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LOWER ST. JOHNS RIVER REUSE AND TREATMENT PROJECT

PHASE II: COMBINED EAST AND WEST RIVER REUSE INITIATIVES SOLUTIONS

Final Report

Lower St. Johns River Reuse and Treatment Project

Phase II: Combined East and West River Reuse Initiative Solutions

Prepared for

St. Johns River Water Management District,
JEA,
St. Johns County Utility Department,
& Clay County Utility Authority

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EXECUTIVE SUMMARY

The St. Johns River Water Management District (SJRWMD) is offering assistance with water supply planning and wastewater integrated management planning for utilities in the Lower St. Johns River Basin (LSJRB). To achieve the desired planning goals, utilities are looking for opportunities to (1) maximize reclaimed water reuse to offset potable water supply and (2) reduce discharges into the lower St. Johns River for compliance with total maximum daily load (TMDL) allocations.

This project was completed in two phases. Phase I focused on the west side of the St. Johns River and the two main utilities with wastewater discharges: JEA and Clay County Utility Authority (CCUA), although other smaller utilities are included in the analysis. Phase II focused on the east side of the river and its two primary utilities: JEA and St. Johns County Utility District (SJCUD), in addition to other smaller utilities are included in the analysis. This report presents the compiled results from both Phase I and Phase II of the LSJR study.

For complex decision-making situations, where there are many important variables or where the cost or other consequences of selecting the best alternative are deemed high, there is sometimes merit in using a more refined alternative selection / project prioritization process. For this project the alternatives were developed with stakeholders input. The alternatives were represented in an optimized systems model—a water balance model that can use optimization techniques to estimate the resulting infrastructure. The various objective functions that were considered for this study consisted of:

- 300 Million Dollar Construction costs
- 60 percent reuse target
- 75 percent reuse target
- 100 percent reuse target

The results are summarized in Table ES-1. The base case is the amount of future reuse water demand that could be met if no additional pipelines and reclaimed treatment is provided. While not likely to occur, it provides a low-end estimate for comparison purposes only.

Table ES-1. Summary of Combined East and West Side Master Planning Results

Scenario	Total RWT Capacity (mgd)	Capital Cost (million $)	Annual O&M Cost (million $)	Reuse % Achieved	Potable Water Offset (MG/yr)	Discharge to SJR (MG/yr)	TN Load (kg/yr)	% TN Reduction
Base Case - 2030 No Expansion	42.7	$0	$4	14%	6,931	33,908	1,069,702	0%
$300 Million Capital Cost Constraint	78.0	$286	$8	45%	22,174	25,331	811,680	24%
60% Reuse Target	100.0	$480	$13	60%	29,073	19,447	610,401	43%
75% Reuse Target	117.0	$730	$17	75%	30,268	11,673	340,583	68%
100% Reuse Target	157.0	$1,242	$21	94%	30,865	2,773	39,136	96%

*O&M Costs do not include the cost of Potable Water

The base case scenario fails to meet discharge and TN load reduction targets. In contrast, the 100 percent reduction alternative more than meets water quality targets, and provides 30.9 BG/yr of potable water offset. However, the capital cost of this scenario ($1,242 million) is over 4 times the current budgeted construction costs ($300 million). The $300 million and 60 and 75 percent reuse alternatives increase reuse capacity substantially, achieve satisfactory water quality results, and offset potable water supplies by 22, 26 and 31 BG/yr respectively.

It is important to note that the approach taken does not take into consideration interim steps needed to achieve the next highest reuse level. Rather, each result meets the given goal ($300 millon, 60% reuse, etc.) in a non-sequential fashion. So these results can be used to see what the optimum system would be if, say 75% Reuse was your goal. In the 75% case the amount of storage or certain pipe sizes may be reduced from the 60% Reuse system. Consequently, it is up to the utilities to use these results to determine what the targeted system would be in 2030, and then complete implementation plans to meet their goal. While their systems may not be the same as the "optimum" layout when finished, there should not be a large difference.

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ACRONYMS AND ABBREVIATIONS

BG	billion gallon(s)
CCUA	Clay County Utility Authority
DFT	discrete Fourier transform
FFT	Fast Fourier Transform
FY	fiscal year
LSJR	Lower St. Johns River
LSJRB	Lower St. Johns River Basin
MG	million gallon(s)
mgd	million gallon(s) per day
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
RIB	Rapid Infiltration Basin
RWT	reclaimed water treatment
SJCUD	St. Johns County Utility Department
SJRWMD	St. Johns River Water Management District
TDS	total dissolved solids
TMDL	total maximum daily load
TN	total nitrogen
WRF	water reclamation facility
WTF	water treatment facility
WTP	water treatment plant
WWTP	wastewater treatment plant

INTRODUCTION

The St. Johns River Water Management District (SJRWMD) is working with affected stakeholders collaboratively to improve water quality in the St. Johns River. Local governments and industries in the Lower St. Johns River Basin (LSJRB) must comply with recently established total maximum daily loads (TMDLs) for nutrients, which are regulated under the National Pollutant Discharge Elimination System (NPDES). In an effort to comply with TMDL standards and further improve the water quality of the St. Johns River, SJRWMD initiated a cooperative water quality improvement effort. Through the LSJRB Reuse and Treatment Project, SJRWMD assists affected utilities in the LSJRB by facilitating joint planning and co-founding the construction of regional reclaimed water infrastructure.

The ultimate goal of the LSJRB Reuse and Treatment Project is to remove as much wastewater discharge from the river as possible in an accelerated (about 10 years) manner. Preliminary analyses of the cost of complying with the TMDL illustrated that reuse is relatively expensive when compared to advanced wastewater treatment, if only the cost of nitrogen removal is considered. In addition to meeting water quality goals, reuse projects must offset demands on potable water supplies in the LSJRB. Therefore, by co-funding reclaimed water infrastructure projects, the District will accelerate the local governments' plans to utilize reclaimed water as quickly as possible for water supply needs.

One impediment to wider use of reclaimed water identified by the stakeholders was the need for inter-utility regional planning. This project was initiated jointly with SJRWMD, JEA, and CCUA in the LSJRB to address this need for demand projections up to 2030. The regional reuse master plan for the LSJR Reuse and Treatment Project has been completed in two phases. The draft water supply plan for the West Side of the LSJR was completed in fiscal year (FY) 2007 while the plan for the East Side was completed fiscal year (FY) 2008. The two sides have been combined and an overall basin master plan prepared. This report provides the results of both the East and West Side analyses.

The lower St. Johns River stakeholders have identified a broad range of feasible project alternatives capable of maximizing water reuse in the LSJRB. The stakeholders worked closely with CH2M HILL programmers to develop an optimization model as a planning-level tool to evaluate these projects. This model considered the seasonal variability in the potable and reclaimed water demand and supply balance, water quality, cost, and the most effective and efficient infrastructure solutions through the optimization formulation.

The use of reclaimed water is an important alternative for water resources management. Common uses of reclaimed water in the U.S. include irrigation, industrial uses, groundwater recharge, stream flow augmentation for fish habitat, and indirect potable reuse via augmentation of groundwater and/or surface supplies. In this study, however, use of future reclaimed water will be primarily for residential irrigation, unless otherwise noted. Additionally, opportunities for groundwater recharge via Rapid Infiltration Basins (RIBs) were also investigated.

PROJECT OBJECTIVES

The objective of the LSJRB Reuse Initiative Solutions project is to assist local governments in their regional planning and permitting efforts for future water supply and wastewater management. The two main utilities providing cost-share involved in the west side effort included JEA and Clay County Utility Authority (CCUA). The reuse and nitrogen reduction needs of the Town of Orange Park and the City of Green Cove Springs were also included in the west side project. The two main utilities providing cost-share in the east side effort were JEA and St. John's County Utility District (SJCUD). The reuse need of the city of interconnecting the Beaches was also considered. To achieve their desired planning goals, the utilities are exploring opportunities to maximize reclaimed water reuse. By doing so, they expect to offset demands on potable water supplies and to remove wastewater discharges, particularly nitrogen, from the lower St. Johns River for compliance with TMDL allocations.

DATA COLLECTION AND ANALYSIS

The input data consisted of potable water supply, wastewater production, and reuse water demands for each service area. Figure 1 shows the study area map along with existing and future infrastructure such as wastewater treatment plants (WWTPs), pump stations, and pipe lines. Input data was provided by CCUA, JEA, and SJCUD and summarized in Table 1.

SJRWMD is in the process of developing new population and water use demands for the next districtwide Water Supply Plan. SJRWMD developed draft projections, which were under review by the utilities at the time of this study. The utilities preferred that this study used their own projections to determine the approximate future water needs. In this way, the results of this master plan will better correspond with their current planning efforts.

DATA ANALYSIS

In developing a future reuse water supply and wastewater management plan for a given study area, it is necessary to have reuse water demand and supply data available, together with data regarding wastewater treatment capacity of existing WWTPs and reclaimed water distribution infrastructure, such as pipeline, pump stations, and storage facilities.

The following questions related to reuse water demand were addressed by utilizing the available data for this study area:

- How much reclaimed water is being used?
- Where are the points of consumption located?
- How does the usage change as a function of time?

Similarly, information for the potential sources of future reclaimed water supply should be known in terms of their location, quantity, and quality.

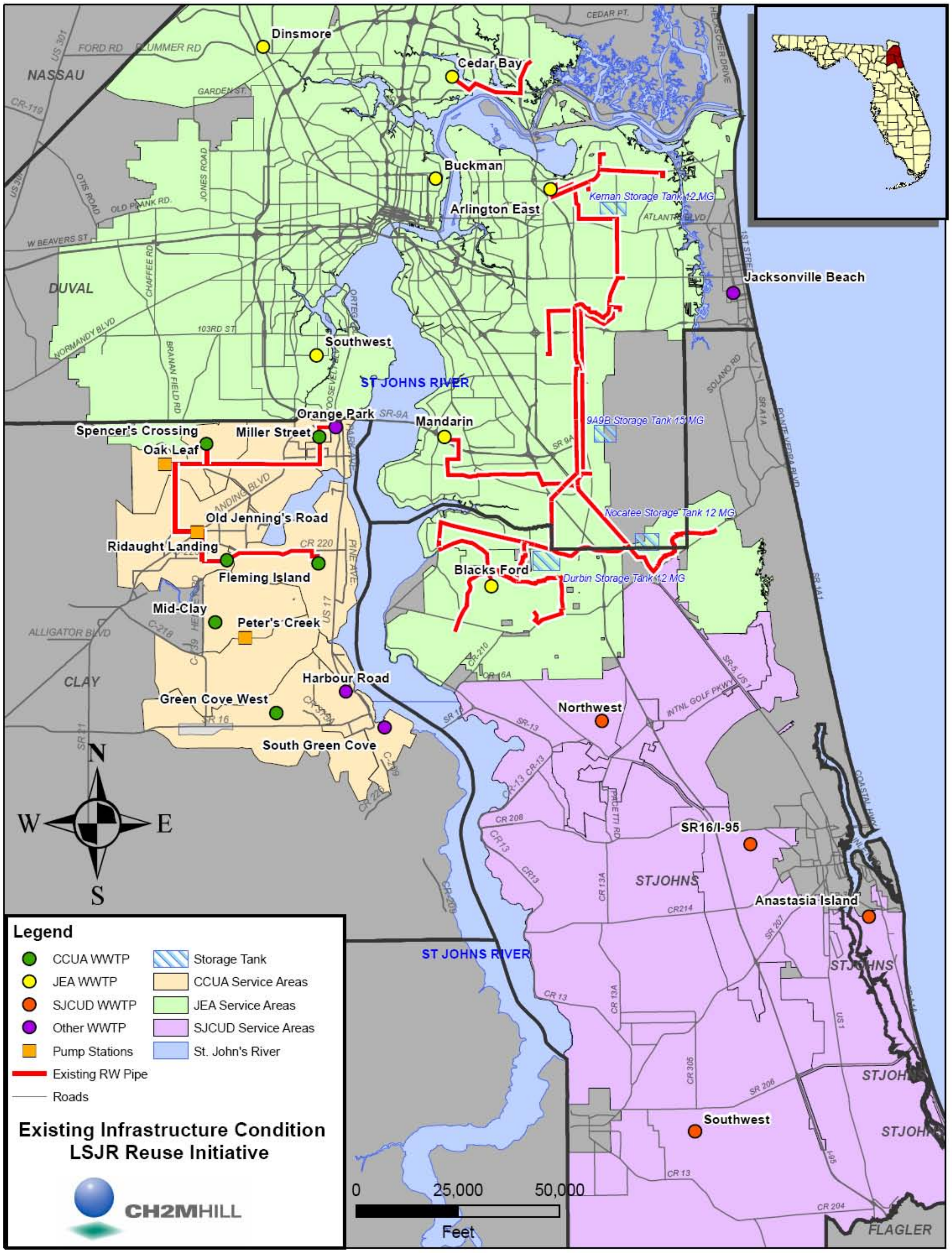

Figure 1. Reclaimed Water Master Map of CCUA, JEA, and SJCUD Service Areas

Table 1. Available Data and Sources

Item	Source	Data Type	Remarks
Population data	GIS Associates	5-yr interval	While analyzed, it was decided not to use these estimates.
CCUA wastewater production	CCUA	Daily (1995 - 2007)	Only Miller, Fleming, Ridaught, and Mid-Clay included
JEA wastewater production	JEA	Daily 2006	
SJCUD wastewater production	SJCUD	5-yr interval	
CCUA reclaimed water demand	CCUA	Daily (1995 - 2007)	
JEA reclaimed water demand	Assumed	5-yr interval	
SJCUD reclaimed water demand	SJCUD	5-yr interval	
CCUA potable water usage	GIS Associates	5-yr interval	
JEA potable water usage	GIS Associates	5-yr interval	
Future projections of annual average wastewater effluent	CCUA	2006-2031	CCUA Service Areas
Future projections of annual average reclaimed water demand	CCUA	2006-2031	CCUA Service Areas
Future projections of annual average wastewater effluent	JEA	2005-2030	JEA Service Areas
Future projections of annual average reclaimed water demand	JEA	2005-2030	JEA Service Areas
Future projections of annual average wastewater effluent	SJCUD	2005-2030	SJCUD Service Areas
Future projections of annual average reclaimed water demand	SJCUD	2005-2030	SJCUD Subservice Areas

WASTEWATER EFFLUENT PRODUCTION AND RECLAIMED WATER DEMAND ANALYSIS FOR CCUA

Wastewater collection systems convey domestic, commercial, and industrial wastewater from its sources to locations where it may be treated and ultimately reclaimed for reuse or recycling, or discharged to surface waters. Generally, reclaimed water is a certain fraction of the total potable water supply. Based on the information obtained from CCUA, Table 2 and Figure 2 provide the projected wastewater production for CCUA service areas.

Table 2. Wastewater Effluent Projections for CCUA Service Areas

Year	Fleming Island Regional	Green Cove West	Mid-Clay WWTP	Miller Street WWTP	Ridaught Landing WWTF	Spencer's WWTP	Spencer's WWTF + 1.5 from Miller Street	Black Creek DRI	Mid-Clay WWTP + Black Ck	Total CCUA
2006	2.31	0.04	0.25	3.59	0.83	0.47	1.97	0.00	0.25	9.70
2011	2.72	0.31	0.48	3.59	1.16	1.17	2.67	0.18	0.65	12.92
2016	2.72	1.07	0.70	3.59	1.50	1.91	3.41	0.48	1.18	16.54
2021	2.72	2.22	1.07	3.59	1.66	2.02	3.52	0.89	1.96	19.67
2026	2.72	3.44	1.47	3.59	1.83	2.02	3.52	1.08	2.55	22.24
2031	2.72	4.73	2.65	3.67	2.14	2.02	3.52	1.17	3.82	26.44

Data Source: CCUA

All numbers are annual average effluent

Units: million gallons per day (mgd)

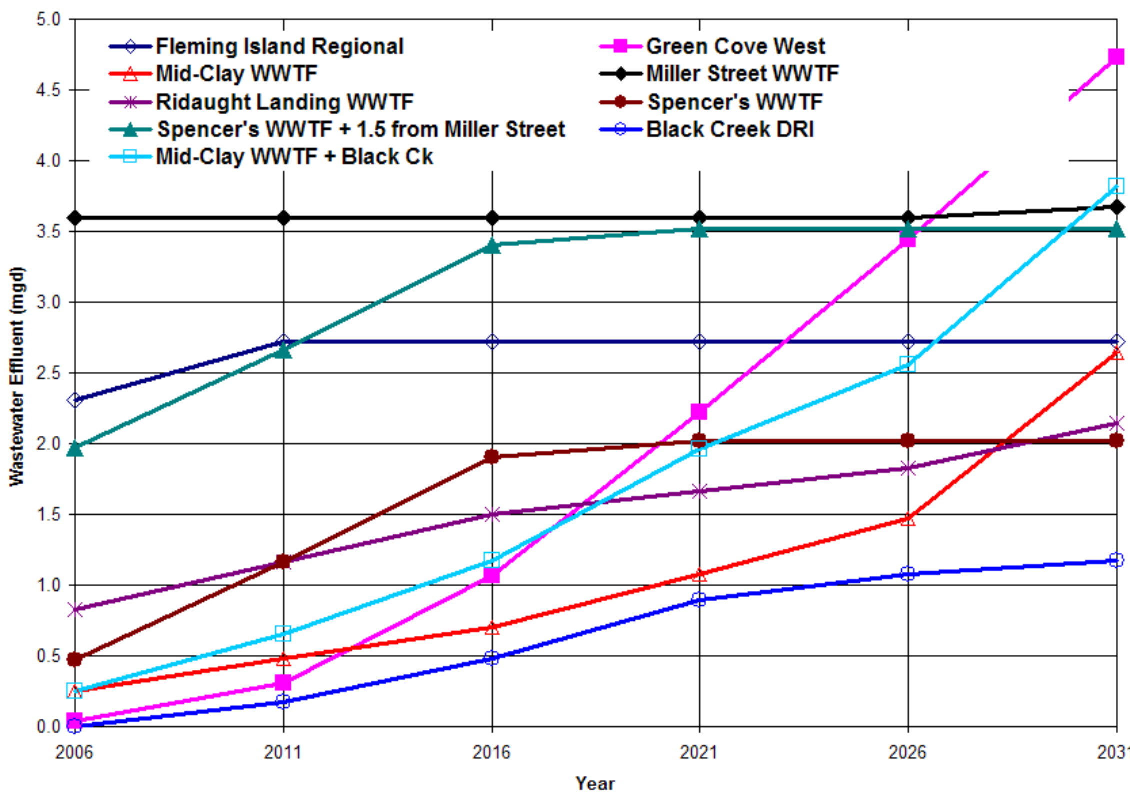

Figure 2. Wastewater Effluent Projections for CCUA Service Areas

The annual average reclaimed water demand projections as obtained from CCUA for its various service areas are presented in Table 3 and Figure 3. There is very little, if any, non-irrigation reclaimed water use in the CCUA service area. It is assumed that these flow projections include both golf courses and residential demands. These numbers are extrapolated from recent use patterns by relatively new developments in Clay County.

Table 3. Reclaimed Water Demand Projections for CCUA Service Areas

Year	Fleming Island Regional	Green Cove West (Future)	Peter's Creek (Future)	Mid-Clay (WWTP)	Miller Street WWTP	Old Jennings Road	Spencer's & Oakleaf Plantation	Black Creek DRI (Future)	Total
2005	1.27	0.00	0.00	0.10	0.00	0.21	0.79	0.00	2.37
2010	2.28	0.33	0.29	0.62	0.00	1.41	2.44	0.41	7.79
2015	2.28	0.96	1.42	1.15	0.00	2.45	4.42	1.10	13.78
2020	2.28	1.84	3.21	2.03	0.00	2.98	4.73	2.06	19.12
2025	2.28	2.78	5.09	2.97	0.00	3.50	4.73	2.50	23.85
2030	2.28	5.85	5.09	6.23	0.00	4.47	4.73	2.71	31.35

Data Source: CCUA

All numbers are annual average reclaimed water demands

Units: mgd

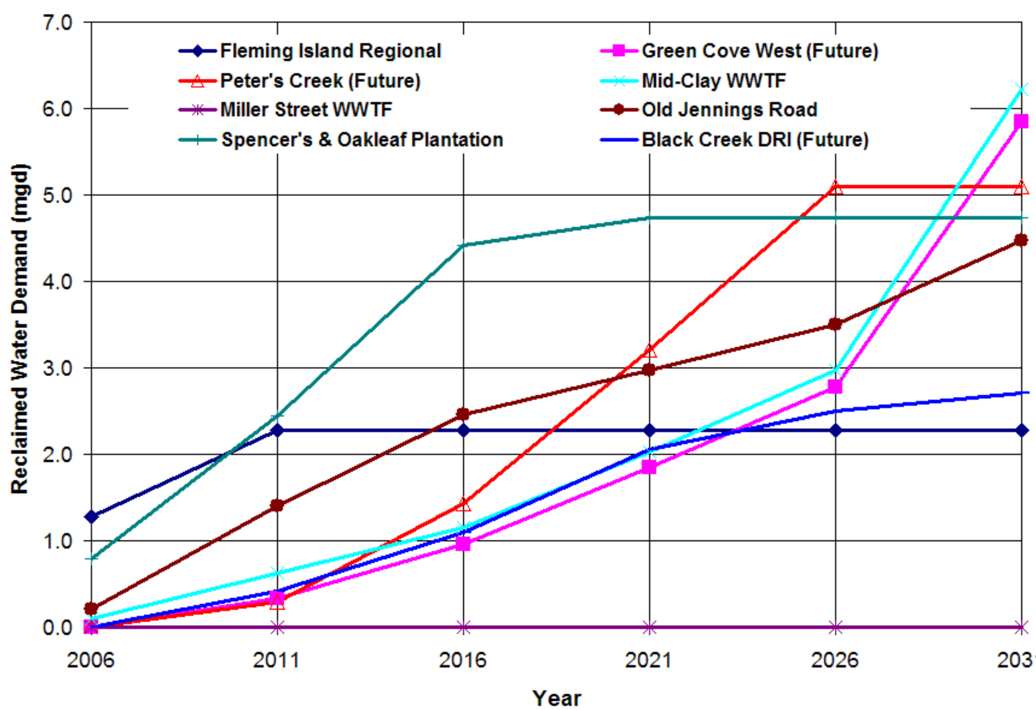

Figure 3. Reclaimed Water Demand Projections for CCUA Service Areas

Using the annual average wastewater production and reclaimed water demand projections, an approximate reclaimed water surplus-deficit analysis was conducted by subtracting the reclaimed water demand from wastewater production for a given year as given in Table 4 and Figure 4.

It is clear from Figure 4 that by 2031, most service areas of CCUA will have reclaimed water deficits.

Table 4. Annual Average Reclaimed Water Demand and Wastewater Production Surplus/Deficit Analysis for CCUA Service Areas

Year	Fleming Island Regional	Green Cove West (Future)	Peter's Creek (Future)	Mid-Clay WWTF	Miller Street WWTF	Old Jennings Road	Spencer's & Oakleaf Plantation	Black Creek DRI	Mid-Clay WWTF + Black Ck
2006	1.03	0.00	0.00	0.16	NA	0.61	-0.32	0.00	0.16
2011	0.44	-0.03	-0.29	-0.15	NA	-0.24	-1.28	-0.23	-0.38
2016	0.44	0.11	-1.42	-0.45	NA	-0.96	-2.51	-0.63	-1.07
2021	0.44	0.38	-3.21	-0.95	NA	-1.31	-2.71	-1.17	-2.12
2026	0.44	0.66	-5.09	-1.50	NA	-1.67	-2.71	-1.42	-2.91
2031	0.44	-1.12	-5.09	-3.58	NA	-2.33	-2.71	-1.54	-5.12

Data Source: CCUA

All numbers are annual average reclaimed water surplus (+) or deficit (-)
Units: mgd

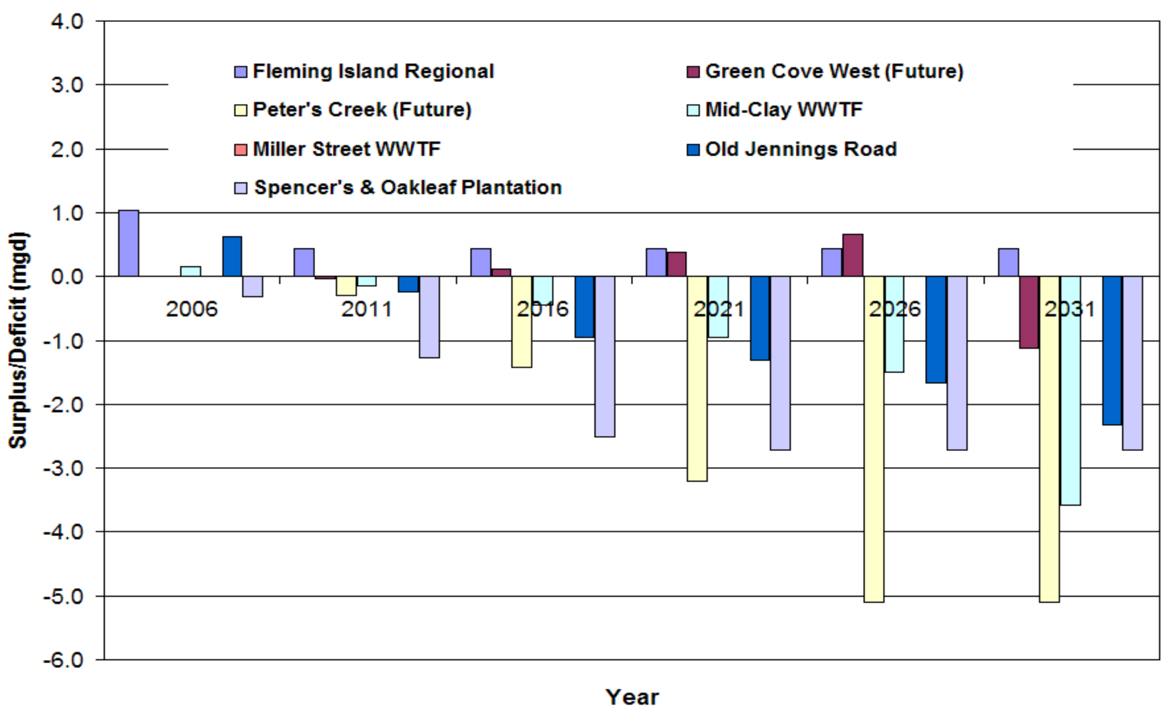

Figure 4. Annual Average Reclaimed Water Demand and Wastewater Production Surplus/Deficit Analysis for CCUA Service Areas

WASTEWATER EFFLUENT PRODUCTION AND RECLAIMED WATER DEMAND ANALYSIS FOR JEA WEST

Similarly, Table 5 and Figure 5 represent the projected annual average effluent production from JEA service areas on the west side of the LSJR. In Table 5, the effluent from the Buckman service area is the net effluent after subtracting its local reclaimed water demand of 5 mgd.

Table 5. Wastewater Effluent Projections for JEA West River Service Areas

Year	Buckman	Cedar Bay	Dinsmore	Southwest
2006	30.25	5.18	0.17	9.22
2010	31.1	5.42	2.58	11.32
2015	32.18	5.72	4.54	12.4
2020	33.23	6.02	6.09	13.47
2025	34.22	6.33	7.17	14.56
2030	35.12	6.63	7.45	15.59

Data Sources: JEA

All numbers are annual average mgd

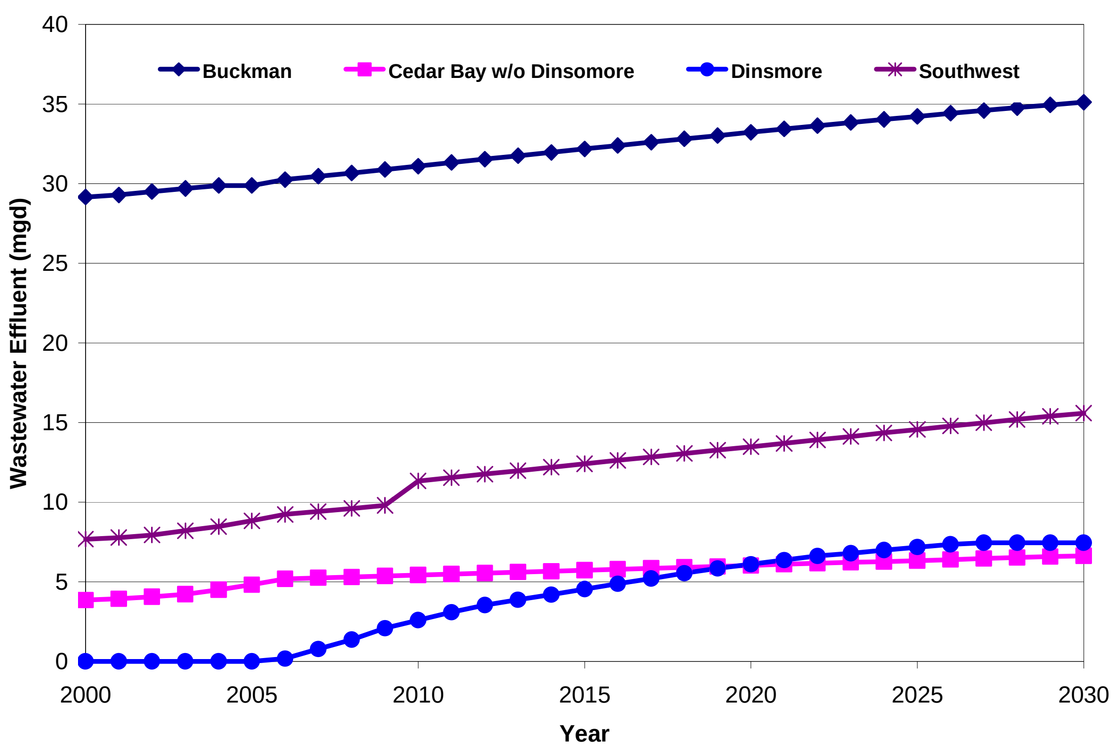

Figure 5. Projected Average Wastewater Effluent from JEA West River Service Areas

Table 6 and Figure 6 present the reclaimed water projections for the JEA service areas.

Table 6. Reclaimed Water Demand Projections for JEA West River Service Areas

Year	Buckman	Cedar Bay	Dinsmore	Southwest
2006	2.46	1.31	0.00	0
2010	5.00	5.00	1.96	0
2015	5.00	6.90	4.35	0
2020	5.00	8.20	6.76	0
2025	5.00	9.60	8.44	0
2030	5.00	11.00	8.89	0

Data Source: JEA
All numbers are annual average mgd

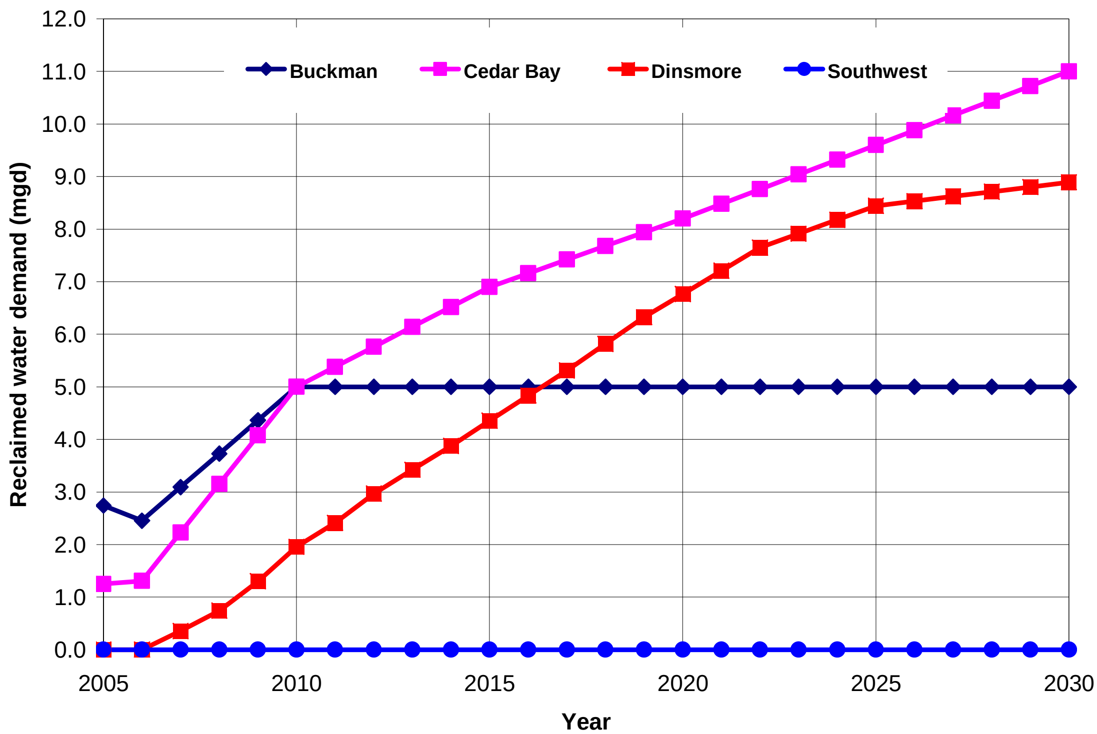

Figure 6. Projected Average Reclaimed Water Demand for JEA West River Service Areas

It is clear from Figure 7 that by before 2012, all the JEA west service areas have surplus of reclaimed water. However, after 2012, both

Cedar Bay and Dinsmore have reclaimed water deficits. Further, the deficit in the Cedar Bay service area is much higher than the deficit of Dinsmore. It can also be noted that both Buckman and Southwest have a consistently large amount of reclaimed water surplus.

Table 7. Annual Average Reclaimed Water Surplus/Deficit Analysis for JEA West River Service Areas

Year	Buckman	Cedar Bay	Dinsmore	Southwest
2005	29.88	3.56	0.00	8.83
2010	31.1	0.42	0.62	11.32
2015	32.18	-1.18	0.19	12.40
2020	33.23	-2.18	-0.67	13.47
2025	34.22	-3.27	-1.27	14.56
2030	35.12	-4.37	-1.44	15.59

Data Source: JEA

All numbers are annual average reclaimed water surplus (+) or deficit (-)
Units: mgd

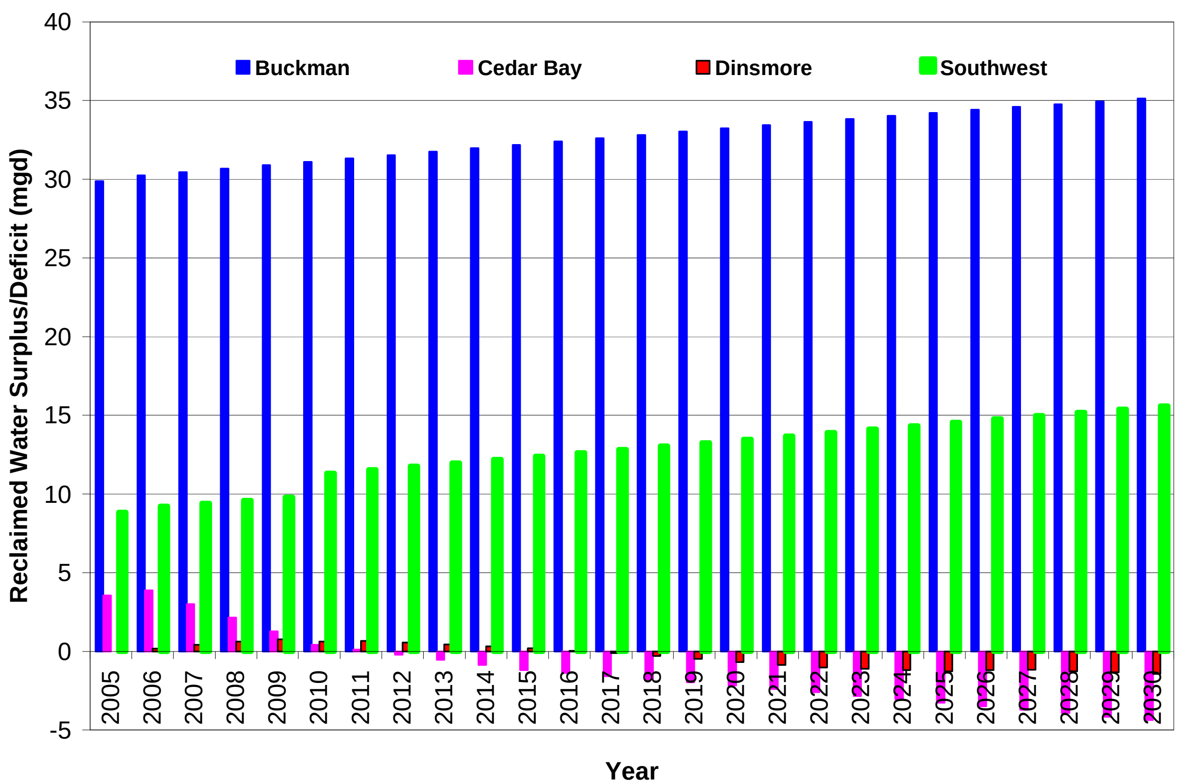

Figure 7. Annual Average Reclaimed Water Surplus/Deficit Analysis for JEA West River Service Areas

WASTEWATER EFFLUENT PRODUCTION AND RECLAIMED WATER DEMAND ANALYSIS FOR JEA EAST

Table 8 and Figure 8 represent the projected annual average effluent production from JEA service areas east of the LSJR.

Table 8. Wastewater Effluent Projections for JEA East River Service Areas

Year	Arlington East	Mandarin	Blacks Ford	JEA Total
2010	14.73	8.08	3.28	26.09
2015	18.63	8.71	5.71	33.05
2020	19.79	9.34	7.15	36.28
2025	20.84	9.89	8.45	39.18
2030	21.12	10.14	9.74	41.00

Data Sources: JEA, JEA Reclaimed Water Forecast 2008.xls
All numbers are annual average mgd

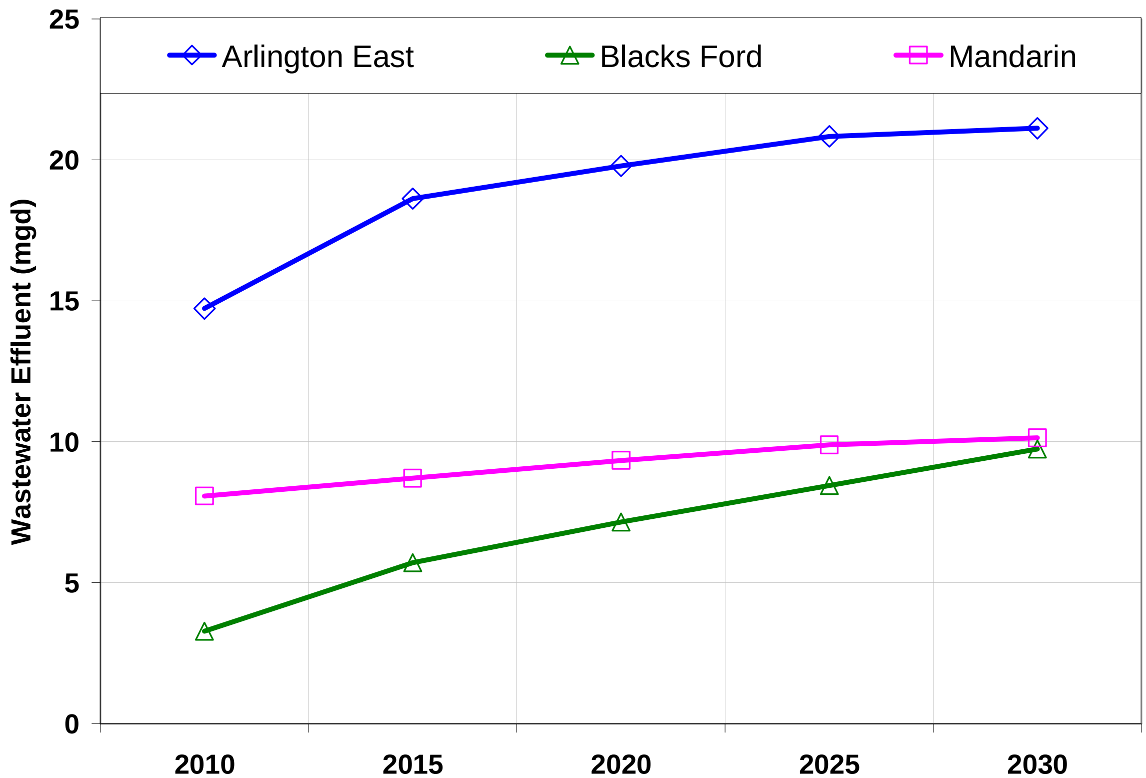

Figure 8. Projected Average Wastewater Effluent from JEA East River Service Areas

Table 9 and Figure 9 present the reclaimed water projections for the JEA east service areas.

Table 9. Reclaimed Water Demand Projections for JEA West River Service Areas

Year	Arlington East	Mandarin	Blacks Ford	Total
2010	5.50	4.15	1.55	11.20
2015	9.40	6.41	2.55	18.36
2020	9.40	8.21	3.15	20.76
2025	9.40	10.04	3.25	22.69
2030	9.40	11.54	3.33	24.27

Data Source: JEA, JEA Reclaimed Water Forecast 2007.xls
All numbers are annual average mgd

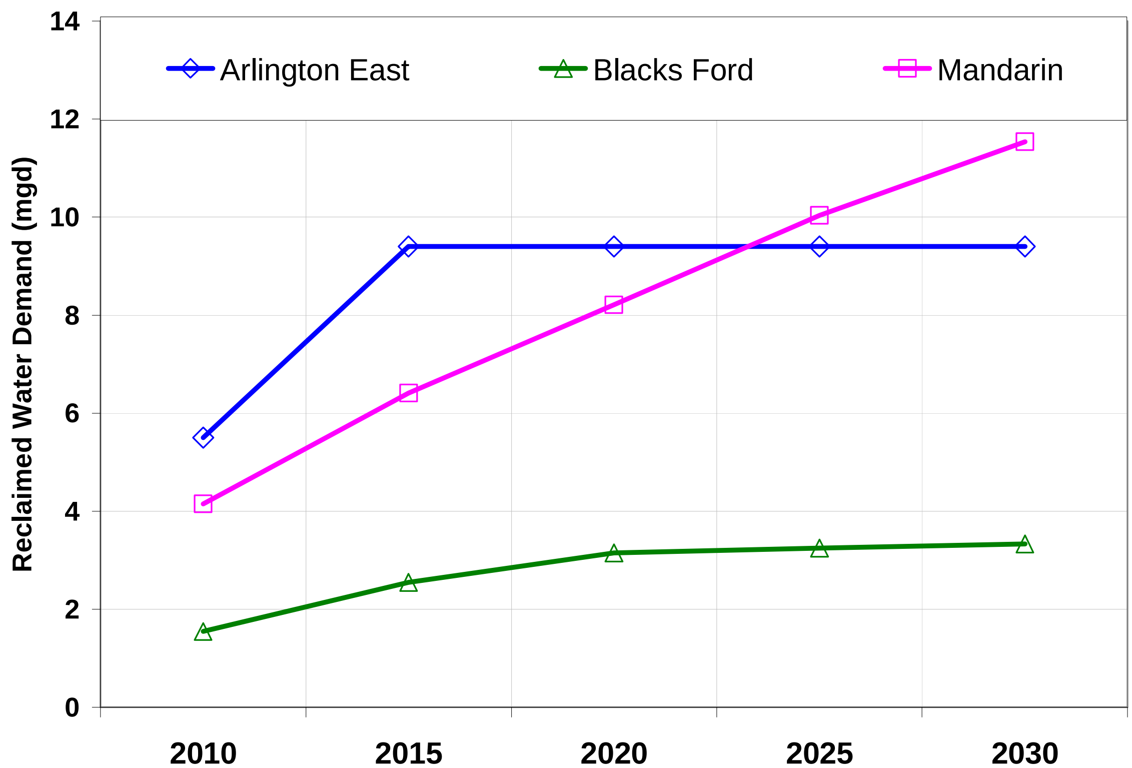

Figure 9. Projected Average Reclaimed Water Demand for JEA West River Service Areas

It is clear from Figure 10 that prior to 2025, all the JEA east service areas have surplus of reclaimed water. By 2025, the Mandarin service area has a reclaimed water deficit that persists through 2030. However, the combined surplus of reclaimed water in the Arlington East and Blacks Ford service areas exceeds this deficit through 2030.

Table 10. Annual Average Reclaimed Water Surplus/Deficit Analysis for JEA East River Service Areas

Year	Arlington East	Mandarin	Blacks Ford	JEA Total
2010	9.23	3.93	1.73	14.89
2015	9.23	2.30	3.16	14.69
2020	10.39	1.13	4.00	15.52
2025	11.44	-0.15	5.20	16.49
2030	11.72	-1.40	6.41	16.73

Data Source: JEA

Assumed 100% reuse of available wastewater

All numbers are annual average reclaimed water surplus (+) or deficit (-)
Units: mgd

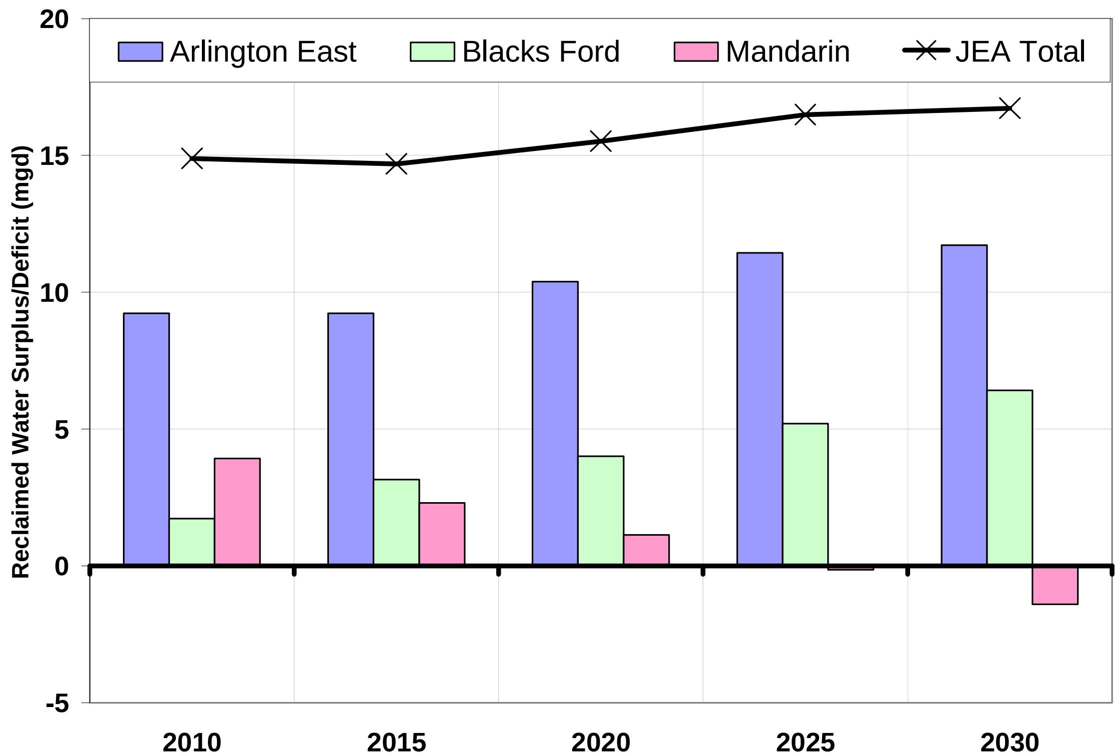

Figure 10. Annual Average Reclaimed Water Surplus/Deficit Analysis for JEA West River Service Areas

WASTEWATER EFFLUENT PRODUCTION AND RECLAIMED WATER DEMAND ANALYSIS FOR SJCUD

Table 11 and Figure 11 represent the projected annual average effluent production from SJCUD service areas.

Table 11. Wastewater Effluent Projections for SJCUD Service Areas

Year	Northwest	SR16	Anastasia Island	Southwest
2010	1.297	0.388	2.638	0.000
2015	1.697	0.544	2.951	0.000
2020	2.437	0.721	3.381	0.091
2025	3.263	0.890	3.710	0.334
2030	4.377	0.961	3.976	0.597

Data Sources: SJCUD, WastewaterProjections20080822rev1.xls
All numbers are annual average mgd

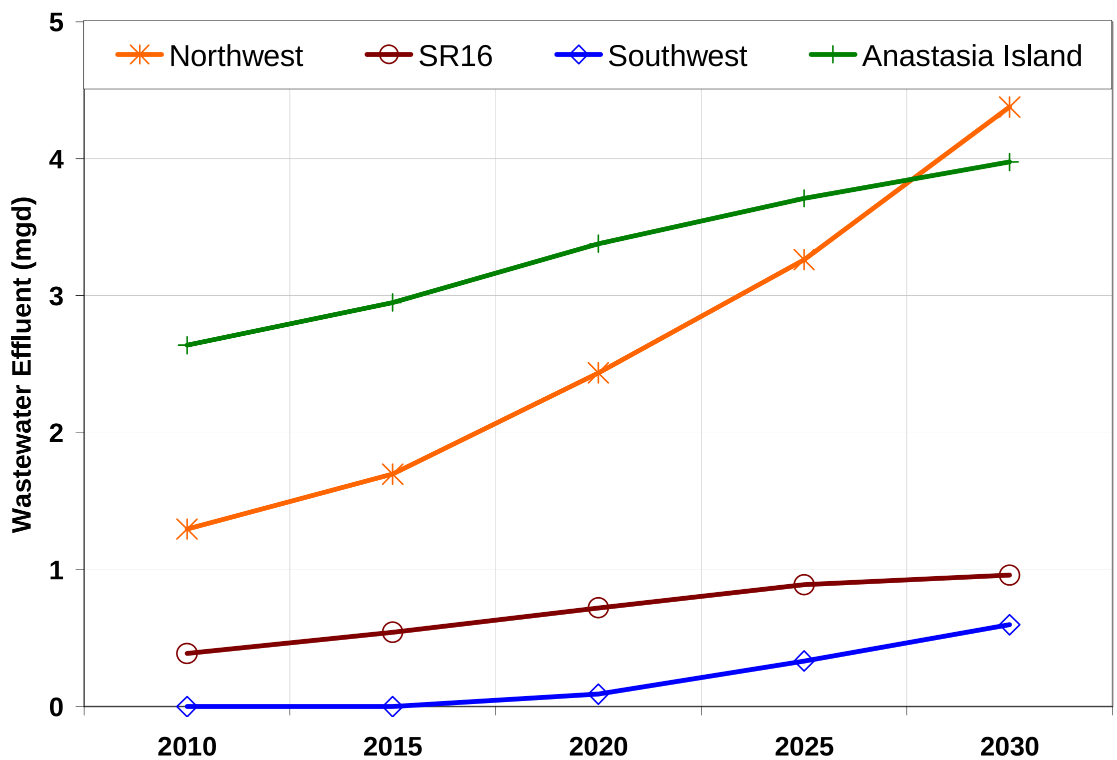

Figure 11. Projected Average Wastewater Effluent from SJCUD River Service Areas

Table 12 and Figure 12 present the reclaimed water projections for the JEA service areas.

Table 12. Reclaimed Water Demand Projections for SJCUD Service Areas

Year	Northwest	SR16	Anastasia Island	Southwest
2010	0.94	0.00	0.22	0.00
2015	1.11	0.08	0.30	0.00
2020	1.64	0.24	0.37	0.12
2025	2.30	0.45	0.49	0.48
2030	3.26	0.54	0.60	0.86

Data Source: SJCUD, WastewaterProjections20080722.xls
All numbers are annual average mgd

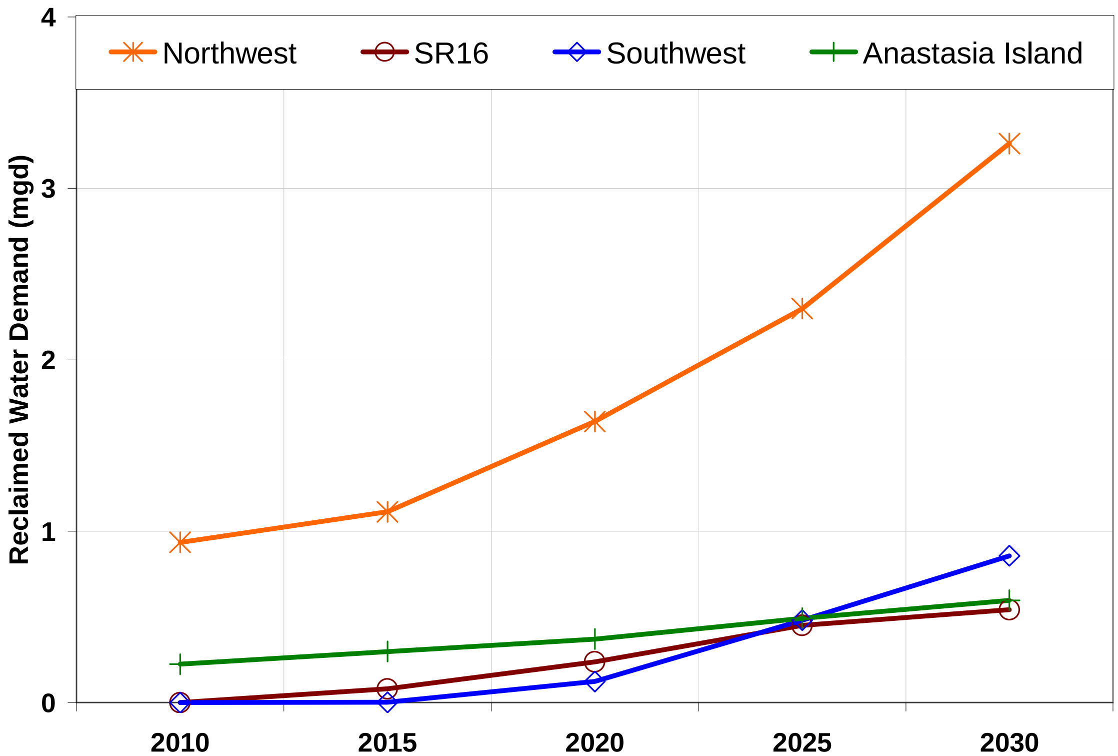

Figure 12. Projected Average Reclaimed Water Demand for SJCUD River Service Areas

It is clear from Figure 13 that prior to 2020, all the SJCUD service areas have surplus of reclaimed water. By 2020, Southwest has reclaimed water deficit. However, the combined surplus of reclaimed water in the Northwest, SR16, and Anastasia Island exceeds this deficit through 2030.

Table 13. Annual Average Reclaimed Water Surplus/Deficit Analysis for SJCUD River Service Areas

Year	Northwest	SR16	Anastasia Island	Southwest
2010	0.36	0.39	2.41	0.00
2015	0.58	0.46	2.65	0.00
2020	0.80	0.48	3.01	-0.03
2025	0.96	0.44	3.22	-0.15
2030	1.12	0.42	3.38	-0.26

Data Source: SJCUD

Assumed 100% reuse of available wastewater

All numbers are annual average reclaimed water surplus (+) or deficit (-)
Units: mgd

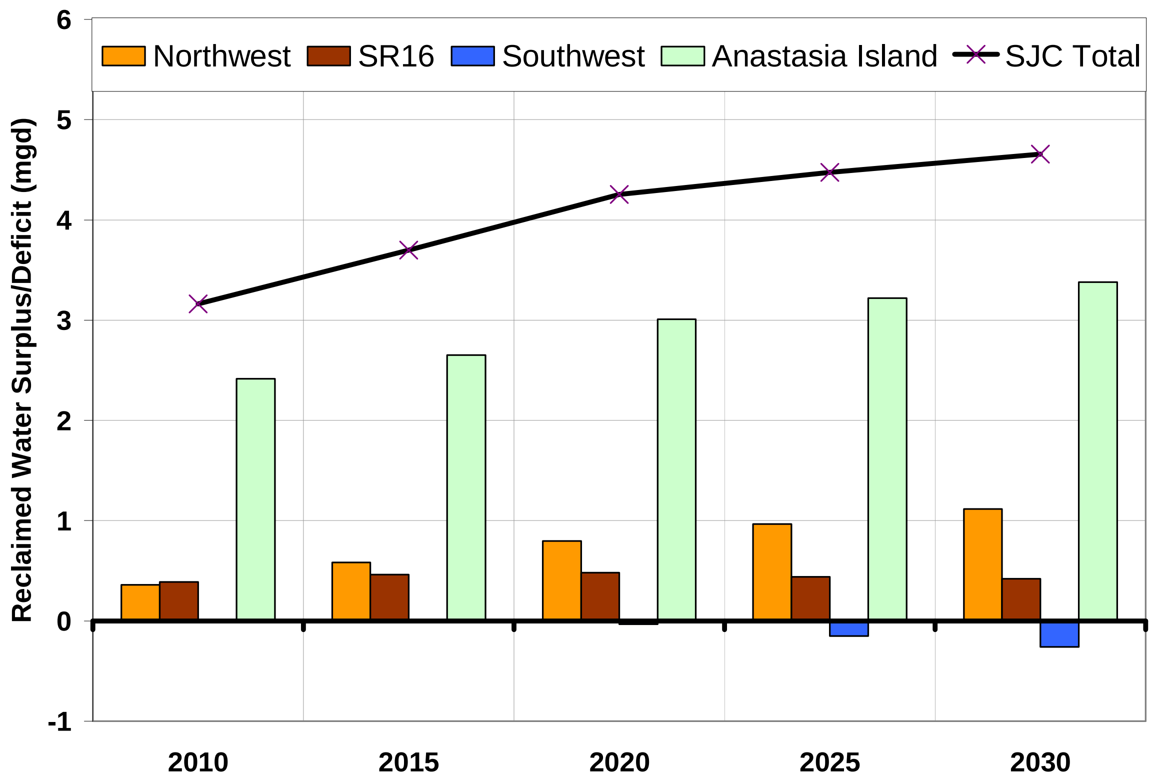

Figure 13. Annual Average Reclaimed Water Surplus/Deficit Analysis for JEA West River Service Areas

DETERMINATION OF SEASONAL COMPONENTS OF RECLAIMED WATER SUPPLY AND RECLAIMED WATER DEMAND

Generally, the weekly irrigation demand for reclaimed water generated by a particular urban system can be estimated from an inventory of the total irrigable acreage to be served by the reclaimed water system and the estimated weekly irrigation rates. These rates are determined by such factors as local soil characteristics, climatic conditions, and type of landscaping. Alternatively, water use records can also be used to estimate the seasonal variation in reclaimed water demand. Similarly, the historic data for the potable water supply can be used to determine the seasonal reclaimed water production.

In the present study, historic data from CCUA's Fleming Island Service Area was utilized to determine the seasonal variation in the reclaimed water supply and demand. This relatively new development was considered typical of modern land use with residential irrigation. This mixed use service area also includes a golf course. The methodology and calculations used to generate seasonal water supply and demand factors are presented in Appendix I. Tables 14 and 16 present the seasonal supply and demand factors, respectively.

Following review of the seasonal water supply factors, SJCUD provided an alternative set of factors that are more appropriate for its SR16 service area. This set of monthly factors is based on observed wastewater supply at SR16, and the data was interpolated to generate the weekly water supply factors presented in Table 15.

Table 14. Seasonal factors for Reclaimed Water Supply (except SR16)

t(weeks)	Weekly Multiplying Factor	t(weeks)	Weekly Multiplying Factor
CCUA Water Service Area Summary			
1	1.021	27	0.984
2	1.017	28	0.989
3	1.013	29	0.993
4	1.008	30	0.997
5	1.004	31	1.002
6	0.999	32	1.006
7	0.995	33	1.011
8	0.991	34	1.015
9	0.986	35	1.019
10	0.982	36	1.023
11	0.978	37	1.026
12	0.975	38	1.029
13	0.972	39	1.032
14	0.969	40	1.034
15	0.967	41	1.035
16	0.965	42	1.036
17	0.964	43	1.037
18	0.963	44	1.037
19	0.963	45	1.036
20	0.964	46	1.035
21	0.965	47	1.033
22	0.966	48	1.031
23	0.968	49	1.029
24	0.971	50	1.026
25	0.973	51	1.022
26	0.977	52	1.019

Notes:

Values generated using the procedure outlined in Appendix I

Data is shown graphically in Figure 7 of Appendix I

Table 15. Seasonal factors for Reclaimed Water Supply – SR16 Service Area

t(weeks)	Weekly Multiplying Factor	t(weeks)	Weekly Multiplying Factor
SR16 Water Service Area Summary			
1	0.990	27	0.985
2	0.920	28	0.988
3	0.850	29	0.990
4	0.880	30	1.010
5	0.910	31	1.030
6	0.940	32	1.050
7	0.970	33	1.070
8	0.948	34	1.054
9	0.925	35	1.038
10	0.888	36	1.022
11	0.850	37	1.006
12	0.880	38	0.990
13	0.888	39	1.010
14	0.895	40	1.030
15	0.903	41	1.050
16	0.910	42	1.070
17	0.908	43	1.100
18	0.905	44	1.130
19	0.903	45	1.160
20	0.900	46	1.190
21	0.920	47	1.192
22	0.940	48	1.194
23	0.960	49	1.196
24	0.970	50	1.198
25	0.980	51	1.200
26	0.983	52	1.130

Notes:

Values provided by SJCUD, Option1_FlowandDemand07282008.xls

Weekly values interpolated using monthly factors

Table 16. Seasonal factors for Reclaimed Water Demand

t(weeks)	Weekly Multiplying Factor	t(weeks)	Weekly Multiplying Factor
CCUA Water Service Area Summary			
1	0.459	27	1.352
2	0.393	28	1.272
3	0.364	29	1.215
4	0.369	30	1.178
5	0.401	31	1.153
6	0.449	32	1.130
7	0.502	33	1.101
8	0.553	34	1.058
9	0.599	35	1.002
10	0.640	36	0.939
11	0.685	37	0.876
12	0.741	38	0.826
13	0.819	39	0.798
14	0.924	40	0.799
15	1.057	41	0.829
16	1.212	42	0.882
17	1.377	43	0.946
18	1.535	44	1.007
19	1.670	45	1.047
20	1.767	46	1.055
21	1.814	47	1.023
22	1.809	48	0.952
23	1.758	49	0.850
24	1.670	50	0.728
25	1.563	51	0.605
26	1.452	52	0.497

Notes:

Values generated using the procedure outlined in Appendix I

Data is shown graphically in Figure 8 of Appendix I

EXISTING, FUTURE, AND PROPOSED SYSTEM CONDITIONS

The existing reclaimed water treatment and pump capacity in each of the CCUA, JEA, and SJCUD service areas are presented in Table 17. Proposed capacity that may be installed in the near future is also listed in the table.

Table 17. CCUA, JEA, and SJCUD Water Service Area Summary

Service Area	Owner	Treatment Capacity (mgd)	Reclaimed Water Plant	Reclaimed Pump Station
CCUA Water Service Area Summary				
Fleming Island	CCUA	4.49	Existing	Existing (2.2 MG)
Miller Street	CCUA	5.0	Proposed	Proposed (2.0 MG)
Mid-Clay	CCUA	0.85	Existing	Existing (0.5 MG)
Spencer's Crossing	CCUA	1.35	Existing	Existing (1.6 MG)
Ridaught Landing	CCUA	1.875	Existing	-
Oakleaf	CCUA	-	-	Existing (0.75 MG)
Old Jennings	CCUA	-	-	Existing (0.75 MG)
GC West	CCUA	0.25	Proposed	Proposed (0.75 MG)
Peter's Creek	CCUA	-	-	Proposed (1.1 MG)
GC Springs Harbour	Green Cove Springs	0.0	Existing	P.S. only
GC Springs South	Green Cove Springs	0.0	-	-
JEA Water West Service Areas Summary				
Buckman	JEA West	0.0	Existing	
Cedar Bay	JEA West	5		
District II	JEA West	0.0	Existing	
Southwest	JEA West	0.0	Existing	
JEA Water East Service Areas Summary				
Arlington East	JEA East	6.0	Existing	
Blacks Ford	JEA East	6.0	Existing	
Mandarin	JEA East	7.0	Existing	
Jacksonville Beach	City of Jacksonville Beach	4.5	Existing	
SJCUD Water Service Areas Summary				
Northwest	SJCUD	3.0	Existing	
SR16	SJCUD	0.85	Existing	
Anastasia Island	SJCUD	1.0	Existing	
Southwest	SJCUD	0.0	Proposed	

Notes:

1. Reclaimed Water Plant = Filtration and High Level Disinfection for Public Use.
2. Reclaimed Water Pump Station = Ground Storage and High Service Pumping Station.
3. Oakleaf Reclaimed Water Pumping Station just started several months ago. Prior to then, the areas were served by the Spencer's Crossing RW PS.
4. Southwest RWTP is expected to come online in 2017. No existing capacity is assumed for this study.

Possible pipe paths and locations of pump stations, reservoirs, and RIBs previously identified by the utilities were provided by CCUA, JEA, and SJCUD. Through a workshop setting, additional potential inter-utility connections were identified by the stakeholders (Figure 14).

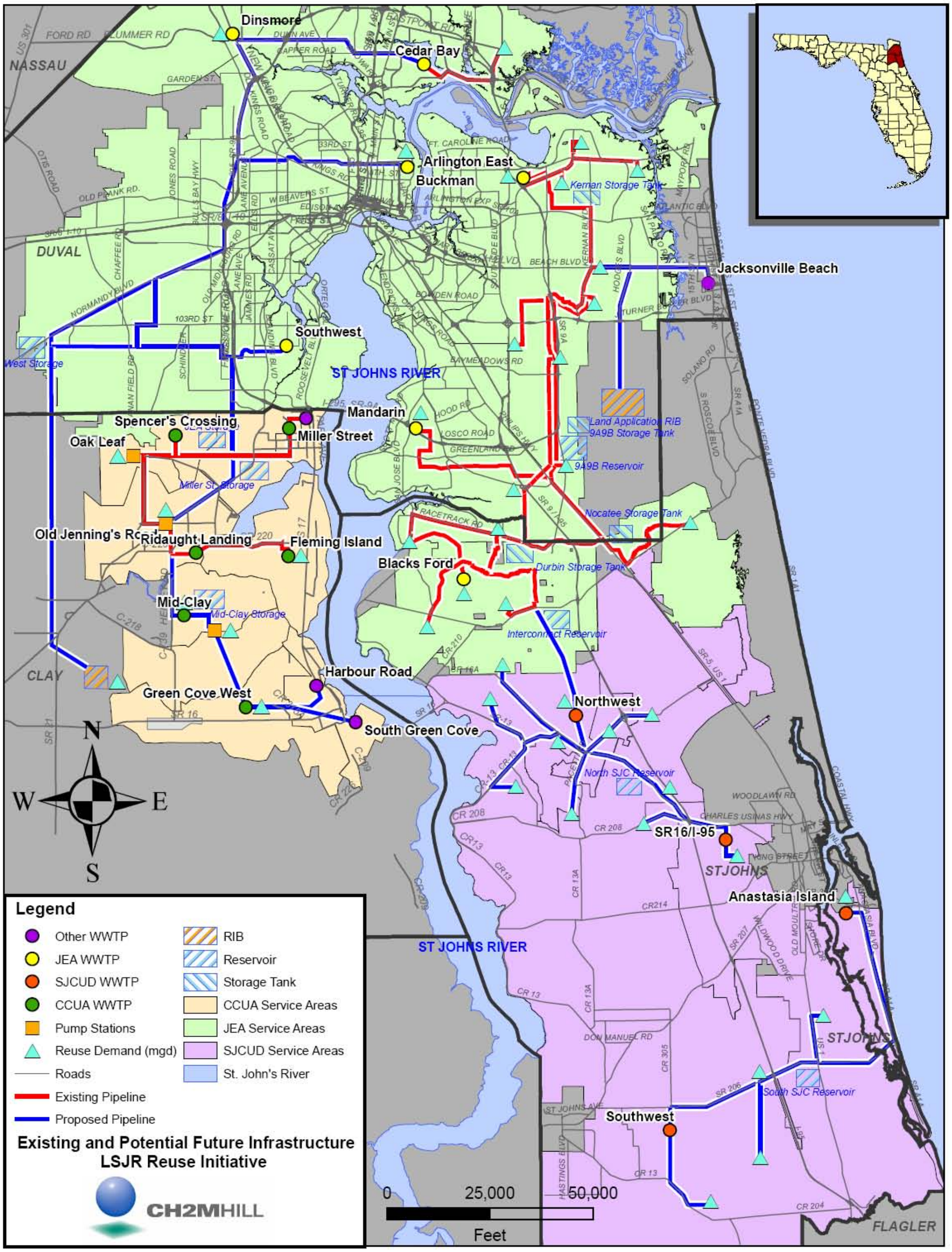

Figure 14. Existing and Potential Future Reclaimed Water Infrastructure

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MODEL DEVELOPMENT

MODEL COMPONENTS

The LSJR water reuse system model was set up to find optimal solution sets for the production and distribution of reclaimed water. The model included the seasonal variability in the potable and reclaimed water demand and supply balance, water quality, cost, and the most effective and efficient infrastructure solutions through the optimization formulation. The various model components can be summarized as follows:

- Reclaimed water production (supply), dependent on available wastewater flows
- Reclaimed water demands
- Non-reclaimed effluent discharged to the St. Johns River
- Demands on potable water that are offset (water demand less reclaimed water)
- Transmission (pipes and pump stations), dependent on physical constraints of system
- Reclaimed water treatment
- Tank storage capacity
- Reservoir capacity
- Recharge (RIBs)

DEVELOPMENT OF COST ESTIMATES

Capital Costs

New Reclaimed Water Treatment Capacity

The capital costs for reclaimed water treatment (RWT) facilities were calculated based on a recent report prepared for the St. Johns River Water Management District by Black and Veatch titled, *Engineering Assistance in Updating Information on Water Supply and Reuse System Component Costs*, District Project No. SK30712, 2008. It is not the intent of the cost estimating methodology to establish an exact treatment process but rather to estimate the cost of general process, in this case cloth media filter and disinfectant, appropriate for bringing the reclaimed water to the reuse standard. Thus, the capital cost of the reclaimed water treatment facility (WTF) is given as

$$RWT\ Capital\ Cost = 0.980 Q_C^{0.4461}$$

where Q_c is the capacity of the reclaimed water treatment plant in mgd and RWT Cost is the capital cost in million dollars. Similarly, the O&M cost of the reclaimed water treatment facility is given as

$$RWT\ O\ \&\ M\ \ Cost = 20.944 Q_C^{-0.5606}$$

Figure 15 presents the estimated capital and O&M costs for various capacities.

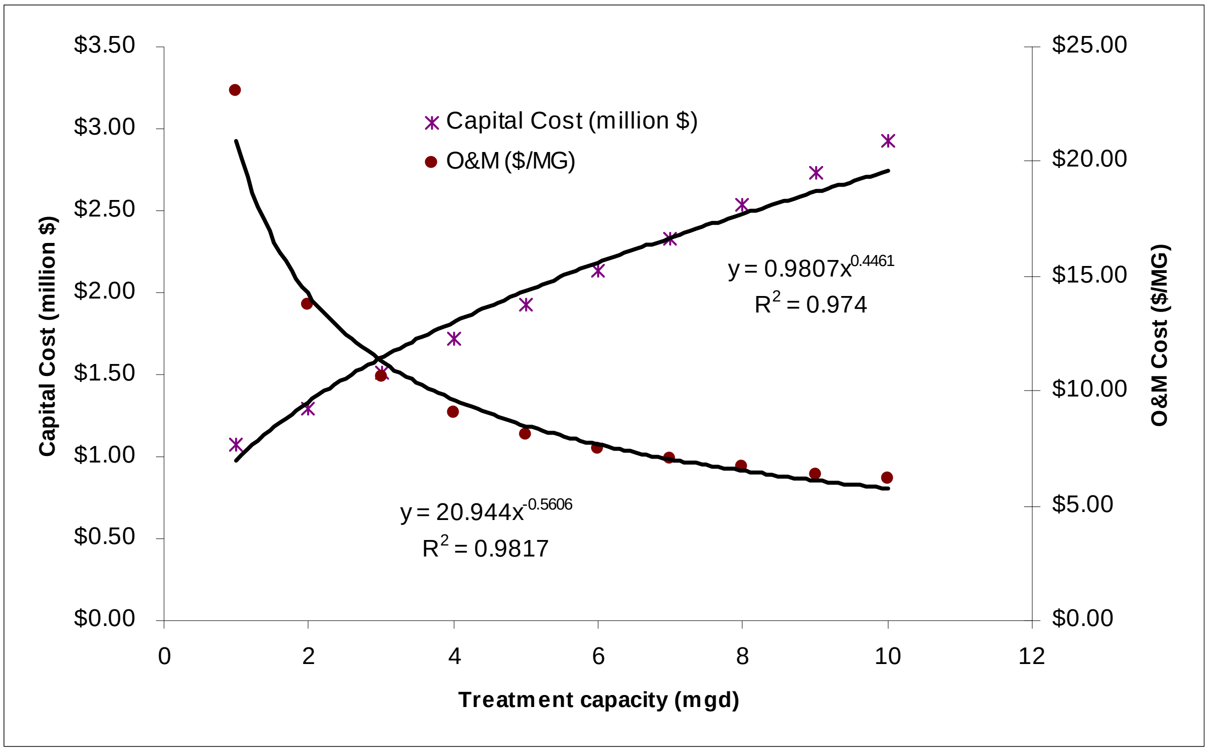


Figure 15. Reclaimed Water Treatment Capital Cost

New Reclaimed Water Pipelines

The capital costs for water distribution pipeline were calculated using values from Black and Veatch (2008). The pipeline cost can be approximated using Figure 16;

$$Pipeline\ \ Cost = 6.867 \mathrm{D}^{1.2104}$$

where pipeline cost is in dollars/linear ft and D = diameter of the pipeline in inches. To determine the cost of a pipeline of diameter D (inches) and length of L (feet), the above function is multiplied by L.

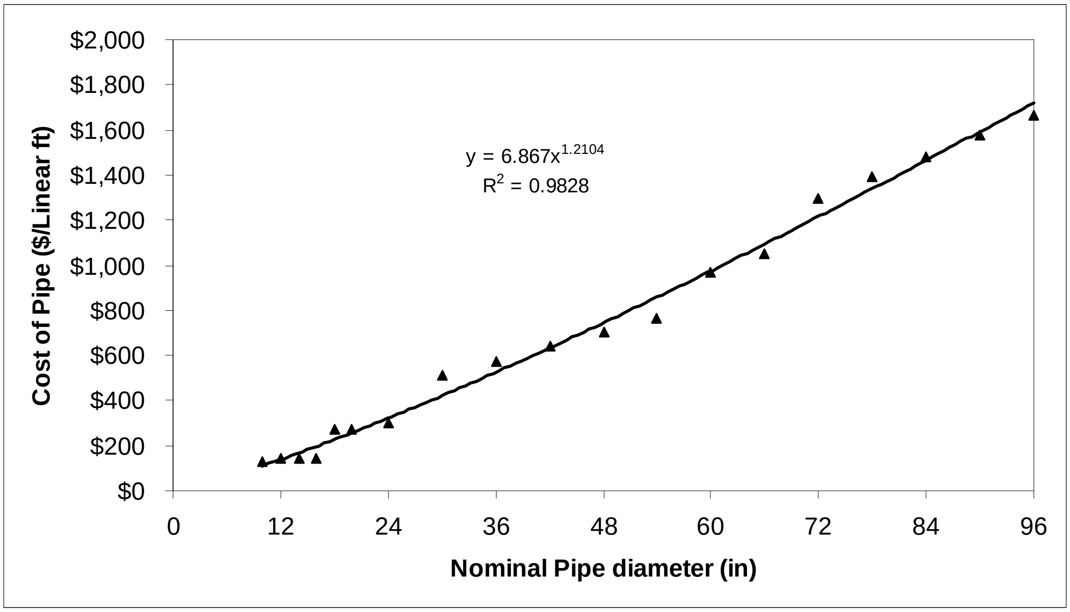


Figure 16. Pipeline Capital Cost Equations

New Reclaimed Water Pump Stations

Design and sizing of pumping stations involves determining the required pumping capacity and the required total dynamic head. The pumping station is sized to meet peak day demands. Pump total dynamic head refers to the feet of head the pump must add to the system for it to reach a desired hydraulic grade line under operating conditions. The dynamic suction head is the vertical distance between the low water level on the suction side of the pump and the pump centerline plus any friction loss. The dynamic discharge head is the vertical distance between the pump centerline and the high water level on the pump discharge side, plus friction losses. The sum of the two is the total dynamic head. Thus, pumps are described by capacity and head. Both of these parameters can be combined to give a singe parameter of required horsepower given as

$$HP = \frac{Q(cfs) * TDH(ft)}{8.8\eta}$$

where Q is the discharge capacity, and TDH is the total amount of energy provided by the pumps to deliver water to a specific destination that accounts for lift and losses. Having determined the required HP, the pump station capital cost function was determined using the data from Black and Veatch (2008). Figure 17 presents the literature cost and estimated cost curve.

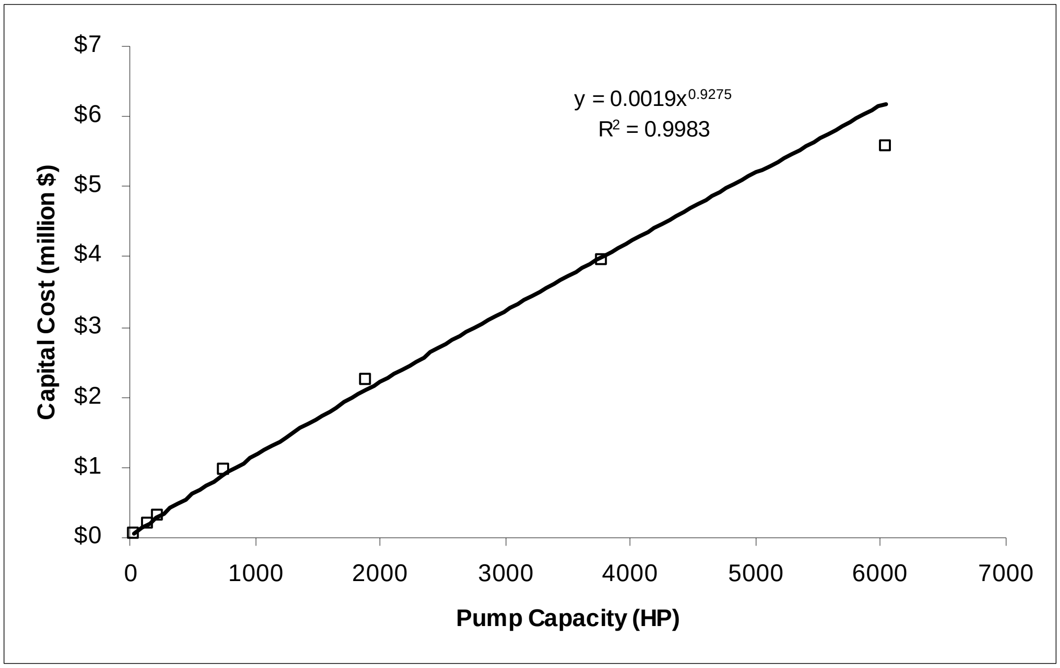


Figure 17. Pump Station Capital Cost

Thus, the pump station capital cost is given as

$$Pump\ Cost = \left[0.08 + \left(\frac{984}{HP}\right)\right]^{-1}$$

where pump cost is in million dollars per HP, and HP is the horsepower of the pump.

New Reclaimed Water Storage Costs

Storage structures can be elevated, ground level, or underground structures that serve to dampen variable flows before pumping into the system. In this study, two types of storage structures are considered: (1) short-term ground storage tanks typically with a maximum size of 20 million gallons (MG), and (2) long-term storage in large ground reservoirs. Using the data from Black and Veatch (2008), the capital costs for these storage facilities are given as

$$Storage\ Tank\ Cost = 0.265 S_C + 0.3115$$

$$Ground\ \ Reservoir\ Cost = 0.026 * S_C + 4.797$$

$$JEA\ East\ Ground\ \ Reservoir\ Cost = 0.0707 * S_C + 4.2935$$

where S_C is the storage capacity of storage facility in MG and the corresponding costs are in million dollars. There are two ground reservoir cost functions due to the difference in the cost of land between the JEA east service areas and elsewhere. These curves are shown in Figures 18, 19, and 20.

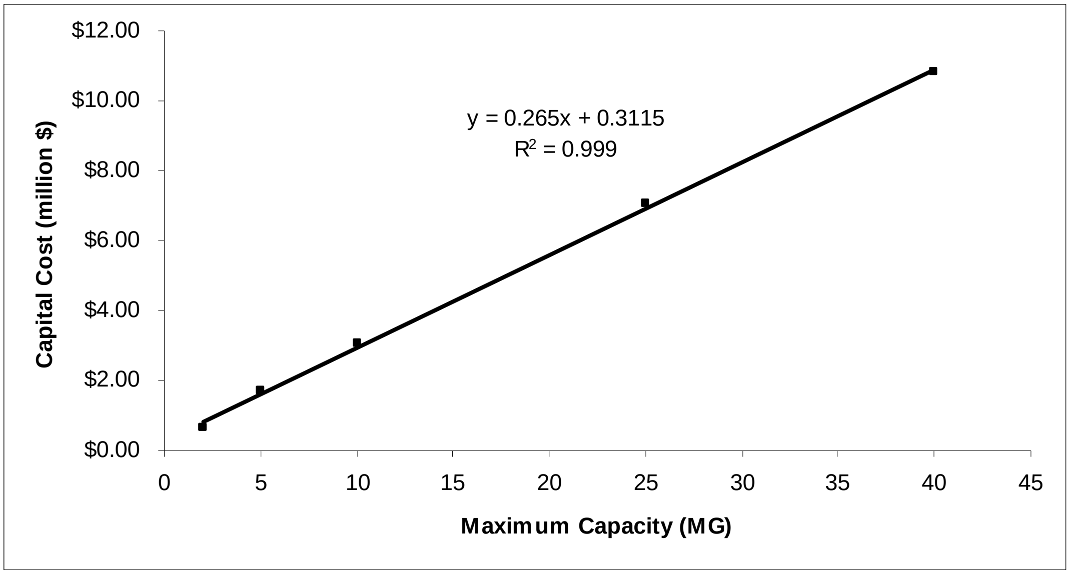


Figure 18. Capital Cost of Storage Tanks

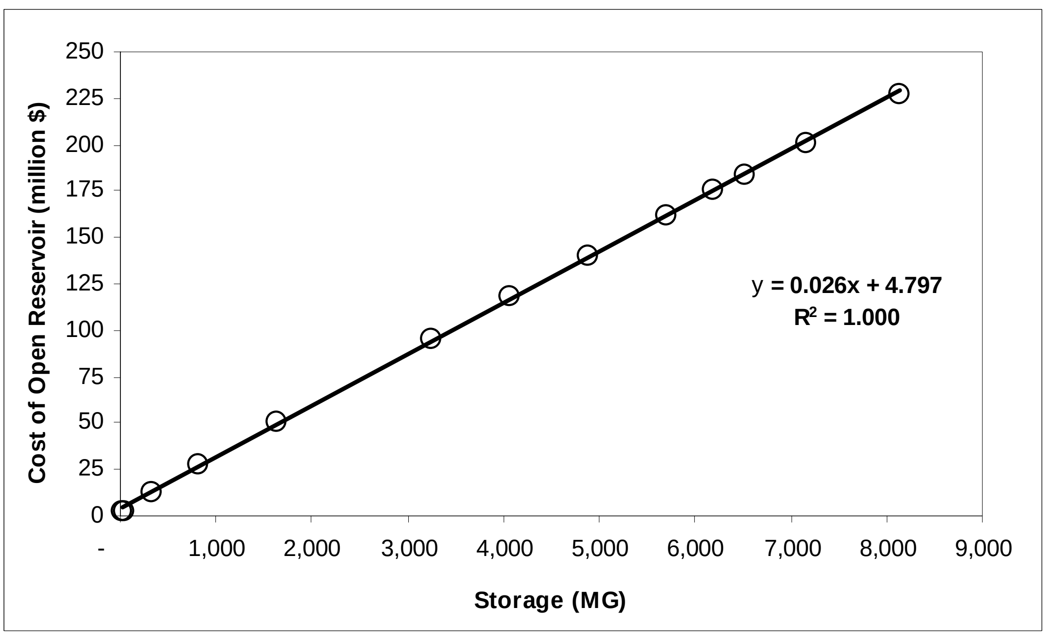


Figure 19. Capital Cost of Ground Reservoirs

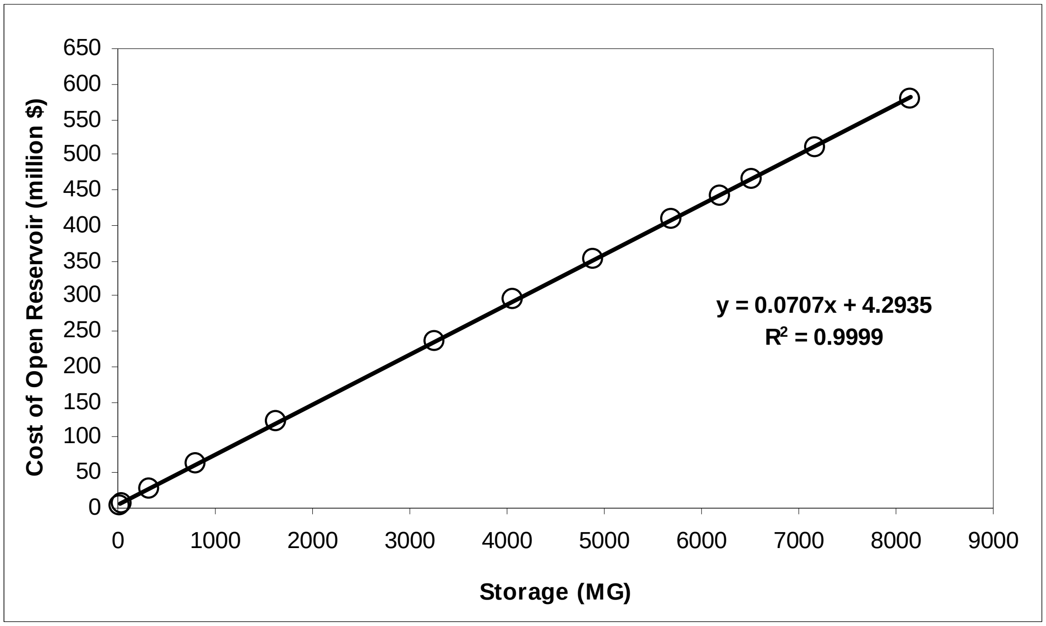


Figure 20. Capital Cost of JEA East Ground Reservoirs

RIB and Land Application Capital Cost

RIBs and land application allow for the land treatment and disposal of wastewater. Applied wastewater percolates through the soil and the treated effluent drains via hydraulic pathways to groundwater or surface water. For example, there are clayey layers of soil in the region that keeps the watertable high and may direct percolated water to local streams (eventually) instead of into the deeper aquifer system.

A RIB system includes multiple basins, piping, and structures to form an entire manageable disposal site. Based on CH2M HILL experience in recent designs for RIB systems in Florida, a costing template was developed. Then the capital costs were estimated for various capacities, as presented in the CH2M HILL 2008 Westside Study, *Construction and O&M Cost Analysis*, and shown in Figure 21. The resulting equation used to describe this technology is

$$RIBs\ Capital\ Cost = 5.49Q + 0.47$$

where Q is the capacity of RIB system in mgd and capital cost is in millions of dollars.

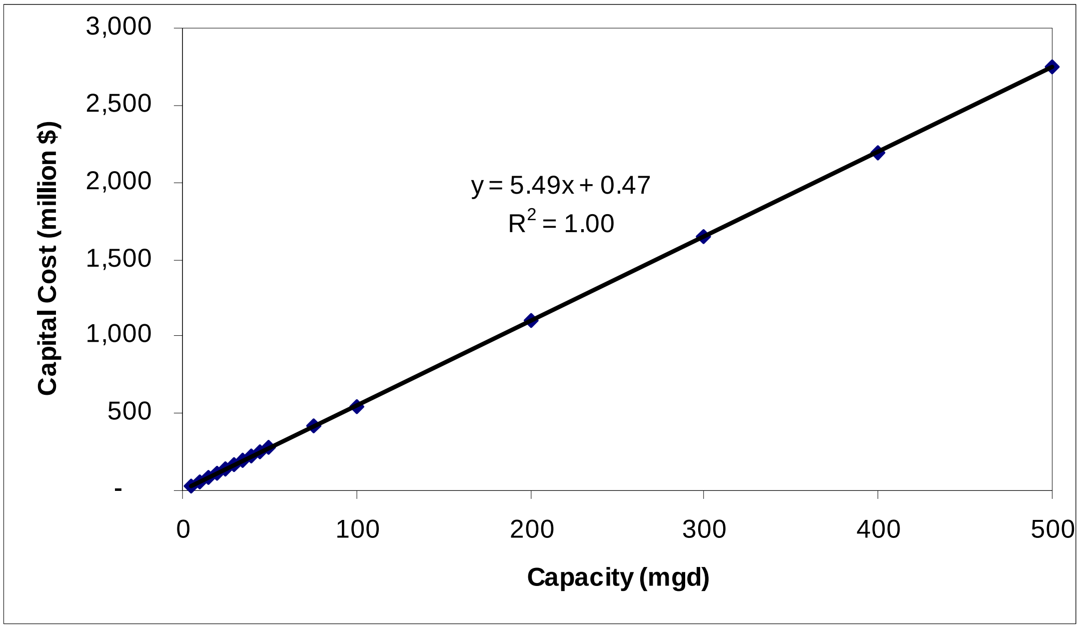


Figure 21. Capital Cost of RIB System

Similarly, land application costs were determined for the proposed location in the JEA East service area as

$$\textit{Land Application Capital Cost} = 18.48Q + 0.36$$

where Q is the capacity of RIB system in mgd and capital cost is in millions of dollars.

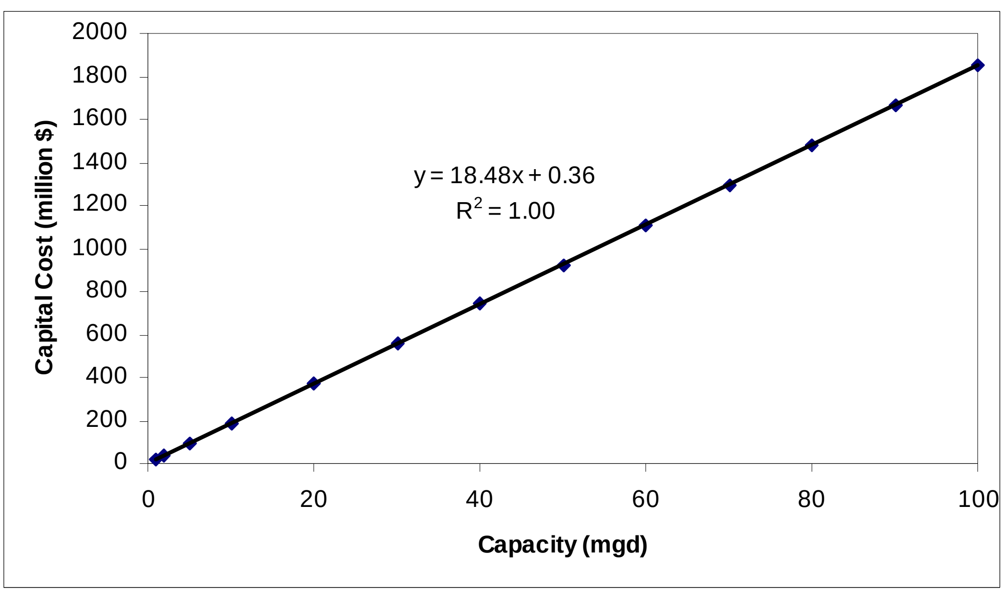


Figure 22. Capital Cost of Land Application (JEA)

Operating Costs

Operation and maintenance (O&M) is an essential part of wastewater management. O&M refers to all activities needed to operate and manage a reclaimed WTF, except for planning and construction of new facilities. O&M costs for pumping stations, pipelines, storage facilities, and RIBs include labor, materials, and equipment replacement. Therefore, the O&M cost considered in the objective function consists of the following components:

O&M Cost = Treatment O&M Cost + Conveyance O&M Cost + Storage O&M Cost + RIBs O&M Cost

To calculate the annual O&M costs for various components assumptions listed in Table 18 were made. Using the estimated capital cost for various components and Table 18, the annual O&M cost functions can be determined. The O&M costs depend upon both the design capacity of the facility, and on the actual capacity used. The present worth factor O&M cost (PWF2) for 20 years was calculated as 12.0.

Table 18. O&M Costs for Various Components as Percentage of the Component Capital Costs

Item	Percentage of the Estimated Component Capital Costs
Conveyance O&M Cost	2.5%
Storage O&M Cost	1.5%
RIBs O&M Cost	1.0%
Land Application O&M Cost*	1.0%

*Land Application O&M Cost assumed to be 3.0% of subtotal construction costs before markups

Development of Hydraulic Equations

The flow of water in the optimization model is governed by the principles of conservation and continuity. As such, the mass of water entering the system must balance the mass of water leaving the system at a given time. These principles are satisfied by the following equation:

$$A_1 u_1 = A_2 u_2 = Q_1 = Q_2$$

where A is the cross-sectional area of the pipe (dimension is length squared, L^2) , u is the velocity of fluid (dimension is length per time, L/T), and Q is the volume flow rate (a.k.a. discharge, dimension is length cubed [volume] per time, L^3/T).

OPTIMIZATION FORMULATION

The optimization function of the LSJR Reuse System model seeks to minimize the total performance cost of implementation for the reclamation system. Performance costs include the cost of penalties, as well as costs associated with constructing, operating, and maintaining the system over its lifetime. The performance cost equation is shown below.

Minimize:

Total Performance Cost = System Performance Penalties (TMDL Load, LSJR Flow) + Potable Water + Financial Performance Costs (Capital, O&M)

Penalties are enforced in terms of monetary loss and contribute to the total performance cost of the system. Penalties are incurred for the following infractions:

- Volume (flow) of wastewater discharged into the St. Johns River exceeds target value
- Total nitrogen load discharged into the St. Johns River exceeds target value
- Reuse of reclaimed water not equal to target (applies to scenarios with reuse target percentages e.g., 60 percent, 75 percent, and 100 percent)
- Over expenditures (applies to fixed cost budget scenario)

The optimization function also accounts for the cost of potable water. Potable water is utilized when reclaimed water supplies are not sufficient to meet reclaimed water demands. Potable water is assumed to cost $2,000/MG (i.e., $2/1,000 gallons, assuming groundwater sources).

The project life cycle cost (LCC) is defined as follows:

*LCC = PWF1 * Capital Cost + PWF2 * 20-years O&M Cost,*

where PWF1 is the present worth factor for the capital cost.

Assuming that the reclaimed water treatment facilities will be built in 2010 and the interest rate and inflation rates will offset each other, PWF1 = 1.0. Both capital and O&M costs are associated with treatment, transmission, and storage components of the reclaimed water system.

CONSTRAINTS

The optimization function must also satisfy various physical constraints of the system in the process of minimizing the performance cost. These constraints include the following:

- Maximum Capacity of RIBs = 52 mgd
- Maximum Capacity of aboveground storage tanks = 20 MG

DECISION VARIABLES

The optimization model alters multiple variables in order to satisfy the optimization function, including the following parameters:

- Reclaimed water production at each WWTP
- Reclaimed water transmission flows (proportions of available and demand)
- Reservoirs, aboveground storage tanks and RIBs

RESULTS

To fulfill the main objective of this project, the CH2M HILL team used the LSJR Reuse System model to conduct optimization modeling. To develop the optimization model, the team first defined system constraints and cost functions as described above. In addition, the existing (2010) and four future feasible alternatives were developed based on the inputs provided by stakeholders for evaluation. The model was then used to determine optimal infrastructure development for each of these alternatives. A description of the system layout established for each alternative is presented below. These results include the location, capacity, and cost of new and expanded pipe segments, pump stations, storage reservoirs, and RIBs for each scenario.

The ability of each alternative to meet project goals effectively was evaluated via several metrics, including volume of water discharged into the St. Johns River (billion gallons [BG]), total nitrogen (TN) load (kg/yr) in the St. Johns River, and potable water offset (mgd). The results produced by the optimization model for each alternative are summarized and the final model project alternatives are evaluated by comparing infrastructure, cost, removal of wastewater flows from the St. Johns River and the offset potable water use associated with each scenario.

BASE CASE CONDITION

The existing system was modeled with 2030 demands and used as the base case for making comparisons. The base case scenario describes the anticipated existing system conditions in the year 2010. Year 2010 was selected because there are facilities being constructed now under the Reuse and Treatment Project that will be operational by then. In this way, alternatives will consist of additional projects not currently planned (or at least not planned well). The existing reclaimed water systems include four WWTPs and two pump stations connected within the CCUA service area, one WWTP in the JEA west service area, as well as three WWTPs in the JEA east service area. A layout of the 2010 reclaimed water system is shown in Figure 23.

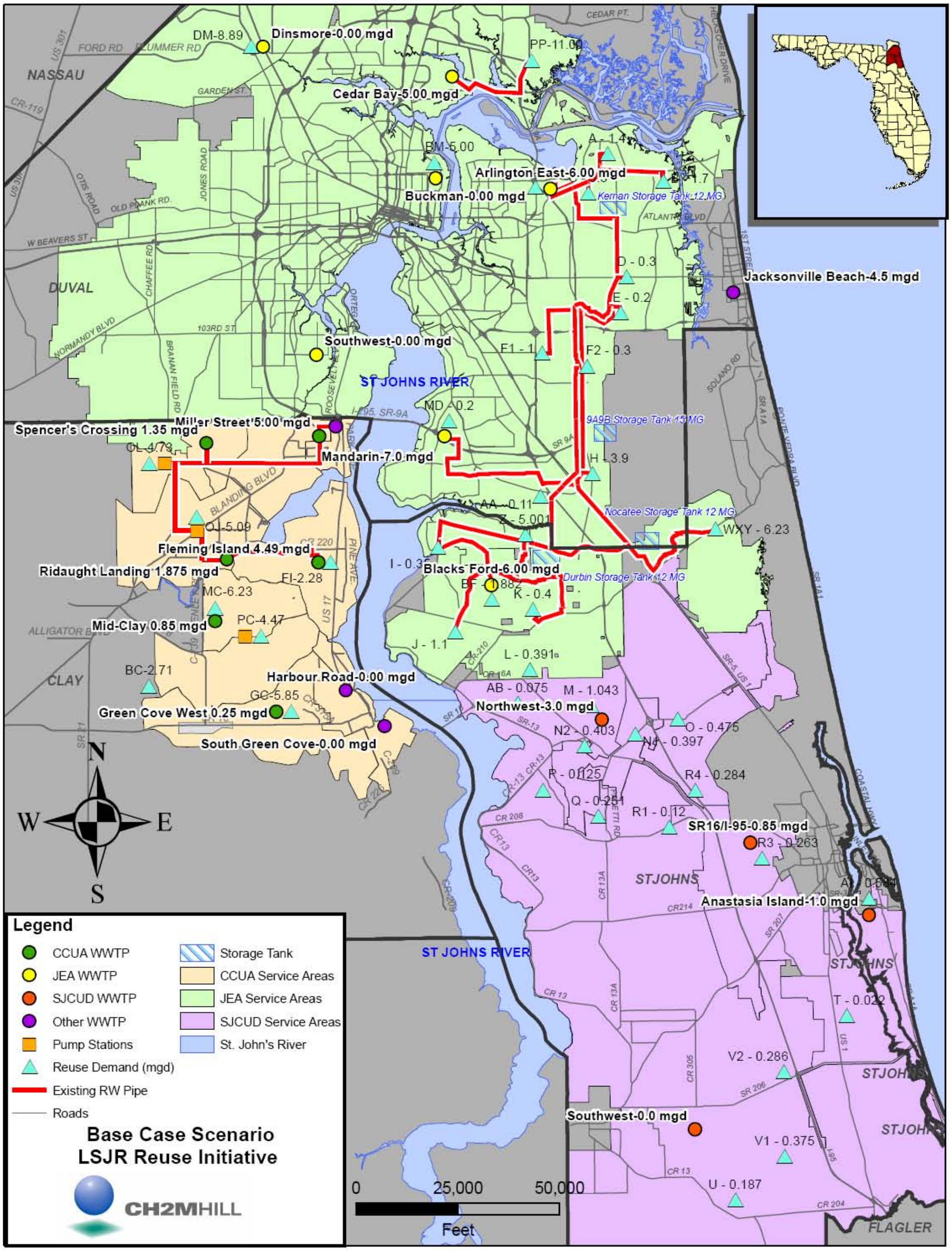


Figure 23. System Layout: Base Case with Existing Conditions of Water Reuse System in 2010

Within the JEA west service area, there is some local non-public access reuse at the Buckman Water Reclamation Facility (WRF) that was included in the analysis by reducing the available wastewater in JEA's flow projections. Most of the existing reclaimed water capacity is limited to 5 mgd at the Cedar Bay WWTP (Table 19). The remaining three WWTPs have no reclaimed water capacity in the base case scenario.

Table 19. 2010 Existing Reclaimed Water Treatment Capacity Summary - JEA West Service Area

Location	Existing Capacity (mgd)
Dinsmore	0 (new DRI just started)
Cedar Bay	5
Buckman	0 (about 2 mgd of local industrial reuse included in flow projections
Southwest	0
Total	**5**

DRI is Development of Regional Impact, a large multi-use development zone.

In contrast, three of the four WWTPs in the JEA east service areas have existing reclaimed water treatment capacity, for a total capacity of 19 mgd (Table 20). In addition, the City of Jacksonville Beach is currently expanding its WWTP. The three beach communities share an outfall. When completed, it was assumed that the combined beaches will have capacity to provide JEA with 4.5 mgd of reclaimed water in addition to meeting its own local demands. However, the Jacksonville Beach WWTP is not currently connected to the JEA system.

Table 20. 2010 Existing Reclaimed Water Treatment Capacity Summary - JEA East Service Area

Location	Existing Capacity (mgd)
Arlington East	6.0
Mandarin	7.0
Blacks Ford	6.0
Beaches	4.5
Total	**23.5**

Six of the Clay County's eight WWTPs have existing reclaimed water treatment capacity (Table 21). The total existing capacity is 13.815 mgd.

Table 21. 2010 Existing Reclaimed Water Treatment Capacity Summary - CCUA Service Area

Location	Existing Capacity (mgd)
Miller Street	5.00
Spencer's Crossing	1.35
Ridaught Landing	1.875
Fleming Island	4.49
Mid-Clay	0.85
Green Cove West	0.25
GC Harbour Road	0.00
Green Cove South	0.00
Total	**13.815**

St. John's County has an existing reclaimed water treatment capacity of 4.85 mgd. The majority of this capacity is at the Northwest WWTP.

Table 22. 2010 Existing Reclaimed Water Treatment Capacity Summary - SJCUD Service Area

Location	Existing Capacity (mgd)
Northwest	3.0
SR16	0.85
Anastasia Island	1.0
Southwest	0.0
Total	**4.85**

On the west side of the LSJR, the existing reclaimed water system includes eight pipe segments totaling 175,500 feet in length (Table 23). All segments have either 16- or 20-inch pipe diameter. One of these pipe segments serves the JEA service area, while the remaining seven serve the CCUA service area.

Table 23. Base Case Scenario: Existing Reclaimed Water Pipe in 2010

Pipe Label	WWTP/Junction Connectivity	Service Area	Length (feet)	Existing Diameter (inches)
C	Cedar Bay – Power Park	JEA	30,300	20
M	Oak Leaf – Spencer's Crossing	CCUA	16,200	16
O	J5 – Miller Street	CCUA	25,500	20
Q	Oak Leaf – Old Jenning's Road	CCUA	28,000	16
S	Old Jenning's Road – J7	CCUA	15,200	16
T	J7 – Ridaught Landing	CCUA	8,000	16
U	Ridaught Landing – Fleming Island	CCUA	32,300	20
AG	Spencer's Crossing – J5	CCUA	20,000	20

The network on the east side of the LSJR is more extensive, due to the well-developed JEA system. The existing reclaimed water system consists of twenty-eight pipe segments totaling 412,000 feet in length (Table 24). Pipe diameters range from 8 to 30 inches. All of these pipes serve the JEA service areas.

Table 24. Base Case Scenario: Existing Reclaimed Water Pipe East of LSJR in 2010

Pipe Label	WWTP/Junction Connectivity	Sub-Service Area	Length (feet)	Existing Diameter (inches)
EA	Delivery to RW Demand Node B	Arlington East	15,391	12
EB	Delivery to RW Demand Node A	Arlington East	3,792	8
EC	Distribution to eastern Arlington East Service Area	Arlington East	5,742	20
ED	Delivery to RW Demand Node C	Arlington East	2,317	8
EE	Distribution to eastern Arlington East Service Area	Arlington East	3,988	20
EF	Conveyance from Arlington East RWTP	Arlington East	7,077	30
EG	Delivery to and bypass through Kernan Boulevard Storage Tank	Arlington East	17,190	16
EH	Conveyance Away from Kernan Boulevard Storage Tank	Arlington East	14,461	16
EI	Conveyance between RW Demand Nodes D and E	Arlington East	9,224	30

Table 24. Base Case Scenario: Existing Reclaimed Water Pipe East of LSJR in 2010

Pipe Label	WWTP/Junction Connectivity	Sub-Service Area	Length (feet)	Existing Diameter (inches)
EJ	Delivery to Demand Node F1	Arlington East	17,846	12
EK	Conveyance through central Arlington East Service Area	Arlington East	12,027	24
EL	Conveyance through central Arlington East Service Area	Arlington East	15,978	30
EM	Delivery to and bypass through 9A/9B Storage area	Arlington East	26,578	30
EN	Conveyance away from Mandarin RWTP	Mandarin	45,783	20
EO	Conveyance toward Nocatee Demand Nodes	Mandarin	19,114	24
EP	Delivery and bypass to Durbin Storage Tank	Mandarin	16,673	20
EQ	Durbin outflow toward Nocatee Demand Nodes	Mandarin	20,250	20
ER	Delivery to Nocatee Storage Tank	Blacks Ford East	32,055	20
ES	Delivery to RW Demand Node I	Blacks Ford West	27,331	12
ET	Conveyance of outflow and bypass from Durbin Storage Tank	Blacks Ford West	6,944	20
EU	Connects pipeline ET to EX	Blacks Ford West	10,653	20
EV	Delivery to RW Demand Node I	Blacks Ford West	17,024	16
EW	Conveyance away from Blacks Ford RWTP Toward SJC service areas	Blacks Ford West	4,761	16
EX	Conveyance from JEA service areas toward Interconnect Storage Reservoir	Blacks Ford West	10,894	12
EY	Delivery to RW Demand Node J	Blacks Ford West	23,557	20
EZ	Delivery to and bypass through Interconnect storage reservoir	Blacks Ford West	8,112	12
EAA	Delivery to RW Demand Node K	Blacks Ford West	12,276	12
EAY	Connects Arlington East service area to Mandarin Service area	Arlington East	4,669	20

Of the 12 WWTPs in the JEA West, CCUA, and other Clay County service areas, seven are expected to have reclaimed water capacity in 2010. These facilities will combine for a total existing reclaimed water capacity of 18.815 mgd in the base case scenario. Of the 8

WWTPs in the JEA East, SCJUD, and Beaches service areas, all but one will have reclaimed water capacity in 2010, for a total of 28.35 mgd. However, the existing reclaimed water distribution network connects the three JEA WWTPs only.

The total existing reclaimed water treatment capacity for the combined east and west reuse systems is 47.165 mgd, which is 51 percent of the 92.9 mgd (annual average) of available 2030 wastewater flows. However, given the existing pipeline network, the 2010 existing system would be able to reuse only 14.4 percent of available 2030 wastewater flows. The remaining four project alternatives propose expansion of this system and their features are compared to these base case conditions.

ALTERNATIVE SCENARIOS

In addition to the base case, four alternative scenarios were developed for evaluation. In one scenario, the water reuse project is constrained by a $300 million budget for total construction costs. This alternative features the most limited overall expansion, with the exception of the base case scenario. Each of the remaining three alternatives is defined not by budget constraints, but by a quantitative reuse target that is given as a percentage of available wastewater flows. The five scenarios are identified as follows:

- Existing Conditions 2010 (Base Case)
- $300 Million in Total Construction Costs
- 60 Percent Reuse of Available Wastewater Flows
- 75 Percent Reuse of Available Wastewater Flows
- 100 Percent Reuse of Available Wastewater Flows

A layout of the proposed future infrastructure alternatives is presented in Figure 24. The optimization model was used to determine which of these potential layouts is best for meeting the constraints and/or target goals of each alternative. The model results associated with each scenario are described in greater detail below.

The RIBs site west of the LSJR as shown in Figure 24 was established at the location of recently purchased SJRWMD lands. This location is near the southwest corner of the study area. It was selected as a placeholder pending further evaluations by others on the suitability of the site and whether it would be a useful location to generate recharge to the aquifer. In general, the Upper Floridan aquifer hydrostatic pressure levels reduce toward the east from a high pressure ridge near Camp Blanding. There are lakes to the south of the study area where there has been public interest in groundwater recharge because their water levels fluctuate greatly. Obviously longer pipelines to the south would raise the project costs. For example, a 30-inch pipeline with about 15 mgd capacity will cost approximately $1 to 1.5 million per mile, plus additional pump station power. The southeast corner of Camp Blanding is approximately 6 miles southeast of the RIB site. Also there are environmental and permitting issues about direct discharge to surface water so land application facilities or man-made wetlands would be required regardless of the final pipeline terminus. Detailed study of the groundwater system to take advantage of reclaimed water available for recharge is beyond the scope of the current project. However, this study does identify the quantity of potential reclaimed water for RIBs.

A FIXED CONSTRUCTION COST TARGET

One proposed alternative to the base case scenario is to expand the system's reclaimed water treatment, delivery, and storage capacities, given a constraint of the project to a total construction cost of approximately $300 million.

With the exception of the base case scenario, this alternative features the most limited overall expansion. West of the LSJR, JEA's Southwest WWTP will neither be expanded to include reclaimed water treatment nor included in the expanded pipe network. CCUA's Miller Street and Fleming Island plants will also not be expanded. Some reclaimed water treatment expansion is required at all of the other west side RWTPs. These projects will more than double the system's total reclaimed water treatment capacity, increasing it from 47.2 mgd to 78.0 mgd. Over 813,000 feet of new pipe will be installed west of the LSJR, while on the east side, 834,000 feet of new pipe will be installed. No reservoirs or RIBs will be installed west of the LSJR for the cost constraint scenario. Two reservoirs and a small land application system will be required east of the LSJR.

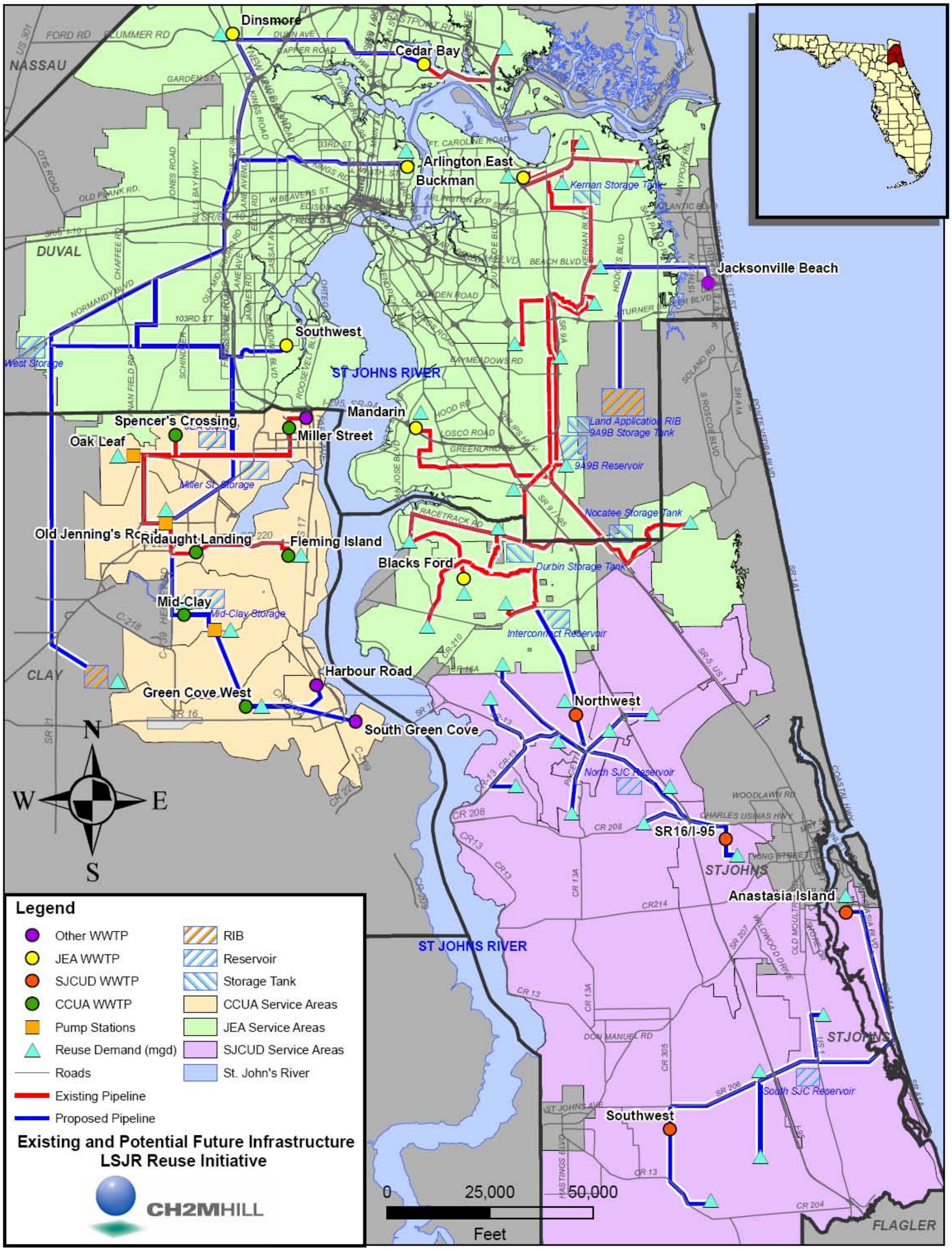


Figure 24. System Layout: Existing System and Proposed Future Infrastructure Development

With this alternative, 3.6 percent of this budget, or just over $10.9 million, would be spent in expanding west side reclaimed water treatment capacity. Upon completion of the project, the Buckman facility will have the largest reclaimed water treatment capacity at 17 mgd. Annual O&M costs for the total treatment capacity are estimated at approximately $0.98 million. (Note: these costs do not consider the PWFs.)

Table 25. 300 Million Construction Expenditure Constraint: Prioritized Reclaimed Water Treatment Project Summary – JEA West and CCUA Service Areas

Location	Existing Capacity (mgd)	Expansion Capacity (mgd)	Final Capacity (mgd)	Capital Cost	Annual O&M Cost
Cedar Bay	5.000	1.000	6.00	$980,700	$16,753
Dinsmore	0.000	1.000	1.00	$980,700	$7,624
Buckman	0.000	17.000	17.00	$3,470,879	$9,193
Southwest	0.000	0.000	0.00	$0	$0
JEA West Total	**5.000**	**19.000**	**24.00**	**$5,432,279**	**$33,569**
Spencers Crossing	1.350	1.650	3.00	$1,226,184	$12,201
Ridaught Landing	1.875	0.125	2.00	$387,854	$8,986
Miller Street	5.000	0.000	5.00	$0	$10,394
Fleming Island	4.490	0.000	4.49	$0	$7,365
Mid Clay	0.850	0.150	1.00	$420,717	$7,624
Green Cove West	0.250	2.750	3.00	$1,540,006	$12,354
South	0.000	1.000	1.0	$980,700	$1,742
Harbour Road	0.000	1.000	1.00	$980,700	$3,788
CCUA Total	**13.815**	**6.675**	**20.49**	**$5,536,162**	**$64,452**
West System Total	**18.815**	**25.675**	**44.49**	**$10,968,440**	**$98,022**

An additional 1.6 percent of the planned budget, $4.7 million, will expand five of the eight east side RWTPs (Table 26). Beaches and SJCUD's Anastasia Island and Northwest facilities will remain unchanged, while expansion at the other plants will provide an additional reclaimed water capacity of 5.15 mgd. The projects will increase the total reclaimed water treatment capacity east of the LSJR to 33.5 mgd. The annual O&M cost of the treatment facilities is estimated at just less than $0.08 million.

Table 26. 300 Million Construction Expenditure Constraint: Prioritized Reclaimed Water Treatment Project Summary – JEA East and SJCUD Service Areas

Location	Existing Capacity (mgd)	Expansion Capacity (mgd)	Final Capacity (mgd)	Capital Cost	Annual O&M Cost

Table 26. 300 Million Construction Expenditure Constraint: Prioritized Reclaimed Water Treatment Project Summary – JEA East and SJCUD Service Areas

Location	Existing Capacity (mgd)	Expansion Capacity (mgd)	Final Capacity (mgd)	Capital Cost	Annual O&M Cost
Arlington East	6.00	1.00	7.00	$980,700	$17,927
Blacks Ford	6.00	1.00	7.00	$980,700	$8,987
Mandarin	7.00	2.00	9.00	$1,336,059	$19,973
Beaches	4.50	0.00	4.50	$0	$12,470
JEA East Total	**23.50**	**4.00**	**27.50**	**$3,297,459**	**$59,357**
Northwest	3.00	0.00	3.00	$0	$5,695
SR16	0.85	0.15	1.00	$420,717	$7,132
Southwest	0.00	1.00	1.00	$980,700	$4,556
Anastasia Island	1.00	0.00	1.00	$0	$6,913
SJC Total	**4.85**	**1.15**	**6.00**	**$1,401,417**	**$24,296**
East System Total	**28.35**	**5.15**	**33.50**	**$4,698,876**	**$83,653**

The $300 million scenario features the most minimal system development of the four expansion alternatives. The system layout for this option is shown in (Figure 25).

Nearly 57 percent of the allotted budget ($170.6 million) will be used to install new pipe segments (Table 27, Table 28). The most extensive installation will connect the Cedar Bay, Dinsmore, and Buckman WWTPs in the JEA west service area. Annual O&M cost for the new pipes on the west side is expected to near $3.2 million. It will be difficult to take a pipeline from the Buckman WRF, through the city and out to the areas of demand. These planning costs need to be carefully reevaluated in the future. Significant expansion is also required to develop SJCUD’s network for its Northwest, SR16, Southwest, and Anastasia Island WWTPs. Annual O&M cost for the new pipes on the east side is expected to slightly exceed $2.9 million.

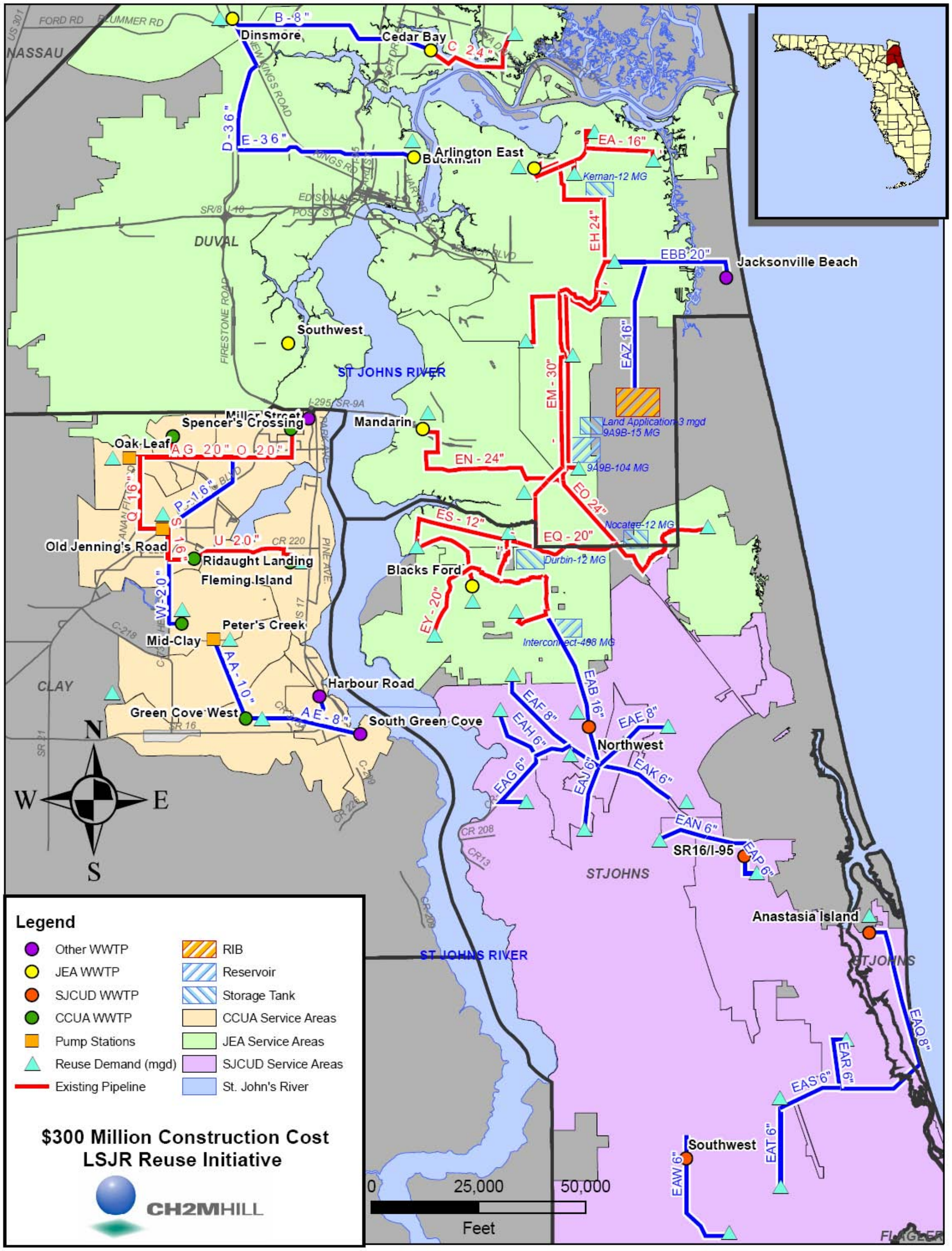


Figure 25. System Layout: $300 Million Construction Expenditure Constraint

Table 27. 300 Million Construction Expenditure Constraint: Prioritized Pipeline Expansion West of the LSJR Project Summary

Service Area	Segment Label	Length (ft)	Existing Diameter (in)	Final Diameter (in)
JEA	A	0	0	36
JEA	B	65,600	0	8
JEA	C	30,300	20	24
JEA	D	44,200	0	36
JEA	E	61,000	0	36
JEA	F	20,000	0	0
JEA	G	30,000	0	0
JEA	H	33,000	0	0
JEA	I	49,600	0	0
JEA	J	12,000	0	0
JEA/CCUA	K	26,300	0	0
JEA West Total		**372,000**		
CCUA	L	115,000	0	0
CCUA	M	16,200	16	16
CCUA	N	0	0	24
CCUA	O	25,500	20	20
CCUA	P	52,000	0	16
CCUA	Q	28,000	16	16
CCUA	R	0	0	16
CCUA	S	15,200	16	16
CCUA	T	8,000	16	20
CCUA	U	32,300	20	20
CCUA	V	0	0	20
CCUA	W	18,000	0	20
CCUA	X	0	0	12
CCUA	Y	11,500	0	0
CCUA	Z	0	0	10
CCUA	AA	28,700	0	10
CCUA	AB	0	0	20
CCUA	AC	11,300	0	12
CCUA	AD	17,500	0	8
CCUA	AE	28,000	0	8
CCUA	AF	14,200	0	0
CCUA	AG	20,000	20	20
CCUA Total		**441,400**		
West Side Total		**813,400**		

Table 28. 300 Million Construction Expenditure Constraint:
Prioritized Pipeline Expansion East of the LSJR Project Summary

Service Area	Segment Label	Length	Existing Diameter (in)	Final Diameter (in)
Arlington East	EA	15,391	12	16
Arlington East	EB	3,792	8	12
Arlington East	EC	5,742	20	24
Arlington East	ED	2,317	8	20
Arlington East	EE	3,988	20	24
Arlington East	EF	7,077	30	30
Arlington East	EG	17,190	16	24
Arlington East	EH	14,461	16	24
Arlington East	EI	9,224	30	30
Arlington East	EJ	17,846	12	12
Arlington East	EK	12,027	24	24
Arlington East	EL	15,978	30	30
Arlington East	EM	26,578	30	30
Arlington East	EAY	4,669	20	24
Arlington East	EAZ	29,912	0	16
Arlington East	EBA	7,281	0	16
Arlington East	EBB	17,000	0	20
Mandarin	EN	45,783	20	24
Mandarin	EO	19,114	24	24
Mandarin	EP	16,673	20	24
Mandarin	EQ	20,250	20	20
Blacks Ford East	ER	32,055	20	24
Blacks Ford West	ES	27,331	12	12
Blacks Ford West	ET	6,944	20	24
Blacks Ford West	EU	10,653	20	24
Blacks Ford West	EV	17,024	16	16
Blacks Ford West	EW	4,761	16	16
Blacks Ford West	EX	10,894	12	24
Blacks Ford West	EY	23,557	20	20
Blacks Ford West	EZ	8,112	12	24
Blacks Ford West	EAA	12,276	12	12
JEA East Total		**465,901**		
North SJC	EAB	28,217	0	16
North SJC	EAC	9,412	0	20

Table 28. 300 Million Construction Expenditure Constraint: Prioritized Pipeline Expansion East of the LSJR Project Summary

Service Area	Segment Label	Length	Existing Diameter (in)	Final Diameter (in)
North SJC	EAD	7,598	0	12
North SJC	EAE	12,225	0	8
North SJC	EAF	21,600	0	8
North SJC	EAG	19,969	0	6
North SJC	EAH	13,746	0	6
North SJC	EAI	8,959	0	6
North SJC	EAJ	15,839	0	6
North SJC	EAK	19,816	0	6
North SJC	EAL	12,682	0	0
North SJC	EAM	12,394	0	6
North SJC	EAN	12,040	0	6
North SJC	EAO	0	0	0
North SJC	EAP	6,629	0	6
North SJC	EAX	7,936	0	12
South SJC	EAQ	56,520	0	8
South SJC	EAR	14,616	0	6
South SJC	EAS	15,186	0	6
South SJC	EAT	19,103	0	6
South SJC	EAU	23,152	0	0
South SJC	EAV	0	0	0
South SJC	EAW	30,491	0	6
SJCUD Total		**368,130**		
East Side Total		**834,031**		

Two new storage reservoirs will be installed east of the LSJR (Table 29). The first will supplement the existing 15 MG storage tank at the 9A/9B location, for a total storage capacity of 116 MG. Another new reservoir with a total storage capacity of 408 MG will be installed at the JEA/SJCUD Interconnect location. The capital costs of these reservoirs are $11.4 and $33.1 million respectively, or nearly 14.8 percent of the total construction budget.

Table 29. 300 Million Construction Expenditure Constraint: Prioritized New Storage Project Summary

Storage Location	Existing Capacity (MG)	Final Capacity (MG)	Type	Capital Cost	Annual O&M Cost
Kernan Blvds	12	12	Storage Tank	0.0	$69,830
9A/9B	15	116	Ground Reservoir	$11,430,011	$314,330
Nocatee	12	12	Storage Tank	$0	$69,830
Durbin	12	12	Storage Tank	$0	$69,830
JEA East Total	**51**	**152**		**$11,430,011**	**$523,820**
Interconnect	0	408	Ground Reservoir	$33,110,494	$662,210
North SJC	0	0	Storage Tank	$0	$0
South SJC	0	0	Storage Tank	$0	$0
SJCUD Total	**0**	**408**		**$33,110,494**	**$662,210**
JEA Storage	0	0	Ground Reservoir	$0	$0
JEA West Total	**0**	**0.0**		**$0**	**$0**
West Storage	0	0		$0	$0
MS Storage	0	0	Ground Reservoir	$0	$0
Mid Clay Storage	0	0	Ground Reservoir	$0	$0
CCUA Total	**0**	**0**		**$0**	**$0**
System Total	**51**	**560**		**$44,540,505**	**$1,186,030**

Lastly, a 3 mgd land application facility will be installed east of the LSJR (Table 30). Its capital cost will be $52.8 million, or 17.6% of the total construction budget.

Table 30. 300 Million Construction Expenditure Constraint: Prioritized New RIBs Project Summary – Combined East and West Sides

Storage Location	Capacity (mgd)	Capital Cost	Annual O&M Cost
West Side	0	$0	$0
East Side	3	$52,800,770	$528,008

Sixty Percent Reuse

Each of the remaining three expansion alternatives is defined by a quantitative reuse target that is given as a percentage of available wastewater flows. This scenario aims to reuse 60 percent of available wastewater flows. That is, a total of 60 percent of the average annual volume of wastewater discharges into the St. Johns River would be reduced through more reclaimed water use.

The total capital cost of this scenario is $479.9 million. This project will add 52.8 mgd to the system's total reclaimed water treatment capacity, increasing it from 47.2 mgd to 100 mgd. Over 813,000 feet of new pipe will be installed west of the LSJR, while on the east side, 834,000 feet of new pipe will be installed. In addition, four new storage reservoirs are required, and RIBs will be installed both east and west of the LSJR.

To achieve the goal of 60 percent reuse, nine of the twelve WWTPs west of the LSJR will need to be expanded (Table 31). The expansion of these facilities will cost an estimated $15.2 million. Only CCUA's Miller Street and Fleming Island plants and the Harbour Road plant will not be expanded. Upon completion of the project, the Buckman WRF will have the largest reclaimed water capacity at 11 mgd, with JEA's Cedar Bay, Dinsmore, and Southwest plants close behind at 7 mgd each. This project will generate an additional 36.7 mgd of capacity, resulting in a total reclaimed water treatment capacity of 55.5 mgd among JEA west facilities. The total annual O&M cost for JEA reclaimed water treatment is approximately $0.14 million.

Table 31. 60 Percent Reuse of Available Wastewater Target: Prioritized Reclaimed Water Treatment Project Summary – JEA West and CCUA Service Areas

Location	Existing Capacity (mgd)	Expansion Capacity (mgd)	Final Capacity (mgd)	Capital Cost	Annual O&M Cost
Cedar Bay	5.00	2.00	7.00	$1,336,059	$16,983
Dinsmore	0.00	7.00	7.00	$2,336,331	$17,360
Buckman	0.00	11.00	11.00	$2,858,258	$21,480
Southwest	0.00	7.00	7.00	$2,336,331	$17,927
JEA West Total	**5.00**	**27.00**	**32.00**	**$8,866,980**	**$73,749**
Spencers Crossing	1.35	0.65	2.00	$809,239	$10,338
Ridaught Landing	1.88	1.13	3.00	$1,033,607	$8,815
Miller Street	5.00	0.00	5.00	$0	$10,394
Fleming Island	4.49	0.00	4.49	$0	$7,472
Mid Clay	0.85	2.15	3.00	$1,379,866	$12,354
Green Cove West	0.25	2.75	3.00	$1,540,006	$12,354
South	0.00	3.00	3.00	$1,600,958	$9,399
Harbour Road	0.00	0.00	0.00	$0	$0
CCUA Total	**13.82**	**9.68**	**23.49**	**$6,363,676**	**$71,125**
West System Total	**18.82**	**36.68**	**55.49**	**$15,230,656**	**$144,875**

Similarly, $8.0 million will go toward expansion of six of the eight east side WWTPs (Table 32). The Beaches and Southwest facilities will remain unchanged, while the largest expansion will occur at the Arlington East plant. The total east side expansion will exceed 16 mgd, and total expanded reclaimed water treatment capacity will be 44.5 mgd. The total annual O&M cost of the treatment facilities will be about $0.07 million.

Table 32. 60 Percent Reuse of Available Wastewater Target: Prioritized Reclaimed Water Treatment Project Summary – JEA East and SJCUD Service Areas

Location	Existing Capacity (mgd)	Expansion Capacity (mgd)	Final Capacity (mgd)	Capital Cost	Annual O&M Cost
Arlington East	6.00	8.00	14.00	$2,479,731	$17,366
Blacks Ford	6.00	4.00	10.00	$1,820,183	$14,667
Mandarin	7.00	2.00	9.00	$1,336,059	$15,290
Beaches	4.50	0.00	4.50	$0	$12,470
JEA East Total	**23.50**	**14.00**	**37.50**	**$5,635,974**	**$59,792**
Northwest	3.00	1.00	4.00	$980,700	$8,499
SR16	0.85	0.15	1.00	$420,717	$829
Southwest	0.00	0.00	0.00	$0	$0
Anastasia Island	1.00	1.00	2.00	$980,700	$3,401
SJC Total	**4.85**	**2.15**	**7.00**	**$2,382,117**	**$12,729**
East System Total	**28.35**	**16.15**	**44.50**	**$8,018,091**	**$72,521**

The system layout for the 60 percent reuse scenario is shown in (Figure 26).

New pipe segments are proposed at a cost of $314 million. The longest segment (115,000 feet) will connect the junction at the proposed West Reservoir location to the Black Creek RIBs on the west side of the LSJR. Additional lengthy segments will connect the Cedar Bay, Dinsmore, and Buckman WWTPs in the JEA service area, as well as the SCJUD plants east of the LSJR. The pipes range in diameter from 6 inches to 42 inches. The total annual O&M cost for the new pipe is expected to be $9.5 million.

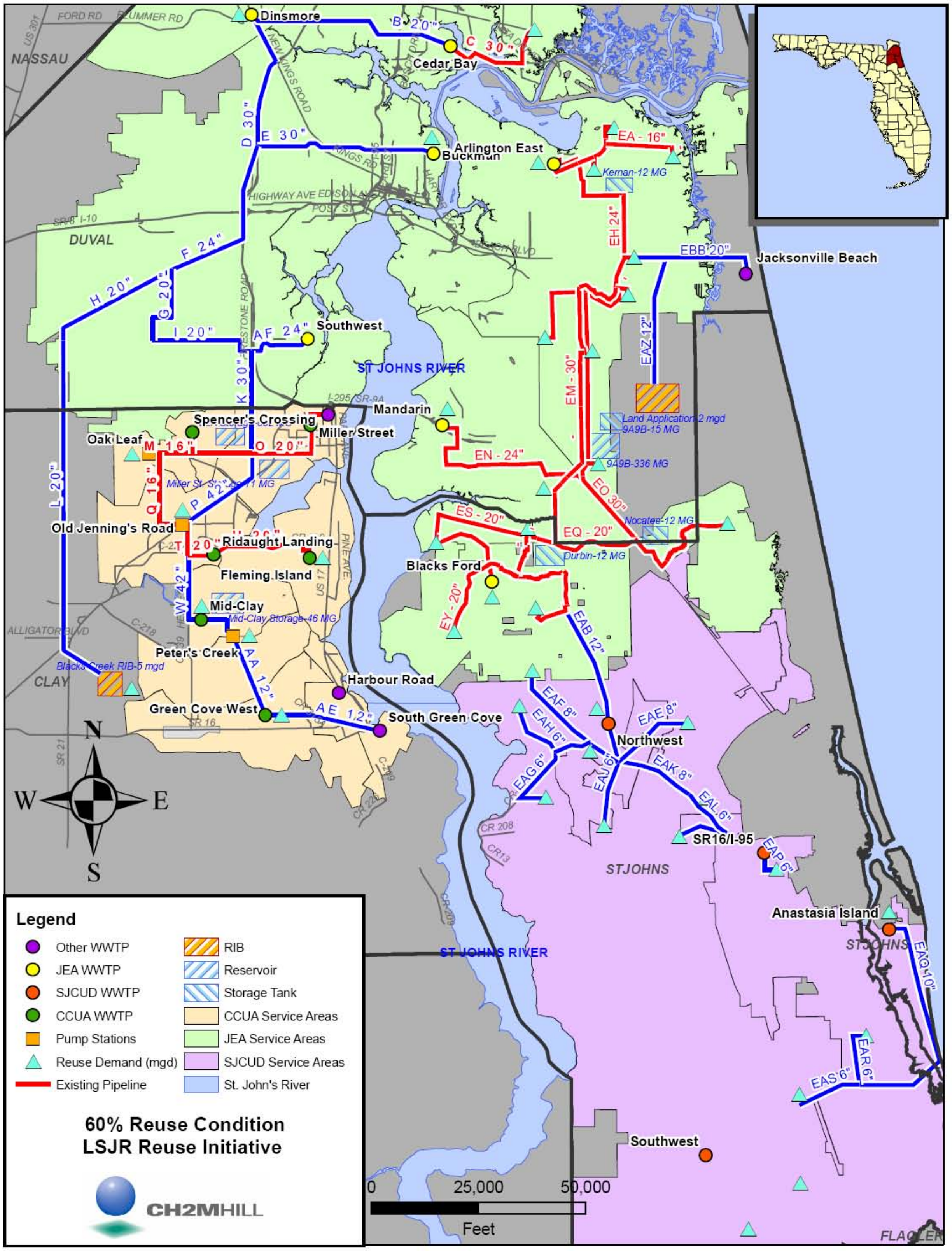


Figure 26. System Layout: 60 Percent Wastewater Reuse Target

Table 33. 60 Percent Reuse of Available Wastewater Target: Prioritized Pipeline Expansion West of the LSJR Project Summary

Service Area	Segmen t Label	Length (ft)	Existing Diameter (in)	Final Diameter (in)
JEA	A	0	0	30
JEA	B	65,600	0	20
JEA	C	30,300	20	30
JEA	D	44,200	0	30
JEA	E	61,000	0	30
JEA	F	20,000	0	24
JEA	G	30,000	0	20
JEA	H	33,000	0	20
JEA	I	49,600	0	20
JEA	J	12,000	0	0
JEA/CCUA	K	26,300	0	30
JEA West Total		**372,000**		
CCUA	L	115,000	0	20
CCUA	M	16,200	16	16
CCUA	N	0	0	24
CCUA	O	25,500	20	20
CCUA	P	52,000	0	42
CCUA	Q	28,000	16	16
CCUA	R	0	0	24
CCUA	S	15,200	16	36
CCUA	T	8,000	16	20
CCUA	U	32,300	20	20
CCUA	V	0	0	20
CCUA	W	18,000	0	42
CCUA	X	0	0	30
CCUA	Y	11,500	0	16
CCUA	Z	0	0	16
CCUA	AA	28,700	0	12
CCUA	AB	0	0	24
CCUA	AC	11,300	0	12
CCUA	AD	17,500	0	0
CCUA	AE	28,000	0	12
CCUA	AF	14,200	0	24
CCUA	AG	20,000	20	24
CCUA Total		**441,400**		
West Side Total		**813,400**		

Table 34. 60 Percent Reuse of Available Wastewater Target: Prioritized Pipeline Expansion East of the LSJR Project Summary

Service Area	Segment Label	Length	Existing Diameter (in)	Final Diameter (in)
Arlington East	EA	15,391	12	16
Arlington East	EB	3,792	8	12
Arlington East	EC	5,742	20	24
Arlington East	ED	2,317	8	20
Arlington East	EE	3,988	20	24
Arlington East	EF	7,077	30	30
Arlington East	EG	17,190	16	24
Arlington East	EH	14,461	16	24
Arlington East	EI	9,224	30	30
Arlington East	EJ	17,846	12	12
Arlington East	EK	12,027	24	30
Arlington East	EL	15,978	30	30
Arlington East	EM	26,578	30	30
Arlington East	EAY	4,669	20	30
Arlington East	EAZ	29,912	0	12
Arlington East	EBA	7,281	0	16
Arlington East	EBB	17,000	0	20
Mandarin	EN	45,783	20	24
Mandarin	EO	19,114	24	30
Mandarin	EP	16,673	20	24
Mandarin	EQ	20,250	20	20
Blacks Ford East	ER	32,055	20	30
Blacks Ford West	ES	27,331	12	20
Blacks Ford West	ET	6,944	20	24
Blacks Ford West	EU	10,653	20	20
Blacks Ford West	EV	17,024	16	24
Blacks Ford West	EW	4,761	16	16
Blacks Ford West	EX	10,894	12	12
Blacks Ford West	EY	23,557	20	20
Blacks Ford West	EZ	8,112	12	12
Blacks Ford West	EAA	12,276	12	12
JEA East Total		465,901		
North SJC	EAB	28,217	0	12

Table 34. 60 Percent Reuse of Available Wastewater Target: Prioritized Pipeline Expansion East of the LSJR Project Summary

Service Area	Segment Label	Length	Existing Diameter (in)	Final Diameter (in)
North SJC	EAC	9,412	0	24
North SJC	EAD	7,598	0	12
North SJC	EAE	12,225	0	8
North SJC	EAF	21,600	0	8
North SJC	EAG	19,969	0	6
North SJC	EAH	13,746	0	6
North SJC	EAI	8,959	0	6
North SJC	EAJ	15,839	0	6
North SJC	EAK	19,816	0	8
North SJC	EAL	12,682	0	6
North SJC	EAM	12,394	0	0
North SJC	EAN	12,040	0	6
North SJC	EAO	0	0	0
North SJC	EAP	6,629	0	6
North SJC	EAX	7,936	0	16
South SJC	EAQ	56,520	0	10
South SJC	EAR	14,616	0	6
South SJC	EAS	15,186	0	6
South SJC	EAT	19,103	0	0
South SJC	EAU	23,152	0	0
South SJC	EAV	0	0	0
South SJC	EAW	30,491	0	0
SJCUD Total		368,130		
East Side Total		834,031		

Two new storage reservoirs will be installed at CCUA's Miller Street and Mid Clay locations having respective capacities of 71 MG and 46 MG (Table 35). A larger reservoir with a capacity of 852 MG will be installed at the JEA / CCUA interconnect location. A fourth reservoir will be installed east of the LSJR at JEA's 9A / 9B location for a total storage capacity of 351 MG (this includes the 15 MG existing storage tank). The capital cost of these reservoirs is $67.6 million.

Table 35. 60 Percent Reuse of Available Wastewater Target: Prioritized New Storage Project Summary

Storage Location	Existing Capacity (MG)	Final Capacity (MG)	Type	Capital Cost	Annual O&M Cost
Kernan Blvds	12	12	Storage Tank	$0	$69,830
9A/9B	15	351	Ground Reservoir	$28,035,890	$646,448
Nocatee	12	12	Storage Tank	$0	$69,830
Durbin	12	12	Storage Tank	$0	$69,830
JEA East Total	**51**	**363**		**$28,035,890**	**$855,938**
Interconnect	0	0		$0	$0
North SJC	0	0		$0	$0
South SJC	0	0		$0	$0
SJCUD Total	**0**	**0**		**$0**	**$0**
JEA Storage	0	852	Ground Reservoir	$26,940,780	$538,816
JEA West Total	**0**	**852**		**$26,940,780**	**$538,816**
West Storage	0	0		$0	$0
MS Storage	0	71	Ground Reservoir	$6,635,374	$132,707
Mid Clay Storage	0	46	Ground Reservoir	$5,994,231	$119,885
CCUA Total	**0**	**117**		**$12,629,605**	**$252,592**
System Total	**51**	**1331**		**$67,606,275**	**$1,647,346**

In addition, a rapid infiltration basin system is to be installed at the proposed Black Creek site (Table 36). The RIB will cost $25.5 million and have a capacity of 5 mgd. Similarly, a 2 mgd land application site will be established east of the LSJR.

Table 36. 60 Percent Reuse of Available Wastewater Target: Prioritized New RIBs Project Summary – Combined East and West Sides

Storage Location	Capacity (mgd)	Capital Cost	Annual O&M Cost
West Side	5	$25,481,199	$254,812
East Side	2	$44,846,482	$448,465

SEVENTY-FIVE PERCENT REUSE

One proposed alternative to the base case scenario is to expand the system's reclaimed water treatment, delivery, and storage capacity, to reach the target goal of 75 percent reuse of available wastewater flows. The capital cost of this scenario totals $729.8 million. This project will expand the system's total reclaimed water treatment capacity, from 47.2 mgd to 117 mgd. In addition, four new storage reservoirs, an RIB facility, and a land application system will be installed.

To achieve the goal of 75 percent reuse, ten of the twelve WWTPs west of the LSJR will need to be expanded (Table 37). The expansion of these facilities will cost an estimated $17.8 million. Only CCUA's Miller Street and Fleming Island plants will not be expanded. Upon completion of the project, the Buckman WRF will have the largest reclaimed water capacity at 19 mgd, with JEA's Southwest plant close behind at 17 mgd. This project will generate an additional 53.7 mgd of capacity, resulting in a total reclaimed water treatment capacity of 72.5 mgd among JEA west facilities. The total annual O&M cost for reclaimed water treatment west of the LSJR River is approximately $0.16 million.

Table 37. 75 Percent Reuse of Available Wastewater Target: Prioritized Reclaimed Water Treatment Project Summary – JEA West and CCUA Service Areas

Location	Existing Capacity (mgd)	Expansion Capacity (mgd)	Final Capacity (mgd)	Capital Cost	Annual O&M Cost
Cedar Bay	5.00	2.00	7.00	$1,336,059	$16,983
Dinsmore	0.00	5.00	5.00	$2,010,697	$15,084
Buckman	0.00	19.00	19.00	$3,647,440	$27,772
Southwest	0.00	17.00	17.00	$3,470,879	$24,284
JEA West Total	**5.00**	**43.00**	**48.00**	**$10,465,075**	**$84,124**
Spencers Crossing	1.35	0.65	2.00	$809,239	$10,338
Ridaught Landing	1.88	1.13	3.00	$1,033,607	$8,815
Miller Street	5.00	0.00	5.00	$0	$10,394
Fleming Island	4.49	0.00	4.49	$0	$7,479
Mid Clay	0.85	2.15	3.00	$1,379,866	$11,861
Green Cove West	0.25	2.75	3.00	$1,540,006	$12,283
South	0.00	3.00	3.00	$1,600,958	$9,436
Harbour Road	0.00	1.00	1.00	$980,700	$5,719
CCUA Total	**13.82**	**10.68**	**24.49**	**$7,344,376**	**$76,324**
West System Total	**18.82**	**53.68**	**72.49**	**$17,809,451**	**$160,447**

Similarly, $8.0 million will go toward expansion of six of the eight east side WWTPs (Table 32). The Beaches and Southwest facilities will remain unchanged, while the largest expansion will occur at the Arlington East plant. The total east side expansion will exceed 16 mgd, and total expanded reclaimed water treatment capacity will be 44.5 mgd. The total annual O&M cost of the treatment facilities will be about $0.07 million.

Table 38. 75 Percent Reuse of Available Wastewater Target: Prioritized Reclaimed Water Treatment Project Summary – JEA East and SJCUD Service Areas

Location	Existing Capacity (mgd)	Expansion Capacity (mgd)	Final Capacity (mgd)	Capital Cost	Annual O&M Cost
Arlington East	6.00	9.00	15.00	$2,613,508	$23,966
Blacks Ford	6.00	2.00	8.00	$1,336,059	$15,040
Mandarin	7.00	2.00	9.00	$1,336,059	$15,390
Beaches	4.50	0.00	4.50	$0	$1,711
JEA East Total	**23.50**	**13.00**	**36.50**	**$5,285,626**	**$56,106**
Northwest	3.00	2.00	5.00	$1,336,059	$7,812
SR16	0.85	0.15	1.00	$420,717	$888
Southwest	0.00	0.00	0.00	$0	$0
Anastasia Island	1.00	1.00	2.00	$980,700	$2,817
SJC Total	**4.85**	**3.15**	**8.00**	**$2,737,476**	**$11,516**
East System Total	**28.35**	**16.15**	**44.50**	**$8,023,102**	**$67,622**

The system layout for the 75 percent reuse scenario is shown in (Figure 27).

New pipe segments are proposed at a cost of $404.4 million. The longest segment (115,000 feet) will connect the junction at the proposed West Reservoir location to the Black Creek RIBs on the west side of the LSJR. Additional lengthy segments will connect the Cedar Bay, Dinsmore, and Buckman WWTPs in the JEA service area, as well as the SCJUD plants east of the LSJR. The pipes range in diameter from 6 inches to 42 inches. The total annual O&M cost for the new pipe is expected to be $11.7 million.

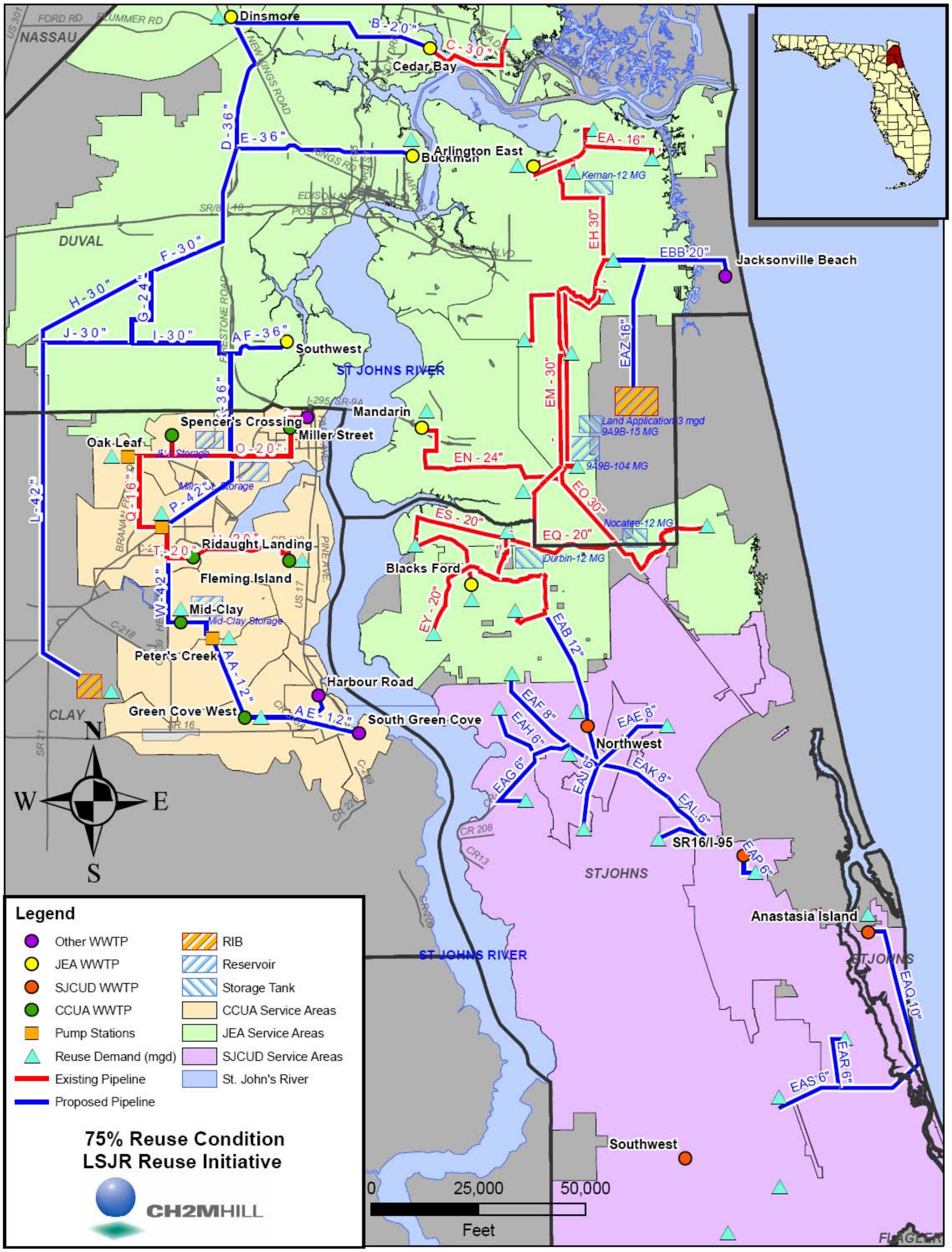


Figure 27. System Layout: 75 Percent Wastewater Reuse Target

Table 39. 75 Percent Reuse of Available Wastewater Target: Prioritized Pipeline Expansion West of the LSJR Project Summary

Service Area	Segment Label	Length (ft)	Existing Diameter (in)	Final Diameter (in)
JEA	A	0	0	36
JEA	B	65,600	0	20
JEA	C	30,300	20	30
JEA	D	44,200	0	36
JEA	E	61,000	0	36
JEA	F	20,000	0	30
JEA	G	30,000	0	24
JEA	H	33,000	0	30
JEA	I	49,600	0	30
JEA	J	12,000	0	30
JEA/CCUA	K	26,300	0	36
JEA West Total		**372,000**		
CCUA	L	115,000	0	42
CCUA	M	16,200	16	16
CCUA	N	0	0	24
CCUA	O	25,500	20	20
CCUA	P	52,000	0	42
CCUA	Q	28,000	16	16
CCUA	R	0	0	24
CCUA	S	15,200	16	36
CCUA	T	8,000	16	20
CCUA	U	32,300	20	20
CCUA	V	0	0	20
CCUA	W	18,000	0	42
CCUA	X	0	0	30
CCUA	Y	11,500	0	16
CCUA	Z	0	0	16
CCUA	AA	28,700	0	12
CCUA	AB	0	0	24
CCUA	AC	11,300	0	16
CCUA	AD	17,500	0	8
CCUA	AE	28,000	0	12
CCUA	AF	14,200	0	36
CCUA	AG	20,000	20	24
CCUA Total		**441,400**		
West Side Total		**813,400**		

Table 40. 75 Percent Reuse of Available Wastewater Target: Prioritized Pipeline Expansion East of the LSJR Project Summary

Service Area	Segment Label	Length	Existing Diameter (in)	Final Diameter (in)
Arlington East	EA	15,391	12	16
Arlington East	EB	3,792	8	12
Arlington East	EC	5,742	20	24
Arlington East	ED	2,317	8	20
Arlington East	EE	3,988	20	24
Arlington East	EF	7,077	30	30
Arlington East	EG	17,190	16	30
Arlington East	EH	14,461	16	30
Arlington East	EI	9,224	30	30
Arlington East	EJ	17,846	12	12
Arlington East	EK	12,027	24	30
Arlington East	EL	15,978	30	30
Arlington East	EM	26,578	30	30
Arlington East	EAY	4,669	20	30
Arlington East	EAZ	29,912	0	16
Arlington East	EBA	7,281	0	16
Arlington East	EBB	17,000	0	20
Mandarin	EN	45,783	20	24
Mandarin	EO	19,114	24	30
Mandarin	EP	16,673	20	24
Mandarin	EQ	20,250	20	20
Blacks Ford East	ER	32,055	20	30
Blacks Ford West	ES	27,331	12	20
Blacks Ford West	ET	6,944	20	24
Blacks Ford West	EU	10,653	20	20
Blacks Ford West	EV	17,024	16	20
Blacks Ford West	EW	4,761	16	16

Table 40. 75 Percent Reuse of Available Wastewater Target: Prioritized Pipeline Expansion East of the LSJR Project Summary

Service Area	Segment Label	Length	Existing Diameter (in)	Final Diameter (in)
Blacks Ford West	EX	10,894	12	12
Blacks Ford West	EY	23,557	20	20
Blacks Ford West	EZ	8,112	12	12
Blacks Ford West	EAA	12,276	12	12
JEA East Total		**465,901**		
North SJC	EAB	28,217	0	12
North SJC	EAC	9,412	0	24
North SJC	EAD	7,598	0	12
North SJC	EAE	12,225	0	8
North SJC	EAF	21,600	0	8
North SJC	EAG	19,969	0	6
North SJC	EAH	13,746	0	6
North SJC	EAI	8,959	0	6
North SJC	EAJ	15,839	0	6
North SJC	EAK	19,816	0	8
North SJC	EAL	12,682	0	6
North SJC	EAM	12,394	0	0
North SJC	EAN	12,040	0	6
North SJC	EAO	0	0	0
North SJC	EAP	6,629	0	6
North SJC	EAX	7,936	0	16
South SJC	EAQ	56,520	0	10
South SJC	EAR	14,616	0	6
South SJC	EAS	15,186	0	6
South SJC	EAT	19,103	0	0
South SJC	EAU	23,152	0	0
South SJC	EAV	0	0	0
South SJC	EAW	30,491	0	0
SJCUD Total		**368,130**		
East Side Total		**834,031**		

Two new storage reservoirs will be installed at CCUA's Miller Street and Mid Clay locations having respective capacities of 73 MG and 34 MG (Table 41). A larger reservoir with a capacity of 552 MG will be installed at the JEA / CCUA interconnect location. A fourth reservoir will be installed east of the LSJR at JEA's 9A / 9B location for a total storage capacity of 497 MG (this includes the 15 MG existing storage tank). The capital cost of these reservoirs is $69.9 million.

Table 41. 75 Percent Reuse of Available Wastewater Target: Prioritized New Storage Project Summary

Storage Location	Existing Capacity (MG)	Final Capacity (MG)	Type	Capital Cost	Annual O&M Cost
Kernan Blvds	12	12	Storage Tank	0.0	$69,830
9A/9B	15	497	Ground Reservoir	$38,339,936	$852,529
Nocatee	12	12	Storage Tank	$0	$69,830
Durbin	12	12	Storage Tank	$0	$69,830
JEA East Total	**51**	**529**		**$38,339,936**	**$1,062,019**
Interconnect	0	0		$0	$0
North SJC	0	0		$0	$0
South SJC	0	0		$0	$0
SJCUD Total	**0**	**0**		**$0**	**$0**
JEA Storage	0	552	Ground Reservoir	$19,156,645	$383,133
JEA West Total	**0**	**552**		**$19,156,645**	**$383,133**
West Storage	0	0		$0	$0
MS Storage	0	73	Ground Reservoir	$6,699,667	$133,993
Mid Clay Storage	0	34	Ground Reservoir	$5,682,656	$113,653
CCUA Total	**0**	**107**		**$12,382,323**	**$247,646**
System Total	**51.0**	**1188**		**$69,878,904**	**$1,692,798**

In addition, a rapid infiltration basin system is to be installed at the proposed Black Creek site (Table 42). The RIBs will cost $147.1 million and have a capacity of 27 mgd. Similarly, a land application system will be installed east of the LSJR. The land application capacity will be 4 mgd, and have a cost of $76.2 million.

Table 42. 75 Percent Reuse of Available Wastewater Target: Prioritized New RIBs Project Summary – Combined East and West Sides

Storage Location	Capacity (mgd)	Capital Cost	Annual O&M Cost
West Side	27	$147,058,090	$1,470,581
East Side	4	$76,248,598	$762,486

ONE HUNDRED PERCENT REUSE

One proposed alternative to the base case scenario is to expand the reuse system's reclaimed water treatment, delivery, and storage capacity, to reach the target goal of 100 percent reuse of available wastewater flows. The total capital cost of this scenario will be approximately $1,242 million. This project will increase the system's total reclaimed water capacity from 47.2 mgd to 157 mgd. In addition, two new storage reservoirs, an RIB facility, and a land application system will be installed.

To achieve the goal of 100 percent reuse, ten of the twelve WWTPs west of the LSJR will need to be expanded (Table 43). The expansion of these facilities will cost an estimated $21.1 million. Only CCUA's Miller Street and Fleming Island plants will not be expanded. Upon completion of the project, the Buckman WRF will have the largest reclaimed water capacity at 40 mgd, with JEA's Southwest plant next at 17 mgd. This project will generate an additional 82.7 mgd of capacity, resulting in a total reclaimed water treatment capacity of 101.5 mgd among JEA west facilities. The total annual O&M cost for reclaimed water treatment west of the LSJR River is approximately $0.16 million.

Table 43. 100 Percent Reuse of Available Wastewater Target: Prioritized Reclaimed Water Treatment Project Summary – JEA West and CCUA Service Areas

Location	Existing Capacity (mgd)	Expansion Capacity (mgd)	Final Capacity (mgd)	Capital Cost	Annual O&M Cost
Cedar Bay	5.000	2.00	7.00	$1,336,059	$16,983
Dinsmore	0.000	8.00	8.00	$2,479,731	$17,707
Buckman	0.000	40.00	40.00	$5,084,112	$33,862
Southwest	0.000	17.00	17.00	$3,470,879	$24,284
JEA West Total	**5.000**	**67.00**	**72.00**	**$12,370,781**	**$92,837**
Spencers Crossing	1.350	2.65	4.00	$1,514,768	$7,461
Ridaught Landing	1.875	1.13	3.00	$1,033,607	$8,607
Miller Street	5.000	0.00	5.00	$0	$10,368
Fleming Island	4.490	0.00	4.49	$0	$7,403
Mid Clay	0.850	3.15	4.00	$1,636,185	$6,600
Green Cove West	0.250	4.75	5.00	$1,965,211	$12,700

Table 43. 100 Percent Reuse of Available Wastewater Target: Prioritized Reclaimed Water Treatment Project Summary – JEA West and CCUA Service Areas

Location	Existing Capacity (mgd)	Expansion Capacity (mgd)	Final Capacity (mgd)	Capital Cost	Annual O&M Cost
South	0.000	3.00	3.00	$1,600,958	$10,183
Harbour Road	0.000	1.00	1.00	$980,700	$5,719
CCUA Total	**13.815**	**15.68**	**29.49**	**$8,731,429**	**$69,041**
West System Total	**18.815**	**82.68**	**101.49**	**$21,102,211**	**$161,877**

Similarly, $9.7 million will go toward expansion of six of the eight east side WWTPs (Table 44). The Beaches and Southwest facilities will remain unchanged, while the largest expansion will occur at the Arlington East plant. The total east side expansion will exceed 27 mgd, and total expanded reclaimed water treatment capacity will be 55.5 mgd. The total annual O&M cost of the treatment facilities will be about $0.08 million.

Table 44. 100 Percent Reuse of Available Wastewater Target: Prioritized Reclaimed Water Treatment Project Summary – JEA East and SJCUD Service Areas

Location	Existing Capacity (mgd)	Expansion Capacity (mgd)	Final Capacity (mgd)	Capital Cost	Annual O&M Cost
Arlington East	6.00	16.00	22.00	$3,378,268	$28,471
Blacks Ford	6.00	5.00	11.00	$2,010,697	$17,653
Mandarin	7.00	3.00	10.00	$1,600,958	$13,553
Beaches	4.50	0.00	4.50	$0	$8,798
JEA East Total	**23.50**	**24.00**	**47.50**	**$6,989,923**	**$68,475**
Northwest	3.00	1.00	4.00	$980,700	$5,578
SR16	0.85	0.15	1.00	$420,717	$557
Southwest	0.00	0.00	0.00	$0	$0
Anastasia Island	1.00	2.00	3.00	$1,336,059	$5,054
SJC Total	**4.85**	**3.15**	**8.00**	**$2,737,476**	**$11,188**
East System Total	**28.350**	**27.15**	**55.50**	**$9,727,400**	**$79,663**

The system layout for the 100 percent reuse scenario is shown in (Figure 28).

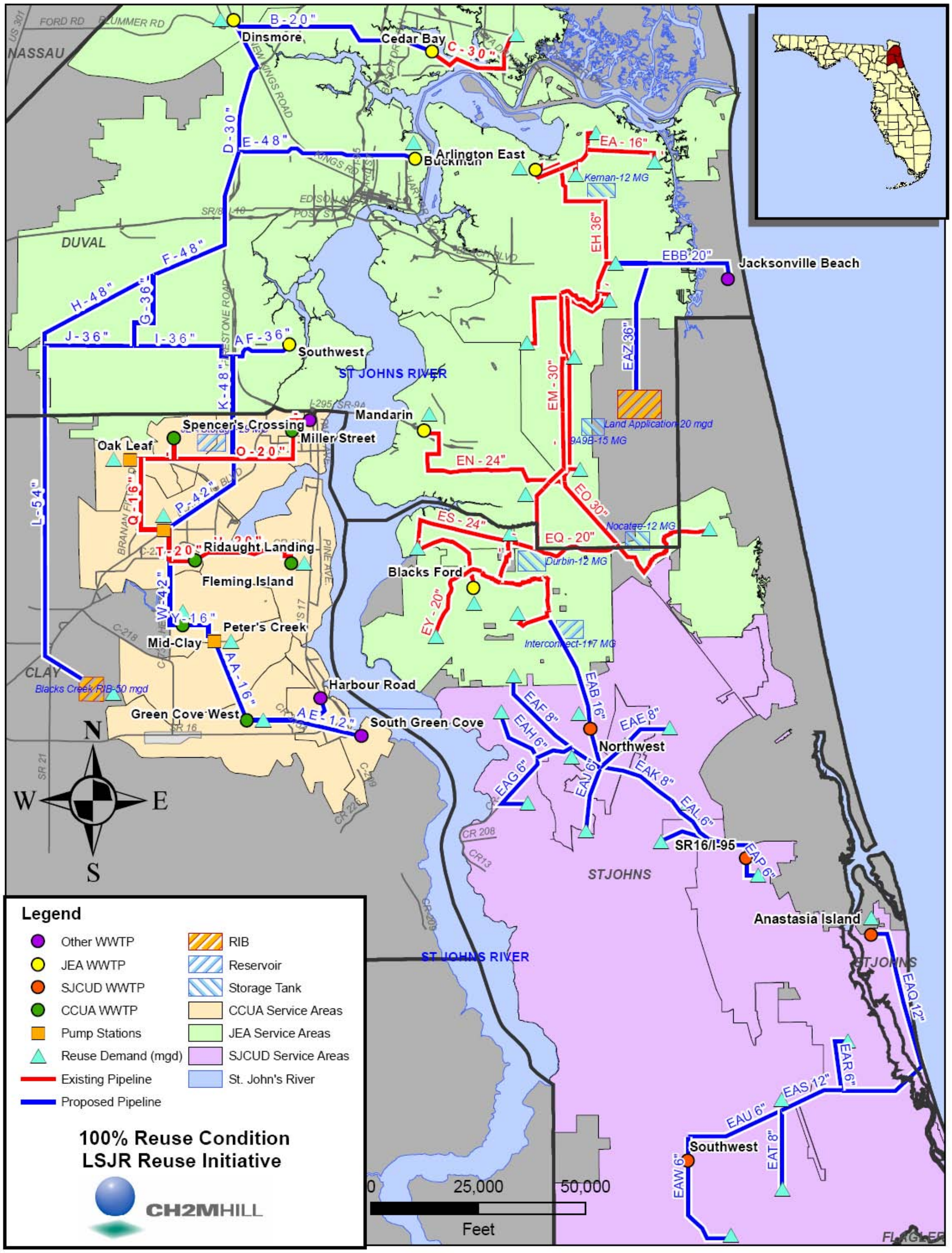


Figure 28. System Layout: 100 Percent Wastewater Reuse Target

New pipe segments are proposed at a cost of $517.2 million. The longest segment (115,000 feet) will connect the junction at the proposed West Reservoir location to the Black Creek RIBs on the west side of the LSJR. Additional lengthy segments will connect the Cedar Bay, Dinsmore, and Buckman WWTPs in the JEA service area, as well as the SCJUD plants east of the LSJR. The pipes range in diameter from 6 inches to 54 inches. The total annual O&M cost for the new pipe is expected to be $14.5 million.

Table 45. 100 Percent Reuse of Available Wastewater Target: Prioritized Pipeline Expansion West of the LSJR Project Summary

Service Area	Segment Label	Length (ft)	Existing Diameter (in)	Final Diameter (in)
JEA	A	0	0	36
JEA	B	65,600	0	20
JEA	C	30,300	20	30
JEA	D	44,200	0	30
JEA	E	61,000	0	48
JEA	F	20,000	0	48
JEA	G	30,000	0	36
JEA	H	33,000	0	48
JEA	I	49,600	0	36
JEA	J	12,000	0	36
JEA/CCUA	K	26,300	0	48
JEA West Total		**372,000**		
CCUA	L	115,000	0	54
CCUA	M	16,200	16	16
CCUA	N	0	0	24
CCUA	O	25,500	20	20
CCUA	P	52,000	0	42
CCUA	Q	28,000	16	16
CCUA	R	0	0	24
CCUA	S	15,200	16	36
CCUA	T	8,000	16	20
CCUA	U	32,300	20	20
CCUA	V	0	0	20
CCUA	W	18,000	0	42
CCUA	X	0	0	30
CCUA	Y	11,500	0	16
CCUA	Z	0	0	16

Table 45. 100 Percent Reuse of Available Wastewater Target: Prioritized Pipeline Expansion West of the LSJR Project Summary

CCUA	AA	28,700	0	16
CCUA	AB	0	0	24
CCUA	AC	11,300	0	16
CCUA	AD	17,500	0	8
CCUA	AE	28,000	0	12
CCUA	AF	14,200	0	36
CCUA	AG	20,000	20	20
CCUA Total		**441,400**		
West Side Total		**813,400**		

Table 46. 100 Percent Reuse of Available Wastewater Target: Prioritized Pipeline Expansion East of the LSJR Project Summary

Service Area	Segment Label	Length	Existing Diameter (in)	Final Diameter (in)
Arlington East	EA	15,391	12	16
Arlington East	EB	3,792	8	12
Arlington East	EC	5,742	20	24
Arlington East	ED	2,317	8	20
Arlington East	EE	3,988	20	24
Arlington East	EF	7,077	30	36
Arlington East	EG	17,190	16	36
Arlington East	EH	14,461	16	36
Arlington East	EI	9,224	30	36
Arlington East	EJ	17,846	12	12
Arlington East	EK	12,027	24	36
Arlington East	EL	15,978	30	30
Arlington East	EM	26,578	30	30
Arlington East	EAY	4,669	20	24
Arlington East	EAZ	29,912	0	36
Arlington East	EBA	7,281	0	36
Arlington East	EBB	17,000	0	20

Table 46. 100 Percent Reuse of Available Wastewater Target:
Prioritized Pipeline Expansion East of the LSJR Project Summary

Service Area	Segment Label	Length	Existing Diameter (in)	Final Diameter (in)
Mandarin	EN	45,783	20	24
Mandarin	EO	19,114	24	30
Mandarin	EP	16,673	20	24
Mandarin	EQ	20,250	20	20
Blacks Ford East	ER	32,055	20	30
Blacks Ford West	ES	27,331	12	24
Blacks Ford West	ET	6,944	20	24
Blacks Ford West	EU	10,653	20	20
Blacks Ford West	EV	17,024	16	24
Blacks Ford West	EW	4,761	16	16
Blacks Ford West	EX	10,894	12	16
Blacks Ford West	EY	23,557	20	20
Blacks Ford West	EZ	8,112	12	16
Blacks Ford West	EAA	12,276	12	12
JEA East Total		**465,901**		
North SJC	EAB	28,217	0	16
North SJC	EAC	9,412	0	24
North SJC	EAD	7,598	0	12
North SJC	EAE	12,225	0	8
North SJC	EAF	21,600	0	8
North SJC	EAG	19,969	0	6
North SJC	EAH	13,746	0	6
North SJC	EAI	8,959	0	6
North SJC	EAJ	15,839	0	6
North SJC	EAK	19,816	0	8
North SJC	EAL	12,682	0	6
North SJC	EAM	12,394	0	0

Table 46. 100 Percent Reuse of Available Wastewater Target: Prioritized Pipeline Expansion East of the LSJR Project Summary

Service Area	Segment Label	Length	Existing Diameter (in)	Final Diameter (in)
North SJC	EAN	12,040	0	6
North SJC	EAO	0	0	0
North SJC	EAP	6,629	0	6
North SJC	EAX	7,936	0	16
South SJC	EAQ	56,520	0	12
South SJC	EAR	14,616	0	6
South SJC	EAS	15,186	0	12
South SJC	EAT	19,103	0	8
South SJC	EAU	23,152	0	6
South SJC	EAV	0	0	0
South SJC	EAW	30,491	0	6
SJCUD Total		**368,130**		
East Side Total		**834,031**		

Two new storage reservoirs will be installed at the two interconnect locations. The smaller reservoir will be installed at the JEA / SJCUD interconnect with a capacity of 117 MG. At the JEA / CCUA interconnect, a reservoir of 131 MG will be installed. The capital cost of these reservoirs is $30.4 million.

Table 47. 100 Percent Reuse of Available Wastewater Target: Prioritized New Storage Project Summary

Storage Location	Existing Capacity (MG)	Final Capacity (MG)	Type	Capital Cost	Annual O&M Cost
Kernan Blvds	12	12	Storage Tank	$0	$69,830
9A/9B	15	15	Storage Tank	$0	$85,730
Nocatee	12	12	Storage Tank	$0	$69,830
Durbin	12	12	Storage Tank	$0	$69,830
JEA East Total	**51**	**51**		**$0**	**$295,220**

Table 47. 100 Percent Reuse of Available Wastewater Target: Prioritized New Storage Project Summary

Storage Location	Existing Capacity (MG)	Final Capacity (MG)	Type	Capital Cost	Annual O&M Cost
Interconnect	0	117	Ground Reservoir	$12,564,201	$251,284
North SJC	0	0		$0	$0
South SJC	0	0		$0	$0
SJCUD Total	**0**	**117**		**$12,564,201**	**$251,284**
JEA Storage	0	131	Ground Reservoir	$8,211,034	$164,221
JEA West Total	**0**	**131**		**$8,211,034**	**$164,221**
West Storage	0	0		$0	$0
MS Storage	0	0		$0	$0
Mid Clay Storage	0	0		$0	$0
CCUA Total	**0**	**0**		**$0**	**$0**
System Total	**51**	**299**		**$20,775,236**	**$710,725**

In addition, a new rapid infiltration basin system is to be installed at the proposed Black Creek site (Table 48). The RIBs will cost $280.9 million and have a capacity of 51 mgd. Similarly, a land application system will be installed east of the LSJR. The land application capacity will be 20 mgd, and have a cost of $374.1 million.

Table 48. 100 Percent Reuse of Available Wastewater Target: Prioritized New RIBs Project Summary – Combined East and West Sides

Storage Location	Capacity (mgd)	Capital Cost	Annual O&M Cost
West Side	51	$280,866,710	$2,808,667
East Side	20	$374,160,892	$3,741,609

EVALUATION AND COMPARISON OF ALTERNATIVES

The five project alternatives are discussed below relative to their ability to meet the goals previously outlined. In addition to the infrastructure and cost features of each alternative, the evaluation is based on a series of quantifiable metrics, the values of which have been estimated by the LSJR Reuse system optimization model. These metrics include total volume discharge, total nitrogen load, and potable water offset. A side-by-side summary of results for each alternative is presented below for the purposes of comparison. When coupled with a weighted, prioritized list of these metrics, this comparison will facilitate the selection of the best project alternatives.

INFRASTRUCTURE

One component of the water reclamation project is the potential expansion of existing pipeline connections (Table 49, Table 50).

Table 49. Summary of Pipeline Expansion West of the LSJR, Diameter (inches)

Pipe Label	Length (feet)	Existing Diameter (inches)	Parallel Pipe Diameter (inches)			
			$300 Million	60% Reuse	75% Reuse	100% Reuse
A	0	0	36	30	36	36
B	65,600	0	8	20	20	20
C	30,300	20	24	30	30	30
D	44,200	0	36	30	36	30
E	61,000	0	36	30	36	48
F	20,000	0	0	24	30	48
G	30,000	0	0	20	24	36
H	33,000	0	0	20	30	48
I	49,600	0	0	20	30	36
J	12,000	0	0	0	30	36
K	26,300	0	0	30	36	48
JEA West Total	**372,000**					
L	115,000	0	0	20	42	54
M	16,200	16	16	16	16	16
N	0	0	24	24	24	24
O	25,500	20	20	20	20	20

Table 49. Summary of Pipeline Expansion West of the LSJR, Diameter (inches)

Pipe Label	Length (feet)	Existing Diameter (inches)	Parallel Pipe Diameter (inches)			
			$300 Million	60% Reuse	75% Reuse	100% Reuse
P	52,000	0	16	42	42	42
Q	28,000	16	16	16	16	16
R	0	0	16	24	24	24
S	15,200	16	16	36	36	36
T	8,000	16	20	20	20	20
U	32,300	20	20	20	20	20
V	0	0	20	20	20	20
W	18,000	0	20	42	42	42
X	0	0	12	30	30	30
Y	11,500	0	0	16	16	16
Z	0	0	10	16	16	16
AA	28,700	0	10	12	12	16
AB	0	0	20	24	24	24
AC	11,300	0	12	12	16	16
AD	17,500	0	8	0	8	8
AE	28,000	0	8	12	12	12
AF	14,200	0	0	24	36	36
AG	20,000	20	20	24	24	20
CCUA Total	**441,400**					
West Side Total	**813,400**					

Table 50. Summary of Pipeline Expansion East of the LSJR, Diameter (inches)

Pipe Label	Length (feet)	Existing Diameter (inches)	Parallel Pipe Diameter (inches)			
			$300 Million	60% Reuse	75% Reuse	100% Reuse
EA	15,391	12	16	16	16	16
EB	3,792	8	12	12	12	12
EC	5,742	20	24	24	24	24
ED	2,317	8	20	20	20	20
EE	3,988	20	24	24	24	24
EF	7,077	30	30	30	30	36
EG	17,190	16	24	24	30	36
EH	14,461	16	24	24	30	36
EI	9,224	30	30	30	30	36
EJ	17,846	12	12	12	12	12
EK	12,027	24	24	30	30	36
EL	15,978	30	30	30	30	30
EM	26,578	30	30	30	30	30
EAY	4,669	20	24	30	30	24
EAZ	29,912	0	16	12	16	36
EBA	7,281	0	16	16	16	36
EBB	17,000	0	20	20	20	20
EN	45,783	20	24	24	24	24
EO	19,114	24	24	30	30	30
EP	16,673	20	24	24	24	24
EQ	20,250	20	20	20	20	20
ER	32,055	20	24	30	30	30
ES	27,331	12	12	20	20	24
ET	6,944	20	24	24	24	24
EU	10,653	20	24	20	20	20
EV	17,024	16	16	24	20	24

Table 50. Summary of Pipeline Expansion East of the LSJR, Diameter (inches)

Pipe Label	Length (feet)	Existing Diameter (inches)	Parallel Pipe Diameter (inches)			
			$300 Million	60% Reuse	75% Reuse	100% Reuse
EW	4,761	16	16	16	16	16
EX	10,894	12	24	12	12	16
EY	23,557	20	20	20	20	20
EZ	8,112	12	24	12	12	16
EAA	12,276	12	12	12	12	12
JEA East Total	**465,901**	**0**				
EAB	28,217	0	16	12	12	16
EAC	9,412	0	20	24	24	24
EAD	7,598	0	12	12	12	12
EAE	12,225	0	8	8	8	8
EAF	21,600	0	8	8	8	8
EAG	19,969	0	6	6	6	6
EAH	13,746	0	6	6	6	6
EAI	8,959	0	6	6	6	6
EAJ	15,839	0	6	6	6	6
EAK	19,816	0	6	8	8	8
EAL	12,682	0	0	6	6	6
EAM	12,394	0	6	0	0	0
EAN	12,040	0	6	6	6	6
EAO	0	0	0	0	0	0
EAP	6,629	0	6	6	6	6
EAX	7,936	0	12	16	16	16
EAQ	56,520	0	8	10	10	12
EAR	14,616	0	6	6	6	6
EAS	15,186	0	6	6	6	12

Table 50. Summary of Pipeline Expansion East of the LSJR, Diameter (inches)

Pipe Label	Length (feet)	Existing Diameter (inches)	Parallel Pipe Diameter (inches)			
			$300 Million	60% Reuse	75% Reuse	100% Reuse
EAT	19,103	0	6	0	0	8
EAU	23,152	0	0	0	0	6
EAV	0	0	0	0	0	0
EAW	30,491	0	6	0	0	6
SJCUD Total	**368,130**					
East Side Total	**834,031**					

RECLAIMED WATER CAPACITY

The four expansion alternatives generate additional reclaimed water treatment capacity ranging from 31 mgd to 110 mgd (Table 51). The additional Mandarin, Beaches, Miller Street, Fleming Island, and SR16 capacities are constant across all four expansion alternatives. In all scenarios, the majority of the proposed capacity expansion is to occur in the JEA west service area which is necessary to achieve the target percent reductions because the Buckman WRF is so large. The interconnection between CCUA and Green Cove Springs facilities has recently been made at the Harbour Road WWTF. Thus, while the City of Green Cove Springs generates the reclaimed water, it is being used in the CCUA service area. Future use of the South Green Cove wastewater for reuse is tied to some new developments in the region that lie in both the City of Green Cove Springs and CCUA service areas.

Table 51. Summary of Reclaimed Water Expansion Capacity (mgd)

Treatment Plant	Existing Capacity (mgd)	Expansion Capacity (mgd)			
		$300 Million	60% Reuse	75% Reuse	100% Reuse
Cedar Bay	5.0	1.0	2.0	2.0	2.0
Dinsmore	0.0	1.0	7.0	5.0	8.0
Buckman	0.0	17.0	11.0	19.0	40.0

Table 51. Summary of Reclaimed Water Expansion Capacity (mgd)

Treatment Plant	Existing Capacity (mgd)	Expansion Capacity (mgd)			
		$300 Million	60% Reuse	75% Reuse	100% Reuse
Southwest	0.0	0.0	7.0	17.0	17.0
JEA West Total	**5.0**	**19.0**	**27.0**	**43.0**	**67.0**
Arlington East	6.0	1.0	8.0	9.0	16.0
Blacks Ford	6.0	1.0	4.0	2.0	5.0
Mandarin	7.0	2.0	2.0	2.0	3.0
Beaches	4.5	0.0	0.0	0.0	0.0
JEA East Total	**23.5**	**4.0**	**14.0**	**13.0**	**24.0**
Spencers Crossing	1.4	1.7	0.7	0.7	2.7
Ridaught Landing	1.9	0.1	1.1	1.1	1.1
Miller Street	5.0	0.0	0.0	0.0	0.0
Fleming Island	4.5	0.0	0.0	0.0	0.0
Mid Clay	0.9	0.2	2.2	2.2	3.2
Green Cove West	0.3	2.8	2.8	2.8	4.8
South	0.0	1.0	3.0	3.0	3.0
Harbour Road	0.0	1.0	0.0	1.0	1.0
CCUA Total	**13.8**	**6.7**	**9.7**	**10.7**	**15.7**
Northwest	3.0	0.0	1.0	2.0	1.0
SR16	0.9	0.2	0.2	0.2	0.2
Southwest	0.0	1.0	0.0	0.0	0.0
Anastasia Island	1.0	0.0	1.0	1.0	2.0
SJC Total	**4.9**	**1.2**	**2.2**	**3.2**	**3.2**
System Total	**47.2**	**30.8**	**52.8**	**69.8**	**109.8**

A summary of the system's total reclaimed water capacity associated with each project alternative is presented in Table 51.

CAPITAL AND O&M COSTS

The capital cost of each group of expanded features is presented in Table 52. The most costly alternative is the 100 percent reuse scenario, which is $1,242 million in capital costs. The capital costs of the 60 and 75 percent reuse alternatives are equivalent to 39 and 59 percent of the cost of the 100 percent reuse alternative, respectively. The lowest-cost expansion alternative is the $300 million alternative, which amounts to 23 percent of the cost of the 100 percent reuse alternative.

Table 52. Summary of Capital Costs Related to Combined System Expansion (mgd)

	$300 Million	60% Reuse	75% Reuse	100% Reuse
Treatment	$15,667,317	$23,248,747	$25,832,554	$30,829,611
Pipe Network	$170,574,716	$313,693,269	$404,412,406	$517,186,180
Pump Stations	$2,458,676	$4,984,237	$6,359,214	$8,698,801
Storage Reservoirs	$44,540,505	$67,606,275	$69,878,904	$20,775,236
RIBs/Land Application	$52,800,770	$70,327,681	$223,306,688	$655,027,602
Total	**$286,041,984**	**$479,860,209**	**$729,789,765**	**$1,242,111,430**

The annual operations and maintenance costs associated with each alternative are presented in Table 53. The O&M costs of the $300 million, 60 percent reuse, and 75 percent reuse alternatives are 40, 62, and 81 percent of the cost of the 100 percent alternative, respectively.

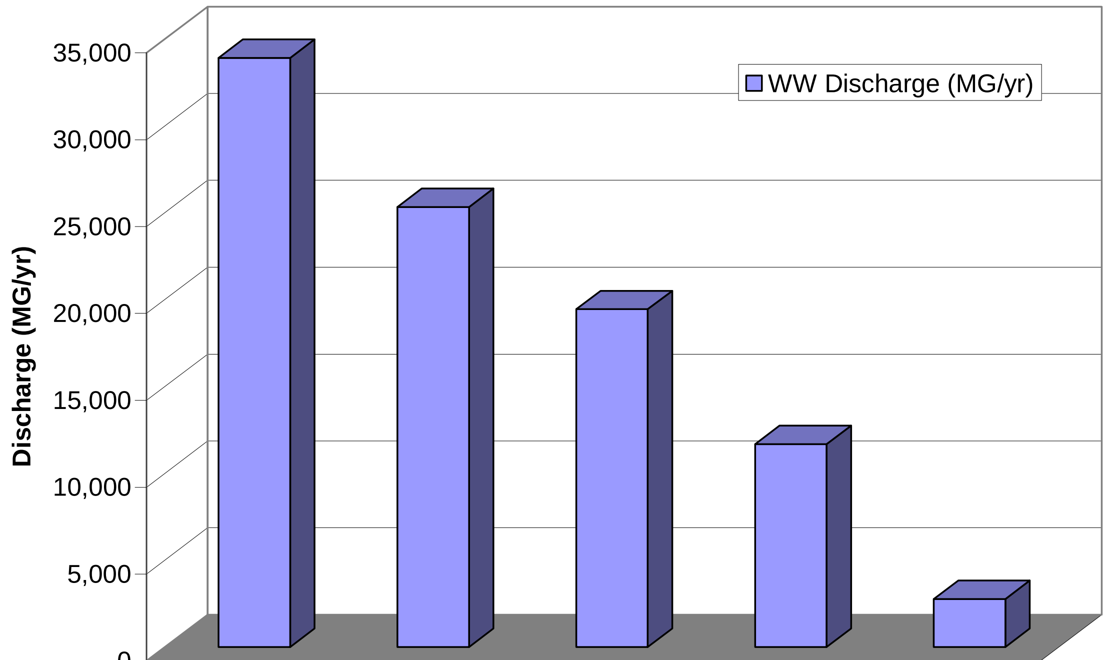
Table 53. Summary of Annual O&M Costs Related to Combined System Expansion (mgd)

	$300 Million	60% Reuse	75% Reuse	100% Reuse
Treatment	$181,675	$217,395	$228,069	$241,541
Pipe Network	$6,147,915	$9,513,314	$11,706,455	$14,494,198
Pump Stations	$825,664	$1,286,147	$1,706,056	$2,264,563
Storage Reservoirs	$1,186,030	$1,647,346	$1,692,798	$710,725
RIBs/Land Application	$528,008	$703,277	$2,233,067	$6,550,276
Total	**$8,869,313**	**$13,367,487**	**$17,566,557**	**$24,261,310**

TOTAL MAXIMUM DAILY LOAD COMPLIANCE

A key goal of the water reclamation project is to reduce the nitrogen loads in the lower St. Johns River and comply with established TMDL standards. Of particular interest are the total volume of discharge (BG) and the TN load produced by wastewater treatment facilities in the LSJRB.

The total volume of wastewater discharged annually into the lower St. Johns River from the combined east and west study areas for each scenario is shown in Figure 29. The most effective alternative is the 100 percent reuse alternative, reducing discharge from the base case value of 33.9 BG to 2.8 BG. In contrast, the $300 million budget limit produces a discharge reduction of 8.6 BG, or 25 percent of the base case discharge.

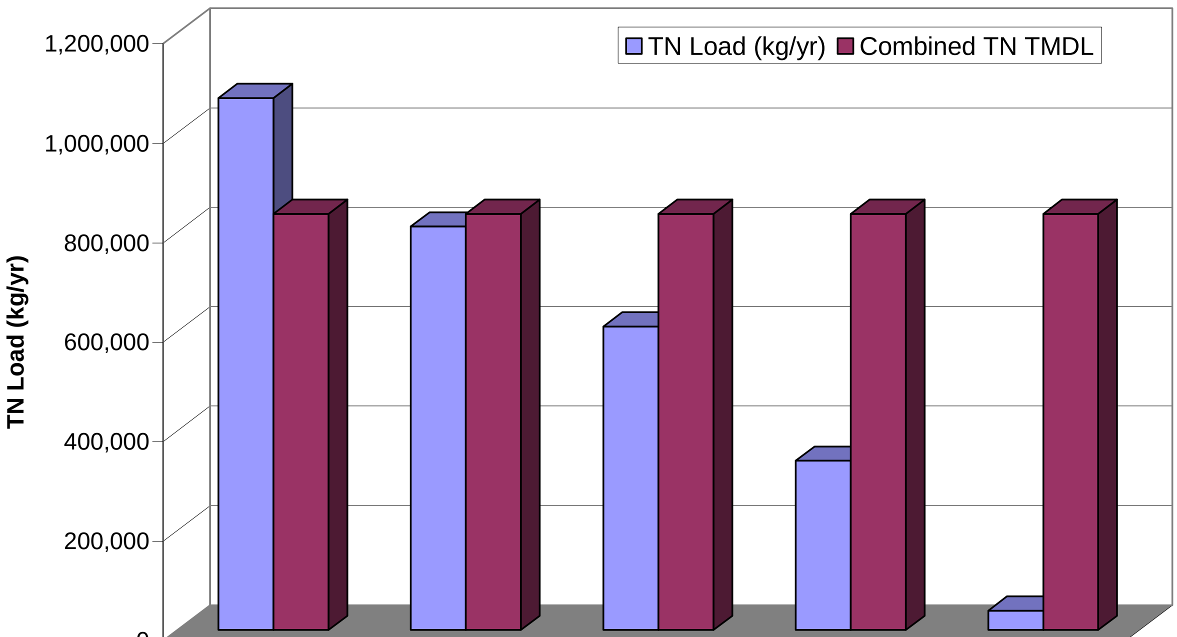


	2030 No Expansion	$300 Million	60% Reuse	75% Reuse	100% Reuse
WW Discharge (MG/yr)	33,908	25,331	19,447	11,673	2,773

Figure 29. St. Johns River Discharge Volumes for Modeled Scenarios

For the purposes of TMDL compliance, the target TN load from the municipal point sources in the combined study area is approximately 837,000 kg / yr[1] (Figure 30). A 22 percent reduction in the base case TN load of 1,069,702 kg / yr is required to meet the target. The $300 million scenario successfully meets the TMDL goal, reducing TN load by only 24.1 percent. The 60, 75, and 100 percent reuse alternatives more than meet the goal, and result in a TN reduction of 42.9 percent (459,301 kg / yr), 68.2 percent (729,119 kg / yr) and 96.3 percent (1,030,566 kg / yr), respectively.

[1] This value is only for the municipal point sources and not every point source in the basin. This total was based on the December 2007 draft TMDL allocation.



	2030 No Expansion	$300 Million	60% Reuse	75% Reuse	100% Reuse
TN Load (kg/yr)	1,069,702	811,680	610,401	340,583	39,136
Combined TN TMDL	837,000	837,000	837,000	837,000	837,000

Figure 30. Total Nitrogen Load for the Modeled Scenarios

Failing to meet the TMDL standards, and in particular, wastewater discharge constraints and TN load requirements, will result in regulatory non-compliance.

POTABLE WATER OFFSET

Another key goal of the LSJRB Reuse Solutions Initiative is to augment water supply in the lower basin. Specifically, the use of reclaimed water to meet demands offsets demands on potable water supply. The amount of potable water offset associated with each alternative is presented in Table 54 below. The 100 percent reuse alternative provides the greatest potable water offset, at 30.9 BG/yr. The 60 and 75 percent reuse alternatives produce offsets of 29.1 mgd and 30.3 mgd, or 94 and 98 percent of that provided by the 100 percent reuse alternative. The main difference between these scenarios is more flow to RIBs for the higher reuse target alternatives, and these flows have no potable offset. The potable water offset generated by the $300 million budget alternative is 22.2 mgd, or 72 percent of that provided by the 100 percent reuse alternative.

Table 54. Summary of Potable Water Offset

	Existing	$300 Million	60% Reuse	75% Reuse	100% Reuse
Potable Water Offset (MG/yr)	6,931	22,174	29,073	30,268	30,865

CONCLUSIONS AND RECOMMENDATIONS

A summary of the results used to evaluate the five alternatives is presented in Table 55 through 57. For purposes of this evaluation, the use of a RIB or land application system for land application is considered part of the reuse program, because the actual effectiveness of recharging the aquifer is unknown. However, the main goal of removing wastewater discharges out of the St. Johns River would be attained by including some form of land application; thus, RIBs were proposed to be used on the west side and a more generic land application on the east side to allow for disposal during periods when irrigation demand did not meet the reclaimed water production. Additional storage is also needed to fully utilize the reclaimed water generated in Clay County.

The base case is the amount of future reuse water demand that could be met if no additional pipelines and reclaimed treatment is provided. While not likely to occur, it provides a low-end estimate for comparison purposes only. The base case scenario fails to meet discharge and TN load reduction targets.

In contrast, the 100 percent reduction alternative more than meets water quality targets, and provides 30.9 BG/yr of potable water offset. However, the capital cost of this scenario ($1,242 million) is over 4 times the current budgeted construction costs ($300 million). The $300 million and 60 and 75 percent reuse alternatives increase reuse capacity substantially, achieve satisfactory water quality results, and offset potable water supplies by 22, 26 and 31 BG/yr respectively.

It is important to note that the approach taken does not take into consideration interim steps needed to achieve the next highest reuse level. Rather, each result meets the given goal ($300 millon, 60% reuse, etc.) in a non-sequential fashion. So these results can be used to see what the optimum system would be if, say 75% Reuse was your goal. In the 75% case the amount of storage or certain pipe sizes may be reduced from the 60% Reuse system. Consequently, it is up to the utilities to use these results to determine what the targeted system would be in 2030, and then complete implementation plans to meet their goal. While their systems may not be the same as the “optimum” layout when finished, there should not be a large difference.

Table 55. Summary of West Side Results

Scenario	Total RWT Capacity (mgd)	Capital Cost (million $)	Annual O&M Cost (million $)	Reuse % Achieved	Potable Water Offset (MG/yr)	Discharge to SJR (MG/yr)	TN Load (kg/yr)	% TN Reduction
Base Case - 2030 No Expansion	18.8	$0	$1	13%	1,820	20,240	813,318	0%
$300 Million Capital Cost Constraint	44.5	$103	$4	41%	10,604	16,495	642,755	21%
60% Reuse Target	55.5	$304	$8	59%	16,474	12,496	477,199	41%
75% Reuse Target	72.5	$506	$12	79%	17,756	6,116	240,303	70%
100% Reuse Target	101.5	$699	$15	99%	17,932	183	3,469	100%

*O&M Costs do not include the cost of Potable Water

Table 56. Summary of East Side Results

Scenario	Total RWT Capacity (mgd)	Capital Cost (million $)	Annual O&M Cost (million $)	Reuse % Achieved	Potable Water Offset (MG/yr)	Discharge to SJR (MG/yr)	TN Load (kg/yr)	% TN Reduction
Base Case - 2030 No Expansion	23.9	$0	$3	17%	5,111	13,668	256,384	0%
$300 Million Capital Cost Constraint	33.5	$183	$5	51%	11,570	8,836	168,925	34%
60% Reuse Target	44.5	$176	$5	62%	12,599	6,950	133,201	48%
75% Reuse Target	44.5	$224	$5	67%	12,513	5,558	100,280	61%
100% Reuse Target	55.5	$543	$6	86%	12,933	2,590	35,667	86%

*O&M Costs do not include the cost of Potable Water

Table 57. Summary of Combined East and West Side Results

Scenario	Total RWT Capacity (mgd)	Capital Cost (million $)	Annual O&M Cost (million $)	Reuse % Achieved	Potable Water Offset (MG/yr)	Discharge to SJR (MG/yr)	TN Load (kg/yr)	% TN Reduction
Base Case - 2030 No Expansion	42.7	$0	$4	14%	6,931	33,908	1,069,702	0%
$300 Million Capital Cost Constraint	78.0	$286	$8	45%	22,174	25,331	811,680	24%
60% Reuse Target	100.0	$480	$13	60%	29,073	19,447	610,401	43%
75% Reuse Target	117.0	$730	$17	75%	30,268	11,673	340,583	68%
100% Reuse Target	157.0	$1,242	$21	94%	30,865	2,773	39,136	96%

*O&M Costs do not include the cost of Potable Water

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APPENDIX I

DETERMINATION OF SEASONAL COMPONENTS OF RECLAIMED WATER SUPPLY AND RECLAIMED WATER DEMAND

To understand the seasonal variation, the historical reclaimed water demand data (1998 to 2006) was converted into monthly averages and presented in a Box-Whisker plot (shown in Figure 1). This plot clearly indicates a significant seasonal pattern in the reclaimed water demand. Therefore, it was deemed necessary to determine the seasonal component of the reclaimed water demand.

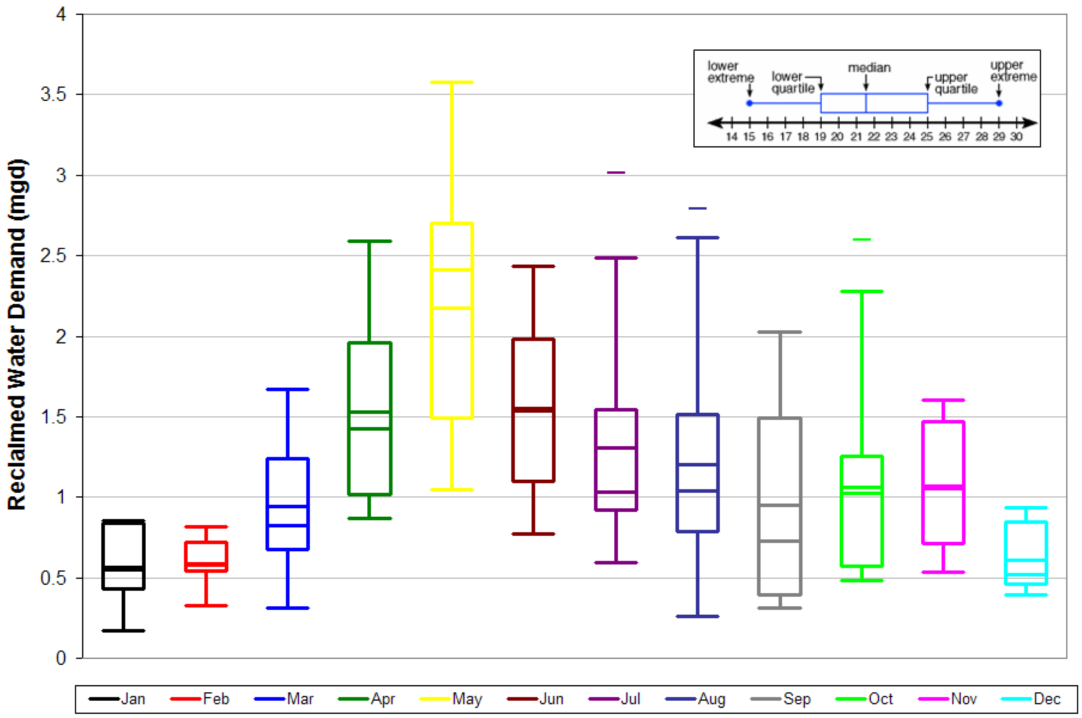

Figure I-1. Box-Whisker Plot for the Reclaimed Water Demand in Fleming Island Service Area

To determine the seasonal component of the reclaimed water demand, the long-term trend needed to be removed first, with the remaining monthly data then used to determine the seasonal variation by conducting spectral analysis. Figure 2 shows the monthly data of the reclaimed water demand along with its two components: the long-term linear trend and seasonal trend.

Figure 2 illustrates significant cyclic trends evident in the monthly time series that is driven by both short-term seasonal and long-term periodic changes (such as occurrence of droughts). Significant frequencies needed to be determined so a mathematical representation of the time series could be constructed.

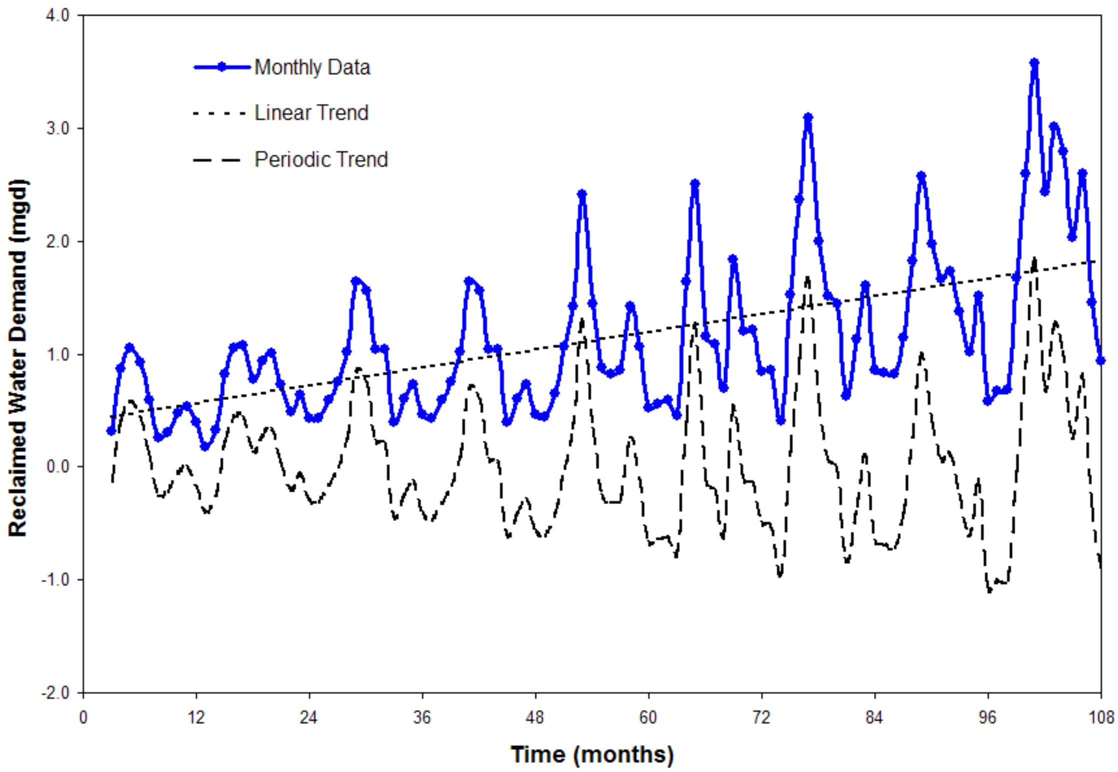

Figure I-2. Historic Monthly Average Reclaimed Water Demand of Fleming Island

To predict the cyclic behavior of the reclaimed water demand over time, a Fourier analysis was used. A sample time series, $y(t)$, t = 1, 2,…….., n can be expressed as a Fourier series having a general form (Box *et al.*, 1994):

$$y(t) = a_0 + \sum_{j=1}^{n/2} a_j \cos\left(2\pi f_j t\right) + \sum_{j=1}^{n/2} b_j \sin\left(2\pi f_j t\right) \qquad (1)$$

where a_0, a_j, and b_j are coefficients; f_j is the j^{th} harmonic of the fundamental frequency $1/n$. Equation 1 is a form of multiple regression analysis. But the question arises: How many and what combinations of harmonics of fundamental frequency should be used in the regression analysis? To determine what frequencies should be used in the regression analysis, a Fourier-Transformation technique was used. The Fourier-Transform is a generalization of the Fourier series. It is a mathematical function that breaks down a signal into its frequency-spectrum as a set of sinusoidal components, converting it from the time domain to the frequency domain. In the time domain, the signal *y* consists of *n* samples. In the frequency domain, the Fourier transformation produces two signals treated as complex numbers representing the real part and the imaginary part. They are seen as the cosine and sine components of the base frequencies. Each of these signals contains $n/2$ samples. Therefore, with the Fourier-Transformation, *n* sample values are transformed to *n* new complex values containing exactly the same information as the time domain.

While dealing with discrete time series, $y(t)$, the discrete Fourier transform (DFT) is used. The DFT can be thought of as a digital tool for analyzing the frequency content of discrete signals. Instead of sines and cosines, as in a Fourier series, the Fourier transform uses exponential and complex numbers. For a discrete function $y(t)$, the DFT is defined (Box *et al.*, 1994) as

$$F(f_j) = \sum_{j=0}^{n-1} y(t) e^{-i 2\pi f_j t} \qquad (2)$$

where $F(f_j)$ is the Fourier transform of $y(t)$ and *i* is the imaginary unity number.

For calculating the DFT, the Fast Fourier Transform (FFT) technique is used. The FFT algorithm is computationally very efficient and extremely useful to achieve adequate frequency resolution while minimizing problems such as aliasing. The output, $F(f_j)$, of an FFT is a series of complex numbers, one for each discretely sampled data point, representing each discrete frequency, only half of which are useful because of the Nyquist criterion. The magnitudes of the complex numbers generated by FFT are used to compare the relative importance of the various frequencies. Therefore, the variance explained by each spectral mode (frequency) is given (Box *et al.*, 1994) by

$$P_j = \frac{\left|F(f_j)\right|^2}{n}, \quad \text{for all } 0 \le j \le n/2 \qquad (3)$$

The plotting estimate of spectral variance against frequency is called periodogram. Figure 5 presents a periodogram for the reclaimed water demand for the Fleming Island Service Area.

While observing this periodogram, four predominant frequencies were detected. As indicated in Figure 3, the strong frequencies include spectral mode corresponding to time periods of 12, 6, 24, and 3 months. These candidate frequencies were evaluated further for fitting the Fourier series model to the historical data.

A multiple regression analysis was used to identify which individual and combinations of frequencies are best for explaining the variance of reclaimed water demand. Based on different combinations of frequencies, a number of Fourier series models were considered. The best Fourier series model was selected based on R-square, F-value of the overall model, and t-statistics and P-values of individual components. A summary of the selected model consisting of full statistical information (Haan, 2002) about the model and its components is presented in Table 1. All four frequencies were significant and retained in the model.

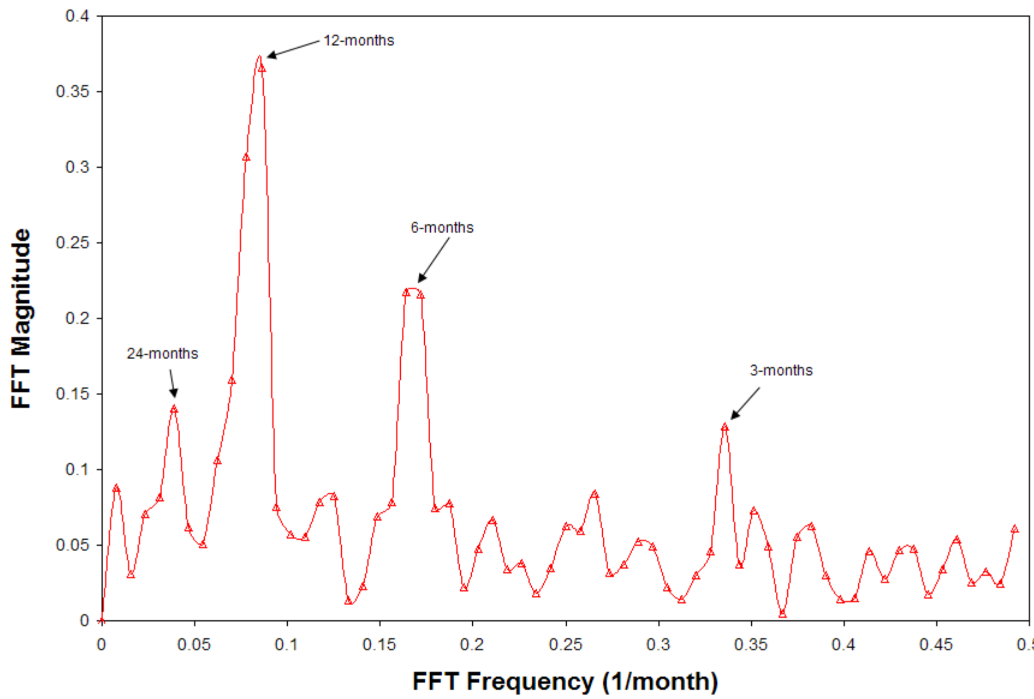

Figure I-3: Identified Significant Frequencies in Reclaimed Water Demand for Fleming Island

Table I-1. Multiple Regression Analysis to Fit the Fourier Series Model to the Fleming Island Reclaimed Demand

Regression Statistics						
F-test	30.48	Prob(F)	0.00	Unrestricted Model		
S.E. Regr	0.38	CV Regr	-99.18	F-test	30.48	
R2	0.60	Durbin-Watson	1.22	R2	0.60	
RBar2	0.59	Rho	0.36	RBar2	0.59	
Akaike Information Criterion	-1.92	Schwarz Information Criterion	-1.79	Goldfeld-Quandt	0.43	
Model Parameters						
Statistics	Constant	SIN1	COS2	COS3	SIN3	COS4
Coefficient	-0.38	0.13	-0.51	0.10	-0.31	-0.12
S.E.	0.04	0.05	0.05	0.05	0.05	0.05
t-test	-10.49	2.55	-9.86	2.00	-6.06	-2.29
Prob(t)	0.00	0.01	0.00	0.05	0.00	0.02

The statistical characteristics (R-square, F-value, and P-value) of the seasonal model are very good. Based on Equation 4 and Table 1, the Fourier series model is given as

$$y(t) = -0.38 + 0.13Sin\left(\frac{2\pi t}{24}\right) - 0.51Cos\left(\frac{2\pi t}{12}\right) + 0.10Cos\left(\frac{2\pi t}{6}\right) - 0.31Sin\left(\frac{2\pi t}{6}\right) - 0.12Cos\left(\frac{2\pi t}{3}\right) \qquad (4)$$

In the above equation, time (t) is in months. Equation 4 is illustrated in Figure 4 to demonstrate the pattern this function predicts. There are seasonal trends for every year, as expected. There is also a longer duration pattern of a 2-year frequency that repeats a cycle of wet and dry years.

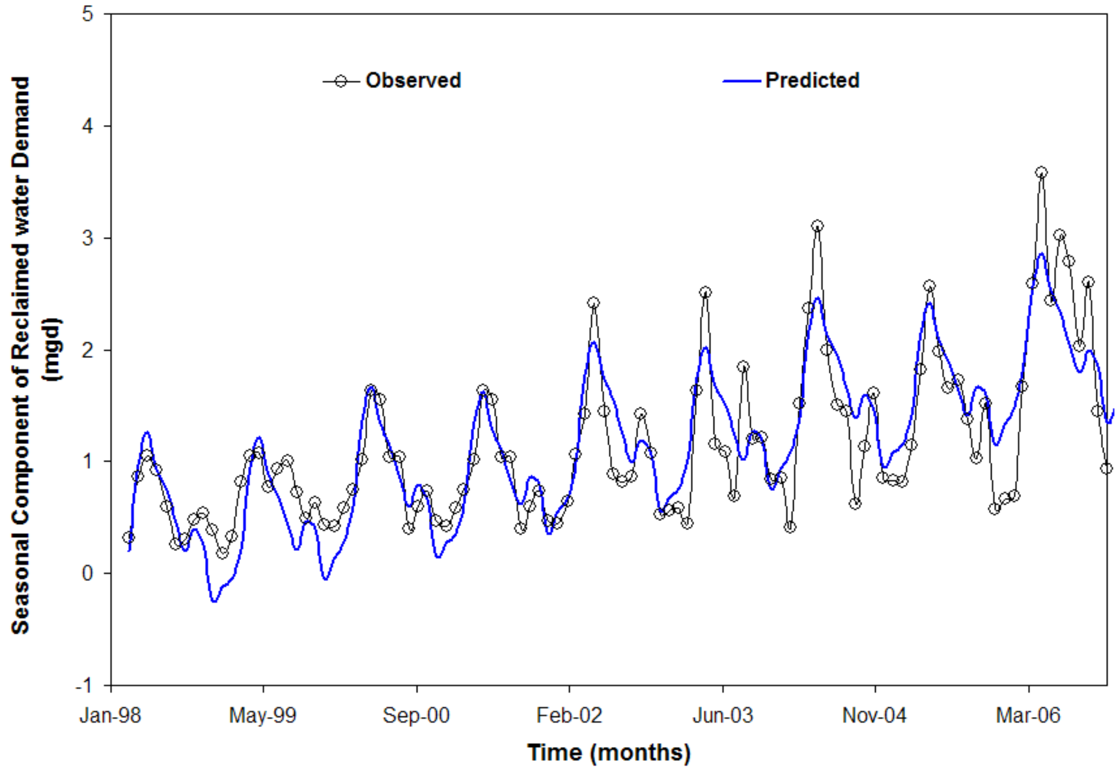

Figure I-4. Observed vs. Fitted Components for Reclaimed Water Demand at Fleming Island

Similarly, the wastewater production data can be analyzed for seasonal component. Since Miller Street WWTP serves a more mature service area with both commercial and residential use, its production is indicative of future wastewater availability for reclaimed water in the CCUA area. Figure 5 shows wastewater flow at the Miller Street WWTP indicating seasonal variations, albeit smaller than observed for water supply. Figure 6 illustrates that no growth trend adjustment was necessary.

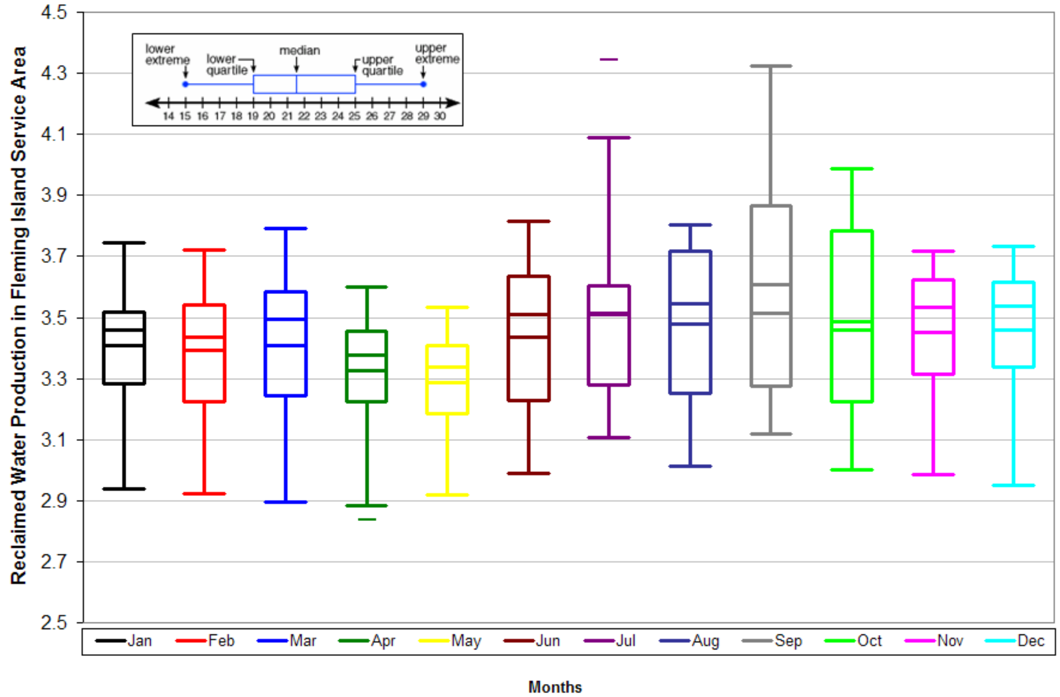

Figure I-5. Box-Whisker Plot for the Wastewater Production in the Miller Street Service Area

Using the same approach, the periodic trend in the reclaimed water production in the Miller Street Service Area is given by the following fitted Fourier series model:

$$y(t) = 0.137Cos\left(\frac{2\pi t}{128}\right) - 0.11Sin\left(\frac{2\pi t}{128}\right) + 0.115Cos\left(\frac{2\pi t}{42}\right) - 0.0.074Sin\left(\frac{2\pi t}{42}\right) + 0.0201Cos\left(\frac{2\pi t}{12}\right)$$
$$- 0.111Sin\left(\frac{2\pi t}{12}\right) - 0.015Cos\left(\frac{2\pi t}{6}\right) + 0.029Sin\left(\frac{2\pi t}{6}\right) + 0.043Cos\left(\frac{2\pi t}{3}\right) + 0.0129\mathrm{Sin}\left(\frac{2\pi t}{3}\right) \quad (5)$$

where t is in months. Figure 6 shows predicted seasonal variation in reclaimed water production in the Miller Street WWTP Service Area.

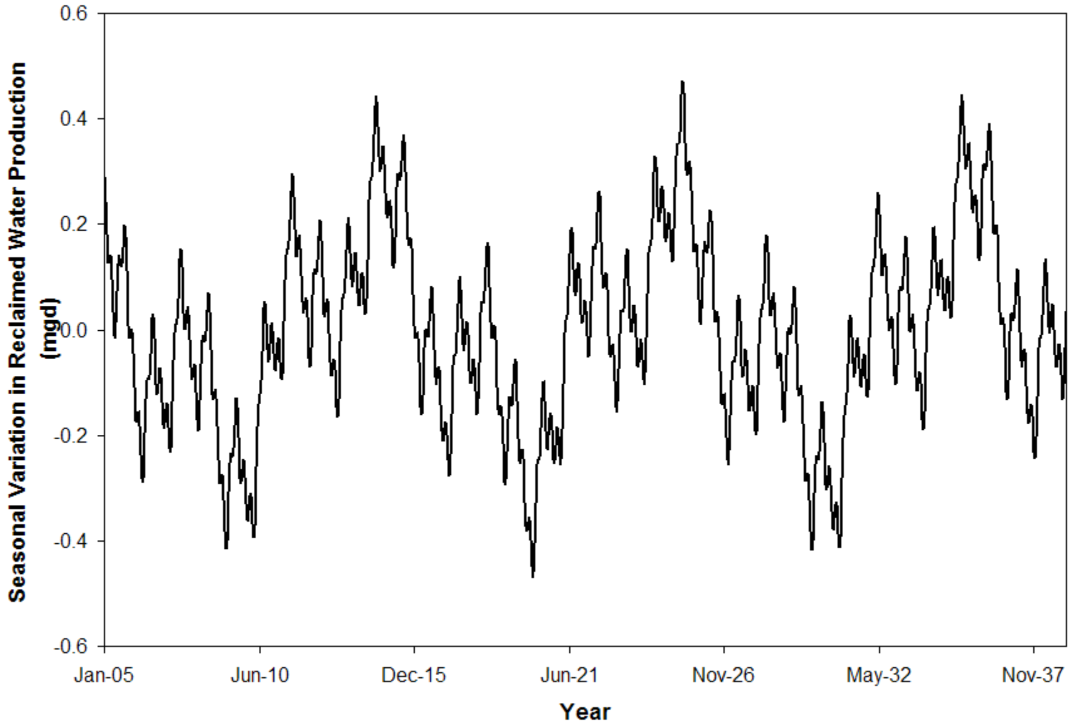

Figure I-6: Predicted Seasonal Variation in Wastewater Production of Miller Street Service Area

The availability of historical data for reclaimed water demand is limited. For some of the service areas, no data exists. Thus, it is not possible to determine the seasonal component for each service area. Furthermore, because of relative magnitudes, the additive components could not be used in other service areas. To apply the seasonality component in other areas, normalized seasonal factors were developed, using the above-mentioned data sets for application to all service areas.

To apply the seasonal factors to the annual average projections for wastewater flow (available reclaimed water), the monthly average data was divided by their respective annual averages. The ratios so obtained were analyzed using Fourier analysis as explained earlier. Based on this analysis, a new mathematical expression of seasonal factor for wastewater demand was developed:

$$SF(Wastewater) = 1 - 0.011Cos\left(\frac{2\pi t}{6}\right) + 0.005Sin\left(\frac{2\pi t}{6}\right) + 0.021Cos\left(\frac{2\pi t}{12}\right) - 0.03Sin\left(\frac{2\pi t}{12}\right) \qquad (6)$$

where t is in months. Figure 7 depicts the seasonal factors for the wastewater effluent as represented by Equation 6. Weekly data are derived by using fraction of months in Equation 6, thus yielding a continuous mathematical expression for the study. As shown in Figure 7, the wastewater production varies ±3.5 percent from the average annual value.

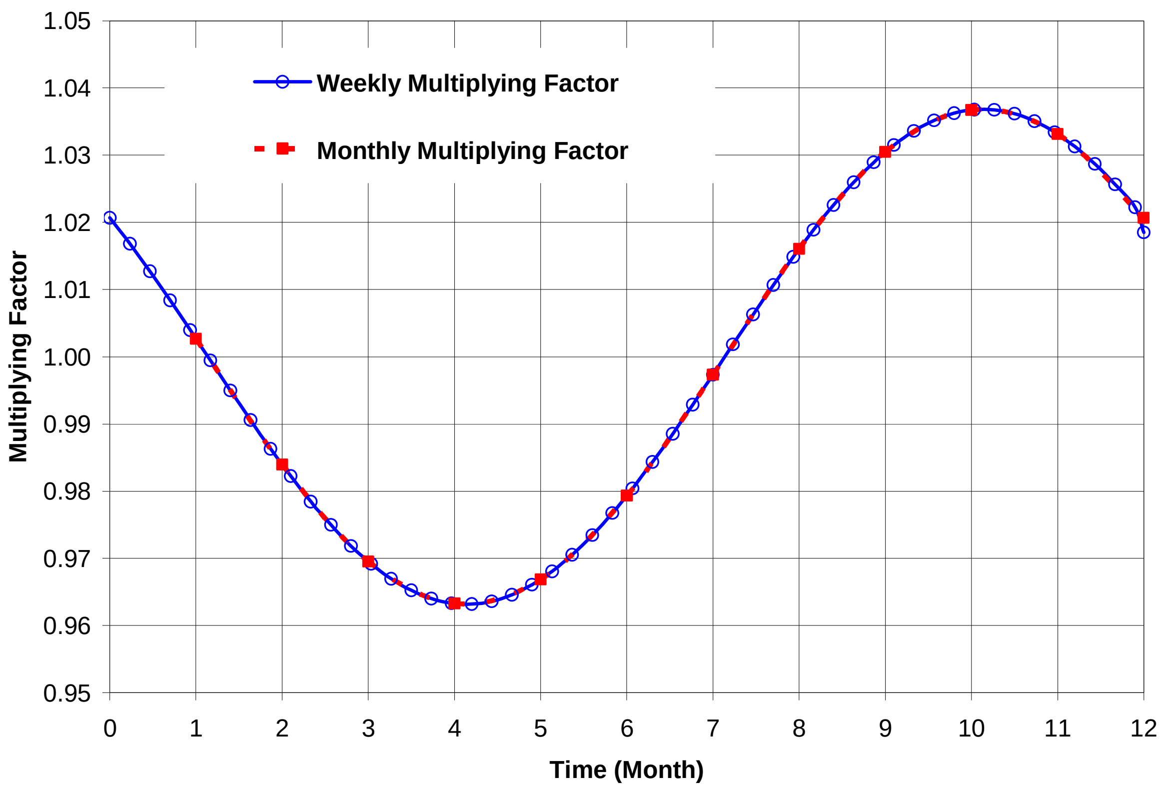

Figure I-7: Predicted Seasonal Variation in Wastewater Production

Similarly, seasonal factor for reclaimed water demand can be obtained using the following expression:

$$y(t) = 1 - 0.087Cos\left(\frac{2\pi t}{3}\right) - 0.082Sin\left(\frac{2\pi t}{3}\right) + 0.1075Cos\left(\frac{2\pi t}{6}\right) - 0.288Sin\left(\frac{2\pi t}{6}\right) - 0.463Cos\left(\frac{2\pi t}{12}\right) \qquad (7)$$

where *t* is in months. Figure 8 depicts the variation in seasonal factor for the reclaimed water demand as represented by Equation 7. For reclaimed water demand there is significant variation during a year.

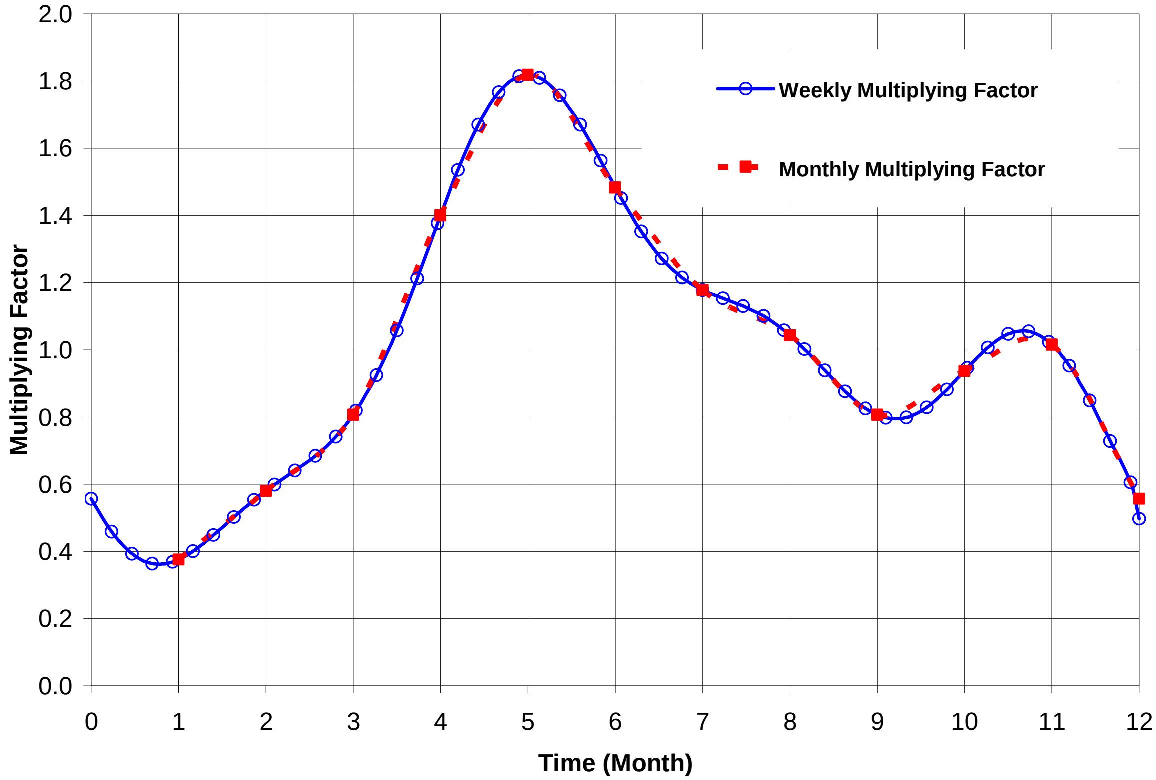

Figure I-8. Predicted Seasonal Variation in Reclaimed Water Demand