Technical and Economic Feasibility of Co-located Desalination Facilities

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PLANNING AND ECONOMICS GROUP

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Acronyms

ACOE	Army Corps of Engineers
ADWEA	Abu Dhabi Water and Electricity Authority
AOC	assimilable organic carbon
AOML	Atlantic Oceanographic and Meteorological Laboratory
AquaDAF	DAF
ASR	aquifer storage and recovery
BOOT	Build-Own-Operate-Transfer
CAA	Clean Air Act
CCCL	Coastal Construction Control Line Program
CDWWTP	central district wastewater treatment plant
CWA	Clean Water Act
D/DBP	Disinfectant and Disinfection By-Product Rule
DAF	Dissolved Air Flotation
DB	Design-Build
DBB	Design-Bid-Build
DBNPA	2, 2-Dibromo-3-Nitrilopropionamide
DBO	Design-Build-Operate
DBOO	Design-Build-Own-Operate
DBOOT	Design-Build-Own-Operate-Transfer
DERM	Department of Environmental Resource Management
DMR’s	Discharge Monitoring Reports
ECHO	Enforcement and Compliance History Online
ECR	East Central Regional
EDR	electro-dialysis reversal
EPA	US Environmental Protection Agency
EPC	engineer, procure, construct
ERP	Environmental Resource Permit
ESTWR	Enhanced Surface Water Treatment Rule
FDEP	Florida Department of Environmental Protection
FPL	Florida Power and Light
FTW	Filter-to-waste
GAC	granular activated carbon
HAAs	haloacetic acids
HVAC	Heating Ventilating and Air Conditioning
I&C	instrumentation & control systems
IWWF	Industrial Wastewater Facility
MDWASD	Miami-Dade Water and Sewer Department
MES	Micro-sand enhanced settling
MF	Membrane microfiltration
mgd	million gallons per day
MSF	multi-stage flash evaporation
NEPA	National Environmental Policy Act
NF	nanofiltration

NOAA	U.S. National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NWI	National Wetlands Inventory
O&M	operations and maintenance
OFW	Outstanding Florida Water
OH&P	overhead and profit
PEG	Planning and Economics Group
PF	present worth factor
PIT	Pelton Impulse Turbine
POTW	publicly owned treatment works
PRT	Project Review Team
RFP	Request for Proposals
RFQ	Request for Qualifications
RO	reverse osmosis
RTW	Rothberg, Tamburini & Winsor, Inc.
SBS	Sodium bisulfite
SDI	Silt Density Index
SDWA	Safe Drinking Water Act
SFWMD or District	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SWCC	Saline Water Conversion Corporation
SWRO	seawater reverse osmosis
SWW	Spent washwater
TDS	total dissolved solids
TOC	total organic carbon
TTHMs	total trihalomethanes
UF	ultrafiltration
USACOE	United States Army Corps of Engineers
USDW	underground sources of drinking water
USEPA	United States Environmental Protection Agency

Appendices

1. Executive Summary

The objective of this study is to evaluate the technical, economic, and regulatory feasibility of seawater/brackish water treatment co-located with an electric power plant within the jurisdictional area of the South Florida Water Management District. For the purpose of this study, only co-location with existing once-through cooling FPL power plants was considered. This methodology was based on the fact that co-location has key advantages by using existing seawater intakes, available cooling water and discharge outfall for concentrate disposal.

Literature review focused on previous studies related to co-location of desalination plants with electric power plants. The current study focused on the seven sites that passed the second-tier screening in a study performed by Water Resource Associates, Inc. in June 2002 titled "Feasibility Study for Co-locating Reverse Osmosis Treatment Facilities with Electric Power Plants." These seven sites are Cutler and Turkey Point in Miami-Dade County, Ft. Myers in Lee County, Ft. Pierce in St. Lucie County, Lauderdale and Port Everglades in Broward County, and Riviera in Palm Beach County.

Each candidate site underwent a first level screening that analyzed 11 criteria used to grade the suitability of the site. Criteria that were screened included availability of suitable water supply, demand for finished water, available and reliable energy supply, access to suitable disposal options, electric and water utility interest, technological feasibility of the Reverse Osmosis (RO) process, available and suitable land, regulatory and environmental suitability, level of public and political interest or opposition. Screening was performed and determined the top three candidate sites, Fort Myers, Lauderdale and Port Everglades, would undergo preliminary development of a conceptual demonstration project and evaluation of unit treatment processes.

Water utilities in the municipalities surrounding each of the candidate sites were interviewed to determine their initial interest in the study. If a utility showed interest, a formal meeting was conducted to provide an in-depth presentation of the goals of the study and establish the parameters of moving the candidate site towards a demonstration project.

Meetings were conducted with water utility representatives of West Palm Beach in Palm Beach County; Fort Lauderdale in Broward County; Lee County, Fort Myers, and Cape Coral in Lee County; and Miami-Dade Water and Sewer Department in Miami-Dade County. Initial discussions with officials from the City of Fort Pierce indicated the candidate site, the Henry D. King Generating Station, was slated for decommissioning in 2007. As a result, the King site was eliminated from additional review as part of this study.

At the conclusion of the meetings with four entities, the cities of West Palm Beach, Fort Lauderdale, Miami-Dade and Lee County expressed continued interest in moving forward as part of the study. Interested utilities provided information regarding projected demands from the candidate RO facility, the timetable the demands must be met, location of connection between the RO facility and the utility's transmission mains, and characteristics of the utility's finished water to be blended with RO water.

Based upon water demands from utilities in proximity to the candidate sites, it was determined that Fort Myers would be studied at a finished water capacity of 10 mgd, Lauderdale at a capacity of 20 mgd and Port Everglades at a capacity of 35 mgd.

As part of preliminary development of a conceptual design, the top three candidate sites underwent a review and evaluation of unit treatment process including a review of historical and available technologies for seawater reverse osmosis (SWRO) desalination The technologies investigated included intakes, pretreatment processes, evaluation of source water issues, RO treatment issues, brine disposal, residuals disposal, energy recovery, and alternative sources of energy. This review resulted in the selection of a candidate SWRO treatment process to be used for subsequent evaluation of capital, O&M costs, and total cost of water for facilities co-located with the three candidate FPL power plant sites identified in the site selection screening process.

Dissolved Air Flotation (DAF) clarification and gravity filtration was selected as the most robust and favorable pretreatment process to be considered in the preliminary evaluation of co-located SWRO facilities at the three candidate sites. Additionally, high rate DAF (AquaDAF) has been selected because of the potential cost advantages of a reduced footprint.

The final conceptual demonstration project for each of the three sites provides process description, including water and solids balance, clarification and filtration, 2-pass RO, disinfection, residual disposal, chemical feed, and energy recovery. Piping, building layout, and process flow diagrams are presented for each of the candidate sites.

Capital costs were developed by sizing individual components for each candidate site. Unit prices were developed from equipment manufacturers and from recent historical data from other projects. When appropriate, additional costs were added for equipment, electrical, and instrumentation. After the construction costs were estimated and totaled, a 25% contingency was added for items that are currently unidentifiable. The final construction cost estimate also includes a 17% contractor's overhead and profit which includes the contractor's overhead expenses, mobilization, demobilization, bonding, and insurance. Finally, the project estimate includes 10% for engineering. Note that the capital costs are based on a finished water production quantity that is unique to each of the candidate sites. The costs presented herein should be considered budget-level costs with an accuracy of +30 percent to -15 percent. A summary of total construction costs, O&M costs and equivalent annual costs is shown below.

Candidate Site	**Plant Capacity (MGD)**	**Water Quality (TDS) (ppm)**	**Total Construction Costs (millions)**	**Total Annual O&M Costs (millions)**	**Equiv. Annual Costs ($/ 1000 gallons)**
Port Everglades	35	33,000	$275.9	$21.3	$4.16
Lauderdale	20	15,000	$148.0	$10.4	$3.88
Fort Myers	10	15,000	$91.1	$6.4	$4.66

This study also evaluated permitting feasibility of co-locating a seawater desalination plant with the existing Central District Wastewater Treatment Plant (CDWWTP) at Virginia Key, FL. Virginia Key is located in Miami-Dade County just north of Key Biscayne, the southernmost of the barrier islands off the east coast of Florida.

This location appears to be favorably suited for siting a 15-20 mgd seawater desalination facility for several reasons: Miami-Dade County owns the land; the SWRO can be located at the site of the existing CDWWTP where there is adequate land available (more than 5 acres); CDWWTP discharge can be used to blend the demineralized concentrate from the SWRO facility prior to discharge through the existing CDWWTP outfall.

Several alternatives are considered for the seawater intake. These include 1) use of an open sea intake consisting of a submerged pipe extending eastward into approximately 60 feet of water; 2) vertical beach wells; 3) linear infiltration galleries; and 4) infiltration Ranney wells. There are advantages and disadvantages to each alternative depending on specific surface and subsurface conditions along the shore and in the offshore coastal area.

There are sensitive environmental areas both on Virginia Key and in the offshore waters. Resources on Virginia Key include jurisdictional wetlands, sea turtle habitats, rare or endangered species, and the presence of hard bottom habitat. Environmental concerns related to installation of open water intake facilities would include potential impingement or entrainment issues. There are "Standard Manatee Protection Construction Conditions" designed to offset impacts during in-water work, including minimizing habitat loss, installing grates for submerged pipes and watching for manatees during construction.

Information from Miami-Dade DERM indicates that a landfill is located on land just south of the existing CDWWTP. The landfill, which is on land owned by the city of Miami, has not been closed; monitoring of leachate from the landfill may be ongoing. Monitoring data would be very helpful in determining the location of the leachate plume in relation to possible sites for the desalination intake.

More detailed evaluation of the resources and activities present on the key and the potential effects associated with construction and operation of desalination facilities would be needed as the concept is more fully developed.

Given that there are many siting factors still to be determined, following are listed key permits anticipated to be required to undertake construction and operation of the proposed desalination facilities.

- National Environmental Policy Act (NEPA)
- The United States Army Corps of Engineers (ACOE) Section 404 Dredge and Fill Permit
- FDEP Environmental Resource Permit (ERP)
- FDEP Construction Control Line Permit
- FDEP Joint Coastal Environmental Resource Permit

- Miami-Dade County Department of Environmental Resources Management Class I Permit for Coastal Construction within Miami-Dade County
- FDEP Industrial Wastewater Facility Permit
- National Pollutant Discharge Elimination System (NPDES) Demineralized Concentrate Permit
- FDEP Air Pollution Sources Permit
- Florida Department of Environmental Protection (FDEP) Application for a Public Drinking Water Facility Construction Permit

1.1 Introduction

1.1.1 Purpose

The South Florida Water Management District (SFWMD or District) is charged with managing water and related resources for the benefit of the public and to meet the needs of the region. Specific regional water supply plan recommendations provide the District with information to comprehensively manage water resources to meet current and future regional water needs. The District's area of jurisdiction extends over sixteen (16) counties from Orlando to Key West, and serves a population of approximately 7 million people. Eight of these counties have coastal boundaries and access to limitless ocean water.

Increased water demands, the state’s growing vulnerability to droughts, and the declining availability of conventional water supply sources have placed great importance on the development of new alternative water supply sources. The District’s 2006 Water Supply Plans recommended seawater desalination as a potential drought-proof alternative source of potable water.

Desalination of brackish groundwater has been very successful in the District. The first desalination plant in the US was installed in the Florida Keys in the early 1970s; using brackish groundwater desalination technologies. Thirty desalination plants currently produce about 120 mgd. This number is expected to be more than doubled by 2015 due to new plant additions or existing plant expansions. At the rate of 4 mgd per groundwater plant, there is hardly any benefit of the economics of scale, which is a major benefit of large seawater desalination plants.

The most important challenge to seawater desalination is to reduce capital and O&M costs through low-energy and high efficiency systems. Compared to using groundwater from the Floridan or Biscayne Aquifer systems as source water, very little seawater sources have been used due to the fact that the cost of seawater desalination is still 100% higher or more than traditional treatment of less saline water groundwater. However, seawater desalination costs have decreased substantially in the last 10 years due to improvements in membrane technologies and energy recovery research.

The objective of this study is to evaluate the technical, economic, and regulatory feasibility of seawater/brackish water treatment co-located with an electric power plant within the jurisdictional area of the South Florida Water Management

District and, if feasible, prepare the conceptual design and specifications for a demonstration project.

1.1.2 Project Scope

The study examined alternative sites and concepts and, if feasible, identified a specific site and general specifications for the desalination treatment application, including opinions of probable capital and operating costs for the project and assistance to the District in establishing planning level cost estimates and a project implementation plan. In particular, the objectives of this study shall include:

- Screening of potential sites for implementation of a demonstration project utilizing the sites that passed the Fatal Flaw Analysis in the Water Resource Associates, Inc. June 2002 "Feasibility Study for Co-locating Reverse Osmosis Treatment Facilities with Electric Power Plants."
- Identifying and recommending applicable treatment technologies, including pretreatment, proven in meeting drinking water standards to be used in the demonstration project.
- Determining the feasibility of up to three (3) sites for development of a demonstration project.
- If one or more feasible sites are identified, developing a conceptual design and specifications for a demonstration project and planning level capital and operating cost estimates.

Development of the demonstration project will be conducted in two major phases. The first phase will address the feasibility of developing a demonstration project. The second phase will consist of implementing the demonstration project, including completion of development and operating agreements, budget and funding arrangements, and implementation schedule. This report covers only the first phase.

1.1.3 Project Organization

Sections two through five of this report each represented a separate draft deliverable. This Final Report is a compilation of the separate sections. A Project Technical Team composed primarily of agency representatives and was convened to review each draft deliverable.

Meetings of the Project Technical Team were held to discuss the draft sections, and this final report represents to the extent feasible a consensus of the Project Technical Team. Recommendations are made based on information reviewed and is not meant for use in detailed engineering design where site-specific conditions may vary from the generalized information found herein.

1.1.4 Sources of Information

This report is a review of existing information and compilation of more up to date information on the power plant facilities evaluated. Current sources that have undergone thorough review were used preferentially and are listed in the References section. In addition to published reports, many reports and documents were reviewed from internet-based sources. These are also referenced and cited in the text.

1.2 Literature Review and Methodology

This task focused on reviewing previous studies related to co-location of desalination plants with electric power plants. Particular attention was given to recent studies performed for the South Florida and St. Johns Water Management Districts. These studies were reviewed to obtain information related to methodologies, site screening analysis, criterion scoring and cost models. Relevant information and methodologies were applied to determine how sites from previous studies may have evolved into more favorable candidates in the current study.

The current study focused on the seven sites that passed the second-tier screening in a study performed by Water Resource Associates, Inc. in June 2002 titled “Feasibility Study for Co-locating Reverse Osmosis Treatment Facilities with Electric Power Plants.” These seven sites are Cutler and Turkey Point in Miami-Dade County, Ft. Myers in Lee County, Ft. Pierce in St. Lucie County, Lauderdale and Port Everglades in Broward County, and Riviera in Palm Beach County.

Additional literature review focused on concentrate disposal through co-location with existing Class I deep well injection facilities. Data was provided by the Florida Department of Environmental Protection (FDEP) to show the location, capacity and permitting status of the 102 existing Class I deep well injection facilities in the state of Florida. Of these facilities, it was determined that 32 active wells are located in proximity (within 10 miles) to the seven candidate power plant sites.

1.3 Screening of Potential Sites

Each candidate site underwent a first level screening that analyzed eleven (11) criteria used to grade the suitability of the site. To quantify the basis for applying each criterion, subcriterion were developed and assigned with a score. The subcriterion was applied to all sites to obtain a weighted score for each of the 11 criteria by multiplying the subcriterion scoring factor by the weighted factor.

Criterion that were screened included availability of suitable water supply, demand for finished water, available and reliable energy supply, access to suitable disposal options, electric and water utility interest, technological feasibility of the RO process, available and suitable land, regulatory and environmental suitability, level of public and political interest or opposition.

1.4 Preliminary Development of Conceptual Demonstration Projects and Evaluation of Demonstration Project Unit Treatment Process

This task involved the review and evaluation of unit treatment process including a review of historical and available technologies for seawater desalination (SWRO). The technologies investigated included intakes, pretreatment processes, evaluation of source water issues, RO treatment issues, brine disposal, residuals disposal, energy recovery, and alternative sources of energy. This review resulted in the selection of a candidate SWRO treatment process to be used for subsequent evaluation of capital, O&M costs, and total cost of water for facilities co-located with the top three FPL power plant sites identified in the site selection screening process. As a result of this evaluation, the top three ranked sites will be carried forward for more detailed site-specific conceptual development under Task 5.

For the purpose of this study, only co-location with existing FPL power plants was considered. This methodology was based on the fact that co-location has key advantages through the utilization of existing seawater intakes used for once through power plant cooling; and utilization of the existing cooling water discharge outfall for concentrate disposal.

1.5 Final Concept of Development of Demonstration Project

The development of a conceptual demonstration project will involve identifying a candidate site and implementing design specifications for the major pretreatment and treatment unit processes. In addition, disposal options for RO concentrate will be selected and identified on generalized site plans.

Planning level cost estimates will be prepared and will include up-front and recurring costs that account for the level of uncertainty in the estimates. Potential financing alternatives including grants and subsidies on construction and/or operation and maintenance costs will also be investigated.

Regulatory issues will also be identified and listed to include a schedule for obtaining the required permits.

2. Literature Review and Methodology

2.1 Methodology

- Literature review
- Screening of potential sites
- Preliminary Development of Conceptual Demonstration Project
- Evaluation of Demonstration project unit treatment processes
- Final concept design of Demonstration Project

The focus of this study centers on the seven Florida Power and Light (FPL) power facilities that passed the Fatal Flaw Analysis in the "Water Resource Associates, Inc. June 2002 Feasibility Study for Co-locating Reverse Osmosis Treatment Facilities with Electric Power Plants" study. These seven sites are Cutler and Turkey Point in Miami-Dade County, Ft. Myers in Lee County, Ft. Pierce in St. Lucie County, Lauderdale and Port Everglades in Broward County, and Riviera in Palm Beach County. Aerial photographs depicting the location of the seven candidate sites and surrounding injection well facilities can be found in Figures 2.1 through 2.5 at the end of this section.

2.2 Literature Review

The literature review began with a review of previous reports related to this study including "Feasibility Study for Co-locating Reverse Osmosis Treatment Facilities with Electric Power Plants," June 2002; R.W. Beck "Criteria for Preliminary Screening of Areas for Potential Seawater Demineralization – Task C.1," December 2002; R.W. Beck "Identification of Favorable Sites for Feasible Seawater Demineralization – Task C.4," September 2003; and R.W. Beck "Final Report on Five Potential Seawater Demineralization Project Sites – Task C-5," January 2004. The contents of each report were reviewed to ascertain methodologies, screening criteria, evaluation ranking, and selection criteria used in siting recommendations.

The "Feasibility Study for Co-locating Reverse Osmosis Treatment Facilities with Electric Power Plants" report was produced for the District for the purpose of evaluating the feasibility of co-locating seawater and/or brackish RO plants with electric power plants. In the study, twenty-three power plants located in South Florida were graded based on a three-tier screening process to assess their ability to comply with technical and regulatory constraints. Of the twenty-three original sites, two successfully passed the second tier of screening and were then subjected to a feasibility cost model to economically assess project planning costs.

The “Criteria for Preliminary Screening of Areas for Potential Seawater Demineralization – Task C.1” report was produced by R.W. Beck for the St. Johns River Water Management District (SJRWMD) in 2002. The purpose of the study was to develop criterion suitable for use as a preliminary (macro level) screening measure for implementation of desalination facilities within the coastal SJRWMD confines (R.W. Beck, 2002). This study established a method to provide preliminary screening to identify preferred sites for further analysis as potential candidates for desalination facilities.

The “Identification of Favorable Sites for Feasible Seawater Demineralization – Task C.4” report was produced in 2003 for the St. Johns River Water Management District. The purpose of the study was to apply screening methodology to develop a list of up to five preferred sites for seawater demineralization. The current study benefits from the 2003 report through its application of screening and ranking methodology, its summary of various treatment technologies, and its comparative project cost estimating methods.

The “Final Report on Five Potential Seawater Demineralization Project Sites – Task C.5” report is the final report by R.W. Beck for the Seawater Demineralization Feasibility Investigation. Completed in 2004, this final phase involves the development of comparative-level cost estimates and concept designs for the five preferred sites for seawater demineralization. One conclusion of the 2004 study is the significant economic advantage of disposing reject concentrate through a co-located power plant ocean outfall. The current study examined many of the same design features and comparative project cost estimates as the 2004 study and will apply them to the co-located candidate sites.

2.3 Evaluation of Criteria and Criteria Weighting

Each candidate location (power plant location) will undergo a first level screening that analyzes eleven (11) criteria used to grade the suitability of a candidate location. A summary of the screening criteria, weighting factors, basis for weighting factors and basis for applying criteria is included in Table 2.1. In order to quantify the basis for applying the criteria, a set of subcriterion will be developed and each subcriterion will be assigned a score. The subcriterion will be applied to all sites and each site will obtain a weighted score for each of the

11 criteria by multiplying the subcriterion scoring factor by the weighted factor. The sum of the 11 weighted scores will represent the total score for the location. The subcriterion and scoring factors will be developed in Task 2.2.

Table 2.1 - Site Screening Criteria and Weighting Factors

First Level Screening Criteria			
Screening Criteria	**Weighting factors**	**Basis for Weighting Factors**	**Basis for Applying Criteria**
a. Current or potential availability of desalination waste byproducts disposal facilities	2	Each potential site has existing or potential waste byproducts disposal facilities, so this is an essential but lower priority screening criterion	Sites with superior existing or potential disposal facilities will receive higher scores
b. Current or potential availability of energy sufficient for facility operation	4	Because energy costs represent up to 30 percent of project costs, sites with better access to electric power will be much preferred	Sites adjacent to larger and base load electric power plants will be rated higher
c. Documented interest of the electric power utility (FPL)	5	Without the full support of the electric power utility, it would be difficult to develop a site	Sites favored by an electric power utility will score higher
d. Documented interest of one or more water utilities	5	A water utility must be interested in site development for it to proceed	Sites favored by a water utility will score higher
e. Acceptable regulatory and permitting requirements, including reasonable costs and schedule	3	Regulatory and permitting requirements may present a barrier to a project, but can usually be satisfactorily addressed	Projects with more demanding permitting requirements will be rated lower
f. Sufficiency of projected demand for potable water in the service area that would be produced from the facility	3	Demand for potable water, or product from the project, is necessary for the project, but replacing existing supplies or firming up the potable water supply may substitute for an increase in demand	Significant growth in the water demand in the vicinity of a project will result in a favorable rating
g. Acceptable raw water supply	2	A raw water supply in proximity to the site will be needed While better quality of the raw water supply is significant, it can be overcome through proper pretreatment	A closer site and one with a longer expected useful life will be preferred Better or more consistent raw water quality will result in a higher rating A higher water temperature of the raw water supply will be preferred
h. Availability of equipment and processes suitable for treating available raw water supply	1	While it will be necessary to ensure that the technology needed to treat the raw water is available, there is not expected to be a situation where the technology will not be adequate	Lower treatment requirements will result in a higher rating
i. Public and political support	4	While the utility's support is separately viewed as essential to the success of a project, the support of elected officials and the general public will also be important	Clear endorsement of the project by elected officials will result in a higher rating
j. Availability of suitable site for project	4	It is necessary to identify a suitable site prior to moving forward with site evaluation	Adequate site size and approved zoning
k. Environmental effects	2	Potential effect of cooling water intake, cooling water discharge, project construction and operation on environmental resources	Needs to be considered but is further considered under regulatory and permitting criterion

Table 2.1 - Site Screening Criteria and Weighting Factors - continued

Final screening criteria		
Final Screening Criteria	**Basis for Weighting Factors**	**Basis for Applying Criteria**
l. Planning level cost estimates expressed in cost per 1,000 gallons of potable water	After the first level screening is completed, this factor will be applied to select the preferred alternatives	Without a compelling reason to the contrary, a project producing potable water at a lower life cycle cost per 1000 gallons will be preferred; a compelling reason could be that another alternative scores significantly better under the first level screening
m. Acceptable risk, including uncertainty in evaluating each of the above criteria	While an alternative achieves an acceptable rating under the first level screening criteria and is low cost, it must not present unacceptable risk	A project whose ratings involve a significant level of uncertainty may present an unacceptable level of risk, downgrading the project's overall attractiveness

2.4 Concentrate Disposal Options

The ability to dispose of concentrate from a desalination facility, whether brackish or sea water is critical to the location of the desalination facility. Therefore co-locating the desalination facility with an existing and available disposal method is desirable when compared to permitting and building a new disposal facility. Therefore, co-location with two existing and available concentrate disposal methods were considered; existing Class I deep well injection, and direct surface water discharge blended with power plant cooling water discharge.

This task focused on looking at co-location with existing Class I deep well injection facilities. Data provided by the Florida Department of Environmental Protection indicates that there are currently 102 existing Class I deep well injection facilities in the state of Florida. Of these facilities, 32 active wells are located in proximity (within 10 miles) to the seven candidate power plant sites. (Table 2.2)

As was established in other related studies, a determination was made to limit a proposed injection well facility to within a five-mile radius of the candidate location in order to mitigate excessive costs associated with placing concentrate pipelines through congested urban areas. This however, limited the options to a very few wells.

Table 2.2 – Class I Injection Well Facilities in Proximity to Power Plants

Power Plant Facility Location	Injection Well Facility	Proposed	Active	Other	Total Wells	Approximate Distance to PP (miles)
Ft. Myers	N. Ft. Myers Utilities WWTP	1	1	1EXM	3	6.4
	Ft. Myers Reverse Osmosis	0	1	0	1	5.6
	North Lee County RO WTP	0	0	1UC	1	2.3
Ft. Pierce	Ft. Pierce Utilities Authority - Island Water Reclaim Facility	0	1	0	1	1.1
	Ft. Pierce Utilities Authority - Henry A. Gahn WTP	0	1	0	1	1.7
Lauderdale	G. T. Lohmeyer Injection Facility	0	5	0	5	4.7
	City of Ft. Lauderdale Peele-Dixie WTP	1	0	0	1	2.1
Port Everglades	G. T. Lohmeyer Injection Facility	0	5	0	5	0.8
	City of Hollywood Southern Regional WWTP	0	2	0	2	4
	City of Ft. Lauderdale Peele-Dixie WTP	1	0	0	1	4.5
Riviera	Palm Beach County RRF	0	2	0	2	5.4
	West Palm Beach East-Central Regional WWTP	0	6	1UC	7	5.3
Turkey Point (oil/gas)	M-DWASD South District WWTP	0	13	4IA	17	7.9
Cutler	M-DWASD South District WWTP	0	13	4IA	17	6.3

Key to Abbreviations

PP - Power Plant

WWTP - Waste Water Treatment Plant

EXM - Exploratory well converted to a monitor well

WTP - Water Treatment Plant

UC - Under Construction / testing

RRF - Resource Recovery Facility

M-DWASD - Miami-Dade Water and Sewer District

IA - Inactive well

FDEP permit information for each of the injection facilities listed was reviewed to determine the permitted capacity versus actual usage at each facility (Table 2.3) and thus establish possible unused capacity. A review of these data indicates that most of these wells are not operated at or near their permitted capacities and thus have capacity available and may be viable candidates for concentrate disposal. The data listed reflects aggregate yearly data and does not adequately portray operating levels on a weekly or monthly basis thus it is not possible, using this data set, to assess seasonal variations in the operation of the wells.

Among the injection facilities in proximity to the candidate sites, the G. T. Lohmeyer facility initially appeared to be an ideal site due to its short distance from the Port Everglades plant. Although the injection well facility is permitted to receive up to 93.5 mgd, the Lohmeyer facility is permitted to treat only 56 mgd and data for 2005 indicates the facility treated an average daily flow of 42 mgd.

However, after review and discussion of this data with the Project Review Team (PRT) it was concluded that co-locating a desalination facility with an existing deep well injection facility should not be further evaluated. The PRT concluded that:

- The injection facilities are not located immediately adjacent to the seven (7) power plants being considered for co-location. Therefore, co-locating with an existing deep well injection facility does not meet the intent of the study. Although co-location of an RO facility with a deep well injection facility would entail treating brackish water and would constitute an expansion of an existing water utility, pumping concentrate from an off-site RO facility to an injection facility was considered.

- The injection facilities, on a seasonal basis may not always have the capacity to adequately address concentrate disposal requirements from a new desalination facility while fulfilling their primary disposal task to their existing facility.

Table 2.3 - Class I Injection Well Facilities - Permitted Capacity vs. Actual Usage

Power Plant Facility Location	Injection Well Facility	Permitted Capacity for 2005 (mgd)	Average Actual Usage for 2005 (mgd)	Capacity Available (mgd)
Ft. Myers	North Ft. Myers Utilities WWTP	N/A – greater than 5 miles away		
	Ft. Myers Reverse Osmosis WTP	4.0	2.1	1.9
	N. Lee County Reverse Osmosis WTP	N/A – greater than 5 miles away		
Ft. Pierce	Ft. Pierce Utilities Authorities-Island Water Reclaim Facility	14.9	5.7	9.2
	Ft. Pierce Utilities Authority-Henry A Gahn WTP	0.7	0.4	0.3
Lauderdale	G. T. Lohmeyer Injection Facility	93.5	36.6	56.9
	City of Ft. Lauderdale Peele-Dixie WTP	Not in Operation		
Port Everglades	G. T. Lohmeyer Injection Facility	93.5	42	51.5
	City of Hollywood Southern Regional WWTP	37.2	4.4	32.8
	City of Ft. Lauderdale Peele-Dixie WTP	Not in Operation		
Riviera	Palm Beach County Resource Recovery Facility	N/A – greater than 5 miles away		
	West Palm Beach East-Central Regional WWTP	105.7	38.5	67.2
Cutler	M-DWASD South District WWTP	N/A – greater than 5 miles away		
Turkey Point	M-DWASD South District WWTP	N/A – greater than 5 miles away		

Key to Abbreviations

WWTP - Wastewater Treatment Plant

WTP - Water Treatment Plant

M-DWASD - Miami-Dade Water and Sewer District

2.5 Source Water

Each of the seven candidate power facilities uses a system of once through cooling water from adjacent intake structures to cool their turbines. The source water at these intake structures is taken from the ocean, inter-coastal waterways or rivers. The existing discharge structures associated with these systems make them ideal candidates for blending RO concentrate into the high flow plant discharge.

As a condition of discharging into surface water bodies, the plants are required to collect water samples and submit the data as Discharge Monitoring Reports (DMR's) to the FDEP on a quarterly basis. A review of the available DMR data showed a large variance between the candidate sites in the number of constituents that are monitored. Many of these constituents are monitored to maintain the water quality and ecosystem of the receiving water body and are therefore irrelevant to the design of an RO facility. However, several of the monitored constituents can provide data that may provide preliminary information that is relevant to RO pretreatment and process design (Table 2.4).

Due to the limited water quality data relevant to RO design, it will be necessary to perform detailed source water sampling and analysis during pilot testing for any of the prospective desalination plant locations. Raw water sampling would include characteristics essential to determining pretreatment requirements, RO membrane selection, and membrane scaling potential, such as: salinity, conductivity, turbidity, total dissolved solids, pH, temperature, boron, barium, strontium, fluoride, bromide, and microbiology including phytoplancton and membrane scaling potential.

Table 2.4 – Power Plant DMR Constituents Relevant to RO Pretreatment and Design

Parameter	Cutler	Ft Myers	Ft Pierce	Lauderdale	Port Everglades	Riviera	Turkey Point
NPDES Number	FL0001481	FL0001490	FL0027081	FL0001503	FL0001538	FL0001546	FL0001562
Temperature	✓	✓	✓	✓	✓	✓	✓
pH	-	✓	-	✓	✓	-	✓
Salinity	-	-	-	-	-	-	✓
TSS	-	✓	-	✓	✓	✓	✓
TDS	-	-	-	✓	-	-	-
Dissolved Oxygen	-	-	-	-	✓	-	-
Oil & Grease	✓	✓	-	✓	✓	✓	✓
Specific Conductance	-	-	-	-	-	-	✓
Nitrogen, Tot. (as N)	-	-	-	-	-	-	-
Chloride (as Cl)	-	-	-	-	-	-	-
Notes: ✓ = Constituent monitored on a quarterly basis - = Constituent not monitored							

Additional review of the DMR's was performed in order to determine the quality and range of values of the available data. In addition, a review of data available on governmental web sites failed to provide adequate water quality information. Sources searched included web sites from SFWMD, National Oceanic and Atmospheric Administration, Environmental Protection Agency and the Florida Department of Environmental Protection.

Additional discharge sampling may be warranted to provide the proper information required for final design decisions related to a demonstration project.

A summary of brackish/seawater desalination facilities within the SFWMD was prepared to provide the District with a survey of current and proposed desalination capacity. Data was collected from the District, FDEP and various utilities within the region to determine the level of capacity that is currently under construction or slated for construction in the near future. In addition, current capacity from the various utilities was included in the survey to provide the total desalination capacity of the region.

Information collected and summarized in Appendix A includes:

- County, city, and utility
- Current desalination capacity
- Total system capacity
- Annual daily flow
- Capacity of desalination slated for construction

2.6 Economic Analysis

The framework for conducting the economic analysis was developed in parallel with the screening process to ensure that the feasibility analysis procedures and sequential activities are internally compatible. The economic evaluation of alternative sites and water treatment projects will be conducted using a structured procedure designed to produce the following specific results:

- Initial investment and recurring costs
- Life cycle cost
- Equivalent annual cost
- Unit product cost estimates

2.6.1 Cost Estimates

The cost estimates developed for this project will be developed in accordance with the guidelines of the Society of Cost Estimating and Analysis suitable for planning level efforts. The cost estimates, which will be developed for each major component of each alternative project, will be suitable for project planning purposes, but will require additional refinement for purposes of more detailed project planning, project procurement, and funding and financing. For project alternatives selected for additional analysis in subsequent tasks, the cost estimates developed during this analysis will be reexamined and refined during subsequent steps in the project. The cost estimates will be prepared based on midyear 2006 construction prices and best available information on the operation and maintenance requirements for each type of project component.

In addition to the estimated cost of constructing each project component, each cost estimate will include three important factors needed to calculate the life cycle cost:

- Facility type, used to associate the project component with an expected useful life, which is needed to estimate renewal and replacement expense
- The year in which the project component would become operational – often the same year in which the project itself would become operational, which is needed to calculate life cycle cost
- The construction duration in years, which is needed to calculate life cycle cost

2.6.2 Economic Analysis Procedures and Assumptions

With two modifications, the economic evaluation procedure will follow the process described in "Cost Estimating and Economic Criteria for 2005 District Water Supply Plan," dated June 16, 2004, which was developed for the St. Johns River Water Management District, and which has been used by the South Florida Water Management District for project planning purposes. The two modifications are the following:

- Inflation, which was not included in the District's Cost Estimating and Economic Criteria, is included in this analysis to allow the results to be used for determining funding and financing requirements, both for initial investment as well as recurring costs
- Renewal and replacement costs, also not included in the District's Cost Estimating and Economic Criteria, is included in this analysis because renewal and replacement, or depreciation, is a standard project expense and one that is incurred to allow a project's useful life to reach and extend beyond the period of analysis – in this case 20 years

While the costs of alternative projects may meaningfully be compared to one another without taking into account inflation or renewal and replacement, estimating funding and financing requirements associated with each project alternative require inclusion of these factors in the analysis.

The economic analysis is based mainly on the individual project component cost estimates discussed above, estimated water production from the project, and a set of economic parameters.

2.6.3 Economic Parameters

The economic parameters that are included in the analysis are those needed to perform life cycle costing and estimate useful life of each type of facility or project component, and an annual facility availability factor.

The life cycle cost parameters are the nominal discount rate, inflation rate, year of cost estimate, base year of analysis, and period of analysis (from the base year), which are directly applied in calculating the life cycle cost of the initial investment, operation and maintenance, and renewal and replacement costs. The useful life of each type of facility is used in calculating each project component's average annual renewal and replacement expense.

The final economic parameter is the annual facility availability factor, which reflects expected time that the facility will be out of service for both scheduled and unscheduled maintenance. The availability factor is used to estimate annual water production from each facility. While the availability factor could vary from one type of facility to another, variability would not be expected to be significant, so a single availability factor was used in the initial screening of alternatives.

2.6.4 Life Cycle Cost

The estimated life cycle cost of each alternative is expressed as the total present value of initial investment, operation and maintenance costs during the period of analysis, and renewal and replacement costs during the period of analysis. All the life cycle costs will be estimated for the base year of the analysis. The resulting life cycle cost represents the estimated amount that would be needed to fully fund the project during the period of analysis. It is based on the key assumption that earnings on all project account balances would accrue at the discount rate shown in the economic parameters.

The present value of initial investment takes into account the estimated cost in the year of the cost estimate, the year in which the component will be operational, and the duration of the component's construction. Services such as planning, design, permitting, and services during construction will also be included in the calculation of present value of the initial investment so that these services, which are generally viewed as an integral part of the project's development, can be capitalized and fully reflected in the comparison of alternatives and estimation of funding and financing requirements.

It is important to note that the cost of acquiring land for each project alternative was not included in the cost estimates due to uncertainty concerning the project location and method by which land would be acquired. Initial project concepts included siting development on land owned by an electric utility, in which case the land could be leased rather than purchased. Future, site-specific analyses of any of the alternatives addressed in this study will need to include costs for land acquisition or lease.

The present value of operation and maintenance costs will be based on the estimated annual cost of operation and maintenance in the year of the cost estimate, beginning in the year that the project component is scheduled to be completed. The calculation also takes into account inflation in the cost of operation and maintenance over the period of analysis.

With the exception of reverse osmosis membranes and filter media, the present value of renewal and replacement cost was based on 10 percent of the Equivalent Annual Cost of each capital item, a method previously applied and accepted in District cost estimates. For reverse osmosis membranes and filter media, the renewal and replacement cost estimates were based on straight line depreciation over their estimated five year useful life. Although the cost of renewal and replacement may vary over time, the estimated renewal and replacement costs were kept level over time, consistent with the common practice of annually depositing a uniform amount into a renewal and replacement fund and withdrawing from the fund on an as-needed basis.

2.6.5 Equivalent Annual Cost

This is the annual amount needed during the period of analysis, beginning in the base year, to fund the project's total present value, or life cycle, cost.

2.6.6 Facility Capacity and Estimated Annual Water Production

The water production from each alternative project is calculated based on its design capacity and its availability factor, or the percentage of the time during any 12-month period that the facility can be expected to be operational.

2.6.7 Equivalent Annual Cost per 1,000 Gallons

This is the equivalent annual cost divided by the estimated annual water production. Equivalent cost per 1,000 gallons serves as an excellent basis for comparing the costs of alternative projects.

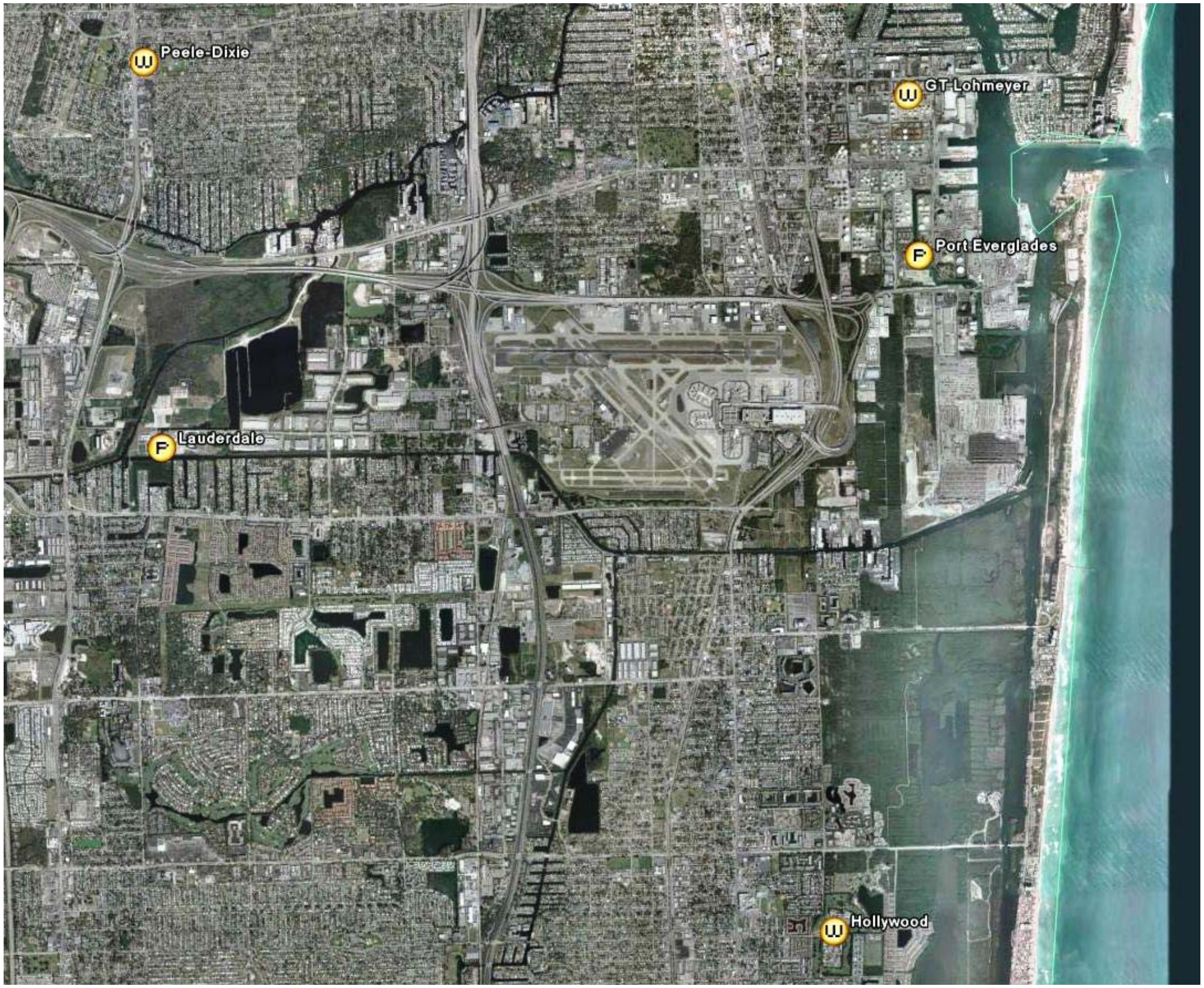


Figure 2.1 – Reverse osmosis candidate sites in Broward County

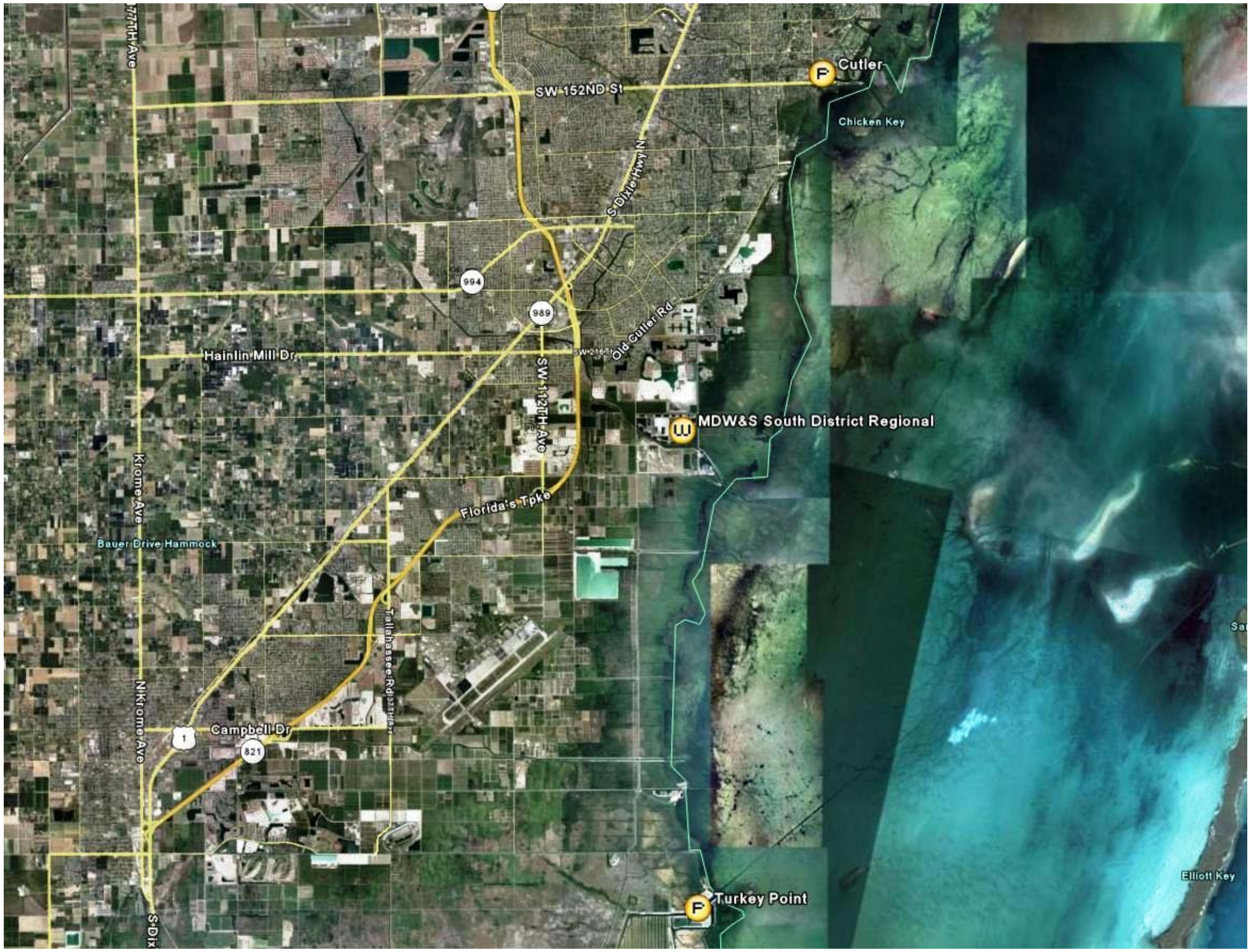


Figure 2.2 – Reverse osmosis candidate sites in Miami-Dade County

Figure 2.3 – Reverse osmosis candidate sites in Palm Beach County

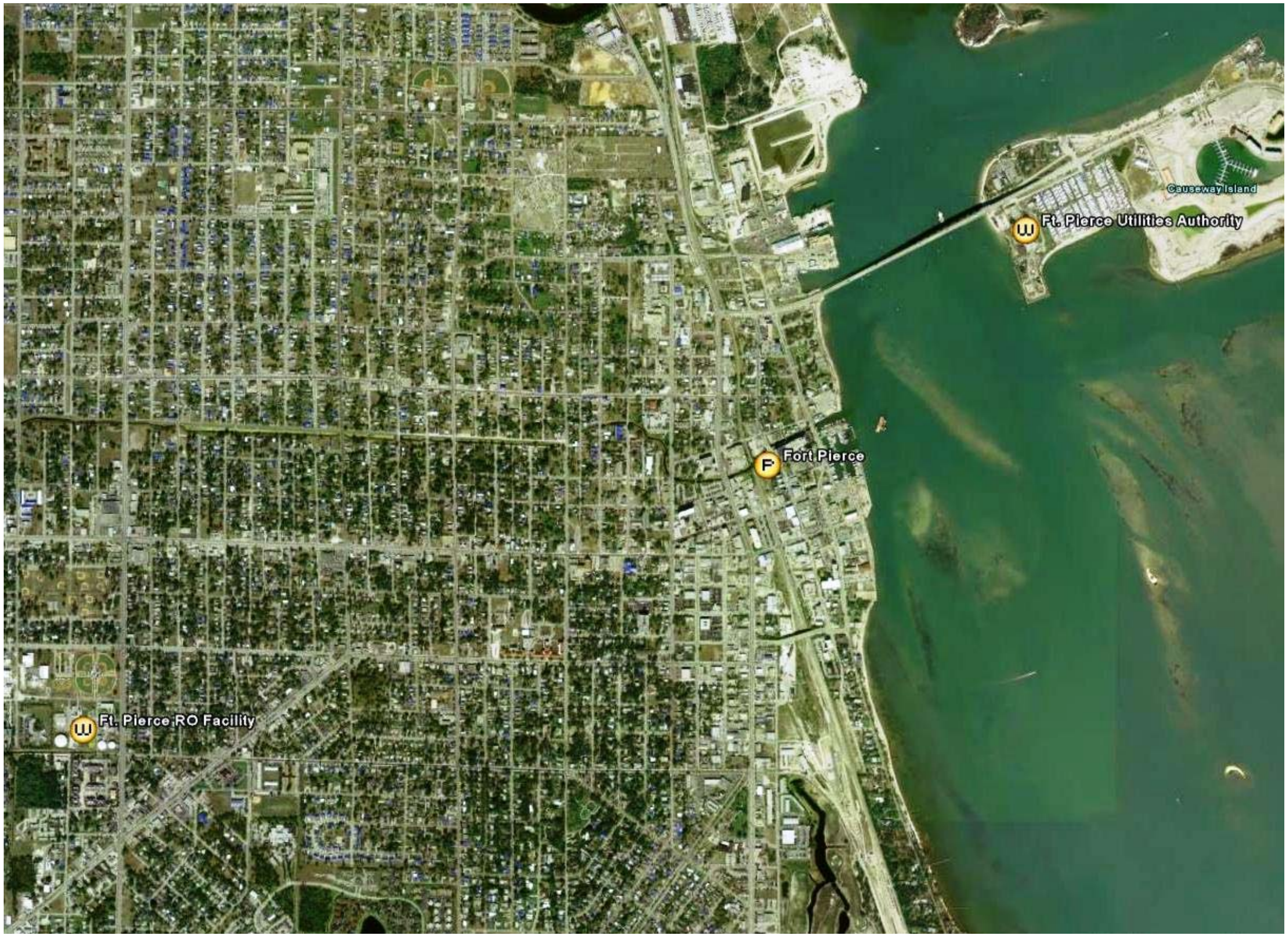


Figure 2.4 – Reverse osmosis candidate sites in St. Lucie County

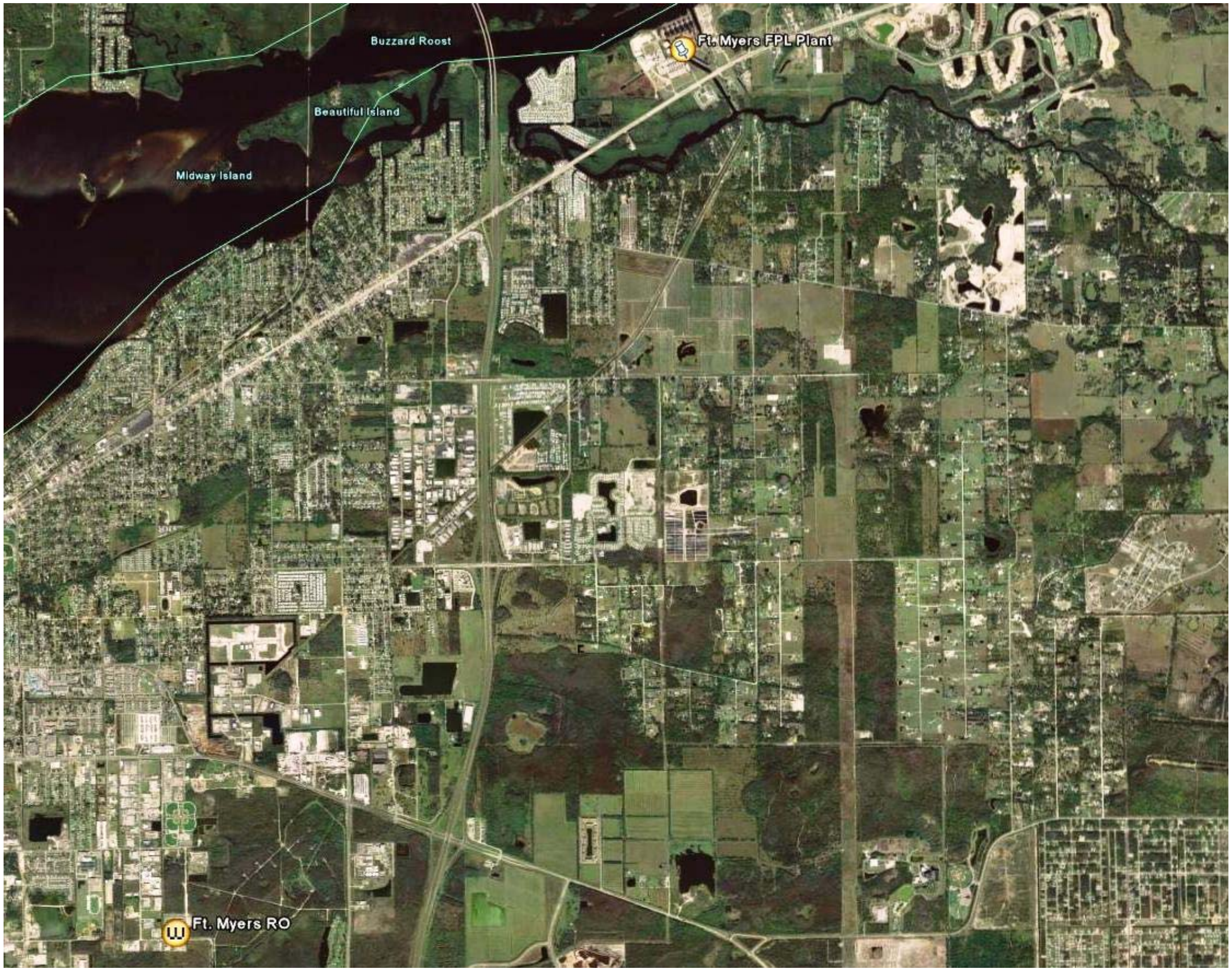


Figure 2.5 – Reverse osmosis candidate sites in Lee County

3. Screening of Potential Sites

3.1 Information Collection

Section 2 focused on reviewing previous literature and studies related to the seven FPL power facilities that passed the first tier screening criteria in the Water Resource Associates, Inc. June 2002 “Feasibility Study for Co-locating Reverse Osmosis Treatment Facilities with Electric Power Plants” study. For the current task, meetings were held with water utilities located in the vicinity of the candidate sites to determine their future water demands and to assess their willingness to pursue desalination as a means of augmenting those demands.

Meetings were also held with personnel from Florida Power & Light (FPL). FPL expressed much interest on this project recognizing that it is still very early in the planning stages. FPL provided some information regarding the seven power plants being evaluated. Appendix B includes the information provided by FPL.

FPL did indicate that as these projects show more potential and become more feasible, it would be necessary for FPL to fully understand the need for land, the size of the desalination facility, as well as permitting requirements for this facility.

3.2 Site Screening Process

The initial site screening process focused on the basic characteristics necessary for the co-location of a reverse osmosis or membrane treatment facility. Stated another way, the analysis identified those sites possessing no known characteristic that would positively prevent their development as a co-located reverse osmosis or membrane based water treatment facility. From this initial screening, the seven sites listed below, qualified for additional detailed evaluation:

- Ft. Myers – Lee County
- Turkey Point – Miami-Dade County
- Cutler – Miami-Dade County
- Port Everglades – Broward County
- Lauderdale – Broward County
- Riviera – Palm Beach County
- Ft. Pierce – St. Lucie County

Each of these sites was subsequently evaluated in detail based on the following six-step process:

1. A set of evaluation criteria was developed for evaluating the feasibility of each site. The criteria addressed the design and institutional requirements of a co-located reverse osmosis or membrane water treatment facility. These criteria were developed in Task 2.1.

2. Each criterion was weighted based on its relative importance in determining the feasibility of developing and operating the site, with weights from 1 to 5, with 5 being the most important. The weights were developed based on an assessment of each of the specific factors or site characteristics required to develop a co-located reverse osmosis or membrane water treatment facility in proximity to an electric power generating station.

3. An objective basis for applying each criterion was developed, designed to provide a consistent and meaningful basis for rating and comparing sites. The basis for applying criteria provided guidelines for assigning a score of 1 to 5 for each criterion.

4. Each criterion was applied to each site to produce a raw score, indicating each site's relative attractiveness with respect to the criterion.

5. The respective weighting factor was applied to each raw score to produce a weighted score.

6. The weighted scores for each potential site were summed to give a total score for the site.

Table 3.1 lists the screening criteria, the weight that was assigned to each criterion, the basis for the weight, and the basis for applying each criterion and assigning a score. The criteria are classified as either design or institutional. Considerable emphasis was placed on applying the criteria as consistently as possible. To this end, the basis for applying each criterion is as quantitative as possible.

The procedures and screening criteria developed for this project drew liberally from procedures and criteria applied in two similar analyses, the Water Resource

Associates 2002 study and the R.W. Beck 2004 study, both described in Task 2.1.2. However, the procedures and criteria applied in these, and other similar projects, were significantly augmented by the project team to ensure the best possible fit with the requirements of the current project.

Design-based criteria. The design-based criteria relate to the basic requirement for constructing and operating a co-located reverse osmosis or membrane water treatment facility, beginning with the demand for potable water. Other than this one fundamental consideration, the design criteria are directly related to the requirements for the specific reverse osmosis and membrane treatment process – the adequacy and quality of the raw water supply, availability of treatment technology, availability of a site adequate for constructing and operating the facility and its proximity to necessary resources, availability of the electric power needed for such a facility, ability to dispose of treatment byproducts, and the absence of any unacceptable environmental impacts associated with either project development or operation.

Institutional criteria. The institutional criteria focus on the business, regulatory, and public and political aspects of project development. A co-located water facility requires willingness on the part of both the electric power utility as well as the water utility to enter into a business arrangement. If either party would not derive a net benefit from such an arrangement, the development of the site is probably not feasible. Conversely, a site offering major benefits to both the electric utility and the water utility has a greater likelihood of success, everything else being equal. Also, it is imperative that the regulatory burden be acceptable to both parties, and it is important to have support from both the general public and elected officials, or at least the absence of strong opposition from these groups, to allow a project to proceed.

Table 3.1 – First Level Screening Criteria and Basis for Applying Criteria

Screening Criteria		Description of Criteria	Weight (1-5)	Basis for Weight	Basis for Applying Criteria (Assigning Values 1-5)
Design Criteria					
1	**Demand for potable water**	Sufficiency of projected demand for potable water in the service area that would be produced from the facility	3	Demand for potable water, or product from the project, is necessary for the project, but replacing existing supplies or firming up the potable water supply may substitute for an increase in demand	Projected demand from project of 5mgd or greater - 5 Projected demand from project of 4-5 mgd - 4 Projected demand from project of 3-4 mgd - 3 Projected demand from project of 2-3 mgd - 2 Projected demand from project of 1-2 mgd - 1 Add 1 if project is in water use caution area Subtract 1 if demand or transmission line is greater than 3.0 miles from facility
2	**Raw water supply**	Acceptable raw water supply	2	A raw water supply in proximity to the site will be needed While better quality of the raw water supply is significant, it can be overcome through proper pretreatment	Raw water supply of 10 mgd or greater within 0.5 mile and conventional pretreatment needed - 5 Raw water supply of 10 mgd or greater within 1.0 mile and conventional pretreatment needed - 4 Raw water supply of 10 mgd or greater within 2 miles and conventional pretreatment needed - 3 Raw water supply of 10 mgd or greater within 2 miles and specialized pretreatment needed - 2 Raw water supply of 10 mgd or greater within 2 miles and aggressive pretreatment needed - 1 Add 1 if expected useful life of raw water supply exceeds 20 years Subtract 1 if expected useful life of raw water supply is less than 15 years
3	**Treatment process availability**	Availability of equipment and processes suitable for treating available raw water supply	1	While it will be necessary to ensure that the technology needed to treat the raw water is available, there is not expected to be a situation where the technology will not be adequate	Well tested and energy-efficient process available - 5 Well tested and reasonably energy-efficient process available - 4 Moderately tested and reasonably energy-efficient process available - 3 Relatively untested and reasonably energy-efficiently process available - 2 Relatively untested and energy intensive process available - 1

Table 3.1 – First Level Screening Criteria and Basis for Applying Criteria

Screening Criteria		Description of Criteria	Weight (1-5)	Basis for Weight	Basis for Applying Criteria (Assigning Values 1-5)
4	**Site availability**	Availability of suitable site for project	4	It is necessary to identify a suitable site prior to moving forward with site evaluation	Site of adequate size with suitable zoning available for long term lease or purchase - 5 Site of adequate size requiring change in land use or zoning available for purchase or long term lease - 3 Site of marginal size requiring change in land use or zoning available for purchase or long term lease - 2 Site of marginal size requiring change in land use or zoning with potential environmental issues available for purchase or long term lease - 1
5	**Availability of energy**	Current or potential availability of energy sufficient for facility operation	4	Because energy costs represent up to 30 percent of project costs, sites with better access to electric power will be much preferred	Energy needed for 5 mgd facility available within 0.5 mile at relatively low cost - 5 Energy needed for 5 mgd facility available within 1 mile at relatively low cost - 4 Energy needed for 5 mgd facility available within 1 mile at moderate cost - 3 Energy needed for 5 mgd facility available within 1 mile at relatively high cost - 2 Energy needed for 5 mgd facility available greater than 1 mile available - 1
6	**Availability of byproduct disposal facilities**	Current or potential availability of desalination waste byproducts disposal facilities	2	Each potential site has existing or potential waste byproducts disposal facilities, so this is an essential but lower priority screening criterion	Byproduct disposal facility with 3 mgd capacity available within 0.5 mile - 5 Byproduct disposal facility with 3 mgd capacity available within 1 mile - 4 Byproduct disposal facility with 3 mgd capacity available within 2 miles - 3 Byproduct disposal facility with 2-3 mgd capacity available within 2 miles - 2 Byproduct disposal facility with 2-3 mgd capacity available greater than 2 miles - 1 Add 1 if expected useful life of disposal facility exceeds 20 years Subtract 1 if expected useful life of disposal facility is less than 15 years
7	**Environmental effects**	Potential effect of cooling water intake, cooling water discharge, project construction and operation on environmental resources	2	Needs to be considered but is further considered under regulatory and permitting criterion	No significant environmental effect - 5 Some but nondegradable environmental effects - 3 Significant but permissible environmental effects - 1

Table 3.1 – First Level Screening Criteria and Basis for Applying Criteria

Institutional Criteria					
8	**Electric power utility interest**	Documented interest of the electric power utility (FPL)	5	Without the full support of the electric power utility, it would be difficult to develop a site	Documented electric utility support of project - 5 Expression of electric utility support of project - 3 Electric power utility interest in but reservations concerning project - 1 Electric power utility lack of interest in project - 0
9	**Water utility interest**	Documented interest of one or more water utilities	5	A water utility must be interested in site development for it to proceed	Strong, documented water utility support of project - 5 Moderate, documented water utility support of project - 3 Weak, documented water utility expression of support of project - 1 Water utility lack of interest in project - 0
10	**Regulatory and permitting**	Acceptable regulatory and permitting requirements, including reasonable costs and schedule	3	Regulatory and permitting requirements may present a barrier to a project, but can usually be satisfactorily addressed	No significant environmental issues and no federal permitting required - 5 Some environmental issues and no federal permitting required - 3 Significant environmental issues with project and no federal permitting requirement - 1 Federal permitting requirement - 0
11	**Public and political support**	Documented support from general public and elected officials	4	While the water utility's support is separately viewed as essential to the success of a project, the support of elected officials and the general public will also be important	Documented clear support of project from elected officials - 5 Documented but conditional support of project from elected officials - 3 No documented support of project from elected officials - 1 Opposition of project from some elected officials - 0

3.3 Site Screening Results

Table 3.2 shows the results of the evaluation of each potential site. In addition to the raw scores, weighted scores, total scores and site ranking, the table also provides some explanation of the basis for the scoring.

As is often the case in this type of analysis, there are clear break points in the total scores. The highest scoring site, Ft. Myers, received the highest score based on the design criteria and was among the highest scores on institutional criteria.

The second- and third-ranked sites, Lauderdale and Port Everglades, respectively, share a number of common characteristics, and not unexpectedly received similar scores, both from the design-based as well as the institutional-based criteria. These two sites trailed the Ft. Myers site due to design criteria such as land and raw water availability.

The four remaining sites, Turkey Point, Riviera, Cutler, and especially Ft. Pierce, scored significantly below the top three sites. The score of the Turkey Point site is due largely to its low rating based on institutional criteria. This low rating is the result of an important qualification relating to the commingling of cooling water from both the nuclear and fossil fueled generators. The cooling water at this site is used for both generating facilities and would also serve as the source of raw water to a potential co-located water treatment facility. As a result, this site scored lower than the other candidate sites in the categories related to public and political support and also in permitting and regulations.

The Ft. Pierce site was found to have a number of adverse characteristics that collectively eliminate it from any further consideration. First among those characteristics is that the power plant with which a potential reverse osmosis water treatment plant could be co-located is scheduled to close in 2007.

The Riviera site scored low in both institutional and design-based criteria due to its proximity to the only utility, West Palm Beach, which exhibited interest in the project. The Riviera site is located outside the city limits of West Palm Beach resulting in lower scores for political and public support as well as scoring in the design-based categories. Political and public support for the Riviera site would be expected to be low among the local citizens and politicians for an RO facility that will serve an area outside their local boundaries. Design considerations such as the distance between the facility and the boundary of West Palm Beach and also the amount of available land resulted in lower scores for this site.

The Cutler site scored low on both design-based as well as institutional-based criteria as a result of being a peaking facility, and as such, operating only during peak electrical demand, resulting in a lack of raw water during off-peak hours. In addition, off-peak operation of an RO facility would be hampered by a lack of discharge water for blending of RO concentrate.

These findings indicate that three sites, Ft. Myers in Lee County, and Lauderdale and Port Everglades in Broward County, clearly warrant additional consideration. The remaining four sites, Turkey Point, Riviera, Cutler, and Ft. Pierce, scored significantly lower that the third-place site and are effectively removed from further consideration.

Table 3.2 – Evaluation of Alternative Projects – Results of Potential Site Screening

	Screening Criteria	Ft Myers		Turkey Point		Lauderdale		Riviera		Port Everglades		Cutler		Ft Pierce	
		Score Raw / Weighted	Notes	Score Raw / Weighted	Notes	Score Raw / Weighted	Notes	Score Raw / Weighted	Notes	Score Raw / Weighted	Notes	Score Raw / Weighted	Notes	Score Raw / Weighted	Notes
Design Criteria															
1	**Demand for potable water**	5/15	Lee County has shown demand	4/12	Demand will exceed 3 miles from site	5/15	Ft. Lauderdale has shown demand	1/3	West Palm Beach has shown demand	5/15	Ft. Lauderdale has shown demand	5/15		5/15	
2	**Raw water supply**	5/10		3/6	Raw water supply expected to be greater than 2 miles from site	4/8		4/8		5/10		0/0	Peaking plant - lack of raw water supply during off-peak hours	0/0	Power plant to close in 2007
3	**Treatment process availability**	4/4		4/4		4/4		4/4		4/4		4/4		4/4	
4	**Site availability**	5/20		2/8	Nuclear facility may limit available land	3/12	Limited site availability and potential land use issue	3/12		2/8	Quite limited site availability	3/12	Limited site availability and potential land use issue	2/8	Possible insufficient site availability
5	**Availability of energy**	3/12	Assume energy available at published tariff rate	3/12	Assume energy available at published tariff rate	3/12	Assume energy available at published tariff rate	3/12	Assume energy available at published tariff rate	3/12	Assume energy available at published tariff rate	3/12	Assume energy available at published tariff rate; plant produces peaking power	3/12	Assume energy available at published tariff rate
6	**Availability of byproduct disposal facilities**	5/10		4/8	Byproduct disposal within one mile of site	5/10		4/8		5/10		0/0	Peaking plant - lack of byproduct discharge facility during off-peak hours	0/0	Power plant to close in 2007
7	**Environmental effects**	5/10	Sensitive Resources Present. Land use categorized as industrial	5/10	Potential impact on existing wetlands. Proximity to nuclear plant	5/10	Site is zoned Utility Sensitive Resources Present.	5/10		5/10	Site is zoned Utility Sensitive Resources Present.	3/6	Site adjacent to residential area	3/6	Site adjacent to residential area
Design Subtotal		**81**		**60**		**71**		**57**		**69**		**49**		**45**	
Institutional Criteria															
8	**Electric power utility interest**	3/15	FPL expressed support	3/15	FPL expressed support	3/15	FPL expressed support	3/15	FPL expressed support	3/15	FPL expressed support	3/15	Peaking plant - lack of raw water supply during off-peak hours	0/0	Power plant to close in 2007
9	**Water utility interest**	3/15	Interest expressed by Lee County	4/20	Neutral due to M-D interest in Virginia Key RO site	3/15	Interest expressed by City of Ft. Lauderdale	2/10	Interest expressed by West Palm Beach	3/15	Interest expressed by City of Ft. Lauderdale	3/15	Peaking plant - lack of raw water supply during off-peak hours	0/0	Power plant to close in 2007
10	**Regulatory & political support**	5/15		2/6	Nuclear / fossil commingled cooling water / OFW	5/15		3/9	Proximity to Florida Outstanding Water	5/15		3/9	Peaking plant - lack of raw water supply during off-peak hours. Outstanding Florida Water – Biscayne Bay	0/0	Power plant to close in 2007
11	**Public & political support**	3/12	Public and political support expected to follow water utility interest	2/8	Nuclear / fossil commingled cooling water	3/12	Public and political support expected to follow water utility interest	3/12	Expect limited local support if project only serves West Palm Beach	3/12	Public and political support expected to follow water utility interest	3/12	Peaking plant - lack of raw water supply during off-peak hours	0/0	Power plant to close in 2007
Institutional Subtotal		**57**		**49**		**57**		**46**		**57**		**51**		**0**	
Total Site Score		**138**		**109**		**128**		**103**		**126**		**100**		**45**	
Total Site Ranking		**1**		**4**		**2**		**5**		**3**		**6**		**7**	

3.4 Analysis of Top Ranked Sites

The three potential sites that produced high scores during the screening process, Ft. Myers, Lauderdale and Port Everglades, are further analyzed to select the site most suitable for potential development. To guide the analytical process, a set of three rules was established for selecting the preferred site:

- Significant advantages or disadvantages, reflected in the scoring of design and institutional considerations, may outweigh minor cost differences
- In the absence of a compelling reason to conclude otherwise, alternatives with the lowest equivalent annual cost per 1,000 gallons are preferred
- Project alternatives with greater projected annual water production are favored over smaller projects, where the equivalent annual cost per 1,000 gallons and design and institutional factor scores are close

Accordingly, the site analysis will be conducted in three parts:

- Economic analysis, including development of life cycle cost estimates
- Further analysis of the design-based and institutional-based characteristics affecting each site's overall feasibility for development
- Integration of these two efforts to draw conclusions and select the site or sites most appropriate for final consideration for development

4. Preliminary Development of Conceptual Demonstration Project and Evaluation of Demonstration Project Unit Treatment Process

This section presents the conceptual development of a demonstration project at the top three sites identified in Section 3; Ft. Myers, Lauderdale and Port Everglades.

4.1 Utility Demands

Water utilities in the municipalities surrounding each of the candidate sites were interviewed by phone to determine their initial interest in the study. If a utility showed interest, a formal meeting was conducted to provide an in-depth presentation of the goals of the study and establish the parameters of moving the candidate site towards a demonstration project.

Meetings were conducted with water utility representatives of West Palm Beach in Palm Beach County; Fort Lauderdale in Broward County; Lee County, Fort Myers, and Cape Coral in Lee County; and Miami-Dade Water and Sewer District in Miami-Dade County. Initial discussions with officials from the city of Fort Pierce indicated the candidate site, the Henry D. King Generating Station, was slated for decommissioning in 2007. As a result, the King site was eliminated from additional review as part of this study.

Several common issues were raised by the utilities during the presentation meetings, including questions regarding plant ownership, land ownership, electric utility fees and charges, partnership with FPL, construction costs, grant availability, and funding of the design phase.

At the conclusion of the meetings, four utilities expressed continued interest in moving forward as part of the study. Interested utilities were requested to provide information regarding projected demands from the prospective RO facility, the timetable the demands must be met, location of connection between the RO facility and the utility's transmission mains, and characteristics of the utility's finished water with regard to the RO water. The interested utilities and the amount of demand that exceeds current capacity are depicted in Table 4.1

Table 4.1 – Projected Future Water Demand in Excess of Current Capacity

Water Utility	Candidate Site / County				
	Fort Pierce / St. Lucie	Riviera Beach / Palm Beach	Lauderdale & Port Everglades / Broward	Turkey Point & Cutler / Miami-Dade	Ft. Myers / Lee
Ft. Pierce Utilities Authority	plant closure in 2007	-	-	-	-
City of West Palm Beach Utilities	-	8.5 mgd (2015)	-	-	-
City of Ft. Lauderdale	-	-	35 mgd (2025)	-	-
Miami-Dade Water & Sewer District	-	-	-	20 mgd (2015)	-
Lee County Utilities	-	-	-	-	10 mgd (2025)

Note: Water demands shown only for utilities that expressed interest in co-location study.

4.2 Demonstration Project Unit Treatment Processes

Evaluation of unit treatment process includes review of historical and available technologies for seawater desalination (SWRO) including intakes, pretreatment processes, evaluation of source water issues, RO treatment issues, brine disposal, residuals disposal, energy recovery, and alternative sources of energy. The objective of this review is to select a candidate SWRO treatment process to be used for subsequent evaluation of capital, O&M costs, and total cost of water in $/1,000 gallons for facilities co-located with the top three FPL power plant sites identified in the site-selection screening process.

The work conducted in Task 2.4 is based on available water quality from the WRA Report titled "Feasibility Study for Co-Locating Reverse Osmosis Treatment Facilities with Electric Power Plants" for the candidate sites. In addition, the method of desalination is reverse osmosis (RO) and not heat-based type systems such as multi-stage flash evaporation (MSF) or multi-effect distillation, or electro-dialysis reversal (EDR) because heat-based systems are not economically viable in the U.S. due to high energy costs; and EDR systems have not been widely used for seawater desalination.

For purposes of this study, only co-location with existing FPL power plants is considered. Co-location has the key advantages of utilization of the existing seawater intakes used for once through power plant cooling; and utilization of the existing cooling water discharge outfall for concentrate disposal.

4.3 General Description of the Three Selected Sites

The site selection screening process in Section 3 has identified the top three sites as:

1. Ft. Myers power plant on State Road 80, Fort Myers, Florida

2. Port Everglades power plant on Eisenhower Blvd, Fort Lauderdale, Florida

3. Lauderdale power plant on SW 42nd Avenue, Ft. Lauderdale, Florida

These three sites are carried forward for this evaluation.

4.3.1 Ft. Myers Plant

The Ft. Myers power plant is located on approximately 480 acres at 10650 State Road 80 in Lee County between the Caloosahatchee and Orange Rivers (Figure 4.1). The gas fired plant, containing 6 combined-cycle units and 12 simple cycle gas turbines, receives cooling water from the Caloosahatchee River located on the north boundary of the property and discharges it to the Orange River located south of the site. Previous studies have estimated the waters of the Caloosahatchee River to have an annual average TDS of approximately 15,000 ppm. Currently, the facility uses an annual daily average of 571 mgd of cooling water.

An empty parcel located south of the 12 gas fired peaking units has adequate area for the proposed RO facility. Discharge water from the power plant can be piped approximately 1,500 feet to the facility, while RO concentrate would then be returned to the discharge canal approximately 1,100 feet downstream to be blended with the plant cooling water. The location of the RO plant intake would preclude the reintroduction of RO concentrate into the raw water stream due to the high cooling water flow rates through the discharge canal. Finished water is proposed to be piped to an existing 20-inch transmission line located along the south property line on State Road 80 (Figure 4.2).

Figure 4.1 – Florida Power Ft. Myers Facility, Lee County

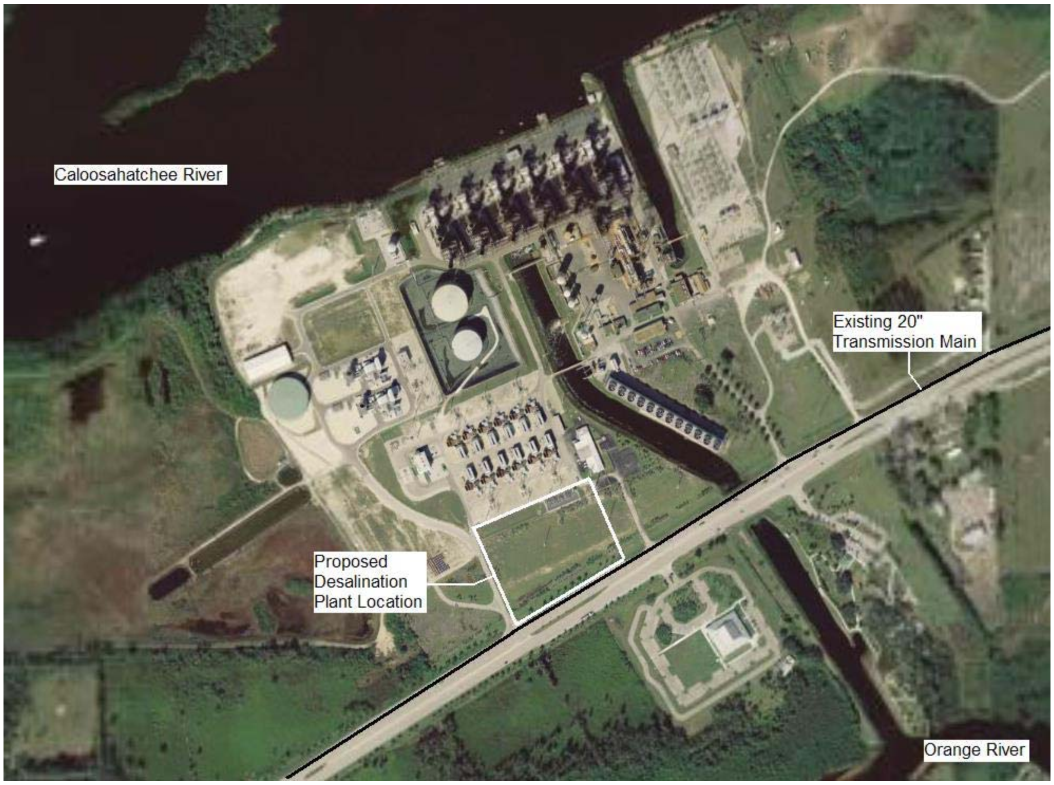


Figure 4.2 – Florida Power Ft. Myers Plant, Proposed Reverse Osmosis Facility Location

4.3.2 Lauderdale Plant

The Lauderdale plant is located in Broward County at 4300 Southwest 42nd Avenue, Fort Lauderdale. The site, positioned at a fork forming the Dania Cutoff Canal and the south fork of the New River, occupies approximately 390 acres. The facility currently operates four combined cycle gas turbines and 24 simple-cycle oil fired turbines for a total electrical capacity of approximately 1,400 MW.

Cooling water for the plant is obtained from the Dania Cutoff Canal and, according to sampling data from the sites NPDES permit, appears to be tidally influenced as evidenced by wide-ranging TDS values. Currently, the facility uses an annual daily average of 310 mgd of cooling water. Heated plant water is discharged to the northeast through a cooling pond that leads to the New River prior to emptying into the Intercoastal Waterway (Figure 4.3).

Figure 4.3 – Florida Power Lauderdale Facility, Broward County

The proposed location of the RO facility, shown in Figure 4.4, is located approximately 2,100 feet to the northeast of the power plant. Raw water from the plant discharge would require piping around the oil fired units to the north of the plant. RO concentrate piping would then be routed back to the plant discharge channel for blending. Mixing of brine concentrate with raw RO intake water is unlikely since the power plant intake and discharge streams are located in different bodies of water. At the present time the city of Fort Lauderdale has not indicated the location of connection to their water transmission system.

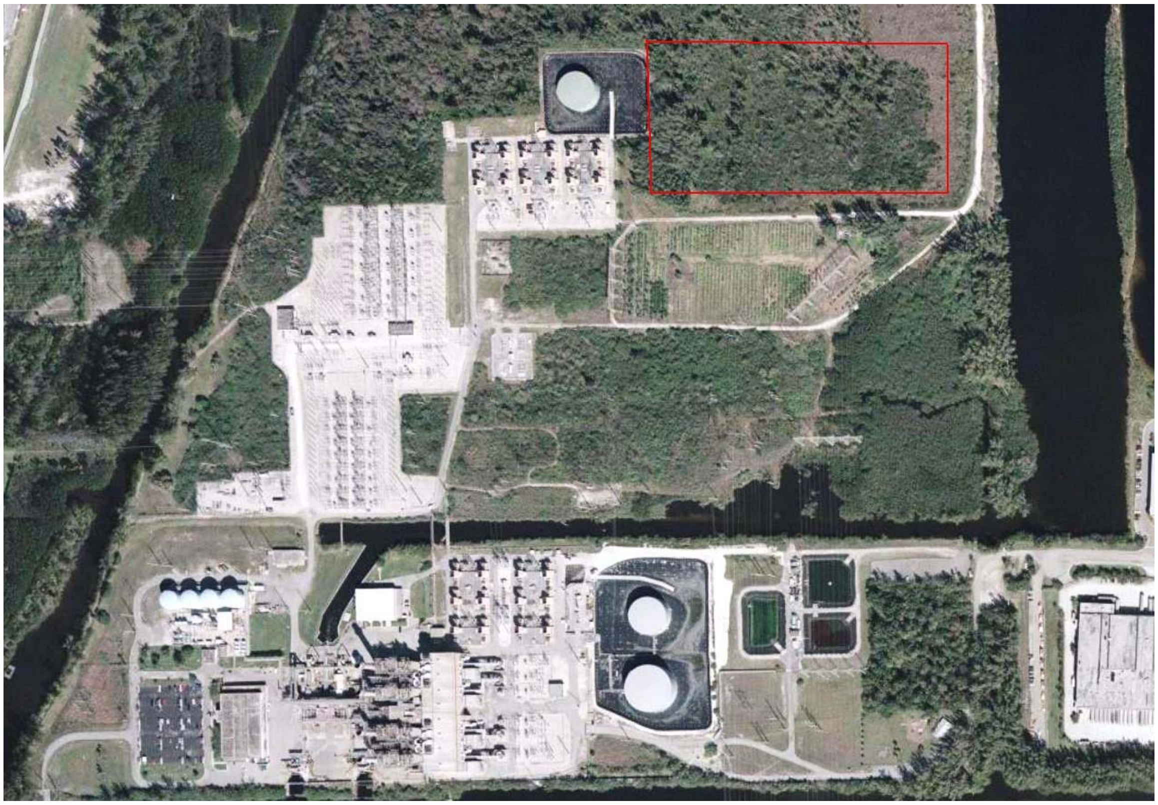


Figure 4.4 – Florida Power Lauderdale Plant, Proposed Reverse Osmosis Facility Location

4.3.3 Port Everglades Plant

The Port Everglades power plant is located in Broward County at 8100 Eisenhower Boulevard, Fort Lauderdale (Figure 4.5). Situated on approximately 94 acres, the plant produces power using four gas/oil units and twelve simple-cycle gas turbines providing a total electrical capacity of approximately 1,200 MW.

The plant uses an average of 1,174 mgd of cooling water obtained from a 2,100-foot canal coming from the Intercoastal Waterway. The TDS of the cooling water is expected to be close to that of seawater. Heated water from the plant is discharged through a 5,300-foot canal that leads to the Intercoastal Waterway at a point approximately one mile south of the intake canal. Flows in the Intercoastal Waterway at this location are likely directed nearly due east from the plant intake canal through Fort Lauderdale Inlet to the Atlantic Ocean.

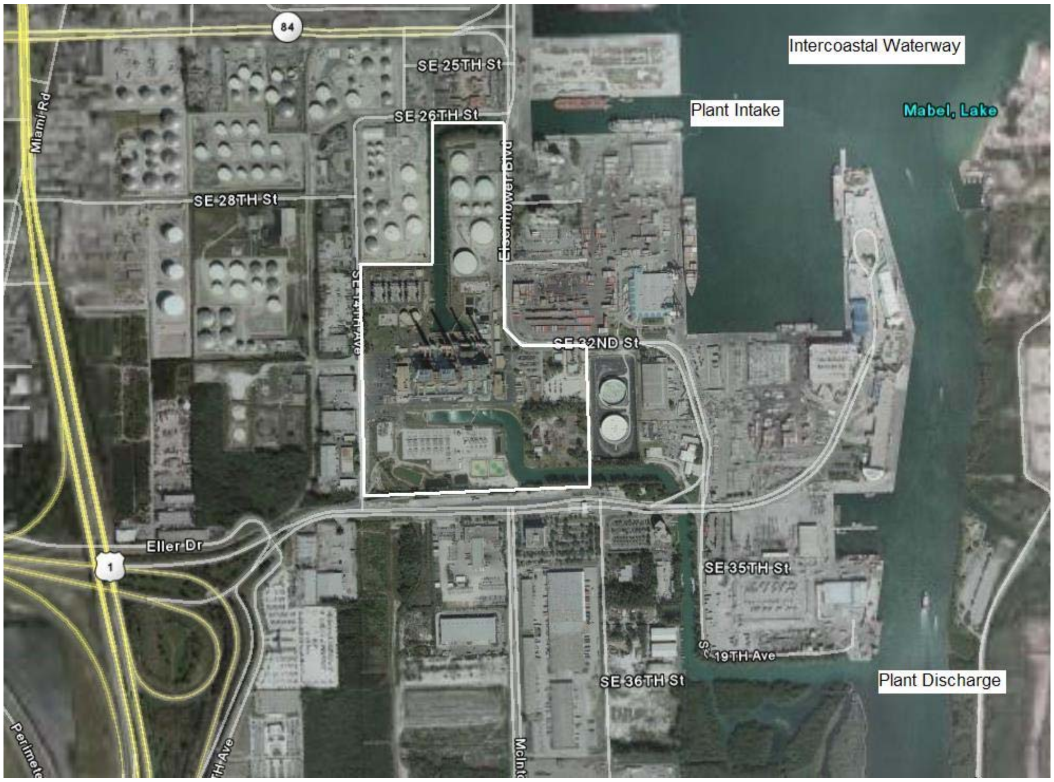


Figure 4.5 – Florida Power Port Everglades Facility, Broward County

The proposed location of the RO facility is located on an empty parcel in the southeast corner of the plant site (Figure 4.6). Raw water piping from the power plant discharge headers to the proposed facility would be approximately 750 feet, while finished water piping north to SE 32nd Street would be approximately 650 feet long. Brine concentrate discharged from the plant would likely flow past the plant intake canal, since the next nearest ocean outlet from the Intercoastal Waterway is located 12 miles to the south.

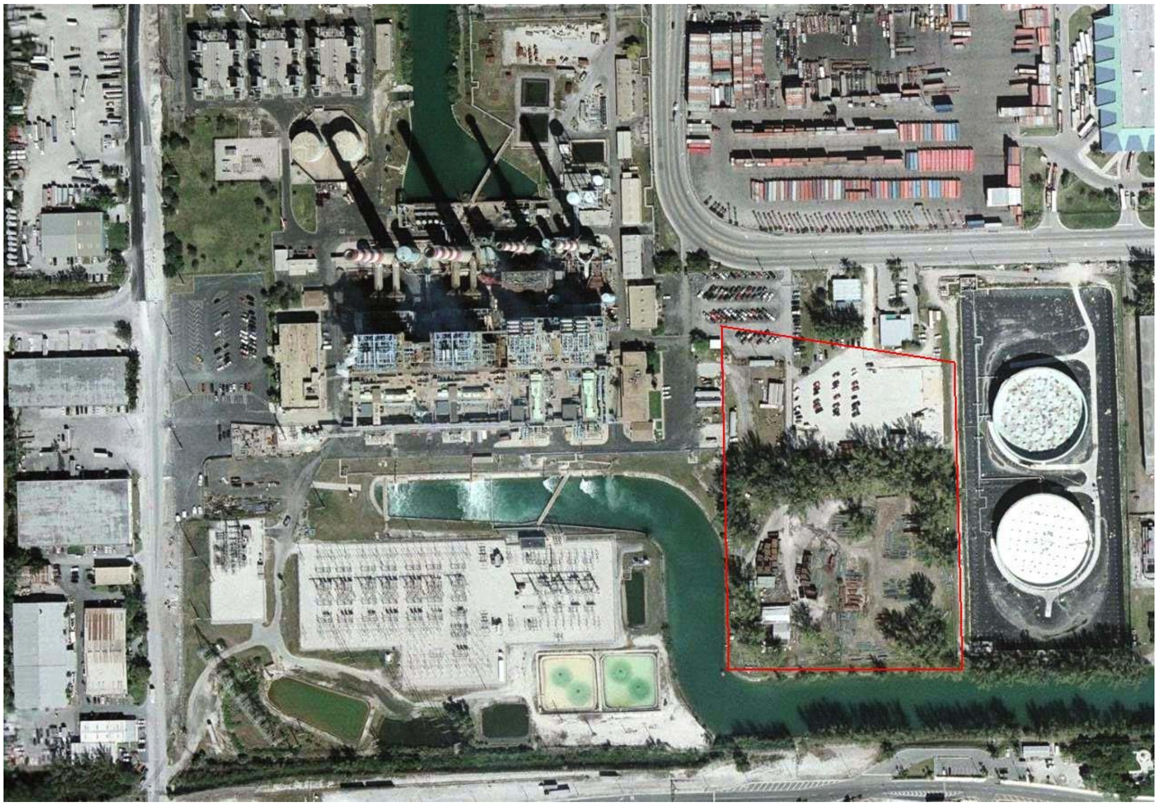


Figure 4.6 – Florida Power Port Everglades Plant, Proposed Reverse Osmosis Facility Location

4.4 Development of Seawater Source

In order to produce finished water by SWRO, a larger portion of raw water is required to account for waste streams for the water treatment plant. These waste streams can include filter wash water, clarifier residuals streams, and brine concentrate.

For a seawater membrane desalination plant, the largest component of the waste stream is the membrane system brine concentrate. This stream will typically comprise over 90% of the total waste for a seawater membrane desalination plant.

The ultimate recovery of a seawater membrane system is typically a factor of the maximum permissible operating pressure and the solubility of sparingly soluble salts such as calcium sulfate. Each is discussed below in further detail.

4.4.1 Maximum Permissible Operating Pressure

The maximum operating pressure is generally a limit set by the safety factors developed. When two water volumes are separated by a semi permeable membrane, water will flow from the side of low solute concentration to the side of high solute concentration via the process of osmosis, until equilibrium is reached. The flow may be stopped, or even reversed, by applying external pressure on the side of higher concentration. The phenomenon resulting from reverse flow through the application of pressure is commonly referred to as reverse osmosis. The thermodynamic energy that provides the driving force for osmosis is referred to as the osmotic pressure.

The osmotic pressure, p, may be determined using the van't Hoff formula:

$$p = cRT \qquad \text{- Equation 1}$$

where: c = total molar solute concentration (moles/L),
R = Universal gas constant (L·atm / mol·K)
T = absolute temperature (degrees Kelvin)

Figure 4.7 shows connected vessels separated by a semi permeable membrane. If there is only water in the device, the level will be the same at both sides. When solute molecules are added to one side, water will start to flow into it, so that its level will go up at this side, and down at the other side. The system will stabilize when the osmotic pressure is balanced by the hydrostatic pressure generated by the difference in the water levels, as indicated in Equation 2.

$$cRT = \rho h \qquad \text{- Equation 2}$$

where: ρ = specific gravity of water (unitless)
h = change in water level due to hydrostatic pressure.

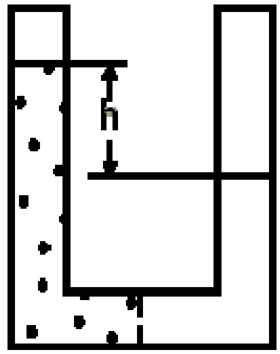


Figure 4.7 – Explanation of Osmosis

The osmotic pressure may be estimated using the relation 0.0115 psig/ppm. For a typical seawater (TDS = 35,000 mg/L) Figure 4.8 was constructed to illustrate the effect of increasing recovery on the osmotic pressure of the concentrate.

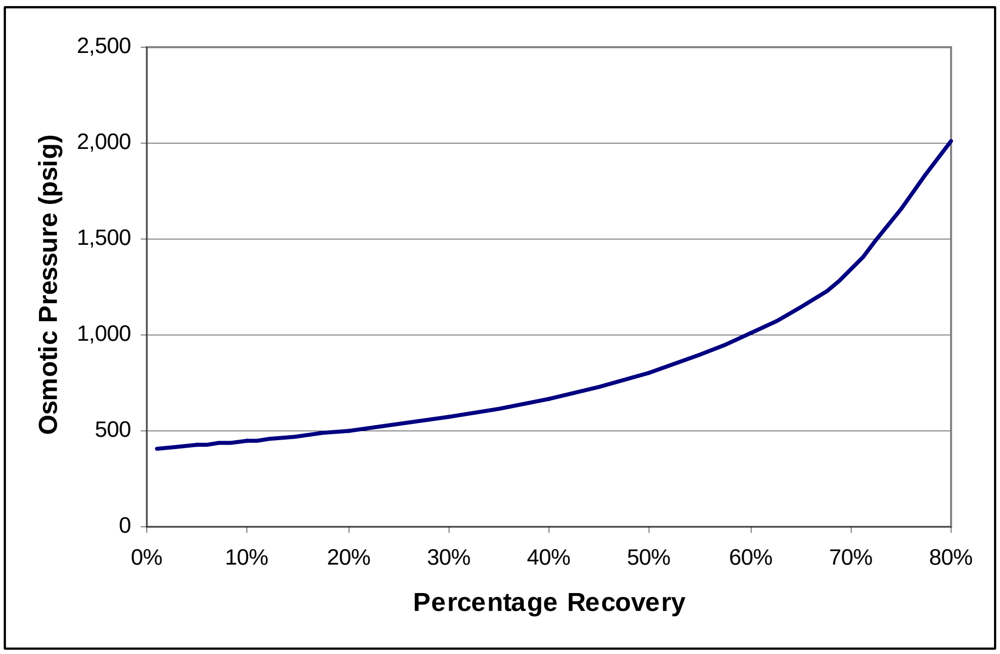


Figure 4.8 – Effect of System Recovery on Concentrate Osmotic Pressure for Standard Seawater

Most systems are designed to operate at a maximum pressure of less than 1,000 psig, although some systems have been designed to operate as high as 1,200 psig. Based upon Figure 4.8, the osmotic pressure of concentrate at 60% recovery is approximately 1,000 psig. In order to produce permeate the operating pressure must exceed the osmotic pressure. For seawater reverse osmosis (SWRO), the practical limit for recovery is typically 50%. Most operating plants today operate with between 35% and 50% recovery depending on the salinity of the water and the type of membrane utilized.

Although mass transfer theories have recently superseded the reverse osmosis theories when describing hyper-filtration, reverse osmosis remains the simplest explanation used to describe the function of hyper-filtration membranes.

4.4.2 Sparingly Soluble Salts

Reverse osmosis seawater desalination systems utilize the differing rates of mass transfer of water and salts through a semi permeable membrane to produce high quality permeate from seawater. Since the membranes reject high percentages of salts (>99%), an accumulation of salts occurs on the feed side of the membrane. At some juncture, the solubility of sparingly soluble salts such as calcium sulfate, barium sulfate, strontium sulfate, or calcium carbonate may occur, resulting in precipitation of these salts on the membrane. Precipitation of these salts can increase pressure drop, requiring higher feed pressures and resulting in higher operating costs, or can result in increased salt concentrations in the permeate stream. Both of these consequences are undesirable.

Reverse osmosis system operators and designers can control the concentration of sparingly soluble salts in the concentrate stream by controlling the system recovery. Reducing the recovery also reduces the concentration of sparingly soluble salts in the concentrate. Chemical conditioning of the feed water using scale inhibitors and dispersants can result in super-saturation of sparingly soluble salts with minimal precipitation. Generally, for seawater desalination, the residence time of the supersaturated water in the membrane vessels is very short – far shorter than the kinetics of precipitation. As a result, many seawater installations have been shown to operate with no scale potential at recoveries on the order of 50% with sparingly soluble salts concentrations exceeding solubility by as high as 300%. As a result, the ultimate recovery of seawater reverse osmosis units is generally determined by operating pressure and salt passage.

Based upon the limits imposed by osmotic pressure and sparingly soluble salts, it is predicted that the reverse osmosis system recovery will be approximately 50%. Detailed modeling using the membrane manufacturer’s proprietary software can be performed to confirm recovery. This determination is discussed in detail in Section 3.1.

The site selection process identified that the municipal entities in the vicinities of the top three SWRO co-location sites could potentially accept potable water production capacities listed in Table 4.2. Also listed in the table are the approximate volumes of raw seawater required to produce the desired volume of finished water assuming a maximum recovery of 50% to account for concentrate discharge and pretreatment waste streams. The final raw water requirement depends on the specific pretreatment and residual handling process selected.

Table 4.2 – Raw and Finished Water Requirements

	Ft. Myers	Port Everglades	Lauderdale
Raw mgd	17.0	70.0	40.0
Finished mgd	8.5	35.0	20.0

4.4.3 Seawater Salinities, Temperature, and pH

For selecting the conceptual process design criteria for the demonstration plant pretreatment and desalination processes, characterization of the feed water is required. Thus far it appears that limited water quality data is available for the selected sites. The most important water quality parameter for conceptual sizing of a SWRO facility is the salinity or total dissolved solids (TDS). FPL may have some data but as yet this has not been made available to Metcalf & Eddy. Thus, at this time, the preliminary concepts will be based strictly on the TDS data obtained from the WRA report for the Ft. Myers and Port Everglades sites and assumed to be 15,000 mg/L and 33,000 mg/L, respectively. The Lauderdale plant site cooling water is extracted from the Dania Canal and exhibits changes in TDS that indicates tidal influence. Limited data obtained from Discharge Monitoring Reports indicates that the source water for the Lauderdale plant varies from fresh water to > 26,000 TDS. Therefore, for the Ft. Lauderdale site, an average TDS of 15,000 mg/l is assumed at this time. M&E performed a brief search of the National Ocean and Atmospheric Administration web site to look for ocean buoys in the vicinity of the proposed sites. Some buoys were identified but none of them seem to be monitoring water quality parameters of interest.

RO feed water temperature is another important parameter for design of desalination facilities because it affects the feed pressure and permeability of the RO membranes, and hence the "size" of the RO system, and operating cost. The higher the temperature, the lower the pressure, and higher the permeability of the membrane, the smaller the system and lower the operating cost. Hence, co-location with power plants and utilization of the warmer post-condenser cooling water for RO desalination is advantageous.

Again the prior WRA report was utilized as the reference for temperature for the Ft. Myers and Port Everglades locations. To have a worst case preliminary design basis M&E selected the coolest reported water temperatures. No data was available for temperature at the Lauderdale site so cooling water temperature was assumed to be the same as for the Port Everglades site. A summary of the cooling water temperature is presented in Table 4.3.

Table 4.3 - Summary of Cooling Water Temperature ^{o}F

	Ft. Myers	Port Everglades	Ft. Lauderdale
Minimum	87.8	89.0	89.0
Maximum	98.6	98.0	98.0

Water pH variations can affect the carbonate equilibrium and impact the solubility of sparingly soluble salts that can result in membrane scaling. No pH data was available at the time of this study or from the prior WRA report.

Ideally, the preliminary SWRO concept should be based on site-specific water quality data. The possibility of SWRO in the U.S. is a new concept and limited water quality data is available. At this time, the only available water quality data is based on fairly broad assumptions made in the WRA report, and not actual seawater analysis. In the absence of comprehensive, site-specific water quality data, Metcalf & Eddy conducted a search of published literature to determine typical water quality parameters for 35,000 mg/L TDS seawater. The results of the search, and the references utilized to establish the water quality data, are summarized in Table 4.4 purely for illustrative purposes. These parameters can be considered indicative of results that would be obtained from generic seawater analysis.

Table 4.4 – Design Seawater Analysis

General		Unit	Average
Turbidity	-	NTU	<20
Conductivity	-	μS/cm	48,000
Total Dissolved Solids	TDS	mg/L	35,323^{+}
Alkalinity (calculated)	Alk	mg/L as $CaCO_3$	117.3$^{\#}$
Total Hardness (calculated)	TH	mg/L as $CaCO_3$	6,392$^{\#}$
Temperature	T(^{o}C)	^{o}C	10 - 30$^{\#\#}$
pH	-	-	8^{+}
Chloride	Cl^{-}	mg/L	19,441^{+}
Sulfate	SO_4^{-}	mg/L	2,713^{+}
Bromide	Br^{--}	mg/L	66.2^{+}
Bicarbonate (calculated)	HCO_3^{-}	mg/L	143.1^{+}
Carbonate (calculated)		mg/L	0$^{\#}$
Hydroxide (calculated)	OH^{-}	mg/L	0$^{\#}$
Carbon Dioxide (calculated)	CO_2	mg/L	0$^{\#}$
Fluoride	F^{-}	mg/L	1.3^{+}
Iodide	I^{-}	mg/L	22.4^{+}
Nitrate	NO_3^{-}	mg/L as N	0.5^{++}
Nitrite	NO_2^{--}	mg/L as N	0.01^{++}
Phosphate	PO_4^{--}	mg/L	0.01^{++}
Sodium	Na^{+}	mg/L	10,812^{+}
Magnesium	Mg^{++}	mg/L	1,302^{+}
Calcium	Ca^{++}	mg/L	409.8^{+}
Potassium	K^{+}	mg/L	389.2^{+}
Iron (dissolved)	Fe^{+++}	mg/L	<0.3*
Manganese (dissolved)	Mn^{++}	mg/L	<0.05*
Boron	B^{+++}	mg/L	5^{++}
Barium	Ba^{++}	mg/L	0.03^{++}
Strontium	Sr^{++}	mg/L	13.6^{+}
Silica (total)	SiO_2	mg/L	2.1^{+}
Hydrogen Sulfide	H_2S	mg/L	n.d.
Silt Density Index	SDI	-	>5
True Color	TCU	-	<15*
Total Organic Carbon	TOC	mg/L	4^{++}
UV254	UV254	cm^{-1}	0.05^{++}
Chlorophyll A	-	mg/L	n.d.
Algae	-	#/mL	n.d.
Dissolved Oxygen	-	mg/L	4 - 8$^{\#\#}$
Ammonium	NH_4^{+}	mg/L	n.d.
Bacterial Counts	-	#/mL	1,000^{++}
Free Chlorine	HOCl	mg/L	n.d.

General		Unit	Average
Specific Gravity	-	-	1.0243[+]

[+] Pankratz, T., J. Tonner (2003) desalination.com an environnemental primer
[++] Personal Communication - Lisa Henthorne
[#] Calculated Value
[##] Texas Water Development Board Bay & Estuary Water Quality Monitoring Program
* EPA Secondary Drinking Water Quality Standards (40CFR143)
n.d. - not determined

For purposes of this study, water quality compositions taken from the WRA report for the Ft. Myers and Port Everglades sites were used and are summarized below in Table 4.5.

Table 4.5 – Water Quality Composition

		Unit	Ft. Myers	Port Everglades	Lauderdale
Total Dissolved Solids	TDS	mg/L	15,000	32,978	15,000
Sodium	Na^+	mg/L	4,590	10,100	4,590
Potassium	K^+	mg/L	165	363	165
Calcium	Ca^{++}	mg/L	175	382	175
Magnesium	Mg^{++}	mg/L	553	1,217	553
Bicarbonate	HCO_3^-	mg/L	140	134	140
Sulfate	SO_4^-	mg/L	1,152	2,534	1,152
Chloride	Cl^-	mg/L	8,204	18,154	8,204
Bromide	Br^{--}	mg/L	28	62	28
Other		mg/L	15	32	15

Historical experience in the design and operation of seawater desalination facilities indicates that the typical recovery of systems desalinating seawater of 35,000 mg/L is approximately 50%. Therefore, a recovery of 50% is assumed for the Port Everglades raw water quality. The Ft. Myers water quality may fluctuate over a wide range of salinity. For purposes of this study M&E assumed a 70% recovery more typical of brackish water treatment as was assumed in the WRA study.

4.4.4 Raw Water Intake

The proposed SWRO treatment plants will tap into the existing post condenser cooling water stream. It is assumed that this will most likely be accomplished by access to a cooling water conduit that is flowing by gravity to the discharge location. Thus low lift pumps will be required to supply the feed water to the high pressure RO pumps. It is assumed that no additional screening will be required, although site-specific conditions may dictate additional screening to remove biological factors such as mussels, or shell fragments, for example.

4.5 Treatment Processes

This section provides background information on the assumptions made, the alternatives evaluated, and the results of the analysis for pretreatment, desalination, and post-treatment. Also discussed will be finished water quality goals. The objective of this section is to recommend the pretreatment process to be used as the basis for the preliminary evaluation of capital and O/M cost for SWRO facilities at all three candidate sites.

4.5.1 Pretreatment

The objectives of this section of the report are to provide an overview of possible pretreatment approaches for an SWRO facility co-located with power plants using once through cooling obtained from a seawater intake; and to preliminarily select a pretreatment approach that can be used for developing conceptual planning level capital and operation and maintenance costs for co-located SWRO facilities at the candidate sites. Other pretreatment approaches are potentially feasible but additional cost evaluations and pilot studies would be used for comparative analysis and selection.

The first commercial seawater reverse osmosis (RO) plants were installed in Saudi Arabia beginning in 1975. Today, there are over 1,000 seawater RO plants constructed worldwide. Pretreatment of the raw seawater is necessary prior to introduction into the RO membrane to remove potential foulants such as particulates, colloidal inorganic and organic material, biological material and debris. If these materials pass onto the RO membrane, they will foul the membrane surface, resulting in increased pressure drop, increased power consumption, reduced permeate production, and reduced permeate quality. Additionally, in the pretreatment process acid and/or scale inhibitor is introduced to eliminate scaling of sparingly soluble salts on the RO membrane surface.

Disinfection, either continuous or intermittent shock, is often included in the pretreatment process as well.

Pretreatment for seawater RO applications should be segregated into two categories in relation to their feedwater supply system: surface supply intake or beach well-type intakes. The pretreatment requirements vary greatly as a function of which supply system is utilized. Seawater drawn through beach wells require significantly less pretreatment than surface supply intakes. Historically, effective pretreatment has been the most challenging issue confronting users of seawater RO at surface supply intake facilities. Even though beach well-type intakes will not be used for these co-location facilities, it is useful to understand the differences from surface supply open ocean intakes that are used for power plant cooling and will be the source of raw feedwater in these locations, as these differences significantly affect pretreatment requirements.

Pretreatment in Beach Well Intake Facilities

Beach well-type intakes can take various forms such as Ranney collector wells, traditional vertical wells on the beach, horizontal wells positioned into the sea, and infiltration galleries. Their commonality is that they all utilize the natural geology in some form to pre-filter the seawater. The limitation of beach wells is almost always the quantity of seawater they can effectively deliver. As a result, only small- to medium-size seawater RO plants have been built using these water delivery methods.

Historically, pretreatment in beach well applications has usually been limited to chemical addition for scale inhibition and cartridge filtration. This limited pretreatment requirement is a result of the low particulate, biological and colloidal material content of the seawater after it is pre-filtered through the sandy seafloor or beach. Additionally, naturally filtered seawater has shown to exhibit almost steady physical characteristics such as temperature and most water quality parameters. Beach wells have been utilized heavily in the Caribbean desalination market in facilities up to approximately 5 mgd.

Pretreatment in Surface Supply Intake Facilities

Surface supply intakes utilize seawater directly from the sea and are usually submerged and extended a distance from the shoreline. Seawater RO plants using open intakes were initially implemented in the Middle East region. One of the original and larger seawater RO plants, the 3.2 mgd facility in Jeddah, Saudi Arabia, became operational in 1978 and was built for the Saline Water

Conversion Corporation (SWCC). Today, SWCC is the largest single user of desalination technology.

Pretreatment has been the Achilles' heel of the open intake seawater RO plant. Early plants in the Middle East utilized primarily hollow-fiber RO membrane, which was generally considered more prone to fouling than the spiral-wound RO membrane elements used today. Many of the pretreatment systems in the early plants were insufficiently sized to handle the high particulate content they experienced. The result was poor RO performance. After start-up, these plants often operated at well below design capacities to reduce the loadings on the pretreatment.

The historical indicator of successful seawater RO pretreatment is the Silt Density Index (SDI). This simple analytical technique provides a guide to the amount of foulant material remaining in the pretreated feedwater. RO manufacturers require SDI values generally less than 4.0 for seawater RO applications, and a value of less than 3.0 is preferable. The SDI is not a perfect indicator but it is still the industry standard used today.

The conventional pretreatment for open intake seawater RO plants has historically consisted of the following, each of which is described in Table 4.6.

- Chlorination
- Coagulation, flocculation and sedimentation
- Filtration
- Chemical dosage for scale inhibition
- Cartridge filtration
- Dechlorination

In limited cases, additional pretreatment processes have been introduced such as diatomaceous earth and granular activated carbon (GAC). The GAC is used most often in Arabian Gulf applications to scavenge oil and grease that may be present in the feedwater.

Technological advancements in recent years have altered pretreatment strategies. These advancements are presently demonstrating their ability to produce pretreated water of a higher quality in pilot plants around the world. These advancements are listed below and are also discussed in Table 4.6.

- Membrane filtration
- Dissolved air flotation

4.5.2 Examples of Full-Scale Installations of Different Pretreatments

Two-stage, Dual-media Filtration

The most common conventional pretreatment system for open intake systems seen around the world is that typified by the 10.6 mgd seawater RO plant located in Okinawa, Japan. This plant has been operating for over approximately 8 years and uses a two-stage, dual-media filtration including:

- Chlorination (3 mg/L as Cl_2) with sodium hypochlorite, continuous
- Direct two-stage gravity filtration with in-line coagulation using ferric chloride (1.5 - 3.0 mg/L as $FeCl_3$) consisting of:
- Dual media filter loading rate of 4.9 gpm/ft^2
- Polishing sand filter loading rate of 6.9 gpm/ft^2
- pH adjustment with H_2SO_4 to 6.5 - 7.0
- Dechlorination with sodium bisulfite
- Cartridge filtration (5 micron)

Single-stage Multi-media Filtration with Diatomaceous Earth-coated Polypropylene Polishing Filter

The Las Palmas III plant located in the Canary Islands of Spain has successfully implemented an innovative pretreatment scheme beginning production in 1989 of 9.5 mgd of product water from an open intake.

- Chlorination with sodium hypochlorite, continuous
- Direct gravity filtration with in-line coagulation using ferric chloride
- Polishing filtration using polypropylene filters coated with diatomaceous earth
- pH adjustment with H_2SO_4
- Dechlorination with sodium bisulfite
- Cartridge filtration (5 micron)

Table 4.6 - Seawater RO Pretreatment Components for Surface Seawater Sources

Pretreatment Component	Description	Discussion
Chlorination	Chlorination is used for disinfecting the intake and pretreatment system in order to mitigate biofouling in the downstream RO. Historically, continuous chlorination was used at levels up to 5 mg/L. Intermittent shock chlorination at higher dosages is more common today. If practical, elimination of chlorination/dechlorination is preferred.	Historically it was believed that continuous chlorination was necessary to prevent RO biofouling. Chlorination of naturally occurring humic and fulvic acids create high concentrations of assimilable organic carbon (AOCs), which we know today to be a principal player in the RO biofouling process. Intermittent shock chlorination has shown to be an improvement in many plants, while some have totally eliminated disinfection with successful results.
Coagulation/ Flocculation/ Sedimentation	Coagulation and flocculation are used to remove the suspended and colloidal material from the raw seawater. The most common coagulants include ferric salts such as ferric chloride and ferric sulfate dosaged at levels of 5-10 mg/L. Multiple flocculation stages followed by settling has been used successfully. Inline coagulation is more common in treating lower fouling water. Anionic polymer as a filter aid may also be used.	Historically, the most severe water quality has benefited from the most extensive coagulation/flocculation/ sedimentation process. Sufficient mixing is critical, especially when only inline coagulation is used following by direct filtration.
Filtration	Media filtration is used combining of sand and/or anthracite and garnet. Both single and two-stage systems are common, as are both pressure and gravity filters. Typical loading rates are 2-6 gpm/ft^2.	The media type is highly variable, many plants only use sand, others a combination of sand and anthracite, while new plants also introduce garnet. There is a high variability in the use of single and two-stage systems and is often a function of the degree of whether inline coagulation is used, i.e. inline coagulation plants more often use two-stage filtration. SDI goals of 3 are generally achievable with sufficient design in the coagulation and filtration processes.
Chemical Addition	Sulfuric acid is used to reduce the pH to prevent calcium carbonate scaling in the RO. Historically, scale inhibitors have also been applied to prevent sparingly soluble sulfate salts from precipitating.	Acid addition has not shown to be problematic but scale inhibitor addition has been greatly reduced in recent years due to lack of real need and potential except in cases of high RO recovery

Pretreatment Component	Description	Discussion
Cartridge Filtration	Cartridge filters are used as the last line of defense against particles reaching the RO membrane surface. Typically 5 micron is used, occasionally 1-3 micron is used especially when a plant initially goes into operation	When the coagulation/filtration processes have not been sufficiently designed, the cartridge filters incur high loadings requiring frequent replacement. Iron deposits and biofouling are frequent complaints in a poor performing plant.
Dechlorination	RO membranes are susceptible to chlorine oxidation and therefore all chlorine must be scavenged from the pretreated water. Sodium bisulfite (SBS) is the most common dechlorinating agent at dosage sufficient to scavenge all chlorine, typically 3-4 mg/L.	Rapid biofouling occurs immediately following dechlorination in plants with continuous chlorination and high organic content. Additionally, reduction of ferric salts can create catalyzed chlorine oxidation. SBS alone is not problematic and has shown to have biostatic properties.
Membrane Filtration	Membrane filtration pretreatment uses microfiltration or ultrafiltration to replace the flocculation/sedimentation and filtration processes of conventional pretreatment	Pilot studies have shown reduced or eliminated coagulant dosage using membrane filtration and enhanced pretreated water quality, with SDI generally around 2.
Dissolved Air Flotation (DAF)	DAF is used upstream of conventional or stacked filters to enhance the removal of algae and colloidal material.	Limited pilot data has shown DAF to improve pretreated water quality especially in removal of algal species.

Ultrafiltration

One full-scale operating open intake seawater RO plant utilizing membrane filtration in a municipal application is located in Bahrain, at the Ad Dur Plant. This facility is rated at 12 mgd treating water of 46,500 mg/L TDS from the Arabian Gulf. This facility successfully piloted hollow fiber UF technology but installed spiral-wound UF technology. The UF pretreatment became operational in 2000 with mixed results due to the difficulties encountered with the spiral-wound UF technology.

A 1.0 mgd seawater RO system operating in Morocco utilizes membrane filtration pretreatment in an industrial application, but limited data is available regarding this facility, other than it has operated successfully for approximately 3 years.

4.5.3 Examples of Pilot Studies of Advanced Pretreatment Processes

Microfiltration (MF) or Ultrafiltration (UF) Membrane Filtration Pilots

Over the last five years there have been about 25 MF/UF pilot studies conducted around the world for seawater RO applications. Public data is not available for approximately half of these pilots. Of those published, the sites have been located in:

- the Middle East, on the Arabian Gulf, the Red Sea, the Mediterranean Sea and the Indian Ocean;
- the United States on the Gulf of Mexico and the Pacific Ocean
- Spain on the Mediterranean Sea
- Gibraltar on the Mediterranean Sea
- Japan on the Pacific Ocean

The results have shown both MF and UF to produce pretreated water with SDI values ranging from 1.5-2.5, with only a few rare cases of UF pretreated waters in excess of SDI of 3. Many of the pilot studies used no coagulant addition. The resulting RO performance has been reduced RO cleanings and lower operating pressures from reduced fouling. Additionally, the membrane filtration systems offer reduced plant footprints over conventional pretreatment processes.

As part of the studies that were performed to identify alternative pretreatment approaches to correct the problems at the Tampa Bay SWRO facility, Zenon Zeeweed UF was evaluated, and it provided an SDI of < 3.0.

Dissolved Air Flotation (DAF) Pilot

There has been a single pilot study conducted utilizing DAF as pretreatment in front of two-stage dual media filtration for open intake seawater RO. This study was recently conducted by ONDEO for the Abu Dhabi Water and Electricity Authority (ADWEA) for an upcoming 50 mgd Tawellah plant in the United Arab Emirates. Recent discussions with the ADWEA consultant indicated the DAF performed well. The overall pretreatment process provided SDI values consistently in the 2-3.5 range.

Actiflo Microsand Pilot

Recently Veolia Water pilot tested Actiflo at the ADWEA pilot site for the Tawellah plant. Unfortunately Veolia Water did not publish any data regarding their testing. In recent discussions with the Veolia Water personnel responsible for the project, they indicated the Actiflo performed well and they would be conducting follow-on piloting of the technology at the Tawellah site beginning April, 2004 in support of their recent win of this project.

As part of studies that were performed at the Tampa Bay SWRO facility in Tampa, Florida to study alternative pretreatment approaches to correct the existing pretreatment problems, Veolia Water pilot tested the Actiflo process. The Actiflo process did not consistently produce water of less than 3.0 SDI.

4.6 Screening of Candidate Pretreatment Processes

Historically, outside the US, seawater reverse osmosis (SWRO) has been performed with direct filtration as pretreatment. Single or two-stage direct filtration can only be used with relatively low raw water turbidities; where water quality has been higher in turbidity or algae, clarification and filtration has been used. In Trinidad, a large SWRO plant is operating with tube settler clarification and dual stage filtration as pretreatment which was necessary due to raw water turbidity excursions. Raw water turbidity has generally been < 10 NTU with some excursions to as high as 35 NTU. The tube settler designed at 1.9 gpm/sf and the filters are designed at (unknown) gpm/sf. In the U.S. the largest SWRO facility (25.0 mgd) in Tampa Bay, FL utilizes two-stage direct filtration. Unfortunately, there have been severe problems with the pretreatment process in Tampa Bay because of water quality issues, including mussels, and mussel shell fragments. American Water, who was not the original provider, developer, or operator, is engaged to install upgrades to the facility to correct the problems. Corrective measures include diatomaceous earth filtration as an additional pretreatment barrier. This "failure" of the first large SWRO facility in the U.S. highlights the importance of careful analysis and selection of the pretreatment process.

To capture potential worst case issues that could affect ultimate plant cost, screening of the pretreatment processes in this feasibility study assumes worst case water quality as follows: turbidity could be greater than 20 NTU; red tides or algae could be present for a significant period of time; there may be variations in temperature of the raw water; there may be moderate TOC; greater than 25 mg/l of coagulant may be required; hurricanes may cause severe water quality excursions; and the density of seawater may affect the performance of the pretreatment processes. Therefore, the assumption is that the pretreatment process must be robust enough to handle expected worst case variations in water quality and still provide low silt density index (SDI) for maximum efficiency of the RO process. Additional assumptions are that the processes should be space efficient to reduce land requirements and facilitate siting of the plant; and be well proven in drinking water treatment applications. Single or two stage direct filtration is not suitable for this type of water quality.

It is recognized that many high rate and innovative clarification processes are well proven in drinking water applications and have achieved significant advancements in performance, although they are not well proven in seawater applications. However the project constraints with respect to area requirements, cost, and performance under worst case water quality conditions make it imperative to consider innovative, advanced and proven technology in this analysis.

The candidate processes that were considered for screening of pretreatment processes capable of treating worst case water quality were:

- Conventional flocculation, sedimentation, and filtration
- Solids contact clarification (Accelator) and filtration
- Plate or tube settler clarification and filtration
- Pulsator or Superpulsator clarification and filtration
- Dissolved air flotation (DAF) clarification and filtration
- Micro-sand enhanced clarification (Actiflo) and filtration
- Ultrafiltration using immersed membranes (Zeeweed 500D)

4.6.1 Conventional Flocculation, Sedimentation and Filtration

Conventional flocculation, sedimentation, filtration represents a very worst case pretreatment with the largest conceivable land area requirements for the SWRO facilities. Typically, according to "10-States Design Standards", a rapid mix of at least 1 minute detention time is used ahead of flocculation that is normally provided in multiple stages with a minimum detention time of 30 minutes and the sedimentation process is designed around a surface loading rate of only 0.45 gpm/sf. Conventional flocculation and sedimentation can treat fairly high turbidity and low levels of algae but is susceptible to rapid variations in raw water temperature. Residuals are generally extracted by periodic manual draindown and washdown; mechanically using chain and flight scrapers that are difficult to maintain and unreliable; or mechanical vacuum extraction systems. If sludge scrapers or vacuum extraction are used the residuals will generally have a solids content of between 0.1 - 0.5 % solids. Because of the large land area requirements, susceptibility to rapid changes in water temperature, inability to treat high algae concentrations, and high probable capital and operating cost, conventional clarification and filtration was eliminated from further consideration.

4.6.2 Solids Contact Clarification and Filtration

Solids contact clarifiers such as the Accelator marketed by Infilco Degremont, Inc. are extraordinarily well proven in drinking water treatment in both coagulation and softening. Rapid mixing is integral with the process as a central draft tube mixing zone that functions in an up-flow direction. Coagulated solids are flocculated in the inner draft tube and pass into an outer draft tube where they exit in a downward direction along the bottom perimeter of the outer draft tube. The solids then sink readily down into a slurry pool of pre-formed solids. Solids from the slurry pool are drawn back under a hood and up into the mixing impeller where they are mixed with incoming raw water that has coagulant, hence, the term-solids contact clarification.

Accelators can operate at between 1.0 and 2.0 gpm/sf or 2 to 4 times the surface loading ranges of conventional flocculation, sedimentation. Accelators can effectively treat high turbidity, low or moderate algae to some extent, and high coagulant dosages, and produce clarifier effluent turbidities of 1.0 - 2.0 NTU but low turbidities are still achieved through filtration. Accelators are less susceptible to variations in raw water temperature than conventional sedimentation but are still susceptible to rapid variations. In large units Accelators can be equipped with scrapers to collect the sludge and move it to sumps in the floor of the units; or they can be equipped with pie-shaped hoppers around the hood. Each pie shaped hopper has a mechanical flap that can be manually opened or closed. When closed the hopper collects sludge because it cannot get back under the hood. Sludge is withdrawn from the hoppers by hydraulic extraction through an air-actuated valve. Residuals concentrations for coagulation are in the range of 0.1-0.5% solids. Because of some susceptibility to temperature variation, limitations on ability to treat algae, low surface loading rates, and large footprint, Accelators were eliminated from further consideration.

4.6.3 Plate or Tube Settler Clarification and Filtration

Plate or tube settlers are well proven in drinking water treatment and have been used in SWRO as mentioned above (in Trinidad) and can be considered as a base-line approach capable of treating worst case water quality. A rapid mix with detention time similar to that used for conventional sedimentation is used ahead of multiple stages of flocculation with a total detention time of about 30 minutes. In these types of clarifiers, tubes or plates that are inclined at a 60 degree angle create a “projected” clarification area that enhances clarification over a smaller surface area.

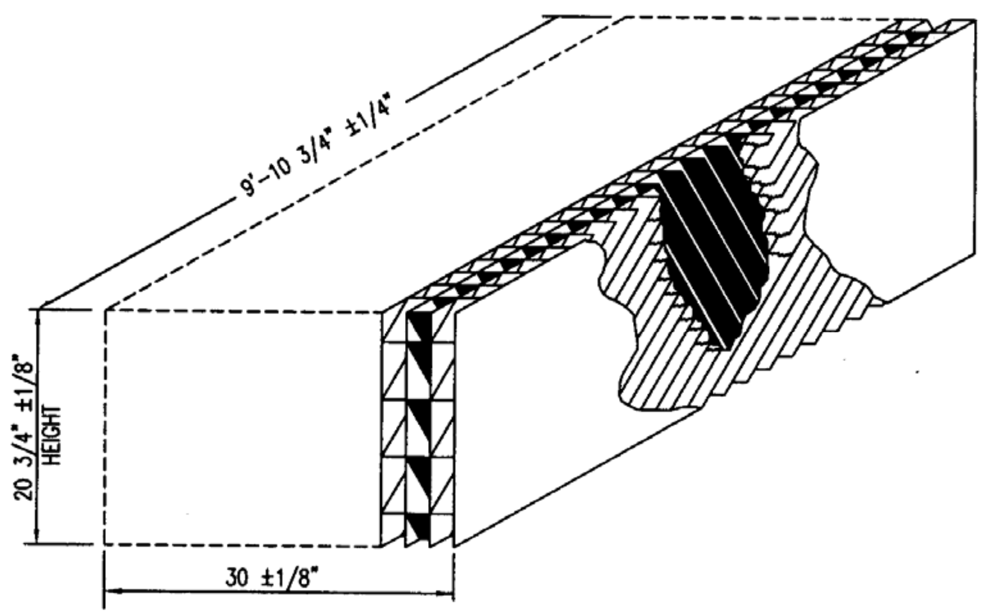


Figure 4.9 - Typical tube settler module (US Filter Microfloc)

The tube settler process can operate at about 2.0 gpm/sf surface loading rate and the plate settler process can operate at higher SLRs of up to 5.0 gpm/sf, depending on plate spacing. Tube settler SLRs are equal to that of Accelators and about 4 times that of conventional sedimentation. This results in a much smaller process footprint than for conventional sedimentation (Figure 4.9). Plate settler SLRs are up to 10 times that of conventional sedimentation and about equal to average dissolved air flotation (DAF) SLRs. Tube and plate settler clarified turbidity may be slightly higher than for conventional sedimentation, but low turbidities are still achieved through filtration. Residuals concentrations are in the range of 0.1 - 0.5 % solids. Plate and tube settlers are susceptible to rapid changes in water temperature and have limitations in treating high turbidity and algae. The tube openings in tube settlers can become blocked with algae and solids creating short circuiting and deterioration in clarifier performance. Plate and tube clarifiers are being replaced with the more advanced and innovative technologies that follow below and are therefore not considered further.

4.6.4 Pulsator and SuperPulsator Clarification and Filtration

Pulsator and SuperPulsator clarifiers are solids contact, moderate rate, up-flow, sludge blanket technology that are well proven in water treatment. The coagulated water from rapid mix is introduced uniformly into the bottom of the clarifier through an inlet channel and lateral distribution pipes. A portion of the raw coagulated water is lifted in a vacuum chamber using vacuum blowers, and periodically released rapidly. The energy imparted by releasing this water quickly through the distribution system in the bottom of the clarifier, causes mixing and flocculation within the sludge blanket. The sludge blanket which is uniformly mixed by the imparted energy, develops to a depth of 9.0 ft. defined by the elevation of a sludge concentrator hopper wall. The clarification zone extends about 6.0 ft. above the sludge blanket surface. Clarified water is collected through uniformly spaced launders or pipes with submerged orifices. Sludge from the sludge blanket flows naturally into the sludge concentrator hoppers, where it becomes more concentrated. Sludge is extracted hydraulically from the sludge concentrator hoppers through piping and valving that is air actuated.

Pulsator clarifiers operate at a SLR of 1.0 gpm/sf. SuperPulsators have inclined plates (60^{o}) spaced about 1 foot apart within the bottom of the clarification zone and extending into the sludge blanket and can operate at SLRs up to 2.5 gpm/sf. SuperPulsators can also be fitted with tubes placed above the inclined plates to further increase surface loading rate to as high as 4.0 gpm/sf. Pulsator and SuperPulsators cover a range of process surface loading rates similar to Accelators, plate and tube settlers and up to the low end of DAF.

Pulsator and SuperPulsator clarifiers can treat high turbidities, low to moderate algae concentrations, and high color and organics. Clarified turbidity may be slightly higher than for conventional sedimentation and similar to that obtained with plate or tube settlers, but low turbidities are still achieved through filtration. Residuals concentrations are in the range of 0.1 - 0.5% solids. Like conventional sedimentation, plate or tube settlers, and Accelators, sludge blanket clarifiers are susceptible to rapid variations in water temperature. Pulsator and SuperPulsator clarifiers are being replaced with the more advanced and innovative technologies that follow below. For these reasons, Pulsator and SuperPulsator clarifiers were not considered further, although they should be considered equal or superior to plate or tube settlers in future applications in treatment of seawater.

4.6.5 Dissolved Air Flotation and Filtration

Dissolved air flotation (DAF) is a high rate process using micro-bubbles to float the coagulated and flocculated particles to the surface of the clarifier. DAF requires a typical two stage rapid mix and two stages of flocculation sized for about 15 minutes of total detention time ahead of the flotation unit. A portion (approximately 10%) of clarified water is drawn off and passed thorough an air saturation system where it is supersaturated with air under high pressure. The supersaturated water under high pressure released through proprietary valves or nozzles into the water leaving the flocculation stage. The sudden release of pressure causes the formation of micro-bubbles (approximately 60 microns in size). The bubbles quickly attach to preformed floc and carry it to the surface of the DAF basin where it forms a thick floating layer. The clarified water is collected in headers located in the bottom of the DAF basin. Figure 4.10 illustrates a typical DAF clarifier.

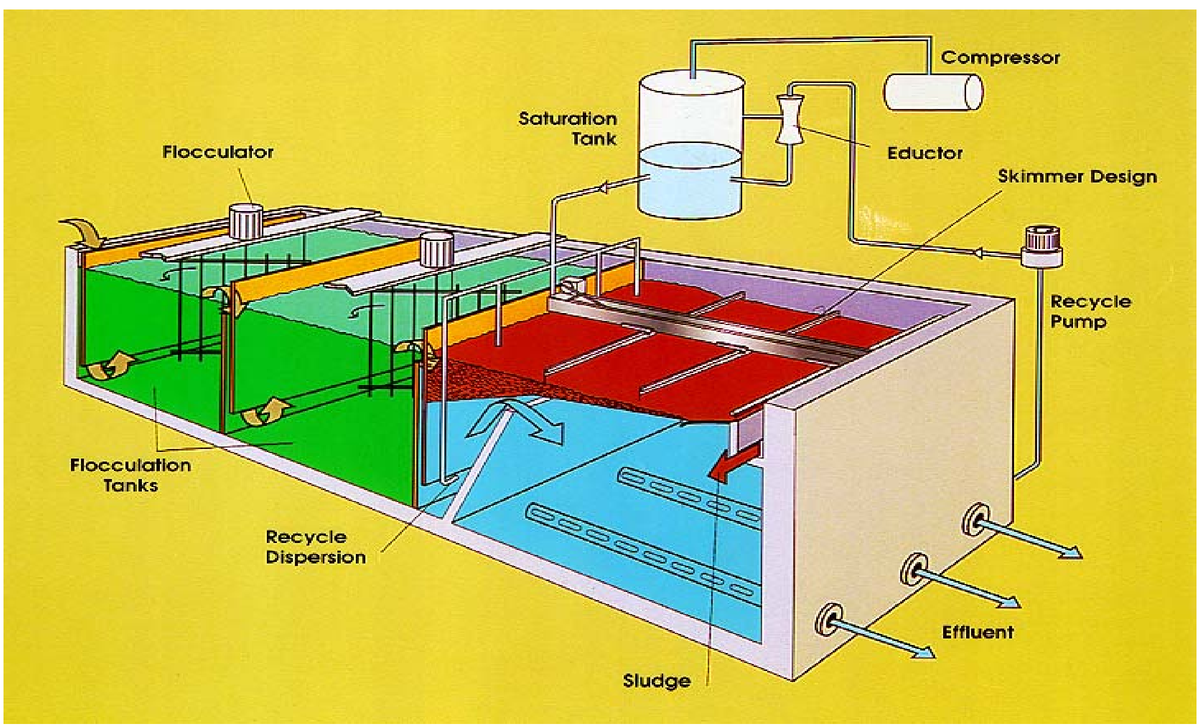


Figure 4.10 – Typical dissolved air flotation and filtration clarifier

DAF can operate at surface loading rates of from 4.0 to 6.0 gpm/sf or up to 13 times the SLR of conventional sedimentation; up to 3 times that of tube settlers; and about 2 times that of SuperPulsators. If ozonation is used between DAF and filtration the DAF can be operated at up to 8.0 gpm/sf SLR without impairing filtration performance, because the ozone provides microflocculation of turbidity and particles, thus making them more filterable.

DAF can achieve very low clarifier effluent turbidities of < 0.5 NTU. DAF can achieve a high level of performance even without using a polymer, which can be an advantage in pretreatment ahead of RO. DAF is not susceptible to thermal variation and has demonstrated significant advantages in treating very cold (dense) water, thus DAF may be very effective in treating high density seawater. Another important advantage of DAF clarification is that it has proven to be the premier clarifier for treating large concentrations of algae, which are notoriously difficult to settle. This may be a distinct advantage in treatment of seawater where red tides or algae may be a concern. DAF can easily treat the expected worst case raw seawater quality.

Another potentially important advantage of DAF, not found with all but one other clarifier, is that it can produce a residual concentration of up to 2% solids when mechanical extraction is used. This sludge concentration is about 4 times the maximum solids concentration achievable with plate, tube, Accelator, or sludge blanket clarifiers. Mechanically extracted DAF residuals can be fed directly to dewatering processes such as belt filter presses or centrifuges without further thickening. This provides a distinct advantage over other clarification processes, where residuals can not be disposed through the sewer to the local publicly owned treatment works (POTW). If residuals can be disposed to the POTW then hydraulic extraction (without mechanical equipment) can be used. Hydraulic extractions are performed by periodically raising the level in the clarification zone and overflowing the float layer into a trough located on the end or side of the basin. Hydraulic extractions produce a very dilute residuals concentration and a greater residuals volume than mechanical residuals extraction; however, this may not be a problem if disposal to the local POTW is possible.

DAF is extremely well proven from pilot tests conducted for large plants as indicated by designs for Boston, Massachusetts at 450 mgd and the New York City Croton Water Treatment Plant at 290 mgd. In the case of the Croton WTP, the design incorporates the filtration stage under the DAF, which reduces process footprint requirements considerably. When the DAF is located above filtration, the maximum surface loading rate of both the DAF and the filter must be limited to less than 5 gpm/sf.

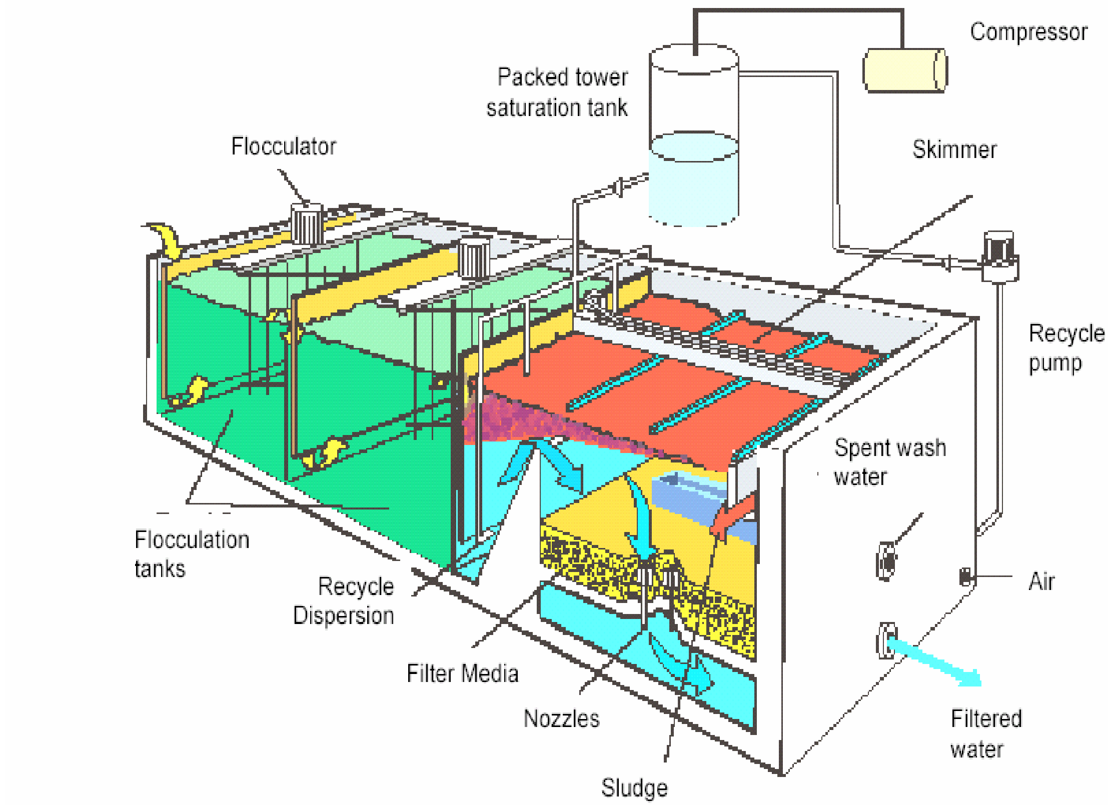


Figure 4.11 – Illustration of a typical DAF (Flofilter) treatment unit

In potable water treatment today, DAF is generally replacing all of the previously mentioned processes: conventional sedimentation, plate and tube settlers, Accelators, and sludge blanket clarifiers. Regular DAF is marketed by both Parkson and Leopold. The stacked DAF was supplied by Parkson under the trade name “Flofilter”; however, they have recently decided to discontinue offering the Flofilter design. The 36-mgd SWRO plant in Tuas, Singapore uses stacked DAF. Because of the uncertainty surrounding continued availability of the stacked DAF configuration, and the availability of advanced high-rate DAF, (discussed below), stacked DAF is not carried forward in this evaluation.

A recent innovation in high-rate DAF technology is the AquaDAF, a proprietary process marketed in the U.S. by Infilco Degremont. The AquaDAF is identical to regular DAF or stacked DAF in that the same rapid mix conditions, flocculation times, and air saturation and recycle system are used. However, the AquaDAF has two distinct innovations that allow operation at flotation SLRs of from 9.0 - 16.0 gpm/sf. First, the geometry of the DAF portion of the process is rotated 90 degrees, such that the flotation tank is wider than it is long. This results in a complete bubble blanket covering the entire DAF basin, which overcomes a limitation of typical DAF designs where the bubble blanket predominantly covers only the front 1/3 of the flotation tank. Second, there is a false floor in the bottom of the DAF basin, which has holes of various sizes spaced differently across the length of the tank. These holes optimize the hydrodynamics of the flow through the DAF tank. These two innovations result in a deep bubble blanket, active flotation throughout the entire surface of the tank, and the ability of achieving the higher surface loading rates. Either mechanical or hydraulic residuals extraction can be used in the AquaDAF design.

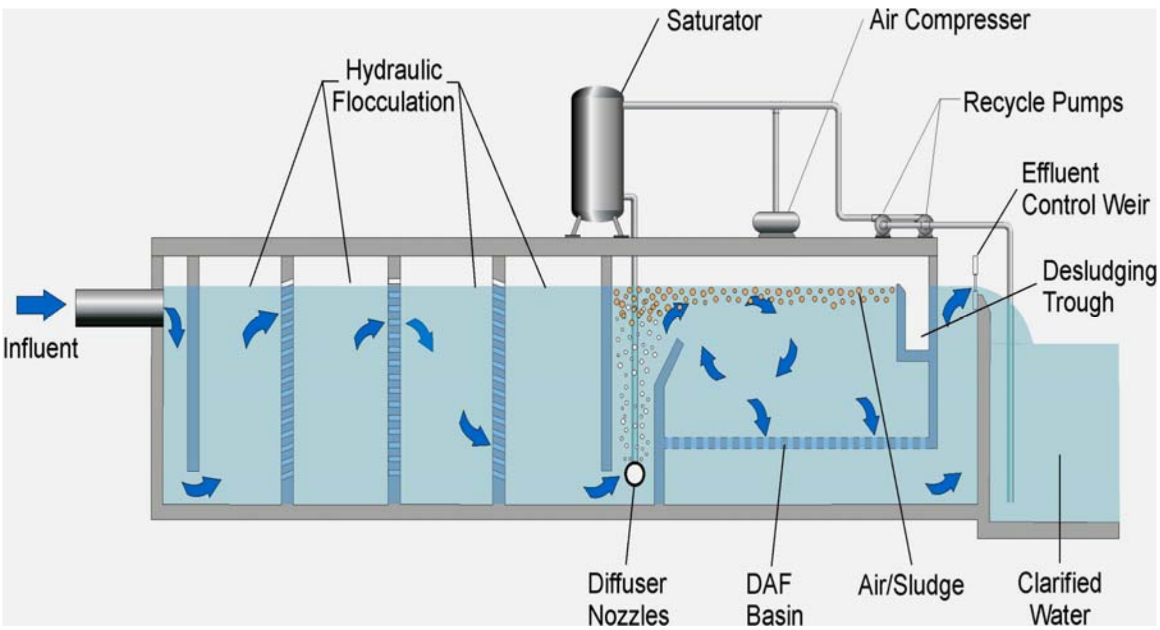


Figure 4.12 – Illustration of a typical AquaDAF clarification process

The first U.S. installation of the AquaDAF is in Lake Deforest, NY, where two units each of 10-mgd capacity are installed and operating. In this installation, baffled flocculation was used instead of mechanical flocculation and the residual extraction is hydraulic and not mechanical. It appears that this new type of DAF has all of the advantages of regular DAF, plus the added benefit of a smaller footprint due to the increased SLR. Although the AquaDAF is much less proven than typical DAF, the innovations represent significant advancements and enhancements. Therefore, the AquaDAF is carried forward in this evaluation, because of the reduced process foot print and potential cost savings.

4.6.6 Micro-Sand Enhanced Clarification (Actiflo)

Micro-sand enhanced settling (MES) uses micro-sand of about 100 microns in size to attach to the floc and greatly enhance settling rate. The MES process is a proprietary process marketed under the trade name “Actiflo” by Kruger, Inc. One stage of rapid mix with a detention time of about 1.0 minutes for coagulation; a second stage of rapid mix with a detention of about 1.0 minutes for addition of micro-sand and polymer, and one stage of maturation (flocculation) of about 6 minutes, are incorporated within the process ahead of a tube settling clarification stage. The tube settling stage can operate at up to 25 - 40 gpm/sf or about 5 to 8 times greater than a stacked DAF process, representing a significant reduction in overall process footprint of the MES process.

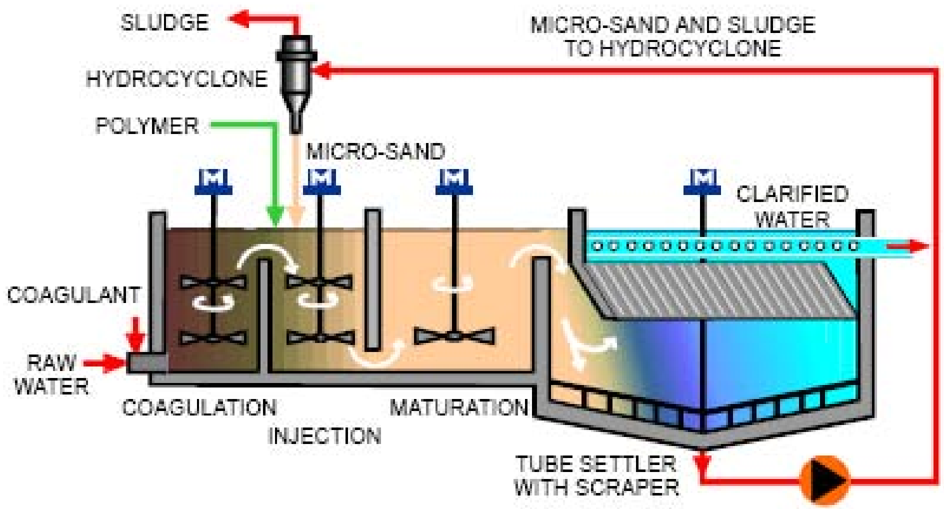


Figure 4.13 – Illustration of the Actiflo clarification process

The MES process can achieve turbidities of less than or equal to 0.5 NTU with very low filtered turbidities. The MES process is not susceptible to thermal variation because the micro-sand overcomes thermal gradients and may also be advantageous in treating high density seawater. The process is extremely robust and can treat high turbidity excursions very effectively. The MES process can treat algae but probably not as effectively as DAF for very high algae levels, which is a concern with respect to the possibility of red tides in seawater applications. The MES process can not be operated without polymer, and the polymer may cause fouling of a downstream RO process.

In large MES units a hopper and scraper is included under the tube settler for collection of residuals. The residuals comprised of coagulated solids and attached sand particles are pumped up to a hydro-cyclone that separates the coagulated solids (residuals) from the micro-sand. The micro-sand is returned into the second stage mixing and is mostly conserved. The coagulated solids residuals stream is discharged at a fairly low concentration of less than 0.1% solids.

The MES process is well proven and is displacing some of the previously mentioned processes except DAF. The primary considerations that eliminated the MES process from further consideration at this time are: the low residuals solids concentration: the limitation on treatment of high algae; and the possibility that the polymer may have an adverse affect on the RO process. The MES process could be considered further in the future as the plant is sited, water quality is confirmed, and residuals disposal options are known.

4.6.7 Ultrafiltration Using Immersed Membranes (Zenon Zeeweed 500D)

Membrane microfiltration (MF) and ultrafiltration (UF) (low pressure hollow fiber membrane treatment) technology has developed rapidly over the last five years, with several manufacturers offering outside-in and inside-out configurations; and pressurized and immersed approaches. In an inside-out configuration, the raw and coagulated water enters the lumen (inside) of the hollow fibers and the purified water flows through the membrane to the outside area. In an outside-in configuration, the raw and coagulated water enters the system on the outside of the hollow fibers and the purified water flows through the membrane surface and into the lumen. Pressurized UF systems use pressure to force the water through the membrane surface. In immersed UF systems the membrane fibers are immersed in the raw or coagulated water and a vacuum is applied to the lumen of the fibers to draw the water through the membrane and into the lumen.

UF membranes provide physical removal of solids, particles, algae; and physical disinfection by removal of pathogens such as *Giardia*, *Cryptosporidium*, and some viruses. Unless a coagulant is used UF membranes do not remove color or organics. MF and UF have demonstrated effectiveness for providing low silt density indices (SDI) ahead of high pressure membrane process such as nanofiltration (NF) and reverse osmosis (RO), potentially resulting in greater efficiencies of the NF and RO processes including reduced fouling and longer cleaning frequencies, associated reduced chemical costs, and possibly longer membrane life. There is limited experience for MF and UF in pretreatment of seawater documenting these perceived benefits to RO efficiencies.

For treating high quality surface water with low turbidity, low solids, low color, low organics, and low coagulant dosage applications, the primary manufacturers are: Degremont (Aquasource); USFilter (Memcor); Koch; Pall (Microza); GE/Ionics/Norit; Leopold; and GE/Zenon (Zeeweed 1000). These processes are generally used to replace filtration within the clarification and filtration process train, and not generally applicable to treating the assumed (for this evaluation) worst case seawater quality, particularly red tides.

Several manufactures have MF or UF systems capable of replacing both clarification and filtration with the single MF or UF process. In fact MF and UF systems are quickly and effectively competing with clarification and filtration processes. These manufacturers are: Pall (Microza MF), Koch, US Filter Memcor (CMFS), GE/Ionics/Norit, and GE/Zenon (Zeeweed 500D). All membranes are by no means equal. There are significant differences in configuration, operation, robustness, and experience within this group of MF and UF systems with respect to treating high levels of turbidity, algae, color, and organics (enhanced coagulation). Generally, the in-side out pressurized systems are less robust and more easily fouled by higher solids from either natural or coagulated solids. Koch, for example, has significant limitations for turbidity and coagulant dosage. Pall and Ionics/Norit UFs, both of which are pressurized UFs, can treat higher solids than Koch but still have limitations for turbidity and coagulant dosage, and are not well proven in enhanced coagulation. Generally, immersed MF or UF systems may be less prone to fouling and more able to treat higher solids from enhanced coagulation, than pressurized UF systems. Both the US Filter Memcor CMFS and the GE/Zenon Zeeweed 500D are immersed membrane UF systems. The Zeeweed 500D immersed UF system evolved from immersed membrane treatment of activated sludge in wastewater treatment, an extremely high solids and microbiological environment. The Zeeweed membrane is a “supported” membrane where the functional membrane surface has been applied as a coating to a very strong fiber structure that forms the hollow fiber. The Memcor CMFS UF evolved from the Memcor pressurized UF where the pressure housing was removed and the fiber bundle, still constrained by a mesh, is immersed. The Memcor membrane is an extruded “unsupported” hollow fiber that is not as strong as a supported membrane. The Memcor CMFS has solids limitations due primarily to the constrained nature of the fiber bundle and the system is much less proven than the Zenon UF.

The Zeeweed 500D immersed UF system is an extremely robust treatment process capable of treating extremely high turbidity, high algae concentrations, high color and organics, with high coagulant dosages (enhanced coagulation), and at the same time high dosages of powdered activated carbon. At this time, no other UF membrane system can match the performance levels of the Zenon Zeeweed 500D UF.

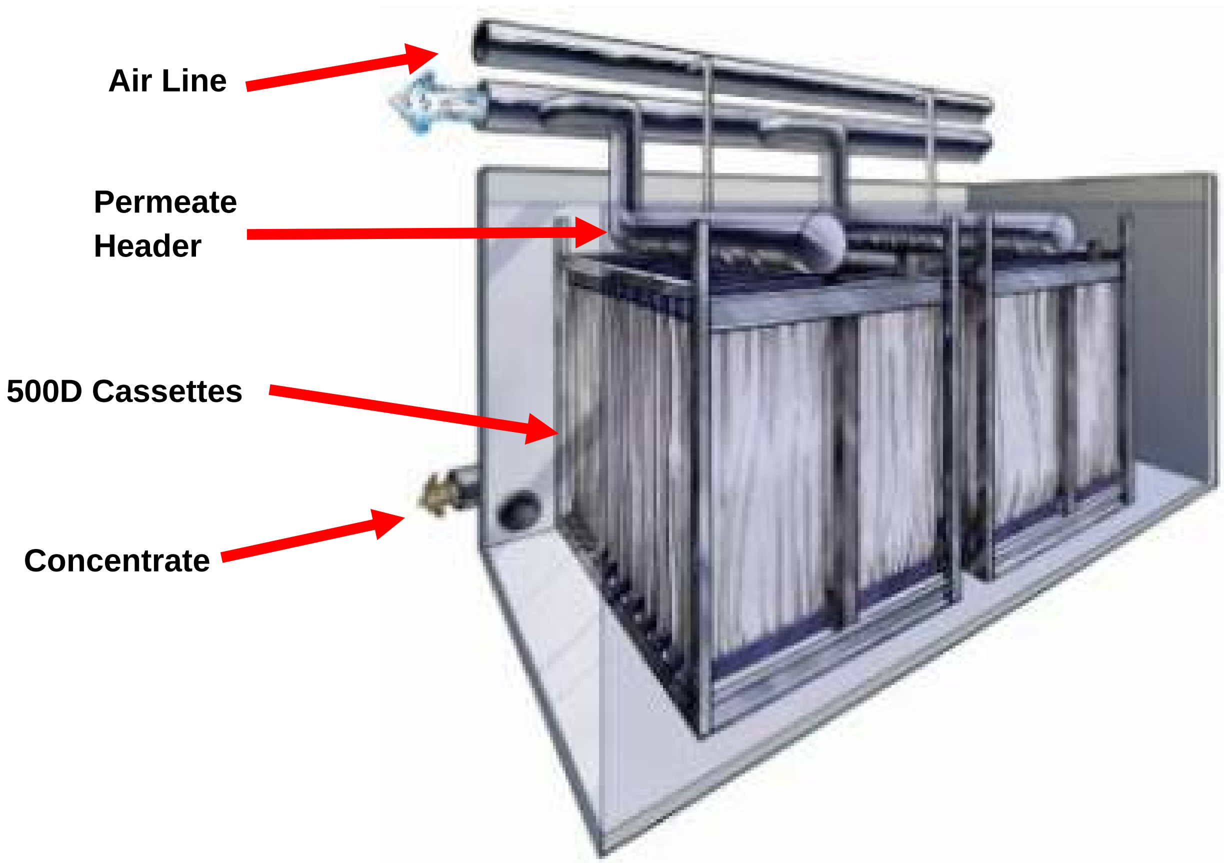


Figure 4.14 – Illustration of the Zeeweed 500D UF process

The Zeeweed 500D UF operates at fluxes between 25-35 gfd and recoveries of from 90-95% depending on water temperature. The residuals stream from the process is generally less than 0.1% solids and will require thickening prior to dewatering. Thermal variation will not have a significant affect on the UF process. Due to limited SWRO experience, the ability of the Zeeweed 500D process to treat red tides is not fully known. The Zeeweed 500B UF was pilot tested in Port Hueneme, CA where red tides were experienced. The red tide reduced permeability quickly in this study but project constraints imposed by the client did not allow coagulation. It is reasonable to assume that if coagulation had been used the impact of the red tide may have been reduced. Based on other experience with the Zeeweed 500D UF and limitations of all other UF membrane systems, it is reasonable to also assume that the Zeeweed 500D UF may be the only UF capable of treating severe red tides as a stand alone process.

While membrane UF and MF processes have perceived benefits for RO pretreatment, an important question still remains concerning their ability to treat red tide events that are becoming increasing common. Red tide events have occurred with increasing frequency and magnitude along the California coast in recent years. Several SWRO pilot studies in California using MF and UF pretreatment have been impacted by red tide events that caused complete shut-down of the process. Therefore MF or UF pretreatment for SWRO when used as a single treatment barrier, may not be able to provide firm capacity during red tide events. Generally the major objective of SWRO is to provide drought protection or peaking capacity where firm capacity is essential to meet demands. In this case, MF or UF pretreatment, with inherent vulnerability to red tide events, may not be the wisest process choice.

UF and MF processes also tend to be more expensive from a capital and O&M cost perspective, than more conventional treatment processes, although costs are continuing to decline due to strong competition between manufacturers.

For the reasons stated above, UF and MF pretreatment is not carried forward in this evaluation. The potential for using UF and MF pretreatment can be revisited and compared with other processes when water quality conditions are more clearly defined.

4.6.8 Filtration

In order to have a robust pretreatment process, a multiple barrier approach using filtration following some form of clarification is required. Filtration can be accomplished using typical gravity filters with either dual media or mixed media. While dual media will provide effective filtration, mixed media will provide greater particle and turbidity removal and potentially a lower SDI than dual media.

Gravity filters are generally arranged in side by side configuration on either side of a large filter gallery containing all of the interconnecting pipes and valves for filter influent (clarified water), filter flow control and filter backwashing.

To reduce space requirements cluster filters offered by several manufacturers can be used. The GreenLeaf cluster filter offered by IDI illustrated in Figure 4.15, is a typical example.

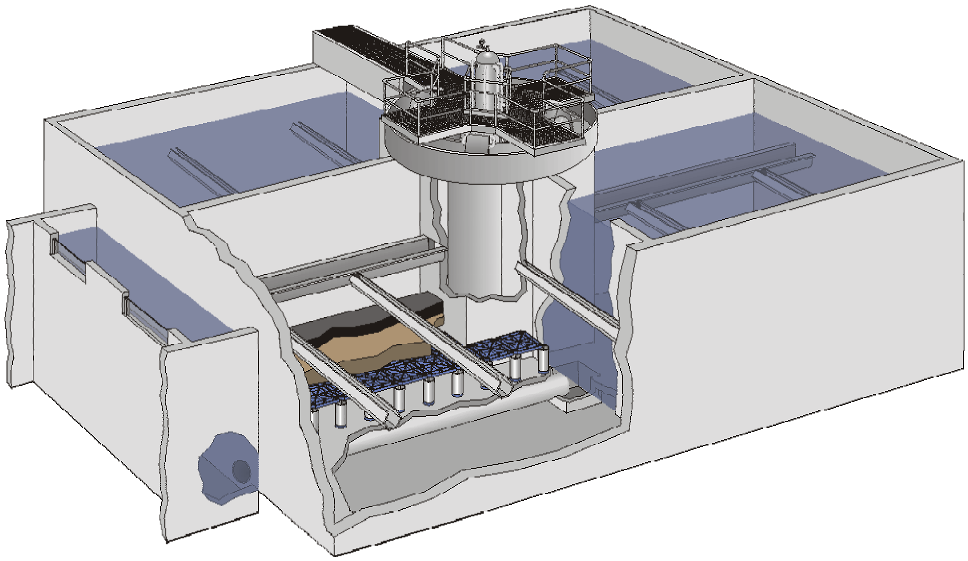


Figure 4.15 – Illustration of the Infilco Degremont, Inc. GreenLeaf "Cluster Filter"

The major advantage of cluster filters is that the typical large pipe gallery and associated piping and valves are completely eliminated due to common wall construction. The piping and valves are replaced by a central structure that performs all of the functions of influent flow distribution and backwashing. This significantly reduces capital cost and space requirements.

4.7 Economic Evaluation of Candidate Pretreatment Processes

To further inform the pretreatment process choice for the current study, M&E provides the following conceptual analysis of a similar co-located SWRO Desalination Feasibility Study by Metcalf & Eddy performed for the city of Corpus Christi, Texas and the Texas Water Development Board. This study, completed in November 2004, was performed based on a co-located SWRO plant capacity of 25.0 mgd and included a comparison of four process trains as follows:

- Option 1: Conventional Pretreatment with Tube Settling and Gravity Filtration
- Option 2: Conventional Pretreatment with Stacked DAF (FloFilter)
- Option 3: Pretreatment with Immersed Membrane Filtration (Zeeweed 500D)
- Option 4: Bank Filtration

In this study, tube settling with gravity filtration was included because of existing experience with seawater pretreatment. Stacked DAF was considered because of the effectiveness treating algae, thermal tolerance, and reduced area requirements. Zeeweed 500D UF was included as the most robust UF process. The IDI AquaDAF was not sufficiently established in the U.S. at the time of the evaluation for it to have been considered.

To evaluate the project costs for each option, capital and operations and maintenance (O&M) cost comparisons were developed. The O&M costs were combined with the capital costs in order to calculate 20-year present worth of each alternative.

Separate capital construction cost estimates were developed for the RO installation and for each pretreatment option. Table 4.7 summarizes the capital construction cost estimates. All costs are in current year US dollars.

Table 4.7 - Capital Cost Summary for Individual Components (rounded to nearest 0.1 $M)

Cost Component	RO Pretreatment Option				RO System, Admin. Bldg, Generator Bldg, Storage tanks, Pump Stations
	Option 1: Tube Settlers	Option 2: DAF FloFilters	Option 3: UF	Option 4: Bank Filtration	
Construction Cost[(1)] ($)	26.3	24.2	50.3	27.4	47.2
Engineering Costs[(2)] ($)	2.3	2.1	4.3	2.3	4.0
Total Cost ($)	28.6	26.3	54.6	29.7	51.2

(1) Construction cost includes a 25% contingency and 17% overhead and profit (OH&P).

(2) Engineering costs assumed at 10% of the total estimated construction costs, not including contractors OH&P.

(3) M = $1 million

(4) Capital costs shown are from Metcalf & Eddy Corpus Christi Feasibility Study, Nov. 2004

Table 4.7 illustrates that UF pretreatment has a much greater capital cost than any other option, whereas the tube settler or DAF options have comparable capital costs, although the DAF (Flofilter) option includes filtration.

Because of the preliminary nature of the conceptual designs, it is necessary to formulate baseline criteria and assumptions in order to conduct the cost estimates. The following is a listing of these criteria and assumptions.

- The construction cost estimates are based on pretreatment options capable of treating 50 mgd of raw water and RO system and finished water pumping capable of producing 25 mgd of finished water.
- The treatment plant cost estimates do not include land acquisition costs.
- The raw water pump station and raw water pump costs have not been included in the capital cost estimates. Since this process component is common to all alternatives, it has no bearing on the comparison of cost estimates.
- With the exception of the bank filtration option, intake costs have not been included in the cost estimates.
- For all process options except the UF alternative, UV was included to provide an equivalent comparison with respect to disinfection, because the UF processes inherently provides additional disinfection capability.

- Concrete unit costs include purchasing and installing the concrete, installing and removing forms, finishing the concrete, and purchasing and installing reinforcing. The unit cost for slab on grade concrete construction is $400 per cubic yard. Otherwise, the unit cost was assumed to be $500 per cubic yard.
- The cost for installing the major equipment, pumps and chemical feed systems was assumed to be 10% of the cost of the particular equipment being installed.
- The cost for the electrical and instrumentation & control systems (I&C) systems for the major equipment and the pumping systems were assumed to be 20% of the equipment costs. For the chemical feed systems, the electrical and I&C costs are included in the sub-total.
- With the exception of the Administration Building, all other buildings were assumed to be pre-engineered metal buildings with a construction costs of $64 per square foot, which is based on an allowance of $50 per square foot for the building installation plus an additional $14 per square foot for lighting and HVAC. It was assumed that the Administration Building would be required to be more aesthetically pleasing, with cavity wall construction and brick veneer. Thus, the assumed unit cost was $100 per square foot with an additional $25 per square foot for lighting and HVAC. The installation cost for the light duty weather enclosure over the DAF basin was assumed to be $35 per square foot.

Table 4.8 shows the estimated costs for each option. These were developed by linking the individual unit process costs as listed in Table 4.7 in order to reflect the complete overall process cost.

Table 4.8 – Capital Cost Estimates for Process Options (rounded to nearest 0.1 $M)

Capital Cost Component (M = $1 million)	**Opt. No. 1 Tubes + Cluster Filters + RO**	**Opt. No. 2 DAF FloFilters + RO**	**Opt. No. 3 UF + RO**	**Opt. No. 4 Bank Filtration + RO + UV**
Construction Cost ($)	73.6	71.4	97.5	74.6
Engineering Costs ($)	6.3	6.1	8.3	6.4
Total Cost ($)	79.9	77.5	105.8	81.0

Note: Capital costs shown are from Metcalf & Eddy Corpus Christi Feasibility Study, Nov. 2004.

As shown, the estimated capital costs for the conventional pretreatment options (tube settlers and DAF) and bank filtration option are comparable, particularly given the planning level nature of these cost estimates. Thus, Option 1, 2, and 4 are considered essentially equal in terms of construction cost. With regard to Option 4, although this option requires the least amount of area and structures, the cost of the UV equipment and Ranney wells is significant. Option 3 is expected to result in the highest construction cost. The high estimated construction cost for this option is influenced primarily by the Zenon UF equipment. MF and UF membrane costs have continued to decline since the time of this evaluation, so it is reasonable to assume that the magnitude of the capital cost differences between these processes may be narrowing to some degree.

4.7.1 Operation and Maintenance Costs of Process Options

The O&M costs include electrical power requirements, chemical costs, labor costs operating and for maintaining the equipment and for operating the treatment facility, sludge disposal costs, and replacement costs. Replacement costs, sometimes referred to as “recurring costs,” account for periodic replacement of certain process components, such as membranes, UV lamps, filter media, and mechanical parts. Table 4.9 lists the O&M costs for each of the four processes.

Table 4.9 – O&M Cost Estimates for Process Options ($ MM)

O&M Cost Component	Opt. No. 1 Tubes + Cluster Filters + RO ($/Yr)	Opt. No. 2 DAF FloFilters + RO ($/Yr)	Opt. No. 3 UF + RO ($/Yr)	Opt. No. 4 Bank Filtration + RO + UV ($/Yr)
Replacement Costs & Maintenance	1.70	1.70	3.4	1.86
Electrical	6.18	6.31	6.77	6.06
Chemicals	2.38	2.16	1.25	0.15
Sludge Disposal	1.62	1.62	1.62	0.0
Labor	1.05	1.05	1.05	0.93
Total Estimated Annual O&M Cost ($/Yr)	12.93	12.83	14.1	9.0

Note: Capital costs shown are from Metcalf & Eddy Corpus Feasibility Christi Study, Nov. 2004.

As with the capital cost estimates, several assumptions and baseline criteria were necessary in order to prepare the O&M cost estimates. The following is a discussion of the major O&M cost criteria and assumptions.

4.7.2 Replacement Costs

Replacement costs are generally defined as anticipated, regularly scheduled maintenance expenditures that result from replacement of process components, such as membranes or media, and are not associated with routine small parts replacements or unforeseen repairs. For the purposes of this analysis, all replacements costs are in today's US dollars and are based on a 20-year period.

For the UF membranes included in Option 3, the vendor recommended a five-year replacement interval for the membranes themselves, at a cost of $703 per module. Over a 20-year period, there will be 4 total replacements.

For the RO membranes included in all options, the vendor recommended a five-year replacement interval for the first pass modules, at a cost of $650 per module. Over a 20-year period, there will be 4 replacements resulting of first pass modules. For the second pass modules the vendor recommended a 10-year replacement interval, at a cost of $500 per module. Over a 20-year period, there will be 2 replacements of the second pass modules.

For the conventional pretreatment Options 1 and 2, it was assumed that the filter media would require replacement once every 20 years.

For Option 4, the UV system will incur replacement costs, because lamps are normally guaranteed only for a certain number of hours. Beyond this guarantee period, the lamps may not operate at the appropriate intensity, which subsequently will reduce the fluence (the UV dose). The UV vendor has stated that a lamp life of 12,000 hours is realistic. This is 1.37 years between replacements. At this rate, over a 20-year period, there will be 15 total replacements. Added to this is the cost of lamp ballast replacement, estimated by the vendor at 2% of the lamp replacement cost.

4.7.3 Miscellaneous Parts & Maintenance

To account for miscellaneous parts replacements and maintenance that will also contribute to the overall O&M costs, it was assumed that the cost of miscellaneous parts replacements and maintenance will be equivalent to 2% of the capital equipment cost (the “equipment” referring to major equipment, pumps, and chemical feed systems as listed in the capital cost spreadsheets). The routine maintenance costs include daily tasks such as flushing, cleaning, installing small replacements parts, etc., but would not include major repairs or major replacements.

4.7.4 Power Costs

A unit power cost of $0.065 was used to estimate annual power consumption costs. This unit power cost was based on current power costs in the Corpus Christi area. The electrical loads form the major equipment, building services (HVAC), and metering pumps was estimated, and the unit power cost was applied in order to estimate total energy costs per option.

4.7.5 Chemicals

Chemical use is based on a raw water flow rate of approximately 50 mgd and a finished water production of 25 mgd. To obtain unit costs for the various chemicals, local area chemical suppliers were contacted for regional prices, wherever possible. It was assumed that all pretreatment options (except Option 4, Bank Filtration) will require 25 mg/L of ferric chloride for coagulation. The chemical doses for thickening operations include 30 mg/L of ferric chloride and 1 mg/L of polymer, at the preliminary recommendation of the equipment vendors. For dewatering, polymer dose of 1 mg/l was assumed. Polymer was also for coagulation in Option 1, at 1 mg/L. Polymer for coagulation is not required for Option 2 and 3.

The chemical use includes membrane cleaning chemicals, such as citric acid, sodium hypochlorite, sodium hydroxide, and sodium bisulfite. Sulfuric acid will be dosed upstream of the RO system for pre-RO pH adjustment. Reverse osmosis post-treatment chemicals include lime and CO_2 for pH adjustment and restabilization, sodium hypochlorite for CT disinfection and ammonia for conversion to chloramines, and fluoride to prevent dental decay.

4.7.6 Sludge Disposal

Sludge disposal costs will contribute to the annual operating expenses. A unit disposal cost of $70 per ton was used, based on previous experience. Sludge disposal will be required for all options with the exception of Option 4, Bank Filtration.

4.7.7 Labor

The projected labor force for each option includes operators, mechanics, supervisors, laboratory technicians, and electricians. Annual salaries consistent with industry standard were applied to each labor category, and adjustments for insurance and benefits (an additional 45%) were then applied.

4.7.8 Present Worth Analysis

A present worth analysis was prepared in order to evaluate and compare the economic impacts of all of the options. The present worth of an expenditure, or “investment” related with a given option is today’s dollar value (i.e., at the date of implementation of a given option) of all routine annual expenditures ascribable to that option. By this definition, since the O&M costs are routine annual expenditures, the O&M costs of the project period (20 years) can be extrapolated back to a present worth value. Thus, the total option cost is comprised of the capital cost plus the present worth of the O&M costs.

The present worth factor, PF, is a function of the assumed interest rate and period of investment. For this analysis, an interest rate of 5.125 percent was assumed. The period used in the analysis was 20 years. The present worth factor is calculated in the following manner:

$$PF_n = \{(1 + i)^n - 1\} / \{i (1 + i)^n \}$$

Where,

n = period of 20 years
i = interest rate

Then,

$$PF_{20} = \{(1+.05125)^{20} - 1\} / \{0.05125(1 + 0.05125)^{20}\} = 12.33$$

To determine the present worth of the O&M costs, the present worth factors are used as multipliers against the O&M costs. The total present worth is then found by adding the present worth of the O&M cost to the capital cost.

Table 4.10 – Cost Estimates for Process Options

	Option 1	**Option 2**	**Option 3**	**Option 4**
Pretreatment	**Tube Settler**	**DAF (Flofilter)**	**UF**	**Bank Filtration**
Estimated Capital Cost	**$79,864,480**	**$77,540,069**	**$105,861,293**	**$80,960,679**
Annual Electricity Cost:	$6,184,955	$ 6,311,756	$6,766,394	$6,061,125
Annual Labor Cost:	$1,048,350	$ 1,048,350	$1,048,350	$926,550
Annual Chemical Cost:	$2,379,898	$ 2,156,393	$1,246,486	$153,316
Annual Maintenance/Parts & Replacement Costs:	$1,697,822	$ 1,695,958	$3,395,667	$0
Annual Solids Handling	$1,615,641	$ 1,615,641	$1,615,641	$1,856,073
Total Yearly O&M Cost	**$12,926,666**	**12,828,098**	**$14,072,537**	**$8,997,064**
Period (years)	20	20	20	$20
Present Worth Interest Rate (%)	5	5	5	5
Present Worth Factor	12.4622	12.4622	12.4622	12.4622
Present Worth O&M Cost	$161,094,828	$159,866,458	$175,374,772	112123303.00
Total Present Worth:	**$240,959,307**	**$ 237,406,527**	**$281,236,064**	**$193,083,982**

Note: Capital costs shown are from Metcalf & Eddy Corpus Christi Feasibility Study, Nov. 2004.

As shown in Table 4.10, the lowest present worth cost is associated with the bank filtration option, since this option results in the lowest O&M costs. The highest present worth cost is associated with the UF option. The conventional options (Options 1 and 2) have essentially equal present worth costs.

In summary, for the technical reasons described in the above discussion of potential pretreatment processes, and the results of the present worth cost comparison in the Corpus Christi Feasibility Study, DAF clarification and gravity filtration is selected as the most robust and favorable pretreatment process to be considered in the preliminary evaluation of co-located SWRO facilities at the three candidate sites. Additionally, high rate DAF (AquaDAF) has been selected because of the potential cost advantages of a reduced foot print. This pretreatment method has been selected as the common denominator pretreatment process for evaluation of SWRO plants at the three candidate facility locations. When more detailed water quality data becomes available the pretreatment choices can be revisited and compared relative to specific plant siting.

4.8 Project Development Options

Traditionally, in the United States, water and wastewater treatment projects have been designed and constructed on the basis of a prescribed, single method for treatment. An engineer codifies the requirements for accomplishing the selected treatment method through a specific design. Then, the engineer produces drawings and specifications to comprehensively define the tanks, piping and equipment, collectively the “process” as well as the support and ancillary facilities. The deliverable is a set of detailed plans and specifications, together with a set of general and specific conditions or contract terms make up a bid package. This bid package is then used to solicit bids from general contractors on the basis of a lump-sum, low-bid award. While the design engineer provides an “engineer’s estimate” of the cost of the project, the contractors are generally viewed as providing a commodity service and are selected on the bid price.

Features of this traditional Design-Bid-Build (DBB) approach may result in some areas of concern: (1) the design engineers’ services are generally procured without regard to the cost of the facility, (2) the selection of the low-bid construction contractor heightens the risk of performance failure, and (3) risks associated with the failure of a facility to operate and perform in accordance with the owner’s needs rest primarily with the owner. Recently more innovative and alternative approaches, some involving public-private partnerships of various forms, have stirred significant interest in the water industry. These alternative approaches include:

- Design-Build (DB)
- Design-Build-Operate (DBO)
- Design-Build-Own-Operate (DBOO)
- Design-Build-Own-Operate-Transfer (DBOOT)

The most common form of alternative project delivery in the United States is the Design-Build-Operate (DBO) form. The DBO form changes the roles of the traditional participants. For example, a water utility procures the services of key project participants differently using a DBO approach. Under the traditional DBB approach the services of the engineer and the contractor are procured by the owner under separate procurements. Under the DBO approach a single Request for Qualifications (RFQ) is issued, followed by a Request for Proposals (RFP) to the pre-qualified bidders, where a single proposer forms a DBO team to provide engineering, construction, and operating services for the project.

The DBO approach allows for wide latitude of innovation on the part of the proposers in meeting the needs of the owner while allowing for an apples-to-apples comparison of the proposals. In responding to the RFP, proposers must focus on the overall performance of the project based upon performance-based specifications, as well as the detailed requirements of the project. Planning, design, engineering, construction, and long-term operations of the facility are combined into a single package, single contract, and a legally and financially responsible entity. In the traditional DBB approach each component is viewed separately, resulting in multiple participants and different contractual arrangements. When there is a problem on the project, there is a triangle of responsibilities with finger-pointing between the engineer-contractor, owner-contractor, and owner-engineer. The DBO approach may offer benefits of a single point of responsibility, innovate technology and/or process, shortened overall project schedule, reduced owner financial and technology risk, and operational and construction cost savings.

Two specific groups have initiated and promoted the DBO and other nontraditional approaches: design engineers and the international water services companies. Several design engineering firms have strategically positioned themselves in the market to foster, develop, and capture a share of the growing Design-Build (DB) market. The international water services companies have brought the Design-Build-Operate (DBO) and Build-Own-Operate-Transfer (BOOT) project delivery approaches to the North American and United States markets.

Market Drivers

There exist four principals, or market drivers, that shape the direction of the water market. The four major market drivers are:

- Aging facilities in need of major capital investment
- Implementation of more strict federal and state regulations
- Water industry globalization; and
- Water industry privatization

One or more of these drivers are the impetus for many in the water industry to examine new and more innovative approaches to project delivery. There is some pressure for water utilities to offer more value to the stakeholders.

Aging Facilities in Need of Major Capital Investments

Many water treatment systems, especially those in the more urban areas, are of an age where they require significant capital renewals and replacements. Water and wastewater utilities are significantly more capital intensive than any other utility. Building new or expanded facilities or replacing outdated or inadequate facilities will require investments by utilities and rate increases to repay the debt.

As many of the utilities received significant contributed assets, such as federal and state funding under the Construction Grants program, these utilities will be replacing these assets with their own funds. Consequently, water rates of today are based upon the recovery of only a fraction of the current replacement costs of the utilities' assets. This means that, in the future, rates will have to be increased significantly, just to keep pace with the current service and new capital requirements.

Implementation of More Strict Regulation

There are a number of new regulatory requirements being mandated by Congress that have a direct effect on water and wastewater utilities. The Safe Drinking Water Act (SDWA) and the Clean Water Act (CWA), and the amendments thereto, as well as the Clean Air Act (CAA), are the source of major new regulatory initiatives. It is expected that, as the science and understanding of pollutants and their effects increases, new regulations will continue to emerge from Congress and the United States Environmental Protection Agency (USEPA).

Under the Safe Drinking Water Act, the Disinfectant and Disinfection By-Product Rule (D/DBP) and the Enhanced Surface Water Treatment Rule (ESTWR) have set new and lower standards for total trihalomethanes (TTHMs), haloacetic acids (HAAs) and lower turbidity limits (expressed in NTUs). Additional filtration and monitoring requirements are likely, and the necessity for active and real-time monitoring for meeting *Cryptosporidium* is also being considered.

The above examples of regulatory drivers suggest that the pace of capital investment and the need for utilities to seek alternative project delivery will increase in the coming years.

Water Industry Globalization

The investor-owned segment of the water industry is also undergoing significant change. Mergers and acquisitions, as well as divestitures, have been occurring with increasing frequency in the water industry. The French companies Veolia (formerly Vivendi) and Suez Lyonnais, as well as the German company RWE have, over the last decade, been strategic acquirers of water utility assets and water equipment manufacturers. More recently, large U.S.-based companies such as General Electric and ITT Industries have been acquiring water equipment manufacturing assets. GE has acquired Glegg, Osmonics, Ionics, and Zenon Environmental, and ITT has acquired Sanitaire and WET.

Water Industry Privatization

Privatization, especially in the delivery of recent large-scale desalination plants, has been a significant factor in the reduction of the cost of delivering high quality potable water. The advantages to the owner of a privatized desalination plant are that the developer, not the owner, bears the technology and financial risk associated with the project. The developer brings private capital to the project, and the financial engineering to underwrite the project. The owner signs a “take-or-pay” contract, which obligates him to buy the water that is produced, but only when the developer produces that water at the predetermined quantity and quality requirements.

Beyond the desalination segment of the water and wastewater industry, there have been significant developments in the establishment of public-private partnerships. These partnerships cover a wide range of activities, from a utility contracting with a private entity for medium-term operations and maintenance services at a specific plant to the long-term contracting of overall utility operations with provisions for capital improvements.

4.8.1 Alternative Project Delivery Options

Alternative project delivery options include the following:

- Traditional Design-Bid-Build (DBB) compared to:

- Design-Build (DB)
- Design-Build-Operate (DBO)
- Design-Build-Own-Operate (DBOO)
- Design-Build-Own-Own-Operate-Transfer) DBOOT

Traditional Design-Bid-Build (DBB)

The traditional approach begins when and owner, such as a state, city, regional utility, municipality, or district, defines the need for a new project and makes a commitment to secure the funding and necessary regulatory approvals and permits to advance the project. A project management group, such as a municipal engineering staff or outside consultant, solicits the services of an engineer/architect to develop the design. The engineer prepares and provides to the owner a complete design, which includes the supporting technical bid specifications. An attorney for the owner may prepare the contract documents or the engineer may utilize standard form contract documents. The design, technical specifications, contract documents including general and specific conditions are issued with a request for bids for the construction of the project. Bids are received and reviewed by the engineer and the owner awards the construction contract to the lowest, responsive bidder. Permits for the construction are secured from relevant agencies based upon the complete design. The engineer generally provides services during construction to the owner, which could include review of shop drawings, field services, review of testing, certification of payment, etc. (see Figure 4.16).

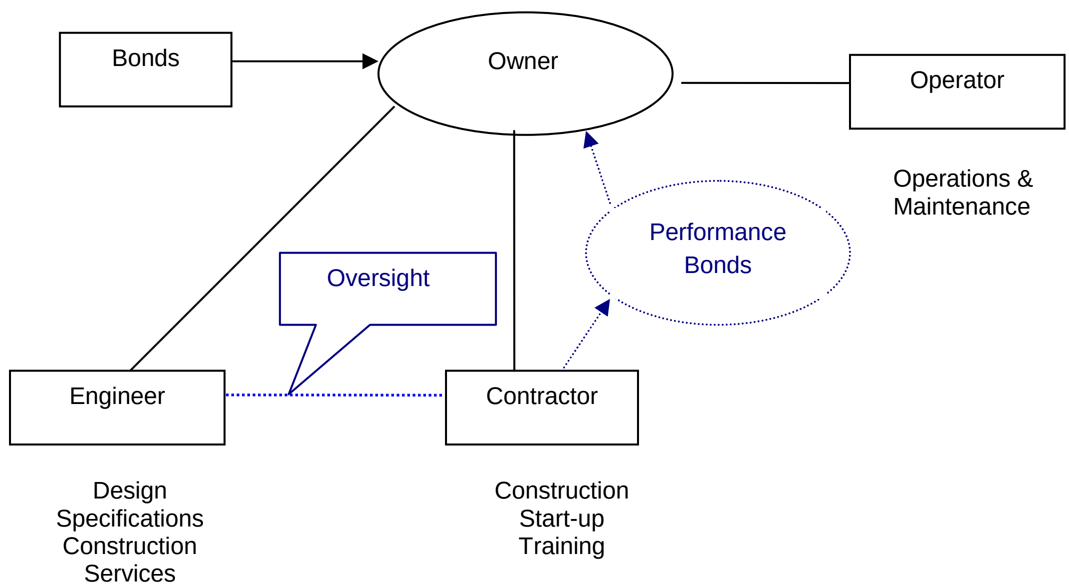


Figure 4.16 – Traditional Design-Bid-Build Structure

The contractor provides certain bonds to the owner in support of the completion and/or performance of the project. In addition, the owner may hold retainage during the course of the project, to maintain leverage over the contractor during the construction and until the project reaches substantial completion.

Ownership and funding for the project are public under the DBB structure. The owner secures funding for the project from revenue, general obligation, or other forms of public debt. Upon completion of the project, the asset becomes a public asset and the responsibility for operations and maintenance of the asset rests with the owner.

The basis for fulfilling the construction contractor's obligations is that the construction has been completed in accordance with the design engineer's specifications. Typically, any guarantees or warrantees provided by the contractor are limited to whether the facilities constructed and equipment installed meet industry standards. Generally, neither the design engineer nor the contractor is explicitly obligated to demonstrate the completed facility will operate and perform to its intended purpose. The contracts are based primarily on delivery of an asset meeting the design specifications. As a result, the owner maintains most of the project risk.

In addition, the process is linear and in distinct phases: planning, design, permitting, construction, start-up, and operations. Deficiencies at any stage of the process may not be understood until the project is complete, and corrections are very expensive. Changed or unforeseen conditions lead to change orders between the owner and the contractor.

The benefits of the DBB process stem from the fact that it is the traditional method and the structure and relative role and relationship of the parties is well understood. As this is the historical benchmark for public water and wastewater projects, the regulatory, legal, financial, insurance, and political requirements are well understood by all stakeholders. The model provides for a maximum of public input, as generally there is public debate at each stage of the development and implementation of the project. There is a high degree of transparency and public acceptance in a "lump-sum award to the lowest, responsive bidder."

The role of the engineer in providing services during construction serves as a check and balance in the process by keeping the designer-of-record involved as a witness, and by providing assurances to the owner, and the public, that the project was constructed in conformance with the plans and specifications.

The drawbacks of the DBB approach when compared to the alternative delivery methods are related to project schedule, allocation of risk, design and technology innovation, project performance, and constructability and operability. While the linear, sequential approach provides maximum potential for public involvement, it necessarily leads to a longer project delivery schedule from conceptualization to operations.

Likewise, as one explicit goal of the DBB process is to achieve the lowest construction bid price, and the public perception is that transferring risk to an engineer or a contractor will increase cost, the majority of the project risk is retained by the owner. When the process works well and the owner, engineer, and contractor communicate well and are committed to resolving issues, disputes, and problems early and fairly, the process can work as intended. However, when, for whatever reason, the process cannot work as intended, the potential for finger-pointing, delays, change orders, claims, arbitration and/or litigation increases dramatically. As demonstrated in Figure 4.16, the owner is responsible for accurately and completely defining the project, communicating those requirements to all the parties, then directing, coordinating, and executing the project delivery to meet all parties' needs. In this role, with multiple contracts with parties with disparate needs, the task is inherently challenging and prone to disputes.

As the design engineer is contracted on a fee-for-service basis, there is limited incentive for the engineer to risk undertaking a more innovative technology. There is no incentive or reward for the engineer to move away from the plans and specifications, which have been repeatedly proven, even though new methods or technologies are within view.

The development of a life cycle cost analysis for a project involves the balancing of the capital costs against the operating costs over the life of the project. In the water sector projects are generally more sensitive to operating costs over capital costs. This means a dollar saved on operating cost has more value that a dollar saved in capital costs. Seeking the lowest construction cost may disregard features which will have a significant impact on reducing operating costs over the 20-year life of the project.

<u>Design-Build (DB)</u>

In the DB approach to project delivery, a DB contractor is retained by the owner. There are two prevalent approaches to the selection by the owner of the DB contactor. In the first approach, the owner uses qualifications and experience as the selection criteria. In the second approach, the owner uses a combination of qualifications and experience and price to select the DB contractor.

In the first approach, a DB contractor generally includes a construction firm and an engineering firm, with one as the prime contractor and the other as a subcontractor; or the business relationship may be a joint venture of the engineer and the contractor. In this case, the engineer develops the project design criteria for the owner, and those criteria are used to contractually define the project that the owner desires. (There is a variation of alternative project delivery known as construction management at risk, which is similar to this model but is not being evaluated in this feasibility study.) Once contractually defined, the owner's project criteria form the basis of payment for the project, either under a lump-sum arrangement or a maximum guaranteed price for construction of the facility.

The second approach involves the owner developing his own project criteria containing either performance specifications or a partial design (30%) with limited specifications. Typically, the owner will use a procurement advisor, or an owner's representative, to advise and assist in the preparation of the documents (RFQs, RFPs, etc.) as well as to develop the owner's project criteria. The DB contractor is then selected based upon an established set of qualification criteria and a fixed price. The owner typically evaluates through a committee the technical merits, as well as the financial proposal, submitted by the DB contractor. Figure 4.17 demonstrates the structure of a typical DB approach.

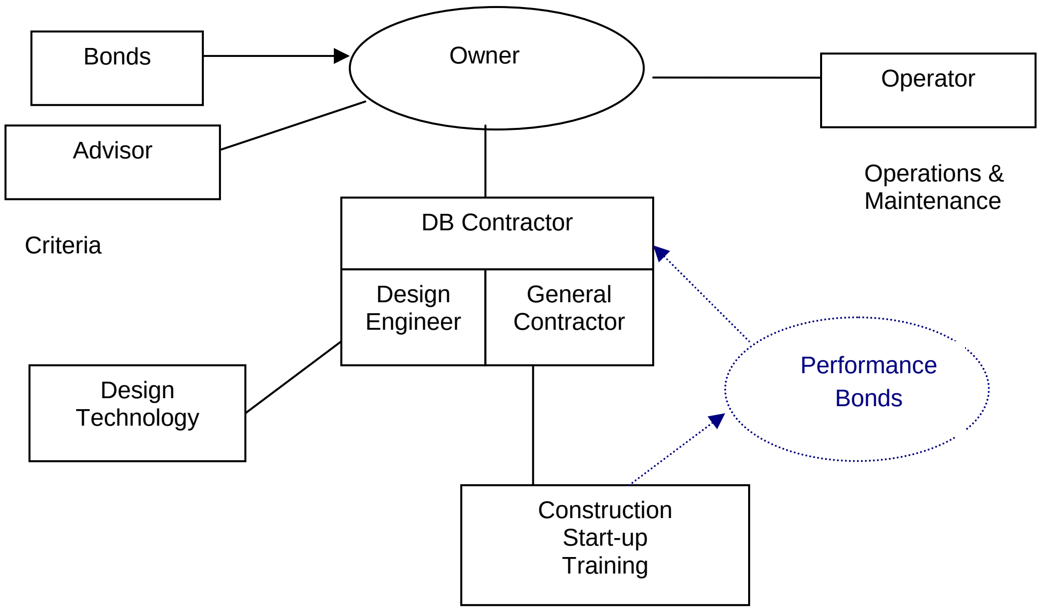


Figure 4.17 – Design-Build Approach Structure

During the design development phase of the project, there can be varying levels of interaction between the design engineer and the construction contractor. In some cases the design engineer may complete the design with limited input from the contractor. This tends to occur in DB projects without lump-sum, fixed-price or guaranteed maximum price provisions. In other instances, the design engineer and the contractor work in an integrated and interactive manner to develop a project that maximizes constructability, expedites schedule, and minimizes cost. This tends to occur in projects with a fixed price and an allocation of schedule risk to the DB contractor. Owners are likely to gain the maximum from the DB approach with the interactive model, and should consider this as a factor in the selection criteria for the DB contractor.

Under the DB approach, the owner necessarily surrenders some control over the details of the design and the schedule. The owner needs to consider the logical points in the public review and approvals under the DB approach. A principal advantage of the DB approach over the DBB approach is that the development of the design, if done in a concurrent and cooperative manner, can often lead to innovation, new technologies, and cost savings, as both the owner and the design engineer have incentives to seek cost-effective solutions for the project.

The single point of responsibility and accountability reduces the potential for disputes between the design engineer and the construction contractor. Even without significant changes to the project's installed material and equipment, the concurrent implementation of the design and permitting activities with the preconstruction work, site preparation, temporary utilities, access road construction, and more can shorten the overall project schedule. A shortened project schedule can lead to a lower project cost.

In a DB approach, the contracted price to design and build the project is established at an earlier point in the project than with a traditional DBB approach. In the DBB approach, the design is completed and the projected permitted before the construction bid is generally available.

As the DB approach is a relatively new method of project delivery, the legal framework for its use and implementation are not as well codified or understood when compared to the more traditional and longstanding DBB approach. Consequently, on a state-by-state basis, the legal basis for the use of the DB approach is frequently unclear, limited, or even precluded. In some areas, the selection of design engineers and/or construction contractors is perceived as controversial. There may be issues with respect to insurance and bonding, as all aspects of the risk allocation aspects of the DB delivery method have not been tested in the full spectrum of the legal system, so precedent and case law may be lacking.

Permitting a DB project requires some planning and forethought, as the design stage is not necessarily completed prior to the commencement of construction, as in the DBB approach. Some states, or other jurisdictions, may require a completed and stamped design prior to the review and issuance of appropriate permits. In order to avoid delays and potential delay claims, the permitting process and division of responsibility between the owner and the DB contractor for the permitting process should be clearly addressed at the outset of the project.

In spite of the areas of concern for the DB approach, there is no question that there is a distinctive trend, especially in certain regions of the United States, toward DB as a method of delivery. As owners, engineers, contractors, attorneys, and the insurance and bonding companies gain more experience with the DB approach, it will gain wider acceptance as a reasonable and more advantageous alternative to the DBB approach.

Design-Build-Operate (DBO) Approach

The BDO approach is fundamentally similar to the DB approach with the important distinction that the responsibility for the operations phase of the project is added. The operations phase can be relatively short, two to three years, or it can be long-term, 15 or 20 years, essentially the life of the project. While the fundamentals are the same, the addition of the operations phase adds another dimension of complexity to the project definition, the preparation of the RFP packages, and the consideration and evaluation of the DBO teams as a third player is now a part of the team. Often this added complexity will require that the owner add additional capabilities and resources to the owner's project team. The owner's project team will establish the project criteria, which may be performance-based, or may have some prescriptive design requirements in addition to the performance requirements.

Like the DB structure, the DBO structure will require a single-point of responsibility between the owner and the DBO contractor. The DBO contractor entity will have the contractual responsibility for the development, design, construction, start-up, and operations of the project. The DBO contractor responsibility is to deliver as asset with a given design/construction and operational performance. Generally, one of the participants in the DBO team is the project guarantor. The project guarantor role is to provide a financial guarantee that the project will meet the design, construction, and operations performance criteria. The performance guarantee is a financial contract between the project guarantor and the owner. The project structure for the DBO method of project delivery is shown in Figure 4.18 below.

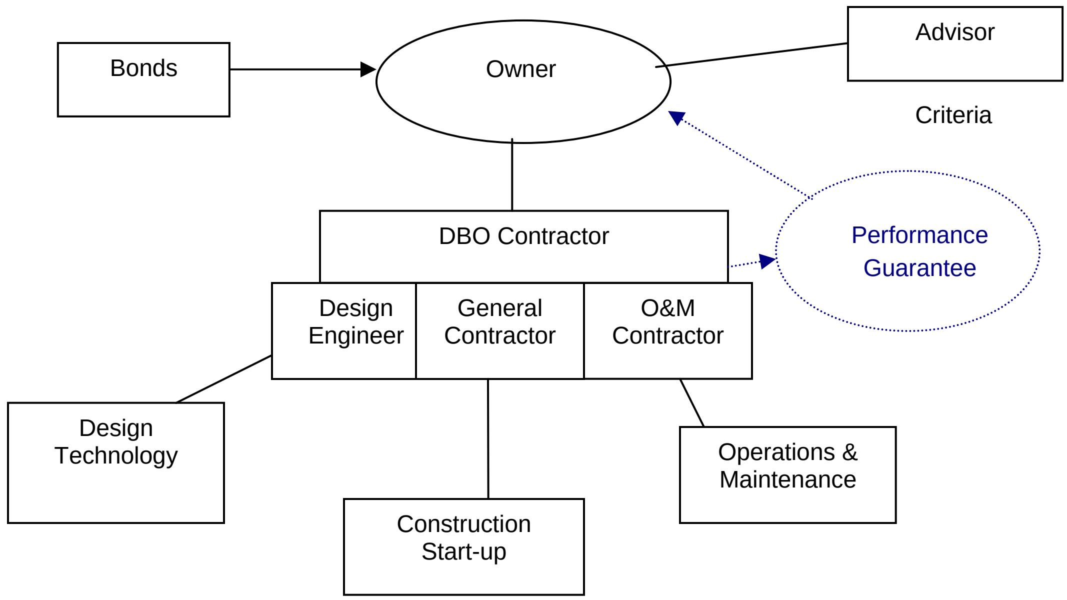


Figure 4.18 – Design-Build-Operate Approach Structure

The DBO contractors are generally selected based upon a combination of the design engineer, construction contractor, operator, and project guarantor qualifications, their technical proposal, and proposed capital and operating price. Each proposal will include the DBO contractor's design approach, construction approach, and operations approach, the fixed capital price, and the operating price. The owner will typically empanel an evaluation committee to evaluate the economic, financial, technical, and legal aspects of the DBO proposals.

The owner may use an owner's agent or owner's representative to provide arm's-length oversight and assure the owner that the construction follows the performance criteria developed and issued by the owner. The design engineer is the engineer of record for the project, and the DBO contractor must meet stringent performance testing requirements to demonstrate that the plant meets all of the performance requirements and will operate to the standards set in the service agreement.

Typically, the RFP characterizes the owner's desired risk position. The objective is to allocate project risk to the party best able to manage that risk. Commercial and performance risks tend to be shifted to the DBO contractor through future capital risk. Risks for future regulatory change, uncontrollable circumstances, and change in law tend to remain with the owner.

The DBO method suffers from some of the same legal impediments in certain jurisdictions as the DB method, since the enabling statutes and case law have generally been developed around the traditional DBB method. While the DBO method blends the operator into the DB method, it also adds the financial guarantee component. Generally the financial guarantee is provided by one of the project partners, or in some cases, by a parent company of one of the partners.

It is very important to the success of the DBO method that the owner develop well-defined project criteria. These should be included in the RFP and should set forth the desired level of quality, cost, and schedule for the project. The criteria define all the requirements that the DBO contractor has to fulfill in terms of design, permitting, construction, and operations of the facilities. The DBO contractor will have substantial control over the details, and even methods to achieve the owner’s criteria.

The DBO contract should protect the owner from delays in any of the stages of the project.

The advantages of the DBO delivery method has all the advantages of the DB method set forth in the previous section, including:

- A single point of contractual accountability for design, construction, and operations
- The cooperative teaming effort of the design engineer and the construction contractor, which can reduce capital costs and shorten the schedule
- A collaborative design and construction effort competitively procured, which can foster innovation and new technologies
- Concurrent design, permitting, and construction activities, which can shorten the project schedule
- The certainty of the project cost determined at an earlier stage in the project

The addition of the operator to a project delivery team has the potential to create a new dynamic in the design process. For example, if the project selection criteria for the DBO contractor include a 20-year life cycle project costs, then the facility's annual operating expense can be a more significant factor in DBO contractor selection than the consideration of only the installed project capital cost. With a significant competitive incentive to minimize project operating expenses, contract Operators have the opportunity to value engineer designs to optimize the facility's operability.

This may involve technologies that have a higher installed capital cost but will result in significantly lower operating costs. Therefore, the overall life cycle project costs are reduced as compared to traditional approaches.

Some DBO contracts include shifting the long-term capital operating risk to the DBO contractors. The long term capital operating risk is associated with the future cost to maintain a facility. Other terms used by utilities to describe these expenses include extraordinary maintenance, non-routine maintenance, and major capital maintenance.

When the Operator is obligated to provide cost guarantees for this long-term operating capital risk, there is an incentive to assure optimal equipment quality to minimize maintenance expense for the term of the contract and renewals. This may have significant cost benefit for the public.

An additional benefit is that the rates for the utility can be reduced to a formula for the term of the contract because of the fixed cost-basis for operations. Many communities have found it beneficial for economic growth and development to be able to predict their utility rates long-term, with the added certainty of a guaranteed contract.

Owners must recognize that the success of the DBO method is predicated upon the owner giving up control over the details that are usually subject to owner control in the DBB method. By allowing the DBO contractor to make the decisions on the details of the project, the owner gains benefits in fixing the construction and the long-term operations costs. Appropriate due diligence in selecting competent and proven performers on the DBO contractor team is crucial to the overall success of the project.

The owner may have very limited experience with long-term DBO contracting, and thus have difficulty adequately defining the contractual relationship with the DBO vendor team. A contract that includes, at minimum, the provisions for project development, design, permitting, start-up, acceptance testing, operations, regulatory compliance, monitoring and reporting, and future plant modifications is undoubtedly complex. A multiphase project contract can be difficult to prepare, understand, and administer. This is the reason that owner agent, procurement advisor, owner representatives, and specialized outside legal counsel are typically used on DBO projects.

The requirements for significant financial strength of the project guarantor and the high cost of developing a DBO proposal are frequently cited as deterrents to smaller, less sophisticated contractors participating in the DBO process. These two features tend to necessitate that at least one of the project participants is a major corporation with significant financial assets. This is often interpreted as meaning that DBO project delivery approach limits competition to major companies in the water and wastewater field.

However, the procurement process can be structured to require a portion of the work to be performed by local, minority, or disadvantaged contractors.

A significant DBO contract issue is the owner's administrative oversight during the operations period and the applicable standards of care for maintenance during the operating period of the contract. In a long-term, fixed-price contract for the operations and maintenance of a facility, the owner must be able to hold the DBO contractor to enforceable standards for equipment maintenance. Otherwise, the DBO contractor has an incentive to increase his profits by shortchanging equipment maintenance. DBO contracts should have clearly defined and measurable standards for acceptable equipment maintenance, periodic inspections, and an owner's remedy for inadequate maintenance by the DBO contractor's operations.

Build-Own-Operate-Transfer (BOOT)

While BOOT projects have generally had little general application in the water and wastewater industry in the United States, BOOT has been the project delivery model used in the Tampa Bay desalination plant project. BOOT projects can be characterized as an absolute performance-based contract in that they are structured around a "take-or-pay" contract, buying a commodity at a fixed price.

The characteristics of a BOOT project include the vendor providing the design, permitting, financing, construction, commissioning, and long-term operation of the constructed utility asset. Consequently, the vendor uses commercial private financing and owns the asset. The security for the BOOT contractor to secure financing is a purchase contract for the asset from the owner. BOOT contractors are generally prequalified, but the final contractor selection is based fundamentally on providing a commodity at a given price or tariff. An example of a tariff for a water contract would be a contract based on providing a minimum quantity of quality water for a fixed dollar value for a specified period of time. This type of project delivery is common throughout many developing nations of the world, where cost of service is critical and design and operational expertise of the owners in these areas can be very limited.

Solicitations for BOOT contractors are similar to those of DBO contractors. The RFPs for BOOTS are typically performance-based. The vendor teams are typically prequalified based on qualifications and experience, including the team's ability to secure financing for facility design and construction. The vendors prepare and submit extensive proposals that generally include a concept design, operating plan, and a guaranteed tariff in a form specified by the owner to either deliver water or treat wastewater. A take-or-pay form of contract between the owner and the private vendor generally secures financing. The private vendor owns the facility until such time as debt is repaid to the investors. Then the asset is transferred to the owner at the end of the contract term for either its market value or some preset, minimal value prescribed in the contract.

The owner’s role and responsibility in a BOOT project may be simpler than in a DBO, because the private investors have an interest in assuring that the project begins commercial operation and generates revenue to repay the debt. Owners will typically utilize an independent engineer to see that the BOOT vendor develops, designs, and constructs the project consistent with the requirements of the service agreement. The designer in the BOOT contractor’s consortium is the designer of record for the project. Upon completion of construction, an acceptance test is performed to demonstrate that the facility can operate within the service agreement performance criteria. Once the facility has met the acceptance test conditions, the facility commences commercial operation and is operated by the BOOT vendor’s operator.

The terms of service and the tariff paid for the operation of the facility are competitively established and guaranteed in the BOOT service agreement. The BOOT vendor is allocated nearly all the project risks, except the commercial risk related to the owner’s ability to pay the tariff, change in law, or *force majeure*. The project structure for a BOOT contract is shown in Figure 4.19.

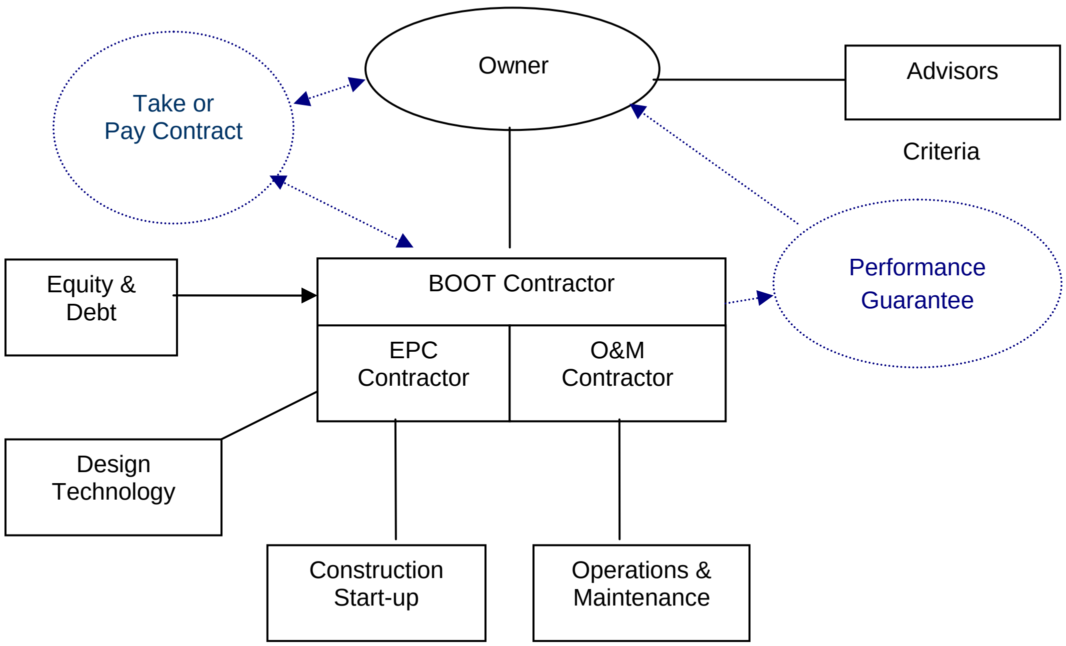


Figure 4.19 – Build-Own-Operate-Transfer Approach Structure

A BOOT project is structurally similar to a DBO project. The major difference is that the BOOT vendor will finance the project based on the strength of a take-or-pay-type water purchase or wastewater treatment agreement. The key contract issues for a BOOT project are then similar to those for a DBO project. The project criteria that define the owner's objectives and desired outcomes for the project must accurately reflect the owner's needs.

The complexity of the termination conditions in a BOOT project also requires careful consideration. A subordinate agreement with an engineer, procure, construct (EPC) contractor is usually developed and is consistent with the service agreement. A key area for disputes can be the inadequate characterization of the quality or quantity of raw water in the case of a water treatment plant, or effluent wastewater in the case of a wastewater treatment plant.

The key benefits of a BOOT project delivery are that the commercial and technology risks of a project can be fully allocated to the BOOT vendor. From the perspective of the owner, the BOOT project is off balance sheet financing. Thus, the project is neither an encumbrance upon, nor directly dependent on the credit limits of the owner. This factor can be significant when the owner needs to preserve public credit or has debt limitations.

One area where BOOT projects have been recently used in the United States is with seawater desalination plants, specifically the Tampa Bay desalination plant project. The risk associated with the design and project implementation associated with a developing technology is daunting to most public owners. In the BOOT approach, with the owner primarily responsible only to buy water exceeding stated quality standards for a fixed unit cost, the owner can be significantly insulated from the project's technology risk.

In the case of Tampa Bay, the wholesale water utility was forced by state regulators to find alternatives to the groundwater pumping as its primary source. After a review of technologies, seawater desalination was selected and an RFP for a BOOT contractor commenced. After three rounds of RFPs, Poseidon Resources (the developer) with Stone & Webster (EPC) was selected for the 30-year, 25-mgd project. Subsequently, Stone & Webster filed for bankruptcy, and they were replaced as EPC with Ogden Water, a subsidiary of Ogden Energy, which later changed its name to Covanta. After the project was under construction, and for reasons having to do with project financing, Tampa Bay Water elected to buy out Poseidon and execute the "T" or transfer provisions of the contract. Unfortunately, Covanta was not able to satisfy the requirements of the performance testing due to problems with its proprietary pretreatment system, and Tampa Bay Water recently settled a lawsuit to default Covanta and take control of the plant, its start-up and completion. Tampa Bay is seeking the services of an interim operator to correct the operational problems and operate the plant.

The negative lesson learned from the Tampa Bay desalination experience is that once committed to the BOOT process, the owner should not change methods in midstream or let the BOOT contractor off the hook, as the owner then takes back much of the technology and financial risk that was initially allocated to the BOOT contractor and his EPC and O&M contractors.

The positive lesson learned from the Tampa Bay desalination experience is that the BOOT process did foster a significant number of innovations in the siting and design of a seawater desalination plant; and some of these innovations (e.g., co-locating the desalination plant at a power generation plant) have become the implied standard for siting of seawater reverse osmosis desalination plants. While a number of the innovations proposed for the Tampa Bay facility may be in question until the design and operational problems are resolved, there is no question that the BOOT process did generate innovations.

The areas of concern applicable to DBO generally apply to BOOT. These include the following:

- Reduced owner control over project details
- Use of a complex multiphase contract
- Cost of proposal preparation may limit competition
- Operations and maintenance oversight standards are required to protect and maximize asset life

In addition, there may be some incrementally higher cost to provide the service due to the higher cost of private capital. Proponents of this form of project development suggest that these incrementally higher costs are offset by risk transfer, project cost reductions, and technology performance guarantees.

4.8.2 Comparison, Analysis and Ranking of Delivery Methods

All desalination plant projects are unique, as the location and site of the plant necessarily require consideration of different factors that affect the design and operations of the plant. These basic factors include feed water salinity, feed water temperature, seasonal variations in salinity, temperature, and other feed water chemistry and biology; and available, cost-effective methods of concentrate disposal.

Likewise, no single project delivery method is likely to fit every potential site for a desalination plant. Factors such as project delivery methods allowed under the statutes of the state of Florida, policies and procedures as well as local practices at each of the candidate sites, and sources of capital and operational revenues will be major factors that the city will have to resolve as the selection of a project delivery method for the desalination plant.

For the purpose of the comparison and analysis of the four methods, DBB, DB, DBO, and BOOT, it is assumed that all other site and physical external factors are neutral. A summary of the project analysis and alternative delivery methods in included in Table 4.11.

Table 4.11 –Project Analysis and Comparison of Alternative Delivery Methods

		Method			
Item	**Criteria**	**Design-Bid-Build**	**Design-Build**	**Design-Build-Operate**	**Build-Own-Operate-Transfer**
1.	Procurement Process and Cost	Owner controls process at each stage; however, procurement costs are spread over the entire process, from planning through construction supervision.	Owner must develop criteria and manage the procurement process, but schedule and costs are less than traditional DBB.	Owner must develop criteria and manage the procurement process, but schedule and costs are less than traditional DBB.	Owner must develop criteria and manage the procurement process, but schedule and costs are less than traditional DBB.
2.	Competition	Competition at each stage in the process. Contractor selected on lump-sum, low-bid and not based on qualifications.	Large number of qualified vendors in the market. Selection is based upon qualifications and price.	Large number of qualified vendors in the market. Selection is based upon qualifications and price.	Limited competition in the USA for privatized desalination plants. Problems with Tampa Bay
3.	Owner PM Costs and Burden	Costs and burden predictable based upon passed experience.	Owner must prepare criteria and provide some review during construction.	Owner must prepare criteria and provide some review during construction.	Owner must prepare criteria and provide some review during construction.
4.	Risk Allocation in Construction and Operations	Owner assumes performance and operations risk.	Owner bears the operations risk. DB contractor bears the construction risk.	DBO contractor bears both the construction and operations risk.	BOOT contractor assumes performance and financial risk.
5.	Project Schedule	Schedule is elongated to meet the pubic input, permitting, and bidding phase requirements.	Schedule improved over DBB. Concurrent activities speed up the process. Permitting is a concern for the owner.	Schedule improved over DBB. Concurrent activities speed up the process. Permitting is a concern for the owner.	BOOT projects can move more quickly than DBB projects, as the BOOT contract has financial incentives.
6.	Capital and Life cycle Cost	Good design engineer will develop life-cycle cost analysis for owner. Up to owner to determine.	DB contractor not required to consider operations cost unless so specified by the owner.	DBO contractor bids construction and operations and owner can easily establish life cycle basis for award.	Life cycle cost inherent in the development of the BOOT bid.
7.	Cost and Schedule Growth	Costs are more predictable than schedule.	Owner has minimal risk for cost and/or schedule growth, DB contractor at risk.	Owner has minimal risk for cost and/or schedule growth, DBO contractor at risk.	Cost and schedule growth favor the owner, as the BOOT contractor holds the financial and completion risk.
8.	Rate Stability	Once capital costs are known the effects on the rate can be determined based upon the cost of debt, but this information comes late in the process.	Costs for the project are known much earlier in the project cycle and can be evaluated for impact on rates earlier than the DBB.	Costs for the project are known much earlier in the project cycle and can be evaluated for impact on rates earlier than the DBB. Owner should realize savings in the O&M.	Owner only pays for water on a take-or-pay basis over the life of the project and is does not need to raise the capital costs for the project. Promotes rate stability
9.	Performance Guarantees	No performance guarantees provided. Owner's risk for design and operations performance	DB contractor must meet the performance criteria for the design. Operations are up to owner after acceptance.	DBO contractor must meet performance criteria for the design and operations of the plant.	BOOT Contractor takes most of the risk. Owner only pays for the water after acceptance test.
10.	Long-term Asset Management	Requires owner to operate, and so asset management over the life of the project is up to the owner.	Owner responsible for long-term maintenance of the asset.	DBO contractor responsible for the long-term maintenance of the asset for the life of the project.	BOOT Contractor has incentive to protect the asset over the life of the project.
11.	Project Financing Flexibility	Traditional project financing available	Traditional financing available	Traditional financing available. Innovation possible in the O&M.	Most flexible as private sector provides the equity and debt.
	Relative Ranking	**Third**	**Second**	**First**	**Fourth**

4.9 Power and Energy Recovery

Energy represents the single greatest cost impact for SWRO facilities. Therefore, in order to continue to reduce the cost of SWRO energy recovery and optimization becomes an essential part of process design. Feed temperature has a significant effect on the treatment efficiency of the RO system. System modeling can be performed at temperatures ranging from 10 to 30°C. At the lower temperatures, water quality is typically better, but more energy is required to operate the system. This is the worst case power required. At higher temperatures, water quality is still excellent, but residual ion values in RO permeate are higher. However, at the higher temperatures, less energy is required to operate the system.

The power requirements can be reduced by taking into account the residual pressure in the waste brine stream from the first pass. There are now a variety of commercially available choices that allow energy recovery from the brine stream to reduce electrical pumping costs. These include the reverse running pump (Francis Turbine), the Pelton wheel turbine, the hydraulic turbocharger, work exchanger, and pressure exchanger. Each of these devices operates on a slightly different concept. Some operate with no moving parts, others with one or many moving parts. Efficiencies also vary between the devices. A brief review of the options is presented below for application on this project and an energy recovery device is recommended.

4.9.1 Francis Turbine

In the Francis Turbine, the water enters the turbine runner with a radial velocity component, and discharges with an axial velocity component, like a reverse running pump. Francis turbines are distinguished by having a band, which surrounds the peripheral end of the blades (also known as buckets), providing a boundary for the water passage and structural rigidity to the runner. Francis Turbines are direct coupled to the feed pump, and must be designed for specific operating conditions. The result is changes in flow and pressure must be bypassed around the unit, lowering recovery efficiency. A basic Francis turbine layout is shown in Figure 4.20.

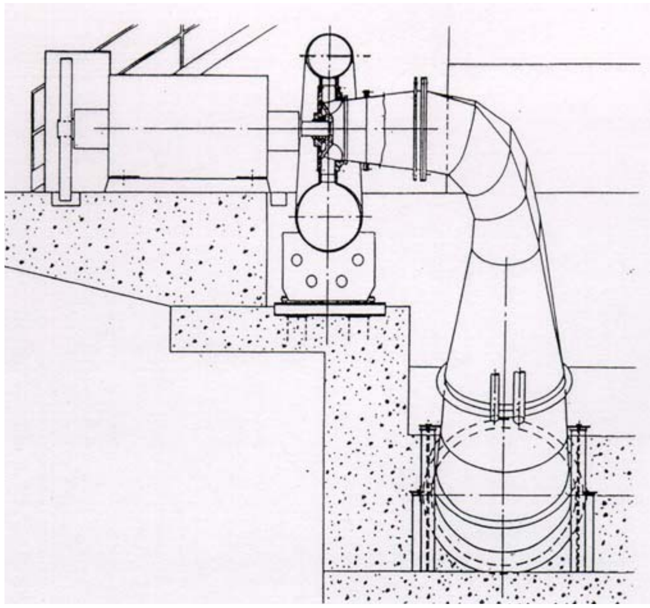


Figure 4.20 – Francis Turbine Diagram

4.9.2 Pelton Wheel

The Pelton wheel turbine operates by converting the velocity energy from a brine stream into kinetic energy. Nozzles aim the pressurized concentrate stream towards the Pelton wheel. The rotating wheel converts the energy to assist the electric motor in driving the high pressure feed pumps. Up to 90 percent of the brine energy can be recovered using this device; however, the initial capital cost is relatively high, since it must be incorporated into the feed pump. Figure 4.21 shows a schematic of a Pelton wheel.

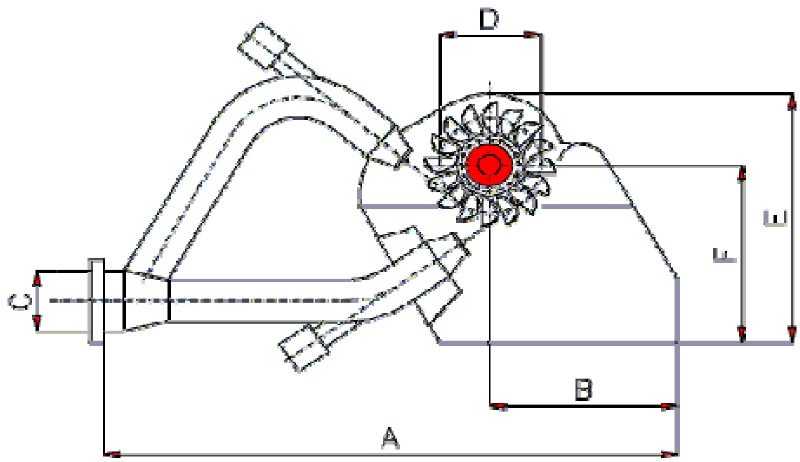


Figure 4.21 – Pelton Wheel Schematic

4.9.3 Work Exchanger

A relatively new energy recovery device called the work exchanger has been developed. The high pressure brine is directed to a work exchanger vessel filled with seawater and pressurizes that seawater to brine pressure. A small re-circulating pump boosts the seawater exiting the work exchanger vessel to equal the feed pump pressure and joins the flow to the membranes. This allows the feed pumps to pump only an amount equal to the permeate flow. Efficiencies of the work exchanger piston system can be 95 percent or higher, more efficient than centrifugal designs that rely on shaft conversion of power. Figure 4.22 shows a typical work exchanger flow diagram.

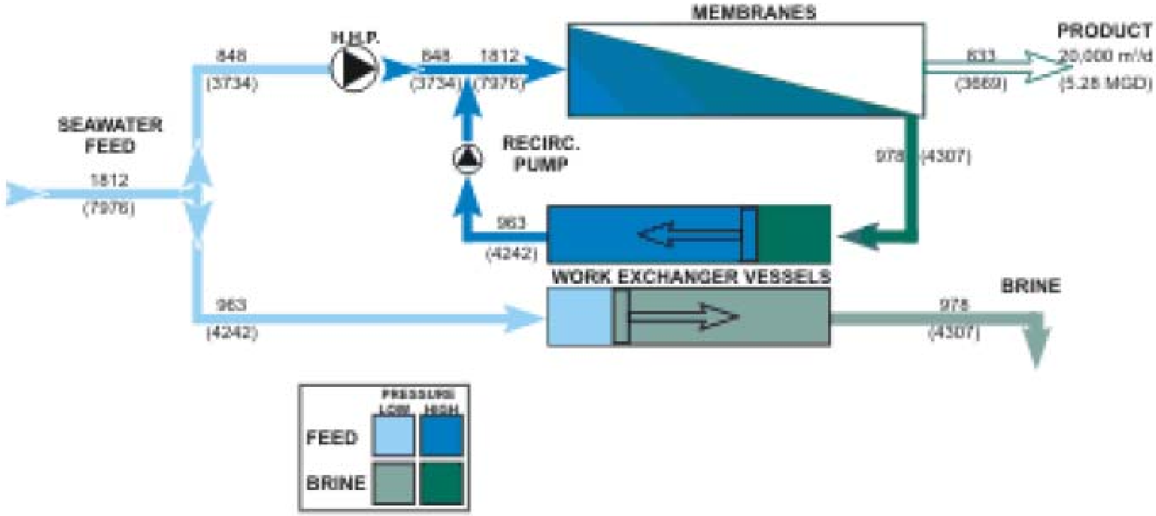


Figure 4.22 – Work Exchanger Typical Flow Diagram

4.9.4 Pressure Exchanger

A pressure exchanger transfers brine pressure energy directly to a portion of the incoming feed water. A booster pump then makes up the hydraulic losses through the system to reach the required feed pressure. This seawater stream then joins the feed from the high pressure feed pumps. The pressure exchanger has a single moving part, a shaftless ceramic rotor, which is suspended within a sleeve. Figure 4.23 shows a picture of a pressure exchanger installed on an RO skid.

Figure 4.23 – Pressure Exchanger Installation

Each of the energy recovery devices offers advantages and disadvantages. However, selection of a device and the power recovery associated with it are sensitive to actual operating conditions. Slight variations in pressure, flow, recovery, and other parameters can significantly affect performance of the devices. For this preliminary evaluation, energy recovery has not been included in the comparative analysis, since it represents a small savings compared to other factors. In Section 5, where more detailed conceptual analysis of the SWRO facilities is performed, Pelton wheels will be included in the evaluation.

4.10 Preliminary Cost Estimates for Candidate Sites

The original project objective was to preliminarily determine the approximate capital and O&M costs for co-located SWRO facilities at the three candidate sites, using the WT-Cost Model for Estimating Brackish and Seawater Desalination Costs developed by Dr. Irving Moch and the U.S. Bureau of Reclamation; and thereby help narrow the site selection process to one of the three candidate sites, at which a more detailed conceptual analysis for one co-located facility would be performed. Presented below are the results of this preliminary cost evaluation using the WT-Cost model.

This model is considered within the industry as a useful method of obtaining simplified rough estimates of construction and operating costs for brackish and seawater desalination facilities. For this analysis, the model was used assuming a common pretreatment process comprised of the high rate DAF (AquaDAF) and gravity filtration for each facility. Each facility cost was developed using the capacity, TDS, and temperatures assumed for each location, as discussed previously. Since co-location with existing power plants using once through cooling is assumed, costs for raw water intakes and outfalls for brine disposal are not included. Low lift pumps for raw water conveyance to the high pressure RO pumps are included. All other residuals from either clarification (DAF) or filtration are assumed to be disposed to a local sewer for conveyance to the local POTW.

Process flow diagrams for the Fort Myers, Port Everglades, and Lauderdale facilities are illustrated below in Figures 4.24, 4.25 and 4.26, respectively. Each show relative flows for raw, permeate and brine, and chemical application points. Cost tables summarizing construction and operating costs per 1,000 gallons for each major process element are shown in Tables 4.12, 4.13, and 4.14, below.

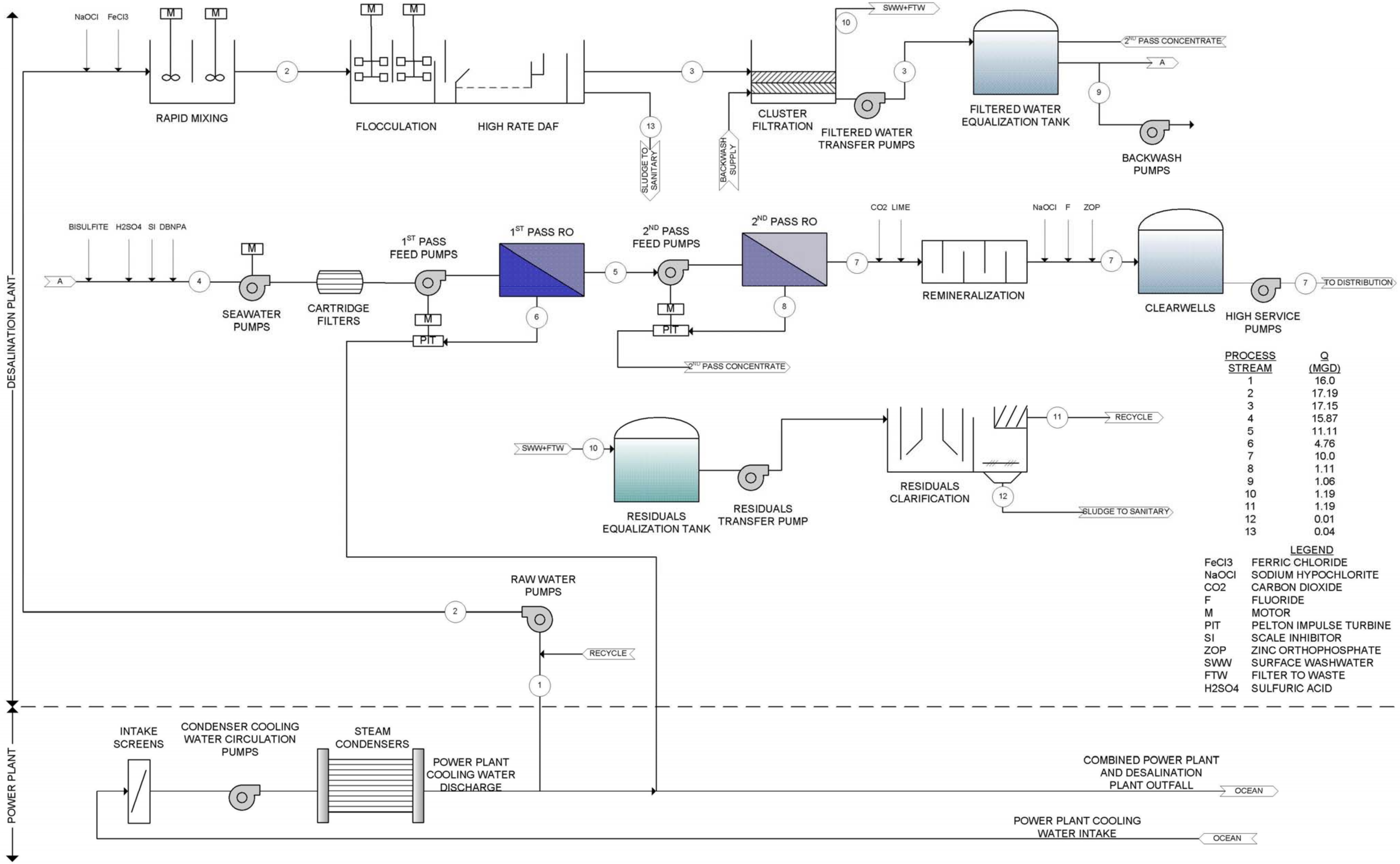
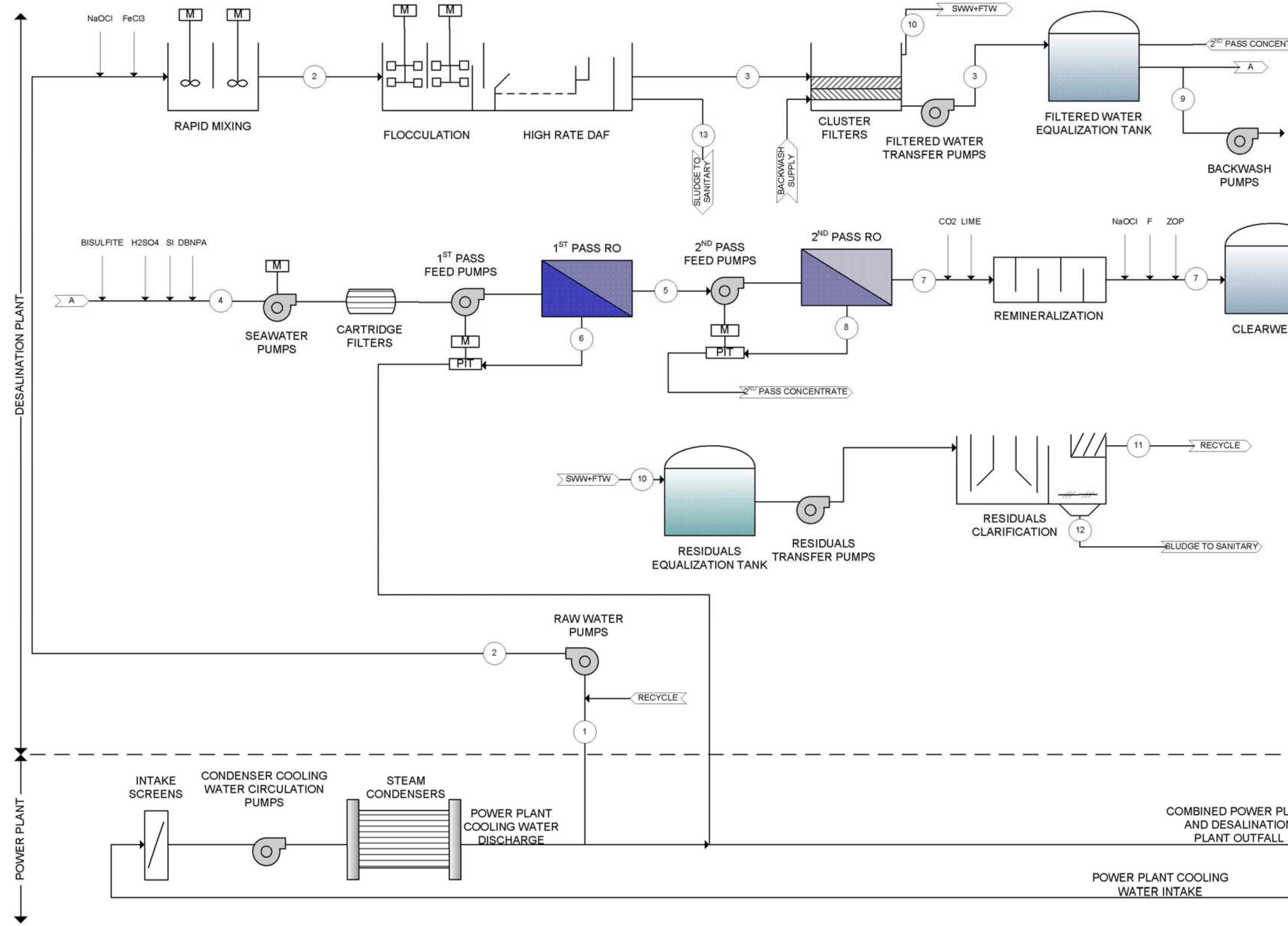


Figure 4.24 – Ft. Myers Facility Proposed Process Flows



PROCESS STREAM	Q (MGD)
1	78.0
2	83.3
3	83.1
4	77.8
5	38.9
6	38.9
7	35.0
8	3.9
9	4.7
10	5.3
11	5.3
12	0.01
13	0.02

LEGEND

FeCl3	FERRIC CHLORIDE
NaOCl	SODIUM HYPOCHLORITE
CO2	CARBON DIOXIDE
F	FLUORIDE
M	MOTOR
PIT	PELTON IMPULSE TURBINE
SI	SCALE INHIBITOR
ZOP	ZINC ORTHOPHOSPHATE
SWW	SURFACE WASHWATER
FTW	FILTER TO WASTE
H2SO4	SULFURIC ACID

Figure 4.25 – Port Everglades Facility Proposed Process Flows

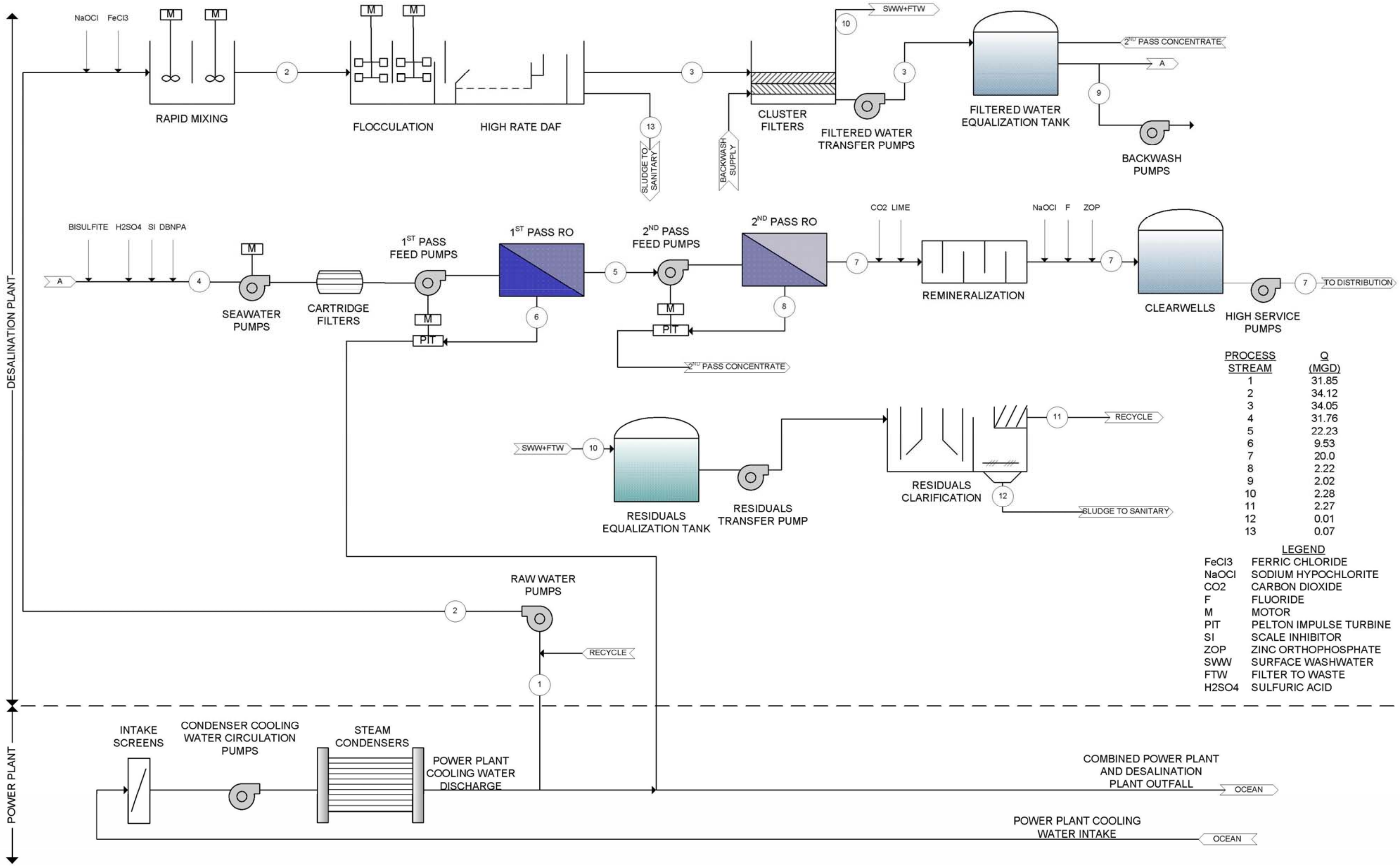


Figure 4.26 – Lauderdale Facility Proposed Process Flows

Table 4.12 – Ft. Myers Facility Construction and Operating Costs per 1,000 Gallons

COST BREAKDOWN (10 mgd Product, 70% R, 15,000 TDS)						
	Construction Cost			Operating Cost		
	Total $	$/m3 Cap	$/kgal Cap	$/yr	$/m3	$/kgal
Raw water low lift pumps	566,141	15	57	230,888		
Alum (dry feed)	25,154	0.66	2.52	105,036		
Polyelectrolyte	46,571	1	5	40,857		
DAF	2,595,000	69	260	173,103		
Gravity Filtration	2,909,727	68	291	190,677		
Intermediate Clearwell	277,590	7	28	0		
Antiscalant	93,113	2	9	206,865		
Sodium Bisulfite: Cost	46,571	1	6	40,857		
Acidification	348,715	9	35	28,384		
Reverse Osmosis/Nanofiltration	18,278,202	483	1,828	3,678,186		
Lime & Soda Ash	268,182	7	27	97,846		
Chlorination	54,650	1	5	28,411		
FW Clearwell	558,062	15	56	0		
Totals	**$26,067,679**	**$679**	**$2,608**	**$4,821,110**		

Note: RO costs include high pressure, intermediate transfer, and finished water pumping.

Table 4.13 – Port Everglades Facility Construction and Operating Costs per 1,000 Gallons

COST BREAKDOWN (35 mgd Product, 50% R, 33,000 TDS)						
	Construction Cost			Operating Cost		
	Total $	$/m^3 Cap	$/kgal Cap	$/yr	$/m^3	$/kgal
Raw water low lift pumps	1,969,905	14.87	56.28	1,100,486		
Alum (dry feed)	28,163	0.21	0.80	678,856		
Polyelectrolyte	78,817	0.59	2.25	170,270		
DAF	8,650,000	65.30	247.14	558,103		
Gravity Filtration	10,403,585	65.47	297.25	642,588		
Intermediate Clearwell	582,389	4.40	16.64	0		
Antiscalant	6,392,098	48.25	182.63	1,003,363		
Sodium Bisulfite: Cost	78,817	0.59	4.55	170,270		
Acidification	348,715	2.63	9.96	42,707		
Reverse Osmosis/Nanofiltration	55,082,566	415.80	1573.79	13,076,890		
Lime & Soda Ash	319,277	2.41	9.12	184,776		
Chlorination	54,650	0.41	1.56	28,411		
FW Clearwell	1,249,895	9.43	35.71	0		
Totals	**$85,238,876**	**$630**	**$2,438**	**$17,656,721**		

Note: RO costs include high pressure, intermediate transfer, and finished water pumping.

Table 4.14 – Lauderdale Facility Construction and Operating Costs per 1,000 Gallons

FORT LAUDERDALE COST BREAKDOWN (20 mgd Product, 70% R , 15,000 TDS)						
	Construction Cost			**Operating Cost**		
	Total $	**$/m3 Cap**	**$/kgal Cap**	**$/yr**	**$/m3**	**$/kgal**
Raw water low lift pumps	943,287	12.46	47.16	462,722		
Alum (dry feed)	69,576	0.92	3.48	281,601		
Polyelectrolyte	52,724	0.70	2.64	73,994		
DAF	3,460,000	45.71	173.00	228,103		
Gravity Filtration	4,972,847	56.36	248.64	317,678		
Intermediate Clearwell	375,294	4.96	18.76	0		
Antiscalant	253,836	3.35	12.69	407,374		
Sodium Bisulfite: Cost	52,724	0.70	4.58	73,994		
Acidification	228,946	3.02	11.45	19,295		
Reverse Osmosis/Nanofiltration	30,703,674	405.60	1535.18	6,192,401		
Lime & Soda Ash	296,836	3.92	14.84	139,759		
Chlorination	42,836	0.57	2.14	23,571		
FW Clearwell	888,059	11.73	44.40	0		
Totals	**$42,340,639**	**$550**	**$2,119**	**$8,220,493**		

Note: RO costs include high pressure, intermediate transfer, and finished water pumping.

It should be noted that the WT-Cost model provides only a rapid and simplified estimate of capital and O&M costs for SWRO facilities using a variety of generalized cost values that are best applied on a comparative basis. Actual costs may differ significantly depending on site and engineering specific details. Therefore, the above results are primarily useful for simplified relative comparison between these candidate SWRO facilities at differing plant capacities, and not useful for judgments concerning ultimate project costs.

5. Final Concept of Development of Demonstration Project

5.1 Introduction

Section 5 of this report addresses the final conceptual details of a demonstration project for the three candidate sites identified in Section 3.4. Concepts to be addressed include water supply source, conceptual design of the major pretreatment and treatment unit processes, waste disposal processes, key provisions of an operating agreement between the water utility and electric power utility, permitting requirements, planning level cost estimates and potential financing alternatives.

5.2 Recommendations

This preliminary estimate of SWRO plant capital and O&M costs presented in Section 4 of this report is based only on the estimating framework of the WT-Cost model supplemented where needed by data from other M&E projects. These estimates are comparable between locations and not intended as representative of expected total project costs considering other site-specific factors that could influence costs. The comparison was intended as a means of selecting one of the co-location sites for more detailed conceptualization and cost estimation of a demonstration facility based strictly on the relative magnitude of the expected investment.

It can be concluded from the above evaluation that the higher plant capacity of 35 mgd and highest TDS has the highest overall capital and O&M cost. While the Ft. Myers location with a capacity of 10.0 mgd could be an acceptable capacity for a SWRO demonstration facility, and represents a medium-range investment, the TDS of the raw water is not truly representative of seawater or potentially associated treatment issues that could affect long-term performance of RO. If the TDS is also lower at the Lauderdale location, this may also not be truly representative of SWRO desalination. The Port Everglades site, on the other hand, would be most representative of SWRO desalination in all respects. A demonstration facility at this location would provide proof of concept considering commonly encountered SWRO treatment issues, and fundamentally validate the feasibility of co-location of SWRO facilities with power plants.

Based on these results, the SFWMD requested that detailed conceptual evaluations be performed for all three facility locations, rather than only at one location. By performing the evaluation at all three sites, the impact of differences in plant capacity and water quality (TDS) on capital and O&M costs will be captured.

The mistakes of the past, such as the one at the Tampa Bay SWRO facility, must be avoided. Because red tide events are unpredictable with respect to location, timing, and magnitude, the SWRO process must be designed to treat these events while still sustaining firm capacity for peaking or drought protection. In this regard it is therefore recommended that this conceptual planning level evaluation should include the following:

- Dissolved air flotation (DAF) (AquaDAF)
- Gravity filtration using cluster type filters
- Two-pass reverse osmosis
- Energy recovery using Pelton wheel technology

5.3 Proposed Port Everglades RO Facility

This section provides background information on the design criteria used to develop the Port Everglades SWRO facility planning level capital and life cycle costs.

5.3.1 Process Description

The proposed Seawater Desalination project at the FPL Port Everglades coastal power generation station consists of the construction and operation of a 35 million gallon per day (mgd) seawater desalination facility. The proposed facility would be located adjacent to the FPL Port Everglades power plant, located south of Fort Port Everglades. The proposed facility would convert a fraction of the power plant's condenser cooling seawater discharge into fresh drinking water using a reverse osmosis desalination process. Source water for this facility would be taken from the existing condenser cooling-seawater discharge pipeline system and is assumed to have an average total dissolved solids (TDS) level of 33,000 mg/L. The desalination facility would intake approximately 78 mgd of the power plant's cooling water discharge and produce 35 mgd of high-quality potable drinking water for use by residents and businesses in the Broward County area. Approximately 38.9 mgd becomes concentrated seawater, which would re-enter the power plant condenser cooling water discharge system downstream of the desalination facility's intake point and blend with the condenser cooling circulation system flow for dilution prior to discharge back to the ocean.

The proposed seawater reverse osmosis (SWRO) plant consists of the following major processes:

- Seawater screening and pumping
- Rapid mixing for the introduction of coagulant and disinfectant

- High-rate dissolved air flotation for suspended solids removal
- Filtration for suspended solids and pathogen removal
- Two-pass reverse osmosis for dissolved solids removal
- Remineralization of hardness and alkalinity for corrosion control
- Clearwell storage for finished water equalization and disinfection
- Filter backwash water equalization and high rate clarification and thickening
- Recycle of clarified filter backwash water to the head of the plant

A process flow diagram depicting the proposed treatment process is illustrated by Figure 5.1.

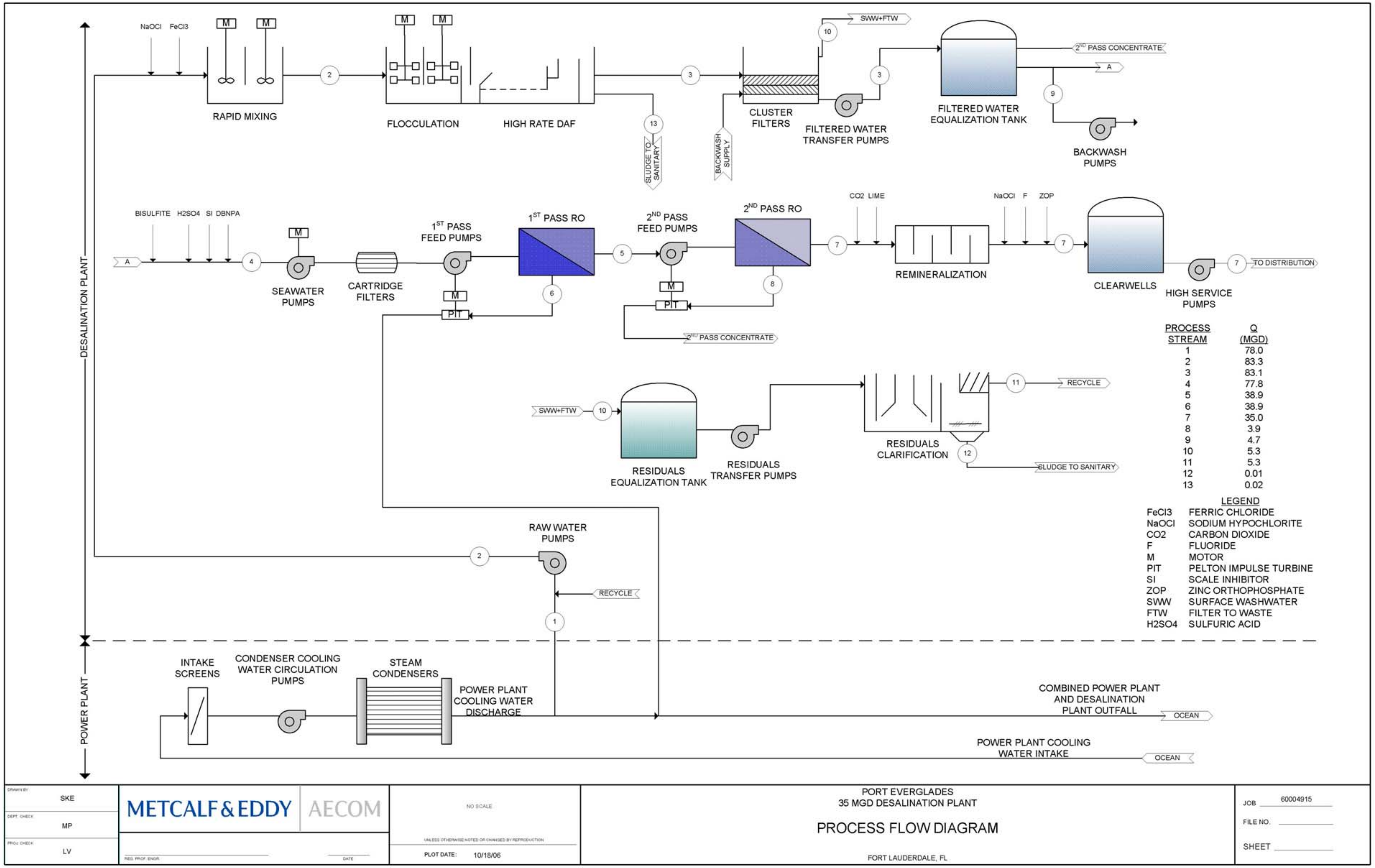


Figure 5-1 - Process Flow Diagram of Proposed SWRO Plant Treatment Process

5.3.2 Water and Solids Mass Balance

An estimation of water flow and quality at each point in the water treatment process is essential for properly sizing each unit process and for estimating initial capital and long-term operating costs. This section summarizes the water flow rates, solids production rates, and solids removal rates for each unit process at the Port Everglades SWRO facility.

Water Mass Balance

A water flow model was developed for estimating process flows assuming a finished water flow of 35 mgd. The process flow rates are summarized below by Table 5.1.

Table 5.1 – Process Flow Rates

Stream	**Description**	**Q (mgd)**
RW	Raw Water	78.0
CF	Clarifier Feed	83.3
CW	Clarified Water	83.12
CS	Clarifier Sludge	0.18
TS	Thickened Sludge	0.0091
FIL	Filtered Water	77.81
ROP	Permeate	35.0
ROC	RO Concentrate	38.9
SWW	Spent Washwater	5.31
REC	Recycle	5.3

Solids Production and Balance

Since the pretreatment options for each plant are the same and are based on the same values of raw water turbidity and coagulant dose, the solids generation for each plant site is similar. The volume of solids produced at each site will differ because the capacities of each plant differ. To assess the volume and magnitude of residuals production for the Port Everglades SWRO facility, a solids balance model was developed.

The solids production and balance is summarized below by Tables 5.2 and 5.3. The solids balance was based on a finished water production of 35 mgd, a raw water turbidity of 20 NTU, a ferric chloride coagulant dose of 25 mg/L (as ferric chloride), and a source water total organic carbon (TOC) of 6 mg/L. Assumed worst case values for turbidity, coagulant dose, and TOC levels were used because of limited available water quality data.

Table 5.2 – Solids Production

From Turbidity:		**Value**
Production Rate	Mg SS/NTU removed	1.5
Turbidity In	NTU	20.0
Turbidity Removal		98.0%
Turbidity Out	NTU	0.4
Solids Produced	Mg SS/L	29.4
From TOC Removal:		
TOC In	mg/L	6.0
TOC Removal		50%
Solids Produced	mg SS/L	3
From Ferric Coagulant:		
Production Rate	mg/mg ferric Dose	0.66
Ferric Dosage	mg/L	25
Solids Produced	mg SS/L	16.5
Total Solids Produced	mg SS/L	48.90
	Raw water flow (mgd)	78.00
	Lbs/day	**31,810**

Table 5.3 – Solids Balance

AquaDAF		
	AquaDAF feed (mgd)	83.3
	Unit solids capture (%)	95.0%
	Floated sludge load (lbs/day)	30,249
	Solids carryover to filtration (lbs/day)	1,592
	Floated sludge solids (%)	2.0
	Floated sludge production (mgd)	0.18

	Clarified Water Flow to Filtration (mgd)	83.12
Cluster Filters		
	Filter Feed (mgd)	83.12
	Solids capture (%)	97%
	Solids to filters (lbs / day)	1,592
	Solids retained by filters (lbs / day)	1,544
	Solids carryover to RO (lbs/day)	48
	No. of filters (N)	20
	No. of washes per day	20
	SWW & FTW per wash (gal)	265,462
	Total SWW & FTW to DensaDeg (mgd)	5.31
	Filtrate to RO (mgd)	77.81
DensaDeg Clarifier-Thickener		
	Unit solids capture (%)	98%
	Solids load to DensaDeg (lbs/day)[1]	1,544
	Solids flow to DensaDeg (mgd)	5.31
	Solids concentration (%)	0.0035
	Thickened sludge solids (%)	2.0
	Thickened sludge production (mgd)	0.0091
	Thickened sludge load (lbs/day)	1,513
	Recycle flow back to headworks (mgd)	5.3
	Solids in recycle stream (lbs/day)	31

5.3.3 Raw Water Screening, Pumping, and Treatment

Raw water will be withdrawn from the power plant's cooling water discharge channel. It is assumed that some form of cooling water prescreening is provided at the existing power plant; however, the mesh size is unknown at this time. Therefore, additional raw water screening is assumed to be required. Screening will be provided to remove suspended solids that could clog piping or damage downstream process equipment. A total of three traveling, automatically cleaned screens will be provided for suspended solids removal followed by raw water pumping. Five vertical turbine pumps will be provided downstream of the screens to pump raw water to the rapid mix system. Note that recycle water from the residuals clarification process is blended with the raw water

between the intake screens and raw water pumps. The detailed design criteria for the raw water screening and pumping system are summarized in Table 5.4.

Table 5.4 – Raw Water Screening and Pumping System Design Criteria

Parameter	Value
Raw Water Screening	
No. of screens (N)	3
Screen type	Traveling
Approach velocity (fps)	0.5
Total screen area required, N-1 (sf)	241
Area per screen, N-1 (sf)	121
Flow per screen, N-1 (mgd)	39.0
Raw Water Pumping	
Raw water flow (mgd)	78.0
Pump type	Vertical turbine
No. of raw water pumps (N)	5
No. of duty pumps (N)	4
Pump capacity (mgd)	20
TDH (ft)	40
Estimated brake horsepower at design conditions (HP)	166.98

Rapid Mix

A two-stage rapid mix system will be provided to disperse pretreatment chemicals in the raw water ahead of clarification. Each stage of the rapid mix system will provide approximately 30 seconds of detention at a maximum flow rate of 83.3 mgd (41.65 mgd per train) for a total detention time of 60 seconds. Coagulated water will flow via gravity to the downstream two-stage flocculation system. The detailed design criteria for the rapid mix system are summarized in Table 5.5.

Table 5.5 – Rapid Mixing System Design Criteria

Parameter	Value
Rapid Mix Basin	
No. Basins	2
No. of stages per basin	2

Parameter	Value
Flow per rapid mix basin (mgd)	41.65
Stage L (ft)	12
Stage W (ft)	12
Stage SWD (ft)	9
Volume per stage (cf)	1,296
Total volume per basin (cf)	2,592
DT per rapid mix stage (s)	20
DT per rapid mix train (s)	40
Rapid Mixers	
No. of mixers (N)	4
G (secs-1)	800
RPM	155
Absolute viscosity, u	0.00003746
Estimated mixer power (BHP)	56.49

Flocculation

A two-stage mechanical flocculation system will be provided ahead of DAF clarification. A total of 24 flocculation trains will be provided, with 3 trains feeding into a single DAF basin. Each flocculation stage will be equipped with a vertical, mechanical flocculator. Flocculated water will flow via gravity to the downstream high-rate DAF system. The detailed design criteria for the flocculation system are presented by Table 5.6.

Table 5.6 – Rapid Mixing System Design Criteria

Parameter	Value
Flocculation Tanks	
No. of flocculation trains	24
No. of stages (basins) per train	2
Total no. of basins	48
Flow per flocculation train (mgd)	3.47
Basin L (ft)	14

Parameter	Value
Basin W (ft)	13.3
Basin SWD (ft)	13.3
Volume per basin (cf)	2,476
Volume per train (cf)	4,952
Total volume (cf)	118,870
HRT per train (min)	15.37
HRT per basin (min)	7.69
Velocity (fpm)	1.82
Flocculators	
Flocculator type	vertical, mechanical
No. of flocculators	48
G (secs-1)	75
RPM	155
Absolute viscosity, u	0.00003746
Mixer power (HP)	0.95

<u>Dissolved Air Flotation (DAF) Clarification</u>

High-rate DAF will be provided for suspended solids and algae removal. A total of 8 DAF trains will be provided, each with a design flow rate of 10.41 mgd. The preliminary design loading rate will be 9.0 gpm/sf, with both units online, and 10.3 gpm/sf, with one unit offline. Clarified water will flow via gravity to the downstream cluster filtration system. Floated sludge will be discharged to the sanitary sewer system. The detailed design criteria for the high-rate DAF system are presented by Table 5.7.

Table 5.7 – AquaDAF™ Clarification System Design Criteria

Parameter	Value
DAF Summary	
Basin W (ft)	40
Basin L (ft)	62.3
SWD (ft)	13.3
Flotation area per basin (sf)	800
Total flotation area (sf)	6,400

Parameter	Value
DAF loading rate at peak flow, N in service (gpm/sf)	9.0
DAF loading rate at peak flow, N-1 in service (gpm/sf)	10.3
Volume per basin (cf)	10,640
Total volume (cf)	85,120
HRT per basin (min)	11.01
Velocity (fpm)	1.82
SLR (gpd/sf)	13,015
Sludge removal mechanism	mechanical
Production Summary	
Estimated clarification sludge flow (mgd)	0.18
Estimated solids concentration (%)	2
Estimated sludge production (ppd)	30,249
Clarified water flow (mgd)	83.12

Cluster Filtration

Following high-rate DAF, clarified water will flow via gravity to the cluster filtration system. Settled water will be conveyed to the filters through a common flume that will distribute water to each train. Slide gates will be installed to isolate each train. Five filter trains are proposed, each with a design capacity of 16.6 mgd. Each filter cluster consists of 4 filter cells, resulting in a total of 20 filter cells. The detailed design criteria for the cluster filtration system are summarized by Table 5.8.

Table 5.8 – Cluster Filter System Design Criteria

Parameter	Value
Filter Design Criteria	
Design flow (mgd)	83.1
No. of trains (N)	5
No. of filter cells per train (N)	4
Total no. of filters (N)	20
Design flow per filter train (mgd)	16.6
Design flow per filter (mgd)	4.2
Filter HLR with all cells in service (gpm/sf)	3.68

Parameter	Value
Filter HLR with one cell out of service (gpm/sf)	3.87
Filter HLR with one train out of service (gpm/sf)	4.60
Cell width (ft)	28
Cell length (ft)	28
Filter cell area (sf)	784
Total filtration area (sf)	15,680
Maximum HLR (gpm/sf)	4
Capacity at maximum HLR (mgd)	90.32
Media Configuration	
Anthracite	20", ES = 1.0 mm, UC = 1.7
Sand	7", ES = 0.45 mm, UC = 1.5
Ilmenite	3", ES = 0.26 mm, UC = 1.3
Coarse garnet	4", ES = 1.0 mm, UC = 1.7
Underdrain	Monoflor HD false bottom with polypropylene nozzles
Residuals	
Supplemental backwash pump type	horizontal split case
Number (N + 1)	3
Backwash rate (gpm/sf)	20
Backwash flow (gpm)	15,680
Backwash air scour blower type	PD
Number of blowers (N+1)	2
Air scour rate (scfm/sf)	3
Air flow (scfm)	2,352
Backwash duration (min)	15
Backwash volume per cell per event (gal)	235,200
Filter to waste HLR (gpm/sf)	3.87
Filter to waste flow (gpm)	3,038
Filter to waste duration (min)	10
Filter to waste volume per cell per event (gal)	30,380
SWW + FTW per cell per event (gal)	265,580
Filter run time (hr)	24
No. of filter washes per day (N)	20

Parameter	**Value**
Filter wash frequency (hr)	1.2
Total residuals volume (mgd)	5.31

Residuals from the filters will be collected, equalized, and clarified using the DensaDeg clarifier-thickener for recycle to the head of the plant. Details of the residuals treatment system are provided later in this report.

Filtered Water Equalization and Transfer Pumping

Because of high-groundwater tables that are common to South Florida, below-grade storage and equalization of filtered water is not possible. Filtered water equalization will be provided in aboveground, pre-stressed wire-wound concrete tanks. Filtered water transfer pumps will be provided to transfer water from the filters to the equalization tanks. The RO process downstream of the filtration process operates most efficiently at constant flow set points. Because variations in filtered water flows are possible, an intermediate equalization tank will provide storage to make up the difference in upstream and downstream flows, dampening the difference and allowing less frequent changes to unit process flows. Following the upstream pretreatment and prior to RO treatment, filtered water will be stored in an intermediate equalization tank. The tank will serve two main functions: (1) to serve as a suction well for the low pressure first pass RO pumps, and (2) to provide the ability to dampen the effects of flow variations between the upstream pretreatment process and the downstream RO process. The design criteria for the filtered water equalization tank and transfer pumping system are summarized by Table 5.9.

Table 5.9 – Filtered Water Equalization Design Criteria

Parameter	**Value**
Filtered Water Suction Well	
Design influent flow (mgd)	83.12
Design influent flow (cfm)	7,716
L (ft)	50
SWD (ft)	20
H (ft)	10
Volume (cf)	10,000
HRT (min)	1.30
Filtered Water Transfer Pumps	

Parameter	**Value**
Pump type	Vertical turbine
No. of pumps (N)	10
Discharge (mgd)	8.31
Head (ft)	20
Driver	Constant speed
Estimated brake horsepower at design conditions (HP)	36
Filtered Water Equalization	
Design influent flow (mgd)	83.12
Design influent flow (cfm)	7,716
No. of storage tanks (N)	2
Diameter (ft)	100
SWD (ft)	25
Volume of each (cf)	196,250
Volume of each (gal)	1,467,950
Influent flow to each tank (mgd)	42
HRT, both tanks in service (min)	51
HRT, one tank in service (min)	25

5.3.4 Reverse Osmosis

A two-pass RO system operating at a total recovery of 50% is proposed for dissolved solids removal. Details of each pass are provided in this section.

<u>First-Pass RO System</u>

Filtered water flows via gravity to the low pressure first-pass feed pumps. These pumps lift water from the filtered water equalization tank and pump it through the cartridge filters. Pretreatment chemicals including bisulfite for oxidant removal, scale inhibitor, and sulfuric acid will be introduced upstream of the cartridge filters. The ability to feed a non-oxidizing biocide such as DBNPA will be provided for periodic application to control biological growth in the RO system. The first-pass high pressure pumps, located downstream of the cartridge filters, pump pretreated water to the first-pass arrays.

Each of the first-pass high pressure feed pumps will be equipped with an energy recovery device to reduce the overall energy consumption of the RO system. For purposes of this report, it is assumed that each high pressure pump will be equipped with a Pelton Impulse Turbine (PIT). Concentrate from the first-pass arrays will be directed through the PITs and will be discharged via gravity to the power plant condenser cooling water discharge system, downstream of the desalination facility's intake point. Permeate from the first-pass RO system will be collected via a common header and will be directed to the second-pass RO system.

The detailed design criteria for the first-pass RO system are summarized in Table 5.10.

Table 5.10 – First-Pass RO System Design Criteria

Parameter	**Value**
RO influent water flow (mgd)	77.81
Cartridge Filtration	
Cartridge filter type	Vertical
No. of cartridge filter housings(N)	24
Cartridge Filter Capacity (mgd)	3.5
Total Capacity (mgd)	84
Capacity, N-1 (mgd)	80.5
Cartridge Filter Loading Rate	3.5 gpm per 10-inch length
Element length (in)	40
Cartridge Filter Element Type	Blown Polypropylene
Cartridge filter element rating (microns)	5
Seawater pump	
Pump type	vertical turbine
No. of pumps (N)	10
Discharge (gpm)	5,403
Head (ft)	178
Driver	Constant speed
Estimated brake horsepower at design conditions (HP)	296
Array design	
No. of arrays	10
Recovery rate	50%
Flux (gfd)	8
Fouling factor	0.85

Parameter	Value
Feed flow per array (mgd)	7.78
1st stage permeate flow per array (mgd)	3.89
Concentrate flow per array (mgd)	3.89
Total permeate flow (mgd)	38.90
Total concentrate flow (mgd)	38.90
Feed temperature (degrees F)	89 - 98
No. of stages per array (N)	1
No. of pressure vessels in first stage (N)	182
No. of elements per vessel (N)	6
No. of elements per array (N)	1,092
Active area per element (sf)	400
Active area per array (sf)	436,800
First stage feed pressure (psi)	740
Concentrate pressure (psi)	724
First-Pass Feed Pump Design	
Pump type	Horizontal centrifugal
No. of pumps (N)	10
Discharge (mgd)	7.78
Head (ft)	1,560
Driver	VFD
Pump shaft power required (kW)	1,919
Pump shaft power required (HP)	2,573
Pump efficiency (%)	85%
Pelton shaft power (kW)	791
Motor shaft power (kW)	1,128
Motor shaft power (HP)	1,512
Motor efficiency (%)	97%
Motor Electrical Power (kW)	1,163
Energy Recovery	
Energy recovery device type	Pelton turbine
No. of devices (N)	10
Inlet pressure (psi)	720
Outlet pressure (psi)	0
Efficiency	90%
Pelton shaft power (kW)	791

Parameter	Value
Pelton shaft power (HP)	1,060
Production Summary	
Total feed flow (mgd)	77.8
Total permeate flow (mgd)	38.9
Total concentrate flow (mgd)	38.9
Permeate TDS (mg/L)	735
Concentrate TDS (mg/L)	65,000
RO influent water flow (mgd)	77.81

Second-Pass RO System

A second-pass RO system is proposed to further reduce dissolved solids not removed by the first-pass system. Permeate from the first-pass system will be collected in a common header and will be directed to the second-pass system.

The second-pass system consists of 10 arrays, each with a permeate capacity of 3.5 mgd. The second-pass system will operate at a recovery rate of 90% in a two-stage system, a flux of 15 gfd, and will utilize low energy brackish water elements. Each array will be equipped with interstage boost pumps to increase the second-stage feed pressure and equalize flux rates between the stages.

Each of the second-pass feed pumps will be equipped with an energy recovery device to reduce the overall energy consumption of the RO system. For purposes of this report, it is assumed that each high pressure pump will be equipped with a Pelton Impulse Turbine (PIT). Concentrate from the second-pass arrays will be directed through the PITs and will be discharged via gravity to the filtered water equalization tank. The second-pass concentrate will be of high quality and will have a lower TDS than that of the first-pass feed. Blending the second-pass concentrate with the first-pass feed will increase first-pass feed quality and will reduce overall plant operating costs. The permeate from the second-pass system will be collected in a common header and will flow via gravity to the downstream remineralization system.

The detailed design criteria for the second-pass RO system are summarized in Table 5.11

Table 5.11 – Second-Pass RO System Design Criteria

Parameter	**Value**
Second-pass influent water flow (mgd)	38.9
Second-pass Feed Pump Design	
Pump type	vertical turbine
No. of pumps (N)	10
Discharge (gpm)	2,702
Head (ft)	185
Driver	VFD
Estimated horsepower (HP)	200
Estimated brake horsepower at design conditions (HP)	154
Array design	
No. of arrays	10
Recovery rate	90%
Flux (gfd)	15
Fouling factor	0.85
Feed flow per array (mgd)	3.89
First-stage permeate flow per array (mgd)	2.30
Inter-stage flow per array (mgd)	1.60
Second-stage permeate flow per array (mgd)	1.22
Second-stage concentrate flow per array (mgd)	0.39
Total permeate flow per array (mgd)	3.52
Feed temperature (degrees F)	89 - 98
No. of stages per array (N)	2
No. of pressure vessels in first stage (N)	50
No. of elements per vessel (N)	7
No. of pressure vessels in second stage (N)	25
No. of elements per vessel (N)	7
No. of elements per array (N)	525
Element basis of design	FilmTec XLE-440
Active area per element (sf)	440
Active area per array (sf)	231,000

Parameter	**Value**
First-stage feed pressure (psi)	740
First-stage concentrate pressure (psi)	80
Inter-stage boost pressure (psi)	60
Second-stage feed pressure (psi)	105
Second-stage concentrate pressure (psi)	91
Concentrate pressure (psi)	724
Second-Pass Inter-stage Pump Design	
Pump type	Vertical multistage centrifugal
No. of pumps (N)	10
Discharge (mgd)	1.60
Head (ft)	140
Driver	VFD
Pump shaft power required (kW)	103
Pump shaft power required (HP)	138
Pump efficiency (%)	85%
Pelton shaft power (kW)	8
Motor shaft power (kW)	95
Motor shaft power (HP)	128
Motor efficiency (%)	97%
Motor Electrical Power (kW)	98
Energy Recovery	
Energy recovery device type	Pelton turbine
No. of devices (N)	10
Inlet pressure (psi)	72
Outlet pressure (psi)	0
Efficiency	90%
Pelton shaft power (kW)	8
Pelton shaft power (HP)	11
Production Summary	
Total feed flow (mgd)	38.90
Total permeate flow (mgd)	35.01
Total concentrate flow (mgd)	3.89
Permeate TDS (mg/L)	80
Concentrate TDS (mg/L)	6,600

Remineralization

Because RO removes such a high degree of dissolved substances such as hardness and alkalinity, the permeate must be remineralized to prevent corrosion in receiving distribution system piping and to produce a finished water that is aesthetically acceptable to the customers. In final design, actual distribution system water quality conditions would be matched as closely as possible. The specific distribution system water quality is unknown at this time; therefore, general assumptions for remineralization have been used. After RO treatment, the permeate stream is projected to have an acidic pH of approximately 5.88. In addition, the RO process removes virtually all alkalinity. The only portion of the carbonate system that passes through the membrane is carbon dioxide (CO_2). To achieve hardness and alkalinity recovery, RO permeate will be remineralized with lime and carbon dioxide. To model the impact of post-treatment remineralization, the Rothberg, Tamburini & Winsor, Inc. (RTW) water chemistry model was used. This model calculates the impact of chemical addition on water quality parameters.

Two forms of lime are typically available, pebble (quick) lime and hydrated lime. While hydrated lime does not require slaking prior to remineralization, it is typically more expensive than quick lime. Therefore, quick lime was selected for this application. To meet the alkalinity and hardness goals, approximately 45 mg/L of lime will be added based on the RTW modeling.

The 45 mg/L of lime will produce a finished water pH that is higher than the water quality goal. Therefore, liquefied carbon dioxide will be used to reduce the pH to the desired range. Carbon dioxide mixes with water to form carbonic acid, a fairly mild acid which acts to reduce pH. The RTW model estimates that approximately 50 mg/L will be required to obtain a pH of approximately 8. With the addition of lime and carbon dioxide at the proposed doses, the LSI is approximately 0, and the total hardness is approximately 60 mg/L.

Carbon dioxide is delivered in the liquid form and stored in an insulated (cryogenic) storage tank. The storage tank is complete with the equipment necessary to maintain the liquid carbon dioxide at approximately 0 degrees F, with non-freezing regulators and temperature gauges. A vaporizer changes the liquid carbon dioxide to a vapor. Carbon dioxide vapor for process use is withdrawn from the tank and passed through regulators, metering equipment and other accessories depending on the type of feed equipment used. The RO permeate will flow to a remineralization rapid mix, where it will be mixed with the CO_2 and lime. The flow will then enter a remineralization basin, which will be baffled to ensure an 8 minute detention time with no short-circuiting. Table 5.12 summarizes the design criteria for the permeate remineralization system.

Table 5.12 – Remineralization System Design Criteria

Parameter	Value
Remineralization Basin	
Flow to remineralization (mgd)	35.0
Type	Rectangular, serpentine channels
Channel length (ft)	30
Channel SWD (ft)	13
Channel W (ft)	10
No. of channels (N)	5
Total length (ft)	150
Volume (gal)	145,860
DT (min)	6.00
Baffle factor:	0.8
T/T10 (min)	4.80
Rapid Mixer	
No. of rapid mixers	1
Mixing area volume (cf)	1,300
G (secs-1)	800
RPM	155
Absolute viscosity, u	0.00003746
Mixer power (HP)	56.67
Lime Feed System	
Application stream	RO Permeate
Flow rate (mgd)	35.00
Dose as CaO (mg/L)	45
Daily consumption (lb)	13,136
30-day storage (lb)	394,065
Lime density (pcf)	55
30-day storage (cf)	7,165
Lime Storage	

Parameter	**Value**
Bulk storage type	silos
Silo diameter (ft)	14.0
Silo height (ft)	55.0
Silo volume (cf)	8,462
No. of silos (N)	1
Lime Feed	
Slaker type	slurry
No. of slakers (N)	1
Slaker capacity (pph)	547.3
Carbon Dioxide Feed	
Application stream	RO Permeate
Flow rate (mgd)	35.0
Dose (mg/L)	60
Daily consumption (lb)	17,514
30-day storage (lb)	525,420
Bulk storage type	pressurized tanks
Tank capacity (lb)	240,000
No. of tanks (N)	2
Recirculation pump flow (1 gpm per pph of CO2)	730
Recirculation pump head (ft)	150

5.3.5 Disinfection and Finished Water Storage

Prior to the finished water pump station, contact time must be provided for disinfection with free chlorine (sodium hypochlorite) and on-site storage to allow the treatment plant to operate somewhat independently of the finished water pump station instantaneous flow.

The LT2ESWTR requires a 3-log removal / inactivation of *Giardia*, a 4-log removal / inactivation of viruses, and a 2-log removal / inactivation of *Cryptosporidium* for surface water treatment facilities. It is assumed that the proposed raw water source will be placed in Bin 1 which will not require additional treatment *Crypto* removal or inactivation. The removal / inactivation requirements are summarized by Table 5.13.

Table 5.13 – Disinfection Requirements

Cryptosporidium	2.0
Giardia	3.0
Viruses	4.0
Cryptosporidium	2.0

The clarification and filtration process will be granted a 2.5-log removal credit for *Giardia*; 2.0-log removal credit for virus; and 2.0-log removal credit for *Crypto*. Therefore, the disinfection process must provide an additional 0.5-log removal/inactivation of *Giardia*, and an additional 2.0-log removal/inactivation of viruses. When free chlorine is used for disinfection, the inactivation of *Giardia* controls disinfection requirements, because *Giardia* is much more difficult to inactivate than viruses with free chlorine. The additional disinfection contact time (T10) requirements have been calculated assuming free chlorine residuals of 1.0 and 2.5 mg/L and based on USEPA CT Tables contained in the Guidance Manual for Compliance with the Surface Water Treatment Rule. This is based on a well-baffled storage tank using dual concentric baffles to obtain a T10/T ratio of at least 0.75, a 25 percent additional capacity for tank level variability with pumping, a pH range of 6-9, and a finished water temperature greater than 25 degrees C.

Circular wire-wound pre-stressed tanks with dual concentric-C baffles were selected for the analysis for finished water storage. The design criteria for these tanks are summarized by Table 5.14. Note that the CT values represent that which is required for 0.5-log *Giardia* inactivation.

Table 5.14 – Finished Water Storage Design Criteria

Parameter	Value
Remineralized permeate flow (mgd)	35.0
Remineralized permeate flow (gpm)	24,315
Number of clearwells (N)	2
Mode of operation	parallel
Flow per clearwell (mgd)	17.51
Flow per clearwell (gpm)	12,158
SWD (ft)	18
Diameter (ft)	120
Actual volume (gal)	1,521,971
CT volume factor (dual concentric C baffles)	0.75
CT volume (gal)	1,141,478
Efficiency factor	0.75
T10 effective volume (gal)	856,108
Actual detention time per clearwell (min)	125
T10 clearwell (min)	70
CT req'd @ C = 1.0 mg/L, 25^{o}C, pH = 9	13
CT achieved @ C = 1.0 mg/L, 25^{o}C, pH = 9	70
CT req'd @ C = 2.5 mg/L, 25^{o}C, pH = 9	15.5
CT achieved @ C = 2.5mg/L, 25^{o}C, pH = 9	176

5.3.6 High Service Pumping

A new high service pumping station will be required. Finished water will flow by gravity to the high service pump suction well, located in the high service pump station. Horizontal split case pumps were selected because of their higher efficiency compared to other types of pumps. The design criteria for the high service pumping system are summarized by Table 5.15.

Table 5.15 – High Service Pumping Design Criteria

Parameter	Value
Finished water flow (mgd)	35.01
Pump type	HSC
No. of high service pumps (N)	5
No. of duty pumps (N-1)	4
Pump capacity at N (mgd)	7.00
Pump capacity at N-1 (mgd)	8.75
TDH (ft)	231
Estimated power (BHP)	350

5.3.7 Residuals Handling and Disposal

The water treatment process will produce a number of waste or residual streams. The streams include:

- Clarification sludge
- Spent washwater (SWW)
- Filter-to-waste (FTW)
- RO concentrate
- Tank drains
- Sanitary sewage

Residuals handling will consist of an equalization tank for SWW and FTW and DensaDeg high-rate clarification. AquaDAF™ sludge, tank drains, and sanitary sewage will be discharged to the sanitary sewer. RO concentrate from the first pass will be discharged to the power plant condenser cooling water discharge system downstream of the desalination facility's intake point and blend with the condenser cooling circulation system flow for dilution prior to discharge back to the ocean.

FTW from the cluster filtration system will be pumped to the residuals EQ tank. SWW from the cluster filtration system will flow via gravity to the residuals EQ tank. Effluent from this tank will be pumped to the DensaDeg clarifier. Supernatant from the DensaDeg clarifier will be recycled to the head of the plant and mixed with raw water prior to rapid mixing. This stream will flow via gravity. Sludge from the DensaDeg clarifier will flow via gravity to the sanitary sewer. The design criteria for the residuals processing system are summarized by Table 5.16.

Table 5.16 – Residuals Processing Design Criteria

Parameter	**Value**
SWW + FTW (mgd)	5.31
Total residuals (mgd)	5.31
Residuals EQ tank influent pumps	
Pump type	vertical turbine
No. of pumps (N)	2
No. of duty pumps (N-1)	1
Pump capacity (mgd)	3,687
TDH (ft)	30
Residuals EQ tank effluent pumps	
Pump type	vertical turbine
No. of pumps (N)	2
No. of duty pumps (N-1)	1
Pump capacity (mgd)	3,687
TDH (ft)	30
Residuals EQ Tank Data	
SWD (ft)	18
Diameter (ft)	79
Volume per eq tank (gal)	659,626
No. of tanks (N)	1
Total volume (gal)	659,626
Equalization time (min)	179
No. of cells per tank (N)	2
Volume per cell (gal)	329,813
No. of mixers per cell (N)	2
Mixer power (HP)	20
DensaDeg Clarifier Design Criteria	
DensaDeg clarifier influent flow (mgd)	5.31
Number of clarifiers	1
Clarifier capacity (mgd)	5.50
Design flow to clarifier (mgd)	5.31
Loading rate at max capacity (gpm/sf)	7.36

Parameter	Value
Unit solids capture (%)	98%
Solids load to DensaDeg (lbs/day)	1544
Solids flow to DensaDeg (mgd)	5.31
Solids concentration (%)	0.0035
Thickened sludge solids (%)	2.00
Thickened sludge production (mgd)	0.0091
Thickened sludge load (lbs/day)	1,513.42
Recycle flow back to headworks (mgd)	5.30
Solids in recycle stream (lbs/day)	31

5.3.8 Chemical Feed

Facilities for receiving, storing, and feeding various chemicals have been included in the analysis to develop conceptual level capital and operating costs. The following chemicals were included:

- Ferric chloride for coagulation
- Scale inhibitor to prevent scale formation in the RO system
- Bisulfite for oxidant removal ahead of the RO system
- Sulfuric acid for scale control in the RO system
- 2,2-Dibromo-3-Nitrilopropionamide (DBNPA) to reduce biological activity in the RO system
- Carbon dioxide and quick lime for permeate remineralization
- Fluoride for dental health
- Phosphate for corrosion protection
- Sodium hypochlorite for disinfection

Table 5.17 summarizes the average dose and consumption for each chemical included in this alternative.

Table 5.17 – Chemical Doses and Consumption

Chemical	Average Dose (mg/L)	Flow (mgd)	lbs/day (required)	lbs/day (from manufacturer)	Gallons per day	30-day storage (lbs)	30-day storage (gallons)
Pretreatment							
Prechlorination	3	83.3	2,084	---	2,498	---	74,931
Ferric Chloride	25	83.3	17,368	---	3,566	---	106,978
RO Pretreatment							
Sulfuric Acid	25	77.8	16,223	---	1,137	---	34,103
Scale Inhibitor	4	77.8	2,596	---	283	---	8,488
Bisulfite	3	77.8	1,947	---	465	---	13,961
DBNPA	0	77.8	0	---	0	---	
Remineralization							
Lime	45	35.0	13,136	13,136	---	394,065	---
Carbon Dioxide	60	35.0	17,514	17,514	---	525,420	---
Post-treatment							
Postchlorination	2	35.0	584	---	700	---	20,989
Fluoride	1	35.0	292	---	156	---	4,671
Phosphate	1	35.0	292	---	83	---	2,500

5.3.9 Buildings and Structures

For the purposes of this feasibility study it is assumed that all process equipment and tankage associated with each process will be housed indoors. The following major structures were included in this analysis:

- Raw water building for housing the raw water pumps and screens;
- Pretreatment building for housing the rapid mix, flocculation, DAF, filtration, filtered water transfer pumps, and pretreatment chemical systems;
- Reverse osmosis building for housing the seawater pumps, cartridge filters, first-pass feed pumps, first-pass RO arrays, second-pass feed pumps, second-pass RO arrays, CIP systems, chemical feed systems associated with the RO process; and

- Post-treatment building for housing the lime feed system, carbon dioxide feed equipment, high service pumping system, post-treatment chemical feed systems, and administrative area.

Each building will also house mechanical rooms, electrical equipment rooms, restrooms, control rooms, tool and workshop areas, and storage areas. A summary of area requirements for each proposed structure is presented in Table 5.18, below.

Table 5.18 – Area Requirements for Major Buildings

Facility	**Length (ft)**	**Width (ft)**	**Footprint (SF)**
Raw Water Building	60	80	4,800
Pretreatment Building	420	210	88,200
RO Building	340	218	74,120
Post-treatment Building	Various	various	16,000

Chemical storage for coagulant and the prechlorination chemicals will be located within the Pretreatment Building. Chemical storage and feeding facilities for lime, carbon dioxide, fluoride, phosphate, and postchlorination will be located in the post-treatment building. Chemical storage and feeding facilities for sulfuric acid, scale inhibitor, bisulfite, and DBNPA will be located in the RO building. A conceptual site plan illustrating the location of the major facilities is presented by Figure 5.2.

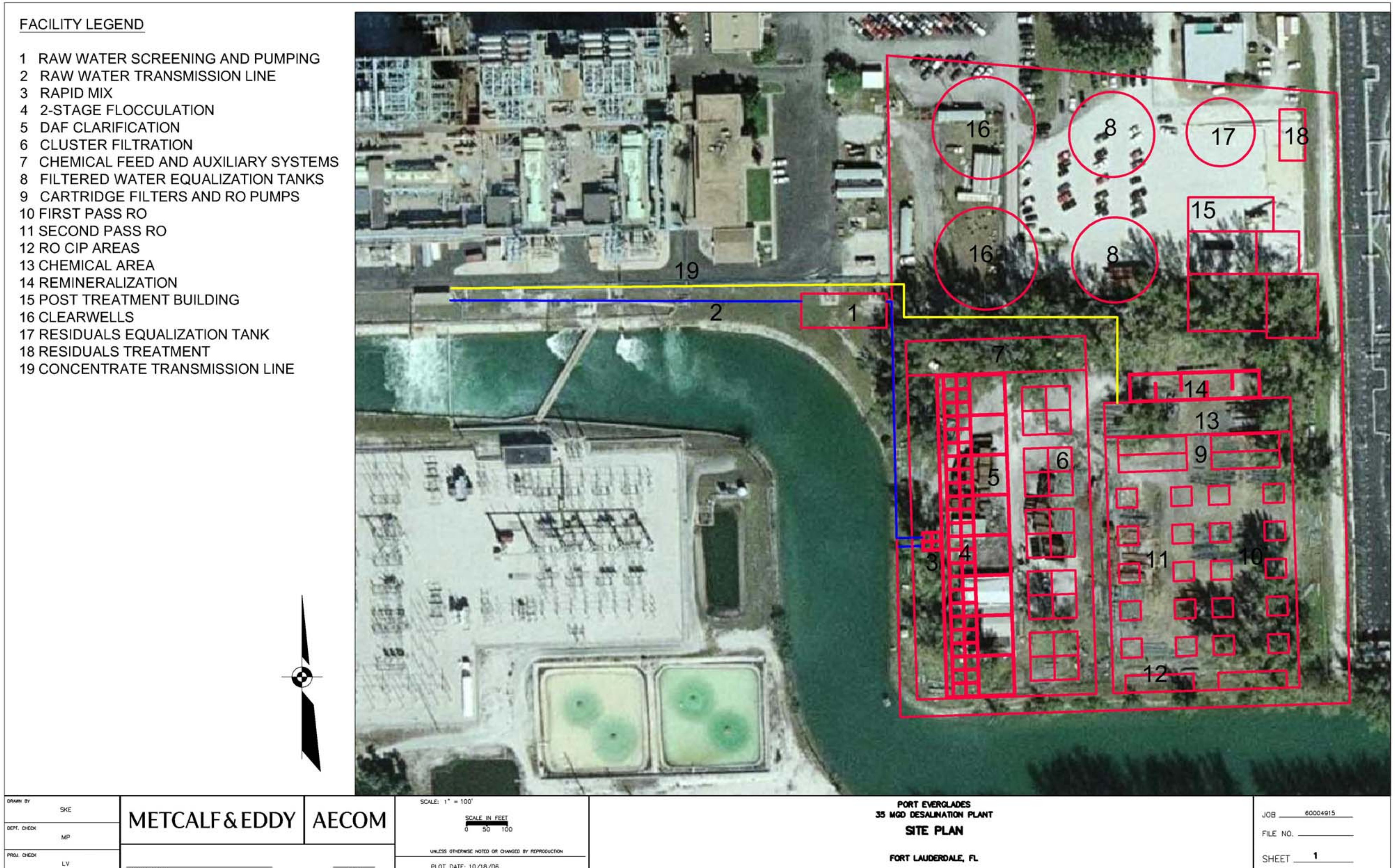


Figure 5-2 – Proposed Port Everglades SWRO Facility Site Plan

5.3.10 Estimate of Capital Costs

This section presents estimated capital costs for the Port Everglades SWRO facility. Capital costs were developed by sizing individual components within each option and estimating the quantities for the major items comprising the option. Unit prices were developed from equipment manufacturers and from recent historical data from other projects. When appropriate, additional costs were added for equipment, electrical, and instrumentation. In some instances, allowances were made for minor components and support facilities. After the construction costs are estimated and totaled, a 25% contingency was added for items that are currently unidentifiable. The final construction cost estimate also includes a 17% contractor's overhead and profit which includes the contractor's overhead expenses, mobilization, demobilization, bonding, and insurance. And finally, the project estimate includes 10% for engineering. Note that the capital costs are based on a finished water production rate of 35 mgd. A detailed cost estimate for this alternative is presented in Table 5.19 below. The costs presented herein should be considered Budget Level as defined by the American Association of Cost Engineers, with an accuracy of +30 percent to -15 percent. All costs are presented in October 2006 dollars.

Table 5.19 – Estimated Capital Costs

Conceptual Design Preliminary Capital Cost Estimate SFWMD Port Everglades SWRO							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
Site work							
1.01	Demolition	1	LS	$20,000	$0	$0	$20,000
1.02	Clearing	1	LS	$15,000	$0	$0	$15,000
1.03	Exterior piping (includes storm and sanitary sewers, footer drains, pavement drains)	1	LS	$1,250,000	$0	$0	$1,250,000
1.04	Site work (includes final grading, seeding, mulching, paving, fencing, sidewalks, curbs and gutters, landscaping, etc.)	1	LS	$1,500,000	$0	$0	$1,500,000
1.05	Temporary sheeting for raw water pump station	200	LF	$576	$0	$0	$115,250
1.06	Excavation for raw water pump station	963	CY	$15	$0	$0	$14,444
1.07	Excavation for pretreatment building	14599	CY	$15	$0	$0	$218,978
1.08	Excavation for filtered water EQ tank	2353	CY	$15	$0	$0	$35,292
1.09	Excavation for RO building	12342	CY	$15	$0	$0	$185,131
1.10	Excavation for remineralization basin	1131	CY	$15	$0	$0	$16,970
1.11	Excavation for lime feed building	646	CY	$15	$0	$0	$9,692
1.12	Excavation for CO2 equipment pad	1025	CY	$15	$0	$0	$15,381
1.13	Excavation for clearwells	5159	CY	$15	$0	$0	$77,378
1.14	Excavation for high service pump building	1329	CY	$15	$0	$0	$19,931
1.15	Excavation for administration building	939	CY	$15	$0	$0	$14,091
1.16	Excavation for post-treatment chemical feed building	963	CY	$15	$0	$0	$14,444
1.17	Excavation for residuals EQ	1366	CY	$15	$0	$0	$20,492
1.18	Excavation for DensaDeg	519	CY	$15	$0	$0	$7,779
						Subtotal	**$3,550,253**
Buildings & Structures							
2.01	Raw water pump and screening station concrete	1000	CY	500	$0	$0	$500,000
2.02	Raw water pump and screening station superstructure	4800	SF	$64	$0	$0	$307,200
2.03	Rapid mix basins concrete	266	CY	$500	$0	$0	$132,889
2.04	Flocculation basins & AquaDAF concrete	3000	CY	$500	$0	$0	$1,500,000

Conceptual Design Preliminary Capital Cost Estimate **SFWMD Port Everglades SWRO**							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
2.05	Cluster filters concrete	3600	CY	$500	$0	$0	$1,800,000
2.06	Pretreatment building concrete	1000	CY	$500	$0	$0	$500,000
2.07	Pretreatment building superstructure	88200	SF	$64	$0	$0	$5,644,800
2.08	Filtered water equalization tanks	2	Ea	$570,000	$0	$0	$1,140,000
2.09	RO building concrete	7500	CY	$500	$0	$0	$3,750,000
2.1	RO building superstructure	74120	SF	$64	$0	$0	$4,743,680
2.11	Remineralization basin concrete	656	CY	$500	$0	$0	$327,962
2.12	Lime feed building concrete	314	CY	$500	$0	$0	$156,980
2.13	Lime feed building	2500	SF	$64	$0	$0	$160,000
2.14	Carbon dioxide equipment pad concrete	445	CY	$500	$0	$0	$222,667
2.15	Clearwells	2	Ea	$687,500	$0	$0	$1,375,000
2.16	High service pump station concrete	1000	CY	$500	$0	$0	$500,000
2.17	High service pump station	6000	SF	$64	$0	$0	$384,000
2.18	Administration building	4000	SF	$125	$0	$0	$500,000
2.19	Post-treatment chemical feed building concrete	150	CY	$500	$0	$0	$75,000
2.2	Post-treatment chemical feed building superstructure	4000	SF	$125	$0	$0	$500,000
2.21	Residuals equalization basin	1	Ea	$705,000	$0	$0	$705,000
2.22	DensaDeg concrete	600	CY	$500	$0	$0	$300,000
2.23	Miscellaneous concrete for equipment pads, pipe supports, fill, containment curbs, etc.	1000	CY	$500	$0	$0	$500,000
						Subtotal	**$25,725,177**
Process Piping & Equipment							
3.01	Raw water screening equipment	3	Ea	$200,000	$60,000	$90,000	$750,000
3.02	Raw water pumps	5	Ea	$75,000	$37,500	$56,250	$468,750
3.03	Coagulation Basin Mixers	4	Ea	$35,000	$14,000	$21,000	$175,000
3.04	Flocculation and AquaDAF equipment	1	LS	$5,880,000	$588,000	$882,000	$7,350,000
3.05	Cluster filtration system	15680	SF	$560.00	$878,080	$1,317,120	$10,976,000
3.06	Filtered water transfer pumps	10	Ea	$75,000.00	$75,000	$112,500	$937,500

Conceptual Design Preliminary Capital Cost Estimate SFWMD Port Everglades SWRO							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
3.07	2-pass reverse osmosis treatment system (includes seawater pumps, cartridge filters, first pass high pressure pumps, 2nd pass feed pumps, inter-stage pumps, arrays, CIP system, interconnecting piping, energy recovery devices, I&C)	35000000	gal	$3.00	$10,500,000	$0	$115,500,000
3.08	Residuals, e.q., tank mixers and cranes	4	Ea	$45,000	$18,000	$27,000	$225,000
3.09	Remineralization basin mixer	1	Ea	$35,000	$3,500	$5,250	$43,750
3.10	Residuals transfer pumps	4	Ea	$50,000	$20,000	$30,000	$250,000
3.11	High service pumps	5	Ea	$50,000	$25,000	$37,500	$312,500
3.12	Coagulant feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$100,000	$10,000	$15,000	$125,000
3.13	Scale inhibitor feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$60,000	$6,000	$9,000	$75,000
3.14	Sulfuric acid feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$100,000	$10,000	$15,000	$125,000
3.15	DBNPA feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$60,000	$6,000	$9,000	$75,000
3.16	Bisulfite feed system	1	LS	$75,000	$7,500	$11,250	$93,750
3.17	Lime feed system (includes storage silos, fill lines, dust collectors, truck unloading station, gravimetric feeders, slakers, instrumentation, and controls	1	LS	$200,000	$20,000	$30,000	$250,000
3.18	Carbon dioxide feed system (includes storage tanks, evaporators, recirculation pumps, and feed system)	2	Ea	$300,000	$60,000	$90,000	$750,000
3.19	Phosphate feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$60,000	$6,000	$9,000	$75,000
3.20	Prechlorination hypochlorite feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$150,000	$15,000	$22,500	$187,500
3.21	Postchlorination hypochlorite feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$150,000	$15,000	$22,500	$187,500

Conceptual Design Preliminary Capital Cost Estimate **SFWMD Port Everglades SWRO**							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
3.23	Chemical storage tanks	22	Ea	$15,000	$33,000	$0	$363,000
3.24	Interior and exterior process piping (excluding RO system)	1	LS	$4,500,000	$450,000	$0	$4,950,000
3.25	Process valves, gates, and appurtenances (excluding RO system)	1	LS	$2,500,000	$250,000	$0	$2,750,000
						Subtotal	**$146,995,250**
Total Construction Cost							**$176,270,680**
Engineering				**10%**			**$17,627,068**
Construction Contingency				**25%**			**$44,067,670**
Contractors OH&P				**17%**			**$29,966,016**
Interest During Construction				**6%**			**$10,576,241**
Total Estimated Construction Cost							**$278,507,674**

5.3.11 O&M Costs

To develop a 20-year life cycle cost of the Port Everglades SWRO facility, operation and maintenance (O&M) costs have been developed. Three O&M categories were established and the annual O&M costs were developed for each category. The three O&M categories used in this analysis are:

- Power
- Chemicals
- Recurring Costs

Major facilities replacement costs are not included in these O&M costs, nor are replacements costs for major pieces of equipment, routine maintenance, and labor. These items are considered to be equivalent for all alternatives that could be considered for this project, and do not create a basis for making an economic comparison between alternatives. Replacement of major consumables that are specific to an alternative that would distinguish an alternative from another on an economic basis, such as membrane element replacement, are included under the recurring costs category.

A unit power cost of $0.066 per kWh was used to estimate annual power consumption costs. The electrical load from the major equipment, pumps, and building services (HVAC and lighting), and the unit power cost was applied to estimate total energy costs. It is assumed that all process buildings will require ventilation, lighting, and periodic heating. Cooling costs were estimated only for administrative areas. Power costs for membrane systems vary depending on water temperature, with power input increasing as feedwater temperature decreases. Because water temperature varies in the course of a year, an average feedwater temperature of 89 degrees F was used to calculate annual power costs.

FPL charges a monthly demand cost based on the highest 30-minute metered power demand in a single month. Based on an estimated daily demand of 473,267 kWh and a 1.25 peaking factor, the estimated maximum 30-minute power draw is 12,325 kW. FPL multiplies this value by $0.0572 to result in a monthly demand charge of $70,500 or an annual charge of $846,000. On top of this, FPL charges a $366 customer fee, for a total annual cost of $4,392. The total estimated annual demand charge is $850,357.

Chemical use is based on a rapid mix feed flow of approximately 83.3 mgd and a finished water production of 35 mgd. To obtain unit costs for the various chemicals,

local area chemical suppliers were contacted for regional prices, wherever possible. Dose rates and chemical costs are summarized earlier in this report.

In this estimate of O&M costs, recurring costs are generally defined as anticipated, regularly scheduled maintenance expenditures that result from replacement of process components that are specific to the alternative. The recurring costs associated with regularly scheduled maintenance such as equipment repair, cleaning, painting, etc., are not included in these estimates.

For the cluster filters, the estimated replacement interval for the filter media is 20 years. It is estimated that the media cost is $215/sf. At a total area of 15,680 sf, the annual replacement cost is $168,560.

For the first pass RO system, the estimated replacement interval for the membrane elements is 5 years and the cost of each membrane element is estimated to be $750. There are a total of 10,920 elements. The annual replacement cost based on these figures is $1,638,000. The first pass RO elements will require periodic cleaning. It is estimated that the system will require cleaning four times annually at a cost of $3,500 per mgd. This cost includes heating of the cleaning water, cleaning chemicals, CIP cartridge filter replacement, and pumping costs. Based on a permeate flow of 38.9 mgd, the annual cost for RO system cleaning is estimated to be $544,666. The cartridge filter elements preceding the RO system will require periodic replacement at $30 each. It has been assumed that 4,224 elements will be required at a replacement frequency of four times per year for a total annual cost of $506,880.

For the second pass RO system, the estimated replacement interval for the membrane elements is 10 years and the cost of each membrane element is estimated to be $650. There are a total of 5,250 elements. The annual replacement cost based on these figures is $341,250. The second pass RO elements will require periodic cleaning. It is estimated that the system will require cleaning once annually at a cost of $3,500 per mgd. This cost includes heating of the cleaning water, cleaning chemicals, CIP cartridge filter replacement, and pumping costs. Based on a permeate flow of 35 mgd, the annual cost for RO system cleaning is estimated to be $122,550.

A present worth analysis was prepared to evaluate and compare the economic impacts of this alternative. The present worth of an expenditure, or “investment”, related with a given alternative is today’s dollar value (i.e. at the date of implementation of a given alternative) of all annual expenditures specific to that alternative. By this definition, since the O&M costs are routine annual expenditures, the O&M costs of the project

period (20 years) can be extrapolated back to a present worth value. Thus, the total option cost is comprised of the capital cost plus the present worth of the O&M costs.

To determine the present worth of an annual expenditure, the annual costs are multiplied by the present worth factor (PF). The present worth factor converts the annual cost to a present day value, which can then be added to the capital costs that results in a single value that can be used to compare otherwise dissimilar alternatives. The present worth factor is a function of the assumed interest rate and period of investment. For this analysis, an interest rate of 6 percent and a term of 20 years were assumed. The present worth factor is calculated from the following equation:

$$PF_n = \frac{(1+i)^n - 1}{i(1+i)^n}$$

Using this equation, the present worth factor is 11.47. The determine the present worth of the O&M costs, the present worth factors are used as multipliers against the O&M costs. The total present worth is then found by adding the present worth of the O&M costs to the capital cost. A detailed estimate for this alternative is presented in Table 5.20 below.

Table 5.20 – Alternative 1 Estimated Operating and Maintenance Costs

Item	**Quantity**	**Unit**	**Annual Cost**	**Present Worth**
Equipment Operation - Electrical				
Major Equipment				
Raw Water Pumps	1	LS	$296,867	$3,405,045
Rapid mix tank mixers	1	LS	$100,436	$1,151,996
Flocculation equipment	1	LS	$20,241	$232,167
AquaDAF equipment	1	LS	$205,126	$2,352,783
Cluster filters	1	LS	$11,856	$135,989
Backwash pumps	1	LS	$23,883	$273,937
Air scour blowers	1	LS	$5,371	$61,601
Filtered water transfer pumps	1	LS	$158,174	$1,814,248
1st pass seawater pumps	1	LS	$1,317,832	$15,115,424
1st pass feed pumps	1	LS	$11,141,904	$127,796,763
1st Pass PIT	1	LS	-$5,437,281	-$62,365,187
2nd pass feed pumps	1	LS	$684,828	$7,854,925

Item	Quantity	Unit	Annual Cost	Present Worth
2nd pass inter-stage pumps	1	LS	$205,613	$2,358,366
2nd pass PIT	1	LS	-$23,546	-$270,069
Remineralization basin mixer	1	LS	$24,431	$280,221
Residuals EQ tank mixers	1	LS	$34,491	$395,606
CO2 recirculation pumps	1	LS	$15,477	$177,517
High service pumps	1	LS	$615,679	$7,061,790
Residuals EQ tank influent pumps	1	LS	$15,155	$173,829
Residuals EQ tank effluent pumps	1	LS	$15,155	$173,829
FPL power demand charges	1	LS	$850,357	$9,753,529
Building HVACL				
Raw water pump station	1	LS	$52,620	$603,553
Pretreatment building	1	LS	$966,901	$11,090,282
RO building	1	LS	$812,548	$9,319,861
Administration building	1	LS	$44,062	$505,383
Lime feed building	1	LS	$27,407	$314,350
High service pump station	1	LS	$65,776	$754,441
		Subtotal	***$12,251,364***	***$140,522,182***
Chemicals				
Coagulant	1	LS	$1,299,564	$14,905,901
Sulfuric acid	1	LS	$286,524	$3,286,404
Scale inhibitor	1	LS	$1,373,786	$15,757,213
Bisulfite	1	LS	$280,492	$3,217,217
DBNPA	1	LS	$15,000	$172,049
Lime	1	LS	$335,612	$3,849,443
Carbon dioxide	1	LS	$367,575	$4,216,057
Fluoride	1	LS	$105,280	$1,207,555
Phosphate	1	LS	$91,250	$7,319,658
Prechlorination	1	LS	$638,161	$1,046,630
Postchlorination	1	LS	$178,757	$7,319,658
		Subtotal	***$4,972,000***	***$62,297,786***
Recurring Costs				

Item	Quantity	Unit	Annual Cost	Present Worth
Filter media	1	LS	$168,560	$1,933,370
1st pass RO elements	1	LS	$1,638,000	$18,787,731
2nd pass RO elements	1	LS	$341,250	$3,914,111
Cartridge filter replacement	1	LS	$506,880	$5,813,874
1st pass RO CIP	1	LS	$544,666	$6,247,274
2nd pass RO CIP	1	LS	$122,550	$1,405,637
		Subtotal	***$3,321,906***	***$38,101,996***
Total O&M Costs			**$20,545,270**	**$240,921,964**

5.3.12 Cost Summary

Capital and O&M costs were developed for this alternative to develop a concept for treating raw water from this location. All costs are in current year U.S. dollars. Present worth costs were developed for a 20-year planning period using an interest rate of 6%. The capital cost estimates are based on the conceptual layouts and design criteria presented earlier in this section and are to be considered planning level only. The intent of the cost estimates is to establish a means of making economic comparison between alternatives for the purpose of ranking and evaluation. The costs are not to be considered total project costs which can only be developed as a result of detailed design. Table 5.21 summarizes the costs for this alternative.

Table 5.21 – Preliminary Estimated Cost Summary

PORT EVERGLADES SWRO		
Preliminary Estimated Cost Summary		
ESTIMATED PROJECT COSTS		
Total Construction Cost		$176,270,680
Engineering (10%)		$17,627,068
Construction Contingency (25%)		$44,067,670
Contractor's OH&P (17%)		$29,966,016
Interest During Construction (6%)		$10,576,241
Total		**$278,507,674**

PORT EVERGLADES SWRO		
Preliminary Estimated Cost Summary		
ESTIMATED PROJECT COSTS		
Unit Costs		
Capital cost ($/m3)		$1,330
Capital cost ($/kgal)		$5,036
Capital cost ($/gal)		$5.04
Project cost ($/m3)		$2,102
Project cost ($/kgal)		$7,957
Project cost ($/gal)		$7.96
Total power cost ($/m3)		$0.21
Total power cost ($/kgal)		$0.81
SWRO power cost ($/m3)		$0.15
SWRO power cost ($/kgal)		$0.56
SWRO specific power (kWh/m3)		2.47
SWRO specific power (kWh/kgal)		9.36
Plant specific power (kWh/m3)		3.57
Plant specific power (kWh/kgal)		13.52
Annual O&M cost ($/m3)		$0.39
Annual O&M cost ($/kgal)		$1.46

A breakdown of estimated life cycle cost and equivalent annual cost per 1,000 gallons of finished water is included as Table 5.22.

Table 5.22 – Estimated Life Cycle and Equivalent Annual Cost per 1,000 Gallons

Estimated Life Cycle Cost and Equivalent Annual Cost per 1,000 Gallons
Proposed Port Everglades Facility

Parameters

Discount rate	5.125%	Base year	2007
Inflation rate	3.000%	Period of analysis - years	20
Year of cost estimate	2006	Annual availability factor	98%

Useful life by facility type or service (See Note 8)	WC	40	PAE	20
	OS	35	M	5
	W	30	NS	0

Item	Facility Type[8]	Initial Investment: Amount in Year of Cost Estimate Dollars	Initial Investment: Amount in Base Year Dollars	Initial Investment: Year Opera-tional	Initial Investment: Construc-tion/ Service Duration - Years	Initial Investment: Useful Life - Years	Initial Investment: Present Value in Base Year[1]	Operation and Maintenance: Annual Amount in Year of Cost Estimate Dollars	Operation and Maintenance: Annual Amount in Base Year Dollars	Operation and Maintenance: Present Value[2]	Renewal and Replacement: Annual Amount in Base Year Dollars[3]	Renewal and Replacement: Present Value[4]	Total Present Value - Life Cycle Cost
Sitework	OS	$ 3,550,253	$ 3,656,760	2012	2	35	$ 3,369,934		$ -	$ -	$ 104,479	$ 1,197,274	$ 4,567,208
Buildings and structures	OS	$ 25,725,177	$ 26,496,933	2012	2	35	$ 24,418,583		$ -	$ -	$ 757,055	$ 8,675,463	$ 33,094,046
Process piping & equipment	PAE	$ 130,385,722	$ 134,297,294	2012	2	20	$ 123,763,369		$ -	$ -	$ 6,714,865	$ 76,948,888	$ 200,712,257
Engineering	NS	$ 17,627,068	$ 18,155,880	2012	2	0	$ 16,731,781		$ -	$ -	$ -	$ -	$ 16,731,781
Construction contingency	PAE	$ 44,067,670	$ 45,389,700	2012	2	20	$ 41,829,452		$ -	$ -	$ 2,269,485	$ 26,007,128	$ 67,836,581
Contractor overhead & profit	PAE	$ 29,966,016	$ 30,864,996	2012	2	20	$ 28,444,027		$ -	$ -	$ 1,543,250	$ 17,684,847	$ 46,128,875
RO elements and media	M	$ 16,609,528	$ 17,107,814	2012	2	5	$ 15,765,922		$ -	$ -	$ 3,421,563	$ 39,209,346	$ 54,975,268
Electrical			$ -	2012		0	$ -	$ 12,251,364	$ 12,618,905	$ 144,606,148	$ -	$ -	$ 144,606,148
Chemicals			$ -	2012		0	$ -	$ 4,972,000	$ 5,121,160	$ 58,685,858	$ -	$ -	$ 58,685,858
Labor			$ -	2012		0	$ -	$ 3,500,000	$ 3,605,000	$ 41,311,442	$ -	$ -	$ 41,311,442
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
Totals			$ 275,969,377				$ 254,323,069		$ 21,345,065	$ 244,603,448	$ 14,810,696	$ 169,722,946	**$ 668,649,463**

Equivalent Annual Cost[5]	$ 54,224,297
Facility capacity - average day - 1,000,000 gallons	35.0
Annual water production - 1,000,000 gallons[6]	12,519.50
Equivalent annual cost per 1,000 gallons[7]	**$ 4.33**

[1]Investment inflated based on time from base year to midpoint of construction, discounted to base year from midpoint of construction
[2]Discounted inflated future O&M during entire period of analysis less discounted inflated O&M expenses avoided prior to startup
[3]Straight line depreciation in base year dollars over use life of project
[4]Discounted inflated future R&R during entire period of analysis less discounted inflated R&R expenses avoided where project starts after base year
[5]Annual amount needed to finance total present value of project
[6]Calculated as average day capacity multiplied by 365 days per year multiplied by average annual availability factor - the percentage of time the facility is expected to operate.
[7]Includes renewal and replacement costs
[8]WC = Water Conveyance; OS = Other Structures; W = Wells; PAE = Process and Auxiliary Equipment; M = RO Membranes; NS = Non-structural Services

Note: Total capital cost for process piping & equipment is estimated to be $146,995,250. Of this amount, RO elements and membranes, with an estimated cost of $16,609,528, must be replaced every five years. Process piping & equipment has an estimated useful life of 20 years, while RO elements and membranes have an estimated useful life of 5 years. Therefore, the estimated cost of the RO elements and membranes was subtracted from the total cost for process piping and equipment and entered as a separate capital cost.

5.4 Proposed Lauderdale RO Facility

This section provides background information on the design criteria used to develop the Lauderdale SWRO facility planning level capital and life cycle costs.

5.4.1 Process Description

The proposed Seawater Desalination project at the FPL Lauderdale coastal power generation station consists of the construction and operation of a 20 million gallon per day (mgd) seawater desalination facility. The proposed facility would be located adjacent to the FPL Lauderdale power plant, located southwest of Fort Lauderdale. The proposed facility would convert a fraction of the power plant's condenser cooling seawater discharge into fresh drinking water using a reverse osmosis desalination process. Source water for this facility would be taken from the existing condenser cooling-seawater discharge pipeline system and is assumed to have an average total dissolved solids (TDS) level of 15,000 mg/L. The desalination facility would intake approximately 31.85 mgd of the power plant's cooling water discharge and produce 20 mgd of high-quality potable drinking water for use by residents and businesses in the Broward County area. Approximately 9.53 mgd becomes concentrated seawater, which would re-enter the power plant condenser cooling water discharge system downstream of the desalination facility's intake point and blend with the condenser cooling circulation system flow for dilution prior to discharge back to the ocean.

The proposed seawater reverse osmosis (SWRO) plant consists of the following major processes:

- Seawater screening and pumping
- Rapid mixing for the introduction of coagulant and disinfectant
- High-rate dissolved air flotation for suspended solids removal
- Filtration for suspended solids and pathogen removal
- Two-pass reverse osmosis for dissolved solids removal
- Remineralization of hardness and alkalinity for corrosion control
- Clearwell storage for finished water equalization and disinfection
- Filter backwash water equalization and high rate clarification and thickening
- Recycle of clarified filter backwash water to the head of the plant

A process flow diagram depicting the proposed treatment process is illustrated by Figure 5.3.

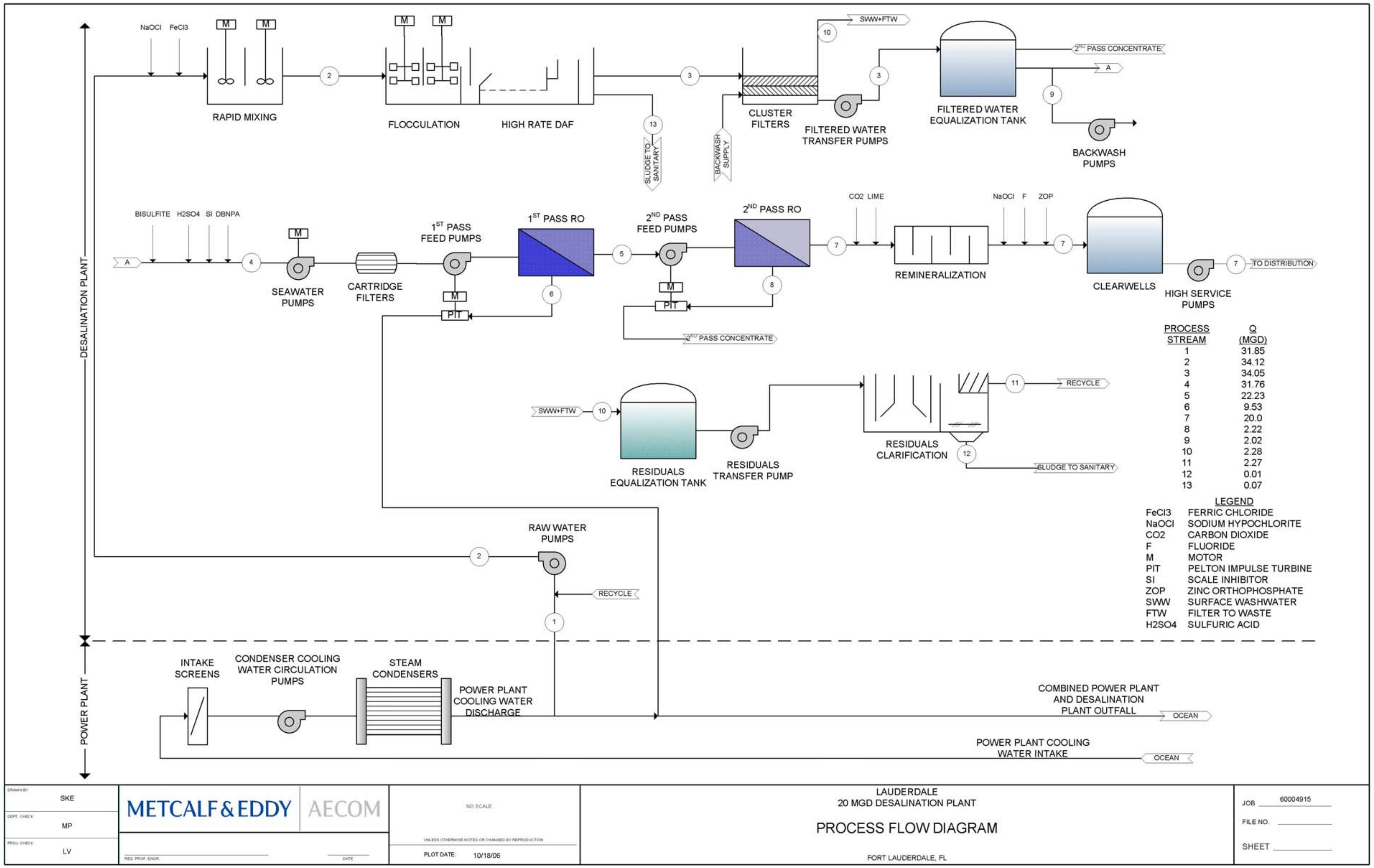


Figure 5-3 - Lauderdale SWRO Facility Process Flow Diagram

5.4.2 Water and Solids Mass Balance

An estimation of water flow and quality at each point in the water treatment process is essential for properly sizing each unit process and for estimating initial capital and long-term operating costs. This section summarizes the water flow rates, solids production rates, and solids removal rates for each unit process at the Lauderdale SWRO facility.

Water Mass Balance

A water flow model was developed for estimating process flows assuming a finished water flow of 20 mgd. The process flow rates are summarized below by Table 5.23.

Table 5.23 – Process Flow Rates

Stream	Description	Q (mgd)
RW	Raw Water	31.85
CF	Clarifier Feed	34.12
CW	Clarified Water	34.05
CS	Clarifier Sludge	0.07
TS	Thickened Sludge	0.0037
FIL	Filtered Water	31.77
ROP	Permeate	20.00
ROC	RO Concentrate	9.53
SWW	Spent Washwater	2.28
REC	Recycle	2.27

Solids Production and Balance

Since the pretreatment options for each plant are the same and are based on the same values of raw water turbidity and coagulant dose, the solids generation for each plant site is similar. The volume of solids produced at each site will differ because the capacities of each plant differ. To assess the volume and magnitude of residuals production for the Lauderdale SWRO facility, a solids balance model was developed.

The solids production and balance is summarized below by Tables 5.24 and 5.25. The solids balance was based on a finished water production of 20 mgd, a raw water turbidity of 20 NTU, a ferric chloride coagulant dose of 25 mg/L (as ferric chloride), and a source water total organic carbon (TOC) of 6 mg/L. Assumed worst case values for turbidity, coagulant dose, and TOC levels were used because of limited available water quality data.

Table 5.24 Solids Production

From Turbidity:		
Production Rate	Mg SS/NTU removed	1.5
Turbidity In	NTU	20.0
Turbidity Removal		98%
Turbidity Out	NTU	0.4
Solids Produced	Mg SS/L	29.4
From TOC Removal:		
TOC In	mg/L	6.0
TOC Removal		50%
Solids Produced	mg SS/L	3
From Ferric Coagulant		
Production Rate	mg/mg ferric Dose	0.66
Ferric Dosage	mg/L	25
Solids Produced	mg SS/L	16.5
Total Solids Produced	mg SS/L	48.9
	Raw water flow (mgd)	31.85
	Lbs/day	12,989

Table 5.25 Solids Balance

AquaDAF		
	AquaDAF feed (mgd)	34.12
	Unit solids capture (%)	95%
	Floated sludge load (lbs/day)	12,352
	Solids carryover to filtration (lbs/day)	650
	Floated sludge solids (%)	2.0
	Floated sludge production (mgd)	0.07

	Clarified Water Flow to Filtration (mgd)	34.05
Cluster Filters		
	Filter Feed (mgd)	34.05
	Solids capture (%)	97%
	Solids to filters (lbs / day)	650
	Solids retained by filters (lbs / day)	631
	Solids carryover to RO (lbs/day)	20
	No. of filters (N)	8
	No. of washes per day	8
	SWW & FTW per wash (gal)	284,763
	Total SWW & FTW to DensaDeg (mgd)	2.28
	Filtrate to RO (mgd)	31.77
DensaDeg		
	Unit solids capture (%)	98.00%
	Solids load to DensaDeg (lbs/day)[1]	631
	Solids flow to DensaDeg (mgd)	2.28
	Solids concentration (%)	0.0033
	Thickened sludge solids (%)	2.00
	Thickened sludge production (mgd)	0.0037
	Thickened sludge load (lbs/day)	618
	Recycle flow back to headworks (mgd)	2.27
	Solids in recycle stream (lbs/day)	13

5.4.3 Raw Water Screening and Pumping

Raw water will be withdrawn from the power plant's cooling water discharge channel. It is assumed that some form of cooling water pre-screening is provided at the existing power plant; however, the mesh size is unknown at this time. Therefore additional raw water screening is assumed to be required. Screening will be provided to remove suspended solids that could clog piping or damage downstream process equipment. A total of three traveling, automatically cleaned screens will be provided for suspended solids removal followed by raw water pumping. Four vertical turbine pumps will be provided downstream of the screens to pump raw water to the rapid mix system. Note that recycle water from the residuals clarification process is blended with the raw water

between the intake screens and raw water pumps. The detailed design criteria for the raw water screening and pumping system are summarized in Table 5.26.

Table 5.26 Raw Water Screening and Pumping System Design Criteria

Parameter	Value
Raw Water Screening	
No. of screens (N)	3
Screen type	traveling
Approach velocity (fps)	0.5
Total screen area required, N-1 (sf)	99
Area per screen, N-1 (sf)	49
Flow per screen, N-1 (mgd)	15.93
Raw Water Pumping	
Raw water flow (mgd)	34.12
Pump type	Vertical turbine
No. of raw water pumps (N)	4
No. of duty pumps (N)	3
Pump capacity (mgd)	11
TDH (ft)	40
Estimated brake horsepower at design conditions (HP)	97.39

Rapid Mix

A two-stage rapid mix system will be provided to disperse pretreatment chemicals in the raw water ahead of clarification. Each stage of the rapid mix system will provide approximately 30 seconds of detention at a maximum flow rate of 34.12 mgd (17.06 mgd per train) for a total detention time of 60 seconds. Coagulated water will flow via gravity to the downstream two-stage flocculation system. The detailed design criteria for the rapid mix system are summarized in Table 5.27.

Table 5.27 – Rapid Mixing System Design Criteria

Parameter	Value
Rapid Mix Basin	
No. Basins	2
No. of stages per basin	2
Flow per rapid mix basin (mgd)	17.06
Stage L (ft)	9
Stage W (ft)	9
Stage SWD (ft)	9
Volume per stage (cf)	729
Total volume per basin (cf)	1,458
DT per rapid mix stage (s)	28
DT per rapid mix train (s)	55
Rapid Mixers	
No. of mixers (N)	4
G (secs-1)	800
RPM	155
Absolute viscosity, u	0.00003746
Estimated mixer power (BHP)	31.78

Flocculation

A two-stage mechanical flocculation system will be provided ahead of DAF clarification. A total of 12 flocculation trains will be provided, with 3 trains feeding into a single DAF basin. Each flocculation stage will be equipped with a vertical, mechanical flocculator. Flocculated water will flow via gravity to the downstream high-rate DAF system. The detailed design criteria for the flocculation system are presented by Table 5.28.

Table 5.28 – Rapid Mixing System Design Criteria

Parameter	**Value**
Flocculation Tanks	
No. of flocculation trains	12
No. of stages (basins) per train	2
Total no. of basins	24
Flow per flocculation train (mgd)	2.84
Basin L (ft)	14
Basin W (ft)	13.33
Basin SWD (ft)	13.3
Volume per basin (cf)	2,482
Volume per train (cf)	4,964
Total volume (cf)	59,569
HRT per train (min)	18.81
HRT per basin (min)	9.40
Velocity (fpm)	1.49
Flocculators	
Flocculator type	vertical, mechanical
No. of flocculators	24
G (secs-1)	75
RPM	155
Absolute viscosity, u	0.00003746
Mixer power (HP)	0.95

Dissolved Air Flotation (DAF) Clarification

High-rate DAF will be provided for suspended solids and algae removal. A total of 4 DAF trains will be provided, each with a design flow rate of 8.53 mgd. The preliminary design loading rate will be 7.4 gpm/sf, with both units online, and 9.9 gpm/sf, with one unit offline. Clarified water will flow via gravity to the downstream cluster filtration system. Floated sludge will be discharged to the sanitary sewer system. The detailed design criteria for the high-rate DAF system are presented by Table 5.29.

Table 5.29 – AquaDAF™ Clarification System Design Criteria

Parameter	**Value**
DAF Summary	
Basin W (ft)	40
Basin L (ft)	62.3
SWD (ft)	13.3
Flotation area per basin (sf)	800
Total flotation area (sf)	3,200
DAF loading rate at peak flow, N in service (gpm/sf)	7.4
DAF loading rate at peak flow, N-1 in service (gpm/sf)	9.9
Volume per basin (cf)	10,640
Total volume (cf)	42,560
HRT per basin (min)	13.44
Velocity (fpm)	1.49
SLR (gpd/sf)	10,662
Sludge removal mechanism	mechanical
Production Summary	
Estimated clarification sludge flow (mgd)	0.07
Estimated solids concentration (%)	2
Estimated sludge production (ppd)	12,352
Clarified water flow (mgd)	34.05

Cluster Filtration

Following high-rate DAF, clarified water will flow via gravity to the cluster filtration system. Settled water will be conveyed to the filters through a common flume that will distribute water to each train. Slide gates will be installed to isolate each train. Two filter trains are proposed, each with a design capacity of 17 mgd. Each filter cluster consists of 4 filter cells, resulting in a total of 8 filter cells. The detailed design criteria for the cluster filtration system are summarized by Table 5.30.

Table 5.30 – Cluster Filter System Design Criteria

Parameter	Value
Filter Design Criteria	
Design flow (mgd)	34.0
No. of trains (N)	2
No. of filter cells per train (N)	4
Total no. of filters (N)	8
Design flow per filter train (mgd)	17.0
Design flow per filter (mgd)	4.3
Filter HLR with all cells in service (gpm/sf)	3.51
Filter HLR with one cell out of service (gpm/sf)	4.02
Filter HLR with one train out of service (gpm/sf)	7.03
Cell width (ft)	29
Cell length (ft)	29
Filter cell area (sf)	841
Total filtration area (sf)	6,728
Maximum HLR (gpm/sf)	4
Capacity at maximum HLR (mgd)	38.75
Media Configuration	
Anthracite	20", ES = 1.0 mm, UC = 1.7
Sand	7", ES = 0.45 mm, UC = 1.5
Ilmenite	3", ES = 0.26 mm, UC = 1.3
Coarse garnet	4", ES = 1.0 mm, UC = 1.7
Underdrain	Monoflor HD false bottom with polypropylene nozzles
Residuals	
Supplemental backwash pump type	horizontal split case
Number (N + 1)	2
Backwash rate (gpm/sf)	20
Backwash flow (gpm)	16,820
Backwash air scour blower type	PD
Number of blowers (N+1)	2
Air scour rate (scfm/sf)	3

Parameter	**Value**
Air flow (scfm)	2,523
Backwash duration (min)	15
Backwash volume per cell per event (gal)	252,300
Filter to waste HLR (gpm/sf)	4.02
Filter to waste flow (gpm)	3,378
Filter to waste duration (min)	10
Filter to waste volume per cell per event (gal)	33,776
SWW + FTW per cell per event (gal)	286,076
Filter run time (hr)	24
No. of filter washes per day (N)	8
Filter wash frequency (hr)	3.0
Total residuals volume (mgd)	2.29

Residuals from the filters will be collected, equalized, and clarified using the DensaDeg clarifier-thickener for recycle to the head of the plant. Details of the residuals treatment system are provided later in this report.

Filtered Water Equalization and Transfer Pumping

Because of high-groundwater tables that are common to south Florida, below-grade storage and equalization of filtered water is not possible. Filtered water equalization will be provided in above-ground, prestressed wire-wound concrete tanks. Filtered water transfer pumps will be provided to transfer water from the filters to the equalization tanks. The RO process downstream of the filtration process operates most efficiently at constant flow set points. Because variations in filtered water flows are possible, an intermediate equalization tank will provide storage to make up the difference in upstream and downstream flows, dampening the difference and allowing less frequent changes to unit process flows. Following the upstream pretreatment and prior to RO treatment, filtered water will be stored in an intermediate equalization tank. The tank will serve two main functions: (1) to serve as a suction well for the low pressure first pass RO pumps, (2) to provide the ability to dampen the effects of flow variations between the upstream pretreatment process and the downstream RO process. The design criteria for the filtered water equalization tank and transfer pumping system are summarized by Table 5.31.

Table 5.31 – Filtered Water Equalization Design Criteria

Parameter	Value
Filtered Water Suction Well	
Design influent flow (mgd)	34.05
Design influent flow (cfm)	3,160.61
L (ft)	50
SWD (ft)	20
H (ft)	10
Volume (cf)	10,000
HRT (min)	3.16
Filtered Water Transfer Pumps	
Pump type	Vertical turbine
No. of pumps (N)	4
Discharge (mgd)	8.51
Head (ft)	20
Driver	Constant speed
Estimated brake horsepower at design conditions (HP)	36
Filtered Water Equalization	
Design influent flow (mgd)	34.05
Design influent flow (cfm)	3,160.61
No. of storage tanks (N)	2
Diameter (ft)	80
SWD (ft)	20
Volume of each (cf)	100,480
Volume of each (gal)	751,590
Influent flow to each tank (mgd)	17
HRT, both tanks in service (min)	64
HRT, one tank in service (min)	32

5.4.4 Reverse Osmosis

A two-pass RO system operating at a total recovery of 70% is proposed for dissolved solids removal. Details of each pass are provided in this section.

First Pass RO System

Filtered water flows via gravity to the low pressure first-pass feed pumps. These pumps lift water from the filtered water equalization tank and pump it through the cartridge filters. Pretreatment chemicals including bisulfite for oxidant removal, scale inhibitor, and sulfuric acid will be introduced upstream of the cartridge filters. The ability to feed a non-oxidizing biocide such as DBNPA will be provided for periodic application to control biological growth in the RO system. The first-pass high pressure pumps, located downstream of the cartridge filters pump pretreated water to the first pass arrays.

A total of 8 first-pass RO arrays will be provided, each with a permeate capacity of 2.77 mgd. The first-pass system will operate at a recovery rate of 70% in a two stage system, a flux of 8 gfd, and will utilize low energy seawater elements. Each array will be equipped with inter-stage boost pumps to increase the second-stage feed pressure and equalize flux rates between the stages.

Each of the first-pass high pressure feed pumps will be equipped with an energy recovery device to reduce the overall energy consumption of the RO system. For purposes of this report, it is assumed that each high pressure pump will be equipped with a Pelton Impulse Turbine (PIT). Concentrate from the first-pass arrays will be directed through the PITs and will be discharged via gravity to the power plant condenser cooling water discharge system, downstream of the desalination facility's intake point. Permeate from the first-pass RO system will be collected via a common header and will be directed to the second-pass RO system.

The detailed design criteria for the first-pass RO system are summarized by Table 5.32.

Table 5.32 – First-Pass RO System Design Criteria

Parameter	**Value**
RO influent water flow (mgd)	31.76
Cartridge Filtration	
Cartridge filter type	Vertical
No. of cartridge filter housings(N)	10
Cartridge Filter Capacity (mgd)	3.5
Total Capacity (mgd)	35
Capacity, N-1 (mgd)	31.5
Cartridge Filter Loading Rate	3.5 gpm per 10-inch

Parameter	**Value**
	length
Element length (in)	40
Cartridge Filter Element Type	Blown Polypropylene
Cartridge filter element rating (microns)	5
Seawater pump	
Pump type	vertical turbine
No. of pumps (N)	5
Discharge (gpm)	4,411
Head (ft)	95
Driver	Constant speed
Estimated brake horsepower at design conditions (HP)	129
Array design	
No. of arrays	8
Recovery rate	70%
Flux (gfd)	8.1
Fouling factor	0.85
Feed flow per array (mgd)	3.97
1st stage permeate flow per array (mgd)	1.93
Inter-stage flow per array (mgd)	2.04
Second stage permeate flow per array (mgd)	0.84
Second stage concentrate flow per array (mgd)	1.19
Total permeate flow per array (mgd)	2.77
Feed temperature (degrees F)	89 - 98
No. of stages per array (N)	2
No. of pressure vessels in first stage (N)	100
No. of elements per vessel (N)	6
No. of pressure vessels in second stage (N)	45
No. of elements per vessel (N)	6
No. of elements per array (N)	870
Element basis of design	FilmTec SW30XLE-400i
Active area per element (sf)	400

Parameter	**Value**
Active area per array (sf)	348,000
First-stage feed pressure (psi)	365
First-stage concentrate pressure (psi)	350
Inter-stage boost pressure (psi)	230
Second-stage feed pressure (psi)	575
Second-stage concentrate pressure (psi)	560
1st Pass Feed Pump Design	
Pump type	Horizontal centrifugal
No. of pumps (N)	8
Discharge (mgd)	3.97
Head (ft)	843
Driver	VFD
Pump shaft power required (kW)	485
Pump shaft power required (HP)	650
Pump efficiency (%)	85%
Pelton shaft power (kW)	188
Motor shaft power (kW)	297
Motor shaft power (HP)	398
Motor efficiency (%)	97%
Motor Electrical Power (kW)	306
1st Pass Inter-stage Pump Design	
Pump type	Vertical multistage centrifugal
No. of pumps (N)	8
Discharge (mgd)	2.04
Head (ft)	531
Driver	VFD
Estimated brake horsepower at design conditions (HP)	224
Energy Recovery	
Energy recovery device type	Pelton turbine
No. of devices (N)	8
Inlet pressure (psi)	560
Outlet pressure (psi)	0
Efficiency	90%

Parameter	**Value**
Pelton shaft power (kW)	188
Pelton shaft power (HP)	252
Production Summary	
Total feed flow (mgd)	31.76
Total permeate flow (mgd)	22.23
Total concentrate flow (mgd)	9.53
Permeate TDS (mg/L)	376
Concentrate TDS (mg/L)	49,100

Second-Pass RO System

A second pass RO system is proposed to further reduce dissolved solids not removed by the first pass system. Permeate from the first-pass system will be collected in a common header and will be directed to the second-pass system.

The second pass system consists of 8 arrays, each with a permeate capacity of 2.5 mgd. The second-pass system will operate at a recovery rate of 90% in a two-stage system, a flux of 15 gfd, and will utilize low energy brackish water elements. Each array will be equipped with inter-stage boost pumps to increase the second-stage feed pressure and equalize flux rates between the stages.

Each of the second-pass high pressure feed pumps will be equipped with an energy recovery device to reduce the overall energy consumption of the RO system. For purposes of this report, it is assumed that each high pressure pump will be equipped with a Pelton Impulse Turbine (PIT). Concentrate from the second-pass arrays will be directed through the PITs and will be discharged via gravity to the filtered water equalization tank. The second pass concentrate will be of high quality and will have a lower TDS than that of the first-pass feed. Blending the second-pass concentrate with the first pass feed will increase first pass feed quality and will reduce overall plant operating costs. The permeate from the second-pass system will be collected in a common header and will flow via gravity to the downstream remineralization system.

The detailed design criteria for the second-pass RO system are summarized by Table 5.33.

Table 5.33 – Second-Pass RO System Design Criteria

Parameter	**Value**
Second-pass influent water flow (mgd)	22.23
Second-Pass Feed Pump Design	
Pump type	vertical turbine
No. of pumps (N)	8
Discharge (gpm)	1,930
Head (ft)	162
Driver	VFD
Estimated brake horsepower at design conditions (HP)	96
Array design	
No. of arrays	8
Recovery rate	90%
Flux (gfd)	15
Fouling factor	0.85
Feed flow per array (mgd)	2.78
First-stage permeate flow per array (mgd)	1.70
Inter-stage flow per array (mgd)	1.08
Second-stage permeate flow per array (mgd)	0.80
Second-stage concentrate flow per array (mgd)	0.28
Total permeate flow per array (mgd)	2.50
Feed temperature (degrees F)	89 – 98
No. of stages per array (N)	2
No. of pressure vessels in first stage (N)	37
No. of elements per vessel (N)	7
No. of pressure vessels in second stage (N)	17
No. of elements per vessel (N)	7
No. of elements per array (N)	378
Element basis of design	FilmTec XLE-440
Active area per element (sf)	440
Active area per array (sf)	166,320
First-stage feed pressure (psi)	70

Parameter	Value
First-stage concentrate pressure (psi)	45
Inter-stage boost pressure (psi)	35
Second-stage feed pressure (psi)	75
Second-stage concentrate pressure (psi)	62
2nd Pass Inter-stage Pump Design	
Pump type	Vertical multistage centrifugal
No. of pumps (N)	8
Discharge (mgd)	1.08
Head (ft)	81
Driver	VFD
Estimated brake horsepower at design conditions (HP)	18
Energy Recovery	
Energy recovery device type	Pelton turbine
No. of devices (N)	8
Inlet pressure (psi)	61
Outlet pressure (psi)	0
Efficiency	90%
Pelton shaft power (kW)	5
Pelton shaft power (HP)	6
Production Summary	
Total feed flow (mgd)	22.23
Total permeate flow (mgd)	20.01
Total concentrate flow (mgd)	2.22
Permeate TDS (mg/L)	40
Concentrate TDS (mg/L)	2,500

Remineralization

Because RO removes such a high degree of dissolved substances such as hardness and alkalinity, the permeate must be remineralized to prevent corrosion in the receiving distribution system piping and to produce a finished water that is aesthetically acceptable to the customers. In final design, actual distribution system water quality conditions would be matched as closely as possible. The specific distribution system water quality is unknown at this time; therefore, general assumptions for remineralization have been used.

After RO treatment, the permeate stream is projected to have an acidic pH of approximately 4.96. In addition, the RO process removes virtually all alkalinity. The only portion of the carbonate system that passes through the membrane is carbon dioxide (CO_2). To achieve hardness and alkalinity recovery, RO permeate will be remineralized with lime and carbon dioxide. To model the impact of post-treatment remineralization, the Rothberg, Tamburini & Winsor, Inc. (RTW) water chemistry model was used. This model calculates the impact of chemical addition on water quality parameters.

Two forms of lime are typically available, pebble (quick) lime and hydrated lime. While hydrated lime does not require slaking prior to remineralization, it is typically more expensive than quick lime. Therefore, quick lime was selected for this application. To meet the alkalinity and hardness goals, approximately 45 mg/L of lime will be added based on the RTW modeling.

The 45 mg/L of lime will produce a finished water pH that is higher than the water quality goal. Therefore, liquefied carbon dioxide will be used to reduce the pH to the desired range. Carbon dioxide mixes with water to form carbonic acid, a fairly mild acid which acts to reduce pH. The RTW model estimates that approximately 20 mg/L will be required to obtain a pH of approximately 8. With the addition of lime and carbon dioxide at the proposed doses, the LSI is approximately 0, and the total hardness is approximately 60 mg/L.

Carbon dioxide is delivered in the liquid form and stored in an insulated (cryogenic) storage tank. The storage tank is complete with the equipment necessary to maintain the liquid carbon dioxide at approximately 0 degrees F, with non-freezing regulators and temperature gauges. A vaporizer changes the liquid carbon dioxide to a vapor. Carbon dioxide vapor for process use is withdrawn from the tank and passed through regulators, metering equipment and other accessories depending on the type of feed equipment used. The RO permeate will flow to a remineralization rapid mix, where it will be mixed with the CO_2 and lime. The flow will then enter a remineralization basin, which will be baffled to ensure a 8 minute detention time with no short-circuiting. Table 5.34 summarizes the design criteria for the permeate remineralization system.

Table 5.34 – Remineralization System Design Criteria

Parameter	Value
Remineralization Basin	
Flow to remineralization (mgd)	20.0
Type	Rectangular, serpentine channels
Channel length (ft)	30
Channel SWD (ft)	13
Channel W (ft)	10
No. of channels (N)	5
Total length (ft)	150
Volume (gal)	145,860
DT (min)	10.50
Baffle factor:	0.8
T/T10 (min)	8.40
Rapid Mixer	
No. of rapid mixers	1
Mixing area volume (cf)	1,300
G (secs-1)	800
RPM	155
Absolute viscosity, u	0.00003746
Mixer power (HP)	56.67
Lime Feed System	
Application stream	RO Permeate
Flow rate (mgd)	20.0
Dose as CaO (mg/L)	45
Daily consumption (lb)	7,506
30-day storage (lb)	225,180
Lime density (pcf)	55
30-day storage (cf)	4,094
Lime Storage	
Bulk storage type	silos
Silo diameter (ft)	14.00
Silo height (ft)	30.00
Silo volume (cf)	4,615.80

Parameter	**Value**
No. of silos (N)	1.0
Lime Feed	
Slaker type	slurry
No. of slakers (N)	1.00
Slaker capacity (pph)	312.75
Carbon Dioxide Feed	
Application stream	RO Permeate
Flow rate (mgd)	20.00
Dose (mg/L)	22
Daily consumption (lb)	3670
30-day storage (lb)	110,088
Bulk storage type	pressurized tanks
Tank capacity (lb)	240,000
No. of tanks (N)	1.0
Recirculation pump flow (1 gpm per pph of CO2)	153
Recirculation pump head (ft)	150

5.4.5 Disinfection and Finished Water Storage

Prior to the finished water pump station, contact time must be provided for disinfection with free chlorine (sodium hypochlorite) and on-site storage to allow the treatment plant to operate somewhat independently of the finished water pump station instantaneous flow.

The LT2ESWTR requires a 3-log removal / inactivation of *Giardia*, a 4-log removal / inactivation of viruses, and a 2-log removal / inactivation of *Crypto* for surface water treatment facilities. It is assumed that the proposed raw water source will be placed in Bin 1, which will not require additional treatment *Crypto* removal or inactivation. The removal / inactivation requirements are summarized by Table 5.35.

Table 5.35 – Disinfection Requirements

Pathogen	**Required Removal / Inactivation (log)**
Crypto	2.0
Giardia	3.0
Viruses	4.0

The clarification and filtration process will be granted a 2.5-log removal credit for *Giardia*; 2.0-log removal credit for virus; and 2.0-log removal credit for *Crypto*. Therefore the disinfection process must provide an additional 0.5-log removal/inactivation of *Giardia*, and an additional 2.0-log removal/inactivation of viruses. When free chlorine is used for disinfection, the inactivation of *Giardia* controls disinfection requirements because *Giardia* is much more difficult to inactivate than viruses with free chlorine. The additional disinfection contact time (T10) requirements have been calculated assuming free chlorine residuals of 1.0 and 2.5 mg/L and based on USEPA CT Tables contained in the Guidance Manual for Compliance with the Surface Water Treatment Rule. This is based on a well-baffled storage tank using dual concentric baffles to obtain a T10/T ratio of at least 0.75, a 25 percent additional capacity for tank level variability with pumping, a pH range of 6-9, and a finished water temperature greater than 25 degrees C.

Circular wire-wound pre-stressed tanks with dual concentric-C baffles were selected for the analysis for finished water storage. The design criteria for these tanks are summarized by Table 5.36. Note that the CT values represent that which is required for 0.5-log *Giardia* inactivation.

Table 5.36 – Finished Water Storage Design Criteria

Parameter	**Value**
Remineralized permeate flow (mgd)	20.0
Remineralized permeate flow (gpm)	13,894
Number of clearwells (N)	2
Mode of operation	parallel
Flow per clearwell (mgd)	10.00
Flow per clearwell (gpm)	6,947

Parameter	Value
SWD (ft)	20
Diameter (ft)	95
Actual volume (gal)	1,059,860
CT volume factor (dual concentric C baffles)	0.75
CT volume (gal)	794,895
Efficiency factor	0.75
T10 effective volume (gal)	596,171
Actual detention time per clearwell (min)	153
T10 clearwell (min)	86
CT req'd @ C = 1.0 mg/L, 25^{o}C, pH = 9	13
CT achieved @ C = 1.0 mg/L, 25^{o}C, pH = 9	86
CT req'd @ C = 2.5 mg/L, 25^{o}C, pH = 9	15.5
CT achieved @ C = 2.5 mg/L, 25^{o}C, pH = 9	215

Under the above disinfection design conditions, the required CT levels are exceeded at either free chlorine residual.

5.4.6 High Service Pumping

A new high service pumping station will be required. Finished water will flow by gravity to the high service pump suction well, located in the high service pump station. Horizontal split case pumps were selected because of their higher efficiency compared to other types of pumps. The design criteria for the high service pumping system are summarized by Table 5.37.

Table 5.37 – High Service Pumping Design Criteria

Parameter	Value
Finished water flow (mgd)	20.01
Pump type	HSC
No. of high service pumps (N)	5
No. of duty pumps (N-1)	4
Pump capacity at N (mgd)	4.0
Pump capacity at N-1 (mgd)	5.0
TDH (ft)	231
Estimated power (BHP)	200

5.4.7 Residuals Handling and Disposal

The water treatment process will produce a number of waste or residual streams. The streams include:

- Clarification sludge
- Spent washwater (SWW)
- Filter-to-waste (FTW)
- RO concentrate
- Tank drains
- Sanitary sewage

Residuals handling will consist of an equalization tank for SWW and FTW and DensaDeg high-rate clarification. AquaDAF™ sludge, tank drains, and sanitary sewage will be discharged to the sanitary sewer. RO concentrate from the first pass will be discharged to the power plant condenser cooling water discharge system downstream of the desalination facility's intake point and blend with the condenser cooling circulation system flow for dilution prior to discharge back to the ocean.

FTW from the cluster filtration system will be pumped to the residuals EQ tank. SWW from the cluster filtration system will flow via gravity to the residuals EQ tank. Effluent from this tank will be pumped to the DensaDeg clarifier. Supernatant from the DensaDeg clarifier will be recycled to the head of the plant and mixed with raw water prior to rapid mixing. This stream will flow via gravity. Sludge from the DensaDeg clarifier will flow via gravity to the sanitary sewer. The design criteria for the residuals processing system are summarized by Table 5.38.

Table 5.38 – Residuals Processing Design Criteria

Parameter	**Value**
SWW + FTW (mgd)	2.28
Total residuals (mgd)	2.28
Residuals EQ tank influent pumps	
Pump type	vertical turbine
No. of pumps (N)	2
No. of duty pumps (N-1)	1
Pump capacity (mgd)	1,582
TDH (ft)	30
Residuals EQ tank effluent pumps	
Pump type	vertical turbine
No. of pumps (N)	2
No. of duty pumps (N-1)	1
Pump capacity (mgd)	1,582
TDH (ft)	30
Residuals EQ Tank Data	
SWD (ft)	18
Diameter (ft)	79
Volume per eq tank (gal)	659,626
No. of tanks (N)	1
Total volume (gal)	659,626
Equalization time (min)	417
No. of cells per tank (N)	2
Volume per cell (gal)	329,813
No. of mixers per cell (N)	2
Mixer power (HP)	20
DensaDeg Clarifier Design Criteria	
DensaDeg clarifier influent flow (mgd)	2.28
Number of clarifiers	1
Clarifier capacity (mgd)	3.00
Design flow to clarifier (mgd)	2.28
Loading rate at max capacity (gpm/sf)	7.36
Unit solids capture (%)	98%
Solids load to DensaDeg (lbs/day)	631

Parameter	Value
Solids flow to DensaDeg (mgd)	2.28
Solids concentration (%)	0.0033
Thickened sludge solids (%)	2.00
Thickened sludge production (mgd)	0.00
Thickened sludge load (lbs/day)	618.00
Recycle flow back to headworks (mgd)	2.27
Solids in recycle stream (lbs/day)	13

5.4.8 Chemical Feed

Facilities for receiving, storing, and feeding various chemicals have been included in the analysis to develop conceptual level capital and operating costs. The following chemicals were included:

- Ferric chloride for coagulation
- Scale inhibitor to prevent scale formation in the RO system
- Bisulfite for oxidant removal ahead of the RO system
- Sulfuric acid for scale control in the RO system
- 2,2-Dibromo-3-Nitrilopropionamide (DBNPA) to reduce biological activity in the RO system
- Carbon dioxide and quick lime for permeate remineralization
- Fluoride for dental health
- Phosphate for corrosion protection
- Sodium hypochlorite for disinfection

Table 5.39 summarizes the average dose and consumption for each chemical included in this alternative.

Table 5.39 – Chemical Doses and Consumption

Chemical	Average Dose (mg/L)	Flow (mgd)	lbs/day (required)	lbs/day (from manufacturer)	Gallons per day	30-day storage (lbs)	30-day storage (gallons)
Pretreatment							
Prechlorination	3	34.1	854	---	1,023	---	30,692
Ferric Chloride	25	34.1	7,114	---	1,461	---	43,818
RO Pretreatment							
Sulfuric Acid	25	31.8	6,624	---	464	---	13,923
Scale Inhibitor	4	31.8	1,060	---	116	---	3,466
Bisulfite	3	31.8	795	---	190	---	5,700
DBNPA	0	0.0	0	---	0	---	
Remineralization							
Lime	45	20.0	7,506	7,506	---	225,180	---
Carbon Dioxide	22	20.0	3,670	3,670	---	110,088	---
Post-treatment							
Postchlorination	2	20.0	334	---	400	---	11,994
Fluoride	1	20.0	167	---	89	---	2,669
Phosphate	1	20.0	167	---	48	---	1,429

5.4.9 Buildings and Structures

For the purposes of this feasibility study it is assumed that all process equipment and tankage associated with each process will be housed indoors. The following major structures were included in this analysis:

- Raw water building for housing the raw water pumps and screens;
- Pretreatment building for housing the rapid mix, flocculation, DAF, filtration, filtered water transfer pumps, and pretreatment chemical systems;
- Reverse osmosis building for housing the seawater pumps, cartridge filters, first-pass feed pumps, first-pass RO arrays, second-pass feed pumps, second-pass RO arrays, CIP systems, chemical feed systems associated with the RO process; and

- Post-treatment building for housing the lime feed system, carbon dioxide feed equipment, high service pumping system, post-treatment chemical feed systems, and administrative area.

Each building will also house mechanical rooms, electrical equipment rooms, restrooms, control rooms, tool and workshop areas, and storage areas. A summary of area requirements for each proposed structure is presented in Table 5.40, below.

Table 5.40 – Area Requirements for Major Buildings

Facility	Length (ft)	Width (ft)	Footprint (SF)
Raw Water Building	60	80	4,800
Pretreatment Building	188	182	34,216
RO Building	362	149	53,938
Post-treatment Building	Various	various	16,000

Chemical storage for coagulant and the prechlorination chemicals will be located within the Pretreatment Building. Chemical storage and feeding facilities for lime, carbon dioxide, fluoride, phosphate, and postchlorination will be located in the post-treatment building. Chemical storage and feeding facilities for sulfuric acid, scale inhibitor, bisulfite, and DBNPA will be located in the RO building. A conceptual site plan illustrating the location of the major facilities is presented in Figure 5.4.

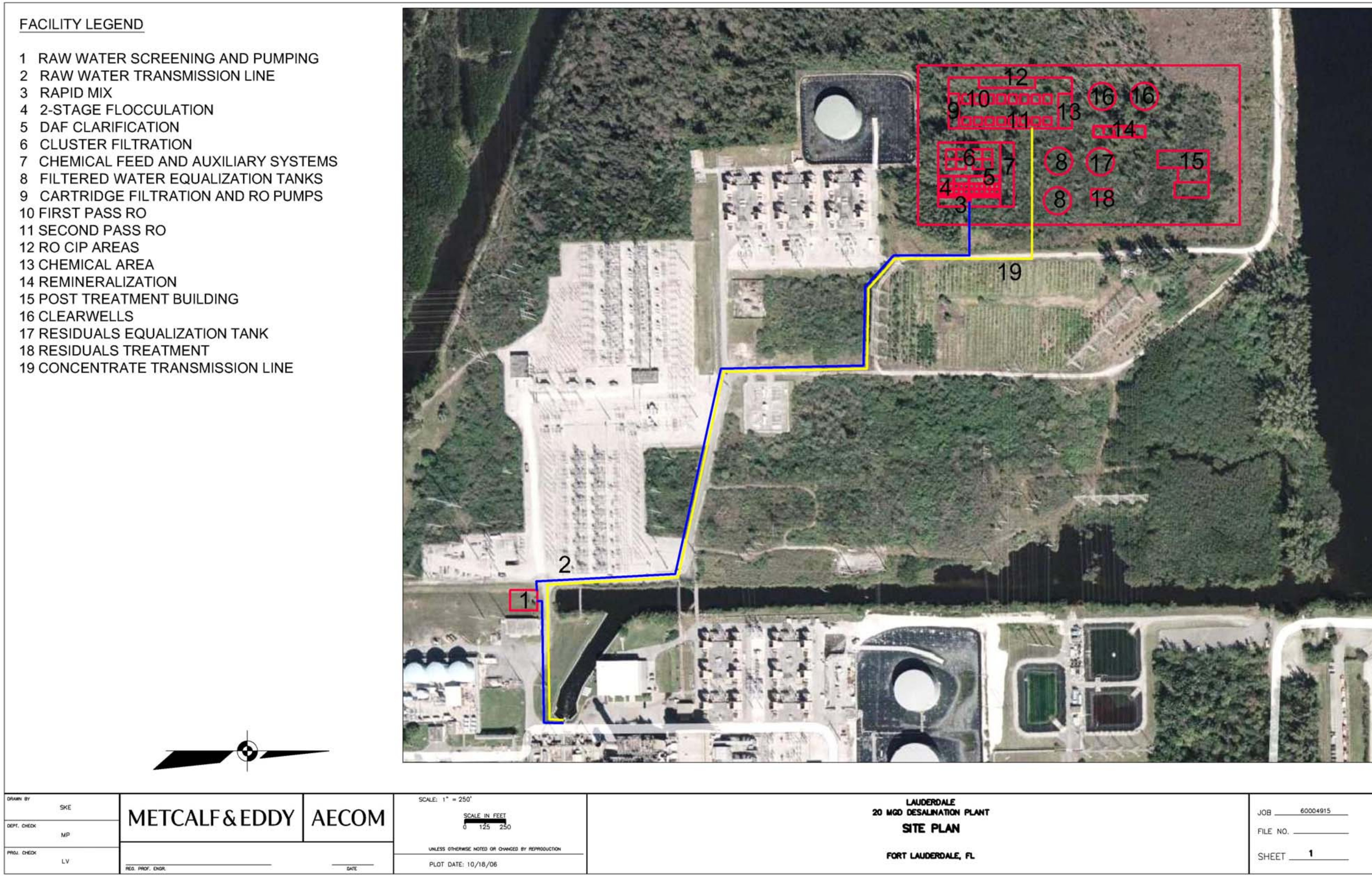


Figure 5-4 - Proposed Lauderdale SWRO Facility Site Plan

5.4.10 Estimate of Capital Costs

This section presents estimated capital costs for the Lauderdale SWRO facility. Capital costs were developed by sizing individual components within each option and estimating the quantities for the major items comprising the option. Unit prices were developed from equipment manufacturers and from recent historical data from other projects. When appropriate, additional costs were added for equipment, electrical, and instrumentation. In some instances, allowances were made for minor components and support facilities. After the construction costs are estimated and totaled, a 25% contingency was added for items that are currently unidentifiable. The final construction cost estimate also includes a 17% contractor's overhead and profit which includes the contractor's overhead expenses, mobilization, demobilization, bonding, and insurance. And finally, the project estimate includes 10% for engineering. Note that the capital costs are based on a finished water production rate of 10 mgd. A detailed cost estimate for this alternative is presented in Table 5.41 below. The costs presented herein should be considered Budget Level as defined by the American Association of Cost Engineers, with an accuracy of +30 percent to -15 percent. All costs are presented in October 2006 dollars.

Table 5.41 – Estimated Capital Costs

Conceptual Design Preliminary Capital Cost Estimate SFWMD Lauderdale SWRO							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
Sitework							
1.01	Demolition	1	LS	$20,000	$0	$0	$20,000
1.02	Clearing	1	LS	$10,000	$0	$0	$10,000
1.03	Exterior piping (includes storm and sanitary sewers, footer drains, pavement drains)	1	LS	$1,000,000	$0	$0	$1,000,000
1.04	Sitework (includes final grading, seeding, mulching, paving, fencing, sidewalks, curbs and gutters, landscaping, etc.)	1	LS	$1,250,000	$0	$0	$1,250,000
1.05	Temporary sheeting for raw water pump station	200	LF	$576	$0	$0	$115,250
1.06	Excavation for raw water pump station	963	CY	$15	$0	$0	$14,444
1.07	Excavation for pretreatment building	5985	CY	$15	$0	$0	$89,772
1.08	Excavation for filtered water EQ tank	1366	CY	$15	$0	$0	$20,492
1.09	Excavation for RO building	9241	CY	$15	$0	$0	$138,608
1.10	Excavation for remineralization basin	1131	CY	$15	$0	$0	$16,970
1.11	Excavation for lime feed building	646	CY	$15	$0	$0	$9,692
1.12	Excavation for CO2 equipment pad	1025	CY	$15	$0	$0	$15,381
1.13	Excavation for clearwells	2504	CY	$15	$0	$0	$37,556
1.14	Excavation for high service pump building	1031	CY	$15	$0	$0	$15,463
1.15	Excavation for administration building	939	CY	$15	$0	$0	$14,091
1.16	Excavation for post-treatment chemical feed building	963	CY	$15	$0	$0	$14,444
1.17	Excavation for residuals EQ	1366	CY	$15	$0	$0	$20,492
1.18	Excavation for DensaDeg	519	CY	$15	$0	$0	$7,779
						Subtotal	$2,810,433
Buildings & Structures							
2.01	Raw water pump and screening station concrete	1000	CY	500	$0	$0	$500,000
2.02	Raw water pump and screening station superstructure	4800	SF	$64	$0	$0	$307,200
2.03	Rapid mix basins concrete	147	CY	$500	$0	$0	$73,418
2.04	Flocculation basins & AquaDAF concrete	1500	CY	$500	$0	$0	$750,000

Conceptual Design Preliminary Capital Cost Estimate SFWMD Lauderdale SWRO							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
2.05	Cluster filters concrete	1600	CY	$500	$0	$0	$800,000
2.06	Pretreatment building concrete	1000	CY	$500	$0	$0	$500,000
2.07	Pretreatment building superstructure	34216	SF	$64	$0	$0	$2,189,824
2.08	Filtered water equalization tanks	2	Ea	$570,000	$0	$0	$1,140,000
2.09	RO building concrete	6000	CY	$500	$0	$0	$3,000,000
2.10	RO building superstructure	53938	SF	$64	$0	$0	$3,452,032
2.11	Remineralization basin concrete	656	CY	$500	$0	$0	$327,962
2.12	Lime feed building concrete	314	CY	$500	$0	$0	$156,980
2.13	Lime feed building	2500	SF	$64	$0	$0	$160,000
2.14	Carbon dioxide equipment pad concrete	445	CY	$500	$0	$0	$222,667
2.15	Clearwells	2	Ea	$687,500	$0	$0	$1,375,000
2.16	High service pump station concrete	700	CY	$500	$0	$0	$350,000
2.17	High service pump station	4500	SF	$64	$0	$0	$288,000
2.18	Administration building	4000	SF	$125	$0	$0	$500,000
2.19	Post-treatment chemical feed building superstructure	4000	SF	$64	$0	$0	$256,000
2.20	Post-treatment chemical feed building concrete	150	CY	$500	$0	$0	$75,000
2.21	Residuals equalization basin	1	Ea	$705,000	$0	$0	$705,000
2.22	DensaDeg concrete	300	CY	$500	$0	$0	$150,000
2.23	Miscellaneous concrete for equipment pads, pipe supports, fill, containment curbs, etc.	1000	CY	$500	$0	$0	$500,000
						Subtotal	**$17,779,083**
Process Piping & Equipment							
3.01	Raw water screening equipment	3	Ea	$200,000	$60,000	$90,000	$750,000
3.02	Raw water pumps	4	Ea	$75,000	$30,000	$45,000	$375,000
3.03	Coagulation basin mixers	4	Ea	$35,000	$14,000	$21,000	$175,000
3.04	Flocculation and AquaDAF equipment	1	LS	$2,940,000	$294,000	$441,000	$3,675,000
3.05	Cluster filtration system	6728	SF	$560.00	$376,768	$565,152	$4,709,600
3.06	Filtered water transfer pumps	4	Ea	$75,000.00	$30,000	$45,000	$375,000

Conceptual Design Preliminary Capital Cost Estimate SFWMD Lauderdale SWRO							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
3.07	2-pass reverse osmosis treatment system (includes seawater pumps, cartridge filters, first pass high pressure pumps, 2nd pass feed pumps, interstage pumps, arrays, CIP system, interconnecting piping, energy recovery devices, I&C)	20000000	gal	$2.50	$5,000,000	$0	$55,000,000
3.08	Residuals, e.q., tank mixers and cranes	4	Ea	$45,000	$18,000	$27,000	$225,000
3.09	Remineralization basin mixer	1	Ea	$35,000	$3,500	$5,250	$43,750
3.10	Residuals transfer pumps	4	Ea	$50,000	$20,000	$30,000	$250,000
3.11	High service pumps	5	Ea	$50,000	$25,000	$37,500	$312,500
3.12	Coagulant feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$100,000	$10,000	$15,000	$125,000
3.13	Scale inhibitor feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$60,000	$6,000	$9,000	$75,000
3.14	Sulfuric acid feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$100,000	$10,000	$15,000	$125,000
3.15	DBNPA feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$60,000	$6,000	$9,000	$75,000
3.16	Bisulfite feed system	1	LS	$75,000	$7,500	$11,250	$93,750
3.17	Lime feed system (includes storage silos, fill lines, dust collectors, truck unloading station, gravimetric feeders, slakers, instrumentation, and controls	1	LS	$200,000	$20,000	$30,000	$250,000
3.18	Carbon dioxide feed system (includes storage tanks, evaporators, recirculation pumps, and feed system)	1	LS	$300,000	$30,000	$45,000	$375,000
3.19	Phosphate feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$60,000	$6,000	$9,000	$75,000
3.20	Prechlorination hypochlorite feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$75,000	$7,500	$11,250	$93,750
3.21	Postchlorination hypochlorite feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$75,000	$7,500	$11,250	$93,750

Conceptual Design Preliminary Capital Cost Estimate SFWMD Lauderdale SWRO							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
3.23	Chemical storage tanks	16	Ea	$15,000	$24,000	$0	$264,000
3.24	Interior and exterior process piping (excluding RO system)	1	LS	$3,750,000	$375,000	$0	$4,125,000
3.25	Process valves, gates, and appurtenances (excluding RO system)	1	LS	$2,125,000	$212,500	$0	$2,337,500
						Subtotal	**$73,998,600**
Total Construction Cost							**$94,588,115**
Engineering				**10%**			**$9,458,812**
Construction Contingency				**25%**			**$23,647,029**
Contractors OH&P				**17%**			**$16,079,980**
Interest During Construction				**6%**			**$5,675,287**
Total Estimated Construction Cost							**$149,449,222**

5.4.11 Estimate of O&M Costs

To develop a 20-year life cycle cost of the Lauderdale SWRO facility, operation and maintenance (O&M) costs have been developed. Three O&M categories were established and the annual O&M costs were developed for each category. The three O&M categories used in this analysis are:

- Power
- Chemicals
- Recurring Costs

Major facilities replacement costs are not included in these O&M costs, nor are replacements costs for major pieces of equipment, routine maintenance, and labor. These items are considered to be equivalent for all alternatives that could be considered for this project, and do not create a basis for making an economic comparison between alternatives. Replacement of major consumables that are specific to an alternative that would distinguish an alternative from another on an economic basis, such as membrane element replacement, are included under the recurring costs category.

A unit power cost of $0.066 per kWh was used to estimate annual power consumption costs. The electrical load from the major equipment, pumps, and building services (HVAC and lighting), and the unit power cost was applied to estimate total energy costs. It is assumed that all process buildings will require ventilation, lighting, and periodic heating. Cooling costs were estimated only for administrative areas. Power costs for membrane systems vary depending on water temperature, with power input increasing as feedwater temperature decreases. Because water temperature varies in the course of a year, an average feedwater temperature of 89 degrees F was used to calculate annual power costs.

FPL charges a monthly demand cost based on the highest 30-minute metered power demand in a single month. Based on an estimated daily demand of 201,500 kWh and a 1.25 peaking factor, the estimated maximum 30-minute power draw is 5,250 kW. FPL multiplies this value by $0.0572 to result in a monthly demand charge of $30,000 or an annual charge of $360,200. On top of this, FPL charges a $366 customer fee, for a total annual cost of $4,392. The total estimated annual demand charge is $364,587.

Chemical use is based on a rapid mix feed flow of approximately 34.12 mgd and a finished water production of 20 mgd. To obtain unit costs for the various chemicals,

local area chemical suppliers were contacted for regional prices, wherever possible. Dose rates and chemical costs are summarized earlier in this report.

In this estimate of O&M costs, recurring costs are generally defined as anticipated, regularly scheduled maintenance expenditures that result from replacement of process components that are specific to the alternative. The recurring costs associated with regularly scheduled maintenance such as equipment repair, cleaning, painting, etc., are not included in these estimates.

For the cluster filters, the estimated replacement interval for the filter media is 20 years. It is estimated that the media cost is $215/sf. At a total area of 6,728 sf, the annual replacement cost is $72,326.

For the first-pass RO system, the estimated replacement interval for the membrane elements is 5 years and the cost of each membrane element is estimated to be $750. There are a total of 6,960 elements. The annual replacement cost based on these figures is $1,044,000. The first-pass RO elements will require periodic cleaning. It is estimated that the system will require cleaning four times annually at a cost of $3,500 per mgd. This cost includes heating of the cleaning water, cleaning chemicals, CIP cartridge filter replacement, and pumping costs. Based on a permeate flow of 22.23 mgd, the annual cost for RO system cleaning is estimated to be $311,222. The cartridge filter elements preceding the RO system will require periodic replacement at $30 each. It has been assumed that 1,760 elements will be required at a replacement frequency of four times per year for a total annual cost of $211,200.

For the second-pass RO system, the estimated replacement interval for the membrane elements is 10 years and the cost of each membrane element is estimated to be $650. There are a total of 3,024 elements. The annual replacement cost based on these figures is $196,560. The second-pass RO elements will require periodic cleaning. It is estimated that the system will require cleaning once annually at a cost of $3,500 per mgd. This cost includes heating of the cleaning water, cleaning chemicals, CIP cartridge filter replacement, and pumping costs. Based on a permeate flow of 20 mgd, the annual cost for RO system cleaning is estimated to be $70,025.

A present worth analysis was prepared to evaluate and compare the economic impacts of this alternative. The present worth of an expenditure, or “investment”, related with a given alternative is today’s dollar value (i.e., at the date of implementation of a given alternative) of all annual expenditures specific to that alternative. By this definition, since the O&M costs are routine annual expenditures, the O&M costs of the project

period (20 years) can be extrapolated back to a present worth value. Thus, the total option cost is comprised of the capital cost plus the present worth of the O&M costs.

To determine the present worth of an annual expenditure, the annual costs are multiplied by the present worth factor (PF). The present worth factor converts the annual cost to a present day value, which can then be added to the capital costs that results in a single value that can be used to compare otherwise dissimilar alternatives. The present worth factor is a function of the assumed interest rate and period of investment. For this analysis, an interest rate of 6 percent and a term of 20 years were assumed. The present worth factor is calculated from the following equation:

$$PF_n = \frac{(1+i)^n - 1}{i(1+i)^n}$$

Using this equation, the present worth factor is 11.47. The determine the present worth of the O&M costs, the present worth factors are used as multipliers against the O&M costs. The total present worth is then found by adding the present worth of the O&M costs to the capital cost. A detailed estimate for this alternative is presented in Table 5.42 below.

Table 5.42 – Alternative 1 Estimated Operating and Maintenance Costs

Item	**Quantity**	**Unit**	**Annual Cost**	**Present Worth**
Equipment Operation - Electrical				
Major Equipment				
Raw Water Pumps	1	LS	$129,860	$1,489,489
Rapid mix tank mixers	1	LS	$56,495	$647,998
Flocculation equipment	1	LS	$10,144	$116,345
AquaDAF equipment	1	LS	$102,551	$1,176,253
Cluster filters	1	LS	$4,742	$54,396
Backwash pumps	1	LS	$25,620	$293,854
Air scour blowers	1	LS	$5,761	$66,080
Filtered water transfer pumps	1	LS	$64,789	$743,128
1st pass seawater pumps	1	LS	$287,062	$3,292,577
1st pass feed pumps	1	LS	$2,457,829	$28,191,109
1st pass inter-stage pumps	1	LS	$795,908	$9,128,999
1st Pass PIT	1	LS	-$1,033,893	-$11,858,667

Item	Quantity	Unit	Annual Cost	Present Worth
2nd pass feed pumps	1	LS	$342,661	$3,930,298
2nd pass inter-stage pumps	1	LS	$64,120	$735,456
2nd pass PIT	1	LS	-$26,117	-$299,563
Remineralization basin mixer	1	LS	$24,431	$280,221
Residuals EQ tank mixers	1	LS	$34,491	$395,606
CO2 recirculation pumps	1	LS	$3,243	$37,194
High service pumps	1	LS	$351,799	$4,035,106
Residuals EQ tank influent pumps	1	LS	$6,503	$74,587
Residuals EQ tank effluent pumps	1	LS	$6,503	$74,587
FPL power demand charges	1	LS	$364,587	$4,181,784
Building HVACL				
Raw water pump station	1	LS	$52,620	$603,553
Pretreatment building	1	LS	$375,096	$4,302,325
RO building	1	LS	$591,301	$6,782,173
Administration building	1	LS	$44,062	$505,383
Lime feed building	1	LS	$27,407	$314,350
High service pump station	1	LS	$49,332	$565,831
		Subtotal	***$5,218,907***	***$59,860,451***
Chemicals				
Coagulant	1	LS	$532,307	$6,105,514
Sulfuric acid	1	LS	$116,981	$1,341,766
Scale inhibitor	1	LS	$560,886	$6,433,319
Bisulfite	1	LS	$114,518	$1,313,518
DBNPA	1	LS	$15,000	$172,049
Lime	1	LS	$191,778	$2,199,682
Carbon dioxide	1	LS	$77,016	$883,364
Fluoride	1	LS	$60,160	$690,031
Phosphate	1	LS	$52,143	$2,998,160
Prechlorination	1	LS	$261,393	$598,074
Postchlorination	1	LS	$102,147	$2,998,160
		Subtotal	***$2,084,329***	***$25,733,638***

Item	**Quantity**	**Unit**	**Annual Cost**	**Present Worth**
Recurring Costs				
Filter media	1	LS	$72,326	$829,574
1st pass RO elements	1	LS	$1,044,000	$11,974,598
2nd pass RO elements	1	LS	$196,560	$2,254,528
Cartridge filter replacement	1	LS	$211,200	$2,422,447
1st pass RO CIP	1	LS	$311,222	$3,569,691
2nd pass RO CIP	1	LS	$70,025	$803,180
		Subtotal	***$1,905,333***	***$21,854,018***
Total O&M Costs			**$9,208,569**	**$107,448,107**

5.4.12 Cost Summary

Capital and O&M costs were developed for this alternative to develop a concept for treating raw water from this location. All costs are in current year U.S. dollars. Present worth costs were developed for a 20-year planning period using an interest rate of 6 percent. The capital cost estimates are based on the conceptual layouts and design criteria presented earlier in this section and are to be considered planning level only. The intent of the cost estimates is to establish a means of making economic comparison between alternatives for the purpose of ranking and evaluation. The costs are not to be considered total project costs which can only be developed as a result of detailed design. Table 5.43 summarizes the costs for this alternative.

Table 5.43 – Preliminary Estimated Cost Summary

SFWMD LAUDERDALE SWRO		
Preliminary Estimated Cost Summary		
ESTIMATED PROJECT COSTS		
Total Construction Cost		$94,588,115
Engineering (10%)		$9,458,812
Construction Contingency (25%)		$23,647,029
Contractor's OH&P (17%)		$16,079,980

Interest During Construction (6%)		$5,675,287
Total		**$149,449,222**
Unit Costs		
Capital cost ($/m3)		$1,249
Capital cost ($/kgal)		$4,729
Capital cost ($/gal)		$4.73
Project cost ($/m3)		$1,974
Project cost ($/kgal)		$7,472
Project cost ($/gal)		$7.47
Total power cost ($/m3)		$0.16
Total power cost ($/kgal)		$0.60
SWRO power cost ($/m3)		$0.09
SWRO power cost ($/kgal)		$0.36
SWRO specific power (kWh/m3)		1.58
SWRO specific power (kWh/kgal)		5.99
Plant specific power (kWh/m3)		2.66
Plant specific power (kWh/kgal)		10.08
Annual O&M cost ($/m3)		$0.30
Annual O&M cost ($/kgal)		$1.15

A breakdown of estimated life cycle cost and equivalent annual cost per 1,000 gallons of finished water is included as Table 5.44.

Table 5.44 – Estimated Life Cycle and Equivalent Annual Cost per 1,000 Gallons

Estimated Life Cycle Cost and Equivalent Annual Cost per 1,000 Gallons
Proposed Lauderdale Facility

Parameters

Discount rate	5.125%	Base year	2007	Useful life by facility type or service (See Note 8)	WC	40	PAE 20
Inflation rate	3.000%	Period of analysis - years	20		OS	35	M 5
Year of cost estimate	2006	Annual availability factor	98%		W	30	NS 0

Item	Facility Type[8]	Initial Investment: Amount in Year of Cost Estimate Dollars	Amount in Base Year Dollars	Year Operational	Construction/ Service Duration - Years	Useful Life - Years	Present Value in Base Year[1]	Operation and Maintenance: Annual Amount in Year of Cost Estimate Dollars	Annual Amount in Base Year Dollars	Present Value[2]	Renewal and Replacement: Annual Amount in Base Year Dollars[3]	Present Value[4]	Total Present Value - Life Cycle Cost
Sitework	OS	$ 2,810,433	$ 2,894,745	2011	1.5	35	$ 2,708,862		$ -	$ -	$ 82,707	$ 1,022,233	$ 3,731,094
Buildings and structures	OS	$ 17,779,083	$ 18,312,455	2011	1.5	35	$ 17,136,536		$ -	$ -	$ 523,213	$ 6,466,748	$ 23,603,284
Process piping & equipment	PAE	$ 64,471,936	$ 66,406,094	2011	1.5	20	$ 62,141,880		$ -	$ -	$ 3,320,305	$ 41,037,923	$ 103,179,803
Engineering	NS	$ 9,458,812	$ 9,742,576	2011	1.5	0	$ 9,116,964		$ -	$ -	$ -	$ -	$ 9,116,964
Construction contingency	PAE	$ 23,647,029	$ 24,356,440	2011	1.5	20	$ 22,792,410		$ -	$ -	$ 1,217,822	$ 15,051,897	$ 37,844,308
Contractor overhead & profit	PAE	$ 16,079,980	$ 16,562,379	2011	1.5	20	$ 15,498,839		$ -	$ -	$ 828,119	$ 10,235,290	$ 25,734,129
RO elements and media	M	$ 9,526,664	$ 9,812,464	2011	2	5	$ 9,229,363		$ -	$ -	$ 1,962,493	$ 24,255,795	$ 33,485,158
Electrical			$ -	2011		0	$ -	$ 5,218,907	$ 5,375,474	$ 66,439,171	$ -	$ -	$ 66,439,171
Chemicals			$ -	2011		0	$ -	$ 2,084,329	$ 2,146,859	$ 26,534,504	$ -	$ -	$ 26,534,504
Labor			$ -	2011		0	$ -	$ 2,800,000	$ 2,884,000	$ 35,645,334	$ -	$ -	$ 35,645,334
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
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			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
Totals			$ 148,087,153				$ 138,624,854		$ 10,406,333	$ 128,619,010	$ 7,934,658	$ 98,069,887	**$ 365,313,750**

Equivalent Annual Cost[5]	$ 29,625,211
Facility capacity - average day - 1,000,000 gallons	20.0
Annual water production - 1,000,000 gallons[6]	7,154.00
Equivalent annual cost per 1,000 gallons[7]	**$ 4.14**

[1]Investment inflated based on time from base year to midpoint of construction, discounted to base year from midpoint of construction

[2]Discounted inflated future O&M during entire period of analysis less discounted inflated O&M expenses avoided prior to startup

[3]Straight line depreciation in base year dollars over use life of project

[4]Discounted inflated future R&R during entire period of analysis less discounted inflated R&R expenses avoided where project starts after base year

[5]Annual amount needed to finance total present value of project

[6]Calculated as average day capacity multiplied by 365 days per year multiplied by average annual availability factor - the percentage of time the facility is expected to operate.

[7]Includes renewal and replacement costs

[8]WC = Water Conveyance; OS = Other Structures; W = Wells; PAE = Process and Auxiliary Equipment; M = RO Membranes; NS = Non-structural Services

Note: Total capital cost for process piping & equipment is estimated to be $73,998,600. Of this amount, RO elements and membranes, with an estimated cost of $9,526,664, must be replaced every five years. Process piping & equipment has an estimated useful life of 20 years, while RO elements and membranes have an estimated useful life of 5 years. Therefore, the estimated cost of the RO elements and membranes was subtracted from the total cost for process piping and equipment and entered as a separate capital cost.

5.5 Proposed Fort Myers RO Facility

This section provides background information on the design criteria used to develop the Fort Myers SWRO facility planning level capital and life cycle costs.

5.5.1 Process Description

The proposed Seawater Desalination project at the FPL Fort Myers coastal power generation station consists of the construction and operation of a 10 million gallon per day (mgd) seawater desalination facility. The proposed facility would be located adjacent to the FPL Fort Myers power plant within the northeastern portion of Fort Myers. The proposed facility would convert a fraction of the power plant's condenser cooling seawater discharge into fresh drinking water using a reverse osmosis desalination process. Source water for this facility would be taken from the existing condenser cooling-seawater discharge pipeline system and is assumed to have an average total dissolved solids (TDS) level of 15,000 mg/L. The desalination facility would intake approximately 16 mgd of the power plant's cooling water discharge and produce 10 mgd of high-quality potable drinking water for use by residents and businesses in the Lee County area. Approximately 5 mgd becomes concentrated seawater, which would re-enter the power plant condenser cooling water discharge system downstream of the desalination facility's intake point and blend with the condenser cooling circulation system flow for dilution prior to discharge back to the ocean.

The proposed seawater reverse osmosis (SWRO) plant consists of the following major processes:

- Seawater screening and pumping
- Rapid mixing for the introduction of coagulant and disinfectant
- High-rate dissolved air flotation for suspended solids removal
- Filtration for suspended solids and pathogen removal
- Two-pass reverse osmosis for dissolved solids removal
- Remineralization of hardness and alkalinity for corrosion control
- Clearwell storage for finished water equalization and disinfection
- Filter backwash water equalization and high rate clarification and thickening
- Recycle of clarified filter backwash water to the head of the plant

A process flow diagram depicting the proposed treatment process is illustrated by Figure 5.5.

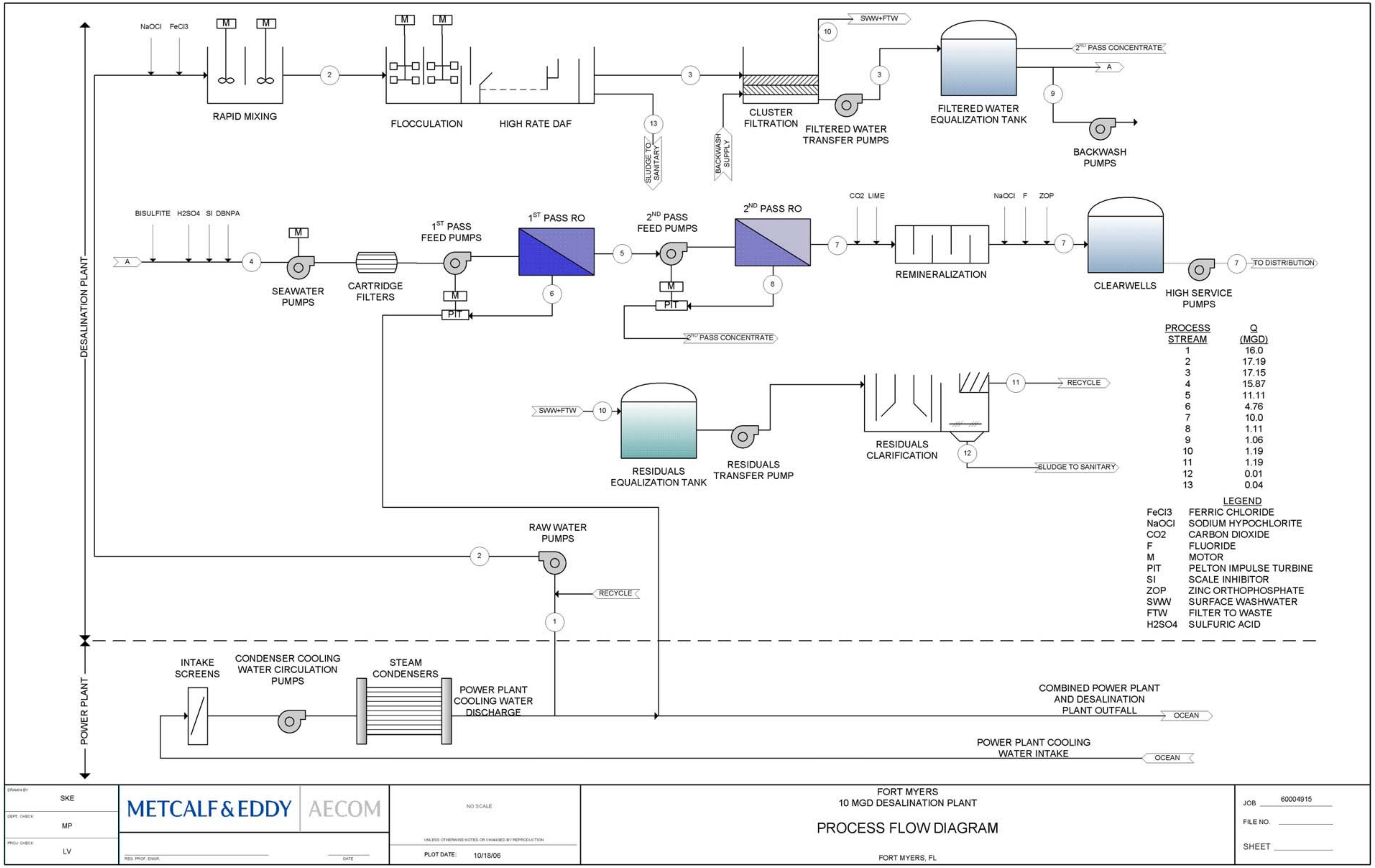

Figure 5-5 - Fort Myers SWRO Facility Process Flow Diagram

5.5.2 Water and Solids Mass Balance

An estimation of water flow and quality at each point in the water treatment process is essential for properly sizing each unit process and for estimating initial capital and long-term operating costs. This section summarizes the water flow rates, solids production rates, and solids removal rates for each unit process at the Fort Myers SWRO facility.

Water Mass Balance

A water flow model was developed for estimating process flows assuming a finished water flow of 10 mgd. The process flow rates are summarized below by Table 5.45.

Table 5.45 Process Flow Rates

Stream	Description	Q (mgd)
RW	Raw Water	16.0
CF	Clarifier Feed	17.19
CW	Clarified Water	17.15
CS	Clarifier Sludge	0.04
TS	Thickened Sludge	0.0019
FIL	Filtered Water	15.96
ROP	Permeate	10.0
ROC	RO Concentrate	4.76
SWW	Spent Washwater	1.19
REC	Recycle	1.19

Solids Production and Balance

Since the pretreatment options for each plant are the same and are based on the same values of raw water turbidity and coagulant dose, the solids generation for each plant site is similar. The volume of solids produced at each site will differ because the capacities of each plant differ. To assess the volume and magnitude of residuals production for Fort Myers SWRO facility, a solids balance model was developed.

The solids production and balance is summarized below by Tables 5.46 and 5.47. The solids balance was based on a finished water production of 10 mgd, a raw water turbidity of 20 NTU, a ferric chloride coagulant dose of 25 mg/L (as ferric chloride), and a source water total organic carbon (TOC) of 6 mg/L. Assumed worst case values for turbidity, coagulant dose, and TOC levels were used because of limited available water quality data.

Table 5.46 Solids Production

From Turbidity:		**Value**
Production Rate	Mg SS/NTU removed	1.5
Turbidity In	NTU	20.0
Turbidity Removal		98.0%
Turbidity Out	NTU	0.4
Solids Produced	Mg SS/L	29.4
From TOC Removal:		
TOC In	mg/L	6.0
TOC Removal		50%
Solids Produced	mg SS/L	3
From Ferric Coagulant:		
Production Rate	mg/mg ferric Dose	0.66
Ferric Dosage	mg/L	25
Solids Produced	mg SS/L	16.5
Total Solids Produced	mg SS/L	48.9
	Raw water flow (mgd)	16.0
	Lbs/day	**6,525**

Table 5.47 - Solids Balance

AquaDAF		
	AquaDAF feed (mgd)	17.19
	Unit solids capture (%)	95%
	Floated sludge load (lbs/day)	6,205
	Solids carryover to filtration (lbs/day)	327
	Floated sludge solids (%)	2.0
	Floated sludge production (mgd)	0.04

	Clarified Water Flow to Filtration (mgd)	17.15
Cluster Filters		
	Filter Feed (mgd)	17.15
	Solids capture (%)	97%
	Solids to filters (lbs / day)	327
	Solids retained by filters (lbs / day)	317
	Solids carryover to RO (lbs/day)	10
	No. of filters (N)	8
	No. of washes per day	8
	SWW & FTW per wash (gal)	149,323
	Total SWW & FTW to DensaDeg (mgd)	1.19
	Filtrate to RO (mgd)	15.96
DensaDeg Clarifier-Thickener		
	Unit solids capture (%)	98%
	Solids load to DensaDeg (lbs/day)[1]	317
	Solids flow to DensaDeg (mgd)	1.19
	Solids concentration (%)	0.0032
	Thickened sludge solids (%)	2.0
	Thickened sludge production (mgd)	0.0019
	Thickened sludge load (lbs/day)	310
	Recycle flow back to headworks (mgd)	1.19
	Solids in recycle stream (lbs/day)	6

5.5.3 Raw Water Screening and Pumping

Raw water will be withdrawn from the power plant's cooling water discharge channel. It is assumed that some form of cooling water pre-screening is provided at the existing power plant, however the mesh size is unknown at this time. Therefore additional raw water screening is assumed to be required. Screening will be provided to remove suspended solids that could clog piping or damage downstream process equipment. A total of two traveling, automatically cleaned screens will be provided for suspended solids removal followed by raw water pumping. Four vertical turbine pumps will be provided downstream of the screens to pump raw water to the rapid mix system. Note that recycle water from the residuals clarification process is blended with the raw water

between the intake screens and raw water pumps. The detailed design criteria for the raw water screening and pumping system are summarized in Table 5.48.

Table 5.48 Raw Water Screening and Pumping System Design Criteria

Parameter	**Value**
Raw Water Screening	
No. of screens (N)	2
Screen type	traveling
Approach velocity (fps)	0.5
Total screen area required, N-1 (sf)	50
Area per screen, N-1 (sf)	50
Flow per screen, N-1 (mgd)	16.0
Raw Water Pumping	
Raw water flow (mgd)	17.19
Pump type	Vertical turbine
No. of raw water pumps (N)	4
No. of duty pumps (N)	3
Pump capacity (mgd)	6
TDH (ft)	40
Estimated brake horsepower at design conditions (HP)	49.07

Rapid Mix

A two-stage rapid mix system will be provided to disperse pretreatment chemicals in the raw water ahead of clarification. Each stage of the rapid mix system will provide approximately 30 seconds of detention at a maximum flow rate of 17.19 mgd for a total detention time of 60 seconds. Coagulated water will flow via gravity to the downstream two-stage flocculation system. The detailed design criteria for the rapid mix system are summarized in Table 5.49.

Table 5.49 Rapid Mixing System Design Criteria

Parameter	Value
Rapid Mix Basin	
No. Basins	1
No. of stages per basin	2
Flow per rapid mix basin (mgd)	17.19
Stage L (ft)	9
Stage W (ft)	9
Stage SWD (ft)	9
Volume per stage (cf)	729
Total volume per basin (cf)	1,458
DT per rapid mix stage (s)	27
DT per rapid mix train (s)	55
Rapid Mixers	
No. of mixers (N)	2
G (secs-1)	800
RPM	155
Absolute viscosity, u	0.00003746
Estimated mixer power (BHP)	31.78

Flocculation

A two-stage mechanical flocculation system will be provided ahead of DAF clarification. A total of 6 flocculation trains will be provided, with 3 trains feeding into a single DAF basin. Each flocculation stage will be equipped with a vertical, mechanical flocculator. Flocculated water will flow via gravity to the downstream high-rate DAF system. The detailed design criteria for the flocculation system are presented by Table 5.50.

Table 5.50 Rapid Mixing System Design Criteria

Parameter	Value
Flocculation Tanks	
No. of flocculation trains	6
No. of stages (basins) per train	2
Total no. of basins	12
Flow per flocculation train (mgd)	2.87
Basin L (ft)	14
Basin W (ft)	13.33
Basin SWD (ft)	13.3
Volume per basin (cf)	2.48
Volume per train (cf)	4.96
Total volume (cf)	29.78
HRT per train (min)	18.66
HRT per basin (min)	9.33
Velocity (fpm)	1.50
Flocculators	
Flocculator type	vertical, mechanical
No. of flocculators	12
G (secs-1)	75
RPM	155
Absolute viscosity, u	0.00003746
Mixer power (HP)	0.95

Dissolved Air Flotation (DAF) Clarification

High-rate DAF will be provided for suspended solids and algae removal. A total of 2 DAF trains will be provided, each with a design flow rate of 8.6 mgd. The preliminary design loading rate will be 7.5 gpm/sf with both units online, and 14.9 gpm/sf with one unit off line. Clarified water will flow via gravity to the downstream cluster filtration system. Floated sludge will be discharged to the sanitary sewer system. The detailed design criteria for the high-rate DAF system are presented by Table 5.51.

Table 5.51 AquaDAF™ Clarification System Design Criteria

Parameter	**Value**
DAF Summary	
Basin W (ft)	40
Basin L (ft)	62.3
SWD (ft)	13.3
Flotation area per basin (sf)	800
Total flotation area (sf)	1,600
DAF loading rate at peak flow, N in service (gpm/sf)	7.5
DAF loading rate at peak flow, N-1 in service (gpm/sf)	14.9
Volume per basin (cf)	10,640
Total volume (cf)	21,280
HRT per basin (min)	13.33
Velocity (fpm)	1.50
SLR (gpd/sf)	10,743.75
Sludge removal mechanism	mechanical
Production Summary	
Estimated clarification sludge flow (mgd)	0.04
Estimated solids concentration (%)	2
Estimated sludge production (ppd)	6,205
Clarified water flow (mgd)	17.15

Cluster Filtration

Following high-rate DAF, clarified water will flow via gravity to the cluster filtration system. Settled water will be conveyed to the filters through a common flume that will distribute water to each train. Slide gates will be installed to isolate each train. Two filter trains are proposed, each with a design capacity of 8.6 mgd. Each filter cluster consists of 4 filter cells, resulting in a total of 8 filter cells. The detailed design criteria for the cluster filtration system are summarized by Table 5.52.

Table 5.52 Cluster Filter System Design Criteria

Parameter	Value
Filter Design Criteria	
Design flow (mgd)	17.2
No. of trains (N)	2
No. of filter cells per train (N)	4
Total no. of filters (N)	8
Design flow per filter train (mgd)	8.6
Design flow per filter (mgd)	2.1
Filter HLR with all cells in service (gpm/sf)	3.38
Filter HLR with one cell out of service (gpm/sf)	3.86
Filter HLR with one train out of service (gpm/sf)	6.75
Cell width (ft)	21
Cell length (ft)	21
Filter cell area (sf)	441
Total filtration area (sf)	3,528
Maximum HLR (gpm/sf)	4
Capacity at maximum HLR (mgd)	20.32
Media Configuration	
Anthracite	20", ES = 1.0 mm, UC = 1.7
Sand	7", ES = 0.45 mm, UC = 1.5
Ilmenite	3", ES = 0.26 mm, UC = 1.3
Coarse garnet	4", ES = 1.0 mm, UC = 1.7
Underdrain	Monoflor HD false bottom with polypropylene nozzles
Residuals	
Supplemental backwash pump type	horizontal split case
Number (N + 1)	2
Backwash rate (gpm/sf)	20
Backwash flow (gpm)	8,820
Backwash air scour blower type	PD
Number of blowers (N+1)	2
Air scour rate (scfm/sf)	3

Parameter	**Value**
Air flow (scfm)	1,323
Backwash duration (min)	15
Backwash volume per cell per event (gal)	132,300
Filter to waste HLR (gpm/sf)	3.86
Filter to waste flow (gpm)	1,702
Filter to waste duration (min)	10
Filter to waste volume per cell per event (gal)	17,017
SWW + FTW per cell per event (gal)	149,317
Filter run time (hr)	24
No. of filter washes per day (N)	8
Filter wash frequency (hr)	3.0
Total residuals volume (mgd)	1.19

Residuals from the filters will be collected, equalized, and clarified using the DensaDeg clarifier-thickener for recycle to the head of the plant. Details of the residuals treatment system are provided later in this report.

Filtered Water Equalization and Transfer Pumping

Because of high-groundwater tables that are common to south Florida, below-grade storage and equalization of filtered water is not possible. Filtered water equalization will be provided in above-ground, prestressed wire-wound concrete tanks. Filtered water transfer pumps will be provided to transfer water from the filters to the equalization tanks. The RO process downstream of the filtration process operates most efficiently at constant flow set points. Because variations in filtered water flows are possible, an intermediate equalization tank will provide storage to make up the difference in upstream and downstream flows, dampening the difference and allowing less frequent changes to unit process flows. Following the upstream pretreatment and prior to RO treatment, filtered water will be stored in an intermediate equalization tank. The tank will serve two main functions: (1) to serve as a suction well for the low pressure first pass RO pumps, (2) to provide the ability to dampen the effects of flow variations between the upstream pretreatment process and the downstream RO process. The design criteria for the filtered water equalization tank and transfer pumping system are summarized by Table 5.53.

Table 5.53 Filtered Water Equalization Design Criteria

Parameter	Value
Filtered Water Suction Well	
Design influent flow (mgd)	17.15
Design influent flow (cfm)	1,592
L (ft)	50
SWD (ft)	20
H (ft)	10
Volume (cf)	10,000
HRT (min)	6.28
Filtered Water Transfer Pumps	
Pump type	Vertical turbine
No. of pumps (N)	4
Discharge (mgd)	4.29
Head (ft)	20
Driver	Constant speed
Estimated brake horsepower at design conditions (HP)	18
Filtered Water Equalization	
Design influent flow (mgd)	17.15
Design influent flow (cfm)	1,592
No. of storage tanks (N)	2
Diameter (ft)	80
SWD (ft)	20
Volume of each (cf)	100,480
Volume of each (gal)	751,590
Influent flow to each tank (mgd)	9
HRT, both tanks in service (min)	126
HRT, one tank in service (min)	63

5.5.4 Reverse Osmosis

A two-pass RO system operating at a total recovery of 70% is proposed for dissolved solids removal. Details of each pass are provided in this section.

First Pass RO System

Filtered water flows via gravity to the low pressure first-pass feed pumps. These pumps lift water from the filtered water equalization tank and pump it through the cartridge filters. Pretreatment chemicals including bisulfite for oxidant removal, scale inhibitor, and sulfuric acid will be introduced upstream of the cartridge filters. The ability to feed a non-oxidizing biocide such as DBNPA will be provided for periodic application to control biological growth in the RO system. The first-pass high pressure pumps, located downstream of the cartridge filters pump pretreated water to the first pass arrays.

A total of 6 first-pass RO arrays will be provided, each with a permeate capacity of 1.85 mgd. The first-pass system will operate at a recovery rate of 70% in a two stage system, a flux of 8 gfd, and will utilize low energy seawater elements. Each array will be equipped with interstage boost pumps to increase the second stage feed pressure and equalize flux rates between the stages.

Each of the first-pass high pressure feed pumps will be equipped with an energy recovery device to reduce the overall energy consumption of the RO system. For purposes of this report, it is assumed that each high pressure pump will be equipped with a Pelton Impulse Turbine (PIT). Concentrate from the first-pass arrays will be directed through the PITs and will be discharged via gravity to the power plant condenser cooling water discharge system, downstream of the desalination facility's intake point. Permeate from the first-pass RO system will be collected via a common header and will be directed to the second-pass RO system.

The detailed design criteria for the first-pass RO system are summarized by Table 5.54.

Table 5.54 1st Pass RO System Design Criteria

Parameter	Value
RO influent water flow (mgd)	15.87
Cartridge Filtration	
Cartridge filter type	Vertical
No. of cartridge filter housings(N)	6
Cartridge Filter Capacity (mgd)	3.5
Total Capacity (mgd)	21
Capacity, N-1 (mgd)	17.5
Cartridge Filter Loading Rate	3.5 gpm per 10-inch

Parameter	**Value**
	length
Element length (in)	40
Cartridge Filter Element Type	Blown Polypropylene
Cartridge filter element rating (microns)	5
Seawater pump	
Pump type	vertical turbine
No. of pumps (N)	6
Discharge (gpm)	1,837
Head (ft)	95
Driver	Constant speed
Estimated brake horsepower at design conditions (HP)	54
Array design	
No. of arrays	6
Recovery rate	70%
Flux (gfd)	8.1
Fouling factor	0.85
Feed flow per array (mgd)	2.65
1st stage permeate flow per array (mgd)	1.28
Interstage flow per array (mgd)	1.36
Second stage permeate flow per array (mgd)	0.57
Second stage concentrate flow per array (mgd)	0.79
Total permeate flow per array (mgd)	1.85
Feed temperature (degrees F)	89 - 98
No. of stages per array (N)	2
No. of pressure vessels in first stage (N)	65
No. of elements per vessel (N)	6
No. of pressure vessels in second stage (N)	30
No. of elements per vessel (N)	6
No. of elements per array (N)	570
Element basis of design	FilmTec SW30XLE-440i
Active area per element (sf)	400

Parameter	**Value**
Active area per array (sf)	228,000
First stage feed pressure (psi)	350
First stage concentrate pressure (psi)	340
Interstage boost pressure (psi)	230
Second stage feed pressure (psi)	565
Second stage concentrate pressure (psi)	555
1st Pass Feed Pump Design	
Pump type	Horizontal centrifugal
No. of pumps (N)	6
Discharge (mgd)	2.65
Head (ft)	809
Driver	VFD
Pump shaft power required (kW)	325
Pump shaft power required (HP)	435
Pump efficiency (%)	85%
Pelton shaft power (kW)	125
Motor shaft power (kW)	200
Motor shaft power (HP)	268
Motor efficiency (%)	97%
Motor Electrical Power (kW)	206
1st Pass Interstage Pump Design	
Pump type	Vertical multistage centrifugal
No. of pumps (N)	6
Discharge (mgd)	1.36
Head (ft)	531
Driver	VFD
Estimated brake horsepower at design conditions (HP)	149
Energy Recovery	
Energy recovery device type	Pelton turbine
No. of devices (N)	6
Inlet pressure (psi)	555
Outlet pressure (psi)	0
Efficiency	90%

Parameter	**Value**
Pelton shaft power (kW)	125
Pelton shaft power (HP)	167
Production Summary	
Total feed flow (mgd)	15.87
Total permeate flow (mgd)	11.11
Total concentrate flow (mgd)	4.76
Permeate TDS (mg/L)	376
Concentrate TDS (mg/L)	49,100

2nd Pass RO System

A second pass RO system is proposed to further reduce dissolved solids not removed by the first pass system. Permeate from the first pass system will be collected in a common header and will be directed to the second pass system.

The second pass system consists of 4 arrays, each with a permeate capacity of 2.5 mgd. The second-pass system will operate at a recovery rate of 90% in a two stage system, a flux of 15 gfd, and will utilize low energy brackish water elements. Each array will be equipped with interstage boost pumps to increase the second stage feed pressure and equalize flux rates between the stages.

Each of the second-pass high pressure feed pumps will be equipped with an energy recovery device to reduce the overall energy consumption of the RO system. For purposes of this report, it is assumed that each high pressure pump will be equipped with a Pelton Impulse Turbine (PIT). Concentrate from the second-pass arrays will be directed through the PIT's and will be discharged via gravity to the filtered water equalization tank. The second pass concentrate will be of high quality and will have a lower TDS than that of the first pass feed. Blending the second pass concentrate with the first pass feed will increase first pass feed quality and will reduce overall plant operating costs. The permeate from the second pass system will be collected in a common header and will flow via gravity to the downstream remineralization system.

The detailed design criteria for the second-pass RO system are summarized by Table 5.55.

Table 5.55 2nd Pass RO System Design Criteria

Parameter	**Value**
2nd pass influent water flow (mgd)	11.11
2nd Pass Feed Pump Design	
Pump type	vertical turbine
No. of pumps (N)	4
Discharge (gpm)	1,929
Head (ft)	162
Driver	VFD
Estimated brake horsepower at design conditions (HP)	96
Array design	
No. of arrays	4
Recovery rate	90%
Flux (gfd)	15
Fouling factor	0.85
Feed flow per array (mgd)	2.78
1st stage permeate flow per array (mgd)	1.75
Inter-stage flow per array (mgd)	1.03
Second stage permeate flow per array (mgd)	0.75
Second stage concentrate flow per array (mgd)	0.28
Total permeate flow per array (mgd)	2.50
Feed temperature (degrees F)	89 - 98
No. of stages per array (N)	2
No. of pressure vessels in first stage (N)	37
No. of elements per vessel (N)	7
No. of pressure vessels in second stage (N)	17
No. of elements per vessel (N)	7
No. of elements per array (N)	378
Element basis of design	FilmTec XLE-440
Active area per element (sf)	440
Active area per array (sf)	166,320
First stage feed pressure (psi)	70

Parameter	**Value**
First stage concentrate pressure (psi)	45
Interstage boost pressure (psi)	35
Second stage feed pressure (psi)	75
Second stage concentrate pressure (psi)	62
Second-Pass Inter-stage Pump Design	
Pump type	Vertical multistage centrifugal
No. of pumps (N)	4
Discharge (mgd)	1.03
Head (ft)	81
Driver	VFD
Estimated brake horsepower at design conditions (HP)	17
Energy Recovery	
Energy recovery device type	Pelton turbine
No. of devices (N)	4
Inlet pressure (psi)	61
Outlet pressure (psi)	0
Efficiency	90%
Pelton shaft power (kW)	5
Pelton shaft power (HP)	6
Production Summary	
Total feed flow (mgd)	11.11
Total permeate flow (mgd)	10.00
Total concentrate flow (mgd)	1.11
Permeate TDS (mg/L)	70
Concentrate TDS (mg/L)	3,400

Remineralization

Because RO removes such a high degree of dissolved substances such as hardness and alkalinity, the permeate must be remineralized to prevent corrosion in the receiving distribution system piping and to produce a finished water that is aesthetically acceptable to the customers. In final design, actual distribution system water quality conditions would be matched as closely as possible. The specific distribution system water quality is unknown at this time, therefore general assumptions for remineralization have been used.

After RO treatment, the permeate stream is projected to have an acidic pH of approximately 4.96. In addition, the RO process removes virtually all alkalinity. The only portion of the carbonate system that passes through the membrane is carbon dioxide (CO_2). To achieve hardness and alkalinity recovery, RO permeate will be remineralized with lime and carbon dioxide. To model the impact of post-treatment remineralization, the Rothberg, Tamburini & Winsor, Inc. (RTW) water chemistry model was used. This model calculates the impact of chemical addition on water quality parameters.

Two forms of lime are typically available, pebble (quick) lime and hydrated lime. While hydrated lime does not require slaking prior to remineralization, it is typically more expensive than quick lime. Therefore, quick lime was selected for this application. To meet the alkalinity and hardness goals, approximately 45 mg/L of lime will be added based on the RTW modeling.

The 45 mg/L of lime will produce a finished water pH that is higher than the water quality goal. Therefore, liquefied carbon dioxide will be used to reduce the pH to the desired range. Carbon dioxide mixes with water to form carbonic acid, a fairly mild acid which acts to reduce pH. The RTW model estimates that approximately 22 mg/L will be required to obtain a pH of approximately 8.0. With the addition of lime and carbon dioxide at the proposed doses, the LSI is approximately 0, and the total hardness is approximately 60 mg/L.

Carbon dioxide is delivered in the liquid form and stored in an insulated (cryogenic) storage tank. The storage tank is complete with the equipment necessary to maintain the liquid carbon dioxide at approximately 0 degrees F, with non-freezing regulators and temperature gauges. A vaporizer changes the liquid carbon dioxide to a vapor. Carbon dioxide vapor for process use is withdrawn from the tank and passed through regulators, metering equipment and other accessories depending on the type of feed equipment used. The RO permeate will flow to a remineralization rapid mix, where it will be mixed with the CO_2 and lime. The flow will then enter a remineralization basin, which will be baffled to ensure a 16 minute detention time with no short-circuiting. Table 5.56 summarizes the design criteria for the permeate remineralization system.

Table 5.56 Remineralization System Design Criteria

Parameter	**Value**
Remineralization Basin	
Flow to remineralization (mgd)	10.0
Type	Rectangular, serpentine channels
Channel length (ft)	30
Channel SWD (ft)	13
Channel W (ft)	10
No. of channels (N)	5
Total length (ft)	150
Volume (gal)	145,860
DT (min)	21.01
Baffle factor:	0.8
T/T10 (min)	16.81
Rapid Mixer	
No. of rapid mixers	1
Mixing area volume (cf)	1,300
G (secs-1)	800
RPM	155
Absolute viscosity, u	0.00003746
Mixer power (HP)	56.67
Lime Feed System	
Application stream	RO Permeate
Flow rate (mgd)	10.0
Dose as CaO (mg/L)	45
Daily consumption (lb)	3753
30-day storage (lb)	112,590
Lime density (pcf)	55
30-day storage (cf)	2,047
Lime Storage	
Bulk storage type	silos
Silo diameter (ft)	14.0
Silo height (ft)	30.0
Silo volume (cf)	4,615.80

Parameter	**Value**
No. of silos (N)	1.0
Lime Feed	
Slaker type	slurry
No. of slakers (N)	1.00
Slaker capacity (pph)	156.38
Carbon Dioxide Feed	
Application stream	RO Permeate
Flow rate (mgd)	10.00
Dose (mg/L)	22
Daily consumption (lb)	1835
30-day storage (lb)	55,044
Bulk storage type	pressurized tanks
Tank capacity (lb)	240,000
No. of tanks (N)	1
Recirculation pump flow (1 gpm per pph of CO2)	76
Recirculation pump head (ft)	150

5.5.5 Disinfection and Finished Water Storage

Prior to the finished water pump station, contact time must be provided for disinfection with free chlorine (sodium hypochlorite) and on-site storage to allow the treatment plant to operate somewhat independently of the finished water pump station instantaneous flow.

The LT2ESWTR requires a 3-log removal / inactivation of *Giardia*, a 4-log removal / inactivation of viruses, and a 2-log removal / inactivation of *Cryptosporidium* for surface water treatment facilities. It is assumed that the proposed raw water source will be placed in Bin 1 which will not require additional treatment *Crypto* removal or inactivation. The removal / inactivation requirements are summarized by Table 5.57.

Table 5.57 Disinfection Requirements

Pathogen	**Required Removal / Inactivation (log)**
Cryptosporidium	2.0
Giardia	3.0
Viruses	4.0

The clarification and filtration process will be granted a 2.5-log removal credit for *Giardia*; 2.0-log removal credit for virus; and 2.0-log removal credit for *Crypto*. Therefore the disinfection process must provide an additional 0.5-log removal/inactivation of *Giardia*, and an additional 2.0-log removal/inactivation of viruses. When free chlorine is used for disinfection, the inactivation of *Giardia* controls disinfection requirements because *Giardia* is much more difficult to inactivate than viruses with free chlorine. The additional disinfection contact time (T10) requirements have been calculated assuming free chlorine residuals of 1.0 and 2.5 mg/L and based on USEPA CT Tables contained in the Guidance Manual for Compliance with the Surface Water Treatment Rule. This is based on a well-baffled storage tank using dual concentric baffles to obtain a T10/T ratio of at least 0.75, a 25 percent additional capacity for tank level variability with pumping, a pH range of 6-9, and a finished water temperature greater than 25 degrees C.

Circular wire-wound pre-stressed tanks with dual concentric-C baffles were selected for the analysis for finished water storage. The design criteria for these tanks are summarized by Table 5.58. Note that the CT values represent that which is required for 0.5-log *Giardia* inactivation.

Table 5.58 Finished Water Storage Design Criteria

Parameter	Value
Remineralized permeate flow (mgd)	10.0
Remineralized permeate flow (gpm)	6,943
Number of clearwells (N)	2
Mode of operation	parallel
Flow per clearwell (mgd)	5.0
Flow per clearwell (gpm)	3,472
SWD (ft)	18
Diameter (ft)	75
Actual volume (gal)	594,520
CT volume factor (dual concentric baffles)	0.75
CT volume (gal)	445,890
Efficiency factor	0.75
T10 effective volume (gal)	334,417
Actual detention time per clearwell (min)	171
T10 clearwell (min)	96
CT req'd @ C = 1.0 mg/L, 25^{o}C, pH = 9	13
CT achieved @ C = 1.0 mg/L, 25^{o}C, pH = 9	96
CT req'd @ C = 2.5 mg/L, 25^{o}C, pH = 9	15.5
CT achieved @ C = 2.5mg/L, 25^{o}C, pH = 9	240

Under the above disinfection design conditions the required CT levels are exceeded at either free chlorine residual.

5.5.6 High Service Pumping

A new high service pumping station will be required. Finished water will flow by gravity to the high service pump suction well, located in the high service pump station. Horizontal split case pumps were selected because of their higher efficiency compared to other types of pumps. The design criteria for the high service pumping system are summarized by Table 5.59.

Table 5.59 High Service Pumping Design Criteria

Parameter	Value
Finished water flow (mgd)	10.0
Pump type	HSC
No. of high service pumps (N)	5
No. of duty pumps (N-1)	4
Pump capacity at N (mgd)	2.0
Pump capacity at N-1 (mgd)	2.5
TDH (ft)	231
Estimated power (BHP)	100

5.5.7 Residuals Handling and Disposal

The water treatment process will produce a number of waste or residual streams. The streams include:

- Clarification sludge
- Spent washwater (SWW)
- Filter-to-waste (FTW)
- RO concentrate
- Tank drains
- Sanitary sewage

Residuals handling will consist of an equalization tank for SWW and FTW and DensaDeg high-rate clarification. AquaDAF™ sludge, tank drains, and sanitary sewage will be discharged to the sanitary sewer. RO concentrate from the first pass will be discharged to the power plant condenser cooling water discharge system downstream of the desalination facility's intake point and blend with the condenser cooling circulation system flow for dilution prior to discharge back to the ocean.

FTW from the cluster filtration system will be pumped to the residuals EQ tank. SWW from the cluster filtration system will flow via gravity to the residuals EQ tank. Effluent from this tank will be pumped to the DensaDeg clarifier. Supernatant from the DensaDeg clarifier will be recycled to the head of the plant and mixed with raw water prior to rapid mixing. This stream will flow via gravity. Sludge from the DensaDeg clarifier will flow via gravity to the sanitary sewer. The design criteria for the residuals processing system are summarized by Table 5.60.

Table 5.60 Residuals Processing Design Criteria

Parameter	Value
SWW + FTW (mgd)	1.19
Total residuals (mgd)	1.19
Residuals EQ tank influent pumps	
Pump type	vertical turbine
No. of pumps (N)	2
No. of duty pumps (N-1)	1
Pump capacity (mgd)	830
TDH (ft)	30
Residuals EQ tank effluent pumps	
Pump type	vertical turbine
No. of pumps (N)	2
No. of duty pumps (N-1)	1
Pump capacity (mgd)	830
TDH (ft)	30
Residuals EQ Tank Data	
SWD (ft)	18
Diameter (ft)	79
Volume per eq tank (gal)	659,626
No. of tanks (N)	1
Total volume (gal)	659,626
Equalization time (min)	795
No. of cells per tank (N)	2
Volume per cell (gal)	329,813
No. of mixers per cell (N)	2
Mixer power (HP)	20
DensaDeg Clarifier Design Criteria	
DensaDeg clarifier influent flow (mgd)	1.19
Number of clarifiers	1
Clarifier capacity (mgd)	1.5

Parameter	Value
Design flow to clarifier (mgd)	1.19
Loading rate at max capacity (gpm/sf)	7.36
Unit solids capture (%)	98%
Solids load to DensaDeg (lbs/day)	317
Solids flow to DensaDeg (mgd)	1.19
Solids concentration (%)	0.0032
Thickened sludge solids (%)	2.0
Thickened sludge production (mgd)	0.0019
Thickened sludge load (lbs/day)	310.43
Recycle flow back to headworks (mgd)	1.19
Solids in recycle stream (lbs/day)	6

5.5.8 Chemical Feed

Facilities for receiving, storing, and feeding various chemicals have been included in the analysis to develop conceptual level capital and operating costs. The following chemicals were included:

- Ferric chloride for coagulation
- Scale inhibitor to prevent scale formation in the RO system
- Bisulfite for oxidant removal ahead of the RO system
- Sulfuric acid for scale control in the RO system
- 2,2-Dibromo-3-Nitrilopropionamide (DBNPA) to reduce biological activity in the RO system
- Carbon dioxide and quick lime for permeate remineralization
- Fluoride for dental health
- Phosphate for corrosion protection
- Sodium hypochlorite for disinfection

Table 5.61 summarizes the average dose and consumption for each chemical included in this alternative.

Table 5.61 Chemical Doses and Consumption

Chemical	Average Dose (mg/L)	Flow (mgd)	lbs/day (required)	lbs/day (from manufacturer)	Gallons per day	30-day storage (lbs)	30-day storage (gallons)
Pretreatment							
Prechlorination	3	17.2	430	---	515	---	15,463
Ferric Chloride	25	17.2	3,584	---	736	---	22,076
RO Pretreatment							
Sulfuric Acid	25	16.0	3,327	---	233	---	6,994
Scale Inhibitor	4	16.0	532	---	58	---	1,741
Bisulfite	3	16.0	399	---	95	---	2,863
DBNPA	0	16.0	0	---	0	---	
Remineralization							
Lime	45	10.0	3,753	3,753	---	112,590	---
Carbon Dioxide	22	10.0	1,835	1,835	---	55,044	---
Post-treatment							
Postchlorination	2	10.0	167	---	200	---	5,997
Fluoride	1	10.0	83	---	44	---	1,335
Phosphate	1	10.0	83	---	24	---	714

5.5.9 Buildings and Structures

For the purposes of this feasibility study it is assumed that all process equipment and tankage associated with each process will be housed indoors. The following major structures were included in this analysis:

- Raw water building for housing the raw water pumps and screens;
- Pretreatment building for housing the rapid mix, flocculation, DAF, filtration, filtered water transfer pumps, and pretreatment chemical systems
- Reverse osmosis building for housing the seawater pumps, cartridge filters, 1st pass feed pumps, 1st pass RO arrays, 2nd pass feed pumps, 2nd pass RO arrays, CIP systems, chemical feed systems associated with the RO process;

- Post-treatment building for housing the lime feed system, carbon dioxide feed equipment, high service pumping system, post-treatment chemical feed systems, and administrative area.

Each building will also house mechanical rooms, electrical equipment rooms, restrooms, control rooms, tool and workshop areas, and storage areas. A summary of area requirements for each proposed structure is presented in Table 5.62, below.

Table 5.62 Area Requirements for Major Buildings

Facility	Length (ft)	Width (ft)	Footprint (SF)
Raw Water Building	60	66	4,000
Pretreatment Building	164	180	29,520
RO Building	149	294	43,806
Post-treatment Building	Various	various	15,910

Chemical storage for coagulant and the prechlorination chemicals will be located within the Pretreatment Building. Chemical storage and feeding facilities for lime, carbon dioxide, fluoride, phosphate, and postchlorination will be located in the post-treatment building. Chemical storage and feeding facilities for sulfuric acid, scale inhibitor, bisulfite, and DBNPA will be located in the RO building. A conceptual site plan illustrating the location of the major facilities is presented by Figure 5.6.

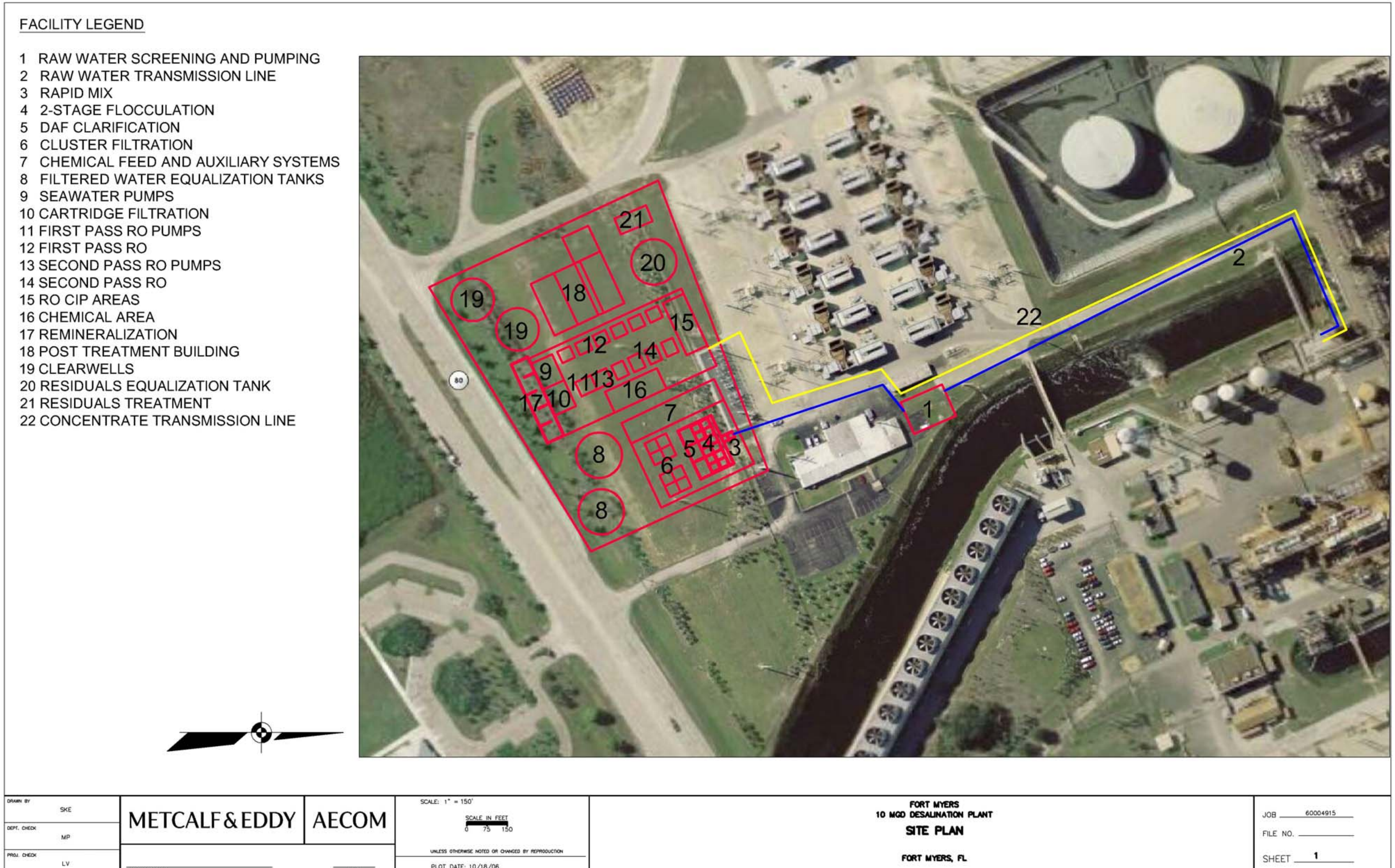

Figure 5-6 - Proposed Fort Myers SWRO Facility Site Plan

5.5.10 Estimate of Capital Costs

This section presents estimated capital costs for the Fort Myers SWRO facility. Capital costs were developed by sizing individual components within each option and estimating the quantities for the major items comprising the option. Unit prices were developed from equipment manufacturers and from recent historical data from other projects. When appropriate, additional costs were added for equipment, electrical, and instrumentation. In some instances, allowances were made for minor components and support facilities. After the construction costs are estimated and totaled, a 25% contingency was added for items that are currently unidentifiable. The final construction cost estimate also includes a 17% contractor's overhead and profit which includes the contractor's overhead expenses, mobilization, demobilization, bonding, and insurance. And finally, the project estimate includes 10% for engineering. Note that the capital costs are based on a finished water production rate of 10 mgd. A detailed cost estimate for this alternative is presented in Table 5.63 below. The costs presented herein should be considered "Budget Level" as defined by the American Association of Cost Engineers, with an accuracy of +30 percent to -15 percent. All costs are presented in October 2006 dollars.

Table 5.63 Estimated Capital Costs

Conceptual Design Preliminary Capital Cost Estimate **SFWMD Ft. Myers SWRO**							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
Sitework							
1.01	Demolition	1	LS	$20,000	$0	$0	$20,000
1.02	Clearing	1	LS	$5,000	$0	$0	$5,000
1.03	Exterior piping (includes storm and sanitary sewers, footer drains, pavement drains)	1	LS	$750,000	$0	$0	$750,000
1.04	Sitework (includes final grading, seeding, mulching, paving, fencing, sidewalks, curbs and gutters, landscaping, etc.)	1	LS	$1,000,000	$0	$0	$1,000,000
1.05	Temporary sheeting for raw water pump station	200	LF	$576	$0	$0	$115,250
1.06	Excavation for raw water pump station	963	CY	$15	$0	$0	$14,444
1.07	Excavation for pretreatment building	5227	CY	$15	$0	$0	$78,412
1.08	Excavation for filtered water EQ tank	1366	CY	$15	$0	$0	$20,492
1.09	Excavation for RO building	7578	CY	$15	$0	$0	$113,676
1.10	Excavation for remineralization basin	1131	CY	$15	$0	$0	$16,970
1.11	Excavation for lime feed building	646	CY	$15	$0	$0	$9,692
1.12	Excavation for CO2 equipment pad	1025	CY	$15	$0	$0	$15,381
1.13	Excavation for clearwells	2504	CY	$15	$0	$0	$37,556
1.14	Excavation for high service pump building	1031	CY	$15	$0	$0	$15,463
1.15	Excavation for administration building	939	CY	$15	$0	$0	$14,091
1.16	Excavation for residuals EQ	1366	CY	$15	$0	$0	$20,492
1.17	Excavation for DensaDeg	519	CY	$15	$0	$0	$7,779
						Subtotal	**$2,254,697**
Buildings & Structures							
2.01	Raw water pump and screening station concrete	1000	CY	500	$0	$0	$500,000
2.02	Raw water pump and screening station superstructure	4000	SF	$64	$0	$0	$256,000
2.03	Rapid mix basins concrete	95	CY	$500	$0	$0	$47,440
2.04	Flocculation basins & AquaDAF concrete	800	CY	$500	$0	$0	$400,000

Conceptual Design Preliminary Capital Cost Estimate **SFWMD Ft. Myers SWRO**							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
2.05	Cluster filters concrete	800	CY	$500	$0	$0	$400,000
2.06	Pretreatment building concrete	1000	CY	$500	$0	$0	$500,000
2.07	Pretreatment building superstructure	29520	SF	$64	$0	$0	$1,889,280
2.08	Filtered water equalization tanks	2	Ea	$570,000	$0	$0	$1,140,000
2.09	RO building concrete	4500	CY	$500	$0	$0	$2,250,000
2.10	RO building superstructure	43806	SF	$64	$0	$0	$2,803,584
2.11	Remineralization basin concrete	656	CY	$500	$0	$0	$327,962
2.12	Lime feed building concrete	314	CY	$500	$0	$0	$156,980
2.13	Lime feed building	2500	SF	$64	$0	$0	$160,000
2.14	Carbon dioxide equipment pad concrete	445	CY	$500	$0	$0	$222,667
2.15	Clearwells	2	Ea	$687,500	$0	$0	$1,375,000
2.16	High service pump station concrete	700	CY	$500	$0	$0	$350,000
2.17	High service pump station	4500	SF	$64	$0	$0	$288,000
2.18	Administration building	4000	SF	$125	$0	$0	$500,000
2.19	Post-treatment chemical feed building concrete	150	CY	$500	$0	$0	$75,000
2.20	Post-treatment chemical feed building superstructure	4000	SF	$64	$0	$0	$256,000
2.21	Residuals equalization basin	1	Ea	$705,000	$0	$0	$705,000
2.22	DensaDeg concrete	300	CY	$500	$0	$0	$150,000
2.23	Miscellaneous concrete for equipment pads, pipe supports, fill, containment curbs, etc.	1000	CY	$500	$0	$0	$500,000
						Subtotal	**$15,252,913**
Process Piping & Equipment							
3.01	Raw water screening equipment	2	Ea	$200,000	$40,000	$60,000	$500,000
3.02	Raw water pumps	4	Ea	$75,000	$30,000	$45,000	$375,000
3.03	Coagulation basin mixers	2	Ea	$35,000	$7,000	$10,500	$87,500
3.04	Flocculation and AquaDAF equipment	1	LS	$1,470,000	$147,000	$220,500	$1,837,500
3.05	Cluster filtration system	3528	SF	$560.00	$197,568	$296,352	$2,469,600
3.06	Filtered water transfer pumps	4	Ea	$75,000.00	$30,000	$45,000	$375,000

Conceptual Design Preliminary Capital Cost Estimate **SFWMD Ft. Myers SWRO**							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
3.07	2-pass reverse osmosis treatment system (includes seawater pumps, cartridge filters, first pass high pressure pumps, 2nd pass feed pumps, interstage pumps, arrays, CIP system, interconnecting piping, energy recovery devices, I&C)	10000000	gal	$2.50	$2,500,000	$0	$27,500,000
3.08	Residuals eq tank mixers and cranes	4	Ea	$45,000	$18,000	$27,000	$225,000
3.09	Remineralization basin mixer	1	Ea	$35,000	$3,500	$5,250	$43,750
3.10	Residuals transfer pumps	4	Ea	$50,000	$20,000	$30,000	$250,000
3.11	High service pumps	5	Ea	$50,000	$25,000	$37,500	$312,500
3.12	Coagulant feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$100,000	$10,000	$15,000	$125,000
3.13	Scale inhibitor feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$60,000	$6,000	$9,000	$75,000
3.14	Sulfuric acid feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$100,000	$10,000	$15,000	$125,000
3.15	DBNPA feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$60,000	$6,000	$9,000	$75,000
3.16	Bisulfite feed system	1	LS	$75,000	$7,500	$11,250	$93,750
3.17	Lime feed system (includes storage silos, fill lines, dust collectors, truck unloading station, gravimetric feeders, slakers, instrumentation, and controls	1	LS	$200,000	$20,000	$30,000	$250,000
3.18	Carbon dioxide feed system (includes storage tanks, evaporators, recirculation pumps, and feed system)	1	LS	$300,000	$30,000	$45,000	$375,000
3.19	Phosphate feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$60,000	$6,000	$9,000	$75,000
3.20	Prechlorination hypochlorite feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$75,000	$7,500	$11,250	$93,750
3.21	Postchlorination hypochlorite feed system (includes metering pumps, piping, valves, instrumentation, and control)	1	LS	$75,000	$7,500	$11,250	$93,750

Conceptual Design Preliminary Capital Cost Estimate SFWMD Ft. Myers SWRO							
ITEM	**DESCRIPTION**	**QUAN.**	**Unit**	**UNIT PRICE**	**Installation** 10%	**Electrical and I&C** 15%	**SUBTOTAL**
3.23	Chemical storage tanks	16	Ea	$15,000	$24,000	$0	$264,000
3.24	Interior and exterior process piping (excluding RO system)	1	LS	$3,000,000	$300,000	$0	$3,300,000
3.25	Process valves, gates, and appurtenances (excluding RO system)	1	LS	$1,750,000	$175,000	$0	$1,925,000
						Subtotal	**$40,846,100**
Total Construction Cost							**$58,191,954**
Engineering				**10%**			**$5,819,195**
Construction Contingency				**25%**			**$14,547,989**
Contractors OH&P				**17%**			**$9,892,632**
Interest During Construction				**6%**			**$3,491,517**
Total Estimated Construction Cost							**$91,943,287**

5.5.11 Estimate of O&M Costs

To develop a 20-year life cycle cost of the Fort Myers SWRO facility, operation and maintenance (O&M) costs have been developed. Three O&M categories were established and the annual O&M costs were developed for each category. The three O&M categories used in this analysis are:

- Power
- Chemicals
- Recurring Costs

Major facilities replacement costs are not included in these O&M costs, nor are replacements costs for major pieces of equipment, routine maintenance, and labor. These items are considered to be equivalent for all alternatives that could be considered for this project, and do not create a basis for making an economic comparison between alternatives. Replacement of major consumables that are specific to an alternative that would distinguish an alternative from another on an economic basis, such as membrane element replacement, are included under the recurring costs category.

A unit power cost of $0.066 per kWh was used to estimate annual power consumption costs. The electrical load from the major equipment, pumps, and building services (HVAC and lighting), and the unit power cost was applied to estimate total energy costs. It is assumed that all process buildings will require ventilation, lighting, and periodic heating. Cooling costs were estimated only for administrative areas. Power costs for membrane systems vary depending on water temperature, with power input increasing as feedwater temperature decreases. Because water temperature varies in the course of a year, an average feedwater temperature of 89 degrees F was used to calculate annual power costs.

FPL charges a monthly demand cost based on the highest 30-minute metered power demand in a single month. Based on an estimated daily demand of 116,000 kWh and a 1.25 peaking factor, the estimated maximum 30-minute power draw is 3,026 kW. FPL multiplies this value by $0.0572 to result in a monthly demand charge of $17,313 or an annual charge of $207,757. On top of this, FPL charges a $366 customer fee, for a total annual cost of $4,392. The total estimated annual demand charge is $212,150.

Chemical use is based on a rapid mix feed flow of approximately 17.2 mgd and a finished water production of 10 mgd. To obtain unit costs for the various chemicals,

local area chemical suppliers were contacted for regional prices, wherever possible. Dose rates and chemical costs are summarized earlier in this report.

In this estimate of O&M costs, recurring costs are generally defined as anticipated, regularly scheduled maintenance expenditures that result from replacement of process components that are specific to the alternative. The recurring costs associated with regularly scheduled maintenance such as equipment repair, cleaning, painting, etc., are not included in these estimates.

For the cluster filters, the estimated replacement interval for the filter media is 20 years. It is estimated that the media cost is $215/sf. At a total area of 3,528 sf, the annual replacement cost is $37,926.

For the first pass RO system, the estimated replacement interval for the membrane elements is 5 years and the cost of each membrane element is estimated to be $750. There are a total of 3,420 elements. The annual replacement cost based on these figures is $513,000. The first pass RO elements will require periodic cleaning. It is estimated that the system will require cleaning four times annually at a cost of $3,500 per mgd. This cost includes heating of the cleaning water, cleaning chemicals, CIP cartridge filter replacement, and pumping costs. Based on a permeate flow of 11.11 mgd, the annual cost for RO system cleaning is estimated to be $155,526. The cartridge filter elements preceding the RO system will require periodic replacement at $30 each. It has been assumed that 1,056 elements will be required at a replacement frequency of four times per year for a total annual cost of $126,720.

For the second pass RO system, the estimated replacement interval for the membrane elements is 10 years and the cost of each membrane element is estimated to be $650. There are a total of 1,512 elements. The annual replacement cost based on these figures is $98,280. The second pass RO elements will require periodic cleaning. It is estimated that the system will require cleaning once annually at a cost of $3,500 per mgd. This cost includes heating of the cleaning water, cleaning chemicals, CIP cartridge filter replacement, and pumping costs. Based on a permeate flow of 10 mgd, the annual cost for RO system cleaning is estimated to be $34,993.

A present worth analysis was prepared to evaluate and compare the economic impacts of this alternative. The present worth of an expenditure, or “investment”, related with a given alternative is today’s dollar value (i.e. at the date of implementation of a given alternative) of all annual expenditures specific to that alternative. By this definition, since the O&M costs are routine annual expenditures, the O&M costs of the project

period (20 years) can be extrapolated back to a present worth value. Thus, the total option cost is comprised of the capital cost plus the present worth of the O&M costs.

To determine the present worth of an annual expenditure, the annual costs are multiplied by the present worth factor (PF). The present worth factor converts the annual cost to a present day value, which can then be added to the capital costs that results in a single value that can be used to compare otherwise dissimilar alternatives. The present worth factor is a function of the assumed interest rate and period of investment. For this analysis, an interest rate of 6 percent and a term of 20 years were assumed. The present worth factor is calculated from the following equation:

$$PF_n = \frac{(1+i)^n - 1}{i(1+i)^n}$$

Using this equation, the present worth factor is 11.47. The determine the present worth of the O&M costs, the present worth factors are used as multipliers against the O&M costs. The total present worth is then found by adding the present worth of the O&M costs to the capital cost. A detailed estimate for this alternative is presented in Table 5.64 below.

Table 5.64 Alternative 1 Estimated Operating and Maintenance Costs

Item	Quantity	Unit	Annual Cost	Present Worth
Equipment Operation - Electrical				
Major Equipment				
Raw Water Pumps	1	LS	$65,425	$750,420
Rapid mix tank mixers	1	LS	$28,248	$323,999
Flocculation equipment	1	LS	$5,072	$58,173
AquaDAF equipment	1	LS	$51,288	$588,265
Cluster filters	1	LS	$4,742	$54,396
Backwash pumps	1	LS	$13,434	$154,090
Air scour blowers	1	LS	$3,021	$34,651
Filtered water transfer pumps	1	LS	$32,642	$374,398
1st pass seawater pumps	1	LS	$143,453	$1,645,390
1st pass feed pumps	1	LS	$1,177,768	$13,508,905

Item	Quantity	Unit	Annual Cost	Present Worth
1st pass interstage pumps	1	LS	$397,729	$4,561,922
1st Pass PIT	1	LS	-$514,533	-$5,901,652
2nd pass feed pumps	1	LS	$171,237	$1,964,076
2nd pass interstage pumps	1	LS	$30,576	$350,704
2nd pass PIT	1	LS	-$13,059	-$149,781
Remineralization basin mixer	1	LS	$24,431	$280,221
Residuals EQ tank mixers	1	LS	$34,491	$395,606
CO2 recirculation pumps	1	LS	$1,621	$18,597
High service pumps	1	LS	$175,803	$2,016,451
Residuals EQ tank influent pumps	1	LS	$3,410	$39,112
Residuals EQ tank effluent pumps	1	LS	$3,410	$39,112
FPL Power Demand Charges	1	LS	$212,150	$2,433,339
Building HVACL				
Raw water pump station	1	LS	$35,080	$402,369
Pretreatment building	1	LS	$323,616	$3,711,849
RO building	1	LS	$480,228	$5,508,173
Administration building	1	LS	$44,062	$505,383
Lime feed building	1	LS	$27,407	$314,350
High service pump station	1	LS	$49,332	$565,831
		Subtotal	***$3,012,082***	***$34,548,346***
Chemicals				
Coagulant	1	LS	$268,181	$3,076,020
Sulfuric acid	1	LS	$58,764	$674,021
Scale inhibitor	1	LS	$281,755	$3,231,706
Bisulfite	1	LS	$57,527	$659,831
DBNPA	1	LS	$15,000	$172,049
Lime	1	LS	$95,889	$1,099,841
Carbon dioxide	1	LS	$38,508	$441,682
Fluoride	1	LS	$30,080	$345,016
Phosphate	1	LS	$26,071	$1,510,503
Prechlorination	1	LS	$131,693	$299,037

Item	Quantity	Unit	Annual Cost	Present Worth
Postchlorination	1	LS	$51,073	$1,510,503
		Subtotal	***$1,054,542***	***$13,020,209***
Recurring Costs				
Filter media	1	LS	$37,926	$435,008
1st pass RO elements	1	LS	$513,000	$5,884,070
2nd pass RO elements	1	LS	$98,280	$1,127,264
Cartridge filter replacement	1	LS	$126,720	$1,453,468
1st pass RO CIP	1	LS	$155,526	$1,783,871
2nd pass RO CIP	1	LS	$34,993	$401,371
		Subtotal	***$966,445***	***$11,085,052***
Total O&M Costs			**$5,033,069**	**$58,653,606**

5.5.12 Cost Summary

Capital and O&M costs were developed for this alternative to develop a concept for treating raw water from this location. All costs are in current year US dollars. Present worth costs were developed for a 20-year planning period using an interest rate of 6%. The capital cost estimates are based on the conceptual layouts and design criteria presented earlier in this section and are to be considered planning level only. The intent of the cost estimates is to establish a means of making economic comparison between alternatives for the purpose of ranking and evaluation. The costs are not to be considered total project costs which can only be developed as a result of detailed design. Table 5.65 summarizes the costs for this alternative.

Table 5.65 Preliminary Estimated Cost Summary

SFWMD Ft. Myers SWRO		
Preliminary Estimated Cost Summary		
ESTIMATED PROJECT COSTS		
Total Construction Cost		$58,191,954
Engineering (10%)		$5,819,195
Construction Contingency		$14,547,989

(25%)		
Contractor's OH&P (17%)		$9,892,632
Interest During Construction (6%)		$3,491,517
Total		**$91,943,287**
Unit Costs		
Capital cost ($/m3)		$1,537
Capital cost ($/kgal)		$5,819
Capital cost ($/gal)		$5.82
Project cost ($/m3)		$2,429
Project cost ($/kgal)		$9,194
Project cost ($/gal)		$9.19
Total power cost ($/m3)		$0.18
Total power cost ($/kgal)		**$0.70**
SWRO power cost ($/m3)		$0.09
SWRO power cost ($/kgal)		$0.35
SWRO specific power (kWh/m3)		1.53
SWRO specific power (kWh/kgal)		5.78
Plant specific power (kWh/m3)		3.07
Plant specific power (kWh/kgal)		11.62
Annual O&M cost ($/m3)		$0.33
Annual O&M cost ($/kgal)		$1.25

A breakdown of estimated life cycle cost and equivalent annual cost per 1,000 gallons of finished water is included as Table 5.66.

A summary of present worth, O&M, capital and equivalent annual costs for each of the top three sites can be found in Table 5.67.

Table 5.66 – Estimated Life Cycle and Equivalent Annual Costs per 1,000 Gallons

Estimated Life Cycle Cost and Equivalent Annual Cost per 1,000 Gallons
Proposed Ft. Myers Facility

Parameters

Discount rate	5.125%	Base year		2007
Inflation rate	3.000%	Period of analysis - years		20
Year of cost estimate	2006	Annual availability factor		98%

Useful life by facility type or service	WC	40	PAE	20
(See Note 8)	OS	35	M	5
	W	30	NS	0

Item	Facility Type[8]	Initial Investment: Amount in Year of Cost Estimate Dollars	Amount in Base Year Dollars	Year Operational	Construction/ Service Duration - Years	Useful Life - Years	Present Value in Base Year[1]	Operation and Maintenance: Annual Amount in Year of Cost Estimate Dollars	Annual Amount in Base Year Dollars	Present Value[2]	Renewal and Replacement: Annual Amount in Base Year Dollars[3]	Present Value[4]	Total Present Value - Life Cycle Cost
Sitework	OS	$ 2,269,141	$ 2,337,215	2011	1.5	35	$ 2,187,133		$ -	$ -	$ 66,778	$ 825,350	$ 3,012,483
Buildings and structures	OS	$ 15,076,713	$ 15,529,014	2011	1.5	35	$ 14,531,831		$ -	$ -	$ 443,686	$ 5,483,821	$ 20,015,652
Process piping & equipment	PAE	$ 36,013,873	$ 37,094,289	2011	1.5	20	$ 34,712,309		$ -	$ -	$ 1,854,714	$ 22,923,688	$ 57,635,998
Engineering	NS	$ 5,819,195	$ 5,993,771	2011	1.5	0	$ 5,608,886		$ -	$ -	$ -	$ -	$ 5,608,886
Construction contingency	PAE	$ 14,547,989	$ 14,984,428	2011	1.5	20	$ 14,022,215		$ -	$ -	$ 749,221	$ 9,260,141	$ 23,282,356
Contractor overhead & profit	PAE	$ 9,892,632	$ 10,189,411	2011	1.5	20	$ 9,535,106		$ -	$ -	$ 509,471	$ 6,296,896	$ 15,832,002
RO elements and media	M	$ 4,832,227	$ 4,977,194	2011	2	5	$ 4,681,426		$ -	$ -	$ 995,439	$ 12,303,310	$ 16,984,736
Electrical			$ -	2011		0	$ -	$ 3,012,082	$ 3,102,445	$ 38,345,242	$ -	$ -	$ 38,345,242
Chemicals			$ -	2011		0	$ -	$ 1,054,542	$ 1,086,178	$ 13,424,821	$ -	$ -	$ 13,424,821
Labor			$ -	2011		0	$ -	$ 2,200,000	$ 2,266,000	$ 28,007,048	$ -	$ -	$ 28,007,048
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
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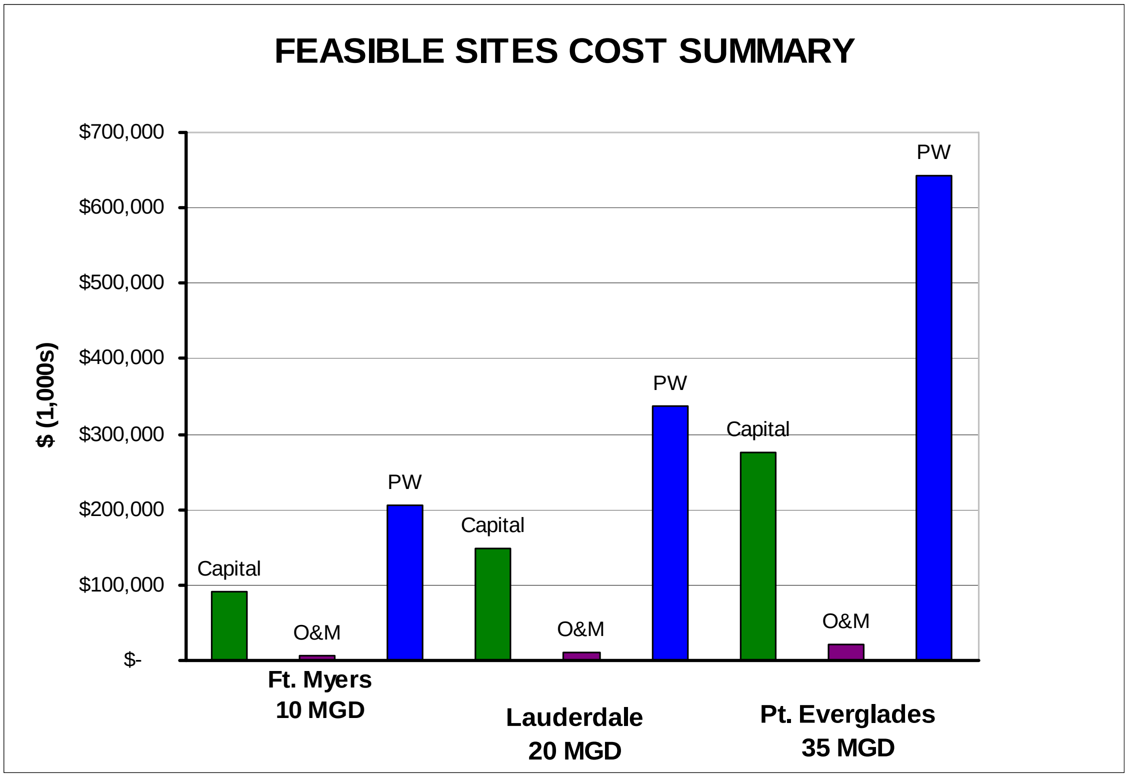
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
			$ -			0	$ -		$ -	$ -	$ -	$ -	$ -
Totals			$ 91,105,323				$ 85,278,907		$ 6,454,623	$ 79,777,111	$ 4,619,309	$ 57,093,206	**$ 222,149,224**

Equivalent Annual Cost[5]	$ 18,015,247
Facility capacity - average day - 1,000,000 gallons	10.0
Annual water production - 1,000,000 gallons[6]	3,577.00
Equivalent annual cost per 1,000 gallons[7]	**$ 5.04**

[1]Investment inflated based on time from base year to midpoint of construction, discounted to base year from midpoint of construction
[2]Discounted inflated future O&M during entire period of analysis less discounted inflated O&M expenses avoided prior to startup
[3]Straight line depreciation in base year dollars over use life of project
[4]Discounted inflated future R&R during entire period of analysis less discounted inflated R&R expenses avoided where project starts after base year
[5]Annual amount needed to finance total present value of project
[6]Calculated as average day capacity multiplied by 365 days per year multiplied by average annual availability factor - the percentage of time the facility is expected to operate.
[7]Includes renewal and replacement costs
[8]WC = Water Conveyance; OS = Other Structures; W = Wells; PAE = Process and Auxiliary Equipment; M = RO Membranes; NS = Non-structural Services

Note: Total capital cost for process piping & equipment is estimated to be $40,846,100. Of this amount, RO elements and membranes, with an estimated cost of $4,832,227, must be replaced every five years. Process piping & equipment has an estimated useful life of 20 years, while RO elements and membranes have an estimated useful life of 5 years. Therefore, the estimated cost of the RO elements and membranes was subtracted from the total cost for process piping and equipment and entered as a separate capital cost.

Table 5.67 – Cost Summary of the Top Three Candidate Sites



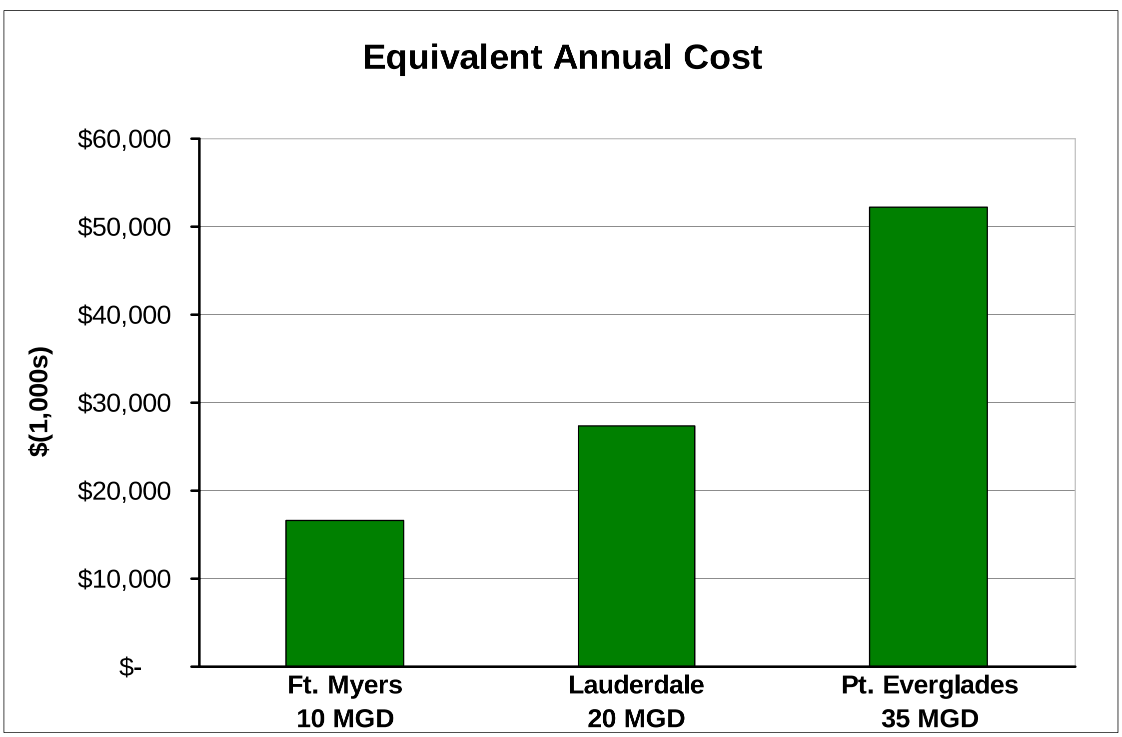
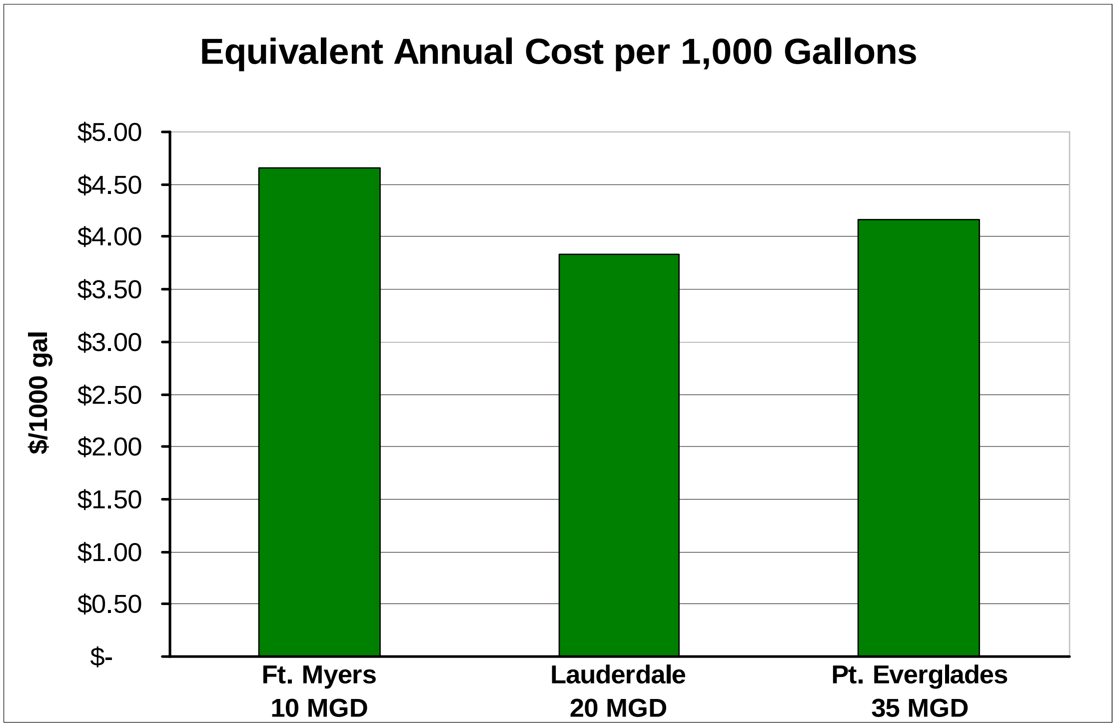


Table 5.67 – Cost Summary of the Top Three Candidate Sites (con't)



5.6 Permitting Requirements

5.6.1 Site Description and Environmental Characteristics

This section provides an overview of the site characteristics and environmental conditions at the three candidate sites. Wetlands resources described below were identified using National Wetlands Inventory (NWI) maps, 2006. Field verification would need to be completed to document the presence of jurisdictional wetlands and other environmental resources.

Ft. Myers Plant. As previously mentioned, the Ft. Myers power plant is located on approximately 480 acres in Lee County, between the Caloosahatchee and Orange Rivers. The plant receives cooling water from the Caloosahatchee River, a brackish river fed by Lake Okeechobee located on the north boundary of the property. The Caloosahatchee River is estimated to have an annual average total dissolved solids (TDS) concentration of approximately 15,000 ppm, while chloride concentrations have been measured at 8,204 mg/L at the plant intake. The plant discharges to the Orange River, located south of the site, which flows to the Caloosahatchee River.

For the purpose of this study, the projected capacity of the Ft. Myers facility is assumed to be 10 mgd of finished water. At a raw water TDS of 15,000 ppm and an RO recovery rate of 70%, it is estimated that 14.2 mgd of raw water will be required to provide 10 mgd of finished water. This will result in a brine discharge of approximately 4.2 mgd at a concentration of approximately 50,000 ppm. Brine discharge from the RO process will be blended with the cooling water discharge stream to reduce TDS concentrations to a level that minimizes environmental impacts to the receiving waters.

In order to determine the blended TDS concentration, cooling water flow data was analyzed using Discharge Monitoring Reports submitted by FPL on a yearly basis to the DEP. The 2005 data for the Ft. Myers facility indicated minimum, maximum and average cooling water flows of 533 mgd, 577 mgd and 571 mgd, respectively. To estimate a worst case scenario, blended TDS concentrations were calculated using the minimum cooling water flows reported in conjunction with the highest anticipated brine concentration and flow. With a minimum cooling water flow of 533 mgd and a brine reject flow of 4.2 mgd, it is calculated that the blended flow would have an approximate TDS of 15,300 ppm. This represents a TDS increase over raw source water TDS levels of approximately 2%.

Both the Caloosahatchee and Orange rivers are classified as Class III Waters, which are suitable for recreation and fish and wildlife. There are sensitive environmental areas in the vicinity of the power plant, including the Caloosahatchee National Wildlife Refuge, which is an Outstanding Florida Water (OFW) across the river from the plant site. The OFW has anti-degradation criteria associated with it (WRA, 2002). The discharge basin is a manatee aggregation site and a major wintering area for the endangered West Indian manatee. The power plant has a Manatee Protection Plan (WRA, 2002). A bird rookery is located 1500 feet northeast of the site (WRA, 2002). The plant site is zoned as industrial.

Within the plant property boundaries, the NWI map identifies freshwater emergent wetlands, freshwater ponds, freshwater forested/shrub wetlands, and estuarine and marine wetlands adjacent to the Caloosahatchee River in northwest section of the property. Freshwater forested/shrub wetlands are also located in the northeast area of the power plant property.

It appears that there is a pending Minimum Flow and Level Rule for the Caloosahatchee River regarding withdrawal of water from the river (SFWMD 2005). The feasibility of permit acquisition for the desalination facility depends on the size of the desalination facility and the final rule language. The option to blend the power plant cooling water discharge with the demineralized concentrate may be limited by the pending SFWMD rules, which may prohibit discharge of even slightly saline water to the Orange River, and eventually the Caloosahatchee River (WRA, 2002). Another option is the deep well injection of concentrate discharge, however, this geographical area is used for aquifer storage and recovery (ASR), which is a mechanism for storing potential drinking water during times of excess supply for later use. It may therefore be difficult to permit deep well injection of the discharge due to the presence of chlorides in the discharge, which may not meet Florida’s drinking water quality standards. The permitting process needs to address these and other expected environmental issues such as wetland impacts, stormwater control, and hazardous waste management.

Lauderdale Plant. As previously mentioned, the Lauderdale power plant is located in Broward County, Fort Lauderdale. Cooling water is obtained from the Dania Cutoff Canal, which is classified as Class III Waters. The Dania Cutoff Canal is estimated to have an annual average TDS concentration of approximately 15,000 ppm. Chloride concentrations are 8,204 mg/L at the plant intake. The plant discharges to the northeast through a cooling pond that leads to the New River prior to emptying into the Intercoastal Waterway, which is also classified as Class III Waters.

For the purpose of this study, the projected capacity of the Lauderdale facility is assumed to be 20 mgd of finished water. At a raw water TDS of 15,000 ppm and an RO recovery rate of 70%, it is estimated that 28.6 mgd of raw water will be required to provide 20 mgd of finished water. This will result in a brine discharge of approximately 8.6 mgd at a concentration of approximately 50,000 ppm. Brine discharge from the RO process will be blended with the cooling water discharge stream to reduce TDS concentrations to a level that minimizes environmental impacts to the receiving waters.

In order to determine the blended TDS concentration, cooling water flow data was analyzed using Discharge Monitoring Reports submitted by FPL on a yearly basis to the DEP. The 2005 data for the Lauderdale facility indicated minimum, maximum and average cooling water flows of 179 mgd, 363 mgd and 310 mgd, respectively. To estimate a worst case scenario, blended TDS concentrations were calculated using the minimum cooling water flows reported in conjunction with the highest anticipated brine concentration and flow. With a minimum cooling water flow of 179 mgd and a brine reject flow of 8.6 mgd, it is calculated that the blended flow would have an approximate TDS of 16,600 ppm. This represents a TDS increase over raw source water TDS levels of approximately 11%.

Within the plant property boundaries, the NWI map identifies freshwater forested/shrub wetlands adjacent to the New River in northwest section of the property. According to the NWI map, freshwater forested/shrub wetlands and freshwater emergent wetlands are located along the New River downstream of the plant site. In addition, the NWI map depicts a lake to the east of the power plant property.

The power plant site is zoned as utility. Sensitive environmental areas in the vicinity of the power plant include a manatee aggregation site in the discharge basin, which is a significant wintering site for endangered manatees. The permitting process would address environmental issues such as wetland impacts, stormwater control, and hazardous waste management.

Port Everglades Plant. As previously mentioned, the Port Everglades power plant is located in Broward County, Fort Lauderdale and is situated on approximately 94 acres. Cooling water is obtained from a 2,100 foot canal that leads out to Lake Mabel on the Atlantic Intercoastal Waterway. The canal at the plant intake is estimated to have an annual average TDS concentration of approximately 33,000 ppm. Chloride concentrations are 18,154 mg/L at the plant intake. The plant discharges to a 5,300 foot canal that leads to the Intercoastal Waterway at a point approximately one mile south of the power plant intake canal.

For the purpose of this study, the projected capacity of the Port Everglades facility is assumed to be 35 mgd of finished water. At a raw water TDS of 33,000 ppm and an RO recovery rate of 50%, it is estimated that 35 mgd of raw water will be required to provide 35 mgd of finished water. This will result in a brine discharge of approximately 35 mgd at a concentration of approximately 66,000 ppm. Brine discharge from the RO process will be blended with the cooling water discharge stream to reduce TDS concentrations to a level that minimizes environmental impacts to the receiving waters.

In order to determine the blended TDS concentration, cooling water flow data was analyzed using Discharge Monitoring Reports submitted by FPL on a yearly basis to the DEP. The 2005 data for the Port Everglades facility indicated minimum, maximum and average cooling water flows of 1,079 mgd, 1,202 mgd and 1174 mgd, respectively. To estimate a worst case scenario, blended TDS concentrations were calculated using the minimum cooling water flows reported in conjunction with the highest anticipated brine concentration and flow. With a minimum cooling water flow of 1,079 mgd and a brine reject flow of 35 mgd, it is calculated that the blended flow would have an approximate TDS of 34,000 ppm. This represents a TDS increase over raw source water TDS levels of approximately 3%.

Within the plant property boundaries, the NWI map identifies a freshwater pond to the southwest. According to the NWI map, there are also freshwater forested/shrub wetlands in the vicinity of the power plant property and estuarine and marine wetlands south of the property. The canal from which cooling water is obtained is depicted on the NWI map as estuarine and marine deepwater.

Sensitive environmental areas in the vicinity of the power plant include a manatee aggregation site in the discharge basin, which is a significant wintering site for endangered manatees. The power plant has a Manatee Protection Plan (WRA, 2002). The power plant site is zoned as industrial. The permitting process will address environmental issues such as wetland impacts, stormwater control, and hazardous waste management.

5.6.2 Potential Permits to be Required

The following summarizes several of the key federal, state, and county permits anticipated to be required for construction and operation of the facility. Permit requirements and the likelihood of obtaining permits would need to be verified with regulatory agencies should the proposed concept be pursued.

Assumptions made for the permitting requirements are the following:

1. The desalination plant will be co-located on the site of the power plant.
2. The desalination plant will take its feedwater from the cooling water discharge from the power plant. It is not anticipated that a new intake would be necessary.
3. The desalination plant demineralized concentrate will be blended with the power plant cooling water discharge downstream of the intake (or possibly deep well injected if Ft. Myers is the selected location and discharge to surface waters is deemed not feasible).

Note that some permits, such as NEPA, address both construction and operational issues and concerns.

National Environmental Policy Act (NEPA). The National Environmental Policy Act (NEPA) requires federal agencies to consider environmental impacts of their proposed actions and reasonable alternatives to those actions. Federal agencies such as the US Army Corps of Engineers (ACOE) and US Environmental Protection Agency (EPA) are required to prepare environmental documentation to assess the potential short- and long-term effects of their actions. Actions may include direct actions, as well as permitting and funding actions. Depending on the extent of impacts related to the construction and operation of the desalination facilities at any of the power plant sites, it is possible that the ACOE or EPA may determine that the action requires preparation of NEPA documentation.

The United States Army Corps of Engineers (ACOE) Section 404 Dredge and Fill Permit. An ACOE Dredge and Fill permit would be required for the construction of the desalination facility if it is anticipated that the project would impact jurisdictional wetlands or surface waters. The extent to which these resource areas are modified would determine which specific level of ACOE permit is required. If a project results in minimal cumulative impacts, it may be included under abbreviated forms of authorization, including Letters of Permission, Nationwide Permits or General Permits (ACOE, 2006). Letters of Permission are used when the proposed work is minor and would not have significant impact on environmental conditions. Nationwide Permits are activity specific and may require pre-construction notification. General permits are authorizations issued on a nationwide or regional basis for a category of activities when the activities are similar in nature and cause only minimal impacts. Individual permits are required when more significant alteration of resource areas is proposed.

FDEP Environmental Resource Permit. The ERP program regulates activities involving the alteration of surface water flows. This can include work in uplands that may affect stormwater flow, and dredging and filling of wetlands. The processing of applications can be delegated to the counties or to the water management districts. In some cases, the ERP is delegated, or partially delegated, to local governments. Information in a permit application typically includes an assessment of any wetlands or other environmentally sensitive areas and a discussion of the possible adverse impacts of the project.

If the proposed activities involve work in adjacent water bodies, such as the Intracoastal Waterway or Lake Okeechobee, SFWMD may request a title determination from the State of Florida as to whether the State has any claim to the submerged lands (SFWMD, 2006a). If so, the SFWMD will also process any required authorizations from the State of Florida for use of the submerged lands. These authorizations must be processed along with the permit application.

For parcels containing wetlands in the vicinity of the Ft. Myers Power Plant, the ERP must be obtained and a copy provided to Lee County prior to the release of Lee County development orders and building permits (Lee County Government, 2006). Lee County incorporates FDEP conditions into building permits. For work in waters in the vicinity of Lauderdale and Port Everglades Power Plants, an addendum must be completed and submitted, along with a copy of the ERP, to Broward County (Broward County, 2006).

South Florida Water Management District (SFWMD) Consumptive Use Permit. This permit allows a user to withdraw a specified amount of groundwater or surface water for a public water supply or for industrial processes. Water use permits are required for fresh and saline sources but are not anticipated to be required for seawater sources. Therefore, it is expected that this permit will not be required for plants that take feedwater directly from seawater. Saline water is defined by South Florida Water Management District (SFWMD) as an aqueous solution with a chloride concentration greater than 250 mg/L and less than that of seawater (SFWMD, 2003). Seawater is defined as an aqueous solution with a chloride concentration equal to or greater than 19,000 mg/L. The chloride concentrations of 8,204 mg/L at the Ft. Myers and Lauderdale plant intakes and 18,154 mg/L at the Everglades plant intake would be considered saline according to the SFWMD definition of saline water.

The information that would typically be provided in a Consumptive Use Permit includes the quantity and source of the water requested, the location of the water source and groundwater or surface water wells, the intended uses for the water, and any water conservation and recycling plans.

FDEP Application for a Public Drinking Water Facility Construction Permit. Approval will be needed for operation of the proposed desalination facility. FDEP regulations (Chapter 62-555) address public water supply construction permitting. FDEP has delegated authority for permit approval to some county Departments of Health.

FDEP Industrial Wastewater Facility Permit. This permit is required for the discharge of effluent to receiving waters. It may be possible to modify the current FDEP Industrial Wastewater Facility (IWWF) permit for the power plant. If modification of the permit is not feasible, then a separate NPDES permit for discharge of demineralized concentrate would be needed (see below).

Information typically included in permit applications include a map of the discharge location, a line drawing indicating direction of flow from intake to discharge and including all operations that contribute to wastewater, and tabular data regarding plant production and intake and effluent characteristics.

FDEP NPDES Demineralized Concentrate Permit. FDEP may determine that a separate discharge permit is required for the desalination facility to discharge demineralization concentrate. FDEP has developed proposed rules in Chapter 62-620 F.A.C. The rules were effective July 9, 2006, although EPA Region 4 Water Quality Standards Section's approval of ionic imbalance toxicity mixing zone revisions to Rule 62-4.244(3)(d) may be pending.

The permit application should include a description of the discharge location, information regarding the permitted capacity of the existing facility, and analytical data regarding the blend of demineralized concentrate and wastewater.

FDEP Class I Test/Injection Well Construction and Testing Permit. Class I wells are used to inject nonhazardous waste or municipal waste below the lowermost underground sources of drinking water (USDW). This permit would need to be obtained if surface water discharges are not permitted at Ft. Myers Power Plant and a deep well injection system is necessary. The type of information typically provided in the permit application includes tabulation of data for wells within the area of review that penetrate the proposed injection zone, proposed operating data, including injection rate and injection pressure, a proposed injection procedure and stimulation program, contingency plans for well failure, monitoring plans, and construction procedures.

FDEP Class I Injection Well Operation Permit. If discharging to surface water is not a possibility at Ft. Myers Power Plant, this permit application would be submitted following the completion of the operational injection test program. A typical permit application would include results of the information obtained under the construction permit, a certification of completion and a proposed monitoring program.

Broward County Wastewater Discharge Permit. Broward County may determine that a wastewater discharge permit is required for the desalination facility in accordance with Broward County Code Chapter 34-142(A)2. Permitting is required to ensure that pretreatment equipment proposed is adequate to meet appropriate discharge limits. Information typically provided in a discharge permit application includes a list of environmental permits held, sources for water, and the intended water use.

FDEP Air Pollution Sources Permit. Emission sources, including emergency generator would be reviewed to determine if thresholds are exceeded and permit would be required. This permit may be delegated to the county level.

5.7 Key Provisions of an Operating Agreement between Water Utility and Electric Utility

The principal types of provisions for an operating agreement between a water utility and electric utility relating to the co-location of a water treatment plant include the following:

- Definitions of terms
- Contract duration
- Services to be provided by electric utility
- Services to be provided by water utility
- Electric utility performance requirements
- Water utility performance requirements
- Prices
- Price adjustments
- Liquidated damages

This is not intended to be a complete list of the terms and conditions that would appear in the agreement between a water utility and electric utility. Numerous other terms and conditions such as insurance, indemnification, severability, and termination must be included as well, but these types of contractual terms do not bear as directly on co-location of a water treatment plant as the key provisions listed above.

The principal components of these of these contractual provisions are described below.

Definitions of terms

The agreement will address a wide range of services, commodities, and other factors that must be fully defined up front to ensure a common understanding of the commitments and obligations of each party to the agreement. The terms may need to clarify each component of the raw water supply, electric power delivery, and disposal of desalination waste byproducts.

Contract duration

The contract duration must be carefully considered to ensure that it corresponds to the expected operating life of the electric power facility and the expected useful life of the water treatment plant, taking into account the time required to bring the water treatment plant on line.

Services to be provided by electric utility

The principal services likely to be provided by the electric utility are the following:

- Site lease
- Raw water supply
- Electric power – may be provided separate from this agreement through standard utility tariff
- Disposal of desalination waste byproducts

Services to be provided by water utility

The principal service likely to be provided by the water utility is the following:

- On-site provision of process and sanitary water

Electric utility performance requirements

The principal areas in which the electric utility would commit to perform are the following:

- Delivery of property lease, including necessary easements – if lease is needed from electric utility
- Delivery of raw water, including point of delivery, quantity, quality, and schedule
- Delivery of electric power, including point of connection, energy, demand, and schedule – as noted above, may be provided separate from this agreement through standard tariff
- Acceptance of desalination waste byproducts, including point of connection, quantity, quality, and schedule
- Land use permitting and zoning – if site is on electric utility property
- Environmental permitting – if site is on electric utility property

Water utility performance requirements

The principal areas in which the water utility would commit to perform are the following:

- Agreement to construct water plan on leased site, including conformance to lease terms
- Acceptance of raw water, including point of delivery, quantity, quality, and schedule
- Acceptance of electric power, including point of connection, energy, demand, and schedule – as noted above, may be provided separate from this agreement through standard tariff
- Delivery of desalination waste byproducts, including point of connection, quantity, quality, and schedule
- Land use permitting and zoning
- Environmental permitting

Prices

This agreement provision must include the prices to be paid by each party, including commodity prices, demand charges, and put-or-pay amounts. Prices must be established for the following services:

- Property lease
- Site development, including permitting and zoning
- Raw water supply
- Electric power
- Disposal of desalination waste byproducts
- Process and sanitary water supply
- Other services

Price adjustments

Each price must ordinarily be subject to adjustment based on a predetermined factor, such as inflation rates or energy costs.

Liquidated damages

This contract provision must reflect the estimated cost that either party would incur in the event of the other party's failure to perform. Liquidated damages must be fair and reasonable.

5.8 Potential Funding of Co-Located Desalination Project

There are two principal potential funding sources for a co-located desalination project:

- Standard rates and charges of the water utility
- Grant or loan from the South Florida Water Management District pursuant to Section 373.196 Florida Statutes, as amended by the 2005 State of Florida Legislature by Senate Bill 444

The use of a utility's standard funding sources is self-explanatory. A utility may fund any water supply project through its rates and charges.

The grant funding available through the South Florida Water Management District generally requires that the project be a part of the District's approved regional water supply plans, and relate to "alternative water supply projects." Alternative water supply projects are defined as those that use saltwater or brackish water, surface water from wet-weather flow, sources from new storage capacity, reclaimed water, stormwater, and any other non-traditional water supply. Co-located desalination clearly qualifies as an alternative water supply, and would quality for funding assistance through this channel.

Grant funding from the South Florida Water Management District would greatly assist in the development of any co-located desalination project due to the relatively high cost of the project when measured in terms of the cost per gallon produced. Under State Statutes, under normal circumstances the financial assistance may not exceed 60 percent of the capital cost of the project, but a grant of such amount would generally fund all or much of the additional cost of the project over a traditional water supply project.

Aside from these two funding sources, the only additional source of financial assistance for a co-located desalination project is available through the State of Florida State Revolving Fund loan program. This program, which offers low interest loans to municipal water and sewer utilities, provides loans well below the interest rate available through the municipal revenue bond market.

5.9 Implementation Plan

Implementation of a demonstration project at any of the three sites evaluated above, include the following phases:

Treatment Pilot Program - Implementation of a pilot program is critical to collect adequate water quality and testing of the technology for both pretreatment and membranes for proper sizing and configuration. It will also help address the production and management of the brine and residuals.

Permitting - This phase will look at all sensitive environmental resources and environmental concerns at each site and identify key environmental issues associated with siting of the facilities as well as disposal of the brine. All required environmental permits will be obtained during this phase.

Design - This phase involves the design of the full scale plant, bid and award of construction contracts.

Construction - This phase involves the actual construction of the treatment facility and any ancillary infrastructure such as distribution system improvements and pumping stations.

Operating Agreement - This phase is critical in order for the utility and FPL to develop an agreement to implement and operate the facility. This phase must commence at the same time as the pilot program, if not earlier.

Figure 5.6 shows a concept schedule for the implementation of the demonstration project.

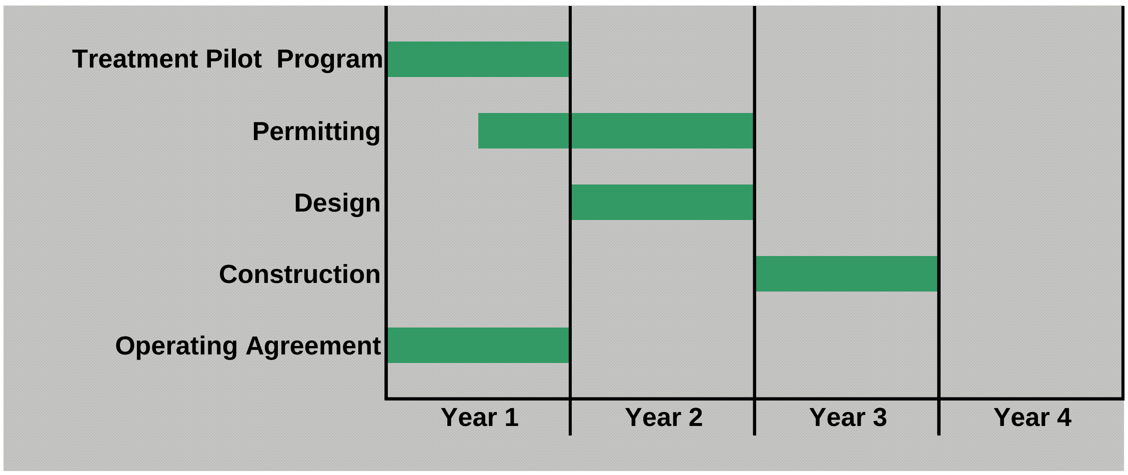


Figure 5.7 – Proposed Demonstration Project Implementation Schedule

6. Permitting Investigation of Co-located Seawater Desalination Facility at Virginia Key

6.1 Site Evaluation

The South Florida Water Management District (SFWMD) in collaboration with the Miami-Dade Water and Sewer Department (MDWASD) is evaluating the technical and permitting feasibility of co-locating a seawater desalination plant with the existing central district wastewater treatment plant (CDWWTP) at Virginia Key, FL. Virginia Key is located in Miami-Dade County just north of Key Biscayne, the southernmost of the barrier islands off the east coast of Florida. Virginia Key is connected to the city of Miami by the Rickenbacker Causeway (Figure 6.1).

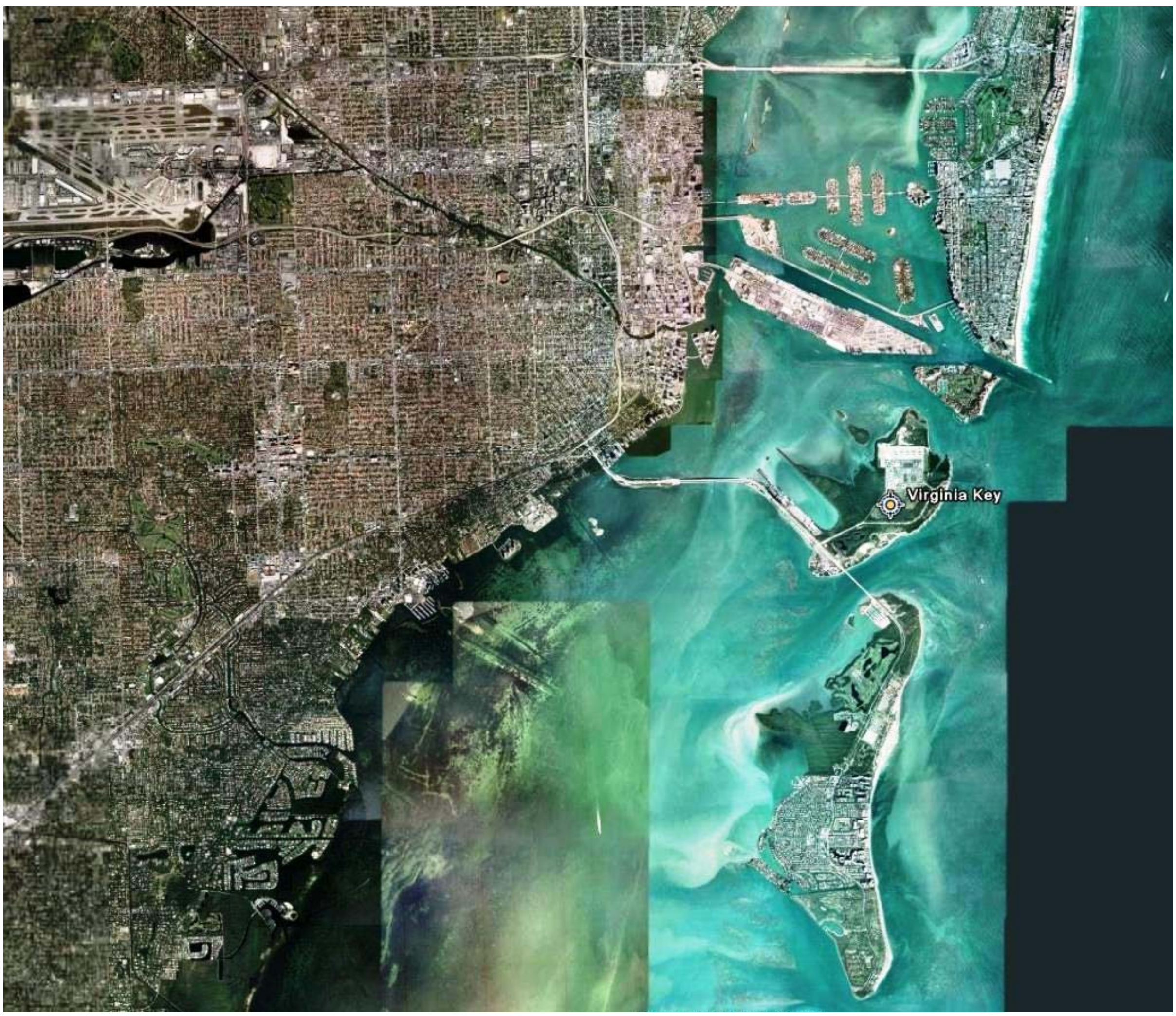


Figure 6-1—Location Map of Virginia Key

The proposed desalination facility would be located on the northeast corner of the CDWWTP on the site of the former sludge drying beds associated with the CDWWTP (Figure 6.2). The SFWMD and the MDWASD would like to pursue the development of a desalination facility in this location. A desalination plant located in this area would provide valuable additional potable water capacity for the MDWASD system. This location appears to be favorably suited for siting a seawater reverse osmosis (SWRO) facility, for several reasons: Miami-Dade County owns the land; the SWRO can be located at the site of the existing CDWWTP where there is adequate land available (> 5 acres); CDWWTP discharge can be used to blend the demineralized concentrate from the SWRO facility prior to discharge through the existing CDWTTP outfall.

Figure 6-2—Proposed Location of Desalination Plant

Existing Environmental Conditions at Virginia Key

For the purpose of this feasibility study, available mapping was reviewed and preliminary correspondence was initiated with regulatory agencies such as the Florida Department of Environmental Protection (FDEP), the Florida Fish and Wildlife Conservation Commission, and the Miami Dade Department of Environmental Resource Management (DERM) to determine the general environmental conditions and sensitive resources on the Key. Preliminary meetings with DEP and DERM were also held to informally discuss permitting requirements.

There are sensitive environmental areas both on Virginia Key and in the offshore waters. Biscayne Bay Aquatic Preserve, a critical wildlife area, and a U.S. Army Corps Important Manatee Area, are located between western shore of Virginia Key and the city of Miami. In addition, a No Entry Zone preventing boat traffic for manatee protection is located to the west of the island and a slow speed zone is located to the north/northeast between Virginia Key and Fisher Island and to the south between Virginia Key and Key Biscayne. There appear to be protected areas in the off shore waters to the east of the site, as the existing CDWWTP outfall runs through an area identified as “particularly” sensitive. In addition, staff from both FDEP and MD DERM noted the presence of natural and artificial reefs in the waters to the east of Virginia Key, as well as the presence of important seagrass and turtle habitat.

Resources on Virginia key include jurisdictional wetlands. The National Wetlands Inventory Maps, 2006 for the Key show freshwater ponds in the central and south central portion of the key, and estuarine and marine wetlands along the shoreline for almost the entire perimeter of the key. A formal delineation would be needed to verify the presence of all wetlands areas. Other resources on the key or in the waters offshore of the key include sea turtle habitat, the presence of rare or endangered species, and the presence of hard bottom habitat. Environmental concerns related to installation of open water intake facilities would include potential impingement or entrainment issues. There are “Standard Manatee Protection Construction Conditions” designed to offset impacts during in-water work, including minimizing habitat loss, installing grates for submerged pipes (depending on pipe dimensions), and watching for manatees during construction. The beach area itself provides valuable recreational area.

Information from MD DERM indicates that a landfill is located on land just south of the existing CDWWTP. The landfill, which is on land owned by the city of Miami, has not been closed, and monitoring of leachate from landfill may be ongoing. Monitoring data would be very helpful in determining the location of the plume in relation to possible sites for the desalination intake.

Land uses in the southern portion of Virginia Key consist of commercial uses, including campus facilities and governmental property. There are no permanent residential facilities on the island, although there are residential developments on Fisher Island, located to the north of Virginia Key, with views to the area of the CDWWTP. The City of Miami has just recently commenced the development and preparation of a master plan for Virginia Key. At this point however, the City has indicated is too early in the process to identify specific issues related to future land use/development in Virginia Key. The historical Virginia Key Beach, which was listed on the National Register of Historic Places in 2002, is located in the southern portion of Virginia Key. Also located in the southern region of Virginia Key are Miami Seaquarium, the University of Miami Rosenstiel School of Marine and Atmospheric Science, the National Marine Fisheries Service’s Southeast Fisheries Science Center, and the U.S. National Oceanic and Atmospheric Administration (NOAA) Atlantic Oceanographic and Meteorological Laboratory (AOML).

More detailed evaluation of the resources and activities present on the key and the potential effects associated with construction and operation of desalination facilities would be needed as the concept is more fully developed

6.2 SWRO Facility Sizing

Based on preliminary meetings and discussions with the Miami-Dade Water Sewer Department, a 15-20 mgd desalination facility is proposed. This capacity responds to the current needs as well as to the capacity of the existing water distribution system going into Virginia Key.

Seawater would be withdrawn from the ocean, pretreated, and then treated by reverse osmosis to remove the salt. The reverse osmosis process would operate at 50 percent recovery, thus 40 mgd of seawater would be withdrawn to produce 20 mgd of potable water. The remaining 20 mgd of water will be demineralized concentrate and will be blended with the effluent from the CDWWTP prior to discharge via the CDWWP existing outfall. The CDWWTP currently discharges just under an average of 120 million gallons per day (mgd) thus providing a 6:1 blending ratio with 20 mgd of demineralized concentrate. It is assumed that TDS concentration in the raw seawater would be approximately 33,000 mg/l. At a 50 percent recovery rate, the demineralized concentrate would have TDS concentration of 66,000 mg/l. Blending of the demineralized concentrate with the CDWWTP effluent will reduce the TDS concentration in the brine to 11,000 mg/l at the outfall discharge point (this does not factor in the TDS of the CDWWTP effluent). Note that the concentration of TDS in the blended demineralized concentrate would vary depending on variations in the volume of discharge from the CDWWTP.

Several alternatives are under consideration for the seawater intake. These include 1) use of an open sea intake; 2) vertical beach wells; 3) linear infiltration galleries; and 4) infiltration Ranney wells. There are advantages and disadvantages to each alternative and much is dependent on specific surface and subsurface conditions along the shore and in the offshore coastal area. Further study would need to be done to fully study the alternatives, however, for the purpose of this feasibility study the experience with other desalination projects is helpful in assessing the potential environmental concerns that might be associated with the alternatives at Virginia Key.

Seawater Intake. A seawater intake would consist of a submerged pipe extended eastward into approximately 60 feet of water. Due to the extent of shoals, it is expected that the pipe would need to extend approximately three miles off shore. Two alternative routes have been preliminarily proposed and are shown in Figure 6.3. Both of the alternatives, which would extend from the site to the northeast or to the southeast of the existing CDWWTP outfall pipe, cross sensitive maritime or environmental resource areas. In both alternatives, the pipe would be buried and protected with heavy armor stone. At the end of the intake a riser pipe bearing the intake screen would protrude above the ocean floor. Figure 6.4 shows the typical profile of a seawater intake running from the beach to the riser. It may be possible to install the pipeline using trenchless technology if open cut construction is not feasible due to environmental constraints.

Vertical Beach Wells. The use of vertical beach wells for seawater intake is limited in the United States. There are no known vertical seawater beach wells operating

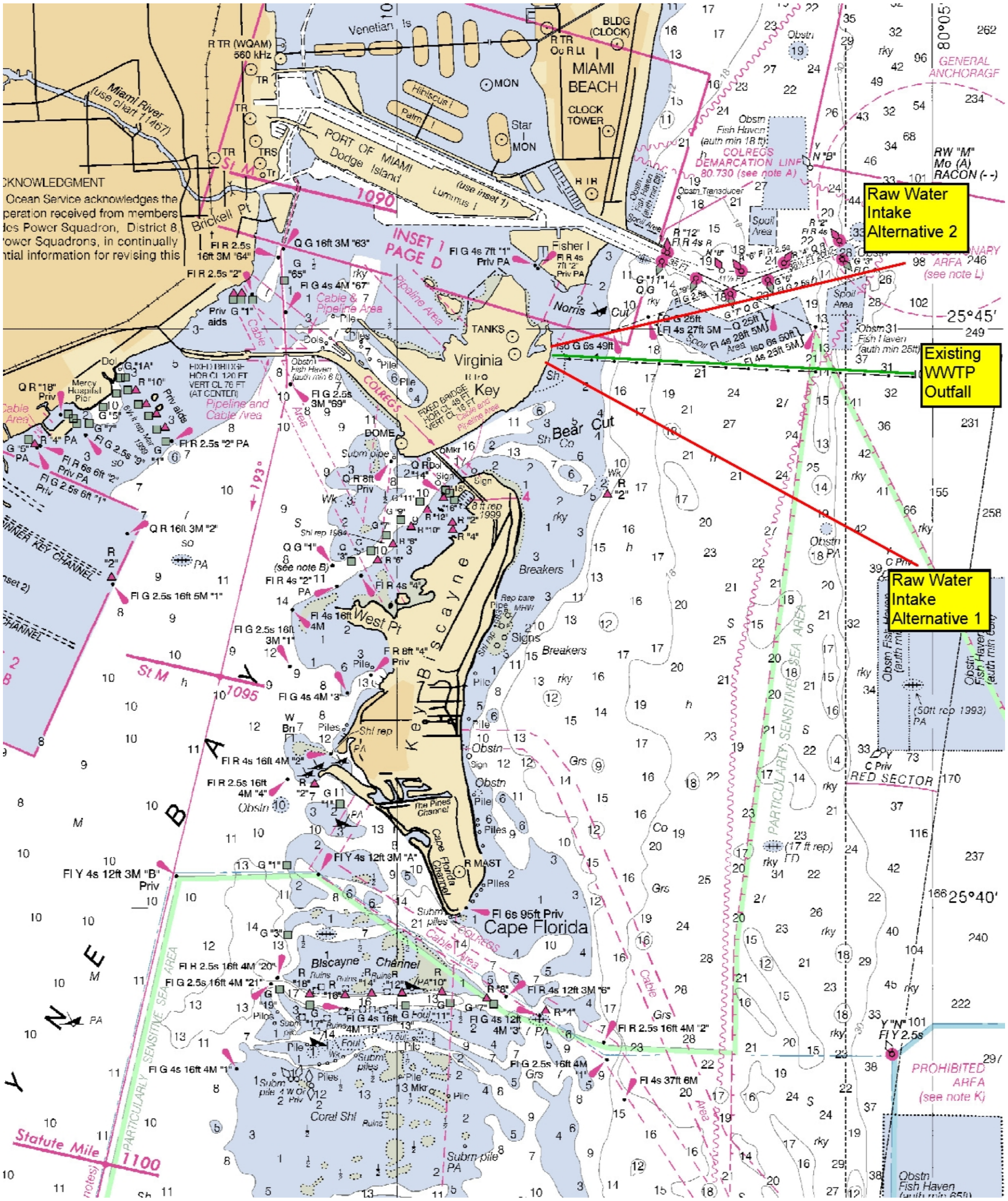


Figure 6-3—Possible Location of Off-Shore Seawater Intake

continuously in the US serving plant capacities over 0.8 mgd. The yield of each individual well often is not substantial thus it is estimated that in excess of 20 wells may be needed at the Virginia Key site. Operation and maintenance of the wells also can be onerous, and the location on the eastern shore of Virginia key would raise concerns about stability during extreme storm events. The wells may affect the balance between intruded seawater and freshwater and can result in potential upcoming of deeper brines. Figure 6.5 shows a typical profile of a vertical beach well.

Linear Infiltration Gallery. A linear gallery would lie on the beach parallel to the coastline, drain from each end to a central sump and subsequently to a pumping station landward of the beach (see typical plan view shown in Figure 6.6). Depending on specific hydrogeologic conditions, the gallery may be up to five miles in length and thus would result in substantial alteration of the beach area, unless it is feasible to site the gallery further landward.

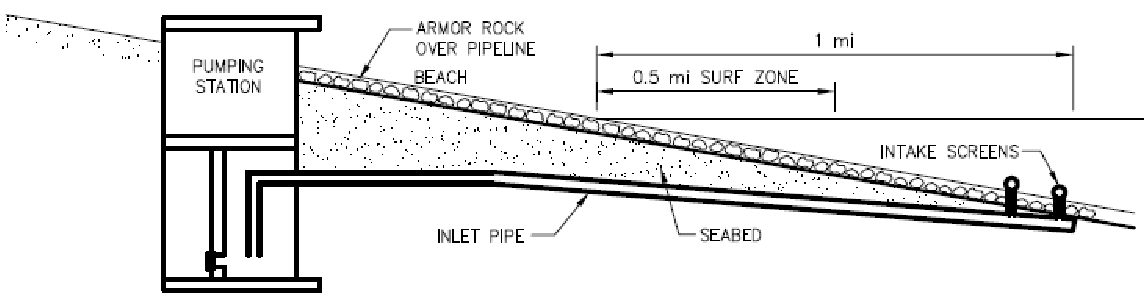


Figure 6-4 - Profile of Typical Seawater Intake

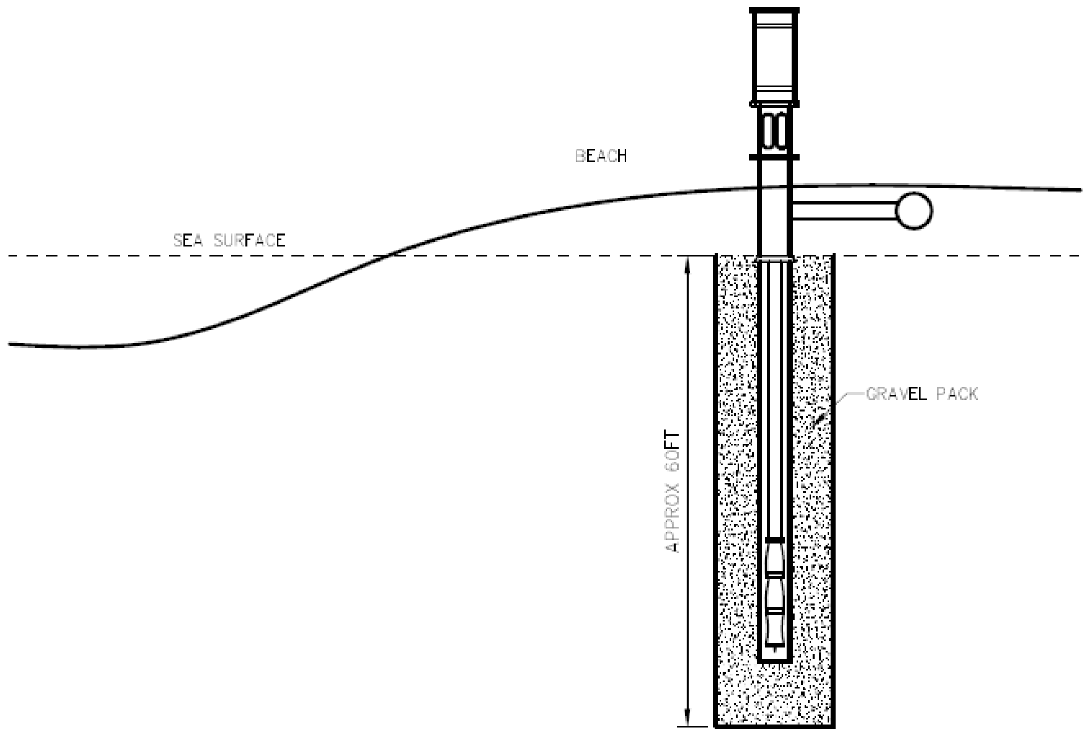


Figure 6-5— Profile of Typical Vertical Beach Well

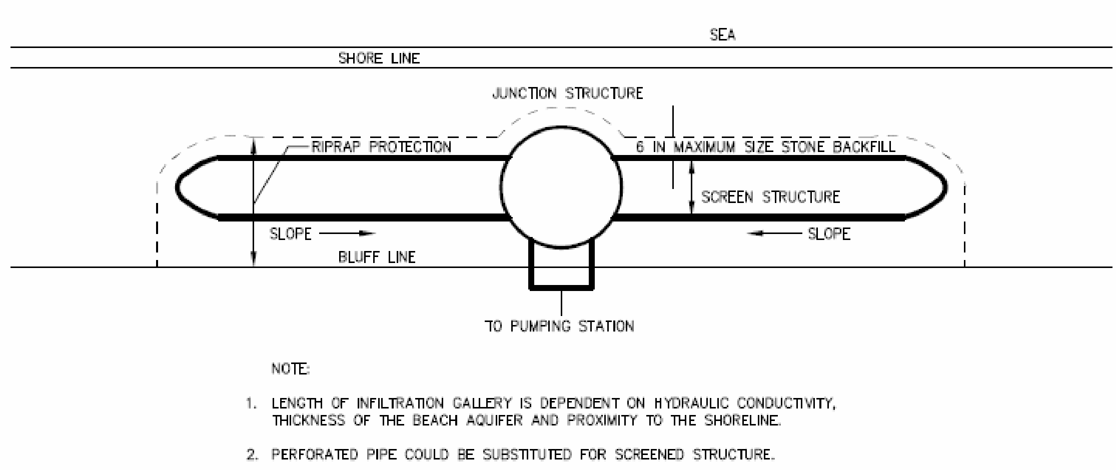


Figure 6-6—Plan View of Typical Linear Beach Infiltration Gallery

Ranney Well. Another type of infiltration system consists of two or more long screens jacked out under the seabed from an onshore caisson, sometimes called a Ranney Well (see Figure 6.7 for plan view of Ranney Well). The number of caissons depends on hydraulic conductivity of the seabed; it is assumed for this project that up to five caissons may be needed. The caissons would each contain a pump station conveying water to a common header connecting to the desalination plant.

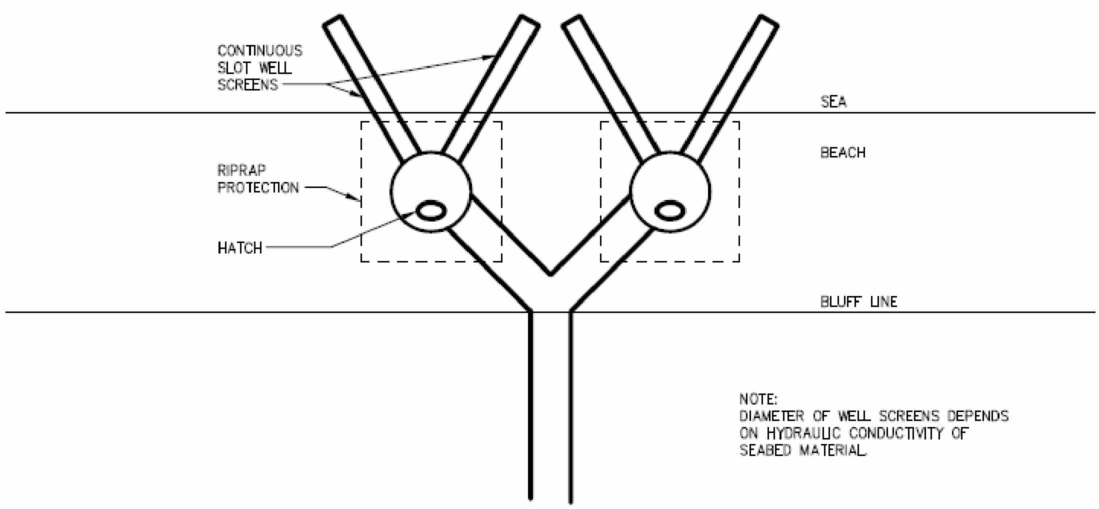


Figure 6-7 — Plan View Typical Ranney Well

Potable water from the desalination facility would be connected to the existing MDAWSD water distribution system. .

6.3 Evaluation of Permitting Requirements

Site plans or layouts of the various components of a desalination facility have not yet been prepared. These will be prepared in subsequent phases of the project as more detailed environmental and design information becomes available. Depending on which of the various alternatives for seawater intake is selected, permitting requirements will vary. For example, construction of a seawater intake through open cut construction methods would result in potentially significant environmental impacts to a number of different resources, and the associated permitting and mitigation development would likely be onerous. Choosing an alternative construction method such as directional drilling, which minimizes surface disturbance, would reduce the permitting challenges. Siting of alternative intake facilities such as the vertical or horizontal infiltration galleries/wells would avoid disturbance in the open water, however, there would be potentially significant temporary disturbance of the beach area during construction. While much of the surface area would be restored, helping to reduce long-term effects, both FDEP and MD DERM suggest siting facilities upland of the coastal beach and dunes to the extent possible. Installation of the Ranney wells would also potentially require temporary disturbance of the beach area, depending on where the caissons are located, however, the screens would be jacked beneath the seafloor, thus the disturbance during construction in the near shore area would be minimized.

Given that there are many siting factors still to be determined, the following discussion of permits that may be required for construction or operation of the desalination facilities outlines many of the key permits that may be required, and the regulating agency. This is not intended to be an exhaustive list of all state, county and local permits and approvals that may be required. Such a list would need to be prepared for the selected alternatives in later phases of project development. It is important to note that a number of different consulting agencies and environmental resource groups have the ability to provide comment during the permit review process. These agencies include the natural resource agencies such as the Florida Fish and Wildlife Conservation Commission and the US Fish and Wildlife Service. In addition, public interest groups may also provide comment during the public review process. Permit requirements will be verified through continued discussions with the permitting agencies throughout the development and refinement of the proposed project.

The following outlines key permits anticipated to be required to undertake construction and operation of the proposed desalination facilities. Note that some permitting processes, such as NEPA, address both construction and operational issues and concerns.

National Environmental Policy Act (NEPA)- The National Environmental Policy Act (NEPA) requires federal agencies to integrate environmental values into their decision making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. Federal agencies such as the US Army Corps of Engineers and US Environmental Protection Agency (EPA) are required to prepare environmental documentation to assess the potential effects of their actions which include permitting and funding. Depending on the extent of impacts related to the construction and operation of the desalination facilities it is possible that the ACOE or EPA may determine the action requires preparation of NEPA documentation. This is assumed to be more likely for alternatives that would result in extensive alterations or loss of resource areas, such as the open seawater intake alternative constructed by open cut construction as this alternative would be likely to result in significant effects to coastal resource areas.

The United States Army Corps of Engineers (ACOE) Section 404 Dredge and Fill Permit. An ACOE Dredge and Fill permit would be required for the construction of the desalination facility if it is anticipated that the project would impact jurisdictional wetlands or surface waters. The extent to which these resource areas are modified would determine which specific level of ACOE permit is required. If a project results in minimal cumulative impacts, it may be included under abbreviated forms of authorization, including Letters of Permission, Nationwide Permits or General Permits (ACOE, 2006). Letters of Permission are used when the proposed work is minor and would not have significant impact on environmental conditions. Nationwide Permits are activity specific and may require pre-construction notification. General permits are authorizations issued on a nationwide or regional basis for a category of activities when the activities are similar in nature and cause only minimal impacts. Individual permits are required when more significant alteration of resource areas is proposed. It is anticipated that an individual permit would be required for construction of an open seawater intake constructed by open cut construction methods. It is also anticipated that ACOE approval under Section 10 of the River and Harbors Act may be required for the open ocean intake alternative, or for other alternatives encroaching into the bay area.

FDEP Environmental Resource Permit (ERP)—The ERP program regulates activities involving the alteration of surface water flows. This can include work in uplands that may affect stormwater flow, and dredging and filling of wetlands. The processing of applications can be delegated to the counties or to the water management districts. For activities at Virginia Key related to a proposed desalination facility, FDEP has indicated that it will likely take the lead in processing the application. MD DERM has existing limited delegation of ERPs for stormwater management of project of certain sizes not in jurisdictional wetlands. Since it is expected that components of the proposed desalination project (regardless of which intake alternative is selected) would result in impacts to jurisdictional wetlands, it is expected that FDEP will act as the primary regulatory authority for the Virginia key desalination project. The ERP may also provide regulatory authority to use sovereign submerged lands. This permit would be coordinated with permitting requirements for the United States Army Corps of Engineers (USACOE).

FDEP Construction Control Line Permit. Initial indications from FDEP are that a Coastal Construction Control Line Program (CCCL) permit may be required. This will be determined once a site plan has been developed and the location of the facilities can be confirmed. The Construction Control Line permitting program provides protection for Florida's beaches and dunes while assuring reasonable use of private property. The intent of the program is to protect the coastal system from improperly sited and designed structures which can destabilize or destroy the beach and dune system. Approval or denial of a permit application is based upon a review of the potential impacts to the beach dune system, adjacent properties, native salt resistant vegetation, and marine turtles.

FDEP Joint Coastal Environmental Resource Permit- Initial indications from FDEP are that this permit may not be needed; that the ERP would address the environmental issues associated with coastal construction activity. However, the need for JCP will be verified as more definitive site plans are developed for the project. This permit may be required for all activities located on Florida's natural sandy beaches facing the Atlantic Ocean, extend seaward of the mean high water line, and that are likely to affect the distribution of sand along the beach.

Miami-Dade County Department of Environmental Resources Management Class I Permit for Coastal Construction within Miami-Dade County-A Class I permit is anticipated to be required as project activities may involve dredging in coastal or tidal waters of Miami-Dade County. DERM may require modification of the project to eliminate avoidable impacts and reduce other impacts. Mitigation is required for unavoidable impacts.

FDEP Industrial Wastewater Facility Permit- FDEP has indicated that it may be possible to modify the current Florida Department of Environmental Protection Industrial Wastewater Facility (IWWF) permit for the CDWWTP. FDEP notes that US EPA also participates in the review process of new outfall discharges. Information regarding the quality of the blended demineralized concentrate and wastewater treatment plant effluent and information regarding discharge plume movement would need to be provided as part of the application. If, for some reason, modification of the CSWWTP NPDES permit is not feasible, then separate NPDES permit for discharge of demineralized concentrate would be needed (see below).

National Pollutant Discharge Elimination System (NPDES) Demineralized Concentrate Permit- As noted above, FDEP may determine that separate discharge permit is required for the desalination facility to discharge demineralization concentrate. DEP has developed proposed rules in Chapter 62-620 F.A.C. The rules were effective July 9, 2006 with the exception of pending decision related to EPA Region 4 Water Quality Standards Section approval of ionic imbalance toxicity mixing zone revisions to Rule 62-4.244(3)(d).

FDEP Air Pollution Sources Permit- FDEP has indicated that approval of applications for air emissions would be provided by DERM. DERM notes that requests for approval are reviewed by the DERM Air Quality Management Division. As more design information becomes available, emission sources, including emergency generator use, would be reviewed with the Division to determine if thresholds are exceeded and to confirm the required permitting documentation.

Florida Department of Environmental Protection (FDEP) Application for a Public Drinking Water Facility Construction Permit - Approval will be needed for operation of the proposed desalination facility. FDEP regulations (Chapter 62-555) address public water supply construction permitting. FDEP has delegated authority for permit approval to some county Departments of Health. Initial discussions with FDEP indicated that FDEP has delegated the approval process for Miami-Dade County to the Miami-Dade Department of Health, however, the FDEP did request that they be copied on all filings. It appears from the FDEP regulations that construction and operation of a small scale facility may not require full permit approval if the pilot plant discharges the water to waste, instead of to a public water supply system. The specific requirements will need to be confirmed with the Miami-Dade County DOH as more details on the proposed pilot program become available.

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Appendix A

Membrane Desalination Treatment Systems within the SFWMD

Appendix A

Membrane Desalination Treatment Systems within the SFWMD

Appendix A - Membrane Desalination Treatment Systems within the SFWMD

County	City	System Name	Design Capacity (mgd)	Total System Capacity (mgd)	Desal Under Construction (MDG)	Date In Service
Broward	Deerfield Beach	West WTP brackish Water RO Treatment Improvements - Phase I			1.5	2007
Broward	Sunrise	Pumping and Piping Facilities for Sawgrass Blending Well			2.0	2007
Broward	Hollywood	Rehabilitation of Reverse Osmosis System			3.0	2007
Broward	Miramar	2 Floridan wells, pumping and transmission systems			6.0	2007
Broward	Hallendale	Floridan well and facility			15.0	2007
Broward	Hollywood	Additional Floridan Wells (Phase I)			1.5	2008
Broward	Hollywood	Additional Reverse Osmosis Trains (C&D) at the Water Treatment Plant (WTP)			4.0	2008
Collier		North County Regional Water Treatment Plant			1.0	2007
Collier		Brackish Water Supply Reliability Improvements			3.5	2007
Collier		South County Regional Water Treatment Plant 12 mgd Reverse Osmosis		20.0	12.0	2007
Collier		North County Regional Water Treatment Plant			1.5	2008
Collier		North County Regional Water Treatment Plant		20.0	2.0	2008
Collier		Northeast Regional Water Treatment Plant Wellfield Phase 1.A			15.0	2008
Collier	Marco Island	Marco Island RO Plant 2		12.67		1992
Collier	Naples	Collier County Regional Plant 2				
Collier	Naples	Collier County North	8.0	20.0	2.0	1999
Collier	Naples	Collier County North	8.0	20.0	12.0	2004

Appendix A - Membrane Desalination Treatment Systems within the SFWMD

Collier	Marco Island	Marco Island	6.0	12.7		1992
Hendry	Clewiston	City of Clewiston Reverse Osmosis Water Treatment Plant			3.0	2007
Broward	Ft Lauderdale	Peele-Dixie		59.0	6.0	2008
Lee	Sanibel	Island Water Assoc. - Plant 1		4.7		1973
Lee	Cape Coral	City of Cape Coral		14.7	3.1	1976
Lee	Cape Coral	North			12.0	2006
Lee	Bonita Springs	Bonita Springs Utilities RO WTP	6.0	15.6	3.0	2003
Lee	Fort Myers	Fort Myers	12.0	12.0		2002
Lee	Greater Pine Island	Pine Island	1.5	1.5		1999
Lee		Lee County North	5.0	5.0		2006
Lee		Green Meadows Lower Hawthorne Wells, Lee County Utilities		9.0	2.0	2007
Lee		Pinewoods WTP Expansion Phase II, Lee County Utilities		2.1	3.0	2007
Lee	Fort Myers	Wellfield Expansion			17.5	2007
Lee		North Lee County Lower Hawthorne Wellfield and Water Plant Expansion, Lee County Utilities			5.0	2008
Martin	Jensen Beach	Martin County Utility - North	5.50	8.80		1994
Martin	Hobe Sound	South Martin Regional Utility RO Concentrate Discharge	2.00	8.14		2003
Martin		Tropical Farms Water Treatment Plant Expansion for build-out			4.0	2007
Martin		Completion Tropical Farms Reverse Osmosis Plant Trains A,B,D		8.0	6.0	2006
Martin		North Water Treatment Plant New Floridan Well NRO-4		8.8	2.3	2008
Miami-Dade	Florida City	RO Plant			4.5	2007
Miami-Dade	North Miami	Winson Water Plant Expansion			16.0	2007
Palm	Jupiter	1.7 mgd Brackish water RO treatment	13.7	27.7		2006

Appendix A - Membrane Desalination Treatment Systems within the SFWMD

Beach		expansion				
Palm Beach	Riviera Beach	New Riviera Beach 1.5 mgd Western Desalination Water Treatment Plant			1.5	2008
Palm Beach	Lake Region Utility	Lake Region Water Treatment Plant Phase 1B & 1C			10.0	2008
Palm Beach	Highland Beach	Highland Beach WTP	2.25	2.25		2004
Palm Beach	Boynton Beach	Boynton Beach		20.0		2006
Palm Beach	Loxahatchee River	Lox River WTP			3.0	2008
Palm Beach	North Palm Beach	Lost Tree			1.0	2006
Palm Beach	Lake Worth	Lake Worth WTP		12.9	4.5	2008
Palm Beach	Jupiter	Jupiter Water System	12.00	27.00	1.7	1989
Palm Beach	Manalapan	Manalapan WTP	1.70	2.35		2004
Palm Beach	Tequesta	Tequesta WTP	1.20	3.90	1.2	2000
St. Lucie	Fort Pierce	Fort Pierce Utility Authority	6.00	15.99	3.2	2002
St. Lucie	St. Lucie West	St. Lucie West Utilities	3.40	3.40		2005
St. Lucie	Port St. Lucie	Port St. Lucie - Prineville	10.00	10.00		1999
St. Lucie	Port St. Lucie	Port St. Lucie - JEA	6.00	6.00		2005
St. Lucie	Fort Pierce	Deepen Existing Floridan Wells from 900' to 1250'			4.0	2007
St. Lucie	Port St. Lucie	JEA WTP Expansion New Florida Wells			5.0	2007
St. Lucie	Port St. Lucie	JEA WTP Expansion			11.5	2007
St. Lucie	Fort Pierce	RO Plant Expansion Phase 3 RO Concentrate Deep Injection Well			7.0	2008

Appendix B

Site Information Provided by Florida Power & Light

FEASIBILITY OF CO-LOCATED DESALINATION FACILITIES
SOUTH FLORIDA WATER MANAGEMENT DISTRICT – DRAFT COPY

	Cutler	Turkey Point (Fossil)	Ft. Myers	Ft. Pierce	Port Everglades	Lauderdale	Riviera
Plant Site							
Address	14925 SW 67th Avenue, Miami	9760 SW 344 Street, Florida City	10650 State Road 80, Ft. Myers		8100 Eisenhower Boulevard, Ft. Lauderdale	4300 Southwest 42nd Avenue, Ft. Lauderdale	200-300 Broadway, Riviera Beach
Available land area (5 to 10 acres)	N/A	N/A	N/A		N/A	N/A	N/A
Land use and zoning	N/A	N/A	N/A		N/A	N/A	N/A
Plant Characteristics							
Plant Status	Active	Active	Active		Active	Active	Active
Type of Facility (Base load, cycling, peaking)	Note 1	Note 1	Note 1		Note 1	Note 1	Note 1
Number of units	2 gas fired units	2 dual fired units	Combined cycle unit 2 peaking units 12 gas turbine units		4 dual fired units 12 gas turbines	2 combined cycle units 24 gas turbines	2 dual fired units
Planned plant expansions/changes to cooling water source	Note 2	1 combined cycle unit Note 2	Note 2		Note 2	Note 2	Note 2
Planned Plant repowering	Note 2	Note 2	Note 2		Note 2	Note 2	Note 2
Planned expansion for co-generation	Note 2	Note 2	Note 2		Note 2	Note 2	Note 2
Power Plant downtime	Note 1	Note 1	Note 1		Note 1	Note 1	Note 1
Power availability/Limitations (Absolute, seasonal)	NA	NA	NA		NA	NA	NA
Cooling system							
Once through cooling	Yes	Yes	Yes		Yes	Yes	Yes
Cooling water source	Biscayne Bay	Cooling canal system	Caloosahatchee River		Intracoastal Waterway	Dania Cutoff Canal	Intracoastal Waterway/ Lake Worth
Florida Surface Water Classification at discharge	Class III	NA	Class III		Class III	Class III	Class III
Number of intake canals (or intake structures)	1	NA	1		1	(2)	(1)
Discharge flow rate annual average daily flow (or maximum daily flow) for reference only	(297 mgd)	NA	529 mgd		1228 mgd	332 mgd	529 mgd
Cooling water source quality and salinity	Marine	NA	Varies		Marine	Varies	Marine
Cooling water discharge	Discharge canal to the Biscayne Bay	NA	Discharge canal to the Orange River		Discharge canal to the Intracoastal Waterway	Cooling pond to the South Fork of New River	Intracoastal Waterway/ Lake Worth
Number of outfalls	Note 3	NA	Note 3		Note 3	Note 3	Note 3
Regulatory Issues							
Current IWWF permit limitations and monitoring	Yes	Yes	Yes		Yes	Yes	Yes
IWWF permits in renewal	No	No	No		No	No	No

N/A - Not available; NA – Not applicable; Note 1 – Varies depending on system demand; Note 2 – See the FPL Ten Year Power Plant Site Plan; Note 3 – See the cooling water discharge information.

Appendix C

Class I Injection Well Facility in the Proximity of the Power Plants

Class I Injection Well Facility in Proximity to Power Plants

Power Plant Facility Location	Facility	Address	Approximate Distance to Power Plant	latitude	longitude
			Miles		
Cutler	MDW&SA North District Regional WWTP	2575 N.E. 151st Street, North Miami, Miami Dade County, Florida 33160	21.8	25°55'13"N	80°08'53"W
25º 27' 00.12" N	MDW&SA South District WWTP	8950 SW 232nd Street, between SW 87 Ave. and SW 97 Ave., in unincorporated Dade County, Florida	6.3	25°33'39"N	80°21'38"W
80º 19' 29.54" W	City of North Miami Beach Norwood-Oeffler WTP (RO)	19150 N.W. 8th Avenue, Miami, Miami Dade County, Florida 33169	22.6	25° 57' 03" N	80° 12' 59" W

Power Plant Facility Location	Facility	Address	Approximate Distance to Power Plant	latitude	longitude
Ft Myers	North Ft. Myers Utilities WWTP	4000 N Del Prado Blv, North Ft Myers FL 33319	6.4		
26º 41' 50.59" N	City of Ft Myers RO WTP	2751 Jacksonville St, City of Ft. Myers	5.6	26° 37' 40" N	81°49'39"W
81º 47' 03.40" W	North Lee County RO WTP	18250 Durrance Rd, North Ft Myers FL 33917	2.4		

Power Plant Facility Location	Facility	Address	Approximate Distance to Power Plant	latitude	longitude
Ft Pierce	The City of Port St. Lucie Northport WWTP	281 Northwest St. James Drive, Port St. Lucie, St. Lucie County, Florida, 34983	8.0	27 20'09" N	80 21'03"W
27º 27' 00.12" N	FPUA-Island Water Reclaim Facility	403 Seaway Dr-South Hutchinson Island	1.1	27°27'20"N	80°18'27"W
81º 19' 29.54" W	Port St. Lucie Western LTC WTP	LTC Parkway, Port St. Lucie, St. Lucie County, Florida	7.1	27°22'12"N	80°24'04"W
	FPUA-Henry A Gahn WTP	South 25th St -Main land	1.7	27°26'43.7"N	80°21'4.4"W
	Tropicana Products, Inc. Facility	6500 Glades Cut-Off Road, Ft. Pierce, Florida, 34981, St. Lucie County, Florida;	6.9	27 22' 47" N	80 24' 16" W

Lauderdale	City of Sunrise Sawgrass Utility Complex	14150 N.W. 8th Street, Sunrise, Broward County, Florida 33325	9.4	26° 07' 48" N	80° 20' 05" W
26º 04' 15.28" N	City of Plantation North Regional (Broward Co.)	6500 Northwest 11th Place, Plantation, Broward County, Florida	5.3	26°08'22.6"N	80°14'13.4"W
80º 11' 49.68" W	G. T. Lohmeyer Injection Facility	The G.T. Lohmeyer injection facility is located in proximity to the G.T. Lohmeyer WWTP. The G.T. Lohmeyer WWTP is located at 1765 S.E. 18th Street, Fort Lauderdale, Broward County, Florida 33309;	4.7	26° 05' 44" N	80° 07' 44" W
	City of Pembroke Pines WWTP	13955 Pembroke Road, Pembroke Pines, Broward County, Florida 33027	9.8	26° 41' 42" N	80° 41' 23" W
	City of Plantation East Water Treatment Plant (RO)	500 Northwest 65th Avenue, Plantation, Broward County, Florida	12.3	26° 07' 31" N	80° 14' 50" W
	City of Plantation Central Water Treatment Plant (RO),	700 N.W. 91st Avenue, Plantation, Broward County, Florida 33324	5.7	26° 07' 36" N	80° 16' 08" W
	City of Hollywood Southern Regional WWTP	1621 North 14th Avenue, Hollywood, Broward County, Florida;	5.5	26°01’38”N	80°07’55”W
	City of Sunrise Sawgrass Utility Complex (RO)	14150 N.W. 8th Street, Sunrise, Broward County, Florida 33325	6.5	26° 09' 35" N	80° 19' 50" W
	Cooper City WTP/WWTP	11791 S.W. 49th Street, Cooper City, Broward County, Florida	6.7	26° 03' 35" N	80° 18' 07" W
	City of Fort Lauderdale Peele Dixie WTP	1500 South State Road 7, Fort Lauderdale, Broward County, Florida 33317	2.1	26° 06‘ 09.9“ N	80° 12‘ 00.6“ W

Port Everglades	City of Sunrise Sawgrass Utility Complex	14150 N.W. 8th Street, Sunrise, Broward County, Florida 33325	13.5	26° 07' 48" N	80° 20' 05" W
26º 05' 05.47" N	City of Plantation North Regional (Broward Co.)	6500 Northwest 11th Place, Plantation, Broward County, Florida	7.8	26°08'22.6"N	80°14'13.4"W
80º 07' 27.70" W	G. T. Lohmeyer Injection Facility	The G.T. Lohmeyer injection facility is located in proximity to the G.T. Lohmeyer WWTP. The G.T. Lohmeyer WWTP is located at 1765 S.E. 18th Street, Fort Lauderdale, Broward County, Florida 33309;	0.8	26° 05' 44" N	80° 07' 44" W
	City of Pembroke Pines WWTP	13955 Pembroke Road, Pembroke Pines, Broward County, Florida 33027	14.0	26° 41' 42" N	80° 41' 23" W
	City of Plantation East Water Treatment Plant (RO)	500 Northwest 65th Avenue, Plantation, Broward County, Florida	11.5	26° 07' 31" N	80° 14' 50" W
	City of Plantation Central Water Treatment Plant (RO),	700 N.W. 91st Avenue, Plantation, Broward County, Florida 33324	9.3	26° 07' 36" N	80° 16' 08" W
	City of Hollywood Southern Regional WWTP	1621 North 14th Avenue, Hollywood, Broward County, Florida;	4.0	26°01’38” N	80°07’55”W
	City of Sunrise Sawgrass Utility Complex (RO)	14150 N.W. 8th Street, Sunrise, Broward County, Florida 33325	13.6	26° 09' 35" N	80° 19' 50" W
	Cooper City WTP/WWTP	11791 S.W. 49th Street, Cooper City, Broward County, Florida	11.0	26° 03' 35" N	80° 18' 07" W
	City of Fort Lauderdale Peele Dixie WTP	1500 South State Road 7, Fort Lauderdale, Broward County, Florida 33317	4.5	26° 06‘ 09.9“ N	80° 12‘ 00.6“ W

Riviera	The Palm Beach County Resource Recovery Facility	6501 Jog Road, West Palm Beach, Florida, Palm Beach County	5.37	26°46’15.83"N	80°08’25.49"W
26º 45' 53.50" N	City of West Palm Beach East Central Regional (ECR) WWTP	4325 N. Haverhill Road, West Palm Beach, Palm Beach County, Florida 33409	5.26	26° 44' 18" N	80° 08' 02" W
80º 03' 11.02" W	Seacoast Utility Authority PGA WWTP	11498 Nursery Lane, Palm Beach Gardens, Palm Beach County, Florida 33410	7.99	26°51'18.5"N	80°07'55"W
Turkey Point (oil/gas)	MDW&SA South District Regional	8950 SW 232nd Street, between SW 87 Ave. and SW 97 Ave., in unincorporated Dade County, Florida	7.85	25°33’39”N	80°21’38”W

25º 26' 05.88" N

80º 19' 51.67" W

Appendix D

Power Plant NPDES Monitoring

PARAMETER	**Cutler**	**Ft Myers**	**Ft Pierce-King**	**Lauderdale**	**Pt Everglades**	**Riviera**	**Turkey Pt.**
NPDES NUMBER	FL0001481	FL0001490	FL0027081	FL0001503	FL0001538	FL0001546	FL0001562
TEMPERATURE	X	X	X	X	X	X	X
PH		X		X	X		X
SALINITY							X
TSS		X		X	X	X	X
TDS				X			
DISSOLVED OXYGEN					X		
OIL AND GREASE	X	X		X	X	X	X
SPECIFIC CONDUCTANCE							X
NITROGEN, TOT (AS N)							
CHLORIDE (AS CL)							

Power Plant NPDES Monitoring

Note :

NPDES - National Pollutant Discharge Elimination System

Appendix E

Florida Power & Light Large Demand Electrical Rates

FLORIDA POWER & LIGHT COMPANY

Twelfth Revised Sheet No. 8.551
Cancels Eleventh Revised Sheet No. 8.551

GENERAL SERVICE LARGE DEMAND

RATE SCHEDULE: GSLD-3

AVAILABLE:

In all territory served.

APPLICATION:

For service to commercial or industrial Customer installations when the Demand of each installation is at least 2,000 kw at the available transmission voltage of 69 kv or higher.

SERVICE:

Three phase, 60 hertz at the available transmission voltage of 69 kv or higher. The Customer will provide and maintain all transformers and related facilities necessary for handling and utilizing the power and energy delivered hereunder. All service required by the Customer at each separate point of delivery served hereunder shall be furnished through one meter at, or compensated to, the available transmission voltage. Resale of service is not permitted hereunder.

MONTHLY RATE:

Customer Charge:	$366.30
Demand Charges:	
Base Demand Charge	$5.72 per kw of Demand
Capacity Payment Charge	See Sheet No. 8.030
Non-Fuel Energy Charges:	
Base Energy Charge	0.553¢ per kwh
Conservation Charge	See Sheet No. 8.030
Environmental Charge	See Sheet No. 8.030
Additional Charges:	
Fuel Charge	See Sheet No. 8.030
Franchise Fee	See Sheet No. 8.031
Tax Clause	See Sheet No. 8.031

Minimum: The Customer Charge plus the charge for the currently effective Base Demand.

DEMAND:

The Demand is the kw to the nearest whole kw, as determined from the Company's metering equipment for the 30-minute period of the Customer's greatest use during the month as adjusted for power factor.

TERM OF SERVICE:

Not less than one year.

RULES AND REGULATIONS:

Service under this schedule is subject to orders of governmental bodies having jurisdiction and to the currently effective "General Rules and Regulations for Electric Service" on file with the Florida Public Service Commission. In case of conflict between any provision of this schedule and said "General Rules and Regulations for Electric Service" the provision of this schedule shall apply.

Issued by: S. E. Romig, Director, Rates and Tariffs
Effective: January 1, 2006

FLORIDA POWER & LIGHT COMPANY

Twenty-Third Revised Sheet No. 8.030
Cancels Twenty-Second Revised Sheet No. 8.030

BILLING ADJUSTMENTS

The following charges are applied to the Monthly Rate of each rate schedule as indicated and are calculated in accordance with the formula specified by the Florida Public Service Commission.

RATE	FUEL			CONSERVATION	CAPACITY			ENVIRONMENTAL
SCHEDULE	¢/kWh	¢/kWh	¢/kWh	¢/kWh	¢/kWh	$/kW		¢/kWh
	Levelized	On-Peak	Off-Peak					
RS-1, 1st 1,000 kWh	5.841			0.142	0.603			0.026
RS-1, all addn kWH	6.841							
RST-1		6.578	6.021	0.142	0.603			0.026
GS-1, WIES-1	6.191			0.137	0.573			0.025
GST-1		6.578	6.021	0.137	0.573			0.025
GSD-1	6.191			0.129		1.94		0.024
GSDT-1, HLFT-1		6.577	6.020	0.129		1.94		0.024
GSDT-1 w/SDTR (June–Sept)		6.557	6.076					
GSDT-1 w/SDTR (Jan-May & Oct-Dec)		6.577	6.020					
GSLD-1, CS-1	6.185			0.122		2.27		0.024
GSLDT-1, CST-1, HLFT-2		6.571	6.015	0.122		2.27		0.024
GSLDT-1 w/SDTR (June–Sept)		6.551	6.071					
GSLDT-1 w/SDTR (Jan-May & Oct-Dec)		6.571	6.015					
GSLD-2, CS-2	6.144			0.117		2.19		0.023
GSLDT-2, CST-2, HLFT-3		6.534	5.981	0.117		2.19		0.023
GSLDT-2 w/SDTR (June–Sept)		6.514	6.037					
GSLDT-2 w/SDTR (Jan-May & Oct-Dec)		6.534	5.981					
GSLD-3, CS-3	5.921			0.107		2.10		0.021
GSLDT-3, CST-3		6.291	5.758	0.107		2.10		0.021
OS-2	6.144			0.122	0.489			0.025
MET	6.144			0.133		2.35		0.025
CILC-1(G)		6.577	6.020	0.113		2.38		0.022
CILC-1(D)		6.524	5.971	0.113		2.38		0.022
CILC-1(T)		6.291	5.758	0.106		2.27		0.021
SL-1,OL-1, PL-1	6.110			0.071	0.175			0.019
SL-2, GSCU-1	6.191			0.109	0.402			0.022
						RDD	DDC	
SST-1(T)		6.291	5.758	0.082		0.27	0.13	0.020
SST-1(D1)		6.577	6.020	0.111		0.28	0.13	0.022
SST-1(D2)		6.571	6.015	0.111		0.28	0.13	0.022
SST-1(D3)		6.534	5.981	0.111		0.28	0.13	0.022
ISST-1(D)		6.524	5.971	0.111		0.29	0.14	0.022
ISST-1(T)		6.291	5.758	0.082		0.27	0.13	0.020

(Continued on Sheet No. 8.031)

Issued by: S. E. Romig, Director, Rates and Tariffs
Effective: January 5, 2006