Appendix A: Proposal to CDPH to Augment San Vicente Reservoir with Purified Recycled Water

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THE CITY OF SAN DIEGO

City of San Diego
Water Purification Demonstration Project

Proposal to Augment San Vicente Reservoir with Purified Recycled Water

March 22, 2012

City of San Diego
PUBLIC UTILITIES
Water & Wastewater

Water Purification | Demonstration Project

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This proposal was prepared by the Water Purification Demonstration Project team, which consists of City staff, plus staff of RMC Water and Environment and its sub-consultants.

This proposal was reviewed by members of the project's Independent Advisory Panel.

The City of San Diego thanks the California Department of Public Health for its participation and input over the past two years regarding the City's Water Purification Demonstration Project. This participation and input has been invaluable as the City's project team structured the proposed project and this proposal.

List of Acronyms

AFY	Acre-Feet per Year
AOP	Advanced Oxidation Processes
AWPF	Advanced Water Purification Facility
CCP	Critical Control Point
CCR	California Code of Regulations
CDPH	California Department of Public Health
CEC	Chemicals of Emerging Concern
CTR	California Toxics Rule
EPA	Environmental Protection Agency
GWRS	Ground Water Replenishment System
IAP	Independent Advisory Panel
IPR/RA	Indirect Potable Reuse / Reservoir Augmentation
MCL	Maximum Contaminant Level
MF	Microfiltration
µg/L	micrograms per liter (equivalent to parts per billion)
mg/L	milligrams per liter (equivalent to parts per million)
mgd	million gallons per day
NCWRP	North City Water Reclamation Plant
NDMA	N-Nitrosodimethylamine
ng/L	Nanograms per liter (equivalent to parts per trillion)
NPDES	National Pollutant Discharge Elimination System
NWRI	National Water Research Institute
OCSD	Orange County Sanitation District
OCWD	Orange County Water District
PLWTP	Point Loma Wastewater Treatment Plant
RO	Reverse Osmosis
SWRCB	State Water Resources Control Board
TOC	Total Organic Carbon
UF	Ultrafiltration
UV	Ultraviolet
WPDP	Water Purification Demonstration Project

Section 1 Introduction

The purpose of this proposal is to obtain concept approval from the California Department of Public Health for the City of San Diego's Indirect Potable Reuse / Reservoir Augmentation Project at San Vicente Reservoir. The project would supplement the roughly 240,000 acre-foot San Vicente Reservoir with up to 15,000 acre-feet per year of purified recycled water produced at the City's North City Water Reclamation Plant. The City understands that California Department of Public Health's concept approval would be specific to the proposed project at San Vicente Reservoir.

In 2007, the San Diego City Council called for a demonstration project that would assess the feasibility of full-scale Indirect Potable Reuse / Reservoir Augmentation. Under direction of the Mayor, the City's Public Utilities Department implemented the Water Purification Demonstration Project to achieve this objective.

The key regulatory authority to approve an Indirect Potable Reuse / Reservoir Augmentation (IPR/RA) project lies with the California Department of Public Health. A final decision by the City to implement a full-scale project will depend, in part, on obtaining concept approval from CDPH.

California Department of Public Health (CDPH) does not yet have formal regulations for IPR/RA. Therefore, this proposal consists of two elements. First, in Sections 1 through 6 the proposal presents the project and its regulatory setting, and the results and conclusions reached in the Water Purification Demonstration Project (WPDP). Second, in Section 7 this proposal presents a suggested regulatory framework of the City's IPR/RA project.

This proposal is organized into seven sections.

Section 1: Introduction

Section 2: Current Activities Supporting Implementation of the Project

Section 3: Need for the Project

Section 4: Regulatory Setting

Section 5: Components of the Full-Scale IPR/RA Project

Section 6: Public Health Protections Provided by the Full-Scale IPR/RA Project

Section 7: Elements of the Suggested Regulatory Framework

Section 2 Current Activities Supporting Implementation of the Project

Scientific research and engineering analyses have been conducted over the last two years as part of the City's WPDP, a phase of work designed to substantiate regulatory and economic feasibility and assess public acceptability of the full-scale project. The project includes the construction and operation of a 1 mgd advanced water purification demonstration facility (herein referred to as the demonstration facility) that uses the same feed water as will be used for a full-scale advanced water purification facility (AWPF). Detailed studies of the demonstration facility's performance are being conducted over the course of one-year of operation, including four quarterly reports on water quality.

To date, three elements of the Water Purification Demonstration Project (WPDP) that are applicable to this concept proposal have been completed.

An assessment of the City's existing wastewater source control program, resulting in a review of City's industrial pretreatment requirements and identification of potential additional source control features to support an IPR/RA project.

Operation of the water purification demonstration facility built as part of the WPDP, which includes full-scale components of micro-filtration or ultra-filtration, reverse osmosis, and ultraviolet disinfection and advanced oxidation; plus testing and monitoring of the demonstration facility yielding first and second quarter reports.

The San Vicente Reservoir Hydrodynamic Study, including development of a 3-dimensional model to assess the reservoir's hydrodynamic responses.

2.1. Independent Advisory Panel

In addition to the above work elements, the National Water Research Institute (NWRI) has convened a ten-member Independent Advisory Panel (IAP) to support the City and regulators in assessing the results of the WPDP and the viability of a full-scale project. Through IAP meetings and project working group meetings, IAP members have been updated on the findings of the WPDP work elements. Feedback received from subsequent review meetings with the IAP has been incorporated into major project documents.

2.2. CDPH Participation

In March 2008, the City met with CDPH to discuss the scope and expectations of the WPDP. Based in part on CDPH input, a 1 mgd demonstration facility was constructed and the studies of San Vicente Reservoir were initiated. A cornerstone of the City's efforts has been keeping CDPH actively engaged throughout the project. California Department of Public Health staff members have been encouraged to attend IAP meetings and have been active participants in project working group meetings. Through these meetings, CDPH has reviewed reservoir technical studies and demonstration facility testing results that support the findings presented in this proposal.

2.3. Public Outreach

A comprehensive public outreach program is essential to moving past negative public perceptions associated with using purified recycled water for potable purposes. To move the public beyond these perceptions, a communication plan was prepared that outlines activities to encourage involvement among community leaders, stakeholders, and residents. Activities include a speakers bureau, developing written materials for English-speaking and non-English speaking audiences, stakeholder interviews, brochures, research surveys, videos, electronic updates, and a website. Tours of the demonstration facility are also available for an up-close experience of the treatment process. To date, more than 1,850 people have attended more than 145 tours.

Outreach efforts have garnered positive coverage both locally and nationally. On January 23, 2011, the San Diego Union-Tribune published an editorial in which the editorial board wrote that it had come to accept the science behind water purification technology and encouraged the rest of San Diego to do the same. Soon after this editorial there was a front page cover story in USA Today (March 3, 2011) and, most notably, an article on the cover page of the New York Times (February 10, 2012).

As a result of this extensive outreach effort, public opinion polls show that strong opposition to indirect potable reuse dropped from 45 percent in 2004 to 12 percent in 2009 to 11 percent in 2011 [San Diego County Water Authority, 2011). The 2011 survey also found that 65 percent of respondents either strongly favored or somewhat favored advanced treated recycled water (referred to as purified water in the City's project) as an addition to the region's supply of drinking water – a dramatic increase over the results of the 2004 survey where only 26 percent of respondents indicated a favorable rating.

Section 3 Need for the Project

Even with aggressive conservation efforts, the City estimates it will need approximately 35 percent more water in 2030 than was required in 2010 (City of San Diego, 2010). For years, the City has attempted to diversify and enhance its existing water supply. The City's 2002 Long-Range Water Resources Plan (City of San Diego, 2002) identifies the need for the City to develop additional local water supply sources as a means of providing reliability and protection from water supply shortages.

In 2004, the San Diego City Council directed the City Manager to conduct a study to evaluate options for increasing the beneficial use of the City's recycled water. The Water Reuse Study (City of San Diego, 2006) found that the strategy of augmenting a local reservoir with purified water both "maximizes the use of the available recycled water supply" and provides the "lowest overall unit cost" of the reuse strategies that were evaluated. In October 2007, the San Diego City Council accepted the Water Reuse Study and recognized the North City-3 strategy, also known as San Vicente Indirect Potable Reuse, as their preferred alternative.

Reservoir augmentation using San Vicente Reservoir would enable the City to maximize available, but unused, recycled water produced at the NCWRP. Currently an average of 7,500 AFY of the recycled water produced at NCWRP is used for irrigation and industrial purposes; the remaining water produced at NCWRP is discharged to the ocean. Recognizing this loss of a valuable resource, the San Diego City Council, in September 2008, approved moving forward with the WPDP. In November 2008, the City Council approved a water rate increase to fund the WPDP.

Section 4 Regulatory Setting

Indirect potable reuse projects via groundwater recharge by surface spreading are generally covered under the California Code of Regulations (CCR), Title 22, Water Recycling Criteria, which enables CDPH to approve such projects on a case-by-case basis. California Department of Public Health has also drafted regulations specific to groundwater replenishment projects using both surface and subsurface applications. Although not adopted, the Draft Groundwater Recharge Regulations (CDPH, 2011; the latest release is dated November 21, 2011) have received substantial review and revision. These draft regulations provide a basis for CDPH to approve groundwater replenishment projects. Six groundwater replenishment projects have been approved over the years by CDPH based through a case-by-case review of each individual project. Currently, there are no existing or draft CDPH regulations that address indirect potable reuse using surface water augmentation.

In 1994, the City, in partnership with the San Diego County Water Authority, initiated a series of technical studies on indirect potable reuse. These included pilot testing of advanced treatment technologies and studies of reservoir hydrodynamics for the purpose of assessing the potential to augment San Vicente Reservoir with purified water from NCWRP (City of San Diego, 1996 and San Diego County Water Authority, 1994). In August 1994, based on a feasibility study submitted by the City, the California Department of Health Services (as CDPH was then called) issued conditional concept approval for that project (California Department of Health Services, 1994). Although deemed technically feasible, work on this "water repurification" project was discontinued in 1999.

Prompted by the City's proposed "water repurification" project, the State of California assembled a blue ribbon panel to assess surface water augmentation. In 1996, the State Water Resources Control Board (SWRCB), in partnership with the California Department of Water Resources and the Department of Health Services, adopted a Framework for Indirect Potable Reuse via Surface Water Augmentation based on the recommendations of this blue ribbon panel (State Water Resources Control Board, 1996).

In 2003, a State Recycled Water Advisory Committee was convened to provide guidance in achieving the State's water recycling goals. One of the findings of the Advisory Committee was that, through a combination of previous research and policy direction (including the 1996 framework document), a sufficient basis was in place to enable the regulatory community to approve surface water augmentation projects. That basis included the then-applicable version of the Draft Groundwater Recharge Regulations.

In 2010, Governor Schwarzenegger signed into law SB 918, which requires CDPH to adopt uniform water recycling criteria for groundwater recharge by December 31, 2013, and for surface water augmentation by December 31, 2016 if a specified expert panel, convened pursuant to the bill, finds that the criteria would adequately protect public health.

Due to the unique project setting and features being proposed by the City, and the City's desire to make a decision on proceeding with a full-scale project by the end of calendar year 2012, CDPH is being formally requested to issue conceptual project approval based on this concept proposal and the scientific research being conducted as part of the City's WPDP.

Based on the State's 1996 framework document, CDPH's 2011 Draft Groundwater Recharge Regulations (specifically relating to subsurface application with full advanced treatment), and input provided by CDPH during the course of the WPDP, the following elements are expected to provide the framework for regulating the City's full-scale IPR/RA project:

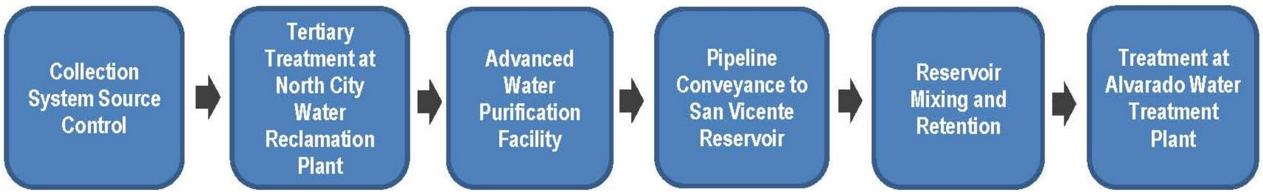
- enhanced wastewater source control
- pathogenic microorganism control
- control of nitrogen compounds
- control of regulated contaminants, monitoring of additional chemicals and contaminants, and control of total organic carbon
- reliability and redundancy
- monitoring and response plan consisting of
    - AWPF integrity monitoring
    - San Vicente Reservoir retention and blending
    - mitigation of an AWPF system failure by San Vicente Reservoir

The following sections describe full-scale project components and address how the City's proposed project will meet the above provisions.

Section 5 Components of the Full-Scale IPR/RA Project

The components of the City's full-scale IPR/RA project are shown in the schematic and described in more detail below.

Components of the Full-Scale IPR/RA Project



5.1. Existing Wastewater Source Control Program

The City maintains a comprehensive industrial pretreatment and source control program approved by the U.S. Environmental Protection Agency for control of waste discharges from industrial sources into the wastewater collection system. The City is responsible for water quality sampling and monitoring the entire wastewater system through treated effluent to fulfill the requirements of its National Pollutant Discharge Elimination System (NPDES) permits issued by the San Diego Regional Water Quality Control Board. The main components of the industrial pretreatment and source control program are

- grant and manage industrial user permits;
- establish sampling, analysis, reporting, record keeping, and notification requirements;
- perform inspections and monitor discharges; and
- enforce limits and authorize penalties for discharge violations.

The program organizes all industrial users into 27 sewersheds throughout the City, four of which cumulatively correspond to the area upstream of NCWRP. Because the full-scale AWPF will be located at NCWRP, these already-established sewersheds will ease the implementation of any enhanced source control practices that may apply specifically to industrial dischargers upstream of the full-scale project. At present there are 198 industries with industrial user permits in the NCWRP drainage area, 102 of which are research and development companies. The remaining 96 industries cover 49 different industry types including car washes, gas stations, electronic equipment manufacturers, and veterinary services.

5.2. North City Water Reclamation Plant

The NCWRP is a 30-mgd water reclamation plant serving roughly 7,500 AFY of recycled water to irrigation and industrial customers throughout the North City area. NCWRP operates as a scalping plant, receiving flows that would otherwise be treated at the Point Loma Wastewater Treatment Plant (PLWTP). As such, flows can be diverted at any time from NCWRP and sent to PLWTP. Biosolids are sent offsite for processing, with no return flow to NCWRP.

NCWRP consists of primary sedimentation, secondary aeration with full nitrification and partial denitrification, secondary clarification, deep bed anthracite filtration, and chlorine disinfection. Although chlorine disinfection is provided to meet the requirements specified in the Water Recycling Criteria for the current nonpotable uses of the recycled water, to control formation of trihalomethanes flows supporting the IPR/RA project would be diverted to the AWPF prior to chlorine disinfection.

The facility operates as a scalping plant, with flow equalization facilities mitigating impacts from diurnal flow variations, supporting a stable biological process. All waste streams are sent offsite to PLWTP for disposal.

Aerial of NCWRP

5.3. Advanced Water Purification Facility

The City proposes to build an 18-mgd capacity AWPF meeting the requirements stipulated in the pending draft CDPH groundwater recharge regulations for subsurface application. The demonstration facility, being operated as part of the WPDP, has validated the performance of standard AWPF technologies at full-scale on NCWRP tertiary filter effluent.

The full-scale facility will have the following main process components.

Membrane filtration Tertiary effluent will flow to a low pressure membrane filtration process consisting of either microfiltration (MF) or ultra-filtration (UF). In addition to minimizing reverse osmosis fouling by removing colloidal and suspended particles, low pressure membranes provide a barrier to a wide array of microbes and will assist in meeting the project’s microbial removal targets.

Reverse osmosis All AWPF flow will receive reverse osmosis (RO) treatment, the primary barrier to organic chemicals. The RO system will meet the applicable salt rejection specification established by CDPH. Permeate from the RO system will flow to AOP, while concentrated brine from the RO system will be discharged back to the sewer (downstream of the diversion to NCWRP).

Disinfection, photolysis, and advanced oxidation The advanced oxidation (AOP) step, as it is referred to in the City’s project, actually serves three purposes. High intensity UV irradiation provides the primary disinfection step in the AWPF. High intensity UV irradiation also provides photolysis of certain classes of organic chemicals such as NDMA. With the addition of hydrogen peroxide, high intensity UV provides an additional barrier to oxidizable contaminants. The AOP process will be designed to adhere to the criteria for advanced oxidation established in the Draft CDPH GWR regulations.

Although the City has tested UV as the primary source of disinfection and advanced oxidation, it is recognized that ozone is also being considered in certain IPR projects. While the City is not proposing to use ozone at this time, it may be considered as this project moves into the facility planning and design phase.

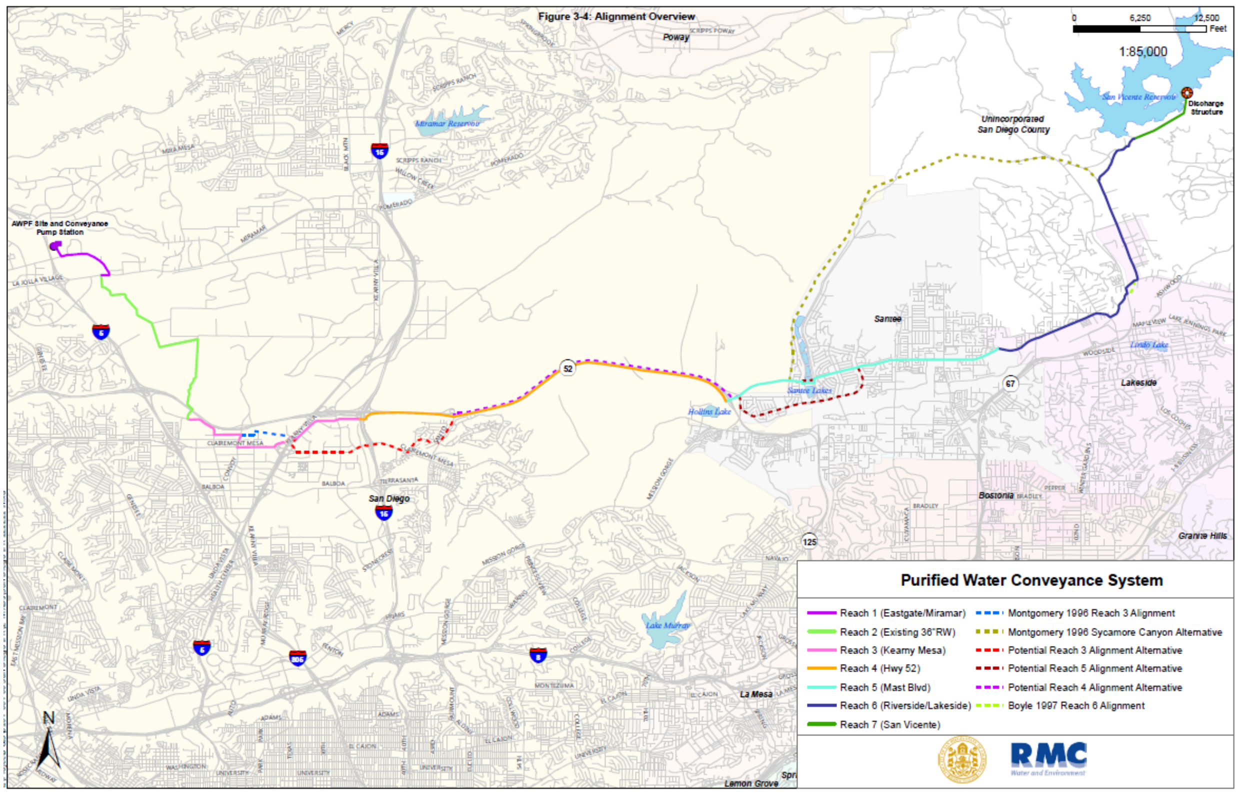
Reverse Osmosis Membranes at the Demonstration Facility

5.4. Purified Water Conveyance to San Vicente Reservoir

Purified recycled water will be pumped through a 23-mile, 36-inch diameter pipeline to San Vicente Reservoir. The static lift from the purified water pump station at the AWPF to San Vicente Reservoir is about 445 feet. A flow control structure at the reservoir outlet and surge control facilities will be required to optimize flow conditions in the pipeline.

The travel time of the purified water from the pumping station to the reservoir discharge structure is approximately 10 hours, based on a maximum pumping rate of 18 mgd. Should there be an operation malfunction at the AWPF, this would allow time to interrupt conveyance before any affected water reaches the reservoir. The pipeline could then be used to hold the affected water while the situation is assessed and resolved based on an approved response plan. The pipeline will be designed so that, if necessary, the entire volume of the pipeline could be drained to a local sanitary sewer via dedicated infrastructure; thus, off-specification water would be sent to the PLWTP.

Potential Alignments of the Conveyance Pipeline



5.5. San Vicente Reservoir

San Vicente Reservoir is located approximately 25 miles northeast of San Diego. The dam was built in 1945. It impounds San Vicente Creek, a tributary of the San Diego River. The dam and reservoir is owned and operated by the City's Public Utilities Department. San Vicente Reservoir impounds local runoff from its 75 square-mile catchment, stores water transferred from Sutherland Reservoir, and stores water imported from the Colorado River and northern California. The reservoir's dominant use is municipal water supply; all other uses of the reservoir are subordinate to water supply. The reservoir also supports limited recreational activities including boating, fishing, and water skiing, although these activities have been suspended during construction of facilities to raise San Vicente Dam. As part of the

San Diego County Water Authority's (SDCWA) Emergency Storage Project, San Vicente Reservoir is being enlarged (i.e., the dam is being raised) from its historical size of 90,000 AF to 247,000 AF. Construction of the expansion is scheduled to be complete by 2013, with refilling expected to take a few years depending on availability of imported water. The City and SDCWA will share storage capacity in the reservoir. The Emergency Storage Project provides local reservoir storage and pipeline connections to serve the region should the imported water supply be disrupted. The enlarged reservoir will be substantially filled prior to initiation of the full-scale IPR/RA project.

With the full-scale IPR/RA project, the City is proposing to augment water stored in San Vicente Reservoir with purified water from the AWPF. The full-scale IPR/RA project will place an annual average of 15,000 AF of purified water into the reservoir. There will be seasonal variation in the inflow of purified water due to non-potable demands at NCWRP, with winter monthly average inflows as high as 18 mgd and summer monthly average inflows as low as 9.5 mgd. The City will have the flexibility to fill San Vicente Reservoir using other water sources, such as local runoff and imported water. After implementation of the full-scale IPR/RA project, the reservoir will continue to store local runoff, imported water, and water transferred from Sutherland Reservoir. Purified water will blend with these other waters and will, in essence, substitute for a similar amount of imported water.

Generally, San Vicente Reservoir provides a substantial retention time for the purified water prior to conveyance to the potable water treatment plant. Based on an average 19,000 AFY reservoir withdrawal and an average reservoir volume of 155,000 AF (based on SDCWA preliminary SVR operations plan), the theoretical average purified water retention time in the reservoir would be on the order of eight years. It should be noted that during the winter months when destratification of the reservoir occurs portions of the purified water inflow will not be retained for this long. During this destratified period, however, the reservoir - and the purified water inflow - undergoes substantial mixing, essentially diluting purified water with the full volume of water in the reservoir. This hydrodynamic effect is further discussed in Section 6.

All operations of San Vicente Reservoir are fully in control of the City. Outflow from the reservoir and inflows to the reservoir (other than runoff) are controlled by the City. There are no releases from the reservoir to the natural stream system downstream. All outflows from the reservoir are pipeline conveyances to the municipal water system. The City has the ability to shut off outflow from the reservoir at any time without disrupting supplies to the municipal system.

San Vicente Reservoir

5.6. Alvarado Water Treatment Plant

Under normal operations water withdrawn from San Vicente Reservoir is conveyed to the City's 200-mgd Alvarado Water Treatment Plant, which serves the central portion of the City. The plant has recently been upgraded to meet federal Safe Drinking Water Act requirements. The Alvarado Water Treatment Plant is a conventional water treatment facility using ozone as a disinfectant. The filtration and disinfection achieves a minimum 3-log *Giardia* cyst reduction and 4-log virus reduction.

The Alvarado Water Treatment Plant has multiple sources of supply. There are direct connections to the SDCWA's First and Second Aqueducts, which carry imported water. The City's El Monte Pipeline carries combined flows from El Capitan Reservoir and San Vicente Reservoir – the plant can receive water from either of these reservoirs or a blend from both reservoirs. Water can be pumped to the plant from Lake Murray, which is immediately adjacent. Each of these sources is at the immediate control of the plant operator, an any of these sources can be shut off without disrupting the Alvarado Water Treatment Plant's capacity or its ability to supply the distribution system. Thus, should San Vicente Reservoir need to be taken offline for any reason, the Alvarado Water Treatment Plant's full demand can be served by the other sources.

Through agreements with SDCWA, a portion of San Vicente Reservoir's storage may be used in emergency and extended drought conditions to supply water treatment plants serving the southern half of San Diego County. In an emergency event, other plants that could be supplied from San Vicente Reservoir are the City's Miramar and Otay Water Treatment Plants, the Helix Water District's Levy Treatment Plant, the Sweetwater Authority's Purdue Water Treatment Plant, and the Santa Fe Irrigation's Districts Badger Water Treatment Plant. Each of these is a full conventional treatment plant achieving virus and *Giardia* reductions comparable to those achieved at the Alvarado Water Treatment Plant.

Alvarado Water Treatment Plant

Section 6 Provision of Public Health Protections by the Full-Scale IPR/RA Project

San Diego's full-scale IPR/RA Project will adhere to the multi-barrier concept that is fundamental to the provision of public health safeguards in IPR projects. The regulatory discussion in Section 5 introduced the elements that are necessary to ensure that public health protections are provided by the full-scale IPR/RA Project, consisting of:

- enhanced wastewater source control
- pathogenic microorganism control
- control of nitrogen compounds
- control of regulated contaminants, monitoring of additional chemicals and contaminants, and control of total organic carbon
- reliability and redundancy
- monitoring and response plan consisting of
    - AWPF integrity monitoring
    - San Vicente Reservoir retention and blending
    - mitigation of an AWPF system failure by San Vicente Reservoir

The following sections describe these provisions in more detail.

6.1. Enhanced Wastewater Source Control

The City's existing wastewater source control program will be expanded to support the IRP/RA project. The City has conducted discussions with Orange County Sanitation District (OCSD) who, as a project co-sponsor with Orange County Water District (OCWD), provides source water for the Ground Water Replenishment System (GWRS). The intent of the discussions was to identify additional applicable source control strategies that would enhance the City's existing program in an IPR setting.

The City's source control program and that of Orange County are similar. Both programs strive to prevent adverse impacts on the treatment facilities and the environment in compliance with state and federal requirements for industrial pretreatment programs. The City recognizes that the OCSD program serves as a model of an expanded source control program that includes contaminants that may be harmful to human health and drinking water supplies in compliance with CDPH goals for IPR projects. As an example, OCSD's enhanced source control program controls NDMA through the following actions.

Incorporate monitoring requirements for NDMA in industrial permits which have the potential to discharge a significant amount of NDMA. This is known as local limit monitoring.

Establish voluntary BMPs for NDMA discharges.

Monitor for NDMA at low concentrations (at least parts per trillion), and do this monitoring at least quarterly. Both OCSD and OCWD independently monitor the GWRS influent (secondary effluent). The GWRS influent and purified recycled water is monitored by OCWD at low detection levels (parts per trillion) on a weekly basis. Close communication between OCSD and OCWD is maintained, particularly if any unusual NDMA spikes are detected.

In the case that an unusual NDMA spike is detected, OCSD uses its geographic information system database to identify potential dischargers upstream of the sampling site. This ability to identify upstream dischargers improves response time and the overall effectiveness of the program.

The City recognizes the preponderance of pharmaceutical research in the NCWRP sewershed. As such, the enhanced wastewater source control program will include specific strategies for pharmaceutical manufacturers. The City currently prohibits discharges of any pharmaceutical manufacturing products or wastes, including incidental wash water or other pharmaceutical residues, to the sewer. Among the strategies that may be added to expand the wastewater source control program are measures such as requiring pharmaceutical manufacturers to report the pharmaceutically-active ingredients in their products, the volume of product they produce annually, the volume of wastes generated, and the disposed methods for the wastes. The City intends to submit a robust source control program for CDPH's review as part of the formal permitting process.

6.2. Pathogenic Microorganism Control

Pathogen removal is one of the key criteria for IPR projects. The November 21, 2011 draft groundwater recharge regulations require a total of at least 12-log enteric virus, 10-log *Giardia* cyst and 10-log *Cryptosporidium* oocyst reduction from raw sewage to drinking water (i.e., to the potable water distribution system). San Diego's full-scale IPR/RA Project can easily meet these removal goals.

The figure below illustrates the theoretical pathogen log reduction provided by the San Diego IPR/RA project. In addition to the removal that occurs at the AWPF, there are multiple barriers for pathogen removal, including at least 2-log reduction at NCWRP, 2-log reduction at San Vicente Reservoir, and 2-log reduction of *Cryptosporidium* and 4-log reduction of viruses at the surface water treatment plant.

Pathogen Removal in the City's IPR/RA Treatment Process

				Advanced Water Purification					
Organism	Log Reduction Required	Log Reduction Obtained	Secondary/ Tertiary [1,2,3] Treatment	Membrane [3] Filtration	Reverse [4,5] Osmosis	UV [6] Disinfection	Advanced Oxidation	Surface [7] Water Augment-ation	Treatment [8] at Drinking Water Plant
Cryptosp-oridium	10	**18**	2	4	2	6		2	2
Giardia	10	**19**	2	4	2	6		2	3
Viruses	12	**16**	2	0	2	6		2	4

1 Water Reuse Issues, Technologies, and Applications, Takashi Asano, et al., 2007

2 A Guide to Waterworks Design, Saskatchewan Ministry of Environment, January 2008

3 California Surface Water Treatment Rule Alternative Filtration Technology Summary, CDPH DDWEM Technical Programs Branch, August 2011

4 Study of Wastewater Reclamation Using Backwashable Capillary Ultrafiltration And Encapsulated Reverse Osmosis Membrane Modules, Hydranautics, June 1999

5 Reverse Osmosis and Nanofiltration, American Water Works Association and Robert Bergman, October 2007

6 Demonstration of UV Disinfection and Oxidation - System Performance Validation Report, Orange County Groundwater Replenishment System, July 2004

Australian Guidelines for Water Recycling: Managing Health and Environmental Risks - Augmentation of Drinking Water Supplies, 2008, Table 4.9

7 Water Purification Demonstration Project: Limnology and Reservoir Detention Study of San Vicente Reservoir - Hydrodynamic Modeling Study, Flow Science, Inc., November 22, 2011

8 Long Term 2 Enhanced Surface Water Treatment Rule, USEPA, January 2006

While not necessary, it may be possible for the project to increase its log reduction credits. For example, integrity testing procedures such as the TRASAR testing used to obtain credit for membrane filtration may become available for RO. Also, advanced oxidation provides yet another microbial barrier that is not accounted for in figure above.
Under normal operation, the project benefits from the advanced disinfection technologies provided by the Alvarado Water Treatment Plant. However, it is noted that all the potable water treatment plants that could potentially receive water from San Vicente Reservoir are required to operate with a minimum removal credit of 4 logs for viruses and 2 logs for *Cryptosporidium*. Therefore, during emergency and extreme drought scenarios when San Vicente Reservoir water may be diverted to other surface water treatment plants, the log removal credits will easily be met.

6.3. Control of Nitrogen Compounds

The secondary treatment process at NCWRP fully nitrifies and partially denitrifies. Coupled with RO at the AWPF, purified water is expected to easily meet the CDPH standard for total nitrogen for direct injection IPR projects of 5 mg/L. Based on First and Second Quarter AWPF Monitoring Reports, AWPF product in a full-scale facility would have total nitrogen of less than 1 mg/L.

6.4. Regulated Contaminants, Additional Chemicals and Contaminant Monitoring, and Total Organic Carbon Control

Based on the results from the water quality monitoring during the first six months (i.e., the first and second quarterly sampling results), the purified water met all drinking water standards that exist for the protection of human health (CDM, 2012). The standards include primary and secondary drinking water standards, disinfection by-products, and notification levels.

Primary drinking water standards Purified water met all primary standard criteria for all 91 pollutants, most measurements were below detection limits.

Secondary drinking water standards All 15 parameters were in compliance with the secondary standard, all below regulated levels.

Disinfection byproducts Disinfection byproduct levels were below regulatory requirements for drinking water.

Notification Levels All compounds were below drinking water notification levels.

Overall, the purified water met all treatment goals for the demonstration project. These goals were based on a combination of CDPH's November 2011 draft groundwater recharge regulations and RWQCB's Water Quality Control Plan for the San Diego Region (aka the Basin Plan).

CECs include currently-used pesticides, industrial chemicals, endocrine disrupting compounds, and pharmaceuticals and personal care products. The "Final Report Monitoring Strategies for CECs in Recycled Water, Recommendations of the Science Advisory Panel" (State Water Resources Control Board, 2010) recommended monitoring indicator compounds based on toxicological relevance (NDMA, 17 beta-estradiol, caffeine, and triclosan) and process performance indicators (DEET [N,N-diethyl-meta-toluamide], gemfibrozil, iopromide, and sucralose) in groundwater recharge projects. While the SWRCB report did not address surface water augmentation projects, this same monitoring program has been applied to the demonstration facility. Of the 91 chemicals of emerging concern monitored at the demonstration facility, all were non-detectable with the exception of low level detections of six compounds (theobromine, oxolinic acid, iohexal, diethanolamine, acesulfame-k, and triclosan). The results of the initial monitoring at the demonstration facility will be used to develop a customized monitoring program for chemicals of concern for the full-scale IRP/RA Project.

Total organic carbon (TOC) is an indicator of treatment process performance and can be used as a surrogate for the potential of a water supply to form disinfection byproducts. The purified water TOC and total disinfection byproducts were substantially lower than the imported water supply, and the TOC was consistently less than the target of 0.5 mg/L.

The testing indicated that NDMA concentrations were below the reporting limit of 2 ng/L.

Of the constituents in purified water measured at detectable and reportable levels, nearly all were present at lower concentrations than in the untreated imported water brought into the San Diego region.

6.5. Reliability and Redundancy

As a scalping plant, the NCWRP can go offline at any time either by ceasing diversion from the sewer or diverting off-specification product back to the sewer for treatment at PLWTP. The full-scale AWPF will also have the capability to go offline by ceasing to receive tertiary water from NCWRP or diverting off-specification water back to either the NCWRP head works or to the sewer for treatment at PLWTP. A variety of on-line monitoring techniques will be employed as noted in the next section.

Additionally, the Alvarado Water Treatment Plant is capable of receiving its full water demand from several other water sources that are not connected to San Vicente Reservoir. In the case of an extended discharge of off-specification purified water that would cause San Vicente Reservoir to exceed acceptable source water quality, it will be possible to discontinue San Vicente Reservoir draw to Alvarado Water Treatment Plant and use the other sources until the problem is resolved.

6.6. Monitoring and Response Plan

CDPH has included a response retention time requirement in its Draft Groundwater Recharge Regulations to address potential treatment failures. While this requirement is applicable to plug flow conditions found in groundwater recharge systems that produce water of drinking water quality, it is not amenable in a raw water reservoir setting where inflows mix through the entire reservoir during the critical winter destratified condition, and is subjected to subsequent surface water treatment with additional microbial and organic chemical removal capabilities. Although during most of the year substantial retention is provided by the reservoir, the predominant value of a large reservoir is the mixing and dilution that is achieved prior to withdrawal and conveyance to downstream water treatment.

For an IPR / reservoir augmentation setting, a monitoring and response plan needs to mitigate two types of hypothetical "treatment failures."

AWPF Malfunction This hypothetical event is characterized as a malfunction of a process or processes at the AWPF. As a worst case, this event would allow filtered NCWRP effluent to flow into the purified water conveyance pipeline. As noted, 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. The City's strategy to address this type of an event is keyed to AWPF integrity monitoring, and is discussed in Section 7.6.1 below.

AWPF Source Water Excursion This hypothetical event is characterized as an elevated level of a constituent of concern in the source water to the AWPF, while the AWPF is operating as designed. This elevated level of constituent of concern would be identified during the routine periodic comprehensive water quality monitoring performed on the AWPF product. The size, mixing, and dilution capacity of San Vicente Reservoir enables the City to address this type of treatment failure, as described in Section 7.6.2 below.

6.6.1. AWPF Integrity Monitoring

The ability of the combination of MF, RO and AOP technologies to remove microbial and chemical contaminants from recycled water is well-established. The demonstration facility currently being tested using NCWRP filter effluent will provide further evidence of the capabilities of these technologies to purify the water that will be used for the full-scale IPR/RA Project. The AWPF will be fully capable of producing water that meets all applicable standards. The questions that must be addressed are: What happens if the plant is not operating properly? How long would it take to respond and correct an operational problem at the plant? What is the relative risk to the public attributable to an operational problem at the plant?

As part of the demonstration project, a Critical Control Point (CCP) monitoring plan for the AWPF is being prepared with input from both the IAP and regulators. It is anticipated that the CCP monitoring plan will be similar to the CCPs specified in the GWRS Operation, Maintenance, and Monitoring Plan, which has been approved by CDPH. The plan will be validated through water quality testing of the demonstration facility at various points along the treatment process. The main purpose of CCP monitoring plan is to provide a systematic approach for applying tools, techniques, and practices to monitor and maintain the integrity of the various AWPF unit processes. The following are key components of the CCP monitoring plan.

- Baseline performance of each unit process under “intact” conditions will be confirmed and established prior to start–up.
- Continuous verification of integrity will be maintained throughout the operational period.
- On-going maintenance and operational practices to mitigate integrity breaches will be implemented on all unit processes.
- The integrity data will be recorded and analyzed.
- Measurable performance criteria will be developed along with action plans to respond to changes in performance due to breaches in integrity.

The main feature of the CCP monitoring will be online (i.e., continuous and real-time) monitoring, online feedback, daily water quality verifications, and automatic control of the system to ensure each system unit is functioning properly. The current monitoring strategy at the demonstration facility has the following components.

- Monitoring of membrane filtration with daily pressure decay tests, bacterial analysis, and online turbidity.
- Monitoring of reverse osmosis with online TOC and online electrical conductivity. Ultra Violet transmittance is also an indication of RO performance.
- Monitoring of advanced oxidation with online UV transmittance, online power draw, and verification of hydrogen peroxide flow.

With appropriate alarms and shutoff mechanisms keyed to these on-line monitoring techniques, it is anticipated that one would know within minutes if there was a problem with system performance at the

AWPF. Response to events could range from heightened scrutiny of operating performance to diverting the purified water to the NCWRP headworks or sewer until the problem was isolated and corrected.

As noted, the travel time of the water from the AWPF pumping station to San Vicente Reservoir outlet structure through the conveyance pipeline is approximately 10 hours. If a treatment failure occurred and purified water was for some reason not immediately diverted, there would still be time to stop conveyance of the affected water to the reservoir. The pipeline could then be used to hold the affected water while the situation is monitored and resolved in consultation with CDPH. If necessary, the entire volume of the pipeline could be drained to sanitary sewer via dedicated infrastructure. These drains would be in the overall sewershed of the PLWTP; thus, all off-specification water retained in the pipeline would be sent to the PLWTP.

During the design phase of this project, the City would develop an AWPF on-line monitoring and response plan that provides sufficient features and assurances to demonstrate that any foreseeable AWPF malfunction could be identified and responded to, via product water diversion or other appropriate remedy, within the conveyance time afforded by the purified water conveyance pipeline. Design features would be incorporated into the purified water conveyance pipeline design to drain off-specification water away from the reservoir and to the sewer.

6.6.2. San Vicente Reservoir Retention and Blending

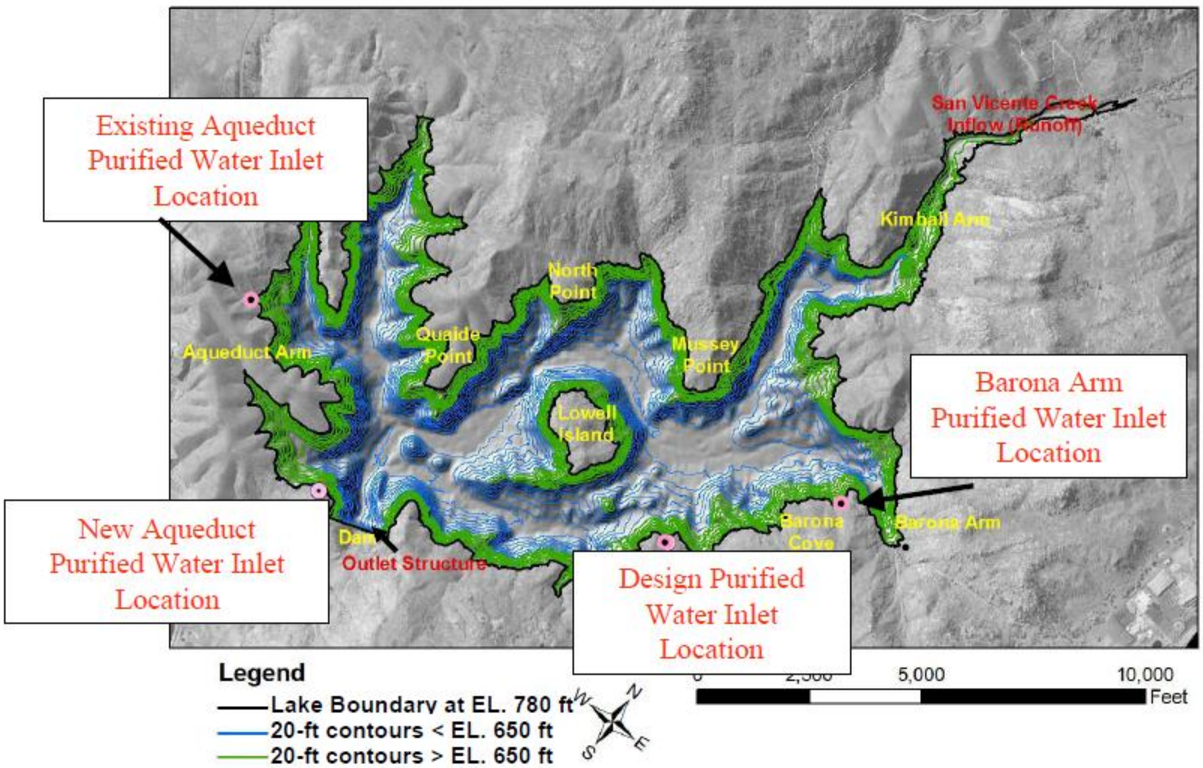
The primary purpose of including San Vicente Reservoir in the full-scale IPR/RA project is to provide substantial retention and blending of purified water in a natural setting prior to delivering it to a water treatment plant for final treatment and distribution. In other words, the reservoir acts as an environmental buffer to significantly dilute any constituents that may be conveyed to the reservoir with the purified water. In the event of a treatment failure not detected by on-line monitoring, such as a source water excursion, San Vicente Reservoir would protect the downstream water treatment plant from receiving compromised source water.

One of the key characteristics of San Vicente Reservoir is the presence of distinct density stratification - a thermocline - separating the epilimnion (the top-most layer in a stratified reservoir) from the hypolimnion (the dense, bottom layer in a stratified reservoir) throughout much of the year. Density stratification persists for about ten months of every year. The consistent and predictable density stratification of San Vicente Reservoir is demonstrated by monitoring data spanning twenty-two years. During the period of stratification, warm light water - and associated constituents - in the epilimnion does readily not mix with the colder heavier water in the hypolimnion. The purified water inflow will be at the surface, and the purified water itself is warm and light; thus, the inflowing purified water will remain in the epilimnion. Outflows from the reservoir are typically deep. This provides is a substantial barrier to short-circuiting of purified water throughout the period of stratification. For a short period each year San Vicente Reservoir loses stratification (i.e., mixes top to bottom). This loss of stratification occurs during winter when the epilimnion cools and water temperature throughout the reservoir equalizes. The fully destratified condition lasts for a few weeks to a month and typically happens in January, February, or March. During the destratified period the reservoir becomes fully mixed, with incoming purified water flows mixing with the entire reservoir volume prior to reaching the reservoir outlet. This mixing and associated dilution would attenuate any AWPF source water excursion or unforeseen extended AWPF malfunction.

As part of the demonstration project, a three-dimensional model of San Vicente Reservoir was developed to evaluate the hydrodynamic and water quality effects of augmenting the reservoir wit purified water (Flow Science, 2010). The model was used to predict residence time, blending, and dilution that will occur over a range of reservoir operating conditions (Flow Science, 2011). The modeling scenarios vaired the following reservoir characteristics.

- Reservoir operations with and without the addition of purified water.
- Operating the reservoir in normal years, over an extended drought, and during an emergency drawdown.
- Introducing purified water into the reservoir in one of four different inlet locations.

Modeled Inlet Locations



The model was calibrated using real-world monitoring data, and validated using field tracer work conducted in the 1990's. The model was then used to simulate eight reservoir operating scenarios. In each of these simulations, various hypothetical tracers were added to the purified water inflow to illustrate the transport, mixing, and dilution of constituents carried with the purified water. In particular, decaying tracers (decay rate of 1 log per month, i.e., a reduction in concentration by a factor of 10 per month) were used to study the dilution and inactivation of potential pathogens entering the reservoir and to evaluate the ability of the reservoir to reduce pathogen concentration before they reach the reservoir outlet. Non-decaying tracers were used to simulate chemical constituents. In all simulations, tracers were added to the reservoir's inflow over a 24-hour period, which is analogous to simulating the reservoir's response to a system failure at the AWPF which leads to the release of off-specification product to the reservoir for a full day. This 24-hour tracer release period was an assumption to support reservoir modeling, and is not related to an hypothetical treatment failure duration.

The IAP reviewed the development and validation of this model and concluded that the model "is a robust tool for simulating reservoir performance" (NWRI, 2010) and "the modeling effort has resulted in an effective and robust model that the City can use to assess the hydrodynamic response of the reservoir" (NWRI, 2012).

There are four key findings of the 3-dimensional hydrodynamic modeling study.

- The addition of purified water into the reservoir does not impact the duration or strength of stratification.
- San Vicente Reservoir provides a substantial barrier to pathogenic organisms due to natural features including photolysis, temperature, and natural predation. Using CDPH's virus reduction metric of 1 log/month in a groundwater setting (this assumption was approved by IAP as reasonable, albeit conservative), San Vicente Reservoir provides greater than 6-log virus reduction for the ten months of each year the reservoir is stratified, and at least a 2-log virus reduction during the destratified portion of the year.
- For all anticipated reservoir operational scenarios and purified water inlet locations, including emergency drawdown and extended drought scenarios, at all times the reservoir provides at least a 200:1 dilution of a 24-hour purified water release event prior to withdrawal from the reservoir.
- During typical operations and using the inlet location currently under consideration (referred to in reservoir hydrodynamic modeling as "design inlet location"), the reservoir provides greater than 2000:1 dilution of a 24-hour purified water release event prior to withdrawal from the reservoir.

6.6.3. Mitigation of a Treatment Failure by San Vicente Reservoir

San Vicente Reservoir provides safety features for both types of hypothetical "treatment failures" in an IPR/RA setting. This mitigation is provided by substantial retention and mixing during the stratified (predominant) portion of the year, and by mixing and dilution during the destratified (lesser) portion of the year.

<u>AWPF Malfunction</u> As noted, the City will develop a plan to identify and respond to an AWPF malfunction using a combination of treatment process integrity and on-line monitoring, plus the travel time in the purified water conveyance pipeline. The reservoir provides a backup protection should that AWPF malfunction last longer than 10 hours. As described above, the minimum dilution a 24-hour release of AWPF flow would undergo in the reservoir prior to withdrawal and conveyance to a downstream water treatment plant is 200:1. This means that in order for a chemical constituent of concern with acute health implications to impair San Vicente Reservoir as a raw water source, the concentration of that constituent over the 24 hour period would need to be in excess of 200 times the applicable MCL or notification level. In reviewing the results of tertiary effluent monitoring at NCWRP over the last several years, there is no monitored chemical constituent that approaches this level.

<u>AWPF Source Water Excursion</u> The primary benefit of the reservoir would be to retain and dilute an extended discharge of a constituent due to its elevated level in the wastewater source to the AWPF, while the AWPF is operating as designed. This benefit can be quantified in terms of mixing and dilution that would be provided by the reservoir during an extended "event." Assuming a monthly comprehensive water quality monitoring frequency, and a second month to identify and respond to a water quality excursion, a hypothetical elevated constituent discharge might occur for up to 60 days before corrected. Assuming the reservoir is a nominal 175,000 AF, for an 18 mgd discharge (highest flow being proposed), it would require that an acutely toxic contaminant level being discharged over that 60 day period (having undergone full AWPF) would need to be roughly 50 times greater than the applicable MCL or notification level to impair the reservoir as a raw water source. This is obviously a highly unlikely scenario.

These scenarios illustrate that implementation of AWPF integrity monitoring combined with the volume and mixing capability in San Vicente Reservoir provides a robust combination of reliability features, assuring that IPR/RA can be implemented at San Vicente Reservoir in a safe and reliable manner.

Section 7 Elements of the Suggested Regulatory Framework

Sections 1 through 6 describe the many studies the City has conducted to assess the potential of blending purified water from the NCWRP into San Vicente Reservoir while maintaining adequate and redundant public health safeguards. The results of these studies have been affirmed by an Independent Advisory Panel and reviewed by the California Department of Health Services. Based on this body of work, and the successful operation of potable reuse projects elsewhere in California, the following elements are offered for CDPH's consideration in establishing the regulatory framework for this project.

- Wastewater source control
  - Establishment of an enhanced source control program for the NCWRP service area similar to that established for Orange County's Groundwater Replenishment System (GWRS) project
- At the North City Water Reclamation Plant (NCWRP)
  - Flow equalization to deliver a constant flow to the AWPF
  - Achievement of full nitrification in the secondary aeration process
  - Operation with no return flows from biosolids processes (biosolids from NCWRP are processed off-site)
  - Tertiary filtered effluent will be the source water for the AWPF
- At the Advance Water Purification Facility (AWPF)
  - Treatment of entire flow stream with reverse osmosis (RO) meeting applicable CDPH specifications and performance measures
  - Treatment of entire flow stream with advanced oxidation (AOP) meeting applicable CDPH specifications and performance measures
  - Implementation of a Critical Control Point Monitoring Plan that includes surrogate indicators recommended by the industry at time of implementation
  - Ability to identify a potential treatment malfunction (based on CDPH-approved on-line process performance monitoring systems), validate that malfunction, and divert AWPF product from the conveyance pipeline in less time than the retention time provided by the conveyance pipeline prior to release to the reservoir (minimum travel time for San Diego project is 10 hours)
  - Certified operator on-site at all times (24 hours/day)
- At San Vicente Reservoir
  - A 12-month theoretical hydraulic retention will be maintained in the reservoir at all times
  - Location of the purified water inflow and the reservoir outflow such that short-circuiting of purified water from the inlet to the outlet is minimized
  - Minimum dilution of purified water with ambient reservoir water, at the outflow, of 100:1 to be maintained at all times
  - Criteria to minimize short circuiting and the criteria for dilution of purified water at the outflow [i.e., the second and third criteria above] to be demonstrated using a calibrated and validated hydrodynamic model

- Purified water will be discharged above the thermocline, and withdrawals will be below the thermocline, when a thermocline is present
- Water from reservoir to be treated at a full conventional water treatment plant before distribution as potable water
- Ability to take the reservoir offline as a source of supply to the municipal water system within 24 hours to be maintained at all times

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