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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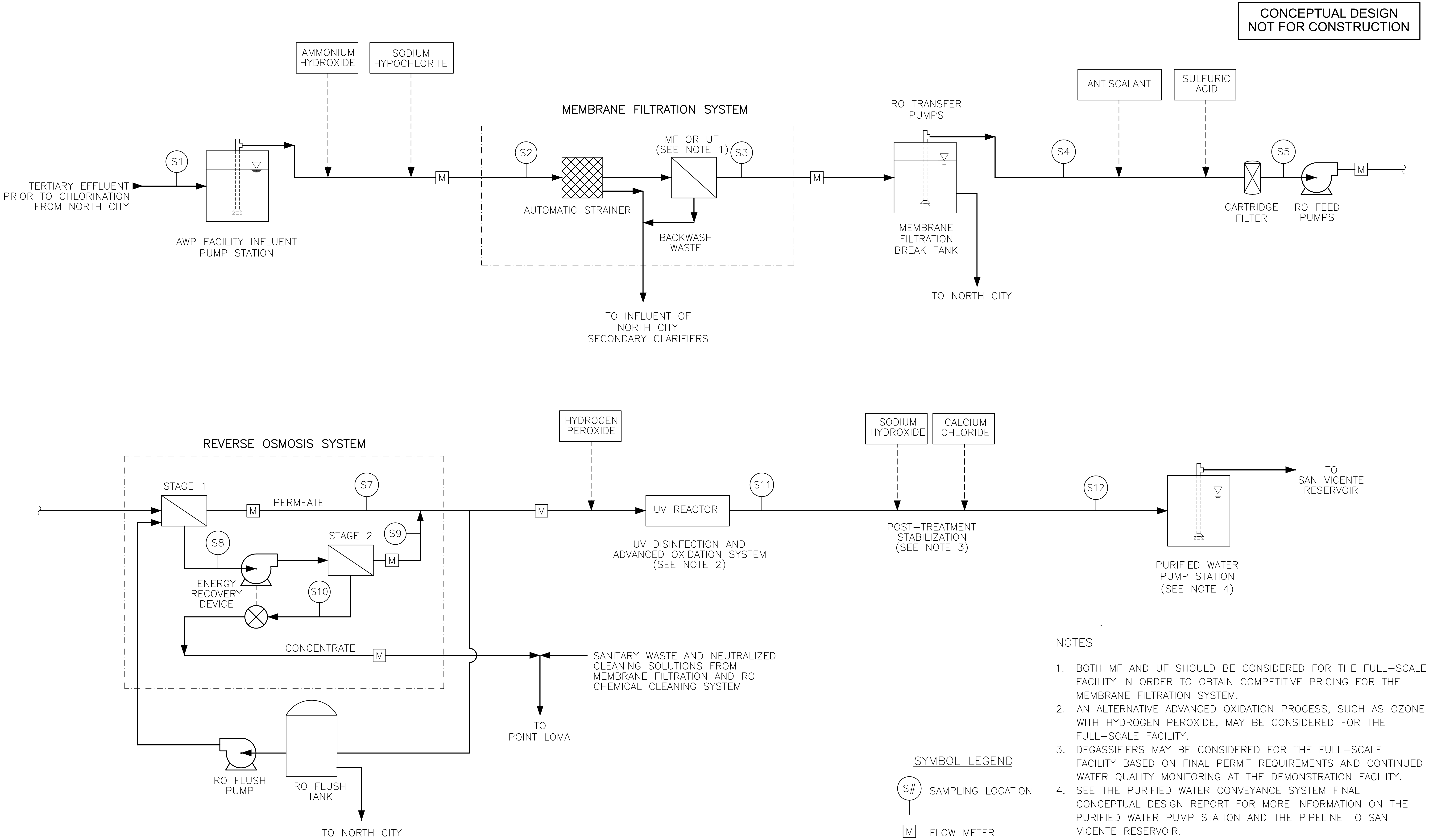

NOTES

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 AUGMENTATION DEMONSTRATION PROJECT

FULL-SCALE FACILITY PROCESS FLOW DIAGRAM (JANUARY 2013)

FIGURE 4-1

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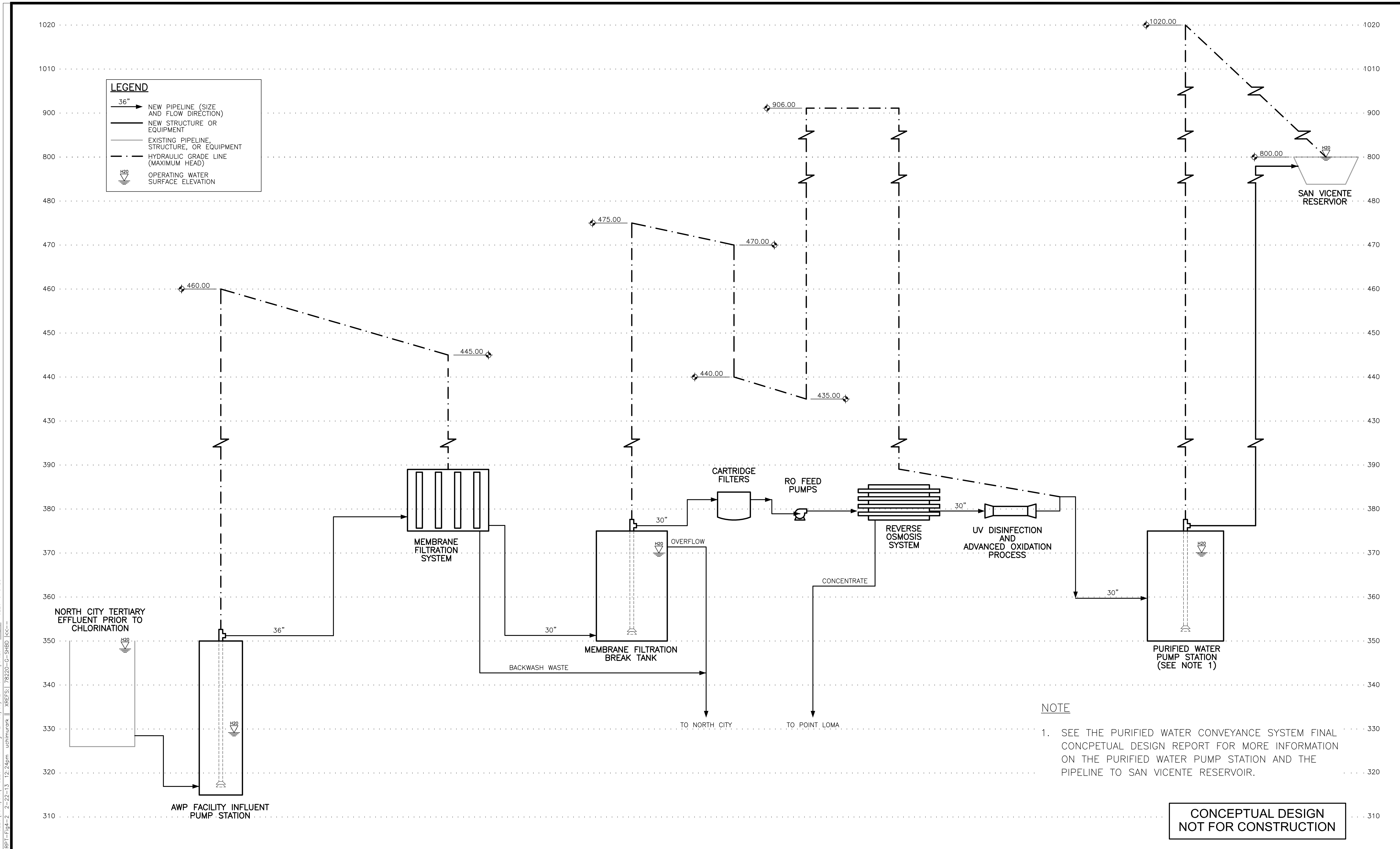

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FULL-SCALE FACILITY HYDRAULIC PROFILE (JANUARY 2013)

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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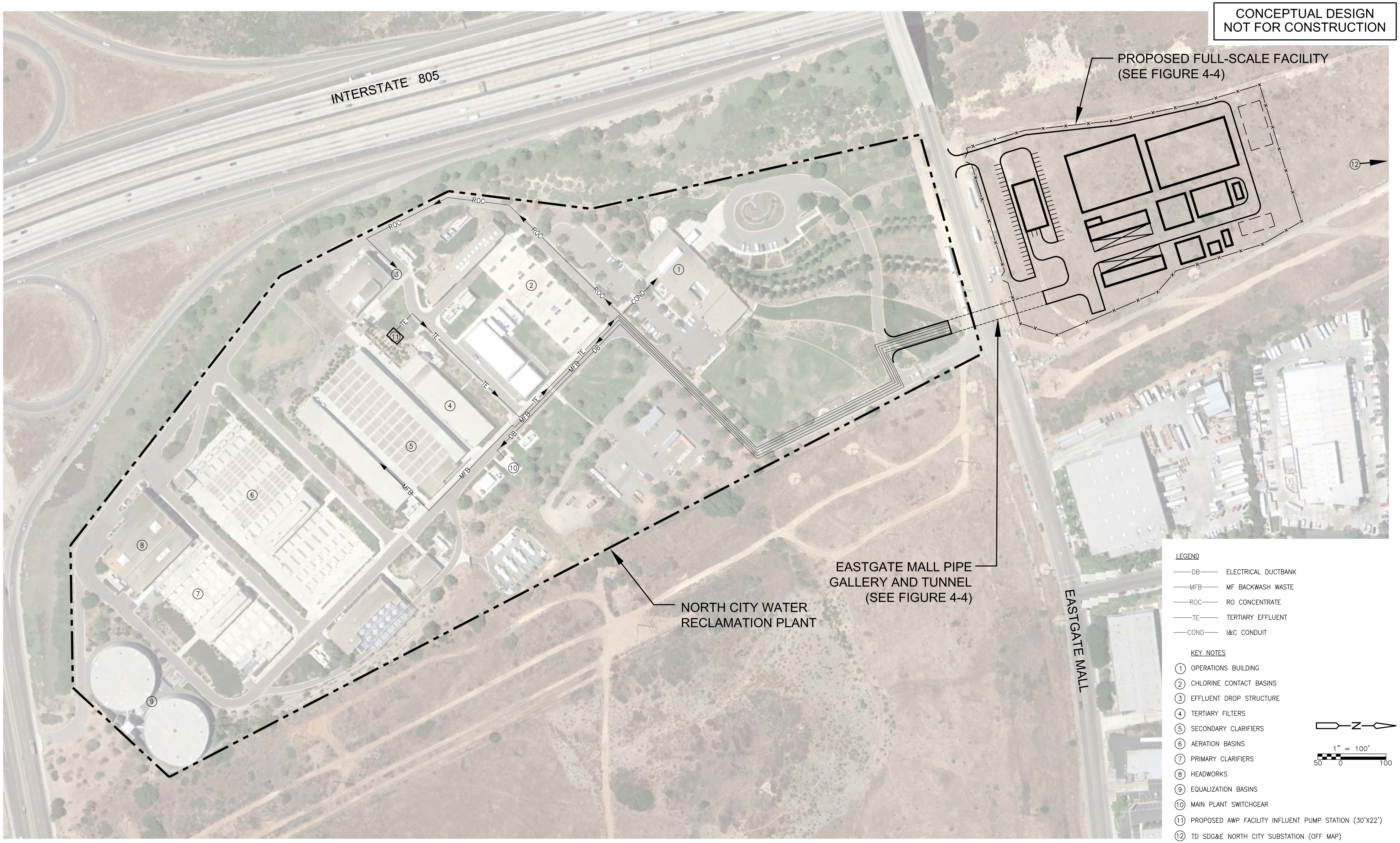

CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR AUGMENTATION DEMONSTRATION PROJECT

FULL-SCALE FACILITY PROPOSED IMPROVEMENTS (JANUARY 2013)

FIGURE 4-3

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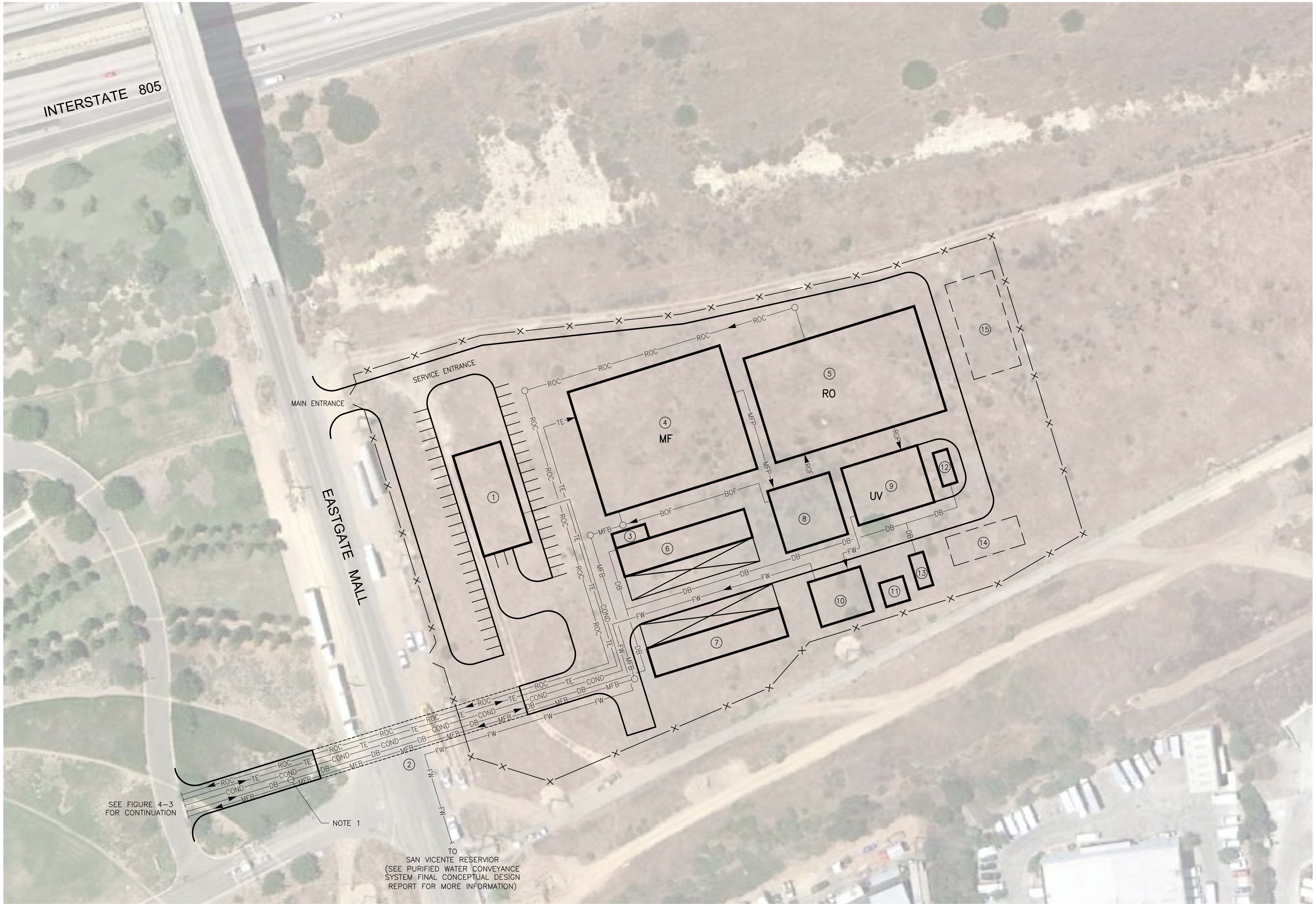

LEGEND

—X—X—	CHAIN LINK FENCE
(box with X)	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 AUGMENTATION DEMONSTRATION PROJECT

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

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

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.

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FULL-SCALE FACILITY DESIGN CRITERIA II (JANUARY 2013)

FIGURE 4-6

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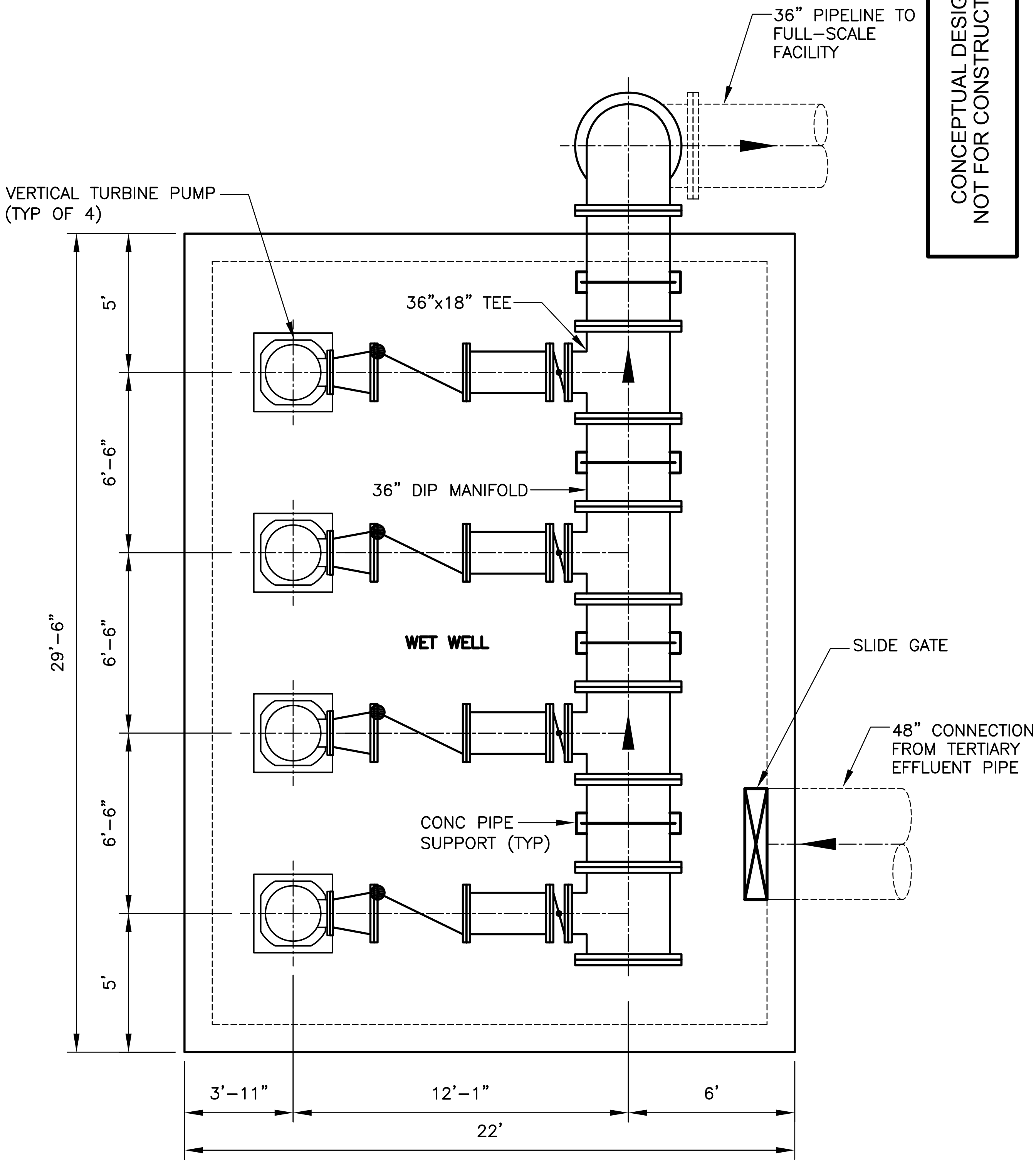

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CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR AUGMENTATION DEMONSTRATION PROJECT

FULL-SCALE FACILITY INFLUENT PUMP STATION LAYOUT (JANUARY 2013)

FIGURE 4-7

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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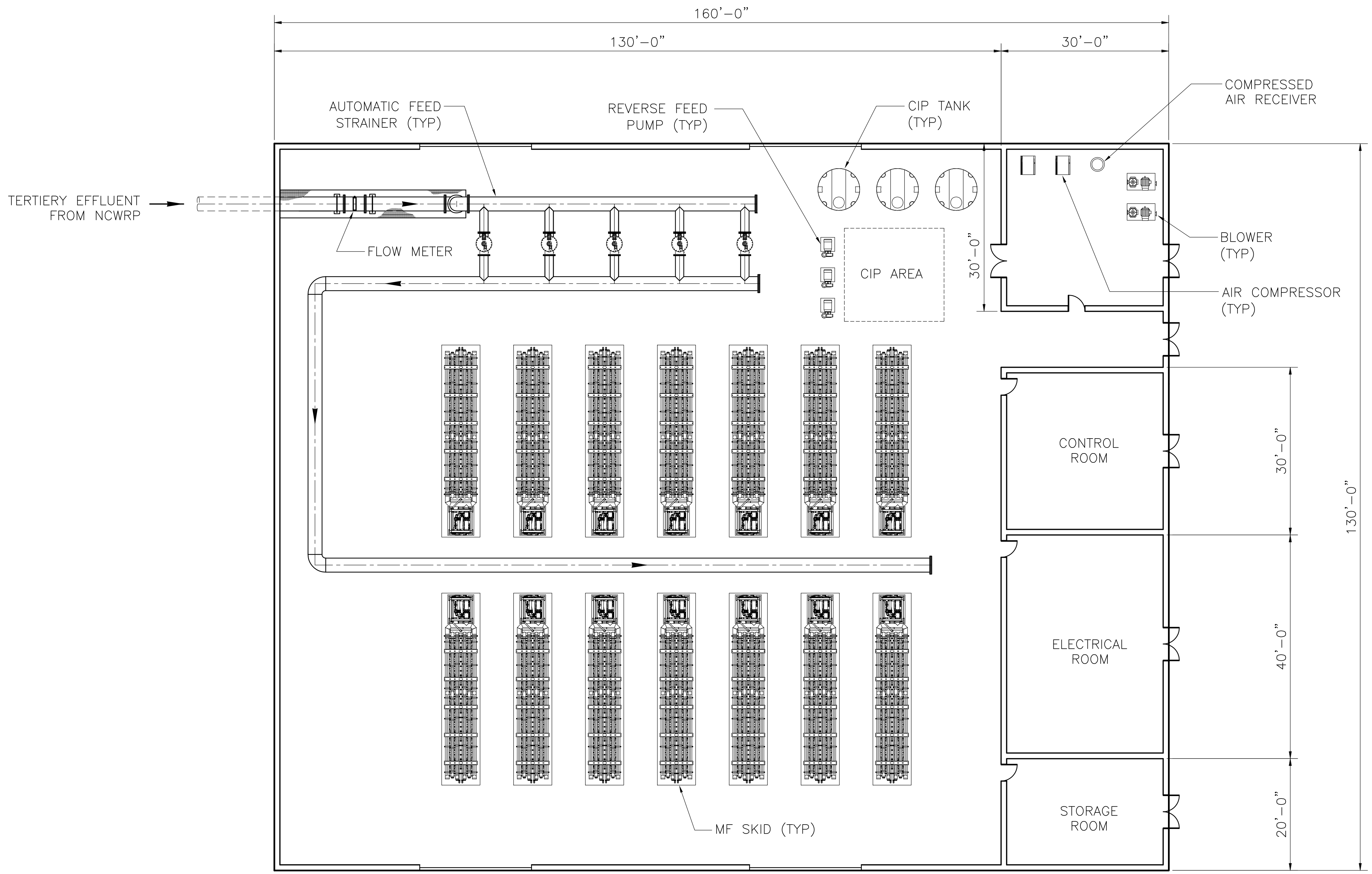

PLAN
3/32"1–=0"

3/32" = 1'– 0"

CITY OF SAN DIEGO INDIRECT POTABLE REUSE/RESERVOIR
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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.

CONCEPTUAL DESIGN
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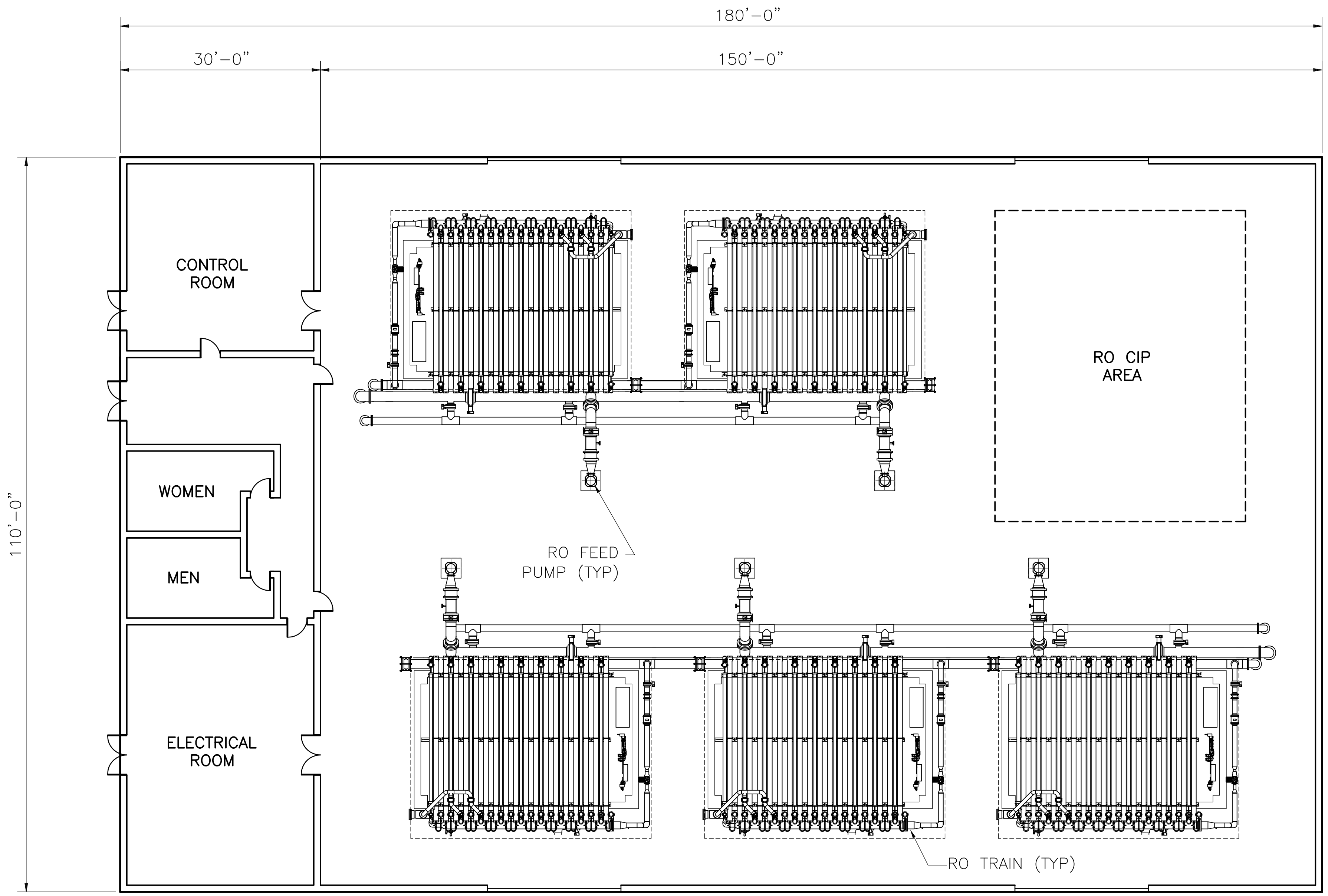

PLAN
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3/32" = 1'– 0"
8 0 8 16

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

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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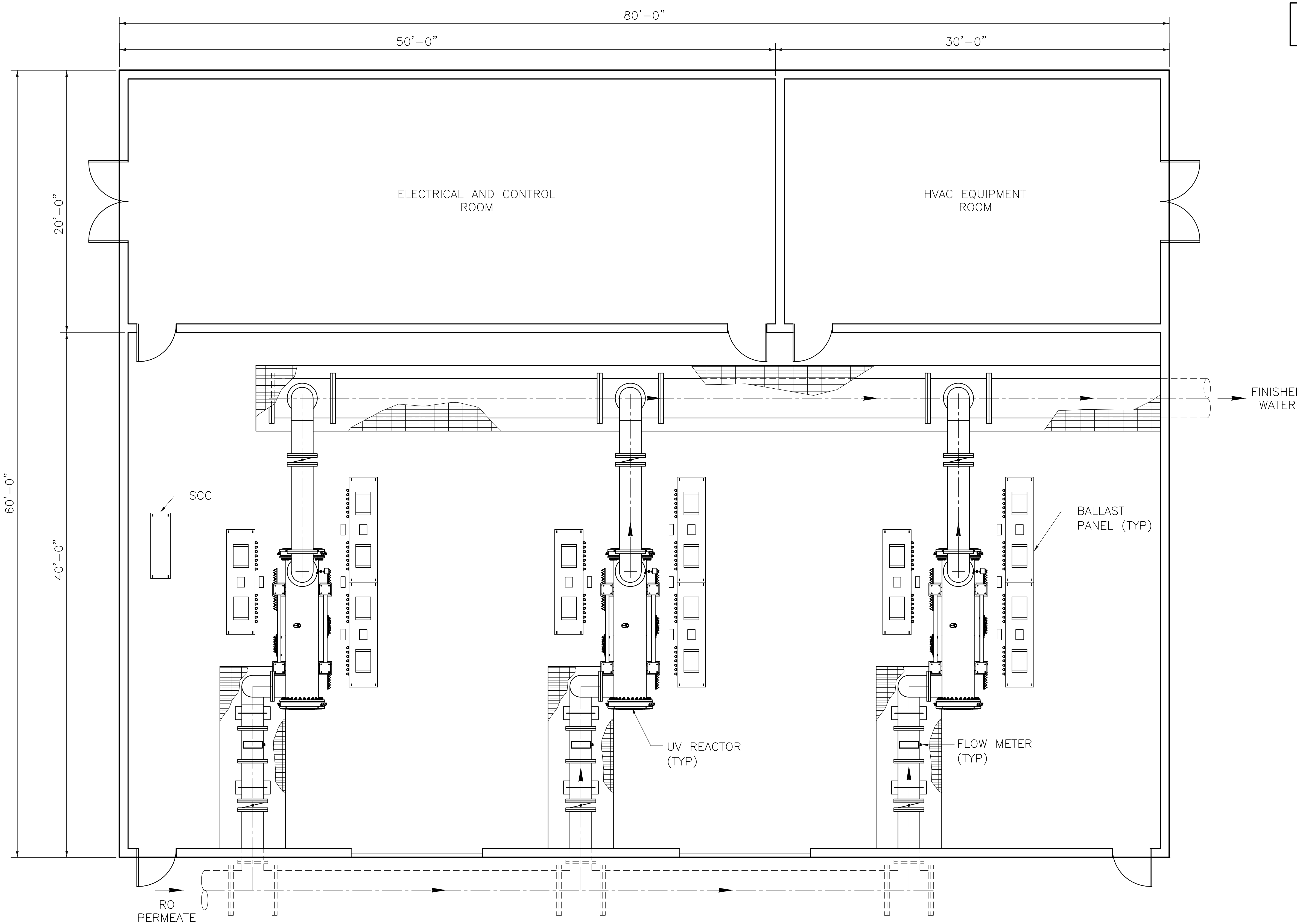

PLAN
1/4"=1'–0"

1/4" = 1'– 0"
2 1 0 2 4

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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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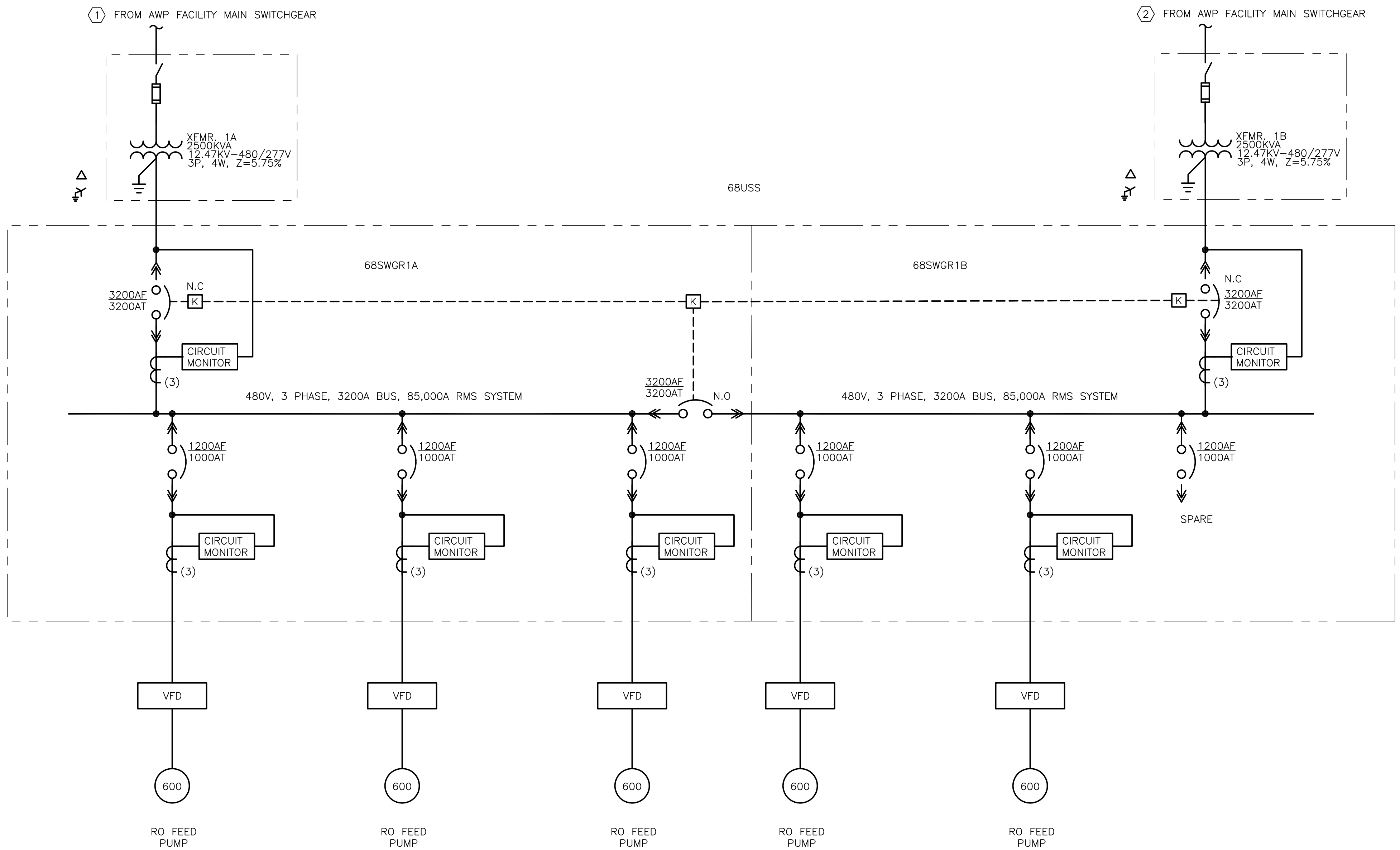

68SWGR1A AND 68SWGR1B

ONE LINE DIAGRAM

N.T.S.

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

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

FIGURE 4-11

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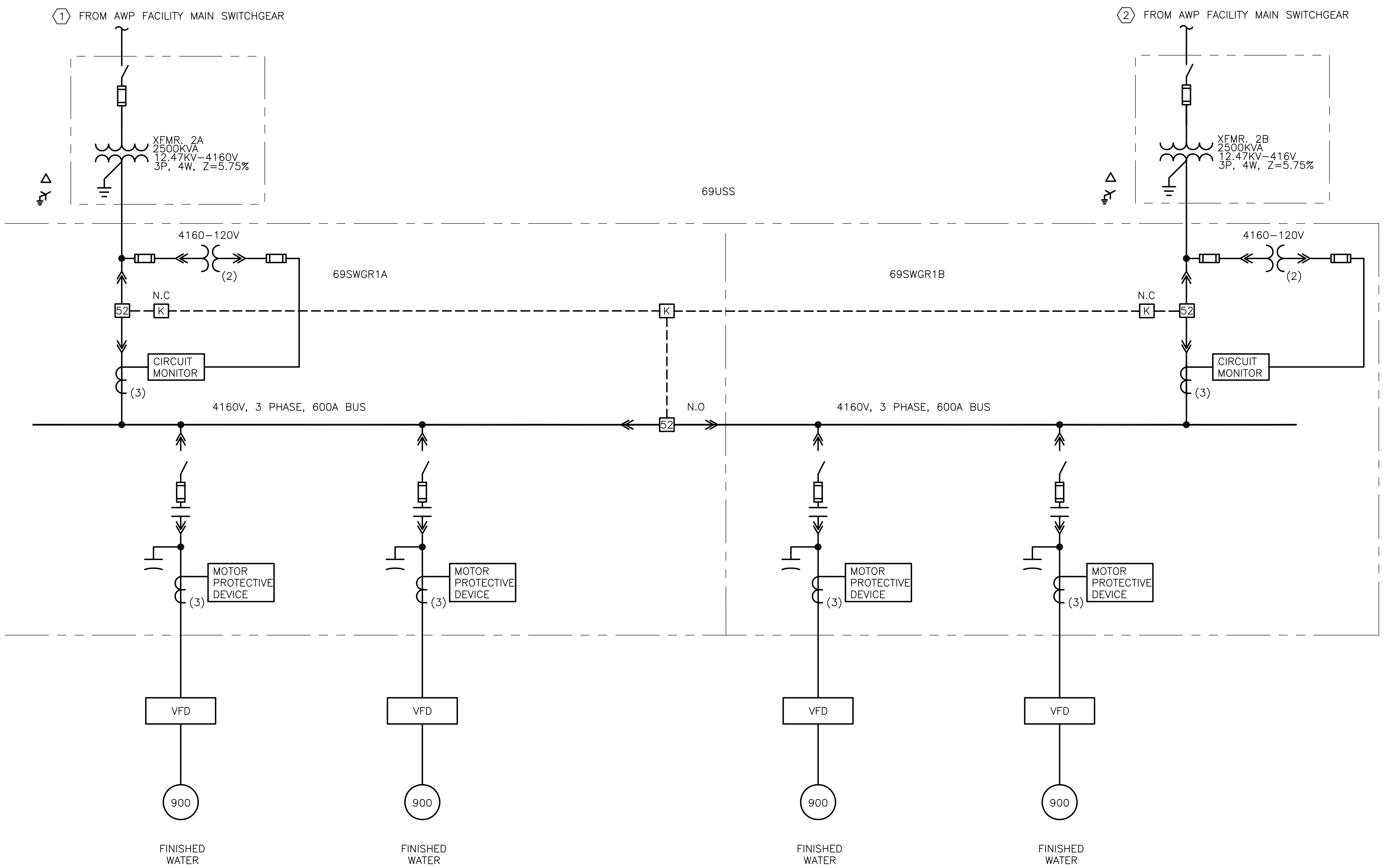

69SWGR1A AND 69SWGR1B

ONE LINE DIAGRAM

N.T.S.

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

FIGURE 4-12

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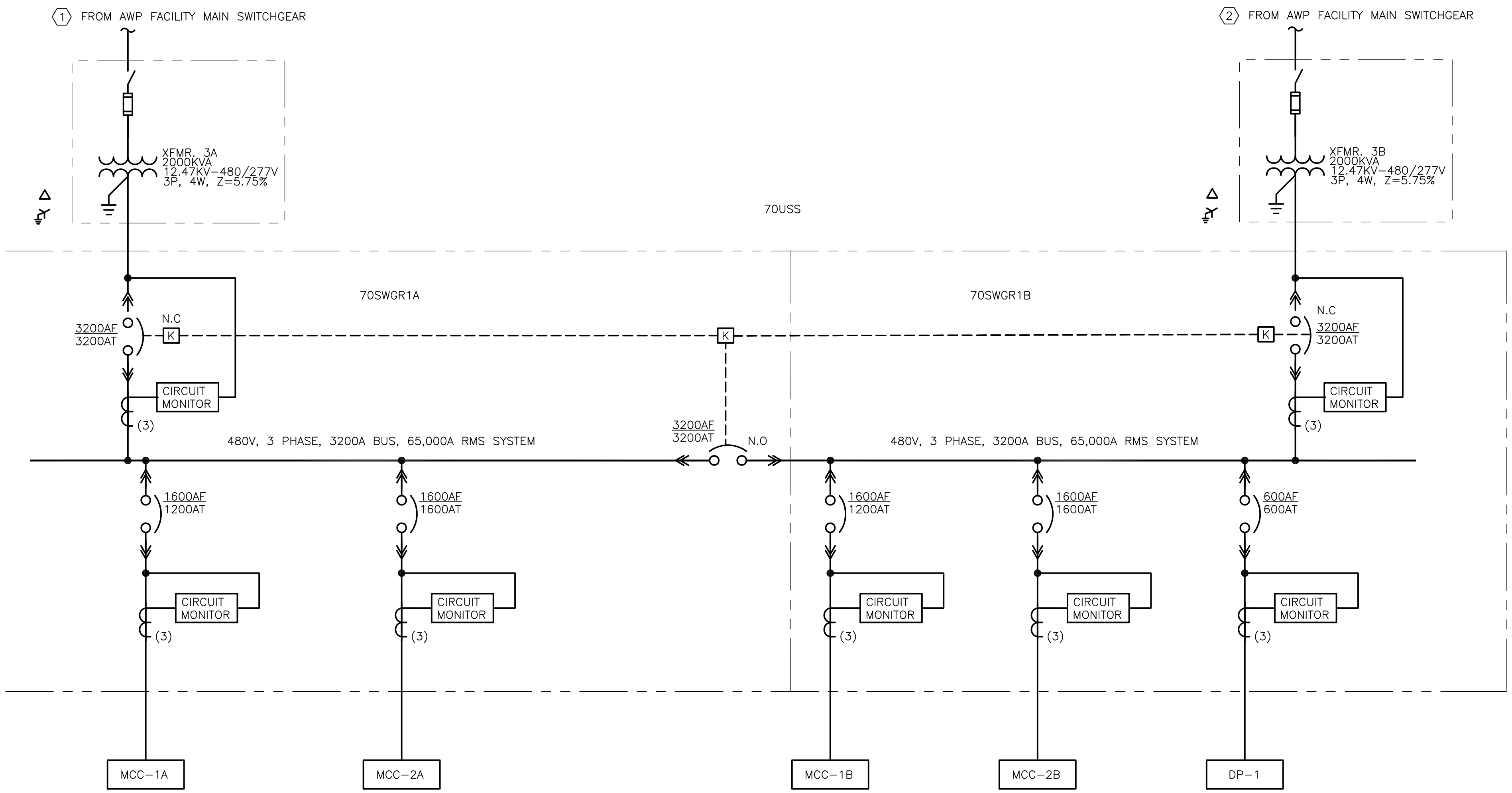

70SWGR1A AND 70SWGR1B

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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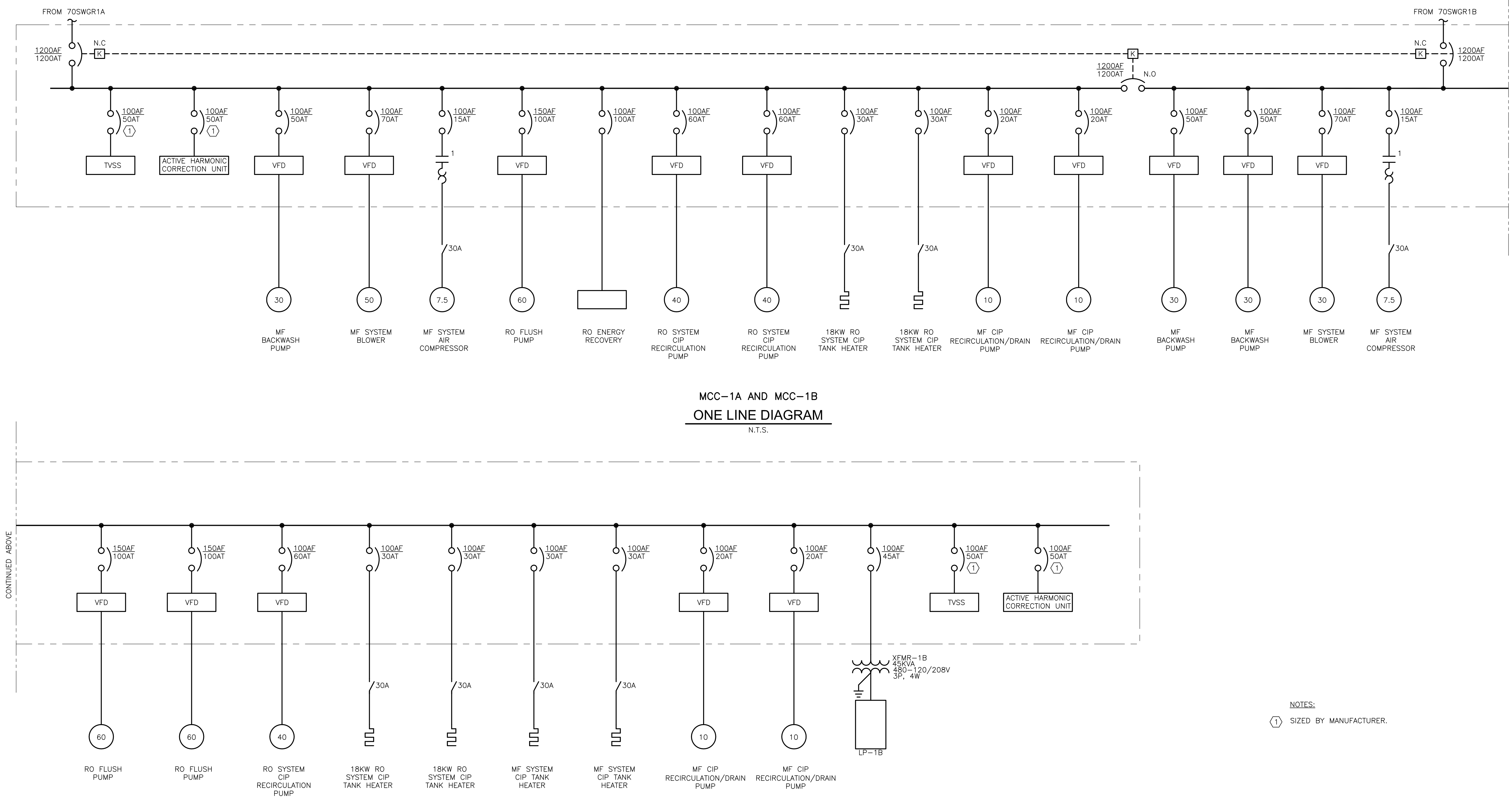

MCC-1A AND MCC-1B

ONE LINE DIAGRAM

N.T.S.

NOTES:

(1) SIZED BY MANUFACTURER.

CONCEPTUAL DESIGN
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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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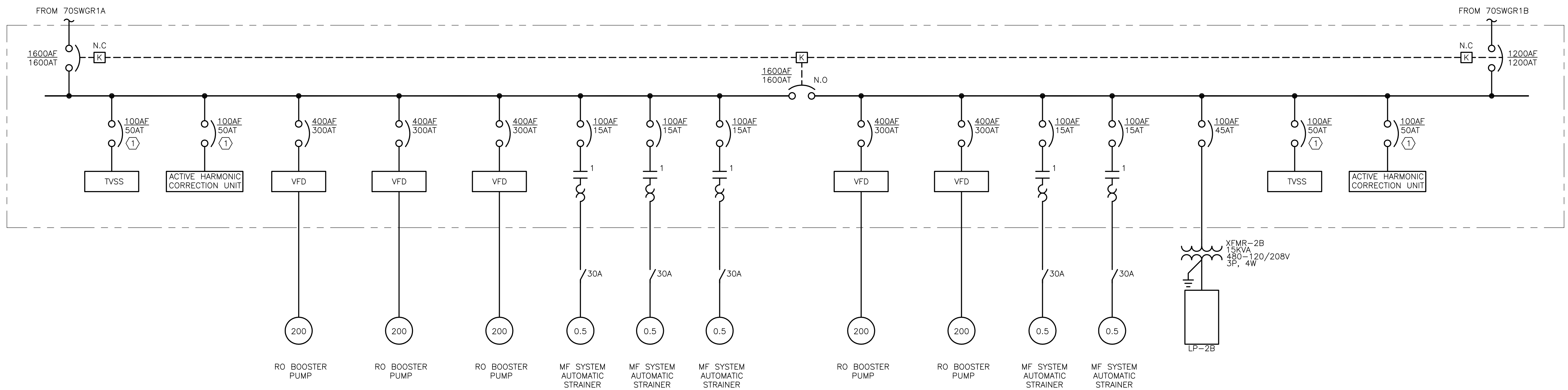

MCC-2A AND MCC-2B

ONE LINE DIAGRAM

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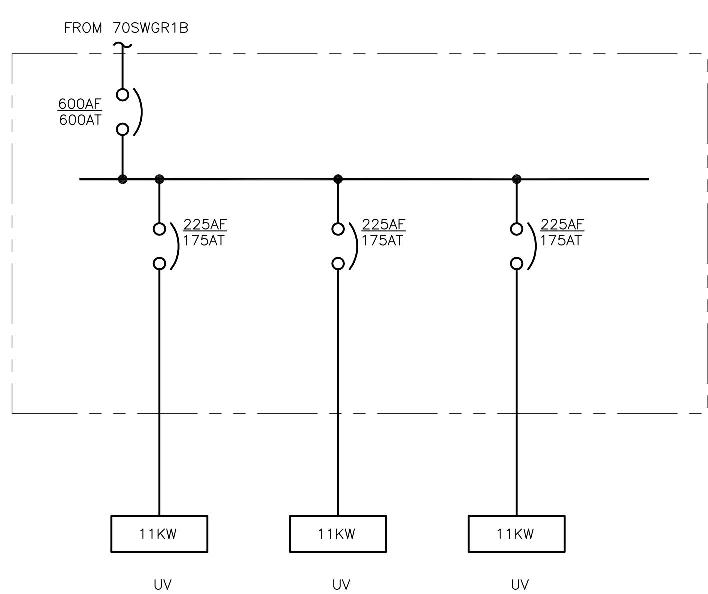

DP-1

ONE LINE DIAGRAM

N.T.S.

NOTES:

(1) SIZED BY MANUFACTURER.

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

FIGURE 4-15

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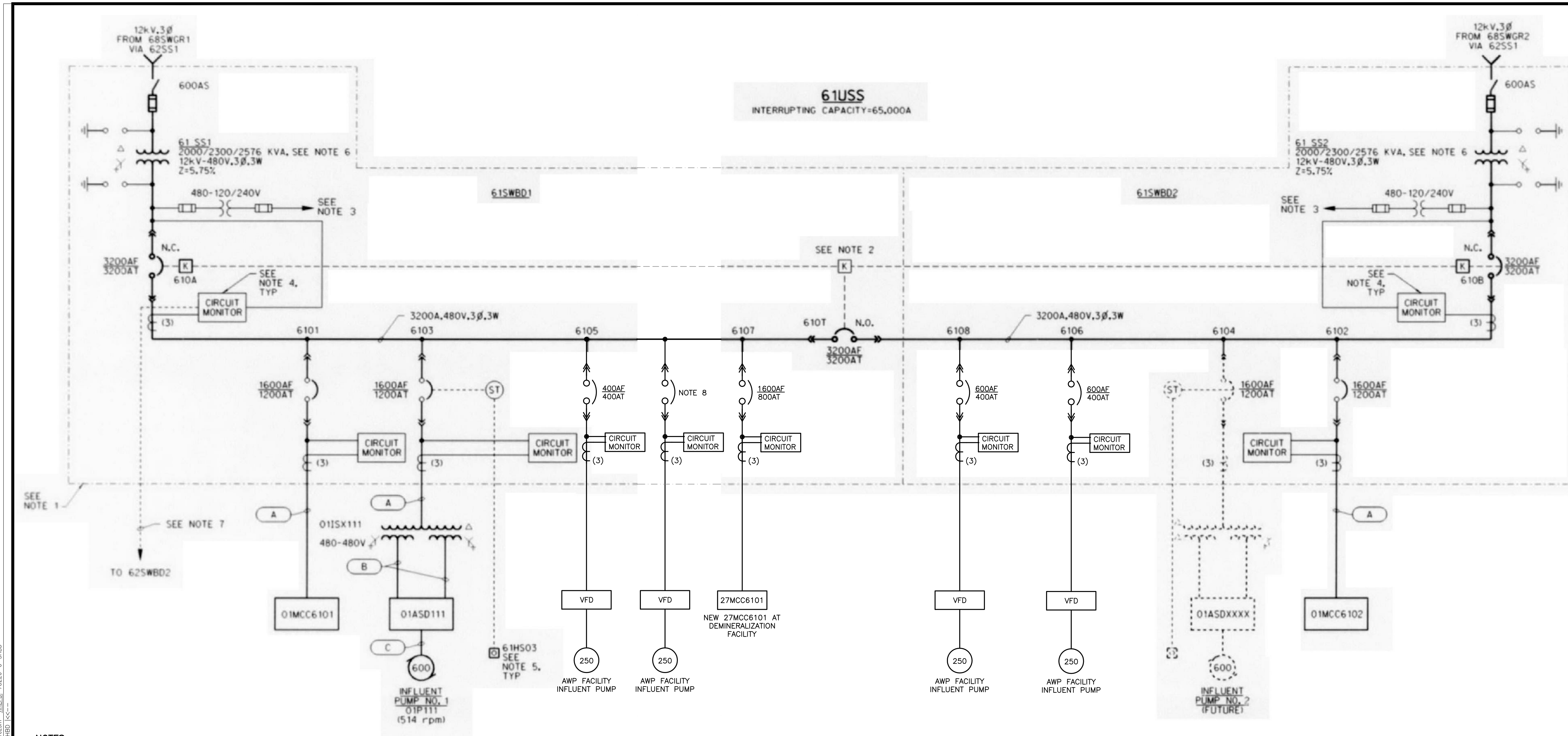

NOTES:

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
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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.