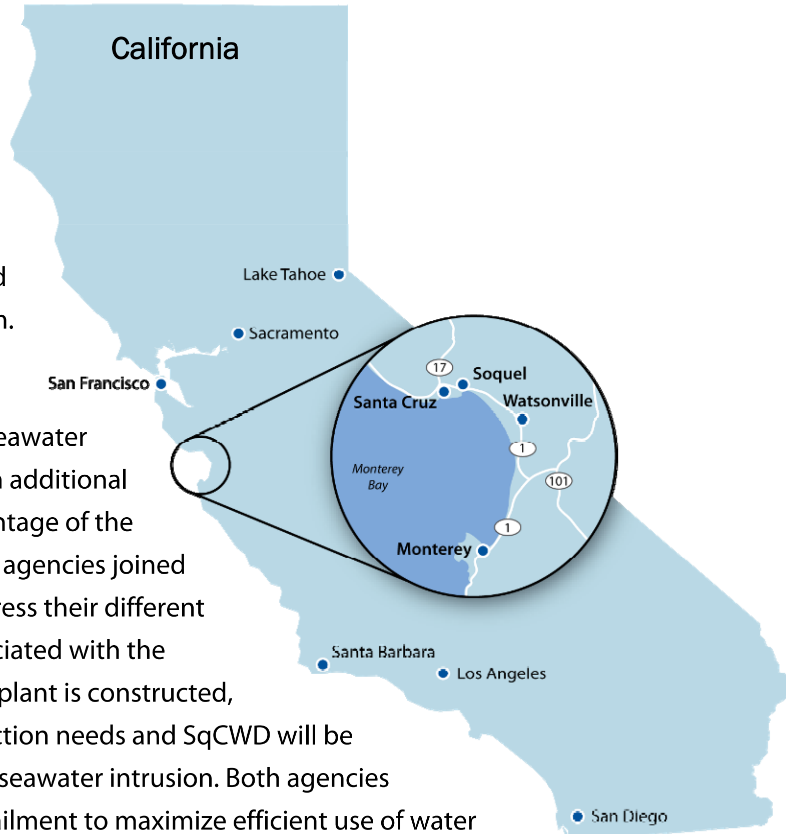
Section 1

Pilot Test Program Introduction

The City of Santa Cruz Water Department (SCWD) and Soquel Creek Water District (SqCWD) depend entirely upon local surface waters and groundwater to meet the needs of their customers. However, SCWD's surface waters are frequently diminished by droughts and SqCWD's groundwater supply is threatened by declining water levels and seawater intrusion.

Each agency conducted separate integrated water planning processes and each identified seawater desalination as the best option for delivering an additional flexible and reliable water source. To take advantage of the benefits derived from a cooperative facility, the agencies joined together, forming the **scwd²** Task Force, to address their different needs and to share the investigative costs associated with the potential desalination plant. If the desalination plant is constructed, SCWD will be able to address its drought protection needs and SqCWD will be able to protect its groundwater resources from seawater intrusion. Both agencies will continue to practice conservation and curtailment to maximize efficient use of water resources.



Santa Cruz is located on the northern coast of Monterey Bay

1.1 Report Organization

This report summarizes the results of the Seawater Reverse Osmosis (SWRO) Desalination Pilot Test Program. The test program was conducted from March 2008 to April 2009. The report describes the activities and results of the pilot test program and is organized as follows:

- **Executive Summary** – the key results and findings of the pilot test program.
- **Section 1, Pilot Program Introduction** – the pilot program purpose, activities, location and test facilities.
- **Section 2, Public Outreach Program** – the public outreach activities included as part of the pilot test program.
- **Section 3, Source Water Monitoring and Treated Water Quality Objectives** – the historical water quality and pilot test monitoring results for key source water quality indicators.

- **Section 4, Permeate Water Quality Results and Special Treatment Studies** – additional information on water quality objectives and the results from the pilot program in regards to 1) project-specific salinity goals and results, 2) project-specific post-treatment goals and results, and 3) regulatory goals and results.
- **Section 5, Pretreatment System Results** – the pretreatment testing objectives and results.
- **Section 6, Performance of the RO System Alternatives** – the RO desalination system testing objectives and results.
- **Section 7, Treatment System Comparison** – the approach, key assumptions and findings from comparing the treatment system alternatives.
- **Section 8, Recommended Treatment Process and Cost Estimates** – describes the recommended treatment process and design criteria and presents the estimated range of capital and annual costs for a desalination facility that would deliver 2.5 million gallons per day (mgd) of desalinated seawater.
- **Appendices** – provide more detailed information on the testing equipment and activities and tests performed including process flow diagrams, pilot plant equipment design criteria, reports submitted for special studies, and the pilot plant testing data charts.
  - Appendix A includes Technical Memoranda (TM) which present the nine investigations performed for the Proposition 50 grant (TM Nos. 1-9), the detailed results of the source water and product water quality monitoring (TM Nos. 10 and 11), and the alternatives comparison process used to determine the recommendations for the facility (TM No.12).
  - Appendix B includes additional information on the pilot testing equipment.
  - Appendix C includes copies of the public outreach materials developed for the program.
  - Appendix D includes the UCSC final report on algal blooms and red tide events in Monterey Bay.
  - Appendix E includes the University of Washington final report on corrosion control.
  - Appendix F includes the RO and UF membrane autopsy reports.
  - Appendix G includes the water quality monitoring data, pilot equipment operations and data charts and pilot study update reports.
  - Appendix H includes the design documents developed for the pilot plant site improvements.
  - Appendix I includes the pilot plant protocol.

1.2 Program Purpose and Activities

The purpose of the pilot program was to establish optimal design and operating parameters for the desalination facility. The pilot test program was funded by the SCWD, SqCWD, and by the State of California through grant money received from the Department of Water Resources (Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002).

The goals of the pilot program were to demonstrate the best desalination technology, test any special treatment needs, and provide water quality data for regulatory approval and permitting. The primary activities conducted to achieve these goals were:

- **Water Quality Monitoring** – 13 months of water quality monitoring was conducted at the proposed intake location as well as the pilot plant to characterize source water quality and product water quality.
- **Pretreatment Comparison** – Granular media filtration (GMF), slow sand filtration (SSF), and two ultrafiltration (UF) systems were tested as pretreatment upstream of the reverse osmosis (RO) desalination membranes.
- **Reverse Osmosis Pilot Testing** – Multiple RO membranes and RO system configurations were evaluated with respect to product water quality and energy consumption.
- **Additional Activities** – Additional activities included a public outreach program, several investigations necessary to fulfill the requirements of the Proposition 50 grant, and special water quality studies.

1.2.1 Water Quality Monitoring

Water quality monitoring was conducted at the proposed intake and the pilot plant for physical, inorganic, organic and microbial constituents. Continuous recording analyzers were used at both locations, and grab sample based monitoring was conducted at both locations on weekly, 12-day, monthly and quarterly frequencies. The purpose was to 1) determine if the seawater supply to the desalination plant had higher than anticipated concentrations of inorganic, organic, and microbial contaminants, including algal toxins and pharmaceutical and personal care products, 2) evaluate seasonal water quality variation and how it might impact performance of the desalination treatment process, 3) confirm that the treatment process alternatives would produce desalinated water that meets drinking water regulations and project-specific water quality and operational goals, and 4) compare the source water from the LML intake with source water at the proposed intake location.

1.2.2 Pretreatment Comparison

Pretreatment requirements vary depending on source water quality and the type of intake used to provide water to the desalination facility. The majority of desalination facilities use open ocean intakes, however, there are several potential benefits associated with the use of subsurface intakes including the potential for reduced environmental impacts, reduced pretreatment, and simplified permitting requirements. An intake study is currently being conducted to determine the feasibility of constructing a subsurface intake along the Santa Cruz coast.

RO desalination plants with open ocean intakes and ineffective pretreatment require frequent cleanings and membrane replacement, resulting in excessive downtime and higher operation and maintenance (O&M) costs. The pretreatment testing activities were conducted to identify the pretreatment processes that are sufficiently robust to provide a reliable and cost-effective desalination plant. The testing indicated that a successful pretreatment system is one that can adjust to variations in source water quality including storm and red tide events. Evaluation of the results identified both design and operational strategies to minimize fouling of the RO membranes during challenging source water quality variations, which is expected to reduce long-term 1) energy use, 2) membrane cleaning, 3) membrane replacement, and 4) other O&M activities and costs.

RO desalination plants with subsurface intakes (e.g., beach wells and offshore infiltration galleries) may be able to reduce the amount of pretreatment ahead of RO because the biologically active filtration provided by natural sediments provides some of the benefits of pretreatment. However, subsurface intakes are often limited to locations with favorable geology, are more expensive than open ocean intakes in terms of initial construction and capital costs, and may potentially have higher O&M costs. There is a lack of sufficient operating data from existing SWRO plants to conclude that a subsurface intake would preclude the necessity for pretreatment and extensive O&M requirements without additional testing.

1.2.3 RO Pilot Testing

The RO membranes and RO system configuration determine energy use and product water quality at a plant. Design considerations are a balance between achieving target water quality parameters (e.g., salt concentrations), providing the lowest energy use, and minimizing construction costs. The RO pilot testing activities were developed to determine the RO system configuration and membranes that will provide the desired balance between these three variables.

1.2.4 Additional Activities

The public outreach activities included public events, tours, and information materials and are summarized in Section 2. The Proposition 50 grant investigations are described below in Section 1.3. The special studies included the harmful algal bloom and toxin assessment report included in Appendix D prepared by Dr. Raphael Kudela with the University of California Santa Cruz, and the corrosion study included in Appendix E conducted by Dr. John Ferguson and Dr. Gregory Korshin of the University of Washington. The Watershed Sanitary Survey conducted by Archibald Consulting will be published under a separate cover.

1.3 Pilot Test Program Investigations

The pilot test program was conducted around a framework of nine primary investigations that are listed below. The objectives and description of each investigation are described in Table 1-1.

1. Pretreatment Comparison – compare pretreatment alternatives to minimize RO membrane fouling.
2. RO Performance Evaluation – achieve target water quality parameters with the lowest energy use.
3. Boron Rejection – determine the need for a second pass RO system and compare alternative operational strategies to enhance boron removal.
4. Algal Toxins and Emerging Contaminants – monitor the occurrence and rejection of selected algal toxins, pharmaceuticals and steroids.
5. New On-line Methods for RO Integrity Monitoring – compare the sensitivity and usefulness of selected on-line monitoring methods.
6. No Chemical Pretreatment – evaluate the performance of selected pretreatment alternatives without any coagulant chemicals or disinfectants.
7. Disinfection By-Product (DBP) Formation – evaluate design considerations to limit DBP formation in the distribution system.
8. Distribution System Water Quality and Corrosion Control – evaluate post-treatment design considerations to limit lead, copper, and iron release in the distribution system.
9. Toxicity of the Concentrate/Wastewater Treatment Facility Effluent Blend – assess the necessity of performing toxicity tests for permitting the RO concentrate (brine) discharge.

Investigations 1 through 5 were specifically required to fulfill the requirements of the Proposition 50 grant. Investigations 6 through 9 provided additional data to address project specific concerns and assist in permitting of a facility. TM Nos. 1 through 9 in Appendix A present the results of the investigations in more detail.

Table 1-1. Pilot Plant Investigations

No.	Investigation	Objective	Description
1.	Pretreatment Comparison	Evaluate multiple treatment approaches for each filter technology and select the approaches to be evaluated during the remainder of the study.	• Perform bench-scale tests to select the coagulant chemical and dose. • Evaluate the impacts of filtration rate, chemical addition, sedimentation, and cleaning methods. • Compare pretreated water quality variables with downstream fouling of the RO membranes.
2.	RO Performance Evaluation Including a Two-stage LPRO/SWRO Membrane Configuration	Evaluate and optimize RO membrane performance and energy consumption using selected RO membranes and RO process configurations.	• Predict performance with computer projections and confirm with pilot-scale performance. • Simultaneously evaluate different pretreatment systems, RO membranes and RO process configurations. • Evaluate performance based on treated water goals, fouling trends, and operating costs.

Table 1-1. Pilot Plant Investigations

No.	Investigation	Objective	Description
3.	Boron Rejection	Evaluate boron rejection of selected RO membranes and RO system configurations.	• Monitor boron levels in the RO permeate and determine the necessity of a "second pass" RO system configuration. • Test a partial second pass RO configuration. • Compare operational strategies (e.g., pH adjustment and flux increase) to enhance boron removal.
4.	Emerging Contaminant and Algal Toxin Rejection	Evaluate the occurrence and rejection of emerging contaminants and algal toxins.	• Quarterly sampling and analysis for emerging contaminants and algal toxins. • If a harmful algal bloom does not occur, determine algal toxin rejection by spiking with a surrogate.
5.	New On-line Methods for RO Membrane Integrity Monitoring	Evaluate the sensitivity of automated methods to monitor the integrity of RO membranes during continuous operation.	• Monitor baseline turbidity, particles and conductivity in the RO permeate with a laser turbidimeter, particle counter, and conductivity meter. • Conduct dye challenge tests. • Breach membrane integrity to test sensitivity.
6.	Pretreatment Alternatives without Chemicals or Disinfectants	Investigate viability of "no chemical and no disinfectant" pre-treatment alternatives for a SWRO plant.	• Operate complete treatment trains using UF and SSF with no chemical addition (i.e., no coagulants, antiscalant, and chemical disinfectants prior to the RO process). • Evaluate UV disinfection for bio-fouling mitigation. • Evaluate slow sand filtration as a viable pretreatment method for SWRO.
7.	DBP Formation Testing	Characterize the change in distribution system concentrations of DBP from blending desalinated water with treated surface water.	• Analyze the DBP formation potential of different blends of desalinated water and SCWD treated surface water, using free chlorine for residual disinfection. • Evaluate the impact of different bromide concentration in the desalinated water on the DBP formation of the blends.
8.	Distribution System Water Quality and Corrosion Control	Characterize the change in lead and copper concentrations in the distribution system from blending desalinated water with treated surface water. Evaluate the potential for releasing iron from corrosion tubercules in the existing distribution system pipes.	• Conduct coupon testing to evaluate the corrosivity of different blends of desalinated water and SCWD treated surface water. Evaluate different water characteristics (e.g., pH, alkalinity, corrosion inhibitor doses) for the desalinated water.
9.	Toxicity of the Concentrate/ Wastewater Treatment Facility Effluent Blend	Determine blending ratios of RO concentrate and WWTP effluent that would be compatible with the existing wastewater discharge permit.	• Conduct a desktop analysis to characterize potential blending ratios of RO concentrate and WWTP effluent to determine the brine storage required to provide flow equalization. • Meet with the RWQCB to determine if bioassay toxicity testing and additional data would be required for permitting the discharge of the concentrate/wastewater effluent blend.

1.4 Pilot Study Location and Facilities

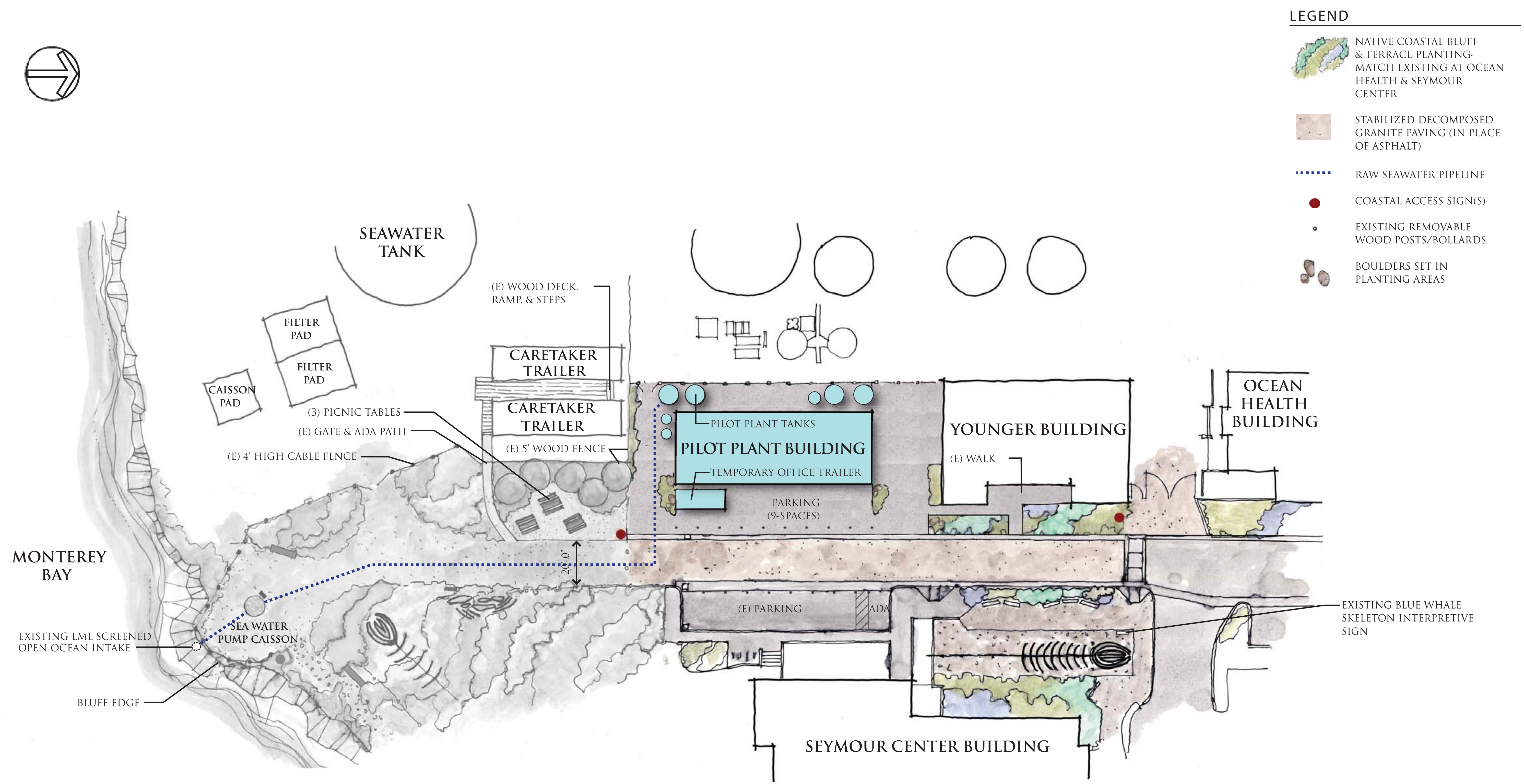
The pilot study was conducted at the University of California Santa Cruz Long Marine Laboratory (LML). Source water for the pilot study was provided from existing LML open ocean intakes. Raw seawater was conveyed from the intake to the pilot testing equipment via a buried pipeline prior to the LML filtration system. Figure 1-1 shows a site plan of the intake and pilot plant building at the LML.

The pilot plant equipment was located inside a temporary 30 foot by 80 foot building with some tanks located exterior to the building as shown in Figure 1-1. Major equipment included the following systems:

Pilot Plant Building at the LML

- Raw Water Supply and Storage.
- Pretreatment Systems:
  - Disk strainer with 100 micron nominal removal.
  - Flocculation and sedimentation basins.
  - Granular media filters.
  - Slow sand filters.
  - Submerged ultrafiltration system (Zenon Zeeweed 1000 membranes).
  - Pressurized ultrafiltration system (Norit XIGA SXL225 membranes).
- Four RO desalination systems.
- RO permeate and concentrate blend tank for discharge to the LML filtered seawater line for re-use.
- Chemical storage and feed systems:
  - Chlorine dioxide generator.
  - Containment for bulk chemical storage.
  - Chemical storage and feed systems.
- Residuals storage and discharge systems:
  - Sump and pumps to transfer gravity drain water and settled sludge to the residuals storage tanks for disposal.
  - Residuals storage tanks for equalization and discharge of waste streams to the sewer.
- Data acquisition system.

Equipment Installed in the Pilot Plant Building



Source: Long Marine Lab Public Access & Pilot Study Prepared By - Joni L. Janecki & Associates, Inc., August 4, 2006

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Figure 1-1
Conceptual Layout of the Pilot Plant Facilities at the UCSC Long Marine Laboratory

Table 1-2 provides a summary of the water quality parameters which were monitored onsite using online and bench-top instruments.

Table 1-2. Summary of Onsite Water Quality Monitoring Parameters

Parameter	Raw Seawater	Settled Water	Pre-treated Water	RO Permeate	RO Concentrate
Turbidity	Continuous	Continuous	Continuous	Grab	Grab
Particles	Grab	Grab	Continuous for UF; grab for GMF & SSF	Grab	Grab
Silt Density Index	Grab	N/A	Grab	N/A	N/A
UV_{254} Absorbance	Grab	Grab	Grab	Grab	Grab
pH	Continuous	Continuous	Continuous	Grab	Grab
Temperature	Continuous	Continuous	Continuous	Grab	Grab
Conductivity	Grab	Grab	Continuous	Continuous	Continuous

The pilot plant equipment operated continuously, 24 hours a day, 7 days a week. It was staffed 8+ hours per day, 7 days per week by CDM engineers with on-call operators on duty 24 hours a day, 7 days per week.

Figure 1-2 is a schematic of the pilot plant treatment process, which included four independent pretreatment systems each feeding a separate RO system. Process flow diagrams and design criteria for the pilot plant equipment are included in Appendix B.

The following sections provide more information on the equipment used during pilot testing including the functions performed by the equipment and which variables were used to evaluate the performance and effectiveness of the equipment.

1.4.1 Raw Water Supply and Storage Equipment

The raw water supply and storage equipment was designed for maintaining a reliable source of raw seawater supply to the pretreatment equipment throughout the pilot program.

Key equipment for raw water storage and supply included a 100-mircon Arkal disc-type, self-backwashing strainer, two 2,250 gallon storage tanks, a raw water pump, and ancillary instrumentation for monitoring raw water quality.

Table B-1 in Appendix B lists the design criteria for the raw water storage and supply equipment. A diagram of the process flows and the configuration for raw water storage and supply equipment is presented in Figure B-1.

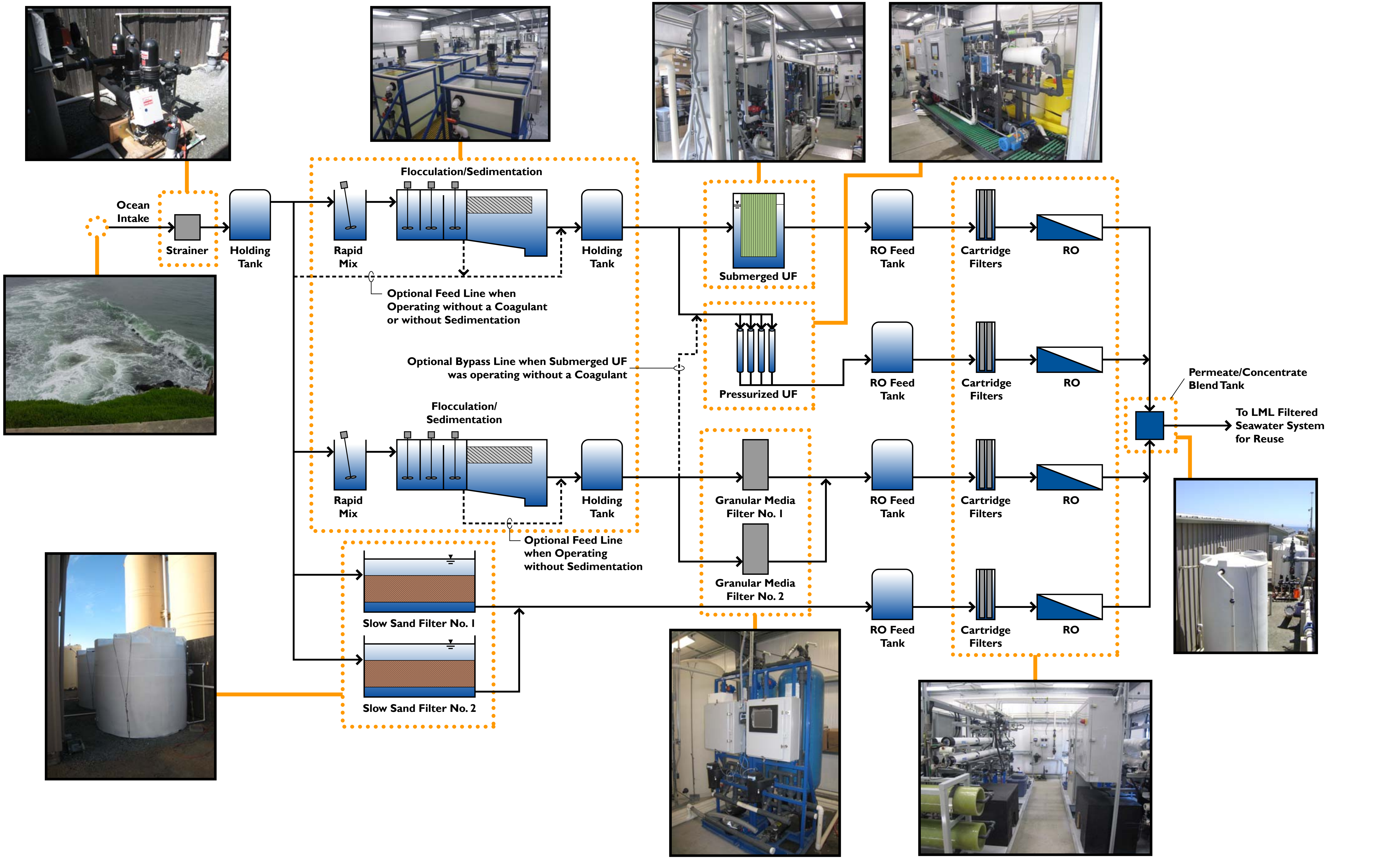

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Figure 1-2
Pilot Plant Flow Schematic

1.4.2 Pretreatment Systems

Pretreatment refers to the process which conditions and filters the seawater to prevent clogging and fouling of the RO membranes used for desalination. Pretreatment equipment was designed and custom fabricated to reliably treat raw seawater assuming seasonal variations in water quality. Key equipment included rapid mixers, flocculators, sedimentation basins, two media filters, two slow sand filters, two ultrafiltration systems, chemical feed systems, ancillary storage tanks, ancillary pumps, and ancillary instrumentation.

Pilot Horizontal Flocculation Mixing Basins

The pilot program included two independent coagulation, flocculation and sedimentation treatment trains, upstream of both the GMF and UF units. Each train could be operated with and without chemical addition and with and without settling.

Tables B-2, B-3, and B-4 in Appendix B list design criteria for the pretreatment equipment. Process flow diagrams of the flocculation and sedimentation basins, granular media filters (GMF), and slow sand filter (SSF) pretreatment equipment are presented in Figures B-2, B-3, and B-4.

The pretreatment systems tested during the program were configured and operated as follows:

- **GMF pretreatment:** GMF pretreatment for the pilot program included chemical coagulation, rapid mixing, 3-stage tapered flocculation, and clarification (rectangular settling basin with plates) followed by pressure granular media filters (GMF). This process is commonly used to produce drinking water when treating water from lakes, rivers, and other non-saline surface water sources. The system primarily consists of coagulant chemical addition, mixing tanks for flocculation during which the coagulant chemical interacts with suspended and dissolved material to form larger "floc" particles, sedimentation, which allows the "floc" particles to settle to the bottom of the sedimentation basin for disposal, and filtration using a combination of granular media.

  The pilot program included two granular media filters and a total of three different media configurations. Maintaining this process required backwashing and frequent optimization of the coagulant chemical during changes in source water quality to improve performance of the GMF filter media.

Pilot Pressurized Granular Media Filters

The GMF operated at a filtration rate of 3 gallons per minute per square foot (gpm/sf). Backwashes were performed with air and water to clean the media. Three GMF media configurations were evaluated:

- Mono-medium (40 inches of 1.0 millimeter [mm] anthracite).
- Dual-media (20 inches of 1.0 mm anthracite over 10 inches of 0.5 mm sand).
- Tri-media (20 inches of 1.0 mm anthracite over 8 inches of 0.5 mm sand over 6 inches of 0.25 mm garnet).

- **Slow sand filters (SSF):** Slow sand filtration is a biological process that cleans water much the same way a sandy bed of a river cleans and recharges an aquifer. The system primarily consists of a layer of sand and a layer of microbes that naturally develops on top of the sand (called the schmutzdecke) which can effectively remove particulates and bacteria before the ocean water is processed through the reverse osmosis membranes. Slow sand filters have not been used as a pretreatment process for seawater desalination; however, this process was evaluated during the pilot program because SSF requires no chemicals and uses a fraction of the energy used by other pretreatment processes. A trade-off with SSFs is that it requires a larger footprint than the other pretreatment processes evaluated.

Pilot Slow Sand Filters

The pilot program included two slow sand filters with different media configurations and exposure to sunlight. Maintaining SSF is minimal since they do not require chemical addition, clarification, or backwashing. Periodically, the filter beds are harrowed to improve filter performance and flow through the sand/gravel media.

The pilot plant SSFs were operated at a low filtration rate (0.1 to 0.2 gpm/sf). The filter beds were cleaned by harrowing, which consisted of scouring the top of the media bed with a rake and discharging the water column to waste. The following two media configurations were evaluated:

- SSF1 (24 inches of 0.35 mm sand over 10 inches of gravel)
- SSF2 (24 inches of 0.80 mm sand over 10 inches of gravel)

- **Ultrafiltration (UF) Membranes:** UF pretreatment uses membrane type filters instead of filter media such as sand or anthracite. The UF membranes are small strands of synthetic material that include millions of small holes which allow water through, but are small enough to remove pathogens and most suspended solids. This process has become more common as a replacement or substitute for GMF treatment to produce drinking water quality when treating water from lakes, rivers, and other non-saline surface water sources. One reason that UF is selected to replace GMF is because UF is given a higher number of pathogen removal credits than GMF by the EPA and state regulatory agencies including DPH. This is because testing has shown that UF is able to sustain a higher removal of suspended solids than GMF even when the coagulation process is not frequently optimized. Therefore, UF is less susceptible to upsets or particle breakthrough than GMF.

UF filtration typically treats water after coagulation when treating non-saline surface waters; one of the tests included in the program was to determine if coagulation is required when treating seawater from an open ocean intake.

The pilot program included proprietary UF systems from two different manufacturers (Norit and Zenon) to evaluate flux rates from 20 to 50 gfd and to investigate different backwash and chemical clean procedures. The Norit unit utilized Norit pressurized XIGA UF membranes and the Zenon unit utilized Zeeweed 1000 submerged UF membranes. Key equipment for membrane pretreatment included the UF filtrations skids, an air compressor, ancillary storage tanks and ancillary pumps. Instrumentation, chemical feed systems, pumps and other equipment necessary for UF operation and treatment were provided by the membrane vendors and mounted on each skid.

The systems utilized hollow-fiber membranes with pore sizes of 0.04 micron for the Zenon Zeeweed-1000 UF and 0.01 micron for the Norit XIGA SXL225 UF. The UF systems were operated in three different modes: 1) without coagulant, 2) with coagulant addition and flocculation, and 3) with coagulant addition, flocculation, and clarification/sedimentation. The UF membranes were cleaned with a combination of the following activities:

- Automatic 1-minute high-rate backwashes every 40 to 50 minutes (air and water for the Zenon UF and water only for the Norit UF).
- Automatic 15-minute chemically-enhanced backwashes (CEB) multiple times per week (sodium hypochlorite and citric acid for both the Zenon UF and Norit UF).
- 4- to 8-hour clean-in-place (CIP) chemical washes every 2 months (sodium hypochlorite and citric acid).

Pilot Zenon UF System

Pilot Norit UF System

1.4.3 SWRO Desalination Systems

Seawater reverse osmosis utilizes semi-permeable membranes to remove salts while allowing water to pass through. The water is unable to pass through the membrane until the driving pressure into the RO system surpasses the natural osmotic pressure of seawater. This pressure requirement is what dictates the energy requirement of a RO system.

Pilot SWRO skids

The membranes are rolled into cartridges which are loaded into pressure vessels so that a sufficient amount of driving pressure (typically 750 to 900 psi to achieve efficient production from Pacific Ocean seawater at standard operating rates) can be supplied by high pressure feed pumps for desalination.

The SWRO test equipment included cartridge filters (with nominal 5 micron pore sizes to protect the pumps and RO membranes from damage due to debris), high pressure feed pumps, RO pressure vessels loaded with RO membranes, and control systems. The SWRO test equipment's configuration, design criteria, and operating parameters were:

- 2 skids, each with 2 independent RO trains
- Number of RO membrane elements per train: 7 to 8
- Membrane elements: 4-inch diameter, 40 inches long
- Flux rate per train: 8 to 10 gallons per foot per day (gfd)
- Recovery rate: 40% to 55%
- Energy recovery devices were not tested because the types of devices recommended for the proposed facility were not available in sizes suitable for the pilot-scale RO systems.

Table B-7 in Appendix B lists the design criteria used for RO membrane treatment. A diagram of the RO skid process flows is presented in Figure B-6.

1.4.4 RO Permeate and Concentrate Blend Tank

During SWRO desalination, approximately 45 to 50% of the seawater permeates through the RO membrane and can be used as drinking water; this water is commonly referred to as RO permeate. The remaining 50 to 55% does not pass through the membranes and is referred to as salty "brine" or "RO concentrate."

Samples of RO permeate and RO concentrate were collected for daily, weekly, monthly, and quarterly water quality monitoring. RO permeate samples were also collected to perform bench-scale testing including DBP formation tests, corrosion control tests, and post-treatment conditioning tests for taste testing. Post-treatment consisted of adding minerals in the form of calcium hydroxide (hydrated lime) and adjusting pH with carbon dioxide to improve taste and stabilize the water for corrosion control. Additional information on post-treatment bench-scale testing is included in TM No. 8 in Appendix A.

During the pilot program the concentrate and permeate were recombined in a tank after treatment, and the combined stream was pumped into the UCSC LML filtered seawater pipeline for reuse at LML facilities. Reuse of this water was required by the California Coastal Commission permit so that additional water would not be required from the LML open water intake. At the proposed full-scale facility, it is planned that the RO concentrate will be disposed back to the ocean via the existing ocean outfall from the City wastewater treatment facility. More information on the proposed method of co-disposal can be found in TM No. 9 in Appendix A.

Table B-10 in Appendix B lists the design criteria for the RO permeate and brine handling equipment and a process flow diagram can be found in Figure B-7.

1.4.5 Residuals Storage and Discharge Systems

Settled solids, filtered solids, and cleaning chemicals generated from operation and cleaning of the pretreatment and SWRO systems must be disposed from a treatment facility.

During the pilot program the sample and residual (solids, backwash water and cleaning solution) streams were transferred into two large holding tanks so that the residuals could be slowly discharged into the local sewer system. Water quality was monitored before and after the holding tanks to fulfill the discharge permit requirements.

Table B-9 in Appendix B lists the design criteria used for the waste residuals equipment, and a diagram of waste residual process flows can be found in Figure B-7.

1.4.6 Data Acquisition System

Controls, data acquisition and online instrumentation were specified for each process to characterize variations in raw, pretreated, and SWRO permeate water quality.

Data acquisition was performed using programmable logic controllers (PLCs) that transferred data and signals to and from the plant SCADA system. Data from on-line instruments was displayed real-time on plant SCADA screens. SCADA alarms and setpoints were determined during equipment startup to alert operators of instrument failures and process shutdowns.

Table 1-2 outlines the parameters that were monitored continuously with SCADA monitoring and data acquisition and which parameters were monitored onsite using grab samples and benchtop or handheld instruments used to confirm online instrument readings and to monitor additional sample streams.

1.5 Summary

The SCWD and the SqCWD formed **scwd²** to evaluate seawater desalination as an additional source of supply for both agencies. A comprehensive pilot test program was conducted from March 2008 to April 2009. The pilot plant facility consisted of:

- Source seawater from the existing UCSC Long Marine Laboratory seawater intake.
- 2,400 square-foot temporary building.
- Custom fabricated pilot-scale treatment units treating up to 50 gallons per minute (gpm).

The goals of the pilot program were to:

- Demonstrate the best desalination technology.
- Test any special treatment needs.
- Provide water quality data to assist in regulatory approval and permitting of the proposed facility.
- Establish optimal design on operating parameters

The pilot plant was operated successfully for 13-months and demonstrated that:

- Seawater desalination will be a safe and reliable source of supply.
- Pretreatment should be designed to protect the downstream SWRO membranes from fouling.
- A single-stage SWRO system with a hybrid SWRO membrane combination will achieve water quality goals and require the least amount of energy.
- A robust treatment process is recommended for a SWRO desalination plant.