WATER SUPPLY COST ESTIMATION STUDY

JANUARY 2023

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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Acronyms

AADD	Annual Average Day Demand
AOP	Advanced Oxidation Process
APPZ	Avon Park Permeable Zone
ASR	Aquifer Storage and Recovery
AWTF	Advanced Water Treatment Facility
AWS	Alternative Water Supply
AWT	Advanced Wastewater Treatment
AWWA	American Water Works Association
BAF	Biologically Active Filtration
BG	Billion Gallons
CCI	Construction Cost Index
CEPP	Central Everglades Planning Project
CERP	Comprehensive Everglades Restoration Plan
CFP	Cooperative Funding Program
CFS	Cubic Feet Per Second
CFWI	Central Florida Water Initiative
CMU	Concrete Masonry Units
DI	Ductile Iron
DIP	Ductile Iron Pipe
DIW	Deep Injection Well
DPR	Direct Potable Reuse
DR	Dimensional Ratio
DZMW	Dual-Zone Monitoring Well
EAA	Everglades Agricultural Area
ENR	Engineering News Record
EPA	Environmental Protection Agency
ESB	Engineering Storage Buffer
F.A.C.	Florida Administrative Code
FAS	Floridan Aquifer System

FDD	Florida Design Drilling Corporation
FDEP	Florida Department of Environmental Protection
FEB	Flow Equalization Basin
FPL	Florida Power and Light
FRP	Fiberglass Reinforced Plastic
F.S.	Florida Statutes
FY	Fiscal Year
GAC	Granular Active Carbon
GMF	Granular Media Filters
GST	Ground Storage Tank
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene
HP	Horsepower
H2S	Hydrogen Sulfide
HVAC	Heating Ventilation and Air Conditioning
ID	Identification
IFAS	Integrated Fixed Film Activated Sludge
IPR	Indirect Potable Reuse
IRC	Indian River County
IW	Injection Well
IX	Ion Exchange
KB	Kissimmee Basin
KWh	kilowatt-hour
LEC	Lower East Coast
LF	Linear Feet
LFA	Lower Floridan Aquifer
LKB	Lower Kissimmee Basin
LWC	Lower West Coast
MBR	Membrane Bioreactors
MDD	Maximum Day Demand
MF	Microfiltration
mgd	Million Gallons Per Day
mgy	Million Gallons Per Year
MIT	Mechanical Integrity Test

MPI	Material Price Index
MW	Monitoring Wells
NF	Nanofiltration
O&P	Overhead and Profit
O&M	Operation and Maintenance
OPCC	Opinion of Probable Construction Cost
PFAS	Polyfluoroalkyl Substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonic Acid
PPT	Parts per Trillion (or ug/L)
PSI	Pounds Per Square Inch
PVC	Polyvinyl Chloride
R&R	Rehabilitation and Replacement
RAS	Returned Activated Sludge
RO	Reverse Osmosis -
RW	Raw Water
RWM	Raw Watermain
RWSP	Regional Water Supply Plan
SAPT	Standard Annular Pressure Test
SAS	Surficial Aquifer System
SCADA	Supervisory Control and Data Acquisition
SFWMD	South Florida Water Management District
SJWMD	St. Johns River Water Management District
SMW	Shallow Monitoring Well
SOP	Standard Operating Procedure
SOV	Schedule Of Values
STA	Stormwater Treatment Areas
SWRO	Seawater Reverse Osmosis
SWS	Surface Water Storage
SZMW	Storage Zone Monitoring Well
TDH	Total Dynamic Head
TDS	Total Dissolved Solids
UEC	Upper East Coast
UF	Ultraflitration

UFA	Upper Floridan Aquifer
UIC	Underground Injection Control
UKB	Upper Kissimmee Basin
USACE	United States Army Corps of Engineers
USDW	Underground Source of Drinking Water
USEPA	US Environmental Protection Agency
UV	Ultraviolet
WAS	Waste Activated Sludge
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

ES.1 BACKGROUND

The South Florida Water Management District (SFWMD or District) is comprised of five regional water supply planning areas: Upper Kissimmee Basin (UKB), Lower Kissimmee Basin (LKB), Upper East Coast (UEC), Lower West Coast (LWC), and Lower East Coast (LEC). The UKB is part of the Central Florida Water Initiative (CFWI), which covers Orange, Osceola, Polk, and Seminole counties as well as southern Lake County. Water management districts are required to develop a regional water supply plan (RWSP) if they determine the existing sources of water are inadequate to supply water for all existing and future reasonable-beneficial uses, and/or may not sustain water resources and related natural systems for a 20-year planning horizon.

Development (capital and operation and maintenance) costs of alternative water supply options play an important role in evaluating alternatives associated with water supply planning. The SFWMD had previously relied upon the Water Supply Cost Estimation Study (Study) and Phase II Addendum completed in February 2007 and December 2007, respectively, by CDM Smith. The information and cost data included in the 2007 Study is considered obsolete and the update of water supply development costs, which includes capital and operation and maintenance (O&M) costs, is required to help the SFWMD with water supply planning and funding objectives and goals. The objective is to update the Study with current engineering costs, construction costs, and cost estimating relationships using cost data for projects constructed within the last 10 years and other cost sources such as RSMeans (http://www.rsmeansonline.com), suppliers, contractors, and vendors where appropriate.

The scope of work for this effort was to identify the most relevant alternative water supply options and treatment facilities and their development costs and to provide current cost data (December 2021 dollars) for all options. Additionally, a detailed description of each system and their components is summarized within each Chapter. The systems evaluated in this study are as follows:

- Water Supply Wells
- Advanced Water Treatment Technologies
- Water Reclamation and Advanced Wastewater Treatment Technologies
- Deep Injection Wells
- Aquifer Storage and Recovery
- Surface Water Storage
- Pipeline Systems

Each chapter will contain sections that discuss assumptions and approach, capital costs, O&M, and a total cost summary for each system's cost analysis as it relates to each specific water supply component. The cost data collected reflects the source, costs, year of construction, and detailed description of each system, as well as O&M costs. Any relevant cost increases due to COVID-19 supply chain challenges, petroleum costs, trade policy action, or any other cost implications that impacted construction costs between 2011 and 2021 are discussed for each applicable system. The construction and O&M costs utilize the *Engineering News Record's (ENR)* Construction Cost Index (CCI) and Material Price Index (MPI) to bring forward development costs to December 2021 dollars, where appropriate.

For advanced water treatment and water reclamation and advanced wastewater treatment technologies, a 20-year projected capital costs and total production costs for these technologies are graphically represented and bracketed between expected accuracy range of -30% and +50% of the calculated costs, per Association for the Advancement of Cost Engineering (AACE) International's Estimating Class 4 (AACE, 2020). Total production costs are presented based off plant capacity (or maximum daily flow) or annual average daily flow. A 7% discount rate over 20 years was used to develop capital investment for these technologies.

ASSUMPTIONS AND APPROACH

This section in each chapter discusses assumptions and approach to cost analysis as it relates to each specific water supply component and a summary of the development cost data collected for each system.

CAPITAL COSTS

This section in each chapter discusses each system's capital costs which typically include material costs, equipment costs, electrical system costs for installation, yard piping costs and site work costs for which each utility, municipality or agency is responsible. Other capital costs include administrative, technical, general conditions (permits, fees, project management, etc.), mobilization, demobilization, bonds, and insurance which are typical "add-ons" associated with each project during design and construction.

OPERATION AND MAINTENANCE COSTS

This section in each chapter discusses the cost associated with operating and maintaining the system which include power, chemicals, replacement and rehabilitation (R&R) (if available), labor, administrative, and regulatory compliance costs.

TOTAL COST SUMMARY

This section in each chapter provides an overall cost summary for each system and project presented. The cost summary will reflect an overall comparison of project costs for each system evaluated and will summarize the data collected.

ES.2 WATER SUPPLY WELLS

Construction and O&M costs included in **Chapter 2** reflect water supply wells with water sources from the Surficial Aquifer System (SAS) and the Floridan Aquifer System (FAS) within the SFWMD Planning Areas and Indian River County (IRC). The data included: drilling of the well, wellhead, appurtenances, and limited site improvements, such as well pad and fencing for four of the five planning regions and IRC. Initially, data was analyzed for each of these planning areas individually as the cost of construction may be directly impacted by well location; depth of well as it relates to water source (i.e., depth to aquifer the water is drawn from); and well diameter. After evaluating the costs for each well, within each planning area, it was determined that the planning area (or location) was not the driver for overall well costs. The well parameters (i.e., well capacity, well depth, etc.) appeared to be the basis of the resulting costs. Therefore, this evaluation applies to costs District-wide.

Depending on casing diameter, depth and location the overall adjusted construction costs for SAS system wells range from approximately $210,456 to $741,546 and overall costs for FAS system wells range from approximately $629,054 to $1,901,802. The information collected for the two FAS wells in IRC are $755,841 and $816,680, respectively. **Table ES.2-1** summarizes the well construction costs from projects evaluated in this study.

Table ES.2-1: Well Construction Cost Summary

Planning Area	Number of Wells Evaluated	Well Casing Diameter (in)		Well Casing Depth (ft)		Well Cost (December 2021 Dollars)	
		Min	Max	Min	Max	Min	Max
LEC (SAS)	21	12	24	75	140	$210,456	$737,920
LEC (FAS)	9	14	20	1,006	1,300	$1,179,397	$1,901,802
UEC (SAS)	1	10	12	65	75	$354,903	$741,546
UEC (FAS)	7	12	14	140	1,150	$1,584,075	$1,605,905
LWC (FAS)	11	10	14	600	865	$629,054	$911,949
UKB (FAS)	2	--	10	--	274	--	$199,311
IRC (FAS)	2	--	17	395	415	$755,841	$816,680

Depending on flow capacity, wellhead construction costs for SAS well systems range from approximately $77,362 to $855,371 and wellhead construction costs for FAS well systems range from approximately $113,867 to $981,222. Adjusted wellhead construction costs for the two wells constructed in IRC are $416,018 and $501,993, respectively. **Table ES.2-2** summarizes the wellhead construction costs from projects evaluated in this study.

Table ES.2-2: Range of Wellhead Construction Cost Summary

Planning Area	Capacity (gpm)		Wellhead Cost (in December 2021 Dollars)	
	Min	Max	Min	Max
LEC (SAS)	500	2,200	$105,475	$855,371
LEC (FAS)	880	1,600	$113,867	$891,906
UEC (SAS)	250	350	$77,362	$112,887
UEC (FAS)	1,100	1,620	$392,536	$674,214
LWC (FAS)	696	700	$356,230	$981,222
UKB (FAS)	--	275	$308,172	$413,673
IRC (FAS)	--	1,400	$416,018	$501,993

Different factors such as economy of scale, site access, depth of well, well design, capacity, lithology, formation disposal requirements, added smart technology for monitoring, etc. play a major role in how a contractor bids a well project. When producing an opinion of probable construction cost for a well project, it is typical to review costs of other nearby well projects constructed in the last five years, as it is typical that the well design, and therefore costs, will be similar.

For O&M costs, the LEC wells pump and motor information were used as a basis to evaluate overall power consumption and routine maintenance costs and are representative of costs for all typical well systems. The majority of the public water supply well pump information collected was from the LEC Planning Area and represent a sample of the monthly operating costs for all electric powered well pumps in the SFWMD area. The motor horsepower information evaluated were bracketed between 35 and 75 horsepower. The annual operating costs range from $27,120 to $50,100, assuming continuous operation. Annual operating costs based on annual average daily demand range from approximately $18,010 to $33,400. This data is summarized in **Table ES.2-3**.

Table ES.2-3: Estimated Range of Monthly Operating Cost per Well

Horsepower	Flow (gpm)	Power Cost ($/hr)	Monthly Operating Costs (Continuous Operation)	Annual Operating Costs (Continuous Operation)	Annual Operating Costs (Annual Average Daily Demand)
35	700	$3.14	$2,260	$27,510	$18,080
75	1,400	$5.80	$4,175	$50,810	$33,400

In addition to the operating costs associated with power consumption, routine maintenance costs such as chlorination/disinfection and acidification are incurred by municipalities. Centerline Drilling, Inc. provided a range (based on smallest [10-inch] to largest diameter [24-inch] of wells) of costs for typical maintenance procedures. **Table ES.2-4** summarizes well Maintenance costs.

Table ES.2-4: Well Maintenance Costs

Maintenance Activity	Range of Cost (Based on Diameter of Well)
Chlorinate	$1,500 to $5,000
Acidify	$7,500 to $30,000
Pull pump and motor	$2,500 to $6,000
Reinstall pump motor	$2,500 to $6,000
Replace valves, flow meter, etc.	$2,500 to $15,000

O&M costs vary by a number of factors such as runtime (which effects power costs); size of well; parts requiring replacement; how often maintenance occurs or is required, age of well, and contractual agreement of rehabilitation of multiple wells (scale of construction/rehabilitation). In a given year, it can be assumed (using the available average annual operating cost data in **Table ES.2-3** and the maintenance information in **Table ES.2-4**), that overall average annual O&M costs (based on annual average daily demand), per well, may range from $34,600 (for smaller wells with lower power requirements) to $95,500 (for larger wells with higher power requirements and age of well).

ES.3 ADVANCED WATER TREATMENT TECHNOLOGIES

Construction costs and O&M costs included in **Chapter 3** reflect raw water supply, pretreatment, post-treatment, intermediate storage, finished water storage, transfer pumps, high service pumps, plant infrastructure, concentrate disposal (at the plant), mechanical, yard piping, electrical and instrumentation, and site work. Chapter 3 addresses four treatment technology areas which are summarized below.

General Water Treatment Technologies: The cost data in this subsection assumes a "green field" (i.e., starting with a cleared or undeveloped piece of land) plant construction project. Treatment technologies in this subsection include an evaluation of reverse osmosis (RO) and nanofiltration (NF) processes along with their ancillary components such as pre-treatment and post-treatment systems, ion exchange (IX) and granulated activated carbon (GAC). Other elements included in this evaluation include raw water supply, as well as byproduct disposal by Deep Injection Well (DIW). However, this section does not include water storage or high service pumps. See water distribution plant components for these plant components.

Opinion of probable construction costs, O&M, and total production cost are presented in **Table ES.3-1** for the following treatment technologies, process components, and plant components:

- NF with DIW Disposal of Concentrate
- RO with DIW Disposal of Concentrate
- Seawater reverse osmosis (SWRO)

For seawater desalination, which uses a water source from seawater, (or water source that has the equivalent total dissolved solids [TDS] or higher "salt" content), treatment costs from the Claude "Bud" Lewis Carlsbad Desalination Plant in San Diego, California, were used.

Water Treatment Technology Process Components: The cost data included in this subsection reflect costs for adding incremental process capacity, or an additional treatment technology, to an existing water treatment plant. Reverse osmosis and nanofiltration were included in this study for adding incremental process capacity, while IX was included for adding additional treatment technology. A case study is also included that evaluates treatment of per- and polyfluoroalkyl Substances (PFAS), nicknamed the "Forever Chemical", utilizing ion exchange.

Opinion of probable construction costs, O&M, and total production costs are presented in **Table ES.3-2** for the following treatment technologies, process components, and plant components:

- NF Process Units
- RO Process Units
- IX
- GAC

Water Distribution Plant Components: The cost data included in this subsection are water storage tanks and high service pumps. These two components are typical for all plant types, whether it is an RO, NF, or seawater desalination plant.

Opinion of probable construction costs, O&M, and total production cost are presented in **Table ES.3-3** for the following treatment technologies, process components, and plant components:

- Finished Water Storage Plant Components
- High Service Pumping Plant Components

Disinfection Plant Components: The cost data included in this subsection reflects construction costs associated with disinfection and are also typical for all plant types as disinfection is required prior to distribution pursuant to Chapter 62-550, Florida Administrative Code. Further, chlorine disinfection (using sodium hypochlorite) is a required means of disinfection for all plants within the state of Florida. Additional disinfection processes such as ultraviolet light, may be used as an added level of disinfection.

Opinion of probable construction costs, O&M, and total production cost are presented in **Table ES.3-3** for the following treatment technologies, process components, and plant components:

- Sodium Hypochlorite Disinfection
- Ultraviolet Light (UV) Disinfection

Table ES.3-1: Opinion of Probable Costs for General Water Treatment Technologies

Plant Capacity (mgd)	Raw Water Source	Concentrate Disposal [1]	Capital Cost [2]	Annual O&M Cost	Production Cost ($/1,000 gallons)
Nanofiltration					
1	Groundwater	DIW (3-5 mgd)	$8,302,560	$473,000	$5.50
3	Groundwater	DIW (3-5 mgd)	$21,779,520	$1,351,000	$4.95
5	Groundwater	DIW (3-5 mgd)	$34,235,320	$2,198,000	$4.73
10	Groundwater	DIW (3-5 mgd)	$63,509,880	$4,459,000	$4.09
15	Groundwater	DIW (two 5 mgd)	$91,365,400	$6,672,000	$3.84
20	Groundwater	DIW (two 5 mgd)	$118,378,120	$8,933,000	$3.63
Brackish Groundwater Reverse Osmosis					
1	Groundwater	DIW (3-5 mgd)	$19,232,000	$578,000	$10.58
3	Groundwater	DIW (3-5 mgd)	$47,998,000	$1,516,000	$8.90
5	Groundwater	DIW (3-5 mgd)	$73,608,000	$2,360,000	$8.22
10	Groundwater	DIW (3-5 mgd)	$131,841,000	$4,466,000	$6.71
15	Groundwater	DIW (two 5 mgd)	$185,674,000	$6,389,000	$6.09
20	Groundwater	DIW (two 5 mgd)	$236,909,000	$8,266,000	$5.63
Seawater Reverse Osmosis					
1	Surface Water	N/A	$52,656,317	$3,394,000	$36.43
3	Surface Water	N/A	$126,807,800	$8,179,000	$29.24
5	Surface Water	N/A	$190,821,400	$12,309,000	$26.40
10	Surface Water	N/A	$332,239,600	$22,451,000	$21.06
15	Surface Water	N/A	$459,540,200	$31,597,000	$18.83
20	Surface Water	N/A	$578,461,800	$40,510,000	$17.22

(1) Typical capacity of DIW for concentrate disposal
(2) Costs do not include deep well injection costs

Table ES.3-2: Opinion of Probable Costs for Water Treatment Technologies Process Components

Plant Capacity (mgd)	Capital Cost	Annual O&M Cost	Production Cost ($/1,000 gallons)
Nanofiltration Process Addition			
1	$5,290,040	$473,000	$4.21
3	$12,740,000	$1,351,000	$3.66
5	$19,168,800	$2,198,000	$3.44
10	$33,378,800	$4,459,000	$2.93
15	$46,169,760	$6,672,000	$2.72
20	$58,119,880	$8,933,000	$2.56
Brackish RO Process Addition			
1	$16,396,000	$578,000	$9.39
3	$39,474,000	$1,516,000	$7.69
5	$59,399,000	$2,360,000	$7.01
10	$103,420,000	$4,466,000	$5.62
15	$143,041,000	$6,389,000	$5.04
20	$180,059,000	$8,266,000	$4.62
Ion Exchange(1)			
1	$6,528,072	N/A	N/A
3	$10,881,121	N/A	N/A
5	$15,233,169	N/A	N/A
10	$26,115,289	N/A	N/A
15	$36,995,410	N/A	N/A
20	$47,877,530	N/A	N/A
Granular Activated Carbon			
1	$3,620,400	$42,000	$1.20
3	$7,023,576	$121,000	$0.83
5	$10,318,140	$198,000	$0.75
10	$17,920,980	$417,000	$0.66
15	$24,618,720	$615,000	$0.61
20	$30,411,360	$804,000	$0.57

(1) Ion Exchange O&M data was not available at the time of this evaluation

Table ES.3-3: Probable Costs for Water Distribution and Disinfection Components

Plant Capacity (mgd)	Capital Cost	Annual O&M Cost	Production Cost ($/1,000 gallons)
Finish Water Storage [1]			
1	$928,000	N/A	$0.36
3	$2,776,000	N/A	$0.36
5	$4,620,000	N/A	$0.36
10	$9,236,000	N/A	$0.32
15	$13,853,000	N/A	$0.31
20	$18,467,000	N/A	$0.30
High Service Pumping			
1	$131,460	$29,700	$0.18
3	$391,380	$90,200	$0.18
5	$650,300	$150,700	$0.18
10	$1,296,600	$300,000	$0.16
15	$1,947,900	$451,000	$0.16
20	$2,593,200	$601,700	$0.15
Sodium Hypochlorite Disinfection [2]			
1	$1,055,000	$38,000	$0.57
3	$2,540,000	$114,000	$0.48
5	$3,819,000	$190,000	$0.45
10	$6,651,000	$380,000	$0.37
15	$9,195,000	$570,000	$0.34
20	$11,579,000	$760,000	$0.32
Ultraviolet Light Disinfection			
1	$355,000	$29,700	$0.40
3	$1,004,000	$90,200	$0.40
5	$1,671,000	$150,700	$0.40
10	$3,334,000	$300,300	$0.36
15	$5,005,000	$451,000	$0.34
20	$6,672,000	$601,700	$0.33

(1) O&M costs are reflected in the plant O&M costs
(2) O&M costs reflect chemical costs only. Remaining O&M costs are reflected in the plant O&M costs

ES.4 WATER RECLAMATION & ADVANCED WASTEWATER TREATMENT TECHNOLOGIES

Construction costs and O&M costs included in **Chapter 4** reflect costs associated with water reclamation and advanced wastewater treatment technologies. Urban populations, agricultural operations, and the environment depend on adequate water supplies. Fresh surface and groundwater will not be sufficient to satisfy all future demands. Meeting this growing demand hinges on efforts to develop alternative water sources (SFWMD, 2022). Water reuse has become the logical option for conserving and extending available water supply by potentially:

- Substituting reclaimed water for drinking (potable) water, fresh groundwater and surface water on applications that can use lower quality water, or
- Augmenting existing water sources and providing an additional source of water primarily for irrigation.

The demand for reclaimed water is projected to increase over the long term in South Florida. As water reuse applications have increased, additional treatment processes designed to fit with the specific water reuse purpose has become necessary. This "Fit for Purpose" approach provides a framework for cost-effective treatment to be applied to wastewater sufficient to meet the water quality standards appropriate for the intended use.

The "Fit for Purpose" approach has been applied to **Chapter 4** of the study with focus on three specific levels of water quality treatment. The general categories of treatment technologies and purpose discussed in Chapter 4 are:

1. Advanced Wastewater Treatment to produce unrestricted public access reclaimed water quality.

- <u>Treatment Requirement:</u> Removal of residual particulate matter from secondary effluent and inactivation of pathogens (disinfection) to produce reclaimed water as an alternative water source.
- <u>Purpose:</u> Unrestricted public access reclaimed water
- <u>Cost Scenario No. 1 through No. 3:</u> Convert existing basic level disinfection (secondary treatment) wastewater treatment facilities to high level disinfection (tertiary treatment) to achieve water quality standards for unrestricted public access reclaimed water (except nutrient discharge limits). These scenarios all include liquid sodium hypochlorite (chlorine) high-level disinfection. UV disinfection was not considered under Tertiary Wastewater Treatment because State regulations require a chlorine residual used for unrestricted public access reuse. Probable costs for Scenario No. 1 through 3 are presented in **Table ES.4-1** and **Chapter 4**.

Cost Scenario No. 1: Construct new granular media filtration (GMF) and high-level disinfection treatment processes
Cost Scenario No. 2: Construct new cloth media filtration system and high-level disinfection treatment processes
Cost Scenario No. 3: Construct new membrane filtration and high-level disinfection treatment processes

2. Advanced Wastewater Treatment to produce reclaimed water meeting nutrient discharge requirements with high-level disinfection.

- Treatment Requirement: Removal of nitrogen and phosphorus (nutrients) for production of reclaimed water as alternative water source
- Purpose: Nutrient removal, pre-treatment for advanced water treatment facilities (AWTF)
- Cost Scenario No. 4 through No. 7: New construction or conversion of existing high-level disinfection (tertiary treatment) facilities to nutrient (nitrogen and phosphorus) removal facilities to produce unrestricted public access reuse water quality meeting nutrient reduction goals or nutrient discharge limits. Probable costs for Scenario No. 4 through 7 are presented in **Table ES.4-2** and **Chapter 4**.

Cost Scenario No. 4: New Construction - 5-Stage Bardenpho Process (conventional treatment) for nutrient removal with tertiary treatment (GMF and high-level disinfection)
Cost Scenario No. 5: Conversion of an existing tertiary treatment facility to 5-Stage Bardenpho process with nutrient removal (conventional treatment) with high level disinfection
Cost Scenario No. 6: New Construction - 5-Stage Bardenpho process with immersed membranes (membrane bioreactor [MBR]) for nutrient removal with tertiary treatment and high-level disinfection. Note: MBR replaces both secondary clarification and tertiary filtration.
Cost Scenario No. 7: Conversion of an existing tertiary treatment facility to 5-Stage Bardenpho process with immersed membranes (membrane bioreactor, MBR) for nutrient removal with high level disinfection.

3. Advanced Water Treatment to achieve indirect or direct potable reclaimed water quality standards.

- Treatment Requirement: Removal of residual dissolved and trace constituents for production of reclaimed water as alternative water source for indirect or direct potable reuse.
- Purpose: Direct and indirect potable reuse
- Cost Scenario No. 8 and No. 9: Convert existing tertiary treatment facility to produce reclaimed water quality meeting applicable indirect or direct potable water quality criteria. Probable costs for Scenario No. 8 and No. 9 are presented in **Table ES.4-3** and **Chapter 4**.

Cost Scenario No. 8: New Construction - RO based AWTF infrastructure. Includes microfiltration (MF) membrane pretreatment, cartridge filtration, RO membrane treatment, advanced oxidation process (AOP: UV + chlorine), and an engineering storage buffer.
Cost Scenario No. 9: Adding non-RO based AWTF infrastructure. Includes ozone addition prior to biologically active filtration (BAF), ultrafiltration (UF) membrane pretreatment, GAC, AOP: UV + chlorine, and an engineering storage buffer (ESB).

Table ES.4-1: Probable Costs for Water Reclamation and Advanced Wastewater Treatment Technologies: Scenario No. 1 through 3

Plant Capacity (mgd)	Capital Cost	Annual O&M Cost	Annual Production Cost ($/1,000 gallons)
Scenario No. 1: New Granular Media Filtration with High-level Disinfection			
1	$3,213,210	$158,167	$1.35
3	$9,350,441	$460,265	$1.31
5	$15,262,748	$751,292	$1.28
10	$28,918,890	$1,423,500	$1.21
15	$40,968,428	$2,016,625	$1.15
20	$51,411,360	$2,530,667	$1.08
Scenario No. 2: New Cloth Media Filtration with High-level Disinfection			
1	$1,977,360	$142,958	$0.95
3	$5,754,118	$416,009	$0.93
5	$9,392,460	$679,052	$0.91
10	$17,796,240	$1,286,625	$0.86
15	$25,211,340	$1,822,719	$0.81
20	$31,637,760	$2,287,333	$0.76
Scenario No. 3: New Membrane Filtration with High-level Disinfection			
1	$3,583,965	$173,375	$1.49
3	$10,429,338	$504,521	$1.45
5	$17,023,834	$823,531	$1.42
10	$32,255,685	$1,560,375	$1.35
15	$45,695,554	$2,210,531	$1.27
20	$57,343,440	$2,774,000	$1.20

Table ES.4-2: Probable Costs for Water Reclamation and Advanced Wastewater Treatment Technologies (AWT): Scenario No. 4 through No. 7

Plant Capacity (MGD)	Capital Cost	Annual O&M Cost	Annual Production Cost ($/1,000 gallons)
Scenario No. 4: New Construction of 5-Stage Bardenpho with Conventional Activated Sludge			
1	$27,092,100	$401,500	$8.81
3	$78,838,011	$1,168,365	$8.54
5	$128,687,475	$1,907,125	$8.37
10	$243,828,900	$3,613,500	$7.93
15	$345,424,275	$5,119,125	$7.49
20	$433,473,600	$6,424,000	$7.05
Scenario No. 5: Conversion to 5-Stage Bardenpho with Conventional Activated Sludge			
1	$8,095,500	$438,000	$3.50
3	$23,557,905	$1,274,580	$3.40
5	$38,453,625	$2,080,500	$3.33
10	$72,859,500	$3,942,000	$3.15
15	$103,217,625	$5,584,500	$2.98
20	$129,528,000	$7,008,000	$2.80
Scenario No. 6: New Construction of 5-Stage Bardenpho with MBR			
1	$27,650,700	$511,000	$9.27
3	$80,463,537	$1,487,010	$8.99
5	$131,340,825	$2,427,250	$8.80
10	$248,856,300	$4,599,000	$8.34
15	$352,546,425	$6,515,250	$7.88
20	$442,411,200	$8,176,000	$7.41
Scenario No. 7: Conversion to 5-Stage Bardenpho with MBR			
1	$14,706,825	$389,090	$5.25
3	$42,796,861	$1,132,252	$5.09
5	$69,857,419	$1,848,178	$4.99
10	$132,361,425	$3,501,810	$4.72
15	$187,512,019	$4,960,898	$4.46
20	$235,309,200	$6,225,440	$4.20

Table ES.4-3: Probable Costs for Water Reclamation and Advanced Wastewater Treatment Technologies (Potable Reuse): Scenario No. 8 and No. 9

Plant Capacity (MGD)	Capital Cost	Annual O&M Cost	Annual Production Cost ($/1,000 gallons)
Scenario No. 8: New Construction of AWTF with Reverse Osmosis for Potable Reuse			
1	$9,216,900	$511,000	$4.02
3	$26,821,179	$1,487,010	$3.90
5	$43,780,275	$2,427,250	$3.82
10	$82,952,100	$4,599,000	$3.62
15	$117,515,475	$6,515,250	$3.42
20	$147,470,400	$8,176,000	$3.22
Scenario No. 9: Addition of AWTF without Reverse Osmosis for Potable Reuse			
1	$9,077,250	$511,000	$3.98
3	$24,789,272	$1,487,010	$3.71
5	$40,463,588	$2,427,250	$3.63
10	$76,667,850	$4,599,000	$3.44
15	$108,612,788	$6,515,250	$3.25
20	$136,298,400	$8,176,000	$3.06

ES.5 MEMBRANE TREATMENT BY-PRODUCT DISPOSAL – DEEP INJECTION WELLS

Construction costs and O&M costs included in **Chapter 5** reflect costs associated with DIW technologies. In south Florida, DIWs are the primary method for disposal of domestic wastewater effluent, industrial wastewater (includes concentrate from membrane water treatment facilities), or radioactive waste below protected aquifers or beneath the lowermost formation of an underground source of drinking water. Most DIWs in south Florida discharge to the Boulder Zone, a cavernous limestone unit of the Lower Florida Aquifer, located generally about 3,000 feet below land surface. These DIWs are classified as Class I DIWs in Chapter 62-528 of the Florida Administrative Code and are under the regulatory jurisdiction of the Florida Department of Environmental Protection (FDEP).

The costs of DIWs have risen significantly within the past five years with the most significant cost increase observed within the last two years due to impacts discussed in **Chapter 1** as well as other influences such as lack of competition between qualified contractors. The larger, deeper DIWs are predominantly constructed by a single contractor, Youngquist Brothers, Inc. (YBI), due to their drill rigs capacity and staff expertise. Other considerations related to cost variability include site access, material availability, depth of DIW, piping diameters, piping material, annulus fill material, scale of construction (i.e., one DIW and MW versus multiple DIWs and MWs within one construction project), etc. The DIW construction costs summary is for capacities ranging from 2.17 to 19.94 mgd with injection casing depths ranging from 2,400 to 5,800 feet below land surface and injection casing diameters ranging from 16-inch to 36-inch. Class V DIWs are shallower wells, constructed with a tubing and packer, and/or are rated at a lower capacity than Class I DIWs and therefore have a lower cost per mgd. In general, the construction costs collected for this evaluation did not appear to have a direct correlation to the design and capacity of each well. However, based on the market impacts and other factors discussed above, the DIW projects constructed within the last three to four years (**Table ES.5-1**) appear to reflect present day costs with the City of Hollywood (December 2019) being on the high end of the construction costs.

Table ES.5-1: Summary of DIW Project Construction Costs in December 2021 Dollars

Well Name	County	Class	DIW Capacity (MGD)	Total Cost per IW in December 2021 Dollars	Total Cost per MGD	Total Cost Casing Depth (per foot)
NSID (IW-1)	Broward	I	3.2	$8,439,253	$2,637,267	$2,910
PBCWUD WTP2 (IW-1)	Palm Beach	I	9.66	$15,884,881	$1,644,398	$5,478
TWA (Exploratory Well)	Osceola	V, Group 9	4.05	$7,345,062	$1,813,595	$4,739
City of Hollywood (December 2019)	Broward	I	19.94	$29,662,702	$1,487,598	$5,115
Miami-Dade South District (Three DIWs) (per well)(1)	Miami-Dade	I	18.65	$12,694,135	$680,650	$5,290
Collier County Landfill (IW-1)	Collier	I	2.17	$8,882,800	$4,093,456	$3,993

(1) MW was not constructed with this project.

Three (3) drilling companies that routinely perform MITs were contacted by phone for typical costs associated with MIT testing for each of the testing procedure for concrete filled annulus and fluid-filled annulus. The five-year MIT exercise, costs for testing a tube and packer DIW construction with a concrete filled annulus is typically higher than one with a fluid-filled annulus due to the labor, additional equipment and brine needed for required pressure testing. **Table ES.5-2** summarizes the typical annual O&M costs.

Table ES.5-2: Typical Annual O&M Costs for Laboratory Costs, Permit Renewal, and MITs

Description	MIT for Fluid-filled Annulus (Standard Annular Pressure Test) (Annual Costs)	MIT for Concrete Filled Annulus (with Packer Test) (Annual Costs) (Annual Costs)
MIT Costs	$6,000 to $15,000	$8,000 to $20,000
Laboratory Costs	$45,500	$45,500
Permit Renewal Costs	$2,000	$2,000
Total Costs Range	**$53,500 to $62,500**	**$55,500 to $67,500**

ES.6 AQUIFER STORAGE AND RECOVERY

Construction costs and O&M costs included in **Chapter 6** reflect costs associated with Aquifer Storage and Recovery (ASR) technologies. ASR refers to the process of recharge, storage, and recovery of water in an aquifer via use of a constructed bi-directional well. ASR systems are used to store excess amounts of potable water, reclaimed water, stormwater or surface water underground for future use. ASR systems reduce stress on traditional potable water sources and can reduce disposal of wastewater effluent. Construction costs for ASR systems vary with depth of well, treatment requirements and quantity of wells constructed. The construction costs for most ASR systems are significantly higher than the cost for typical Floridan aquifer wells due to the permitting constraints, need for monitor wells, treatment and testing requirements, and design considerations.

The cost of construction of ASR wells can be impacted by depth, casing material, recovery capacity, and treatment requirements. Often, the most feasible option for a municipality is to incorporate or co-locate an ASR system with a Water Treatment Plant (WTP) or Wastewater Treatment Plant (WWTP). In this arrangement, any additional treatment requirements associated with post or pre-treatment are limited to additions to existing WTPs or WWTPs.

The average total cost of construction of an ASR well is approximately $1.1 million (December 2021 Dollars), with the price varying significantly with depth and pumping capacity. Monitoring well costs will vary with depth and functionality (single vs dual-zone monitoring well). The average cost for a shallow monitoring well is approximately $124,000. The average cost of a single- zone deep monitoring well is approximately $987,000. Lastly, an average cost for a dual-zone deep monitoring well is about $2.4 million.

In general, the construction costs collected for this evaluation did not appear to have a direct correlation to the design and capacity of each well. However, to evaluate the overall construction costs for recovery capacities for 1 mgd, 1.5 mgd, 2 mgd, and 5 mgd (projected based on smaller capacity well data), ASR well projects were selected that included the respective recovery capacity and a MW as part of the construction activities. Since a direct correlation could not be determined, the data used for the ASR construction costs are real data assumed to be representative of the construction costs in December 2021 dollars. The opinion of probable construction costs for ASR wells and associated MW is summarized in **Table ES.6-1**. Only one O&M data source was available for this technology. Without having sufficient data from multiple ASR wells and capacities, the overall annual O&M costs could not be determined.

Table ES.6-1: Opinion of Probable Construction Costs for ASR Well and MW

Region		KB	SWFWMD	LWC	LWC	Estimated Value
Owner		Polk County Utilities	City of Bradenton	City of Naples	Collier County	
ASR Type		RW	PW	RW	RW	N/A
Recovery Capacity (mgd)		1	1.5	2	2	5
Total Cost per ASR in December 2021 Dollars		$1,754,560	$3,818,062	$2,269,658	$3,880,090	N/A
MW Cost December 2021 Dollars		$1,990,538	$177,064	$349,353	$349,353	N/A
Total Cost for ASR + MW December 2021 Dollars		$3,745,098	$3,995,126	$2,619,011	$4,229,443	$5,421,725
Technical Services	20%	$749,020	$799,025	$523,802	$845,889	$1,084,345
Owner Administration and Legal	5%	$187,255	$199,756	$130,951	$211,472	$271,086
Project Contingency	15%	$561,765	$599,269	$392,852	$634,416	$813,259
Opinion of Probable Capital Cost		$5,243,137	$5,593,176	$3,666,615	$5,921,220	$7,590,415

ES.7 SURFACE WATER RESERVOIR

Construction costs and O&M costs included in **Chapter 7** reflect costs associated with surface water storage projects. Reservoirs serve many purposes within South Florida, such as storage for water supply, stormwater storage, or stormwater treatment. The largest cost components of reservoir construction are earthwork and associated equipment and labor costs. Engineering costs typically range from 10 to 20% of the overall construction cost and include design, engineering services during construction or construction management services. For this study, construction costs were provided by project managers at the SFWMD, municipalities, or from other reliable sources available on the internet. To be conservative, an average of 20% of construction costs should be added to capture the engineering costs described above. O&M costs were provided by the SFWMD and other municipalities, where available.

Some projects within **Chapter 7** were designed and constructed in separate construction packages and were performed in different phases and time periods of the overall surface water storage (SWS) or reservoir project. Further, the different construction packages were completed at various start dates over various timeframes. Therefore, the project components in the different packages were initially evaluated separately. Each SWS component was then projected to December 2021 dollars and were added together to have an overall construction cost for each SWS project, where applicable.

It should be noted that some of the projects listed within this section are larger reservoir projects intended to capture stormwater runoff versus provide an alternative water supply for storage, treatment, and consumption. In addition, other projects listed in this section are considered shallow stormwater treatment areas (STA). It was determined during this evaluation that these projects should not be discounted from a construction cost standpoint since these projects include similar construction components as those needed for a SWS system intended as an alternative water supply source for treatment and consumption.

A summary of capital costs (in December 2021 dollars) for all SWS areas reviewed in this study are represented in **Table ES.7-1** in terms of total costs in December 2021 dollars and cost per acre-feet. Annual O&M costs are also included in **Table ES.7-1** where information was available at the time of this study.

Table ES.7-1: Summary of Capital Costs for Reservoir Projects in December 2021 Dollars

Surface Water Impoundment	Total Cost In December 2021 Dollars (millions)	Total Storage Capacity (acre-feet)	Total Cost ($/Acre-feet of Storage)	Annual O&M Estimates
Caloosahatchee River West Basin Storage Reservoir	$823	170,000	$4,841	Unknown/Under Construction
Indian River Lagoon - South C44 STA (Cells 1 through 6)	$604	50,600	$11,937	$802,774
A1 FEB	$94	60,000	$1,567	$219,902
Everglades Agricultural Area Reservoir	$1,772	240,000	$7,383	Unknown/In Design Phase
Peace River Reservoir 2	$86.1	18,413	$4,676	$1,055,000
McCarty Ranch Extension Area 1	$2.5	840	$2,976	$180,000 (This is estimated based on information from City of PSL website. Source: www.cityofpsl.com)
McCarty Ranch Extension Area 2	$3.4	1,100	$3,091	
McCarty Ranch Extension Area 3	$2.6	1,160	$2,241	
McCarty Ranch Extension Area 4	$2.6	1,148	$2,265	
McCarty Ranch Extension Area 5	$1.64	312	$3,475	
McCarty Ranch Extension Area 6		160		
McCarty Ranch Preserve Area 7 (7A and 7B)	$16.81	2,112	$7,960	
Lakeside Ranch STA Phase 2 – South	$53.75	1,840	$29,212	$185,975
Lakeside Ranch STA Phase 2 – South (Pump Station S-191A)	$42.38	--	--	$275,690

ES.8 PIPELINE SYSTEMS

Construction costs included in **Chapter 8** reflect costs associated with pipeline projects. Pipeline construction costs were evaluated for varying pipe diameters, ranging from 12 to 42 inches and were derived from available contractor schedule of values collected from each project. Pipeline projects reviewed were limited to those greater than 500 linear feet (LF) as shorter runs of pipe are typically more expensive. Project construction dates ranged from 2014 to 2021. Sources for this information include current and past projects and recent manufacturer/supplier quotes. Cost of installation is included but is limited to the following: excavation/trenching, pipe bedding, backfilling and compaction, dewatering, and separately horizontal directional drilling (HDD). All costs will vary based on construction duration, trench depth, pipe size, length of pipe and dewatering method (i.e., well points or trash pump).

Table ES.8-1 summarizes overall probable construction costs based on collected cost information and recent construction bids and calculated costs using RSMeans, a construction cost estimating software. The RSMeans evaluation includes construction setting costs to assist with pipeline project planning in rural, suburban or urban settings. Generally, estimates from the RSMeans database/supplier/manufacturer quotes are slightly higher than the observed construction costs. RSMeans and quoted material costs do not account for reductions due to economy of scale. It also appears that the variation of costs may be due to the higher material costs provided by the suppliers at the time of this analysis due to market impacts described in **Chapter 1**, and as further discussed in **Chapter 8**, of this Study.

Table ES.8-1: Overall Summary of Unit Costs for Pipeline Systems

Overall Cost Summary Table						
Diameter (Inches)	Material	Method of Construction	OPCC per LF[1]	RSMeans Cost per LF (Rural)[2]	RSMeans Cost per LF (Suburban)[2]	RSMeans Cost per LF (Urban)[2]
12	DIP	Trench	$114	$100	$200	$300
12	HDPE	Trench	$113	$106	$212	$318
12 [3]	HDPE	HDD	$105	$151	N/A	N/A
16	DIP	Trench	$144	$142	$285	$425
16	HDPE	Trench	$150	$143	$285	$428
16	HDPE	HDD	$144	$199	N/A	N/A
18 [3]	DIP	Trench	$165	$175	$350	$525
18 [3]	HDPE	Trench	$169	$176	$352	$528
18	HDPE	HDD	$162	$239	N/A	N/A
20	DIP	Trench	$180	$196	$392	$588
20 [3]	HDPE	Trench	$174	$216	$432	$648
20 [3]	HDPE	HDD	$174	$287	N/A	N/A
24	DIP	Trench	$216	$258	$516	$773
24 [3]	HDPE	Trench	$225	$305	$610	$915
24 [3]	HDPE	HDD	$350	$395	N/A	N/A
30 [3]	DIP	Trench	$173	$442	$883	$1,325
30 [3]	HDPE	Trench	$261	$464	$927	$1,391
30	HDPE	HDD	$400	$594	N/A	N/A
36 [3]	DIP	Trench	$422	$593	$1,187	$1,780
36 [3]	HDPE	Trench	$338	$660	$1,320	$1,980
36 [3]	HDPE	HDD	$1,045	$847	N/A	N/A
42	DIP	Trench	$505	$806	$1,612	$2,418
42 [3]	HDPE	Trench	$394	$1,145	$2,291	$3,436
42	HDPE	HDD	$1,260	$1,414	N/A	N/A

(1) All construction project costs are escalated to December 2021 dollars using CCI
(2) Material prices in "RSMeans Total Installed cost per LF" are manufacturer prices
(3) Denotes information was derived from available construction cost information
N/A = Not Applicable. Costs for HDD construction is not typically impacted by construction setting.

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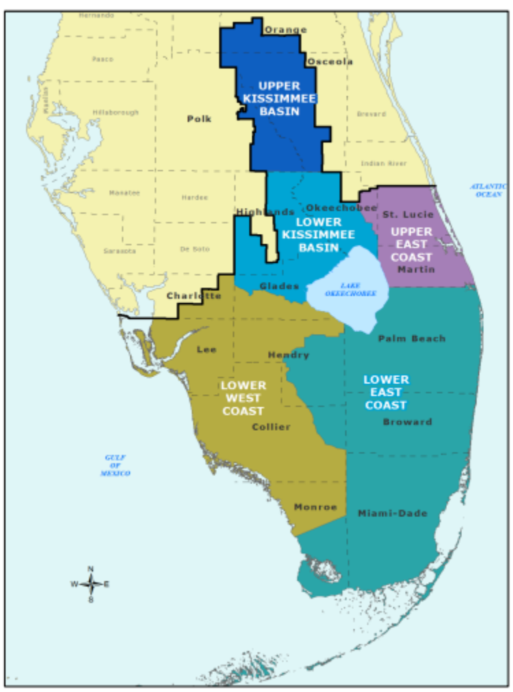
1

BACKGROUND

1.1 INTRODUCTION

The South Florida Water Management District (SFWMD or District) is comprised of five regional water supply planning areas (**Figure 1-1**): Upper Kissimmee Basin, Lower Kissimmee Basin, Upper East Coast, Lower West Coast, and Lower East Coast. The Upper Kissimmee Basin is part of the Central Florida Water Initiative (CFWI), which covers Orange, Osceola, Polk, and Seminole counties as well as southern Lake County. The CFWI is a collaborative planning effort by three water management districts (SFWMD, Southwest Florida Water Management District, and St. Johns River Water Management District).



- **Upper Kissimmee Basin:** Portions of Osceola, Orange, and Polk counties
- **Lower Kissimmee Basin:** Portions of Okeechobee, Highlands, and Glades counties
- **Upper East Coast:** Martin and St. Lucie counties and eastern Okeechobee County
- **Lower East Coast:** Palm Beach, Broward, and Miami-Dade counties, and portions of Monroe, Collier, and Hendry counties
- **Lower West Coast:** Lee County and portions of Collier, Glades, Hendry, Monroe, and Charlotte counties

Figure 1-1: Regional Water Supply Planning Areas within the SFWMD

Water management districts are required to develop a regional water supply plan (RWSP) if they determine the existing sources of water are inadequate to supply water for all existing and future reasonable-beneficial uses, and/or may not sustain water resources and related natural systems for a 20-year planning period. RWSPs include analysis of current and future water demands, evaluation of available water sources, and identification of water resource and water supply development projects to meet demands. The legal authority and requirements for water supply planning are outlined and described in Chapter 373, Florida Statutes (F.S.) with additional requirements provided in Chapters 163, 187, 403, and 507, F.S.

Water supply plans include a water supply development component, which involves "planning, design, construction, operation, and maintenance of public or private facilities for water collection, production, treatment, transmission, or distribution for sale, resale, or end user" [Section 373.019(26), F.S.] and are primarily the responsibility of the local water providers. This cost estimation study will be used to provide estimated planning-level costs for capital investment and operation and maintenance of the water supply development projects, where needed.

To assist local water providers and users in implementation of the water supply development component of the water supply plan, the SFWMD provides funding assistance to public water suppliers, local governments, special districts, homeowner's associations, and other public and private water users for AWS and water conservation projects consistent with the SFWMD's core mission, through the Cooperative Funding Program (CFP). The focus of the CFP is to support the development of AWS projects that will diversify the water supply while reducing dependence on freshwater resources. This study will assist with the review of project application costs for the development of AWS projects. As part of the CFP, funding was made available for AWS projects which has historically included the following project-types:

- Reverse osmosis plants
- Brackish water supply wells
- Reclaimed water plant expansions and transmission mains
- Aquifer storage and recovery wells

1.2 OBJECTIVES

Current development costs of water supply options can play an important role in evaluating water supply alternatives and AWS type projects. Currently, the SFWMD relies on the Water Supply Cost Estimation Study (Cost Estimation Study) completed in February 2007 by CDM Smith. The information and cost data included in the 2007 Cost Estimation Study is considered obsolete and the update of water supply development costs, which includes capital and operation and maintenance (O&M) costs, is required to help the SFWMD with water supply planning and funding objectives and goals. The water supply options include sources from groundwater (fresh and saline), sea water, and reclaimed water. Other water supply options include storage such as aquifer storage and recovery (ASR) and aboveground reservoirs that make water supply available during times of the year where water is limited or may not be available. These sources could require different types of treatment prior to use, and the associated costs for these need to be understood.

The objective is to update the Cost Estimation Study with current engineering costs, construction costs, and cost estimating relationships using cost data for projects constructed within the last 10 years and other cost sources such as RSMeans (http://www.rsmeansonline.com), suppliers, contractors, and vendors where appropriate. This cost data should be used for planning level estimates only. The water supply development costs include various water supply options such as surficial aquifer wells and confined aquifer wells, reclaimed water, ASR wells and reservoirs, as well as associated treatment technologies, storage, and distribution. The construction cost data from projects that were started or completed in the last 10 years have been escalated to reflect present day costs using industry standard cost indices.

1.3 SCOPE OF WORK

The scope of work for this Study is to identify the most relevant projects and their development costs to provide current cost data (December 2021) for all system type options. Assessment of land value is not included in this evaluation. Additionally, a detailed description of each system and their components will be summarized within each Chapter. The systems evaluated in this study are as follows:

- Water Supply Wells
- Advanced Water Treatment Technologies
- Water Reclamation and Advanced Wastewater Treatment Technologies
- Deep Injection Wells
- Aquifer Storage and Recovery
- Surface Water Storage
- Pipeline Systems

The costs for Advanced Water Treatment and Water Reclamation and Advanced Wastewater Treatment technologies were evaluated for 1 million gallon per day (mgd), 3 mgd, 5 mgd, 10 mgd, 15 mgd and 20 mgd facilities. Ancillary treatment components, such as disinfection technologies including sodium hypochlorite and ultraviolet (UV) and pumping facilities and storage, are also included.

The following sections generally describe how each Chapter will be organized and what information will be provided in each of the respective sections as it relates to each system.

DISCUSSION OF ASSUMPTIONS AND APPROACH

This section in each chapter will discuss assumptions and approach to cost analysis as it relates to each specific water supply component and a summary of the development cost data collected for each system. The development cost data collected will reflect the source, costs, year of construction, and detailed description of each system. Any relevant cost increases due to COVID-19 supply chain challenges, petroleum costs, trade policy action, or any other relevant cost implications that impacted construction costs between 2011 and 2021 will be discussed for each applicable system. Other cost impacts will also be described (e.g., raw water quality that affects membrane selection and recovery versus concentrate ratio and membrane selection).

CAPITAL COSTS

This section in each chapter will discuss each systems' capital costs which typically include material costs, equipment costs, electrical system costs for installation, yard piping costs and site work costs for which each utility, municipality or agency is responsible. Other capital costs include general conditions (administrative costs, permits, fees, project management, etc.), mobilization, demobilization, bonds, and insurance. Other capital cost add-ons may be included and used to supplement information not provided or available. The construction cost information was typically collected from pay applications, bid forms, or schedule of values. Typically, the work description in each of the line items listed in each source does not include detail of what is included or "tucked in" to the costs. There may also be instances where the costs may be front loaded or distributed amongst all line items within the source so the contractor is paid up front for their services and develop profit early in the construction schedule. All capital costs were adjusted to reflect estimated cost as of December 2021.

OPERATION AND MAINTENANCE COSTS

This section in each chapter discusses the cost associated with operating and maintaining the system which includes power, chemicals, rehabilitation and replacement (R&R) (if available), labor, administrative, and regulatory compliance costs.

TOTAL COST SUMMARY

This section in each chapter will provide an overall cost summary for each system and project presented in each chapter. The cost summary will reflect an overall comparison of project costs for each system evaluated and will summarize the data collected.

1.4 MARKET IMPACTS

From approximately August 2020 to December 2021, the construction industry has experienced unprecedented impacts on overall construction costs and labor due to steep increases in material prices, supply chain issues, and difficulty staffing laborers. These issues are generally due to the following impacts:

- The Coronavirus (COVID-19) which has led to supply chain challenges, such as delayed deliveries and long lead times, and shortages of employees or laborers to complete the work. Other COVID-19 impacts included shutdown of manufacturing facilities due to government orders deeming them "non-essential". Once production facilities could re-open, it was difficult staffing the facilities due to illness, required quarantine or having to take care of family members at home. This led to a backlog of production while demand began to increase. This, in turn, led to supply chain challenges and ultimately increases in production and material costs.
- Dramatic shifts in demand for goods and services partially triggered by the pandemic has led to price pressure and shortages of goods and material.
- Increases in petroleum, natural gas and diesel costs has led to price increases in products that require fuel for production (e. g., PVC piping) and fuel for material delivery and heavy equipment operation.

- Trade policy action for imported and exported material (increase in tariffs for materials purchased from other countries).
- The Texas winter storm in 2020 knocked out production facilities and power to petrochemical plants that led to damages such as frozen pipe bursts. Loss of production and repairing damages created a surge in demand for products that use plastic resins (such as PVC piping), adhesives, and packaging products used for protecting construction materials.

At the time of this study, the market is highly volatile, and not anticipated to stabilize soon. A slow economic recovery is anticipated in 2022 with the first half of 2022 continuing to see upward pressure on prices, according to Engineering News Record's (*ENR*'s) 2022 forecast (Zevin and Rubin, 2021). For water supply projects, an overall 6.8% increase is anticipated in 2022 as compared to 2021, according to FMI Corp. evaluation (Zevin and Rubin, 2021).

1.5 COST PROJECTION METHODOLOGY

As discussed in the previous sections, historical and present-day market fluctuations have impacted construction costs, including labor and material costs. These impacts need to be considered when estimating construction costs of projects from historical cost data. In order escalate historical costs to December 2021 dollars, the *ENR* Construction Cost Index (CCI) and Material Price Index (MPI) were used to bring forward construction costs to December 2021 dollars, where appropriate. Each index measures how much current construction and material costs escalated as compared to what it was in the base month/year (month/year the cost was initially determined). For example, for August 2016 (base month/year), the CCI value is 10385. For August 2020, the CCI value is 11455. Therefore, the cost escalation multiplier from the basis month/year of August 2016 to August 2020 is 11455 divided by 10385 or 1.10 (10% escalation). The CCI is typically used where labor costs are a high proportion of total costs and is based on a 20-city average rate for wages and benefits times 200 hours of common labor. The MPI is a 20-city average of material costs. Both indices apply to general construction costs and reflect monthly inflation rates. Due to the effects of COVID-19, increases in tariffs and other issues previously mentioned, the market has been in flux between August 2020 and December 2021. The CCI has typically been used to project costs to today's dollars. However, the CCI does not appear to reflect the increase of material costs contractors are seeing in the 2021 market. The MPI, however, appears to better reflect the material cost increases and ultimately the overall construction costs contractors are experiencing for the types of projects described in this Study. Therefore, a combination of the CCI and MPI were used to estimate current costs (in December 2021 dollars) of previous projects included in this Study. The CCI was used between the construction start date, or the bid tabulation dates of the project, and August 2020, where material costs began to increase at a steeper rate than historical values within the last 10 years. From August 2020 to December 2021, a 30% increase was added to the August 2020 adjusted costs, as this is the average increase for overall construction costs according to *ENR*'s MPI data and input from contractors' cost estimators of the market during this period.

To reflect current construction costs, projects' capital costs that were bid within the last 10-years were escalated to present-day costs. The *ENR* cost indices were used to project construction costs data to 2021 dollars. Other construction costs' impacts were also considered as it relates to historical and current market fluctuations and impacts within the last 10 years. O&M add-ons include power costs of $0.12 per kilowatt-hour (KWh) and chemical costs are based on current values provided by municipalities and other reliable sources (2021). The chemical costs include Sodium Hypochlorite for Disinfection and Sulfuric Acid or Carbon Dioxide for pre-treatment and post-treatment for Membrane Technology.

Summary of Capital Cost add-ons are listed in **Table 1-1** below. Note these capital cost add-ons are assumed based on industry standard percentages used for cost estimating, as well as data collected from construction cost information provided for this water supply study.

Table 1-1: Summary of Capital Cost Add-ons

Add On	Cost
General Conditions	Varies
Mobilization/Demobilization	Varies
Bonds	2%
Contractor Overhead and Profit	15%
Technical Services(1)	20%
Owner Administration and Legal	5%
Project Contingency	15%
Federal Discount Rate for 2021 (Water Resources Discount Rate)	2.5%
Annual Interest Rate(2)	7%
Sales Tax (where applicable)	7%
Plant Service Life	20 years

(1) Includes Engineering, Geotechnical, Survey, Permitting, Engineering Services During Construction
(2) Derived from the Federal Discount Rate

For advanced water treatment (**Chapter 3**) and reclaimed/reuse water treatment (**Chapter 4**) technologies, today's capital costs and 20-year projected capital costs for all systems are graphically represented within the respective Chapters along with expected accuracy range between -30% and +50% of the calculated costs, per Association for the Advancement of Cost Engineering (AACE) International's Estimating Class 4 (AACE, 2020). Total production costs are presented based off plant capacity (or maximum daily flow) or annual average daily flow. A 7% discount rate over 20 years was used to develop capital investment for these technologies. An annual deposit of 10% of the equivalent annual capital cost is assumed for budgeting for a R&R account. Capital costs to do not include the cost of acquisition of land, rights-of-way, transmission mains, and utilities.

In addition to the methodology described above for projects performed in the last 10 years, another cost estimating tool, RSMeans, was used to determine costs for pipeline construction projects (**Chapter 8**).

2

WATER SUPPLY WELLS

2.1 DISCUSSION OF ASSUMPTIONS AND APPROACH

Capital costs and O&M data were collected and summarized for water supply wells. This data included: drilling of the well, wellhead, appurtenances, and limited site improvements, such as well pad and fencing for four of the five planning areas within the SFWMD (Lower East Coast, Upper East Coast, Lower West Coast, and Upper Kissimmee Basin). The Lower Kissimmee Basin was not included in this analysis due to the lack of available information. Data was analyzed for each of these planning areas individually as the location of the well may directly impact the cost of construction due to well location; depth of well as it relates to water source (i.e., aquifer the water is drawn from); and well diameter. After evaluating the costs for each well, within each planning area, it was determined that the planning area (or location) was not the driver for overall well costs. The well parameters (i.e., well capacity, well depth, etc.) appeared to be the basis of the resulting costs. Therefore, this evaluation applies to costs District-wide. Data was obtained through both internal and external resources. The Florida Department of Environmental Protection (FDEP) MapDirect website (https://ca.dep.state.fl.us/mapdirect/) was used to download and sort data for all wells within the SFWMD service area. The SFWMD ePermitting website was also used to collect well casing depth, well diameter, and capacity.

In addition to the costs discussed in **Chapter 1**, costs for water supply wells include all relevant data such as construction date (cost basis month-year), *Engineering News Record* CCI and MPI values (per methodology discussed in Chapter 1), material, well casing diameter, depth, capacity, aquifer, and pump type (with HP). There were several well cost comparisons for wells constructed in different years, that may be indicative of a higher cost increase than what the CCI and MPI capture. It could not be determined if the higher cost percent increase were attributed to local or project specific impacts versus market impacts, to rely on the percent increase for this evaluation. Therefore, the *ENR* CCI and MPI methodology, described in **Chapter 1**, was used in this section for consistency and reliability of data for cost adjustments. The projects used are throughout the SFWMD service area and ranged in depth and water source (i.e., surficial or confined aquifer), with the exception of the wells in Indian River County (IRC), which were included to provide additional well information near the Upper East Coast (UEC) Planning Area.

Water Supply Wells

The depth of each well varies by location and use. Wells included in this Study contain casing sizes ranging from 10 to 24 inches and are primarily constructed of polyvinyl chloride (PVC), stainless steel, steel, or fiberglass reinforced plastic (FRP). Modern wells primarily utilize submersible pumps with an appropriate size and number of pump bowls to accommodate required flow and pressure head. In general, the well systems reviewed in the LEC Planning Area were placed within a concrete slab and are enclosed by a chain-link fence, as required by Chapter 62-555, Florida Administrative Code (F.A.C.).

The water supply sources in each area evaluated are from either a surficial aquifer or confined aquifer which includes the Biscayne Aquifer, Lower Tamiami Aquifer, Floridan Aquifer and Mid-Hawthorn Aquifer. **Figure 2-1** through **Figure 2-4** present generalized cross-sections of each planning area and associated aquifer zones with corresponding depths (Source: https://www.sfwmd.gov/document/cuptech-aquifer-cross-sections-and-maps)

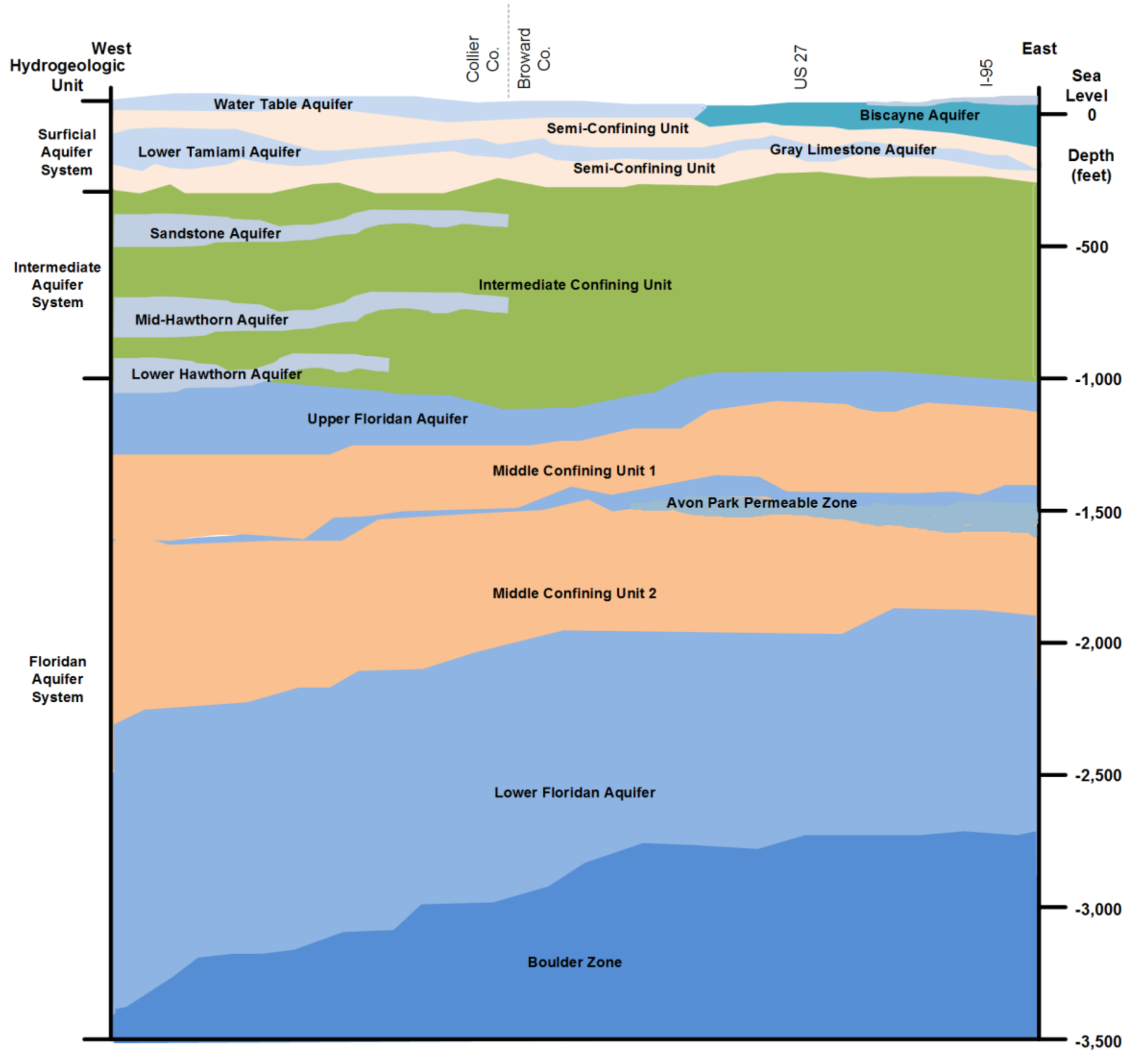


Figure 2-1: Lower East Coast Planning Area: Miami-Dade and Broward Counties Generalized Cross-section

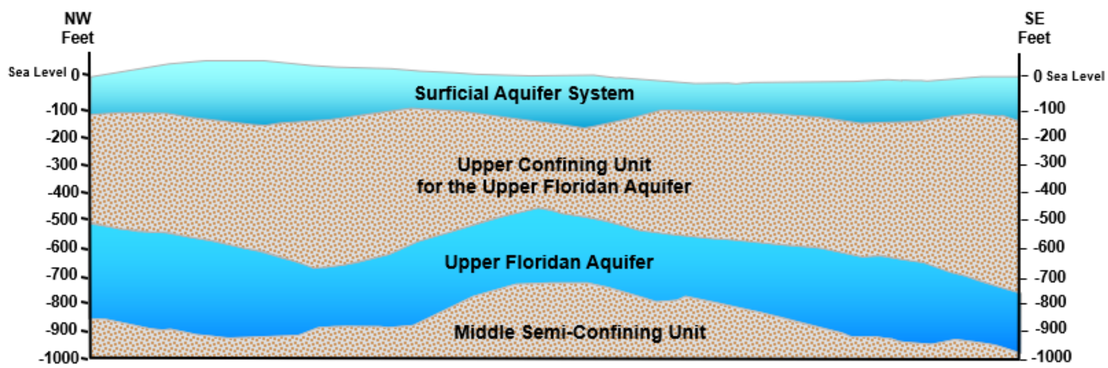


Figure 2-1: Upper East Coast Planning Area: Generalized Cross-section Northwest to Southeast

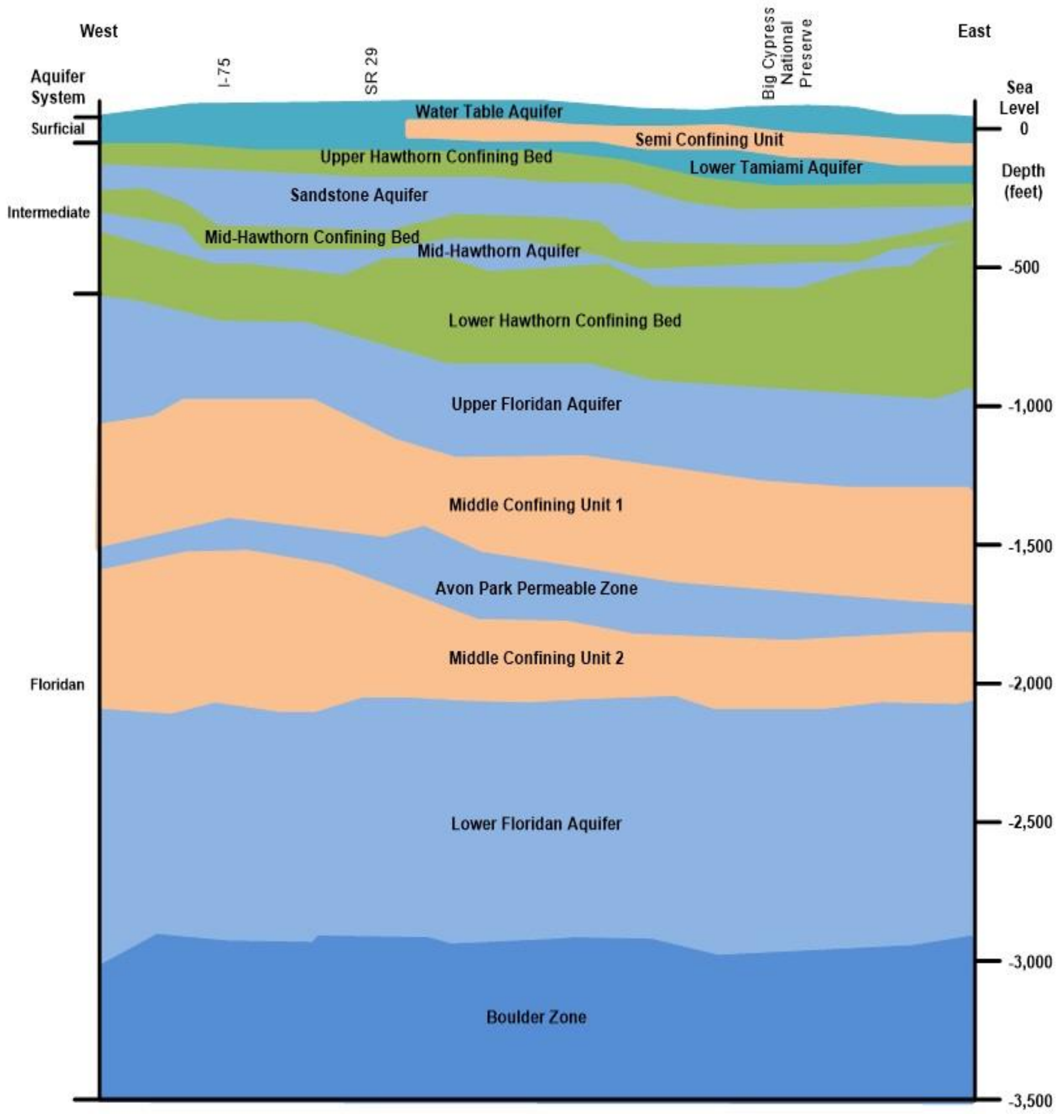


Figure 2-2: Lower West Coast Planning Area: Generalized Cross-section Northwest to Southeast

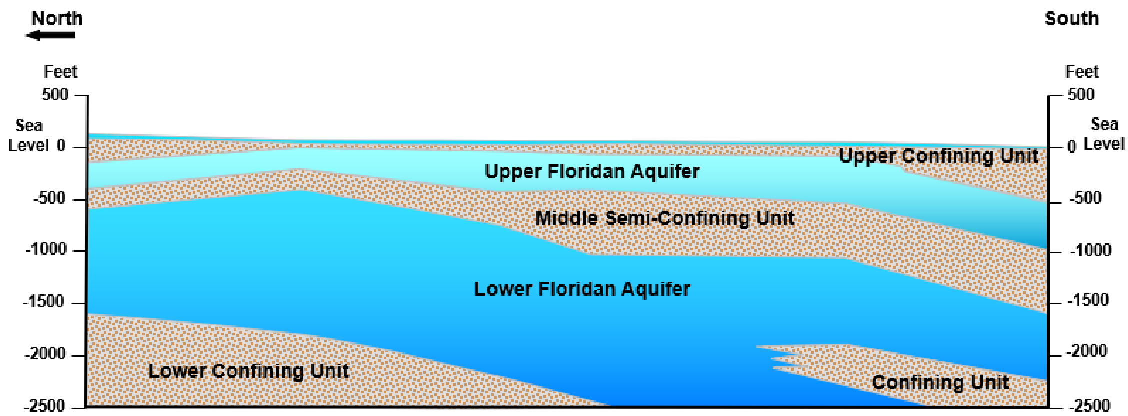


Figure 2-3: Upper and Lower Kissimmee Basin Planning Area: Generalized Cross-section North to South

Wellhead Costs

Wellhead costs typically include the piping, monitoring equipment (flow, pressure, etc.) valves, and fittings required to complete the wellhead assembly. Additional costs include all remaining features required to complete the well site such as a vault or concrete pad to enclose the well; required pipe supports; and surrounding fencing for public access control and safety. Mechanical, electrical, control panels, and associated appurtenances are all considered within the wellhead cost. It was determined that general conditions costs varied in the contractor's general conditions values to where an "apples to apples" comparison was difficult to achieve. For example, two contractors that bid on the Palm Beach County Water Utilities Department (PBCWUD) 19-022 project had general conditions value of 5.7% and 8.7% respectively, which resulted in a bid difference of approximately $350,000. This cost difference is significant enough to skew the cost data for comparative purposes. In evaluating the available cost data, the general conditions value was not included in the evaluation but the reader should assume the general conditions to be approximately 5 to 10% of the overall construction costs.

Operating Costs

Operating costs reflect resulting power consumption based on pump horsepower, efficiency, and power costs in dollars per kilowatt-hour ($/KWh) as of December 2021. Well maintenance costs reflect chlorination/disinfection, acidization, and general repair and rehabilitation work including brushing of casing, downhole video, removal and replacement of motors and replacement of well appurtenances.

2.2 LOWER EAST COAST

Internal and external databases were used to develop a list of recently completed wells within the Lower East Coast Planning (LEC) Area. Wells from both the Surficial aquifer system (SAS) and Floridan aquifer system (FAS) were evaluated. Some of the information was collected from vendor pay applications provided by municipalities and utilities for each project. Other data was obtained from contractors including Florida Design and Drilling, Inc., and consultant JLA Geosciences, Inc. See **Table 2-1** for the list of wells used for this study and their corresponding municipality and aquifer water source.

Table 2-1: Wells Evaluated within the LEC Planning Area

Location of Well	Utility	Project Name	Aquifer
Broward County	Coral Springs Improvement District (CSID)	Wells 7R, 18, 19, and 20	Surficial
Broward County	North Springs Improvement District (NSID)	Well 10	Surficial
Broward County	City of Hallandale Beach	Well 9	Surficial
Broward County	City of Sunrise Utilities Department	Wells SGF-1 and SGF-2	Floridan
Palm Beach County	Seacoast Utility Authority	Wells HR-8A, HR-8B, HR-9B, HR-11A, HR-12A, HR-14A, HR-16A, and HR-18A	Surficial
Palm Beach County	Seacoast Utility Authority	Well F-9	Floridan
Palm Beach County	Town of Jupiter Utilities	Wells 12A, 8A, and 11A	Floridan
Palm Beach County	Palm Beach County Water Utilities District	Wells 3W-13R, 9W-2R, and 9W-11R (16-077 Phase I)	Surficial
Palm Beach County	Palm Beach County Water Utilities District	Wells 9W-1R, 9W-5R, 8W-10R, and 2W-1R (16-077 Phase II)	Surficial
Palm Beach County	Palm Beach County Water Utilities District	Well 2W-3R (19-022 Phase II)	Surficial
Palm Beach County	Palm Beach County Water Utilities District	Wells PW-8, PW-9, and PW-11	Floridan
Palm Beach County	City of Boca Raton Water Utilities	Wells SR 28W, SR 21W, and SR 33W	Surficial

2.2.1 CAPITAL COSTS

Well, Well Pumps, and Appurtenances Costs (LEC Summary)

Production well costs can be impacted by various attributes of the well, such as size (diameter), depth of well casing, completed well depth, and location. Other impacts on construction costs are labor and overall material costs, which have dramatically increased within the last four years. For example, from the cost data collected, a significant cost increase has been observed in the data within the last four years. From 2017 to 2018, the average cost for a surficial well installation had increased by over 25% when comparing the PBCWUD well costs. The 2017 average cost of surficial wells (including the wellhead) constructed in the PBCWUD 16-077 Phase I projects (3W-13R, 9W-2R, and 9W-11R) was approximately $390,092 and the average 2018 costs for the PBCWUD Phase II project (9W-5R and 2W-1R) was $486,725. An additional 75% cost increase was observed between the well costs associated with PBCWUD 19-022 Phase II project (2W-3R) and the wells associated with the PBCWUD Phase II project (9W-5R and 2W-1R), where the total cost of Well 2W-3R was approximately $830,252 in August 2021 dollars. Technology was added to the wells constructed as part of the PBCWUD Phase I and Phase II project construction costs to make them "smarter", which drove the costs of these wells higher as compared to other wells constructed in other municipalities that do not typically incorporate this type of program for their wellfield systems. This 70% increase may not be representative of all wells recently constructed as compared to wells constructed prior to 2020. However, a portion of the significant cost increase may include the combination of the volatile market impact within the last two to three years or where most of the cost impact was observed starting August 2020, as discussed in **Chapter 1**. These cost increases may also include the differences in depth, the work involved, required improvements related to the electrical and instrumentation effort, and access and location of each well that cannot be derived from the schedule of values for each well in a given year. For these wells, estimated construction costs in December 2021 dollars are listed in the **Tables 2-2**, respectively.

The well construction costs for Seacoast Utility Authority (SUA) wells were also compared to evaluate cost increase between 2018 and 2020. Five SUA wells and associated wellheads (HR-9B, HR-11A, HR-14A, HR-16A, and HR-18A), similar in size and material of the HR-8B well and wellhead, were constructed in July 2018 and had an average overall construction cost of $436,704 per well. Well HR-8B was completed in April 2020 with cost of approximately $502,420. The overall construction cost of Well HR-8B had increased by 15% as compared to the July 2018 wells. Note, this was prior to the market impacts discussed in **Chapter 1**. For these wells, adjusted construction costs in December 2021 dollars are listed in the **Tables 2-2**, respectively.

For the FAS wells (PBCWUD PW-8, PBCWUD PW-11, SUA F-9, SUA SGF-1, and SUA SGF-2) constructed in the LEC, the adjusted well costs (in December 2021 dollars) range from $483,899 to $1,462,925 (at time of respective construction dates or cost basis month) with well depths ranging from 632 feet to 1,800 feet below land surface (bls), respectively. Casing material varied and included PVC, black steel, PVC and FRP. Casing diameters ranged from 12 to 17 inches. The well characteristics and cost information can be found in **Table 2-3**.

Submersible pumps are the most common type of pump used for SAS water supply wells. Vertical turbine pumps followed by end-suction centrifugal type pumps were the least common and were typically used for FAS water supply wells. It should be noted the cost of wellhead and miscellaneous appurtenances varies depending on the size and type of pump installed. Costs for wellheads, including pump and motor, were developed from bid tabs, pay applications, and AWS funding program applications from the District for Palm Beach, Broward, and Hendry counties.

Present-day (December 2021 dollars) wellhead costs for the LEC Planning Area are provided as part of **Tables 2-2 and Table 2-3** and range from $105,475 to $855,371 for SAS wells and from $113,867 to $891,906 for FAS wells. Wellhead costs include pump and motor, valves and appurtenances, electrical, and instrumentation. The wellhead costs appear to be driven by the wellhead size, capacity, and technology added to the well.

See **Table 2-2** and **Table 2-3** for data collected for SAS wells and FAS wells, located in the LEC Planning Area, respectively.

Table 2-2: SAS Well Costs within the LEC Planning Area

UTILITY/ OWNER WELL ID	CSID: Well 18, 19, 20 (average cost per well)	CSID: Well 7R	NSID: Well 10	City of Hallandale Beach: Well #9
Well Location	Broward County	Broward County	Broward County	Broward County
Construction Date (Cost Basis Month-Year)	June 2018	May 2015	October 2018	February 2021
Well Depth (ft)	87, 102, 94 (respectively)	67	80	100
Casing Depth (ft)	137	132	140	100
Well Capacity (gpm)	700	900	500	2,200
Casing Material	PVC	Stainless Steel	PVC	Not Available
Casing Diameter (in)	16	16	16	24
Well Construction Cost at Cost Basis Month-Year	$493,500	$320,781	$282,500	$168,000
CCI at Cost Basis Month-Year (1)	11069	9975	11183	--
Adjusted Well Construction Cost in August 2020 Dollars (2)	$510,709	$368,376	$289,371	--
Adjusted Well Construction in December 2021 Dollars (3)	$663,922	$478,889	$376,182	--
MPI at Cost Basis Month-Year (4)	--	--	--	3836
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--	--	$217,401
Wellhead Construction Cost at Cost Basis Month-Year	$227,200	$38,902	$192,500	$661,000
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$235,123	$44,674	$197,182	--
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$305,660	$58,076 (6)	$256,337	--
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--	--	$855,371

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")
(6) Appears low, not included in summary table

Table 2-2: SAS Well Costs within LEC Planning Area (Continued)

UTILITY/ OWNER WELL ID	PBCWUD 16-017 Phase I: 3W-13R	PBCWUD 16-017 Phase I: WUD 9W-2R	PBCWUD 16-017 Phase II: 9W-5R	PBCWUD 16-017 Phase I: WUD 9W-11R
Well Location	Palm Beach County	Palm Beach County	Palm Beach County	Palm Beach County
Construction Date (Cost Basis Month-Year)	August 2017	August 2017	January 2018	August 2017
Well Depth (ft)	155	148	148	156
Casing Depth (ft)	105	98	98	96
Well Capacity (gpm)	1,250	1,100	1,100	1,100
Casing Material	PVC	PVC	PVC	PVC
Casing Diameter (in)	16	16	16	16
Well Construction Cost at Cost Basis Month-Year	$155,875	$153,000	$243,910	$155,400
CCI at Cost Basis Month-Year (1)	10826	10826	10878	10826
Adjusted Well Construction Cost in August 2020 Dollars (2)	$164,931	$161,889	$256,848	$164,428
Adjusted Well Construction in December 2021 Dollars (3)	$214,411	$210,456	$333,902	$213,758
MPI at Cost Basis Month-Year (4)	--	--	--	--
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--	--	--
Wellhead Construction Cost at Cost Basis Month-Year	$252,000	$227,000	$316,000	$227,000
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$266,641	$240,189	$332,762	$240,189
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$346,634	$312,246	$432,590	$312,246
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--	--	--

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")

Table 2-2: SAS Well Costs within LEC Planning Area (Continued)

UTILITY/ OWNER WELL ID	PBCWUD 16-017 Phase II: 2W-1R	PBCWUD 19-022 Phase I: 8W-10R	PBCWUD Well 2W-3R
Well Location	Palm Beach County	Palm Beach County	Palm Beach County
Construction Date (Cost Basis Month-Year)	January 2018	January 2018	August 2021
Well Depth (ft)	118	105	140
Casing Depth (ft)	86	75	90
Well Capacity (gpm)	1,200	1,000	1,200
Casing Material	PVC	PVC	PVC
Casing Diameter (in)	16	16	24
Well Construction Cost at Cost Basis Month-Year	$212,540	$217,091	$495,352
CCI at Cost Basis Month-Year (1)	10878	10878	
Adjusted Well Construction Cost in August 2020 Dollars (2)	$223,814	$228,606	
Adjusted Well Construction in December 2021 Dollars (3)	$290,958	$297,188	--
MPI at Cost Basis Month-Year (4)	--	--	4933
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--	$498,465
Wellhead Construction Cost at Cost Basis Month-Year	$201,000	$271,000	$361,000
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$221,662	$285,375	--
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$275,160	$370,987	--
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--	$363,270

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")

Table 2-2: SAS Well Costs within LEC Planning Area (Continued)

UTILITY/ OWNER WELL ID	Boca Raton Water Treatment Plant SR 28W	Boca Raton Water Treatment Plant SR 31W	Boca Raton Water Treatment Plant SR 33W
Well Location	Palm Beach County	Palm Beach County	Palm Beach County
Construction Date (Cost Basis Month-Year)	October 2012	October 2012	October 2012
Well Depth (ft)	213	195	205
Casing Depth (ft)	115	113	121
Well Capacity (gpm)	1,400	1,000	1,400
Casing Material	PVC	PVC	PVC
Casing Diameter (in)	20	20	20
Well Construction Cost at Cost Basis Month-Year	$235,628	$216,771	$223,057
CCI at Cost Basis Month-Year (1)	9376	9376	9376
Adjusted Well Construction Cost in August 2020 Dollars (2)	$287,875	$264,837	$272,516
Adjusted Well Construction in December 2021 Dollars (3)	$374,237	$344,288	$354,271
MPI at Cost Basis Month-Year (4)	--	--	--
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--	--
Wellhead Construction Cost at Cost Basis Month-Year	$217,400	$218,350	$207,450
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$265,605	$266,766	$253,449
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$345,287	$346,796	$329,484
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--	--

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")

Table 2-2: SAS Well Costs within LEC Planning Area (Continued)

UTILITY/ OWNER WELL ID	Seacoast Utility Authority HR-8B Replacement	Seacoast Utility Authority Well HR-9B	Seacoast Utility Authority Well HR-11A	Seacoast Utility Authority Well HR-14A/16A (average cost per well)
Well Location	Palm Beach County	Palm Beach County	Palm Beach County	Palm Beach County
Construction Date (Cost Basis Month-Year)	April 2020	July 2018	July 2018	July 2018
Well Depth (ft)	120	120	110	105
Casing Depth (ft)	90	80	80	75
Well Capacity (gpm)	-	1,230	1,230	1,230
Casing Material	PVC	PVC	PVC	PVC
Casing Diameter (in)	16	16	16	16
Well Construction Cost at Cost Basis Month-Year	$340,420	$221,250	$234,520	$226,000
CCI at Cost Basis Month-Year (1)	11413	11116	11116	11116
Adjusted Well Construction Cost in August 2020 Dollars (2)	$341,673	$227,997	$241,394	$232,892
Adjusted Well Construction in December 2021 Dollars (3)	$444,175	$296,397	$313,812	$302,759
MPI at Cost Basis Month-Year (4)	--	--	--	--
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--	--	--
Wellhead Construction Cost at Cost Basis Month-Year	$162,000	$210,000	$210,000	$210,000
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$162,596	$216,404	$216,404	$216,404
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$211,375	$281,326	$218,326	$218,326
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--	--	--

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")

Table 2-2: SAS Well Costs within LEC Planning Area (Continued)

UTILITY/ OWNER WELL ID	Seacoast Utility Authority Well HR-18A	Town of Jupiter Well 12A	Town of Jupiter Well 8A/11A (average cost per well)
Well Location	Palm Beach County	Palm Beach County	Palm Beach County
Construction Date (Cost Basis Month-Year)	July 2018	January 2021	October 2019
Well Depth (ft)	110	160	160
Casing Depth (ft)	80	120	129
Well Capacity (gpm)	1,230	700	Not Available
Casing Material	PVC	PVC	PVC
Casing Diameter (in)	16	12	12
Well Construction Cost at Cost Basis Month-Year	$230,500	$563,995	$273,488
CCI at Cost Basis Month-Year (1)	11116	--	11326
Adjusted Well Construction Cost in August 2020 Dollars (2)	$237,529	--	$276,602
Adjusted Well Construction in December 2021 Dollars (3)	$308,788	--	$359,583
MPI at Cost Basis Month-Year (4)	--	3794	--
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	$737,920	--
Wellhead Construction Cost at Cost Basis Month-Year	$210,000	$80,615	Not Available
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$216,404	--	--
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$218,326	--	--
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	$105,475	--

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")

Table 2-3: FAS Well Costs within LEC Planning Area

UTILITY/ OWNER WELL ID	City of Sunrise SGF-1/SGF-1 (average cost per well)	Seacoast Utility Authority F-9	Lake Region Wellfield Improvement PW-8	Lake Region Wellfield Improvement PW-11
Well Location	Broward County	Palm Beach County	Palm Beach County	Palm Beach County
Construction Date (Cost Basis Month-Year)	January 2012	June 2018	May 2012	August 2017
Well Depth (ft)	1,800	1,600	1,350	1,350
Casing Depth (ft)	1,014; 1,006 (respectively)	1,300	1,150	1,140
Well Capacity (gpm)	1,400	1,600	880	900
Casing Material	Burgess "EON" 500 FRP	PVC	PVC	PVC
Casing Diameter (in)	17	14	14	14
Well Construction Cost at Cost Basis Month-Year	$827,050	$1,358,787	$1,186,431	$857,412
CCI at Cost Basis Month-Year (1)	9176	11069	9290	10826
Adjusted Well Construction Cost in August 2020 Dollars (2)	$1,032,462	$1,358,787	$1,462,925	$907,228
Adjusted Well Construction in December 2021 Dollars (3)	$1,342,199	$1,766,423	$1,901,802	$1,179,397
MPI at Cost Basis Month-Year (4)	--	--	--	--
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--	--	--
Wellhead Construction Cost at Cost Basis Month-Year	$12,000(6)	$150,000	$71,036	$648,408
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$14,908	$155,231	$87,590	$686,081
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$19,474(7)	$201,808	$113,867	$891,906
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--	--	--

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")
(6) Pump/motor not included
(7) Not included in summary

2.3 UPPER EAST COAST

Internal and external databases were used to develop a list of recently completed wells within the Upper East Coast (UEC) Planning Area. Wells from both the Floridan and Surficial Aquifers were evaluated. All information was collected from vendor pay applications provided by municipalities and utilities for each project. The list of wells used for this study, their corresponding municipality, and aquifer water source is shown below in **Table 2-4**. As previously discussed, the wells included in this section that are located in Indian River County (IRC), are not located within the SFWMD UEC Planning Area. However, the IRC wells were included in this evaluation to provide additional cost information for the area near the UEC Planning Area, due to the wells' proximity.

Table 2-4: Wells evaluated within the UEC Planning Area

Location of Well	Municipality	Project Name	Aquifer
Indian River County	Indian River County Utilities	Wells S-7 and S-4	Floridan
Martin County	City of Stuart Utilities	Well FA-1	Floridan
Martin County	North Jensen, Martin County Utilities	Well 9A	Surficial
Martin County	Martin County Utilities	Wells TFRO-6 and TFRO-7	Floridan
St. Lucie County	Fort Pierce Utilities Authority	Wells 1R, 2R, and S-8R	Surficial

2.3.1 CAPITAL COSTS

Well, Well Pumps and Appurtenances Costs (UEC Summary)

Well construction costs from both the SAS and FAS were analyzed. All FAS and SAS wells were constructed of PVC. For the UEC SAS wells, the adjusted construction costs in December 2021 dollars range from $354,903 to $741,546. The well casing depths range from 65 to 75 feet bls with well casing diameters ranging from 10 to 12 inches. For the UEC FAS wells, the adjusted construction costs in December 2021 dollars range from approximately $1.26 million to $1.6 million. The casing depths for these FAS wells range from 1,100 to 1,600 feet bls with a well casing diameter ranging from 12 to 14 inches.

Submersible pumps were the typical pump types used for SAS water supply wells. Vertical turbine pumps followed by end-suction centrifugal type pumps were typically used for FAS water supply wells. Wellhead costs were developed from bid tabs, pay applications, and AWS funding program applications from the District for City of Stuart, Fort Pierce Authority, IRC, and Martin County Utilities.

Adjusted wellhead costs for the UEC Planning Area range from $77,362 to $112,887 for SAS wells and from $392,536 to $674,214 for FAS wells. Wellhead costs include pump and motor, valves and appurtenances, electrical, and instrumentation. The wellhead costs appear to be driven by the wellhead size and capacity. See **Table 2-5** through **Table 2-7** for data collected for wells located in the UEC Planning Area.

Table 2-5: SAS Well Costs within UEC Planning Area

UTILITY/ OWNER WELL ID	Fort Pierce Utilities Authority Replacement Well W-1R	Fort Pierce Utilities Authority Replacement Well W-2R	Fort Pierce Utilities Authority Replacement Well S-8R	North Jensen (Martin County Utilities) Well 9A
Well Location	St. Lucie County	St. Lucie County	St. Lucie County	Martin County
Construction Date (Cost Basis Month-Year)	June 2017	June 2017	June 2017	April 2018
Well Depth (ft)	105	125	115	125
Casing Depth (ft)	65	65	70	75
Well Capacity (gpm)	350	350	250	300
Casing Material	Stainless Steel	Stainless Steel	--	PVC
Casing Diameter (in)	12	12	10	12
Well Construction Cost at Cost Basis Month-Year	$304,075	$255,080	$327,965	$538,650
CCI at Cost Basis Month-Year (1)	10703	10703	10703	10817
Adjusted Well Construction Cost in August 2020 Dollars (2)	$325,439	$273,003	$351,008	$570,420
Adjusted Well Construction in December 2021 Dollars (3)	$423,071	$354,903	$456,310	$741,546
MPI at Cost Basis Month-Year (4)	--	--	--	--
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--	--	--
Wellhead Construction Cost at Cost Basis Month-Year	$70,043	$70,043	$55,602	$82,000
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$74,965	$74,965	$59,507	$86,836
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$97,454	$97,454	$77,362	$112,887
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--	--	--

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")

Table 2-6: FAS Well Costs within UEC Planning Area

UTILITY/ OWNER WELL ID	City of Stuart FA-1	Martin County Utilities TFRO 6/TFRO 7 (average cost per well)
Well Location	Martin County	Martin County
Construction Date (Cost Basis Month-Year)	November 2019	March 2020
Well Depth (ft)	1,620	1,150/1,400
Casing Depth (ft)	940	1,100/1,150
Well Capacity (gpm)	1,100	1,620
Casing Material	PVC	PVC
Casing Diameter (in)	14	12
Well Construction Cost at Cost Basis Month-Year	$1,227,319	$1,212,350
CCI at Cost Basis Month-Year (1)	11381	11397
Adjusted Well Construction Cost in August 2020 Dollars (2)	$1,235,312	$1,218,520
Adjusted Well Construction in December 2021 Dollars (3)	$1,605,905	$1,584,075
MPI at Cost Basis Month-Year (4)	--	--
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--
Wellhead Construction Cost at Cost Basis Month-Year	$300,000	$516,000
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$301,951	$518,626
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$392,536	$674,214
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")

Table 2-7: FAS Well Costs in Indian River County

UTILITY/ OWNER WELL ID	Indian River County Well S-7	Indian River County Well S-4
Well Location	Indian River County	Indian River County
Construction Date (Cost Basis Month-Year)	November 2019	March 2017
Well Depth (ft)	700	835
Casing Depth (ft)	395	415
Well Capacity (gpm)	1,400	1,400
Casing Material	PVC	PVC
Casing Diameter (in)	17	17
Well Construction Cost at Cost Basis Month-Year	$530,000	$585,000
CCI at Cost Basis Month-Year (1)	10442	10667
Adjusted Well Construction Cost in August 2020 Dollars (2)	$581,416	$628,216
Adjusted Well Construction in December 2021 Dollars (3)	$755,841	$816,680
MPI at Cost Basis Month-Year (4)	--	--
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--
Wellhead Construction Cost at Cost Basis Month-Year	$352,000	$298,000
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$388,416	$320,014
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$501,993	$416,018
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")

2.4 LOWER WEST COAST

External databases were used to develop a list of recently completed wells within the Lower West Coast (LWC) Planning Area. All recently completed projects were all FAS wells. All information was collected from contractor pay applications provided by municipalities and utilities for each project. The list of wells used for this study, source of the data, and their corresponding municipality is shown below in **Table 2-8**.

Table 2-8: FAS Wells Evaluated within the LWC Planning Area

Location of Well	Source of Data	Municipality	Project Name
Hendry County	AWS – District Provided Data	City of LaBelle	Wells UFA 2 and UFA 33
Lee County	Bonita Springs Utilities	Bonita Springs	RO Wells BS33, BS34, and BS35
Lee County	Bonita Springs Utilities	Bonita Springs	Wells 37, 38, and 40

2.4.1 CAPITAL COSTS

Well, Well Pumps and Appurtenances Costs (LWC Summary)

Bonita Springs Utilities provided well and wellhead costs for two separate phases of FAS well construction. Construction of the first phase of the Bonita Springs' FAS wells (BS33-BS35) began in February 2015 and had an average adjusted well construction cost of $751,576 in December 2021 dollars. The associated adjusted wellhead average cost was approximately $581,846, with a total overall construction cost of $1,333,422 in December 2021 dollars. Construction of the second phase of the Bonita Springs' FAS wells (Wells 37, 38, and 40) were completed in 2018 and had an adjusted average well construction cost $869,045 in December 2021 dollars. The associated adjusted wellhead average cost was approximately $547,994, with a total overall construction cost of $1,417,039 in December 2021 dollars. The overall well installation and material cost reflected a cost increase of approximately $83,617, or 6%, between 2015 and 2018. This increase is reflected in the well construction costs. The wellhead costs did not appear to have a significant cost increase between 2015 and 2018.

The well construction and wellhead cost for the City LaBelle UFA 2 well was also included in this evaluation. The adjusted well construction costs and adjusted wellhead cost was $629,054 and $356,230, respectively.

See **Table 2-9** for data collected for wells located in the LWC Planning Area.

Table 2-9: FAS Well Costs within LWC Planning Area

UTILITY/ OWNER WELL ID	City of LaBelle UFA 2	Bonita Springs Well 37	Bonita Springs Well 38	Bonita Springs Well 40
Well Location	Hendry County	Lee County	Lee County	Lee County
Construction Date (Cost Basis Month-Year)	July 2013	June 2018	June 2018	June 2018
Well Depth (ft)	697	1,040	1,100	1,060
Casing Depth (ft)	600	850	865	810
Well Capacity (gpm)	696	700	700	700
Casing Material	PVC	PVC	PVC	PVC
Casing Diameter (in)	10	14	14	14
Well Construction Cost at Cost Basis Month-Year	$403,500	$677,862	$622,282	$637,767
CCI at Cost Basis Month-Year (1)	9552	11069	11069	11069
Adjusted Well Construction Cost in August 2020 Dollars (2)	$483,887	$701,499	$643,983	$660,008
Adjusted Well Construction in December 2021 Dollars (3)	$629,054	$911,949	$837,177	$858,010
MPI at Cost Basis Month-Year (4)	--	--	--	--
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--	--	--
Wellhead Construction Cost at Cost Basis Month-Year	$228,500	$354,832	$329,607	$537,549
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$274,023	$367,206	$341,101	$556,294
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$356,230	$477,367	$443,431	$723,183
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--	--	--

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")

Table 2-9: FAS Well Costs within LWC Planning Area (Continued)

UTILITY/ OWNER WELL ID	Bonita Springs Utilities BS33 RO Wells	Bonita Springs Utilities BS34 RO Wells	Bonita Springs Utilities BS35 RO Wells
Well Location	Lee County	Lee County	Lee County
Construction Date (Cost Basis Month-Year)	February 2015	February 2015	February 2015
Well Depth (ft)	1,030	1,050	886
Casing Depth (ft)	805	830	705
Well Capacity (gpm)	700	700	700
Casing Material	PVC	PVC	PVC
Casing Diameter (in)	14	14	14
Well Construction Cost at Cost Basis Month-Year	$503,533	$569,094	$435,725
CCI at Cost Basis Month-Year (1)	9962	9962	9962
Adjusted Well Construction Cost in August 2020 Dollars (2)	$578,997	$654,384	$501,027
Adjusted Well Construction in December 2021 Dollars (3)	$752,696	$$850,699	$651,335
MPI at Cost Basis Month-Year (4)	--	--	--
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--	--
Wellhead Construction Cost at Cost Basis Month-Year	$558,441	$530,688	$656,410
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$642,134	$610,222	$754,786
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$898,988	$981,222	$723,183
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--	--

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")

2.5 UPPER KISSIMMEE BASIN/CENTRAL FLORIDA WATER INITIATIVE

External databases were used to develop a list of recently completed wells within the Upper Kissimmee Basin (UKB) Planning Area. UKB is part of the CFWI Planning Area since the District does not maintain a separate UKB Planning Area for water supply planning purposes. Information collected for the LWC Planning Area consisted of recently constructed FAS wells. All information was collected from pay applications provided by municipalities and utilities for each project. Two FAS wells (Bay Lakes Estates Well Number 2 and Harmony Well 2R) owned and operated by the Tohopekaliga Water Authority (TWA or Toho) were used for this Study.

2.5.1 CAPITAL COSTS

Well, Well Pumps, and Appurtenances Costs (UKB/CFWI Summary)

TWA provided construction cost information associated with the Bay Lake Estates Well Number 2 and the Harmony Well 2R that were constructed under the same contract but were completed in phases. The first phase of construction was limited to drilling the wells. The second phase finished the construction with the installation of the pump column pipe and wellhead facilities such as pump and motor, flow meters, miscellaneous piping, concrete well slabs and pipe supports. Each well had a casing diameter of 10 inches and a depth of approximately 500-ft bls. Adjusted average costs to construct the wells were approximately $199,311 with an adjusted wellhead cost of $308,172 for Bay Lakes Estates Well Number 2 and $413,673 for Harmony Well 2R. See **Table 2-10** for FAS well costs within the UKB Planning Area.

Table 2-10: FAS Well Costs within UKB Planning Area

UTILITY/ OWNER WELL ID	Toho Bay Lake Estates Well No. 2	Toho Harmony Well
Well Location	Osceola County	Osceola County
Construction Date (Cost Basis Month-Year)	March 2017	March 2017
Well Depth (ft)	500	500
Casing Depth (ft)	274	274
Well Capacity (gpm)	275	275
Casing Material	PVC	PVC
Casing Diameter (in)	10	10
Well Construction Cost at Cost Basis Month-Year	$136,400	$136,400
CCI at Cost Basis Month-Year (1)	10667	10667
Adjusted Well Construction Cost in August 2020 Dollars (2)	$153,316	$153,316
Adjusted Well Construction in December 2021 Dollars (3) (6)	$199,311	$199,311
MPI at Cost Basis Month-Year (4)	--	--
Adjusted Well Construction Cost in December 2021 Dollars (5)	--	--
Wellhead Construction Cost at Cost Basis Month-Year	$210,900	$283,100
Adjusted Wellhead Construction Cost in August 2020 Dollars (2)	$237,056	$318,210
Adjusted Wellhead Construction Cost in December 2021 Dollars (3)	$308,172	$413,673
Adjusted Wellhead Construction Cost in December 2021 Dollars (5)	--	--

(1) Construction date before August 2020 utilized a CCI adjustment
(2) Adjusted Well/Wellhead Construction Cost in August 2020 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 11455 divided by "CCI at Cost basis Month-Year")
(3) A 30% increase was added to the August 2020 value to reflect estimated construction costs in December 2021 dollars
(4) Construction date after August 2020 utilized as MPI adjustment
(5) Adjusted Well/Wellhead Construction Cost in December 2021 Dollars ("Well/Wellhead Construction Cost at Cost Basis Month-Year" multiplied by 4964 divided by "MPI at Cost Basis Month-Year")
(6) Adjusted Well Construction Costs are average costs as the construction cost information was provided assuming both wells are the same.

2.6 WELL OPERATION AND MAINTENANCE COSTS

As it relates to O&M costs, the LEC Planning Area wells were used as a basis to evaluate overall power consumption and routine maintenance costs. This approach can be used for all well pumps when evaluating power costs. Pump and motor efficiency may vary for each pump size and therefore, will need to be considered when evaluating operation costs specific for the user's application. However, for the purpose of this study, the range of motor horsepower and resulting operating cost per well, depicted in **Table 2-11**, below, can be used to bracket general operating costs.

The majority of the LEC Planning Area public water supply wells are submersible pumps and range in horsepower (HP) from 35 to 75 HP. Pump curve data was collected for several of the LEC Planning Area wells (with water supply sources from both the SAS and FAS) and analyzed to develop a cost per kilowatt-hour (kWh) and ultimately operating costs per month (assumed 30 days). The power consumption formula used to calculate the data in **Table 2-11** is below:

$$Power\ Consumption\ (\$/hr) = \frac{Q(gpm)x\ TDH(feet)x\ 0.746\ x\ Power\ cost\ (\$/kWh)}{3{,}960\ x\ Efficiency\ (pump)x\ Efficiency\ (motor)}$$

Using the power consumption formula above, the power consumption for a pump flow rate of 700 gallons per minute (gpm) with 160 feet of total dynamic head (TDH), pump efficiency of 79%, motor efficiency of 85% and continuous operation yields a monthly electric cost of approximately $2,260 per well. This is equivalent to $0.07 per thousand gallons to pump water from a water supply well to the plant. An assumed power cost factor of $0.10 per kWh was used in the power consumption formula based on a typical Florida Power and Light rate for the LEC Planning Area and average power cost factor derived from the Jupiter Water Treatment Plant. It should be noted that the amount of power consumed by a production well is dependent on the motor horsepower (which is determined by flow rate and TDH), against which the pump operates and how many hours the pump is in operation. The range of motor horsepower, bracketed between 35 and 75 hp below, and corresponding flows and TDH that were collected from available well pump curves provided for wells within the LEC planning area are shown in **Table 2-11** below.

Table 2-11: Estimated Range of Monthly Operating Cost per Well

Horsepower	Flow (gpm)	TDH (ft)	Power Cost ($/hr)	Monthly Operating Costs(1)	Annual Operating Costs(1)	Annual Operating Costs (1)
35	700	160	$3.14	$2,260	$27,510	$18,080
75	1400	155	$5.80	$4,175	$50,810	$33,400

(1) Continuous Operation
(2) Average Daily Demand (67% of continuous operating costs)

In addition to the operating costs associated with power consumption, routine maintenance costs such as chlorination/disinfection and acidification are incurred by municipalities. Kimley-Horn contacted a well drilling contractor, Centerline Drilling, Inc. (Centerline), for costs associated with well maintenance. Centerline provided a range (based on smallest diameter [10-inch] of wells to largest diameter [24-inch] of wells) of costs for typical maintenance procedures. **Table 2-12** below summarizes the costs provided by Centerline.

Table 2-12: Well Operation and Maintenance Costs

Maintenance Activity	Range of Cost (Based on Diameter of Well)
Chlorinate	$1,500 to $5,0000
Acidify	$7,500 to $30,000
Pull pump and motor	$2,500 to $6,000
Reinstall pump motor	$2,500 to $6,000
Replace valves, flow meter, etc.	$2,500 to $15,000

2.7 TOTAL COST SUMMARY

Well Construction Costs

Adjusted well construction costs for SAS wells range from approximately $210,456 to $741,546 and adjusted well construction costs for FAS wells range from approximately $629,054 to $1,901,802 based on cost data collected District wide. The information collected for the two FAS wells in IRC are $755,841 and $816,680, respectively. See **Table 2-13** for well construction cost summary of wells within the SFWMD service areas and Indian River County. This table does not include wellhead costs.

Table 2-13: Well Construction Cost Summary throughout the SFWMD Service Area

	Adjusted Well Construction Cost Summary Table						
Planning Area	Number of Wells Evaluated	Well Casing Diameter (in)		Well Casing Depth (ft)		Well Cost (December 2021 Dollars)	
		Min	Max	Min	Max	Min	Max
LEC (SAS)	21	12	24	75	140	$210,456	$737,920
LEC (FAS)	9	14	30	1,006	1,300	$1,179,397	$1,901,802
UEC (SAS)	1	10	12	65	75	$354,903	$741,546
UEC (FAS)	7	12	14	940	1,150	$1,584,075	$1,605,905
LWC (FAS)	11	10	14	600	865	$629,054	$911,949
UKB (FAS)	2	-	10	-	274	-	$199,311
IRC (FAS)	2	-	17	395	415	$755,841	$816,680

Direct correlation between the December 2021 adjusted costs of the well, the well casing diameter, and the well casing depth was not apparent. However, to determine the construction cost trend, the well casing depth and costs were plotted (with a trendline) since the well casing depth appeared to drive the construction costs of each well included in this section for both the SAS and the FAS well systems. A trendline, showing a linear and exponential relationship for the SAS and FAS well systems, respectively, was also applied. See **Figure 2-5 and Figure 2-6** below.

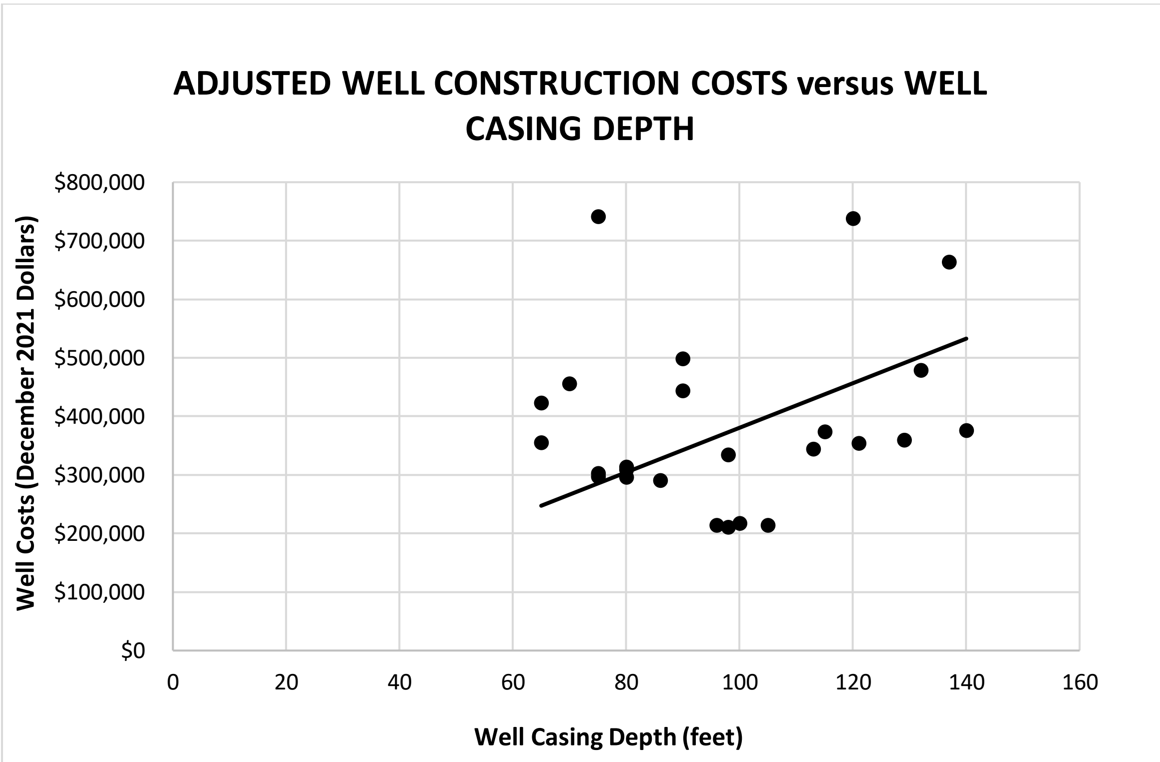


Figure 2-4: Adjusted Well Construction Costs versus Well Casing Depth for SAS Wells (Linear Relationship)

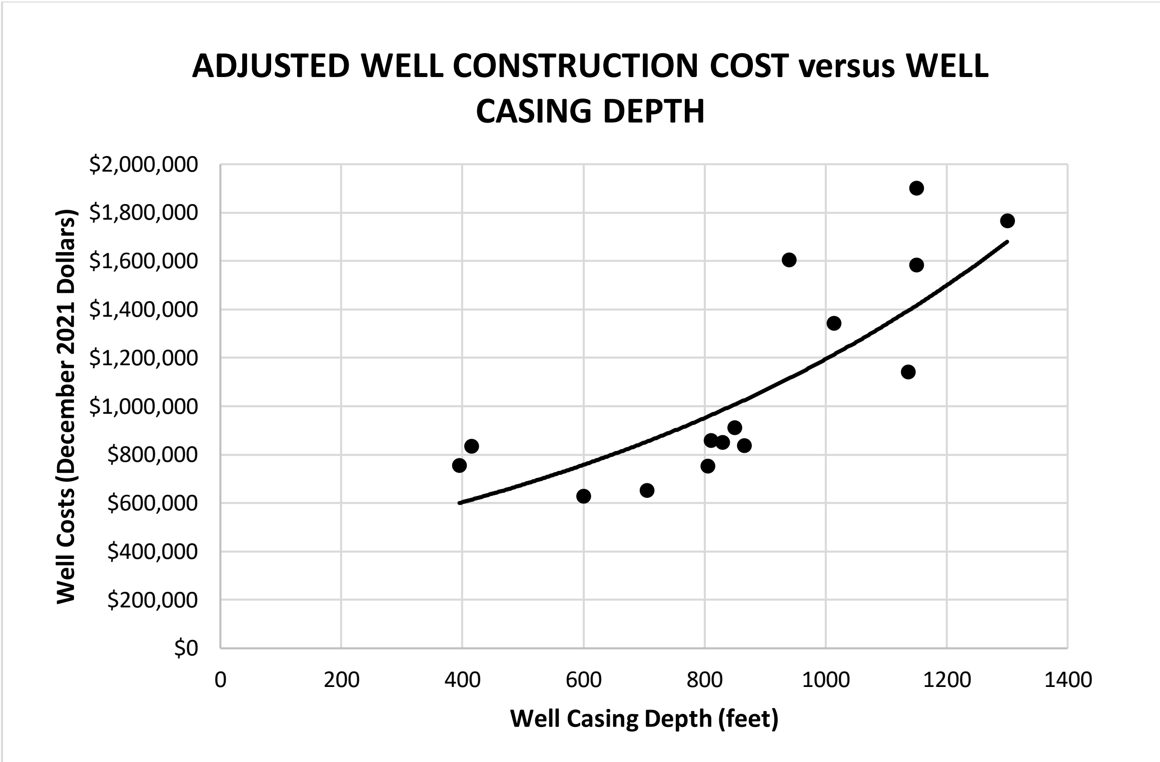


Figure 2-5: Adjusted Well Construction Costs versus Well Casing Depth for FAS System Wells (Exponential Relationship)

Wellhead Construction Costs

Adjusted wellhead construction costs for SAS well systems range from approximately $112,887 to $855,371 and adjusted wellhead construction costs for FAS well systems range from approximately $105,475 to $891,906 based on cost data collected Districtwide. Adjusted wellhead construction costs for the two wells constructed in IRC, were $416,068 and $501,993, respectively. See **Table 2-14** for well construction cost summary of wells within the SFWMD service area and IRC.

Table 2-14: Adjusted Wellhead Construction Cost Summary throughout the SFWMD Service Area

Planning Area	Capacity (gpm)		Wellhead Cost (in December 2021 Dollars)	
	Min	Max	Min	Max
LEC (SAS)	500	2,200	$105,475	$855,371
LEC (FAS)	900	1,600	$113,867	$891,906
UEC (SAS)	--	350	$77,362	$112,887
UEC (FAS)	940	1,620	$392,536	$674,214
LWC (FAS)	--	700	$356,230	$981,222
UKB (FAS)	--	275	$308,172	$413,673
IRC (FAS)	-	1,400	$416,018	$501,993

The construction cost of the wellhead is predominantly driven by the pump and motor costs and corresponding design flow (or capacity) and design pressure to pump the water from the well to the water treatment plant. The higher required capacity and pressure for water supply needs, the larger the pump and motor required (which drives the material cost of the pump and motor).

Design pumping parameters were requested from each of the municipalities, however, there was not enough information provided to include the design pressure as a factor of construction costs. Therefore, only well capacity was used as a correlation to wellhead construction costs. A trendline, showing the linear relationship between SAS wellhead adjusted construction costs and well capacity is shown in **Figure 2-7** below. A correlation between FAS wellhead costs and well capacity could not be determined from the information collected. The FAS wellhead collected data showed that as the well capacity increased, the cost of the well head decreased. This is not typically the case so it is assumed that the wellhead costs may be skewed in the available data provided to where a relationship could not be determined.

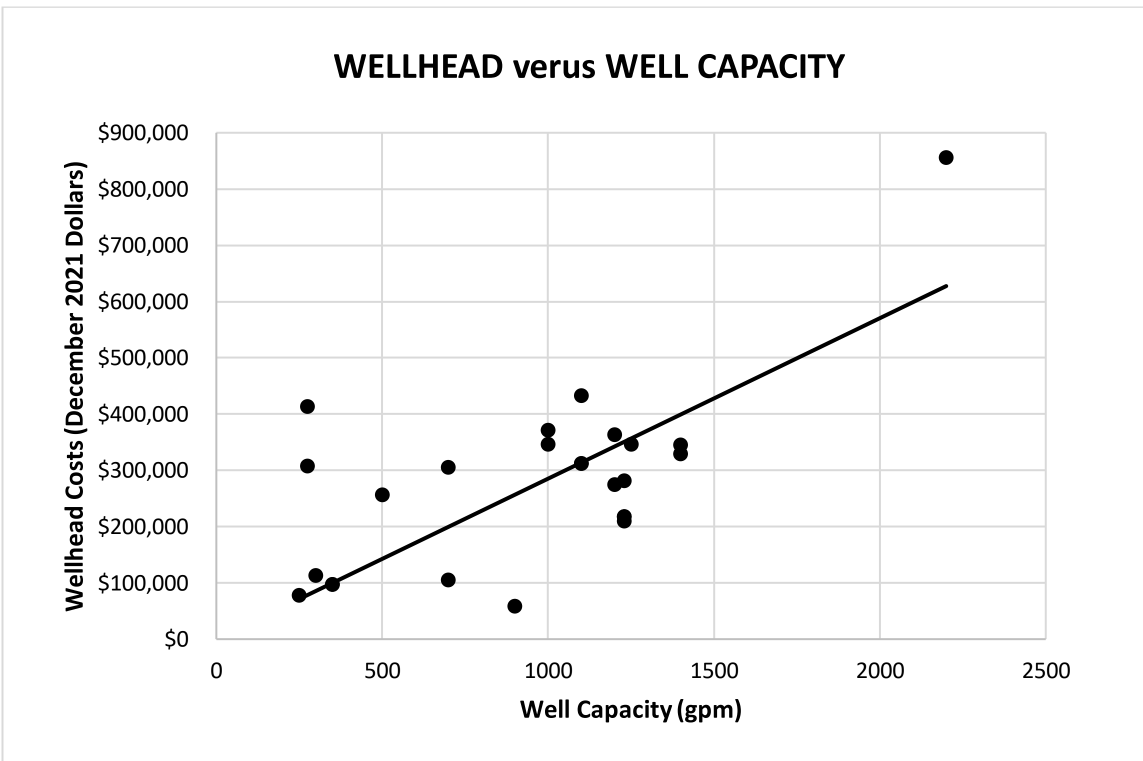


Figure 2-6: Adjusted Wellhead Construction Costs versus Well Capacity for SAS Wells (Linear Relationship)

O&M Costs

As previously discussed, the LEC Planning Area wells were used as a basis to evaluate overall power consumption costs and routine maintenance. The range of motor horsepower, bracketed between 35 and 75 hp, shown in **Table 2-15**, results in an annual cost between $27,120 and $50,100, assuming continuous operation. Annual operating costs based on annual average daily demand ranges from approximately $18,010 to $33,400.

Table 2-15: Estimated Range of Monthly Operating Cost per Well

Horsepower	Monthly Operating Costs (Continuous Operation)	Annual Operating Costs (Continuous Operation)	Annual Operating Costs (Average Daily Demand)
35	$2,260	$27,510	$18,080
75	$4,175	$50,810	$33,400

A summary of the routine maintenance costs such as chlorination/disinfection and acidification are incurred by municipalities and is summarized in **Table 2-16**.

Table 2-16: Well System Maintenance Costs

Maintenance Activity	Range of Cost (Based on Diameter of Well)
Chlorinate	$1,500 to $5,000
Acidify	$7,500 to $30,000
Pull pump and motor	$2,500 to $6,000
Reinstall pump motor	$2,500 to $6,000
Replace valves, flow meter, etc.	$2,500 to $15,000

O&M costs vary by a number of factors such as runtime (which effects power costs); size of well; parts requiring replacement; how often maintenance occurs or is required, age of well, and contractual agreement of rehabilitation of multiple wells (scale of construction/rehabilitation). In a given year, it can be assumed (using the available O&M data in this section), that overall annual O&M costs (based on annual average daily demand), per well, may range from $34,600 (for smaller wells with lower power requirements) to $95,500 (for larger wells with higher power requirements and age of well).

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3

ADVANCED WATER TREATMENT TECHNOLOGIES

3.1 DISCUSSION OF ASSUMPTIONS AND APPROACH

Construction costs included in this chapter reflect raw water supply, pre-treatment, post-treatment, intermediate storage, finished water storage, transfer pumps, high service pumps, plant infrastructure, concentrate disposal (at the plant), mechanical, yard piping, electrical and instrumentation, and site work. Disinfection using sodium hypochlorite is included. Construction costs reflect rated capacity or maximum day demand (MDD) and annual average day demand (AADD). Costs are evaluated for plant sizes of 1, 3, 5, 10, 15, and 20 million gallons per day (mgd). Additionally, 20-year projected capital costs and total production costs for these technologies are graphically represented and bracketed between an expected accuracy range of -30% and +50% of the calculated costs, per Association for the Advancement of Cost Engineering (AACE) International's Estimating Class 4 (AACE, 2020). Total production costs are presented based on plant capacity (or maximum daily flow) or annual average daily flow. Plant service life is assumed to be 20 years with an annual interest rate of 7%.

This chapter addresses five technologies. They are as follows:

- General Water Treatment
- Water Treatment Process Components
- Water Distribution Plant Components
- Disinfection Plant Components
- PFAS Treatment Case Study

General Water Treatment Technologies: The cost data in this section assumes a "green field" plant construction project (i.e., starting with a cleared or undeveloped piece of land). Treatment technologies in this subsection include an evaluation of reverse osmosis (RO) and nanofiltration (NF) processes along with their ancillary components such as pre-treatment and post-treatment technologies. Other elements included in this evaluation include raw water supply respective of the treatment process, as well as byproduct disposal. However, this section does not include water storage or high service pumps. See water distribution plant components for these plant components.

Opinion of probable construction costs, O&M, and total production cost are presented for the following treatment technologies, process components, and plant components:

- NF with deep injection well (DIW) disposal of concentrate
- Brackish Groundwater RO with DIW disposal of concentrate
- Seawater reverse osmosis (SWRO), surface water intake

NF, also called membrane softening, is generally used to treat fresh groundwater supplies with total dissolved solids (TDS) less than 1,500 mg/L. NF is mainly used for water softening as it effectively removes calcium and magnesium which are the ions that most contribute to the hardness of water. NF membrane treated water can be corrosive so blending with the raw water source or adding chemicals such as sodium hydroxide (caustic) and carbon dioxide, to stabilize the water, may be required. If hydrogen sulfide (H2S) is present at higher concentrations within the raw water supply, degasification towers are used for hydrogen sulfide removal. Chlorine addition for treating very low levels of H2S within the treated water may be required prior to distribution. If H2S is elevated and chlorine is not effective in H2S removal, scrubbers, which uses sodium hydroxide to react with H2S gas to form sulfide compounds in their solid forms, may be needed.

Brackish RO, or hyper-filtration, treats brackish water sources which exhibit elevated salinities (e.g., greater than fresh water but less than seawater). Brackish RO is effective in removing dissolved ions which are present in the brackish raw water supply source. RO membrane treated water can be highly corrosive so blending with the raw water source or adding chemicals such as sodium hydroxide (caustic) or carbon dioxide to stabilize the water is typically required to avoid corrosion issues in the water distribution system. Elevated concentrations of H2S are also typical in the brackish water supply source, and therefore, require degasification for H2S removal. Chlorine addition and scrubbers are required for removing the H2S prior to distribution or disposal, respectively.

The Claude “Bud” Lewis Carlsbad Desalination Plant, located in San Diego, California, was used to represent costs for seawater desalination, which uses a seawater source (or water source that has the equivalent TDS or higher “salt” content).,

Table 3-1, below summarizes the desalination process characteristics for NF, Brackish RO and Seawater RO.

Table 3-1: Desalination Process Characteristics

Water Source	Seawater RO	Brackish RO	Nanofiltration
Total Dissolved Solids (mg/L)	10,000 – 45,000	1,500 – 10,000	Less than 1,500
Minimum Particle Size Removal (Micron)	<0.0001 Micron	0.0001	0.0005
Pressure (psi)	800 – 1,200	170 – 600	70 – 170
Salt Rejection	High	Moderate to High	Low
Fresh Water Recovery	50 to 65%	70 to 80%	75 to 90%

Water Treatment Technology Process Components: The cost data included in this section reflects costs for adding incremental process capacity, or an additional treatment technology, to an existing water treatment plant. NF and RO, described above, was included in this study for adding incremental process capacity, while ion exchange (IX) was included for adding an additional treatment technology. A case study is also included that evaluates treatment of per- and polyfluoroalkyl Substances (PFAS), nicknamed the “Forever Chemical”, utilizing ion exchange.

Opinion of probable construction costs, O&M, and total production cost are presented for the following treatment technologies, process components, and plant components:

- NF Process Units
- RO Process Units
- Ion Exchange
- Granular Activated Carbon

IX is a water treatment method that removes undesirable ions using a bed of resin beads that are “charged” with sodium ions in solution. When the water flows through the bed of resin, the undesirable ions attach to the resin beads and replace the loosely held sodium solution into the water. When the resin beads are saturated with the undesirable ions, the resin gets regenerated with a salt brine solution flush, where the chloride ions replace the undesirable ions on the resin. The undesirable ions then get flushed out with the wastewater. Some of the undesirable ions include calcium, sodium or total organic compounds (which effects color or contribute to disinfection byproducts). Cost data for IX technology from a pilot test for the City of Stuart, described later, is also included in this Chapter.

Granular Activated Carbon is a water treatment method that uses carbon for removal of contaminants such as pharmaceuticals and personal care products, taste and odor causing compounds, and total organic compounds. Molecular compounds are kinetically attracted to the porous area of the carbon where these compounds attach to the outer surface of the media. The media is also stored in a vessel similar to IX treatment systems but uses carbon in lieu of resin for treatment. The volume of carbon required is three times the volume of resin needed for treatment of a similar capacity.

Water Distribution Plant Components: The cost data included in this subsection are water storage tanks and high service pumps. These two components are typical for all plant types, whether it is an RO, NF, or seawater desalination plant. Opinion of probable construction costs, O&M, and total production cost are presented for the finished water storage and high service pump plant components.

Disinfection Plant Components: The cost data included in this subsection reflects construction costs associated with disinfection and are also typical for all plant types as disinfection is required prior to distribution, per Chapter 62-550, Florida Administrative Code. Further, chlorine disinfection is a required means of disinfection for all plants within the state of Florida. Additional disinfection processes such as ultraviolet light, may be used as an added level of disinfection. Opinion of probable construction costs, O&M, and total production cost are presented for Sodium Hypochlorite and UV Light Disinfection.

The following sections describe the different cost analyses conducted for each water treatment technology and includes capital construction cost, O&M cost and total production cost.

Capital Construction Cost

Available Construction Costs were divided into three subgroups: individual plant and process components, general plant improvements, and contractor administrative costs. Individual plant and process components were developed from direct costs on bid tabulations. General plant improvements (yard piping, mechanical, electrical, instrumentation and controls, and site work) were developed by analyzing a study group of construction projects to develop a representative percentage of the total project cost. The representative percentage was then used consistently across all capital cost analysis. It should be noted that the relationship between plant size and construction costs is not linear. To account for the relationship between the two, the following formula (AWWA, 2007) was used.

$$C_B = C_A(\frac{S_B}{S_A})^n$$

Where:

C_B=cost of the new size plant

C_A=cost of the known plant

S_B=capacity of new plant (in gallons per day)

S_A=capacity of known plant (in gallons per day)

n = scaling factor

In addition to construction costs the opinion of probable construction costs provides an estimate of the "Owner's Costs" (engineering design, surveying, engineering services during construction, permitting, contingency). The Owner's Cost estimate was developed by the respective percentages shown in **Table 1-1**. The total construction estimates for construction and Owner's Costs were added together to develop a total opinion of probable construction cost. The results of the opinion of probable construction costs were then converted to an opinion of equivalent annual capital costs.

To develop the opinion of probable cost for each treatment process and ancillary components or facilities, Kimley-Horn reviewed bid tabulations or schedule of values from construction projects for various municipalities within the state of Florida. Each bid tabulation was broken down into respective sections described in detail below. The opinion of probable cost was represented as a subtotal and further broken down into an opinion of equivalent annual capital cost. The opinion of equivalent amortization or pay off is based on an annual interest rate of 7% over a 20-year period.

Operation and Maintenance Costs

O&M costs for each treatment system are represented in two categories: variable costs and fixed costs. Costs that vary with the amount of finished water produced by the plant within a year are considered variable costs. These variable costs include power, chemicals, replacement parts and materials, and replacement membranes. Fixed costs are limited to labor and regulatory compliance and do not vary with finished water production rates.

O&M costs are presented for two operating conditions: plant operating at rated capacity or MDD and plant operating at AADD. The plant's capacity rating is developed from the MDD.

AADD is a factor of the plant's capacity rating. The methodology for estimating the AADD is based on the respective MDD and an assumed ratio of MDD/AADD (peaking factor). This peaking factor is related to the average demand of the distribution system, or amount of water being used by customers, and the plant capacity. The MDD/AADD generally decreases as the size of the system increases. Assumptions of the peaking factor is based on experience and knowledge of typical peaking factors for different size plants. The peaking factors are listed in the O&M tables for each scenario. Annual production costs are represented in terms of AADD and MDD. An example of the calculation for the AADD for a 1 mgd plant capacity based on peaking factor of 1.5 (MDD/AADD) is below:

$$AADD = [\text{Plant Capacity (mgd)}]/[MDD/AADD]$$

For a plant capacity rating of 1 mgd, the estimated AADD

$$AADD = 1\ \text{mgd}/1.50\ \text{(where 1.50 is an assumed peaking factor)}$$

$$= 0.667\ \text{mgd or 243.46 million gallons per year (mgy)}$$

The above calculation is included for each case within the O&M tables and defines the basis for the variable costs for the AADD scenario. Total unit O&M costs are summarized within each table and is also included in the total production cost summary table.

It should be noted that some of the water treatment components are assumed to be included in the overall plant O&M costs and, therefore, were not evaluated for O&M costs.

Total Cost Summary

Total Production Costs are presented per mgd for each treatment system. This total cost estimate includes all estimates discussed thus far (annual capital cost, annual O&M cost [variable and fixed]) and additionally an estimated cost allocated for a renewal and replacement fund. Yearly contributions to this fund are equivalent to 10% of the respective annual capital cost. This fund would be used for replacement of major components within the treatment system when the useful life has been met.

Unit probable costs are provided to describe opinion of probable construction costs only and is reflected in dollars per thousand gallons ($/gpd). Unit probable total capital costs are provided to include the opinion of probable construction costs plus technical services, owner administration and legal and project contingency and is also reflected in $/gpd.

3.2 GENERAL WATER TREATMENT TECHNOLOGIES

As previously discussed, the cost data in this subsection assumes a "green field" plant construction project (i.e., starting with a cleared or undeveloped piece of land). Treatment technologies in this subsection include an evaluation of RO and NF processes along with their ancillary components such as pre-treatment and post-treatment technologies. Other components included in this section are raw water supply, finished water stabilization, intermediate storage, transfer pumping, back-up power generation (if included in available cost data), general infrastructure, etc. Finished water storage, disinfection (sodium hypochlorite and UV), and high service pumping components are under the Water Distribution Plant Components and are addressed in subsequent sections.

The following are general assumptions used to evaluate costs for NF and RO technologies:

Raw Water Supply: All raw water supply is groundwater supply wells unless specifically stated otherwise. It is assumed all wells are either on, or in close proximity to, the water treatment plant site. The cost included in the raw water supply is all material and labor costs associated with the construction of the well and wellhead only. Cover or shelter for the well is not included. Site work, underground piping, electrical, and instrumentation and controls are included in the general plant allowances.

Pretreatment: Pretreatment costs are tailored to water quality conditions in South Florida. Any chemical or filtration required for NF or RO processes were included.

Process Equipment: Inclusive of pumps, pressure vessels, valves, membrane elements, process tanks, and other misc. equipment required for water treatment in South Florida.

Post-treatment: Inclusive of degasification towers, odor control scrubbers, chemical storage and feed pumps.

Intermediate Storage: Construction of below-grade, cast-in-place, concrete clearwell with capacity of a five-minute disinfection contact time and adequate intake design which meets the Hydraulic Institute Standard for vertical turbine transfer pump systems.

Transfer Pumping: Transfer pumping includes two vertical turbine transfer pumps, sized for the total plant capacity, and aboveground piping, fittings and valves.

Plant infrastructure: Inclusive of buildings for process equipment, equipment pads, and awning structures.

Concentrate Disposal: Membrane process concentrate disposal system will be through a DIW. Transmission piping for the concentrate disposal is included separately in the yard piping line item. No additional pumps were included as it is assumed the residual pressure from the membrane system will be adequate for the disposal system. It is assumed for plants with a capacity greater than 10 MGD disposal rate two concentrate disposal wells will be required. For plants with a capacity of 10 mgd or less, it is assumed one concentrate disposal well will be required.

Yard Piping: All water (raw, finished, sanitary sewer, plant and concentrate) piping within the water treatment plant limits.

Mechanical: Includes fire protection systems, Heating Ventilation and Air Conditioning (HVAC), and plumbing.

Electrical: Includes transformers, switchgear, motor control centers, variable frequency drives, control panels, electrical service, and underground yard electrical.

Instrumentation and Controls: Includes process control programming, testing, startup, software and hardware, field instrumentation, and control system architecture.

Site Work: Includes site preparation, paving, grading and drainage, fill, compaction, site restoration, and landscaping.

General Requirements: Includes permitting, mobilization, demobilization, bonds, insurance, construction trailers and facilities,

Contractor Overhead and Profit: Represented as 15% of the material and installation costs.

Construction Contingency: Represented as 15% of the material and installation cost.

Technical Services: Includes preliminary engineering, surveying, geotechnical, hydrogeological preliminary and final design, permitting, bidding services, construction contract administration, and shop drawing reviews for a design-bid-build project style.

Owner Administration and Legal: Includes expenses incurred by the owner for permitting and administration.

Project Contingency: Represented as 15% of the construction cost.

Other General Assumptions: Capital cost estimates are based on similar projects completed within the last 10 years in Florida or California (seawater desalination project only). The project information collected was either design-bid-build or design-build. Cost information was pulled from project construction costs based on similarity between construction items of the respective plant projects. Water supply source is assumed to be wells located within the plant site and associated yard piping is included in the plant yard piping costs. Capital costs do not include the cost of acquisition of land, rights-of-way, transmission mains, and utilities. O&M costs assumes a unit power cost of $0.12 per kWh, with typical rates for chemicals within the South Florida area. Capital costs for concentrate disposal are included in the opinion of probable construction costs tables for information only. However, the costs are not used to evaluate the unit probable total capital costs because, historically, NF or RO plant projects and DIW projects are generally constructed under separate contracts due to different expertise required for each project type. Further, when evaluating plant construction costs, the unit probable capital costs typically only reflect treatment plant construction costs. See **Chapter 5** for additional information on DIWs.

3.2.1 NANOFILTRATION - NEW CONSTRUCTION

The opinion of probable construction costs and cost curves for NF are summarized in this section. The raw water supply is assumed to be from the SAS. The design capacity for each well is assumed to be one mgd of raw water per well. The NF process is assumed to operate at an average of 85% recovery based on known plant information of existing NF plants. The number of wells are based on plant capacity and an additional 20% of the plant capacity for standby wells (20% is assumed to provide enough capacity, assuming one well is out of service).

Pre-treatment includes raw water anti-scalant feed and micron-cartridge filtration. The membrane system includes pressure vessels, piping, membrane elements, control valves, instrumentation, membrane cleaning system, and process piping. Pre-treatment chemical systems include bulk storage tanks and containment basins, day tanks, metering pumps, chemical piping, and chemical injection diffusers.

Post-treatment includes packed-tower type degasifiers, a caustic feed system for pH adjustment, and application of a corrosion inhibitor. Post-treatment chemical systems include bulk storage tanks and containment basins, day tanks, metering pumps, chemical piping, and chemical injection diffusers.

Cost for DIW for concentrate disposal was determined based on size of plant and required capacity for concentrate disposal. It was assumed that a 3 mgd capacity DIW will be required for plant sizes up to 10 mgd, while plant sizes 15 and 20 mgd, may require two DIWs.

Not all relevant cost data was available for all projects or provided timely by the municipalities for inclusion in this study. It should be noted that there are similarities between the RO and NF processes, such as pre-treatment and post-treatment components. Some of the cost data between both processes were used interchangeably to determine the overall opinion of probable construction costs. In order to provide a better assessment of costs, applicable processes associated with the RO evaluation was used to supplement cost information and provide a basis for the overall costs for each plant capacity. The RO processes used as supplemental information for this section were intermediate storage (clear well) and transfer pumping. Concentrate disposal costs values are the same for both RO and NF.

3.2.1.1 CAPITAL COSTS

Two NF plant projects, along with supplemental construction cost data from the RO Treatment evaluation, were used to complete the capital cost evaluation related to NF treatment technology. The projects included in this evaluation are listed in **Table 3-2** below. Opinion of Probable Construction Costs and Opinion of Probable Capital Costs were evaluated without the DIW costs in order to calculate unit probable cost and unit probable total capital cost that is best reflective of the relationship between the plant costs and capacity.

Table 3-2: Nanofiltration Project Cost Data Sources

Location	Municipality	Project Name
Broward County	Dania Beach Water Treatment Plant	Dania Beach NF Water Treatment Plant
Broward County	North Springs Improvement District (NSID)	NSID Nanofiltration Plant (7.5 MGD)

The opinion of probable capital costs for a "green field" or new construction NF Plant are summarized in **Table 3-3**. The NF Construction Cost Curve is depicted in **Figure 3-1**.

Table 3-3: Opinion of Probable Capital Costs for Nanofiltration

Item No.	Description Allowance Factor		Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	Raw Water Supply		$1,098,000	$3,294,000	$5,490,000	$10,980,000	$16,470,000	$21,960,000
2.	Pretreatment		$28,000	$67,000	$101,000	$177,000	$244,000	$308,000
3.	Process Equipment		$496,000	$1,195,000	$1,798,000	$3,130,000	$4,329,000	$5,449,000
4.	Post Treatment		$324,000	$780,000	$1,174,000	$2,044,000	$2,828,000	$3,559,000
5.	Intermediate Storage		$286,000	$689,000	$1,036,000	$1,805,000	$2,496,000	$3,142,000
6.	Transfer Pumping		$69,000	$166,000	$250,000	$435,000	$602,000	$758,000
7.	Plant Infrastructure		$725,000	$1,746,000	$2,627,000	$4,574,000	$6,327,000	$7,965,000
8.	Concentrate Disposal		$9,000,000	$9,000,000	$9,000,000	$9,000,000	$13,500,000	$13,500,000
	Subtotal (w/ DIW) (1-8):		**$12,026,000**	**$16,937,000**	**$21,476,000**	**$32,145,000**	**$46,796,000**	**$56,641,000**
	Subtotal (w/o DIW) (1-7):		**$3,026,000**	**$7,937,000**	**$12,476,000**	**$23,145,000**	**$33,296,000**	**$43,141,000**
9.	Yard Piping	8%	$242,000	$635,000	$998,000	$1,852,000	$2,664,000	$3,451,000
10.	Mechanical	2%	$61,000	$159,000	$250,000	$463,000	$666,000	$863,000
11.	Electrical (1)	20%	$605,000	$1,587,000	$2,495,000	$4,629,000	$6,659,000	$8,628,000
12.	Instrumentation and Controls (1)	5%	$151,000	$397,000	$624,000	$1,157,000	$1,665,000	$2,157,000
13.	Site work	5%	$151,000	$397,000	$624,000	$1,157,000	$1,665,000	$2,157,000
	Subtotal (1-13):		**$4,236,000**	**$11,112,000**	**$17,467,000**	**$32,403,000**	**$46,615,000**	**$60,397,000**
14.	General Requirements	10%	$423,600	$1,111,200	$1,746,700	$3,240,300	$4,661,500	$6,039,700
15.	Contractor O&P	15%	$635,400	$1,666,800	$2,620,050	$4,860,450	$6,992,250	$9,059,550
16.	Construction Contingency	15%	$635,400	$1,666,800	$2,620,050	$4,860,450	$6,992,250	$9,059,550
	Opinion of Probable Construction Costs (1-15):		**$5,930,400**	**$15,556,800**	**$24,453,800**	**$45,364,200**	**$65,261,000**	**$84,555,800**
17.	Technical Services	20%	$1,186,080	$3,111,360	$4,890,760	$9,072,840	$13,052,200	$16,911,160
18.	Owner Administration and Legal	5%	$296,520	$777,840	$1,222,690	$2,268,210	$3,263,050	$4,227,790
19.	Project Contingency	15%	$889,560	$2,333,520	$3,668,070	$6,804,630	$9,789,150	$12,683,370
	Opinion of Probable Capital Cost (1-19)(2):		**$8,302,560**	**$21,779,520**	**$34,235,320**	**$63,509,880**	**$91,365,400**	**$118,378,120**
	Opinion of Equivalent Annual Capital Cost(2):		**$783,703**	**$2,055,833**	**$3,231,572**	**$5,994,883**	**$8,624,247**	**$11,174,057**
Unit Probable Cost ($/gpd)			$5.93	$5.19	$4.89	$4.54	$4.35	$4.23
Unit Probable Total Capital Cost ($/gpd)			$8.30	$7.26	$6.85	$6.35	$6.09	$5.92

(1) "Electrical" and "Instrumentation and Controls" cost items are estimated as 20% and 5% respectively, of the subtotal of the preceding cost components minus the cost for concentrate disposal. This is because a concentrate disposal DIW has minimal electrical and instrumentation and controls costs relative to other plant components, while the construction cost for a DIW is typically a substantial portion of the total facility cost.

(2) Does not include concentrate disposal costs

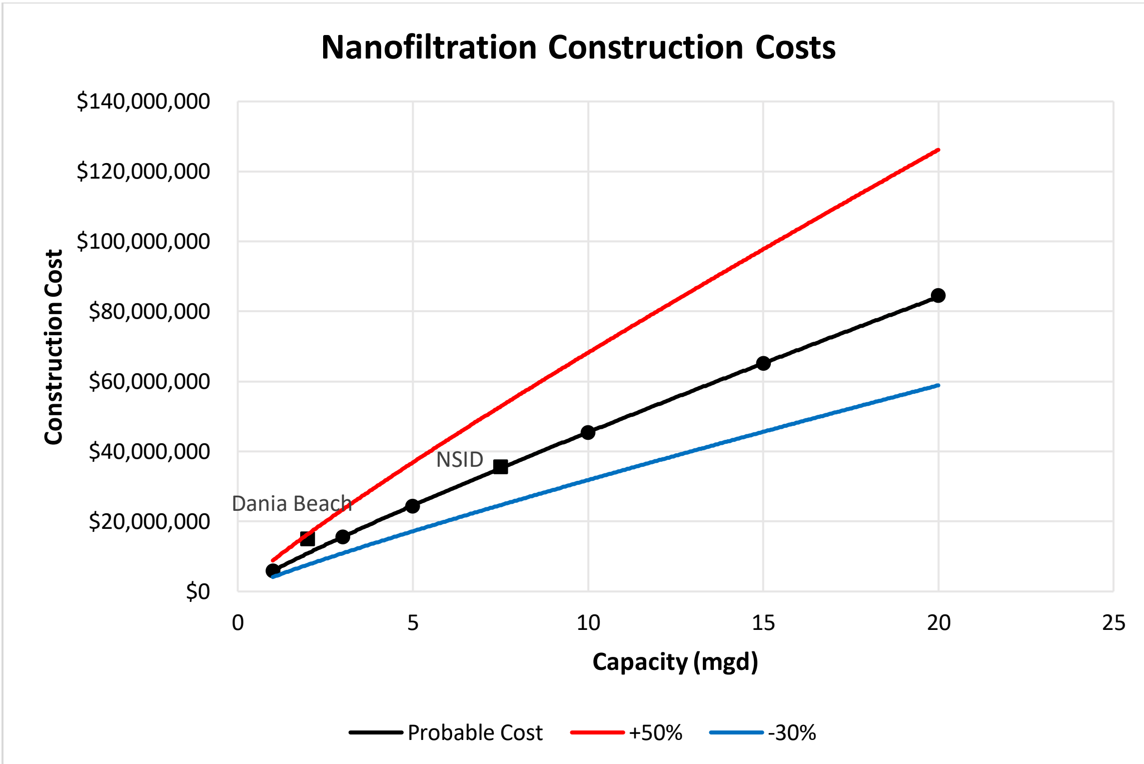

Figure 3-1: Nanofiltration Construction Cost Curve

3.2.1.2 OPERATION AND MAINTENANCE COSTS

Four NF and RO treatment plants were used to complete the O&M cost evaluation for an NF water treatment plant. The projects included in this evaluation are listed in **Table 3-4**. The O&M costs for a NF water treatment plant are summarized in **Table 3-5**.

Table 3-4: Nanofiltration O&M Cost Data Sources

Location	Municipality	Water Treatment Plant
Palm Beach County	Seacoast Utilities	Hood Road WTP (26 mgd) (NF and RO)
Palm Beach County	Town of Jupiter Utilities	Jupiter WTP (28.2 mgd) (NF and RO)
Indian River County	Indian River County Utilities	South Oslo WTP (8.57 mgd) (NF)
Broward County	North Springs Improvement District (NSID)	NSID Nanofiltration Plant (7.5 MGD) (NF)

Table 3-5: Opinion of Annual Operation and Maintenance Costs for Nanofiltration

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
Variable Costs							
1.	Power(1)	$120,000	$342,000	$557,000	$1,078,000	$1,585,000	$2,084,000
2.	Chemicals	$82,000	$233,000	$379,000	$734,000	$1,079,000	$1,418,000
3.	Replacement Parts and Materials	$76,000	$216,000	$352,000	$681,000	$1,002,000	$1,317,000
4.	Replacement Membranes	$29,000	$83,000	$135,000	$262,000	$385,000	$506,000
Fixed Costs							
5.	Operation and Maintenance Labor	$125,000	$357,000	$580,000	$1,123,000	$1,651,000	$2,170,000
6.	Administration/ Regulatory Compliance	$144,000	$411,000	$669,000	$1,295,000	$1,905,000	$2,503,000
Annual Production at Rated Capacity, (mgy)		365	1,095	1,825	3,650	5,475	7,300
Annual O&M Cost at Rated Capacity		**$576,000**	**$1,642,000**	**$2,672,000**	**$5,173,000**	**$7,607,000**	**$9,998,000**
Unit Cost at Rated Capacity, ($/kgal)		**$1.58**	**$1.50**	**$1.46**	**$1.42**	**$1.39**	**$1.37**
Annual Production at Avg Day Demand, (mgy)		243	730	1,217	2,704	4,212	5,840
Annual O&M Cost at AADD Capacity		**$473,000**	**$1,351,000**	**$2,198,000**	**$4,459,000**	**$6,672,000**	**$8,933,000**
Unit Cost at AADD Capacity, ($/kgal)		**$1.95**	**$1.85**	**$1.81**	**$1.65**	**$1.58**	**$1.53**

(1) Unit power cost = $0.12 per kWh

3.2.1.3 TOTAL COST SUMMARY

Opinion of total production costs are summarized in **Table 3-6**. The cost curve reflects the combination of probable construction cost, estimated annual O&M (fixed and variable costs), and R&R fund deposit. The Total Production Cost curve is depicted in **Figure 3-2.**

Table 3-6: Opinion of Total Production Cost for Nanofiltration[4]

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
Production Costs at Rated Capacity							
1.	Equivalent Annual Capital Cost	$784,000	$2,056,000	$3,232,000	$5,995,000	$8,625,000	$11,175,000
2.	Annual O&M Cost - Variable	$307,000	$874,000	$1,423,000	$2,755,000	$4,051,000	$5,325,000
3.	Annual O&M Cost - Fixed	$269,000	$768,000	$1,249,000	$2,418,000	$3,556,000	$4,673,000
4.	Annual R&R Fund Deposit (1)	$78,400	$205,600	$323,200	$599,500	$862,500	$1,117,500
	Total Annual Cost:	**$1,438,400**	**$3,903,600**	**$6,227,200**	**$11,767,500**	**$17,094,500**	**$22,290,500**
	Annual Production at Rated Capacity, (mgy)	365	1,095	1,825	3,650	5,475	7,300
	Annual Production Cost at Rated Capacity ($/kgal)	**$3.94**	**$3.56**	**$3.41**	**$3.22**	**$3.12**	**$3.05**
Production Costs at Average Annual Day Demand (AADD)							
MDD/AADD factor (2):		1.5	1.5	1.5	1.35	1.3	1.25
1.	Equivalent Annual Capital Cost	$784,000	$2,056,000	$3,232,000	$5,995,000	$8,625,000	$11,175,000
2.	Annual O&M Cost - Variable	$204,386	$582,667	$948,927	$2,040,964	$3,116,495	$4,260,000
3.	Annual O&M Cost - Fixed	$269,000	$768,000	$1,249,000	$2,418,000	$3,556,000	$4,673,000
4.	Annual R&R Fund Deposit (1):	$78,400	$205,600	$323,200	$599,500	$862,500	$1,117,500
	Total Annual Cost:	**$1,335,786**	**$3,612,267**	**$5,753,127**	**$11,053,464**	**$16,159,995**	**$21,225,500**
Annual Finished Water Production Rate, (mgy) (3)		243	730	1,217	2,704	4,212	5,840
	Annual Production Cost at AADD ($/kgal):	**$5.50**	**$4.95**	**$4.73**	**$4.09**	**$3.84**	**$3.63**

(1) Annual deposit to a R&R fund is equal to 10% of the equivalent annual capital cost.
(2) MDD (mgd), equal to the plant capacity rating divided by the AADD. This factor is used to calculate the AADD (mgd) to be used in the calculation of the annual production cost.
(3) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.
(4) Does not include concentrate disposal costs

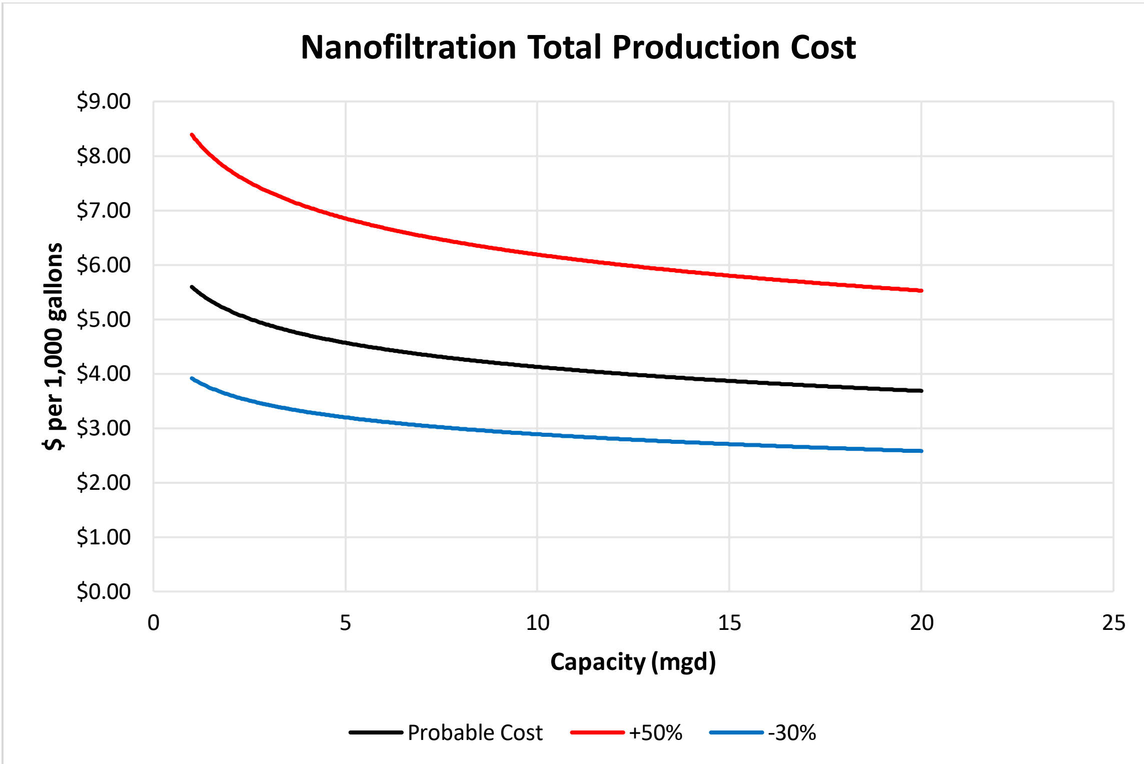

Figure 3-2: Nanofiltration Total Production Cost Curve

3.2.2 BRACKISH GROUNDWATER REVERSE OSMOSIS - NEW CONSTRUCTION

The raw water supply is assumed to be from the FAS or the Mid-Hawthorn Aquifer. The design capacity for each well is assumed to be 2 mgd of raw water per well. The number of wells are based on capacity of plant plus 20% for standby wells. The RO process is assumed to operate at an average of 75 to 80% recovery based on known information of existing RO plants.

Pre-treatment includes raw water anti-scalant feed and micron cartridge filtration. The membrane system includes pressure vessels, piping, membrane elements, control valves, instrumentation, a membrane cleaning system, and process piping. Pre-treatment chemical systems include bulk storage tanks, containment basins, day tanks, metering pumps, chemical piping, and chemical injection diffusers.

Post-treatment includes packed-tower type degasifiers, a caustic feed system for pH adjustment, and application of a corrosion inhibitor. Post-treatment chemical systems include bulk storage tanks and containment basins, day tanks, metering pumps, chemical piping, and chemical injection diffusers. Information was received from each of these plants in form of a schedule of values, pay applications, or bid tabulations. Data was sorted through and categorized based on data tables sections. The data was separated into the subcategories listed in Section 3.2. Once the costs were broken into subcategories, the data was broken down into 1 mgd increments. Cost for pre-treatment, process equipment, post treatment, intermediate storage (clearwell), transfer pumping, and plant infrastructure for plant size above 1 mgd were calculated using the formula discussed in Section 3.1.

Cost for DIW for concentrate disposal was determined based on size of plant and required capacity for concentrate disposal. It was assumed that a 3 mgd capacity DIW will be required for plant sizes up to 10 mgd, while plant sizes 15 and 20 mgd, may require two DIWs.

3.2.2.1 CAPITAL COSTS

Six RO plant projects were used to complete the capital cost evaluation for RO treatment plants. The projects included in this evaluation are listed in **Table 3-7** below. Probable Construction Costs and Probable Capital Costs were evaluated without the DIW costs to calculate a unit probable cost and a unit probable total capital costs that is best reflective of the relationship between the plant costs and capacity. The opinion of probable capital costs for Brackish RO are summarized in **Table 3-8**. The Brackish RO Construction Cost Curve is depicted in **Figure 3-3**.

Table 3-7: Project Cost Data Sources

Location	Municipality	Project Name
Martin County	City of Stuart	Stuart RO WTP Phase 1 (1.5 MGD)
Charlotte County	City of Punta Gorda	NSID Nanofiltration Plant (4.5 MGD)
Tampa Bay	City of Clearwater	Water Treatment Plant No. 2 – Contract 4: Reverse Osmosis Plant Site Expansion (6.25 MGD)
Hendry County	City of Labelle RO WTP	Membrane Water Treatment Facility (1.5 MGD)
Charlotte County	Town and Country Utilities	Phase 3 WTP Expansion (2.5 MGD Expansion)
Monroe County	Florida Keys Aqueduct Authority	Kermit H Lewin RO Facility (4 MGD)

Table 3-8: Opinion of Probable Capital Cost for Brackish Reverse Osmosis

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	Raw Water Supply		$1,036,000	$3,108,000	$5,180,000	$10,360,000	$15,540,000	$20,720,000
2.	Pretreatment		$486,000	$1,170,000	$1,761,000	$3,066,000	$4,241,000	$5,339,000
3.	Process Equipment		$1,802,000	$4,340,000	$6,530,000	$11,370,000	$15,726,000	$19,796,000
4.	Post Treatment		$1,465,000	$3,528,000	$5,309,000	$9,244,000	$12,785,000	$16,094,000
5.	Intermediate Storage		$286,000	$689,000	$1,036,000	$1,805,000	$2,496,000	$3,142,000
6.	Transfer Pumping		$69,000	$166,000	$250,000	$435,000	$602,000	$758,000
7.	Plant Infrastructure		$1,865,000	$4,491,000	$6,759,000	$11,767,000	$16,276,000	$20,488,000
8.	Concentrate Disposal		$9,000,000	$9,000,000	$9,000,000	$9,000,000	$13,500,000	$13,500,000
		Subtotal w/ DIW (1-8):	**$16,009,000**	**$26,492,000**	**$35,825,000**	**$57,047,000**	**$81,166,000**	**$99,837,000**
		Subtotal w/o DIW (1-7):	**$7,009,000**	**$17,492,000**	**$26,825,000**	**$48,047,000**	**$67,666,000**	**$86,337,000**
9.	Yard Piping	8%	$561,000	$1,399,000	$2,146,000	$3,844,000	$5,413,000	$6,907,000
10.	Mechanical	2%	$140,000	$350,000	$537,000	$961,000	$1,353,000	$1,727,000
11.	Electrical (1)	20%	$1,402,000	$3,498,000	$5,365,000	$9,609,000	$13,533,000	$17,267,000
12.	Instrumentation and Controls (1)	5%	$350,000	$875,000	$1,341,000	$2,402,000	$3,383,000	$4,317,000
13.	Site Work	5%	$350,000	$875,000	$1,341,000	$2,402,000	$3,383,000	$4,317,000
		Subtotal (1-13):	**$9,812,000**	**$24,489,000**	**$37,555,000**	**$67,265,000**	**$94,731,000**	**$120,872,000**
14.	General Requirements	10%	$981,000	$2,449,000	$3,756,000	$6,727,000	$9,473,000	$12,087,000
15.	Contractor O&P	15%	$1,472,000	$3,673,000	$5,633,000	$10,090,000	$14,210,000	$18,131,000
16.	Construction Contingency	15%	$1,472,000	$3,673,000	$5,633,000	$10,090,000	$14,210,000	$18,131,000
		Opinion of Probable Construction Cost (1-16):	**$13,737,000**	**$34,284,000**	**$52,577,000**	**$94,172,000**	**$132,624,000**	**$169,221,000**
17.	Technical Services	20%	$2,747,000	$6,857,000	$10,515,000	$18,834,000	$26,525,000	$33,844,000
18.	Owner Administration and Legal	5%	$687,000	$1,714,000	$2,629,000	$4,709,000	$6,631,000	$8,461,000
19.	Project Contingency	15%	$2,061,000	$5,143,000	$7,887,000	$14,126,000	$19,894,000	$25,383,000
		Opinion of Probable Capital Cost (1-19)(2):	**$19,232,000**	**$47,998,000**	**$73,608,000**	**$131,841,000**	**$185,674,000**	**$236,909,000**
		Opinion of Equivalent Annual Capital Cost(2):	**$1,815,365**	**$4,530,672**	**$6,948,074**	**$12,444,858**	**$17,526,312**	**$22,362,534**
Unit Probable Cost ($/gpd)			$13.74	$11.43	$10.52	$9.42	$8.84	$8.46
Unit Probable Total Capital Cost ($/gpd)			$19.23	$16.00	$14.72	$13.18	$12.38	$11.85

(1) "Electrical" and "Instrumentation and Controls" cost items are estimated as 20% and 5% respectively, of the subtotal of the preceding cost components minus the cost for concentrate disposal. This is because a concentrate DIW has negligible electrical and instrumentation and controls costs relative to other plant components, while the construction cost for a DIW is typically a substantial portion of the total facility cost.

(2) Does not include concentrate disposal costs

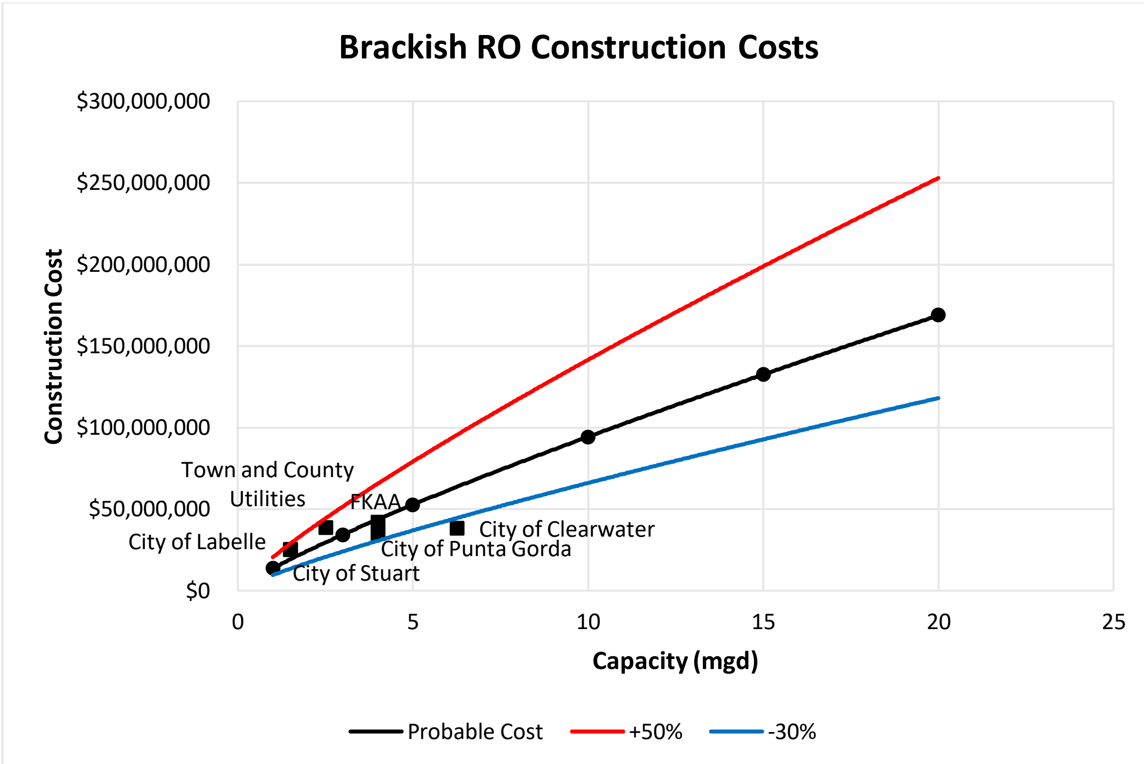

Figure 3-3: Brackish RO Construction Cost Curve

3.2.2.2 OPERATION AND MAINTENANCE COSTS

Three RO treatment plants were used to complete the O&M cost evaluation for NF treatment plant. The projects included in this evaluation are listed in **Table 3-9** below. The O&M costs for a Brackish RO Water Treatment Plant are summarized in **Table 3-10**.

Table 3-9: O&M Cost Data Sources

Location	Municipality	Water Treatment Plant
Martin County	City of Stuart Utilities	City of Stuart WTP (6.0 mgd) (1.5 mgd RO)
Palm Beach County	Town of Jupiter Utilities	Jupiter WTP (28.2 mgd) (NF and RO)
Pinellas County	City of Clearwater Utilities	WTP No. 2 RO Plant)6.25 mgd)

Table 3-10: Opinion of Annual Operation and Maintenance Cost for Brackish Reverse Osmosis

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
Variable Costs							
1.	Power (1)	$148,000	$388,000	$604,000	$1,091,000	$1,533,000	$1,947,000
2.	Chemicals	$101,000	$264,000	$411,000	$742,000	$1,043,000	$1,325,000
3.	Replacement Parts and Materials	$94,000	$246,000	$382,000	$689,000	$969,000	$1,230,000
4.	Replacement Membranes	$36,000	$94,000	$147,000	$265,000	$373,000	$473,000
Fixed Costs							
5.	Operation and Maintenance Labor	$148,000	$388,000	$604,000	$1,091,000	$1,533,000	$1,947,000
6.	Administration/ Regulatory Compliance	$178,000	$467,000	$726,000	$1,310,000	$1,842,000	$2,339,000
Annual Production at Rated Capacity, (mgy)		365	1,095	1,825	3,650	5,475	7,300
Annual O&M Cost at Rated Capacity		**$705,000**	**$1,847,000**	**$2,874,000**	**$5,188,000**	**$7,293,000**	**$9,261,000**
Unit Cost at Rated Capacity, ($/kgal)		**$1.93**	**$1.69**	**$1.57**	**$1.42**	**$1.33**	**$1.27**
Annual Production at Avg Day Demand, (mgy)		243	730	1,217	2,704	4,212	5,840
Annual O&M Cost at AADD Capacity		**$578,000**	**$1,516,000**	**$2,360,000**	**$4,466,000**	**$6,389,000**	**$8,266,000**
Unit Cost at Rated Capacity, ($/kgal)		**$2.38**	**$2.08**	**$1.94**	**$1.65**	**$1.52**	**$1.42**

(1) Unit power cost = $0.12 per kWh

3.2.2.3 TOTAL COST SUMMARY

Opinion of total production costs for a Brackish RO Water Treatment Plant are summarized in **Table 3-11.** The Brackish RO total production costs are depicted in **Figure 3-4.**

Table 3-11: Opinion of Total Production Cost for Brackish Reverse Osmosis[4]

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
Production Costs at Rated Capacity							
1.	Equivalent annual capital cost	$1,815,365	$4,530,672	$6,948,074	$12,444,858	$17,526,312	$22,362,534
2.	Annual O&M Cost - Variable	$379,000	$992,000	$1,544,000	$2,787,000	$3,918,000	$4,975,000
3.	Annual O&M Cost - Fixed	$326,000	$855,000	$1,330,000	$2,401,000	$3,375,000	$4,286,000
4.	Annual R&R Fund Deposit [1]	$181,536	$453,067	$694,807	$1,244,486	$1,752,631	$2,236,253
Total Annual Cost:		**$2,701,901**	**$6,830,739**	**$10,516,882**	**$18,877,343**	**$26,571,943**	**$33,859,787**
Annual Production at Rated Capacity, (mgy)		365	1,095	1,825	3,650	5,475	7,300
Annual Production Cost at Rated Capacity ($/kgal)		**$7.40**	**$6.24**	**$5.76**	**$5.17**	**$4.85**	**$4.64**
Production Costs at Average Day Demand (AADD)							
MDD/AADD factor[2]:		1.5	1.5	1.5	1.35	1.3	1.25
1.	Equivalent Annual Capital Cost	$1,815,365	$4,530,672	$6,948,074	$12,444,858	$17,526,312	$22,362,534
2.	Annual O&M Cost - Variable	$252,667	$661,333	$1,029,333	$2,064,444	$3,013,846	$3,980,000
3.	Annual O&M Cost - Fixed	$326,000	$855,000	$1,330,000	$2,401,000	$3,375,000	$4,286,000
4.	Annual R&R Fund Deposit[1]	$181,536	$453,067	$694,807	$1,244,486	$1,752,631	$2,236,253
Total Annual Cost:		**$2,575,568**	**$6,500,072**	**$10,002,215**	**$18,154,788**	**$25,667,789**	**$32,864,787**
Annual Finished Water Production Rate, (mgy) [3]		243	730	1,217	2,704	4,212	5,840
Annual Production Cost at AADD ($/kgal):		**$10.58**	**$8.90**	**$8.22**	**$6.71**	**$6.09**	**$5.63**

(1) Annual deposit to a R&R fund is equal to 10% of the equivalent annual capital cost.
(2) MDD (mgd), equal to the plant capacity rating divided by the AADD. This factor is used to calculate the AADD (mgd) to be used in the calculation of the annual production cost.
(3) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.
(4) Does not include concentrate disposal costs

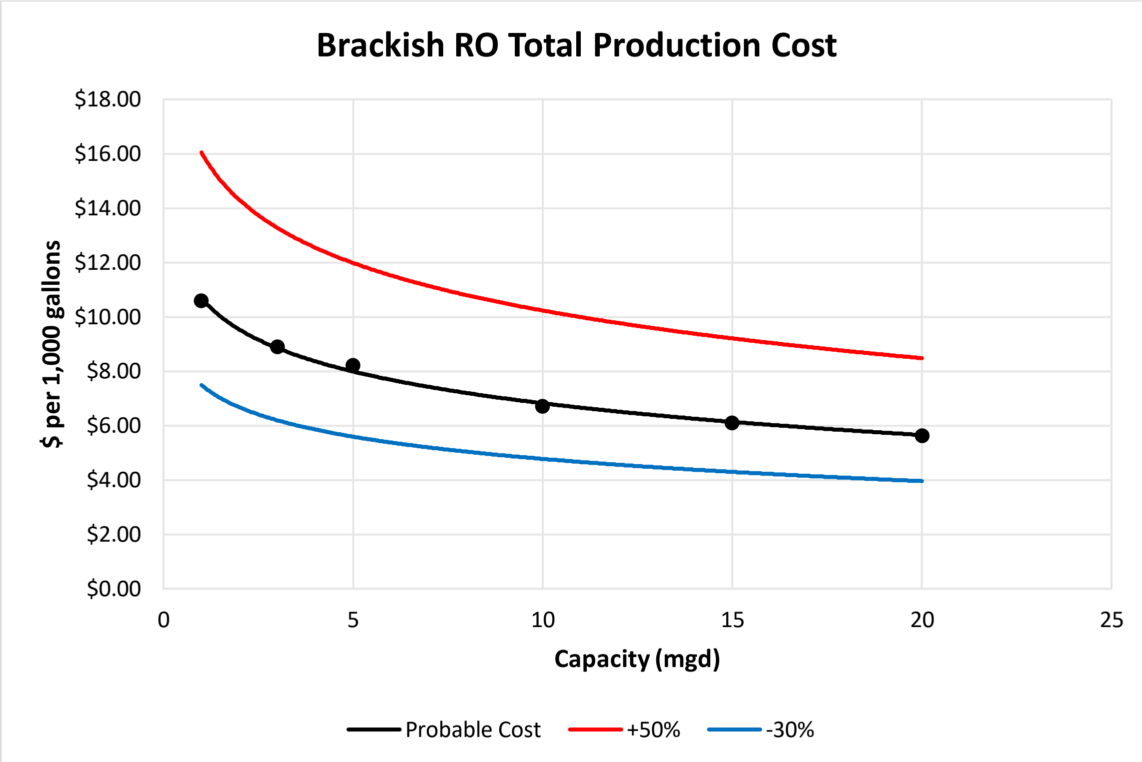

Figure 3-4: Brackish RO Total Production Cost Curve

3.2.3 SEAWATER REVERSE OSMOSIS – NEW CONSTRUCTION

For seawater desalination, which uses seawater as the water source (or a water source that has the equivalent TDS or higher "salt" content), the Claude "Bud" Lewis Carlsbad (Carlsbad) Desalination Water Treatment Plant (WTP) was used to represent costs for this type of treatment process. The Carlsbad WTP is located along the Agua Hedianda Lagoon in Carlsbad, California. This project was a design-build delivery financed by Poseidon Water (a private project developer). Poseidon initiated the project by establishing a 30-year water purchase agreement through public partnership with San Diego Water Authority with buyout provisions after 10 years of operation. Project design started in January 2013 and the facility was online in late 2015, with a 36-month design and construction schedule.

The Carlsbad Seawater Desalination Project is a 50 mgd water treatment plant facility and is currently the largest seawater RO treatment plant in the United States. The construction of a new intake and discharge facilities were necessary to allow for a transition to standalone operation of the desalination plant. The treatment process requires an average seawater intake of 106.7 mgd. The concentrated brine discharge (the liquid that is rejected by the RO treatment process) averages 57 mgd, and based on available information, is blended with 200 mgd of intake seawater prior to ocean discharge.

The project, which provides water supply for approximately 400,000 residents, included a desalination plant, a pumping station, product water storage and a ten-mile finished water conveyance pipe. Seawater is pumped from the Pacific Ocean to the pre-treatment process. Pre-treatment of the water uses sand/anthracite filtration technology with a micro-screen filtration process. Backwash of the pre-treatment membranes is conducted using acid, chlorine and base conditioning of the membrane modules. The source water is then processed through RO membranes (specific for seawater) for producing water for consumption. This facility includes 12 treatment trains and 1 backup train. Total water production capacity of the treatment trains is 54 mgd. Other components of the facility include 13 high-speed RO feed pumps to enable the water and salt separation utilizing high pressure from the pumps. The water is disinfected using chloramines (sodium hypochlorite and ammonia). The chloramines control biological growth in the transmission pipelines and the reservoirs within the distribution system. The water is temporarily stored in on-site storage tanks prior to conveyance through a 10-mile, 54-inch distribution piping system by distribution pumps.

3.2.3.1 CAPITAL COSTS

Unfortunately, the breakdown of the costs by process was not available at the time of this study. However, the overall construction costs for the desalination plant and conveyance pipeline are listed in **Table 3-12** below.

Table 3-12: Summary of Total Desalination Plant and 10-mile Conveyance Pipeline for Carlsbad WTP

Description	Costs June 2012 (midpoint) Dollars (million dollars)	Costs in December 2021 Dollars (million dollars unless otherwise noted)
Total Desalination Plant	$537	$860
Total Conveyance Pipeline (10-miles)	$159	$255
Total	**$696**	**$1,115**

Using the data collected for the Carlsbad WTP, probable total capital costs were evaluated for plant capacities ranging from 1 to 20 mgd. The results are summarized in **Table 3-13**. **Figure 3-5** depicts the Seawater RO construction cost curve.

Table 3-13: Opinion of Probable Capital Cost for Seawater Reverse Osmosis (Desalination Plant Only)

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
Opinion of Probable Construction Cost:			$37,611,655	$90,577,000	$136,301,000	$237,314,000	$328,243,000	$413,187,000
1.	Technical services	20%	$7,522,331	$18,115,400	$27,260,200	$47,462,800	$65,648,600	$82,637,400
2.	Owner administration and legal	5%	$1,880,583	$4,528,850	$6,815,050	$11,865,700	$16,412,150	$20,659,350
3.	Project contingency	15%	$5,641,748	$13,586,550	$20,445,150	$35,597,100	$49,236,450	$61,978,050
Opinion of Probable Annual Capital Cost:			**$52,656,317**	**$126,807,800**	**$190,821,400**	**$332,239,600**	**$459,540,200**	**$578,461,800**
Opinion of Equivalent Annual Capital Cost:			**$4,970,384**	**$11,969,759**	**$18,012,190**	**$31,361,068**	**$43,377,344**	**$54,602,702**
Unit Probable Cost ($/gpd)			$37.61	$30.19	$27.26	$23.73	$21.88	$20.66
Unit Probable Total Capital Cost ($/gpd)			$52.66	$42.27	$38.16	$33.22	$30.64	$28.92

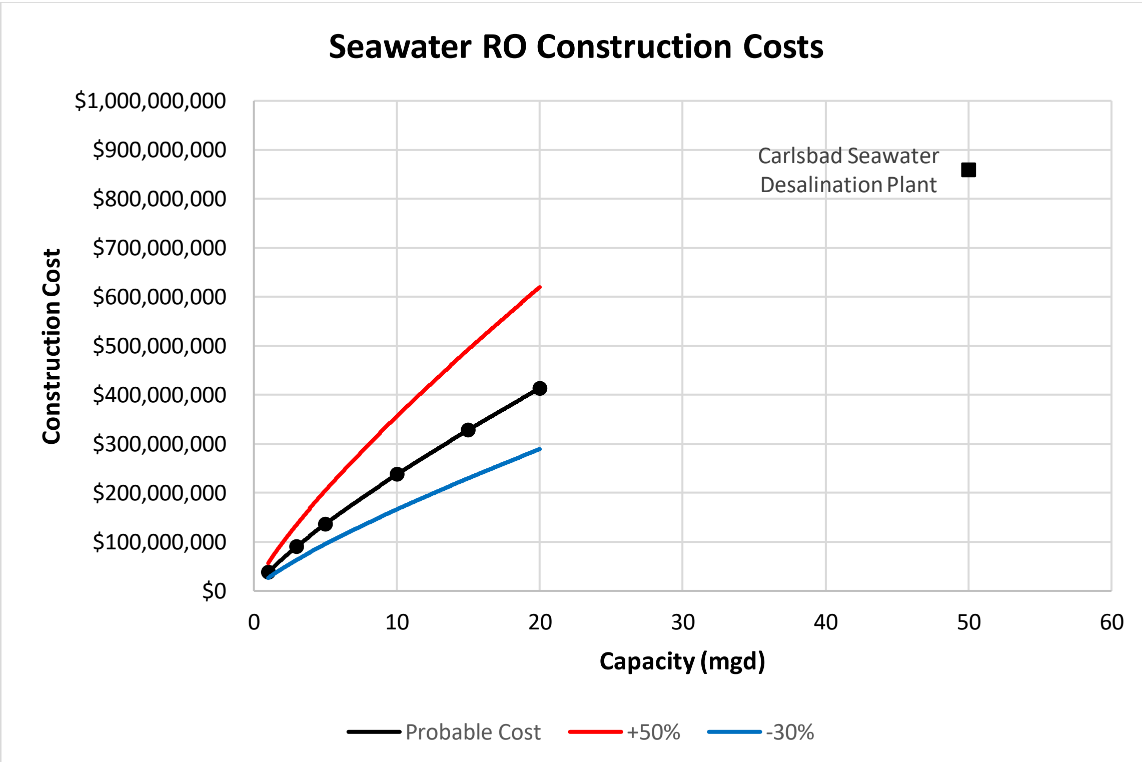

Figure 3-5: Seawater RO Construction Costs

3.2.4.2 OPERATION AND MAINTENANCE COSTS

A financial statement dated December 21, 2020 was available and reflected high level O&M costs for the plant. The overall O&M costs for the desalination plant and conveyance pipeline, as of December 31, 2020, is listed in **Table 3-14** below. O&M was provided for fixed and variable costs in terms of amount per acre-foot. Average Daily Demand is 50 mgd according to resources provided and additional research.

Table 3-14: Summary of Fixed and Variable Costs for Carlsbad WTP

Description	Amount per Acre-Foot	Amount per Day (Average Daily Demand)	Annual O&M Costs (Average Daily Demand)
Fixed			
Debt Service Charge	$609	$112,171	$40,942,236
Equity Return Charge	$425	$78,355	$28,599,702
Fixed Operating Charge	$511	$94,209	$34,386,232
Fixed Electricity Charge	$148	$27,288	$9,960,122
Total Fixed Charge	**$1,693**	**$312,023**	**$113,888,292**
Variable			
Variable Operating Charge	$124	$22,836	$8,335,078
Variable Electricity Charge	$619	$114,048	$41,627,633
Total Variable	**$743**	**$136,884**	**$49,962,711**
Total O&M	**$2,436**	**$273,768**	**$163,851,003**

The O&M costs for Seawater RO Treatment Plant (derived from the Carlsbad WTP) are summarized in **Table 3-15**.

Table 3-15: Opinion of Annual Operation and Maintenance Cost for Seawater Reverse Osmosis (Desalination Plant Only)

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Variable Costs	$2,185,093	$5,262,000	$7,919,000	$13,787,000	$19,070,000	$24,005,000
2.	Fixed Costs	$1,939,465	$4,671,000	$7,028,000	$12,237,000	$16,926,000	$21,306,000
Annual Production at Avg Day Demand, (mgy)		243	730	1,217	2,704	4,212	5,840
Annual O&M Cost at AADD Capacity		**$3,394,000**	**$8,179,000**	**$12,309,000**	**$22,451,000**	**$31,597,000**	**$40,510,000**
Unit Cost at AADD Capacity, $/kgal		**$13.97**	**$11.20**	**$10.11**	**$8.30**	**$7.50**	**$6.94**

3.2.4.3 TOTAL COST SUMMARY

Opinion of total production costs for a Seawater RO Plant are summarized in **Table 3-16.** The Seawater RO total production costs are depicted in **Figure 3-6.**

Table 3-16: Opinion of Total Production Cost for Seawater RO

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
Production Costs at Rated Capacity							
1.	Equivalent annual capital cost	$4,970,384	$11,969,759	$18,012,190	$31,361,068	$43,377,344	$54,602,702
2.	Annual O&M Cost - Variable	$2,185,093	$5,262,000	$7,919,000	$13,787,000	$19,070,000	$24,005,000
3.	Annual O&M Cost - Fixed	$1,939,465	$4,671,000	$7,028,000	$12,237,000	$16,926,000	$21,306,000
4.	Annual R&R Fund Deposit(1)	$497,038	$1,196,976	$1,801,219	$3,136,107	$4,337,734	$5,460,270
	Total Annual Cost:	**$9,591,980**	**$23,099,735**	**$34,760,409**	**$60,521,175**	**$83,711,078**	**$105,373,972**
Annual Production at Rated Capacity, (mgy)		365	1,095	1,825	3,650	5,475	7,300
Annual Production Cost at Rated Capacity ($/kgal)		**$26.28**	**$21.10**	**$19.05**	**$16.58**	**$15.29**	**$14.43**
Production Costs at Annual Average Day Demand (AADD)							
	MDD/AADD factor(2)	1.5	1.5	1.5	1.35	1.3	1.25
1.	Equivalent annual capital cost	$4,970,384	$11,969,759	$18,012,190	$31,361,068	$43,377,344	$54,602,702
2.	Annual O&M Cost - Variable	$1,456,729	$3,508,000	$5,279,333	$10,212,593	$14,669,231	$19,204,000
3.	Annual O&M Cost - Fixed	$1,939,465	$4,671,000	$7,028,000	$12,237,000	$16,926,000	$21,306,000
4.	Annual R&R Fund Deposit(1)	$497,038	$1,196,976	$1,801,219	$3,136,107	$4,337,734	$5,460,270
	Total Annual Cost:	**$8,863,616**	**$21,345,735**	**$32,120,743**	**$56,946,767**	**$79,310,309**	**$100,572,972**
Annual finished water production rate, (mgy)(3)		243	730	1,217	2,704	4,212	5,840
Annual Production Cost at AADD ($/kgal):		**$36.43**	**$29.24**	**$26.40**	**$21.06**	**$18.83**	**$17.22**

(1) Annual deposit to a R&R fund is equal to 10% of the equivalent annual capital cost.
(2) MDD (mgd), equal to the plant capacity rating divided by the AADD. This factor is used to calculate the AADD (mgd) to be used in the calculation of the annual production cost.
(3) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

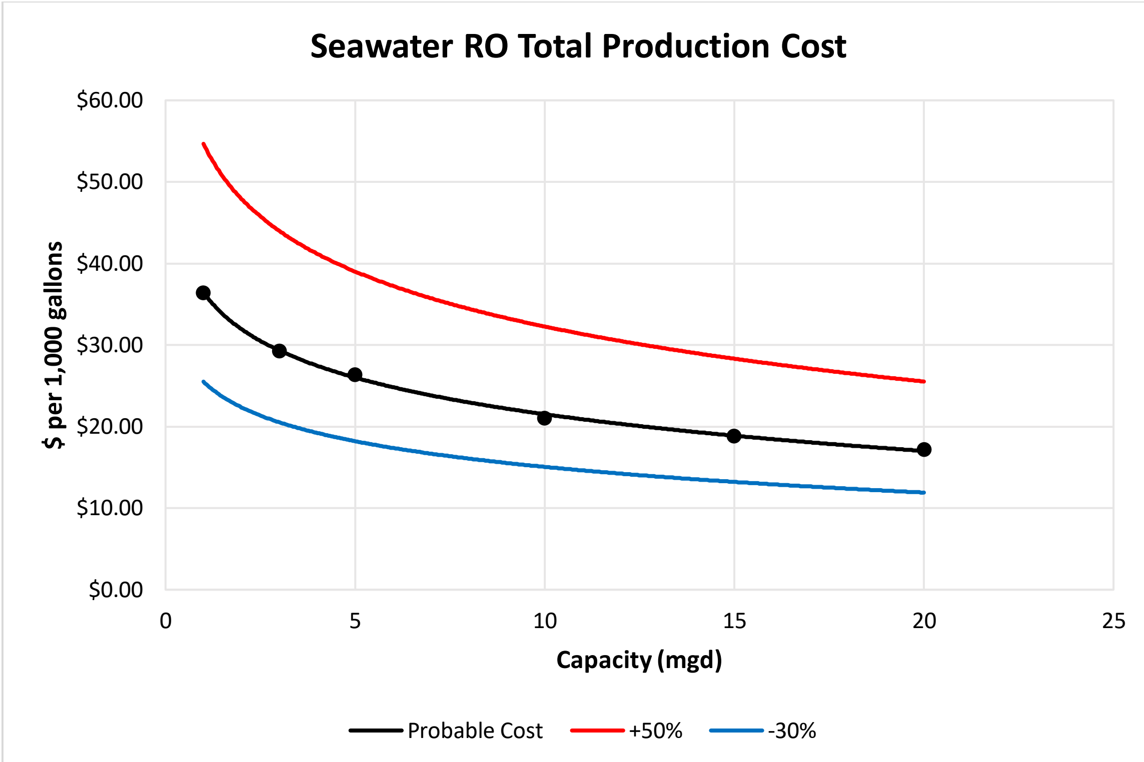

Figure 3-6: Seawater RO Total Production Costs

3.3 WATER TREATMENT TECHNOLOGY PROCESS COMPONENTS

Opinion of probable construction costs for NF and RO process addition, as well as IX are summarized in this section. The NF and RO process additions' costs were derived from collected data included in section 3.2 and 3.3, respectively. Cost data reflect membrane trains (NF/RO), pressurized vessels, media, regeneration (IX), mechanical, yard piping, electrical and instrumentation, and site work.

3.3.1 NANOFILTRATION PROCESS – ADDITIONAL CAPACITY

This section addresses the addition of NF treatment capacity to an existing water treatment plant. Cost data reflects raw water supply, NF membrane trains (process equipment), post-treatment, mechanical, yard piping, electrical and instrumentation, and site work. Opinion of probable construction costs are reflected based on rated capacity for MDD and AADD. Cost data used for this section was derived from **Section 3.2.1**.

3.3.1.1 CAPITAL COSTS

The opinion of probable construction costs for NF process addition are summarized in **Table 3-17**. The Construction Cost Curve for NF process addition is depicted in **Figure 3-7**.

Table 3-17: Opinion of Probable Capital Cost for Nanofiltration – Process Addition

Item No.	Description		Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	Pretreatment		$28,000	$67,000	$101,000	$177,000	$244,000	$308,000
2.	Process Equipment		$496,000	$1,195,000	$1,798,000	$3,130,000	$4,329,000	$5,449,000
3.	Post Treatment		$324,000	$780,000	$1,174,000	$2,044,000	$2,828,000	$3,559,000
4.	Intermediate Storage		$286,000	$689,000	$1,036,000	$1,805,000	$2,496,000	$3,142,000
5.	Transfer Pumping		$69,000	$166,000	$250,000	$435,000	$602,000	$758,000
6.	Plant Infrastructure		$725,000	$1,746,000	$2,627,000	$4,574,000	$6,327,000	$7,965,000
7.	Concentrate Disposal		$9,000,000	$9,000,000	$9,000,000	$9,000,000	$13,500,000	$13,500,000
	Subtotal w/ DIW (1-7):		**$10,928,000**	**$13,643,000**	**$15,986,000**	**$21,165,000**	**$30,326,000**	**$34,681,000**
	Subtotal w/o DIW (1-6):		**$1,928,000**	**$4,643,000**	**$6,986,000**	**$12,165,000**	**$16,826,000**	**$21,181,000**
8.	Yard Piping	8%	$154,000	$371,000	$559,000	$973,000	$1,346,000	$1,694,000
9.	Mechanical	2%	$39,000	$93,000	$140,000	$243,000	$337,000	$424,000
10.	Electrical [(1)]	20%	$386,000	$929,000	$1,397,000	$2,433,000	$3,365,000	$4,236,000
11.	Instrumentation and Control [(1)]	5%	$96,000	$232,000	$349,000	$608,000	$841,000	$1,059,000
12.	Site Work	5%	$96,000	$232,000	$349,000	$608,000	$841,000	$1,059,000
	Subtotal (1-12):		**$2,699,000**	**$6,500,000**	**$9,780,000**	**$17,030,000**	**$23,556,000**	**$29,653,000**
12.	General Requirements	10%	$269,900	$650,000	$978,000	$1,703,000	$2,355,600	$2,965,300
13.	Contractor Overhead and Profit	15%	$404,850	$975,000	$1,467,000	$2,554,500	$3,533,400	$4,447,950
14.	Construction Contingency	15%	$404,850	$975,000	$1,467,000	$2,554,500	$3,533,400	$4,447,950
	Opinion of Probable Construction Cost (1-14):		**$3,778,600**	**$9,100,000**	**$13,692,000**	**$23,842,000**	**$32,978,400**	**$41,514,200**
15.	Technical Services	20%	$755,720	$1,820,000	$2,738,400	$4,768,400	$6,595,680	$8,302,840
17.	Owner Administration and legal	5%	$188,930	$455,000	$684,600	$1,192,100	$1,648,920	$2,075,710
18.	Project Contingency	15%	$566,790	$1,365,000	$2,053,800	$3,576,300	$4,946,760	$6,227,130
	Opinion of Probable Capital Cost (1-18)[(2)]:		**$5,290,040**	**$12,740,000**	**$19,168,800**	**$33,378,800**	**$46,169,760**	**$58,119,880**
	Opinion of Equivalent Annual Capital Cost[(2)]:		**$499,342**	**$1,202,566**	**$1,809,399**	**$3,150,723**	**$4,358,099**	**$5,486,106**
	Unit Probable Cost ($/gpd)		$3.78	$3.03	$2.74	$2.38	$2.20	$2.08
	Unit Probable Total Capital Cost ($/gpd)		$5.29	$4.25	$3.83	$3.34	$3.08	$2.91

(1) "Electrical" and "Instrumentation and Controls" cost items are estimated as 10% and 5% respectively, of the subtotal of the preceding cost components minus the cost for concentrate disposal. This is because a concentrate disposal DIW has negligible electrical and instrumentation and controls costs relative to other plant components, while the construction cost for a DIW is typically a substantial portion of the total facility cost.

(2) Does not include concentrate disposal costs

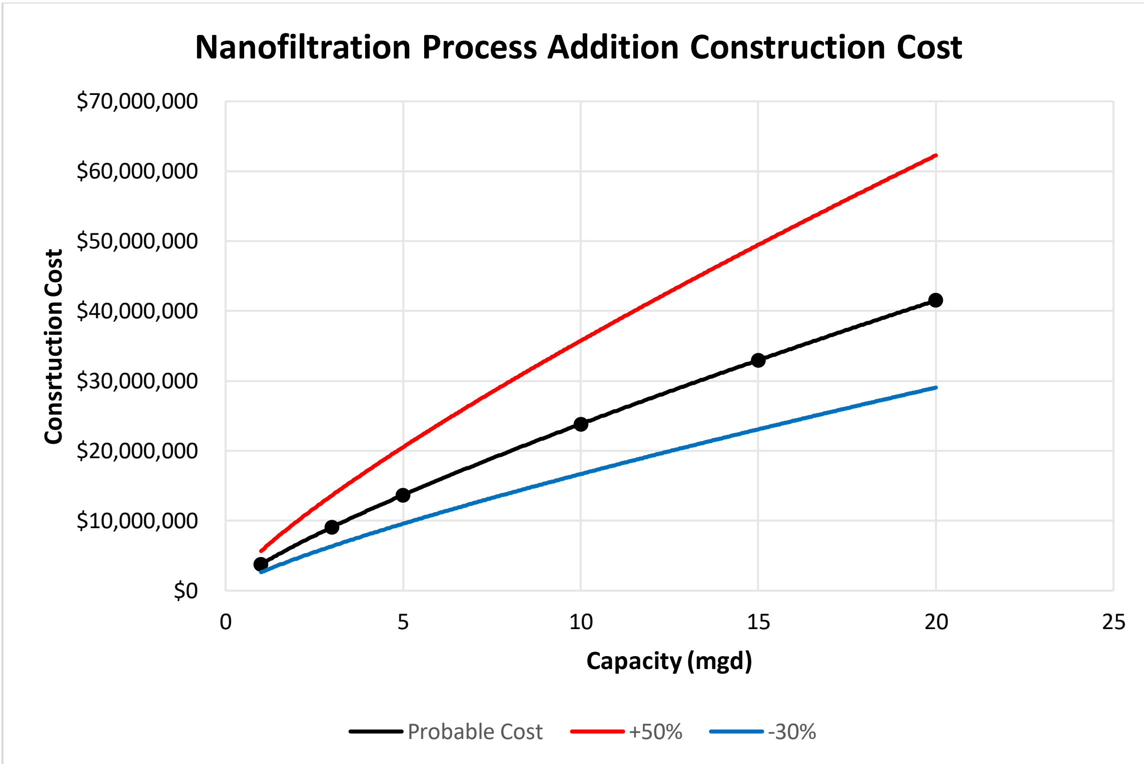

Figure 3-7: Nanofiltration Process Addition Construction Cost Curve

3.3.1.2 OPERATION AND MAINTENANCE COSTS

The O&M costs for NF process addition are summarized in **Table 3-18**. This information was derived using the data sources listed in **Table 3-4**.

Table 3-18: Opinion of Annual Operation and Maintenance Cost for Nanofiltration – Process Addition

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
Variable Costs							
1.	Power[1]	$120,000	$342,000	$557,000	$1,078,000	$1,585,000	$2,084,000
2.	Chemicals	$82,000	$233,000	$379,000	$734,000	$1,079,000	$1,418,000
3.	Replacement Parts and Materials	$76,000	$216,000	$352,000	$681,000	$1,002,000	$1,317,000
4.	Replacement Membranes	$29,000	$83,000	$135,000	$262,000	$385,000	$506,000
Fixed Costs							
5.	Operation and Maintenance Labor	$125,000	$357,000	$580,000	$1,123,000	$1,651,000	$2,170,000
6.	Administration/ Regulatory Compliance	$144,000	$411,000	$669,000	$1,295,000	$1,905,000	$2,503,000
Annual Production at Rated Capacity, (mgy)		365	1,095	1,825	3,650	5,475	7,300
Annual O&M Cost at Rated Capacity		**$576,000**	**$1,642,000**	**$2,672,000**	**$5,173,000**	**$7,607,000**	**$9,998,000**
Unit Cost at Rated Capacity, ($/kgal)		**$1.58**	**$1.50**	**$1.46**	**$1.42**	**$1.39**	**$1.37**
Annual Production at Avg Day Demand, (mgy)		243	730	1,217	2,704	4,212	5,840
Annual O&M Cost at AADD Capacity		**$473,000**	**$1,351,000**	**$2,198,000**	**$4,459,000**	**$6,672,000**	**$8,933,000**
Unit Cost at AADD Capacity, $/(kgal)		**$1.95**	**$1.85**	**$1.81**	**$1.65**	**$1.58**	**$1.53**

(1) Unit power cost = $0.12 per kWh

3.3.1.3 TOTAL COST SUMMARY

Opinion of total production costs are summarized in **Table 3-19**. These costs do not include concentrate disposal costs. The cost curve reflects the combination of opinion of probable construction cost, estimated annual O&M (fixed and Variable costs), and R&R fund deposit. The Total Production Cost curve is depicted in **Figure 3-8**.

Table 3-19: Opinion Total Production Cost for Nanofiltration – Process Addition

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
Production Costs at Rated Capacity							
1.	Equivalent annual capital cost	$499,342	$1,202,566	$1,809,399	$3,150,723	$4,358,099	$5,486,106
2.	Annual O&M Cost - Variable	$307,000	$874,000	$1,423,000	$2,755,000	$4,051,000	$5,325,000
3.	Annual O&M Cost - Fixed	$269,000	$768,000	$1,249,000	$2,418,000	$3,556,000	$4,673,000
4.	Annual R&R fund deposit (1)	$49,934	$120,257	$180,940	$315,072	$435,810	$548,611
	Total Annual Cost:	**$1,125,277**	**$2,964,822**	**$4,662,339**	**$8,638,795**	**$12,400,909**	**$16,032,716**
Annual Production at Rated Capacity, (mgy)		365	1,095	1,825	3,650	5,475	7,300
Annual Production Cost at Rated Capacity ($/kgal)		$3.08	$2.71	$2.55	$2.37	$2.27	$2.20
Production Costs at Average Day Demand (AADD)							
MDD/AADD factor (2)		1.5	1.5	1.5	1.35	1.3	1.25
1.	Equivalent annual capital cost	$499,342	$1,202,566	$1,809,399	$3,150,723	$4,358,099	$5,486,106
2.	Annual O&M Cost - Variable	$204,386	$582,667	$948,927	$2,040,964	$3,116,495	$4,260,000
3.	Annual O&M Cost - Fixed	$269,000	$768,000	$1,249,000	$2,418,000	$3,556,000	$4,673,000
4.	Annual R&R fund deposit(1)	$49,934	$120,257	$180,940	$315,072	$435,810	$548,611
	Total Annual Cost:	**$1,022,663**	**$2,673,489**	**$4,188,266**	**$7,924,759**	**$11,466,404**	**$14,967,716**
Annual production at AADD, (mgy)(3)		243	730	1,217	2,704	4,212	5,840
Annual Production Cost at AADD ($/kgal):		**$4.21**	**$3.66**	**$3.44**	**$2.93**	**$2.72**	**$2.56**

(1) Annual deposit to a R&R fund is equal to 10% of the equivalent annual capital cost.
(2) MDD (mgd), equal to the plant capacity rating divided by the AADD. This factor is used to calculate the AADD (mgd) to be used in the calculation of the annual production cost.
(3) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

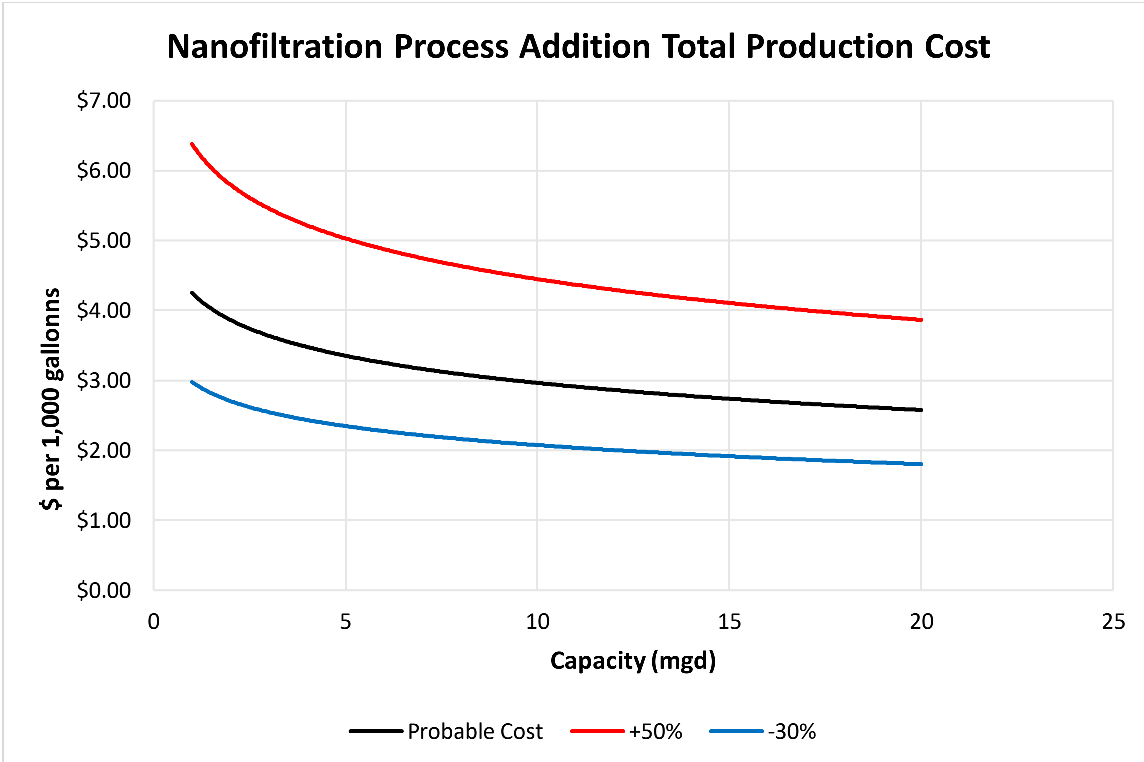

Figure 3-8: Nanofiltration Process Addition Total Production Cost Curve

3.3.2 REVERSE OSMOSIS PROCESS – ADDITIONAL CAPACITY

This section addresses the addition of RO treatment capacity to an existing water treatment plant. Cost data reflects raw water supply, RO membrane trains (process equipment), post-treatment, mechanical, yard piping, electrical and instrumentation, and site work. Opinion of probable construction costs are reflected based on rated capacity for MDD and AADD. Data used for this section was derived from projects listed in **Section 3.2.1**.

3.3.2.1 CAPITAL COSTS

The opinion of probable capital construction costs for RO process addition are summarized in **Table 3-20**. The capital construction costs curve for RO process addition is depicted in **Figure 3-9**.

Table 3-20: Opinion of Probable Capital Cost for Brackish Reverse Osmosis Process Addition

Item No.	Description Allowance Factor		Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	Pretreatment		$486,000	$1,170,000	$1,761,000	$3,066,000	$4,241,000	$5,339,000
2.	Process Equipment		$1,802,000	$4,340,000	$6,530,000	$11,370,000	$15,726,000	$19,796,000
3.	Post Treatment		$1,465,000	$3,528,000	$5,309,000	$9,244,000	$12,785,000	$16,094,000
4.	Intermediate Storage		$286,000	$689,000	$1,036,000	$1,805,000	$2,496,000	$3,142,000
5.	Transfer Pumping		$69,000	$166,000	$250,000	$435,000	$602,000	$758,000
6.	Plant Infrastructure		$1,865,000	$4,491,000	$6,759,000	$11,767,000	$16,276,000	$20,488,000
7.	Concentrate Disposal		$9,000,000	$9,000,000	$9,000,000	$9,000,000	$13,500,000	$13,500,000
Subtotal w/ DIW (1-7)			**$14,973,000**	**$23,384,000**	**$30,645,000**	**$46,687,000**	**$65,626,000**	**$79,117,000**
Subtotal w/o DIW (1-6)			**$5,973,000**	**$14,384,000**	**$21,645,000**	**$37,687,000**	**$52,126,000**	**$65,617,000**
8.	Yard Piping	8%	$478,000	$1,151,000	$1,732,000	$3,015,000	$4,171,000	$5,250,000
9.	Mechanical	2%	$120,000	$288,000	$433,000	$754,000	$1,043,000	$1,313,000
10.	Electrical (1)	20%	$1,195,000	$2,877,000	$4,329,000	$7,538,000	$10,426,000	$13,124,000
11.	Instrumentation and Controls (1)	5%	$299,000	$720,000	$1,083,000	$1,885,000	$2,607,000	$3,281,000
12.	Site Work	5%	$299,000	$720,000	$1,083,000	$1,885,000	$2,607,000	$3,281,000
Subtotal:			**$8,364,000**	**$20,140,000**	**$30,305,000**	**$52,764,000**	**$72,980,000**	**$91,866,000**
13.	General Requirements	10%	$837,000	$2,014,000	$3,031,000	$5,277,000	$7,298,000	$9,187,000
14.	Contractor Overhead and Profit	15%	$1,255,000	$3,021,000	$4,546,000	$7,915,000	$10,947,000	$13,780,000
15.	Construction contingency	15%	$1,255,000	$3,021,000	$4,546,000	$7,915,000	$10,947,000	$13,780,000
Opinion of Probable Construction Cost:			**$11,711,000**	**$28,196,000**	**$42,428,000**	**$73,871,000**	**$102,172,000**	**$128,613,000**
16.	Technical Services	20%	$2,342,000	$5,639,000	$8,486,000	$14,774,000	$20,434,000	$25,723,000
17.	Owner Administration and Legal	5%	$586,000	$1,410,000	$2,121,000	$3,694,000	$5,109,000	$6,431,000
18.	Project Contingency	15%	$1,757,000	$4,229,000	$6,364,000	$11,081,000	$15,326,000	$19,292,000
Opinion of Probable Capital Cost(2):			**$16,396,000**	**$39,474,000**	**$59,399,000**	**$103,420,000**	**$143,041,000**	**$180,059,000**
Opinion of Equivalent Annual Capital Cost(2):			**$1,547,666**	**$3,726,066**	**$5,606,845**	**$9,762,116**	**$13,502,058**	**$16,996,296**
Unit Probable Cost ($/gpd)			$11.71	$9.40	$8.49	$7.39	$6.81	$6.43
Unit Probable Total Capital Cost ($/gpd)			$16.40	$13.16	$11.88	$10.34	$9.54	$9.00

(1) “Electrical" and "Instrumentation and Controls" cost items are estimated as 10% and 5% respectively, of the subtotal of the preceding cost components minus the cost for concentrate disposal. This is because a concentrate disposal DIW has negligible electrical and instrumentation and controls costs relative to other plant components, while the construction cost for a DIW is typically a substantial portion of the total facility cost.

(2) Does not include concentrate disposal costs

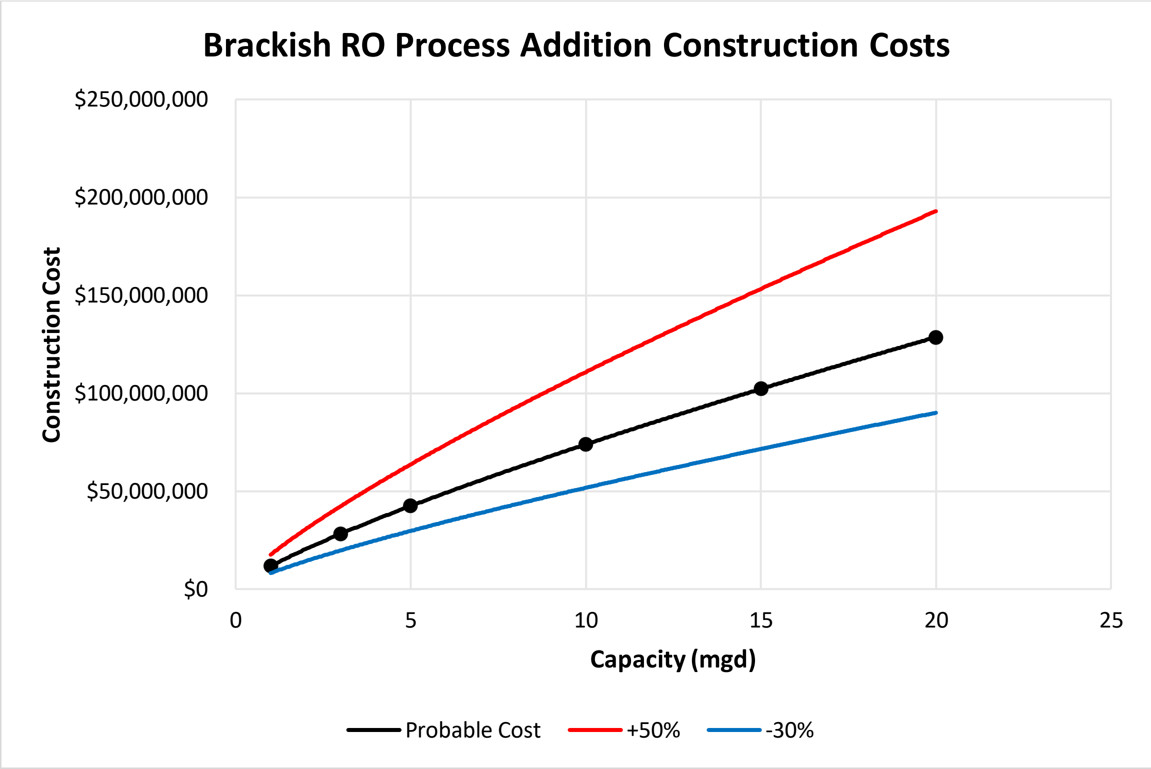

Figure 3-9: Brackish RO Process Addition Construction Costs Curve

3.3.2.2 OPERATION AND MAINTENANCE COSTS

The O&M costs for RO process addition are summarized in **Table 3-21**. This information was derived using the data sources listed in **Table 3-9.**

Table 3-21: Opinion of Annual Operation and Maintenance Cost for Brackish Reverse Osmosis Process Addition

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
	Variable Costs						
1.	Power [1]	$148,000	$388,000	$604,000	$1,091,000	$1,533,000	$1,947,000
2.	Chemicals	$101,000	$264,000	$411,000	$742,000	$1,043,000	$1,325,000
3.	Replacement Parts and Materials	$94,000	$246,000	$382,000	$689,000	$969,000	$1,230,000
	Replacement Membranes	$36,000	$94,000	$147,000	$265,000	$373,000	$473,000
	Fixed Costs						
4.	Operation and Maintenance Labor	$148,000	$388,000	$604,000	$1,091,000	$1,533,000	$1,947,000
5.	Administration/ Regulatory Compliance	$178,000	$467,000	$726,000	$1,310,000	$1,842,000	$2,339,000
	Annual Production at Rated Capacity, (mgy)	365	1,095	1,825	3,650	5,475	7,300
	Annual O&M Cost at Rated Capacity	**$705,000**	**$1,847,000**	**$2,874,000**	**$5,188,000**	**$7,293,000**	**$9,261,000**
	Unit Cost at Rated Capacity, ($/kgal)	**$1.93**	**$1.69**	**$1.57**	**$1.42**	**$1.33**	**$1.27**
	Annual Production at Avg Day Demand, (mgy)	243	730	1,217	2,704	4,212	5,840
	Annual O&M Cost at AADD Capacity	**$578,000**	**$1,516,000**	**$2,360,000**	**$4,466,000**	**$6,389,000**	**$8,266,000**
	Unit Cost at AADD Capacity, ($/kgal)	**$2.38**	**$2.08**	**$1.94**	**$1.65**	**$1.52**	**$1.42**

(1) Unit power cost = $0.12 per kWh

3.3.2.3 TOTAL COST SUMMARY

Opinion of total production costs are summarized in **Table 3-22**. These costs do not include concentrate disposal costs. The cost curve reflects the combination of opinion of probable construction cost, estimated annual O&M (fixed and Variable costs), and R&R fund deposit. The Total Production Cost curve is depicted in **Figure 3-8.**

Table 3-22: Opinion of Total Production Cost for Brackish Reverse Osmosis Process Addition

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
Production Costs at Rated Capacity							
1.	Equivalent annual capital cost	$1,547,666	$3,726,066	$5,606,845	$9,762,116	$13,502,058	$16,996,296
2.	Annual O&M Cost - Variable	$379,000	$992,000	$1,544,000	$2,787,000	$3,918,000	$4,975,000
3.	Annual O&M Cost - Fixed	$326,000	$855,000	$1,330,000	$2,401,000	$3,375,000	$4,286,000
4.	Annual R&R Fund Deposit (1)	$154,767	$372,607	$560,685	$976,212	$1,350,206	$1,699,630
	Total Annual Cost:	**$2,407,433**	**$5,945,673**	**$9,041,530**	**$15,926,328**	**$22,145,264**	**$27,956,925**
Annual Production at Rated Capacity, (mgy)		365	1,095	1,825	3,650	5,475	7,300
Annual Production Cost at Rated Capacity ($/kgal)		**$6.60**	**$5.43**	**$4.95**	**$4.36**	**$4.04**	**$3.83**
Production Costs at Average Day Demand (AADD)							
MDD/AADD factor (2)		1.50	1.50	1.50	1.35	1.30	1.25
1.	Equivalent annual capital cost	$1,547,666	$3,726,066	$5,606,845	$9,762,116	$13,502,058	$16,996,296
2.	Annual O&M Cost - Variable	$252,321	$661,333	$1,029,615	$2,064,671	$3,014,176	$3,980,000
3.	Annual O&M Cost - Fixed	$326,000	$855,000	$1,330,000	$2,401,000	$3,375,000	$4,286,000
4.	Annual R&R Fund Deposit (1)	$154,767	$372,607	$560,685	$976,212	$1,350,206	$1,699,630
	Total Annual Cost:	**$2,280,754**	**$5,615,006**	**$8,527,145**	**$15,203,999**	**$21,241,441**	**$26,961,925**
Annual Finished Water Production Rate, (mgy) (3)		243	730	1,217	2,704	4,212	5,840
Annual Production Cost at AADD ($/kgal):		**$9.39**	**$7.69**	**$7.01**	**$5.62**	**$5.04**	**$4.62**

(1) Annual deposit to a R&R fund is equal to 10% of the equivalent annual capital cost.
(2) MDD, equal to the plant capacity rating) divided by the AADD. This factor is used to calculate the AADD to be used in the calculation of the annual production cost.
(3) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

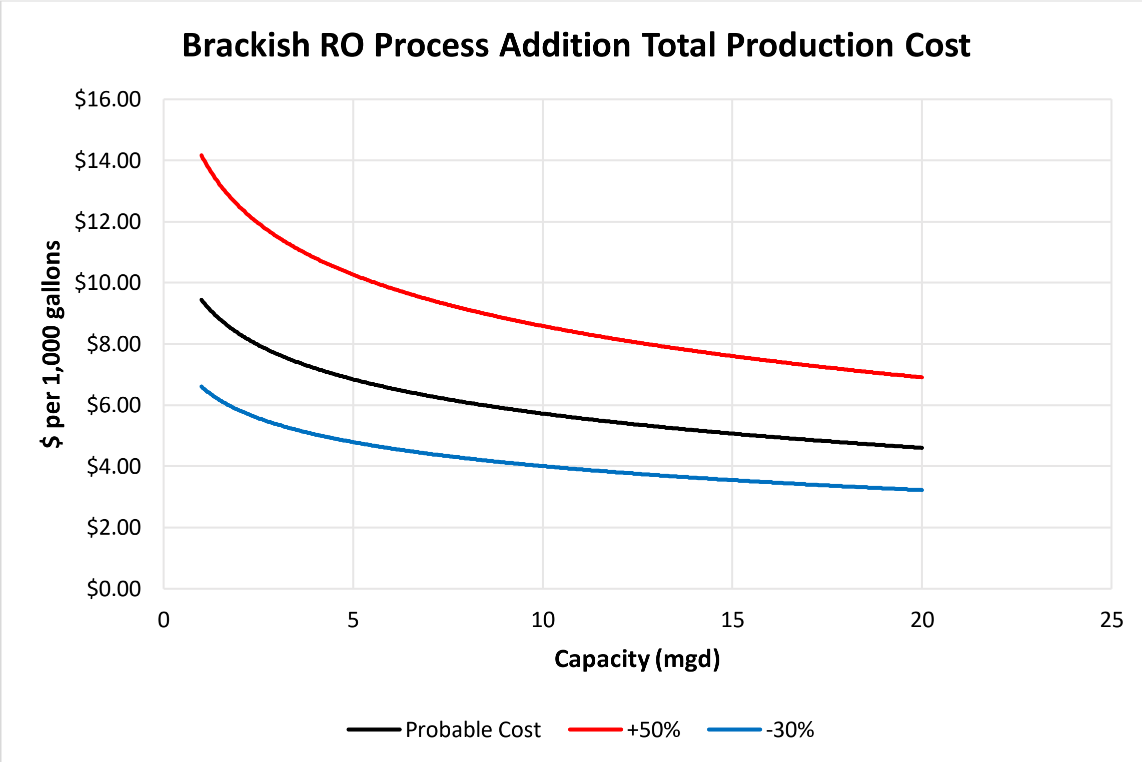

Figure 3-10: Brackish RO Process Addition Total Production Cost Curve

3.3.3 ION EXCHANGE

This section addresses the addition of IX treatment to an existing or new water treatment plant. Cost data reflect the process equipment which includes the pressurized vessels, media, regeneration, mechanical, yard piping, electrical and instrumentation, and site work. Opinion of probable construction costs are reflected based on rated capacity for MDD and AADD.

Opinion of probable construction costs for the IX treatment process were derived from the projects listed in **Table 3-23** below.

Table 3-23: Project Cost Data Sources for Ion Exchange

Location	Municipality	Project Name
Broward County	City of Sunrise	Sawgrass Water Treatment Plant IX (3 mgd)
Palm Beach County	Palm Beach County Water Utilities Department	Water Treatment Plant 8 IX (30 mgd)

3.3.3.1 CAPITAL COSTS

The opinion of probable construction costs for IX are summarized in **Table 3-24**. The construction costs curve for IX is depicted in **Figure 3-11**

Table 3-24: Opinion of Probable Capital Cost for Ion Exchange

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	Process equipment		$3,000,000	$5,000,000	$7,000,000	$12,000,000	$17,000,000	$22,000,000
2.	Yard piping	6%	$164,492	$274,153	$383,814	$657,967	$932,120	$1,206,273
3.	Electrical	5%	$138,472	$230,787	$323,101	$553,888	$784,674	$1,015,461
4.	Instrumentation and Controls	2%	$37,466	$62,443	$87,420	$149,864	$212,307	$274,750
5.	Site Work	5%	$139,643	$232,738	$325,833	$558,571	$791,308	$1,024,046
Subtotal (1-5):			$3,480,072	$5,800,121	$8,120,169	$13,920,289	$19,720,410	$25,520,530
6.	General Requirements	4%	$139,000	$232,000	$325,000	$557,000	$789,000	$1,021,000
7.	Contractor overhead and Profit	15%	$522,000	$870,000	$1,218,000	$2,088,000	$2,958,000	$3,828,000
8.	Construction Contingency	15%	$522,000	$870,000	$1,218,000	$2,088,000	$2,958,000	$3,828,000
Opinion of Probable Construction Cost (1-8):			**$4,663,072**	**$7,772,121**	**$10,881,169**	**$18,653,289**	**$26,425,410**	**$34,197,530**
9.	Technical services	20%	$933,000	$1,554,000	$2,176,000	$3,731,000	$5,285,000	$6,840,000
10.	Owner Administration and Legal	5%	$233,000	$389,000	$544,000	$933,000	$1,321,000	$1,710,000
11.	Project Contingency	15%	$699,000	$1,166,000	$1,632,000	$2,798,000	$3,964,000	$5,130,000
Opinion of Probable Capital Cost (1-11):			**$6,528,072**	**$10,881,121**	**$15,233,169**	**$26,115,289**	**$36,995,410**	**$47,877,530**
Opinion of Equivalent Annual Capital Cost:			**$616,204**	**$1,027,101**	**$1,437,903**	**$2,465,099**	**$3,492,105**	**$4,519,300**
Unit Probable Cost ($/gpd)			$4.66	$2.59	$2.18	$1.87	$1.76	$1.71
Unit Probable Total Capital Cost ($/gpd)			$6.53	$3.63	$3.05	$2.61	$2.47	$2.39

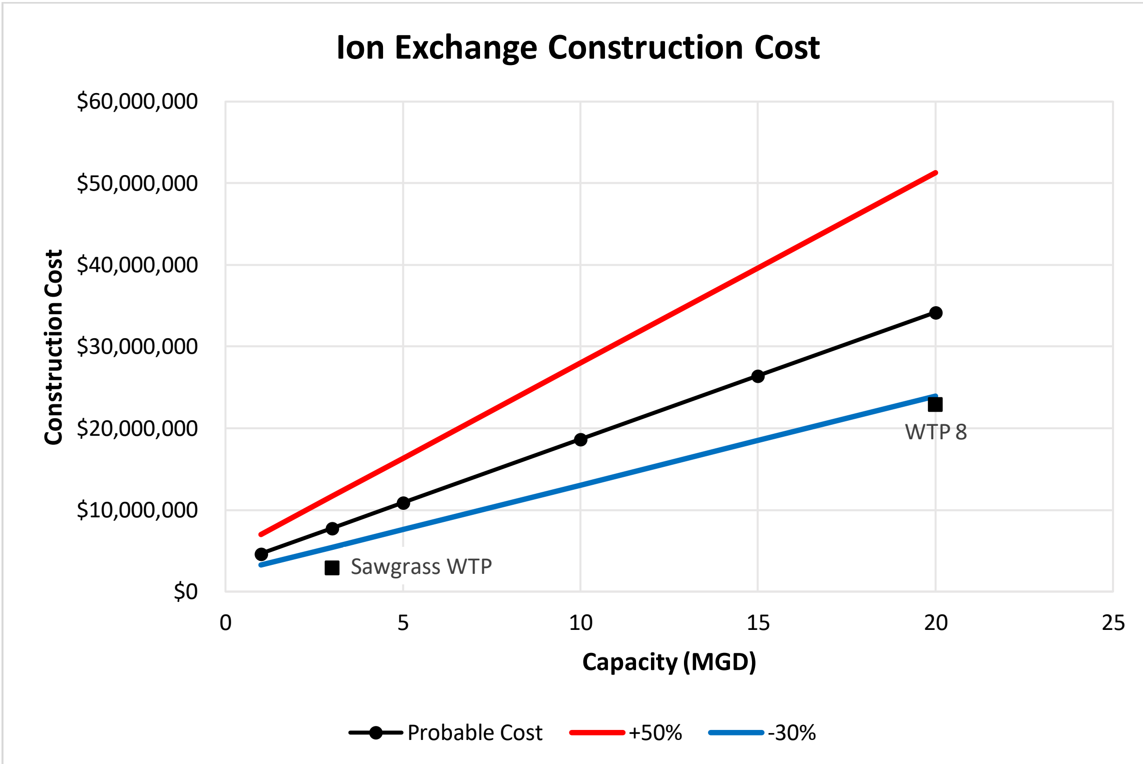

Figure 3-11: Ion Exchange Construction Cost

3.3.3.2 OPERATION AND MAINTENANCE COSTS

O&M costs were not available at the time of this study.

3.3.3.3 TOTAL COST SUMMARY

O&M costs were not available at the time of this study. Therefore, an overall production cost could not be determined.

3.3.4 GRANULATED ACTIVATED CARBON

This evaluation reflects the process equipment (which includes the pressurized vessels [GAC]), media, regeneration by incineration, mechanical, yard piping, electrical and instrumentation, and site work. Opinion of probable construction costs are reflected based on rated capacity or MDD and AADD.

Opinion of probable construction costs for GAC treatment process were derived from the vessels that were constructed for the projects listed in the IX section and also cost data information that was provided by Florida Keys Aqueduct Authority (FKAA) for the Kermit H. Lewis RO Facility. IX vessels and GAC vessels are of similar construction. However, approximately three times as much GAC media is required to treat raw water as compared to

IX resin. It is assumed that an additional 1 mgd capacity vessel, beyond the plant capacity, will be constructed to ensure that when one vessel is out of service for maintenance or regeneration by incineration, the remaining vessels can still treat the flow that is equivalent to the plant rated capacity.

3.3.4.1 CAPITAL COSTS

The opinion of probable construction costs for GAC are summarized in **Table 3-25**. The construction costs curve for IX is depicted in **Figure 3-12**.

Table 3-25: Opinion of Probable Capital Cost for Granular Activated Carbon

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	Process Equipment		$2,000,000	$3,880,000	$5,700,000	$9,900,000	$13,600,000	$16,800,000
2.	Yard piping	6%	$120,000	$232,800	$342,000	$594,000	$816,000	$1,008,000
3.	Electrical	5%	$100,000	$194,000	$285,000	$495,000	$680,000	$840,000
4.	Instrumentation and Controls	2%	$40,000	$77,600	$114,000	$198,000	$272,000	$336,000
5.	Site Work	5%	$100,000	$194,000	$285,000	$495,000	$680,000	$840,000
Subtotal (1-5):			$360,000	$698,400	$1,026,000	$1,782,000	$2,448,000	$3,024,000
6.	General Requirements	5%	$118,000	$228,920	$336,300	$584,100	$802,400	$991,200
7.	Contractor Overhead and Profit	15%	$54,000	$104,760	$153,900	$267,300	$367,200	$453,600
8.	Construction Contingency	15%	$54,000	$104,760	$153,900	$267,300	$367,200	$453,600
Opinion of Probable Construction Cost (1-8):			**$2,586,000**	**$5,016,840**	**$7,370,100**	**$12,800,700**	**$17,584,800**	**$21,722,400**
9.	Technical Services	20%	$517,200	$1,003,368	$1,474,020	$2,560,140	$3,516,960	$4,344,480
10.	Owner Administration and Legal	5%	$129,300	$250,842	$368,505	$640,035	$879,240	$1,086,120
11.	Project Contingency	15%	$387,900	$752,526	$1,105,515	$1,920,105	$2,637,720	$3,258,360
Opinion of Probable Capital Cost (1-11):			**$3,620,400**	**$7,023,576**	**$10,318,140**	**$17,920,980**	**$24,618,720**	**$30,411,360**
Opinion of Equivalent Annual Capital Cost:			$341,740	$662,976	$973,959	$1,691,614	$2,323,833	$2,870,617
Unit Probable Cost ($/gpd)			$2.59	$1.67	$1.47	$1.28	$1.17	$1.09
Unit Probable Total Capital Cost ($/gpd)			$3.62	$2.34	$2.06	$1.79	$1.64	$1.50

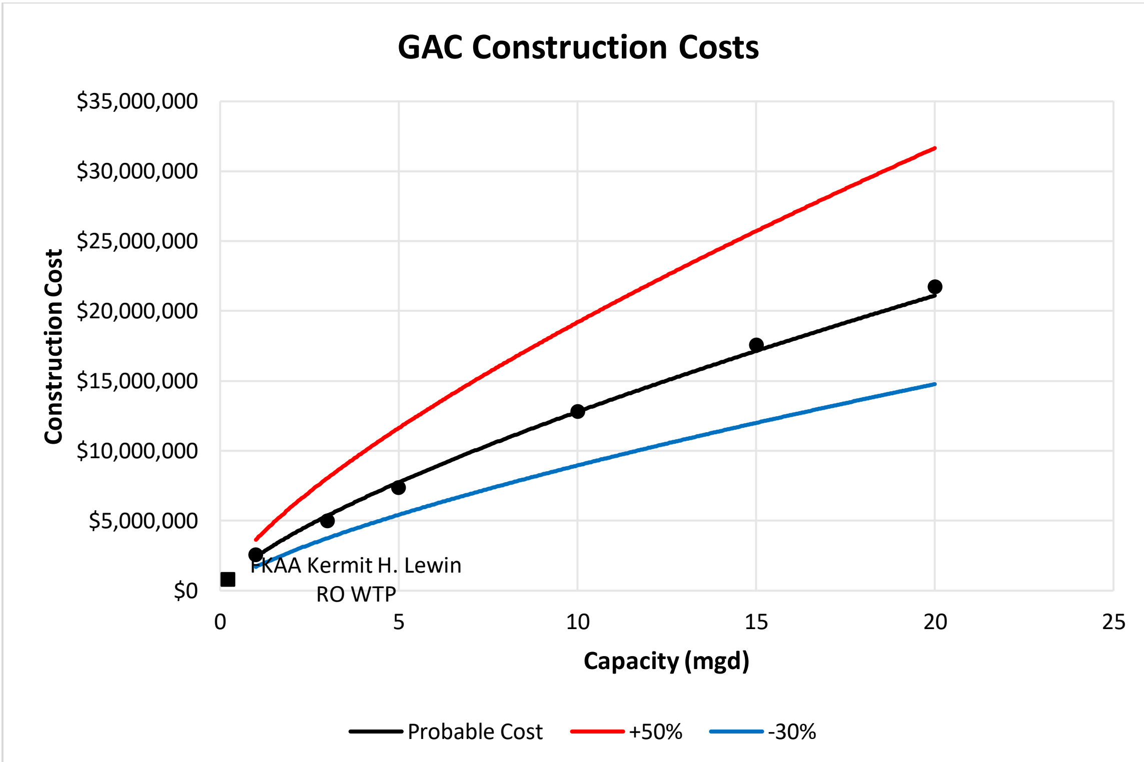

Figure 3-12: GAC Construction Costs Curve

3.3.4.2 OPERATION AND MAINTENANCE COSTS

The O&M costs for GAC are summarized in **Table 3-26**. O&M costs were not available at the time of this study. Assumptions were made to determine the O&M costs based on the following:

- 2,000 cubic feet of GAC media for each vessel treats 2 MGD of raw water.
- GAC requires regeneration after 10,000 bed volumes (equivalent to 74,800 gallons per cubic foot of GAC media)
- Regeneration is by incineration where the media is hauled off-site to an incinerator then hauled back and placed in vessel

Table 3-26: Opinion of Operation and Maintenance Cost for Granular Activated Carbon

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Process Equipment	$60,833	$177,025	$288,958	$547,500	$775,625	$973,333
2	Regeneration by Incineration	$1,299	$3,904	$6,508	$14,460	$22,524	$31,230
Annual Production at Rated Capacity, (mgy)		365	1,095	1,825	3,650	5,475	7,300
Annual O&M Cost at Rated Capacity		**$62,133**	**$180,929**	**$295,466**	**$561,960**	**$798,149**	**$1,004,563**
Unit Cost at Rated Capacity, $/kgal		**$0.17**	**$0.17**	**$0.16**	**$0.15**	**$0.15**	**$0.14**
Annual Production at Avg Day Demand, (mgy)		243	730	1,217	2,704	4,212	5,840
Annual O&M Cost at AADD Capacity		**$42,000**	**$121,000**	**$198,000**	**$417,000**	**$615,000**	**$804,000**
Unit Cost at AADD Capacity, $/kgal		**$0.17**	**$0.17**	**$0.16**	**$0.15**	**$0.15**	**$0.14**

3.3.4.3 TOTAL COST SUMMARY

Opinion of total production costs are summarized in **Table 3-27**. The cost curve reflects the combination of opinion of probable construction cost and estimated annual O&M as well as R&R fund deposit. The Total Production Cost curve is depicted in **Figure 3-13.**

Table 3-27 Opinion of Total Production Cost for Granular Activated Carbon

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual Capital Cost	$341,740	$662,976	$973,959	$1,691,614	$2,323,833	$2,870,617
2.	Annual O&M Cost (12-months)	$62,133	$180,929	$295,466	$561,960	$798,149	$1,004,563
3	Annual R&R Fund Deposit (1)	$34,174	$66,298	$97,396	$169,161	$232,383	$287,062
Total Annual Cost at Rated Capacity:		**$438,047**	**$910,202**	**$1,366,822**	**$2,422,735**	**$3,354,365**	**$4,162,242**
Annual Finished Water Production Rate (mgy)(2)		365	1,095	1,825	3,650	5,475	7,300
Annual Production Cost at AADD ($/kgal)		**$1.20**	**$0.83**	**$0.75**	**$0.66**	**$0.61**	**$0.57**

(1) Annual deposit to a R&R fund is equal to 10% of the equivalent annual capital cost.
(2) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

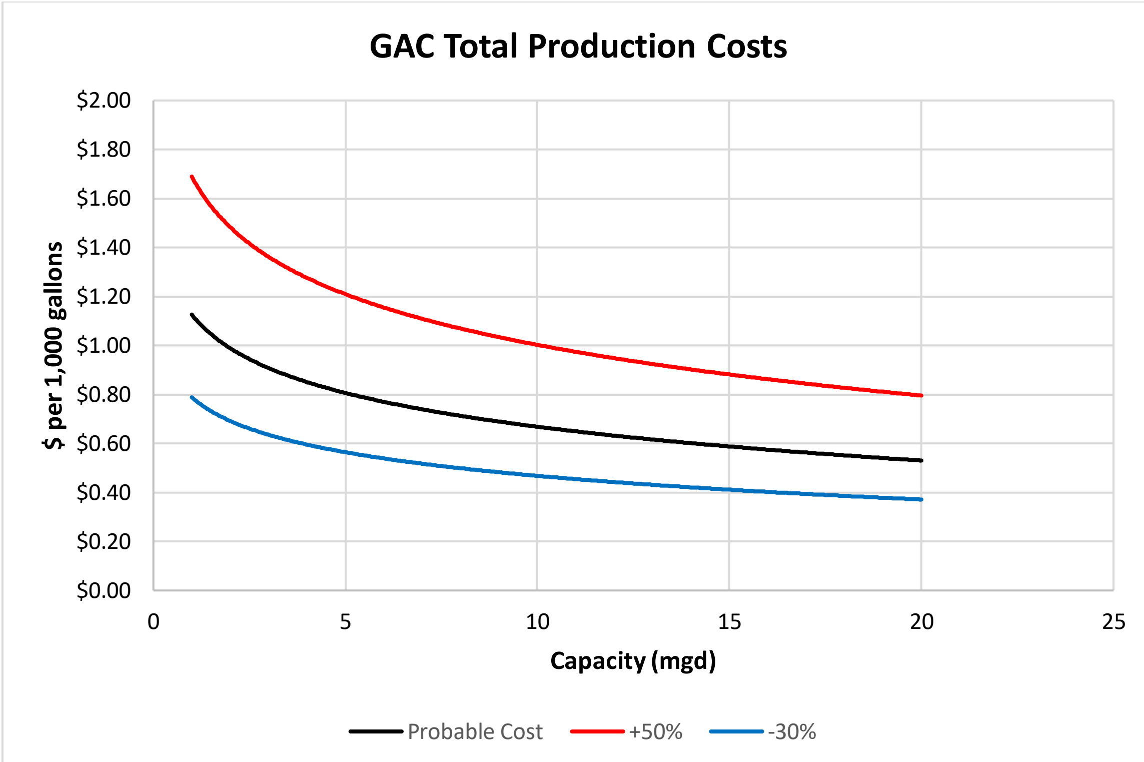

Figure 3-13: GAC Total Production Costs Curve

3.4 WATER DISTRIBUTION PLANT COMPONENTS

3.4.1 FINISH WATER STORAGE

Information was provided by four municipalities related to the finished water storage or ground storage tank (GST) construction costs. These were used to complete the capital cost evaluation. The projects included in this evaluation are listed in **Table 3-28** below.

Table 3-28: Project Cost Data Sources

Location	Utility	Project Name
Pinellas County	City of Clearwater Utility	Clearwater Plant No. 2 - 2.5 mgd GST
Lake County	City of Punta Gorda Utilities	Shell Creek RO WTP – 2 mgd GST
Palm Beach County	Palm Beach County Water Utilities Department	Water Treatment Plant No. 2 Plant Improvements – 5 mgd GST
Hendry County	City of LaBelle Utilities	LaBelle RO WTP – 1 mgd GST

3.4.1.1 CAPITAL COSTS

The opinion of probable construction costs for finished water storage are summarized in **Table 3-29**. The construction cost curve for finished water storage is depicted in **Figure 3-14**.

Table 3-29: Opinion of Probable Capital Cost for Finished Water Storage

Item No.	Description	Allowance Factor	Plant Capacity (mgd) 1	3	5	10	15	20
1.	Finished Water Storage		$370,000	$1,110,000	$1,850,000	$3,700,000	$5,550,000	$7,400,000
2.	Yard Piping	18%	$67,000	$200,000	$333,000	$666,000	$999,000	$1,332,000
3.	Site Work	15%	$56,000	$167,000	$278,000	$555,000	$833,000	$1,110,000
	Subtotal (1-3):		**$493,000**	**$1,477,000**	**$2,461,000**	**$4,921,000**	**$7,382,000**	**$9,842,000**
4.	General Requirements	4%	$20,000	$60,000	$99,000	$197,000	$296,000	$394,000
5.	Contractor Overhead and Profit	15%	$74,000	$222,000	$370,000	$739,000	$1,108,000	$1,477,000
6.	Construction Contingency	15%	$74,000	$222,000	$370,000	$739,000	$1,108,000	$1,477,000
	Opinion of Probable Construction Cost (1-6):		**$661,000**	**$1,981,000**	**$3,300,000**	**$6,596,000**	**$9,894,000**	**$13,190,000**
7.	Technical Services	20%	$133,000	$397,000	$660,000	$1,320,000	$1,979,000	$2,638,000
8.	Owner Administration and Legal	5%	$34,000	$100,000	$165,000	$330,000	$495,000	$660,000
9.	Project Contingency	15%	$100,000	$298,000	$495,000	$990,000	$1,485,000	$1,979,000
	Opinion of Probable Capital Cost (1-9):		**$928,000**	**$2,776,000**	**$4,620,000**	**$9,236,000**	**$13,853,000**	**$18,467,000**
	Opinion of Equivalent Annual Capital Cost:		**$87,597**	**$262,035**	**$436,095**	**$871,813**	**$1,307,625**	**$1,743,154**

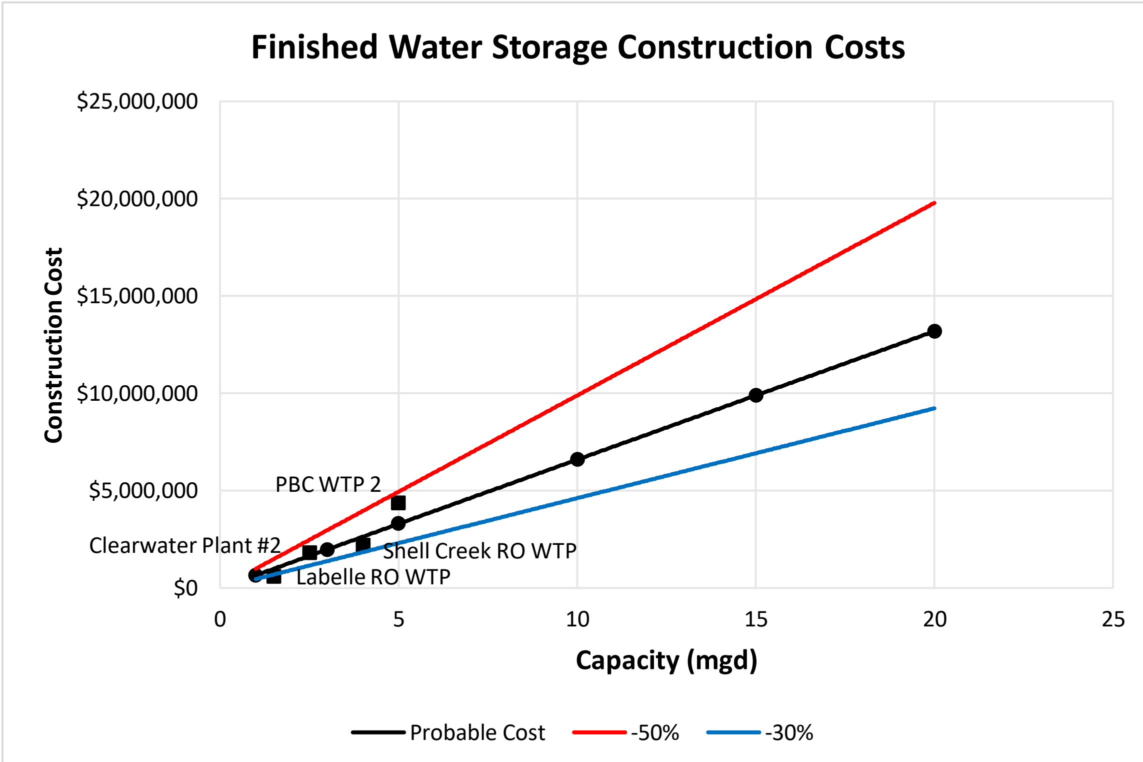

Figure 3-14: Finished Water Construction Cost Curve

3.4.1.2 OPERATION AND MAINTENANCE COSTS

The O&M costs associated with the finished water storage plant component is included in the overall plant O&M costs. Therefore, an O&M evaluation was not conducted as a stand-alone component.

3.4.1.3 TOTAL COST SUMMARY

Opinion of total production costs for finished water storage is summarized in **Table 3-30.** The total production costs table reflect the opinion of probable construction cost. The Total Production Cost curve is depicted in **Figure 3-15**.

Table 3-30: Opinion of Total Production Cost for: Finished Water Storage

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual Capital Cost	$87,597	$262,035	$436,095	$871,813	$1,307,625	$1,743,154
2.	Annual Operation and Maintenance Cost	Not Applicable					
3.	Annual R&R Fund Deposit(1)	Not Applicable					
	Total Annual Cost:	**$88,000**	**$263,000**	**$437,000**	**$872,000**	**$1,308,000**	**$1,744,000**
MDD/AADD Factor(2)		1.5	1.5	1.5	1.35	1.30	1.25
Annual Finished Water Production Rate (mgy)(3)		243	730	1,217	2,704	4,212	5,840
Annual Production Cost at ADD ($/kgal)		**$0.36**	**$0.36**	**$0.36**	**$0.32**	**$0.31**	**$0.30**

(1) Annual deposit to a R&R fund is equal to 10% of the equivalent annual capital cost.
(2) MDD (mgd), equal to the plant capacity rating divided by the AADD. This factor is used to calculate the AADD (mgd) to be used in the calculation of the annual production cost.
(3) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

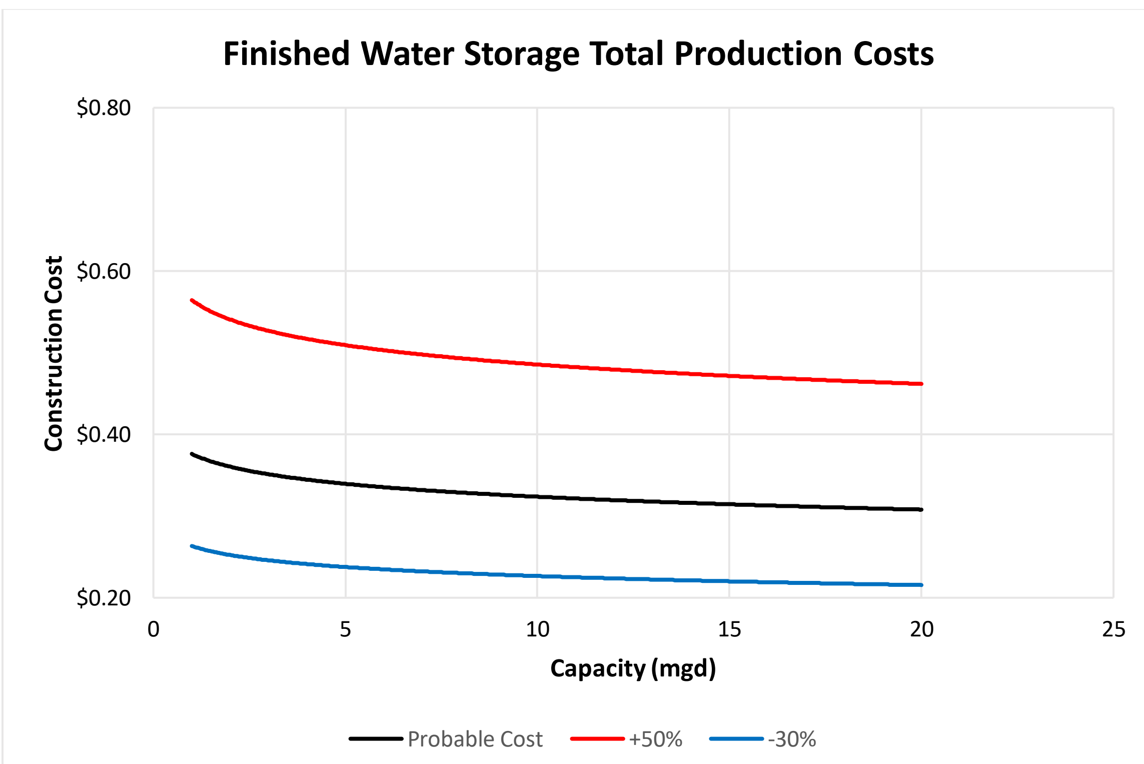

Figure 3-15: Finished Water Storage Total Production Cost Costs Curve

3.4.2 HIGH SERVICE PUMPING

Information was provided by four municipalities related to construction costs. These were used to complete the capital cost evaluation. The projects included in this evaluation are listed in **Table 3-31** below.

Table 3-31: Project Cost Data Sources

Location	Municipality	Project Name
Pinellas County	City of Clearwater Utility	Clearwater Plant No. 2 – 6.25 mgd
St. Lucie County	Fort Pierce Utilities Authority (FPUA)	FPUA Hutchinson Repump Station – 3.17 mgd
Palm Beach County	Town of Jupiter Utilities	Town of Jupiter WTP – 11.51 mgd
Hendry County	City of LaBelle Utilities	LaBelle RO WTP – 1.5 mgd

3.4.2.1 CAPITAL COSTS

The opinion of probable capital costs for high service pumps is summarized in **Table 3-32**. The construction cost curve for high service pumps is depicted in **Figure 3-16**.

Table 3-32: Opinion of Probable Capital Cost for High Service Pumping

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	High Service Pumping		$45,000	$135,000	$225,000	$450,000	$675,000	$900,000
2.	Piping	10%	$5,000	$14,000	$23,000	$45,000	$68,000	$90,000
3.	Electrical	10%	$14,000	$41,000	$68,000	$135,000	$203,000	$270,000
4.	Instrumentation and Controls	2%	$2,000	$7,000	$11,000	$23,000	$34,000	$45,000
5.	Site work	1%	$1,000	$3,000	$5,000	$9,000	$14,000	$18,000
	Subtotal (1-5)		**$67,000**	**$200,000**	**$332,000**	**$662,000**	**$994,000**	**$1,323,000**
6.	General Requirements	10%	$6,615	$19,845	$33,075	$66,150	$99,225	$132,300
7.	Contractor Overhead and Profit	15%	$9,923	$29,768	$49,613	$99,225	$148,838	$198,450
8.	Construction Contingency	15%	$9,923	$29,768	$49,613	$99,225	$148,838	$198,450
	Opinion of Probable Construction Cost (1-8):		**$93,460**	**$279,380**	**$464,300**	**$926,000**	**$1,390,900**	**$1,852,200**
9.	Technical Services	20%	$19,000	$56,000	$93,000	$185,000	$278,000	$370,000
10.	Owner Administration and Legal	5%	$5,000	$14,000	$23,000	$46,000	$70,000	$93,000
11.	Project Contingency	15%	$14,000	$42,000	$70,000	$139,000	$209,000	$278,000
	Opinion of Probable Capital Cost (1-11):		**$131,460**	**$391,380**	**$650,300**	**$1,296,600**	**$1,947,900**	**$2,593,200**
	Opinion of Equivalent Annual Capital Cost:		**$12,409**	**$36,944**	**$61,384**	**$122,390**	**$183,868**	**$244,780**

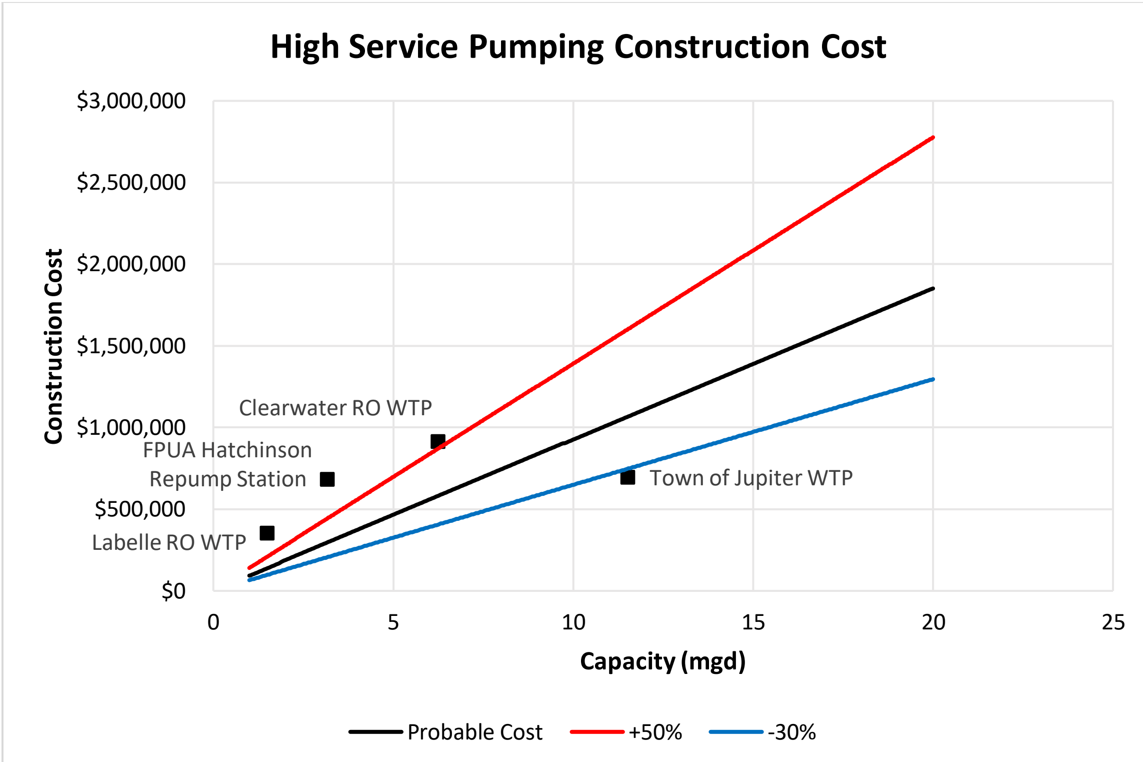

Figure 3-16: High Service Pump Construction Cost Curve

3.4.2.2 OPERATIONAL AND MAINTENANCE COSTS

The O&M costs associated with the high service pumps are included in the overall plant O&M costs. However, power costs and replacement parts and materials are budgeted for as an annual cost and can be quantified separate from the overall plant O&M costs. The O&M cost reflecting power and replacement parts and materials are summarized in **Table 3-33**.

Table 3-33: Opinion of Annual Operation and Maintenance Cost for High Service Pumping

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Power [1]	$27,000	$82,000	$137,000	$273,000	$410,000	$547,000
2.	Operation and maintenance labor	Included in plant operation and maintenance labor.					
3.	Replacement parts and materials	$2,970	$9,020	$15,070	$30,030	$45,100	$60,170
Opinion of Annual O&M Cost:		**$29,700**	**$90,200**	**$150,700**	**$300,300**	**$451,000**	**$601,700**

(1) Unit power cost = $0.12 per kWh

3.4.2.3 TOTAL COST SUMMARY

Opinion of total production costs for high service pumps is summarized in **Table 3-34**. The total production costs table reflect the of opinion of probable construction cost. The Total Production Cost curve for high service pumps is depicted in **Figure 3-17**.

Table 3-34: Opinion of Total Production Cost for High Service Pumping

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual capital Cost	$12,409	$36,944	$61,384	$122,390	$183,868	$244,780
2.	Annual Operation and Maintenance Cost	$29,700	$90,200	$150,700	$300,300	$451,000	$601,700
3.	Annual R&R Fund Deposit (1)	$1,241	$3,694	$6,138	$12,239	$18,387	$24,478
	Total Annual Cost:	**$43,350**	**$130,838**	**$218,222**	**$434,929**	**$653,255**	**$870,958**
MD/AADD Factor(2)		1.50	1.50	1.50	1.35	1.30	1.25
Annual Finished Water Production Rate (mgy)(3)		243	730	1,217	2,704	4,212	5,840
Annual Production Cost at AADD ($/kgal)		**$0.18**	**$0.18**	**$0.18**	**$0.16**	**$0.16**	**$0.15**

(1) Annual deposit to a R&R fund is equal to 10% of the equivalent annual capital cost.
(2) MDD (mgd), equal to the plant capacity rating divided by the AADD. This factor is used to calculate the AADD (mgd) to be used in the calculation of the annual production cost.
(3) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

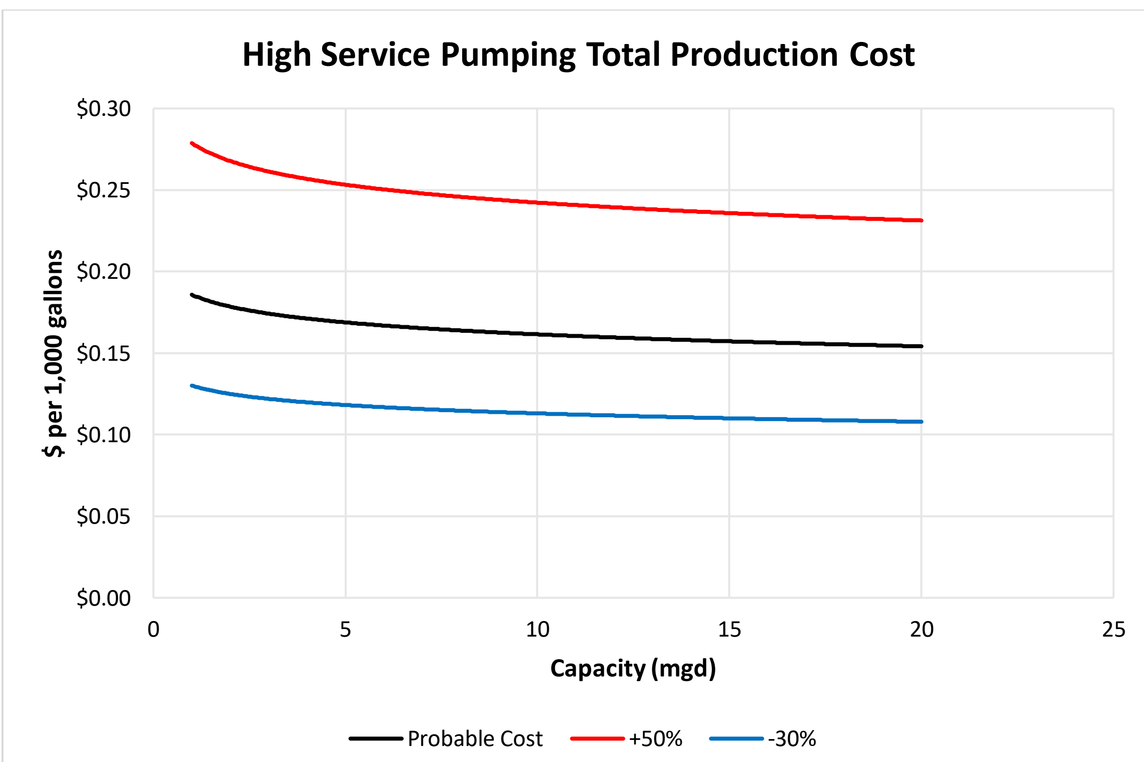

Figure 3-17: High Service Pump Total Production Cost Curve

3.5 DISINFECTION PLANT COMPONENTS

Similar to water distribution plant components, disinfection plant components are common for all water treatment technologies and also can be added to the cost data provided in the previous NF and RO sections. Sodium hypochlorite disinfection is required for all water treated for consumption, per Florida Administrative Code. UV can be added as additional disinfection if desired. Both Sodium hypochlorite and UV disinfection process cost data are included in the following sections.

3.5.1 SODIUM HYPOCHLORITE DISINFECTION

Three water treatment plant projects that included an onsite sodium hypochlorite disinfection storage component were used to complete the capital cost evaluation for this disinfection component. This disinfection component only reflects bulk storage, day tank, metering pumps and corresponding infrastructure. Onsite generation of sodium hypochlorite was not evaluated since typically it is only cost effective for water treatment plants that are larger than 20 mgd. The projects included in this evaluation are listed in **Table 3-35** below.

Table 3-35: Project Cost Data Sources

Location	Utility	Project Name
Martin County	City of Stuart	Stuart RO WTP Phase 1 (1.5 MGD)
Charlotte County	City of Punta Gorda Utilities	Shell Creek RO WTP
Pinellas County	City of Clearwater	Water Treatment Plant No. 2 – Contract 4: Reverse Osmosis Plant Site Expansion (6.25 MGD)

3.5.1.1 CAPITAL COSTS

The opinion of probable construction costs for sodium hypochlorite disinfection component are summarized in **Table 3-36**. The construction cost curve for sodium hypochlorite disinfection component is depicted in **Figure 3-18**.

Table 3-36: Opinion of Probable Capital Cost for Sodium Hypochlorite Disinfection

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	Sodium Hypochlorite System		$303,000	$730,000	$1,098,000	$1,912,000	$2,644,000	$3,329,000
2.	Infrastructure		$139,000	$335,000	$504,000	$877,000	$1,213,000	$1,527,000
3.	Electrical	26%	$115,000	$277,000	$417,000	$725,000	$1,003,000	$1,263,000
4.	Instrumentation and Controls	2%	$9,000	$21,000	$32,000	$56,000	$77,000	$97,000
5.	Site Work	2%	$9,000	$21,000	$32,000	$56,000	$77,000	$97,000
	Subtotal (1-5):		**$575,000**	**$1,384,000**	**$2,083,000**	**$3,626,000**	**$5,014,000**	**$6,313,000**
6.	General Requirements	1%	$6,000	$14,000	$21,000	$36,000	$50,000	$63,000
7.	Contractor Overhead and Profit	15%	$86,000	$208,000	$312,000	$544,000	$752,000	$947,000
8.	Construction Contingency	15%	$86,000	$208,000	$312,000	$544,000	$752,000	$947,000
	Opinion of Probable Construction Cost (1-8):		**$753,000**	**$1,814,000**	**$2,728,000**	**$4,750,000**	**$6,568,000**	**$8,270,000**
9.	Technical Services	20%	$151,000	$363,000	$546,000	$950,000	$1,314,000	$1,654,000
10.	Owner Administration and Legal	5%	$38,000	$91,000	$136,000	$238,000	$328,000	$414,000
11.	Project Contingency	15%	$113,000	$272,000	$409,000	$713,000	$985,000	$1,241,000
	Opinion of Probable Capital Cost (1-11):		**$1,055,000**	**$2,540,000**	**$3,819,000**	**$6,651,000**	**$9,195,000**	**$11,579,000**
	Opinion of Equivalent Annual Capital Cost:		**$99,585**	**$239,758**	**$360,487**	**$627,807**	**$867,943**	**$1,092,976**

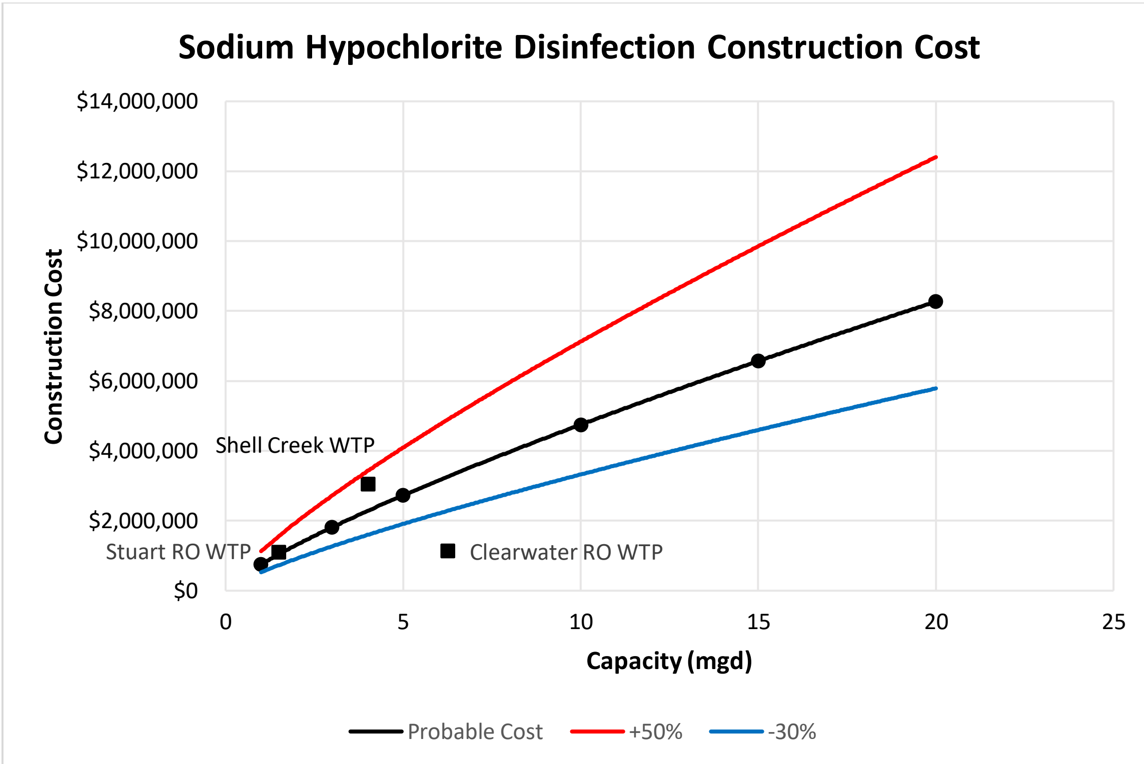

Figure 3-18: Sodium Hypochlorite Disinfection Construction Cost Curve

3.5.1.2 OPERATION AND MAINTENANCE COSTS

The O&M costs associated with the sodium hypochlorite disinfection plant component is included in the overall plant O&M costs. However, chemical costs (Source: City of Clearwater and City of Stuart) are budgeted for as an annual cost and can be quantified separate from the overall plant O&M costs. The O&M cost reflecting chemical costs is summarized in **Table 3-37**.

Table 3-37: Opinion of Annual Operation and Maintenance Cost Disinfection Plant Component for Sodium Hypochlorite Disinfection

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Chemicals	$38,000	$114,000	$190,000	$380,000	$570,000	$760,000
2.	Operation and maintenance labor	Included in plant operation and maintenance labor.					
Opinion of Annual O&M Cost:		$38,000	$114,000	$190,000	$380,000	$570,000	$760,000

3.5.1.3 TOTAL COST SUMMARY

Opinion of total production costs for sodium hypochlorite disinfection component is summarized in **Table 3-38**. The total production costs table reflect the opinion of probable construction cost and O&M costs for chemicals. The Total Production Cost curve is depicted in **Figure 3-19**.

Table 3-38: Opinion of Total Production Cost for Sodium Hypochlorite Disinfection

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual Capital Cost	$99,585	$239,758	$360,487	$627,807	$867,943	$1,092,976
2.	Annual Operation and Maintenance Cost	$38,000	$114,000	$190,000	$380,000	$570,000	$760,000
3.	Annual R&R Fund Deposit(1)	Not Applicable					
		$137,585	$353,758	$550,487	$1,007,807	$1,437,943	$1,852,976
MDD/AADD Factor(2)		1.50	1.50	1.50	1.35	1.30	1.25
Annual Finished Water Production Rate (mgy)(3)		243	730	1,217	2,704	4,212	5,840
Annual Production Cost at AADD ($/kgal):		**$0.57**	**$0.48**	**$0.45**	**$0.37**	**$0.34**	**$0.32**

(1) Annual deposit to a R&R fund is equal to 10% of the equivalent annual capital cost.
(2) MDD, equal to the plant capacity rating) divided by the AADD. This factor is used to calculate the AADD to be used in the calculation of the annual production cost.
(3) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

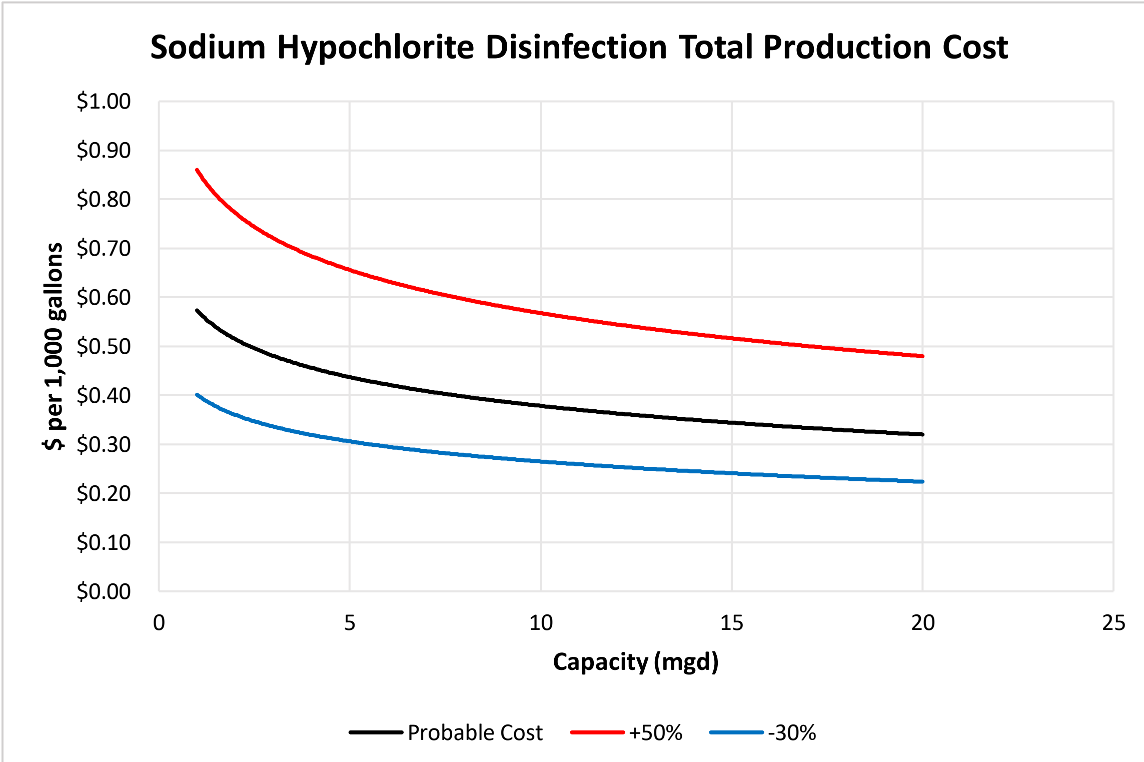

Figure 3-19: Sodium Hypochlorite Disinfection Total Production Cost Curve

3.5.2 ULTRAVIOLET LIGHT DISINFECTION (FOR BIOLOGICAL TREATMENT)

Information for capital costs was obtained for the UV system at the West Palm Beach Water Treatment Plant. Cost estimation assumptions were applied based on the West Palm Beach Water Treatment Plant's UV system, as well as vendor and Environmental Protection Agency (EPA) information and cost estimates completed by other engineering firms. O&M costs were calculated based on vendor/supplier information and number of lamps required for each capacity that was evaluated. UV dose of 40 mj/cm^2 and UV transmittance of 65% per 1 cm (at end of lamp life) was used as a conservative dose for inactivation of pathogens (Giardia and Cryptosporidium) to meet the Long Term 2 Enhanced Surface Water Treatment Rule requirements. To determine the number of lamps required, an assumption was made based on vendor information for Trojan UV3000 Series and WEDECO LBX Series UV equipment specifications.

3.5.2.1 CAPITAL COSTS

The opinion of probable construction costs for UV disinfection for biological treatment and disinfection are summarized in **Table 3-39**. The construction cost curve for UV disinfection component is depicted in **Figure 3-20**.

Table 3-39: Opinion of Probable Capital Cost for Ultraviolet Disinfection

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	UV Equipment		$35,000	$105,000	$175,000	$350,000	$525,000	$700,000
2.	UV Building		$66,000	$198,000	$330,000	$660,000	$990,000	$1,320,000
3.	Pipes and Valves		$14,000	$42,000	$70,000	$140,000	$210,000	$280,000
4.	Yard Piping	8%	$9,000	$28,000	$46,000	$92,000	$138,000	$184,000
5.	Mechanical	10%	$12,000	$35,000	$58,000	$115,000	$173,000	$230,000
6.	Electrical	14%	$16,000	$48,000	$81,000	$161,000	$242,000	$322,000
7.	Instrumentation and Controls	8%	$9,000	$28,000	$46,000	$92,000	$138,000	$184,000
8.	Site Work	8%	$9,000	$28,000	$46,000	$92,000	$138,000	$184,000
	Subtotal (1-8):		**$170,000**	**$512,000**	**$852,000**	**$1,702,000**	**$2,554,000**	**$3,404,000**
9.	General Requirements	10%	$17.000	$51,000	$85,000	$170,000	$255,000	$340,000
10.	Contractor Overhead and Profit	15%	$26,000	$77,000	$128,000	$255,000	$383,000	$511,000
11.	Construction Contingency	15%	$26,000	$77,000	$128,000	$255,000	$383,000	$511,000
	Opinion of Probable Construction Cost (1-11):		**$239,000**	**$717,000**	**$1,193,000**	**$2,382,000**	**$3,575,000**	**$4,766,000**
12.	Technical Services	20%	$48,000	$143,000	$239,000	$476,000	$715,000	$953,000
13.	Owner Administration and Legal	5%	$12,000	$36,000	$60,000	$119,000	$179,000	$238,000
14.	Project Contingency	15%	$36,000	$108,000	$179,000	$357,000	$536,000	$715,000
	Opinion of Probable Capital Cost (1-14):		**$335,000**	**$1,004,000**	**$1,671,000**	**$3,334,000**	**$5,005,000**	**$6,672,000**
	Opinion of Equivalent Annual Capital Cost:		**$31,622**	**$94,770**	**$157,731**	**$314,706**	**$472,437**	**$629,790**

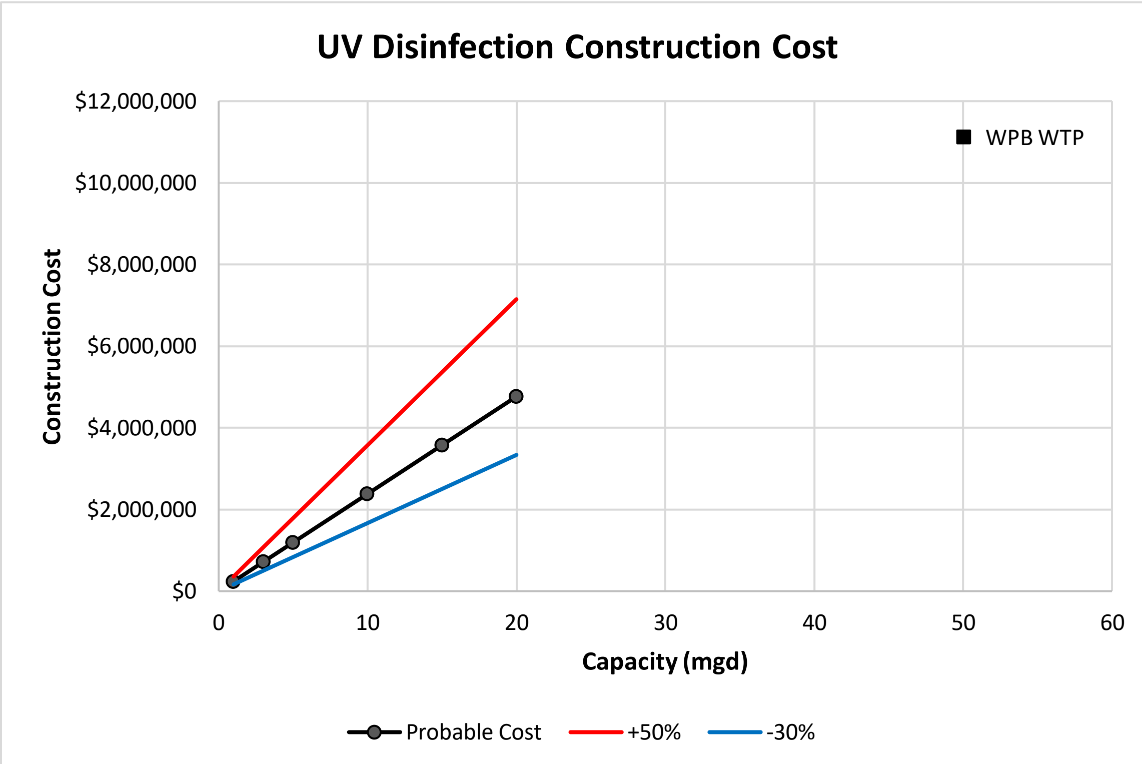

Figure 3-20: UV Disinfection Construction Cost Curve

3.5.2.2 OPERATION AND MAINTANANCE AND COSTS

The operation and maintenance labor costs associated with the ultraviolet disinfection plant component is included in the overall plant O&M costs. However, power costs and replacement parts costs, such as lamps, sleeves, ballasts, sensors, etc., are budgeted for as an annual O&M cost and can be quantified separate from the overall plant O&M costs. The O&M cost reflecting power and replacement parts costs is summarized in **Table 3-40**.

Table 3-40: Opinion of Annual Operation and Maintenance Cost Disinfection Plant Component: Ultraviolet Disinfection

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Power (1)	$27,000	$82,000	$137,000	$273,000	$410,000	$547,000
2.	Operation and maintenance labor	Included in plant operation and maintenance labor.					
3.	Replacement parts and materials (lamps, sleeves, ballasts, sensors)	$2,970	$9,020	$15,070	$30,030	$45,100	$60,170
Opinion of Annual O&M Cost:		**$29,700**	**$90,200**	**$150,700**	**$300,300**	**$451,000**	**$601,700**

(4) Unit power cost = $0.12 per kWh

3.5.2.3 TOTAL COST SUMMARY

Opinion of total production costs for UV Disinfection is summarized in **Table 3-41.** The total production costs table reflect the of opinion of probable construction cost. The Total Production Cost curve is depicted in **Figure 3-21**.

Table 3-41: Opinion of Total Production Cost Disinfection Plant Component: UV Disinfection

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual Capital Cost	$31,622	$94,770	$157,731	$314,706	$472,437	$629,790
2.	Annual Operation and Maintenance Cost	$29,700	$90,200	$150,700	$300,300	$451,000	$601,700
3.	Annual R&R Fund Deposit(1)	$34,784	$104,248	$173,504	$346,177	$519,680	$692,769
Total Annual Cost:		**$96,105**	**$289,218**	**$481,934**	**$961,183**	**$1,443,117**	**$1,924,258**
MDD/AADD Factor(2)		1.5	1.5	1.5	1.35	1.30	1.25
Annual Finished Water Production Rate (mgy)(3)		243	730	1,217	2,704	4,212	5,840
Annual Production Cost ($/kgal)		**$0.40**	**$0.40**	**$0.40**	**$0.36**	**$0.34**	**$0.33**

(1) Annual deposit to a R&R fund is equal to 10% of the equivalent annual capital cost.
(2) MDD (mgd), equal to the plant capacity rating divided by the AADD. This factor is used to calculate the AADD (mgd) to be used in the calculation of the annual production cost.
(3) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

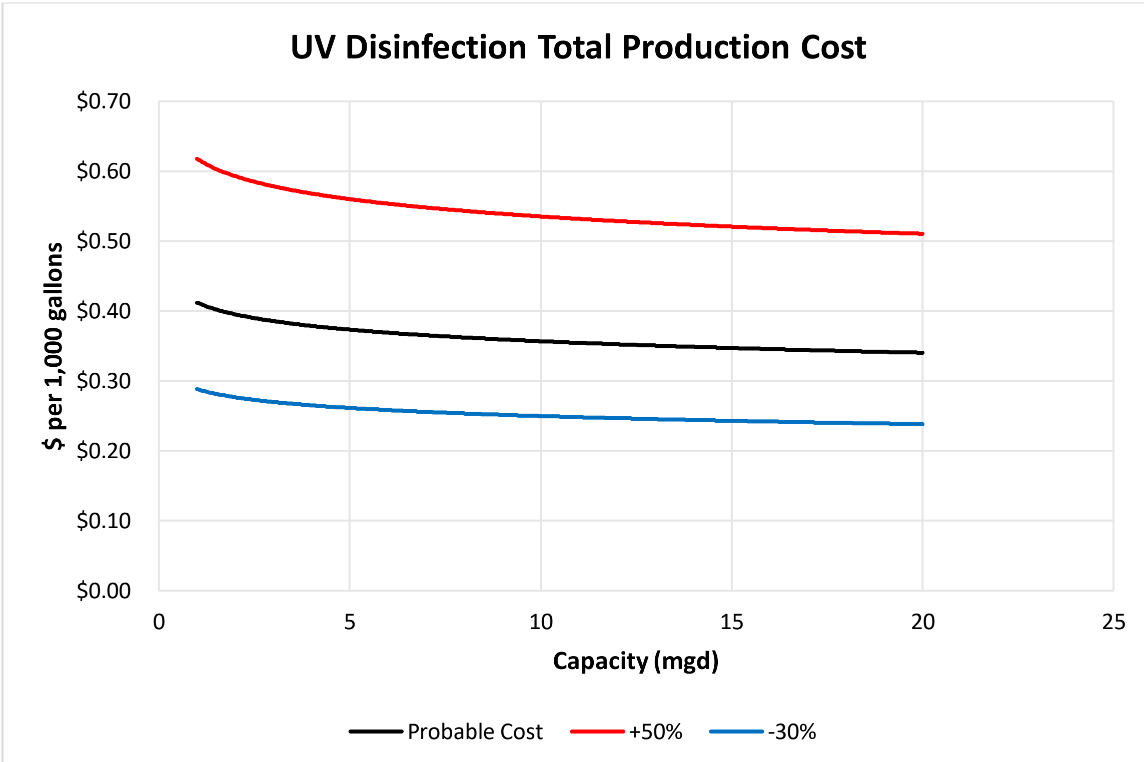

Figure 3-21: UV Disinfection Total Production Cost Curve

3.6 PFAS TREATMENT CASE STUDY

3.6.1 BACKGROUND

For decades the City of Stuart (Stuart) has been confronted with soil and groundwater contamination from a variety of chemicals and sources. Contamination of groundwater used for Stuart's water supply has been particularly problematic and required extensive remediation over the years. When the U.S. Environmental Protection Agency (EPA) issued lower drinking water health advisory levels in 2016 for PFOA, PFOS and PFAS, Stuart was further challenged to review and implement the best technology to manage these contaminants. Furthermore, discovery of groundwater contamination from aqueous film-forming foams, which are used for firefighting, had forced the City to shut down some of its primary supply wells. The City contracted with Kimley-Horn to help research and implement treatment technologies to remove PFAS from groundwater.

Kimley Horn conducted pilot studies and performed pilot testing using both GAC and IX technology, resulting in the installation of a treatment system to remove PFAS from the incoming groundwater supply. Based on results of the pilot study and testing, it was determined that IX treatment was the most effective treatment method.

3.6.2 CAPITAL COSTS

Construction of the 4 MGD (with potential to treat a maximum of 8 mgd) IX system, partially funded by State Revolving Fund loans, was completed in early June 2019 and has undergone full-scale testing using multiple types of IX resins and GAC mixes. The full-scale testing has been completed. Engineering design efforts began in 2016. FDEP issued a permit to construct the PFAS IX treatment system in February 2018 and construction of the system started in October 2018, with an awarded bid amount of $2.14 million ($2.85 million in December 2021 dollars). Corresponding engineering design costs were $240,330 at the start of construction. Based on an assumed 15% rate increase (3% rate increase per year), engineering design costs in December 2021 dollars is $276,330. Total capital construction cost in December 2021 dollars is $3,126,330.

The process parameters for the final constructed treatment plant are as follows (**Table 3-42**):

Table 3-42: Current Ion Exchange Treatment Plant Process Parameters

Parameter	Value
Design flow rate	2,800 gpm
Vessels	4
Vessel diameter	12 feet
Resin type	Dupont PSR2 Plus or Calgon CalRes 2304
Resin load	600 ft^3 per vessel
Flow configuration	Series pairs[1]
Empty bed contact time	3.2 minutes per vessel
Loading rate (series flow)	12.4 gpm/ft^2

Assumptions and Notes:
(1) Vessels pairs are configured to allow parallel or series flow.
(2) Vessels were initially operated in parallel to facilitate side-by side testing of four media profiles.

3.6.3 OPERATION AND MAINTENANCE COSTS

Operating costs for the IX treatment system is constantly changing due to resin use. The longer the resins are in use, the lower the operating costs. These costs are due in part by resin costs, spent resin costs, and PFAS treatment goals given 30% laboratory analysis error. They range from the following:

Treatment Level	Operating Cost
Non-detect	$0.47/kgal to $0.83/kgal
Up to 10 PPT	$0.26/kgal to $0.49/kgal
Up to 20 PPT	$0.29/kgal to unknown

The cost of Stuart's labor directly associated with the PFAS contamination between May of 2016 and February of 2022 was estimated to be $349,091 (based on their evaluation of historical labor costs). The average labor cost over the past two years (February 2020 through February 2022), was $39,437 per year.

Bag filters are installed upstream of the IX vessels to remove filterable solids from the water. IX systems cannot be backwashed after being placed into service and preventing sediment from building up on the resin is therefore critical. The bag filters are disposable and must be periodically replaced. It is estimated that the bag filters are replaced approximately every two weeks; there are 34 bags in the existing two filter unit configuration. The cost of the replacement bag elements is $18.95. The cost to replace bag elements is currently approximately $16,752 per year. Power costs are approximately $32,500 per year.

Samples are required to be collected either weekly or monthly, for FDEP compliance. At the time of this study, the laboratory costs were reported to have an annual cost of approximately $99,440.

3.6.4 TOTAL COST SUMMARY

Opinion of total production costs for the IX system for PFAS treatment is summarized in **Table 3-43**. The total production costs table reflect the of opinion of probable construction cost.

Table 3-43: Opinion of Total Production Cost - IX System for PFAS Treatment

Item No.	Description	Costs
1.	Equivalent Annual Capital Cost	$3,126,330
2.	Annual Operation and Maintenance Cost	$188,129
3.	Average Cost for Resin Replacement at Non-detect Treatment Level (for 4 mgd using $0.65/kgal)	$950,196
	Total Annual Cost:	**$4,264,655**
MDD/AADD Factor[(1)]		1.50
Annual Finished Water Production Rate (mgy)[(2)]		973
	Annual Production Cost ($/kgal):	**$4.38**

(1) MDD (mgd), equal to the plant capacity rating) divided by the AADD (mgd). This factor is used to calculate the AADD to be used in the calculation of the annual production cost.

(2) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

4

WATER RECLAMATION & ADVANCED WASTEWATER TREATMENT TECHNOLOGIES

4.1 DISCUSSION AND APPROACH

For this study, an order-of-magnitude approach was used to develop planning level capital and operating costs based on cost-capacity curves, scale factors, bid prices, and costs from other miscellaneous studies. This approach is appropriate for planning where detailed engineering data has not yet been developed. This type of estimate cannot be substituted for carefully prepared estimates of costs based on sound, thorough engineering evaluation and a complete set of construction plans and specifications.

Costs are generated by an order-of-magnitude approach and reflect 1 mgd, 3 mgd, 5 mgd, 10 mgd, 15 mgd, and 20 mgd plant sizes. Each treatment process is evaluated based on existing plants that have been implemented/constructed in the last 10 years. Yard piping, mechanical, electrical, instrumentation and controls, and site work will be part of the costs for each treatment process, unless otherwise noted.

O&M costs were developed utilizing existing data and were evaluated based on order of magnitude. O&M costs reflect labor, chemical costs, power, maintenance and replacement of equipment and appurtenances, as applicable.

The following are general assumptions used to evaluate costs for each cost scenario described in each section of this Chapter:

- General requirements, Contractor overhead and profit, and construction contingency, are assumed as a percentage allowance of the equipment and installation construction costs.
- Technical services during construction, owner administration and legal, and project contingency are assumed as a percentage allowance of the overall construction costs.
- O&M costs were developed from standard units costs, cost survey information, and American Water Works Association (AWWA) Utility Benchmark O&M cost data (AWWA, 2022).

- The annual production costs were calculated based on total annual cost [i.e., equivalent annual capital, plus annual O&M cost, plus annual R&R fund deposit divided by the average treated water rate (in mgy)].

Water Reclamation Treatment Technology: The demand for reclaimed water is projected to increase over the long term in South Florida. Urban populations, agricultural operations, and the environment depend on adequate water supplies. Fresh groundwater and surface water will not be sufficient to satisfy all future demands. Meeting this growing demand hinges on efforts to develop alternative water sources (SFWMD, 2022). Water reuse has become the logical option for extending available water supplies by potentially:

- Substituting reclaimed water for applications that do not require drinking (potable) water
- Augmenting existing water sources and providing an additional source of water supply to assist in meeting both present and future water needs

In Florida, "Reclaimed water" means water that has received at least secondary treatment and basic disinfection and is reused after flowing out of a domestic wastewater treatment facility. Whereas, "Reuse" means the deliberate application of reclaimed water, in compliance with Department and Water Management District rules, for a beneficial purpose. Criteria used to classify projects as "reuse" or "effluent disposal" are contained in Rule 62-610.810, F.A.C.

The use or application in which reclaimed water will be used determines the water quality requirements. As water reuse applications have increased, additional treatment processes designed to fit with the specific water reuse purpose has become necessary. This "Fit for Purpose" approach provides a framework for cost-effective treatment of reclaimed water to meet the water quality appropriate for the intended use (USEPA, 2012).

The "Fit for Purpose" approach has been applied to this Chapter of study with focus on three types of treatment depending on the water quality required for use:

1. Tertiary Wastewater Treatment to produce unrestricted public access reclaimed water quality.

- <u>Treatment Requirement:</u> Removal of residual particulate matter from secondary effluent and inactivation of pathogens (disinfection) to produce reclaimed water as an alternative water source.
- <u>Purpose:</u> Unrestricted public access reclaimed water
- <u>Cost Scenario No. 1 through No. 3:</u> Convert existing basic level disinfection (secondary treatment) wastewater treatment facilities to high level disinfection (tertiary treatment) to produce unrestricted public access reclaimed water quality (except nutrient discharge limits). These scenarios all include liquid sodium hypochlorite (chlorine) high-level disinfection. UV disinfection was not considered under Tertiary Wastewater Treatment because State regulations requires a chlorine residual used for unrestricted public access reuse.

Cost Scenario No. 1: Construct new granular media filtration (GMF) and high-level disinfection treatment processes

Cost Scenario No. 2: Construct new cloth media filtration system and high-level disinfection treatment processes

Cost Scenario No. 3: Construct new membrane filtration and high-level disinfection treatment processes

2. Advanced Wastewater Treatment to produce reclaimed water meeting nutrient discharge requirements with high level disinfection.

- Treatment Requirement: Removal of nitrogen and phosphorus (nutrients) for production of reclaimed water as alternative water source
- Purpose: Nutrient removal, pre-treatment for advanced water treatment facilities (AWTF)
- Cost Scenario No. 4 through No. 7: New construction or conversion of existing high-level disinfection (tertiary treatment) facilities to nutrient (nitrogen and phosphorus) removal facilities to produce unrestricted public access reclaimed water quality meeting nutrient reduction goals or nutrient discharge limits.

Cost Scenario No. 4: New Construction - 5-Stage Bardenpho Process (conventional treatment) for nutrient removal with tertiary treatment (GMF and high-level disinfection)
Cost Scenario No. 5: Conversion of an existing tertiary treatment facility to 5-Stage Bardenpho process with nutrient removal (conventional treatment) with high level disinfection
Cost Scenario No. 6: New Construction - 5-Stage Bardenpho process with immersed membranes (membrane bioreactor [MBR]) for nutrient removal with tertiary treatment and high-level disinfection. Note: MBR replaces both secondary clarification and tertiary filtration.
Cost Scenario No. 7: Conversion of an existing tertiary treatment facility to 5-Stage Bardenpho process with immersed membranes (membrane bioreactor, MBR) for nutrient removal with high level disinfection.

3. Advanced Water Treatment to achieve indirect or direct potable reclaimed water quality.

- Treatment Requirement: Removal of residual dissolved and trace constituents for production of reclaimed water as alternative water source for indirect or direct potable reuse (DPR).
- Purpose: Direct and indirect potable reuse (IPR)
- Cost Scenario No. 8 and No. 9: Convert an existing tertiary treatment facility to produce reclaimed water quality meeting applicable indirect or direct potable water criteria.

Cost Scenario No. 8: New Construction - RO based AWTF infrastructure. Includes microfiltration (MF) membrane pretreatment, cartridge filtration, RO membrane treatment, advanced oxidation process (AOP: UV + chlorine), and an engineering storage buffer.
Cost Scenario No. 9: Adding non-RO based AWTF infrastructure. Includes ozone addition prior to biologically active filtration (BAF), ultrafiltration (UF) membrane pretreatment, GAC, AOP: UV + chlorine, and an engineering storage buffer (ESB).

Treatment Process Redundancy Common to All Cost Scenarios: Chapter 62-610.462(1) of the F.A.C. requires treatment process redundancy (i.e., Class I reliability) for wastewater treatment facilities providing reclaimed water for public access reuse systems. An exception to the redundancy requirement applies only when an alternate treatment or discharge system exists (e.g., deep injection well) which has sufficient capacity to handle any reclaimed water flows which do not meet the reclaimed water standards.

For the purpose of this Study, the cost scenarios include compliance with Class I Reliability standards (USEPA, 1974). That is, the basis for cost scenario development includes redundancy of treatment processes with the largest unit or one (1) mechanical equipment out of service, multiple treatment units for all unit processes, and an emergency generator for uninterrupted power service.

Applicable treatment components, within listed construction projects (included in this evaluation) along with vendor information were compiled to determine the planning level costs. Projects that include all process components, for each scenario described above, were not attainable at the time of this evaluation. Therefore, project costs (with all process components described in each scenario) could not be plotted.

4.2 TERTIARY WASTEWATER TREATMENT

Tertiary treatment involves the removal of residual particulate matter remaining after secondary biological treatment through filtration is required pursuant to Chapter 62-610, F.A.C. to produce reclaimed for unrestricted public access reuse. The purpose of filtration is to remove suspended particulate solids that carry over from the secondary treatment process and to condition the water, providing a high-quality filtrate to optimize the disinfection process. Tertiary filtration is a vital component in producing public access reclaimed water since particulate matter contributes to turbidity, which may be associated with pathogens and may interfere with disinfection processes. The removal of residual dissolved constituents is considered in **Section 4.6** (advanced water treatment).

This section of the study introduces the technologies used for the removal of residual suspended particulate matter including granular (depth) filtration, cloth media (surface) filtration, and membrane filtration (MF and UF). All filtration processes are followed by high-level disinfection using liquid sodium hypochlorite.

Not included in this section of the study are dissolved air floatation technology (typically used for treating secondary effluent containing algae), ozone and UV disinfection. Ozone and UV radiation disinfection technologies are discussed in **Section 4.6** (advanced water treatment).

4.2.1 Cost Scenario No.1 – New Granular Media Filtration with High-Level Disinfection

Granular Media Filtration

Granular media gravity filters are designed with mono-, dual-, or multi-granular media configurations supported by an underdrain system. Mono-granular media filters experience rapid head loss buildup as particles are generally retained within the top few inches of sand, while dual and multi-media filters allow particles to penetrate deeper into the media bed, and thus experience slower head loss formation and longer filter run times before the media needs to be cleaned/regenerated. The filtration/upflow backwash cycle is sequential. Periodically, one filter is stopped for cleaning. Once the filter is stopped, the backwash is started where it utilizes water to "push" off all the rejected particles that has accumulated on the outside surface of the media. The backwash water and particles are then flushed to a drain system that discharges back to the WWTF. An added feature is application of air scour. Air can be applied simultaneously to the bottom of the filter to scour the surface and aid in the cleaning process. The cycles of filtration and backwash are typically automated. For reliability requirements, multiple filters are provided to account for one filter being out of service during backwash. Filtration rates are typically two to five gallons per minute per square foot.

The footprint requirements for conventional downflow granular media filters are generally larger than other filtration technologies. Deep bed downflow filters are similar to conventional downflow granular media filters, except that the depth and size of granular media is greater than a conventional filter in order to store more solids and extend the filter run time between backwash cycles. Media depths generally range from six to nine feet.

Denitrification filtration, upflow continuous backwashing filters, and traveling bridge style granular filters are not included in the cost scenario.

High-Level Disinfection

Filtered effluent is dosed with liquid sodium hypochlorite to achieve reclaimed water limitations related to fecal coliform, contact time, and chlorine residual.

Cost Scenario Development

The following components and criteria were used in developing the planning level costs for converting an existing secondary wastewater treatment facility to a tertiary wastewater treatment facility by constructing new granular filtration and sodium hypochlorite disinfection.

- New at-grade, cast-in-place, concrete structure for deep bed (6-foot) depth, dual-media granular (depth) filtration
- New, granular filtration treatment units including backwash and air scour components with the capacity to treat the specified design flows (with applicable peaking factors) with the largest unit out of service.
- New filter inlet pump station to maintain existing hydraulic profile by pumping secondary clarifier effluent to filter inlet, filtration, and then gravity discharge to existing chlorine contact chamber.

- New liquid sodium hypochlorite storage and feed system to achieve 1.0 mg/L total chlorine residual.
- New chlorine contact chamber to achieve 15-minute contact time at peak hour and Class I reliability (i.e., treat 50% of design flow with largest unit out of service)

Specific Approach for Developing Planning Costs

In addition to the general assumptions described in Section 4.1, the following was used in this cost estimating effort for granulated media filter plus sodium hypochlorite disinfection.

- Construction costs for granular (depth) filters, filter inlet pump station, and sodium hypochlorite storage and feed improvements were obtained from unit costs derived from vendor equipment and bid prices. The unit costs include furnishing and installing the equipment/infrastructure. The projects, where cost information was derived, are included in this evaluation are listed in **Table 4-1** below.

- Construction costs for the associated yard piping, ancillary mechanical equipment, electrical equipment, instrumentation and control equipment, and site work are assumed as a percentage allowance of the construction costs for the granular (depth) filters, filter inlet pumps, and sodium hypochlorite storage and feed improvements.

Table 4-1: Projects Evaluated for Cost Scenario No. 1: Granular (Depth) Filtration with High-Level Disinfection

Location (County)	Municipality	Project Name
Sarasota	City of Northport	West Villages Wastewater Reclamation Facility
Palm Beach	Village of Wellington	WRF Improvements
-	-	Vendor equipment pricing

The opinion of probable construction costs for granulated media filter plus sodium hypochlorite disinfection component are summarized in **Table 4-2**. The construction cost curve for granulated media filter + sodium hypochlorite disinfection component is depicted in **Figure 4-1**. The opinion of annual O&M cost for granulated media filter + sodium hypochlorite disinfection component is summarized in **Table 4-3**. The total production cost for granulated media filter + sodium hypochlorite disinfection component is summarized in **Table 4-4**. The total production costs curve is depicted on **Figure 4-2.**

Table 4-2: Opinion of Probable Capital Cost: Granular Media Filtration with High-level Disinfection

Item No.	Description Allowance Factor		Plant Capacity (mgd) 1	3	5	10	15	20
1.	Granular Media Filters		$1,000,000	$2,910,000	$4,750,000	$9,000,000	$12,750,000	$16,000,000
2.	Sodium Hypochlorite Storage and Feed		$100,000	$291,000	$475,000	$900,000	$1,275,000	$1,600,000
3.	Filter Inlet Pump Station		$200,000	$582,000	$950,000	$1,800,000	$2,550,000	$3,200,000
	Subtotal (1-3):		**$1,300,000**	**$3,783,000**	**$6,175,000**	**$11,700,000**	**$16,575,000**	**$20,800,000**
4.	Yard piping	10%	$130,000	$378,300	$617,500	$1,170,000	$1,657,500	$2,080,000
5.	Mechanical	10%	$130,000	$378,300	$617,500	$1,170,000	$1,657,500	$2,080,000
6.	Electrical	15%	$195,000	$567,450	$926,250	$1,755,000	$2,486,250	$3,120,000
7.	Instrumentation and Controls	8%	$104,000	$302,640	$494,000	$936,000	$1,326,000	$1,664,000
8.	Site Work	10%	$130,000	$378,300	$617,500	$1,170,000	$1,657,500	$2,080,000
	Subtotal (1-8):		**$1,989,000**	**$5,787,990**	**$9,447,750**	**$17,901,000**	**$25,359,750**	**$31,824,000**
9.	General Requirements	5%	$99,450	$289,400	$472,388	$895,050	$1,267,988	$1,591,200
10.	Contractor Overhead and Profit	15%	$103,350	$300,749	$490,913	$930,150	$1,317,713	$1,653,600
11.	Construction Contingency	15%	$103,350	$300,749	$490,913	$930,150	$1,317,713	$1,653,600
	Opinion of Probable Construction Cost (1-11):		**$2,295,150**	**$6,678,887**	**$10,901,963**	**$20,656,350**	**$29,263,163**	**$36,722,400**
12.	Technical Services	20%	$459,030	$1,335,777	$2,180,393	$4,131,270	$5,852,633	$7,344,480
13.	Owner Administration and Legal	5%	$114,758	$333,944	$545,098	$1,032,818	$1,463,158	$1,836,120
14.	Project Contingency	15%	$344,273	$1,001,833	$1,635,294	$3,098,453	$4,389,474	$5,508,360
	Opinion of Probable Capital Cost (1-14):		**$3,213,210**	**$9,350,441**	**$15,262,748**	**$28,918,890**	**$40,968,428**	**$51,411,360**
	Opinion of Equivalent Annual Capital Cost:		**$303,304**	**$882,615**	**$1,440,695**	**$2,729,739**	**$3,867,130**	**$4,852,869**

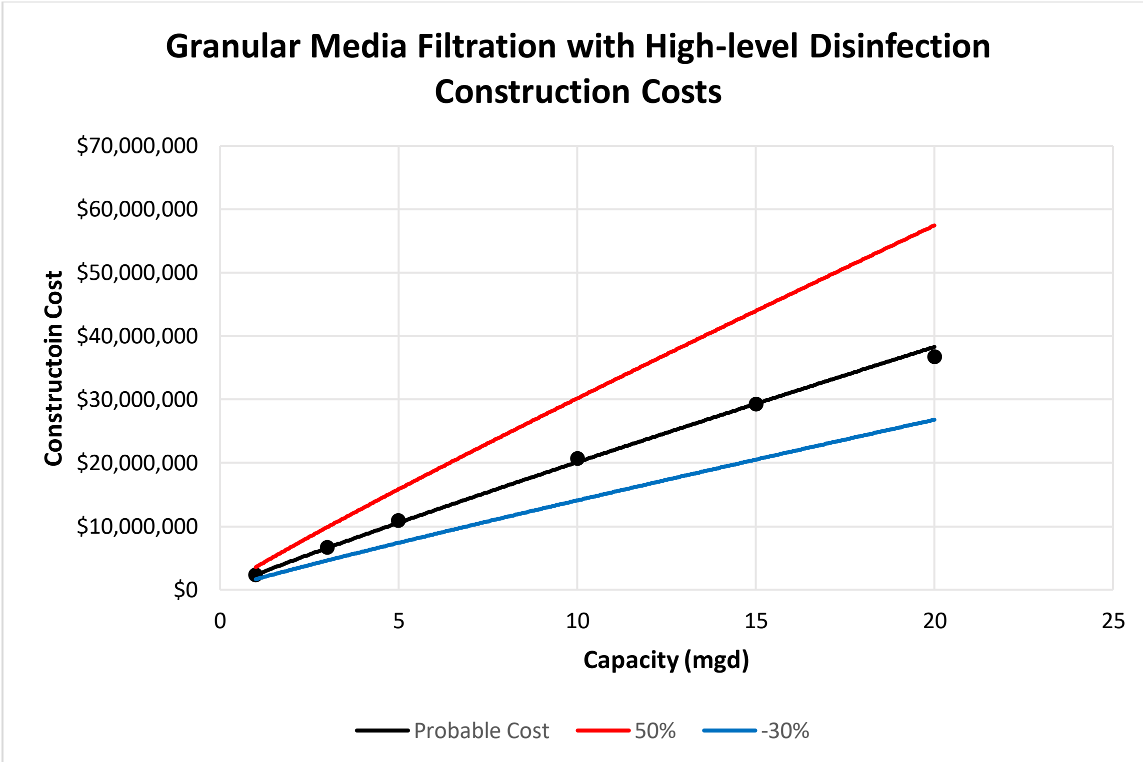

Figure 4-1: Granular Media Filtration with High-level Disinfection Construction Cost Curve

Table 4-3: Opinion of Annual Operation and Maintenance Cost: Granular Media Filtration with Sodium Hypochlorite Disinfection

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Granular Bed Filters	$60,833	$177,025	$288,958	$547,500	$775,625	$973,333
2.	Sodium Hypochlorite Storage and Feed	$36,500	$106,215	$173,375	$328,500	$465,375	$584,000
3.	Filter Inlet Pump Station	$60,833	$177,025	$288,958	$547,500	$775,625	$973,333
	Opinion of Annual O&M Cost:	**$158,167**	**$460,265**	**$751,292**	**$1,423,500**	**$2,016,625**	**$2,530,667**

Table 4-4: Opinion of Total Production Cost - Granular Media Filtration with High-level Disinfection

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual Capital Cost	$303,304	$882,615	$1,440,695	$2,729,739	$3,867,130	$4,852,869
2.	Annual O&M Cost	$158,167	$460,265	$751,292	$1,423,500	$2,016,625	$2,530,667
3	Annual R&R Fund Deposit(1)	$30,330	$88,262	$144,070	$272,974	$386,713	$485,287
	Total Annual Cost:	**$491,801**	**$1,431,142**	**$2,336,057**	**$4,426,212**	**$6,270,468**	**$7,868,822**
	Annual Finished Reclaimed Water Production Rate (mgy)(2)	365	1,095	1,825	3,650	5,475	7,300
	Annual Production Cost ($/kgal):	**$1.35**	**$1.31**	**$1.28**	**$1.21**	**$1.15**	**$1.08**

(1) Annual deposit to a renewal and replacement (R&R) fund is equal to 10% of the equivalent annual capital cost.
(2) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

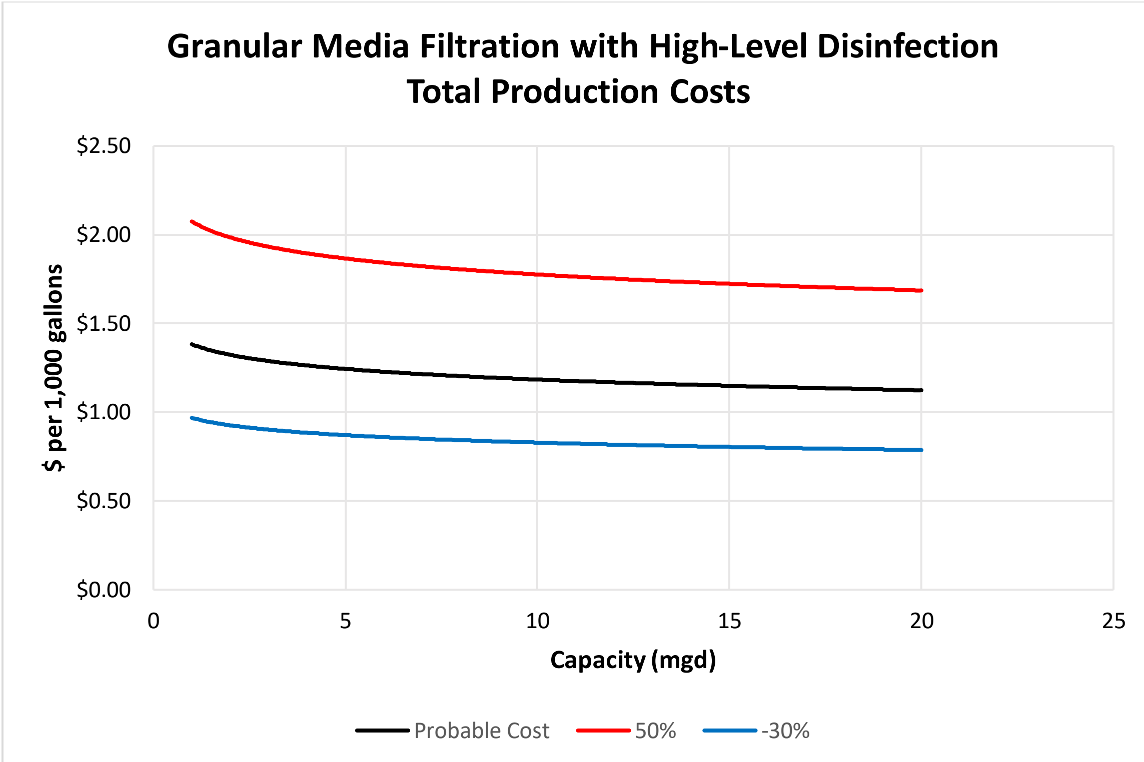

Figure 4-2: Granular Media Filtration with High-level Disinfection Total Production Cost Curves

4.2.2 Cost Scenario No. 2 – Cloth Media Filtration with Liquid Sodium Hypochlorite High-Level Disinfection

Cloth Media Filtration

Cloth media filtration involves the removal of particulate material suspended in the secondary effluent by passing the effluent through filter material such as cloth fabric of different weaves. Filtration rates are typically two to five gallons per minute per square foot. The footprint requirements for cloth media (surface) filtration structure is generally smaller than granular media (depth) filtration technologies.

Cost Scenario Development

The following are the components and criteria used in developing the planning level costs for converting an existing secondary wastewater treatment facility to a tertiary wastewater treatment facility by constructing new cloth filtration and sodium hypochlorite disinfection.

- New at-grade, cast-in-place, concrete structure for cloth-media filtration components.
- New cloth-media filter components and equipment including backwash components with the capacity to treat the specified design flows (with applicable peaking factors) with the largest unit out of service.
- New filter inlet pump station to maintain existing hydraulic profile by pumping secondary clarifier effluent to filter inlet, filtration, and then gravity discharge to the new existing chlorine contact chamber.
- New liquid sodium hypochlorite storage and feed system to achieve 1.0 mg/L total chlorine residual.
- New chlorine contact chamber to achieve 15-minute contact time at peak hour and Class I reliability (i.e., treat 50% of design flow with largest unit out of service)

Specific Approach for Developing Planning Costs

In addition to the general assumptions described in Section 4.1, the following is the specific approach used in this cost estimating effort for cloth media filtration with sodium hypochlorite disinfection:

- Construction costs for cloth filters, filter pump station, and sodium hypochlorite storage and feed improvements were obtained from unit costs derived from vendor equipment and bid prices. The unit costs include furnishing and installing the equipment/infrastructure. The projects included in this evaluation are listed in **Table 4-5** below.
- Construction costs for the associated yard piping, ancillary mechanical equipment, electrical equipment, instrumentation and control equipment, and site work are assumed as a percentage allowance of the construction costs for the cloth filters, filter inlet pumps, and sodium hypochlorite storage and feed improvements.

Table 4-5: Projects Evaluated for Cost Scenario No. 2: Cloth Media Filtration with High-level Disinfection

Location (County)	Municipality	Project Name
Flagler	Bunnell	Plantation Bay WRF – Phase 2
Lake	Lady Lake	WRF Expansion – Phase 2
Sumter	Wildwood	WRF Improvements
-	-	Vendor Pricing

The opinion of probable construction costs for cloth media filter plus sodium hypochlorite disinfection component are summarized in **Table 4-6**. The construction cost curve for cloth media filtration with sodium hypochlorite disinfection component is depicted in **Figure 4-3**. The opinion of annual O&M cost for cloth media filtration plus sodium hypochlorite disinfection component is summarized in **Table 4-7**. The total production cost for cloth media filtration with sodium hypochlorite disinfection component is summarized in **Table 4-8**. The total production costs curve is depicted on **Figure 4-4.**

Table 4-6: Opinion of Probable Capital Cost: Cloth Media Filtration with High-level Disinfection

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	Cloth Media Disk Filters		$500,000	$1,455,000	$2,375,000	$4,500,000	$6,375,000	$8,000,000
2.	Sodium Hypochlorite Storage and Feed		$100,000	$291,000	$475,000	$900,000	$1,275,000	$1,600,000
3.	Filter Inlet Pump Station		$200,000	$582,000	$950,000	$1,800,000	$2,550,000	$3,200,000
		Subtotal (1-3):	**$800,000**	**$2,328,000**	**$3,800,000**	**$7,200,000**	**$10,200,000**	**$12,800,000**
5.	Yard Piping	10%	$80,000	$232,800	$380,000	$720,000	$1,020,000	$1,280,000
6.	Mechanical	10%	$80,000	$232,800	$380,000	$720,000	$1,020,000	$1,280,000
7.	Electrical	15%	$120,000	$349,200	$570,000	$1,080,000	$1,530,000	$1,920,000
8.	Instrumentation and Controls	8%	$64,000	$186,240	$304,000	$576,000	$816,000	$1,024,000
9.	Site Work	10%	$80,000	$232,800	$380,000	$720,000	$1,020,000	$1,280,000
		Subtotal (1-9):	**$1,224,000**	**$3,561,840**	**$5,814,000**	**$11,016,000**	**$15,606,000**	**$19,584,000**
10.	General Requirements	5%	$61,200	$178,092	$290,700	$550,800	$780,300	$979,200
11.	Contractor Overhead and Profit	15%	$63,600	$185,076	$302,100	$572,400	$810,900	$1,017,600
12.	Construction contingency	15%	$63,600	$185,076	$302,100	$572,400	$810,900	$1,017,600
		Opinion of Probable Construction Cost (1-12):	**$1,412,400**	**$4,110,084**	**$6,708,900**	**$12,711,600**	**$18,008,100**	**$22,598,400**
13.	Technical Services	20%	$282,480	$822,017	$1,341,780	$2,542,320	$3,601,620	$4,519,680
14.	Owner Administration and Legal	5%	$70,620	$205,504	$335,445	$635,580	$900,405	$1,129,920
15.	Project Contingency	15%	$211,860	$616,513	$1,006,335	$1,906,740	$2,701,215	$3,389,760
		Opinion of Probable Capital Cost (1-15):	**$1,977,360**	**$5,754,118**	**$9,392,460**	**$17,796,240**	**$25,211,340**	**$31,637,760**
		Opinion of Equivalent Annual Capital Cost:	**$186,649**	**$543,148**	**$886,582**	**$1,679,839**	**$2,379,772**	**$2,986,381**

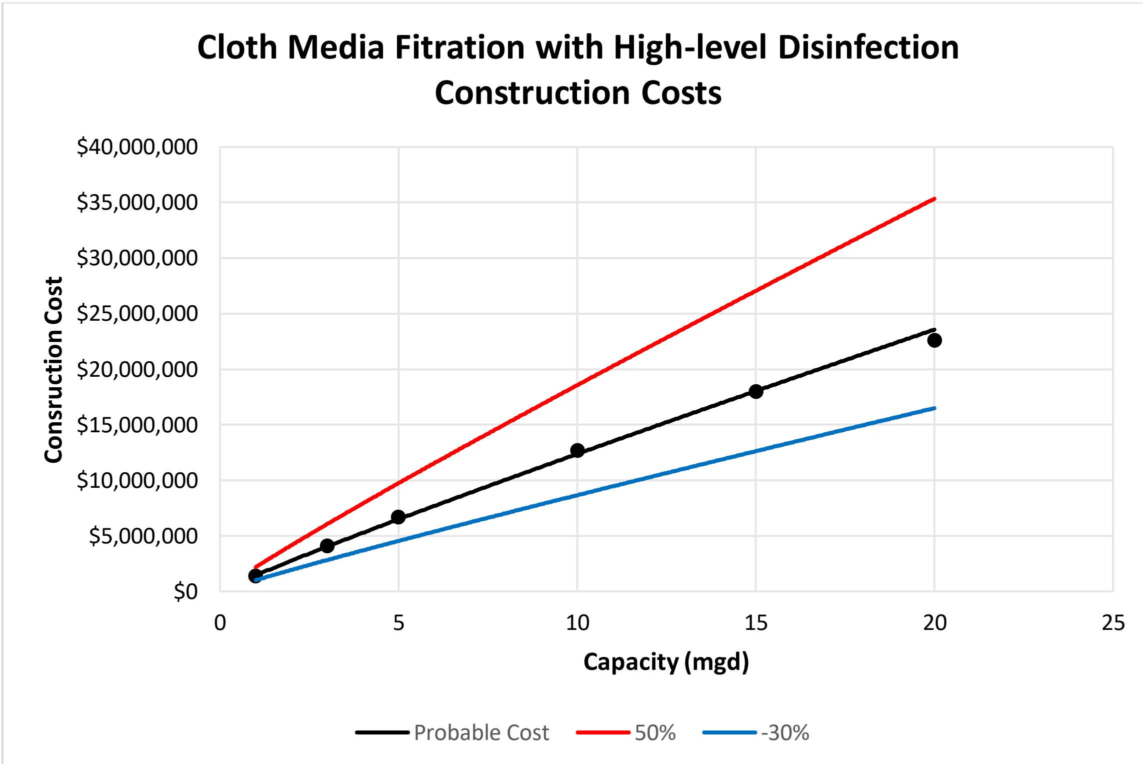

Figure 4-3: Cloth Media Filtration with High-level Disinfection Construction Cost Curves

Table 4-7: Opinion of Annual Operation and Maintenance Cost: Cloth Media Filtration with High-level Disinfection

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Cloth Media Disk Filters	$45,625	$132,769	$216,719	$410,625	$581,719	$730,000
2.	Sodium Hypochlorite Storage and Feed	$36,500	$106,215	$173,375	$328,500	$465,375	$584,000
3.	Filter Inlet Pump Station	$60,833	$177,025	$288,958	$547,500	$775,625	$973,333
	Opinion of Annual O&M Cost:	**$142,958**	**$416,009**	**$679,052**	**$1,286,625**	**$1,822,719**	**$2,287,333**

Table 4-8: Opinion of Total Production Cost - Cloth Media Filtration with High-level Disinfection

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual Capital Cost	$186,649	$543,148	$886,582	$1,679,839	$2,379,772	$2,986,381
2.	Annual Operation and Maintenance Cost	$142,958	$416,009	$679,052	$1,286,625	$1,822,719	$2,287,333
3.	Annual R&R Fund Deposit(1)	$18,665	$54,315	$88,658	$167,984	$237,977	$298,638
	Total Annual Cost:	**$348,272**	**$1,013,472**	**$1,654,292**	**$3,134,448**	**$4,440,468**	**$5,572,352**
Annual Finished Water Reuse Production Rate (mgy)(2)		365	1,095	1,825	3,650	5,475	7,300
	Annual Production Cost ($/kgal):	**$0.95**	**$0.93**	**$0.91**	**$0.86**	**$0.81**	**$0.76**

(1) Annual deposit to a renewal and replacement (R&R) fund is equal to 10% of the equivalent annual capital cost.
(2) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

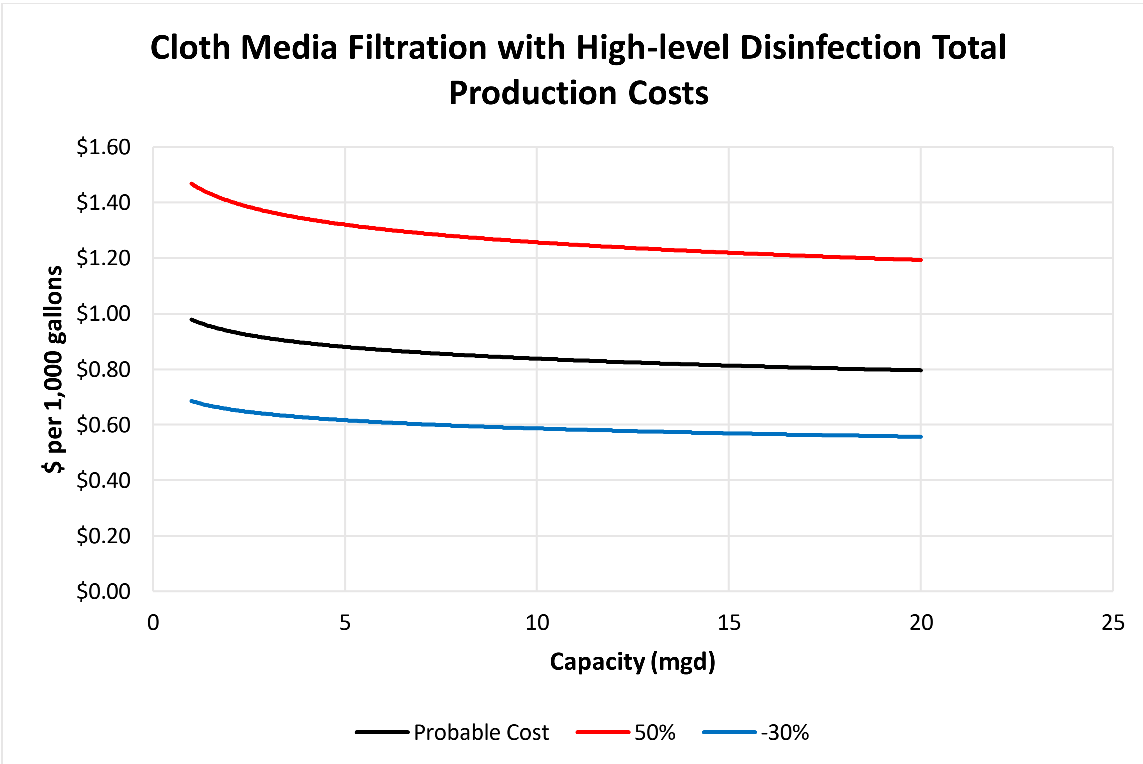

Figure 4-4: Cloth Media Filtration with High-level Disinfection Total Production Cost Curves

4.2.3 Cost Scenario No. 3 – Membrane Filtration with High-Level Disinfection

Membrane Filtration

Membrane filtration involves the passage of wastewater effluent through a thin membrane for the purpose of removing particulate material, pathogens, organic matter, nutrients, and dissolved substances not removed by treatment processes. Membrane processes include MF, ultrafiltration (UF), NF, RO, dialysis, and electrodialysis. In this section, MF and UF membranes are considered for the filtration of secondary effluent in place of granular (depth) and surface (cloth media) filtration presented in previous sections. RO membrane processes used for the removal of dissolved solids are considering in **Section 4.6**.

MF and UF processes use membranes with pore sizes ranging from 0.1 to 10 micrometers (μm) in a low-pressure application (up to approximately 30 pounds per square inch [PSI]). Solids removal is achieved through size exclusion in which particles larger than the membrane pore size are retained on the membrane surface and filtered water passes through the membrane (permeate). MF/UF processes are capable of reliably producing a high-quality effluent, with turbidity less than 0.1 Nephelometric Turbidity Unit. Membranes are available in an outside-in or an inside-out configuration and can be installed in pressure vessels or directly submerged in a tank.

The membrane filtration system considered for this section function by pumping secondary effluent (i.e., pressurized feedwater) to the bottom of the UF module. Once inside the UF module, the pressurized feedwater surrounds the UF membrane hollow fibers contained within the module. The pressure causes the liquid to travel (permeate) across the outside layer of the hollow fiber membrane and flow to the inside of the hollow fiber, leaving particulate material behind. Treated water (permeate) then travels up, through the membrane fibers and exits from the top of the module.

Periodically, membrane filtration is stopped for cleaning. Permeate is pressurized on the inside of the membrane hollow fibers and flows to the inside-out. This pushes off all the rejected material that has accumulated on the outside surface of the hollow fiber membrane and flushes it to drain system (waste). Simultaneous, air is applied to the bottom of the module to scour the membrane surface and aid in the cleaning process. This sequence of events is a called a backwash. These cycles of filtration and backwash are typically automated. Therefore, multiple filters are provided to account for one membrane unit being out of service during backwash

Cost Scenario Development

The following are the components and criteria used in developing the planning level costs for converting an existing secondary wastewater treatment facility to a tertiary wastewater treatment facility by constructing new membrane filtration and sodium hypochlorite disinfection.

- New concrete masonry unit (CMU) block building with roll-up service doors for UF membrane modules and associated equipment.
- New, skid mounted, UF membrane treatment system including backwash and air scour components with the capacity to treat the specified design flows (with applicable peaking factors) with the largest unit out of service.
- New membrane feedwater (secondary effluent) pump station to pressurize the UF membrane module feedwater and maintain existing hydraulic profile. The UF membrane treated water (permeate) gravity discharges to the new chlorine contact chamber.
- New liquid sodium hypochlorite storage and feed system to achieve 1.0 mg/L total chlorine residual.
- New chlorine contact chamber to achieve 15-minute contact time at peak hour and Class I reliability (i.e., treat 50% of design flow with largest unit out of service)

Specific Approach for Developing Planning Costs

In addition to the general assumptions described in Section 4.1, the following is the specific approach used in this cost estimating effort for membrane filtration plus sodium hypochlorite high level disinfection.

- Construction costs for UF membrane filtration system including membrane filtration equipment building, membrane feedwater pump station, and sodium hypochlorite storage and feed improvements were obtained from unit costs derived from vendor equipment and bid prices. The unit costs include furnishing and installing the equipment/infrastructure. The projects included in this evaluation are listed in **Table 4-9** below.
- Construction costs for the associated yard piping, ancillary mechanical equipment, electrical equipment, instrumentation and control equipment, and site work are assumed as a percentage allowance of the construction costs for the membrane filtration, membrane feedwater pump station, and sodium hypochlorite storage and feed improvements.

Table 4-9: Projects Evaluated for Cost Scenario No. 3: Membrane Filtration with High Level Disinfection

Location (County)	Municipality	Project Name
Seminole	Altamonte Springs	pureALTA
Duvall	Jacksonville Electric Authority	Water Purification Treatment
Hillsborough	Hillsborough County	DPR Demonstration
Pinellas	City of Clearwater	Groundwater Replenishment
Volusia	Daytona Beach	DPR Demonstration
-	-	Vendor Pricing

The opinion of probable construction costs for membrane filtration plus sodium hypochlorite disinfection component are summarized in **Table 4-10**. The construction cost curve for Membrane Filtration with Liquid Sodium Hypochlorite High-Level Disinfection is depicted in **Figure 4-5**. The opinion of annual O&M cost for Membrane Filtration plus Liquid Sodium Hypochlorite High-Level Disinfection is summarized in **Table 4-11**. The total production cost for Membrane Filtration plus Liquid Sodium Hypochlorite High-Level Disinfection is summarized in **Table 4-12**. The total production costs curve is depicted on **Figure 4-6.**

Table 4-10: Opinion of Probable Capital Cost - Membrane Filtration with High-level Disinfection

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	Membrane Filtration System		$1,000,000	$2,910,000	$4,750,000	$9,000,000	$12,750,000	$16,000,000
2.	Membrane Filtration Building		$150,000	$436,500	$712,500	$1,350,000	$1,912,500	$2,400,000
3.	Sodium Hypochlorite Storage and Feed		$100,000	$291,000	$475,000	$900,000	$1,275,000	$1,600,000
4.	Membrane Feedwater Pump Station		$200,000	$582,000	$950,000	$1,800,000	$2,550,000	$3,200,000
	Subtotal (1-4):		**$1,450,000**	**$4,219,500**	**$6,887,500**	**$13,050,000**	**$18,487,500**	**$23,200,000**
5.	Yard Piping	10%	$145,000	$421,950	$688,750	$1,305,000	$1,848,750	$2,320,000
6.	Mechanical	10%	$145,000	$421,950	$688,750	$1,305,000	$1,848,750	$2,320,000
7.	Electrical	15%	$217,500	$632,925	$1,033,125	$1,957,500	$2,773,125	$3,480,000
8.	Instrumentation and Controls	8%	$116,000	$337,560	$551,000	$1,044,000	$1,479,000	$1,856,000
9.	Site Work	10%	$145,000	$421,950	$688,750	$1,305,000	$1,848,750	$2,320,000
	Subtotal (1-9):		**$2,218,500**	**$4,641,450**	**$10,537,875**	**$19,966,500**	**$28,285,875**	**$35,496,000**
10.	General Requirements	5%	$110,925	$322,792	$526,894	$998,325	$1,414,294	$1,774,800
11.	Contractor Overhead and Profit	15%	$115,275	$335,450	$547,556	$1,037,475	$1,469,756	$1,844,400
12.	Construction Contingency	15%	$115,275	$335,450	$547,556	$1,037,475	$1,469,756	$1,844,400
	Opinion of Probable Construction Cost (1-12):		**$2,559,975**	**$7,449,527**	**$12,159,881**	**$23,039,775**	**$32,639,681**	**$40,959,600**
13.	Technical Services	20%	$511,995	$1,489,905	$2,431,976	$4,607,955	$6,527,936	$8,191,920
14.	Owner Administration and Legal	5%	$127,999	$372,476	$607,994	$1,151,989	$1,631,984	$2,047,980
15.	Project Contingency	15%	$383,996	$1,117,429	$1,823,982	$3,455,966	$4,895,952	$6,143,940
	Opinion of Probable Capital Cost (1-15):		**$3,583,965**	**$10,429,338**	**$17,023,834**	**$32,255,685**	**$45,695,554**	**$57,343,440**
	Opinion of Equivalent Annual Capital Cost:		**$338,301**	**$984,456**	**$1,606,929**	**$3,044,708**	**$4,313,337**	**$5,412,815**

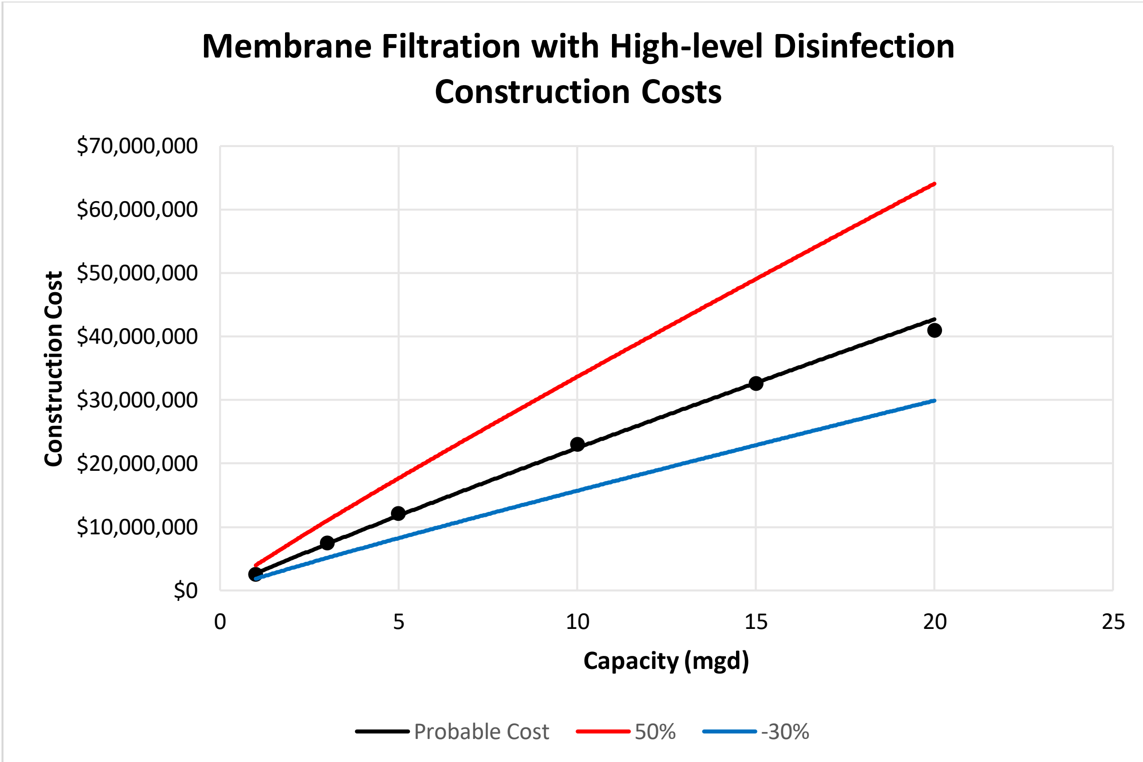

Figure 4-5: Membrane Filtration with High-level Disinfection Construction Cost Curve

Table 4-11: Opinion of Annual Operation and Maintenance Cost - Membrane Filtration with High-level Disinfection

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Membrane Filtration System	$76,042	$221,281	$361,198	$684,375	$969,531	$1,216,667
2.	Sodium Hypochlorite Storage and Feed	$36,500	$106,215	$173,375	$328,500	$465,375	$584,000
3.	Membrane Feedwater Pump Station	$60,833	$177,025	$288,958	$547,500	$775,625	$973,333
Opinion of Annual O&M Cost:		**$173,375**	**$504,521**	**$823,531**	**$1,560,375**	**$2,210,531**	**$2,774,000**

Table 4-12: Opinion of Total Production Cost – Membrane Filtration with High-level Disinfection

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual Capital Cost	$338,301	$984,456	$1,606,929	$3,044,708	$4,313,337	$5,412,815
2.	Annual Operation and Maintenance Cost	$173,375	$504,521	$823,531	$1,560,375	$2,210,531	$2,774,000
3.	Annual R&R Fund Deposit(1)	$33,830	$98,446	$160,693	$304,471	$431,334	$541,282
Total Annual Cost:		**$545,506**	**$1,587,423**	**$2,591,154**	**$4,909,554**	**$6,955,202**	**$8,728,097**
Annual Finished Water Reuse Production Rate (mgy)(2)		365	1,095	1,825	3,650	5,475	7,300
Annual Production Cost ($/kgal)		**$1.49**	**$1.45**	**$1.42**	**$1.35**	**$1.27**	**$1.20**

(1) Annual deposit to a renewal and replacement (R&R) fund is equal to 10% of the equivalent annual capital cost.
(2) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

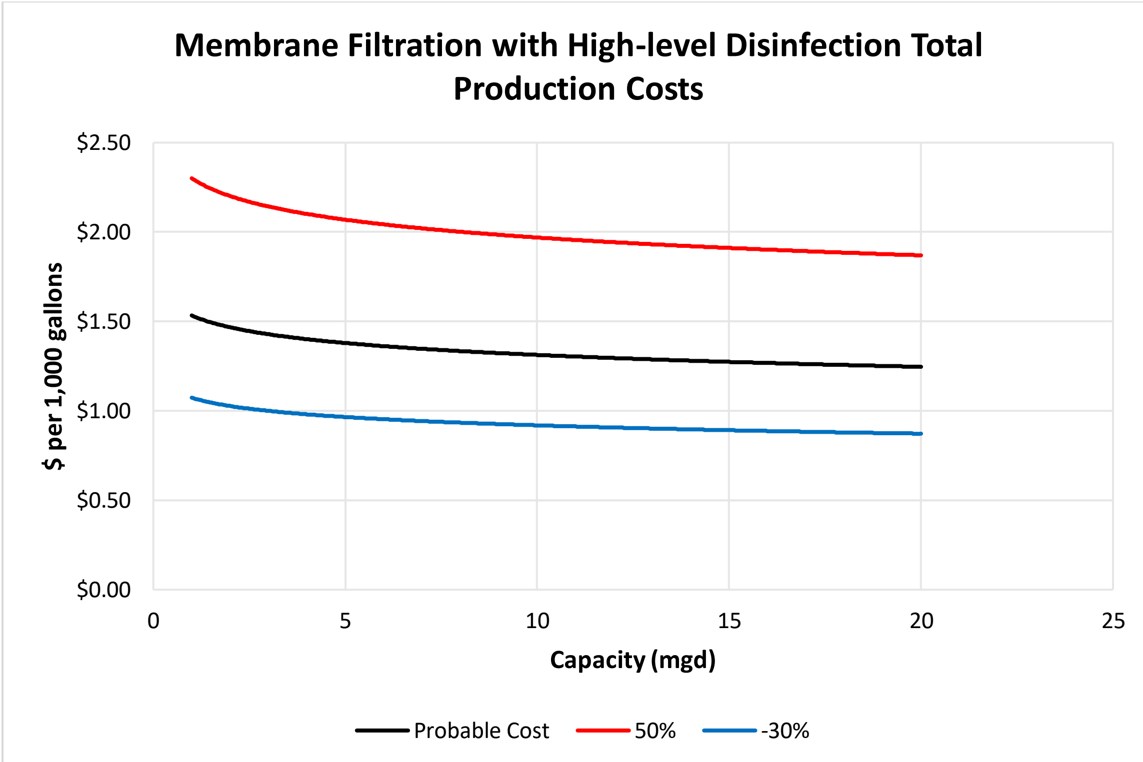

Figure 4-6: Membrane Filtration with High-level Disinfection Total Production Cost Curves

4.3 ADVANCED WASTEWATER TREATMENT

Nutrient removal is often required where reclaimed water is discharged to recreational or sensitive water bodies, used for groundwater recharge, or used for other reuse applications. The principal nutrients of concern are nitrogen and phosphorus. In selecting a technology for nutrient removal in water reuse applications, it is important to assess the characterization of the untreated wastewater; the type of available infrastructure (if existing); and the level of nutrient removal required. The approaches may involve the integration of nutrient removal with the main biological process, chemical addition, or adding a process for the removal of nutrients.

Technologies for nitrogen removal (nitrification/denitrification) and phosphorus removal (chemical addition and biological phosphorus removal) are discussed in the following section, specifically as it relates to the 5-stage Bardenpho, tapered diffused aeration, and suspended growth activated sludge process for advanced wastewater treatment.

Biological Treatment

The function of the biological treatment process is to remove biological oxygen demand, which is indicative of the amount of oxygen required to breakdown organic pollutants biologically with microorganisms; total suspended solids; suspended and non-settleable colloidal solids; nitrogen; and phosphorous from the wastewater to below acceptable effluent limits. Biological treatment processes use suspended growth and attached growth processes to maintain biological activity.

Suspended growth processes use biomass suspended in the wastewater to perform the required biological transformations. Suspended growth systems include, but are not limited to, the following:

- Sequencing batch reactors with batch treatment and clarification
- Conventional activated sludge with secondary clarifiers
- Activated Sludge with immersed membrane filtration (Membrane Bioreactors – MBR)

Attached growth processes use biomass attached to media to perform the required biological transformations. In these applications, the attached growth forms a film on the media referred to as biofilm. Attached growth systems include, but are not limited to, the following:

- Moving bed bioreactors/integrated fixed film activated sludge (IFAS)
- Rotating biological contactors
- Trickling filters
- Biologically activated filtration
- Fluidized bed biofilm reactor

Note: IFAS incorporates both suspended and attached biological growth processes.

Advanced Wastewater Treatment Utilizing the 5-stage Bardenpho Process

The 5-stage Bardenpho process is a suspended growth process that has been used successfully to meet advanced wastewater treatment standards with total effluent total nitrogen less than 3.0 mg/L and total phosphorus less than 1.0 mg/L. The 5-stage Bardenpho can be configured using sequence batch reactors, conventional activated sludge, and MBR systems.

The 5-stage Bardenpho process with conventional Activated Sludge (with immersed MBR) was selected as the basis for the development of the cost scenarios in this section. The following is brief description of the 5-stage Bardenpho Process.

The nutrient removal biological process includes an initial anaerobic zone (first-stage) followed by an anoxic zone (second-stage), aeration zone (third-stage), secondary anoxic zone (fourth-stage) and re-aeration zone (fifth-stage) in series (plug flow) through a common wall process tank.

- The first-stage anaerobic zone provides an environment for biological phosphorus removal (i.e., phosphorus release). The biological treatment for phosphorous removal includes an initial anaerobic zone that promotes the release and then subsequent 'luxury' uptake of phosphorus by the phosphorus accumulating organism population in the aerobic zone.
- The second-stage anoxic zone and third-stage aeration zone are configured with an internal recycle stream from the third-stage aerobic zone to the second-stage anoxic zone. The internal recycle enhances nutrient removal by brining nitrified (aerobic microorganisms oxidize ammonia [ammonium ions, NH_4^+] to nitrite [NO_2] and then nitrate [NO_3]) mixed liquor to the anoxic zone for denitrification (biological process by which microorganisms reduce nitrate (NO_3) to nitrogen gas [N_2]). The anaerobic and anoxic zones are equipped with submersible mixers to keep the mixed liquor in suspension and well mixed.
- The third-stage aeration zone is equipped with fine bubble diffused aeration to provide oxygen to biological treatment process. The fine bubble diffuser grid density is typically the highest in the first part of the aerated zone and decreases in subsequent zones to achieve a tapered aeration effect. Tapered aeration can increase process control and improve energy efficiency by providing, for example, more oxygen (more diffusers) in the first section, less in the second section, and the least in the section zone.
- The fourth-stage (secondary) anoxic zone is provided for additional denitrification to further reduce the effluent total nitrogen.
- The fifth-stage reaeration zone at the end of the biological process is provided to add dissolved oxygen to the mixed liquor prior to the secondary clarifiers to avoid denitrification 'pop-ups' the clarifier. Note: The 5-Stage Bardenpho MBR configuration does not require dedicated re-aeration zones.

4.3.2 Cost Scenario No. 4 – Advanced Wastewater Treatment: New Construction of 5-Stage Bardenpho with Conventional Activated Sludge

Cost Scenario Development

The following are the components and criteria used in developing the planning level costs for constructing a 5-Stage Bardenpho with conventional Activated Sludge facility utilizing tertiary wastewater treatment.

- New influent pump station including wet well, rail-mounted submersible pumps with the capacity to pump the specified design flows (with applicable peaking factors) with one pump out of service.
- New above-grade, cast-in-place concrete structure for raw wastewater screening and grit removal with the capacity to pretreat the specified design flows (with applicable peaking factors) with one screen out of service. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, cast-in-place concrete structure for screened and de-gritted wastewater with the capacity to equalize influent flows and loads to reduce downstream design peaking factors. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, cast-in-place concrete structure for five-stage advanced wastewater treatment with multiple process trains and the capacity to treat the specified design flows (with applicable peaking factors) with one train out of service. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, cast-in-place concrete structure for secondary clarification with multiple clarifiers and the capacity for liquid/solids separation at the specified design flows (with applicable peaking factors) with one clarifier out of service. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, returned activated sludge/waste activated sludge (RAS/WAS) pump station including with the capacity to pump the specified design RAS and WAS flows (with applicable peaking factors) with one pump out of service.
- New at-grade, cast-in-place, concrete structure for deep bed (6-foot) depth, dual-media granular (depth) filtration
- New, granular filtration treatment units including backwash and air scour components with the capacity to treat the specified design flows (with applicable peaking factors) with the largest unit out of service.
- New filter inlet pump station to maintain existing hydraulic profile by pumping secondary clarifier effluent to filter inlet, filtration, and then gravity discharge to existing chlorine contact chamber.
- New liquid sodium hypochlorite storage and feed system to achieve 1.0 mg/L total chlorine residual.
- New chlorine contact chamber to achieve 15-minute contact time at peak hour and Class I reliability (i.e., treat 50% of design flow with largest unit out of service)

- New above-grade, cast-in-place concrete structure for aerated sludge holding with multiple tanks and the capacity to treat (or hold), aerate, and batch process the specified WAS design flows (with applicable peaking factors) with one tank out of service. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, biosolids dewatering station with multiple units and the capacity to dewater the specified biosolids generated at the facility (with applicable peaking factors) with one unit out of service.
- New above-grade, emergency generator with fuel storage with the capacity to provide emergency backup power to the required equipment to maintain operations.
- New operations and control building including administration offices, locker rooms, break room, equipment storage, operator's workstations, laboratory, and associated building infrastructure.

Specific Approach for Developing Planning Costs

The following is the approach used in this cost estimating effort.

- Construction costs for unit process structures, equipment, and associated appurtenances were obtained from unit costs derived from vendor equipment and bid prices. The unit costs include furnishing and installing the equipment/infrastructure. The projects included in this evaluation are listed in **Table 4-13** below.
- Construction costs for the associated yard piping, ancillary mechanical equipment, electrical equipment, instrumentation and control equipment, and site work are assumed as a percentage allowance of the construction costs for the 5-Stage Bardenpho Process with Conventional Activated Sludge.

Table 4-13: Projects Evaluated for Cost Scenario No. 4: New Construction of 5-Stage Bardenpho with Conventional Activated Sludge

Location (County)	Municipality	Project Name
Brevard	Palm Bay	South Regional WRF
Manatee	Manatee County	NCRWRF Improvements
Sarasota	Sarasota County	Bee Ridge Interim Improvements
Palm Beach	East Central Regional	Aeration Improvements
Sarasota	City of North Port	West Villages WRF
Lake	Lady Lake	WRF Expansion – Phase 2
-	-	Vendor Pricing

The opinion of probable construction costs for new construction of a 5-Stage Bardenpho process with conventional Activated Sludge are summarized in **Table 4-14**. The construction cost curve facility is depicted in **Figure 4-7**. The opinion of annual O&M cost for new construction – 5-Stage Bardenpho Process with conventional Activated Sludge is summarized in **Table 4-15**. The total production cost for new construction – 5-Stage Bardenpho Process with conventional Activated Sludge is summarized in **Table 4-16**. The total production costs curve is depicted on **Figure 4-8.**

Table 4-14: Opinion of Probable Capital Cost: New Construction of 5-Stage Bardenpho Process with Conventional Activated Sludge

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Influent Pump Station	$300,000	$873,000	$1,425,000	$2,700,000	$3,825,000	$4,800,000
2.	Headworks	$1,000,000	$2,910,000	$4,750,000	$9,000,000	$12,750,000	$16,000,000
3.	Flow Equalization	$500,000	$1,455,000	$2,375,000	$4,500,000	$6,375,000	$8,000,000
4.	5-stage Bardenpho Process	$3,500,000	$10,185,000	$16,625,000	$31,500,000	$44,625,000	$56,000,000
5.	Secondary Clarification	$750,000	$2,182,500	$3,562,500	$6,750,000	$9,562,500	$12,000,000
6.	RAS/WAS Pump Station	$400,000	$1,164,000	$1,900,000	$3,600,000	$5,100,000	$6,400,000
7.	Granular Filtration	$1,300,000	$3,783,000	$6,175,000	$11,700,000	$16,575,000	$20,800,000
8.	Chlorine Contact Chambers	$300,000	$873,000	$1,425,000	$2,700,000	$3,825,000	$4,800,000
9.	Sodium Hypochlorite Storage and Feed	$200,000	$582,000	$950,000	$1,800,000	$2,550,000	$3,200,000
10.	Aerated Sludge Holding	$400,000	$1,164,000	$1,900,000	$3,600,000	$5,100,000	$6,400,000
11.	Dewatering Facility	$500,000	$1,455,000	$2,375,000	$4,500,000	$6,375,000	$8,000,000
12.	Emergency Generator	$350,000	$1,018,500	$1,662,500	$3,150,000	$4,462,500	$5,600,000
13.	Operations/ Control Building	$200,000	$582,000	$950,000	$1,800,000	$2,550,000	$3,200,000
	Subtotal (1-13):	**$9,700,000**	**$28,227,000**	**$46,075,000**	**$87,300,000**	**$123,675,000**	**$155,200,000**

Table 4-14: Opinion of Probable Capital Cost: New Construction of 5-Stage Bardenpho Process with Conventional Activated Sludge (Continued)

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
14.	Yard piping	10%	$970,000	$2,822,700	$4,607,500	$8,730,000	$12,367,500	$15,520,000
15.	Mechanical	10%	$970,000	$2,822,700	$4,607,500	$8,730,000	$12,367,500	$15,520,000
16.	Electrical	25%	$2,425,000	$7,056,750	$11,518,750	$21,825,000	$30,918,750	$38,800,000
17.	Instrumentation and Controls	15%	$1,455,000	$4,234,050	$6,911,250	$13,095,000	$18,551,250	$23,280,000
18.	Site Work	10%	$970,000	$2,822,700	$4,607,500	$8,730,000	$12,367,500	$15,520,000
Subtotal (1-18):			**$16,490,000**	**$47,985,900**	**$78,327,500**	**$107,185,000**	**$173,872,500**	**$263,840,000**
19.	General Requirements	5%	$824,500	$2,399,295	$3,916,375	$7,420,500	$10,512,375	$13,192,000
20.	Contractor Overhead and Profit	15%	$1,018,500	$2,963,835	$4,837,875	$9,166,500	$12,985,875	$16,296,000
21.	Construction contingency	15%	$1,018,500	$2,963,835	$4,837,875	$9,166,500	$12,985,875	$16,296,000
Opinion of Probable Construction Cost (1-21):			**$19,351,500**	**$56,312,865**	**$91,919,625**	**$174,163,500**	**$246,731,625**	**$309,624,000**
22.	Technical Services	20%	$3,870,300	$11,262,573	$18,383,925	$34,832,700	$49,346,325	$61,924,800
23.	Owner Administration and Legal	5%	$967,575	$2,815,643	$4,595,981	$8,708,175	$12,336,581	$15,481,200
24.	Project Contingency	15%	$2,902,725	$8,446,930	$13,787,944	$26,124,525	$37,009,744	$46,443,600
Opinion of Probable Capital Cost(1-24):			**$27,092,100**	**$78,838,011**	**$128,687,475**	**$243,828,900**	**$345,424,275**	**$433,473,600**
Opinion of Equivalent Annual Capital Cost:			**$2,557,303**	**$7,441,751**	**$12,147,187**	**$23,015,723**	**$32,605,608**	**$40,916,841**

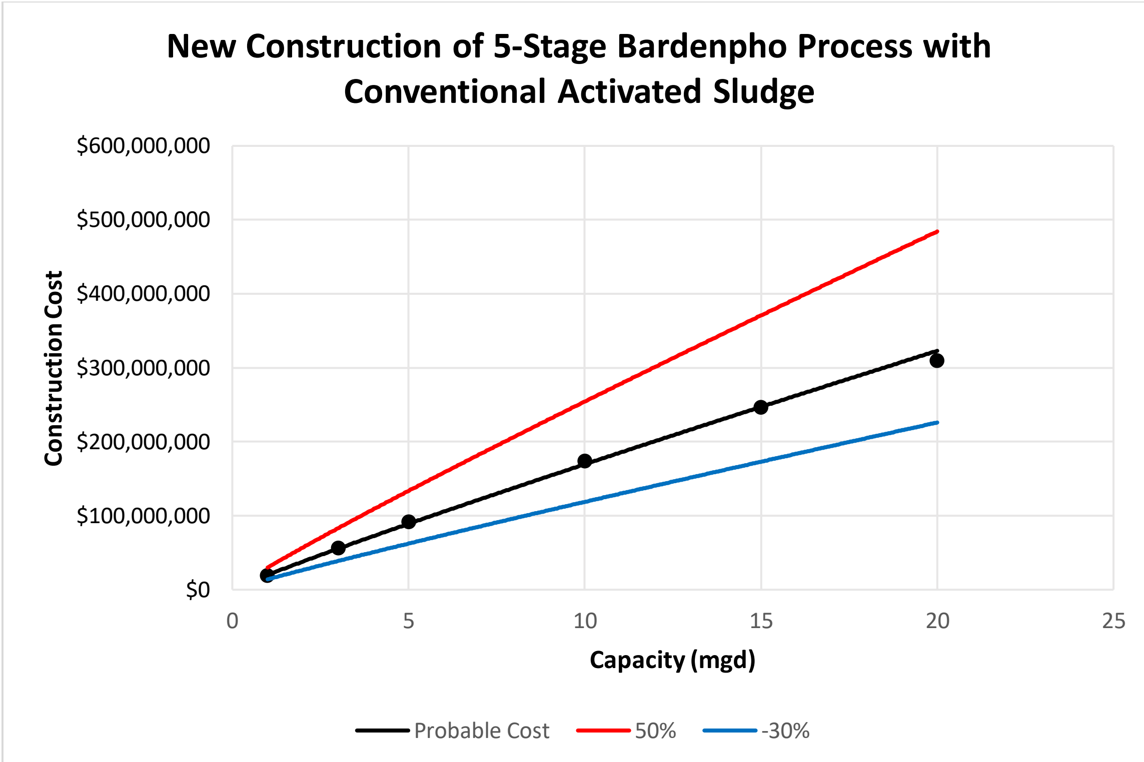

Figure 4-7: New Construction of 5-Stage Bardenpho Process with Conventional Activated Sludge Construction Cost Curves

Table 4-15: Opinion of Annual Operation and Maintenance Costs: New Construction of 5-Stage Bardenpho Process with Conventional Activated Sludge

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Influent Pump Station	$28,105	$81,786	$133,499	$252,945	$358,339	$449,680
2.	Headworks	$28,105	$81,786	$133,499	$252,945	$358,339	$449,680
3.	Flow Equalization	$28,105	$81,786	$133,499	$252,945	$358,339	$449,680
4.	5-stage AWT Process	$160,600	$467,346	$762,850	$1,445,400	$2,047,650	$2,569,600
5.	Secondary Clarification	$8,030	$23,367	$38,143	$72,270	$102,383	$128,480
6.	RAS/WAS Pump Station	$24,090	$70,102	$114,428	$216,810	$307,148	$385,440
7.	Granular Filtration	$24,090	$70,102	$114,428	$216,810	$307,148	$385,440
8.	Chlorine Contact Chambers	$4,015	$11,684	$19,071	$36,135	$51,191	$64,240
9.	Sodium Hypochlorite Storage and Feed	$4,015	$11,684	$19,071	$36,135	$51,191	$64,240
10.	Aerated Sludge Holding	$40,150	$116,837	$190,713	$361,350	$511,913	$642,400
11.	Dewatering Facility	$40,150	$116,837	$190,713	$361,350	$511,913	$642,400
12.	Emergency Generator	$8,030	$23,367	$38,143	$72,270	$102,383	$128,480
13.	Operations/Control Building	$4,015	$11,684	$19,071	$36,135	$51,191	$64,240
	Opinion of Annual O&M Cost:	**$401,500**	**$1,168,365**	**$1,907,125**	**$3,613,500**	**$5,119,125**	**$6,424,000**

Table 4-16: Opinion of Total Production Cost: New Construction of 5-Stage Bardenpho Process with Conventional Activated Sludge

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual Capital Cost	$2,557,303	$7,441,751	$12,147,187	$23,015,723	$32,605,608	$40,916,841
2.	Annual Operation and Maintenance Cost	$401,500	$1,168,365	$1,907,125	$3,613,500	$5,119,125	$6,424,000
3.	Annual R&R Fund Deposit(1)	$255,730	$744,175	$1,214,719	$2,301,572	$3,260,561	$4,091,684
	Total Annual Cost:	**$3,214,533**	**$9,354,291**	**$15,269,031**	**$28,930,796**	**$40,985,294**	**$51,432,525**
Annual Finished Reclaimed Water Production Rate (mgy)(2)		365	1,095	1,825	3,650	5,475	7,300
	Annual Production Cost ($/kgal)	**$8.81**	**$8.54**	**$8.37**	**$7.93**	**$7.49**	**$7.05**

(1) Annual deposit to a renewal and replacement (R&R) fund is equal to 10% of the equivalent annual capital cost.
(2) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

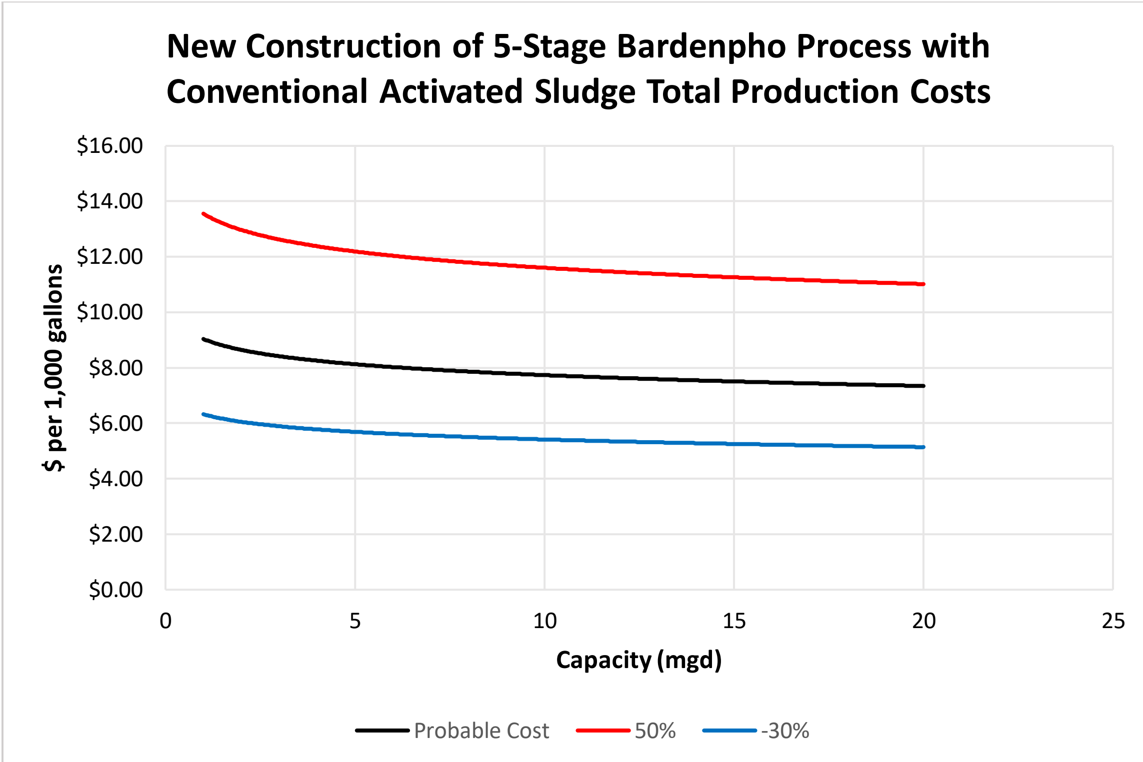

Figure 4-8: New Construction of 5-Stage Bardenpho Process with Conventional Activated Sludge Total Production Cost Curves

4.3.2 Cost Scenario No. 5 – Advanced Wastewater Treatment: Conversion to 5-Stage Bardenpho with Conventional Activated Sludge

Cost Scenario Development

The following are the components and criteria used in developing the planning level costs for converting an existing wastewater treatment facility producing public access reuse (i.e., high-level disinfection with tertiary filtration) to an AWT facility utilizing the 5-stage Bardenpho with Conventional Activated Sludge process.

It was assumed the existing facility is not required to be re-rated for additional treatment flow and loading capacity from the collection system. That is, it was assumed the existing headworks, grit removal (if existing), flow equalization (if required or existing), secondary clarification including RAS/WAS pump station, tertiary filtration system, disinfection components, biosolids storage and processing, and administrative buildings are sufficiently sized at the permitted flow and loadings and do not require improvements to meet AWT effluent standard. This was assumed due to the unique configuration and process flow of most wastewater treatment facilities. It is noted that this assumption will likely be valid for most facilities and unit process cost estimates from the greenfield (new) cost scenario could be used to complete a planning level cost estimate specific to an existing facility's configuration.

- New above-grade, cast-in-place concrete structure for five-stage advanced wastewater treatment with multiple process trains and the capacity to treat the specified design flows (with applicable peaking factors) with one train out of service. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances as described in Cost Scenario 4.

Specific Approach for Developing Planning Costs

The following is the specific approach used in this cost estimating effort.

- Construction costs for conversion to 5-Stage Bardenpho process with conventional Activated Sludge were obtained from unit costs derived from vendor equipment and bid prices. The unit costs include furnishing and installing the equipment/infrastructure. The projects included in this evaluation are listed in **Table 4-17** below.
- Construction costs for the associated yard piping, ancillary mechanical equipment, electrical equipment, instrumentation and control equipment, and site work are assumed as a percentage allowance of the construction costs for the addition of a 5-stage Bardenpho Process with Conventional Activated Sludge.

Table 4-17: Projects Evaluated for Cost Scenario No. 5: Conversion to 5-Stage Bardenpho with Conventional Activated Sludge

Location (County)	Municipality	Project Name
Brevard	Palm Bay	South Regional WRF
Manatee	Manatee County	NCRWRF Improvements
Sarasota	Sarasota County	Bee Ridge Interim Improvements
Palm Beach	East Central Regional	Aeration Improvements
Sarasota	City of North Port	West Villages WRF
Lake	Lady Lake	WRF Expansion – Phase 2
-	-	Vendor Pricing

The opinion of probable construction costs for converting a conventional AWT facility to utilize the 5-stage Bardenpho Process with Conventional Activated Sludge are summarized in **Table 4-18**. The construction cost curve is depicted in **Figure 4-9**. The opinion of annual O&M cost for converting a conventional AWT facility to utilize the 5-stage Bardenpho Process with Conventional Activated Sludge is summarized in **Table 4-19**. The total production cost for converting a conventional AWT facility to utilize the 5-stage Bardenpho Process with Conventional Activated Sludge is summarized in **Table 4-20**. The total production costs curve is depicted on **Figure 4-10.**

Table 4-18: Opinion of Probable Capital Cost: Conversion to 5-Stage Bardenpho Process with Conventional Activated Sludge

Item No.	Description	Allowance Factor	Plant Capacity (mgd) 1	3	5	10	15	20
1.	5-stage Bardenpho Process and Conventional Activated Sludge		$3,000,000	$8,730,000	$14,250,000	$27,000,000	$38,250,000	$48,000,000
	Subtotal:		**$3,000,000**	**$8,730,000**	**$14,250,000**	**$27,000,000**	**$38,250,000**	**$48,000,000**
2.	Yard piping	10%	$300,000	$873,000	$1,425,000	$2,700,000	$3,825,000	$4,800,000
3.	Mechanical	10%	$300,000	$873,000	$1,425,000	$2,700,000	$3,825,000	$4,800,000
4.	Electrical	20%	$600,000	$1,746,000	$2,850,000	$5,400,000	$7,650,000	$9,600,000
5.	Instrumentation and Controls	15%	$450,000	$1,309,500	$2,137,500	$4,050,000	$5,737,500	$7,200,000
6.	Site Work	10%	$300,000	$873,000	$1,425,000	$2,700,000	$3,825,000	$4,800,000
	Subtotal (1-6):		**$4,950,000**	**$14,404,500**	**$23,512,500**	**$44,550,000**	**$63,112,500**	**$79,200,000**
7.	General Requirements	5%	$247,500	$720,225	$1,175,625	$2,227,500	$3,155,625	$3,960,000
8.	Contractor Overhead and Profit	15%	$292,500	$851,175	$1,389,375	$2,632,500	$3,729,375	$4,680,000
9.	Construction contingency	15%	$292,500	$851,175	$1,389,375	$2,632,500	$3,729,375	$4,680,000
	Opinion of Probable Construction Cost (1-9):		**$5,782,500**	**$16,827,075**	**$27,466,875**	**$52,042,500**	**$73,726,875**	**$92,520,000**
10.	Technical Services	20%	$1,156,500	$3,365,415	$5,493,375	$10,408,500	$14,745,375	$18,504,000
11.	Owner Administration and Legal	5%	$289,125	$841,354	$1,373,344	$2,602,125	$3,686,344	$4,626,000
12.	Project Contingency	15%	$867,375	$2,524,061	$4,120,031	$7,806,375	$11,059,031	$13,878,000
	Opinion of Probable Capital Cost (1-12):		**$8,095,500**	**$23,557,905**	**$38,453,625**	**$72,859,500**	**$103,217,625**	**$129,528,000**
	Opinion of Equivalent Annual Capital Cost		**$764,158**	**$2,223,700**	**$3,629,750**	**$6,877,421**	**$9,743,014**	**$12,226,527**

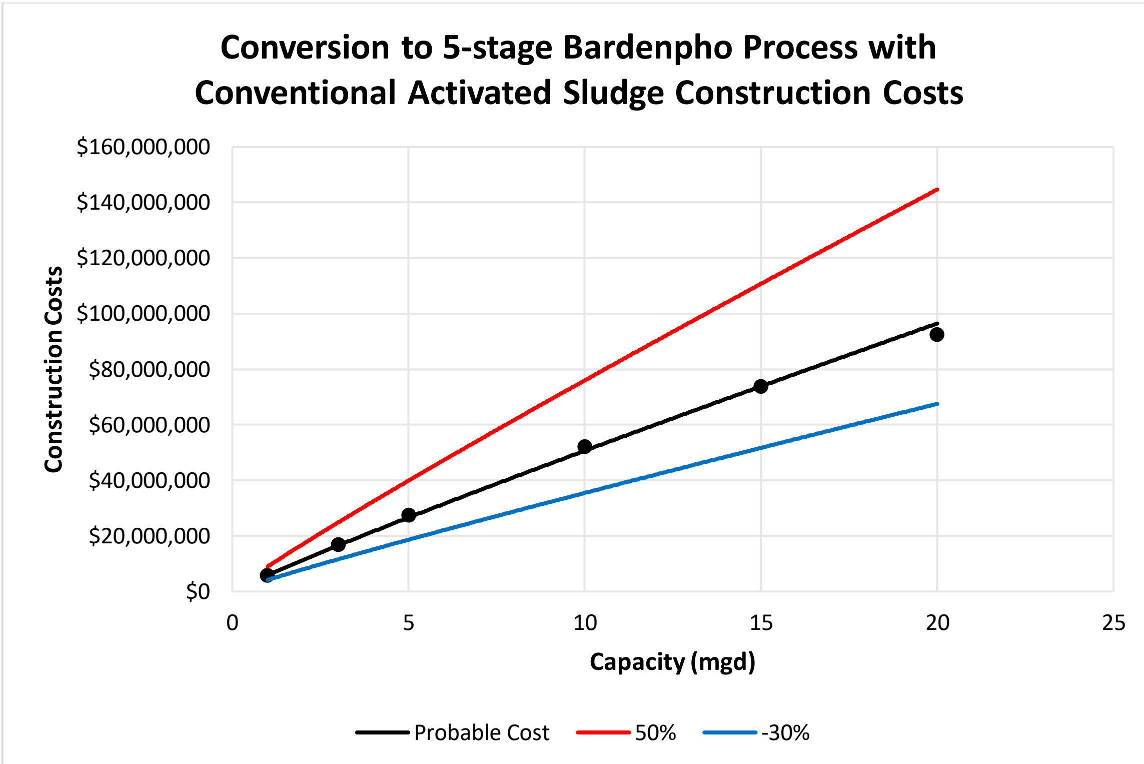

Figure 4-9: Conversion to 5-Stage Bardenpho Process with Conventional Activated Sludge Construction Cost Curves

Table 4-19: Opinion of Annual Operation and Maintenance Cost: Conversion to 5-stage Bardenpho Process with Conventional Activated Sludge

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	5-stage Bardenpho Process and Conventional Activated Sludge	$1,200	$3,492	$5,700	$10,800	$15,300	$19,200
	Opinion of Annual O&M Cost:	**$438,000**	**$1,274,580**	**$2,080,500**	**$3,942,000**	**$5,584,500**	**$7,008,000**

Table 4-20: Opinion of Total Production Cost: Conversion to 5-stage Bardenpho Process with Conventional Activated Sludge

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual Capital Cost	$764,158	$2,223,700	$3,629,750	$6,877,421	$9,743,014	$12,226,527
2.	Annual Operation and Maintenance Cost	$438,000	$1,274,580	$2,080,500	$3,942,000	$5,584,500	$7,008,000
3.	Annual R&R Fund Deposit(1)	$76,416	$222,370	$362,975	$687,742	$974,301	$1,222,653
	Total Annual Cost:	**$1,278,574**	**$3,720,650**	**$6,073,225**	**$11,507,164**	**$16,301,815**	**$20,457,180**
Annual Finished Reclaimed Water Production rate (mgy)(2)		365	1,095	1,825	3,650	5,475	7,300
	Annual Production Cost ($/kgal):	**$3.50**	**$3.40**	**$3.33**	**$3.15**	**$2.98**	**$2.80**

(1) Annual deposit to a renewal and replacement (R&R) fund is equal to 10% of the equivalent annual capital cost.
(2) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

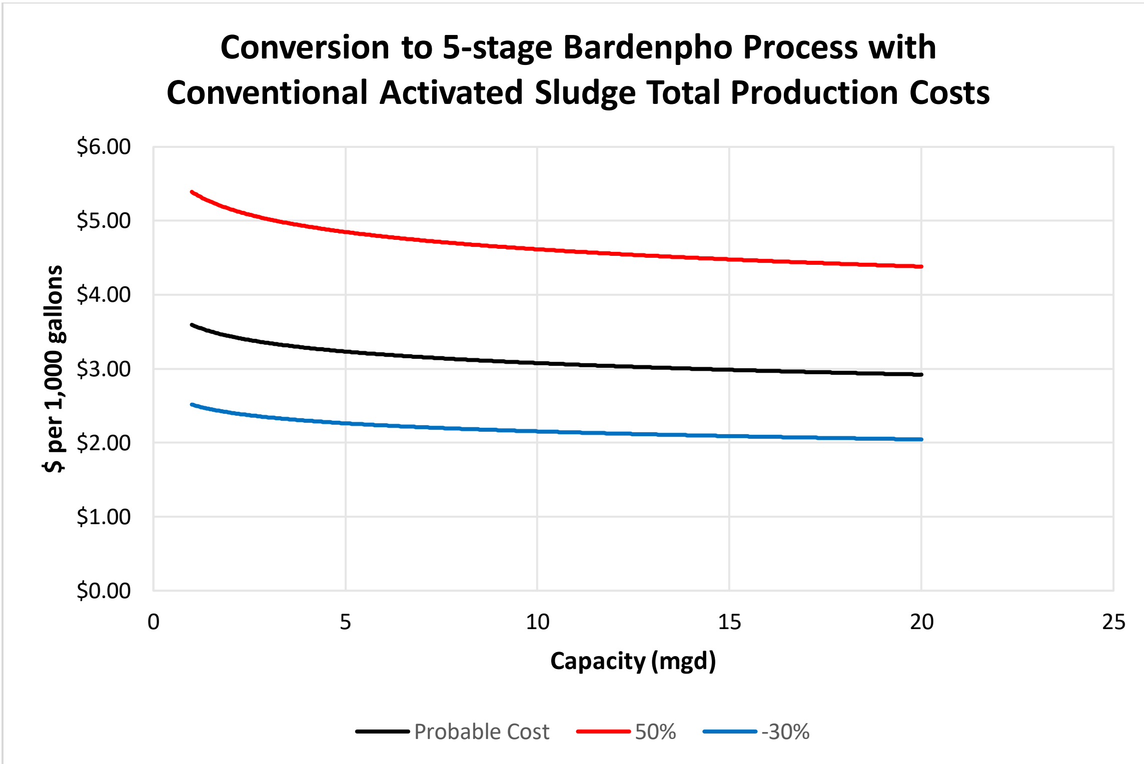

Figure 4-10: Conversion to 5-Stage Bardenpho Process with Conventional Activated Sludge Total Production Cost Curves

4.3.3 Cost Scenario No. 6 – Advanced Wastewater Treatment: New Construction of Five-Stage Bardenpho with Membrane Bioreactor

Cost Scenario Development

The following are the components and criteria used in developing the planning level costs for constructing a new AWTF utilizing 5-stage Bardenpho process with immersed MBR.

- New influent pump station including wet well, rail-mounted submersible pumps with the capacity to pump the specified design flows (with applicable peaking factors) with one pump out of service.
- New above-grade, cast-in-place concrete structure for raw wastewater coarse screening and grit removal with the capacity to pretreat the specified design flows (with applicable peaking factors) with one screen out of service. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, cast-in-place concrete structure for raw wastewater fine screening with the capacity to pretreat the specified design flows (with applicable peaking factors) with one screen out of service. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, cast-in-place concrete structure for screened and de-gritted wastewater with the capacity to equalize influent flows and loads to reduce downstream design peaking factors. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, cast-in-place concrete structure for 5-stage advanced wastewater treatment with multiple process trains and the capacity to treat the specified design flows (with applicable peaking factors) with one train out of service. Includes concrete structure, piping, coatings, aeration system components, mechanical equipment, and associated appurtenances.
- New above-grade, cast-in-place concrete structure for UF membrane with multiple membrane process trains using MBR and the capacity (flux) for liquid/solids separation at the specified design flows (with applicable peaking factors) with one membrane process train out of service. Includes concrete structure, piping, coatings, permeate pump station, air scour blowers, mechanical equipment, and associated appurtenances.
- New above-grade, RAS/WAS pump station with the capacity to pump the specified design RAS and WAS flows (with applicable peaking factors) with one pump out of service.
- New liquid sodium hypochlorite storage and feed system to achieve 1.0 mg/L total chlorine residual.
- New chlorine contact chamber to achieve 15-minute contact time at peak hour and Class I reliability (i.e., treat 50% of design flow with largest unit out of service)
- New above-grade, cast-in-place concrete structure for aerated sludge holding with multiple tanks and the capacity to treat (or hold), aerate, and batch process the specified WAS design flows (with applicable peaking factors) with one tank out of service. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, biosolids dewatering station with multiple units and the capacity to dewater the specified biosolids generated at the facility (with applicable peaking factors) with one unit out of service.

- New above-grade, emergency generator with fuel storage with the capacity to provide emergency backup power to the required equipment to maintain operations.
- New operations and control building including administration offices, locker rooms, break room, equipment storage, operator's workstations, laboratory, and associated building infrastructure.

Specific Approach for Developing Planning Costs

The following is the specific approach used in this cost estimating effort.

- Construction costs for unit process structures, equipment, and associated appurtenances were obtained from unit costs derived from vendor equipment and bid prices. The unit costs include furnishing and installing the equipment/infrastructure. The projects included in this evaluation are listed in **Table 4-21** below.
- Construction costs for the associated yard piping, ancillary mechanical equipment, electrical equipment, instrumentation and control equipment, and site work are assumed as a percentage allowance of the construction costs for the and 5-stage Bardenpho Process with MBR.

Table 4-21: Projects Evaluated for Cost Scenario No. 6: New Construction of 5-Stage Bardenpho with MBR

Location (County)	Municipality	Project Name
Volusia	Deltona	Eastern WRF Membrane Addition
Chatham (GA)	City of Savannah	Travis Fields
Brevard	Palm Bay	South Regional WRF
Manatee	Manatee County	NCRWRF Improvements
Sarasota	Sarasota County	Bee Ridge Interim Improvements
Palm Beach	East Central Regional	Aeration Improvements
Sarasota	City of North Port	West Villages WRF
Lake	Lady Lake	WRF Expansion – Phase 2
-	-	Vendor Pricing

The opinion of probable construction costs for an AWTF, 5-stage Bardenpho with MBR, are summarized in **Table 4-22**. The construction cost is depicted in **Figure 4-11**. The opinion of annual O&M cost for an AWTF utilizing 5-stage Bardenpho with MBR is summarized in **Table 4-23**. The total production cost for an AWTF, utilizing 5-stage Bardenpho with MBR are summarized in **Table 4-24**. The total production costs curve is depicted on **Figure 4-12.**

Table 4-22: Opinion of Probably Capital Cost: New Construction of 5-stage Bardenpho with MBR

Item No.	Description Allowance Factor		Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	Influent Pump Station		$300,000	$873,000	$1,425,000	$2,700,000	$3,825,000	$4,800,000
2.	Headworks - Coarse Screen and Grit Removal		$600,000	$1,746,000	$2,850,000	$5,400,000	$7,650,000	$9,600,000
3.	Headworks - Fine Screening		$750,000	$2,182,500	$3,562,500	$6,750,000	$9,562,500	$12,000,000
4.	Flow Equalization		$400,000	$1,164,000	$1,900,000	$3,600,000	$5,100,000	$6,400,000
5.	5-stage Bardenpho Process		$3,000,000	$8,730,000	$14,250,000	$27,000,000	$38,250,000	$48,000,000
6.	MBR		$2,500,000	$7,275,000	$11,875,000	$22,500,000	$31,875,000	$40,000,000
7.	RAS/WAS Pump Station		$400,000	$1,164,000	$1,900,000	$3,600,000	$5,100,000	$6,400,000
8.	Chlorine Contact Chambers		$300,000	$873,000	$1,425,000	$2,700,000	$3,825,000	$4,800,000
9.	Sodium Hypochlorite Storage and Feed		$200,000	$582,000	$950,000	$1,800,000	$2,550,000	$3,200,000
10.	Aerated Sludge Holding		$400,000	$1,164,000	$1,900,000	$3,600,000	$5,100,000	$6,400,000
11.	Dewatering Facility		$500,000	$1,455,000	$2,375,000	$4,500,000	$6,375,000	$8,000,000
12.	Emergency Generator		$350,000	$1,018,500	$1,662,500	$3,150,000	$4,462,500	$5,600,000
13.	Operations/Control Building		$200,000	$582,000	$950,000	$1,800,000	$2,550,000	$3,200,000
Subtotal (1-13):			**$9,900,000**	**$28,809,000**	**$47,025,000**	**$89,100,000**	**$126,225,000**	**$158,400,000**
14.	Yard piping	10%	$990,000	$2,880,900	$4,702,500	$8,910,000	$12,622,500	$15,840,000
15.	Mechanical	10%	$990,000	$2,880,900	$4,702,500	$8,910,000	$12,622,500	$15,840,000
16.	Electrical	25%	$2,475,000	$7,202,250	$11,756,250	$22,275,000	$31,556,250	$39,600,000
17.	Instrumentation and controls	15%	$1,485,000	$4,321,350	$7,053,750	$13,365,000	$18,933,750	$23,760,000
18.	Site work	10%	$990,000	$2,880,900	$4,702,500	$8,910,000	$12,622,500	$15,840,000
Subtotal (1-18):			**$16,830,000**	**$48,975,300**	**$79,942,500**	**$151,470,000**	**$214,582,500**	**$269,280,000**
19.	General Requirements	5%	$841,500	$2,448,765	$3,997,125	$7,573,500	$10,729,125	$13,464,000
20.	Contractor Overhead and Profit	15%	$1,039,500	$3,024,945	$4,937,625	$9,355,500	$13,253,625	$16,632,000
21.	Construction Contingency	15%	$1,039,500	$3,024,945	$4,937,625	$9,355,500	$13,253,625	$16,632,000
Opinion of Probable Construction Cost (1-21):			**$19,750,500**	**$57,473,955**	**$93,814,875**	**$177,754,500**	**$251,818,875**	**$316,008,000**
22.	Technical Services	20%	$3,950,100	$11,494,791	$18,762,975	$35,550,900	$50,363,775	$63,201,600
23.	Owner Administration and Legal	5%	$987,525	$2,873,698	$4,690,744	$8,887,725	$12,590,944	$15,800,400
24.	Project Contingency	15%	$2,962,575	$8,621,093	$14,072,231	$26,663,175	$37,772,831	$47,401,200
Opinion of Probable Capital Cost (1-24):			**$27,650,700**	**$80,463,537**	**$131,340,825**	**$248,856,300**	**$352,546,425**	**$442,411,200**
Opinion of Equivalent Annual Capital Cost			**$2,610,030**	**$7,595,189**	**$12,397,645**	**$23,490,274**	**$33,277,889**	**$41,760,488**

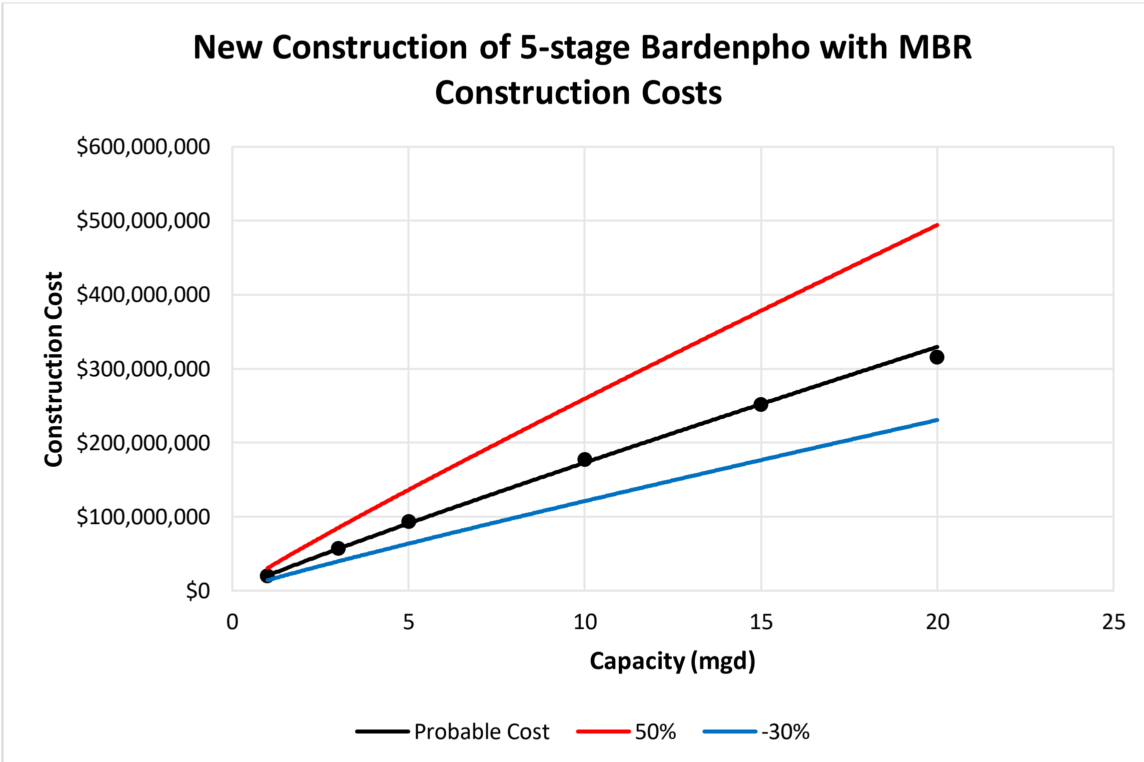

Figure 4-11: New Construction of 5-Stage Bardenpho with MBR Construction Cost Curves

Table 4-23: Opinion of Annual Operation and Maintenance Cost: New Construction of 5-stage Bardenpho with MBR

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Influent Pump Station	$35,770	$104,090	$169,907	$321,930	$456,067	$572,320
2.	Headworks - Coarse Screen and Grit Removal	$35,770	$104,090	$169,907	$321,930	$456,067	$572,320
3.	Headworks - Fine Screening	$35,770	$104,090	$169,907	$321,930	$456,067	$572,320
4.	Flow Equalization	$51,100	$148,701	$242,725	$459,900	$651,525	$817,600
5.	5-stage Bardenpho Process	$168,630	$490,713	$800,992	$1,517,670	$2,150,032	$2,698,080
6.	MBR	$61,320	$178,441	$291,270	$551,880	$781,830	$981,120
7.	RAS/WAS Pump Station	$30,660	$89,220	$145,635	$275,940	$390,915	$490,560
8.	Chlorine Contact Chambers	$5,110	$14,870	$24,272	$45,990	$65,152	$81,760
9.	Sodium Hypochlorite Storage and Feed	$5,110	$14,870	$24,272	$45,990	$65,152	$81,760
10.	Aerated Sludge Holding	$35,770	$104,090	$169,907	$321,930	$456,067	$572,320
11.	Dewatering Facility	$35,770	$104,090	$169,907	$321,930	$456,067	$572,320
12.	Emergency Generator	$5,110	$14,870	$24,272	$45,990	$65,152	$81,760
13.	Operations/Control Building	$5,110	$14,870	$24,272	$45,990	$65,152	$81,760
	Opinion of Annual O&M Cost:	**$511,000**	**$1,487,010**	**$2,427,250**	**$4,599,000**	**$6,515,250**	**$8,176,000**

Table 4-24: Opinion of Total Production Cost - New Construction of 5-stage Bardenpho with MBR

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent annual Capital Cost	$2,610,030	$7,595,189	$12,397,645	$23,490,274	$33,277,889	$41,760,488
2.	Annual Operation and Maintenance Cost	$511,000	$1,487,010	$2,427,250	$4,599,000	$6,515,250	$8,176,000
3.	Annual R&R Fund Deposit(1)	$261,003	$759,519	$1,239,764	$2,349,027	$3,327,789	$4,176,049
	Total Annual Cost:	**$3,382,034**	**$9,841,718**	**$16,064,659**	**$30,438,302**	**$43,120,927**	**$54,112,536**
Annual Finished Reclaimed Water Production Rate (mgy)(2)		365	1,095	1,825	3,650	5,475	7,300
	Annual Production Cost ($/kgal)	**$9.27**	**$8.99**	**$8.80**	**$8.34**	**$7.88**	**$7.41**

(1) Annual deposit to a renewal and replacement (R&R) fund is equal to 10% of the equivalent annual capital cost.
(2) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

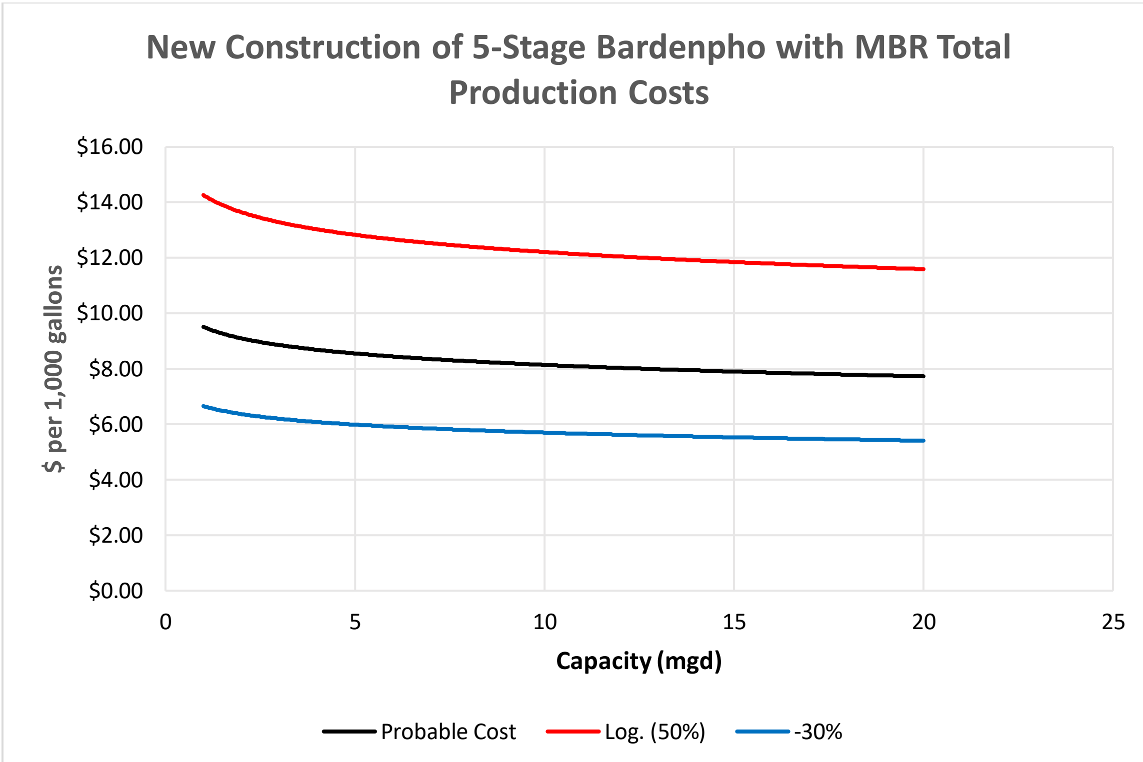

Figure 4-12: New Construction of 5-stage Bardenpho with MBR Total Production Costs

4.3.4 Cost Scenario No. 7 – Advanced Wastewater Treatment: Conversion to Five-Stage Bardenpho with Membrane Bioreactor

Cost Scenario Development

The following are the components and criteria used in developing the planning level costs for converting an existing wastewater treatment facility producing public access reuse (i.e., high-level disinfection with tertiary filtration) to an AWTF utilizing the 5-stage Bardenpho with MBR process. It was assumed new influent pump station, headworks, RAS/WAS pump station, and flow equalization is required.

It was assumed the existing facility is not required to be re-rated for additional treatment flow and loading capacity from the collection system. That is, it was assumed the existing tertiary filtration system, disinfection components, biosolids storage and processing, and administrative buildings are sufficiently sized at the permitted flow and loadings and do not require improvements to meet AWT effluent standard. This was assumed due to the unique configuration and process flow of most wastewater treatment facilities. It is noted that this assumption will likely to be valid for most facilities and unit process cost estimates from the new construction cost scenario could be used to complete a planning level cost estimate specific to an existing facility's configuration.

- New above-grade, cast-in-place concrete structure for raw wastewater coarse screening and grit removal with the capacity to pretreat the specified design flows (with applicable peaking factors) with one screen out of service. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, cast-in-place concrete structure for raw wastewater fine screening with the capacity to pretreat the specified design flows (with applicable peaking factors) with one screen out of service. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, cast-in-place concrete structure for screened and de-gritted wastewater with the capacity to equalize influent flows and loads to reduce downstream design peaking factors. Includes concrete structure, piping, coatings, mechanical equipment, and associated appurtenances.
- New above-grade, cast-in-place concrete structure for five-stage advanced wastewater treatment with multiple process trains and the capacity to treat the specified design flows (with applicable peaking factors) with one train out of service. Includes concrete structure, piping, coatings, aeration system components, mechanical equipment, and associated appurtenances.
- New above-grade, cast-in-place concrete structure for UF liquid/solids separation with multiple MBR trains and the capacity (flux) for liquid/solids separation at the specified design flows (with applicable peaking factors) with one membrane process train out of service. Includes concrete structure, piping, coatings, permeate pump station, air scour blowers, mechanical equipment, and associated appurtenances.

Specific Approach for Developing Planning Costs

The following is the specific approach used in this cost estimating effort.

- Construction costs for unit process structures, equipment, and associated appurtenances were obtained from unit costs derived from vendor equipment and bid prices. The unit costs include furnishing and installing the equipment/infrastructure. The projects included in this evaluation are listed in **Table 4-25** below.
- Construction costs for the associated yard piping, ancillary mechanical equipment, electrical equipment, instrumentation and control equipment, and site work are assumed as a percentage allowance of the construction costs for the new influent pump station, headworks, flow equalization, and feed improvements, and 5-stage Bardenpho with MBR.

Table 4-25: Projects Evaluated for Cost Scenario No. 7: Conversion to 5-Stage Bardenpho with MBR

Location (County)	Municipality	Project Name
Volusia	Deltona	Eastern WRF Membrane Addition
Chatham (GA)	City of Savannah	Travis Fields
Brevard	Palm Bay	South Regional WRF
Manatee	Manatee County	NCRWRF Improvements
Sarasota	Sarasota County	Bee Ridge Interim Improvements
Palm Beach	East Central Regional	Aeration Improvements
Sarasota	City of North Port	West Villages WRF
Lake	Lady Lake	WRF Expansion – Phase 2
-	-	Vendor Pricing

The opinion of probable construction costs for AWTF utilizing five-stage Bardenpho process with UF/MBR are summarized in **Table 4-26**. The construction cost curve is depicted in **Figure 4-13**. The opinion of annual O&M cost for AWTF utilizing five-stage Bardenpho process with UF/MBR is summarized in **Table 4-27**. The total production cost AWT facility utilizing 5-stage Bardenpho process with MBR is summarized in **Table 4-28**. The total production costs curve is depicted on **Figure 4-14**

Table 4-26: Opinion of Probable Capital Cost: Conversion to 5-stage Bardenpho with MBR

Item No.	Description	Allowance Factor	Plant Capacity (mgd) 1	3	5	10	15	20
1.	Influent Pump Station		$300,000	$873,000	$1,425,000	$2,700,000	$3,825,000	$4,800,000
2.	Headworks - Coarse Screen and Grit Removal		$400,000	$1,164,000	$1,900,000	$3,600,000	$5,100,000	$6,400,000
3.	Headworks - Fine Screening		$450,000	$1,309,500	$2,137,500	$4,050,000	$5,737,500	$7,200,000
4.	Flow Equalization		$400,000	$1,164,000	$1,900,000	$3,600,000	$5,100,000	$6,400,000
5.	5-stage Bardenpho Process		$2,000,000	$5,820,000	$9,500,000	$18,000,000	$25,500,000	$32,000,000
6.	MBR		$1,500,000	$4,365,000	$7,125,000	$13,500,000	$19,125,000	$24,000,000
7.	RAS/WAS Pump Station		$400,000	$1,164,000	$1,900,000	$3,600,000	$5,100,000	$6,400,000
Subtotal (1-7):			**$5,450,000**	**$15,859,500**	**$25,887,500**	**$49,050,000**	**$69,487,500**	**$87,200,000**
8.	Yard piping	10%	$545,000	$1,585,950	$2,588,750	$4,905,000	$6,948,750	$8,720,000
9.	Mechanical	10%	$545,000	$1,585,950	$2,588,750	$4,905,000	$6,948,750	$8,720,000
10.	Electrical	20%	$1,090,000	$3,171,900	$5,177,500	$9,810,000	$13,897,500	$17,440,000
11.	Instrumentation and Controls	15%	$817,500	$2,378,925	$3,883,125	$7,357,500	$10,423,125	$13,080,000
12.	Site Work	10%	$545,000	$1,585,950	$2,588,750	$4,905,000	$6,948,750	$8,720,000
Subtotal (1-12):			**$8,992,500**	**$26,168,375**	**$42,714,375**	**$129,982,500**	**$114,654,375**	**$143,880,000**
13.	General Requirements	5%	$449,625	$1,308,409	$2,135,719	$4,046,625	$5,732,719	$7,194,000
14.	Contractor Overhead and Profit	15%	$531,375	$1,546,301	$2,524,031	$4,782,375	$6,775,031	$8,502,000
15.	Construction Contingency	15%	$531,375	$1,546,301	$2,524,031	$4,782,375	$6,775,031	$8,502,000
Opinion of Probable Construction Cost (1-15):			**$10,504,875**	**$30,569,186**	**$49,898,156**	**$94,543,875**	**$133,937,156**	**$168,078,000**
16.	Technical Services	20%	$2,100,975	$6,113,837	$9,979,631	$18,908,775	$26,787,431	$33,615,600
17.	Owner Administration and legal	5%	$525,244	$1,528,459	$2,494,908	$4,727,194	$6,696,858	$8,403,900
18.	Project Contingency	15%	$1,575,731	$4,585,378	$7,484,723	$14,181,581	$20,090,573	$25,211,700
Opinion of Probable Capital Cost (1-18):			**$14,706,825**	**$42,796,861**	**$69,857,419**	**$132,361,425**	**$187,512,019**	**$235,309,200**
Opinion of Equivalent Annual Capital Cost:			**$1,388,220**	**$4,039,721**	**$6,594,046**	**$12,493,982**	**$17,699,808**	**$22,211,524**

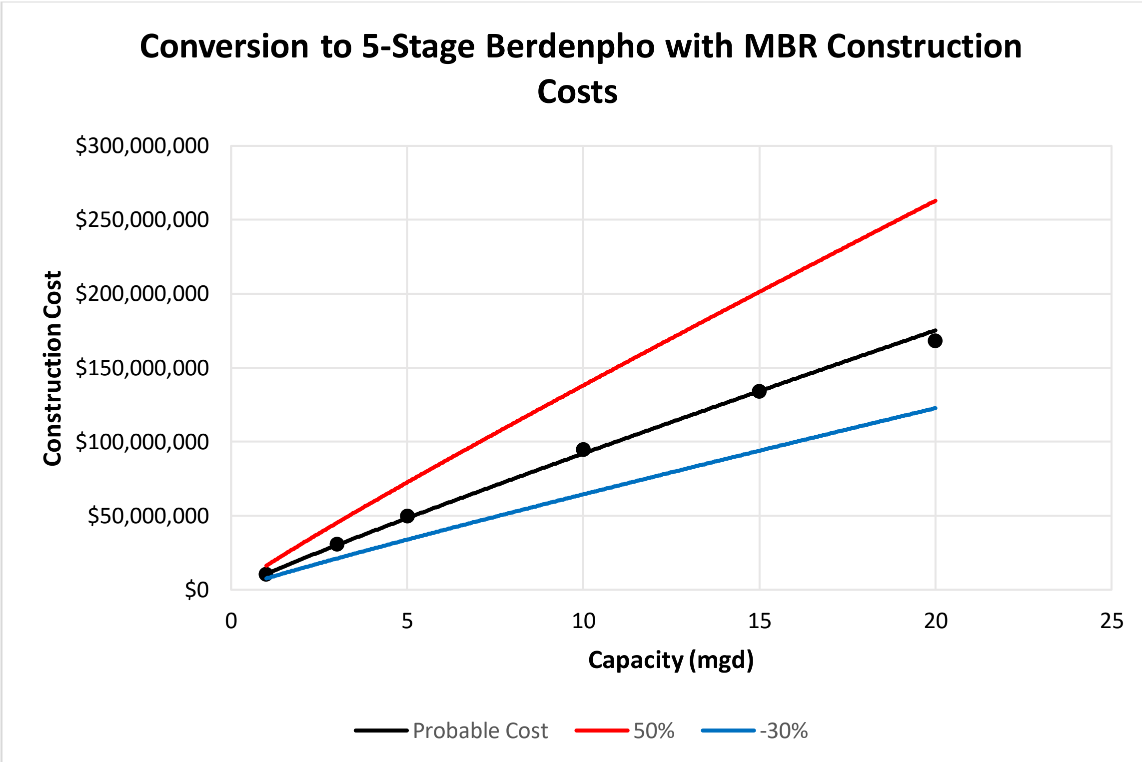

Figure 4-13: Conversion to 5-Stage Bardenpho with MBR Construction Costs

Table 4-27: Opinion of Annual Operation and Maintenance Cost: Conversion to 5-Stage Bardenpho with MBR

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Influent Pump Station	$33,215	$96,656	$157,771	$298,935	$423,491	$531,440
2.	Headworks - Coarse Screen and Grit Removal	$33,215	$96,656	$157,771	$298,935	$423,491	$531,440
3.	Headworks - Fine Screening	$33,215	$96,656	$157,771	$298,935	$423,491	$531,440
4.	Flow Equalization	$47,450	$138,080	$225,388	$427,050	$604,988	$759,200
5.	5-Stage Bardenpho Process	$156,585	$455,662	$743,779	$1,409,265	$1,996,459	$2,505,360
6.	MBR	$56,940	$165,695	$270,465	$512,460	$725,985	$911,040
7.	RAS/WAS Pump Station	$28,470	$82,848	$135,233	$256,230	$362,993	$455,520
	Opinion of Annual O&M Cost:	**$389,090**	**$1,132,252**	**$1,848,178**	**$3,501,810**	**$4,960,898**	**$6,225,440**

Table 4-28: Opinion of Total Production Cost: Conversion to 5-Stage Bardenpho with MBR

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual Capital Cost	$1,388,220	$4,039,721	$6,594,046	$12,493,982	$17,699,808	$22,211,524
2.	Annual Operation and Maintenance Cost	$389,090	$1,132,252	$1,848,178	$3,501,810	$4,960,898	$6,225,440
3.	Annual R&R Fund Deposit(1)	$138,822	$403,972	$659,405	$1,249,398	$1,769,981	$2,221,152
	Total Annual Cost:	**$1,916,132**	**$5,575,945**	**$9,101,628**	**$17,245,190**	**$24,430,686**	**$30,658,116**
Annual Finished Reclaimed Water Production rate (mgy)(2)		365	1,095	1,825	3,650	5,475	7,300
Annual Production Cost ($/kgal)		**$5.25**	**$5.09**	**$4.99**	**$4.72**	**$4.46**	**$4.20**

Annual deposit to a renewal and replacement (R&R) fund is equal to 10% of the equivalent annual capital cost.
Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

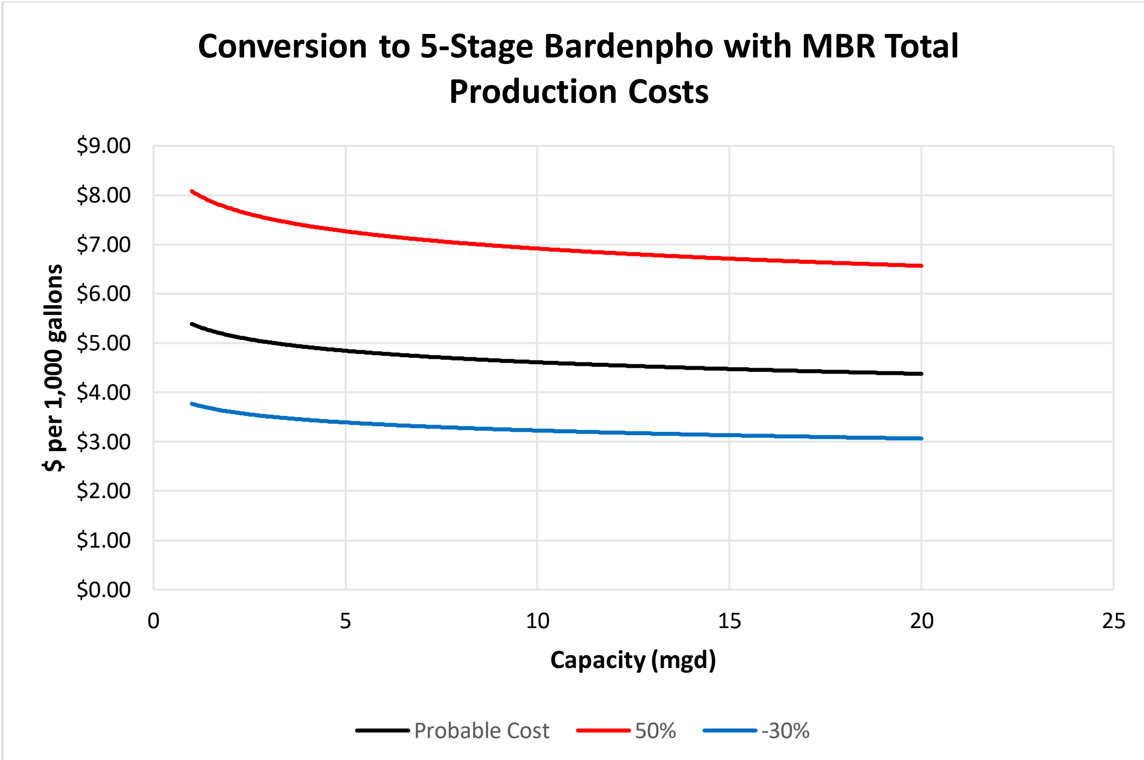

Figure 4-14: Conversion to 5-Stage Bardenpho with MBR Total Production Costs

4.4 ADVANCED WATER TREATMENT FACILITIES FOR POTABLE REUSE

4.4.1 INTRODUCTION

The purpose of this section is to provide an overview of AWTF for DPR and IPR. An AWTF uses advanced water treatment technologies (extending beyond secondary, tertiary, and advanced wastewater treatment) for DPR and IPR applications such as:

- **Direct potable reuse** – The introduction of reclaimed water (with or without retention in an engineered storage buffer) directly into a drinking water treatment plant, either co-located or remote from the advanced wastewater treatment system. A key distinction is the absence of an environmental buffer, or additional treatment through natural resources such as groundwater aquifer or rapid infiltration basins, although an environmental buffer may be included.
- **Indirect Potable Reuse** – This type of reuse system involves the planned use of reclaimed water to augment surface water resources which are used or will be used for public water supplies. The treatment requirements depend on the class of surface waters to which the reclaimed water is discharged. While the injection of reclaimed water into a drinking water aquifer is also sometimes referred to as IPR, this is included as groundwater recharge.

Individual unit processes are assembled in a range of combinations to achieve water quality appropriate for potable reuse with and without RO. The individual processes for AWTF with RO are listed below.

Advanced Water Treatment Technology

For AWT technologies, a number of different treatment processes are grouped together to remove the particulate, colloidal, and dissolved inorganic and organic constituents found in the effluent from wastewater treatment facilities. Although many of the treatment processes can be used to remove particulate and colloidal constituents, only specific treatment processes remove total dissolved solids and specific target constituents. The grouping of technologies to achieve a specific treatment objective is known as a treatment train.

The cost scenarios in this section assume the wastewater treatment facility is currently operating with tertiary (filtration and high-level disinfection) and advanced wastewater treatment (nutrient removal).

Cost Scenario No. 8 in this study, represents cost associated with a new AWTF using RO-based treatment trains.

Cost Scenario No. 9 in this study, represents cost associated the addition of AWTF without RO-based treatment trains.

Treatment Trains with Reverse Osmosis

The individual processes for AWTF with RO are listed below

- Pre-treatment with MF or UF
- Cartridge filtration
- Multi-stage RO trains
- Concentrate disposal
- AOP
- Post-processing including stabilization
- ESB with liquid sodium hypochlorite disinfection

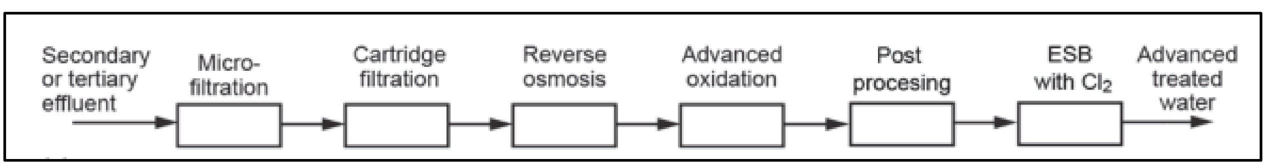

Figure 4-15: AWTF with RO Process Flow Diagram (Florida Potable Reuse Commission, 2015)

Micro-filtration (MF and UF) are used for pre-treatment of the wastewater and remove additional residual suspended solids by mechanical sieving.

Cartridge filtration is a process which removes suspended and colloidal impurities to prevent fouling on RO membranes. Typical filter cartridge pore size range is 5 to 10 micrometers (μm).

Multi-stage RO, a high pressure-driven membrane process, separates dissolved constituents from water into a concentrate and permeate stream. RO membranes are effective at removing

TDS, pathogens, and organic chemicals, including regulated contaminants and emerging constituents such as hormones, pharmaceuticals, endocrine disruptors, and personal care products. Treating reclaimed water with RO usually results in product water recoveries of 70% to 85%. As a result, there is a net loss of water through disposal of the concentrate.

Treatment Trains without Reverse Osmosis

Because of high energy cost of operation and logistical issues associated with managing RO concentrate, non-RO based treatment trains have been developed using other treatment processes such as ozone, biologically active filtration, UF, granular active carbon filtration, and advanced oxidation processes. The lack of TDS removal in the finished water are the principal differences between the RO-based and non-RO based treatment trains (Florida Potable Reuse Commission, 2015).

Pathogen control can be accomplished in non-RO treatment technologies using disinfection treatment along with alternative treatment technologies and typically include the following processes:

- Ozone and BAF
- Pre-treatment with MF and UF
- GAC Filtration (not shown in **Figure 4-16**)
- AOP
- ESB with liquid sodium hypochlorite disinfection

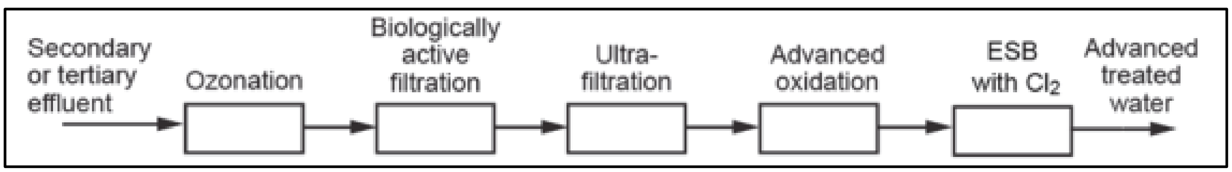

Figure 4-16: WTF without RO Process Flow Diagram (Florida Potable Reuse Commission, 2015)

Technologies included in AWTF without RO that are not considered in AWTF with RO are ozone and BAF and GAC filtration. Ozone followed by BAF is a process that achieves a reduction in pathogenic microorganisms and trace organics, and condition treated secondary effluent to enhance the performance of downstream processes.

GAC is a process that removes trace organic compounds. This technology can be used with other technologies for the removal of trace organic compounds.

Treatment Trains Common to Both

The AOP process destroys or alters chemical constituents that are not completely removed by upstream processes, especially trace organics. AOP may contain a range of processes, but most commonly uses ozone with H_2O_2 or UV with H_2O_2. More recent projects are implementing UV with sodium hypochlorite for AOP. The use of UV, ozone, and sodium hypochlorite also provides disinfection.

After treatment in an AWTF with or without RO, the water may be sent to an ESB or to a drinking water treatment plant WTP for further treatment. An ESB can be used for storage to provide additional confirmation of water quality to ensure that the advanced treated water will only be released to the drinking water facility for additional treatment or be released to the public water system. Several configurations can be used for the design such as plug-flow pipelines, lined and possibly covered reservoirs, baffled tanks, or tanks in parallel operated in a fill, store, and draw mode.

4.4.2 Cost Scenario No. 8 – Adding Advanced Water Treatment with RO to Existing Tertiary and Advanced Wastewater Treatment Facilities

Cost Scenario Development

The following are the components and criteria used in developing the planning level costs for adding AWT to existing tertiary wastewater treatment facilities or AWTF.

- New CMU building with roll-up service doors for the advanced water treatment unit processes and associated equipment.
- New feedwater (tertiary or advanced effluent) pump station to pressurize the MF membrane module feedwater.
- New, skid mounted, MF/UF membrane treatment system including backwash and air scour components with the capacity to treat the specified design flows (with applicable peaking factors) with the largest unit out of service.
- New flow buffer tank and RO high pressure pump station to pressurize the two-stage RO membrane pressure vessels.
- New, two-stage, 85% recovery, RO membrane treatment system including cleaning system components with the capacity to treat the specified design flows (with applicable peaking factors) with the largest unit out of service. The RO membrane treated water (permeate) discharges to the AOP system. The RO system includes cartridge filtration, chemical treatment (biocide), antiscalant addition, and all associated RO membrane treatment equipment.
- New AOP system includes liquid sodium hypochlorite addition coupled with ultraviolent light disinfection to generate hydroxyl radicals for advanced oxidation. Includes associated supporting infrastructure and equipment.
- New liquid sodium hypochlorite storage and feed system for the AOP system and engineered storage buffer.
- New, above-grade, cast-in-place concrete tank to provide an engineered storage buffer for post-processing, compliance sampling and liquid sodium hypochlorite addition to achieve four-log disinfection. Includes associated supporting infrastructure and equipment.
- New, above-grade, cast-in-place, concrete structure, AWT pump station including clear well, and vertical turbine pumps with the capacity to pump the specified design flows (with applicable peaking factors) with one pump out of service.
- Note: Concentrate disposal was not included in this cost scenario. Concentration disposal from the water treatment section could be used to complete a planning level cost estimate.

Specific Approach for Developing Planning Costs

The following is the specific approach used in this cost estimating effort.

- Construction costs for unit process structures, equipment, and associated appurtenances were obtained from unit costs derived from vendor equipment and bid prices. The unit costs include furnishing and installing the equipment/infrastructure. The projects included in this evaluation are listed in **Table 4-29** below.
- Construction costs for the associated yard piping, ancillary mechanical equipment, electrical equipment, instrumentation and control equipment, and site work are assumed as a percentage allowance of the construction costs for the addition of the AWT system with RO to an existing Tertiary or AWTF.

Table 4-29: Projects Evaluated for Cost Scenario No. 8: Addition of AWT System with RO

Location (County)	Municipality	Project Name
Palm Beach	Wellington	WTP R&R
Seminole	Altamonte Springs	pureALTA
Broward	City of Hollywood	Effluent Recharge Treatment Pilot Study
Duvall	Jacksonville Electric Authority	Water Purification Treatment
Hillsborough	Hillsborough County	DPR Demonstration
Pinellas	City of Clearwater	Groundwater Replenishment
Volusia	Daytona Beach	DPR Demonstration
-	-	Vendor Pricing

The opinion of probable construction costs for adding AWT with RO are summarized in **Table 4-30**. The construction cost curve is depicted in **Figure 4-17**. The opinion of annual O&M cost for adding AWT with RO is summarized in **Table 4-31**. The total production cost adding AWT with RO is summarized in **Table 4-32**. The total production costs curve is depicted on **Figure 4-18.**

Table 4-30: Opinion of Probable Capital Cost: Addition of AWT with Reverse Osmosis

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	Membrane Feedwater Pump Station		$300,000	$873,000	$1,425,000	$2,700,000	$3,825,000	$4,800,000
2.	Membrane Pre-Treatment (MF/UF)		$500,000	$500,000	$1,455,000	$2,375,000	$4,500,000	$6,375,000
3.	Reverse Osmosis System		$1,000,000	$1,000,000	$2,910,000	$4,750,000	$9,000,000	$12,750,000
4.	Advanced Oxidation Process		$500,000	$500,000	$1,455,000	$2,375,000	$4,500,000	$6,375,000
5.	Engineered Storage Buffer		$1,000,000	$2,910,000	$4,750,000	$9,000,000	$12,750,000	$16,000,000
	Subtotal (1-5):		**$3,300,000**	**$9,603,000**	**$15,675,000**	**$29,700,000**	**$42,075,000**	**$52,800,000**
6.	Yard Piping	10%	$330,000	$960,300	$1,567,500	$2,970,000	$4,207,500	$5,280,000
7.	Mechanical	10%	$330,000	$960,300	$1,567,500	$2,970,000	$4,207,500	$5,280,000
8.	Electrical	25%	$825,000	$2,400,750	$3,918,750	$7,425,000	$10,518,750	$13,200,000
9.	Instrumentation and Controls	15%	$495,000	$1,440,450	$2,351,250	$4,455,000	$6,311,250	$7,920,000
10.	Site Work	10%	$330,000	$960,300	$1,567,500	$2,970,000	$4,207,500	$5,280,000
	Subtotal (1-10):		**$5,610,000**	**$16,325,100**	**$26,647,500**	**$50,490,000**	**$71,527,500**	**$89,760,000**
11.	General Requirements	5%	$280,500	$816,255	$1,332,375	$2,524,500	$3,576,375	$4,488,000
12.	Contractor Overhead and Profit	15%	$346,500	$1,008,315	$1,645,875	$3,118,500	$4,417,875	$5,544,000
13.	Construction Contingency	15%	$346,500	$1,008,315	$1,645,875	$3,118,500	$4,417,875	$5,544,000
	Opinion of Probable Construction Cost (1-13):		**$6,583,500**	**$19,157,985**	**$31,271,625**	**$59,251,500**	**$83,939,625**	**$105,336,000**
14.	Technical Services	20%	$1,316,700	$3,831,597	$6,254,325	$11,850,300	$16,787,925	$21,067,200
15.	Owner Administration and Legal	5%	$329,175	$957,899	$1,563,581	$2,962,575	$4,196,981	$5,266,800
16.	Project Contingency	15%	$987,525	$2,873,698	$4,690,744	$8,887,725	$12,590,944	$15,800,400
	Opinion of Probable Capital Cost (1-16):		**$9,216,900**	**$26,821,179**	**$43,780,275**	**$82,952,100**	**$117,515,475**	**$147,470,400**
	Opinion of Equivalent Annual Capital Cost:		**$870,010**	**$2,531,730**	**$4,132,548**	**$7,830,091**	**$11,092,630**	**$13,920,163**

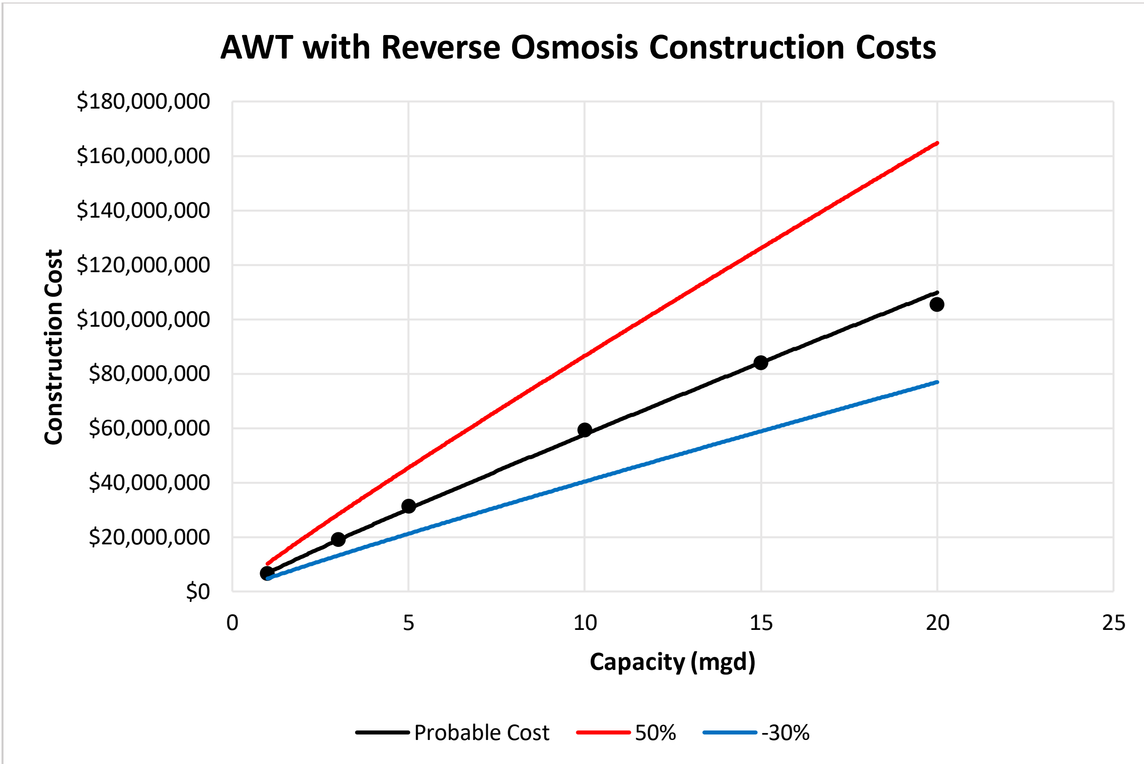

Figure 4-17: AWT with Reverse Osmosis Construction Costs

Table 4-31: Opinion of Annual Operation and Maintenance Cost Treatment Technology: AWT with Reverse Osmosis

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Membrane Feedwater Pump Station	$73,000	$212,430	$346,750	$657,000	$930,750	$1,168,000
2.	Membrane Pre-Treatment (MF/UF)	$109,500	$318,645	$520,125	$985,500	$1,396,125	$1,752,000
3.	Reverse Osmosis System	$182,500	$531,075	$866,875	$1,642,500	$2,326,875	$2,920,000
4.	Advanced Oxidation Process	$109,500	$318,645	$520,125	$985,500	$1,396,125	$1,752,000
5.	Engineered Storage Buffer ESB	$36,500	$106,215	$173,375	$328,500	$465,375	$584,000
	Opinion of Annual O&M Cost:	**$511,000**	**$1,487,010**	**$2,427,250**	**$4,599,000**	**$6,515,250**	**$8,176,000**

Table 4-32: Opinion of Total Production Cost Treatment Technology: AWT with Reverse Osmosis

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent Annual Capital Cost	$870,010	$2,531,730	$4,132,548	$7,830,091	$11,092,630	$13,920,163
2.	Annual Operation and Maintenance Cost	$511,000	$1,487,010	$2,427,250	$4,599,000	$6,515,250	$8,176,000
3.	Annual R&R Fund Deposit(1)	$87,001	$253,173	$413,255	$783,009	$1,109,263	$1,392,016
	Total Annual Cost:	**$1,468,011**	**$4,271,913**	**$6,973,053**	**$13,212,101**	**$18,717,142**	**$23,488,179**
Annual Finished Reclaimed Water Production Rate (mgy)(2)		365	1,095	1,825	3,650	5,475	7,300
Annual Production Cost ($/kgal)		**$4.02**	**$3.90**	**$3.82**	**$3.62**	**$3.42**	**$3.22**

(1) Annual deposit to a renewal and replacement (R&R) fund is equal to 10% of the equivalent annual capital cost.
(2) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

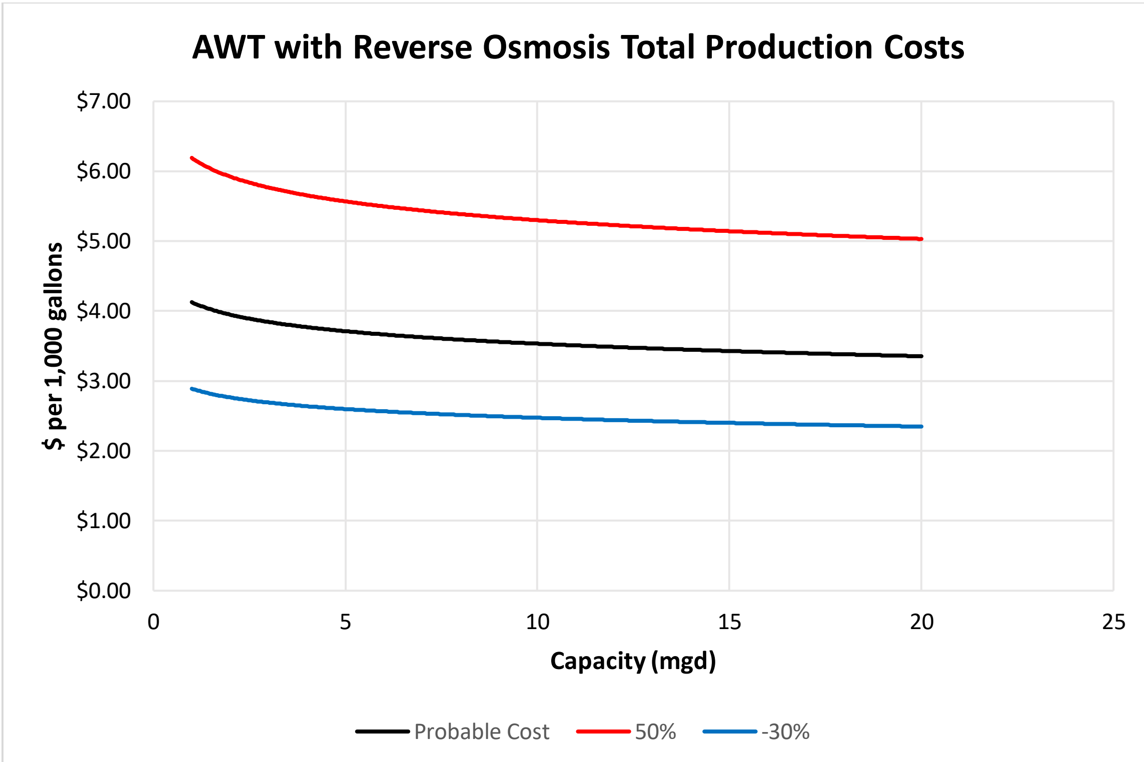

Figure 4-18: AWT with Reverse Osmosis Total Production Costs

4.4.3 Cost Scenario No. 9 – Adding Advanced Water Treatment without RO to Existing Tertiary and Advanced Wastewater Treatment Facilities

Cost Scenario Development

The following are the components and criteria used in developing the planning level costs for adding AWT to existing tertiary wastewater treatment facilities or AWTF.

- New CMU building with roll-up service doors for the advanced water treatment unit processes and associated equipment
- New feedwater (tertiary or advanced effluent) pump station for the ozone and biological active filtration system
- New ozone and BAF system including ozone generation coupled with BAF. Includes associated supporting infrastructure and equipment.
- New flow buffer tank and UF pump station to pressurize the MF membrane module feedwater
- New, skid mounted, UF membrane treatment system including backwash and air scour components with the capacity to treat the specified design flows (with applicable peaking factors) with the largest unit out of service
- New GAC filtration system including backwash. Includes associated supporting infrastructure and equipment
- New flow buffer tank and AOP feedwater pump station to feed the AOP system
- New AOP system includes liquid sodium hypochlorite addition coupled with ultraviolent light disinfection to generate hydroxyl radicals for advanced oxidation. Includes associated supporting infrastructure and equipment
- New liquid sodium hypochlorite storage and feed system for the AOP system and engineered storage buffer
- New, above-grade, cast-in-place concrete tank to provide an engineered storage buffer for compliance sampling and liquid sodium hypochlorite addition to achieve four-log disinfection. Includes associated supporting infrastructure and equipment.
- New, above-grade, cast-in-place concrete structure advanced water treatment pump station including clear well, vertical turbine pumps with the capacity to pump the specified design flows (with applicable peaking factors) with one pump out of service

Specific Approach for Developing Planning Costs

The following is the specific approach used in this cost estimating effort.

- Construction costs for unit process structures, equipment, and associated appurtenances were obtained from unit costs derived from vendor equipment and bid prices. The unit costs include furnishing and installing the equipment/infrastructure. The projects included in this evaluation are listed in **Table 4-33** below.
- Construction costs for the associated yard piping, ancillary mechanical equipment, electrical equipment, instrumentation and control equipment, and site work are assumed as a percentage allowance of the construction costs for AWT without RO.

Table 4-33: Projects Evaluated for Cost Scenario No. 9: Addition of AWT System without RO

Location (County)	Municipality	Project Name
Seminole	Altamonte Springs	pureALTA
Broward	City of Hollywood	Effluent Recharge Treatment Pilot Study
Duvall	Jacksonville Electric Authority	Water Purification Treatment
Hillsborough	Hillsborough County	DPR Demonstration
Pinellas	City of Clearwater	Groundwater Replenishment
Volusia	Daytona Beach	DPR Demonstration
-	-	Vendor Pricing

The opinion of probable construction costs for AWT without RO are summarized in **Table 4-34**. The construction cost curve is depicted in **Figure 4-19**. The opinion of annual O&M cost for AWT without RO is summarized in **Table 4-35**. The total production cost AWT without RO is summarized in **Table 4-36**. The total production costs curve is depicted on **Figure 4-20.**

Table 4-34: Opinion of Probable Capital Cost - Treatment Technology: AWT without Reverse Osmosis

Item No.	Description	Allowance Factor	Plant Capacity (mgd)					
			1	3	5	10	15	20
1.	AWTF Feedwater Pump Station		$300,000	$873,000	$1,425,000	$2,700,000	$3,825,000	$4,800,000
2.	Ozone + BAF System		$600,000	$1,746,000	$2,850,000	$5,400,000	$7,650,000	$9,600,000
3.	MF/UF System		$500,000	$1,164,000	$1,900,000	$3,600,000	$5,100,000	$6,400,000
4.	GAC Filtration System		$350,000	$1,018,500	$1,662,500	$3,150,000	$4,462,500	$5,600,000
5.	Advanced Oxidation Process		$500,000	$1,164,000	$1,900,000	$3,600,000	$5,100,000	$6,400,000
6.	Engineered Storage Buffer		$1,000,000	$2,910,000	$4,750,000	$9,000,000	$12,750,000	$16,000,000
Subtotal (1-6):			**$3,250,000**	**$8,875,500**	**$14,487,500**	**$27,450,000**	**$38,887,500**	**$48,800,000**
7.	Yard piping	10%	$325,000	$887,550	$1,448,750	$2,745,000	$3,888,750	$4,880,000
8.	Mechanical	10%	$325,000	$887,550	$1,448,750	$2,745,000	$3,888,750	$4,880,000
9.	Electrical	25%	$812,500	$2,218,875	$3,621,875	$6,862,500	$9,721,875	$12,200,000
10.	Instrumentation and Controls	15%	$487,500	$1,331,325	$2,173,125	$4,117,500	$5,833,125	$7,320,000
11.	Site Work	10%	$325,000	$887,550	$1,448,750	$2,745,000	$3,888,750	$4,880,000
Subtotal (1-11):			**$5,525,000**	**$15,088,350**	**$24,628,750**	**$46,665,000**	**$66,108,750**	**$82,960,000**
12.	General Requirements	5%	$276,250	$754,418	$1,231,438	$2,333,250	$3,305,438	$4,148,000
13.	Contractor Overhead and Profit	15%	$341,250	$931,928	$1,521,188	$2,882,250	$4,083,188	$5,124,000
14.	Construction contingency	15%	$341,250	$931,928	$1,521,188	$2,882,250	$4,083,188	$5,124,000
Opinion of Probable Construction Cost (1-14):			**$6,483,750**	**$17,706,623**	**$28,902,563**	**$54,762,750**	**$77,580,563**	**$97,356,000**
15.	Technical Services	20%	$1,296,750	$3,541,325	$5,780,513	$10,952,550	$15,516,113	$19,471,200
16.	Owner Administration and Legal	5%	$324,188	$885,331	$1,445,128	$2,738,138	$3,879,028	$4,867,800
17.	Project Contingency	15%	$972,563	$2,655,993	$4,335,384	$8,214,413	$11,637,084	$14,603,400
Opinion of Probable Capital Cost (1-17):			**$9,077,250**	**$24,789,272**	**$40,463,588**	**$76,667,850**	**$108,612,788**	**$136,298,400**
Opinion of Equivalent Annual Capital Cost:			**$856,828**	**$2,339,932**	**$3,819,476**	**$7,236,903**	**$10,252,279**	**$12,865,605**

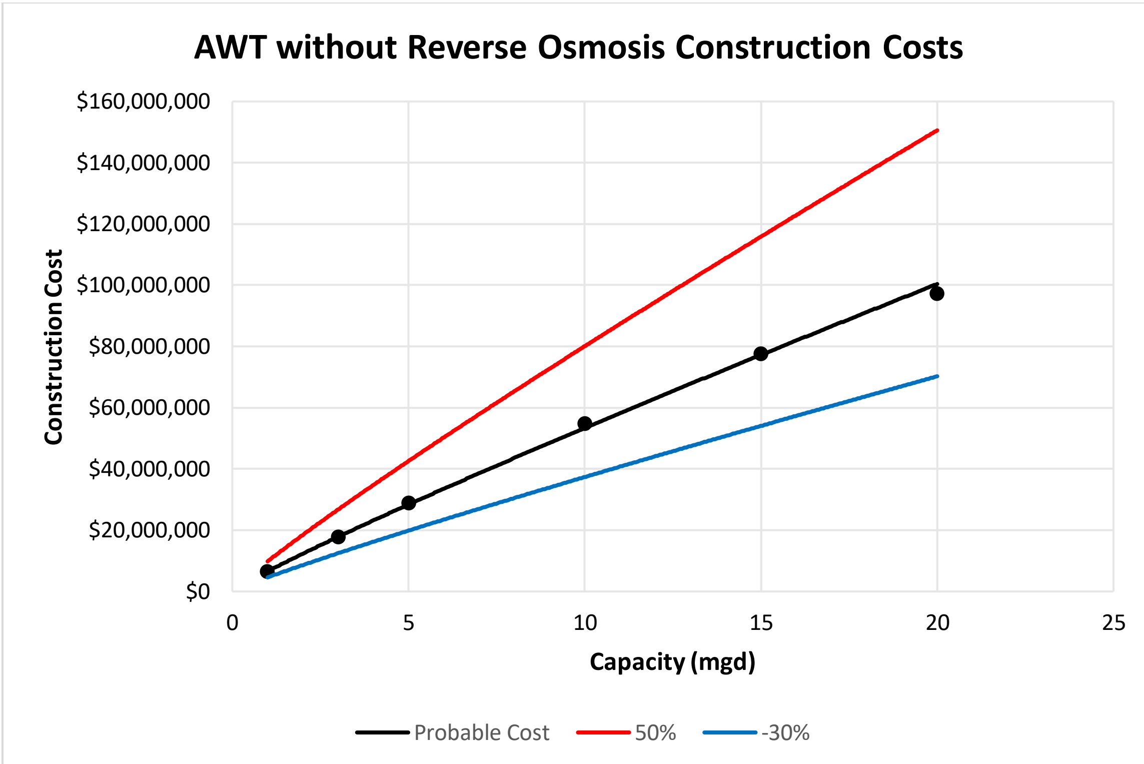

Figure 4-19: AWT without Reverse Osmosis Construction Costs

Table 4-35: Opinion of Annual Operation and Maintenance Cost - AWT without Reverse Osmosis

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	AWFT Feedwater Pump Station	$73,000	$212,430	$346,750	$657,000	$930,750	$1,168,000
2.	Ozone + BAF System	$73,000	$212,430	$346,750	$657,000	$930,750	$1,168,000
3.	MF/UF System	$146,000	$424,860	$693,500	$1,314,000	$1,861,500	$2,336,000
4.	GAC Filtration System	$109,500	$318,645	$520,125	$985,500	$1,396,125	$1,752,000
5.	AOP	$109,500	$318,645	$520,125	$985,500	$1,396,125	$1,752,000
6.	Engineered Storage Buffer						
	Opinion of Annual O&M Cost:	**$511,000**	**$1,487,010**	**$2,427,250**	**$4,599,000**	**$6,515,250**	**$8,176,000**

Table 4-36: Opinion of Total Production Cost - AWT without Reverse Osmosis

Item No.	Description	Plant Capacity (mgd)					
		1	3	5	10	15	20
1.	Equivalent annual Capital Cost	$856,828	$2,339,932	$3,819,476	$7,236,903	$10,252,279	$12,865,605
2.	Annual Operation and Maintenance Cost	$511,000	$1,487,010	$2,427,250	$4,599,000	$6,515,250	$8,176,000
3.	Annual R&R Fund Deposit(1)	$85,683	$233,993	$381,948	$723,690	$1,025,228	$1,286,560
	Total Annual Cost:	**$1,453,511**	**$4,060,935**	**$6,628,674**	**$12,559,593**	**$17,792,757**	**$22,328,165**
Annual Finished Reclaimed Water Production Rate (mgy)(2)		365	1,095	1,825	3,650	5,475	7,300
	Annual Production Cost ($/kgal)	**$3.98**	**$3.71**	**$3.63**	**$3.44**	**$3.25**	**$3.06**

(1) Annual deposit to a renewal and replacement (R&R) fund is equal to 10% of the equivalent annual capital cost.
(2) Annual finished water production rate in million gallons per year (mgy) is equal to the AADD (mgd) times 365 days.

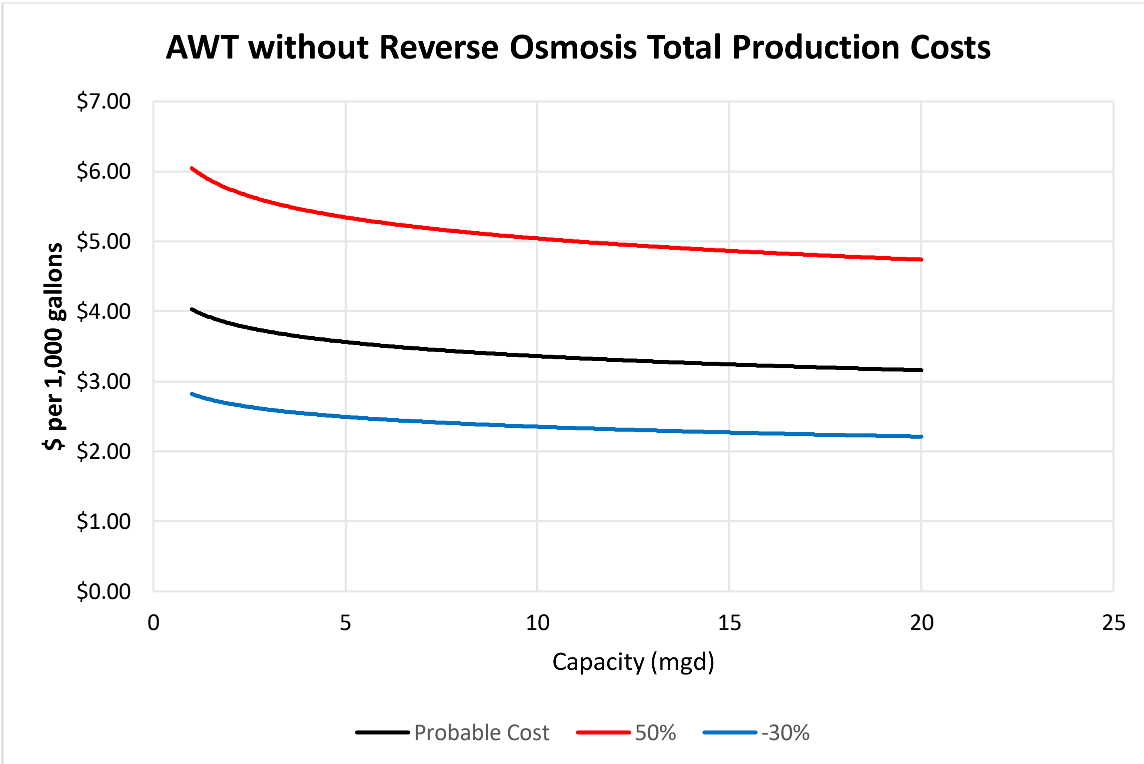

Figure 4-20: AWT without Reverse Osmosis Total Production Costs

5

MEMBRANE TREATMENT BY-PRODUCT DISPOSAL - DEEP INJECTION WELL

5.1 ASSUMPTIONS AND APPROACH

In south Florida, deep well injection is the primary method for disposal of domestic wastewater effluent, industrial wastewater (includes concentrate from membrane water treatment facilities), or radioactive waste below protected aquifers or beneath the lowermost formation of an underground source of drinking water. Most deep well injection wells (DIWs) in south Florida discharge to the Boulder Zone, a cavernous limestone unit of the Floridan Aquifer located generally about 3,000 feet below land surface. These DIWs are classified as Class I DIWs in Chapter 62-528 of the Florida Administrative Code and are under the regulatory jurisdiction of the FDEP.

Class I DIWs are typically constructed with a tubing and packer with either a fluid-filled annulus or cement- filled annulus as shown in **Figure 5-1**. Class I DIWs typically are constructed with two single zone monitoring wells (upper and lower monitoring zone) or one dual-zone monitoring well (DZMW) (one single monitoring well that contains an upper and lower monitoring zone). Operators of all Class I DIWs are required to submit a monthly report that provides physical and chemical property data related to their operation.

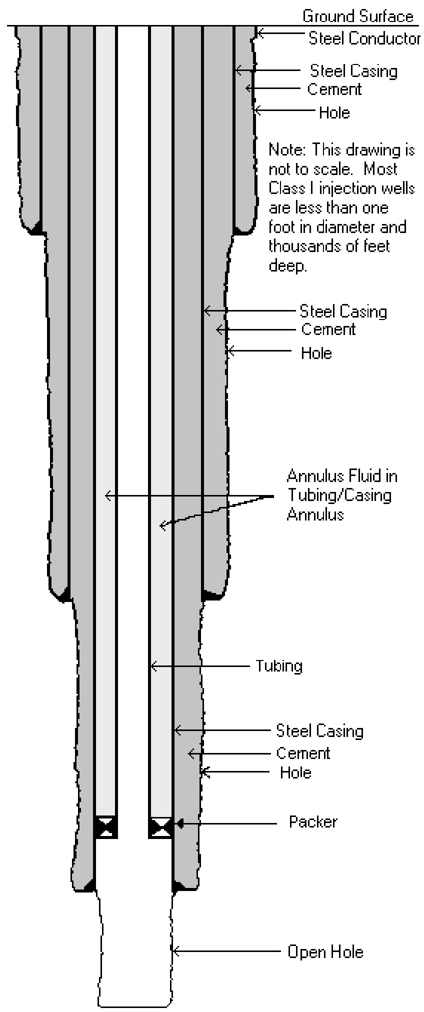

Figure 5-1: Typical construction of a DIW (with fluid filled annulus) (Roy, 2016)

FDEP categorizes DIWs, group 9, as other Class V Wells such as exploratory wells; injection wells associated with recovery of geothermal energy for heating, aquaculture and production of electricity; swimming pool drainage wells, injection wells used for experimental technology, etc.

This section addresses construction (or capital costs) and maintenance-related costs associated with Class I concentrate DIWs along with associated monitoring well(s) (MW) at the DIW site and Class V exploratory wells. The review of the construction and maintenance costs included relevant data associated with construction dates of wells, material used, casing diameter, depths, capacities, MW configuration, and current *ENR* values. The DIW sites included in this section are sites located within the SFWMD service area.

Each MW contains small pump(s) (submersible and/or aboveground pumps) ranging from approximately 0.5 horsepower to 10 horsepower. These small pumps operate intermittently during weekly or monthly sampling events related to regulatory requirements. Operational costs are minor and therefore were not considered in this evaluation. Maintenance costs will reflect regulatory requirements such as the mechanical integrity test (MIT) required every five years, laboratory costs, and required FDEP operational permit renewal for well integrity and maintenance.

Class V DIWs are constructed similar to a Class I DIW. However, Class V DIWs may only contain a steel casing with no internal tubing. Therefore, an annulus is not included in the design of a Class V Exploratory Well. Also, Class V Exploratory Wells are typically used to gather information required for assessing the hydrogeology of the overlying zones and completing the injection well within the appropriate formation. The exploratory well may be converted to either a MW or a Class I DIW, after information has been collected and an ideal injection zone has been identified.

5.2 CAPITAL COSTS

The type of DIW projects evaluated were either Class I DIWs or Class V Exploratory Wells. The Class V wells listed below are only Class V because they were exploratory wells that would have to be re-permitted as Class I wells should the aquifer and confining unit characteristics be deemed suitable for actual injection. At the time of this study, it was unknown if any Class V DIW were converted to a Class I DIW. The following construction projects, listed in **Table 5-1**, were evaluated for this cost analysis:

Table 5-1: DIWs used for Capital Construction Cost Evaluation

Location	Utility	Project Name	Capacity (mgd)
Broward County	City of Hollywood	Class I DIW and MW: IW-1	13.68
Broward County	City of Hollywood	Class I DIW and MW: IW-1	19.94
Broward County	City of Sunrise, Springtree WTP	Two (2) Class I DIW and MW: IW_1 and IW-2	12.55 each
Broward County	North Springs Improvement District	Class I DIW and MW: IW-1	3.20
Broward County	Town of Davie	Class I DIW and MW: IW-1	11.44
Collier County	Collier County Landfill	Class I DIW and MW: IW-1	2.17
Hendry County	City of LaBelle	Class I DIW and MW: IW-1	7.39
Miami-Dade County	Miami-Dade Water and Sewer Department, South District	Three (3) Class I DIWs	18.65 each
Orange County	Orlando Utilities Commission	Class V Exploratory Well	-
Orange County	Tohopekaliga Water Authority, Cypress Lakes Wellfield	Class V DIW and MW, Exploratory Well converted to a DIW	4.05
Palm Beach County	Palm Beach County Water Utilities Department, WTP No. 2	Class I DIW: IW-1	9.66
Pinellas County	City of Clearwell	Exploratory Well	2.16 to 2.76

The construction costs for each DIW and MW (where applicable) are summarized in **Table 5-2.** Engineering costs include design, engineering services during construction or construction management services and typically range from 10% to 20% of the overall construction cost. To be conservative, an average of 20% of construction costs should be added to capture the engineering costs described above.

The table is organized as follows:

- **Table 5-2** includes the well identification name and municipality, County where the well is located, start date of construction and completion date, CCI or MPI (where applicable) at time of construction, DIW capacity, tubing diameter, casing depth, total depth, and well depth. Other information provided includes the construction method (i.e., tubing and packer) and whether the DIW includes a MW. Refer to the following bullets for applied cost adjustments to reflect costs in December 2021 dollars.
- Methodology on calculating adjusted costs are footnoted for each table.
- MPI and CCI values were collected from the respective *ENR* tables related to material price indices and construction costs indices, respectively.

Table 5-2: Summary of Costs and projects for DIWs and Exploratory Wells

Well Name	City of LaBelle DIW (IW-1)	NSID (IW-1)	Miami-Dade South District (Three DIWs) [(2)]
County	Hendry	Broward	Miami-Dade
Construction Date (Cost Basis Month-Year)	December-12	January-19	September-19
Finish Date	October-13	Ongoing	Ongoing
Class	I	I	I
DIW Capacity (mgd)	7.39	3.20	18.65
Tubing and Packer Construction (Y/N)	Y	Y	-
Deep Injection Well (Y/N)	Y	Y	Y
Monitoring Well (Y/N)	Y	Y	N
Injection Casing Diameter (inches)	24	16	24
Tubing Diameter (inches)	16	10.75	-
Casing Depth (feet bpl)	2,552	~2,900	2,400
Total Depth (feet bls)	3,300	3,500	3,200
CCI at Cost Basis Month-Year	9412	11206	11311
MPI at Cost Basis Month-Year	-	-	-
DIW Cost at Cost Basis Month-Year	$5,277,700	$6,350,621	$9,641,967
Adjusted Cost per DIW (December 2021 Dollars)	$8,350,284[(1)]	$8,439,253[(1)]	$12,694,134[(1)]
Adjusted DIW Cost per mgd	$1,129,795	$2,637,267	$680,651
Adjusted DIW Cost per foot of Casing	$3,272	$2,910	$5,290

(1) Construction date before August 2020 utilized a CCI adjustment. "DIW Cost at Basis Month-Year" is multiplied by 11455 divided by "CCI at Cost Basis Month-Year". A 30% increase was added to the August 2020 value to reflect estimated costs in December 2021 dollars.

(2) Miami-Dade South District project costs reflect one (1) DIW. However, three (3) DIWs were included in this project.

Table 5-2: Summary of Costs and projects for DIWs and Exploratory Wells (Continued)

Well Name	PBCWUD WTP2 (IW-1)	TWA (IW-2 Exploratory Well)	Sunrise Springtree WTP (IW-1/IW-2) (3)
County	Palm Beach	Osceola	Broward
Construction Date (Cost Basis Month-Year)	July-21	November-20	May-15
Finish Date	Ongoing	Ongoing	November-16
Class	I	V, Group 9	I
DIW Capacity (mgd)	9.66	4.05	12.55 (per DIW)
Tubing and Packer Construction (Y/N)	Y	N	Y
Deep Injection Well (Y/N)	Y	Y	Y
Monitoring Well (Y/N)	Y	Y (Single Zone, Lower)	Y (one for both DIWs)
Injection Casing Diameter (inches)	26	20	26 (per DIW)
Tubing Diameter (inches)	17.75	11.75	17.98 (per DIW)
Casing Depth (feet bpl)	2,900	1,550	2,997 (IW-1) 2,784 (IW-2)
Total Depth (feet bls)	3,500	2,400	3,510 (per DIW)
CCI at Cost Basis Month-Year	-	-	9975
MPI at Cost Basis Month-Year	4634	3713	-
DIW Cost at Cost Basis Month-Year	$14,828,876	$5,494,000	$4,800,529
Adjusted Cost per DIW (December 2021 Dollars)	$15,884,881(2)	$7,345,062(2)	$7,166,675(1)
Adjusted DIW Cost per mgd	$1,644,398	$1,813,595	$571,050
Adjusted DIW Cost per foot of Casing	$5,478	$4,739	$2,391 (IW-1) $2,574 (IW-2)

(1) Construction date before August 2020 utilized a CCI adjustment. “DIW Cost at Basis Month-Year” is multiplied by 11455 divided by “CCI at Cost Basis Month-Year”. A 30% increase was added to the August 2020 value to reflect estimated costs in December 2021 dollars.

(2) Construction date after August 2020 utilized a MPI adjustment. “DIW Cost at Basis Month-Year” is multiplied by 4964 divided by MPI at Cost Basis Month-Year”.

(3) Sunrise Springtree WTP project costs reflect one (1) DIW. However, two (2) DIWs and (1) MW was included in this project.

Table 5-2: Summary of Costs and projects for DIWs and Exploratory Wells (Continued)

Well Name	Town of Davie (IW-1)	City of Hollywood (IW-1)	City of Hollywood (IW-1)
County	Broward	Broward	Broward
Construction Date (Cost Basis Month-Year)	January-11	June-12	December-19
Finish Date	August-11	February-13	Almost Complete
Class	I	I	I
DIW Capacity (mgd)	11.44	13.68	19.94
Tubing and Packer Construction (Y/N)	Y	Y	Y
Deep Injection Well (Y/N)	Y	Y	Y
Monitoring Well (Y/N)	Y	Y	Y
Injection Casing Diameter (inches)	30	26	36
Tubing Diameter (inches)	20	18	24
Casing Depth (feet bpl)	2,902	2,956	5,800
Total Depth (feet bls)	3,685	3,526	-
CCI at Cost Basis Month-Year	8938	9291	11381
MPI at Cost Basis Month-Year	-	-	-
DIW Cost at Cost Basis Month-Year	$6,049,500	$9,583,726	$22,670,061
Adjusted Cost per DIW (December 2021 Dollars)[(1)]	$10,079,003 [(1)]	$15,360,677 [(1)]	$29,662,702
Adjusted DIW Cost per mgd	$881,032	$1,122,856	$1,487,598
Adjusted DIW Cost per foot of Casing	$3,473	$5,197	$5,115

(1) Construction date before August 2020 utilized a CCI adjustment. "DIW at Cost Basis Month-Year" is multiplied by 11455 divided by "CCI at Cost Basis Month-Year". A 30% increase was added to the August 2020 value to reflect estimated costs in December 2021 dollars.

(2) Construction date after August 2020 utilized a MPI adjustment. "DIW Cost Basis Month-Year" is multiplied by 4964 divided by MPI at Cost Basis Month-Year".

Table 5-2: Summary of Costs and projects for DIWs and Exploratory Wells (Continued)

Well Name	Collier County Landfill (IW-1)	City of Clearwater (Exploratory Well)
County	Collier	Pinellas
Construction Date (Cost Basis Month-Year)	November-19	April-13
Finish Date	February-21	February-13
Class	I	V, Group 9
DIW Capacity (MGD)	2.17	2.16 - 2.76 (range)
Tubing and Packer Construction (Y/N)	Y	N
Deep Injection Well (Y/N)	Y	Y
Monitoring Well (Y/N)	Y	Y (Lower Zone)
Injection Casing Diameter (inches)	20	32
Tubing Diameter (inches)	8.8	12.25
Casing Depth (feet bpl)	2,225	650
Total Depth (feet bls)	3,007	1,100
CCI at Cost Basis Month-Year	11381	9291
MPI at Cost Basis Month-Year	--	--
DIW Cost at Cost Basis Month-Year	$6,788,782	$857,764
Adjusted Cost per DIW (December 2021 Dollars)(1)	$8,882,800 (1)	$1,374,814 (1)
Adjusted DIW Cost per mgd	$4,093,456	$498,121(3)
Adjusted DIW Cost per foot of Casing	$3,993	$2,115

(1) Construction date before August 2020 utilized a CCI adjustment. “DIW at Cost Basis Month-Year” is multiplied by 11455 divided by “CCI at Cost Basis Month-Year”. A 30% increase was added to the August 2020 value to reflect estimated costs in December 2021 dollars.
(2) Construction date after August 2020 utilized a MPI adjustment. “DIW Cost Basis Month-Year” is multiplied by 4964 divided by MPI at Cost Basis Month-Year”.
(3) Cost reflective of upper range of capacity (~2.76 mgd).

5.3 OPERATION AND MAINTENANCE COSTS

Most operational costs associated with DIWs are related to meeting FDEP regulatory permit requirements. Expenditures for maintenance and repairs are minimal. Examples of major repairs would be related to tubing and/or casing deterioration due to corrosion and also corrosion of the packer (in a packer and tubing construction) where replacement is required. These major repairs could be in the hundreds of thousands to 5 million dollars depending on the repairs required. Major repair costs were not quantified for this evaluation due to the number of factors that play a role. Because there is very little maintenance required for DIWs, the focus of this section was on the regulatory requirements, where the primary O&M costs include laboratory analyses, five-year operational permit renewal, and five-year MIT.

Laboratory costs and operational data (system pressures and flow rates) are based on established FDEP permitting requirements. There are several testing requirements such as onsite instruments or laboratory methods, of the physical, chemical, or biological parameters required to evaluate the performance of an injection well system that are conducted either continuously, daily, monthly, or quarterly. An example of the different regulatory required test parameters and reporting is presented in **Figure 5-2** below. In addition to testing for the different parameters, the effluent of the waste stream DIW must also be tested for the primary and secondary drinking water standards.

PARAMETER	UNIT	RECORDING FREQUENCY OR SAMPLING METHOD	FREQUENCY OF ANALYSES		
			IW-1 *14155*	DZMW-1 Upper Zone *30538A*	DZMW-1 Lower Zone *30538B*
Injection Pressure, max.	psi	continuous	D/M [a]		
Injection Pressure, min.	psi	continuous	D/M [a]		
Injection Pressure, avg.	psi	continuous	D/M [a]		
Flow Rate, max.	GPM	continuous	D/M [a]		
Flow Rate, min.	GPM	continuous	D/M [a]		
Flow Rate, avg.	GPM	continuous	D/M [a]		
Volume Injected per Well	MG	daily/monthly	D/M		
Pressure or Water Level max.	psi or ft NAVD	continuous		D/M [a]	D/M [a]
Pressure or Water Level min.	psi or ft NAVD	continuous		D/M [a]	D/M [a]
Pressure or Water Level avg.	psi or ft NAVD	continuous		D/M [a]	D/M [a]
pH[b]	standard units	grab/purge	M	M	M
Specific Conductance[b]	μmhos/cm	grab/purge	M	M	M
Temperature[b]	°C	grab/purge	M	M	M
Chloride	mg/L	grab/purge	M	M	M
Sulfate	mg/L	grab/purge	M	M	M
Total Dissolved Solids	mg/L	grab/purge	M	M	M
Total Kjeldahl Nitrogen	mg/L	grab/purge	M	M	M
Total Organic Carbon	mg/L	grab/purge	M	M	M
Bicarbonate	mg/L	grab/purge	M	M	M
Calcium	mg/L	grab/purge	M	M	M
Total Iron	mg/L	grab/purge	M	M	M
Magnesium	mg/L	grab/purge	M	M	M
Potassium	mg/L	grab/purge	M	M	M
Sodium	mg/L	grab/purge	M	M	M
Gross Alpha	pCi/L	grab/purge	M		M
Radium^{226}	pCi/L	grab/purge	M		M
Radium^{228}	pCi/L	grab/purge	M		M

D - daily; W – Weekly; M - Monthly

[a] - Operational data reporting for flows, pressures and water levels: daily maximum, minimum and average from continuous reporting; monthly maximum, minimum and average (calculated from daily averages).

[b] - Field samples

Figure 5-2: Example of Regulatory Required Testing and Reporting at each Monitoring Well/Zone and DIW (DZMW-1 Upper Zone and DZMW-1 Lower Zone) and DIW (IW-1) (Source: Notice of Permit for Proposed Palm Beach County Class I Injection Well System [IW-1 and DZMW-1])

JLA Geosciences, Inc., a local hydrogeologist firm, provided an estimate of costs associated with laboratory testing for required parameters listed above as well as, testing for secondary and primary drinking water standards. Monthly laboratory costs are approximately $3,500 for testing and recording of all parameters, while annual laboratory testing for secondary and primary drinking water standards is between $3,000 to $3,500. See **Table 5-3** for a summary of annual laboratory costs.

Table 5-3: Laboratory Costs for Regulatory Required Sampling and Reporting for DIW and MWs

Description	Annual Costs
Monthly Parameters	$42,000 per year
Annual Primary and Secondary Drinking Water Standards	$3,000 to $3,500 per year

As previously noted, operational permit renewals for DIWs are required every five (5) years. According to recent FDEP fee schedule, the renewal fee is $10,000. Although this renewal fee is applied every five (5) years, it can be broken down to an annual cost of $2,000.

During the permit renewal process, a MIT is required to demonstrate that the DIW has no leaks in the casing and tubing, and that there is no fluid movement into an Underground Source of Drinking Water (USDW) (Rule 62-528.300(6), Florida Administrative Code). This test typically consists of either a Standard Annular Pressure Test (SAPT) or a Packer Test.

- An SAPT can be conducted on either a fluid-filled annulus, tubing and packer or a non-tubing and packer constructed DIW. Pressure is applied to the annular space (or annulus) between the tubing and casing. The pressure is then observed for variations in pressure over a period of time. For the well to pass the test, the pressure must be maintained within the allowable pressure window of plus or minus 5% of the starting pressure.
- A Packer Test is a pressure test method that is typically conducted on a tube and packer construction type DIW where the annulus is filled with concrete (versus fluid filled) and only the tubing can be pressure tested. To insert the packer into the tubing, the well will need to be "killed" using a brine that consists of a higher total dissolved solids (or "salt" content) than the water within the bottom of the well. Costs for testing a tube and packer DIW with a concrete filled annulus is typically higher than one with a fluid-filled annulus due to the labor, additional equipment, and brine solution for the required pressure test.

Three (3) drilling companies, Youngquist Brothers, Inc. (YBI), All Webb's Enterprises, Inc. (AWE), and Florida Design Drilling Corporation (FDD), that routinely perform MITs were contacted by phone for typical costs associated with MIT testing for each of the testing procedures described above. **Table 5-4** summarizes the estimated costs for MITs for a SAPT for fluid-filled annulus construction and a packer test for a concrete-filled annulus construction.

Table 5-4: MIT Costs provided by YBI, AWE, and FDD

Drilling Company	Fluid-filled Annulus (Standard Annular Pressure Test)	Concrete Filled Annulus (with Packer Test)
YBI	$70,000	$100,000
AWE	$30,000 to $75,000	$40,000 to $200,000
FDD	$40,000 to $50,000	$65,000 to $75,000

In summary, for the five-year MIT exercise, costs for testing a tube and packer DIW construction with a concrete filled annulus is typically higher than one with a fluid-filled annulus due to the labor, additional equipment and brine needed for required pressure testing. **Table 5-5** summarizes the typical annual O&M costs.

Table 5-5: Typical Annual O&M Costs for Laboratory Costs, Permit Renewal, and MITs

Description	MIT for Fluid-filled Annulus (Standard Annular Pressure Test) (Annual Costs)	MIT for Concrete Filled Annulus (with Packer Test) (Annual Costs) (Annual Costs)
MIT Costs	$6,000 to $15,000	$8,000 to $20,000
Laboratory Costs	$45,500	$45,500
Permit Renewal Costs	$2,000	$2,000
Total Costs Range	**$53,500 to $62,500**	**$55,500 to $67,500**

5.4 TOTAL COST SUMMARY

The costs of DIWs have risen significantly within the past five (5) years with the most significant cost increase observed within the last two (2) years due to impacts discussed in Chapter 1, as well as other influences such as lack of competition between qualified contractors. Other considerations related to cost variability include site access, material availability, depth of DIW, piping diameters, piping material, annulus-filled with fluid versus concrete, scale of construction (i.e., one DIW and MW versus multiple DIWs and MWs within one construction project), etc. See **Table 5-6** for a summary of the construction costs that range in capacity of 2.17 to 19.94 MGD.

Table 5-6: Summary of Project Construction Costs in December 2021 Dollars

Well Name	County	Class	DIW Capacity (MGD)	Total Cost per IW in December 2021 Dollars	Total Cost per MGD	Total Cost Casing Depth
City of LaBelle DIW (IW-1)	Hendry	I	7.39	$8,350,284	$1,129,944	$3,272
NSID (IW-1)	Broward	I	3.2	$8,439,253	$2,637,267	$2,910
PBCWUD WTP2 (IW-1)	Palm Beach	I	9.66	$15,884,881	$1,644,398	$5,478
TWA (Exploratory Well)	Osceola	V, Group 9	4.05	$7,345,062	$1,813,595	$4,739
City of Sunrise Springtree WTP (IW-1/IW-2) (per well)	Broward	I	12.55	$7,166,675	$571,050	$2,391 (IW-1) $2,574 (IW-2)
Town of Davie (IW-1)	Broward	I	11.44	$10,079,003	$881,032	$3,473
City of Hollywood (December 2019)	Broward	I	19.94	$29,662,702	$1,487,598	$5,115
City of Hollywood (February 2013)	Broward	I	13.68	$15,360,677	$1,122,856	$5,197
Miami-Dade South District (Three DIWs) (per well) (1)	Miami-Dade	I	18.65	$12,694,135	$680,650	$5,290
Collier County Landfill (IW-1)	Collier	I	2.17	$8,882,800.00	$4,093,456.00	$3,993.00
City of Clearwater	Pinellas	V	2.16 - 2.76	$1,374,814.00	$498,121.00	$2,115.00

(1) MW was not constructed with this project.

As previously discussed, O&M costs include laboratory analyses, operational permit renewal with a renewal period of every five (5) years, and five-year MIT. Laboratory costs include periodic testing of several different parameters, as well as annual testing for primary and secondary drinking water standards. permit renewals for DIW are every five (5) years. According to FDEP fee schedule, the renewal fee is $10,000.

In general, the construction costs collected for this evaluation did not appear to have a direct correlation to the design and capacity of each well. However, based on the market impacts and other factors discussed above, the DIW projects constructed within the last three to four years (**Table 5-7**) appear to reflect present day costs with the City of Hollywood (December 2019) being on the high end of the construction costs. Since a direct correlation could not be determined, the data used was for the DIW construction costs and O&M costs are real data (versus breaking down the wells by incremental capacities) collected from the projects listed in **Table 5-7**.

Table 5-7: Summary of DIW Construction Costs in December 2021 Dollars

Well Name	County	Class	Total Cost per IW in December 2021 Dollars	DIW Capacity (MGD)	Total Cost per MGD	Casing Depth (ft)	Total Cost Casing Depth (per foot)
NSID (IW-1)	Broward	I	$8,439,253	3.2	$2,637,267	~2,900	$2,910
PBCWUD WTP2 (IW-1)	Palm Beach	I	$15,884,881	9.66	$1,644,398	~2,900	$5,478
TWA (Exploratory Well)	Osceola	V, Group 9	$7,345,062	4.05	$1,813,595	1550	$4,739
City of Hollywood (December 2019)	Broward	I	$29,662,702	19.94	$1,487,598	2,956	$5,115
Miami-Dade South District (Three DIWs) (per well) [(1)]	Miami-Dade	I	$12,694,135	18.65	$680,650	2,400	$5,290
Collier County Landfill (IW-1)	Collier	I	$8,882,800	2.17	$4,093,456	2,225	$3,993

(1) MW was not constructed with this project.

The opinion of probable construction costs for DIWs and associated MWs, based on the data in **Table 5-7** (above), is summarized in **Table 5-8**. The construction cost curve for DIW and associated MW is depicted in **Figure 5-3**.

Table 5-8: Opinion of Probable Construction Cost for DIWs and Associated MWs

Well Name		Collier County Landfill (IW-1)	NSID (IW-1)	TWA (Exploratory Well)	PBCWUD WTP2 (IW-1)	Miami-Dade South District (Three DIWs) (per well)	City of Hollywood (December 2019)
County		Collier	Broward	Osceola	Palm Beach	Miami-Dade	Broward
Class		I	I	V, Group 9	I	I	I
DIW Capacity (mgd)		2.17	3.2	4.05	9.66	18.65	19.94
Total Cost per IW in December 2021 Dollars		$8,882,800	$8,439,253	$7,345,062	$15,884,881	$12,694,135	$29,662,702
Total Cost per MGD		$4,093,456	$2,637,267	$1,813,595	$1,644,398	$680,650	$1,487,598
Technical Services	20%	$1,776,560	$1,687,851	$1,469,012	$3,176,976	$2,538,827	$5,932,540
Owner Administration and Legal	5%	$444,140	$421,963	$367,253	$794,244	$634,707	$1,483,135
Project Contingency	15%	$1,332,420	$1,265,888	$1,101,759	$2,382,732	$1,904,120	$4,449,405
Opinion of Probable Capital Cost		$12,435,920	$11,814,954	$10,283,087	$22,238,833	$17,771,789	$41,527,783
Total Cost Casing Depth (per foot)		$3,993	$2,910	$4,739	$5,478	$5,290	$5,115

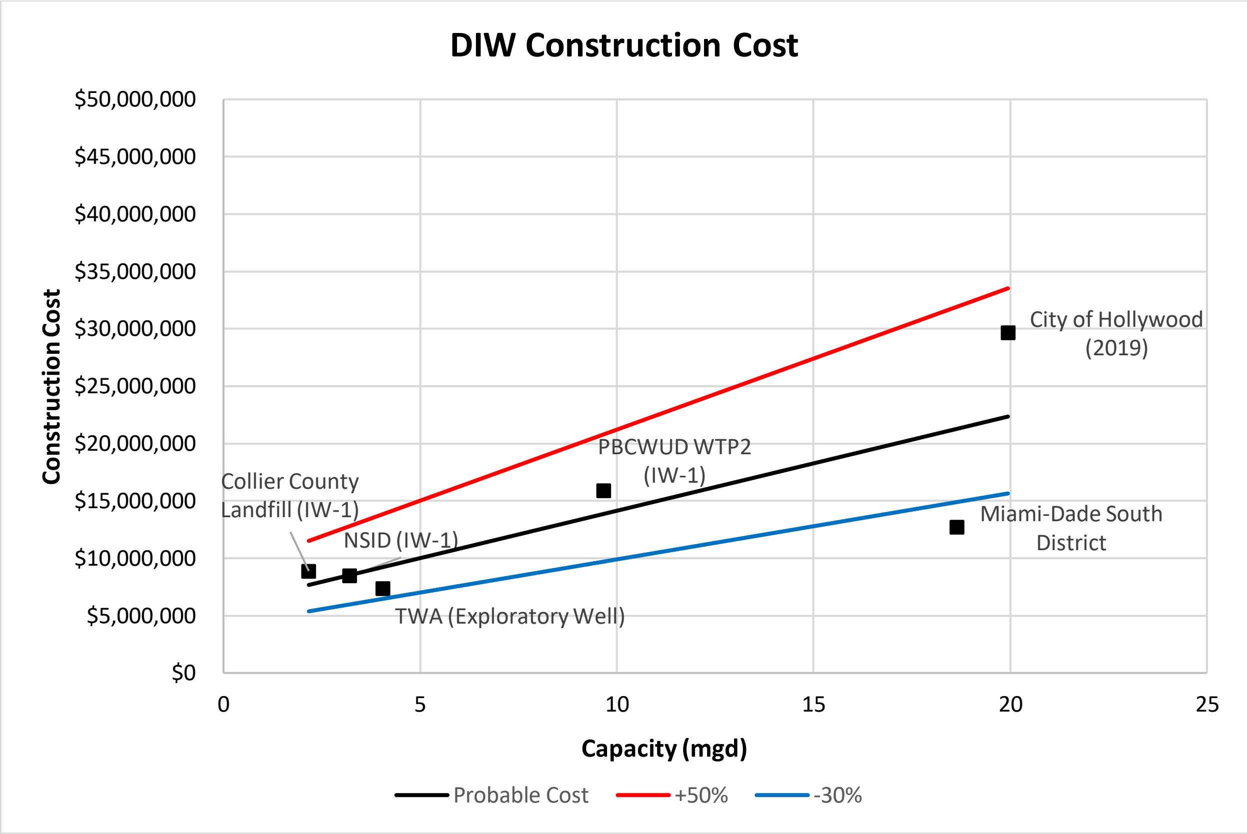

Figure 5-3: DIW Construction Cost Curve

The total construction cost plus O&M costs are summarized in **Table 5-11** along with the associated total construction cost plus O&M Curve (**Figure 5-4**).

Table 5-9: Opinion of Probable Construction Costs plus O&M Costs

Well Name	Collier County Landfill (IW-1)	NSID (IW-1)	TWA (Exploratory Well)	PBCWUD WTP2 (IW-1)	Miami-Dade South District (Three DIWs) (1) (per well)	City of Hollywood (December 2019)
DIW Capacity (mgd)	2.17	3.2	4.05	9.66	18.65	19.94
Opinion of Probable Construction Cost	$12,435,920	$11,814,954	$10,283,087	$22,238,833	$17,771,789	$41,527,783
Opinion of Probable Construction Cost plus O&M	$12,546,920	$11,925,954	$10,394,087	$22,330,083	$17,906,789	$41,662,783

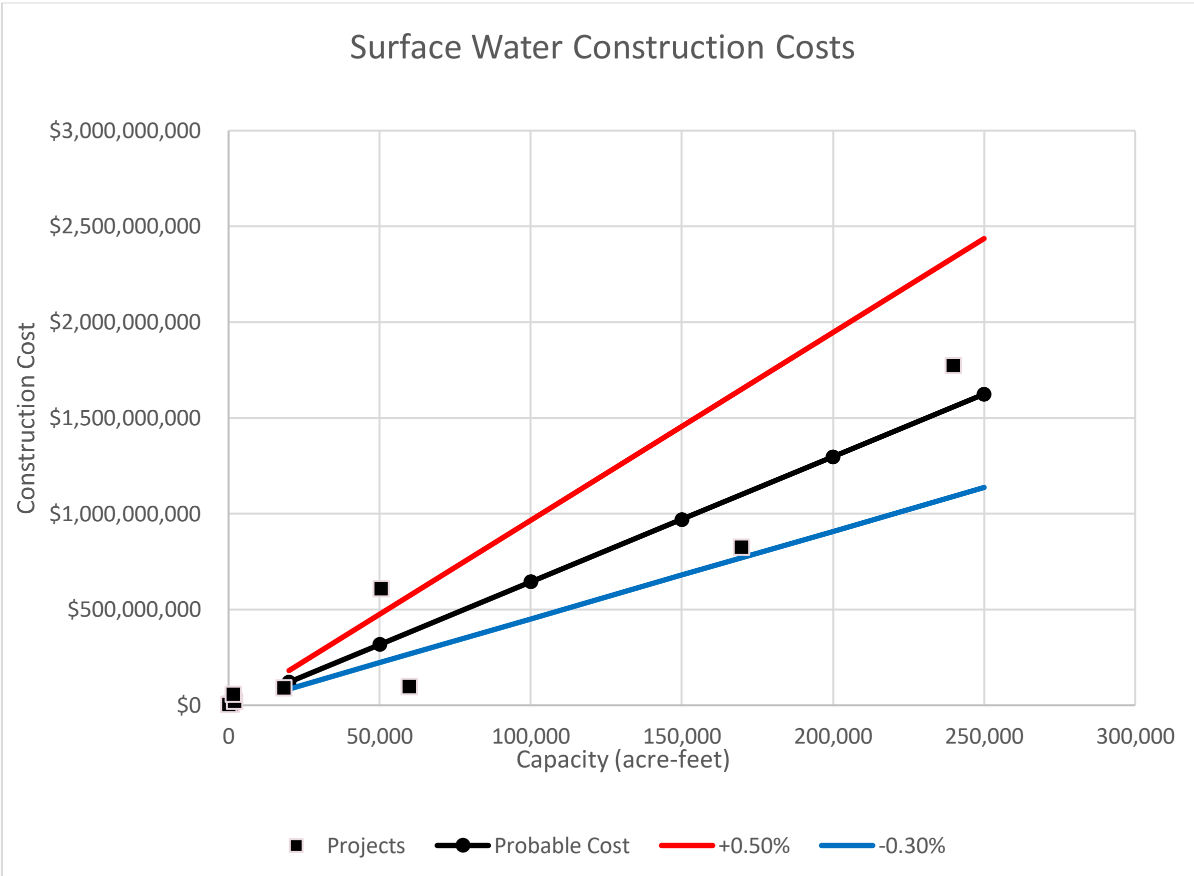

Figure 5-4: DIW Construction Cost plus O&M Cost Curve

6

AQUIFER STORAGE AND RECOVERY SYSTEMS

6.1 DISCUSSION OF ASSUMPTIONS AND APPROACH

Aquifer Storage and Recovery (ASR) refers to the process of recharging an aquifer with excess water that is recovered and used during periods of peak demand or dry conditions. ASR systems are used to store excess amounts of potable water, treated reclaimed water, stormwater or surface water underground for future use. Construction costs for ASR systems vary with well depths, treatment requirements, and scale of construction (quantity of wells) constructed (more wells within a project may result in a lower cost per well versus one well being constructed). The construction costs for most ASR well systems are significantly higher than the cost for typical Floridan aquifer supply wells due to the permitting constraints, need for additional monitor wells, treatment needs, and design considerations.

ASR construction projects were identified through SFWMD's AWS grant list as well as review of FDEP Underground Injection Control (UIC) database of permitted Class V ASR wells. Class V wells are defined by the United States Environmental Protection Agency (EPA) as wells that inject non-hazardous fluids either into or below an underground source of drinking water (USDW). The USDW is defined as an aquifer with TDS concentrations less than 10,000 milligrams per liter (mg/L). The EPA defines ASR as a subset of Class V wells; Complex Class V wells that includes injection wells not included in other well classes.

Kimley-Horn reviewed the ASR systems on **Table 6-1** for capital construction costs:

Table 6-1: ASR Wells used for Capital Construction Cost Evaluation

ASR Wells
City of Naples Reclaimed ASR #3
Collier County Livingston Road IQ Water ASR System ASR-2
Fort Myers Beach ASR System
City of Marco Island ASR System (Pump Replacement Only)
Polk County Utilities ASR Well System
SFWMD Lake Okeechobee Watershed Restoration Project ASR Wells (LOWRP) ASR C-38 North and C-38 South Clusters (Exploratory Wells)
City of Cocoa Beach Water Reclamation Facility
City of Bradenton Bill Evers Reservoir

A typical ASR system is equipped with an ASR well, a dual injection and recovery pump, transmission piping and treatment equipment (if required) and a MW network. The MW network is used to measure the operation of the ASR system and confirm the groundwater quality of the aquifers above and within the injection zone. If construction is limited to the addition of an ASR well within an existing ASR system, existing MWs may be sufficient to address the monitoring requirements for the additional ASR well. This requirement is determined in the investigative phase by the hydrogeologist and is bound by the permit requirements.

The water quality criteria for the injection water is based on whether the injection zone is within or below the USDW. The FDEP requires water being injected into the USDW to meet primary drinking water standards. These requirements make the treatment process, before injection and after recovery, one of the most variable components of an ASR system. Recovery treatment requirements will depend on the use of the water after recovery such as public consumption, surface water augmentation or irrigation. If the ASR system is co-located with a water treatment plant (WTP) or wastewater treatment plant (WWTP), additional treatment processes may be incorporated at the treatment plant therefore eliminating the need for a standalone ASR treatment facility.

Other construction cost considerations are that ASR wells have extensive testing periods following well construction and again before full activation. A pilot well must be drilled and tested to determine the best zone for injection. The injection zone must be sufficiently transmissive to accommodate injection and storage of the water. Additionally, the pilot well may be used to characterize the level of confinement present above the injection zone. For sites with multiple ASR wells, the preliminary data from the pilot well will be used to determine the optimum spacing of the wells to minimize interference and optimize recovery of the stored water between the ASR wells.

6.2 CAPITAL COST

Construction costs for the surveyed ASR wellfields were derived from pay applications and schedules of values obtained from each municipality or through the District's AWS Grant Funding Program. This study includes costs associated with the construction of ASR wells and excludes any consulting or permitting fees. Data were divided into costs associated with the ASR well and ASR monitor wells. ASR surface facilities include any piping, pumps, wellheads, and treatment components that make up the ASR system. However, most of the collected data was limited to the construction of the ASR well, because ASR wells are commonly co-located with wastewater or water treatment plants. Many ASR facilities have been in operation beyond our 10-year study period.

The cost for each ASR well and MW was separated into drilling costs versus wellhead and yard piping costs (if available). Drilling costs are associated with drilling pads, boring pilot holes, installation of casings, acidization and drawdown tests. Wellhead and yard piping costs are associated with injection and recovery pumps, electrical work, controls and instrumentation, and piping within then ASR facility (facility can be co-located with WTP or WWTP) site.

ASR well casing sizes in this study ranged from 12 to 24-inches (in). Total depths of the well range from 682 to 2,944-feet (ft) below land surface (bls). Total ASR well costs ranged from $520,017 to $4.3 million (in December 2021 dollars). Many variables such as depth, location, casing material and capacity of the well can impact the total cost of an ASR well. Additionally, overall drilling costs for ASR wells that are constructed to depths within the USDW, such as those discussed in this section, are comparable to that of a FAS production well based on the fact that ASR wells are typically drilled to depths similar to a FAS production well. ASR wells that are drilled to depths below the USDW are constructed at a higher cost.

Each ASR system requires an extensive MW network to evaluate the storage zone and the overlying aquifers. MWs can be constructed at various depths and with the functionality to monitor one or two confined aquifer layers. A MW that observes two aquifer zones is referred to as a DZMW and is typically the most expensive type of MW due to the depth and functionality. Other types of MWs are shallow MWs and storage zone MWs. These MWs monitor overlying surficial aquifers and storage zone aquifers, respectively. The total MW depths ranged from 120 to 2,100-ft bls, and costs ranged from $122,089 to $3.2 million (in December 2021 Dollars). Construction costs increase proportionally with the depth and function (how many zones the well monitors) of the MW. The projects evaluated in this section are described below. All construction costs are summarized in **Table 6-3** and **Table 6-4**. The following methodology was used for projecting constructions costs from cost basis month to December 2021 dollars is listed below:

CITY OF NAPLES ASR #3

The City of Naples ASR system serves as a relief to their potable water system during periods of high irrigation demands. The system was constructed in phases: Phase 1 ASR Well No. 1 completed March 2010; Phase 2 completed January 2011; and Phase 3 ASR 3 and MW-3 completed July 2014. Since ASR 3 and MW-3 were constructed within the 10-years study period, the construction costs were included as part of this study. Specific costs for the wellhead were not included within the provided pay application. It was assumed that wellhead costs were included as part of a construction line-item cost within the SOV provided by the City of Naples.

COLLIER COUNTY LIVINGSTON ROAD ASR SYSTEM ASR-2

Collier County Public Utilities Division's Livingston Road ASR system stores excess reclaimed water during the wet season when irrigation demands are low. The construction costs associated with ASR-2 were examined as a part of this study. ASR-2 was designed to accept and recover at a rate of 1.0 to 2.0 MGD. Costs for this project are inclusive of the drilling and wellhead construction of an ASR well and wellhead (vertical turbine pump and centrifugal injection pump), and yard piping to the existing ASR facility. Instrumentation and controls to accommodate the addition of ASR-2 was also included in the construction costs. Construction of a MW was not included as a part of this project and therefore, could not be quantified.

LEE COUNTY FORT MYERS BEACH ASR SYSTEM

Lee County incorporated a reclaimed water ASR system to manage seasonal variations of the demand of irrigation supply. The reclaimed water was previously discharged to surface waters (Caloosahatchee River) or injected via a Class I injection well. The construction costs analyzed in this study are specific to an exploratory ASR well and a storage zone monitoring well. The exploratory ASR well was anticipated to be converted to a functioning ASR well once testing was complete. In phone conversations, Lee County stated that the wellhead for the exploratory well has not been constructed and there are currently no plans to construct it in the foreseeable future due to funding deficiencies.

CITY OF MARCO ISLAND ASR SYSTEM

The Marco Island ASR system is comprised of seven ASR wells constructed from 1997-2010. Construction costs of this project focus on costs associated with the replacement of two 200 horsepower centrifugal injection pumps with a maximum capacity of 8.7 MGD. Costs of this project also include miscellaneous piping, a pre-fabricated building, electrical work and instrumentation and controls. It should be noted that the installation of the new pumps is provided for replacement costs. The pump costs cannot be relied upon for new ASR well construction.

POLK COUNTY UTILITIES ASR SYSTEM

Polk County Utilities incorporated an ASR system at the Northwest Regional Wastewater Treatment Facility. Construction costs of this project include an ASR well (ASR-1) and two monitoring wells: storage zone monitoring well (SZMW-1) and shallow monitoring well (SMW-1). Construction costs are related to drilling costs and wellhead construction costs.

SFWMD LAKE OKEECHOBEE WATERSHED RESTORATION PROGRAM (LOWRP) ASR C-38 NORTH AND C-38 SOUTH CLUSTERS

SFWMD has partnered with the United States Army Corps of Engineers (USACE) on the LOWRP as a part of the overall Comprehensive Everglades Restoration Plan (CERP). LOWRP is currently in the evaluation phase, with a projected fully implemented date of FY 2028. The first test wells have been constructed at both the C-38 North and C-38 South cluster sites and are undergoing testing to determine the optimal spacing and recovery efficiency. Drilling costs associated with the C-38 North and C-38 South test wells was reviewed as a part of this study, however, the wellheads for each of the sites have not yet been constructed.

CITY OF COCOA BEACH WATER RECLAMATION FACILITY

The City of Cocoa Beach constructed an ASR system to supplement the reclaimed water system supply, constructed at the City of Cocoa Beach Water Reclamation Facility. The SOV provided by Cocoa Beach represented the cost of the construction of the ASR well and wellhead as one cost and was unable to be broken out as separate costs for each. Construction costs include construction of one (1) ASR well (TPW-1) and two (2) monitoring wells: LFA Storage Zone Monitor Well (SZMW-1) and Upper Floridan Aquifer (UFA) shallow monitoring well (SMW-1).

CITY OF BRADENTON BILL EVERS RESERVOIR

The City of Bradenton owns and operates two (2) ASR wells, ASR-1 and ASR-2. ASR-1 is located at the City's high service pump station and ASR-2 is located at the Bill Evers Reservoir WTP. Both ASR wells store potable water during the wet season and recover that water during the dry season or when demand is high. Construction costs include ASR-2 and a storage zone well (SZMW-2).

The cost of construction of ASR wells is affected by depth, casing material, recovery capacity, and treatment requirements. Often, the most feasible option for a municipality is to incorporate or co-locate an ASR system with a WTP or WWTP. In this scenario, any additional treatment requirements associated with post or pre-treatment are limited to additions to existing WTPs or WWTPs.

The average total cost of construction of an ASR well is approximately $1.1 million (December 2021 Dollars) and the construction costs vary significantly with depth and recovery capacity. Monitoring well costs vary with depth and functionality (single vs DZMW). An average cost for a shallow monitoring well is approximately $124,000. The average cost of a single zone monitoring well is approximately $987,000. The total monitoring well depths ranged from 120 to 2,100-ft bls, and costs ranged from $122,089 to $3.2 million (in December 2021 Dollars). Lastly, range in cost for a DZMW is about $1.3 million. See **Table 6-3** and **Table 6-4** for a summary of costs.

Table 6-2: ASR System Construction Costs

Region	LWC	LWC	LWC	LWC	KB	LEC
Owner	City of Naples	Collier County	Lee County Utilities	City of Marco Island	Polk County Utilities	SFWMD
Site	City of Naples WWTP, ASR #3	Livingston Road ASR Site	Fort Myers Beach WWTP	North Water Treatment Plant	Northwest Regional Wastewater Treatment Facility	Lake Okeechobee Watershed Restoration, ASR C-38 APPZ
ASR Type	RW	RW	RW	RW	RW	PTS
Construction Date (Cost Basis Month-Year)	December 2013	October 2013	November 2018	December 2013	November 2012	May 2021
Well Depth (ft)	1,350	1,475	682	-	2,944	1,600
Casing Depth (ft)	1,150	1,450	510	-	1,998	1,300
Recovery Capacity (mgd)	2	2	1.5	-	1	5
Casing Material Type	Steel	FRP	Steel	-	Steel	FRP
Casing Diameter (in)	24	12	14	-	12	24
ASR Well Pump Type	-	Horizontal Split Case Centrifugal, Vertical Turbine	-	Centrifugal	Vertical Turbine	Vertical Turbine
ASR Well Drilling Cost at Cost basis Month-Year	$1,233,310	$1,369,400	$390,550	-	$967,500	$3,417,450
Wellhead and Yard Piping Appurtenances Cost at Cost Basis Month-Year	$240,219.00	$1,003,000	-	$519,008	$89,800	-
CCI at Cost Basis Month-Year	9668	9689	11184	9668	9398	-
MPI at Cost Basis Month-Year	-	-	-	-	-	4239
ASR Well Cost at Cost Basis Month-Year (3)	$1,473,529	$2,524,540	$390,550	-	$1,107,300	$3,427,450
Adjusted ASR Well Cost (December 2021 Dollars)	$2,269,658(1)	$3,880,090(1)	$520,017(1)	$799,422(1)	$1,754,560(1)	$4,013,650(2)
2021 Cost/MGD Recovery Capacity	$1,134,829	$1,940,045	$346,678	-	$1,754,560	$802,730

Table 6-2: ASR System Construction Costs (Continued)

Region	LEC	LEC	LEC	SJWMD	SWFWMD
Owner	SFWMD	SFWMD	SFWMD	City of Cocoa Beach	City of Bradenton
Site	Lake Okeechobee Watershed Restoration, ASR C-38 UFA	Lake Okeechobee Watershed Restoration, ASR SOUTH C-38 APPZ	Lake Okeechobee Watershed Restoration, ASR SOUTH C-38 UFA	City of Cocoa Beach Water Reclamation Facility	Bill Evers Reservoir
ASR Type	PTS	PTS	PTS	RW	PW
Construction Date (Cost Basis Month – Year)	May 2021(2)	May 2021(2)	May 2021(2)	May 2012	March 2016
Well Depth (ft)	900	1,600	900	1,320	710
Casing Depth (ft)	600	1,300	600	1,230	535
Recovery Capacity (mgd)	5	5	5	1	1.5
Casing Material Type	FRP	FRP	FRP	FRP	PVC
Casing Diameter (in)	24	24	24	18	18
ASR Well Pump Type	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine	Vertical Turbine
ASR Well Drilling Costs at Cost Basis Month-Year	$1,373,700	$2,969,250	$1,598,250	-	$406,520
Wellhead and Yard Piping Appurtenances Cost at Cost Basis Month-Year	-	-	-	-	$2,219,447
ASR Well Cost at Cost Basis Month-Year (3)	$1,391,200	$2,979,250	$1,616,750	$1,745,500	$2,625,967
CCI from at Cost Basis Month-Year	-	-	-	9351	10242
MPI from at Cost Basis Month-Year	4239	4239	4239	-	-
Adjusted ASR Well Cost (December 2021 Dollars)	$1,629,138(2)	$3,488,794(2)	$1,893,264(2)	$2,779,715(1)	$3,818,062(1)
December 2021 Cost/mgd	$325,828	$697,759	$378,653	$2,779,715	$2,545,374

(1) Construction date before August 2020 utilized a CCI adjustment. "ASR Well Cost at Cost Basis Month-Year" is multiplied by 11455 divided by "CCI at Cost Basis Month-Year". A 30% increase was added to the August 2020 value to reflect estimated costs in December 2021 dollars.
(2) Construction date after August 2020 utilized a MPI adjustment. "ASR Well Cost at Cost Basis Month-Year" is multiplied by 4964 divided by MPI at Cost Basis Month-Year".
(3) Total ASR Well Costs includes general condition add-on obtained from data sources.

Table 6-3: ASR System Monitoring Well Construction Cost

Region	LWC	LWC	KB	LEC
Owner	City of Naples	Lee County Utilities	Polk County Utilities	SFWMD
Site	City of Naples WWTP	Fort Meyers Beach WWTP	Northwest Regional Wastewater Treatment Facility	Lake Okeechobee Watershed Restoration, ASR C-38 APPZ
Start Date (Cost Basis Month-Year)	December 2013	November 2018	November 2012	May 2021
No. of Monitoring Wells	1	1	2	1
Casing Depth	670	160	1,040; 2,000	1,300
Well Depth	740	240	2,100; 1,130	1,400
Casing Material Type	FRP	PVC	Steel	FRP
CCI at Cost Basis Month-Year	9668	11184	9398	-
MPI at Cost Basis Month-Year	-	-	-	4239
Monitoring Well Cost at Cost Basis Month-Year (3)	$226,810	$188,000	$1,256,225	$2,552,800
Adjusted Monitoring Well Cost (December 2021 Dollars)	$349,353(1)	$250,322(1))	$1,990,538(1)	$2,989,408(2)

Table 6-3: ASR System Monitoring Well Construction Cost (Continued)

Region	LEC	LEC	LEC	SJWMD	SWFWMD	SWFWMD
Owner	SFWMD	SFWMD	SFWMD	City of Cocoa Beach	City of Bradenton	City of Bradenton
Site	Lake Okeechobee Watershed Restoration, ASR C-38 UFA	Lake Okeechobee Watershed Restoration, ASR SOUTH C-38 APPZ	Lake Okeechobee Watershed Restoration, ASR SOUTH C-38 UFA	City of Cocoa Beach Water Reclamation Facility	Bill Evers Reservoir, Storage Zone Monitoring Well	Bill Evers Reservoir, Shallow Monitoring Well
Start Date (Cost Basis Month-Year)	May 2021	May 2021	May 2021	May 2021	March 2016	March 2016
No. of Monitoring Wells	1	1	1	2	1	1
Casing Depth	100	1300	100	800; 1,235	538	385
Well Depth	120	1400	120	950; 1,320	658	435
Casing Material Type	PVC	FRP	PVC	PVC	PVC	PVC
CCI at Cost Basis Month-Year	-	-	-	-	10242	10242
MPI at Cost Basis Month-Year	4239	4239	4239	4239	-	-
Monitoring Well Cost at Cost Basis Month-Year (3)	$98,300	$1,358,950	$100,550	$390,000	$115,900	$121,780
Adjusted Monitoring Well Cost (December 2021 Dollars)	$115,112(2)	$1,591,372(2)	$117,747(2)	$456,702(2)	$168,514(1)	$177,064(1)

(1) Construction date before August 2020 utilized a CCI adjustment. "Monitoring Well Cost at Cost Basis Month-Year" is multiplied by 11455 divided by "CCI at Cost Basis Month-Year". A 30% increase was added to the August 2020 value to reflect estimated costs in December 2021 dollars.
(2) Construction date after August 2020 utilized a MPI adjustment. "Monitoring Well Cost at Cost Basis Month-Year" is multiplied by 4964 divided by MPI at Cost Basis Month-Year".
(3) Total Monitoring Well Costs includes general condition costs obtained from data sources.

6.3 OPERATION AND MAINTENANCE COSTS

Generally, O&M practices and costs can be categorized as sampling and general maintenance procedures. Peace River Manasota Regional Water Supply Authority's (PRMRWS Authority) O&M manual was reviewed to develop an understanding of typical maintenance procedures for ASR systems. The PRMRWS Authority's system has three (3) modes of operation: recharge, recovery and storage. Each mode has its respective monitoring requirements from FDEP and SWFWMD.

The PRMRWS Authority monitors the Peace River Facility (PRF) in accordance with F.A.C. 62-528-425(i)(g) and 62-52-8430(2) and reports data to FDEP in a Monthly Operating Report for each mode of operation. The Authority follows sampling procedures and requirements described in DEP-SOP-001/01. SWFWMD also has monitoring requirements for each mode of operation. Samples are tested for sulfates, conductivity, chlorides, and pH on a monthly basis. The District requires reporting of water levels at both monitoring wells (min. and max daily) and production wells (weekly). Cumulative volumes of water stored and recovered per ASR well are reported on a monthly basis.

The PRMRWS Authority inspects the entire ASR wellfield system on a weekly basis. The Authority also has a typical maintenance schedule for each component of the system as described below:

- ASR Production Well Vertical Turbine Pumps
- ASR Production Well Modulating Control Valves
- ASR Production and Monitoring Well Pressure Transmitting Transducer
- ASR Production and Monitoring Well PSI Gauges
- Monitoring Well Casing, Valves and Piping
- SCADA undergoes constant evaluation, maintenance, upgrades and repairs to ensure functionality and data integrity."

The PRMRWS Authority provided a budgetary estimate of $20,000 associated with general repair and maintenance practices described above. Separately, the PRMRWS Authority estimated $100,000 per well every 20 years for rehabilitation and replacement. Detailed annual costs for O&M were received and analyzed from the City of Naples and Marco Island. **Table 6-4** summarizes the O&M costs provided by the municipalities. It should be noted, maintenance costs vary greatly across regions: Marco Island spends approximately $106,000 every year for chemical costs during injection while, the City of Naples's ASR system does not require the use of chemicals and therefore has zero annual chemical costs. The City of Naples ASR wells operate under artesian pressure and therefore do not incur electrical costs for pumping when recovering the stored water.

Table 6-4: Average Annual Operation and Maintenance Costs

Sampling	$42,882
Chemical Costs	$105,500 (Marco Island)
Electrical Costs	$48,721 (Marco Island)
Meter/Gauge Calibrations	$778
Equipment Repairs/Replacement	$18,546
Physical Maintenance	$3,000
Total	**$219,427**

6.4 TOTAL COST SUMMARY

In general, the construction costs collected for this evaluation did not appear to have a direct correlation to the design and capacity of each well. However, to evaluate the overall construction costs for recovery capacities for 1 mgd, 1.5 mgd, 2 mgd, and 5 mgd (estimated) based on smaller capacity well data), ASR well projects were selected that included the respective recovery capacity and a MW as part of the construction activities. Since a direct correlation could not be determined, the data used for the ASR construction costs are real data that is assumed to be representative of the construction costs in December 2021 dollars. The opinion of probable construction costs for ASR wells and associated MW is summarized in **Table 6-5**. The construction cost curve for ASR wells and associated MW is depicted in **Figure 6-1**. Only one O&M data source was available for this technology. Without having sufficient data from multiple ASR wells and capacities, the overall annual O&M costs could not be determined.

Table 6-5: Opinion of Probable Construction Costs for ASR Well and MW

Region		KB	SWFWMD	LWC	LWC	Estimated Value
Owner		Polk County Utilities	City of Bradenton	City of Naples	Collier County	
ASR Type		RW	PW	RW	RW	N/A
Recovery Capacity (mgd)		1	1.5	2	2	5
Total Cost per ASR in December 2021 Dollars		$1,754,560	$3,818,062	$2,269,658	$3,880,090	N/A
MW Cost December 2021 Dollars		$1,990,538	$177,064	$349,353	$349,353	N/A
Total Cost for ASR + MW December 2021 Dollars		$3,745,098	$3,995,126	$2,619,011	$4,229,443	$5,421,725
Technical Services	20%	$749,020	$799,025	$523,802	$845,889	$1,084,345
Owner Administration and Legal	5%	$187,255	$199,756	$130,951	$211,472	$271,086
Project Contingency	15%	$561,765	$599,269	$392,852	$634,416	$813,259
Opinion of Probable Capital Cost		$5,243,137	$5,593,176	$3,666,615	$5,921,220	$7,590,415

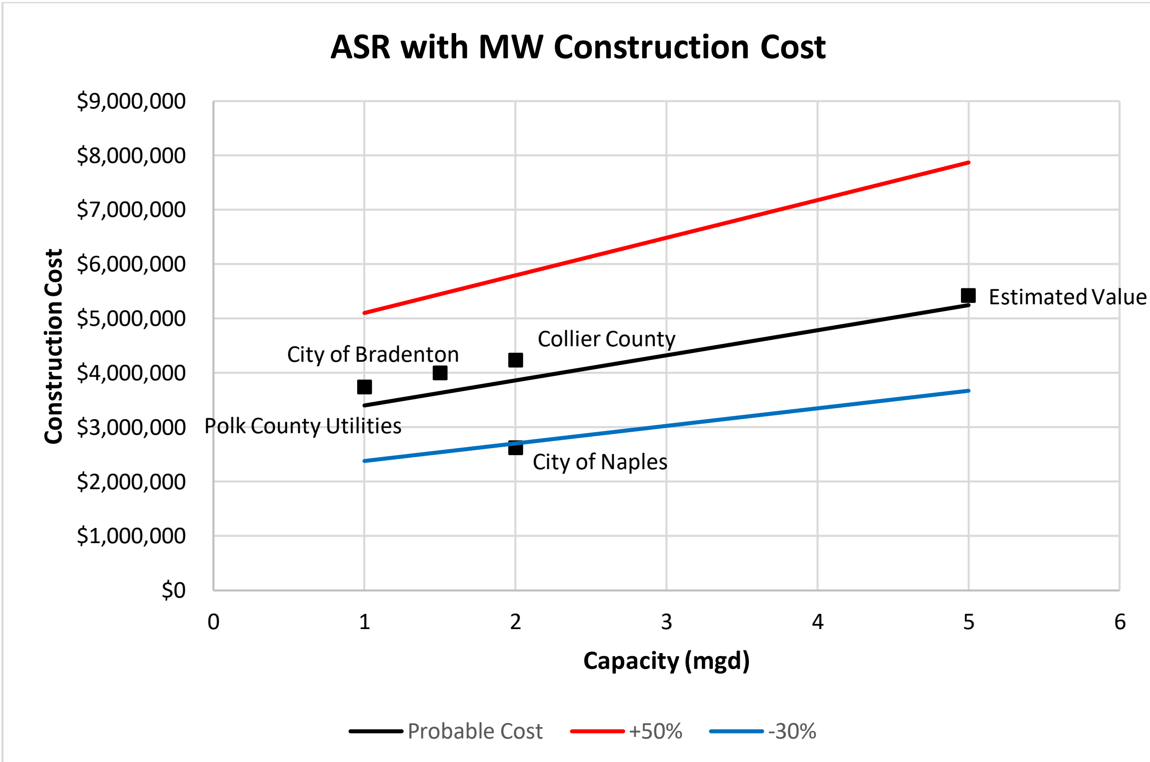

Figure 6-1: ASR with MW Construction Cost Curve

7

SURFACE WATER STORAGE

7.1 DISCUSSION OF ASSUMPTIONS AND APPROACH

Reservoirs serve many purposes within South Florida, such as storage for water supply, stormwater storage, or stormwater treatment. The largest cost components of reservoir construction are earthwork and associated equipment and labor costs. Engineering costs include design, engineering services during construction or construction management services and typically range from 10% to 20% of the overall construction cost. For this study, construction costs were provided by project managers at the SFWMD, and from municipalities, or from other reliable sources available on the internet. To be conservative, an average of 20% of construction costs should be added to capture the engineering costs described above. O&M costs were provided by the SFWMD and other municipalities, where available.

Some projects within this Chapter were designed and constructed in separate construction packages and were performed in different phases and time periods of the overall surface water storage (SWS) or reservoir project. Further, the different construction packages were completed at various time frames and start dates. Therefore, the project components in the different packages were initially evaluated separately. Each SWS component was then escalated or adjusted to December 2021 dollars and were added together to have an overall construction cost for each SWS project, where applicable. Escalated costs for projects constructed before August 2020, follow the methodology described in Chapter 1, where a combination of the CCI (August 2020) and the MPI (30% increase) were used to project costs to December 2021. For projects constructed after August 2020, the MPI was used to project costs from construction date to December 2021 dollars.

It should also be noted that some of the projects listed within this section are larger reservoir projects intended to capture stormwater runoff versus providing an alternative water supply for storage, treatment, and consumption. In addition, other projects listed in this section are considered shallow stormwater treatment areas (STA). It was determined during this study these projects should not be discounted from a construction cost standpoint since these projects include similar construction components as that needed for a SWS system. For example, the Peace River Reservoir 2 used similar earthwork construction methodologies as the Caloosahatchee River West Basin Storage Reservoir (C-43 WBSR), such as the use of a slurry wall for water storage retention, as well as a taller embankment than a typical SWS system (i.e. Peace River Reservoir 2 embankment height is comparable to the C-43 WSBR embankment height). STAs may also be comparable in costs to shallow SWS systems used for alternative water supply sources as similar construction methodologies appear to be used.

7.2 CAPITAL COSTS

Caloosahatchee River West Basin Storage Reservoir

The Caloosahatchee River West Basin Storage Reservoir (C-43 WSBR) is a part of the CERP designed to improve the quantity and timing of water releases through the Caloosahatchee River and Estuary during the dry season. The C-43 Reservoir is in Hendry County, west of LaBelle. The C-43 Reservoir is located within a 10,500-acre area of former farmland and allows for the storage of 170,000 acre-feet of water at depths ranging between 15 and 25 feet. The C-43 Reservoir project includes the following components:

- Dam at a height of 27 to 38 feet (with a separator dam to split the reservoir into two cells). Perimeter dam is constructed with a soil bentonite wall.
- Inflow pump station (S-470) with a capacity of 1,500 cubic feet per second (cfs),
- Fourteen (14) water control structures
- Irrigation pump station (S-476) with a capacity of 195 cfs
- Perimeter canal
- Recreational features
- Townsend Canal improvements
- Local and site access bridges

Other earthwork efforts were also required, such as preloading, or temporarily loading areas with soil mounds to compact subsurface soils. This also reduces long-term settlement and increases the capacity of soil to support future water control structures; demolition of existing structures; and a temporary bypass to convey irrigation water to farm areas east of the project. The project components and associated costs are detailed in **Table 7-1**.

Table 7-1: Caloosahatchee River West Basin Storage Reservoir Construction Costs

Bid Package	Preload & Demolition	Pump Station S-476	Inflow Pump Station S-470	Site Preparation (Tree Clearing Progress)	Site Preparation Access Roads	Civil Works	Total Construction Costs
Project Cost (million)	$11	$13	$59	$5	$3	$524	$615
NTP Date (Cost Basis Month-Year)	November 2015	June 2016	March 2018	November 2017	April 2018	January 2019(1)	
CCI at Cost Basis Month-Year (2)	9173	10337	10959	10870	10971	11206	
Adjusted Cost (August 2020 Dollars) (million) (3)	$14	$14	$62	$5.3	$3.1	$536	
Adjusted Cost (December 2021 Dollars) (million) (4)	$18	$19	$80	$7	$4.1	$696	$823

(1) Bid Date not NTP Date
(2) NTP date before August 2020 utilized a CCI adjustment
(3) "Project Cost" is multiplied by 11455 divided by "CCI at Cost Basis Month-Year")
(4) 30% increase is added to "Adjusted Cost (August 2020 Dollars)" to reflect estimated costs in December 2021 dollars

Indian River Lagoon – South C-44 Reservoir & Stormwater Treatment Area

The Indian River Lagoon - South C-44 Reservoir (C-44 Reservoir) & STA, located in Martin County, Florida, is also part of CERP. The intent of the C-44 Reservoir is to capture local nutrient laden stormwater runoff collected within the C-44 Canal, or surrounding watershed tributary areas, to help reduce the average annual total nutrient load discharged to the St. Lucie River. In addition, periodic storage of water into this reservoir will improve the timing of the releases of the freshwater flows providing improvement to the overall salinity regime in the St. Lucie River Estuary and the southern portion of the Indian River Lagoon. The project covers approximately 12,000 acres of aboveground storage allowing for the storage of 50,600 acre-feet of water at a depth of 15 feet. Construction also included an inflow pump station with a capacity of 1,100 cfs and 6,300 acres of STA. Other components of the C-44 Reservoir project are listed below:

- 35,000-foot long western reservoir perimeter canal
- 50-foot wide spillway
- 15,000-foot long eastern reservoir perimeter canal
- Reservoir discharge tower structure comprised of three slide gates to convey a maximum of 1,100 cfs and 600 cfs under normal operations through two culverts to the system discharge canal

- Two miles of systems discharge canal that will convey flows from the reservoir through the distribution canal to the eastern STA collection canal

Construction of all major components were completed in November 2021. The project components and associated costs are detailed in **Table 7-2**.

Table 7-2: South C-44 Reservoir & Stormwater Treatment Area Construction Costs

Bid Package	Intake Canal (USACE)	Contract 1 Canals, Roads, Bridge, Spillway (USACE)	Contract 2 Reservoir & Discharge Canal (USACE)	System Discharge Canal (Spillway & Canal Segment) (SFWMD)	Pump Station	Stormwater Treatment Area	Total Construction Costs
Project Cost (million)	$20	$36.7	$227	$5	$40	$100	$429
NTP Date (Cost Basis Month-Year)	July 2011	July 2015	August 2019	September 2014	April 2015	October 2014	
CCI at Cost Basis Month-Year (1)	9080	10037	11311	9870	9992	9886	
Adjusted Cost (August 2020 Dollars) (million) (2)	$25	$42	$230	$6	$46	$116	$465
Adjusted Cost (December 2021 Dollars) (million) (3)	$33	$54	$299	$8	$60	$150	$604

(1) NTP date before August 2020 utilized a CCI adjustment
(2) "Project Cost" is multiplied by 11455 divided by "CCI at Cost Basis Month-Year")
(3) 30% increase is added to "Adjusted Cost (August 2020 Dollars)" to reflect estimated costs in December 2021 dollars

A1 Flow Equalization Basin

The A1 Flow Equalization Basin (FEB) is located west of Highway 27 in Palm Beach County and was completed in 2015. It was designed to attenuate stormwater flows and temporarily store water. The A1 FEB also provides water quality treatment using vegetation to remove phosphorus from the water before it is released into STA-2 and STA-3/4. The storage feature has an area of approximately 15,000 acres at a depth of 4 feet, giving it a capacity of about 60,000 acre-feet and can accept stormwater at a rate up to 4,600 cubic feet per second. Components of the A1 FEB include:

- 15,000-acre FEB
- 60,000 acre-feet attenuation capacity with an average depth of 4feet
- 13 miles of perimeter levees

The project components and associated costs are detailed in **Table 7-3.**

Table 7-3: A1 FEB Construction Costs

Project Cost ($ Millions)	$60
NTP Date (Cost Basis Month-Year)	July 2013
CCI at Cost Basis Month-Year (1)	9552
Adjusted Cost (August 2020 Dollars) million) (2)	$72
Adjusted Cost (December 2021 Dollars) (million) (3)	$94

(1) NTP date before August 2020 utilized a CCI adjustment
(2) "Project Cost" is multiplied by 11455 divided by "CCI at Cost Basis Month-Year")
(3) 30% increase is added to "Adjusted Cost (August 2020 Dollars)" to reflect estimated costs in December 2021 dollars

Everglades Agricultural Area Reservoir (A2 Reservoir and STA)

The Everglades Agricultural Area (EAA) Reservoir, which includes the A2 Reservoir and STA, is a part of the USACE Central Everglades Planning Project (CEPP) and is located just north of the Holey Land Wildlife Management Area, between the Miami Canal and the North New River Canal. The goal of CEPP is to implement features that will control the quantity, quality, timing, and distribution of water that flows into the Central Everglades. The A2 Reservoir is proposed to cover 10,500 acres with 240,000 acre-feet of storage with a depth of 23 feet. The accompanying A2 STA is proposed to be approximately 6,500 acres. The A2 Reservoir can receive water from the Miami Canal and the North New River Canal and will integrate with the A1 FEB. The reservoir can also discharge water to STA-A2, STA-3/4, and STA-2. Construction of the conveyance canals associated with the EAA Reservoir and STA began in 2021. The overall EAA Reservoir construction is anticipated to be completed in 2029. The planned capital costs for the A2 Reservoir are anticipated to be about $1.3 billion, which includes the reservoir, STA, real estate, canal conveyance improvements, and recreation costs. The construction costs associated with the Reservoir's STA are estimated to be approximately $89 million. **Table 7-4** summarizes the estimated EAA Reservoir and STA Construction Costs as of June 2018. These costs were not adjusted to December 2021 dollars due to unknown adjustments in design costs and other factors that may impact the construction costs.

Table 7-4: EAA Reservoir (A2 Reservoir and STA) Estimated Construction Costs

Description	A2 Reservoir	A2 STA	Pump Station and Water Control Structures	Canal Conveyance	Recreation Costs
Project Cost (million) (1)	$1,340	$89	$280	$100	$2
Adjusted Cost (December 2021 Dollars) million (2) (3)	$1,750	$120	$377	$134.5	$2.69

(1) Cost is planned capital cost. Includes Reservoir + Stormwater Treatment Area + Real Estate, Canal Conveyance Improvement, and Recreation Plan Costs Use CCI at NTP date (June 2018) if before August 2020
(2) "Project Cost" is multiplied by 11455 divided by 11069) to determine adjusted cost in August 2020 Dollars
(3) 30% increase is added to adjusted cost in August 2020 Dollars to reflect estimated costs in December 2021 dollars

Peace River Reservoir 2

The Peace River Regional Water Authority (Authority) works in partnership with its four member counties: Charlotte, DeSoto, Manatee, and Sarasota to provide potable water to its residents. The Authority operates a 51 MGD drinking water treatment facility located in southwest DeSoto County. The water source for the Peace River Treatment Facility includes an ASR system of twenty-one (21 ASR wells with a storage capacity of 6.3 billion gallons (BG) and an off-stream reservoir system with a total storage capacity of 6.52 (BG). The current reservoir system is comprised of two reservoirs: Reservoir 1 (constructed in the 1980s) and Reservoir 2 (constructed in 2009), with a storage of 0.52 BG and 6.0 BG respectively. The construction costs for Reservoir 2 will be the focus of this evaluation.

Reservoir 2 consists of a 4-mile long aboveground earthen embankment, with a subsurface slurry wall, at an average height of 35-feet above grade and receives water from Peace River via a pipeline. Design and Construction of this project was completed outside of the ten (10) year window established for this study. However, it was included since this project is representative of a Florida water supply storage facility for drinking water and best represents the intent of this section and scope of work. **Table 7-5** includes construction costs that reflect engineering design, permitting and environmental services, as well as engineering services during construction, reservoir construction, and construction of mitigation areas.

Table 7-5: Peace River Reservoir 2 Overall Cost Summary for Engineering Services, Environmental Services and Construction Costs for Reservoir and Mitigation Areas

Bid Package	Engineering Fees for Design and Permitting	Engineering Fees for Mitigation Plans	Engineering Fees for Construction Phase Services	Regional Reservoir Construction (6 BG)	Construction of Mitigation Areas	Total
Cost (million)	$6.5	$1.4	$7.6	$70	$0.6	$86.1
NTP Date (Cost Basis Month-Year at midpoint)	June 2002	June 2007	June 2007	June 2007	September 2014	
CCI at Cost Basis Month-Year (1)	6532	7939	7939	7939	9870	
Adjusted Costs (August 2020 Dollars) (million)(2)	$11	$2	$11	$101	$1	
Adjusted Cost (December 2021 Dollars) (million) (3)	$15	$3	$14	$131	$1	$164

(1) NTP date before August 2020 utilized a CCI adjustment
(2) "Project Cost" is multiplied by 11455 divided by "CCI at Cost Basis Month-Year")
(3) 30% increase is added to "Adjusted Cost (August 2020 Dollars)" to reflect estimated costs in December 2021 dollars

McCarty Ranch Preserve and Extension

McCarty Ranch Extension (an extension of the McCarty Ranch Preserve) was purchased by the City of Port St. Lucie in 2012 with plans to use the land as a SWS and treatment facility. The McCarty Ranch Preserve and Extension is located within the C-23 basin, north of the C-23 Canal. The project is intended to convert 1,871 acres of citrus grove and an existing 528-acre impoundment to shallow water storage facilities pumped from the C-23 Canal. This will prevent approximately 9 BG of excess surface water from entering the North Fork of the St. Lucie River annually. The water stored within this water storage facility is to be used as an alternative water supply and is intended to be treated for ASR storage or public consumption. A total of seven (7) reservoirs will be constructed in phases. Areas 1 through 6 are located on the McCarty Ranch Extension property and Area 7 (includes 7A and 7B) is located on the McCarty Ranch Preserve property. Areas 1 - 4 have either been completed or are in construction. Capital costs for Area 1 through 4 are presented in **Table 7-6**. Area 5 and 6 (to be constructed together) and Area 7 (7A and 7B) have not been constructed yet. However, for these areas, cost estimates were compiled from available information, provided by the City, at the time of this study. The estimated costs for Area 5, 6, and 7 (7A and 7B) are presented in **Table 7-7**.

Table 7-6: McCarty Ranch Preserve and Extension for Areas 1, 2, 3 and 4

Description	Area 1	Area 2	Area 3	Area 4
Area Size (Acres)	210	275	290	287
Construction Cost at time of Contract Date (million)	$1.9	$2.6	$2.6	$2.6
NTP Date (Cost Basis Month-Year)	January 2018	June 2019	March 2020	October 2021
CCI at Cost Basis Month-Year(1)	10878	11268	11397	
Adjusted Cost (August 2020) ($ million)(2)	$2	$2.64	$2.64	
MPI at Cost Basis Month-Year(4)				4935
Adjusted Cost (December 2021 Dollars) (million)	$2.6(3)	$3.45(3)	$3.38(3)	$2.62(5)

(1) NTP date before August 2020 utilized a CCI adjustment
(2) "Project Cost" is multiplied by 11455 divided by "CCI at Cost Basis Month-Year"
(3) 30% increase is added to "Adjusted Cost (August 2020 Dollars)" to reflect estimated costs in December 2021 dollars
(4) Use MPI at NTP date after August 2020 utilized a MPI adjustment
(5) "Project Cost" multiplied by 4964 divided by "MPI at Cost Basis Month-Year"

Table 7-7: McCarty Ranch Preserve and Extension Estimated Construction Costs for Areas 5, 6, & 7 (7A and 7B)

Description	Area 5	Area 6	Area 7 (7A and 7B)
Area Size (Acres)	78	40	730
Estimated Construction Cost at time of PSL Evaluation in 2019 (million)	$1.24		$12.72
CCI at Cost Basis Month (Assumed to be June 2019) (1)	11293		
Estimated Construction Cost in August 2021 Dollars ($ million) (2)	1.26		12.90
Estimated Construction Cost at time of PSL Evaluation in December 2021 Dollars (million) (3)	$1.64		$16.81

(1) NTP date before August 2020 utilized a CCI adjustment
(2) "Project Cost" is multiplied by 11455 divided by "CCI at Cost Basis Month-Year")
(3) 30% increase is added to "Adjusted Cost (August 2020 Dollars)" to reflect estimated costs in December 2021 dollars

Lakeside Ranch STA

The Lakeside Ranch STA is in Martin County and is part of the Northern Everglades and Estuaries Protection (NEEP) Program. This project is designed to help remove phosphorus concentrations to reduce nutrient loading to Lake Okeechobee and the Everglades. The project covers 2,700 acres and includes 1,707 acres of treatment cells. The STA is comprised of five treatment cells south of the Preservation Area and includes 30,328 linear feet of perimeter levees, 17,422 linear feet of interior levees, an outflow canal, and a 250-cfs inflow pump station (S-650). In addition to the above features there is a 600 cfs pump station (S-191A) that is intended for flood control and recirculation to the STA. The Lakeside Ranch STA was completed in three phases but Phase I, completed in July of 2012, was not recent enough to be included in this study. The included phases are:

- Lakeside Ranch STA South - Phase II: 788 acres (1,840 acre-feet) of treatment cells (Completed in September 2019)
- S-191A Pump Station - Phase III: 600 cfs Pump Station (Completed in August 2021)

Lakeside Ranch STA South - Phase II was identified as being constructed within the past 10 years. Even though this project is an STA, it is representative of a system that may be required for the pre-treatment of an alternative water supply project. **Table 7-8** summarizes the construction costs for the Lakeside Ranch STA South - Phase II project. The cost data for this project was available at time of completion of construction. Therefore, this data was used to estimate the total construction costs in December 2021 dollars.

Table 7-8: Lakeside Ranch STA – South Phase II and S-191A Pump Station Construction Costs

Description	Phase II	Phase III
Construction Cost at Time of Completion of Construction (million)	$40.37	$31.5
Construction Cost (Cost Basis Month-Year)	November 2018	June 2018
CCI based on Cost Basis Month-Year (1)	11184	11069
Adjusted Cost (August 2020 Dollars) (million)(2)	$41.35	$32.6
Adjusted Cost (December 2021 Dollars) (million)(3)	$53.75	$42.38

(1) Construction Cost before August 2020 utilized a CCI adjustment
(2) "Project Cost" is multiplied by 11455 divided by "CCI at Cost Basis Month-Year")
(3) 30% increase is added to "Adjusted Cost (August 2020 Dollars)" to reflect estimated costs in December 2021 dollars

Table 7-9 summarizes the capital costs of each project evaluated in this Chapter. **Figure 7-1** depicts the surface water impoundment capital costs and capacity relationship.

Table 7-9: Summary of Capital Costs for Reservoir Projects

Surface Water Impoundment	Total Cost (December 2021 Dollars) (million)	Total Storage Capacity – one fill (acre-feet)	Total Capital Cost ($/acre-feet of storage, one fill)
Caloosahatchee River West Basin Storage Reservoir	$823	170,000	$4,841
Indian River Lagoon - South C44 STA (Cells 1 through 6)	$604	50,600	$11,937
A1 FEB	$94	60,000	$1,567
Everglades Agricultural Area Reservoir	$1,770	240,000	$7,383
Peace River Reservoir 2	$86.1	18,413	$4,676
McCarty Ranch Extension Area 1	$2.5	840	$2,976
McCarty Ranch Extension Area 2	$3.4	1,100	$3,091
McCarty Ranch Extension Area 3	$2.6	1,160	$2,241
McCarty Ranch Extension Area 4	$2.6	1,148	$2,265
McCarty Ranch Extension Area 5	$1.6	312	$3,475
McCarty Ranch Extension Area 6		160	
McCarty Ranch Preserve Area 7 (7A and 7B)	$16.8	2,112	$7,960
Lakeside Ranch STA Phase 2 – South	$53.7	1,840	$29,212
Lakeside Ranch STA Phase 2 – South (Pump Station S-191A)	$42.3	--	--

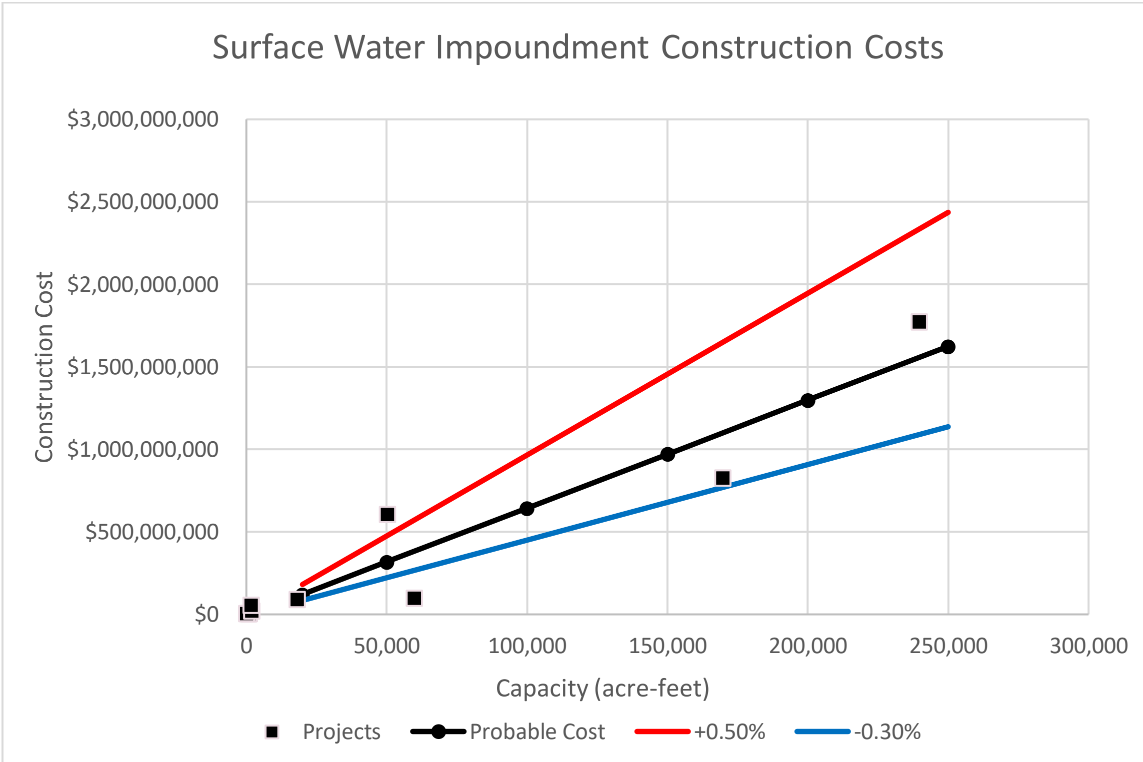

Figure 7-1: Surface Water Impoundment Construction Cost Curve

7.3 OPERATION AND MAINTENANCE COSTS

Estimated O&M costs were provided by the SFWMD and other municipalities and included in this analysis and study. O&M costs related to SWS vary based on the size of impoundment and components of the storage system. **Table 7-10** summarizes the estimated O&M costs associated with several SWS areas or reservoirs where information was available.

Table 7-10: Estimated Surface Water Storage Operation and Maintenance Costs Summary

Project / Project Feature	Annual O&M Estimates ($)	Total Storage Capacity – one fill (Acre-feet)	O&M Cost ($/Acre-feet of Storage Capacity – one fill)	Comments
C-44 Intake Canal and Tower (Contract #1)	$37,022	170,000	$0.22	Operational
C-44 Reservoir - S-401 Pump Station (Contract #2)	$548,260	170,000	$3.23	New Works Estimates - Not Fully Operational
C-44 Reservoir (Contract #2)	$490,731	170,000	$2.89	New Works Estimates - Not Fully Operational
C-44 STA - Cells 1-6 (Contract #3)	$802,774	170,000	$4.72	New Works Estimates - Not Fully Operational
A-1 FEB	$219,902	60,000	$3.66	3-Year average of expenditures (FY2018-19 to FY2020-21) - This is a Flow Equalization Basin (FEB) not a Reservoir
Peace River - Intake (120 MGD)	$250,000	18,413	$13.58	Estimate for Electrical and Maintenance, Original Pump Station (not constructed with Reservoir No. 2)
Peace River - Reservoir No. 2	$500,000	18,413	$27.16	Aeration System/Monitoring System, Reporting Costs, Land Management
Peace River - Annual Maintenance for Mitigation Area A/B for Reservoir No. 2	$30,000	18,413	$1.63	Environmental Services and Construction Necessary to Maintain Mitigation Areas on Property
Peace River – Engineer of Record Annual Costs	$275,000	18,413	$14.94	Recurring Cost for Engineer of Record to Complete all Compliance Monitoring Requirements
Lakeside Ranch North – Phase I	$416,815	~3,600 (treatment)	$115.78	3-Year Average of Expenditures (FY2018-19 to FY2020-21) - This is a STA not a Reservoir
Lakeside Ranch STA South - Phase 2	$185,975	~1,840 (treatment)	$101.07	New Works Estimates - Not Fully Operational (Assume 3-Year Average)
Lakeside Ranch STA Phase 2 – South (Pump Station S-191A)	$275,690	--	--	New Works Estimates - Not Fully Operational
McCarty Ranch Preserve and Extension - General	$180,000	6,832	$26.35	Estimated Operating Costs, Project in Construction

(1) O&M Annual Costs ($/acre-ft) is based on the O&M cost associated with one fill of the reservoir (assuming the reservoir was filled only once in a year). Costs projected over the life of the project cannot be calculated without knowing the total annual storage throughout the life of the reservoir. This information was not available at the time of this study.

7.3 TOTAL COST SUMMARY

A summary of capital costs (in December 2021 dollars) for all SWS areas reviewed in this study are represented in **Table 7-11** in terms of total costs in December 2021 dollars and cost per acre-feet. Annual O&M costs are also included in **Table 7-11** where information was available at the time of this study. Total annual storage was not available or was not provided at the time of this report. Therefore, a Production Cost Curve could not be produced as annual storage over 20 years would be needed to estimate the total production costs as it relates to O&M and capital costs. Annual O&M estimates were provided by the SFWMD and Port St. Lucies online documentation (where noted).

Table 7-11: Summary of Capital Costs for Reservoir Projects Included in This Section

Surface Water Impoundment	Total Cost (December 2021 Dollars) (million)	Total Storage Capacity – one fill (acre-feet)	Total Capital Cost ($/acre-feet of storage, one fill)	Annual O&M Estimates
Caloosahatchee River West Basin Storage Reservoir	$823	170,000	$4,841	Unknown/Under Construction
Indian River Lagoon - South C44 STA (Cells 1 through 6)	$604	50,600	$11,937	$802,774
A1 FEB	$94	60,000	$1,567	$219,902
Everglades Agricultural Area Reservoir	$1,770	240,000	$7,383	Unknown/In Design Phase
Peace River Reservoir 2	$86.1	18,413	$4,676	$1,055,000
McCarty Ranch Extension Area 1	$2.5	840	$2,976	$180,000 (This is estimated based on information from City of PSL website. Source: www.cityofpsl.com)
McCarty Ranch Extension Area 2	$3.4	1,100	$3,091	
McCarty Ranch Extension Area 3	$2.6	1,160	$2,241	
McCarty Ranch Extension Area 4	$2.6	1,148	$2,265	
McCarty Ranch Extension Area 5	$1.6	312	$3,475	
McCarty Ranch Extension Area 6		160		
McCarty Ranch Preserve Area 7 (7A and 7B)	$16.8	2,112	$7,960	
Lakeside Ranch STA Phase 2 – South	$53.7	1,840	$29,212	$185,975
Lakeside Ranch STA Phase 2 – South (Pump Station S-191A)	$42.3	--	--	$275,690

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8

PIPELINE SYSTEMS

8.1 DISCUSSION OF ASSUMPTIONS AND APPROACH

This Chapter evaluated construction costs for pipeline projects that were constructed within the SFWMD service area. Costs were collected from contractor SOV documentation for projects constructed within Martin, Palm Beach, Broward, St. Lucie, Collier, and Lee Counties submitted to the SFWMD AWS funding program and from other known pipeline projects within the SFWMD service area. In general, projects were evaluated by construction setting, method of construction, size of pipe, and materials used. Construction settings include urban, suburban, and rural; methods of construction include open cut (trench) or horizontal directional drilling (HDD); and materials used include polyvinyl chloride (PVC), ductile iron (DI), and high-density polyethylene (HDPE) as these are the most common materials used in pipeline construction.

Pipeline construction costs were evaluated for varying pipe diameters, ranging from 12 to 42 inches (in) and were derived from available contractor SOVs collected from each project. Materials included in the analysis were primarily PVC, DI, and HDPE. Pipeline projects reviewed were limited to those greater than 500 linear feet (LF) as shorter runs of pipe are typically more expensive. Project construction dates ranged from 2014 to 2021. Sources for this information include current and past projects and recent manufacturer/supplier quotes. Cost of installation is included but is limited to the following: excavation/trenching, pipe bedding, backfilling and compaction, dewatering, and separately HDD. All costs will vary based on construction duration, trench depth, pipe size, length of pipe and dewatering method (i.e., well points or trash pump). Land surveying was not specifically considered within this analysis due to cost variability, however, surveying may have been included in general conditions or site restoration costs.

It is important to note that cost data collected from actual construction costs depend on what the contractor includes in the work description of the SOV and how the Engineer of Record structures the measurement and payment section (outline of the Bid Form and distribution of the work the contractor is required to follow during the bidding process) associated with the project. For the purposes of this evaluation, the SOV for each project was evaluated based on the work description for pipeline construction costs via open cut trench or HDD. Costs listed in the SOVs may include dewatering, that is not explicitly noted. It is assumed that dewatering costs are incorporated into the construction cost for pipe sizes that are 24-in and greater.

In addition to analyzing pipeline cost data from construction projects, RSMeans, a cost-estimating database, was used for a comparative analysis of pipeline costs. To estimate the material costs associated with pipeline construction, material costs obtained in November 2021 were collected from wholesale suppliers and industry pipe manufacturers. The material costs were combined with pipe installation costs from the RSMeans database for open cut and HDD construction. Site restoration within the RSMean evaluation were estimated and limited to backfilling and compaction. Percentages were applied to the cost of installed pipe (pipeline material costs plus installation costs) to account for items such as overhead expenses and profit for the contractor, bonds and insurance, sales tax, and mobilization and demobilization.

8.2 CAPITAL COSTS

The pipeline construction costs for each construction project evaluated were converted to a cost per linear foot (cost/LF) to allow for unit comparison between projects. To make a more direct comparison among all project evaluated, (i.e., similar project scope and line items that identify the description of work), only the general conditions (typically includes bonds and insurance, mobilization, demobilization, and maintenance of traffic), piping, and pipe trench were included in the overall cost/LF. Site restoration, which varies among project type, was listed as a separate line item in each of the project summary tables. All pipeline projects include valves, fittings, and appurtenances as part of the construction costs.

The pipeline construction costs reviewed in each of the project's SOV were adjusted from the date of construction (2014 to 2021) to December 2021 using CCI and MPI (30% increase) based on the date of construction. The general conditions add-on for each construction project evaluated was calculated as a percentage of the overall cost of construction. This percentage was then applied to the pipeline construction or line-item costs collected from the project SOV.

$$\textbf{Total Pipeline Costs} = \textbf{Pipeline Line Item Costs x}(\mathbf{1} + \frac{\textbf{General Conditions Costs}}{\textbf{Overall Construction Costs}})$$

The following summarizes the construction projects evaluated in this section:

- Martin County Utilities Tropical Farms Reverse Osmosis (TFRO) Wells 6&7 Raw Water Main Extension
- Broward-Palm Beach Reclaimed Watermain Interconnect (AWS LEC-300)
- City of Cape Coral Water North 2 Utility Extension Program – Reclaimed Water Irrigation Transmission System (AWS LWC-2007)
- City of Naples Reclaimed Water System Expansion – North of Central Ave (AWS LWC-80)
- Palm Beach County's Water Treatment Plant 11 Production Well 11 Raw Watermain
- City of West Palm Beach Clematis Streetscape Phase III

For each cost table in the following sections, a brief project description is provided summarizing the project scope and description of work. The information provided for each project in the cost tables includes the pipe diameter, municipal utility material, length of pipe, construction type, cost/LF, total cost, date of construction, CCI, and adjusted cost based on the CCI. The CCI, as discussed in Chapter 1, is a fixed-weighted index or average of selected commodity prices. Note, costs have increased significantly (up to 30% increase) on material costs since August 2020 (due to the coronavirus impacts on material shortages, labor force, and lead times associated with trucking/deliveries. Other impacts include plastic resin production factory shutdowns (impacting supply and demand for HDPE and PVC pipe), heat resin shortages, and iron products (valves/fittings) impacts (elimination of the tax credit on iron and steel products exported from China, and shortages on shipping containers). As of the date of this study, it has been reported by contractors, suppliers, and several reputable reports that this general increase may fluctuate but will continue to increase similarly to the last two years. However, CBRE

Martin County Utilities TFRO 6&7 Raw Watermain Extension

The Martin County Utilities TFRO 6&7 Raw Watermain Extension includes 1,560 feet (ft) of 12-inch (in) HDPE and 1,450 ft of 16-in HDPE raw watermain (RWM) replacement constructed in a trench. The raw watermain extension also included 947 ft of 16-in HDPE, 510 ft of 18-in HDPE, and 580 ft of 30-in HDPE watermain replacement constructed using HDD. The trench pipe installation was constructed along Southwest Lost River Road in Stuart and crosses under both Interstate 95 and the Florida Turnpike via HDD. The construction setting for this project can be categorized as a suburban setting. Minimal restoration efforts were required due to the utilization of the HDD construction method. The open cut portion of the project was performed in grassy areas where restoration was limited to backfill and compaction as well as sodding. See **Table 8-1** below for Cost Summary.

Table 8-1: Summary of Costs for Martin County Utilities TFRO 6 & 7 Raw Watermain Extension

Martin County Utilities TFRO 6&7 Raw Watermain Extension										
Setting	Item	Material	Length (LF)	Type	Cost LF ($)	Total Cost	Date	CCI[(1)]	Adjusted Costs to August 2020[(2)]	Adjusted Cost to December 2021 Dollars[(3)]
Suburban	12-in RWM	HDPE	1,560	Trench	$64	$99,845	March 2020	11397	$100,353	$130,459
	16-in RWM	HDPE	1,450	Trench	$96	$139,207			$139,916	$181,890
	16-in RWM	HDPE	947	HDD	$117	$111,120			$111,686	$145,192
	18-in RWM	HDPE	510	HDD	$160	$81,604			$82,019	$106,625
	30-in RWM	HDPE	580	HDD	$533	$309,140			$310,713	$403,927
	Site Restoration					$77,250				$84,482

(1) Use CCI at construction date if construction date is before August 2020
(2) Apply August 2020 CCI (11455 divided by "CCI at Construction Date")
(3) Apply 30% increase to reflect estimated costs in December 2021 dollars

Broward-Palm Beach Reclaimed Watermain Interconnect (AWS LEC-300)

The Broward-Palm Beach Reclaimed Water Main Interconnect project includes 30,460 ft of 42-in ductile iron pipe (DIP) and 21,762 ft of 24-in DIP constructed in a trench and 1,211 ft of 42-in HDPE constructed via HDD. This project was split into two separate bid packages. In one of the bid packages, the work description is defined as "F&I 42 Inch DIP HDD" DIP is not used for HDD construction. Therefore, the actual pipe material is assumed to be HDPE. The pipeline runs along Hillsboro Boulevard, crosses the Florida Turnpike, and then runs along South Powerline Road in West Deerfield Beach. Construction methods include both open cut and HDD. The construction setting for this project is classified as suburban. Site restoration included roadway restoration, sidewalk reconstruction, removal and replacement of various fencing, and removal of existing trees. See **Table 8-2** below for Cost Summary.

Table 8-2: Summary of Costs for Broward-Palm Beach Reclaimed Watermain Interconnect (AWS LEC-300)

Broward-Palm Beach Reclaimed Watermain Interconnect (AWS LEC-300)										
Setting	Item	Material	Length	Type	Cost LF ($)	Total Cost	Date	CCI(1)	Adjusted Costs to August 2020(2)	Adjusted to December 2021 Dollars(3)
Suburban	42-in RWM (4)	DI	30,460	Trench	$380	$11,574,800	May 2020	11481	$11,548,427	$15,012,954
	42-in HDD	HDPE*	1,211	HDD	$1,300	$1,574,300			$1,570,713	$2,041,926
	24-in RWM (4)	DI	21,762	Trench	$107	$2,328,449			$2,323,144	$3,020,086
	Site Restoration					$877,898				$105,157

(1) Use CCI at construction date if construction date is before August 2020
(2) Apply August 2020 CCI (11455 divided by "CCI at Construction Date")
(3) Apply 30% increase to reflect estimated costs in December 2021 dollars
(4) Dewatering is assumed to be included in the pipeline due to pipe size

City of Cape Coral Water North 2 Utility Extension Program – Reclaimed Water Irrigation Transmission System (AWS LWC -2007)

The City of Cape Coral North 2 Utility Extension Program – Reclaimed Water Irrigation Transmission System project (Lee County) includes 6,600 ft of 16-in DIP reclaimed watermain, and 2,900 ft of smaller-sized DI reclaimed piping (less than 12 in). The pipe that is less than 12 inches was not included in this analysis, but it is noted here as part of the description of the project scope only. The pipeline was constructed in an open trench. The North 2 Utility Extension was constructed in an urban construction setting. Site restoration includes roadway replacement, sidewalk reconstruction, miscellaneous clearing and grubbing, and landscaping repair. See **Table 8-3** below for cost summary.

Table 8-3: Summary of Costs for City of Cape Coral Water North 2 Utility Extension (AWS LWC-2007) Program

City of Cape Coral Water North 2 Utility Extension Program (AWS LWC – 2007)										
Setting	Item	Material	Length (LF)	Type	Cost LF ($)	Total Cost	Date	CCI(1)	Adjusted Cost to August 2020(2)	Adjusted Cost to December 2021 Dollars(3)
Urban	16-in RWM	DI	6,600	Trench	$82	$544,198	July 2018	11116	$560,794	$729,033
	20-in RWM	DI	5,200	Trench	$138	$719,109			$741,040	$963,352
	Site Restoration					$183,917				$206,220

(1) Use CCI at construction date if construction date is before August 2020
(2) Apply August 2020 CCI (11455 divided by "CCI at Construction Date")
(3) Apply 30% increase to reflect estimated costs in December 2021 dollars

City of Naples Reclaimed Water System Expansion – North of Central Avenue (LWC-80)

The City of Naples Reclaimed Water System Expansion includes approximately 12,500 ft of 12-in PVC reclaimed watermain constructed via open cut trench and approximately 2,000 ft of 16-in HDPE reclaimed watermain utilizing HDD. The setting for this construction project is classified as urban. Site restoration includes repaving roadways, reconstructing sidewalks, and miscellaneous landscaping repair. See **Table 8-4** below for cost summary.

Table 8-4: Summary of Costs for City of Naples Reclaimed Water System Expansion (LWC – 80)

City of Naples Reclaimed Water System Expansion (LWC – 80)										
Setting	Item	Material	Length (LF)	Type	Cost LF ($)	Total Cost	Date	CCI(1)	Adjusted Cost to August 2020(2)	Adjusted Cost to December 2021 Dollars(3)
Urban	12-in RWM	PVC	12,500	Trench	$49	$372,876	July 2014	9835	$434,295	$564,584
	16-in RWM	HDPE	2,000	HDD	$203	$618,154			$719,975	$935,967
	Site Restoration					$86,772				$109,967

(1) Use CCI at construction date if construction date is before August 2020
(2) Apply August 2020 CCI (11455 divided by "CCI at Construction Date")
(3) Apply 30% increase to reflect estimated costs in December 2021 dollars

Palm Beach County's Water Treatment Plant 11 Production Well 11 Raw Watermain

Palm Beach County's Water Treatment Plant 11 Production Well 11 Raw Watermain (Belle Glade, Florida) includes approximately 1,725 ft of 16-in HDPE dimensional ratio (DR) 11 constructed in an open cut trench and 535 ft of HDPE DR 11 utilizing HDD. This project was constructed in a rural setting. Site restoration costs for this project include sod, imported fill, and asphalt driveways with limerock base. Sample points and bacteriological testing are included in the cost/LF. See **Table 8-5** below for cost summary.

Table 8-5: Summary of Costs for Palm Beach County's WTP 11 Production Well 11 Raw Watermain

Palm Beach County Water Treatment Plant 11 Production Well 11 Raw Watermain										
Setting	Item	Material	Length (LF)	Type	Cost LF ($)	Total Cost	Date	CCI (1)	Adjusted Cost to August 2020 (2)	Adjusted Cost to December 2021 Dollars (3)
Rural	16-in RWM	HDPE	118	Trench	$119	$204,795	July 2014	9835	$238,528	$310,087
	16-in RWM	HDPE	2,088	HDD	$141	$75,502			$75,627	$98,316
	Site Restoration					$50,165				$54,674

(1) Use CCI at construction date if construction date is before August 2020
(2) Apply August 2020 CCI (11455 divided by "CCI at Construction Date")
(3) Apply 30% increase to reflect estimated costs in December 2021 dollars

City of West Palm Beach Clematis Streetscape Phase III

The City of West Palm Beach performed a streetscape project that included modifications to roadways, landscaping, public use areas, and utilities. The utility improvements included replacement of 905 ft of 12-in DIP watermain. This construction setting can be classified as urban. Site restoration and general conditions were not included in the cost/LF calculation for this project, due to the utility construction being a subcomponent to the streetscape project. See **Table 8-6** below for cost summary.

Table 8-6: Summary of Costs for City of West Palm Beach Clematis Street Streetscape Phase III

City of West Palm Beach Clematis Streetscape Phase III										
Setting	Item	Material	Length (LF)	Type	Cost LF ($)	Total Cost	Date	CCI(1)	Adjusted Cost to August 2020(2)	Adjusted Cost to December 2021 Dollars(3)
Urban	12-in RWM	DI	905	Trench	$120	$108,600	May 2020	11418	$126,488	$164,435

(1) Use CCI at construction date if construction date is before August 2020
(2) Apply August 2020 CCI (11455 divided by "CCI at Construction Date")
(3) Apply 30% increase to reflect estimated costs in December 2021 dollars

Glades Cutoff Road 24-in Force Main Extension Phase 3

The City of Port St. Lucie Glades Cutoff Road Force Main Extension project includes approximately 8,240 ft of PVC sanitary force main in a rural construction setting. Construction costs for this project were developed by averaging bid costs from fourteen different bidders. The bid tabulation also included two different bid alternative items, Alternate Bid Item 1 being 30-in HDPE HDD and Alternate Bid Item 2 being 24-in fusible PVC HDD. The cost per linear foot of each alternate bid item includes adjustments to account for an accurate general condition cost percentage. Restoration costs for this project include minor asphalt and sidewalk repairs, significant sodding, seeding, and mulching, replacement of barb wire fence swale regrading, and clearing and grubbing. See **Table 8-7** below for cost summary. Since the data was provided in November 2021, only a 30% escalation was added to be consistent with escalating construction costs provided after August 2020.

Table 8-7: Summary of Costs for City of Port St. Lucie Glades Cutoff Road Force Main Extension

City of Port St. Lucie Glades Cutoff Road 24-in Extension Phase 3							
Setting	Item	Material	Length (LF)	Construction Type	Cost/ LF	Total Cost	Bid Date
Rural	24 in RWM	PVC	8,240	Trench	$342	$2,818,080 (1)	Nov-21
	24 in RWM (Alternate Bid Item) (2)	Fusible PVC	1,790	HDD	$530	$948,700 (1)	Nov-21
	30 in RWM (Alternate Bid item) (2)	HDPE	1,790	HDD	$592	$1,059,680 (1)	Nov-21

(1) Apply 30% increase to reflect estimated costs in December 2021 dollars
(2) Dewatering is assumed to be included in the pipeline due to pipe size

A summary of pipeline construction costs for varying diameters, material, and method of construction is presented in **Table 8-8**. Constructions costs presented in the table below reflect a summary of the project data presented in the previous sections. The cost/LF for each pipe diameter was escalated to December 2021 dollars. If a cost/LF for a given pipe size/material/construction was not represented in the construction cost study group, a cost/LF of pipe was interpolated from available costs to develop a unit cost. An Opinion of Probable Construction Cost (OPCC) per LF was derived from the available project information provided an average of observed construction costs based recent construction bids.

Table 8-8: Summary of Pipeline Capital Construction Costs

Capital Construction Cost Summary Table				
Diameter (inches)	Material	Method of Construction	Construction Cost per LF (1)	OPCC per LF (1)
12	DIP	Trench	$157	$114
12	HDPE	Trench	$84	$113
12 (3)	HDPE	HDD	$105	$105
12	PVC	Trench	$75	$110
16	DIP	Trench	$110	$144
16	HDPE	Trench	$150	$150
16	HDPE	HDD	$182	$144
18	DIP	Trench	$104	$165
18 (3)	HDPE	Trench	$169	$169
18	HDPE	HDD	$209	$162
20	DIP	Trench	$185	$180
20 (3)	HDPE	Trench	$174	$174
20 (3)	HDPE	HDD	$174	$174
24	DIP	Trench	$139	$216
24 (3)	HDPE	Trench	$225	$225
24	PVC	Trench	$344	$275
24 (3)	HDPE	HDD	$209	$350
30 (3)	DIP	Trench	$173	$173
30 (3)	HDPE	Trench	$261	$261
30	HDPE	HDD	$696	$400
36 (3)	DIP	Trench	$422	$422
36 (3)	HDPE	Trench	$338	$338
36 (3)	HDPE	HDD	$1,045	$1,045
42	DIP	Trench	$493	$505
42 (3)	HDPE	Trench	$394	$394
42	HDPE	HDD	$1,686	$1,260

(1) All construction project costs are escalated to December 2021 dollars
(2) All construction project costs include installation
(3) Denotes cost was derived from an available cost
(4) PVC costs are for information only

8.3 RSMEANS ANALYSIS

To verify the pipeline construction costs, RSMeans (for the South Florida area) was used along with material piping costs provided by pipe suppliers. RSMeans is an online cost estimating tool that assists with estimating current construction costs including materials, labor and equipment. Material costs are provided based on manufacturers, distributors and contractors to determine national averages for material costs. Labor costs are calculated based on a national average for construction labor costs and calculated based on actual normal working conditions when determining productivity. Equipment costs includes average rental costs as well as normal operating costs, which accounts for equipment parts that are affected by normal wear and tear and labor costs associated with repairs.

For pipe material costs, two industry recognized pipe suppliers and two pipe manufacturers were contacted for material pricing for DIP and HDPE. Due to the current market volatility, pipe manufacturers will only guaranteed material prices for a maximum of 20 to 30 days. This volatility is discussed in detail in **Chapter 1** of this study. Pipe suppliers have noted a material price increase of over 30% since August 2020. Prior to August 2020, the pipe supplier identified a typical yearly increase of approximately 8 to 12%. The significant increase over the last year is unprecedented and skews overall results when comparing to construction costs for projects that were bid in early 2020 (and earlier). The CCI did not appear to account for this increase. However, the MPI did reflect a 30% increase since August 2021. The MPI appeared to be more representative of the cost increase the construction industry was seeing in 2021. The bare material costs collected from the pipe suppliers were paired with RSMeans installation costs to illustrate a total installation cost based on today's market. Cost add-ons assumed are, 15% for overhead and profit (O&P), 2% for bonds and insurance, 5% for mobilization/demobilization, and 7% for sales tax which are based on typical percentages observed within the industry.

Open Trench Construction

To assist in developing costs for open trench construction, a typical open cut trench detail was used to quantify volume in cubic yards for excavation, bedding, and backfill and compaction. RSMeans unit costs for this work were then applied to the calculated volume to determine the overall open trench construction costs. As discussed in the previous section, the material costs were then added to the typical trench construction costs. A Palm Beach County Water Utility Departments' (PBCWUD) typical standard trench restoration detail (**Figure 8-1**) was used as a reference to standardize the trench construction for this evaluation.

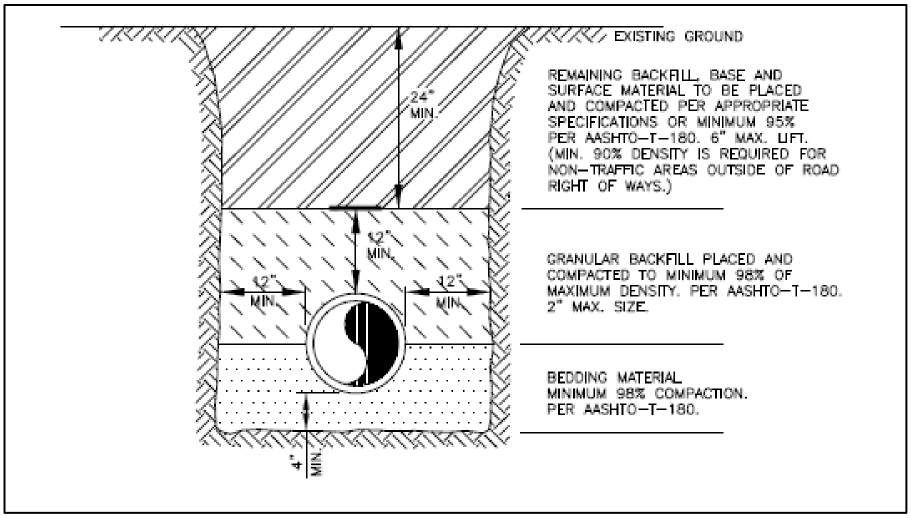

Figure 8-1: PBCWUD Typical Trench Restoration Standard Detail

The trench dimensions determined were based on the following assumptions:

- Pipe bedding material= 6 inches plus half of pipeline diameter
- Trench width = Pipe diameter plus 3 feet
- Pipe cover = 3 feet of cover (typical for cover over a pipeline)
- Total trench depth = 6 inches below bottom of pipe plus pipeline diameter plus 3 feet of cover

Additional considerations to determine excavation, bedding fill, and backfill and compaction are listed below:

- Excavation

  4-ft to 6-ft excavation of common earth soil with a ¾ cubic yard excavator (typical size for shallow trench, listed in RSMeans)

  6-ft to 10-ft excavation of common earth soil with a 1 cubic yard excavator (typical size for moderately deep trench, listed in RSMeans)
- Fill for utility bedding is crushed or screened bank run gravel
- Backfill and compaction with 6-in lifts and a vibrating plate compactor

Pipe materials for pipeline construction are commonly Class 50 (or Class 250) DIP (Class 350 for 12 inches and below) and DR 11 HDPE. Multiple pipeline contractors were contacted to develop an understanding of the cost variations based on construction setting (rural, suburban, or urban) for open trench pipeline work. Typically, a pipeline in a rural setting can be constructed up to three times faster than a construction project in an urban setting. Therefore, savings are realized proportionally in equipment, maintenance of traffic, labor, and restoration costs. It was determined that constructing a pipeline in an urban setting is three times the installation costs of constructing a pipeline in a rural setting. Based upon this determination, the unit cost per linear foot of pipe, using RSMeans under varying construction settings equated to the following factor:

- Rural Setting – base installation cost
- Suburban setting – 2 times the base installation cost
- Urban setting – 3 times the base installation cost

Tables 8-10 and **8-11** summarize the construction cost/LF for DIP and HDPE pipe based on construction setting for open trench construction.

Table 8-9: Summary of Unit Costs for DIP Pipe Trench Installation (RS Means)

Diameter (inches)	RURAL (Cost/LF of Installed DIP Pipe)	SUBURBAN (Cost/LF of Installed DIP Pipe)	URBAN (Cost/LF of Installed DIP Pipe)
12	$100	$103	$108
16	$142	$146	$153
18	$175	$182	$190
20	$196	$204	$213
24	$258	$265	$275
30	$442	$459	$477
36	$593	$615	$637
42	$679	$705	$732

(1) Pipe material costs from pipe suppliers and installation is from RSMeans

Table 8-10: Summary of Unit Costs for HDPE Pipe Trench Installation

Diameter (inches)	RURAL (Cost/LF of Installed HDPE Pipe)	SUBURBAN (Cost/LF of Installed HDPE Pipe)	URBAN (Cost/LF of Installed HDPE Pipe)
12	$106	$109	$114
16	$143	$147	$154
18	$176	$181	$189
20	$216	$221	$230
24	$305	$312	$322
30	$381	$398	$416
36	$469	$491	$513
42	$550	$576	$603

Horizontal Directional Drilling

Costs for pipelines constructed via HDD were also collected from RSMeans for 12-in, 18-in, and 24-in pipe sizes, as these sizes were the only pipe sizes included in the RSMeans database. The remaining pipe sizes were determined by interpolation using this information. HDPE DR 11 was evaluated for HDPE pipe material as this is the most common pipe material (and pressure class) used during HDD construction.

Table 8-11: Summary of Unit Costs for installed HDD HDPE in RSMeans (12-inch through 20-inch)

HDD HDPE, RSMeans Construction Costs				
Pipe size (Inches)	12	16 (1)	18	20 (1)
Raw Material Cost (LF)	$75	$101	$126	$156
Directional Drill (includes Labor and Equipment)	$45	$56	$62	$70
O&P (15%)	$18	$24	$28	$34
Bonds and Insurance (2%)	$2	$3	$4	$5
Sales Tax (7%)	$5	$7	$9	$11
Mob/Demob (5%)	$6	$8	$9	$11
Unit cost (Cost/LF)	$151	$199	$239	$287

(1) Costs calculated by interpolation

Table 8-12: Summary of Unit Costs for installed HDD HDPE in RSMeans (24-inch through 42-inch)

HDD HDPE, RSMeans Construction Costs				
Pipe size (Inches)	24	30 (1)	36 (1)	42 (1)
Raw Material Cost (LF)	$222	$278	$342	$400
Directional Drill (includes Labor and Equipment)	$89	$125	$176	$248
O&P (15%)	$47	$60	$78	$97
Bonds and Insurance (2%)	$6	$8	$10	$13
Sales Tax (7%)	$16	$19	$24	$28
Mob/Demob (5%)	$16	$20	$26	$32
Unit cost (Cost/LF)	$395	$511	$656	$818

(1) Costs calculated by interpolation

Table 8-13 summarizes the unit costs/LF of material costs received from suppliers and unit cost/LF of installed HDD HDPE pipe which includes material costs and data from RSMeans data. Data are organized by size, material, and method of construction.

Table 8-13: Summary of Unit Costs for Installed HDD HDPE in RSMeans

RSMeans Cost Summary Table						
Diameter (Inches)	Material	Method of Construction	Material Cost, per LF	Installed Cost per LF (Rural)	Installed Cost per LF (Suburban)	Installed Cost per LF (Urban)
12	DIP	Trench	$70	$100	$200	$300
12	HDPE	Trench	$75	$106	$212	$318
12	HDPE	HDD	$75	$151	N/A	N/A
16	DIP	Trench	$100	$142	$283	$425
16	HDPE	Trench	$101	$143	$285	$428
16	HDPE	HDD	$101	$199	N/A	N/A
18	DIP	Trench	$128	$175	$350	$525
18	HDPE	Trench	$126	$176	$352	$528
18	HDPE	HDD	$126	$239	N/A	N/A
20	DIP	Trench	$143	$196	$392	$588
20	HDPE	Trench	$156	$216	$432	$648
20	HDPE	HDD	$156	$287	N/A	N/A
24	DIP	Trench	$186	$258	$516	$773
24	HDPE	Trench	$222	$305	$610	$915
24	HDPE	HDD	$222	$395	N/A	N/A
30	DIP	Trench	$325	$442	$883	$1,325
30	HDPE	Trench	$342	$464	$927	$1,391
30	HDPE	HDD	$342	$594	N/A	N/A
36	DIP	Trench	$439	$593	$1,187	$1,780
36	HDPE	Trench	$490	$660	$1,320	$1,980
36	HDPE	HDD	$490	$847	N/A	N/A
42	DIP	Trench	$599	$806	$1,612	$2,418
42	HDPE	Trench	$862	$1,145	$2,291	$3,436
42	HDPE	HDD	$862	$1,414	N/A	N/A

N/A = Not Applicable. Costs for HDD construction is not typically impacted by construction setting.

Valves and Fittings

Valve placement varies by each municipality's standard, but for planning purposes it is common practice to assume a valve at each tie-in location (connection to existing pipeline) and a valve placed every 2500 feet of pipe.

Due to the variability of material costs associated with valves included in the collected construction cost data, costs associated with valves are discussed in this section based on a direct purchase from a local supply house with contractor general conditions add-ons. The general conditions add-ons were assumed to be 15% for O&P, 2% for bonds and insurance, 5% for mobilization/demobilization, and 7% for sales tax, based on typical percentages observed within the industry. **Table 8-14** summarizes the costs for gate valves typically used for isolation valves on a pipeline project.

Table 8-14: Summary of Cost for Gate Valves

Gate Valve Size (Inches)	Cost per Gate Valve (From Supplier)	Cost Per Gate Valve (With General Conditions Add-ons)
12	$3,380	$3,887
16	$8,400	$9,660
18	$18,400	$21,160
20	$19,000	$21,850
24	$28,600	$32,890
30	$60,200	$69,230
36	$84,000	$96,600
42	$128,000	$147,200

All pipeline projects will have varying types and numbers of fittings depending upon the pipe alignment and conflicts that are encountered. Fittings used are typically DI. Urban areas with congested utility corridors may require significantly more fittings as compared to a rural area setting. For the construction projects evaluated in this study, the cost of DI fittings is an additional 15 to 18% of the pipeline costs.

8.4 TOTAL COST SUMMARY

It was determined that cost of construction of pipeline projects depend upon a wide range of variables such as: construction setting, pipe material, length of construction, and construction method. Pipelines of the same diameter, constructed at longer lengths, showed an overall lower cost/LF. Site restoration is a primary cost factor of construction, specifically in urban areas. Urban areas also present challenging construction conditions due to congested utility corridors and a more extensive maintenance of traffic requirements and therefore have higher cost of construction. Urban construction projects will also see increased fitting quantities, further increasing the cost of construction.

At the time of this evaluation, material prices have increased by as much as 30% since August 2020. It is unknown when or if cost impacts from COVID-19 will end or plateau. Contractors and suppliers do not anticipate a sudden or drastic drop in material prices in the near future. The supplier representative noted that a yearly increase of 10% is expected in material costs for pipeline projects.

Table 8-15 summarizes OPCC construction costs based on collected cost information and recent construction bids and calculated costs using RSMeans. The RSMeans evaluation includes construction setting costs to assist with pipeline project planning in rural, suburban or urban settings. Generally, estimates from the RSMeans database/supplier/manufacturer quotes are slightly higher than the observed construction costs and estimated construction costs. RSMeans and quoted material costs do not account for economy of scale. It also appears that the variation of costs may be due to the higher material costs provided by the suppliers, at the time of this analysis.

Table 8-15: Overall Summary of Unit Costs

Overall Cost Summary Table						
Diameter (Inches)	Material	Method of Construction	OPCC per LF(1)	RSMeans Cost per LF (Rural)(2)	RSMeans Cost per LF (Suburban)(2)	RSMeans Cost per LF (Urban)(2)
12	DIP	Trench	$114	$100	$200	$300
12	HDPE	Trench	$113	$106	$212	$318
12 (3)	HDPE	HDD	$105	$151	N/A	N/A
16	DIP	Trench	$144	$142	$285	$425
16	HDPE	Trench	$150	$143	$285	$428
16	HDPE	HDD	$144	$199	N/A	N/A
18 (3)	DIP	Trench	$165	$175	$350	$525
18 (3)	HDPE	Trench	$169	$176	$352	$528
18	HDPE	HDD	$162	$239	N/A	N/A
20	DIP	Trench	$180	$196	$392	$588
20 (3)	HDPE	Trench	$174	$216	$432	$648
20 (3)	HDPE	HDD	$174	$287	N/A	N/A
24	DIP	Trench	$216	$258	$516	$773
24 (3)	HDPE	Trench	$225	$305	$610	$915
24 (3)	HDPE	HDD	$350	$395	N/A	N/A
30 (3)	DIP	Trench	$173	$442	$883	$1,325
30 (3)	HDPE	Trench	$261	$464	$927	$1,391
30	HDPE	HDD	$400	$594	N/A	N/A
36 (3)	DIP	Trench	$422	$593	$1,187	$1,780
36 (3)	HDPE	Trench	$338	$660	$1,320	$1,980
36 (3)	HDPE	HDD	$1,045	$847	N/A	N/A
42	DIP	Trench	$505	$806	$1,612	$2,418
42 (3)	HDPE	Trench	$394	$1,145	$2,291	$3,436
42	HDPE	HDD	$1,260	$1,414	N/A	N/A

(2) All construction project costs are escalated to December 2021 dollars using CCI
(3) Material prices in "RSMeans Total Installed cost per LF" are manufacturer prices
(4) Denotes information was derived from available construction cost information
N/A = Not Applicable. Costs for HDD construction is not typically impacted by construction setting.

To assist the reader in estimating cost for a proposed pipeline construction project, it is recommended to select a cost per linear foot for the respective pipe diameter/material in **Table 8-16** and add the following:

- 15 total linear foot cost for fittings. It is recommended to use a 18% for urban settings versus rural settings.
- Cost per valve as noted in Table 8-1. As mentioned, it is recommended to account for a valve at each connection to existing pipeline, and a valve every 2500 feet.
- Add 15% for a construction contingency

An example of this application is represented below in **Table 8-16**:

Table 8-16: Example Pipeline Construction Cost Estimation (Rural Setting)

Size of pipeline (Inches)	Material of pipe	Method of construction	Cost/LF of pipe	LF of Pipeline	Total Cost of Pipeline	Fittings Add-on (15%)	Number of Valves	Cost per Valve	Total Estimated Cost of Pipeline Construction, with 15% Construction Contingency
16	DIP	Trench	$110	3,000	$330,000	$379,500	3	$10,920	$474,099

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