57,189,600	$500,080	$61,200,000
2	2,240	2,130	30	1,400	450	220	$7,438,000	$60,840,000	$894,000	$69,200,000	$6,991,720	$57,189,600	$840,360	$65,100,000
3	3,370	3,210	30	2,100	460	330	$11,156,000	$60,840,000	$1,230,000	$73,300,000	$10,486,640	$57,189,600	$1,156,200	$68,900,000
4	4,490	4,270	30	2,800	460	440	$14,875,000	$60,840,000	$1,526,000	$77,300,000	$13,982,500	$57,189,600	$1,434,440	$72,700,000
5	5,610	5,330	30	3,500	470	560	$18,594,000	$60,840,000	$1,830,000	$81,300,000	$17,478,360	$57,189,600	$1,720,200	$76,400,000
6	6,730	6,400	30	4,200	480	680	$22,313,000	$60,840,000	$2,128,000	$85,300,000	$20,974,220	$57,189,600	$2,000,320	$80,200,000
7	7,850	7,460	30	4,900	500	830	$26,032,000	$60,840,000	$2,454,000	$89,400,000	$24,470,080	$57,189,600	$2,306,760	$84,000,000
8	8,970	8,530	30	5,600	510	970	$29,751,000	$60,840,000	$2,748,000	$93,400,000	$27,965,940	$57,189,600	$2,583,120	$87,800,000
9	10,090	9,590	30	6,300	530	1,130	$33,469,000	$60,840,000	$3,079,000	$97,400,000	$31,460,860	$57,189,600	$2,894,260	$91,600,000
10	11,210	10,650	30	7,000	550	1,300	$37,188,000	$60,840,000	$3,414,000	$101,500,000	$34,956,720	$57,189,600	$3,209,160	$95,400,000
11	12,320	11,710	30	7,700	560	1,460	$40,907,000	$60,840,000	$3,711,000	$105,500,000	$38,452,580	$57,189,600	$3,488,340	$99,200,000
12	13,340	12,680	30	8,400	590	1,670	$44,626,000	$60,840,000	$4,100,000	$109,600,000	$41,948,440	$57,189,600	$3,854,000	$103,000,000
13	14,280	13,570	30	9,100	610	1,870	$48,345,000	$60,840,000	$4,451,000	$113,700,000	$45,444,300	$57,189,600	$4,183,940	$106,900,000
14	15,020	14,270	30	9,800	630	2,080	$52,064,000	$60,840,000	$4,806,000	$117,800,000	$48,940,160	$57,189,600	$4,517,640	$110,700,000
15	15,570	14,800	30	10,500	660	2,340	$55,782,000	$60,840,000	$5,219,000	$121,900,000	$52,435,080	$57,189,600	$4,905,860	$114,600,000
16	16,040	15,240	30	11,200	680	2,570	$59,501,000	$60,840,000	$5,587,000	$126,000,000	$55,930,940	$57,189,600	$5,251,780	$118,400,000
17	16,400	15,580	30	11,900	710	2,850	$63,220,000	$60,840,000	$6,016,000	$130,100,000	$59,426,800	$57,189,600	$5,655,040	$122,300,000
18	16,560	15,740	30	12,500	740	3,120	$66,939,000	$60,840,000	$6,454,000	$134,300,000	$62,922,660	$57,189,600	$6,066,760	$126,200,000
19	16,560	15,740	30	13,200	770	3,430	$70,658,000	$60,840,000	$6,899,000	$138,400,000	$66,418,520	$57,189,600	$6,485,060	$130,100,000
20	16,560	15,740	30	13,900	810	3,800	$74,376,000	$60,840,000	$7,413,000	$142,700,000	$69,913,440	$57,189,600	$6,968,220	$134,100,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Capital Costs				Annualized Capital Costs			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	$7,220,000	$118,000,000	$1,032,000	$126,300,000	$458,000	$7,486,000	$65,000	$8,100,000
2	2,240	2,130	30	1,400	450	$14,430,000	$118,000,000	$1,734,000	$134,200,000	$916,000	$7,486,000	$110,000	$8,600,000
3	3,370	3,210	30	2,100	460	$21,650,000	$118,000,000	$2,386,000	$142,100,000	$1,374,000	$7,486,000	$151,000	$9,100,000
4	4,490	4,270	30	2,800	460	$28,860,000	$118,000,000	$2,960,000	$149,900,000	$1,831,000	$7,486,000	$188,000	$9,600,000
5	5,610	5,330	30	3,500	470	$36,080,000	$118,000,000	$3,550,000	$157,700,000	$2,289,000	$7,486,000	$225,000	$10,000,000
6	6,730	6,400	30	4,200	480	$43,290,000	$118,000,000	$4,128,000	$165,500,000	$2,747,000	$7,486,000	$262,000	$10,500,000
7	7,850	7,460	30	4,900	500	$50,510,000	$118,000,000	$4,761,000	$173,300,000	$3,205,000	$7,486,000	$302,000	$11,000,000
8	8,970	8,530	30	5,600	510	$57,720,000	$118,000,000	$5,331,000	$181,100,000	$3,662,000	$7,486,000	$338,000	$11,500,000
9	10,090	9,590	30	6,300	530	$64,930,000	$118,000,000	$5,973,000	$189,000,000	$4,119,000	$7,486,000	$379,000	$12,000,000
10	11,210	10,650	30	7,000	550	$72,150,000	$118,000,000	$6,623,000	$196,800,000	$4,578,000	$7,486,000	$420,000	$12,500,000
11	12,320	11,710	30	7,700	560	$79,360,000	$118,000,000	$7,199,000	$204,600,000	$5,035,000	$7,486,000	$457,000	$13,000,000
12	13,340	12,680	30	8,400	590	$86,580,000	$118,000,000	$7,954,000	$212,600,000	$5,493,000	$7,486,000	$505,000	$13,500,000
13	14,280	13,570	30	9,100	610	$93,790,000	$118,000,000	$8,635,000	$220,500,000	$5,950,000	$7,486,000	$548,000	$14,000,000
14	15,020	14,270	30	9,800	630	$101,010,000	$118,000,000	$9,324,000	$228,400,000	$6,409,000	$7,486,000	$592,000	$14,500,000
15	15,570	14,800	30	10,500	660	$108,220,000	$118,000,000	$10,125,000	$236,400,000	$6,866,000	$7,486,000	$642,000	$15,000,000
16	16,040	15,240	30	11,200	680	$115,440,000	$118,000,000	$10,839,000	$244,300,000	$7,324,000	$7,486,000	$688,000	$15,500,000
17	16,400	15,580	30	11,900	710	$122,650,000	$118,000,000	$11,671,000	$252,400,000	$7,781,000	$7,486,000	$740,000	$16,100,000
18	16,560	15,740	30	12,500	740	$129,870,000	$118,000,000	$12,521,000	$260,400,000	$8,240,000	$7,486,000	$794,000	$16,600,000
19	16,560	15,740	30	13,200	770	$137,080,000	$118,000,000	$13,384,000	$268,500,000	$8,697,000	$7,486,000	$849,000	$17,100,000
20	16,560	15,740	30	13,900	810	$144,290,000	$118,000,000	$14,381,000	$276,700,000	$9,154,000	$7,486,000	$912,000	$17,600,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annualized O&M Costs				Total Annualized Cost			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	$600,000	$851,760	$18,620	$1,500,000	$1,058,000	$8,337,760	$186,070	$9,600,000
2	2,240	2,130	30	1,400	450	$1,300,000	$851,760	$31,290	$2,200,000	$2,216,000	$8,337,760	$346,040	$10,900,000
3	3,370	3,210	30	2,100	460	$1,900,000	$851,760	$43,050	$2,800,000	$3,274,000	$8,337,760	$501,250	$12,200,000
4	4,490	4,270	30	2,800	460	$2,500,000	$851,760	$53,410	$3,500,000	$4,331,000	$8,337,760	$650,910	$13,400,000
5	5,610	5,330	30	3,500	470	$3,200,000	$851,760	$64,050	$4,200,000	$5,489,000	$8,337,760	$810,300	$14,700,000
6	6,730	6,400	30	4,200	480	$3,800,000	$851,760	$74,480	$4,800,000	$6,547,000	$8,337,760	$969,330	$15,900,000
7	7,850	7,460	30	4,900	500	$4,400,000	$851,760	$85,890	$5,400,000	$7,605,000	$8,337,760	$1,160,390	$17,200,000
8	8,970	8,530	30	5,600	510	$5,100,000	$851,760	$96,180	$6,100,000	$8,762,000	$8,337,760	$1,337,030	$18,500,000
9	10,090	9,590	30	6,300	530	$5,700,000	$851,760	$107,765	$6,700,000	$9,819,000	$8,337,760	$1,538,565	$19,700,000
10	11,210	10,650	30	7,000	550	$6,300,000	$851,760	$119,490	$7,300,000	$10,878,000	$8,337,760	$1,749,390	$21,000,000
11	12,320	11,710	30	7,700	560	$6,900,000	$851,760	$129,885	$7,900,000	$11,935,000	$8,337,760	$1,945,735	$22,300,000
12	13,340	12,680	30	8,400	590	$7,600,000	$851,760	$143,500	$8,600,000	$13,093,000	$8,337,760	$2,202,800	$23,700,000
13	14,280	13,570	30	9,100	610	$8,200,000	$851,760	$155,785	$9,300,000	$14,150,000	$8,337,760	$2,444,235	$25,000,000
14	15,020	14,270	30	9,800	630	$8,800,000	$851,760	$168,210	$9,900,000	$15,209,000	$8,337,760	$2,696,110	$26,300,000
15	15,570	14,800	30	10,500	660	$9,500,000	$851,760	$182,665	$10,600,000	$16,366,000	$8,337,760	$3,002,515	$27,800,000
16	16,040	15,240	30	11,200	680	$10,100,000	$851,760	$195,545	$11,200,000	$17,424,000	$8,337,760	$3,275,595	$29,100,000
17	16,400	15,580	30	11,900	710	$10,700,000	$851,760	$210,560	$11,800,000	$18,481,000	$8,337,760	$3,603,160	$30,500,000
18	16,560	15,740	30	12,500	740	$11,400,000	$851,760	$225,890	$12,500,000	$19,640,000	$8,337,760	$3,923,740	$32,000,000
19	16,560	15,740	30	13,200	770	$12,000,000	$851,760	$241,465	$13,100,000	$20,697,000	$8,337,760	$4,282,915	$33,400,000
20	16,560	15,740	30	13,900	810	$12,600,000	$851,760	$259,455	$13,800,000	$21,754,000	$8,337,760	$4,708,305	$34,900,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs (Constant 30-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annual Unit Cost			
						AWPF ($/AF)	Pipeline ($/AF)	Pump Station ($/AF)	Total ($/AF)
1	1,120	1,070	30	700	450	$990	$7,800	$180	$8,970
2	2,240	2,130	30	1,400	450	$1,050	$3,920	$170	$5,140
3	3,370	3,210	30	2,100	460	$1,020	$2,600	$160	$3,780
4	4,490	4,270	30	2,800	460	$1,020	$1,960	$160	$3,140
5	5,610	5,330	30	3,500	470	$1,030	$1,570	$160	$2,760
6	6,730	6,400	30	4,200	480	$1,030	$1,310	$160	$2,500
7	7,850	7,460	30	4,900	500	$1,020	$1,120	$160	$2,300
8	8,970	8,530	30	5,600	510	$1,030	$980	$160	$2,170
9	10,090	9,590	30	6,300	530	$1,030	$870	$170	$2,070
10	11,210	10,650	30	7,000	550	$1,030	$790	$170	$1,990
11	12,320	11,710	30	7,700	560	$1,020	$720	$170	$1,910
12	13,340	12,680	30	8,400	590	$1,040	$660	$180	$1,880
13	14,280	13,570	30	9,100	610	$1,050	$620	$190	$1,860
14	15,020	14,270	30	9,800	630	$1,070	$590	$190	$1,850
15	15,570	14,800	30	10,500	660	$1,110	$570	$210	$1,890
16	16,040	15,240	30	11,200	680	$1,150	$550	$220	$1,920
17	16,400	15,580	30	11,900	710	$1,190	$540	$240	$1,970
18	16,560	15,740	30	12,500	740	$1,250	$530	$250	$2,030
19	16,560	15,740	30	13,200	770	$1,320	$530	$280	$2,130
20	16,560	15,740	30	13,900	810	$1,390	$530	$300	$2,220

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)
(with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Pump Power (Hp)	Construction Costs				Soft Costs			
							AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	110	$3,719,000	$60,840,000	$532,000	$65,100,000	$3,495,860	$57,189,600	$500,080	$61,200,000
2	2,240	2,130	30	1,400	450	220	$7,438,000	$60,840,000	$894,000	$69,200,000	$6,991,720	$57,189,600	$840,360	$65,100,000
3	3,370	3,210	30	2,100	460	330	$11,156,000	$60,840,000	$1,230,000	$73,300,000	$10,486,640	$57,189,600	$1,156,200	$68,900,000
4	4,490	4,270	30	2,800	460	440	$14,875,000	$60,840,000	$1,526,000	$77,300,000	$13,982,500	$57,189,600	$1,434,440	$72,700,000
5	5,610	5,330	30	3,500	470	560	$18,594,000	$60,840,000	$1,830,000	$81,300,000	$17,478,360	$57,189,600	$1,720,200	$76,400,000
6	6,730	6,400	30	4,200	480	680	$22,313,000	$60,840,000	$2,128,000	$85,300,000	$20,974,220	$57,189,600	$2,000,320	$80,200,000
7	7,850	7,460	30	4,900	500	830	$26,032,000	$60,840,000	$2,454,000	$89,400,000	$24,470,080	$57,189,600	$2,306,760	$84,000,000
8	8,970	8,530	30	5,600	510	970	$29,751,000	$60,840,000	$2,748,000	$93,400,000	$27,965,940	$57,189,600	$2,583,120	$87,800,000
9	10,090	9,590	30	6,300	530	1,130	$33,469,000	$60,840,000	$3,079,000	$97,400,000	$31,460,860	$57,189,600	$2,894,260	$91,600,000
10	11,210	10,650	30	7,000	550	1,300	$37,188,000	$60,840,000	$3,414,000	$101,500,000	$34,956,720	$57,189,600	$3,209,160	$95,400,000
11	12,330	11,720	30	7,700	560	1,460	$40,907,000	$60,840,000	$3,711,000	$105,500,000	$38,452,580	$57,189,600	$3,488,340	$99,200,000
12	13,450	12,780	30	8,400	590	1,670	$44,626,000	$60,840,000	$4,100,000	$109,600,000	$41,948,440	$57,189,600	$3,854,000	$103,000,000
13	14,490	13,770	30	9,100	610	1,870	$48,345,000	$60,840,000	$4,451,000	$113,700,000	$45,444,300	$57,189,600	$4,183,940	$106,900,000
14	15,470	14,700	30	9,800	630	2,080	$52,064,000	$60,840,000	$4,806,000	$117,800,000	$48,940,160	$57,189,600	$4,517,640	$110,700,000
15	16,320	15,510	30	10,500	660	2,340	$55,782,000	$60,840,000	$5,219,000	$121,900,000	$52,435,080	$57,189,600	$4,905,860	$114,600,000
16	16,940	16,100	30	11,200	680	2,570	$59,501,000	$60,840,000	$5,587,000	$126,000,000	$55,930,940	$57,189,600	$5,251,780	$118,400,000
17	17,440	16,570	30	11,900	710	2,850	$63,220,000	$60,840,000	$6,016,000	$130,100,000	$59,426,800	$57,189,600	$5,655,040	$122,300,000
18	17,880	16,990	30	12,500	740	3,120	$66,939,000	$60,840,000	$6,454,000	$134,300,000	$62,922,660	$57,189,600	$6,066,760	$126,200,000
19	18,190	17,290	30	13,200	770	3,430	$70,658,000	$60,840,000	$6,899,000	$138,400,000	$66,418,520	$57,189,600	$6,485,060	$130,100,000
20	18,280	17,370	30	13,900	810	3,800	$74,376,000	$60,840,000	$7,413,000	$142,700,000	$69,913,440	$57,189,600	$6,968,220	$134,100,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)
(with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Capital Costs				Annualized Capital Costs			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	$7,220,000	$118,000,000	$1,032,000	$126,300,000	$458,000	$7,486,000	$65,000	$8,100,000
2	2,240	2,130	30	1,400	450	$14,430,000	$118,000,000	$1,734,000	$134,200,000	$916,000	$7,486,000	$110,000	$8,600,000
3	3,370	3,210	30	2,100	460	$21,650,000	$118,000,000	$2,386,000	$142,100,000	$1,374,000	$7,486,000	$151,000	$9,100,000
4	4,490	4,270	30	2,800	460	$28,860,000	$118,000,000	$2,960,000	$149,900,000	$1,831,000	$7,486,000	$188,000	$9,600,000
5	5,610	5,330	30	3,500	470	$36,080,000	$118,000,000	$3,550,000	$157,700,000	$2,289,000	$7,486,000	$225,000	$10,000,000
6	6,730	6,400	30	4,200	480	$43,290,000	$118,000,000	$4,128,000	$165,500,000	$2,747,000	$7,486,000	$262,000	$10,500,000
7	7,850	7,460	30	4,900	500	$50,510,000	$118,000,000	$4,761,000	$173,300,000	$3,205,000	$7,486,000	$302,000	$11,000,000
8	8,970	8,530	30	5,600	510	$57,720,000	$118,000,000	$5,331,000	$181,100,000	$3,662,000	$7,486,000	$338,000	$11,500,000
9	10,090	9,590	30	6,300	530	$64,930,000	$118,000,000	$5,973,000	$189,000,000	$4,119,000	$7,486,000	$379,000	$12,000,000
10	11,210	10,650	30	7,000	550	$72,150,000	$118,000,000	$6,623,000	$196,800,000	$4,578,000	$7,486,000	$420,000	$12,500,000
11	12,330	11,720	30	7,700	560	$79,360,000	$118,000,000	$7,199,000	$204,600,000	$5,035,000	$7,486,000	$457,000	$13,000,000
12	13,450	12,780	30	8,400	590	$86,580,000	$118,000,000	$7,954,000	$212,600,000	$5,493,000	$7,486,000	$505,000	$13,500,000
13	14,490	13,770	30	9,100	610	$93,790,000	$118,000,000	$8,635,000	$220,500,000	$5,950,000	$7,486,000	$548,000	$14,000,000
14	15,470	14,700	30	9,800	630	$101,010,000	$118,000,000	$9,324,000	$228,400,000	$6,409,000	$7,486,000	$592,000	$14,500,000
15	16,320	15,510	30	10,500	660	$108,220,000	$118,000,000	$10,125,000	$236,400,000	$6,866,000	$7,486,000	$642,000	$15,000,000
16	16,940	16,100	30	11,200	680	$115,440,000	$118,000,000	$10,839,000	$244,300,000	$7,324,000	$7,486,000	$688,000	$15,500,000
17	17,440	16,570	30	11,900	710	$122,650,000	$118,000,000	$11,671,000	$252,400,000	$7,781,000	$7,486,000	$740,000	$16,100,000
18	17,880	16,990	30	12,500	740	$129,870,000	$118,000,000	$12,521,000	$260,400,000	$8,240,000	$7,486,000	$794,000	$16,600,000
19	18,190	17,290	30	13,200	770	$137,080,000	$118,000,000	$13,384,000	$268,500,000	$8,697,000	$7,486,000	$849,000	$17,100,000
20	18,280	17,370	30	13,900	810	$144,290,000	$118,000,000	$14,381,000	$276,700,000	$9,154,000	$7,486,000	$912,000	$17,600,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs (Constant 30-inch Conveyance Pipe) (with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annualized O&M Costs				Total Annualized Cost			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	30	700	450	$600,000	$851,760	$18,620	$1,500,000	$1,058,000	$8,337,760	$186,070	$9,600,000
2	2,240	2,130	30	1,400	450	$1,300,000	$851,760	$31,290	$2,200,000	$2,216,000	$8,337,760	$346,040	$10,900,000
3	3,370	3,210	30	2,100	460	$1,900,000	$851,760	$43,050	$2,800,000	$3,274,000	$8,337,760	$501,250	$12,200,000
4	4,490	4,270	30	2,800	460	$2,500,000	$851,760	$53,410	$3,500,000	$4,331,000	$8,337,760	$650,910	$13,400,000
5	5,610	5,330	30	3,500	470	$3,200,000	$851,760	$64,050	$4,200,000	$5,489,000	$8,337,760	$810,300	$14,700,000
6	6,730	6,400	30	4,200	480	$3,800,000	$851,760	$74,480	$4,800,000	$6,547,000	$8,337,760	$969,330	$15,900,000
7	7,850	7,460	30	4,900	500	$4,400,000	$851,760	$85,890	$5,400,000	$7,605,000	$8,337,760	$1,160,390	$17,200,000
8	8,970	8,530	30	5,600	510	$5,100,000	$851,760	$96,180	$6,100,000	$8,762,000	$8,337,760	$1,337,030	$18,500,000
9	10,090	9,590	30	6,300	530	$5,700,000	$851,760	$107,765	$6,700,000	$9,819,000	$8,337,760	$1,538,565	$19,700,000
10	11,210	10,650	30	7,000	550	$6,300,000	$851,760	$119,490	$7,300,000	$10,878,000	$8,337,760	$1,749,390	$21,000,000
11	12,330	11,720	30	7,700	560	$6,900,000	$851,760	$129,885	$7,900,000	$11,935,000	$8,337,760	$1,945,735	$22,300,000
12	13,450	12,780	30	8,400	590	$7,600,000	$851,760	$143,500	$8,600,000	$13,093,000	$8,337,760	$2,202,800	$23,700,000
13	14,490	13,770	30	9,100	610	$8,200,000	$851,760	$155,785	$9,300,000	$14,150,000	$8,337,760	$2,444,235	$25,000,000
14	15,470	14,700	30	9,800	630	$8,800,000	$851,760	$168,210	$9,900,000	$15,209,000	$8,337,760	$2,696,110	$26,300,000
15	16,320	15,510	30	10,500	660	$9,500,000	$851,760	$182,665	$10,600,000	$16,366,000	$8,337,760	$3,002,515	$27,800,000
16	16,940	16,100	30	11,200	680	$10,100,000	$851,760	$195,545	$11,200,000	$17,424,000	$8,337,760	$3,275,595	$29,100,000
17	17,440	16,570	30	11,900	710	$10,700,000	$851,760	$210,560	$11,800,000	$18,481,000	$8,337,760	$3,603,160	$30,500,000
18	17,880	16,990	30	12,500	740	$11,400,000	$851,760	$225,890	$12,500,000	$19,640,000	$8,337,760	$3,923,740	$32,000,000
19	18,190	17,290	30	13,200	770	$12,000,000	$851,760	$241,465	$13,100,000	$20,697,000	$8,337,760	$4,282,915	$33,400,000
20	18,280	17,370	30	13,900	810	$12,600,000	$851,760	$259,455	$13,800,000	$21,754,000	$8,337,760	$4,708,305	$34,900,000

APPENDIX B

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 30-inch Conveyance Pipe)
(with tertiary and MF backwash recycle)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annual Unit Cost			
						AWPF ($/AF)	Pipeline ($/AF)	Pump Station ($/AF)	Total ($/AF)
1	1,120	1,070	30	700	450	$990	$7,800	$180	$8,970
2	2,240	2,130	30	1,400	450	$1,050	$3,920	$170	$5,140
3	3,370	3,210	30	2,100	460	$1,020	$2,600	$160	$3,780
4	4,490	4,270	30	2,800	460	$1,020	$1,960	$160	$3,140
5	5,610	5,330	30	3,500	470	$1,030	$1,570	$160	$2,760
6	6,730	6,400	30	4,200	480	$1,030	$1,310	$160	$2,500
7	7,850	7,460	30	4,900	500	$1,020	$1,120	$160	$2,300
8	8,970	8,530	30	5,600	510	$1,030	$980	$160	$2,170
9	10,090	9,590	30	6,300	530	$1,030	$870	$170	$2,070
10	11,210	10,650	30	7,000	550	$1,030	$790	$170	$1,990
11	12,330	11,720	30	7,700	560	$1,020	$720	$170	$1,910
12	13,450	12,780	30	8,400	590	$1,030	$660	$180	$1,870
13	14,490	13,770	30	9,100	610	$1,030	$610	$180	$1,820
14	15,470	14,700	30	9,800	630	$1,040	$570	$190	$1,800
15	16,320	15,510	30	10,500	660	$1,060	$540	$200	$1,800
16	16,940	16,100	30	11,200	680	$1,090	$520	$210	$1,820
17	17,440	16,570	30	11,900	710	$1,120	$510	$220	$1,850
18	17,880	16,990	30	12,500	740	$1,160	$500	$240	$1,900
19	18,190	17,290	30	13,200	770	$1,200	$490	$250	$1,940
20	18,280	17,370	30	13,900	810	$1,260	$490	$280	$2,030

APPENDIX C

APPENDIX C

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 36-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Pump Power (Hp)	Construction Costs				Soft Costs			
							AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	36	700	450	110	$3,719,000	$73,008,000	$532,000	$77,300,000	$3,495,860	$68,627,520	$500,080	$72,700,000
2	2,240	2,130	36	1,400	450	220	$7,438,000	$73,008,000	$894,000	$81,400,000	$6,991,720	$68,627,520	$840,360	$76,500,000
3	3,370	3,210	36	2,100	450	320	$11,156,000	$73,008,000	$1,212,000	$85,400,000	$10,486,640	$68,627,520	$1,139,280	$80,300,000
4	4,490	4,270	36	2,800	450	430	$14,875,000	$73,008,000	$1,504,000	$89,400,000	$13,982,500	$68,627,520	$1,413,760	$84,100,000
5	5,610	5,330	36	3,500	460	550	$18,594,000	$73,008,000	$1,804,000	$93,500,000	$17,478,360	$68,627,520	$1,695,760	$87,900,000
6	6,730	6,400	36	4,200	460	660	$22,313,000	$73,008,000	$2,069,000	$97,400,000	$20,974,220	$68,627,520	$1,944,860	$91,600,000
7	7,850	7,460	36	4,900	470	780	$26,032,000	$73,008,000	$2,355,000	$101,400,000	$24,470,080	$68,627,520	$2,213,700	$95,400,000
8	8,970	8,530	36	5,600	470	890	$29,751,000	$73,008,000	$2,603,000	$105,400,000	$27,965,940	$68,627,520	$2,446,820	$99,100,000
9	10,090	9,590	36	6,300	480	1,020	$33,469,000	$73,008,000	$2,884,000	$109,400,000	$31,460,860	$68,627,520	$2,710,960	$102,800,000
10	11,210	10,650	36	7,000	490	1,160	$37,188,000	$73,008,000	$3,164,000	$113,400,000	$34,956,720	$68,627,520	$2,974,160	$106,600,000
11	12,320	11,710	36	7,700	490	1,280	$40,907,000	$73,008,000	$3,398,000	$117,400,000	$38,452,580	$68,627,520	$3,194,120	$110,300,000
12	13,340	12,680	36	8,400	500	1,420	$44,626,000	$73,008,000	$3,676,000	$121,400,000	$41,948,440	$68,627,520	$3,455,440	$114,100,000
13	14,280	13,570	36	9,100	510	1,570	$48,345,000	$73,008,000	$3,955,000	$125,400,000	$45,444,300	$68,627,520	$3,717,700	$117,800,000
14	15,020	14,270	36	9,800	520	1,720	$52,064,000	$73,008,000	$4,235,000	$129,400,000	$48,940,160	$68,627,520	$3,980,900	$121,600,000
15	15,570	14,800	36	10,500	530	1,880	$55,782,000	$73,008,000	$4,516,000	$133,400,000	$52,435,080	$68,627,520	$4,245,040	$125,400,000
16	16,040	15,240	36	11,200	540	2,040	$59,501,000	$73,008,000	$4,799,000	$137,400,000	$55,930,940	$68,627,520	$4,511,060	$129,100,000
17	16,400	15,580	36	11,900	560	2,250	$63,220,000	$73,008,000	$5,144,000	$141,400,000	$59,426,800	$68,627,520	$4,835,360	$132,900,000
18	16,560	15,740	36	12,500	570	2,400	$66,939,000	$73,008,000	$5,432,000	$145,400,000	$62,922,660	$68,627,520	$5,106,080	$136,700,000
19	16,560	15,740	36	13,200	580	2,580	$70,658,000	$73,008,000	$5,722,000	$149,400,000	$66,418,520	$68,627,520	$5,378,680	$140,500,000
20	16,560	15,740	36	13,900	590	2,770	$74,376,000	$73,008,000	$6,014,000	$153,400,000	$69,913,440	$68,627,520	$5,653,160	$144,200,000

APPENDIX C

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 36-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Capital Costs				Annualized Capital Costs			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	36	700	450	$7,220,000	$141,600,000	$1,032,000	$149,900,000	$458,000	$8,984,000	$65,000	$9,600,000
2	2,240	2,130	36	1,400	450	$14,430,000	$141,600,000	$1,734,000	$157,800,000	$916,000	$8,984,000	$110,000	$10,100,000
3	3,370	3,210	36	2,100	450	$21,650,000	$141,600,000	$2,351,000	$165,700,000	$1,374,000	$8,984,000	$149,000	$10,600,000
4	4,490	4,270	36	2,800	450	$28,860,000	$141,600,000	$2,918,000	$173,400,000	$1,831,000	$8,984,000	$185,000	$11,000,000
5	5,610	5,330	36	3,500	460	$36,080,000	$141,600,000	$3,500,000	$181,200,000	$2,289,000	$8,984,000	$222,000	$11,500,000
6	6,730	6,400	36	4,200	460	$43,290,000	$141,600,000	$4,014,000	$189,000,000	$2,747,000	$8,984,000	$255,000	$12,000,000
7	7,850	7,460	36	4,900	470	$50,510,000	$141,600,000	$4,569,000	$196,700,000	$3,205,000	$8,984,000	$290,000	$12,500,000
8	8,970	8,530	36	5,600	470	$57,720,000	$141,600,000	$5,050,000	$204,400,000	$3,662,000	$8,984,000	$320,000	$13,000,000
9	10,090	9,590	36	6,300	480	$64,930,000	$141,600,000	$5,595,000	$212,200,000	$4,119,000	$8,984,000	$355,000	$13,500,000
10	11,210	10,650	36	7,000	490	$72,150,000	$141,600,000	$6,138,000	$219,900,000	$4,578,000	$8,984,000	$389,000	$14,000,000
11	12,320	11,710	36	7,700	490	$79,360,000	$141,600,000	$6,592,000	$227,600,000	$5,035,000	$8,984,000	$418,000	$14,500,000
12	13,340	12,680	36	8,400	500	$86,580,000	$141,600,000	$7,131,000	$235,400,000	$5,493,000	$8,984,000	$452,000	$15,000,000
13	14,280	13,570	36	9,100	510	$93,790,000	$141,600,000	$7,673,000	$243,100,000	$5,950,000	$8,984,000	$487,000	$15,500,000
14	15,020	14,270	36	9,800	520	$101,010,000	$141,600,000	$8,216,000	$250,900,000	$6,409,000	$8,984,000	$521,000	$16,000,000
15	15,570	14,800	36	10,500	530	$108,220,000	$141,600,000	$8,761,000	$258,600,000	$6,866,000	$8,984,000	$556,000	$16,500,000
16	16,040	15,240	36	11,200	540	$115,440,000	$141,600,000	$9,310,000	$266,400,000	$7,324,000	$8,984,000	$591,000	$16,900,000
17	16,400	15,580	36	11,900	560	$122,650,000	$141,600,000	$9,979,000	$274,300,000	$7,781,000	$8,984,000	$633,000	$17,400,000
18	16,560	15,740	36	12,500	570	$129,870,000	$141,600,000	$10,538,000	$282,100,000	$8,240,000	$8,984,000	$669,000	$17,900,000
19	16,560	15,740	36	13,200	580	$137,080,000	$141,600,000	$11,101,000	$289,800,000	$8,697,000	$8,984,000	$704,000	$18,400,000
20	16,560	15,740	36	13,900	590	$144,290,000	$141,600,000	$11,667,000	$297,600,000	$9,154,000	$8,984,000	$740,000	$18,900,000

APPENDIX C

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs
(Constant 36-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annualized O&M Costs				Total Annualized Cost			
						AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)	AWPF ($)	Pipeline ($)	Pump Station ($)	Total ($)
1	1,120	1,070	36	700	450	$600,000	$1,022,112	$18,620	$1,700,000	$1,058,000	$10,006,112	$186,070	$11,300,000
2	2,240	2,130	36	1,400	450	$1,300,000	$1,022,112	$31,290	$2,400,000	$2,216,000	$10,006,112	$346,040	$12,600,000
3	3,370	3,210	36	2,100	450	$1,900,000	$1,022,112	$42,420	$3,000,000	$3,274,000	$10,006,112	$489,320	$13,800,000
4	4,490	4,270	36	2,800	450	$2,500,000	$1,022,112	$52,640	$3,600,000	$4,331,000	$10,006,112	$637,840	$15,000,000
5	5,610	5,330	36	3,500	460	$3,200,000	$1,022,112	$63,140	$4,300,000	$5,489,000	$10,006,112	$797,090	$16,300,000
6	6,730	6,400	36	4,200	460	$3,800,000	$1,022,112	$72,415	$4,900,000	$6,547,000	$10,006,112	$941,665	$17,500,000
7	7,850	7,460	36	4,900	470	$4,400,000	$1,022,112	$82,425	$5,600,000	$7,605,000	$10,006,112	$1,098,425	$18,800,000
8	8,970	8,530	36	5,600	470	$5,100,000	$1,022,112	$91,105	$6,300,000	$8,762,000	$10,006,112	$1,239,405	$20,100,000
9	10,090	9,590	36	6,300	480	$5,700,000	$1,022,112	$100,940	$6,900,000	$9,819,000	$10,006,112	$1,405,290	$21,300,000
10	11,210	10,650	36	7,000	490	$6,300,000	$1,022,112	$110,740	$7,500,000	$10,878,000	$10,006,112	$1,579,440	$22,500,000
11	12,320	11,710	36	7,700	490	$6,900,000	$1,022,112	$118,930	$8,100,000	$11,935,000	$10,006,112	$1,728,230	$23,700,000
12	13,340	12,680	36	8,400	500	$7,600,000	$1,022,112	$128,660	$8,800,000	$13,093,000	$10,006,112	$1,902,310	$25,100,000
13	14,280	13,570	36	9,100	510	$8,200,000	$1,022,112	$138,425	$9,400,000	$14,150,000	$10,006,112	$2,086,725	$26,300,000
14	15,020	14,270	36	9,800	520	$8,800,000	$1,022,112	$148,225	$10,000,000	$15,209,000	$10,006,112	$2,270,025	$27,500,000
15	15,570	14,800	36	10,500	530	$9,500,000	$1,022,112	$158,060	$10,700,000	$16,366,000	$10,006,112	$2,463,810	$28,900,000
16	16,040	15,240	36	11,200	540	$10,100,000	$1,022,112	$167,965	$11,300,000	$17,424,000	$10,006,112	$2,657,665	$30,100,000
17	16,400	15,580	36	11,900	560	$10,700,000	$1,022,112	$180,040	$12,000,000	$18,481,000	$10,006,112	$2,907,190	$31,400,000
18	16,560	15,740	36	12,500	570	$11,400,000	$1,022,112	$190,120	$12,700,000	$19,640,000	$10,006,112	$3,092,920	$32,800,000
19	16,560	15,740	36	13,200	580	$12,000,000	$1,022,112	$200,270	$13,300,000	$20,697,000	$10,006,112	$3,305,620	$34,100,000
20	16,560	15,740	36	13,900	590	$12,600,000	$1,022,112	$210,490	$13,900,000	$21,754,000	$10,006,112	$3,528,690	$35,300,000

APPENDIX C

City of San Diego WPDP

Detailed Cost Breakdown of Project Costs (Constant 36-inch Conveyance Pipe)

AWPF Capacity (mgd)	Estimated AWPF Product Water Yield (AFY)	AWPF Product Wtr Yield, 95% On-line (AFY)	Adjusted Pipe Dia (in)	Pump Flow Rate (gpm)	Pump TDH (ft)	Annual Unit Cost			
						AWPF ($/AF)	Pipeline ($/AF)	Pump Station ($/AF)	Total ($/AF)
1	1,120	1,070	36	700	450	$990	$9,360	$180	$10,530
2	2,240	2,130	36	1,400	450	$1,050	$4,700	$170	$5,920
3	3,370	3,210	36	2,100	450	$1,020	$3,120	$160	$4,300
4	4,490	4,270	36	2,800	450	$1,020	$2,350	$150	$3,520
5	5,610	5,330	36	3,500	460	$1,030	$1,880	$150	$3,060
6	6,730	6,400	36	4,200	460	$1,030	$1,570	$150	$2,750
7	7,850	7,460	36	4,900	470	$1,020	$1,350	$150	$2,520
8	8,970	8,530	36	5,600	470	$1,030	$1,180	$150	$2,360
9	10,090	9,590	36	6,300	480	$1,030	$1,050	$150	$2,230
10	11,210	10,650	36	7,000	490	$1,030	$940	$150	$2,120
11	12,320	11,710	36	7,700	490	$1,020	$860	$150	$2,030
12	13,340	12,680	36	8,400	500	$1,040	$790	$160	$1,990
13	14,280	13,570	36	9,100	510	$1,050	$740	$160	$1,950
14	15,020	14,270	36	9,800	520	$1,070	$710	$160	$1,940
15	15,570	14,800	36	10,500	530	$1,110	$680	$170	$1,960
16	16,040	15,240	36	11,200	540	$1,150	$660	$180	$1,990
17	16,400	15,580	36	11,900	560	$1,190	$650	$190	$2,030
18	16,560	15,740	36	12,500	570	$1,250	$640	$200	$2,090
19	16,560	15,740	36	13,200	580	$1,320	$640	$220	$2,180
20	16,560	15,740	36	13,900	590	$1,390	$640	$230	$2,260

Appendix D

Estimated Construction Cost Process Area Breakdown

FULL SCALE FACILITY
City Of San Diego
Opinion of Probable Construction Cost- Feb 2012

Project name	2012-02-001-IPR-Full
Labor rate table	RS CA LA 2011
Equipment rate table	00 12 Equip BOF
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design for a preliminary design report. CDM Smith has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding (at least 3 each - both prime bidders and major subcontractors), market conditions or negotiating terms. CDM Smith does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. Assumptions: Site is assumed as relitively flat and 5 foot of over excavation & backfill is included for site prep. Construction duration is assumed to be 30 months based on the concept design provided. Escalation is exculed and the owner is to add this cost to the overall capitol budget for a complet project budget for project funding No rock excavation is required. Only nominal dewatering is needed. No consideration for contaminated soils or hazardous materials (e.g. asbestos, lead) Based on a 40 hour work week with no overtime. Electric Utility line extensions/service drops not estimated.
Report format	Sorted by 'Area/95CSI Sctn/Element' 'Detail' summary Combine items

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
0010.0010 AWPF INFLUENT PUMP STATION								
11210 Water Supply & Treatment Pumps								
11210.2670 Influent Pumps	4.00 ea	433.201	29,853	510,000	11,960		555,205	869,913
11210 Water Supply & Treatment Pumps		433.201	29,853	510,000	11,960		555,205	869,913
15060 Hangers & Supports								
15220.2670 Pump Discharge Piping	64.00 lf	25.200	1,716	1,600			3,316	5,077
15060 Hangers & Supports		25.200	1,716	1,600			3,316	5,077
15110 Valves								
15220.2670 Pump Discharge Piping	64.00 lf	74.284	5,059	166,844			171,903	269,667
15110 Valves		74.284	5,059	166,844			171,903	269,667
15220 Steel Pipe								
15220.2670 Pump Discharge Piping	64.00 lf	398.114	27,096	47,066	2,185		76,387	117,904
15220.2671 Pump Discharge Piping Header	72.00 lf	73.694	4,761	39,051	1,451	149	45,456	71,030
15220 Steel Pipe		471.808	31,857	86,117	3,636	149	121,843	188,935
0010.0010 AWPF INFLUENT PUMP STATION	**1.00 LS**	**1,004.492**	**68,485**	**764,561**	**15,596**	**149**	**852,266**	**1,333,591**
0010.0010A AWPF INFLUENT PUMP STATION STRUCTURE ONLY								
02250 Excavation Support & Protection								
02250.2605 Shoring	5,940.00 sf	1,379.811	80,576	76,329	48,106	8,250	213,261	328,149
02250 Excavation Support & Protection		1,379.811	80,576	76,329	48,106	8,250	213,261	328,149
02300 Earthwork								
02300.2600 Structural Excavation & Backfill	3,706.60 cy	449.815	23,925	1,185	32,665	442	58,217	89,571
02300 Earthwork		449.815	23,925	1,185	32,665	442	58,217	89,571
03212 Concrete Walls								
03212.2670 Concrete Walls @ Pump Wet Well	207.00 cy	1,748.291	108,302	70,080	3,120	3,381	185,286	282,430
03212 Concrete Walls		1,748.291	108,302	70,080	3,120	3,381	185,286	282,430
03310 Concrete Slab on Grade								
03310.2670 Concrete Slab On Grade Base Pump Vault Slab	168.00 cy	563.617	35,969	38,569	311	659	75,835	116,298
03310 Concrete Slab on Grade		563.617	35,969	38,569	311	659	75,835	116,298
03314 Concrete Elevated Slabs								
03314.2670 Concrete Elevated Deck over pump Vault	80.00 cy	885.222	53,472	28,599	2,115	560	84,902	129,194
03314 Concrete Elevated Slabs		885.222	53,472	28,599	2,115	560	84,902	129,194
03410 Precast Concrete								
03410.2670 Exterior Walls	111.50 cy	428.127	27,740	29,544	130	781	58,412	89,556
03410 Precast Concrete		428.127	27,740	29,544	130	781	58,412	89,556
03412 Concrete Equipment Pabs/Curbs/Fill								
03412.2670 Pump Pads	5.33 cy	89.384	5,673	2,006	18	105	7,811	11,824
03412.2671 MCC/ VFD Equipment Pads	10.67 cy	136.817	8,641	3,809	35	209	12,715	19,289
03412 Concrete Equipment Pabs/Curbs/Fill		226.200	14,313	5,815	53	314	20,526	31,113
03470 Walls								
03410.2670 Exterior Walls	111.50 cy	428.127	27,740	29,544	130	781	58,412	89,556
03470.2606 Wall Texture	3,696.00 sf			31,416			31,416	49,355
03470 Walls		428.127	27,740	60,960	130	781	89,828	138,910
04000 Masonry								
04000.2610 Interior Partition Walls	1,012.00 sf					28,336	28,336	42,320
04000 Masonry						28,336	28,336	42,320
05210 Steel Joist								
05210.2605 Building Roof Framing	2,160.00 sf	8.280	572	3,630	247		4,448	6,944
05210 Steel Joist		8.280	572	3,630	247		4,448	6,944
05300 Steel Deck								
05300.2605 Roof Deck	2,160.00 sf	64.800	4,473	12,960	1,930		19,363	30,073
05300 Steel Deck		64.800	4,473	12,960	1,930		19,363	30,073
07000 Thermal & Moisture Protection								

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
07000.2605 EPDM Roofing	22.00 sq	95.040	6,423	9,720			16,143	24,862
07000 Thermal & Moisture Protection		95.040	6,423	9,720			16,143	24,862
08000 Doors & Windows								
08000.2605 Exterior Doors & Windows	1.00 ls	63.132	3,585	10,792		17,280	31,658	48,117
08000 Doors & Windows		63.132	3,585	10,792		17,280	31,658	48,117
15300 Fire Protection								
15300.2605 Fire Protection Allowance	1.00 allw					20,520	20,520	30,647
15300 Fire Protection						20,520	20,520	30,647
15400 Plumbing								
15400.2605 Plumbing Allowance	1.00 allw					14,040	14,040	20,969
15400 Plumbing						14,040	14,040	20,969
15500 HVAC								
15500.2605 HVAC Allowance	1.00 allw					54,000	54,000	80,649
15500 HVAC						54,000	54,000	80,649
0010.0010A AWPF INFLUENT PUMP STATION STRUCTURE ONLY	**2,160.00 SF**	**6,340.462**	**387,090**	**348,184**	**88,806**	**149,343**	**974,776**	**1,489,800**
0010.0020 SITE CIVIL/ YARD PIPING								
02300 Earthwork								
02300.2620 Mass Excavation & Grading	45,510.00 c y	3,753.782	226,992		243,134		470,126	720,977
02300 Earthwork		3,753.782	226,992		243,134		470,126	720,977
02510 Water Distribution								
02510.2600 Open Cut Tunnel For Road Crossing	240.00 lf	918.112	51,561	264,547	39,989	12,100	368,197	573,503
02510.2605 MFB Piping	3,500.00 lf	3,891.029	258,810	181,155	32,943	4,260	477,168	729,243
02510.2610 TE Piping	2,500.00 lf	3,713.482	248,151	206,862	16,396	3,038	474,447	725,890
02510.2615 ROC Piping	3,100.00 lf	3,620.171	241,083	205,376	29,105	3,764	479,328	734,048
02510.2620 MFP Piping	120.00 lf	202.731	13,624	87,617	839	178	102,308	159,655
02510.2625 ROF Piping	20.00 lf	72.628	4,901	41,593	361	74	46,978	73,417
02510.2630 ROP Piping	30.00 lf	74.696	5,027	44,764	210	46	50,047	78,230
02510.2635 FW Piping from AOP to FW Pump Station	72.00 lf	93.914	6,273	16,261	538	107	23,254	36,038
02510.2640 FW Piping to Outside of Plant	960.00 lf	852.399	55,688	181,185	7,952	1,425	246,587	382,962
02510.2645 Small Bore Piping Allowance	4,500.00 lf		157,500	112,500	67,500		337,500	518,006
02510 Water Distribution		13,439.163	1,042,618	1,341,861	195,832	24,992	2,605,813	4,010,993
02600 Drainage & Containment								
02600.2605 Storm Drainage Measures Allowance	1.00 allw	798.788	47,532	73,574	11,892	1,271	135,115	208,484
02600 Drainage & Containment		798.788	47,532	73,574	11,892	1,271	135,115	208,484
02700 Pavements & Surfaces								
02700.2605 Paving & Surface Allowances	1.00 allw	233.176	13,087	201,655	8,904	19,937	243,583	380,109
02700 Pavements & Surfaces		233.176	13,087	201,655	8,904	19,937	243,583	380,109
02800 Site Improvements								
02800.2600 Landscaping Allowance	1.00 allw					350,000	350,000	522,725
02800 Site Improvements						350,000	350,000	522,725
0010.0020 SITE CIVIL/ YARD PIPING	**1.00 LS**	**18,224.909**	**1,330,230**	**1,617,090**	**459,763**	**396,200**	**3,804,637**	**5,843,287**
0020.0010 OPERATIONS, MAINTENANCE & ADMINISTRATION BLDG								
A Conceptual Buildings								
A-01111 Admin Building Allowance	1.00 allw	10,789.701	752,974	307,025			1,059,999	1,606,902
A Conceptual Buildings		10,789.701	752,974	307,025			1,059,999	1,606,902
0020.0010 OPERATIONS, MAINTENANCE & ADMINISTRATION BLDG	**5,300.00 SF**	**10,789.701**	**752,974**	**307,025**			**1,059,999**	**1,606,902**
0080.0005 MEMBRANE FILTRATION BREAK TANK & RO TRANSFER PUMP STATION								
11200 Water Treatment Equipment								
11200.2630 RO Transfer Pumps	5.00 ea	269.000	18,594	930,394	4,157		953,144	1,495,949
11200 Water Treatment Equipment		269.000	18,594	930,394	4,157		953,144	1,495,949
11228 Filter Membrane Systems								

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
11228.2620 Cartridge Filter Pre RO	8.00 ea	189.000	12,893	302,209	2,771		317,874	498,381
11228 Filter Membrane Systems		189.000	12,893	302,209	2,771		317,874	498,381
15110 Valves								
15220.26101 Break Tank Feed Piping	36.00 lf	19.700	1,335	3,651			4,986	7,729
15220.26102 Break Tank Discharge Piping	65.00 lf	19.700	1,335	3,651			4,986	7,729
15220.26107 24" Pump Discharge Header	65.00 lf	75.020	5,109	38,430			43,539	68,003
15221.2619 14" Filter Connections	28.00 lf	59.680	4,064	13,724			17,788	27,630
15110 Valves		174.101	11,842	59,456			71,298	111,091
15120 Pipe Specialties								
15220.26101 Break Tank Feed Piping	36.00 lf	6.811	464	573			1,037	1,593
15220.26102 Break Tank Discharge Piping	65.00 lf	6.811	464	573			1,037	1,593
15120 Pipe Specialties		13.622	928	1,146			2,074	3,186
15220 Steel Pipe								
15220.26101 Break Tank Feed Piping	36.00 lf	69.342	4,722	11,775	881		17,398	26,967
15220.26102 Break Tank Discharge Piping	65.00 lf	84.395	5,753	10,115	1,573		17,461	26,985
15220.26105 14" Pump Branch Connections to Pump Cans	30.00 lf	35.800	2,438	6,767			9,205	14,272
15220.26106 14" Pump Discharge Piping	60.00 lf	120.750	8,269	20,947	4,249		33,522	52,022
15220.26107 24" Pump Discharge Header	65.00 lf	56.590	3,880	20,683	2,126		26,728	41,689
15220 Steel Pipe		366.877	25,062	70,286	8,830		104,314	161,935
15221 Stainless Steel Pipe								
15221.2619 14" Filter Connections	54.00 lf	64.996	4,426	36,894			41,320	64,571
15221.2650 16" Filter Discharge Connections	96.00 lf	137.840	9,402	105,264	2,080		116,961	183,016
15221.2651 24" Discharge Header	65.00 lf	72.750	4,970	89,065	2,080		96,437	151,117
15221 Stainless Steel Pipe		275.586	18,797	231,223	4,160		254,718	398,705
0080.0005 MEMBRANE FILTRATION BREAK TANK & RO TRANSFER PUMP STATION	**21.20 MGD**	**1,288.185**	**88,117**	**1,594,713**	**19,917**		**1,703,422**	**2,669,246**
0080.0005A MEMBRANE FILTRATION BREAK TANK & RO TRANSFER PUMP STATION STRUCTURE ON								
02300 Earthwork								
02300.2610 Structural Excavation & backfill	2,652.00 cy	299.752	16,139	4,507	21,050	1,682	43,378	66,766
02300 Earthwork		299.752	16,139	4,507	21,050	1,682	43,378	66,766
03212 Concrete Walls								
03212.2620 Concrete Walls Break Tank	260.67 cy	1,990.262	123,368	85,903	3,788	6,940	220,611	336,481
03212 Concrete Walls		1,990.262	123,368	85,903	3,788	6,940	220,611	336,481
03310 Concrete Slab on Grade								
03310.226344 Strainer Pad	12.50 cy	61.875	3,899	2,192	41	2,046	8,428	12,779
03310.2605 Building Base Slab	79.19 cy	280.167	17,630	18,853	131	925	37,737	57,847
03310.2650 Concrete Slab On Grade Break Tank	138.89 cy	482.802	30,676	32,837	259	880	64,923	99,548
03310 Concrete Slab on Grade		824.845	52,205	53,882	432	3,851	111,087	170,174
03314 Concrete Elevated Slabs								
03314.2605 Concrete Elevated Deck @ Break Tank	100.15 cy	1,103.105	66,787	36,851	2,599	571	107,043	162,944
03314 Concrete Elevated Slabs		1,103.105	66,787	36,851	2,599	571	107,043	162,944
03412 Concrete Equipment Pabs/Curbs/Fill								
03412.226008 Pipe Supports-Spread Footing	12.80 cy	143.191	8,551	2,685	79		11,315	17,114
03412.226020 Pipe Supports	8.00 cy	82.601	5,013	2,113	43	1,877	9,045	13,676
03412 Concrete Equipment Pabs/Curbs/Fill		225.792	13,564	4,798	122	1,877	20,361	30,790
03470 Walls								
03470.2605 Exterior Walls	87.04 cy	270.530	17,397	20,216	29	497	38,343	58,850
03470.2606 Wall Texture				50,036			50,036	78,606
03470 Walls		270.530	17,397	70,252	29	497	88,379	137,456
05210 Steel Joist								
05210.2605 Building Roof Framing	4,500.00 sf	51.960	3,587	22,051	1,548		27,186	42,431

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
05210 Steel Joist		51.960	3,587	22,051	1,548		27,186	42,431
05300 Steel Deck								
05300.2605 Roof Deck	4,500.00 sf	134.730	9,300	26,957	4,014		40,270	62,544
05300 Steel Deck		134.730	9,300	26,957	4,014		40,270	62,544
07000 Thermal & Moisture Protection								
07000.2605 EPDM Roofing	45.00 sq	197.730	13,362	20,217			33,580	51,718
07000 Thermal & Moisture Protection		197.730	13,362	20,217			33,580	51,718
08000 Doors & Windows								
08000.2605 Exterior Doors & Windows	1.00 ls	57.808	3,226	11,023		8,626	22,875	35,018
08000 Doors & Windows		57.808	3,226	11,023		8,626	22,875	35,018
15300 Fire Protection								
15300.2605 Fire Protection Allowance	1.00 allw					42,681	42,681	63,745
15300 Fire Protection						42,681	42,681	63,745
15400 Plumbing								
15400.2605 Plumbing Allowance	1.00 allw					29,203	29,203	43,615
15400 Plumbing						29,203	29,203	43,615
15500 HVAC								
15500.2605 HVAC Allowance	1.00 allw					112,319	112,319	167,749
15500 HVAC						112,319	112,319	167,749
0080.0005A MEMBRANE FILTRATION BREAK TANK & RO TRANSFER PUMP STATION STRUCTURE ON	**4,500.00 SF**	**5,156.513**	**318,936**	**336,439**	**33,581**	**208,248**	**898,973**	**1,371,430**
0080.0006 CHEMICAL STORAGE AREA #1 (PRETREATMENT)								
11210 Water Supply & Treatment Pumps								
60 Chem System Sodium Bisulfite	2.00 ea	11.250	745	15,723	208		16,676	26,140
61 Chem System Ammonium Hydroxide	4.00 ea	25.663	1,680	38,758	261		40,699	63,807
62 Chem System Antiscalent	4.00 ea	20.530	1,350	31,978	261		33,588	52,663
64 Chem System Sufuric Acid	4.00 ea	30.330	1,958	40,723	261		42,941	67,309
65 Chem System Sodium Hypochlorite	4.00 ea	27.663	1,803	63,466	261		65,529	102,807
11210 Water Supply & Treatment Pumps		115.437	7,535	190,648	1,251		199,434	312,726
11240 Chemical/Disinfection Equipment								
41 Water Softener	1.00 ea	19.000	1,276	17,232	79	950	19,537	30,521
11240 Chemical/Disinfection Equipment		19.000	1,276	17,232	79	950	19,537	30,521
13200 Tanks								
61 Chem System Ammonium Hydroxide	2.00 ea	97.714	6,616	44,088	1,583		52,288	81,631
62 Chem System Antiscalent	2.00 ea	97.714	6,616	15,170	1,583		23,369	36,200
64 Chem System Sufuric Acid	3.00 ea	188.286	12,750	181,732	4,453		198,935	311,539
65 Chem System Sodium Hypochlorite	2.00 ea	120.571	8,173	26,088	1,583		35,844	55,678
13200 Tanks		504.285	34,155	267,078	9,204		310,436	485,048
15060 Hangers & Supports								
CPVC80 Sch 80 CPVC Pipe & Fittings	780.00 lf	68.266	4,649	9,185			13,834	21,373
PVC80 Sch 80 PVC Pipe & Fittings	320.00 lf	13.333	908	2,200			3,108	4,812
15060 Hangers & Supports		81.600	5,557	11,385			16,942	26,185
15110 Valves								
ALOYBV Alloy 20 Ball Valves	8.00 ea	21.059	1,682	20,000			21,682	33,933
CPVCBFV CPVC Butterfly Valves	6.00 ea	8.206	656	2,688			3,343	5,202
CPVCBV CPVC Ball Valves	15.00 ea	13.257	1,059	854			1,913	2,923
CPVCDV CPVC Diaphragm Valves	4.00 ea	5.228	418	3,680			4,098	6,405
PVCBFV PVC Butterfly Valves	6.00 ea	15.206	1,215	2,405			3,619	5,592
PVCCV PVC Check Valves	2.00 ea	1.074	86	1,104			1,190	1,862
15110 Valves		64.029	5,115	30,730			35,845	55,916
15120 Pipe Specialties								

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
CPVC80 Sch 80 CPVC Pipe & Fittings	780.00 lf	8.307	570	1,350			1,920	2,972
PVC80 Sch 80 PVC Pipe & Fittings	320.00 lf	6.487	442	1,452			1,894	2,941
15120 Pipe Specialties		14.793	1,011	2,802			3,813	5,912
15240 Plastic Pipe								
CPVC80 Sch 80 CPVC Pipe & Fittings	780.00 lf	93.204	6,347	23,078	3		29,428	45,739
PVC80 Sch 80 PVC Pipe & Fittings	320.00 lf	62.637	4,265	6,718	1		10,985	16,926
15240 Plastic Pipe		155.841	10,612	29,796	4		40,413	62,666
0080.0006 CHEMICAL STORAGE AREA #1 (PRETREATMENT)	**1.00 LS**	**954.985**	**65,262**	**549,670**	**10,538**	**950**	**626,420**	**978,974**
0080.0006a CHEMICAL STOREAGE AREA #1 (PRETREATMENT) STRUCTURE ONLY								
02300 Earthwork								
02310.100 Site Earthwork	1,134.00 cy					39,690	39,690	59,277
02300 Earthwork						39,690	39,690	59,277
02600 Drainage & Containment								
CT Chemical Trench	1.00 ls	23.993	1,512		1,575		3,086	4,732
CT - MH Chemical Trench - Manholes	4.00 ea	10.332	619	6,000	676		7,295	11,413
02600 Drainage & Containment		34.326	2,131	6,000	2,251		10,382	16,144
03000 Concrete								
03210.100 Reinforcing Steel	77.60 tn	1,254.830	91,002	70,667	960		162,629	248,437
03300.2602 Chemical Building Slabs/Walls/Foundations	664.68 cy	3,350.435	201,452	109,949	1,260	9,643	322,304	489,979
03000 Concrete		4,605.265	292,454	180,617	2,219	9,643	484,933	738,417
04000 Masonry								
04400.2600 Chemical Partition Walls	1,088.00 sf					34,816	34,816	51,998
04000 Masonry						34,816	34,816	51,998
06000 Wood								
FRP - Rail FRP Railing	578.00 lf	72.013	4,595	43,350	106		48,051	75,132
FRP Stairs FRP Stairs	312.00 sf	52.633	3,359	35,040	175		38,573	60,339
06000 Wood		124.646	7,954	78,390	280		86,624	135,470
10000 Specialties								
10520.000 Fire Protection Specialty	6.00 ea	9.000	612	2,100			2,712	4,212
10000 Specialties		9.000	612	2,100			2,712	4,212
13000 Special Construction								
MC Metal Canopy	5,550.00 sf					249,750	249,750	373,002
13000 Special Construction						249,750	249,750	373,002
0080.0006a CHEMICAL STOREAGE AREA #1 (PRETREATMENT) STRUCTURE ONLY	**5,550.00 SF**	**4,773.236**	**303,150**	**267,107**	**4,751**	**333,899**	**908,906**	**1,378,520**
0080.0010 MEMBRANE FILTRATION FACILITY								
01190 Manufacture Spare Parts & start-up Services								
01190.2600 Start-up Services & Spare Parts	1.00 ls			9,150			9,150	14,374
01190 Manufacture Spare Parts & start-up Services				9,150			9,150	14,374
11210 Water Supply & Treatment Pumps								
11228.2612 MF CIP Pumps	2.00 ea	73.006	5,061				5,061	7,559
11228.2630 MF Citric Acid Transfer Pump	1.00 ea	41.669	2,868	12,559			15,427	24,014
11228.2631 MF Sodium Hydroxide Transfer Pump	1.00 ea	41.669	2,868	12,559			15,427	24,014
11228.2632 Sodium Hypochlorite Transfer Pump	1.00 ea	41.669	2,868	12,559			15,427	24,014
11210 Water Supply & Treatment Pumps		198.013	13,666	37,677			51,343	79,601
11228 Filter Membrane Systems								
11228.2600 Pall Membrane System	21.20 mgd	4,592.067	313,458	9,384,000	54,692		9,752,149	15,296,333
11228.2603 MF Plant Air Equipment	1.00 ea	233.057	16,191				16,191	24,181
11228.2604 MF Reverse Flush Pumps	4.00 ea	146.012	10,123				10,123	15,118
11228.2606 MF Feed Pumps	4.00 ea	1,111.938	77,531	1,143,904			1,221,435	1,912,866
11228.2610 MF EFM Pumps	2.00 ea	73.006	5,061				5,061	7,559

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
11228 Filter Membrane Systems		6,156.080	422,363	10,527,904	54,692		11,004,959	17,256,057
11300 Fluid Waste Treatement & Disposal								
11300.2600 Submersable Pump Discharge	2.00 ea	81.430	5,581	15,984	7,781		29,345	45,669
11300.2601 Submersable Pump Circulation	2.00 ea	81.430	5,581	8,884	7,781		22,245	34,515
11300 Fluid Waste Treatement & Disposal		162.860	11,161	24,868	15,561		51,591	80,184
13200 Tanks								
13200.2600 MF Reverse Filtration Tank	2.00 ea	70.857	4,812		1,237		6,049	9,131
13200.2601 MF CIP Tank	2.00 ea	70.857	4,812	36,614	1,237		42,663	66,651
13200.2603 MF EFM Tank	1.00 ea	26.179	1,788	16,599	619		19,005	29,719
13200.2604 Citric Acid Dedicated Tote	2.00 ea	8.000	547	16,000	173		16,720	26,225
13200.2605 Sodium Hydroxide Dedicated Tote	2.00 ea	8.000	547	16,000	173		16,720	26,225
13200.2606 Sodium Hypochlorite Storage Tank	2.00 ea	70.857	4,812	29,828	1,237		35,878	55,991
13200 Tanks		254.750	17,318	115,041	4,676		137,036	213,941
15051 Mechanical Welding								
15051.2600 Weld Rig For Make-up Joints	1.00 ls					177,600	177,600	265,246
15051 Mechanical Welding						177,600	177,600	265,246
15060 Hangers & Supports								
15220.26001 42" Manifold For Strainer Feed	100.00 lf	60.000	4,086	7,700			11,786	18,199
15220.2612 24" MFF Supply Piping	210.00 lf	12.000	817	7,500			8,317	13,003
15220.2613 14" MFF Suction Piping	100.00 lf	18.000	1,226	4,200			5,426	8,429
15220.2614 MF Feed Pump Discharge	50.00 lf	36.000	2,451	4,200			6,651	10,259
15220.2616 24" MFE Manifold Piping	120.00 lf	96.000	6,537	53,292			59,829	93,484
15220.2618 MFF Piping @Strainers	40.00 lf	66.150	4,505	3,150			7,655	11,676
15240.2610 6" MCR/EFMR Piping From MF to CIP Area	120.00 lf	2.667	182	560			742	1,151
15240.2611 MCF/EFMF Feed Piping From MF area to CIP area	120.00 lf	2.500	170	560			730	1,134
15240.2615 10" PVC RF Feed Pipe from MF System to CIP Area	70.00 lf	30.000	2,043	2,224			4,267	6,545
15240.2618 16" MFBWW Piping	330.00 lf	24.000	1,634	14,880			16,514	25,817
15240.2625 RF Tank Feed to RF Pumps	90.00 lf	27.000	1,839	1,230			3,069	4,678
15240.2626 RF Pump Discharge Piping	70.00 lf	24.000	1,634	980			2,614	3,980
15240.2627 ROP Piping Acid CIPTank	60.00 lf	5.000	340	1,315			1,656	2,575
15240.2631 ROP Piping Caustic	60.00 lf	5.000	340	1,315			1,656	2,575
15240.2633 SCH Piping To Caustic Tank	120.00 lf	10.000	681	2,458			3,139	4,879
15240.2634 SH Piping to Caustic Tank	120.00 lf	10.000	681	2,458			3,139	4,879
15240.2638 Citric Acid Feed to Acid Tank	120.00 lf	10.000	681	2,458			3,139	4,879
15240.2639 NaOCL Feed to EFM tank	120.00 lf	10.000	681	2,458			3,139	4,879
15240.2640 ROP Piping to EFM Tank	60.00 lf	5.000	340	1,315			1,656	2,575
15240.2644 MCR/EFMR Pump Feed/ Discharge	80.00 lf	19.775	1,347	800			2,147	3,268
15240.2645 Citric Acid From Tote to Transfer Pump	40.00 lf	2.400	163	125			288	440
15240.2646 Citric Acid transfer Pump Discharge	40.00 lf	1.680	114	175			289	446
15240.2647 Sodium Hydroxide From Tote to Transfer Pump	40.00 lf	2.400	163	125			288	440
15240.2648 Sodium Hydroxide From Transfer Pump	80.00 lf	1.680	114	175			289	446
15240.2649 Sodium Hypochlorite Storage From tank to Pump	40.00 lf	2.400	163	125			288	440
15240.2650 3" Tank Feed Piping	60.00 lf	2.400	163	1,315			1,479	2,310
15240.2651 m Hypochlorite From transfer Pump	40.00 lf	1.680	114	175			289	446
15240.2652 Citric Acid Waste Tank Discharge	30.00 lf	10.150	691	318			1,010	1,532
15240.2653 SH Dosing Influent	20.00 lf	10.150	691	318			1,010	1,532
15240.2654 Circ Pump Piping	20.00 lf	8.960	610	287			897	1,361
15060 Hangers & Supports		516.992	35,206	118,192			153,397	238,259
15110 Valves								
15220.2612 24" MFF Supply Piping	210.00 lf	87.360	5,949	31,882			37,831	58,971
15220.2613 14" MFF Suction Piping	72.00 lf	68.400	4,658	64,800			69,458	108,757

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
15220.2614 MF Feed Pump Discharge	36.00 lf	106.800	7,273	55,057			62,330	97,357
15220.2617 6" MFE Piping to RF tank	30.00 lf	5.520	376	9,400			9,776	15,329
15220.2618 MFF Piping @Strainers	40.00 lf	137.480	9,362	39,640			49,002	76,256
15221.2600 EF Suction Piping	40.00 lf	70.080	4,772	35,926			40,698	63,567
15224.2605 PA Piping	270.00 lf	74.820	5,095	6,482			11,577	17,793
15224.2606 1" Control Air Piping	270.00 lf	10.660	726	4,503			5,229	8,158
15224.2607 PA Piping Tank & Compressor Piping	70.00 lf	41.680	2,838	8,226			11,064	17,162
15240.2611 MCF/EFMF Feed Piping From MF area to CIP area	120.00 lf	14.220	968	13,440			14,408	22,560
15240.2619 MFE/OF Piping	40.00 lf	5.520	376	356			732	1,121
15240.2620 LI Tank Pipe Reverse Filtration Tank	20.00 lf	2.660	181	133			314	479
15240.2621 LI tank Piping Acid CIP tank	20.00 lf	2.660	181	133			314	479
15240.2622 LI tank Piping Caustic CIP Tank	20.00 lf	2.660	181	133			314	479
15240.2623 LI Piping MF EFM Tank	20.00 lf	2.660	181	133			314	479
15240.2624 LI Piping NaOCL Tank	20.00 lf	2.660	181	964			1,145	1,785
15240.2625 RF Tank Feed to RF Pumps	60.00 lf	43.080	2,934	8,284			11,218	17,396
15240.2626 RF Pump Discharge Piping	70.00 lf	52.691	3,588	32,580			36,168	56,542
15240.2627 ROP Piping Acid CIPTank	60.00 lf	5.824	397	5,172			5,569	8,718
15240.2628 MCW/OF Piping From Acid CIP	50.00 lf	4.634	316	700			1,016	1,571
15240.2629 MCR Piping From Acid Tank	120.00 lf	41.664	2,837	18,848			21,685	33,848
15240.2630 MCF PipingFrom Acid feed Pump	100.00 lf	43.204	2,942	16,944			19,886	31,013
15240.2631 ROP Piping Caustic	60.00 lf	5.824	397	5,172			5,569	8,718
15240.2633 SCH Piping To Caustic Tank	120.00 lf	2.618	178	1,560			1,738	2,717
15240.2634 SH Piping to Caustic Tank	120.00 lf	2.618	178	1,560			1,738	2,717
15240.2635 MCR Piping From Caustic Tank	40.00 lf	5.208	355	2,356			2,711	4,231
15240.2636 MCF Piping From Caustic Tank to Feed Pump	60.00 lf	10.416	709	5,424			6,133	9,580
15240.2637 MCF Piping From caustic Feed Pump to System	60.00 lf	6.748	460	2,452			2,912	4,538
15240.2638 Citric Acid Feed to Acid Tank	120.00 lf	2.618	178	1,560			1,738	2,717
15240.2639 NaOCL Feed to EFM tank	120.00 lf	2.618	178	1,560			1,738	2,717
15240.2640 ROP Piping to EFM Tank	60.00 lf	5.824	397	5,928			6,325	9,905
15240.2641 MCW/OF Piping EFM Tank	40.00 lf	4.634	316	700			1,016	1,571
15240.2642 EFMF Piping From Tank Through Pumps	160.00 lf	29.120	1,983	7,972			9,955	15,486
15240.2643 EFMR Piping From EFM tank	40.00 lf	5.208	355	2,356			2,711	4,231
15240.2644 MCR/EFMR Pump Feed/ Discharge	80.00 lf	11.956	814	3,344			4,158	6,470
15240.2645 Citric Acid From Tote to Transfer Pump	40.00 lf	8.988	612	2,570			3,182	4,952
15240.2646 Citric Acid transfer Pump Discharge	40.00 lf	6.252	426	2,000			2,426	3,778
15240.2647 Sodium Hydroxide From Tote to Transfer Pump	40.00 lf	31.066	2,116	7,540			9,656	15,006
15240.2648 Sodium Hydroxide From Transfer Pump	80.00 lf	8.052	548	4,650			5,198	8,124
15240.2649 Sodium Hypochlorite Storage From tank to Pump	40.00 lf	10.472	713	3,000			3,713	5,778
15240.2650 3" Tank Feed Piping	60.00 lf	20.818	1,418	14,540			15,958	24,960
15240.2651 m Hypochlorite From transfer Pump	40.00 lf	3.852	262	1,300			1,562	2,434
15240.2652 Citric Acid Waste Tank Discharge	30.00 lf	3.766	256	217			473	724
15240.2653 SH Dosing Influent	20.00 lf	1.498	102	149			251	386
15240.2654 Circ Pump Piping	20.00 lf	5.698	388	441			829	1,272
15240.2655 3" BW Discharge	40.00 lf	7.154	487	1,658			2,145	3,332
15110 Valves		1,029.963	70,137	433,743			503,881	786,161
15120 Pipe Specialties								
15120.2001 Instrument Valves	93.00 ea	31.568	2,150	6,636			8,785	13,635
15120.2600 24" Static Mixer MF Influent	2.00 ea	44.927	3,059	37,204			40,263	63,017
15120.2601 Strainers	8.00 ea	20.000	1,362	20,580			21,942	34,365
15120.2602 Auto Strainers MF System	8.00 ea	116.661	7,927	627,442	4,157		639,525	1,004,080
15120.2620 Flex Couplings for Plastic Pipe	41.00 ea			2,379			2,379	3,738

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
15220.2612 24" MFF Supply Piping	210.00 lf	39.000	2,656	7,035			9,691	15,018
15220.2613 14" MFF Suction Piping	72.00 lf	19.320	1,316	2,347			3,663	5,652
15220.2614 MF Feed Pump Discharge	36.00 lf	19.320	1,316	2,347			3,663	5,652
15220.2616 24" MFE Manifold Piping	120.00 lf	23.352	1,590	4,690			6,280	9,743
15220.2618 MFF Piping @Strainers	40.00 lf	81.732	5,566	10,201			15,767	24,339
15240.2625 RF Tank Feed to RF Pumps	60.00 lf	11.000	749	1,370			2,119	3,271
15240.2626 RF Pump Discharge Piping	70.00 lf	10.490	714	1,250			1,964	3,031
15240.2645 Citric Acid From Tote to Transfer Pump	40.00 lf	5.808	396	2,120			2,516	3,921
15240.2647 Sodium Hydroxide From Tote to Transfer Pump	40.00 lf	5.808	396	2,120			2,516	3,921
15120 Pipe Specialties		428.986	29,195	727,721	4,157		761,072	1,193,382
15220 Steel Pipe								
15220.26001 42" Manifold For Strainer Feed	100.00 lf	56.100	3,820	57,889			61,710	96,650
15220.2612 24" MFF Supply Piping	210.00 lf	261.300	17,794	91,975			109,768	171,067
15220.2613 14" MFF Suction Piping	72.00 lf	78.280	5,331	25,402			30,733	47,868
15220.2614 MF Feed Pump Discharge	36.00 lf	54.300	3,698	24,307			28,005	43,709
15220.2615 12" MFE Piping to Manifold	36.00 lf	51.000	3,473	14,324			17,797	27,690
15220.2616 24" MFE Manifold Piping	120.00 lf	66.000	4,494	38,839			43,333	67,728
15220.2617 6" MFE Piping to RF tank	30.00 lf	12.560	855	2,366			3,221	4,995
15220.2618 MFF Piping @Strainers	40.00 lf	289.800	19,735	86,533			106,268	165,417
15220 Steel Pipe		869.340	59,199	341,635			400,835	625,123
15221 Stainless Steel Pipe								
15221.2600 EF Suction Piping	40.00 lf	24.480	1,667	4,865			6,532	10,133
15221.2601 EF Discharge Pipe	80.00 lf	65.040	4,429	12,803			17,232	26,728
15221 Stainless Steel Pipe		89.520	6,096	17,668			23,764	36,861
15224 Copper Pipe								
15224.2605 PA Piping	270.00 lf	178.489	12,155	24,496			36,651	56,637
15224.2606 1" Control Air Piping	270.00 lf	86.973	5,923	2,714			8,637	13,109
15224.2607 PA Piping Tank & Compressor Piping	70.00 lf	92.174	6,277	8,137			14,414	22,158
15224 Copper Pipe		357.635	24,354	35,348			59,702	91,904
15240 Plastic Pipe								
15240.2610 6" MCR/EFMR Piping From MF to CIP Area	120.00 lf	19.600	1,335	4,031			5,366	8,326
15240.2611 MCF/EFMF Feed Piping From MF area to CIP area	120.00 lf	23.940	1,630	4,239			5,869	9,094
15240.2615 10" PVC RF Feed Pipe from MF System to CIP Area	70.00 lf	33.977	2,314	6,627			8,941	13,867
15240.2616 4" MF BWW Piping From MF to Backwash Main	120.00 lf	28.392	1,933	1,112			3,045	4,634
15240.2617 4" MFBWW Piping	100.00 lf	23.296	1,586	960			2,546	3,877
15240.2618 16" MFBWW Piping	220.00 lf	114.162	7,774	16,949			24,723	38,237
15240.2619 MFE/OF Piping	40.00 lf	19.894	1,355	1,430			2,784	4,269
15240.2620 LI Tank Pipe Reverse Filtration Tank	20.00 lf	4.293	292	92			384	581
15240.2621 LI tank Piping Acid CIP tank	20.00 lf	4.293	292	92			384	581
15240.2622 LI tank Piping Caustic CIP Tank	20.00 lf	4.293	292	92			384	581
15240.2623 LI Piping MF EFM Tank	20.00 lf	4.293	292	92			384	581
15240.2624 LI Piping NaOCL Tank	20.00 lf	4.293	292	92			384	581
15240.2625 RF Tank Feed to RF Pumps	60.00 lf	48.757	3,320	8,673			11,993	18,584
15240.2626 RF Pump Discharge Piping	70.00 lf	68.228	4,646	10,207			14,853	22,974
15240.2627 ROP Piping Acid CIPTank	60.00 lf	13.644	929	507			1,436	2,184
15240.2628 MCW/OF Piping From Acid CIP	50.00 lf	17.547	1,195	830			2,025	3,088
15240.2629 MCR Piping From Acid Tank	120.00 lf	55.029	3,747	4,949			8,696	13,371
15240.2630 MCF PipingFrom Acid feed Pump	100.00 lf	44.310	3,017	4,445			7,462	11,489
15240.2631 ROP Piping Caustic	60.00 lf	15.350	1,045	507			1,552	2,357
15240.2633 SCH Piping To Caustic Tank	120.00 lf	18.144	1,236	208			1,443	2,172
15240.2634 SH Piping to Caustic Tank	120.00 lf	9.072	618	208			826	1,249

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
15240.2635 MCR Piping From Caustic Tank	40.00 lf	17.024	1,159	921			2,080	3,178
15240.2636 MCF Piping From Caustic Tank to Feed Pump	60.00 lf	23.240	1,583	1,481			3,064	4,690
15240.2637 MCF Piping From caustic Feed Pump to System	60.00 lf	31.209	2,125	2,497			4,623	7,097
15240.2638 Citric Acid Feed to Acid Tank	120.00 lf	9.072	618	208			826	1,249
15240.2639 NaOCL Feed to EFM tank	120.00 lf	9.072	618	208			826	1,249
15240.2640 ROP Piping to EFM Tank	60.00 lf	12.280	836	507			1,343	2,045
15240.2641 MCW/OF Piping EFM Tank	40.00 lf	15.512	1,056	819			1,876	2,865
15240.2642 EFMF Piping From Tank Through Pumps	160.00 lf	63.541	4,327	5,508			9,835	15,116
15240.2643 EFMR Piping From EFM tank	40.00 lf	15.232	1,037	781			1,818	2,776
15240.2644 MCR/EFMR Pump Feed/ Discharge	80.00 lf	18.113	1,233	1,570			2,804	4,309
15240.2645 Citric Acid From Tote to Transfer Pump	40.00 lf	4.396	299	95			394	596
15240.2646 Citric Acid transfer Pump Discharge	40.00 lf	6.370	434	171			605	917
15240.2647 Sodium Hydroxide From Tote to Transfer Pump	40.00 lf	4.396	299	94			394	596
15240.2648 Sodium Hydroxide From Transfer Pump	80.00 lf	8.442	575	230			805	1,221
15240.2649 Sodium Hypochlorite Storage From tank to Pump	40.00 lf	4.396	299	94			394	596
15240.2650 3" Tank Feed Piping	60.00 lf	22.724	1,547	1,105			2,652	4,047
15240.2651 m Hypochlorite From transfer Pump	40.00 lf	6.370	434	171			605	917
15240.2652 Citric Acid Waste Tank Discharge	30.00 lf	2.982	203	163			366	560
15240.2653 SH Dosing Influent	20.00 lf	2.562	174	138			313	478
15240.2654 Circ Pump Piping	20.00 lf	3.878	264	320			584	897
15240.2655 3" BW Discharge	40.00 lf	6.440	439	565			1,004	1,543
15240 Plastic Pipe		862.059	58,704	83,986			142,690	219,616
0080.0010 MEMBRANE FILTRATION FACILITY	**22.80 MGD**	**10,926.197**	**747,400**	**12,472,933**	**79,086**	**177,600**	**13,477,019**	**21,100,709**
0080.0010A MEMBRANE FILTRATION FACILITY STRUCTURE ONLY								
02300 Earthwork								
02300.2605 Structural Excavation & Backfill	4,307.10 cy	441.470	23,885		31,022		54,907	84,407
02300 Earthwork		441.470	23,885		31,022		54,907	84,407
03212 Concrete Walls								
03212.226001 Containment Curbs 18" high	12.13 cy	241.174	14,583	5,959	111	1,471	22,124	33,513
03212.226002 Pipe Trench Walls	62.79 cy	491.687	29,372	12,675	193	10,299	52,538	79,463
03212 Concrete Walls		732.861	43,955	18,634	304	11,770	74,663	112,976
03310 Concrete Slab on Grade								
03310.226004 Pipe Trench Floor	25.22 cy	115.409	6,996	5,036	128	5,738	18,602	28,237
03310.226006 Air Supply Pad	19.40 cy	73.967	4,382	3,369	63	4,904	13,224	20,055
03310.2605 Building Base Slab	847.81 cy	3,013.841	189,653	202,835	1,410	9,953	405,977	622,320
03310 Concrete Slab on Grade		3,203.217	201,032	211,239	1,600	20,595	437,803	670,612
03412 Concrete Equipment Pabs/Curbs/Fill								
03412.226002 Housekeeping pads - tanks/pumps	24.00 cy	136.429	7,951	3,502	57	3,961	15,953	24,139
03412.226006 Pipe Supports on MF Pad	8.00 cy	83.001	5,037	2,123	43	1,886	9,089	13,743
03412.226008 Pipe Supports-Spread Footing	12.80 cy	118.211	7,121	2,699	79		9,899	14,999
03412.226302 Strainer pad	16.00 cy	147.760	8,901	3,373	99		12,373	18,749
03412.226306 Pipe Supports - Strainer Header	40.00 cy	340.026	20,609	9,266	171	7,545	37,591	56,873
03412.226308 Pipe Supports - Strainer Feed Line	10.00 cy	85.008	5,152	2,317	43	1,886	9,398	14,218
03412 Concrete Equipment Pabs/Curbs/Fill		910.435	54,771	23,280	493	15,278	94,303	142,721
03470 Walls								
03470.2605 Exterior Walls	512.00 cy	1,599.159	102,836	119,500	174	2,936	226,653	347,874
03470.2606 Wall Texture	13,340.00 sf			113,765			113,765	178,724
03470 Walls		1,599.159	102,836	233,265	174	2,936	340,417	526,598
05210 Steel Joist								
05210.2605 Building Roof Framing	20,800.00 sf	203.523	14,049	97,449	6,063		117,561	183,599
05210 Steel Joist		203.523	14,049	97,449	6,063		117,561	183,599
05300 Steel Deck								

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
05300.2605 Roof Deck	20,800.00 sf	625.248	43,159	125,212	18,626		186,998	290,428
05300 Steel Deck		625.248	43,159	125,212	18,626		186,998	290,428
07000 Thermal & Moisture Protection								
07000.2605 EPDM Roofing	208.00 sq	918.320	62,058	93,909			155,967	240,215
07000 Thermal & Moisture Protection		918.320	62,058	93,909			155,967	240,215
08000 Doors & Windows								
08000.2605 Exterior Doors & Windows	1.00 ls	215.607	12,382	37,099		52,011	101,493	154,454
08000 Doors & Windows		215.607	12,382	37,099		52,011	101,493	154,454
15300 Fire Protection								
15300.2605 Fire Protection Allowance	1.00 allw					260,859	260,859	389,593
15300 Fire Protection						260,859	260,859	389,593
15400 Plumbing								
15400.2605 Plumbing Allowance	1.00 allw					313,031	313,031	467,511
15400 Plumbing						313,031	313,031	467,511
15500 HVAC								
15500.2605 HVAC Allowance	1.00 allw					626,061	626,061	935,023
15500 HVAC						626,061	626,061	935,023
0080.0010A MEMBRANE FILTRATION FACILITY STRUCTURE ONLY	**20,800.00 SF**	**8,849.841**	**558,127**	**840,087**	**58,282**	**1,302,541**	**2,764,061**	**4,198,139**
0080.0030 REVERSE OSMOSIS FACILITY								
11200 Water Treatment Equipment								
11200.2610 RO Train Feed Pumps	5.00 ea	269.000	18,594	1,130,394	4,157		1,153,144	1,810,149
11200 Water Treatment Equipment		269.000	18,594	1,130,394	4,157		1,153,144	1,810,149
11201 Process Equipment N.O.C.								
11201.2605 Energy Recovery Turbines	5.00 ea	128.000	8,877	197,500			206,919	324,382
11201 Process Equipment N.O.C.		128.000	8,877	197,500			206,919	324,382
11210 Water Supply & Treatment Pumps								
11210.2610 RO Flush Pumps	3.00 ea	238.500	16,647	77,575	2,078		96,847	150,856
11210 Water Supply & Treatment Pumps		238.500	16,647	77,575	2,078		96,847	150,856
11228 Filter Membrane Systems								
11228.2650 RO Train 1	882.00 ea	601.700	41,881	1,490,715			1,532,596	2,404,462
11228.2651 RO Train 2	882.00 ea	601.700	41,881	1,490,715			1,532,596	2,404,462
11228.2652 RO Train 3	882.00 ea	601.700	41,881	1,490,715			1,532,596	2,404,462
11228.2653 RO Train 4	882.00 ea	601.700	41,881	1,490,715			1,532,596	2,404,462
11228.2654 RO Train 5	882.00 ea	601.700	41,881	1,490,715			1,532,596	2,404,462
11228 Filter Membrane Systems		3,008.500	209,403	7,453,575			7,662,978	12,022,309
13200 Tanks								
13200.2650 RO Flush Tanks	2.00 ea	70.857	4,812	105,676	1,237		111,725	175,148
13200.2655 CIP Tanks	2.00 ea	70.857	4,812	73,742	1,237		79,792	124,980
13200 Tanks		141.714	9,625	179,418	2,474		191,517	300,128
15060 Hangers & Supports								
15221.2621 RO Feed Pump Discharge Piping Train 1 Through 3	57.00 lf	16.380	1,115	4,977			6,093	9,485
15221.2622 RO Feed Pump Discharge Piping Train 4 & 5	38.00 lf	10.920	744	3,318			4,062	6,323
15221.2623 6" ROF Piping train 1 Through 3	24.00 lf	7.896	538	1,920			2,458	3,819
15221.2624 6" ROF Piping train 4 & 5	16.00 lf	5.264	358	1,280			1,638	2,546
15221.2625 8" ROF Piping train 1 Through 3	52.50 lf	7.896	538	1,920			2,458	3,819
15221.2626 8" ROF Piping train 4 & 5	35.00 lf	5.264	358	1,280			1,638	2,546
15221.2627 6" ROC Piping train 1 Though 3	57.00 lf	7.896	538	1,920			2,458	3,819
15221.2628 6" ROC Piping train 4 & 5	38.00 lf	5.264	358	1,280			1,638	2,546
15240.2659 1-1/2" D Line	190.00 lf	20.300	1,382	637			2,019	3,065
15240.2661 10" CF/CR Piping	720.00 lf	369.600	25,169	22,241			47,409	72,530
15240.2665 10" PVC ROP Header	216.00 lf	36.960	2,517	2,224			4,741	7,253

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
15240.2670 4" ROP Drains	60.00 lf	25.725	1,752	820			2,572	3,904
15240.2671 12" PVC ROP	150.00 lf	85.680	5,835	3,825			9,660	14,723
15240.2672 4" PCR Piping	495.00 lf	58.800	4,004	1,874			5,878	8,924
15248.2600 16" FRP Pipe Header	350.00 lf	84.231	5,736	13,800			19,536	30,246
15248.2601 12" FRP Pipe to RO Feed Pump Header	140.00 lf	33.600	2,288	1,500			3,788	5,774
15248.2602 12" FRP Pipe to RO Feed Pump Branch Piping	440.00 lf	33.600	2,288	1,500			3,788	5,774
15248.2603 20" FRP ROP	75.00 lf	54.000	3,677	2,400			6,077	9,262
15060 Hangers & Supports		869.276	59,195	68,715			127,910	196,359
15110 Valves								
15221.2621 RO Feed Pump Discharge Piping Train 1 Through 3	57.00 lf	59.100	4,025	40,679			44,703	69,917
15221.2622 RO Feed Pump Discharge Piping Train 4 & 5	38.00 lf	39.400	2,683	27,119			29,802	46,611
15221.2627 6" ROC Piping train 1 Though 3	57.00 lf	17.400	1,185	58,150			59,335	93,123
15221.2628 6" ROC Piping train 4 & 5	38.00 lf	11.600	790	38,767			39,557	62,082
15240.2659 1-1/2" D Line	190.00 lf	11.340	772	342			1,114	1,690
15240.2661 10" CF/CR Piping	720.00 lf	15.480	1,054	3,433			4,487	6,968
15240.2662 6" CF/CR Piping	18.00 lf	18.780	1,279	74,254			75,533	118,564
15240.2663 6" CR Piping	18.00 lf	18.780	1,279	74,254			75,533	118,564
15240.2664 8" CR/CF Piping	18.00 lf	20.820	1,418	77,293			78,711	123,545
15240.2670 4" ROP Drains	60.00 lf	30.480	2,076	69,035			71,111	111,554
15240.2671 12" PVC ROP	150.00 lf	118.200	8,049	82,799			90,848	142,098
15240.2672 4" PCR Piping	495.00 lf	36.060	2,456	9,909			12,365	19,235
15248.2601 12" FRP Pipe to RO Feed Pump Header	140.00 lf	59.311	4,039	21,622			25,661	40,001
15248.2602 12" FRP Pipe to RO Feed Pump Branch Piping	440.00 lf	59.311	4,039	21,622			25,661	40,001
15110 Valves		516.063	35,142	599,280			634,422	993,954
15221 Stainless Steel Pipe								
15221.2621 RO Feed Pump Discharge Piping Train 1 Through 3	57.00 lf	71.881	4,895	107,967			112,862	176,926
15221.2622 RO Feed Pump Discharge Piping Train 4 & 5	38.00 lf	47.920	3,263	71,978			75,241	117,951
15221.2623 6" ROF Piping train 1 Through 3	24.00 lf	7.056	481	19,800			20,281	31,824
15221.2624 6" ROF Piping train 4 & 5	16.00 lf	4.704	320	13,200			13,521	21,216
15221.2625 8" ROF Piping train 1 Through 3	52.50 lf	19.268	1,312	15,966			17,278	27,043
15221.2626 8" ROF Piping train 4 & 5	35.00 lf	12.845	875	10,644			11,519	18,028
15221.2627 6" ROC Piping train 1 Though 3	57.00 lf	13.230	901	23,284			24,185	37,925
15221.2628 6" ROC Piping train 4 & 5	38.00 lf	8.820	601	15,523			16,123	25,283
15221 Stainless Steel Pipe		185.724	12,647	278,363			291,010	456,197
15240 Plastic Pipe								
15240.2659 1-1/2" D Line	190.00 lf	27.790	1,892	546			2,438	3,684
15240.2661 10" CF/CR Piping	720.00 lf	179.574	12,228	29,116			41,344	64,004
15240.2662 6" CF/CR Piping	18.00 lf	7.140	486	536			1,022	1,567
15240.2663 6" CR Piping	18.00 lf	7.140	486	1,136			1,622	2,510
15240.2664 8" CR/CF Piping	18.00 lf	20.280	1,381	1,034			2,415	3,687
15240.2665 10" PVC ROP Header	216.00 lf	151.803	10,337	26,347			36,685	56,831
15240.2666 6" PVC ROP Drops	36.00 lf	3.528	240	186			426	651
15240.2667 4" PVC ROP Drops	36.00 lf	2.520	172	101			272	414
15240.2668 6" PVC ROP Header	90.00 lf	29.783	2,028	2,190			4,218	6,469
15240.2669 3" ROP Header	90.00 lf	16.032	1,092	597			1,689	2,568
15240.2670 4" ROP Drains	60.00 lf	28.476	1,939	1,351			3,290	5,018
15240.2671 12" PVC ROP	150.00 lf	89.734	6,111	15,239			21,349	33,066
15240.2672 4" PCR Piping	495.00 lf	47.970	3,267	2,812			6,078	9,296
15240.2673 6" FW Piping	495.00 lf	75.296	5,127	4,677			9,804	15,005
15240 Plastic Pipe		687.066	46,787	85,865			132,652	204,771
15248 FRP Pipe								

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
15248.2600 16" FRP Pipe Header	350.00 lf	503.113	34,260	95,829			130,090	201,716
15248.2601 12" FRP Pipe to RO Feed Pump Header	140.00 lf	395.877	26,958	108,706			135,664	211,039
15248.2602 12" FRP Pipe to RO Feed Pump Branch Piping	440.00 lf	578.799	39,415	158,498			197,912	307,866
15248.2603 20" FRP ROP	75.00 lf	105.692	7,197	59,158			66,356	103,687
15248 FRP Pipe		1,583.481	107,830	422,191			530,022	824,307
0080.0030 REVERSE OSMOSIS FACILITY	**21.20 MGD**	**7,627.323**	**524,749**	**10,492,875**	**8,709**		**11,027,421**	**17,283,411**
0080.0030A RO FACILITY STRUCTURE ONLY								
02300 Earthwork								
02300.2605 Structural Excavation & Backfill	4,307.00 cy	439.984	23,804		30,918		54,722	84,123
02300 Earthwork		439.984	23,804		30,918		54,722	84,123
03212 Concrete Walls								
03212.228102 Walls w/ 18" x 18" columns	216.00 cy	1,720.300	103,450	75,577	1,035	50,383	234,765	356,893
03212 Concrete Walls		1,720.300	103,450	75,577	1,035	50,383	234,765	356,893
03310 Concrete Slab on Grade								
03310.228102 Pipe Trench Base Slab	128.00 cy	269.885	16,245	16,782	253	36,095	71,936	108,955
03310.228104 RO Equipment Slabs @ TOW	128.00 cy	200.175	11,838	14,751	148	30,080	59,376	90,032
03310.2605 Building Base Slab	465.63 cy	1,650.620	103,868	111,079	772	5,451	222,335	340,816
03310 Concrete Slab on Grade		2,120.680	131,951	142,612	1,174	71,626	353,647	539,803
03470 Walls								
03470.2605 Exterior Walls	512.00 cy	1,593.858	102,495	119,105	173	2,926	225,902	346,721
03470.2606 Wall Texture	13,340.00 sf			113,388			113,388	178,133
03470 Walls		1,593.858	102,495	232,493	173	2,926	339,290	524,854
05210 Steel Joist								
05210.2605 Building Roof Framing	20,800.00 sf	202.867	14,003	97,126	6,043		117,173	182,994
05210 Steel Joist		202.867	14,003	97,126	6,043		117,173	182,994
05300 Steel Deck								
05300.2605 Roof Deck	20,800.00 sf	624.000	43,073	124,798	18,589		186,460	289,591
05300 Steel Deck		624.000	43,073	124,798	18,589		186,460	289,591
05505 Metal Fabrications								
05505.2710 Aluminum Grating	20,800.00 sf	1,176.661	81,049	158,372	18,799		258,220	399,382
05505 Metal Fabrications		1,176.661	81,049	158,372	18,799		258,220	399,382
07000 Thermal & Moisture Protection								
07000.2605 EPDM Roofing	208.00 sq	915.408	61,861	93,599			155,460	239,433
07000 Thermal & Moisture Protection		915.408	61,861	93,599			155,460	239,433
08000 Doors & Windows								
08000.2605 Exterior Doors & Windows	1.00 ls	214.889	12,341	36,977		51,839	101,157	153,943
08000 Doors & Windows		214.889	12,341	36,977		51,839	101,157	153,943
15300 Fire Protection								
15300.2605 Fire Protection Allowance	1.00 allw					197,597	197,597	295,111
15300 Fire Protection						197,597	197,597	295,111
15400 Plumbing								
15400.2605 Plumbing Allowance	1.00 allw					135,198	135,198	201,918
15400 Plumbing						135,198	135,198	201,918
15500 HVAC								
15500.2605 HVAC Allowance	1.00 allw					519,992	519,992	776,607
15500 HVAC						519,992	519,992	776,607
0080.0030A RO FACILITY STRUCTURE ONLY	**20,800.00 SF**	**9,008.647**	**574,028**	**961,554**	**76,730**	**1,029,560**	**2,653,680**	**4,044,653**
0090.0010 UV AOP FACILITY								
11240 Chemical/Disinfection Equipment								
11240.2620 UV System Trojen UVPhox	4.00 ea	279.000	18,466	4,374,080	3,117		4,395,664	6,904,157
11240 Chemical/Disinfection Equipment		279.000	18,466	4,374,080	3,117		4,395,664	6,904,157
13200 Tanks								

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
13200.2660 Hydrogen Peroxide Storage	1.00 ea	32.000	2,187		2,771		4,958	7,619
13200 Tanks		32.000	2,187		2,771		4,958	7,619
15060 Hangers & Supports								
15221.2632 UV Reactor Outlet Piping	417.00 lf	121.500	8,274	22,950			31,224	48,411
15221.2633 UV Reactor Inlet Piping	117.00 lf	36.000	2,451	5,850			8,301	12,852
15221.2660 UV Reactor Inlet Header	110.00 lf	36.000	2,451	11,250			13,701	21,335
15240.26600 Hydrogen Peroxide Piping	120.00 lf	10.000	681	2,458			3,139	4,879
15060 Hangers & Supports		203.500	13,858	42,508			56,366	87,477
15110 Valves								
15221.2632 UV Reactor Outlet Piping	417.00 lf	82.710	5,632	89,262			94,894	148,642
15221.2633 UV Reactor Inlet Piping	117.00 lf	342.900	23,350	189,378			212,728	332,387
15240.26600 Hydrogen Peroxide Piping	120.00 lf	2.618	178	1,560			1,738	2,717
15110 Valves		428.228	29,161	280,200			309,361	483,746
15221 Stainless Steel Pipe								
15221.2632 UV Reactor Outlet Piping	417.00 lf	363.308	24,740	289,989			314,729	492,522
15221.2633 UV Reactor Inlet Piping	117.00 lf	396.351	26,990	343,888			370,878	580,558
15221.2660 UV Reactor Inlet Header	110.00 lf	201.354	13,743	288,224	4,160		306,126	479,859
15221 Stainless Steel Pipe		961.013	65,473	922,101	4,160		991,734	1,552,939
15240 Plastic Pipe								
15240.26600 Hydrogen Peroxide Piping	120.00 lf	9.072	618	208			826	1,249
15240 Plastic Pipe		9.072	618	208			826	1,249
0090.0010 UV AOP FACILITY	**18.00 MGD**	**1,912.813**	**129,762**	**5,619,097**	**10,048**		**5,758,908**	**9,037,187**
0090.0010A UV AOP SYSTEM STRUCTURE ONLY								
02300 Earthwork								
02310.100 Site Earthwork	1,995.00 cy					69,815	69,815	104,269
02300 Earthwork						69,815	69,815	104,269
03310 Concrete Slab on Grade								
03310.2605 Building Base Slab	107.41 cy	380.584	23,949	25,612	178	1,257	51,264	78,582
03310 Concrete Slab on Grade		380.584	23,949	25,612	178	1,257	51,264	78,582
03470 Walls								
03470.2605 Exterior Walls	113.28 cy	352.659	22,678	26,353	38	647	49,983	76,715
03470.2606 Wall Texture	6,329.00 sf			53,797			53,797	84,515
03470 Walls		352.659	22,678	80,149	38	647	103,779	161,230
05210 Steel Joist								
05210.2605 Building Roof Framing	4,800.00 sf	59.850	4,131	26,823	1,783		32,737	51,110
05210 Steel Joist		59.850	4,131	26,823	1,783		32,737	51,110
05300 Steel Deck								
05300.2605 Roof Deck	4,800.00 sf	144.000	9,940	28,800	4,290		43,030	66,829
05300 Steel Deck		144.000	9,940	28,800	4,290		43,030	66,829
07000 Thermal & Moisture Protection								
07000.2605 EPDM Roofing	48.00 sq	211.200	14,272	21,600			35,873	55,250
07000 Thermal & Moisture Protection		211.200	14,272	21,600			35,873	55,250
08000 Doors & Windows								
08000.2605 Exterior Doors & Windows	1.00 ls	63.133	3,585	10,792		17,280	31,658	48,117
08000 Doors & Windows		63.133	3,585	10,792		17,280	31,658	48,117
15300 Fire Protection								
15300.2605 Fire Protection Allowance	1.00 allw					45,600	45,600	68,104
15300 Fire Protection						45,600	45,600	68,104
15400 Plumbing								
15400.2605 Plumbing Allowance	1.00 allw					31,200	31,200	46,597
15400 Plumbing						31,200	31,200	46,597
15500 HVAC								

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
15500.2605 HVAC Allowance	1.00 allw					120,000	120,000	179,220
15500 HVAC						120,000	120,000	179,220
0090.0010A UV AOP SYSTEM STRUCTURE ONLY	**4,800.00 SF**	**1,211.426**	**78,556**	**193,777**	**6,289**	**285,800**	**564,957**	**859,309**
0090.0020 CHEMICAL STORAGE AREA #2 (POST TREATMENT)								
11210 Water Supply & Treatment Pumps								
70 Chem System-Calcium Chloride	4.00 ea	25.663	1,680	51,395	261		53,336	83,660
71 Chem System- Sodium Hydroxide	4.00 ea	21.667	1,425	38,758	208		40,391	63,343
11210 Water Supply & Treatment Pumps		47.330	3,104	90,153	469		93,726	147,003
13200 Tanks								
70 Chem System-Calcium Chloride	4.00 ea	195.428	13,232	100,176	3,167		116,575	182,114
71 Chem System- Sodium Hydroxide	3.00 ea	146.572	9,924	49,332	2,375		61,631	96,054
13200 Tanks		342.000	23,156	149,508	5,542		178,206	278,168
15060 Hangers & Supports								
CPVC80 Sch 80 CPVC Pipe & Fittings	797.00 lf	53.800	3,664	7,062			10,726	16,566
PVC80 Sch 80 PVC Pipe & Fittings	265.00 lf	10.667	726	1,760			2,486	3,850
15060 Hangers & Supports		64.466	4,390	8,822			13,212	20,416
15110 Valves								
CPVCBFV CPVC Butterfly Valves	10.00 ea	13.677	1,093	5,088			6,180	9,625
CPVCBV CPVC Ball Valves	14.00 ea	12.191	974	774			1,748	2,670
CPVCDV CPVC Diaphragm Valves	4.00 ea	5.228	418	3,680			4,098	6,405
PVCBFV PVC Butterfly Valves	6.00 ea	15.206	1,215	2,405			3,619	5,592
PVCCV PVC Check Valves	2.00 ea	1.074	86	1,104			1,190	1,862
15110 Valves		47.375	3,785	13,050			16,835	26,154
15120 Pipe Specialties								
CPVC80 Sch 80 CPVC Pipe & Fittings	797.00 lf	6.895	473	1,121			1,593	2,467
PVC80 Sch 80 PVC Pipe & Fittings	265.00 lf	5.384	367	1,205			1,572	2,441
15120 Pipe Specialties		12.278	839	2,326			3,165	4,907
15240 Plastic Pipe								
CPVC80 Sch 80 CPVC Pipe & Fittings	797.00 lf	77.360	5,268	19,155	2		24,425	37,964
PVC80 Sch 80 PVC Pipe & Fittings	265.00 lf	51.989	3,540	5,576	1		9,117	14,049
15240 Plastic Pipe		129.348	8,808	24,731	3		33,542	52,013
0090.0020 CHEMICAL STORAGE AREA #2 (POST TREATMENT)	**1.00 LS**	**642.798**	**44,083**	**288,590**	**6,014**		**338,687**	**528,660**
0090.0020A CHEMICAL STORAGE AREA #2 (POST TREATMENT) STRUCTURE ONLY								
02300 Earthwork								
02310.100 Site Earthwork	1,394.82 cy					48,819	48,819	72,911
02300 Earthwork						48,819	48,819	72,911
02600 Drainage & Containment								
CT Chemical Trench	1.00 ls	29.511	1,859		1,937		3,796	5,820
CT - MH Chemical Trench - Manholes	5.00 ea	12.815	767	7,500	839		9,106	14,246
02600 Drainage & Containment		42.327	2,627	7,500	2,776		12,902	20,066
03000 Concrete								
03210.100 Reinforcing Steel	197.63 tn	1,543.423	111,931	86,920	1,180		200,031	305,574
03300.2602 Chemical Building Slabs/Walls/Foundations	817.56 cy	4,121.036	247,786	135,238	1,549	11,861	396,434	602,675
03000 Concrete		5,664.460	359,717	222,158	2,730	11,861	596,465	908,250
06000 Wood								
FRP - Rail FRP Railing	710.00 lf	88.576	5,652	53,321	130		59,102	92,412
FRP Stairs FRP Stairs	383.76 sf	64.739	4,132	43,099	215		47,445	74,217
06000 Wood		153.315	9,783	96,420	345		106,548	166,628
10000 Specialties								
10520.000 Fire Protection Specialty	6.00 ea	9.000	612	2,100			2,712	4,213
10000 Specialties		9.000	612	2,100			2,712	4,213
13000 Special Construction								

Spreadsheet Level	Takeoff Quantity	Labor Man Hrs	Labor Amount	Material Amount	Equip Amount	Sub Amount	Direct Cost Total	Capital Cost
MC Metal Canopy	5,250.00 sf					236,250	236,250	352,839
13000 Special Construction						236,250	236,250	352,839
0090.0020A CHEMICAL STORAGE AREA #2 (POST TREATMENT) STRUCTURE ONLY	**5,250.00 SF**	**5,869.102**	**372,739**	**328,177**	**5,850**	**296,929**	**1,003,696**	**1,524,906**

Estimate Totals

Description	Amount	Totals	Hours	Rate	
Labor	6,343,686		94,581 hrs		
Material	36,981,879				
Subcontract	4,181,218				
Equipment	883,961		13,139 hrs		
Other	27,082				
	48,417,826	48,417,826			
MOT Allowance	2,420,891			5.00 %	
Misc Metals Allowance	968,357			2.00 %	
Painting Allowance	968,357			2.00 %	
I&C Allowance	3,873,426			8.00 %	
Electrical Allowance	8,715,209			18.00 %	
Subtotal Allowance Cost	16,946,240	65,364,066			

Client Permits	653,641			1.00 %	
GC General Conditions	6.294.317			13.00 %	5.70%
Sales Tax (MEO)	2,936,701			7.75 %	
Subtotal Capital Cost	9,884,659	75,248,725			
Construction Contingency	22,574,618			30.00 %	
Subtotal Contingency	22,574,618	97,823,343			
Contractor Total OH&P	9,782,334			10.00 %	
Subtotal OH&P	9,782,334	107,605,677			
Bldr's Risk Insurance	215,211			0.20 %	
Gen Liab Insurance	1,076,057			1.00 %	
GC Bonds	1,614,085			1.50 %	
Subtotal Insurance & Bond	2,905,353	110,511,030			
Engineering & Pre-Construction					
Enviromental Documentation					
Construction Management					
Escalation to Mid Point Constr					
Escalation NOT INCLUDED					
Subtotal Escalation		110,511,030			
Total		***110,511,030***			

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Appendix E

Estimated O&M Cost Process Area Breakdown

Client: **City of San Diego** Job No.: **2072-78220** Computed By: **A.Goh**
Project: **IPR/RA Demonstration Project AWP Facility**
4/9/2012
Checked By: **L. Voelz** Date: **Updated 6/7/2012**
Updated 11/5/2012
Detail: **Full-Scale Facility O&M Costs - 15 mgd** Date Checked: **6/7/2012** Page No.: **1 of 2**

INPUT

Power cost	0.12	$/kWh
Hours of operation per day	24	hours
Days of operation per year	365	days
AWP Facility Online Factor	95%	
Annual Average Flow	15	mgd

1) Equipment/Building Operations

#	Load	HP	kW	# Operating	Demand	Annual Power (kWh/yr)	Annual Cost ($/yr)
1	AWP Facility Influent Pumps	137	102	3	100%	2,548,536	$305,824
2	MF System Automatic Strainers	0.5	0	6	100%	18,650	$2,238
3	MF Backwash Pumps	30	22	2	22%	80,815	$9,698
4	MF System Blowers	50	37	1	22%	67,346	$8,081
5	MF System Air Compressors	15	11	1	100%	93,248	$11,190
6	MF CIP Recirculation/Drain Pumps	20	15	2	3.6%	8,856	$1,063
7	MF System CIP Tank Heaters	24	18	2	28%	85,363	$10,244
8	RO Booster Pumps	149	111	3	100%	2,777,506	$333,301
9	RO Feed Pumps	572	427	3	100%	10,665,622	$1,279,875
10	RO Energy Recovery *(accounted for in RO Feed Pumps)*	▨	▨	▨	100%	▨	▨
11	RO Flush Pumps	60	45	2	0.20%	1,480	$178
12	RO System CIP Recirculation Pumps	40	30	2	0.27%	1,363	$164
13	RO System CIP Tank Heaters	24	18	2	1.5%	4,378	$525
14	UV	116	86	3	71%	1,540,759	$184,891
15	Sodium Hypochlorite Feed Pump	0.5	0.37	3	100%	9,325	$1,119
16	Ammonium Hydroxide Feed pump	0.5	0.37	3	100%	9,325	$1,119
17	Sulfuric Acid Feed Pump	0.5	0.37	3	100%	9,325	$1,119
18	Antiscalant Feed Pump	0.5	0.37	3	100%	9,325	$1,119
19	Hydrogen Peroxide Feed Pump	0.5	0.37	3	100%	9,325	$1,119
20	Calcium Chloride Feed Pump	0.5	0.37	2	100%	6,294	$755
21	Caustic Soda Feed Pump	0.5	0.37	2	100%	6,294	$755
22	Sodium Hypochlorite Feed Pump MF MC	0.5	0.37	1	14%	421	$51
23	Sodium Hypochlorite Feed Pump MF CIP	0.5	0.37	1	0.9%	28	$3
24	Sodium Bisulfite Feed Pump MF CIP	0.5	0.37	1	0.9%	28	$3
25	Citric Acid Feed Pump for MF CIP	0.5	0.37	1	0.9%	28	$3
26	Caustic Soda Feed Pump MF CIP	0.5	0.37	1	0.9%	28	$3
27	Citric Acid Feed Pump RO CIP	0.5	0.37	1	0.09%	3	$0
28	Caustic Soda Feed Pump RO CIP	0.5	0.37	1	0.09%	3	$0
#	**Load**	**Area (SF)**	**Unit Power (kW/SF)**	**Total Power (kW)**	**Demand**	**Annual Power (kWh/yr)**	**Annual Cost ($/yr)**
29	Multiple Buildings	50,700	0.01	482	100%	4,008,291	$480,995
	Operations Subtotal					**21,961,962**	**$2,635,435**

CDM Smith Client: **City of San Diego**	Job No.: **2072-78220**	Computed By:	**A.Goh**
Project: **IPR Project/Reservoir Augmentation Demonstration Project AWP Project**	Checked By: **L. Voelz**	Date:	**4/9/2012** **Updated 6/7/2012**
Detail: **Full-Scale Facility O&M Costs - 15 mgd**	Date Checked: **6/7/2012**	Page No.:	**1 of 2**

2) Chemical Usage Costs

#	Chemical	Dose (mg/L)	Usage (gal/day)	Usage (gal/yr)	Demand	Unit Cost ($/gal)	Annual Cost ($)
	Pre-/Post-Treatment						
1	Sodium Hypochlorite (Pre-treatment)	5.0	632	230,835	100%	0.66	$144,734
2	Ammonium Hydroxide	1.5	163	59,426	100%	1.39	$78,240
3	Sulfuric Acid	60.0	619	225,817	100%	1.39	$298,191
4	Antiscalant	4.0	59	21,468	100%	6.49	$132,359
5	Hydrogen Peroxide	5.0	126	46,002	100%	4.94	$215,893
6	Calcium Chloride	20.0	640	233,718	100%	0.53	$118,118
7	Caustic Soda	15.0	294	107,338	100%	2.35	$239,641
8	Sodium Hypochlorite (Membrane Cleaning)	1000.0		1,441		0.66	$951
9	Caustic Soda (Membrane Cleaning)	Varies		2,946		2.35	$6,923
10	Citric Acid (Membrane Cleaning)	Varies		8,974		10.55	$94,659
	Chemical Usage Subtotal						**$1,329,710**

*MF/RO CIP chemicals not included

3) Major Equipment Replacement Costs

#	Equipment	Units/ Modules	Unit Cost ($/unit)	Replacement (#/year)			Annual Cost ($)
1	MF Membrane Replacement[(1)]	1,084	$ 3,000.00	0.14			$441,167
2	Cartridge Filter Replacement[(2)]	6					$72,818
3	RO Element Replacement[(2)]	3					$245,759
4	UV Lamp Replacement[(3)]	1,296	$268.00	0.7			$225,474
5	UV Ballast Replacement[(4)]	648	$636.00	0.14			$55,932
	Major Equipment Replacement Subtotal						**$1,041,149**

(1) Assumes replacement every 7 years. Unit cost provided by MF manufacturer (Pall).

(2) Based on information from similar sized AWPF.

(3) Assumes 8200 hours of lamp operation per year. Per vendor (Trojan): 12,000 hours life per lamp. Unit cost provided UV manufacturer (Trojan)

(4) Assumes replacement every 7 years. Unit cost provided by UV manufacturer (Trojan).

4) Maintenance Cost

#	Item	Percentage	Equipment Cost				Annual Cost ($)
1	Maintenance Cost	1.7%	$82,883,273				$1,409,016
	Maintenance Cost Subtotal						**$1,409,016**

5) Other Costs

#	Item						Annual Cost ($)
1	Compliance Testing						$150,000
2	Security						$160,000
	Other Costs Subtotal						**$310,000**

6) Labor Costs

#	Personnel	#				Full Labor Cost ($)	Annual Labor Cost ($)
1	Associate Civil Engineer	0.5				$173,384.60	$86,692
2	Water Plant Operator	3				$136,749.18	$410,248
3	Water Operations Supervisor	2				$141,935.48	$283,871
4	Water Production Superintendent	0.5				$171,983.84	$85,992
5	Water Systems Technician II	2				$78,581.88	$157,164
6	Electrician	2				$104,177.17	$208,354
7	Laboratory Technician	0.5				$85,522.93	$42,761
8	Assistant Chemist	0.5				$110,646.90	$55,323
9	Clerical II/Receptionist	1				$62,865.50	$62,866
10	Outside Lab Sample/Special Testing Allowance	-				-	$25,000
	Labor Subtotal	12.00					**$1,418,271**

	Phase 1 Total Annual O&M Cost						**$8,143,581**

Client: **City of San Diego**
Project: **IPR/RA Demonstration Project AWP Facility**
Detail: **Full-Scale Facility Electrical Load List - 15 mgd**

Job No.: **2072-78220**
Checked By: **L. Voelz**
Date Checked: **4/9/2012**

Computed By: **A.Goh**
Date: **4/9/2012**
Page No.: **1 of 1**

INPUT

Phase 1													
							Loads						
#	**Load**	**Volts**	**Phase**	**HP**	**KVA**	**kW**	**Total #**	**Operating**	**Standby**	**Operating Frequency**	**Demand**	**Current**	**VFD**
	Major Process Equipment												
1	AWP Facility Influent Pumps	480	3	137		102	4	3	1	Continuous	100%		Yes
2	MF System Automatic Strainers	480	3	0.5		0.37	7	6	1	Continuous	100%		No
3	MF Backwash Pumps	480	3	30		22	3	2	1	1x30sec/30min/skid	22%		Yes
4	MF System Blowers	480	3	50		37	2	1	1	1x30sec/30min/skid	22%		Yes
5	MF System Air Compressors	480	3	15.0		11	2	1	1	Continuous	100%		No
6	MF CIP Recirculation/Drain Pumps	480	3	20		15	4	2	2	1x2hr/mo/skid	3.6%		Yes
7	MF System CIP Tank Heaters	480	3	24		18	3	2	1	1x16hr/mo/skid	28%		No
8	RO Booster Pumps	480	3	149		111	4	3	1	Continuous	100%		Yes
9	RO Feed Pumps	480	3	572		427	4	3	1	Continuous	100%		Yes
10	RO Energy Recovery	480	3	0		0	1	1	0	Continuous	100%		Yes
11	RO Flush Pumps	480	3	60		45	3	2	1	1 x 5min/wk/train	0.20%		Yes
12	RO System CIP Recirculation Pumps	480	3	40		30	3	2	1	2 x 3hr/yr/train	0.27%		Yes
13	RO System CIP Tank Heaters	480	3	24		18	3	2	1	2 x 16hr/yr/train	1.5%		No
14	UV	480	3	116		86	3	3	0	Continuous	100%		No
15	Finished Water Pumps					0				Continuous	100%		Yes
	Influent Pre-treatment Chemicals												
16	Sodium Hypochlorite Feed Pumps	115	1	0.5		0.37	4	3	1	Continuous	100%		Integral to Pump
17	Ammonium Hydroxide Feed Pumps	115	1	0.5		0.37	4	3	1	Continuous	100%		Integral to Pump
	RO Pre-treatment Chemicals												
18	Sulfuric Acid Feed Pumps	115	1	0.5		0.37	4	3	1	Continuous	100%		Integral to Pump
19	Antiscalant Feed Pumps	115	1	0.5		0.37	4	3	1	Continuous	100%		Integral to Pump
	AOP Chemicals												
21	Hydrogen Peroxide Feed Pumps	115	1	0.5		0.37	4	3	1	Continuous	100%		Integral to Pump
	Product Water Post-treatment Chemicals												
22	Calcium Chloride Feed Pumps	115	1	0.5		0.37	3	2	1	Continuous	100%		Integral to Pump
23	Caustic Soda Feed Pumps	115	1	0.5		0.37	3	2	1	Continuous	100%		Integral to Pump
	MF MC Chemicals												
25	Sodium Hypochlorite Feed Pumps for MF MC	115	1	0.5		0.37	1	1	0	1 x 15min/day/skid	14%		Integral to Pump
	MF CIP and Neutralization Chemicals												
26	Sodium Hypochlorite Feed Pumps for MF CIP	115	1	0.5		0.37	2	1	1	1 x 30min/mo/skid	0.9%		Integral to Pump
27	Sodium Bisulfite Feed Pumps for MF CIP Neutralization	115	1	0.5		0.37	2	1	1	1 x 30min/mo/skid	0.9%		Integral to Pump
28	Citric Acid Feed Pumps for MF CIP	115	1	0.5		0.37	2	1	1	1 x 30min/mo/skid	0.9%		Integral to Pump
29	Caustic Soda Feed Pumps for MF CIP Neutralization	115	1	0.5		0.37	2	1	1	1 x 30min/mo/skid	0.9%		Integral to Pump
	RO CIP and Neutralization Chemicals												
30	Citric Acid Feed Pumps for RO CIP/Neutralization	115	1	0.5		0.37	2	1	1	2 x 1hr/yr/train	0.09%		Integral to Pump
31	Caustic Soda Feed Pumps for RO CIP/Neutralization	115	1	0.5		0.37	2	1	1	2 x 1hr/yr/train	0.09%		Integral to Pump
	TOTAL			**4,545**		**3,395**							

Volts - Typically 120, 208, 240 or 480
Phase - 1 or 3 (Usually 3 phase for motors except for 120 V chemical metering pumps)
HP, KVA, KW - Only one of these columns would be filled out (typically HP for motors, KVA for transformers, KW for heaters)
Total # - Total number of that particular load (EG. 3 RO Feed Pumps)
Operating - Total number of that particular load that runs during normal operations (EG. 1 RO Feed Pump runs during normal operations)
Standby - The additional number of that particular load that can run during emergency operations (EG. 1 additional RO Feed Pump runs during emergency operations)
Demand (HP loads) - The amount of time a load runs. If a pump runs continuously, the number will be 100%. If a pump runs occasionally then the % of the day the pump will run.
Demand (kVA loads) - The percent loaded a transformer is based on panel schedules.
Current - This column will be filled out by the electrical engineer based on the data in the other columns.

Appendix F

Demonstration Facility Power Consumption

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City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - MF Control Panel Power Consumption

Calc By: E. You
Calc Date: 5/31/2012
Checked By: J. Thompson
Checked Date: 6/7/2012

MF Control Panel Power Consumption

Power = Voltage*Current

I (current) =	5	amps	(MF control panel internal power, based on co)
V (current) =	120	volts	(Power source for MF control panel was 120 V)
W = I*V =	0.6	kW	
MF control panel power usage =	14.4	kW-hr/day	for 24 hour/day plant operation

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - MF Compressor Power Consumption

Calc By: E. You
Calc Date: 5/31/2012
Checked By: J. Thompson
Checked Date: 6/7/2012

Summary of MF Compressor Runtime (hours) for One Week

(Received from Jay DeCarolis on 5/31/12)

Date / Time	MF Compressor Runtime (hour)	Compresor Runtime on day of reading (hour)	Plant Runtime on day of reading (hour)	
5/25/2012 6:29	3324.61	9.37	20.9	
5/26/2012 7:17	3333.98	11.47	24	
5/27/2012 10:04	3345.45	2.74	13	
5/28/2012 11:20	3348.19	18.7	24	
5/30/2012 7:02	3366.89	3.17	24	
5/30/2012 14:24	3370.06	7.12	24	
5/31/2012 7:20	3377.18		7.7	
Total		52.57	137.6	38%

Assume compressor and dryer operate 40% of time MF is online.

MF Air Dryer Power Consumption

W = 0.3 kW (see vendor cutsheet)
T = 9.6 hrs/day for 24-hr plant operation
W = 2.88 kW-hr/day

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (August 2011)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
8/1/2011		69,382	483,747	14,400	2,880	570,409	177,175	468,854	646,029	154,749	785,020	275,289		2,431,496		1,478,895		RO A power meter reading low.
8/2/2011		71,411	483,747	14,400	2,880	572,438	174,969	468,854	643,823	270,270	820,177	273,271		2,579,979		1,627,378		RO A power meter reading low.
8/3/2011		62,367	483,747	14,400	2,880	563,394	164,713	468,854	633,567	207,498	642,896	214,921		2,262,276		1,309,675		RO A power meter reading low.
8/4/2011																		Offline for North City filter mudball chlorination
8/5/2011																		Offline for North City filter mudball chlorination
8/6/2011																		Offline for North City filter mudball chlorination
8/7/2011		3,197	20,156	600	120	24,073	105,975	468,854	574,829	0	0	21,600		620,502		131,492		RO systems offline.
8/8/2011		50,077	483,747	14,400	2,880	551,104	153,239	468,854	622,093	190,139	260,084	199,665		1,823,085		870,484		RO A power meter reading low.
8/9/2011		76,340	483,747	14,400	2,880	577,367	166,572	468,854	635,426	268,418	827,364	280,904		2,589,479		1,636,878		RO A power meter reading low.
8/10/2011		76,306	483,747	14,400	2,880	577,333	168,510	468,854	637,364	285,679	802,415	281,882		2,584,673		1,632,072		RO A power meter reading low.
8/11/2011		73,287	483,747	14,400	2,880	574,314	158,422	468,854	627,276	507,055	761,544	270,528		2,740,717		1,788,116		Electrician swapped 2 wires on RO A power meter.
8/12/2011		72,739	483,747	14,400	2,880	573,766	172,002	468,854	640,856	786,253	840,360	286,875		3,128,110		2,175,509		
8/13/2011		70,661	483,747	14,400	2,880	571,688	164,452	468,854	633,306	769,482	820,144	264,656		3,059,276		2,106,675		
8/14/2011		47,229	483,747	14,400	2,880	548,256	144,236	468,854	613,090	507,716	540,324	243,933		2,453,319		1,500,718		
8/15/2011		67,876	483,747	14,400	2,880	568,903	154,829	468,854	623,683	743,783	791,380	274,836		3,002,585		2,049,984		
8/16/2011		71,481	483,747	14,400	2,880	572,508	157,357	468,854	626,211	784,927	835,420	302,400		3,121,466		2,168,865		
8/17/2011		71,754	483,747	14,400	2,880	572,781	146,844	468,854	615,698	783,901	833,325	300,013		3,105,718		2,153,117		
8/18/2011		71,502	483,747	14,400	2,880	572,529	144,077	468,854	612,931	794,484	838,166	302,465		3,120,575		2,167,974		
8/19/2011																		Totals not recorded.
8/20/2011		29,478	483,747	14,400	2,880	530,505	124,587	468,854	593,441	290,233	309,204	109,878		1,833,261		880,660		
8/21/2011		17,433	483,747	14,400	2,880	518,460	118,133	468,854	586,987	173,358	160,102	67,017		1,505,924		553,323		
8/22/2011		50,326	483,747	14,400	2,880	551,353	133,286	468,854	602,140	551,012	569,555	208,435		2,482,495		1,529,894		
8/23/2011		74,411	483,747	14,400	2,880	575,438	148,203	468,854	617,057	811,023	829,978	301,956		3,135,452		2,182,851		
8/24/2011		72,283	483,747	14,400	2,880	573,310	154,231	468,854	623,085	805,821	856,534	302,195		3,160,945		2,208,344		
8/25/2011		72,297	483,747	14,400	2,880	573,324	149,646	468,854	618,500	806,455	858,888	310,680		3,167,847		2,215,246		
8/26/2011		58,773	483,747	14,400	2,880	559,800	148,074	468,854	616,928	647,053	675,318	244,696		2,743,795		1,791,194		
8/27/2011																		Totals not recorded.
8/28/2011		72,920	483,747	14,400	2,880	573,947	154,274	468,854	623,128	799,079	854,588	311,392		3,162,134		2,209,533		
8/29/2011		72,549	483,747	14,400	2,880	573,576	160,316	468,854	629,170	805,315	848,794	302,346		3,159,201		2,206,600		
8/30/2011		72,399	483,747	14,400	2,880	573,426	155,077	468,854	623,931	816,466	861,770	302,412		3,178,005		2,225,404		
8/31/2011		72,574	483,747	14,400	2,880	573,601	153,396	468,854	622,250	819,239	862,184	298,566		3,175,840		2,223,239		
TOTAL (kW-hr)		**1,621**	**12,114**	**361**	**72**	**14,168**	**3,953**	**12,190**	**16,143**	**14,379**	**18,086**	**6,553**		**69,328**		**45,024**		
AVERAGE (kW-hr/MG)		**122**	**913**	**27**	**5**	**1,067**	**287**	**885**	**1,171**	**1,150**	**1,447**	**262**		**2,773**		**1,801**		

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (September 2011)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
9/1/2011		71,884	483,747	14,400	2,880	572,911	150,591	468,854	619,445	822,969	849,608	268,390		3,133,323		2,180,722		
9/2/2011		66,237	483,747	14,400	2,880	567,264	141,659	468,854	610,513	741,020	755,582	237,032		2,911,411		1,958,810		
9/3/2011		53,834	483,747	14,400	2,880	554,861	137,444	468,854	606,298	591,336	612,258	184,835		2,549,588		1,596,987		
9/4/2011																		Totals not available.
9/5/2011		3,089	483,747	14,400	2,880	504,116	107,038	468,854	575,892	0	0	0		1,080,008		127,407		RO and UV/AOP offline.
9/6/2011		88,037	483,747	14,400	2,880	589,064	128,629	468,854	597,483	562,688	580,606	186,182		2,516,023		1,563,422		
9/7/2011		191,669	483,747	14,400	2,880	692,696	178,902	468,854	647,756	796,060	542,594	274,407		2,953,513		2,000,912		UF cleaning.
9/8/2011																		Blackout occurred at 3:30 p.m. Offline for weekend
9/9/2011																		Offline due to blackout
9/10/2011																		Offline due to blackout
9/11/2011		0					43,260	117,214	160,474	0	0	0		160,474		43,260		Offline due to blackout
9/12/2011		50,852	322,498	9,600	1,920	384,870	121,213	312,569	433,782	525,600	458,486	178,267		1,981,006		1,345,938		Back online at ~8 A.M.
9/13/2011		72,443	483,747	14,400	2,880	573,470	174,005	468,854	642,859	814,238	859,576	263,788		3,153,931		2,201,330		
9/14/2011		72,086	483,747	14,400	2,880	573,113	170,557	468,854	639,411	826,192	862,508	262,035		3,163,259		2,210,658		
9/15/2011		71,458	483,747	14,400	2,880	572,485	175,543	468,854	644,397	834,726	863,430	261,465		3,176,503		2,223,902		
9/16/2011		62,254	483,747	14,400	2,880	563,281	163,775	468,854	632,629	726,872	743,700	238,493		2,904,975		1,952,374		
9/17/2011		72,249	483,747	14,400	2,880	573,276	171,963	468,854	640,817	840,096	863,858	267,446		3,185,493		2,232,892		
9/18/2011		70,673	483,747	14,400	2,880	571,700	176,938	468,854	645,792	839,302	863,892	265,498		3,186,184		2,233,583		
9/19/2011	722.91	71,472	483,747	14,400	2,880	572,499	171,889	468,854	640,743	835,564	846,810	271,549		3,167,165		2,214,564		
9/20/2011	702.67	71,943	483,747	14,400	2,880	572,970	167,910	468,854	636,764	837,178	814,944	269,463		3,131,319		2,178,718		
9/21/2011	687.11	71,865	483,747	14,400	2,880	572,892	173,320	468,854	642,174	840,548	826,312	268,666		3,150,592		2,197,991		
9/22/2011	736.78	70,729	483,747	14,400	2,880	571,756	173,608	468,854	642,462	828,866	832,392	264,021		3,139,497		2,186,896		
9/23/2011	2.99																	Totals not available.
9/24/2011	687.83	71,068	483,747	14,400	2,880	572,095	194,134	468,854	662,988	838,174	811,920	201,340		3,086,517		2,133,916		
9/25/2011	709.57	70,878	483,747	14,400	2,880	571,905	195,343	468,854	664,197	832,254	804,412	4		2,872,772		1,920,171		UV/AOP offline.
9/26/2011	662.62	71,214	483,747	14,400	2,880	572,241	193,885	468,854	662,739	804,784	767,424	194,237		3,001,425		2,048,824		
9/27/2011	691.19	71,366	483,747	14,400	2,880	572,393	190,600	468,854	659,454	835,984	805,804	282,694		3,156,329		2,203,728		
9/28/2011	708.83	40,928	483,747	14,400	2,880	541,955	169,839	468,854	638,693	462,392	451,376	173,747		2,268,163		1,315,562		
9/29/2011	232.59	51,536	483,747	14,400	2,880	552,563	174,505	468,854	643,359	520,864	561,296	209,871		2,487,953		1,535,352		
9/30/2011	712.37	58,670	483,747	14,400	2,880	559,697	180,890	468,854	649,744	622,260	672,508	237,928		2,742,137		1,789,536		
TOTAL (kW-hr)		**1,668**	**11,449**	**341**	**68**	**13,526**	**4,027**	**11,213**	**15,241**	**17,180**	**17,051**	**5,261**		**68,260**		**45,597**		
AVERAGE (kW-hr/MG)		**133**	**913**	**27**	**5**	**1,078**	**318**	**885**	**1,202**	**1,516**	**1,505**	**243**		**3,150**		**2,104**		

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (October 2011)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
10/1/2011	733.37	71,720	483,747	14,400	2,880	572,747	172,270	468,854	641,124	816,800	849,632	300,201		3,180,504		2,227,903		
10/2/2011	697.21	71,950	483,747	14,400	2,880	572,977	174,610	468,854	643,464	813,808	846,920	337,770		3,214,939		2,262,338		
10/3/2011	712.21	71,260	483,747	14,400	2,880	572,287	181,130	468,854	649,984	810,744	844,152	331,570		3,208,737		2,256,136		
10/4/2011	721.33																	Totals not available.
10/5/2011	333.67	77,960	483,747	14,400	2,880	578,987	180,010	468,854	648,864	810,744	3,612	318,560		2,360,767		1,408,166		MF cleaning. RO B offline.
10/6/2011	382.43	163,170	0	0	0	163,170	179,870	468,854	648,724	823,136	607,880	306,130		2,549,040		2,080,186		RO B Cleaning.
10/7/2011	728.60	328,000	0	0	0	328,000	181,190	468,854	650,044	812,024	263,412	314,110		2,367,590		1,898,736		RO B Cleaning.
10/8/2011	330.84																	Totals not available.
10/9/2011	687.71	64,620	483,747	14,400	2,880	565,647	195,070	468,854	663,924	830,600	824,432	337,490		3,222,093		2,269,492		
10/10/2011	685.95	62,610	483,747	14,400	2,880	563,637	198,260	468,854	667,114	815,200	814,184	352,790		3,212,925		2,260,324		
10/11/2011	732.95	64,100	483,747	14,400	2,880	565,127	200,490	468,854	669,344	824,320	828,432	350,530		3,237,753		2,285,152		
10/12/2011	723.43	64,070	483,747	14,400	2,880	565,097	201,950	468,854	670,804	802,168	835,616	294,820		3,168,505		2,215,904		
10/13/2011	703.74	43,200	483,747	14,400	2,880	544,227	209,210	468,854	678,064	650,692	719,760	261,660		2,854,403		1,901,802		
10/14/2011	758.02	216,800	0	0	0	216,800	203,640	468,854	672,494	243,188	822,336	227,770		2,182,588		1,713,734		RO A Cleaning. (MF/RO A/UV offline)
10/15/2011	353.75	154,040	0	0	0	154,040	205,610	468,854	674,464	296,972	829,672	118,420		2,073,568		1,604,714		RO A Cleaning. (MF/RO A/UV offline)
10/16/2011	699.35	64,350	483,747	14,400	2,880	565,377	199,630	468,854	668,484	814,980	838,960	304,300		3,192,101		2,239,500		
10/17/2011	716.54	64,560	483,747	14,400	2,880	565,587	198,400	468,854	667,254	814,832	837,464	302,420		3,187,557		2,234,956		
10/18/2011	673.47	56,580	403,123	12,000	2,400	474,103	190,220	390,712	580,932	719,648	739,600	265,780		2,780,063		1,986,228		All systems offline for ~ 4 hours.
10/19/2011	680.00	63,840	483,747	14,400	2,880	564,867	200,870	468,854	669,724	822,300	844,800	302,340		3,204,031		2,251,430		
10/20/2011	716.40	63,440	483,747	14,400	2,880	564,467	200,650	468,854	669,504	823,960	846,064	303,800		3,207,795		2,255,194		
10/21/2011	658.21	54,270	423,279	12,600	2,520	492,669	185,450	410,247	595,697	674,788	700,952	276,240		2,740,346		1,906,820		All systems offline for ~ 3 hours.
10/22/2011	725.29	63,930	483,747	14,400	2,880	564,957	197,810	468,854	666,664	809,192	846,880	362,210		3,249,903		2,297,302		
10/23/2011	671.29	63,460	483,747	14,400	2,880	564,487	194,730	468,854	663,584	807,568	845,760	311,430		3,192,829		2,240,228		
10/24/2011	685.50	63,070	483,747	14,400	2,880	564,097	191,690	468,854	660,544	806,584	844,008	304,990		3,180,223		2,227,622		
10/25/2011	667.76	62,810	483,747	14,400	2,880	563,837	194,180	468,854	663,034	812,520	850,880	302,610		3,192,881		2,240,280		
10/26/2011	702.31	63,000	483,747	14,400	2,880	564,027	190,480	468,854	659,334	806,728	845,136	301,720		3,176,945		2,224,344		
10/27/2011	729.80	63,720	483,747	14,400	2,880	564,747	190,810	468,854	659,664	817,688	859,104	304,480		3,205,683		2,253,082		
10/28/2011	673.06	57,490	483,747	14,400	2,880	558,517	182,170	468,854	651,024	746,472	783,920	276,400		3,016,333		2,063,732		
10/29/2011	678.68	63,140	483,747	14,400	2,880	564,167	188,780	468,854	657,634	824,152	866,568	305,230		3,217,751		2,265,150		
10/30/2011	481.82	53,160	483,747	14,400	2,880	554,187	177,060	468,854	645,914	678,688	711,600	244,740		2,835,129		1,882,528		
10/31/2011	667.71	63,670	483,747	14,400	2,880	564,697	194,310	468,854	663,164	820,288	859,520	298,030		3,205,699		2,253,098		
TOTAL (kW-hr)		**2,438**	**11,953**	**356**	**71**	**14,818**	**5,561**	**13,460**	**19,021**	**21,951**	**22,211**	**8,619**		**86,619**		**61,206**		
AVERAGE (kW-hr/MG)		**186**	**913**	**27**	**5**	**1,132**	**365**	**885**	**1,250**	**1,644**	**1,663**	**323**		**3,243**		**2,292**		

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (November 2011)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
11/1/2011	718.37	63,260	483,747	14,400	2,880	564,287	199,080	468,854	667,934	826,400	865,336	333,772		3,257,729		2,305,128	NA	
11/2/2011	732.68	58,030	443,435	13,200	2,640	517,305	192,000	429,783	621,783	746,280	781,184	275,416		2,941,968		2,068,750	NA	All systems offline for ~2 hours.
11/3/2011	728.24	64,040	483,747	14,400	2,880	565,067	197,890	468,854	666,744	832,344	872,424	306,584		3,243,163		2,290,562	NA	
11/4/2011	712.08	44,060	322,498	9,600	1,920	378,078	171,680	312,569	484,249	567,168	593,936	212,868		2,236,300		1,601,232	NA	All systems offline for ~8 hours.
11/5/2011	23.93	35,850	483,747	14,400	2,880	536,878	140,795	468,854	609,650	498,769	548,883	181,349		2,375,528		1,422,927	NA	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/6/2011	688.19	62,360	483,747	14,400	2,880	563,387	196,160	468,854	665,014	847,048	886,792	313,860		3,276,101		2,323,500	NA	
11/7/2011	704.11	63,570	483,747	14,400	2,880	564,597	199,020	468,854	667,874	844,960	884,672	313,200		3,275,303		2,322,702	NA	
11/8/2011	677.76	63,170	483,747	14,400	2,880	564,197	202,120	468,854	670,974	855,552	897,256	311,212		3,299,191		2,346,590	NA	
11/9/2011	611.19	42,040	483,747	14,400	2,880	543,068	165,105	468,854	633,960	584,887	643,654	212,661		2,618,230		1,665,628	NA	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/10/2011	311.41	32,750	221,718	6,600	1,320	262,388	157,930	214,891	372,821	393,912	405,496	146,784		1,581,401		1,144,792	NA	All systems offline for ~13 hours.
11/11/2011	53.23	40,390	483,747	14,400	2,880	541,417	158,623	468,854	627,477	561,923	618,382	204,311		2,553,509		1,600,908	NA	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/12/2011	444.31	40,390	483,747	14,400	2,880	541,417	158,623	468,854	627,477	561,923	618,382	204,311		2,553,509		1,600,908	NA	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/13/2011	401.37	40,390	483,747	14,400	2,880	541,417	158,623	468,854	627,477	561,923	618,382	204,311		2,553,509		1,600,908	NA	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/14/2011	546.35	51,400	382,967	11,400	2,280	448,047	181,330	371,176	552,506	693,800	715,344	251,344		2,661,041		1,906,898	NA	All systems offline for ~5 hours.
11/15/2011	569.12	41,940	282,186	8,400	1,680	334,206	148,660	273,498	422,158	498,892	502,728	189,416		1,947,400		1,391,716	NA	All systems offline for ~10 hours.
11/16/2011	132.77	26,980	181,405	5,400	1,080	214,865	144,240	175,820	320,060	319,268	332,760	119,920		1,306,874		949,648	NA	All systems offline for ~15 hours.
11/17/2011	6.75	22,590	141,093	4,200	840	168,723	145,890	136,749	282,639	260,308	260,608	97,560		1,069,838		791,996	NA	All systems offline for ~17 hours.
11/18/2011	129.23	32,730	241,874	7,200	1,440	283,244	156,820	234,427	391,247	384,012	442,840	154,840	2,606,518	1,656,183	4,262,701	1,179,882	3,786,400	All systems offline for ~12 hours. Total AWPF Power Meter Installed.
11/19/2011	738.27	62,320	483,747	14,400	2,880	563,347	205,690	468,854	674,544	858,300	897,944	300,852	109,894	3,294,987	3,404,881	2,342,386	2,452,280	
11/20/2011	713.42	62,030	483,747	14,400	2,880	563,057	207,820	468,854	676,674	860,536	900,576	300,212	113,086	3,301,055	3,414,141	2,348,454	2,461,540	
11/21/2011	686.73	61,900	483,747	14,400	2,880	562,927	206,470	468,854	675,324	867,816	907,632	325,200	110,692	3,338,899	3,449,591	2,386,298	2,496,990	
11/22/2011	673.24	61,630	483,747	14,400	2,880	562,657	204,720	468,854	673,574	875,704	914,952	356,040	112,414	3,382,927	3,495,341	2,430,326	2,542,740	
11/23/2011	657.91	62,158	483,747	14,400	2,880	563,185	244,113	468,854	712,967	864,772	951,661	314,425	102,441	3,407,010	3,509,451	2,454,409	2,556,849	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
11/24/2011	687.66	61,730	483,747	14,400	2,880	562,757	203,850	468,854	672,704	870,944	911,264	436,920	114,302	3,454,589	3,568,891	2,501,988	2,616,290	
11/25/2011	674.87	61,560	483,747	14,400	2,880	562,587	207,110	468,854	675,964	863,920	904,248	432,752	110,340	3,439,471	3,549,811	2,486,870	2,597,210	
11/26/2011	660.51	60,890	483,747	14,400	2,880	561,917	202,060	468,854	670,914	875,064	914,760	434,248	113,748	3,456,903	3,570,651	2,504,302	2,618,050	
11/27/2011	669.91	61,430	483,747	14,400	2,880	562,457	207,050	468,854	675,904	868,504	909,288	434,740	116,648	3,450,893	3,567,541	2,498,292	2,614,940	
11/28/2011	672.47	61,620	483,747	14,400	2,880	562,647	211,570	468,854	680,424	869,200	909,864	361,280	114,566	3,383,415	3,497,981	2,430,814	2,545,380	
11/29/2011	651.35	61,350	483,747	14,400	2,880	562,377	217,290	468,854	686,144	875,540	916,688	299,892	113,610	3,340,641	3,454,251	2,388,040	2,501,650	
11/30/2011	709.50	61,410	483,747	14,400	2,880	562,437	200,170	468,854	669,024	875,704	914,832	298,068	109,796	3,320,065	3,429,861	2,367,464	2,477,260	
TOTAL (kW-hr)		**1,566**	**12,860**	**383**	**77**	**14,885**	**5,593**	**12,464**	**18,056**	**21,265**	**22,443**	**8,328**		**84,978**		**59,654**		
AVERAGE (kW-hr/MG)		**111**	**913**	**27**	**5**	**1,056**	**397**	**885**	**1,282**	**1,600**	**1,688**	**313**		**3,197**		**2,244**		

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (December 2011)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
12/1/2011	700.98	55,830	423,279	12,600	2,520	494,229	206,210	410,247	616,457	778,264	813,840	267,052	99,796	2,969,842	3,069,638	2,136,316	2,236,112	All systems offline for ~3 hours.
12/2/2011	736.18	61,100	483,747	14,400	2,880	562,127	213,390	468,854	682,244	884,864	922,928	302,068	98,906	3,354,231	3,453,137	2,401,630	2,500,536	
12/3/2011	659.63	61,030	483,747	14,400	2,880	562,057	223,180	468,854	692,034	801,808	838,088	275,480	102,278	3,169,467	3,271,745	2,216,866	2,319,144	RO Trains and UV offline for ~3 hours.
12/4/2011	734.79	61,360	483,747	14,400	2,880	562,387	202,450	468,854	671,304	884,432	925,496	304,252	105,798	3,347,871	3,453,669	2,395,270	2,501,068	
12/5/2011	657.36	59,890	483,747	14,400	2,880	560,917	188,950	390,712	579,662	741,376	901,856	294,760	101,808	3,078,571	3,180,379	2,204,112	2,305,920	UF and ROA offline for ~4 hours.
12/6/2011	685.86	60,770	483,747	14,400	2,880	561,797	201,290	468,854	670,144	869,408	932,992	301,568	104,412	3,335,909	3,440,321	2,383,308	2,487,720	
12/7/2011	687.67	60,740	483,747	14,400	2,880	561,767	190,510	468,854	659,364	833,504	937,712	301,208	100,138	3,293,555	3,393,693	2,340,954	2,441,092	
12/8/2011	696.77	57,720	463,591	13,800	2,760	537,871	189,320	449,319	638,639	832,880	890,296	285,392	103,032	3,185,078	3,288,110	2,272,168	2,375,200	All systems offline for ~1 hour.
12/9/2011	688.49	55,670	443,435	13,200	2,640	514,945	186,670	429,783	616,453	810,336	862,792	277,440	101,788	3,081,966	3,183,754	2,208,748	2,310,536	All systems offline for ~2 hours.
12/10/2011	684.62	61,210	483,747	14,400	2,880	562,237	217,020	468,854	685,874	883,824	943,168	302,728	107,154	3,377,831	3,484,985	2,425,230	2,532,384	
12/11/2011	723.24	60,970	483,747	14,400	2,880	561,997	217,970	468,854	686,824	883,656	941,936	302,272	105,284	3,376,685	3,481,969	2,424,084	2,529,368	
12/12/2011	700.65	60,530	483,747	14,400	2,880	561,557	210,410	468,854	679,264	872,808	930,560	298,128	109,516	3,342,317	3,451,833	2,389,716	2,499,232	
12/13/2011	694.04	62,050	483,747	14,400	2,880	563,077	212,540	468,854	681,394	887,680	943,360	302,292	87,638	3,377,803	3,465,441	2,425,202	2,512,840	
12/14/2011	703.49	61,420	483,747	14,400	2,880	562,447	207,080	468,854	675,934	892,152	946,424	304,612	107,728	3,381,569	3,489,297	2,428,968	2,536,696	
12/15/2011	697.67	61,090	483,747	14,400	2,880	562,117	197,880	468,854	666,734	890,200	939,256	301,088	104,926	3,359,395	3,464,321	2,406,794	2,511,720	
12/16/2011	571.53	51,480	403,123	12,000	2,400	469,003	190,080	390,712	580,792	726,960	769,512	246,752	100,680	2,793,019	2,893,699	1,999,184	2,099,864	All systems offline for ~4 hours.
12/17/2011	439.82	54,770	423,279	12,600	2,520	493,169	206,570	410,247	616,817	778,768	825,224	263,280	102,092	2,977,258	3,079,350	2,143,732	2,245,824	All systems offline for ~3 hours.
12/18/2011	692.05	61,240	483,747	14,400	2,880	562,267	216,410	468,854	685,264	890,968	946,408	303,608	109,430	3,388,515	3,497,945	2,435,914	2,545,344	
12/19/2011	719.79	61,960	483,747	14,400	2,880	562,987	213,990	468,854	682,844	891,232	946,616	303,672	110,322	3,387,351	3,497,673	2,434,750	2,545,072	
12/20/2011	662.09	43,490	342,654	10,200	2,040	398,384	185,170	332,105	517,275	619,712	657,592	211,568	96,532	2,404,531	2,501,063	1,729,772	1,826,304	All systems offline for ~7 hours.
12/21/2011	79.38	41,970	322,498	9,600	1,920	375,988	180,810	312,569	493,379	589,264	623,336	205,400	93,908	2,287,368	2,381,276	1,652,300	1,746,208	All systems offline for ~8 hours.
12/22/2011	679.24	63,130	483,747	14,400	2,880	564,157	211,690	468,854	680,544	888,896	943,952	306,792	110,676	3,384,341	3,495,017	2,431,740	2,542,416	
12/23/2011	312.87	49,620	382,967	11,400	2,280	446,267	165,550	371,176	536,726	705,440	746,528	241,656	94,198	2,676,617	2,770,815	1,922,474	2,016,672	All systems offline for ~5 hours.
12/24/2011	673.52	60,095	483,747	14,400	2,880	561,122	236,010	468,854	704,864	836,066	920,070	303,987	98,467	3,326,110	3,424,576	2,373,508	2,471,975	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
12/25/2011	684.25	61,820	483,747	14,400	2,880	562,847	196,540	468,854	665,394	892,312	946,744	305,200	102,096	3,372,497	3,474,593	2,419,896	2,521,992	
12/26/2011	703.81	61,030	483,747	14,400	2,880	562,057	200,860	468,854	669,714	899,616	949,472	303,092	105,306	3,383,951	3,489,257	2,431,350	2,536,656	
12/27/2011	670.02	61,420	483,747	14,400	2,880	562,447	193,100	468,854	661,954	902,928	950,336	303,492	102,228	3,381,157	3,483,385	2,428,556	2,530,784	
12/28/2011	686.76	60,800	483,747	14,400	2,880	561,827	193,660	468,854	662,514	909,304	952,520	303,328	110,044	3,389,493	3,499,537	2,436,892	2,546,936	
12/29/2011	663.57	60,868	483,747	14,400	2,880	561,896	239,048	468,854	707,902	846,831	931,917	307,901	99,957	3,356,447	3,456,404	2,403,846	2,503,803	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
12/30/2011	588.91	53,800	423,279	12,600	2,520	492,199	199,720	410,247	609,967	775,680	818,560	263,852	100,628	2,960,258	3,060,886	2,126,732	2,227,360	All systems offline for ~3 hours.
12/31/2011	720.68	61,900	483,747	14,400	2,880	562,927	243,100	468,854	711,954	861,184	947,712	313,120	101,944	3,396,897	3,498,841	2,444,296	2,546,240	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
TOTAL (kW-hr)		**1,811**	**14,271**	**425**	**85**	**16,591**	**6,337**	**13,753**	**20,090**	**25,762**	**27,547**	**8,907**	**3,179**	**98,898**	**102,077**	**70,874**	**74,053**	
AVERAGE (kW-hr/MG)		**116**	**913**	**27**	**5**	**1,061**	**408**	**885**	**1,292**	**1,764**	**1,876**	**305**	**109**	**3,386**	**3,495**	**2,427**	**2,535**	

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (January 2012)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
1/1/2012	685.48	61,330	483,747	14,400	2,880	562,357	210,870	468,854	679,724	895,440	948,720	306,432	110,640	3,392,673	3,503,313	2,440,072	2,550,712	
1/2/2012	689.21	61,290	483,747	14,400	2,880	562,317	210,870	468,854	679,724	896,248	949,424	305,388	110,956	3,393,101	3,504,057	2,440,500	2,551,456	
1/3/2012	673.73	61,390	483,747	14,400	2,880	562,417	213,840	468,854	682,694	877,672	937,760	301,620	113,430	3,362,163	3,475,593	2,409,562	2,522,992	
1/4/2012	698.29	61,700	483,747	14,400	2,880	562,727	216,520	468,854	685,374	892,608	947,888	303,592	114,060	3,392,189	3,506,249	2,439,588	2,553,648	
1/5/2012	683.36	61,120	483,747	14,400	2,880	562,147	212,100	468,854	680,954	895,768	950,368	304,776	117,444	3,394,013	3,511,457	2,441,412	2,558,856	
1/6/2012	707.14	51,820	382,967	11,400	2,280	448,467	194,900	371,176	566,076	731,960	772,304	257,224	103,224	2,776,031	2,879,255	2,021,888	2,125,112	All systems offline for ~5 hours.
1/7/2012	704.90	61,270	483,747	14,400	2,880	562,297	212,300	468,854	681,154	898,584	950,192	309,028	108,610	3,401,255	3,509,865	2,448,654	2,557,264	
1/8/2012	683.52	62,110	483,747	14,400	2,880	563,137	204,230	468,854	673,084	904,952	951,936	309,060	105,328	3,402,169	3,507,497	2,449,568	2,554,896	
1/9/2012	712.06	62,970	483,747	14,400	2,880	563,997	206,940	468,854	675,794	905,584	951,920	311,232	104,018	3,408,527	3,512,545	2,455,926	2,559,944	
1/10/2012	688.64	34,190	282,186	8,400	1,680	326,456	162,030	273,498	435,528	484,688	551,376	182,136	91,268	1,980,184	2,071,452	1,424,500	1,515,768	All systems offline for ~10 hours. Energy recovery device removed from RO Train A.
1/11/2012	7.12	6,440	483,747	14,400	2,880	507,467	113,400	468,854	582,254	9,816	8,816	11,760	54,080	1,120,113	1,174,193	167,512	221,592	Systems offline for ERD maintenance.
1/12/2012	0.00	39,350	302,342	9,000	1,800	352,492	173,412	293,034	466,446	569,488	576,752	193,640	97,878	2,158,818	2,256,696	1,563,442	1,661,320	All systems offline for ~9 hours.
1/13/2012	698.12	59,470	483,747	14,400	2,880	560,497	192,656	468,854	661,510	921,472	946,208	302,172	107,686	3,391,859	3,499,545	2,439,258	2,546,944	
1/14/2012	716.47	60,000	483,747	14,400	2,880	561,027	188,904	468,854	657,758	926,504	954,512	301,300	101,308	3,401,101	3,502,409	2,448,500	2,549,808	
1/15/2012	668.57	60,510	483,747	14,400	2,880	561,537	204,708	468,854	673,562	931,680	953,824	305,900	102,450	3,426,503	3,528,953	2,473,902	2,576,352	
1/16/2012	679.50	60,540	483,747	14,400	2,880	561,567	204,260	468,854	673,114	931,304	955,136	305,188	106,692	3,426,309	3,533,001	2,473,708	2,580,400	
1/17/2012	683.65	57,900	483,747	14,400	2,880	558,927	208,672	468,854	677,526	886,480	867,776	290,744	100,796	3,281,453	3,382,249	2,328,852	2,429,648	
1/18/2012	673.50	60,450	483,747	14,400	2,880	561,477	254,888	468,854	723,742	937,496	955,200	309,408	100,110	3,487,323	3,587,433	2,534,722	2,634,832	Positioner on UF feed valve controller replaced.
1/19/2012	724.74	60,530	483,747	14,400	2,880	561,557	267,432	468,854	736,286	939,224	955,184	311,592	103,606	3,503,843	3,607,449	2,551,242	2,654,848	
1/20/2012	722.54	18,620	382,967	11,400	2,280	415,267	245,968	371,176	617,144	733,080	747,696	246,976	127,596	2,760,163	2,887,759	2,006,020	2,133,616	All systems offline for ~5 hours.
1/21/2012	715.58	60,760	483,747	14,400	2,880	561,787	266,550	468,854	735,404	931,936	954,112	311,632	119,778	3,494,871	3,614,649	2,542,270	2,662,048	
1/22/2012	669.42	60,760	483,747	14,400	2,880	561,787	265,340	468,854	734,194	932,880	954,976	312,408	103,860	3,496,245	3,600,105	2,543,644	2,647,504	
1/23/2012	717.65	60,470	483,747	14,400	2,880	561,497	259,820	468,854	728,674	937,256	954,304	315,760	108,358	3,497,491	3,605,849	2,544,890	2,653,248	
1/24/2012	709.55	60,660	483,747	14,400	2,880	561,687	262,020	468,854	730,874	934,400	954,656	310,440	103,920	3,492,057	3,595,977	2,539,456	2,643,376	
1/25/2012	717.28	60,830	483,747	14,400	2,880	561,857	266,040	468,854	734,894	936,960	954,464	310,112	108,826	3,498,287	3,607,113	2,545,686	2,654,512	
1/26/2012	654.56	59,940	483,747	14,400	2,880	560,967	266,120	468,854	734,974	923,280	935,840	304,992	112,356	3,460,053	3,572,409	2,507,452	2,619,808	
1/27/2012	638.93	57,980	483,747	14,400	2,880	559,007	231,260	468,854	700,114	496,280	886,368	276,240	97,840	2,918,009	3,015,849	1,965,408	2,063,248	
1/28/2012	325.45	62,610	483,747	14,400	2,880	563,637	226,840	468,854	695,694	489,360	956,368	295,920	97,462	3,000,979	3,098,441	2,048,378	2,145,840	
1/29/2012	647.18	60,890	483,747	14,400	2,880	561,917	250,920	468,854	719,774	928,616	956,448	315,176	103,774	3,481,931	3,585,705	2,529,330	2,633,104	
1/30/2012	704.74	51,150	403,123	12,000	2,400	468,673	240,400	390,712	631,112	762,712	785,056	261,240	98,722	2,908,793	3,007,515	2,114,958	2,213,680	All systems offline for ~4 hours.
1/31/2012	674.16	61,400	483,747	14,400	2,880	562,427	267,348	468,854	736,202	928,240	958,528	314,384	110,388	3,499,781	3,610,169	2,547,180	2,657,568	
TOTAL (kW-hr)		**1,720**	**14,331**	**427**	**85**	**16,563**	**6,902**	**13,890**	**20,791**	**25,372**	**27,084**	**8,797**	**3,246**	**98,608**	**101,855**	**70,387**	**73,634**	
AVERAGE (kW-hr/MG)		**110**	**913**	**27**	**5**	**1,055**	**440**	**885**	**1,324**	**1,713**	**1,828**	**297**	**110**	**3,329**	**3,438**	**2,376**	**2,486**	

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Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (February 2012)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
2/1/2012	750.29	60,190	483,747	14,400	2,880	561,217	266,864	468,854	735,718	928,600	957,712	312,388	108,902	3,495,635	3,604,537	2,543,034	2,651,936	
2/2/2012	723.27	60,270	483,747	14,400	2,880	561,297	263,280	468,854	732,134	928,904	956,528	315,240	101,490	3,494,103	3,595,593	2,541,502	2,642,992	
2/3/2012	762.94	54,520	483,747	14,400	2,880	555,547	254,416	468,854	723,270	823,528	849,328	280,628	98,588	3,232,301	3,330,889	2,279,700	2,378,288	
2/4/2012	680.75	60,868	483,747	14,400	2,880	561,896	239,048	468,854	707,902	846,831	931,917	307,901	99,957	3,356,447	3,456,404	2,403,846	2,503,803	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
2/5/2012	681.86	60,350	483,747	14,400	2,880	561,377	262,320	468,854	731,174	934,344	957,632	316,420	102,246	3,500,947	3,603,193	2,548,346	2,650,592	
2/6/2012	751.82	60,860	483,747	14,400	2,880	561,887	262,860	468,854	731,714	929,640	956,864	316,440	105,736	3,496,545	3,602,281	2,543,944	2,649,680	
2/7/2012	741.66	60,950	483,747	14,400	2,880	561,977	268,440	468,854	737,294	929,352	956,784	313,320	120,818	3,498,727	3,619,545	2,546,126	2,666,944	
2/8/2012	692.53	60,710	483,747	14,400	2,880	561,737	269,060	468,854	737,914	933,360	958,640	313,460	113,570	3,505,111	3,618,681	2,552,510	2,666,080	
2/9/2012	741.90	60,890	483,747	14,400	2,880	561,917	269,928	468,854	738,782	937,600	958,688	309,220	113,626	3,506,207	3,619,833	2,553,606	2,667,232	
2/10/2012	692.76	51,780	403,123	12,000	2,400	469,303	256,532	390,712	647,244	775,936	794,768	261,300	96,516	2,948,551	3,045,067	2,154,716	2,251,232	All systems offline for ~4 hours.
2/11/2012	712.89	61390	483,747	14,400	2,880	562,417	264612	468,854	733,466	936064	958000	317392	103,150	3,507,339	3,610,489	2,554,738	2657888	
2/12/2012	704.15	60790	483,747	14,400	2,880	561,817	264840	468,854	733,694	930496	956896	318028	104,662	3,500,931	3,605,593	2,548,330	2652992	
2/13/2012	688.73	60830	483,747	14,400	2,880	561,857	262928	468,854	731,782	928032	956208	317988	106,030	3,495,867	3,601,897	2,543,266	2649296	
2/14/2012	684.65	60410	483,747	14,400	2,880	561,437	267688	468,854	736,542	932080	956720	318532	104,490	3,505,311	3,609,801	2,552,710	2657200	
2/15/2012	677.95	60540	483,747	14,400	2,880	561,567	261852	468,854	730,706	931392	943600	311508	104,708	3,478,773	3,583,481	2,526,172	2630880	
2/16/2012	692.83	58030	483,747	14,400	2,880	559,057	260680	468,854	729,534	898768	909872	298160	101,434	3,395,391	3,496,825	2,442,790	2544224	
2/17/2012	684.41	59870	483,747	14,400	2,880	560,897	246440	468,854	715,294	747568	755584	249584	79,786	3,028,927	3,108,713	2,076,326	2156112	
2/18/2012	673.55	61100	483,747	14,400	2,880	562,127	266020	468,854	734,874	940368	954688	315560	104,408	3,507,617	3,612,025	2,555,016	2659424	
2/19/2012	693.96	61100	483,747	14,400	2,880	562,127	267780	468,854	736,634	938592	954832	320120	105,416	3,512,305	3,617,721	2,559,704	2665120	
2/20/2012	705.63	52490	483,747	14,400	2,880	553,517	251612	468,854	720,466	774320	809904	271856	96,346	3,130,063	3,226,409	2,177,462	2273808	
2/21/2012	676.50	61390	483,747	14,400	2,880	562,417	262056	468,854	730,910	862000	957728	318960	101,722	3,432,015	3,533,737	2,479,414	2581136	
2/22/2012	720.19	60550	483,747	14,400	2,880	561,577	258832	468,854	727,686	861552	958992	316652	113,118	3,426,459	3,539,577	2,473,858	2586976	
2/23/2012	723.71	60400	483,747	14,400	2,880	561,427	260840	468,854	729,694	847072	873648	290900	105,380	3,302,741	3,408,121	2,350,140	2455520	
2/24/2012	664.92	61620	483,747	14,400	2,880	562,647	261432	468,854	730,286	872352	955680	316760	107,292	3,437,725	3,545,017	2,485,124	2592416	
2/25/2012	721.22	61190	483,747	14,400	2,880	562,217	260268	468,854	729,122	872128	955264	316352	105,342	3,435,083	3,540,425	2,482,482	2587824	
2/26/2012	705.81	61320	483,747	14,400	2,880	562,347	259040	468,854	727,894	868592	952840	320344	105,864	3,432,017	3,537,881	2,479,416	2585280	
2/27/2012	680.39	61416	483,747	14,400	2,880	562,444	243759	468,854	712,613	788134	885108	320021	89,535	3,268,321	3,357,855	2,315,719	2405254	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
2/28/2012	678.96	60390	483,747	14,400	2,880	561,417	259536	468,854	728,390	867296	948624	315296	105,834	3,421,023	3,526,857	2,468,422	2574256	
2/29/2012	660.96	61250	483,747	14,400	2,880	562,277	261112	468,854	729,966	878144	957024	317632	105,366	3,445,043	3,550,409	2,492,442	2597808	
TOTAL (kW-hr)		**1,737**	**13,948**	**415**	**83**	**16,184**	**7,554**	**13,519**	**21,073**	**25,643**	**26,880**	**8,918**	**3,011**	**98,698**	**101,709**	**71,231**	**74,242**	
AVERAGE (kW-hr/MG)		**114**	**913**	**27**	**5**	**1,059**	**494**	**885**	**1,379**	**1,779**	**1,865**	**309**	**104**	**3,423**	**3,527**	**2,470**	**2,575**	

City of San Diego
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Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (March 2012)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
3/1/2012	705.49	61,360	483,747	14,400	2,880	562,387	259,900	468,854	728,754	875,760	956,400	318,176	109,684	3,441,477	3,551,161	2,488,876	2,598,560	
3/2/2012	736.44	55,080	483,747	14,400	2,880	556,107	249,700	468,854	718,554	758,144	828,960	278,464	96,916	3,140,229	3,237,145	2,187,628	2,284,544	
3/3/2012	737.78	55,850	483,747	14,400	2,880	556,877	252,680	468,854	721,534	794,624	869,456	293,600	98,926	3,236,091	3,335,017	2,283,490	2,382,416	
3/4/2012	2.33	5,370	483,747	14,400	2,880	506,397	172,448	312,569	485,017	4,672	4,560	11,632	51,222	1,012,279	1,063,501	215,962	267,184	UF Critical alarm shut down plant (Bray air valve)
3/5/2012	2.63	32,940	483,747	14,400	2,880	533,967	199,532	371,176	570,708	414,061	456,848	15,728	224,459	1,991,313	2,215,772	1,136,389	1,360,848	
3/6/2012	761.64	61,210	483,747	14,400	2,880	562,237	241,612	468,854	710,466	844,544	899,632	315,536	104,314	3,332,415	3,436,729	2,379,814	2,484,128	
3/7/2012	657.01	49,930	483,747	14,400	2,880	550,957	226,948	468,854	695,802	670,400	738,000	250,872	91,562	2,906,031	2,997,593	1,953,430	2,044,992	
3/8/2012	690.75	61,740	483,747	14,400	2,880	562,767	239,300	468,854	708,154	866,112	952,640	322,672	101,760	3,412,345	3,514,105	2,459,744	2,561,504	
3/9/2012	746.76	56,410	483,747	14,400	2,880	557,437	236,740	468,854	705,594	776,480	858,944	287,360	100,258	3,185,815	3,286,073	2,233,214	2,333,472	
3/10/2012	688.76	61,820	483,747	14,400	2,880	562,847	246,132	468,854	714,986	851,368	948,416	313,560	107,728	3,391,177	3,498,905	2,438,576	2,546,304	
3/11/2012	695.63	61,580	483,747	14,400	2,880	562,607	244,640	468,854	713,494	851,360	948,496	318,648	106,732	3,394,605	3,501,337	2,442,004	2,548,736	
3/12/2012	667.07	61,990	483,747	14,400	2,880	563,017	244,760	468,854	713,614	844,560	948,816	318,400	106,050	3,388,407	3,494,457	2,435,806	2,541,856	
3/13/2012	686.46	62,100	483,747	14,400	2,880	563,127	244,868	468,854	713,722	848,800	948,160	309,296	104,760	3,383,105	3,487,865	2,430,504	2,535,264	
3/14/2012	738.25	61,900	483,747	14,400	2,880	562,927	245,740	468,854	714,594	848,480	949,376	309,992	106,700	3,385,369	3,492,069	2,432,768	2,539,468	
3/15/2012	705.61	62,130	483,747	14,400	2,880	563,157	244,940	468,854	713,794	846,576	948,432	313,048	104,906	3,385,007	3,489,913	2,432,406	2,537,312	
3/16/2012	717.17	61,500	483,747	14,400	2,880	562,527	245,280	468,854	714,134	843,552	948,960	313,328	104,020	3,382,501	3,486,521	2,429,900	2,533,920	
3/17/2012	681.82	62,010	483,747	14,400	2,880	563,037	243,300	468,854	712,154	844,192	946,080	313,504	103,874	3,378,967	3,482,841	2,426,366	2,530,240	
3/18/2012	696.55	61,680	483,747	14,400	2,880	562,707	243,760	468,854	712,614	853,632	948,928	316,272	101,616	3,394,153	3,495,769	2,441,552	2,543,168	
3/19/2012	737.05	61,750	483,747	14,400	2,880	562,777	242,700	468,854	711,554	854,640	948,352	315,488	102,510	3,392,811	3,495,321	2,440,210	2,542,720	
3/20/2012	654.64	60,470	483,747	14,400	2,880	561,497	240,360	468,854	709,214	851,952	937,152	307,568	103,554	3,367,383	3,470,937	2,414,782	2,518,336	
3/21/2012	740.29	61,900	483,747	14,400	2,880	562,927	243,100	468,854	711,954	861,184	947,712	313,120	101,944	3,396,897	3,498,841	2,444,296	2,546,240	
3/22/2012	646.07	342,470	483,747	14,400	2,880	843,497	204,528	390,712	595,240	857,712	481,664	288,640	120,026	3,066,753	3,186,779	2,192,294	2,312,320	UF cleaning.
3/23/2012	342.38	290,286	483,747	14,400	2,880	791,313	199,472	390,712	590,184	838,352	418,128	281,344	122,242	2,919,321	3,041,563	2,044,862	2,167,104	UF cleaning.
3/24/2012	666.30	61,870	483,747	14,400	2,880	562,897	244,072	468,854	712,926	863,200	951,312	316,248	104,450	3,406,583	3,511,033	2,453,982	2,558,432	
3/25/2012	667.90	62,270	483,747	14,400	2,880	563,297	240,536	468,854	709,390	862,176	951,456	314,352	102,874	3,400,671	3,503,545	2,448,070	2,550,944	
3/26/2012	641.09	61,270	483,747	14,400	2,880	562,297	243,652	468,854	712,506	861,856	950,256	317,288	103,150	3,404,203	3,507,353	2,451,602	2,554,752	
3/27/2012	638.37	58,050	483,747	14,400	2,880	559,077	239,012	468,854	707,866	832,736	935,792	297,136	96,602	3,332,607	3,429,209	2,380,006	2,476,608	
3/28/2012	658.41	52,700	483,747	14,400	2,880	553,727	244,640	468,854	713,494	871,072	1,024,640	314,856	114,428	3,477,789	3,592,217	2,525,188	2,639,616	
3/29/2012	691.55	52,310	483,747	14,400	2,880	553,337	243,768	468,854	712,622	870,432	1,019,616	319,552	113,522	3,475,559	3,589,081	2,522,958	2,636,480	
3/30/2012	737.82	56,210	483,747	14,400	2,880	557,237	233,552	468,854	702,406	779,840	914,912	286,456	98,470	3,240,851	3,339,321	2,288,250	2,386,720	
3/31/2012	703.09	59,140	483,747	14,400	2,880	560,167	240,368	468,854	709,222	863,152	1,024,384	304,200	98,932	3,461,125	3,560,057	2,508,524	2,607,456	
TOTAL (kW-hr)		**2,277**	**14,996**	**446**	**89**	**17,809**	**7,342**	**14,124**	**21,466**	**24,706**	**26,606**	**8,896**	**3,308**	**99,484**	**102,792**	**70,363**	**73,672**	
AVERAGE (kW-hr/MG)		**139**	**913**	**27**	**5**	**1,084**	**460**	**885**	**1,344**	**1,594**	**1,717**	**287**	**107**	**3,209**	**3,316**	**2,270**	**2,377**	

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (April 2012)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
4/1/2012	709.80	62,050	483,747	14,400	2,880	563,077	244,100	468,854	712,954	863,680	1,085,504	317,360	105,898	3,542,575	3,648,473	2,589,974	2,695,872	
4/2/2012	785.51	61,870	483,747	14,400	2,880	562,897	243,040	468,854	711,894	860,768	1,043,136	316,728	108,730	3,495,423	3,604,153	2,542,822	2,651,552	
4/3/2012	683.45	61,770	483,747	14,400	2,880	562,797	240,892	468,854	709,746	860,272	1,057,616	315,192	109,378	3,505,623	3,615,001	2,553,022	2,662,400	
4/4/2012	685.26	238,810	483,747	14,400	2,880	739,837	238,968	468,854	707,822	836,208	1,028,688	307,040	103,438	3,619,595	3,723,033	2,666,994	2,770,432	
4/5/2012	695.09	182,990	483,747	14,400	2,880	684,017	244,872	468,854	713,726	685,936	981,968	306,192	101,082	3,371,839	3,472,921	2,419,238	2,520,320	
4/6/2012	772.50	105,050	483,747	14,400	2,880	606,077	236,208	468,854	705,062	772,480	893,552	286,088	97,502	3,263,259	3,360,761	2,310,658	2,408,160	
4/7/2012	712.52	62,060	483,747	14,400	2,880	563,087	242,280	468,854	711,134	849,232	1,036,224	312,176	106,828	3,471,853	3,578,681	2,519,252	2,626,080	
4/8/2012	714.10	62,600	483,747	14,400	2,880	563,627	245,368	468,854	714,222	846,288	1,037,232	311,976	105,016	3,473,345	3,578,361	2,520,744	2,625,760	
4/9/2012	685.09	62,090	483,747	14,400	2,880	563,117	243,840	468,854	712,694	839,232	1,023,536	312,296	106,686	3,450,875	3,557,561	2,498,274	2,604,960	
4/10/2012	703.56	62,340	483,747	14,400	2,880	563,367	243,192	468,854	712,046	840,304	1,009,312	308,448	102,836	3,433,477	3,536,313	2,480,876	2,583,712	
4/11/2012	779.18	62,040	483,747	14,400	2,880	563,067	245,632	468,854	714,486	842,048	1,007,008	305,584	104,920	3,432,193	3,537,113	2,479,592	2,584,512	
4/12/2012	673.57	62,850	483,747	14,400	2,880	563,877	245,256	468,854	714,110	839,728	1,002,528	306,104	100,846	3,426,347	3,527,193	2,473,746	2,574,592	
4/13/2012	751.96	56,920	483,747	14,400	2,880	557,947	235,712	468,854	704,566	753,232	900,544	272,400	95,528	3,188,689	3,284,217	2,236,088	2,331,616	
4/14/2012	719.99	61,990	483,747	14,400	2,880	563,017	243,560	468,854	712,414	847,840	1,010,224	307,696	101,842	3,441,191	3,543,033	2,488,590	2,590,432	
4/15/2012	750.11	61,800	483,747	14,400	2,880	562,827	246,060	468,854	714,914	846,368	1,006,304	315,624	103,812	3,446,037	3,549,849	2,493,436	2,597,248	
4/16/2012	677.57	598,720	483,747	14,400	2,880	1,099,747	245,692	468,854	714,546	441,216	991,952	301,160	145,708	3,548,621	3,694,329	2,596,020	2,741,728	RO A offline for approximately 12 hours for cleaning; Extra power usage at MF due to heating CIP water
4/17/2012	384.99	462,370	483,747	14,400	2,880	963,397	244,200	468,854	713,054	286,368	990,336	303,840	131,670	3,256,995	3,388,665	2,304,394	2,436,064	RO A offline for approximately 15 hours for cleaning; Extra power usage at MF due to heating CIP water
4/18/2012	643.70	297,120	423,279	12,600	2,520	735,519	230,128	410,247	640,375	293,888	349,072	110,408	696,264	2,129,262	2,825,526	1,295,736	1,992,000	All systems offline for approx. 3 hours; RO B offline for approximately 16 hours for cleaning; Extra power usage at MF due to heating CIP water
4/19/2012	326.57	125,610	483,747	14,400	2,880	626,637	243,808	468,854	712,662	840,291	445,648	303,684	67,135	2,928,922	2,996,057	1,976,321	2,043,456	RO B offline for approximately 12 hours for cleaning; Extra power usage at MF due to heating CIP water. Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/20/2012	685.96	55,680	423,279	12,600	2,520	494,079	234,452	410,247	644,699	735,254	832,384	283,008	60,038	2,989,424	3,049,462	2,155,898	2,215,936	All systems offline for approximately 3 hours. Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/21/2012	708.89	61,880	483,747	14,400	2,880	562,907	243,932	468,854	712,786	840,291	939,776	319,488	45,545	3,375,248	3,420,793	2,422,647	2,468,192	Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/22/2012	608.97	58,080	443,435	13,200	2,640	517,355	239,948	429,783	669,731	770,267	882,080	300,768	65,913	3,140,201	3,206,114	2,266,983	2,332,896	All systems offline for approximately 2 hours. Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/23/2012	681.64	61,180	483,747	14,400	2,880	562,207	244,188	468,854	713,042	840,291	907,808	316,152	39,853	3,339,500	3,379,353	2,386,899	2,426,752	Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/24/2012	562.18	56,560	423,279	12,600	2,520	494,959	233,512	410,247	643,759	735,254	779,120	275,896	55,322	2,928,988	2,984,310	2,095,462	2,150,784	All systems offline for approximately 3 hours. Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/25/2012	656.22	62,030	483,747	14,400	2,880	563,057	243,392	468,854	712,246	778,624	874,640	302,256	98,482	3,230,823	3,329,305	2,278,222	2,376,704	Power total for RO A not available, usage estimated based on runtime and typical power usage.
4/26/2012	649.71	61,520	483,747	14,400	2,880	562,547	243,048	468,854	711,902	778,928	876,576	300,992	100,472	3,230,945	3,331,417	2,278,344	2,378,816	
4/27/2012	737.47	53,739	423,279	12,600	2,520	492,138	213,289	410,247	623,536	689,618	774,470	280,018	78,343	2,859,780	2,938,123	2,026,254	2,104,597	All systems offline for approximately 3 hours. Power totals not available. Usage estimated based on runtime and typical power usage.
4/28/2012	686.76	61,540	483,747	14,400	2,880	562,567	243,428	468,854	712,282	780,128	876,480	315,912	98,832	3,247,369	3,346,201	2,294,768	2,393,600	
4/29/2012	710.65	60,930	483,747	14,400	2,880	561,957	242,632	468,854	711,486	780,528	877,488	345,992	101,582	3,277,451	3,379,033	2,324,850	2,426,432	
4/30/2012	677.13	56,930	463,591	13,800	2,760	537,081	240,312	449,319	689,631	745,024	823,552	327,069	102,233	3,122,357	3,224,590	2,209,447	2,311,680	All systems offline for approximately 1 hour
TOTAL (kW-hr)		**3,401**	**14,210**	**423**	**85**	**18,119**	**7,225**	**13,773**	**20,998**	**22,720**	**27,345**	**8,988**	**3,442**	**98,168**	**101,610**	**70,186**	**73,627**	
AVERAGE (kW-hr/MG)		**218**	**913**	**27**	**5**	**1,164**	**464**	**885**	**1,349**	**1,608**	**1,894**	**306**	**117**	**3,342**	**3,459**	**2,389**	**2,506**	

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (May 2012)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
5/1/2012	691.82	61,470	483,747	14,400	2,880	562,497	244,000	468,854	712,854	775,296	874,272	318,192	100,978	3,243,111	3,344,089	2,290,510	2,391,488	
5/2/2012	696.28	61,360	483,747	14,400	2,880	562,387	242,880	468,854	711,734	777,760	879,024	359,032	100,872	3,289,937	3,390,809	2,337,336	2,438,208	
5/3/2012	693.84	61,380	483,747	14,400	2,880	562,407	244,888	468,854	713,742	773,072	874,992	357,496	100,108	3,281,709	3,381,817	2,329,108	2,429,216	
5/4/2012	745.35	56,910	443,435	13,200	2,640	516,185	237,040	429,783	666,823	686,048	794,784	314,104	95,210	2,977,944	3,073,154	2,104,726	2,199,936	All systems offline for approxmiately 2 hours
5/5/2012	720.72	60,830	483,747	14,400	2,880	561,857	243,480	468,854	712,334	771,648	875,664	293,872	98,890	3,215,375	3,314,265	2,262,774	2,361,664	
5/6/2012	735.24	61,460	483,747	14,400	2,880	562,487	245,480	468,854	714,334	772,912	879,472	290,848	99,268	3,220,053	3,319,321	2,267,452	2,366,720	
5/7/2012	698.04	35,826	282,186	8,400	1,680	328,092	142,193	273,498	415,691	459,745	516,313	186,679	52,229	1,906,520	1,958,749	1,350,836	1,403,065	All sytems offline for approximately 10 hours. Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
5/8/2012	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	All systems offline all day
5/9/2012	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	All systems offline all day
5/10/2012	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	All systems offline all day
5/11/2012	383.26	38,385	302,342	9,000	1,800	351,527	152,349	293,034	445,383	492,584	553,193	200,013	55,960	2,042,700	2,098,660	1,447,324	1,503,284	All systems offline for approximately 9 hours. Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
5/12/2012	688.36	62,740	483,747	14,400	2,880	563,767	198,680	468,854	667,534	766,224	872,080	296,536	100,060	3,166,141	3,266,201	2,213,540	2,313,600	
5/13/2012	738.32	62,110	483,747	14,400	2,880	563,137	198,380	468,854	667,234	764,800	873,264	295,544	99,150	3,163,979	3,263,129	2,211,378	2,310,528	
5/14/2012	700.96	61,930	483,747	14,400	2,880	562,957	197,780	468,854	666,634	759,328	871,808	295,680	99,170	3,156,407	3,255,577	2,203,806	2,302,976	
5/15/2012	680.77	62,560	483,747	14,400	2,880	563,587	192,988	468,854	661,842	762,288	876,864	296,528	100,036	3,161,109	3,261,145	2,208,508	2,308,544	
5/16/2012	694.54	62,900	483,747	14,400	2,880	563,927	193,944	468,854	662,798	762,416	873,760	293,104	101,556	3,156,005	3,257,561	2,203,404	2,304,960	
5/17/2012	667.47	55,960	483,747	14,400	2,880	556,987	190,600	468,854	659,454	719,248	789,808	264,656	95,856	2,990,153	3,086,009	2,037,552	2,133,408	
5/18/2012	688.49	55,824	483,747	14,400	2,880	556,851	172,125	468,854	640,979	676,644	775,462	260,130	88,187	2,910,067	2,998,253	1,957,465	2,045,652	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
5/19/2012	687.87	62,310	483,747	14,400	2,880	563,337	197,904	468,854	666,758	817,312	875,584	293,264	97,146	3,216,255	3,313,401	2,263,654	2,360,800	
5/20/2012	706.77	62,170	483,747	14,400	2,880	563,197	193,216	468,854	662,070	814,192	868,608	292,896	98,678	3,200,963	3,299,641	2,248,362	2,347,040	
5/21/2012	714.98	61,940	483,747	14,400	2,880	562,967	200,144	468,854	668,998	811,200	864,240	297,432	99,220	3,204,837	3,304,057	2,252,236	2,351,456	
5/22/2012	737.93	62,300	483,747	14,400	2,880	563,327	196,416	468,854	665,270	818,912	867,536	296,936	100,620	3,211,981	3,312,601	2,259,380	2,360,000	
5/23/2012	694.26	62,270	483,747	14,400	2,880	563,297	196,772	468,854	665,626	820,032	872,080	280,304	96,638	3,201,339	3,297,977	2,248,738	2,345,376	
5/24/2012	674.21	61,720	483,747	14,400	2,880	562,747	195,588	468,854	664,442	819,472	871,952	292,352	99,652	3,210,965	3,310,617	2,258,364	2,358,016	
5/25/2012	684.48	54,280	423,279	12,600	2,520	492,679	197,612	410,247	607,859	710,544	679,152	237,944	87,940	2,728,178	2,816,118	1,894,652	1,982,592	All systems offline for ~3 hours; ROB and UV offline for ~5 hours
5/26/2012	679.13		483,747	14,400	2,880	501,027		468,854	468,854				-17,280	969,881	952,601	17,280		
5/27/2012	376.72	35,810	262,030	7,800	1,560	307,200	180,680	253,963	434,643	442,816	479,568	164,312	82,878	1,828,538	1,911,416	1,312,546	1,395,424	All systems offline for ~11 hours
5/28/2012	49.76	50,058	382,967	11,400	2,280	446,705	154,347	371,176	525,523	606,756	695,367	233,262	80,894	2,507,613	2,588,507	1,753,470	1,834,364	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~ 5 hours.
5/29/2012	686.71	50,058	382,967	11,400	2,280	446,705	154,347	371,176	525,523	606,756	695,367	233,262	80,894	2,507,613	2,588,507	1,753,470	1,834,364	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~ 5 hours.
5/30/2012	682.85	231,900	483,747	14,400	2,880	732,927	188,780	468,854	657,634	786,720	872,080	306,656	99,208	3,356,017	3,455,225	2,403,416	2,502,624	Extra power usage on MF due to heating of water for UF CIP
5/31/2012	663.21	285,150	483,747	14,400	2,880	786,177	177,068	214,891	391,959	364,800	853,488	279,184	136,214	2,675,609	2,811,823	1,976,970	2,113,184	UF and ROA offline for ~13 hours due to UF cleaning; Extra power usage on MF due to heating of water for UF CIP
TOTAL (kW-hr)		**1,942**	**12,638**	**376**	**75**	**15,031**	**5,330**	**11,995**	**17,325**	**19,140**	**21,676**	**7,530**	**2,530**	**80,701**	**83,231**	**56,068**	**58,598**	
AVERAGE (kW-hr/MG)		**140**	**913**	**27**	**5**	**1,086**	**393**	**885**	**1,278**	**1,496**	**1,665**	**289**	**97**	**3,099**	**3,196**	**2,153**	**2,250**	

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (June 2012)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
6/1/2012	346.82	199,139	483,747	14,400	2,880	700,166	171,593	468,854	640,447	692,067	844,410	270,463	84,614	3,147,553	3,232,167	2,194,951	2,279,565	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
6/2/2012	685.87	61,680	483,747	14,400	2,880	562,707	195,472	468,854	664,326	789,280	882,624	306,784	98,816	3,205,721	3,304,537	2,253,120	2,351,936	
6/3/2012	707.57	61,660	483,747	14,400	2,880	562,687	192,328	468,854	661,182	784,432	888,944	307,104	105,532	3,204,349	3,309,881	2,251,748	2,357,280	
6/4/2012	694.28	62,040	483,747	14,400	2,880	563,067	191,472	468,854	660,326	780,416	887,264	306,912	93,976	3,197,985	3,291,961	2,245,384	2,339,360	
6/5/2012	695.82	61,440	483,747	14,400	2,880	562,467	192,840	468,854	661,694	780,752	924,640	306,632	99,264	3,236,185	3,335,449	2,283,584	2,382,848	
6/6/2012	693.39	225,440	483,747	14,400	2,880	726,467	194,256	468,854	663,110	783,472	955,936	306,184	98,072	3,435,169	3,533,241	2,482,568	2,580,640	Extra power usage on MF due to heating water for ROB CIP
6/7/2012	700.85	206,870	141,093	4,200	840	353,003	193,672	468,854	662,526	771,984	287,168	178,672	102,482	2,253,353	2,355,835	1,643,406	1,745,888	MF and ROB offline for ~17 hours, UV offline for ~9 hours; Extra power usage on MF due to heating water for ROB CIP
6/8/2012	365.15	94,873	201,561	6,000	1,200	303,634	81,749	195,356	277,105	329,711	402,290	128,852	41,344	1,441,593	1,482,937	1,044,675	1,086,019	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~ 14 hours.
6/9/2012	691.19	61,360	483,747	14,400	2,880	562,387	195,800	468,854	664,654	768,512	914,272	289,416	99,536	3,199,241	3,298,777	2,246,640	2,346,176	
6/10/2012	716.41	62,080	483,747	14,400	2,880	563,107	192,720	468,854	661,574	760,928	906,752	297,752	99,320	3,190,113	3,289,433	2,237,512	2,336,832	
6/11/2012	697.37	57,680	443,435	13,200	2,640	516,955	192,160	429,783	621,943	709,040	847,584	278,160	97,680	2,973,682	3,071,362	2,100,464	2,198,144	All systems offline for ~2 hours
6/12/2012	487.45	44,900	342,654	10,200	2,040	399,794	186,976	332,105	519,081	538,336	643,904	193,656	87,924	2,294,771	2,382,695	1,620,012	1,707,936	All systems offline for ~7 hours
6/13/2012	709.75	62,400	483,747	14,400	2,880	563,427	195,144	468,854	663,998	760,880	911,040	293,600	98,536	3,192,945	3,291,481	2,240,344	2,338,880	
6/14/2012	764.56	61,500	483,747	14,400	2,880	562,527	197,608	468,854	666,462	765,648	918,464	294,976	98,220	3,208,077	3,306,297	2,255,476	2,353,696	
6/15/2012	664.89	43,190	342,654	10,200	2,040	398,084	140,856	332,105	472,961	530,512	637,696	203,840	80,306	2,243,093	2,323,399	1,568,334	1,648,640	All systems offline for ~7 hours
6/16/2012	704.58	63,030	483,747	14,400	2,880	564,057	194,096	468,854	662,950	762,384	915,008	289,344	100,746	3,193,743	3,294,489	2,241,142	2,341,888	
6/17/2012	712.99	63,070	483,747	14,400	2,880	564,097	198,912	468,854	667,766	758,896	912,224	290,128	101,634	3,193,111	3,294,745	2,240,510	2,342,144	
6/18/2012	672.25	62,910	423,279	12,600	2,520	501,309	195,512	410,247	605,759	743,760	869,216	286,992	105,050	3,007,036	3,112,086	2,173,510	2,278,560	
6/19/2012	684.73	27,660	201,561	6,000	1,200	236,421	175,960	195,356	371,316	311,440	370,368	125,976	80,916	1,415,521	1,496,437	1,018,604	1,099,520	All systems offline for ~14 hours due to leak at chlorine pump
6/20/2012	487.38	44,850	282,186	8,400	1,680	337,116	185,944	273,498	459,442	540,592	639,200	212,632	94,734	2,188,982	2,283,716	1,633,298	1,728,032	All systems offline for ~7 hours due to leak at chlorine pump
6/21/2012	733.28	62,110	483,747	14,400	2,880	563,137	198,024	468,854	666,878	758,400	902,496	293,648	104,042	3,184,559	3,288,601	2,231,958	2,336,000	
6/22/2012	737.44	52,960	403,123	12,000	2,400	470,483	191,312	390,712	582,024	632,768	748,832	254,056	96,872	2,688,163	2,785,035	1,894,328	1,991,200	All systems offline for ~4 hours
6/23/2012	676.15	52,794	403,123	12,000	2,400	470,316	168,320	390,712	559,032	644,640	767,122	249,601	88,724	2,690,711	2,779,435	1,896,876	1,985,600	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~4 hours.
6/24/2012	2.64	4,710	0	0	0	4,710	161,752	0	161,752	4,320	3,904	11,736	68,170	186,422	254,592	186,422	254,592	All systems offline all day
6/25/2012	27.66	26,080	181,405	5,400	1,080	213,965	173,080	175,820	348,900	272,048	317,600	114,584	80,944	1,267,098	1,348,042	909,872	990,816	All systems offline for ~15 hours
6/26/2012	665.22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Power Outage plant shutdown
6/27/2012	685.98	61,690	483,747	14,400	2,880	562,717	195,016	468,854	663,870	754,192	888,736	299,000	102,966	3,168,515	3,271,481	2,215,914	2,318,880	
6/28/2012	694.48	61,270	483,747	14,400	2,880	562,297	196,408	468,854	665,262	753,328	888,032	298,856	100,058	3,167,775	3,267,833	2,215,174	2,315,232	
6/29/2012	715.90	53,739	423,279	12,600	2,520	492,138	172,266	410,247	582,514	660,731	778,878	262,122	87,795	2,776,382	2,864,178	1,942,856	2,030,651	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~3 hours for maintenance.
6/30/2012	686.19	53,739	423,279	12,600	2,520	492,138	172,266	410,247	582,514	660,731	778,878	262,122	87,795	2,776,382	2,864,178	1,942,856	2,030,651	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~3 hours for maintenance.
TOTAL (kW-hr)		**2,057**	**11,469**	**341**	**68**	**13,935**	**5,294**	**11,448**	**16,741**	**18,804**	**21,633**	**7,214**	**2,686**	**78,328**	**81,014**	**55,412**	**58,098**	
AVERAGE (kW-hr/MG)		**164**	**913**	**27**	**5**	**1,109**	**409**	**885**	**1,294**	**1,615**	**1,825**	**300**	**112**	**3,258**	**3,370**	**2,305**	**2,417**	

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Daily Power Consumption (W-hr) (July 2012)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
7/1/2012	686.30	61,530	443,435	13,200	2,640	520,805	196,080	429,783	625,863	748,160	890,592	305,432	103,774	3,090,852	3,194,626	2,217,634	2,321,408	Shutdown for ~2hrs due to pump failure.
7/2/2012	683.71	61,110	483,747	14,400	2,880	562,137	201,600	468,854	670,454	745,968	887,264	303,472	104,778	3,169,295	3,274,073	2,216,694	2,321,472	
7/3/2012	626.00	56,419	443,435	13,200	2,640	515,694	180,859	429,783	610,642	693,690	817,729	275,197	92,209	2,912,952	3,005,161	2,039,734	2,131,943	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period. All systems offline ~2 hours.
7/4/2012	685.74	61,200	483,747	14,400	2,880	562,227	193,360	468,854	662,214	751,520	894,976	894,976	-	3,765,913	3,270,681	2,813,312	2,318,080	
7/5/2012	757.62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Plant shutdown due to pump failures & EDR exercises
7/6/2012		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Plant shutdown all weekend due to comm. Failures
7/7/2012		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Plant shutdown all weekend due to comm. Failures
7/8/2012		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Plant shutdown all weekend due to comm. Failures
7/9/2012		39,430	0	0	0	39,430	185,136	0	185,136	457,504	540,192	540,192	-	1,762,454	1,512,256	1,762,454	1,512,256	Plant shutdown all weekend due to comm. Failures
7/10/2012	742.63	55,610	483,747	14,400	2,880	556,637	193,720	468,854	662,574	665,296	774,976	774,976	-	3,434,459	3,029,017	2,481,858	2,076,416	
7/11/2012	714.10	61,120	483,747	14,400	2,880	562,147	197,656	468,854	666,510	738,112	861,312	296,784	103,768	3,124,865	3,228,633	2,172,264	2,276,032	
7/12/2012	761.65	61,480	483,747	14,400	2,880	562,507	196,784	468,854	665,638	739,328	866,816	294,720	104,936	3,129,009	3,233,945	2,176,408	2,281,344	
7/13/2012	682.49	56,229	483,747	14,400	2,880	557,256	179,975	468,854	648,830	676,177	792,775	269,546	94,497	2,944,584	3,039,081	1,991,982	2,086,479	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
7/14/2012	686.46	56,229	483,747	14,400	2,880	557,256	179,975	468,854	648,830	676,177	792,775	269,546	94,497	2,944,584	3,039,081	1,991,982	2,086,479	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
7/15/2012	685.26	60,740	483,747	14,400	2,880	561,767	198,480	468,854	667,334	736,368	858,240	293,688	100,804	3,117,397	3,218,201	2,164,796	2,265,600	
7/16/2012	673.47	60,350	483,747	14,400	2,880	561,377	197,352	468,854	666,206	738,448	860,032	292,096	99,210	3,118,159	3,217,369	2,165,558	2,264,768	
7/17/2012	717.20	61,350	483,747	14,400	2,880	562,377	196,960	468,854	665,814	746,112	870,400	294,984	99,506	3,139,687	3,239,193	2,187,086	2,286,592	
7/18/2012	738.82	60,480	483,747	14,400	2,880	561,507	193,464	468,854	662,318	748,800	874,368	296,856	104,688	3,143,849	3,248,537	2,191,248	2,295,936	
7/19/2012	673.81	55,550	483,747	14,400	2,880	556,577	189,304	468,854	658,158	675,040	786,144	268,320	101,418	2,944,239	3,045,657	1,991,638	2,093,056	
7/20/2012	727.18	60,900	483,747	14,400	2,880	561,927	193,320	468,854	662,174	743,360	865,920	294,632	102,156	3,128,013	3,230,169	2,175,412	2,277,568	
7/21/2012	684.05	60,900	483,747	14,400	2,880	561,927	193,320	468,854	662,174	743,360	865,920	294,632	102,156	3,128,013	3,230,169	2,175,412	2,277,568	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
7/22/2012	684.88	61,300	483,747	14,400	2,880	562,327	197,592	468,854	666,446	743,776	876,040	293,424	93,852	3,142,013	3,235,865	2,189,412	2,283,264	
7/23/2012	712.83	60,420	483,747	14,400	2,880	561,447	194,792	468,854	663,646	743,328	869,120	291,856	103,140	3,129,397	3,232,537	2,176,796	2,279,936	
7/24/2012	396.00	48,760	382,967	11,400	2,280	445,407	190,976	371,176	562,152	588,160	688,096	231,080	97,424	2,514,895	2,612,319	1,760,752	1,858,176	Plant shutdown ~5 hrs due to pump failure while operator not present
7/25/2012	658.36	60,700	483,747	14,400	2,880	561,727	194,464	468,854	663,318	745,968	878,144	294,824	99,884	3,143,981	3,243,865	2,191,380	2,291,264	
7/26/2012	682.36	60,480	483,747	14,400	2,880	561,507	198,288	468,854	667,142	742,096	871,552	295,184	101,328	3,137,481	3,238,809	2,184,880	2,286,208	
7/27/2012	674.07	56,448	483,747	14,400	2,880	557,475	185,069	468,854	653,923	692,623	813,449	275,505	93,421	2,992,975	3,086,396	2,040,373	2,133,794	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
7/28/2012	684.54	56,448	483,747	14,400	2,880	557,475	185,069	468,854	653,923	692,623	813,449	275,505	93,421	2,992,975	3,086,396	2,040,373	2,133,794	Power totals not available. Values estimated based on runtime and typical power usage for 24 hour period.
7/29/2012	684.37	60,620	483,747	14,400	2,880	561,647	196,928	468,854	665,782	737,920	863,840	293,712	99,908	3,122,901	3,222,809	2,170,300	2,270,208	
7/30/2012	652.18	60,270	483,747	14,400	2,880	561,297	198,392	468,854	667,246	735,520	862,400	291,488	100,058	3,117,951	3,218,009	2,165,350	2,265,408	
7/31/2012	724.27	60,780	483,747	14,400	2,880	561,807	201,760	468,854	670,614	734,832	861,920	289,488	99,668	3,118,661	3,218,329	2,166,060	2,265,728	
TOTAL (kW-hr)		**1,577**	**12,396**	**369**	**74**	**14,416**	**5,211**	**12,014**	**17,225**	**19,180**	**22,498**	**9,092**	**2,390**	**82,412**	**83,651**	**58,001**	**59,241**	
AVERAGE (kW-hr/MG)		**116**	**913**	**27**	**5**	**1,061**	**384**	**885**	**1,268**	**1,497**	**1,756**	**355**	**93**	**3,216**	**3,264**	**2,263**	**2,312**	

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility
Demonstration Facility Power Consumption - With MF/UF Feed Pumping Power Consumption Measured from EDR Feed Pump

		Power Monitor	Calculated	*Calculated*	*Calculated*	*Calculated*	Power Monitor	*Calculated*	*Calculated*	Power Monitor	Power Monitor	Power Monitor	*Calculated*	*Calculated*	*Calculated*	*Calculated*	Power Monitor	
		Total Monthly Power Consumption (kW-hr/month)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
Aug-11		1,621	12,114	361	72	14,168	3,953	12,190	16,143	14,379	18,086	6,553	0	69,328	0	45,024	0	
Sep-11		1,668	11,449	341	68	13,526	4,027	11,213	15,241	17,180	17,051	5,261	0	68,260	0	45,597	0	
Oct-11		2,438	11,953	356	71	14,818	5,561	13,460	19,021	21,951	22,211	8,619	0	86,619	0	61,206	0	
Nov-11		1,566	12,860	383	77	14,885	5,593	12,464	18,056	21,265	22,443	8,328	0	84,978	0	59,654	0	
Dec-11		1,811	14,271	425	85	16,591	6,337	13,753	20,090	25,762	27,547	8,907	3,179	98,898	102,077	70,874	74,053	
Jan-12		1,720	14,331	427	85	16,563	6,902	13,890	20,791	25,372	27,084	8,797	3,246	98,608	101,855	70,387	73,634	
Feb-12		1,737	13,948	415	83	16,184	7,554	13,519	21,073	25,643	26,880	8,918	3,011	98,698	101,709	71,231	74,242	
Mar-12		2,277	14,996	446	89	17,809	7,342	14,124	21,466	24,706	26,606	8,896	3,308	99,484	102,792	70,363	73,672	
Apr-12		3,401	14,210	423	85	18,119	7,225	13,773	20,998	22,720	27,345	8,988	3,442	98,168	101,610	70,186	73,627	
May-12		1,942	12,638	376	75	15,031	5,330	11,995	17,325	19,140	21,676	7,530	2,530	80,701	83,231	56,068	58,598	
Jun-12		2,057	11,469	341	68	13,935	5,294	11,448	16,741	18,804	21,633	7,214	2,686	78,328	81,014	55,412	58,098	
Jul-12		1,577	12,396	369	74	14,416	5,211	12,014	17,225	19,180	22,498	9,092	2,390	82,412	83,651	58,001	59,241	
TOTAL POWER (kW-hr)		**23,816**	**156,633**	**4,663**	**933**	**186,044**	**70,327**	**153,843**	**224,170**	**256,102**	**281,061**	**97,104**		**1,044,481**		**734,005**		
TOTAL FLOWS TREATED (gallons)		**171,609,583**	**171,609,583**	**171,609,583**	**171,609,583**	**171,609,583**	**173,906,250**	**173,906,250**	**173,906,250**	**161,187,500**	**162,020,833**	**323,708,333**	**323,708,333**	**323,708,333**	**323,708,333**	**323,708,333**	**323,708,333**	
AVERAGE (kW-hr/MG)		**139**	**913**	**27**	**5**	**1,084**	**404**	**885**	**1,289**	**1,589**	**1,735**	**300**		**3,227**		**2,267**		

		Average Power Consumption per Treated Flow (kW-hr/MG)																
Date	**Purified Water Flow (gpm)**	**MF Power Monitor (a)**	**MF Feed Pumping (b)**	**MF Control Panel (c)**	**MF Air Dryer (d)**	**Total MF (e) = (a)+(b)+(c)+(d)**	**UF Power Monitor (f)**	**UF Feed Pumping (g)**	**Total UF (h) = (f)+(g)**	**RO Train A Power Monitor (i)**	**RO Train B Power Monitor (j)**	**UV/AOP Power Monitor (k)**	**Ancillary Loads (l) = (p)-(o)**	**Total AWPF Processes Including MF/UF Feed Pumping (m) = (e)+(h)+(i)+(j)+(k)**	**Total AWPF Including MF/UF Feed Pumping (n) = (p)+(b)+(g)**	**Total AWPF Process without MF/UF Feed Pumping (o) = (m)-(b)-(g)**	**Total AWPF without MF/UF Feed Pumping (Main Power Monitor) (p)**	**Comments**
Aug-11		122	913	27	5	1,067	287	885	1,171	1,150	1,447	262	0	2,773	0	1,801	0	
Sep-11		133	913	27	5	1,078	318	885	1,202	1,516	1,505	243	0	3,150	0	2,104	0	
Oct-11		186	913	27	5	1,132	365	885	1,250	1,644	1,663	323	0	3,243	0	2,292	0	
Nov-11		111	913	27	5	1,056	397	885	1,282	1,600	1,688	313	0	3,197	0	2,244	0	
Dec-11		116	913	27	5	1,061	408	885	1,292	1,764	1,876	305	109	3,386	3,495	2,427	2,535	
Jan-12		110	913	27	5	1,055	440	885	1,324	1,713	1,828	297	110	3,329	3,438	2,376	2,486	
Feb-12		114	913	27	5	1,059	494	885	1,379	1,779	1,865	309	104	3,423	3,527	2,470	2,575	
Mar-12		139	913	27	5	1,084	460	885	1,344	1,594	1,717	287	107	3,209	3,316	2,270	2,377	
Apr-12		218	913	27	5	1,164	464	885	1,349	1,608	1,894	306	117	3,342	3,459	2,389	2,506	
May-12		140	913	27	5	1,086	393	885	1,278	1,496	1,665	289	97	3,099	3,196	2,153	2,250	
Jun-12		164	913	27	5	1,109	409	885	1,294	1,615	1,825	300	112	3,258	3,370	2,305	2,417	
Jul-12		116	913	27	5	1,061	384	885	1,268	1,497	1,756	355	93	3,216	3,264	2,263	2,312	
AVERAGE		**139**	**913**	**27**	**5**	**1,084**	**402**	**885**	**1,286**	**1,581**	**1,727**	**299**	**71**	**3,219**	**3,383**	**2,332**	**2,432**	