Summary and Methodology
C-25 Basin and Upper St. Johns River Basin Reconnection
St. Lucie and Indian River Counties

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Final

Prepared for

SJRMWD
4049 Reid Street
Palatka, Florida

and

SFWMD
3301 Gun Club Road
West Palm Beach, Florida

Prepared by

PBSJ

482 S. Keller Road
Orlando, Florida

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Executive Summary

This project initiates a process to evaluate the benefits and constraints of restoring hydraulic connection between basins along the C-25 canal bordering the SJRWMD and SFWMD. Hydraulic re-connection is a return toward restoring pre-development flows with the added benefits of increasing water supply and improving water quality. This report summarizes available data, identifies stakeholders, estimates freshwater available for storage, demonstrates reservoir sizing, examines differences in rainfall between Districts, and presents a methodology for further analysis.

The study area is currently drained by an extensive network of canals and drainage ditches that discharge on the east coast to the Indian River Lagoon (IRL) estuarine system and to the north to the Upper St. Johns basins and Blue Cypress Water Management Areas (Figure ES-1). In concert with restoration, tandem goals are to capture freshwater currently lost and to increase flexibility in managing flows for flood control and consumptive use. In the final analysis, benefits and constraints that will be evaluated include, but are not limited to,

- Water supply augmentation,
- Reduction in groundwater pumping and protection from saline intrusion,
- Improvement in soil and surficial aquifer salinity levels (currently elevated from pumping Upper Floridan Aquifer groundwater for agricultural irrigation),
- Restoration of timing and volume of flows to estuarine environments,
- Increased flexibility in source and timing of fresh water available for all uses in multiple basins,
- Increased storage capacity and increased flexibility for directing flow to storage,
- Water quality improvements (groundwater, surface water, and estuarine water quality),
- Wetland augmentation, restoration, mitigation, and/or construction,
- Restoration of flows necessary to maintain minimum flows and levels, maintain recession dynamics, and maintain variability within naturally occurring ranges,
- Maintenance of current levels of flood protection,
- Utilization of the lowest quality water to fulfill the needs of different water uses, and
- Compatibility with local and regional water and land use plans.

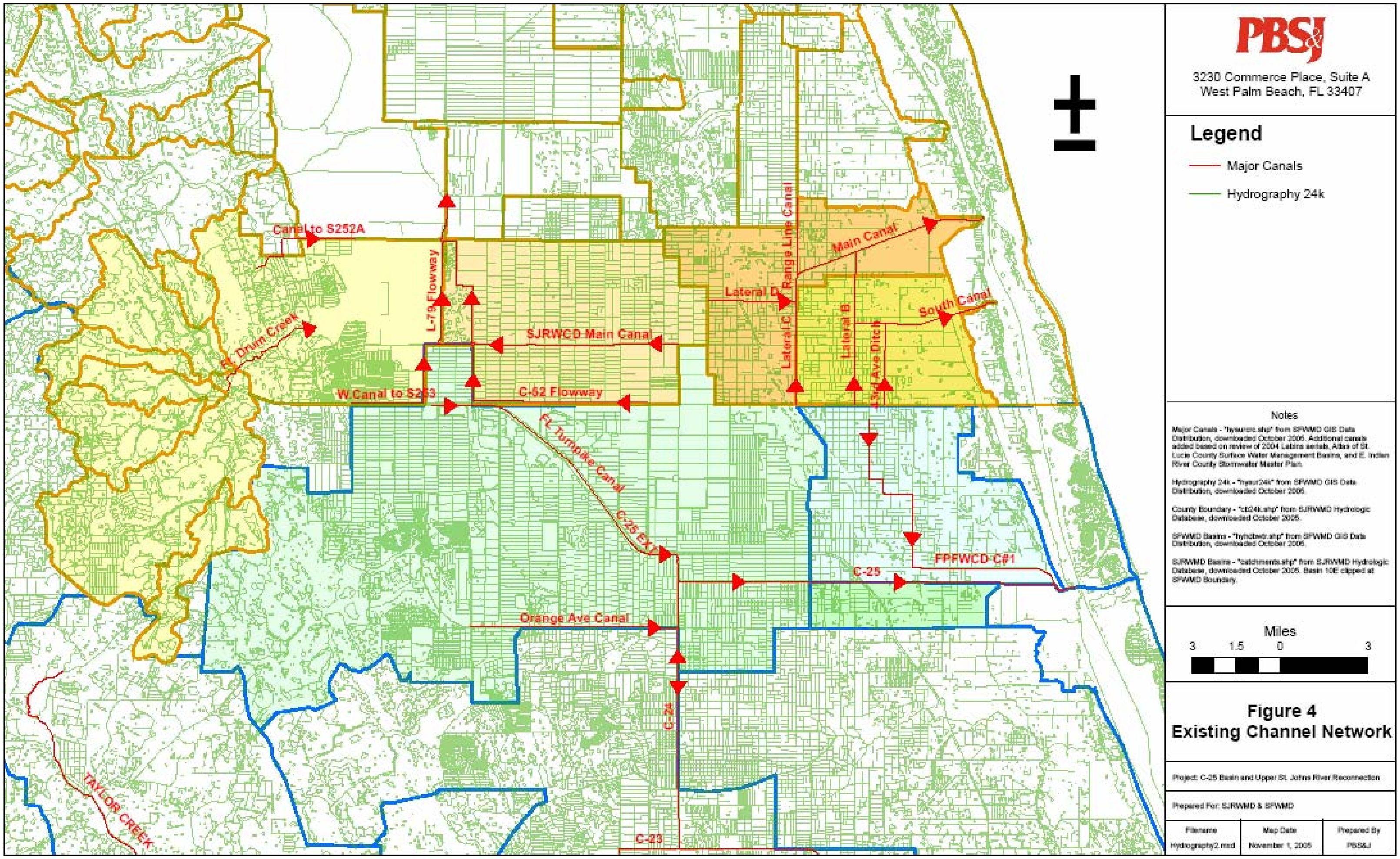


Figure ES-1 Existing Drainage Network in the Study Area

The main discharge points within the study area are listed below. The S-50, Main, and South spillways were selected for this analysis because daily mean flow data are available for each over a reasonably long historic record (40 or more years). These three points discharge drainage from about half of the study area acreage.

Table ES-1 Drainage Basin Area (Acres)

Discharge Point or Spillway	Drainage Basin(s)	Approximate Drainage Area (Acres)	Percent
S-50	C-25 C-25 East	110,000 6,000	40%
Indian River Farms - South	South Portions of 10E	17,000	6%
Indian River Farms - Main	Central Portions of 10E	22,000	8%
FPFWCD	Basin 1	26,000	9%
SJWCD	Portions of 6A Portions of 6C	78,000 29,000	37%
Total		288,000	100%

Analysis of Daily Mean Flow Data at Discharge Structures

This report presents estimates of the volume of water available based on daily mean flow and stage data at several discharge points within the study area. Logically, when the water reaches the point of discharge, all upstream basin functions (inflows, storages, withdrawals, and losses) are accounted for. Thus, the volume that reaches the discharge structure is the remaining fraction of freshwater available for redirection.

As example, the S-50 spillway is the primary point of discharge from the C-25 canal. The C-25 canal drains freshwater from approximately 116,000 acres in Basins C-25 and C-25 East. The canal discharges through the S-50 spillway to the IRL. Daily mean flow and stage data for the S-50 Spillway are available for the period of record from December 1964 to September 2005.

Similarly, daily mean flow discharge data are available for the Main and South spillway in the Indian River Farms Water Control District for longer periods of record (1949 to 2004 and 1950 to 2004, respectively). The use of data over several decades helps to account for hydrologic variability over time. Historic flows for these three points account for drainage over about half of the study area acreage.

The flow data were imported to a spreadsheet for analysis. The daily data were summed and averaged monthly and annually. The volumes of water available at various pumping rates were calculated to demonstrate potential capture volumes and losses. The pumping calculations assumed constant rates of continuous pumping based on available water from daily mean flows.

The data from just these three discharge points (S-50, Main, and South spillways) indicates that millions of acre-feet of freshwater have been lost over the past 50 years from man-made ditches and channels. If the volume from all discharge structures in the basins were included in the analysis, the estimated losses (conversely, the estimated available water) would be higher. Total volumes calculated from 40 to 50 years of record indicate there is sufficient volume from just these three discharge points to justify further analysis of hydraulic re-connection.

The total volume of water available from each of three of the five primary discharge points in the basins is summarized below with the total period of record shown in the first table (ES-1). The second table (ES-2) and chart summarizes total flows for the corresponding years where the three datasets overlap (1965-2004).

Table ES-1
Estimation of Available Freshwater per Spillway
3 of 5 Primary Discharge Points in the C-25 and Upper St. Johns Study Area
Based on Daily Mean Flow Data at Each Spillway for 40 to 50 Years of Record

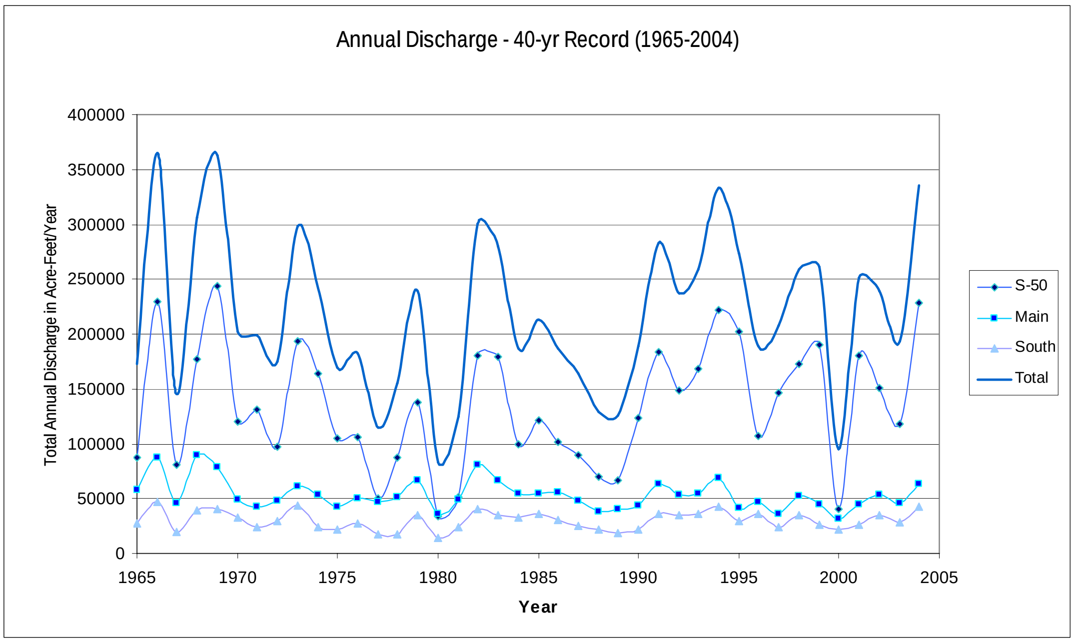
	C-25 Canal	Indian River Farms	
	S-50	Main	South
Years of Record	1965-2005	1949-2004	1950-2004
Grand Total (acre-ft)	5,540,675	3,008,205	1,573,950
Median (acre-ft per year)	131,513	50,729	29,028
Minimum* (acre-ft per year)	33,524	19,141	10,256
Maximum (acre-ft per year)	243,780	96,637	47,139
Standard Deviation (acre-ft per year)	55,081	14,942	9,070

* Minimum volumes for S-50 and Main are conservative in that there were days of record missing in these years.

As example, the following summarizes data that can be roughly estimated from this analysis.

- In excess of 10 million acre-feet of fresh water has been discharged off the coast over the past 50 years.
- The C-25 canal drains about 40% of the study area and 3 times the acreage of the Main and South spillways; S-50 has discharge volumes over 1.5 times the sum of the Main and South spillway volumes.
- Redirecting flows from multiple discharge points to a single or series of reservoirs may maximize capture volumes and flexibility in determining optimum pump and delivery schedules.

Table ES-2 Estimation of Available Freshwater – Total 3 Spillways 3 of 5 Primary Discharge Points in the C-25 and Upper St. Johns Study Area Based on Daily Mean Flow Data at Each Spillway in Overlapping Years of Data 1965-2004		
	Total S50 + Main + South	
Grand Total (1965-2004)	8,731,379	Acre-feet over 40 years
Median	204,661	Acre-feet per year
Minimum	82,978	Acre-feet per year
Maximum	364,541	Acre-feet per year
Standard Deviation	72,309	Acre-feet per year



- In looking at the 40 years of overlapping data for the three discharge points, an estimated total of 200,000 acre-feet of water may be available per year (median value).
- In given years, this may range from a low of about 80,000 to peak flows of about 350,000 acre-feet per year for the 3 discharge points.
- From interviews and review of past reports, it appears more than 22,000 acres of suitable land may be available for purchase in the study area to accommodate one or more large reservoir storage areas.

- It appears that the network of drainage ditches and canals necessary to connect these flows to storage areas already exists. More study is needed to determine what, if any, modifications might be required to accommodate the flows.

As a note it is highly recommended that future analysis use a data time range consistent with CERP projects, currently this is the 41 year range from Jan 1, 1965 through December 31, 2005. This report uses the range from Jan 1, 1965 to December 31, 2004 because complete datasets for 2005 were not yet available for all of the discharge points. This should be updated in future analyses.

<u>Preliminary Method of Reservoir Sizing</u>

A spreadsheet analysis of cumulative flows was developed to simulate filling a reservoir over 40 years and to give a preliminary estimate of optimum size based on various pumping rates. This *preliminary* analysis was constructed as demonstration; it is not complete and will require further development prior to use of even preliminary results.

For example, Figure ES-2 depicts a simulation, based on the historical data from the past 40 years, of a 30,000 acre – 30-foot deep reservoir storing available water from the S-50 spillway pumped at a continuous rate of 1000 cfs. Based on the previous flow analysis from the 3 spillways, this is roughly 93% of the available freshwater.

As noted, this simulation is not accurate but the order of magnitude estimates allows preliminary planning in terms of the size and placement of storage options. In reality, the storage areas might be filled progressively in cells and there may be a combination of storage and treatment options.

Max Surface Area	30000	ac
Storage Depth	30	ft
Side slope	4	:1
bank width	120	
Assume:	Length =	2 width
b =	720	
Bottom Width =	25382.32384	ft
Bottom Length =	50764.64768	ft
Bottom Area =	29580.45746	ac
Ratio to top area	0.986015249	
Total	893706.8619	ac-ft
Initial Volume %	0	
Initial Volume	0	
Outflows		
ET	0.008219178	ft/day
Use	300	ac-ft/day
Refer Reservoir Stage and ET chart for time dynamics.		
Rain	0.010958904	ft/day
	48	inches/yr
Seepage	20%	percentage of Rainfall
	65.75342466	ac-ft/day
Pumping Rate	1000	cfs

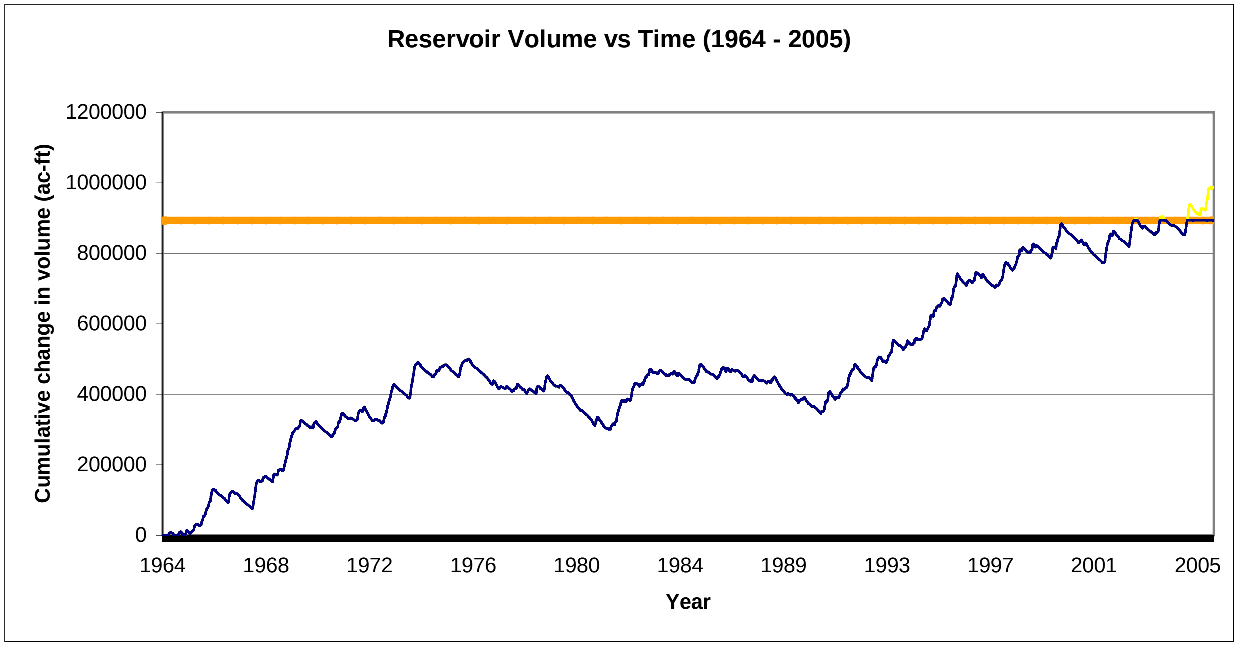


Figure ES-2 S-50 Daily Discharge, Pumping Rate = 1000 cfs, Maximum Cumulative Volume = 985,925 ac-ft

Rainfall Distribution Between the SJRWMD and SFWMD in the Study Area

Two long term rainfall monitoring points were selected to evaluate the variability of local rainfall and water availability across the SJRWMD-SFWMD boundary. The analysis includes three approaches to evaluating rainfall input conditions:

- cumulative rainfall differences between stations over the period of record, looking in particular for systematic variability,
- comparison of rainfall totals in several temporal quanta (total, annual, monthly, weekly) to observe patterns of difference, and comparison of these differences to variances determined for each quanta to detect statistically significant deviation, and
- examination of the statistical properties of the data for differences; exploring variability in daily rainfall volume-frequency relationships.

-

Cumulative Delivery Although total rainfall over the entire period of record differ by about 1%, the pattern of delivery over that time deviates substantially from random variability (Figure ES-3) The peak difference in cumulative rainfall is over 10 feet (120”) of rainfall, a total that would be expected to have significant consequences for local water supply variability.

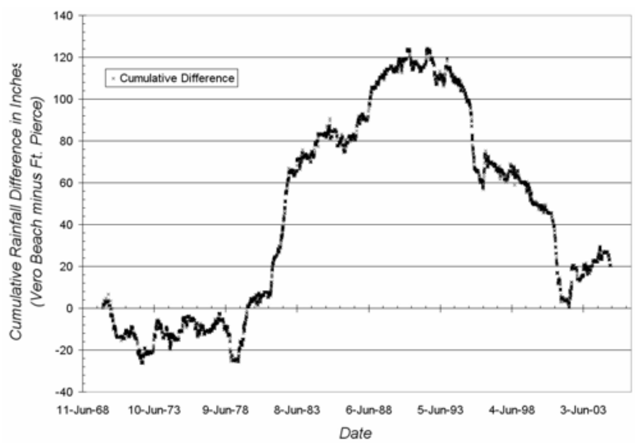


Figure ES-3. Cumulative rainfall difference between Vero Beach and Ft. Pierce Towers, 1969 to 2005.

Quantized Rainfall Comparisons To compare the frequency of significant deviations from equal rainfall delivery, the rainfall data were divided by several quanta (month, week, year) and the time series of differences were plotted. The plots show that there are regular occurrences of significant deviation from the expected condition of equal rainfall delivery at both time scales.

The relatively large differences in total rainfall that are used as thresholds for each quanta, and the high frequency of exceedance further reinforce the conclusion that rainfall delivery can vary between areas with sufficient magnitude to warrant consideration of local water storage and transfer.

Statistical Rainfall Delivery Properties The final analysis evaluates the implicit properties of the rainfall delivery systems at each location. Figure ES-4 below shows the relationship between rainfall event frequency and magnitude. As expected, the relationship is logarithmic (log[frequency] α rainfall^{-1}) and qualitatively similar between locations. We note that large events (>5") are statistically less likely at the Ft. Pierce location, but, given the relatively short period of record, this is assumed to be circumstantial. The slope and intercept values of fitted lines are not statistically significantly different (a = 0.05) suggesting that the intrinsic properties of the rainfall delivery between the locations are the same.

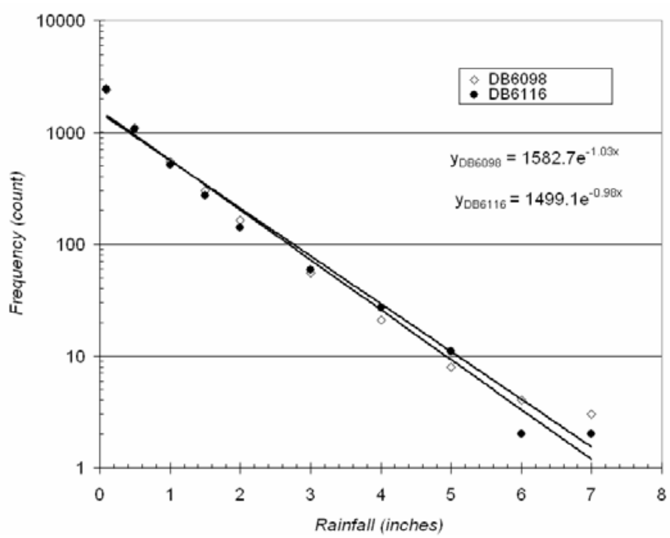


Figure ES-4. Comparison of frequency-magnitude relationship for rainfall delivery between locations. Fitted lines (exponential curves) are shown; parameter values for the fitted lines are not statistically different based on predicted standard error estimates.

In summary, this is a preliminary analysis and further work could document variability between additional stations over longer time to deduce if these data are anomalous. However, based on these observations, it appears that there is significant variability in rainfall delivery between locations over a time scale that warrants further study of storage and delivery alternatives providing local shared access between Districts to attenuate water allocation constraints.

Methodology for Conceptual Design through Final Plans

A general approach for further study is outlined in this report and is listed below – although presented as a chain of events, it is an adaptive process with successive steps potentially feeding back to and refining prior steps (Figure ES-5).

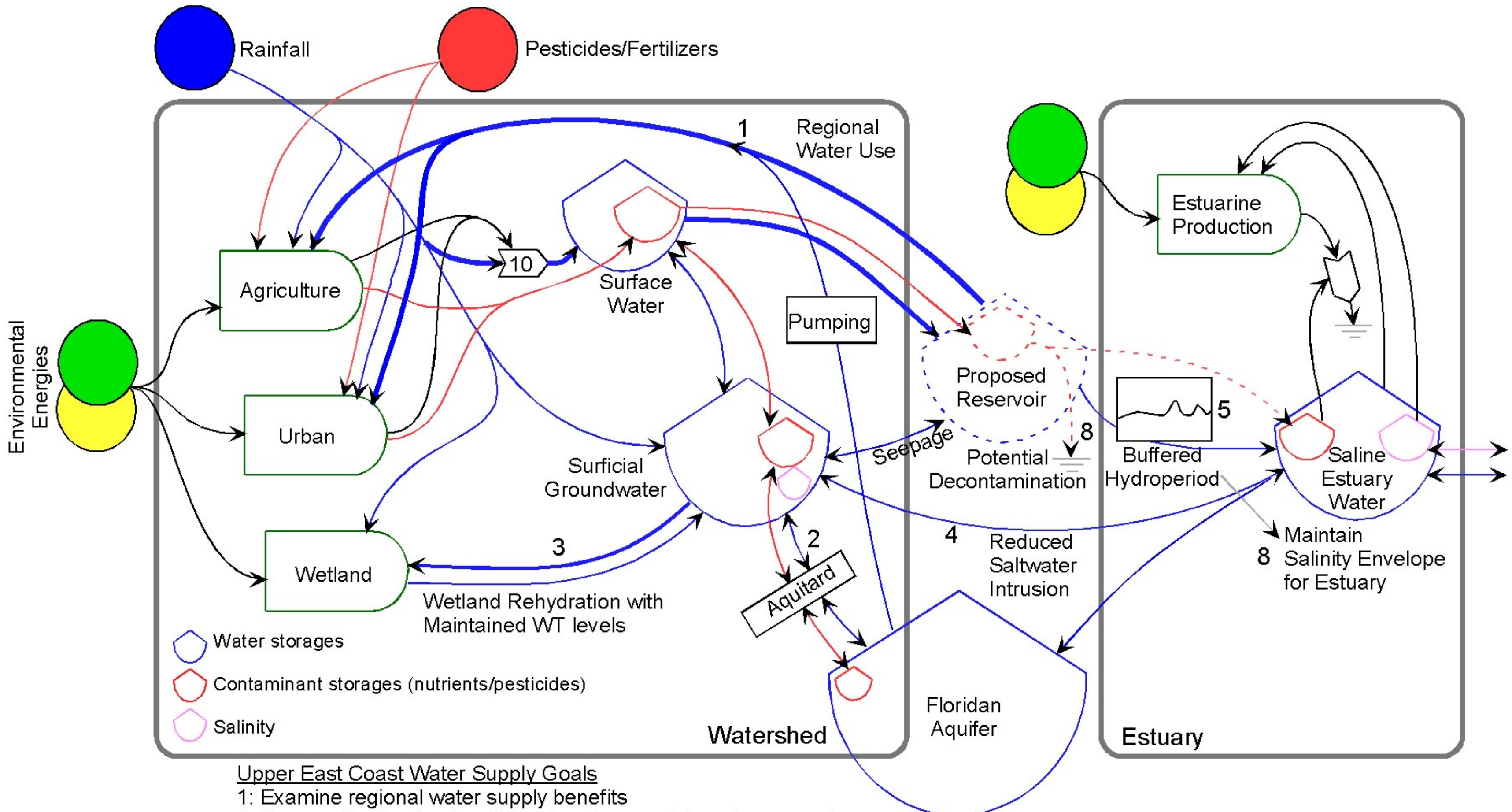
- Conceptual Model and Alternative Formulation
- Dynamic Systems Model and Preliminary Scenario Analysis
- Hydraulic and Hydrologic Model
- Geotechnical Studies
- Feasibility Studies
- Basis of Design Report
- Preliminary Design Through Final Plans and Specifications

Summary

There are a number of previous reports and modeling efforts for basins in this study area. However, each was prepared for only a portion of the study area and each had different goals and objectives. The analysis in this report directly uses available historic discharge data. These data indicate that in excess of 10 million acre-feet of fresh water has been discharged off the coast over the past 50 years and, further, a median value of about 200,000 acre-feet of water will continue to be discharged each year. The mitigation of this loss and the potential benefits of restoring natural flows warrants further study in this area.

A next step in the recommended methodology is to summarize demands and critical interactions. Together these data form the basis for preliminary scenario analysis. Statistical review of historical data indicate that there are local, short-term, differences in rainfall between the two Districts. These differences are sufficient to warrant restoration of cross-boundary flows in the form of shared storage and flexible distribution systems. Land use in the region is projected to rapidly shift to urban and residential coverage. This joint storage can serve as a flexible future source of drinking water for both Districts and a buffer for use by either District in times of local drought, fire, or unexpected need or offering additional diversion and capacity in times of excess water. This preliminary analysis indicates that the volume of freshwater currently lost, the projected future growth of this region, the on-going impacts to the IRL, and the variability in local rainfall in the area, all provide justification for the continued study and evaluation of this project. .

Figure ES-5 Systems Diagram of Conceptual Study Area



<u>Upper East Coast Water Supply Goals</u>

1: Examine regional water supply benefits
2: Protect Floridan Aquifer (limited exchange with surface water)
3: Protect regional wetlands
4: Reduce saltwater intrusion
5: Establish maximum drought levels (for wetlands and estuaries)
6: Flood protection **(unknown)**
7: Compatibility with local governments **(unknown)**
8: Protect St. Lucie Estuary and Indian River Lagoon (salinity envelope maintenance and contaminant removal)
9: Link with other Regional Planning Efforts **(unknown)**
10: Effect of land development on surface water dynamics via impervious surfaces, compaction, tile drainage, canals, etc.

1.0 Introduction and Project Background

The purpose of this project is to conduct a preliminary assessment of the C-25 Basin and Upper St. Johns River Reconnection, St. Lucie and Indian River Counties, and a corresponding compilation of data available to support a more detailed feasibility analysis of the project. Project tasks are described in Statement of Work (SOW) No. 34, contract SE604F0, issued by the St. Johns River Water Management District (SJRWMD) and in cooperation with the South Florida Water Management District (SFWMD). The C-25 canal is a constructed conveyance that discharges to the Indian River Lagoon (IRL) estuarine system. Canal construction altered historic flow paths. Historic surface water flows varied between flow south through Five- or Ten-Mile Creek or overland flow to the north, depending on seasonal rainfall and storage availability.

This project initiates a process to evaluate the benefits and constraints of restoring hydraulic connection between basins along the C-25 canal bordering the SJRWMD and SFWMD. Hydraulic re-connection is a return toward restoring pre-development flows with the added benefits of increasing water supply and improving water quality. This report summarizes available data, identifies stakeholders, estimates freshwater available for storage, and presents a methodology for further analysis.

The SOW tasks the development of a methodology for evaluating the quantity and frequency of available water assuming basin reconnection and the construction of reservoirs and/or the use of wetland augmentation for water storage. This includes development of a method for use in feasibility analysis to evaluate water quality benefits to the Indian River Lagoon, local water supply augmentation, flood reduction, and the reduction in agricultural groundwater withdrawals for irrigation. The reconnection cannot result in unmitigated loss of existing environmental, water supply or flood control.

Section 1.0 of this report gives an overview of the project background and goals. Section 2.0 provides tables of available reports and data provided by SJRWMD, SFWMD, and other sources. Section 3.0 includes a summary of stakeholder interests and Section 4.0 provides preliminary analyses of the volume of fresh water currently and historically discharged to the IRL. Section 5.0 includes a brief outline of possible work efforts to initiate analysis and evaluation of the volume, frequency, and benefits of hydraulically reconnecting the basins and constructing a reservoir for storage of water supply.

1.1 Project Background

The study area is located within St. Lucie and Indian River Counties (Figure 1). This includes an area roughly bounded by State Highway 60 and County Road 68 with the entire SFWMD C-25 and Ft. Pierce Farms (Basin 1) drainage basins and the portions of the Upper St. Johns River Basin Project (USJRBP) and Basin 10E (Figure 2). Many studies have been performed in various basins and both Districts have evaluated storage and water quality treatment facilities.

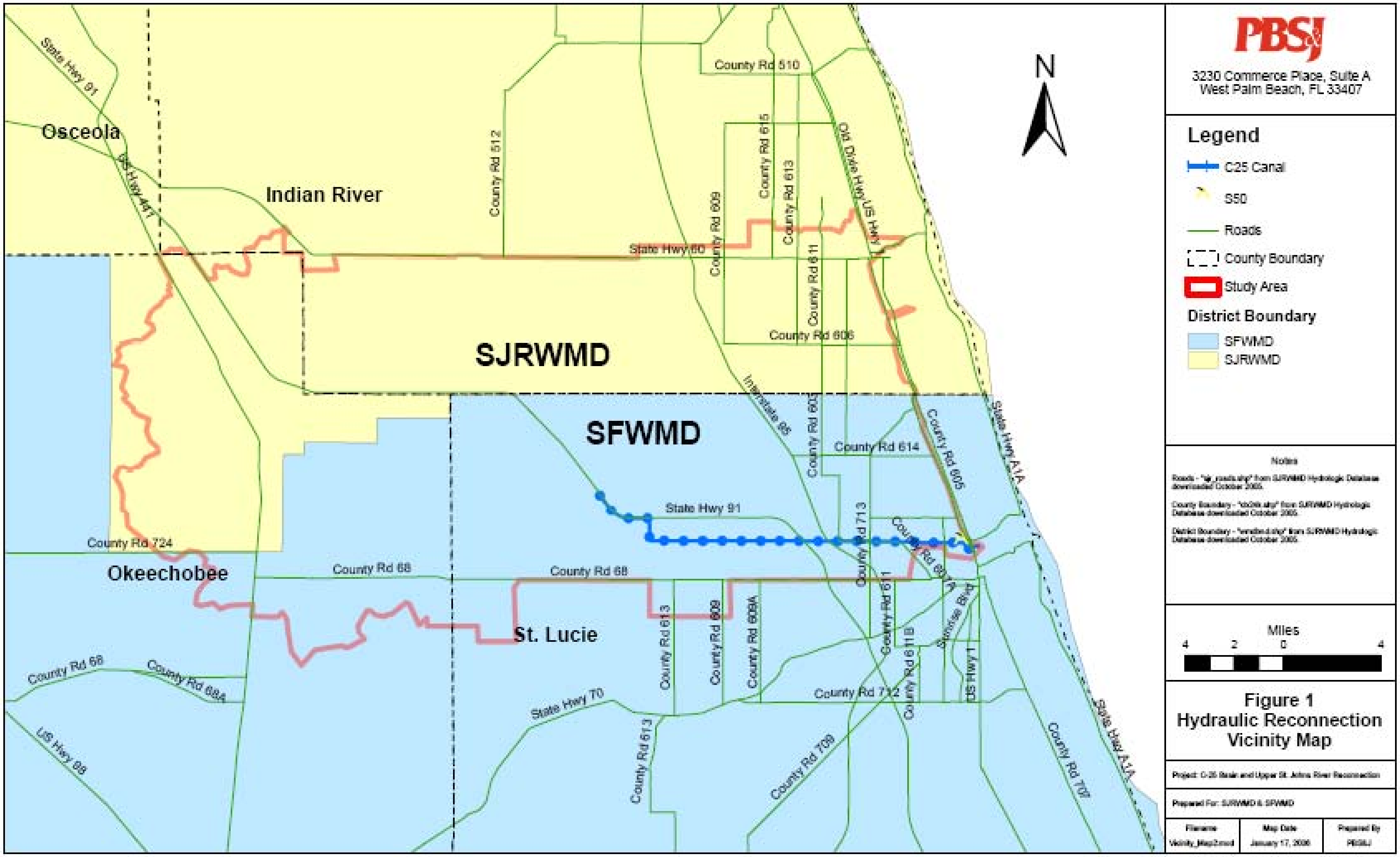


Figure 1 Hydraulic Reconnection Vicinity Map

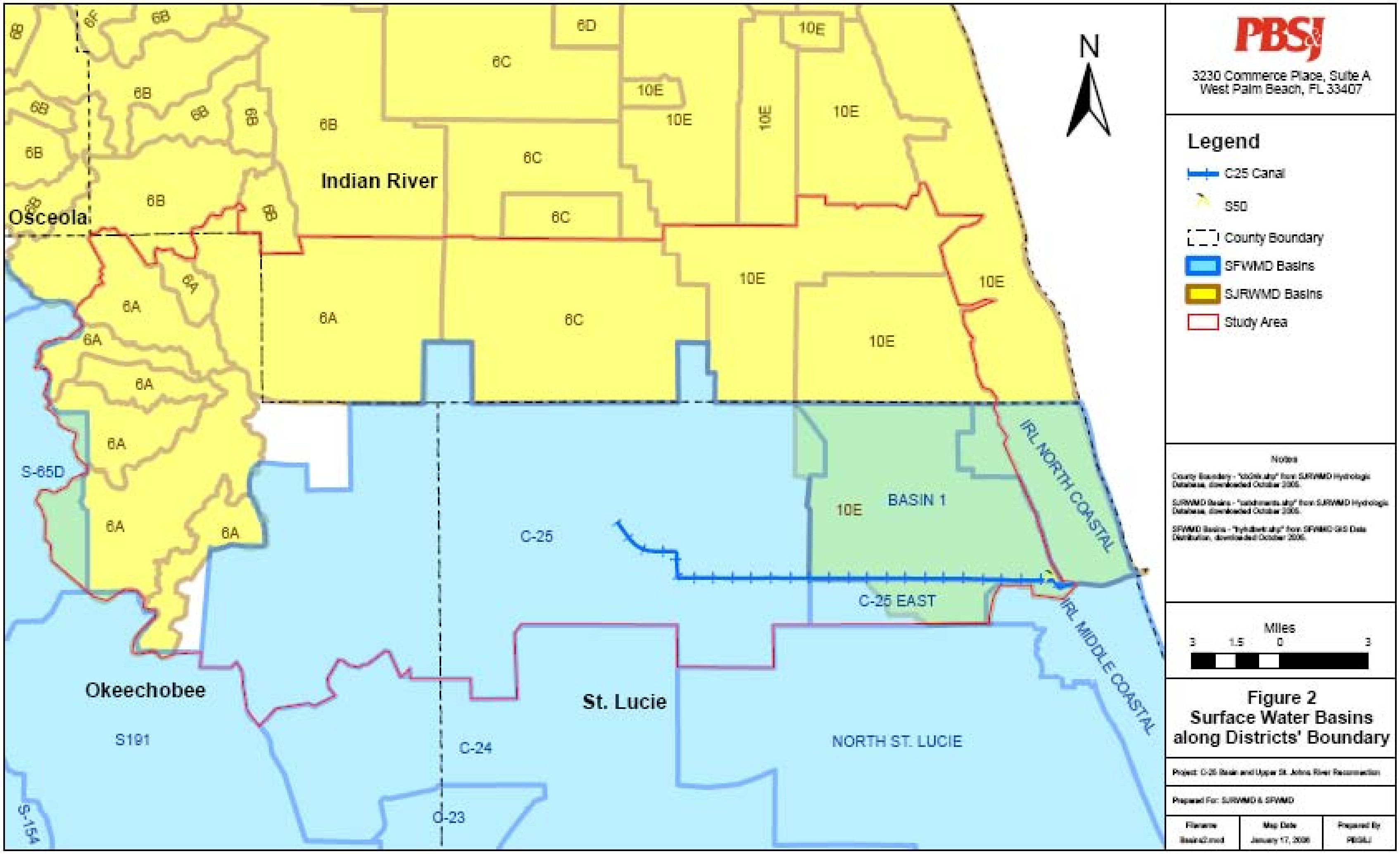


Figure 2 Surface Water Basins along Districts' Boundary

As stated in the SOW:

> There are many citizens on both sides of the agencies' borders who believe that hydraulically reconnecting this divided basin and the construction of additional water storage would result in beneficial water supplies and flood protection available to local users and additional benefits to the local environment.

Excerpts of prior studies highlighted in the SOW are included below and highlights from additional background material review follows.

SFWMD C-25 and Ft. Pierce Farms Basins (excerpts from SOW)

> The primary drainage basins on the SFWMD side of the canal are the C-25 and the Ft. Pierce Farms Basins. HSPF (Hydrologic Simulation Program Fortran) data have been provided for a period of record covering 1965-1995, including time-series of simulated flows and recorded stages entering the Indian River Lagoon near the Ft. Pierce Inlet.
>
> SFWMD and the U. S. Army Corps of Engineers have completed a detailed study for the design of a storage and water quality treatment facility in the C-25 and neighboring drainage basins within SFWMD boundaries. A daily time series of simulated flows for C-25 representing the implemented plan is available. Additional storage may be proposed in the C-25 or another SFWMD basin or in basins on the SJRWMD side of the border.
>
> Recommendations for additional storage in this project should:
> - minimally provide the same or equal benefits to the region as the recommended Indian River Lagoon – South (IRLS) components in the C-25 basin; and
> - provide a description and analysis of benefits to justify any additional cost of providing additional storage or water quality treatment.

Upper St. Johns River Restoration Project (excerpts from SOW)

> The Upper St. Johns River Restoration Project consists of a complex series of reservoirs, water quality treatment facilities, canals and flowways. The system is used for flood control, water quality treatment, and environmental and agricultural water supply purposes. It begins at the boundary between the SJRWMD and SFWMD and extends northward to State Highway 528. It includes more than 125,000 acres of pristine and restored freshwater marshes.
>
> In close coordination with SJRWMD staff, recommendations in this project should:
> - determine if the USJRBP is the optimal basin for the connection, or
> - identify other potential basins and property.

The following provides a brief review of project area background and historical conditions based on a review of available material. This information will be used to develop a conceptual basis for hydraulic reconnection alternatives and in the development of an evaluation methodology.

Historic Conditions

Pre-development conditions within the study area were characterized by a “large spatial extent of south Florida wetlands.” (USACE, 2004) As such, most stormwater was contained on land and either stored in shallow wetland reservoirs, transpirated back to the atmosphere or infiltrated into the subsurface groundwater system. Only limited volumes of stormwater from the most coastal areas ultimately discharged to the Indian River Lagoon (IRL).

Records and analysis indicate that prior to the construction of drainage and flood control facilities, stormwater flowed across the SJRWMD and SFWMD boundary. Because of the flatness of the natural terrain, the direction of flow was influenced as much by the intensity and spatial distribution of rainfall as it was by the slope of the ground surface (SJRWMD SOW). A digital elevation map of the study area is provided in Figure 3. Overall ground surface elevation slopes from highs in Okeechobee and Osceola Counties in the west to sea level along the eastern coast. There is little to no elevation relief directing flow across the SJRWMD and SFWMD boundary.

Current Conditions

Over the past 100 years, significant alterations have been made to the landscape and drainage patterns in order to address development, farming and flood protection demands. Most of the study area is now defined by farming and ranching activities as well as some residential development. Only limited “natural” areas remain and are concentrated within the northwest portion of the study area within the Ft. Drum Marsh and Blue Cypress Lake watersheds. The study area is underlain by the shallow surficial Aquifer which influences flow levels within the canal networks. The Floridan Aquifer underlies the surficial aquifer and is used intensively in the study area, primarily for Citrus irrigation. (SFWMD, 1992).

The Study Area (C-25, B-1 & 10E) is defined by a complex and dense network of primary, secondary and tertiary constructed drainage channels. Flow and water levels within most of the drainage channels including tertiary channels are controlled by weirs and other man-operable structures to facilitate flood protection and irrigation uses. As such, drainage timing, flow and volumes are likely to fluctuate depending on status of control structures within each drainage basin.

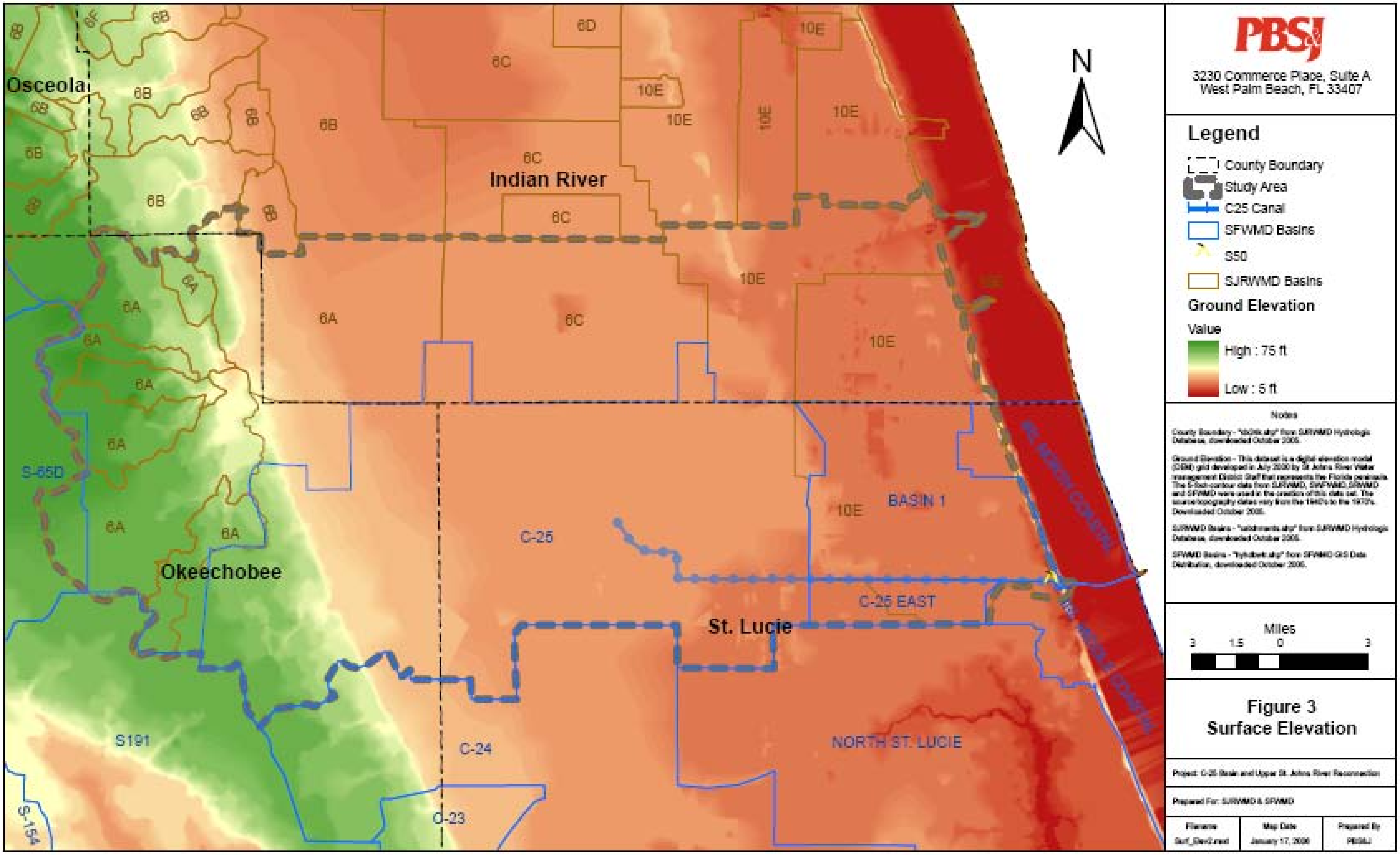


Figure 3 Surface Elevation

Water Resource Conservation Areas (WRCAs)

SJRWMD defines WRCAs as those areas where impacts of current or projected water supply withdrawls exceed the established constraint criteria for natural systems, for ground water quality, or for existing legal users of water, or where the water supplier has failed to identify an adequate supply source to meet the projected need. Five constraints were established for identifying WRCAs:

- impacts to native vegetation, primarily wetlands,
- impacts to minimum flows and levels, primarily spring flows,
- impacts to groundwater quality in terms of increased salt water intrusion,
- impacts to existing legal users, and
- failure to identify a source of supply for future development.

The 1998 SJRWMD assessment indicates that 40% of the District is in WRCAs, including all or parts of Brevard, Duval, Flagler, Lake, Orange, Osceola, Seminole, St. Johns, Putnam, and Volusia counties. Priority Water Resource Caution Areas (PWRCAs) are defined as areas where water supply may not be adequate to meet future demand within their boundaries. The 1998 boundaries of the PWRCAs include: northern St.Johns County, southeastern Duval County and a portion of Lake County south of the Ocala National Forest. These areas are identified because both have significant planned growth without an identified source of supply.

Changes in projected quantities and locations of 2020 groundwater and surface water withdrawals can change the boundaries of PWRCAs. Therefore, areas located outside of the identified priority water resource caution areas should not be assumed to be able to support future groundwater and surface water withdrawals without resulting in unacceptable water resource conditions.

While none of the PWRCAs are directly within the study area, a large PWRCA is in the northern portion of the Upper St. Johns River Watershed which contains Ft. Drum Marsh and Blue Cypress Creek basins. Diversions of available surface water within the study area could conceivably augment surface and groundwater supplies in these downstream regions.

SFWMD defines WRCAs as areas that have existing water resource problems or are placed where water resource problems are projected to develop during the next 20 years (previously referred to as critical water supply problem areas). The Upper East Coast (including the study area) and the Lower East Coast are considered WRCAs. Projects providing additional water supply and mitigation of impacts are needed in these areas.

1.2 Study Area Goals

In the study area, freshwater flows to the IRL have increased in both quantity and frequency as a result of the aggregate alterations to landscape and drainage patterns (PBS&J, 1999; USACE, 2004). In addition, high concentrations of sediments and nutrients within the freshwater discharges may have adversely impacted the pre-existing habitat communities within the IRL (USACE, 2004 and PBS&J, 1999). Much of the historic wetland area has been replaced by farmland and other forms of development. Wetlands that remain have been adversely impacted by changes in surface water flow and surficial aquifer groundwater elevations associated with the dense network of drainage and irrigation channels.

Agricultural interests withdraw groundwater for irrigation from a unit in the Floridan Aquifer that is higher in total dissolved solids (TDS) than the surficial aquifer. A fraction of the irrigation water infiltrates back into the ground and recharges the surficial aquifer. The higher TDS content of the water has increased the salinity of the soils and the surficial aquifer over time. This creates a negative feedback loop that concentrates salts and increases the salinity of the groundwater in both the surficial and lower aquifer units and results in a fractional loss of groundwater resources to runoff, evapotranspiration, and plant uptake. The re-direction and use of stored surface water that is currently discharged to the estuary could provide an alternate source of irrigation water. This would help to mitigate salinity increases and recharge groundwater losses.

In summary, the following are goals to be considered in the evaluation of the hydraulic reconnection of the basins:

- Reduction of anthropogenic freshwater flows and restoration of water quality in the IRL
- Restoration, augmentation, mitigation, and/or creation of wetland areas
- Augmentation of water supply and reduction of the volume of groundwater and surface water losses
- Mitigation of saltwater intrusion and degradation of groundwater quality
- Improvement in groundwater and surface water quality
- Restoration of flows necessary to maintain minimum levels, maintain recession dynamics, and maintain variability within naturally occurring ranges (i.e., avoidance of rapid reduction in flow, rapid discharge of peak flows, and frequent variations 'shocking' the system outside of recoverable ranges)
- Maintenance of current levels of flood protection
- Utilization of the lowest quality water to fulfill the needs of different water uses
- Compatibility with local and regional water and land use plans

2.0 Summary of Available Background Data

The following series of tables present summaries of reports and data provided by SJRWMD, SFWMD, and other sources. These include:

- a summary and description of reports or data by source
- a list of material provided, presented as a checklist against items in the SOW

The following tables are included in this section:

- Reports and Data Provided by SJRWMD
  - Table 1: Inventory of SJRWMD Background Materials
  - Table 2: List by Type of Data from SJRWMD
- Reports and Data Provided by SFWMD
  - Table 3: Inventory of SFWMD Background Materials
  - Table 4: List by Type of Data from SFWMD
- Other Reports and Data
  - Table 5: Data Gaps

Table 1: Inventory of SJRWMD Background Materials				
Format	Title	Author (Date)	Basins	Summary and *Comments*
Report - Digital	East Indian River County Master Stormwater Management Plan	East Indian River County (December 2002)	10E	Report summarizes the results of a study of the Indian River Farms Water Control District (IRFWCD) drainage basin. Pollutant load reduction of 50% for nutrients and 60% for suspended solids identified. A series of alternatives to reduce pollutant loads outlined, evaluated and prioritized.
Report - Digital	Environmental Water Management Plan For The Upper St. Johns River Basin Project (USJRBP)	SJRWMD (June 1996)		Plan was developed to direct operation of USJRBP water control structures when project water levels are below flood control regulation schedules. Plan developed using simulated hydrologic stage data derived from the Upper Basin Hydrologic Model. *Several key Figures showing basin features within the study area missing from report.*
Technical data sheets - Digital	Hydraulic design criteria for water control structures and conveyance system "Scan001.pdf"	E-mail from Charles Tai (SJRWMD)	Drainage area above Lake Harney (2043 sq.mi.)	Spillway, Culvert, Weir, levee and canal data for SJRWMD areas.
Report - Digital	District Water Management Plan	SJRWMD (May 2000)	6A, 6C & 10E + multiple other SJRWMD basins.	Long-range guidance document for WMD activities & present compilation of water resource information. First half of document describes District-wide goals and associated programs. Second half describes specific programs and goals to be met within each of the 10 major watersheds.
Report – Hard Copy	Applicants Handbook: Agricultural Surface Water Management Systems Chapter 40C-44, F.A.C.	SJRWMD (March 2003)	N/A	Handbook provides information and guidance regarding the Agricultural Surface Water Management System permitting program. Contains a sample water budget analysis for a potential permittee.
Report - Digital	District Water Supply Plan	SJRWMD (June 2000)	SJRWMD	Summarizes existing water demand (1995) and forecasted water demand in the year 2020. Document also identifies water supply and infrastructure improvements required to meet 2020 usage.
Report - Digital	Pub# SJ2004-SP28 2004 Interim Update to Special Publication SJ200-SP1 District Water Supply Plan	SJRWMD (April 2004)	SJRWMD	The 2004 Update builds on the 2000 Plan.

Table 1: Inventory of SJRWMD Background Materials

Format	Title	Author (Date)	Basins	Summary and *Comments*
Chapter Excerpt - Digital	USJRB model by Rao Chapter 3: Theory	SJRWMD e-mail contained document "usjrbmodel.pdf"	N/A	Chapter describes how the hydrologic cycle is represented in hydrologic models, the specific relations chosen for the model & how various USJRBP components are simulated by the model.
Report - Digital	Paper SJ2001-PP3 Projected 2020 Aquifer Drawdowns at the City of Vero Beach and Indian River County Wellfields	SJRWMD (2001)	10E (partial)	Paper summarizes results of analytical model (MLTLAY) used to simulate changes in the potentiometric surfaces of the surficial aquifer system and the Floridan Aquifer System based on 2010, 2015 & 2020 projected pumpages at the city of Vero Beach and Indian River County wellfields. *Contains hydrogeologic information for the area.*
Report - Digital	Pub# SJ98-SP19 Investigation of Groundwater Resources in Central Indian River County, Florida	SJRWMD (1998)	6A, 6C & 10E (partial coverage of each basin)	Summary of investigation to assess the availability of water in the surficial, intermediate and Floridan aquifer in central Indian River County as a source of supply for citrus irrigation.
Report – Hard Copy	Proposed TMDL Development for the Northern & Central IRL & Banana River Lagoon	EPA (June 2003)	10E	Required 303(d) listing of water bodies in the area not meeting designated water quality standards. Impairment parameters identified in the document. TMDL Parameters for the 10E and Basin 1 [aka Belcher Canal (Ft. Pierce Farms)] basins are identified as Nutients, DO & Chorophyll a.
Report - Digital	Technical Pub# SJ 86-4 Rainfall Analysis for Northeast Florida	SJRWMD (July 1986)	6A, 6C & 10E	Identifies rain gage stations in NE Florida including four gages in the project vicinity: Fellsmere, Fort Pierce, Fort Drum & Vero Beach. Monthly and annual rainfall data provided for each station. *Rainfall data ends in 1984 and not in daily increments.*
Maps – Hard Copy	Potential Landholdings for IRL-North / IRL South Water Resources Project	TAC Environmental (February 2004)	6C	Contains two maps showing potential locations ofr a "SJRWMD and SFWMD Inter-Basin Connection. *Maps not supported by text summary.*
Fact Sheet – Digital	The Upper St. Johns River Basin Project	SJRWMD (October 2003)	6A (partial)	Briefly discusses problems within the USJRB as well as solutions and benefits from the USJRBP. *Excellent map of water management and conservation areas in the USJRBP.*

Table 1: Inventory of SJRWMD Background Materials				
Format	Title	Author (Date)	Basins	Summary and *Comments*
Fact Sheet – Digital	Fort Drum March Conservation Area – Quick Guide	SJRWMD (April 2003)	6A& 6C (partial)	General recreational information about the Fort Drum Marsh. *Good map of marsh and hydraulic structures in the area.*
Fact Sheet – Digital	Blue Cypress Conservation Area – Quick Guide	SJRWMD (April 2003)	6A& 6C (partial)	General recreational information about the Blue Cypress Lake and water management area. *Good map of area and some hydraulic structures in vicinity.*
Imagery – Digital (DVD)	Indian River County 2004 DOQQ	SJRWMD	10E, 6A & 6C (Partial)	Digital aerial imagery in ECW format. Covers Indian River County. *Not all of basins along boundary fully covered.*
Imagery – Website	Land Boundary Information System (LABINS)	FDEP (2005)	10E, 6A & 6C	2004 digital aerial imagery for the entire study area. Link: http://data.labins.org/2003/index.cfm
Imagery – Website	FDEP GIS	FDEP (2005)	10E, 6A & 6C	On-line catalog of GIS shapefiles and imagery including County boundaries, WBIDs, HUC Basins, etc. Link: http://www.dep.state.fl.us/gis/
Imagery – Website	Indian River County Property Appraiser (IRCPA) Public Downloads	IRCPA (2005)	10E, 6A & 6C	On-line catalog of GIS shapefiles and imagery including parcels, city locations, etc. Link: http://mail01.ircpa.org/
Imagery - Website	SJRWMD GIS Download Library	SJRWMD (2005)	10E, 6A & 6C (Partial)	On-line catalog of GIS shapefiles and imagery including, basin boundaries, land uses, aerial imagery, etc. Link: http://www.sjrwmd.com/programs/data.html
Database - Website	SJRWMD Data Index	SJRWMD (2005)	10E, 6A & 6C (Partial)	On-line databases containing rainfall & hydrologic data. Stage data typically limited to less than 10 years at each station. Limited Flow information. Link: http://www.sjrwmd.com/programs/data.html

Table 2: List by Type of Data from SJRWMD	
SOW Item	Received/Obtained Material
1. Aerial or satellite imagery of the study area.	1. Indian River County 2004 DOQQ (DVD-SJRWMD) 2. Imagery also available on SJRWMD website. 3. 2004 DOQQS downloaded from LABINS.
2. Hydraulic design criteria for the related water control structures and conveyance systems within the St. Johns District.	Received e-mail from SJRWMD containing "Scan001.pdf" file, which provides hydraulic design criteria for the following structures: Spillways: S-96, 96B, C, D, 157, 161, 161A, & 164; Culverts: S-231, 251, 250A, 250B, 250C, 252A, B, C, 255, 256, 257 & 258; Weirs: S-250A, B, C & 254; Levees: 73-1, 73-2, 74-E, 74-N, 74-W, 75, 77, 78, 79 & 82; and Canal: 54.
3. Observed water level and flow data for the L-79 flowway and for the Blue Cypress and St. Johns water management areas.	Received e-mail from SJRWMD containing 12 files addressing Item #3. Files contained: BCWMAEast.xls, C-52WestStg.prn, S-251Stg.prn, S-253Stg.prn, S96ADis.xls, S96BDis.xls, S-96BStg.prn, S96DDis.xls, S-96DStg.prn, SJRVero.prn, SJWCDSTG.prn and USJRWMA-2004Dis.prn. Stage and limited flow data for some hydraulic structures in study area also available on SJRWMD online Hydrologic Database. http://www.sjrwmd.com/programs/data.html
4. Environmental hydrologic criteria, water use inventory/requirements, flood control regulation schedules and the simulated hydrologic information.	Received report entitled, Environmental Water Management Plan For The Upper St. Johns River Basin Project – *Figures showing USJRBP area and features mising from the report.*
5. Description of the Upper St. Johns River Model and the simulation process.	Received e-mail containing document "usjrbmodel.pdf" describing the USJRB model.
6. HSPF generated time series of flow in Blue Cypress, Ft. Drum, and Fellsmere planning units.	Received two e-mails from the SJRWMD containing HSPF simulated flows for: S96B, C, D and S252A, B, and C. Time series of flow also provided for S252D. - *Both e-mails accompanied by disclaimer that HSPF models are not yet finished products.*
7. Drainage basin boundary maps.	Basin boundaries available on SJRWMD website. Hard Copy boundaries also contained in District Water Management Plan and East Indian River County Master Stormwater Management Plan.
8. Relevant rainfall and ET data.	Rainfall data on SJRWMD website: http://arcimspub.sjrwmd.com/website/dahds/design/index.html Mean monthly pan evaporation rates contained in Applicants Handbook: Agricultural Surface Water Management Systems Chapter 40C-44, F.A.C. (SJRWMD 2003).

Table 3: Inventory of SFWMD Background Materials				
Format	Title	Author (Date)	Basins	Summary and *Comments*
Report – Hard Copy	St. Lucie Estuary Watershed Water Quality Model for Development of Basin Mgmt Strategies Phase 1 (of 4)	URS Corporation (May 2001)	C-25, Basin 1, + multiple other SFWMD Basins	Document summarizes the initial development of a watershed water quality model for selected basins within the St. Lucie Estuary and Indian River Lagoon watersheds. *Only Phase I report obtained.*
Report - Digital	An Atlas of St. Lucie County Surface Water Management Basins	SFWMD (November 1988)	C-25, Basin 1, + multiple other SFWMD Basins	Atlas contains information about the surface water management basins in St. Lucie County. Contains detailied information on canals and control structures.
Report – Hard Copy	C-25 Basin & Basin 1 Watershed Assessment Volumes A-C	PBS&J (Januray 1999)	C-25 & Basin 1	Volume A - Presents results of data compilation, literature review & watershed characterization for the study area. Volume B - Prioritizes basins delineated in Volume A based on freshwater discharge, nutrient and sediment loading. Volume C - Identifies priority management areas to address freshwater, sediment and nutrient loads to the IRL. *Basin Boundaries do not correleate with most recent District shapefiles from SFWMD GIS Data Distribution.*
Report - Digital	Central and Southern Florida Project, Indian River Lagoon-South (IRL-S) Final Integrated Project Implementation Report (PIR) & Environmental Impact Statement (EIS)	USACOE & SFWMD (March 2004)	C-25, Basin 1, + multiple other SFWMD Basins	Report describes public and agency comment and response, clarifies the plan formulation and alternative selection process, and documents recommended plan features, costs and environmental benefits. *Souce data for determining recommended solutions not part of the report.*
Report – Hard Copy	Hydrologic Report for St. Lucie County And Preferred Database Development Technical Memorandum #401	SFWMD (January 2002)	C-25, Basin 1, + multiple other SFWMD Basins	Summary of the hydrometeorologic data (rainfall, ET, stage & flow) for St. Lucie County available from the SFWMD DBHYDRO database. *More recent data available on dbhydro website.*

Table 3: Inventory of SFWMD Background Materials				
Format	Title	Author (Date)	Basins	Summary and *Comments*
Report – Hard Copy	A 3-D Finite Difference Groundwater Flow Model Of the Floridan Aquifer System in Martin, St. Lucie & Eastern Okeechobee Counties, Florida Technical Publication 92-03	SFWMD (April 1992)	C-25, Basin 1, + multiple other SFWMD Basins	Summarizes the results of a 3-D groundwater flow model (USGS MODFLOW) representing the Floridan Aquifer System (FAS) in the St. Lucie/Martin County area (Study Location Map in Figure 1 on Page 2 of Report). Model developed to be used as tool in establishment of regional comprehensive water supply plans. Assist in evaluating requests for large GW withdrawals. Document summarizes subsurface geology, hydrogeology and groundwater usage demands.
Report - Digital	Upper East Coast (UEC) Water Supply Plan	SFWMD (1998)	C-25, Basin 1, + multiple other SFWMD Basins	Document provides a framework for future water use decisions to provide adequate water supply through 2020. The plan estimates the future water supply needs, weighs those demands against historically used water sources, and identifies areas where these demands cannot be met without harming the resource and environment, including wetlands. The document evaluates the potential of several alternative water source options to meet any unmet demand and makes recommendations for their development.
Report - Digital	Upper East Coast (UEC) Water Supply Plan	SFWMD (2004)	C-25, Basin 1, + multiple other SFWMD Basins	The 2004Update builds on the 1998 Plan.
Report – Hard Copy	Evidence of Impairment: C-25 Canal (WBID 3163B)	FDEP SE District (February 2003)	C-25 & Basin 1	Report summarizes monitoring results for major pollutant parameters associated with the C-25 and Ft.Pierce Farms canals that discharge to the IRL via Taylor Creek.
Report – Hard Copy	Minimum Flows and Levels (MFLs) within SFWMD	The Florida Bar (2003)	Outside area	Legal overview of MFLs and requirements. Describes existing MFLs for 5 areas in District but none within the study area.
Maps – Hard Copy	Potential Landholdings for IRL-North / IRL South Water Resources Project	TAC Environmental (February 2004)	6C	Contains two maps showing potential locations ofr a "SJRWMD and SFWMD Inter-Basin Connection. *Maps not supported by text summary.*
Fact Sheet – Digital	Ft Pierce Farms WCD Canal #1 Ecosummary	FDEP (December 2000)	Basin 1	Information about water quality conditions associated with the FPFWCD Canal as well as information about the drainage area served by the canal including land use and major developments.
Fact Sheet – Digital	SFWMD Canal C-25 Ecosummary	FDEP (May 1998)	C-25	Information about water quality conditions associated with the C-25 Canal.
Database - Website	DBHYDRO	SFWMD (2005)	C-25, Basin 1, + multiple other SFWMD Basins	On-line database containing hydrologic and water quality data for the District. Link: http://www.sfwmd.gov/org/ema/dbhydro/index.html

Table 3: Inventory of SFWMD Background Materials				
Format	Title	Author (Date)	Basins	Summary and *Comments*
Imagery - Website	SFWMD.gov GIS Data Distribution	SFWMD (2005)	C-25, Basin 1, + multiple other SFWMD Basins	On-line catalog of GIS shapefiles and imagery including, basin boundaries, land uses, aerial imagery, etc. Link: http://spatial1.sfwmd.gov/sfwmdxwebdc/dataview.asp
Imagery – Website	Land Boundary Information System (LABINS)	FDEP (2005)	C-25 & Basin 1	2004 digital aerial imagery for the entire study area. Link: http://data.labins.org/2003/index.cfm
Imagery – Website	FDEP GIS	FDEP (2005)	C-25 & Basin 1	On-line catalog of GIS shapefiles and imagery including County boundaries, WBIDs, HUC Basins, etc. Link: http://www.dep.state.fl.us/gis/

Table 4: List by Type of Data from SFWMD	
SOW Item	Received/Obtained Material
1. Aerial or satellite imagery of the study area.	1. Available on website (http://spatial1.sfwmd.gov/sfwmdxwebdc/dataview.asp) 2. 2004 DOQQS downloaded from LABINS.
2. Drainage basin boundaries.	1. Available on website (http://spatial1.sfwmd.gov/sfwmdxwebdc/dataview.asp) 2. Hard copy basin boundaries identified in C-25 Basin and Basin 1 Watershed Assessment and St. Lucie Estuary Watershed Water Quality Model for Development of Basin Management Strategies (Phase I)
3. HSPF generated time series of flow in C-25 and Ft. Pierce Farms Water Control District. Data will be in daily time steps.	Received Excel spreadsheet "c25 & FPF hydrology for IRL preferred alternative.xls"
4. S-99 daily flows as measured.	Available on dbhydro: http://www.sfwmd.gov/org/ema/dbhydro/index.html
5. Rainfall and ET data for period of record.	Available on dbhydro: http://www.sfwmd.gov/org/ema/dbhydro/index.html
6. Storage hydrograph based on the proposed storage facility.	*-Insufficient information obtained to date.*
7. C-25 irrigation demands in daily time increments.	1. Monthly Citrus, Pasture & Sod Irrigation requirements in SFWMD UEC Water Supply Plan (for St.Lucie County). 2. Excel spreadsheet "c25 & FPF hydrology for IRL preferred alternative.xls" also identifies *ag* demands for C-25 and FPF basins.
8. An Atlas of St. Lucie County Surface Water Management Basins.	Report received.
9. C-25 Basin and Basin 1 Watershed Assessment, (3 volumes).	Report received (Volumes A, B & C).
10. Agency Contacts.	Received.
11. Relevant land use, water quality and hydrogeologic data.	1. Hydrogeologic and water quality data available on dbhydro: http://www.sfwmd.gov/org/ema/dbhydro/index.html 2. Land use available on website (http://spatial1.sfwmd.gov/sfwmdxwebdc/dataview.asp) 3. Data also available in C-25 Basin and Basin 1 Watershed Assessment and St. Lucie Estuary Watershed Water Quality Model for Development of Basin Management Strategies (Phase I).
12. Indian River Lagoon-South Project Implementation Report.	Report received.

Table 5: Data Pertinent to Water Budget Calculation						
Data Category	**SFWMD**		**SJRWMD**			
	C-25	**Basin 1**	**10E**	**6A**	**6B**	**6C**
Rainfall	Frm DBHYDRO (Daily) S-99R (1/8/91 – 10/6/05) OR Ft Pierc R (10/31/69 - 4/30/05)		Frm DBHYDRO (Daily) Vero Tow (11/3/69 – 4/30/05) OR Frm SJRWMD Hydrologic Website (Daily) Vero Beach Airport (2/10/96 – 10/23/05) *10E* S-252D @ Fellsmere (2/28/90 – 10/23/05) *6A, 6B, 6C*			
ET	Frm DBHYDRO (Daily) Ft Pier E (3/1/82 – 8/31/05) OR Frm Applicant's Handbook: Agricultural Surface Water Management Systems Chapter 40C-44, F.A.C Calculate Daily ET Rates from Mean monthly Pan rates in Table 11-1 OR Calculate PET using the Blaney – Criddle method (see page 11-3 of Applicant's Handbook, requires Temp & Crop Coefficient, Obtain SCS TR-21)					
Irrigation Demand	Frm UEC Water Supply Plan (2000) Monthly net irrigation requirements for Citrus, Pasture and Sod provided in Appendix A.					
Basin Boundaries	Frm SFWMD Website "hyhdbwtr.shp" (shapefile for C-25, Basin 1, etc.)		Frm SJRWMD Website "catchments.shp" (shapefile for 6A, 6B, 6C, 10E, etc.) *Use SFWMD Boundaries in Ft.Pierce Farms area where boundaries do not match*			
Land Use	Frm SFWMD Website "sec7_99_polygon.shp"		Frm SJRWMD Website "lulc2000_osceola.shp", "lulc2000_okeechobee.shp", "lulc2000_indian_river.shp" & "lulc2000_brevard.shp"			
Soils	Frm SFWMD Website "sossrunt.shp" (SSURGO covers entire project area. North of SH60 not included.)					
Aerials	Frm Labins website 2004 DOQQs					
Canals-Primary	Frm SFWMD Website "hysurcrc.shp" *(Ft Pierce Farms canal not contained within original shapefile. Additional canals digitized based on 2004 aerial imagery & Fact Sheet maps,)*		DATA GENERATED Canals digitized based on 2004 aerials, SJRWMD Fact Sheets & IR County Stormwater Master Plan *SJRWMD reports comparable primary canal shapefile not readily available from District.*			

Table 5: Data Pertinent to Water Budget Calculation

Data Category	SFWMD		SJRWMD			
	C-25	Basin 1	10E	6A	6B	6C
Canals-Secondary	Frm SFWMD Website "hysur24k.shp" (Shapefile covers entire study area)					
Hydraulic Structure Locations	Frm SFWMD Website "hysurstm.shp" *(Gate G-81 and culverts/bridges under FL Turnpike digitized using 2004 aerial.)*		Frm SJRWMD "wcs.shp"			
Hydraulic Structure Dimensions	Frm Atlas of St.Lucie Co Surface Water Mngmt Basins S99: Gated Spillway (2 gates, 15.4' high x 25.8' wide. Net crest length = 50', Crest elev = 5.6' NGVD) G81: Steel Sheet-Pile Dam (3-timber gates on concrete weir, 9.5' high x 5.7' wide, net crest length = 15.0', Crest elev = 13.5' NGVD)	Frm Atlas of St.Lucie Co Surface Water Mngmt Basins S50: Fixed crest weir (126' long, crest elev = 12.0' NGVD) DATA UNAVAILABLE FPFWCD C-1 Structure (No Data)	Frm USGS Main Spillway: Control type, Dimensions, elevation South Canal Spillway: Control type, Dimensions, elevation DATA UNAVAILABLE Lateral C Spillway	Frm SJRWMD S252A: Two 60" CMP culverts at invert 16.0. (w/ Slidegate). Culvert 162' long. S252B: Two 60" CMP culverts at invert 16.0. (no control). Culvert 162' long. S252C: One 60" CMP culvert at invert 16.0. (no control). Culvert 162' long. S252D: One 72" screw gate at 18.0'. S253: 160' long weir with crest elev at 25.5'. DATA UNAVAILABLE SR60 Gap S252A - EWMP also reports one ungated culvert (dimensions not given). *Indicates additional structural data in "USACOE USJRB Water Control Plan."*	Not evaluating data in 6B w/ exception of structures along 6A/6B boundary as recorded under 6A.	Frm SJWCD Fax (11/23/05) SJWCD Discharge Structure: Four bottom opening radial gates + One three piece bottom opening lift gate. Gates 20' per gate bay. Top of gates at 27.44' msl.

Table 5: Data Pertinent to Water Budget Calculation

Data Category	SFWMD		SJRWMD			
	C-25	Basin 1	10E	6A	6B	6C
Stage Data	Frm DBHydro (Daily Mean) S99H (2/27/64 – 9/27/05) S99T (2/26/64 – 9/27/05) G81H (9/26/95 – 9/25/05) G81T (9/26/95 - 9/25/05)	Frm DBHydro (Daily Mean) S50H (12/8/64 -5/18/95, 5/31/95-9/23/05) DATA UNAVAILABLE FPFWCD C-1 Structure (No Data)	Frm SJR HydData Website Lateral-C Canal *(1/2/88 – 7/31/89)* Frm USGS Main Canal 1950-2004 South Canal Spillway 1949-2004	Frm SJR HydData Website S253 L,H (12/12/96 – 12/31/04) S252A N (2/8/95 – 12/18/03) S252A S (2/8/95 – 10/26/05) S252B N,S *(4/12/94 – 10/30/01)* S252C N (2/1/95 – 11/11/03) S252C S (2/1/95 – 10/26/05) S252D (9/3/98 – 10/26/05) FtDrumMarshCenter (1/5/02 – 7/27/05)	Not evaluating data in 6B w/ exception of structures along 6A/6B boundary as recorded under 6A.	Frm SJR HydData Website SJWCD E (3/1/90 – 10/27/05)
Hydraulic Structure Dimensions	Frm Atlas of St.Lucie Co Surface Water Mngmt Basins S99: Gated Spillway (2 gates, 15.4' high x 25.8' wide. Net crest length = 50', Crest elev = 5.6' NGVD) G81: Steel Sheet-Pile Dam (3-timber gates on concrete weir, 9.5' high x 5.7' wide, net crest length = 15.0', Crest elev = 13.5' NGVD)	Frm Atlas of St.Lucie Co Surface Water Mngmt Basins S50: Fixed crest weir (126' long, crest elev = 12.0' NGVD) DATA UNAVAILABLE FPFWCD C-1 Structure (No Data)	Frm USGS Main Spillway: Control type, Dimensions, elevation South Canal Spillway: Control type, Dimensions, elevation DATA UNAVAILABLE Lateral C Spillway	Frm SJRWMD S252A: Two 60" CMP culverts at invert 16.0. (w/ Slidegate). Culvert 162' long. S252B: Two 60" CMP culverts at invert 16.0. (no control). Culvert 162' long. S252C: One 60" CMP culvert at invert 16.0. (no control). Culvert 162' long. S252D: One 72" screw gate at 18.0'. S253: 160' long weir with crest elev at 25.5'. DATA UNAVAILABLE SR60 Gap S252A - EWMP also reports one ungated culvert (dimensions not given). *Indicates additional structural data in "USACOE USJRB Water Control Plan."*	Not evaluating data in 6B w/ exception of structures along 6A/6B boundary as recorded under 6A.	Frm SJWCD Fax (11/23/05) SJWCD Discharge Structure: Four bottom opening radial gates + One three piece bottom opening lift gate. Gates 20' per gate bay. Top of gates at 27.44' msl.

Table 5: Data Pertinent to Water Budget Calculation						
Data Category	**SFWMD**		**SJRWMD**			
	C-25	**Basin 1**	**10E**	**6A**	**6B**	**6C**
Hydraulic Structure Locations	Frm SFWMD Website "hysurstm.shp" *(Gate G-81 and culverts/bridges under FL Turnpike digitized using 2004 aerial.)*		Frm SJRWMD "wcs.shp"			
Hydraulic Structure Dimensions	Frm Atlas of St.Lucie Co Surface Water Mngmt Basins S99: Gated Spillway (2 gates, 15.4' high x 25.8' wide. Net crest length = 50', Crest elev = 5.6' NGVD) G81: Steel Sheet-Pile Dam (3-timber gates on concrete weir, 9.5' high x 5.7' wide, net crest length = 15.0', Crest elev = 13.5' NGVD)	Frm Atlas of St.Lucie Co Surface Water Mngmt Basins S50: Fixed crest weir (126' long, crest elev = 12.0' NGVD) DATA UNAVAILABLE FPFWCD C-1 Structure (No Data)	Frm USGS Main Spillway: Control type, Dimensions, elevation South Canal Spillway: Control type, Dimensions, elevation DATA UNAVAILABLE Lateral C Spillway	Frm SJRWMD S252A: Two 60" CMP culverts at invert 16.0. (w/ Slidegate). Culvert 162' long. S252B: Two 60" CMP culverts at invert 16.0. (no control). Culvert 162' long. S252C: One 60" CMP culvert at invert 16.0. (no control). Culvert 162' long. S252D: One 72" screw gate at 18.0'. S253: 160' long weir with crest elev at 25.5'. DATA UNAVAILABLE SR60 Gap S252A - EWMP also reports one ungated culvert (dimensions not given). *Indicates additional structural data in "USACOE USJRB Water Control Plan."*	Not evaluating data in 6B w/ exception of structures along 6A/6B boundary as recorded under 6A.	Frm SJWCD Fax (11/23/05) SJWCD Discharge Structure: Four bottom opening radial gates + One three piece bottom opening lift gate. Gates 20' per gate bay. Top of gates at 27.44' msl.

Table 5: Data Pertinent to Water Budget Calculation

Data Category	SFWMD		SJRWMD			
	C-25	Basin 1	10E	6A	6B	6C
Stage Data	Frm DBHydro (Daily Mean) S99H (2/27/64 – 9/27/05) S99T (2/26/64 – 9/27/05) G81H (9/26/95 – 9/25/05) G81T (9/26/95 - 9/25/05)	Frm DBHydro (Daily Mean) S50H (12/8/64 -5/18/95, 5/31/95-9/23/05) DATA UNAVAILABLE FPFWCD C-1 Structure (No Data)	Frm SJR HydData Website Lateral-C Canal *(1/2/88 – 7/31/89)* Frm USGS Main Canal 1950-2004 South Canal Spillway 1949-2004	Frm SJR HydData Website S253 L,H (12/12/96 – 12/31/04) S252A N (2/8/95 – 12/18/03) S252A S (2/8/95 – 10/26/05) S252B N,S *(4/12/94 – 10/30/01)* S252C N (2/1/95 – 11/11/03) S252C S (2/1/95 – 10/26/05) S252D (9/3/98 – 10/26/05) FtDrumMarshCenter (1/5/02 – 7/27/05)	Not evaluating data in 6B w/ exception of structures along 6A/6B boundary as recorded under 6A.	Frm SJR HydData Website SJWCD E (3/1/90 – 10/27/05)
Flow Data	Frm DBHydro (Daily Mean) S99 (4/22/87- 4/28/94, 5/20/94- 12/31/05 DATA UNAVAILABLE G81 no flow data.	Frm DBHydro (Daily Mean) S50 (12/8/64-5/17/95, 5/31/95-12/31/05 DATA UNAVAILABLE FPFWCD C-1 Structure (No Data)	Frm USGS Main Canal Data Unavailable South Canal Spillway Data Unavailable DATA UNAVAILABLE Lateral C Spillway	Frm Environmental Water Management Plan for the Upper St. Johns River Basin Project Design vs. actual discharge (as measured 8/91-3/93) from all S252 structures provided in Figure 4 (pg 6). DATA UNAVAILABLE No historical flow data for: S252A, B, C and D, S253, and SR60 Gap	Not evaluating data in 6B w/ exception of structures along 6A/6B boundary as recorded under 6A.	Frm SJWCD Fax (11/23/05) SJWCD (2003 – 2005): Data in form of timing of gate openings and corresponding discharge volumes in units of Acre-ft.
Operational Constraints	Frm Atlas of St.Lucie Co Surface Water Mngmt Basins S99: Maintain headwater between 19.2 & 20.2' NGVD (5/15-10/15) & between 21.5' and 22.5' (10/15-5/15). G81: normally	Frm Atlas of St.Lucie Co Surface Water Mngmt Basins S50: Maintain stage > 12' in lower reach of C-25 canal (prevent saltwater intrusion). DATA UNAVAILABLE FPFWCD C-1 Structure (No operational	Frm USGS Main Canal: constraints? South Canal Spillway: Constraints? DATA UNAVAILABLE Constraint information for Lateral C Spillway.	Frm Environmental Water Management Plan for the Upper St. Johns River Basin Project S252A: Two gated culverts to remain closed until water levels in Fort Drum Marsh Conservation Area (FDMCA) > 26.0' NGVD, unless additional discharges needed for	Not evaluating data in 6B w/ exception of structures along 6A/6B boundary as recorded under 6A.	Frm SJWCD Fax (11/23/05) SJWCD: Consent Order Water Levels of 27.50' (Nov-May) and 26.50' (Jun-Oct)

Table 5: Data Pertinent to Water Budget Calculation						
Data Category	**SFWMD**		**SJRWMD**			
	C-25	**Basin 1**	**10E**	**6A**	**6B**	**6C**
	closed and acts as divide between C25 & C24. G81 can be opened during dry season to supply water to C24 or to pass flood flows (details on page 6 of Atlas). *Should assume gate closed for a simple water budget.*	constraint data)		environmental purposes (pg 5). <u>DATA UNAVAILABLE</u> Constraint information for S252D, S253, SR60 Gap.		

3.0 Stakeholder Interests

This section presents a summary of perceived benefits and constraints as presented by some of the project stakeholders in the media, reports, public meetings, and interviews with regard to possible projects in the C-25 basin including an above-ground reservoir, stormwater treatment area (STA) and/or the modification of existing canals to allow water to flow between the C-25, and 6A, 6C and 10E basins. This document presents information provided by stakeholders and does not attempt any review or further statement.

Primary stakeholders for projects within these basins include:

- Residents that live in the basins or use the Indian River Lagoon
- Business Owners in the basins or those that rely on the Indian River Lagoon
- Agricultural Interests
  - Indian River Citrus League
  - Citrus Farmers
  - Vegetable Farmers
- Water Utilities
  - St. Lucie County
  - Indian River County
  - Stormwater Departments
  - St. Lucie County
  - Indian River County
- Water Control Districts
  - Indian River Farms Water Control District
  - Ft. Pierce Farms Water Control District
  - Sebastian River Water Control District
  - St. Johns Water Control District
- Water Management Districts
  - St. Johns River Water Management District
  - South Florida Water Management District
- Florida Department of Environmental Protection

3.1 Residents and Business Owners

The quality of life and a large part of the economics of Indian River and St. Lucie Counties can be linked to the IRL and beaches along the Atlantic Ocean. Aerial photographs of the discharge plume from the C-25 Canal after rainfall events have been presented with concurrent reports of increasing pollution. Although the tidal flush from the Ft. Pierce Inlet may mitigate the effects of this plume, a project or projects that reduce or eliminate this plume and its fresh water and associated pollutants would be viewed positively by the public. In addition, the creation of a reservoir and STA as a public multi-use facility would provide recreational benefits to the public.

3.2 Water Utilities

St. Lucie and Indian River Counties are two of the fastest growing counties in Florida which provides pressure on local water supplies. County water utilities are responsible for providing potable water to the existing residents, as well as planning for water supplies for future residents. The Upper East Coast Water Supply Plan, including St. Lucie County and recently updated in 2004, concluded that with appropriate management and diversification of water resources, there is sufficient water to meet the needs of this region during a 1-in-10 year drought condition through 2025. In addition to the recommendations of this Plan, the Comprehensive Everglades Restoration Plan (CERP) will maximize water resources by addressing issues of timing, retention and freshwater flow regimes to the coastal environmental resources in the planning area and increase availability of fresh water for future use. A proposed reservoir and STA along the C-25 canal in the vicinity of Structure S-99 are included in this plan. The proposed locations and footprints of the CERP-25 reservoir and STA are shown in Figure 5 (presented at the end of this document).

The SFWMD and SJRWMD are both discouraging the permitting of any new water wells in Northern St. Lucie County and Southern Indian River County because of the increasing salinity in existing well water. A project that would capture and store fresh water runoff, decreasing agriculture pumping, and possibly augmenting re-use water supplies with stormwater would be viewed positively by water supply utilities.

3.3 Agriculture

Agricultural concerns are interested in this project from the perspective of increased flexibility in moving water from one area to another. They have noted that before the water management districts were formed they were free to move water within the limits of the canal system without regard to the institutional boundary between the water management districts. In addition, it is believed that historical flows (pre-canal) were based on which way the wind was blowing and how much rain an area received. In recent years there is a perception that there have been times when the canal has restricted natural distribution of water resulting in excess water in the SJRWMD basins when the basins in the SFWMD were dry. There is also concern with the increasing salinity in water being pumped from the aquifer for irrigation and a resulting increase in soil salinity. These stakeholders are very interested in a hydraulic reconnection across District boundaries and the ability to store water in an above-ground reservoir because of the flexibility it provides in using regional water and in making it available for use during dry periods. There are concerns that property values will continue to increase in this area reducing the possibility of a large above-ground reservoir.

3.4 County Stormwater Departments and Water Control Districts

St. Lucie County has several subdivisions that ultimately discharge to the C-25 Canal including Lakewood Park and Ft. Pierce Farms. These subdivisions have localized flooding problems due to lack of adequate drainage. Improvement projects are underway that will improve drainage and stormwater quality discharge. It is important to these stakeholders that the stages in the canals are not increased by any project under consideration.

The County Stormwater Departments and Water Control Districts have EPA National Pollutant Discharge Elimination System (NPDES) permits that require programs and systems to reduce pollutants discharged to waters of the United States. In addition, the C-24 and C-25 (Belcher) Canals along with C-25 Cowbone Creek have been listed in the State of Florida 303d list of impaired water bodies requiring that a Total Maximum Daily Load (TMDL) be established for the pollutants that impair the water body. The impairments for the listed water bodies are:

C-25 (Belcher) Canal:	dissolved oxygen and nutrients
C-24 basin:	dissolved oxygen and nutrients.
C-25 basin (Cowbone Creek):	dissolved oxygen, nutrients and coliform.

These stakeholders would support a project or projects that will improve water quality in these basins as well as the Indian River Lagoon.

The Ft. Pierce Farms Water Control District discharges stormwater to the C-25 canal downstream of the S50 Structure. Because this is a residential area, stormwater discharged from this area has common pollutants associated with this type of land use including, but not limited to, fertilizers, herbicides, and pesticides. A project that would reduce or eliminate the stormwater discharge from this area to the IRL would be viewed as positive by the public, the County and the water control district.

3.5 Water Management Districts

Both the SJRWMD and the SFWMD are concerned with overall resource management and must consider all benefits and costs before supporting any project. Their responsibilities reflect the Districts' four areas of responsibility: water supply, flood protection, water quality, and natural systems management. Both districts are concerned with the freshwater discharges into the Indian River Lagoon as well as the possible impact from herbicides, pesticides, fertilizers and suspended sediments from agriculture runoff. These issues as well as the increasing salinity in the groundwater and the increasing demand for potable water have both districts concerned. Under statutory direction in 1998, the SFWMD has developed the Upper East Coast Water Supply Plan addressing water supplies through 2020. In addition through SB 444, the legislature recently has directed the Districts to explore opportunities for alternative water supplies. The bill also addresses TMDLs and makes funding available for both alternative water supply projects and projects that address TMDLs. Both issues would apply to the hydraulic reconnection and restoration opportunities under consideration in the C-25 basin.

3.6 Florida Department of Environmental Protection

Indian River Lagoon, the most biologically diverse estuary in North America has been designated as Outstanding Florida Waters by the State of Florida and as such is afforded the highest level of protection. Commercial and recreational fishing are very important activities in this region that are directly dependent on the health of the estuary. The West Indian Manatee, an endangered species, is dependent on sea grass found in the IRL as a primary food source. There is scientific evidence that the overall health of the Indian River lagoonal system is threatened due to increasing runoff from watershed drainage throughout the watershed and the lower IRL has been listed as an "impaired water body" in the State of Florida's 1998 303d list. In 2003, the IRL, including the C-25/Belcher Canal, was issued a draft Total Maximum Daily Load (TMDL) by the United States Environmental Protection Agency. Entities that discharge stormwater or wastewater to this water body must comply with their allocated TMDL.

Excess stormwater due to drainage improvements can cause fluctuations in the magnitude and timing of freshwater flows to the lagoon. This results in variations in salinity concentration in the IRL at rates and durations that exceed the system's ability to adapt. This results in the destruction or disruption of viable habitat, marine fish spawning, and key system species such as sea grass and oysters. State biologists have documented fish abnormalities that could be the result of the low-salinity induced stress to the fish population. In addition to the fresh water runoff, fertilizers, pesticides and herbicides are washed into the lagoon from residential, commercial and agricultural areas that discharge into the lagoon. It is believed that restoring more natural flow regimes, stabilizing salinity concentrations, and reducing fertilizer, pesticide and herbicide accumulations will greatly enhance the IRL's ability to recover and support an important and diverse estuarine ecosystem.

4.0 Preliminary Maps and Flow Data Analyses

This section presents preliminary estimates of discharge volumes and graphs of preliminary flow data analyses including:

- Total discharge for 3 of 5 spillways in the study area with coincident data covering the past 40 years,
- Hydrographs and graphs of total discharge volume vs. volume captured at various pumping rates for each of the 3 spillways selected, monthly and annually (based on the prior 40 years of daily rainfall data), and
- A preliminary simulation of sizing and filling a reservoir storing water diverted and pumped from the spillways (projected from the prior 40 years of daily rainfall data).

4.1 Preliminary Estimation of Alternative Supply of Fresh Water

Drainage in the study area has been historically altered through a series of drainage networks and canals that discharge to the IRL, or in the case of the SJRWCD, to the Upper St. Johns basin (Figure 4). The volume of fresh water discharged at these points is essentially lost from the system and represents fresh water that is available as an alternative supply.

The main discharge points within the study area are listed in Table 6. The S-50, Main, and South spillways were selected for this analysis because daily mean flow data are available for each over a reasonably long historic record (40 or more years). These three points discharge drainage from about half of the study area acreage.

Table 6 Drainage Basin Area (Acres)

Discharge Point or Spillway	Drainage Basin(s)	Approximate Drainage Area (Acres)	Percent
S-50	C-25	110,000	
	C-25 East	6,000	40%
Indian River Farms - South	South Portions of 10E	17,000	6%
Indian River Farms - Main	Central Portions of 10E	22,000	8%
FPFWCD	Basin 1	26,000	9%
SJWCD	Portions of 6A	78,000	
	Portions of 6C	29,000	37%
Total		288,000	100%

Table 6 Drainage Basin Area (Acres)

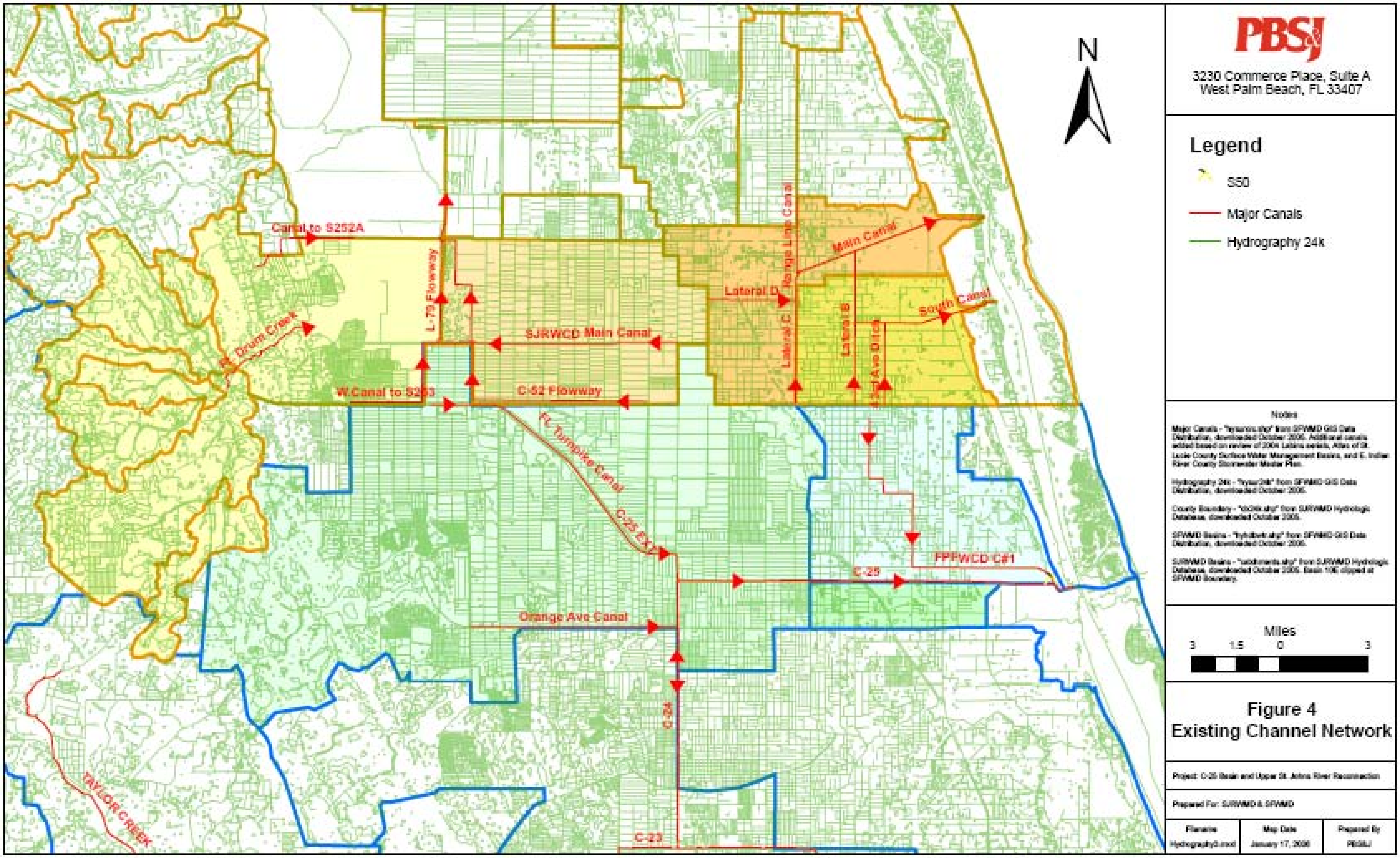


Figure 4 Existing Channel Network

The following presents estimates of the volume of water available based on daily mean flow and stage data at several discharge points within the study area. This method aggregates all upstream basin functions in that inputs, storages, withdrawals, and losses are already accounted for and the ‘end of pipe’ flow is the remaining fraction available for redirection. An additional benefit of this method is that it avoids introducing uncertainty through assumptions made in developing a more complex lumped parameter model, particularly when land use and soil type do not control surface flows in these basins, flows are controlled by canals and man-made drainage networks.

As example, the S-50 spillway is the primary point of discharge from the C-25 canal. The C-25 canal drains freshwater from approximately 116,000 acres in Basins C-25 and C-25 East. The canal discharges through the S-50 spillway to the IRL. Daily mean flow and stage data for the S-50 Spillway are available for the period of record from December 1964 to September 2005.

Similarly, daily mean flow discharge data are available for the Main and South spillway in the Indian River Farms Water Control District for longer periods of record (1949 to 2004 and 1950 to 2004, respectively). The use of data over several decades helps to account for hydrologic variability over time. Historic flows for these three points account for drainage over about half of the study area acreage.

The flow data were imported to a spreadsheet for analysis. The daily data were summed and averaged monthly and annually. The volumes of water available at various pumping rates were calculated to demonstrate potential capture volumes and losses. This volume assumed a constant pumping rate, 24 hours per day. If the volume of available water exceeds the volume that can be pumped at the given rate, the excess is assumed to discharge to the IRL.

The data from just these three discharge points (S-50, Main, and South spillways) indicates that millions of acre-feet of freshwater have been lost over the past 50 years from man-made ditches and channels. If the volume from all discharge structures in the basins were included in the analysis, the estimated losses (conversely, the estimated available water) would be higher. Total volumes calculated from 40 to 50 years of record indicate there is sufficient volume from just these three discharge points to justify further analysis of hydraulic re-connection.

The total volume of water available from each of three of the five primary discharge points in the basins is summarized below with the total period of record shown in Table 7. Total flows for the corresponding years where the three datasets overlap (1965-2004) are shown in Tables 8 and 9 and Figure 5

Table 7 Estimation of Available Freshwater per Spillway 3 of 5 Primary Discharge Points in the C-25 and Upper St. Johns Study Area Based on Daily Mean Flow Data at Each Spillway for 40 to 50 Years of Record			
	C-25 Canal	Indian River Farms	
	S-50	Main	South
Years of Record	1965-2005	1949-2004	1950-2004
Grand Total (acre-ft)	5,540,675	3,008,205	1,573,950
Median (acre-ft per year)	131,513	50,729	29,028
Minimum* (acre-ft per year)	33,524	19,141	10,256
Maximum (acre-ft per year)	243,780	96,637	47,139
Standard Deviation (acre-ft per year)	55,081	14,942	9,070
* Minimum volumes for S-50 and Main are conservative in that there were days of record missing in these years.			

Table 7 Estimation of Available Freshwater per Spillway

Table 8 Estimation of Freshwater (1965 – 2004) Based on Daily Mean Flow Data at Each Spillway in Overlapping Years of Data		
	Total Discharge (Ac-Ft/Yr)	% of Total
S-50	5,387,935	61.7%
South	1,201,598	13.8%
Main	2,141,846	24.5%
Total	8,731,379	
S-50	5,387,935	61.7%
South + Main	3,343,444	38.3%
Total	8,731,379	

Table 8 Estimation of Freshwater (1965 – 2004)

As example, the following summarizes data that can be roughly estimated from this analysis.

- In excess of 10 million acre-feet of fresh water has been discharged off the coast over the past 50 years.
- The C-25 canal drains about 40% of the study area and 3 times the acreage of the Main and South spillways combined. However, the S-50 discharge volumes are less than 2 times the volume of the Main and South spillways combined (see Table 8 for comparable data in the same range of years)..
- Redirecting flows from multiple discharge points to a single or series of reservoirs may maximize capture volumes and flexibility in determining optimum pump and delivery schedules.

Table 9 Estimation of Total Sum of 3 Spillways 3 of 5 Primary Discharge Points in the C-25 and Upper St. Johns Study Area Based on Daily Mean Flow Data at Each Spillway in Overlapping Years of Data 1965-2004		
	Total S50 + Main + South	
Grand Total (1965-2004)	8,731,379	Acre-feet over 40 years
Median	204,661	Acre-feet per year
Minimum	82,978	Acre-feet per year
Maximum	364,541	Acre-feet per year
Standard Deviation	72,309	Acre-feet per year

Table 9 Estimation Total Sum of 3 Spillways

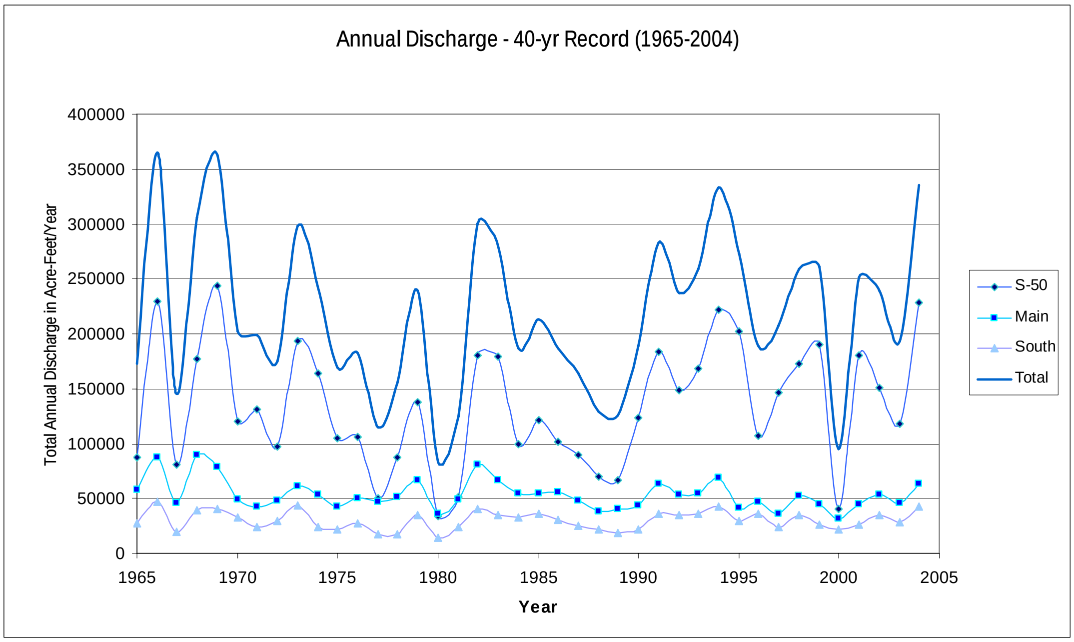


Figure 5 Annual Discharge – 40 Year Record (1965 – 2004)

- In looking at the 40 years of overlapping data for the three discharge points, an estimated total of 200,000 acre-feet of water may be available per year (median value).
- In given years, this may range from a low of about 80,000 to peak flows of about 350,000 acre-feet per year for the 3 discharge points.
- From interviews and review of past reports, it appears more than 22,000 acres of suitable land may be available for purchase in the study area to accommodate one or more large reservoir storage areas.

- It appears that the network of drainage ditches and canals necessary to connect these flows to storage areas already exists. More study is needed to determine what, if any, modifications might be required to accommodate the flows.

As a note it is highly recommended that future analysis use a data time range consistent with CERP projects, currently this is the 41 year range from Jan 1, 1965 through December 31, 2005. This report uses the range from Jan 1, 1965 to December 31, 2004 because complete datasets for 2005 were not yet available for all of the discharge points. This should be updated in future analyses.

4.2 S-50: Volume, Hydrograph, and Pumping Capture Scenarios

The graphs on the following pages (Figures 6 through 9) depict the volume of water available and flow capture volumes for various pumping capacities for the S-50 discharge point alone. As example, the following summarizes data that can be roughly estimated from this analysis.

- Statistics for data over the past 40 years show that there is a considerable loss of fresh water from the S-50 spillway alone (Figure 6). Simple arithmetic averages indicate:
  - In excess of 5.5 million acre-feet of fresh water has been discharged off the coast over the past 40 years,
  - a median value of about 132,000 acre-feet of fresh water is discharged each year,
  - the mean over the 40 years is about 135,000 acre-feet (note that averaging may give more weight to high flow events), and
  - annual discharges have historically ranged from about 34,000 to 244,000 acre-feet per year with a standard deviation of about 55,000 acre-feet.

- The stage-discharge relationship (Figure 6) shows the historic range and distribution of flows and stages over the weir crest fixed at an elevation of 12-feet NGVD. A cursory look at the data suggests that peak flows and stages over the past 10 years may be characteristically different from the prior 20 years.

- The stage and discharge hydrograph (Figure 7) shows the patterns of flow over time, with no flow when the volume of water falls below the 12-foot elevation of the weir.

Available Water in S-50

Annual Total and Stats - Acre Feet/ Year	
Grand Total	5,540,675
Median	131,513
Avg	135,138
Max	243,780
Min	33,524
Std	55,081

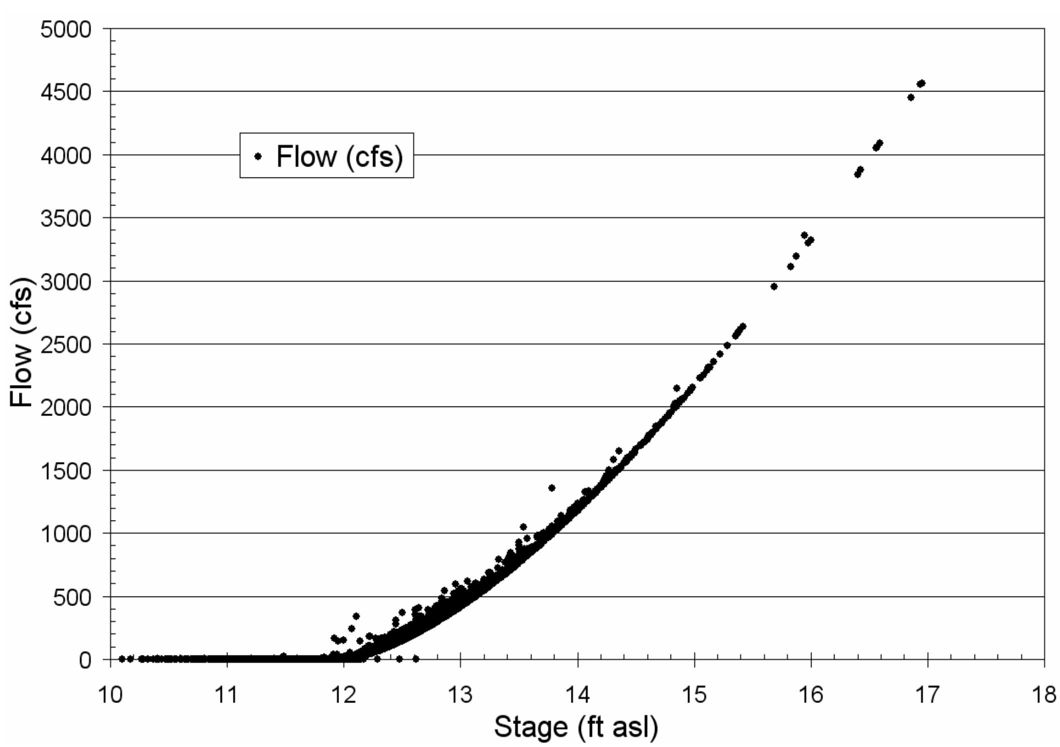


Figure 6 – Summary Statistics and Stage-Discharge Relationship for S-50 spillway, from daily discharge and stage records Dec. 8, 1964 to Sept. 23, 2005

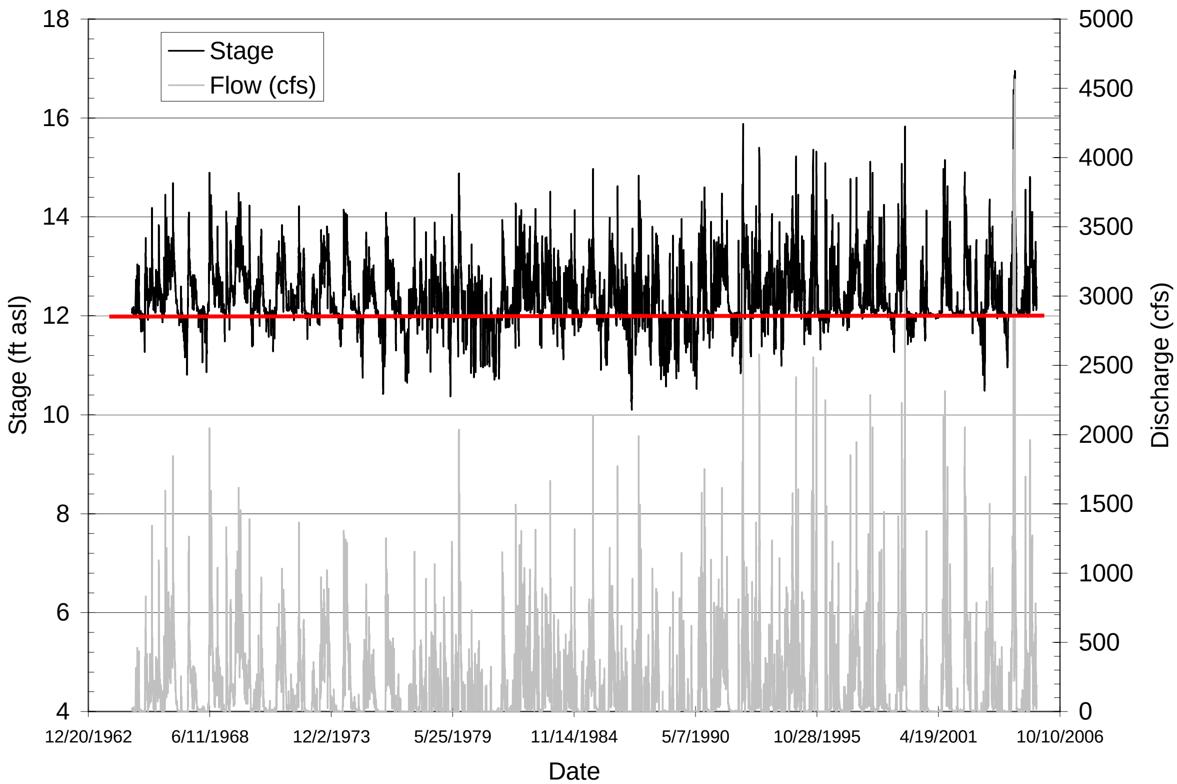


Figure 7 - Hydrograph for S-50 Spillway between Dec. 8th 1964 and Sept. 23rd 2005 for stage (ft) and discharge (cfs)

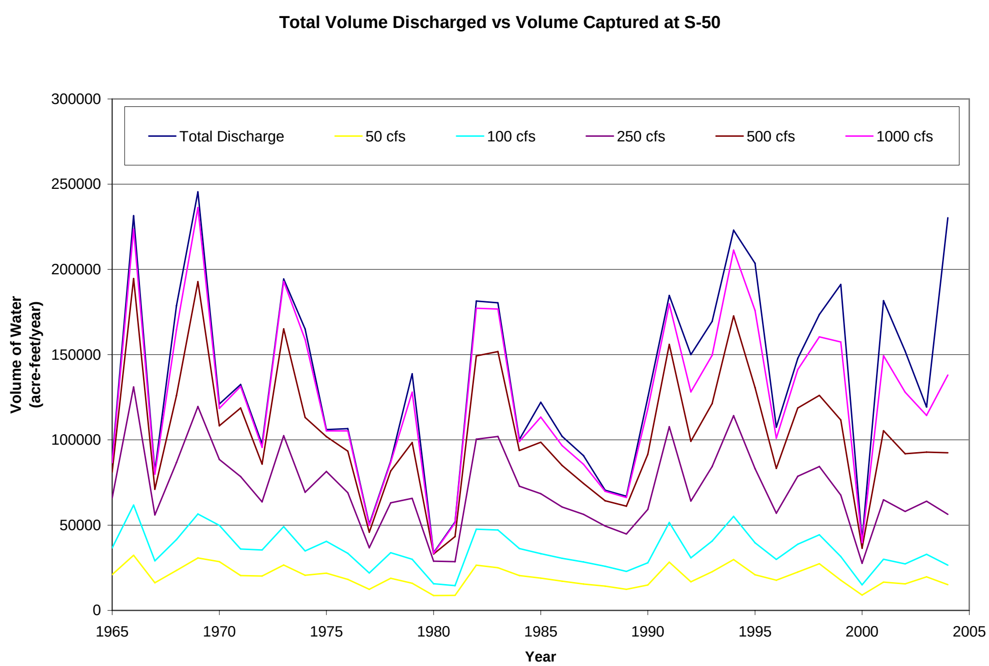


Figure 8 - Annual Total Volume vs. Volume Captured (S-50).

Average Monthly Water Available vs Captured at S-50 Acre-Feet/Month Derived from Average Daily Flow Data 1965-2004						
		Volume Captured at Continuous Pumping Rate				
Month	Total Discharge	50 cfs	100 cfs	250 cfs	500 cfs	1000 cfs
Jan	4,796	1,255	2,062	3,609	4,426	4,724
Feb	4,906	1,048	1,810	3,264	4,231	4,828
Mar	7,691	1,218	2,216	4,289	5,739	6,887
Apr	3,206	774	1,309	2,268	2,860	3,100
May	4,269	778	1,292	2,386	3,383	4,092
Jun	14,456	1,805	3,339	6,993	10,473	13,118
Jul	20,033	2,552	4,842	10,390	15,429	18,898
Aug	23,776	2,686	5,179	11,523	18,361	22,575
Sep	23,179	2,645	4,999	10,860	16,608	20,182
Oct	18,386	2,264	4,104	8,698	13,123	16,690
Nov	7,969	1,618	2,651	4,855	6,601	7,588
Dec	3,484	1,174	1,704	2,687	3,243	3,428
Annual Average	136,152	19,817	35,508	71,823	104,477	126,111

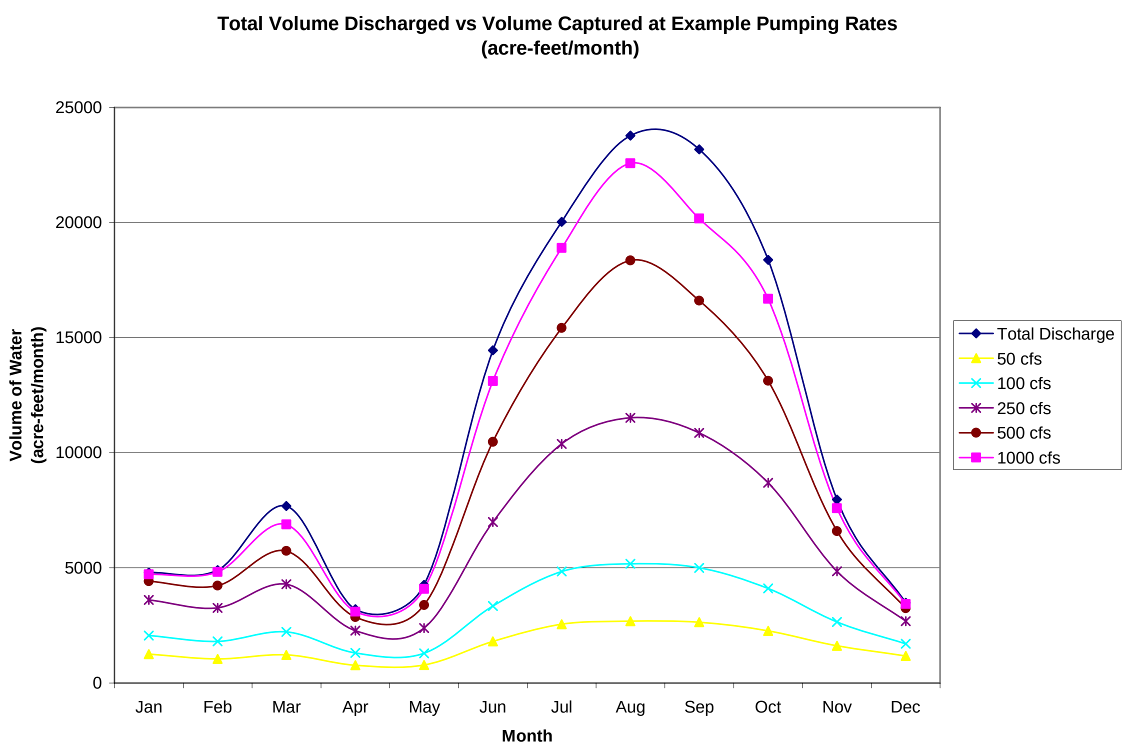


Table 10 and Figure 9- Monthly Total Volume vs. Volume Captured (S-50).

- Both Figures 6 and 7 also serve as a visual first-order check of the data. Peak stage heights correspond to peak flows and there are no apparent irregularities in the measured data.

- In the spreadsheet model, daily flows from 1965 to 2004 were summed over each month (e.g., sum and average of flow each January from 1965 to 2004) and each year (e.g., sum and average of flows, January to December, for each year 1965 to 2004). The average total flows per year and per month (over 40 years) are shown in Figures 8 and 9, respectively.

- The amount of available water that could be captured at various pumping rates was calculated assuming a continuous pumping rate each day for each year (Figure 8 and 9, rates from 50 to 1000 cfs). The difference between the pumping rate curve and the total discharge curve shows the volume of water lost to the lagoon (i.e., available water not captured or in excess of the pumping rate).

- For example, pumping at a continuous rate of 500cfs would capture most of the available water during dry months but will still release about 4000 to 5000 acre-feet per month during the wet season.

- As demonstrated below, pumping at a rate of 1000cfs captures 93% of the total discharge during dry and wet seasons. This flow can be seasonally adjusted to optimize delivery to the IRL and reduce impacts to the estuary.

	Pumping Rate					
	50 cfs	100 cfs	250 cfs	500 cfs	1000 cfs	Total
Volume (ac-ft)	808,218	1,447,634	2,926,915	4,263,443	5,162,176	5,580,342
Percent Captured	14%	26%	52%	76%	93%	

- Note that these rough estimates are for flows to the C-25 canal alone. Proportionally more fresh water is available if flows from other discharge points are redirected. For example, these volumes could be substantially increased if the volumes currently discharged from the FPFWCD spillway; the main, and south spillways from Indian River Farms; and a portion of the flows from the SJRWCD discharges are also redirected to storage. As example, daily discharge data for the Indian River Farms Main and South spillway points are summarized in the next subsection.

- From interviews and review of past reports, it appears that more than 22,000 acres may be available for purchase to accommodate one or more large reservoir storage areas.

- It appears that the network of drainage ditches and canals necessary to connect these flows already exists. More study is needed to determine what, if any, modifications might be required to accommodate the flows.

4.3 Main and South: Volume, Hydrographs, and Pumping Capture Scenarios

As in the S-50 spillway example presented above, daily discharge data for the Main and South spillway in the Indian River Farms Water Control District were reviewed in a spreadsheet analysis. The total volume of water available from just these three discharge points is summarized in Table 11 as follows:

Table 11 Available Volume of Water – per Spillway (acre-feet/year)

	S-50	Main	South
Grand Total	5,540,675	3,008,205	1,573,950
Years	1965-2005	1949-2004	1950-2004
Mininum	33524	19141	10256
Maxium	243780	96637	47139

Millions of acre-feet of freshwater have been discharged from these 3 spillway points alone over the past several decades. Similar to the S-50 example, charts of hydrographs and total volumes of water available at various pumping rates for the Main and South spillways are presented below (Figures 10 through 15).

Available Water in Main Tributary

Annual Total and Stats - Acre Feet/ Year	
Grand Total	3,008,205
Median	50,729
Avg	53,718
Max	96,637
Min	19,141
Std	14,942

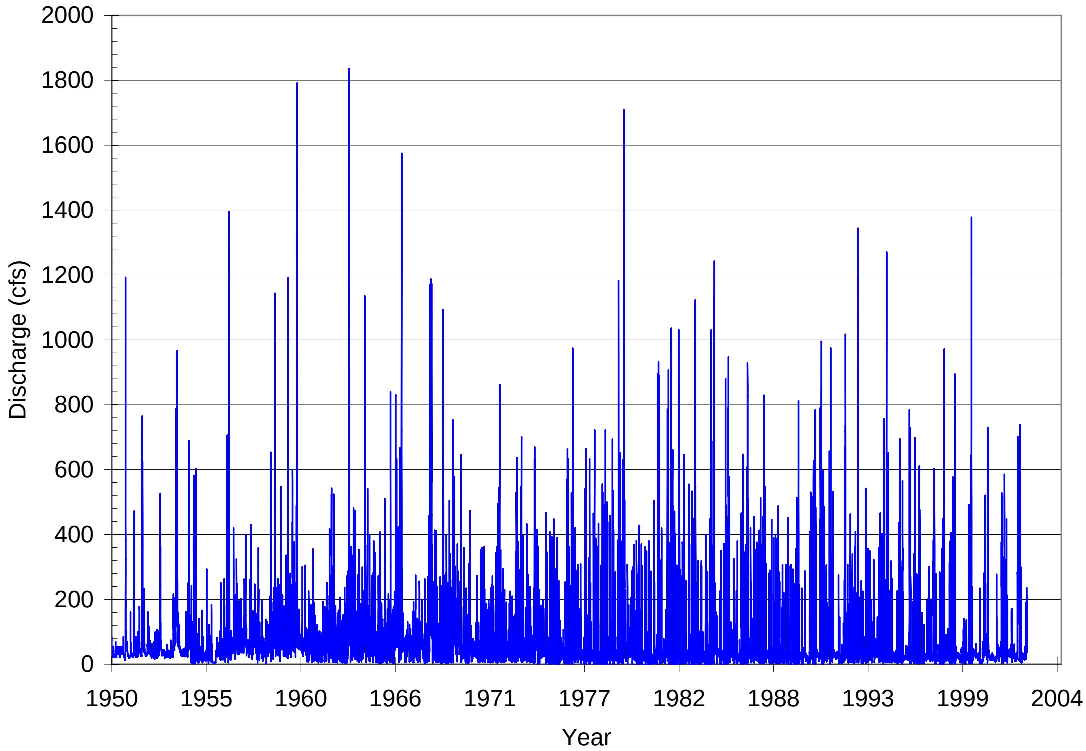


Figure 10 – Total Flow Statistics and Hydrograph for Daily Discharge Data at the Indian River Farms Main Spillway (1949 -2004)

Average Monthly and Annual Water Available Main Spillway Acre-Feet/Month					
		Volume Captured at Continuous Pumping Rate			
Month	Total Discharge	50 cfs	100 cfs	250 cfs	500 cfs
January	3,603	2,166	2,715	3,216	3,424
February	3,494	1,990	2,559	3,089	3,329
March	3,955	2,078	2,706	3,382	3,729
April	2,808	1,907	2,362	2,721	2,800
May	3,279	1,898	2,422	2,982	3,196
June	5,524	2,112	3,076	4,419	5,183
July	5,271	2,301	3,402	4,692	5,167
August	5,667	2,328	3,492	4,897	5,505
September	6,685	2,292	3,546	5,239	6,073
October	6,536	2,354	3,548	5,094	6,045
November	3,904	2,156	2,812	3,412	3,725
December	3,147	2,103	2,607	3,012	3,126
Annual Average	53,873	25,686	35,248	46,156	51,302

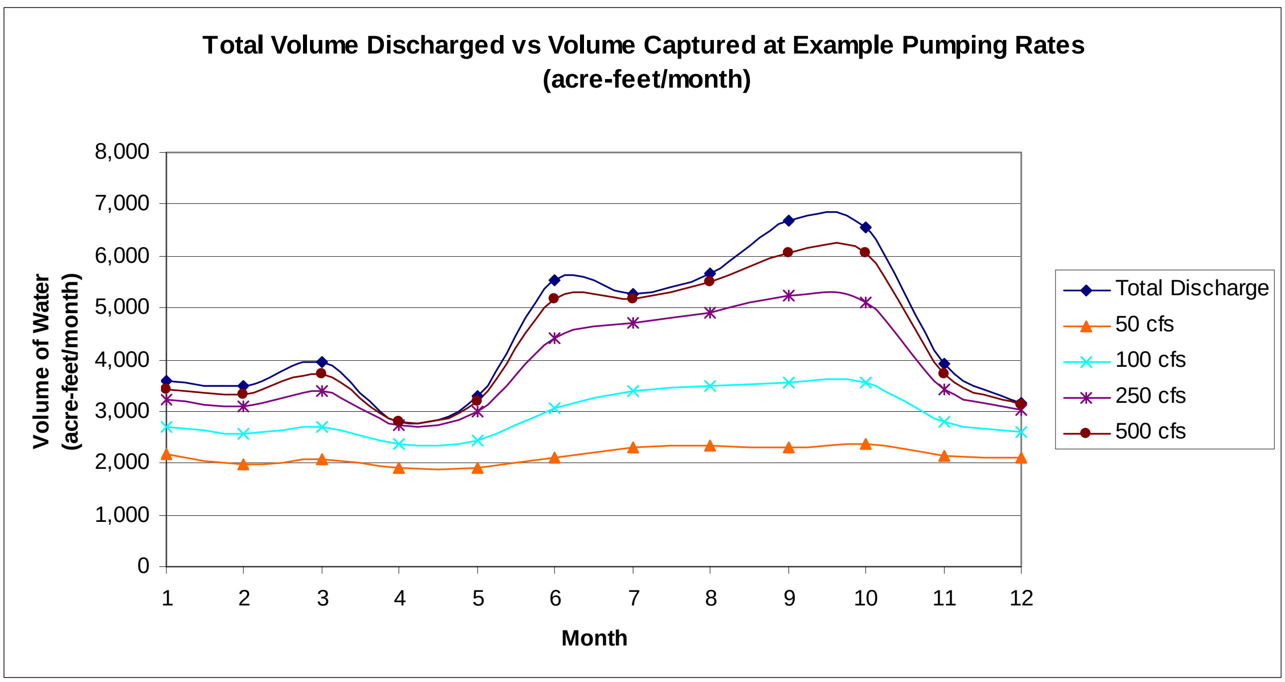


Table 12 and Figure 11- Monthly Total Volume vs. Volume Captured (Main).

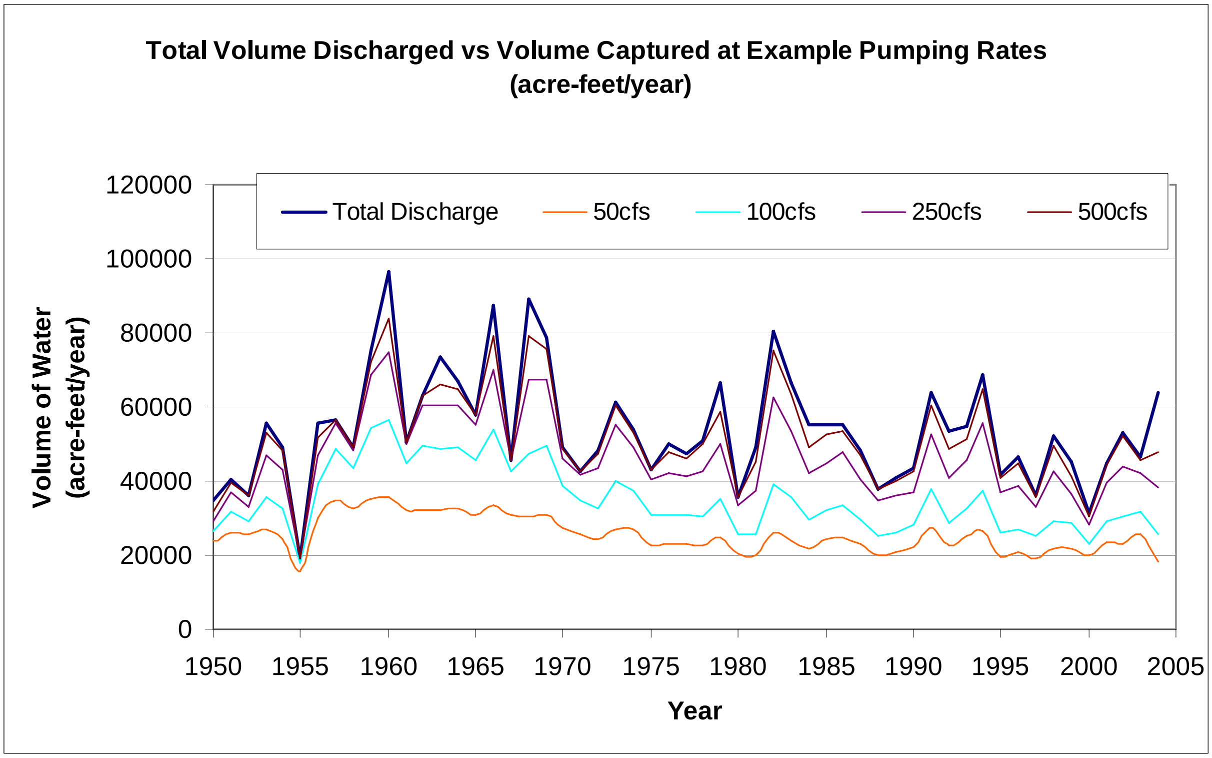


Figure 12- Annual Total Volume vs. Volume Captured (Main).

Available Water in South Tributary

Annual Total and Stats - Acre Feet/ Year	
Grand Total	1,573,950
Median	29,028
Avg	28,617
Max	47,139
Min	10,256
Std	9,070

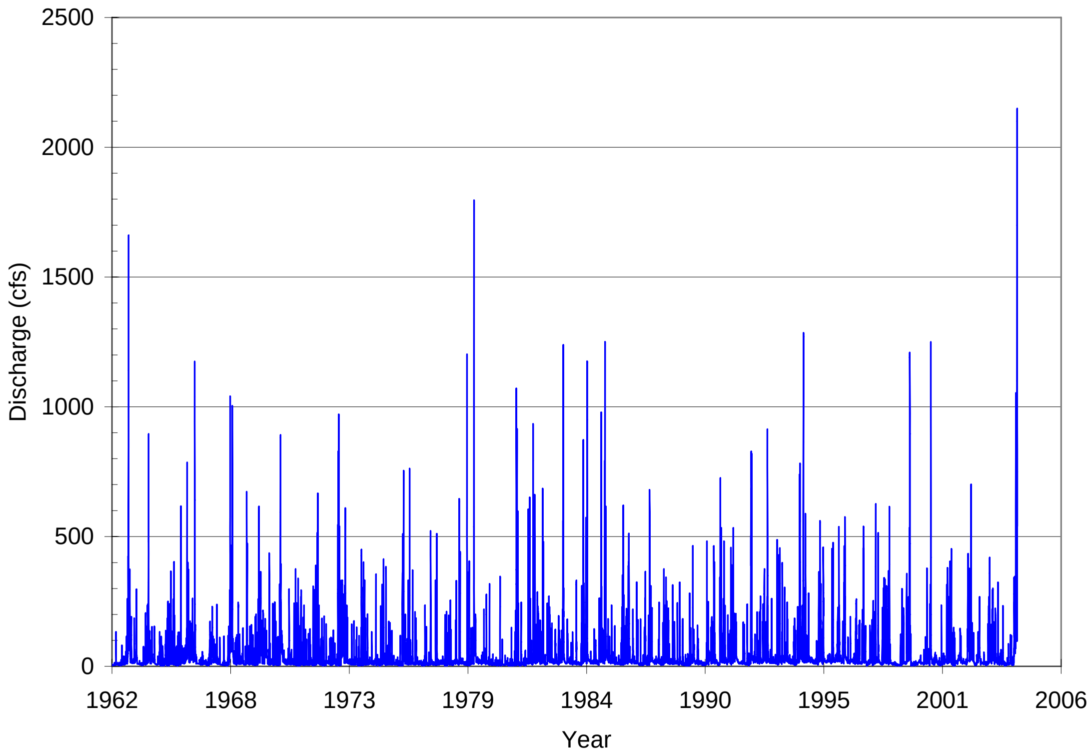


Figure 13 – Total Flow Statistics and Hydrograph for Daily Discharge Data at the Indian River Farms South Spillway (1950 -2004)

Table 13 - Average Monthly and Annual Water Available South Spillway Acre-Feet/Month					
		Volume Captured at Continuous Pumping Rate			
Month	Total Discharge	50 cfs	100 cfs	250 cfs	500 cfs
January	1,556	1,202	1,373	1,517	1,547
February	1,635	1,092	1,252	1,418	1,496
March	1,823	1,173	1,364	1,610	1,763
April	1,269	1,011	1,138	1,255	1,269
May	1,678	1,090	1,280	1,499	1,608
June	3,271	1,449	1,992	2,703	3,094
July	2,583	1,469	1,914	2,388	2,535
August	3,321	1,709	2,347	2,999	3,237
September	4,285	1,777	2,472	3,362	3,834
October	4,156	1,834	2,517	3,428	3,920
November	2,127	1,358	1,595	1,884	2,024
December	1,436	1,186	1,302	1,387	1,428
Annual Average	29,140	16,352	20,547	25,451	27,755

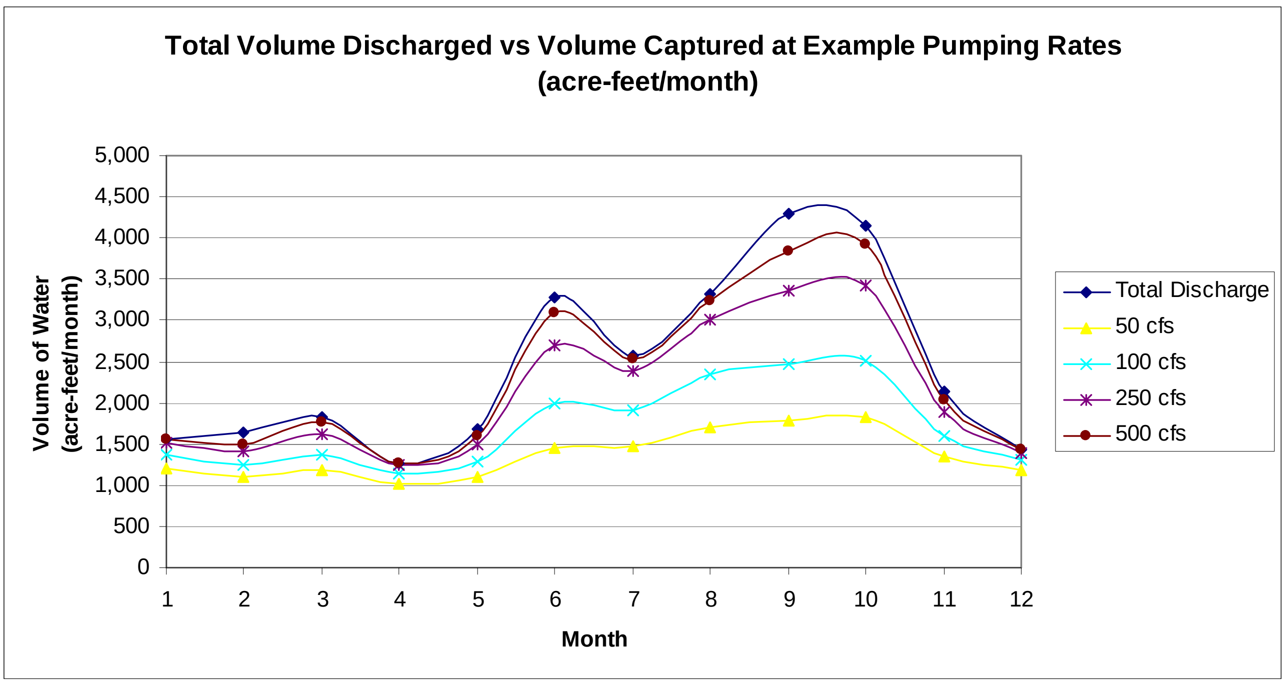


Table 13 and Figure 14- Monthly Total Volume vs. Volume Captured (South).

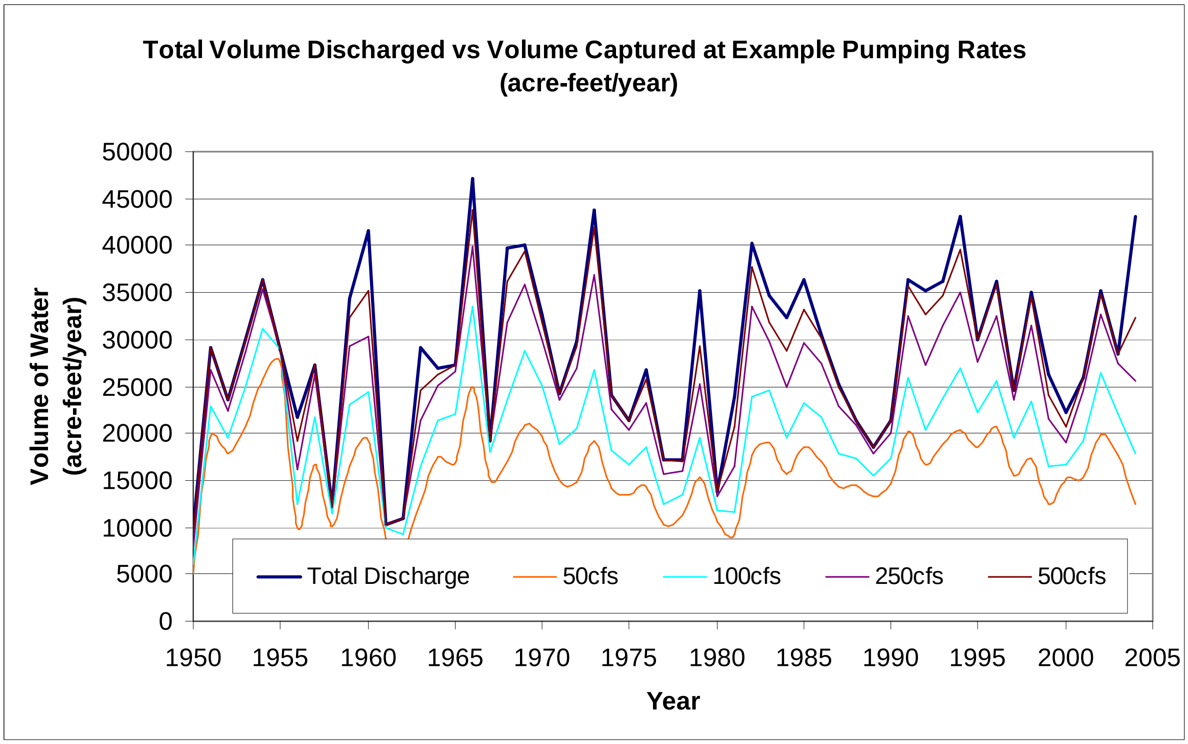


Figure 15 - Annual Total Volume vs. Volume Captured (South).

4.4 Preliminary Methodology of Reservoir Sizing

Spreadsheet analysis of cumulative flows allows the simulation of filling a reservoir and optimization of size based on various pumping rates. A *preliminary* analysis was constructed as a demonstration. This simulation is not complete and will require further development prior to use of even preliminary results. An outline of the rough model is presented below.

- As above, daily discharge data provides total available water for an approximate 40 year period of time.
- Input variables are selected dimensions of the aquifer (area and depth), rainfall, withdrawal (use) rates, seepage (as a percent of rainfall), and pumping rate.
- The selected pumping rate gives the volume of the available water that will be redirected in a given day. The spreadsheet simulates the continuous pumping of this volume of water plus rainfall on a daily basis to a reservoir.
- Losses each day to ET, withdrawals, and seepage are subtracted and a cumulative tally of the remaining volume is kept for the period of record.
- In this preliminary example, cumulative losses are estimated in a relatively simple manner. These can easily be refined to a more dynamic analysis and other factors such

freeboard must be added. Currently, ET takes an average daily rate and distributes it over the year using a sine function (peak in summer, low in winter), based on an estimate of 36 inches per year. This gives an ET estimate in feet per day which is multiplied by the surface area of the reservoir to give acre-feet per day loss to ET. In this way, the surface area and depth of the simulated reservoir can be changed to give an optimal size (balancing inflow, ET losses, and withdrawal demands).

- Withdrawal or consumptive use is simply entered as a constant value in acre-feet per day and seepage is entered as a percentage of rainfall. This can easily be updated to represent variable seasonal and daily losses.

- The simulated accumulation of water in the reservoir over time is shown (Figures 16 and 17, Reservoir Volume vs. Time, 1964 – 2005). The red line at the top shows the maximum volume, based on input area and depth. Freeboard can easily be built into this but the current maximum is the top of the reservoir. **These graphs are presented as a demonstration, not as a final product.**

- Changing the area and depth of the reservoir allows defining an optimum size, at a given pumping rate, that will not exceed the maximum volume (will not overflow) based on historic flow data and estimated ET.

- The examples shown (Figures 16 and 17) use consistent variables for demonstration purposes: Area 30,000 acres, Depth 30 feet, Withdrawals (Use) 300 acre/feet/day, Rain 48 inches/year, and Seepage 20% of rainfall. The pumping rate was changed in the two examples to show the effect of capturing the majority of available water versus a smaller fraction of the water.

- For example, Figure 16 demonstrates that, based on the historical data from the past 40 years, a 30,000 acre – 30-foot deep reservoir could store available water from the S-50 spillway pumped at a continuous rate of 1000 cfs. Based on the previous flow analysis from the 3 spillways, this is 93% of the available freshwater. Figure 17 uses the same baseline variables but fills at a continuous rate of 500 cfs. This is analogous to capturing only 76% of the available freshwater.

- A more shallow depth requires a greater surface area and increases ET losses. In the simulation, a smaller volume (reducing area and/or depth) results in flooding over the top of the reservoir. In reality, scenario testing may include progressively filling cells in a larger reservoir, or using a system of wetlands, reservoirs, and other storage and treatment alternatives.

Max Surface Area	30000	ac
Storage Depth	30	ft
Side slope	4	:1
bank width	120	
Assume:	Length = 2	width
b =	720	
Bottom Width =	25382.32384	ft
Bottom Length =	50764.64768	ft
Bottom Area =	29580.45746	ac
Ratio to top area	0.986015249	
Total	893706.8619	ac-ft
Initial Volume %	0	
Initial Volume	0	
Outflows		
ET	0.008219178	ft/day
Use	300	ac-ft/day
Refer Reservoir Stage and ET chart for time dynamics.		
Rain	0.010958904	ft/day
	48	inches/yr
Seepage	0.2	percentage of Rainfall
	65.75342466	ac-ft/day
Pumping Rate	1000	cfs

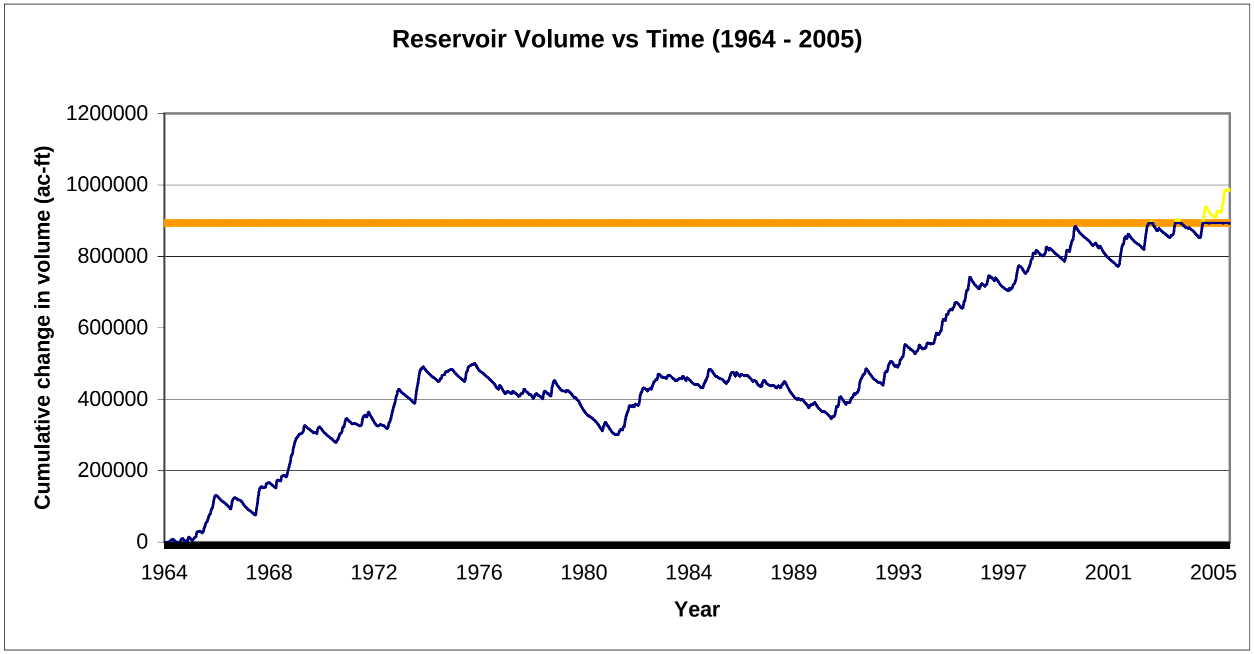


Figure 16 - Reservoir Volume vs. Time - 1000 CFS
S-50 Daily Discharge, Pumping Rate = 1000 cfs, Maximum Cumulative Volume = 985,925 ac-ft

Max Surface Area	30000	ac
Storage Depth	30	ft
Side slope	4	:1
bank width	120	
Assume:	Length =	2 width
b =	720	
Bottom Width =	25382.32384	ft
Bottom Length =	50764.64768	ft
Bottom Area =	29580.45746	ac
Ratio to top area	0.986015249	
Total	893706.8619	ac-ft
Initial Volume %	0	
Initial Volume	0	
Outflows		
ET	0.008219178	ft/day
Use	300	ac-ft/day

Refer Reservoir Stage and ET chart for time dynamics.

Rain	0.010958904	ft/day
	48	inches/yr
Seepage	0.2	percentage of Rainfall
	65.75342466	ac-ft/day
Pumping Rate	500	cfs

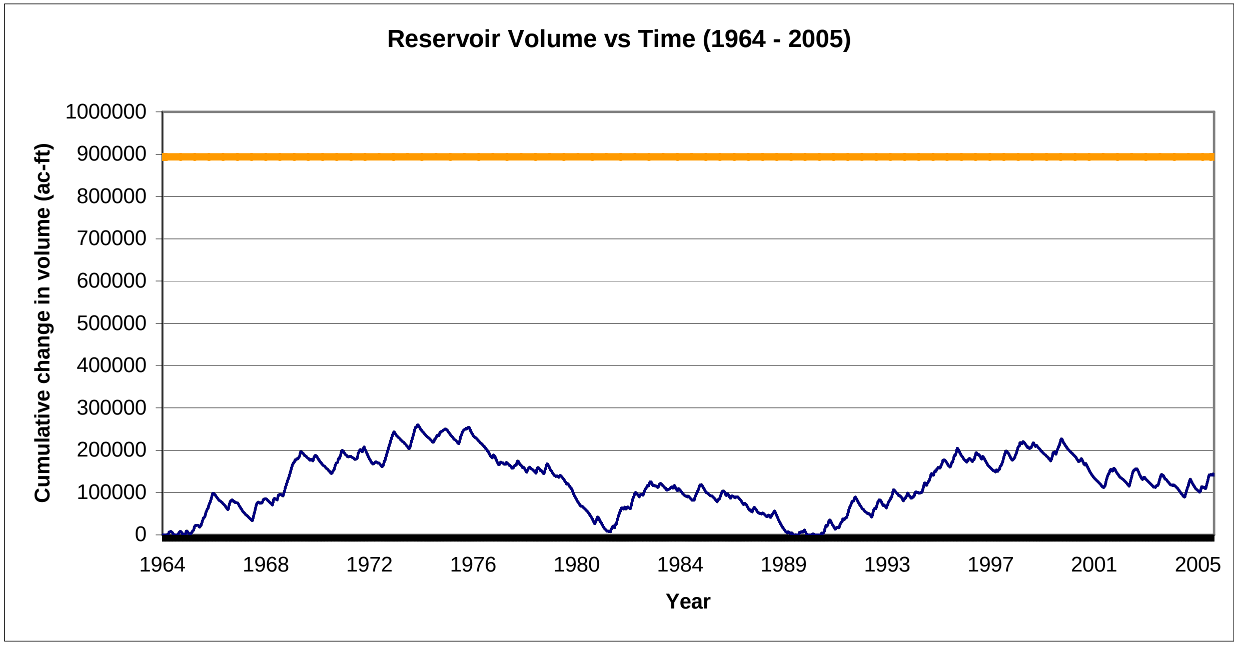


Figure 17 - Reservoir Volume vs. Time - 500 CFS
S-50 Daily Discharge, Pumping Rate = 500 cfs, Maximum Cumulative Volume = 253,330 ac-ft

4.5 Rainfall Distribution Between Districts

Two long term rainfall monitoring points were selected to evaluate the variability of local rainfall and water availability across the SJRWMD-SFWMD boundary. This information may be helpful in assessing the potential need for short-range inter-basin transfers due to shortages in one basin and excess in adjacent basins. The two stations selected are Vero Beach Tower (DBHYDRO Code 6098; 27.36291 N, 80.25532 W) in Indian River County (SJRWMD) and Ft. Pierce Tower (DBHYDRO Code 6116; 27.24371 N, 80.20132 W) in St. Lucie County (SFWMD). They are separated by 78 kilometers, and delineate the northern and southern boundaries, respectively, of the study area.

Data compiled included daily rainfall (in inches) between November 3rd, 1969 and April 30th, 2005; this period of record includes significant wet years (1982, 1994) and significant drought years (1989, 2004).

The analysis takes three approaches to evaluating rainfall input conditions that would make transfer of water between locations desirable. The first observes cumulative rainfall differences between stations over the period of record, looking in particular for systematic variability. The second compares rainfall totals in several temporal quanta (total, annual, monthly, weekly) to observe patterns of difference, and compares these differences to variances determined for each quanta to detect statistically significant deviation. The third examines the statistical properties of the data for differences; exploring variability in daily rainfall volume-frequency relationships.

Part I. Cumulative Rainfall Delivery

Figure 18 shows the cumulative difference in rainfall totals between stations; this is computed as the rainfall at Vero Beach Tower (DB6098) minus the rainfall at Ft. Pierce Tower (DB6116). Positive values suggest higher rainfall at Vero Beach. Over the period of record, the rainfall totals differ by only 1.06% (1964” for Vero Beach vs. 1945” for Ft. Pierce). *However, the pattern of delivery over that time deviates substantially from random variability*. There is a clear systematic trend of increased rainfall in Vero Beach between April 1979 and April 1991, followed by the reverse relationship (systematically higher rainfall at Ft. Pierce) between April 1991 and June of 2002.

The peak difference in cumulative rainfall is over 10 feet (120”) of rainfall, a total that would be expected to have significant consequences for local water supply variability. The expected condition (null hypothesis) of no systematic variability between stations would be supported only if the pattern traced by the points in Figure 18 followed the trends observed between 1969 and 1978; that is, largely random fluctuation within the period of a year. As such, it appears that inter-basin transfers maybe of substantial utility to modulate this natural variability.

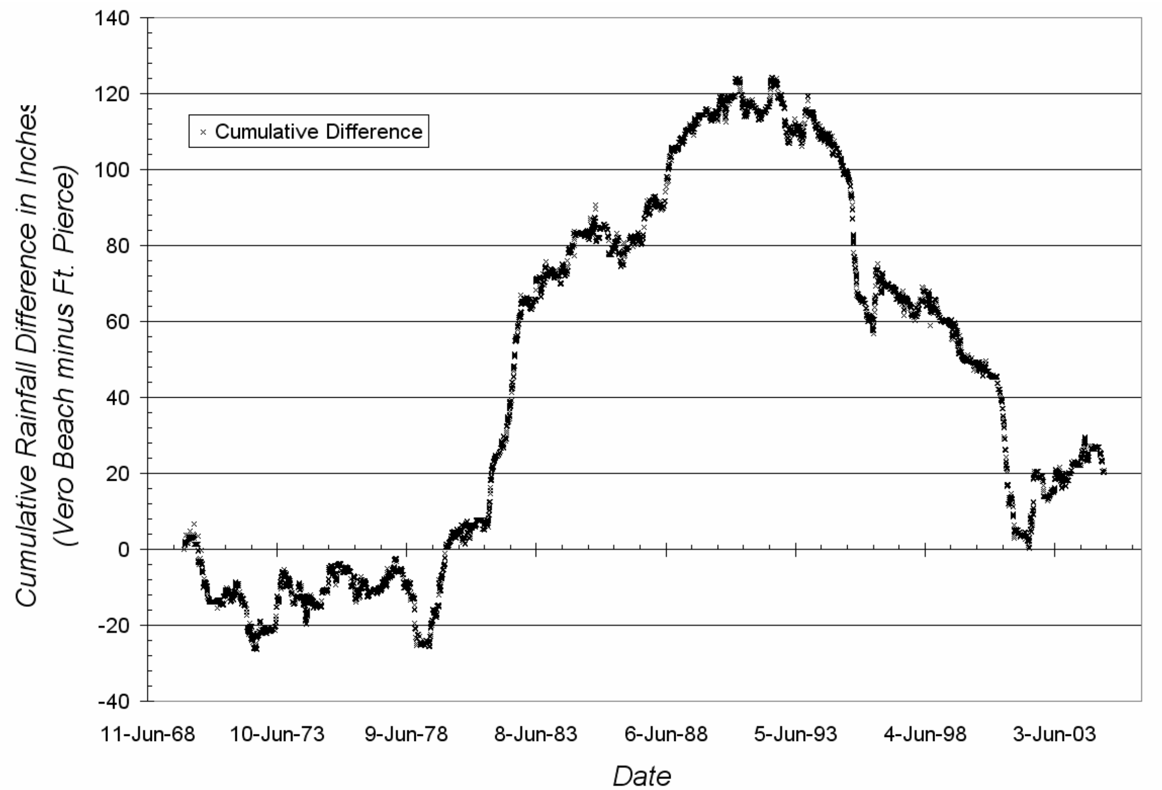


Figure 18. Cumulative rainfall between Vero Beach Tower and Ft. Pierce Tower, 1969 to 2005.

Part II. Quantized Rainfall Comparisons

To compare the frequency of significant deviations from equal rainfall delivery, the rainfall data were divided by several quanta (month, week, year) and the time series of differences were plotted. *The plots (Figures 19 through 22 below) show that there are regular occurrences of significant deviation from the expected condition of equal rainfall delivery at both time scales.* Within-station standard deviations are used as a demarcation of significance; differences between stations exceeding one standard deviation are reasoned to be statistically unlikely. For weekly rainfall totals, this level is 1.3”; for monthly data, this difference is 3.6” while for annual data, this value is 15.6”.

This comparison yields the following conclusions:

1) Rainfall delivery exceeds the threshold in 261 weeks (of 1852) or 14% of the time.
2) Rainfall delivery exceeds the threshold in 60 months (of 426) or 14% of the time.
3) Rainfall delivery exceeds the threshold in 6 years (of 37) or 16% of the time.

The relatively large differences in total rainfall that are used as thresholds for each quanta, and the high frequency of exceedance further reinforce the conclusion that rainfall delivery can vary between areas with sufficient magnitude to warrant consideration of local water storage and transfers.

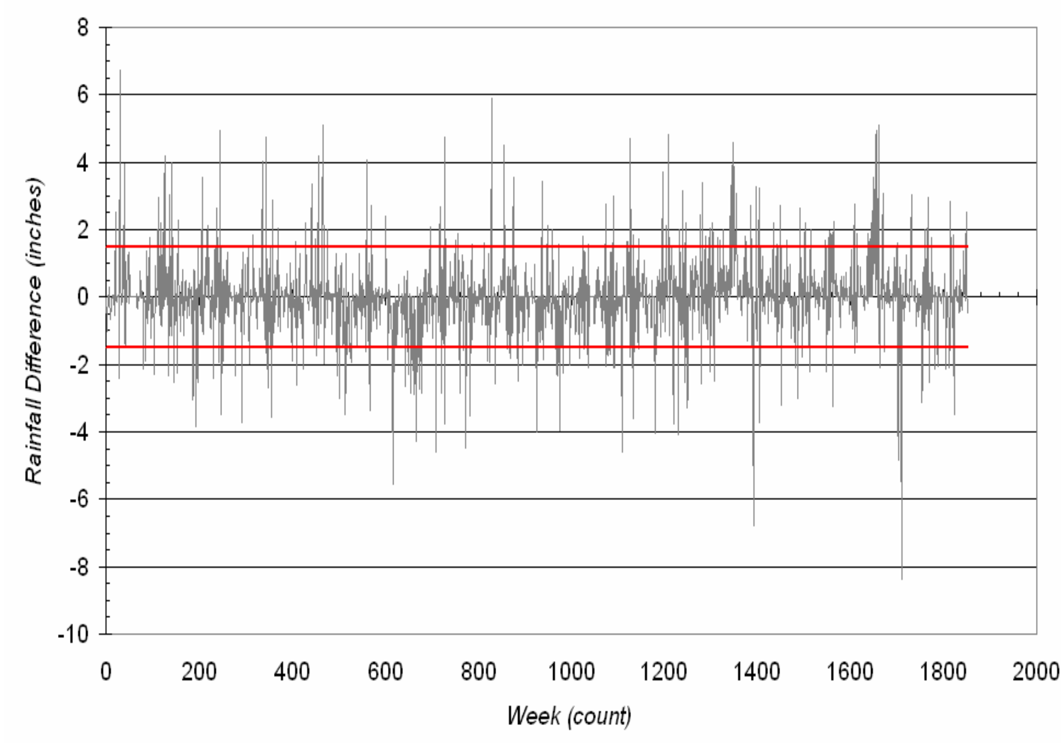


Figure 19. Weekly Rainfall Delivery Differences. Also shown are lines at one standard deviation from the mean as a reference for deviation significance. Differences are computed as Vero Beach Tower minus Ft. Pierce Tower.

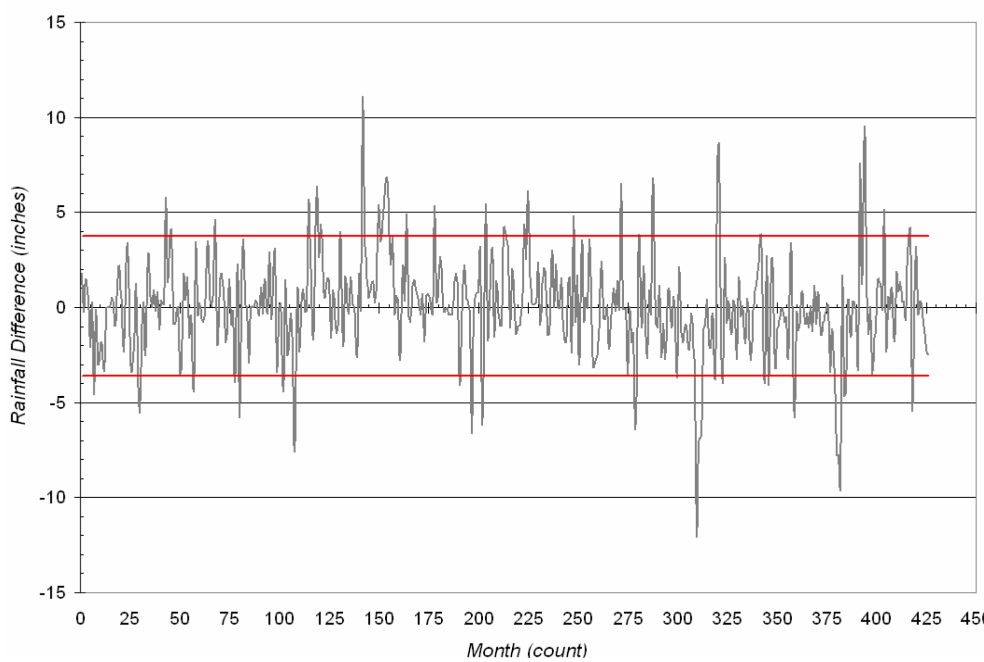


Figure 20. Monthly Rainfall Delivery Differences. Also shown are lines at one standard deviation from the mean as a reference for deviation significance. Differences are computed as Vero Beach Tower minus Ft. Pierce Tower.

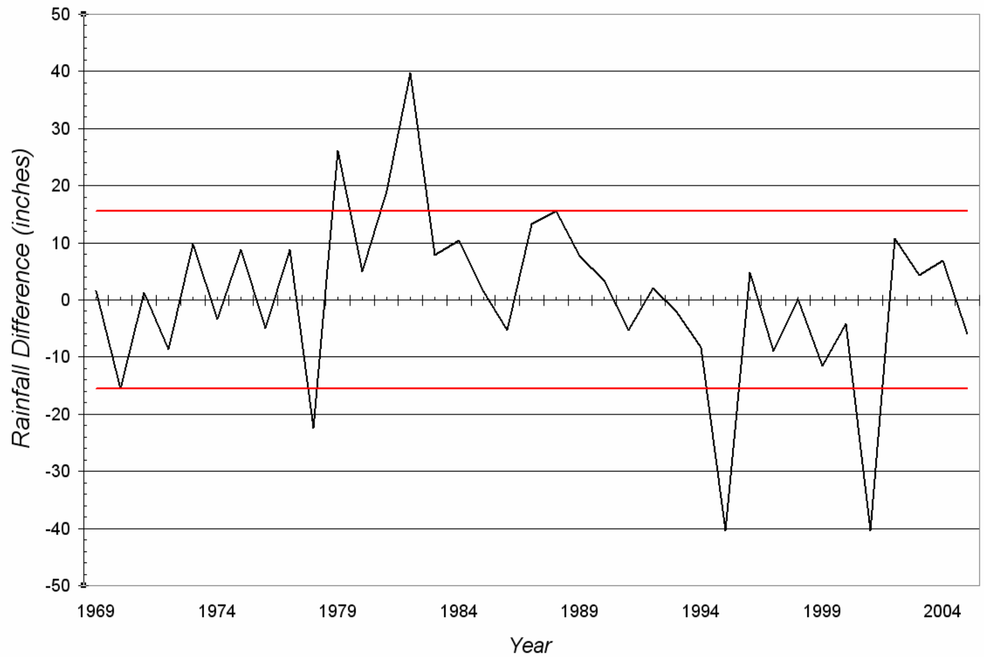


Figure 21. Annual Rainfall Delivery Differences. Also shown are lines at one standard deviation from the mean as a reference for deviation significance. Differences are computed as Vero Beach Tower minus Ft. Pierce Tower.

Part III. Statistical Rainfall Delivery Properties

The final analysis evaluates the implicit properties of the rainfall delivery systems at each location. Figure 5 below shows the relationship between rainfall event frequency and magnitude. As expected, the relationship is logarithmic (log[frequency] α rainfall^{-1}) and qualitatively similar between locations. We note that large events (>5") are statistically less likely at the Ft. Pierce location, but, given the relatively short period of record, this is assumed to be circumstantial. The slope and intercept values of fitted lines are not statistically significantly different (a = 0.05) suggesting that the intrinsic properties of the rainfall delivery between the locations are the same.

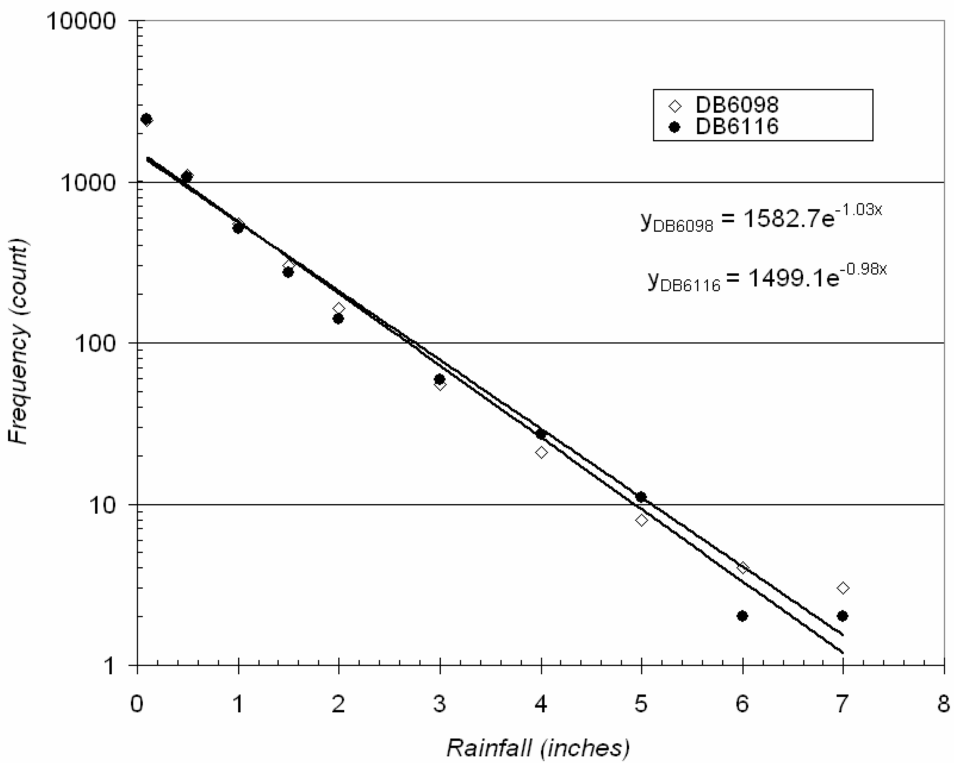


Figure 22. Comparison of Frequency-Magnitude Relationship for Rainfall Delivery Between Locations. Fitted lines (exponential curves) are shown; parameter values for the fitted lines are not statistically different based on predicted standard error estimates.

In summary, this is a preliminary analysis. Further work could document variability between additional stations over longer time to deduce if these data are anomalous. However, based on these observations, it appears that there is significant variability in rainfall delivery between locations over a time scale that warrants further study of projected demands, storage alternatives, and local shared access between Districts to attenuate water allocation constraints.

5.0 Methodology for Conceptual Design through Final Plans

As listed in Section 2.0, there are a number of previous reports and modeling efforts for several of the basins in this study area. However, each was prepared for only a portion of the study area and each had different goals and objectives. The spreadsheet analysis in this report directly uses available historic discharge data. The results present a preliminary indication that a large volume of water has historically been, and is currently, discharged off the coast. The volume is sufficient to represent an alternative supply of freshwater for consumptive and irrigation purposes. Preliminary review suggests that the historic and current discharge of this volume of water may be disruptive to both the IRL estuarine system and the local groundwater-surface water system. In addition, analysis of rainfall patterns indicate that local variability in rainfall can affect short term water supply availability across the District boundary. Together, these data indicate that there is a sufficient volume of freshwater and sufficient need to warrant further study and quantification of the benefits and constraints of storage alternatives.

A general approach for further study is listed below – although presented as a chain of events, it is an adaptive process with successive steps potentially feeding back to and refining prior steps.

General Methods and Approach

- Conceptual Model and Alternative Formulation
- Dynamic Systems Model and Preliminary Scenario Analysis
- Hydraulic and Hydrologic Model
- Geotechnical Studies
- Feasibility Studies
- Basis of Design Report
- Preliminary Design Through Final Plans and Specs

Iit is highly recommended that future analysis use a data time range consistent with CERP projects, currently this is the 41 year range from Jan 1, 1965 through December 31, 2005.

5.1 Conceptual Model and Alternative Formulation

A conceptual model of the study area storages, flows, connections, and feedbacks can assist in the initial analysis of a complex system. The process of mapping connections and identifying data needs to define sub-portions of the system help establish an efficient framework for rigorous analysis. Steps in this stage include:

- Development of a conceptual systems model
- Identification of data needs, availability and QC

- Identification of storage, flow, and feedback rates

For example, the spreadsheet analysis presented in this report represents a conceptual model and preliminary dynamic analysis of sub-portions of the larger surface water system.

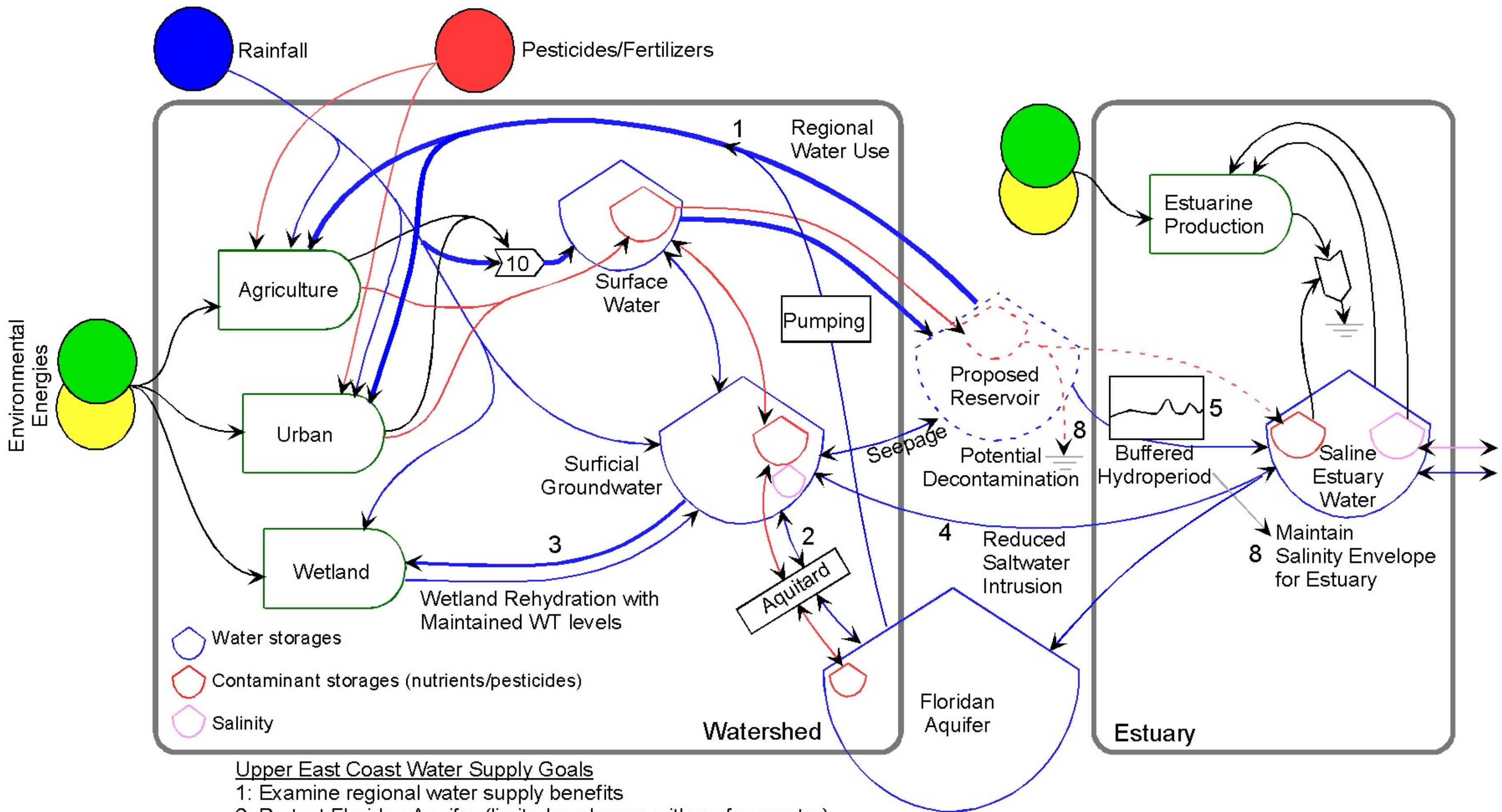
5.2 Dynamic Systems Model and Preliminary Scenario Analysis

The conceptual systems model sets the framework for the development of a dynamic simulation model of aggregate functions in the complex system. As example, Figure 23 depicts a conceptual systems dynamic model of the study area and reservoir. This diagram shows initial inputs, storages, connections, flows, transformations and outputs for natural system and human stakeholders. Application of initial conditions and dynamic rate equations to these storages and flows gives a preliminary scenario analysis tool. Steps in this stage include:

- Development of a dynamic systems model for scenario testing and optimization,
- Preliminary sensitivity analysis,
- Preliminary scenario analysis,
- Development of framework for H&H model needs, and
- Development of framework for Feasibility Study needs.

The reconnection and storage of water potentially serves many benefits by capturing water that is currently lost, via man-made conveyances, from the freshwater system. The redirection of this water represents a restoration to more natural conditions. In addition to channelization, irrigation of farmland in the area currently relies on groundwater withdrawals. The groundwater withdrawals and subsequent infiltration after irrigation have resulted in increasing salinity concentrations in the soil and shallow aquifer and are contributing to saline intrusion on the coast. Cessation of these withdrawals and irrigation with fresh water from storage could help re-balance this system. The cessation of groundwater pumping and the infiltration of added irrigation water will both help to mitigate the saline build-up in soils and surficial groundwater. In addition, the cessation of groundwater withdrawals and increased recharge will both prevent further saltwater intrusion and loss of groundwater resources. The stored fresh water can be transferred and used by both Districts as a flexible source of water for irrigation and other demands. The storage and increase in recharge will support environmental delivery to isolated wetlands, improve water quality, protect surface and groundwater quantities, and create an alternative drinking water supply.

A tool to demonstrate these potential effects and to help optimize placement and sizing of storage areas and timing of flows would be beneficial in the conceptual design stages. This exercise also helps determine data gaps and areas of uncertainty that might be able to be corrected with additional sampling or data gathering.



Upper East Coast Water Supply Goals

1: Examine regional water supply benefits
2: Protect Floridan Aquifer (limited exchange with surface water)
3: Protect regional wetlands
4: Reduce saltwater intrusion
5: Establish maximum drought levels (for wetlands and estuaries)
6: Flood protection **(unknown)**
7: Compatibility with local governments **(unknown)**
8: Protect St. Lucie Estuary and Indian River Lagoon (salinity envelope maintenance and contaminant removal)
9: Link with other Regional Planning Efforts **(unknown)**
10: Effect of land development on surface water dynamics via impervious surfaces, compaction, tile drainage, canals, etc.

Figure 23 Systems Dynamics Flow Diagram

5.3 Geotechnical Studies

In order to adequately predict the behavior of proposed reservoirs and canals considered in the context of hydraulic reconnection and water supply, a detailed evaluation of geologic and hydrogeologic conditions within proposed water storage areas would be necessary. The evaluation would involve the review of existing hydrogeologic studies and reports (ex. SFWMD Technical Publication 92-03) as well as the collection of supportive field data in the form of perimeter and interior soil borings, monitoring of groundwater, percolation rates, etc. Investigative activities would need to be sufficient to support subsequent Hydraulic and Hydrologic modeling and establish design criteria for embankments, canals, seepage, water control structures and erosion control.

5.4 Hydraulic and Hydrologic Model

Upon collection of pertinent field data, Hydraulic and Hydrologic (H&H) modeling of proposed impoundment areas would be conducted to evaluate groundwater movement as well as anticipated impoundment and canal water flows. H&H modeling would typically involve the creation and evaluation of a series of supportive and potentially inter-connected models evaluating various key behaviors of the reservoir system. Modeling elements would potentially include:

- **Seepage Anlyses –** to determine the interaction between proposed reservoirs and underlying aquifers. Used to evaluate vertical flow dynamics and potential impacts to adjacent areas associated with changes in groundwater flow and elevations. (example modeling tool = Seep2D)
- **Hydraulic Model –** to properly size reservoirs, canal systems and water control structures. Involves the creation and calibration of an existing model which adequately reflects the behavior of the existing hydraulic system. Review and assimilation of existing models maintained by the SJRWMD & SFWMD would likely accelerate and minimize efforts necessary to establish an acceptable existing model for the study area. Upon calibration of the existing model, model elements would be adjusted to reflect proposed channel and reservoir locations in order to adequately assess the required size of impoundments, canals and water control features. (example modeling tool = HEC-RAS)
- **Flood Modeling –** to assess potential effect of proposed impoundments and canal modifications on flooding in the study area. Involves the routing of recorded rainfall from extreme storm events through the proposed system as modeled as well as the potential evaluation of embankment failures of proposed resevoirs and canal systems. (example modeling tools = HEC-RAS, DAMBREAK)
- **Wave Run-Up Model –** to evaluate performance and refine design of perimeter embankments and levees associated with proposed impoundments.

- **Ground Water Flow Model** – to evaluate behavior of ground water beneath and surrounding proposed impoundments and canals. (example modeling tool = MODFLOW)
- **Water Budget Analyses** – to predict long term availability of water within the proposed impoundment areas. Involves the evaluation of daily (and monthly) inflows, outflows, rainfall and evaporation to the impoundment areas to predict stages in the reservoirs. Evaluation beneficial for predicting behavior of system during flood and drought periods and refining reservoir sizing and water availability and efficiency.

5.5 Feasibility Study

In order to properly assess the overall benefits and costs of a proposed impoundment and reconnection system a feasibility study would be prepared. H&H modeling results would be evaluated from fiscal and water resource perspectives to anticipate improvements in the ability to meet water demands and address flooding issues within the study area. Benefits to water quality such as reduction of freshwater flows and nutrient loadings to the Indian River Lagoon system would also be quantified. Fiscal costs and effects on local industries (such as citrus) and residential communities would also be evaluated to inventory costs associated with a proposed reservoir system. Typically the costs and benefits associated with several potential system configurations would be evaluated and compared to determine an optimal arrangement.

5.6 Basis of Design Report through Final Plans and Specs

The Basis of Design Report (BODR) should clearly define the goals, objectives, design criteria and recommended arrangement of the reservoir system. Key project components such as reservoir footprints and embankments, canal modifications, pump stations and sizing as well as water routing would be defined within the BODR. Supporting documentation and data generated during previous steps would be summarized and included within the BODR. Conceptual layouts, cross-sections and plans for system components (impoundments, canals, pump stations, gates, etc.) as well as supporting design criteria and limitations would be generated and outlined within the BODR. The BODR would also contain anticipated project costs based on concept plans and potential construction contract alternatives. Upon acceptance of the BODR preliminary through final design plans and specs would be prepared.

5.7 Summary and Recommendations

In summary, there appears to be sufficient freshwater supply available to support going forward with the next phase of analysis. In excess of 10 million acre-feet of fresh water has been discharged off the coast over the past 50 years. A median value of about 200,000 acre-feet of water will continue to be discharged and lost from the local freshwater cycle each year. The mitigation of this loss and the potential benefits of restoring natural flows warrant further study in this area. As estimate for supply is presented but demand for the supply must be identified prior to consideration of capital expenditures. The full recommended approach is:

- *Conceptual Model and Alternative Formulation*
- *Dynamic Systems Model and Preliminary Scenario Analysis*
- Hydraulic and Hydrologic Model
- Geotechnical Studies
- Feasibility Studies
- Basis of Design Report
- Preliminary Design Through Final Plans and Specs

The highlighted first two steps include an analysis of demands and reservations. This report gives an initial indication of supply, the next stages summarize demands and critical interactions. Together these data form the basis for preliminary scenario analysis. As example, the demand and scenario analysis includes (but is not limited to) critical components such as:

- analysis of drinking water demands and supply as land use shifts from agricultural to urban uses,
- analysis of changes in recharge and flooding patterns as land use shifts from agriculture to urban uses,
- consideration of the stored water as a flexible future source of drinking water in terms of both District's water supply planning,
- a demonstration of the usefulness of an alternative supply, joint contribution to storage, and interdistrict transfer, during months of variable rainfall between the Districts:
    - water from both Districts can be stored for use by either District in times of local drought, fire, or unexpected need
    - the storage is available to both Districts in times of excess water when additional diversion and storage capacity is needed
    - additional storage now buffers the uncertainty in projecting future demands and unanticipated future changes in the hydrologic and hydrogeologic cycles and storages,
- analysis of pre- and post-development natural discharges to the IRL and the effect of the volume and timing of flows to the estuary, and
- analysis of potential regional and coastal water quality benefits.

History has shown that there can be local, short-term, variability in rainfall in this area causing severe localized shortages in one area, with excess in near-by areas. Statistical analysis of rainfall stations on either side of the District's boundaries indicate that there is significant variability in rainfall delivery between locations over a time scale that warrants consideration of local storage and transfers for attenuating water allocation constraints Joint contributions to storage and flexible distribution are a natural solution to this variability. In addition, the study area can be classified as a WRCA and is near areas in SFWMD where supply is so constrained that new permits are not being issued. Given the projected future growth of this region, the current impacts of the discharged water to the IRL, the local variability in rainfall, and the volume of water under consideration, additional analysis and scenario testing is recommended.

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(Note: see Tables in Section 2.0 for Bibliography)