Everglades Agricultural Area Regional Feasibility Study

For Period 2010 – 2014

(Work Order No. CN040912-WO04 Phase 2)

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EVERGLADES AGRICULTURAL AREA REGIONAL FEASIBILITY STUDY

FOR PERIOD 2010 – 2014

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1.0 EXECUTIVE SUMMARY

The long-term Everglades water quality goal is for all discharges to the Everglades Protection Area (EPA) to achieve and maintain compliance with water quality standards, including phosphorus, as established in Rule 62-302.540 of the Florida Administrative Code (F.A.C.). The projects in the October 27, 2003 *Everglades Protection Area Tributary Basins Long-Term Plan for Achieving Water Quality Goals* (Long-Term Plan) were designed to achieve compliance with the water quality standards for the EPA by December 31, 2006. Subsequent to completion of the Long-Term Plan, it was determined that all of the Everglades Agricultural Area (EAA) Storage Reservoir Project's water storage goals could be achieved on Compartment A, and that Compartments B and C would not be needed to meet the storage objectives of the EAA Storage Reservoir Project (Phase 1 and 2). It is the South Florida Water Management District's (SFWMD) intent to construct additional stormwater treatment areas on the remaining acreage of Compartments B and C, in association with STA-2, STA-5 and STA-6, to assist the STAs in improving water quality entering the EPA. To meet the objectives of the Long-Term Plan, the SFWMD contracted the A.D.A. Engineering, Inc. (ADA) team (ADA Team) to perform an EAA Regional Feasibility Study (RFS).

One of the objectives of the EAA RFS was to determine if the distribution of flows and loads for the Period of 2006 – 2009 could be optimized prior to the completion of required EAA Canal Improvements, the EAA Storage Reservoir (EAASR) Compartment A-1, and the build-outs of Compartments B and C. Another objective was to identify and evaluate alternatives that would redistribute the hydraulic and total phosphorus (TP) loads to the STAs (both existing and the currently planned STA-6 Section 2, full conversion of Compartments B and C of the Talisman Land Exchange to use in STAs) to optimize phosphorus reduction, given the presence of the EAASR Compartment A-1. This analysis is specific to the Period 2010-2014 (following completion of the above identified projects, but prior to the completion of the planned EAASR Compartment A-2).

To meet the objectives of the EAA RFS, a revised Baseline Data set was developed consistent to the extent practicable with recent actual data and capable of acceptance by other agencies and parties (such as the United States Department of the Interior and the EAA Environmental Protection District) as being representative of inflow volumes and total phosphorus loads to the various stormwater treatment areas. This Baseline Data was used for determining the optimum allocation of phosphorus and hydraulic loads to the existing STAs, including STA-6 Section 2, STA-2 Cell 4 and STA 5 third flow-way. The July 1, 2005 issue of the Dynamic Model for Stormwater Treatment Areas, Version 2 (DMSTA2), developed for the U.S. Department of the Interior and the U.S. Army Corps of Engineers (USACOE) by W. Walker and R. Kadlec, was used to determine the optimum redistribution of the flows and loads within the EAA. The MIKE 11 hydrologic/hydraulic model of the EAA developed by USACOE as part of the EAA Project Implementation Report (PIR) was updated and refined to evaluate the capacity of the existing EAA canals in achieving the optimum flows and loads distribution. This analysis indicated that it does not appear that the existing canals, including implementing minor changes in the Cross Canal, can re-direct flows from the S-5A Basin to the North New River Canal to improve performance of existing STAs. Therefore, a more comprehensive suite of construction projects will be needed to improve the flow deliveries from the S-5A and S-6 Basins to STA-3/4.

A total of five (5) alternatives were developed in close coordination with SFWMD staff and the Long-Term Plan Working Group for redistributing water and associated phosphorus loads from the eastern EAA basins (e.g., the S-5A Basin) to the central and western areas of the EAA and include potential changes to the SFWMD's canal system and structures to meet the water quality improvement goals. Selection of alternatives assumed the availability of prior purchased lands provided by the Talisman Land Exchange. Those lands were Compartments B and C and the A-1 Reservoir.

The key components and features of each alternative are summarized as follows:

Alternative 1 – closing of the S-5AW Structure and doubling the size of the S-5AE structure; addition of new gate in West Palm Beach (WPB) Canal to divert the northern S-5A Basin flows into S-2/S-6 Basin; addition of new Canal from WPB Canal to the Sam Senter Canal; expansion of the Sam Senter Canal; addition of new gate in the Hillsboro Canal south of the Cross Canal; expansion of the Ocean Canal capacity from the Sam Senter Canal to the Hillsboro Canal; expansion of the of the Hillsboro Canal capacity from the Ocean Canal to the Cross Canal; expansion of the Cross Canal capacity and enlarging farm bridges along the Cross Canal; expansion of the North New River Canal (NNRC) capacity; addition of A-1 Reservoir and Compartment B with inflow pumps on the NNRC; and connection of STA-2 Cell 4 to Compartment B without connection to Cells 1, 2, and 3 of STA-2.

Alternative 2 - enlargement of S-5AE to twice the existing capacity and close Structure S-5AW, enlargement of the L-7 Borrow Canal and separation of the Borrow Canal from the Loxahatchee National Wildlife Refuge (Refuge); replacement of G-338 with a new gated control structure that would allow L-7 flows to be delivered to the STA-2 Inflow Canal; construction of a new canal from the STA-2 Inflow Canal to Compartment B; removal of G-336G Structure; enlargement of the Cross Canal and the NNRC; addition of a new inflow pumping station on the NNRC to the A-1 Reservoir; addition of a hydraulic connection of the new STA-2, Cell 4 to the new Compartment B STA; enlargement of the Ocean Canal and Hillsboro Canal; addition of a new gated structure on the Hillsboro Canal to limit flow into STA-2; modification of the operations of S-5A, G-300, G-370, G-335, G-302, and S-155A; and modification of length and cross sections of the STA 2, Cell 4 Discharge Canal.

Alternative 3 – modification of Alternative 1 above and includes all features of Alternative 1, but also includes a pump station in the Manley Ditch to convey additional water to L-2 just north of STA-5.

Alternative 4 – comprised of a mix of components of Alternatives 1, 2, and 3. The objective of this alternative is to take the best features of previous alternatives to reduce the overall cost while maintaining desired nutrient removal performance.

Alternative 5 – comprised of Alternative 1 with a modification of Compartment B internal flow patterns to keep STA-2, Cell 4 hydraulically linked to STA-2 Cells 1, 2, and 3.

An evaluation methodology was developed as part of the EAA RFS to provide a common basis for evaluating the various alternatives and is comprised of three (3) evaluation criteria categories: Technical Factors, Environmental Factors, and Economic Considerations. The evaluation criteria for each factor are summarized as follows:

Technical Factors – include long-term phosphorus concentration achieved, flood impact, operational flexibility, reservoir operation factors and implementation schedule including real estate acquisition;
Environmental Factors – include redistribution of flows and TP loads to receiving waters, and maintaining desirable water levels in the Loxahatchee Wildlife Refuge; and

Economic Considerations – include probable planning-level opinion of cost (50-Year Present Worth, and cash flow analysis).

The MIKE 11 hydrology/hydraulic and DMSTA2 models were used to assess the hydraulic and TP concentration and load reduction performance of the alternatives, respectively. As part of the alternative evaluation, probable planning-level costs were developed for each alternative. The total cost estimate for each alternative includes capital (design and engineering, equipment, land acquisition, construction and civil work), associated program management costs, and operation and maintenance costs. These costs were converted to a 50-year present worth cost in 2006 dollars. As part of the evaluation, a cash flow analysis was performed to determine the timing of cash outlays. Annual costs of project implementation were determined using the detailed information provided in the cost estimate and the implementation schedule.

The alternatives were evaluated and the results of the evaluation are summarized in Table 1.1. Key findings are summarized below:

- Alternative 1 performs well in delivering water to Compartment B and the A-1 Reservoir while maintaining flood control objectives.
- Alternative 2 has low TP outflow concentrations, but is less robust in maintaining flood control objectives.
- Alternative 3 has the same benefits of Alternative 1, and the diversion of runoff from the Miami Canal to STA 5 will provide greater water quality and flood control benefits. However, this alternative cannot proceed until on-going research on STA 5 performance demonstrates that STA 5 can assimilate additional flows beyond C-139 runoff.
- The results of Alternative 4 are not included in this table, because the intent of this alternative was to utilize the best features of Alternatives 1, 2, and 3 to meet project objectives while minimizing cost. However, no combination provided a hydraulic improvement over Alternatives 1 through 3. Therefore further assessment of Alternative 4 was abandoned.
- Alternative 5 utilizes inverted siphons in Compartment B, and hydraulic modeling results indicate large head losses. Maintenance of the siphons is an additional concern for this alternative.
- Compartments B & C and the Cross Canal improvements will be completed by the end of 2009 and required canal improvements to deliver water to Compartment B and the A-1 Reservoir will be completed in the first quarter of 2010.

The single largest uncertainty in this feasibility study is the TP removal effectiveness of STA 5. Currently, STA 5 has received higher unit area TP loads than the other STAs, and has demonstrated lower nutrient retention characteristics. If lower unit area TP loads result in higher nutrient removal, then larger percentages of Miami Canal runoff can be diverted to STA 5/Compartment C, which will enable STA 3/4 to treat runoff that would otherwise be pumped to Lake Okeechobee via existing pump stations S-2 and S-3.

In addition, this feasibility study assumed that L-8 runoff will be not be treated by the EAA STAs but will flow through S-155A to tide. Water supply deliveries to the Lower East Coast will not be treated in the STAs but will pass through the Water Conservation Areas (WCA) during times when water levels in the WCAs are below the floor of their regulation schedules. The re-direction of flows to the A-1 Reservoir and Compartments B and C will change the magnitude of discharges to the WCAs. Overall impacts appear to be minor and are currently being evaluated further using the South Florida Water Management Model using results from this study.

The probable planning-level opinion of capital cost including land acquisition is in the range of $300,000,000. The 50-year present worth cost is in the range of $461,000,000 to $484,000,000. The costs for Alternatives 1 – 3 and 5 are within 5% of each other.

The RFS has been a fact-finding exercise and was not intended to define the final arrangement, location and character of the proposed project. The purpose of the Study has been to develop information necessary for the planning, design and construction of future projects in the EAA. Results of the Study will provide the Legislature, SFWMD Governing Board, and stakeholders information necessary for the policy decisions needed to determine the optimum combination of water quality treatment solutions.

Table 1.1 - Summary Table of Alternatives Evaluation

Evaluation Criterion	Quantitative Measure (see note 1)			
	Alternative 1	Alternative 2	Alternative 3	Alternative 5
Technical Factors				
1. Long-Term Phosphorus Concentration Achieved (Flow-weighted mean value)	17.1 ppb (13.3 – 18.9)	16.4 (14.9 – 18.3)	See note 2 below	17.1 ppb (13.3 – 18.9)
2. Flood Impact Analysis				
• Flooding (>12.5 ft NGVD)	0.0 miles	4.8 miles	0.0 miles	4.8 miles
• Canal Peak Stage, Miami 3914	12.4 ft-NGVD	12.93 ft-NGVD	11.75 ft-NGVD	12.6 ft-NGVD
3. Operational Flexibility				
• Structures/Pump Stations	Two new gates, Two new pump stations	Two new gates, One new pump station	3 new gates, 3 new pump stations	Two new gates, Two new pump stations
• Operational Modifications	Two new flow routes	STA 1W to STA 2 via L-7	3 new flow routes	Two new flow routes
	2,760 cfs Cross to NNR	3,093 cfs Cross to NNR	2,760 cfs Cross to NNR	2,500 cfs Cross to NNR
• Operational Concerns		5,000 cfs A-1 PS required	Implement if STA 5 TP removal improves	Maintenance of siphons is difficult
4. Reservoir Operation Factors				
• Reservoir Avg Annual Inflow Vol.	416,800 ac-ft/yr	416,800 ac-ft/yr	416,800 ac-ft/yr	416,800 ac-ft/yr
• Reservoir Design Inflow Volume	130,800 ac-ft	168,200 ac-ft	130,800 ac-ft	130,800 ac-ft
• Irrigation Supply, Ac-ft/yr	180,000 ac-ft/yr	180,000 ac-ft/yr	180,000 ac-ft/yr	180,000 ac-ft/yr
5. Implementation Schedule including Real Estate (completion year)	2011	2014	2011	2011 (Comp B schedule after 2008)
Environmental Factors				
6. Redistribution of flows and loads	1,715,679 ac-ft/yr	1,540,500 ac-ft/yr	1,715,679 ac-ft/yr	1,715,679 ac-ft/yr
7. Impact to Refuge	See note 3.	See note 3.	See note 3.	See note 3.
Economic Considerations				
8. Opinion of Probable Planning Level Capital, Real Estate, & O&M Cost (50 yrs present worth)	$459 million	$495 million	$480 million	$464 million
9. Cash Flow Analysis (See note 4)	21 million / 3.25 yrs	26 million / 2.5 yrs	21 million / 3.25 yrs	24 million / 2 yrs

Notes:
1. Alternative 4 is not shown due to initial modeling results. See section 5.4.
2. Overall outflow concentration should be less if STA 5 performance improves. See section 5.3.
3. Further study required. See Section 3.2.2.
4. Duration given is the period of primary construction activity.

2.0 INTRODUCTION

2.1 Background

The long-term Everglades water quality goal is for all discharges to the Everglades Protection Area (EPA) to achieve and maintain compliance with water quality standards, including phosphorus, as established in Rule 62-302.540 of the Florida Administrative Code (F.A.C.). Figure 2.1 shows an overview of the EPA. Substantial progress towards reducing phosphorus levels discharged into the EPA has been made by the State of Florida and other stakeholders. The combined performance of the source controls in the EAA and the Stormwater Treatment Areas (STAs) of the Everglades Construction Project (ECP) has exceeded expectations. In addition, some source control measures have been implemented in urban and other tributary basins included in the Everglades Stormwater Program (ESP). Nonetheless, additional measures are necessary to achieve the Everglades water quality goal.

The projects in the October 27, 2003 *Everglades Protection Area Tributary Basins Long-Term Plan for Achieving Water Quality Goals* (Long-Term Plan) (Burns and McDonnell, 2003) were designed to achieve compliance with the water quality standards for the EPA by December 31, 2006. One of the key assumptions during the development of the Long-Term Plan was that Compartments B and C (see Figure 2.2) would be under consideration for use as part of the Everglades Agricultural Area (EAA) Storage Reservoir Project through FY 2010 and for this reason should not be considered for other Everglades restoration uses until FY 2011. Subsequent to completion of the Long-Term Plan, it was determined that all of the EAA Storage Reservoir Project's water storage goals could be achieved on Compartment A, and that Compartments B and C would not be needed to meet the storage objectives of the EAA Storage Reservoir Project (Phase 1 and 2). In light of the recent availability of land in Compartments B and C, construction of additional stormwater treatment areas is proposed in association with STA-2, STA-5 and STA-6, to assist the STAs in improving water quality entering the EPA. It is also the South Florida Water Management District's (SFWMD) intent to construct additional stormwater treatment areas on the remaining acreage of Compartments B and C.

To meet the objectives of the Long Term Plan, the SFWMD contracted the A.D.A. Engineering, Inc. (ADA) team (ADA Team) to perform an EAA Regional Feasibility Study (RFS) to determine the optimal configuration of stormwater treatment areas on Compartments B and C with the objective of assisting the STAs in improving water quality in the EPA. This Study has been completed as recommended in the Revised Part 2 of the Long Term Plan for Achieving Water Quality Goals (November 2004) which can be found at the following location: http://www.sfwmd.gov/org/erd/longtermplan/documents.shtml. To expedite the execution of the RFS, the Study has been conducted in two phases, each under a separate SFWMD contract work order: Phase 1 (CN040912-WO03) and Phase 2 (CN040912-WO04). Phase 1 included the development of the Detailed Work Plan (Phase 1, Task 1); a Methodology and Evaluation Criteria report (Phase 1, Task 2), an Operating Strategy for Optimizing STA Performance with Existing EAA Canals report (Phase 1, Task 3), and Technical Review Meetings (Phase 1, Task 4). Phase 2 included the remaining required tasks for completing the RFS, and was comprised of providing the following deliverables:

- Flows and total phosphorus (TP) Baseline Data (Phase 2, Task 1);
- Optimum Allocation of Phosphorous and Hydraulic Loading to the Existing STAs (Phase 2, Task 2);
- Optimum Allocation of Phosphorous and Hydraulic Loading to the Existing STAs and STAs on Compartments B and C and Reservoir A-1 (Phase 2, Task 3);

- Optimum EAA Canal Improvements for Optimum Existing STAs, STAs on Compartment B and C, and Reservoir A-1 (Phase 2, Task 4);
- Detailed Alternatives Analysis (Phase 2, Task 4);
- Technical Review Meetings (Phase 2, Task 6);
- coordination with Black and Veatch on the A-1 Phase 1 Reservoir Project (Phase 3, Task 7); and
- Feasibility Study Report (Phase 2, Task 8).

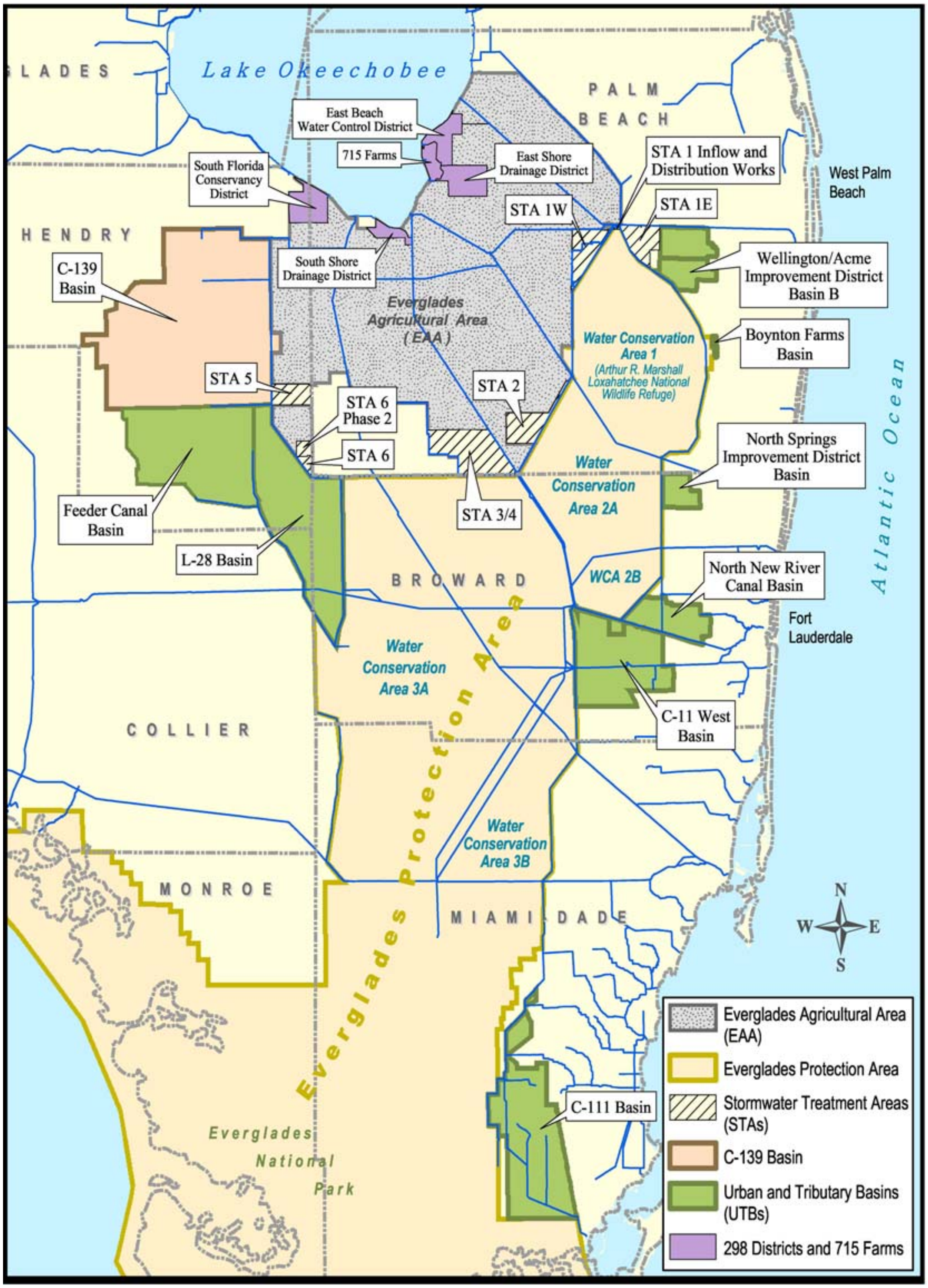

Figure 2.1 – Overview of the Everglades Protection Area

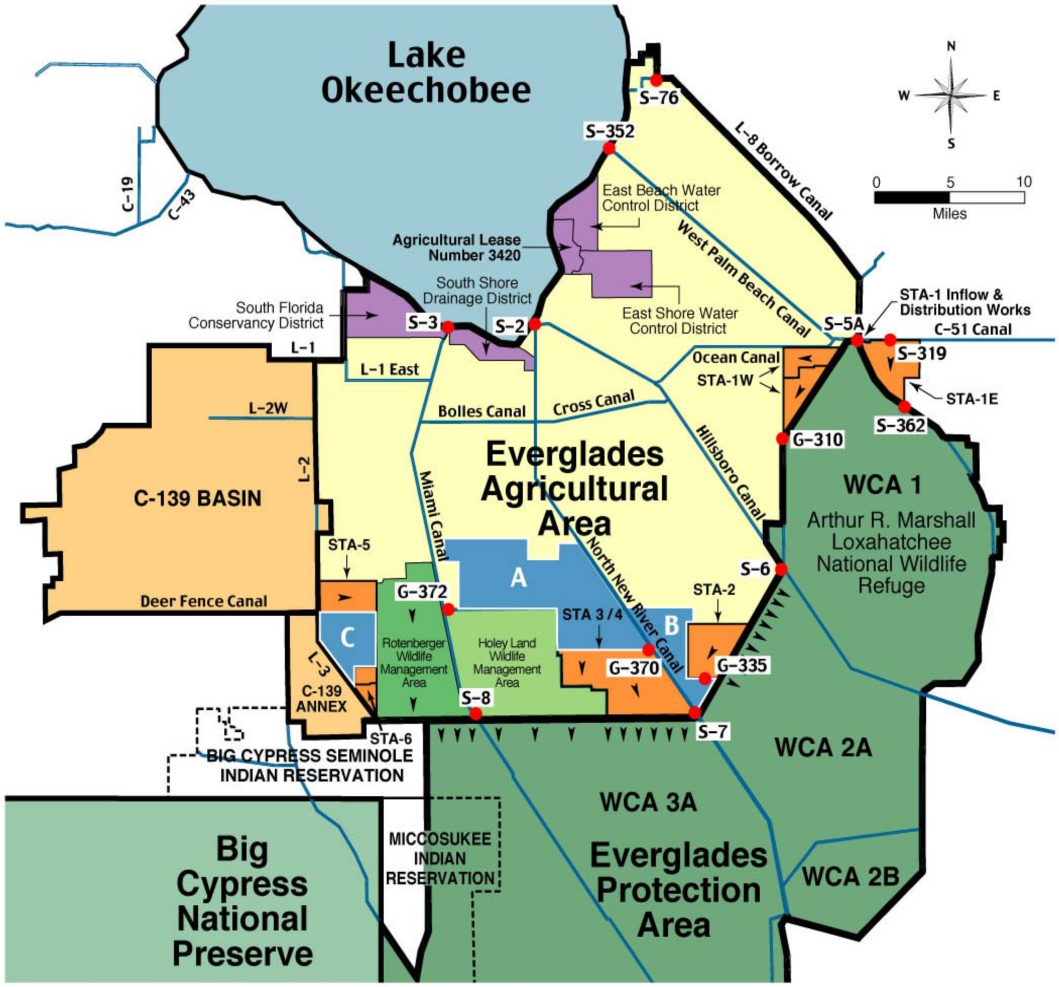

Figure 2.2 – EAA Study Area

To further expedite the development of the EAA RFS, the Phase 2 work order was modified to consolidate several tasks and deliverables as follows:

- Flows and total phosphorus (TP) Baseline Data (Phase 2, Task 1);
- Optimum Allocation of Phosphorous and Hydraulic Loading to the Existing STAs (Phase 2, Task 2);
- Optimum Allocation of Phosphorus and Hydraulic Loading to the Existing STAs Compartments B and C, and A-1 Reservoir, and Optimum Canal Improvements Associated with Optimum Allocation (Phase 2, Task 3);
- Detailed Alternative Analysis (Phase 2, Task 4);
- Technical Review Meetings (Phase 2, Task 6);
- coordination with Black and Veatch on the A-1 Phase 1 Reservoir Project (Phase 3, Task 7); and
- Feasibility Study Report (Phase 2, Task 8).

2.2 Scope of Work

The RFS Report has been prepared in accordance with SFWMD Work Order No. CN040912-WO03 (EAA RFS, Phase 1) and revised CN040912-WO04 (EAA RFS, Phase 2). The overall objective of the alternative analyses and evaluation reported herein is to evaluate the redistribution of hydraulic and total phosphorus (TP) loads to the STAs (both existing and the currently planned STA-6 Section 2, full conversion of Compartments B and C of the Talisman Land Exchange to use in STAs) to optimize phosphorus reduction, given the presence of the Everglades Agricultural Area Storage Reservoir (EAASR) Compartment A-1. This analysis is specific to the Period 2010-2014 (following completion of the above identified projects, but prior to the completion of the planned EAASR Compartment A-2).

In accordance with the revised EAA RFS Phase 2, Task 4, a total of five (5) alternatives have been identified in coordination with the Long-Term Plan Working Group to meet the objectives of the Long-Term Plan. These alternatives focus on redistributing water and associated phosphorus loads from the eastern EAA basins (e.g., the S-5A Basin) to the central and western areas of the EAA and include potential changes to the SFWMD's canal system and structures to meet the water quality improvement goals. Some of the improvements associated with these alternatives include:

1. Providing operational flexibility to redirect STA-1W inflows and/or outflows to the Hillsboro Canal and then to either STA-2 via the S-6 pump station, or to Compartment B and/or STA-3/4 via the North New River Canal;
2. Reducing flows and loads (up to an average of 30,000 acre-feet per year) to STA-1E from the S-5A Basin;
3. Balancing flows and loads across the STAs taking into account the proposed Bolles and Cross Canal Improvements and the recently completed Ocean Canal conveyance improvements;
4. Optimizing configuration of STAs on Compartments B and C with the objective of assisting the STAs in improving water quality in the EPA;
5. Optimizing usage of the EAA Storage Reservoirs with the objective of achieving this project's goals including providing flow equalization for the STAs;
6. Adding redundancy to current STA treatment facilities by providing the ability to take treatment cells off line for maintenance, construction of enhancements, or other purposes;
7. Minimizing potential for overloading the STAs during times of higher than normal runoff or Lake Okeechobee releases;
8. Improving the phosphorus removal performance of the STAs or otherwise reducing the risk associated with uncertainties in treatment performance projections in the Long-Term Plan;
9. Providing a hydraulic connection of STA-5, STA-6 and Compartment C to the Miami Canal (and Lake Okeechobee); and
10. Improving the L-7 and L-40 conveyance, if needed to minimize potential adverse water quality impacts to the interior of Refuge.

The identified alternatives have been evaluated in accordance with Deliverable 2.2 of Phase 1 of the EAA RFS (Evaluation Methodology and Evaluation Criteria, Final Report dated May 30, 2005). A copy of this report is included in Appendix A.

The RFS has been a fact-finding exercise and was not intended to define the final arrangement, location and character of the proposed project. The purpose of the Study has been to develop information necessary for the planning, design and construction of future projects in the EAA.

Results of the Study will provide the Legislature, SFWMD Governing Board, and stakeholders information necessary for the policy decisions needed to determine the optimum combination of water quality treatment solutions.

2.3 Reference Information

This section summarizes previous studies, reports, and data employed in the conduct of the analyses presented herein.

2.3.1 Basic Designs of Proposed STA Expansions

Information on the presently planned configuration and basic layout and design of STA-6 Section 2, Cell 4 of STA-2, and the third flow-way of STA-5 was taken from the following documents:

- *Basis of Design Report (BODR) Stormwater Treatment Area 6 – Section 2 and Modifications to Section 1*; prepared for the South Florida Water Management District by URS Corporation under Contract CN040936-WO02; June 1, 2005;
- *Basis of Design Report (BODR) STA-2/Cell 4 Expansion Project*; prepared for the South Florida Water Management District by Brown & Caldwell under Contract CN040935-WO04; May 12, 2005; and
- Draft Basis of Design Report (BODR) Stormwater Treatment Area 5 Flow-way 3; prepared for the South Florida Water Management District by URS Corporation under Contract CN040936-WO05; April 20, 2005.

No information is presently available for the planned configuration and basic layout and design of the full conversion of Compartments B and C of the Talisman Land Exchange to use as stormwater treatment areas. The layout and configuration of those expanded stormwater treatment areas <u>assumed</u> for use in this analysis is described in this report. The layout, configuration and operation of the EAASR Compartment A-1 <u>assumed</u> for use in this analysis is based on discussions with Black & Veatch and Acceler8 staff and are also described in this report.

2.3.2 Rainfall and Evapotranspiration

Estimates of daily rainfall and evapotranspiration (ET) at each of the STAs were taken from a SFWMD-furnished data file (ET_RF_STAs_ECP2006.xls). That file includes daily values for both rainfall and ET at each cell of the South Florida Water Management Model (SFWMM). There is a time series of rainfall and ET for each STA. The data extends from January 1, 1965 through December 31, 2000. For the analyses included in this document, daily data for those STAs occupying multiple cells of the SFWMM were estimated as the average of the individual cell values. Data for STA-3/4 were applied to the adjacent EAASR Compartment A-1.

2.3.3 Previous Studies and Reports

Certain background data and information discussed in this document were taken from the following previous studies and reports:

- (Draft) *Supplemental Analysis, Everglades Protection Area Tributary Basins*, prepared for the Everglades Agricultural Area Environmental Protection District by Burns & McDonnell; March 2, 2005 (hereinafter referred to as the Supplemental Analysis);

- Final Report, *Everglades Protection Area Tributary Basins, Long-Term Plan for Achieving Water Quality Goals*; prepared for the South Florida Water Management District by Burns & McDonnell; October, 2003 (hereinafter referred to as the Long-Term Plan), together with such modifications to the Long-Term Plan that are embodied in a revised Part 2 (dated November, 2004) submitted to the Florida Department of Environmental Protection (FDEP), and approved by FDEP in December, 2004;

- *Basin-Specific Feasibility Studies (BSFS), Everglades Protection Area Tributary Basins; Evaluation of Alternatives for the ECP Basins*; prepared for the South Florida Water Management District by Burns & McDonnell; October 23, 2002 (hereinafter referred to as the BSFS Evaluation of Alternatives);

- *Addendum to Design Documentation Report, Stormwater Treatment Area 1 East*; prepared for the Jacksonville District, U.S. Army Corps of Engineers by Burns & McDonnell; November 2000;

- *(Draft) Stormwater Treatment Area 1-East (STA-1E) Water Control Plan*, Jacksonville District, U.S. Army Corps of Engineers; August, 2005;

- *(Draft) Design Analysis Report for the STA*-1E Cells 1-2 PSTA/SAV Field-Scale Demonstration Project, Palm Beach County, Florida; prepared for the Jacksonville District, U.S. Army Corps of Engineers by SAIC Engineering, Inc.; June 28, 2005;

- *STA 1W, 2, 3/4, 5, and 6 Operating Plans*; prepared by SFWMD, 2000 (STA 5), 2001 (STA 2), 2004 (STA 1W, STA 3/4, STA 6); and

- *STA 1E Operating Plan* – draft; prepared by SFWMD, In Review.

3.0 ANALYTICAL TOOLS AND METHODOLOGY

3.1 Hydrologic/Hydraulic Modeling

The initial EAA RFS, Phase 1 scope-of-work (Work Order No. CN040912-WO03) stated that an existing conditions HEC-RAS hydraulic analysis model would be developed for the Miami, North New River, Bolles, Cross, Hillsboro, West Palm Beach, Ocean, and STA 3/4 Supply Canals. Based on discussions with the SFWMD Office of Modeling staff, it was concluded that a better approach would be to use, modify and refine the existing MIKE SHE/MIKE 11 hydrologic/hydraulic model of the EAA being completed by the U.S. Army Corps of Engineers (USACOE) as part of the EAA Project Implementation Report (PIR). This approach is outlined in Deliverable 2.2 of Phase 1 of the EAA RFS (Evaluation Methodology and Evaluation Criteria, Final Report dated May 30, 2005). A copy of this report is included in Appendix A. The approach includes decoupling the MIKE SHE model from the MIKE 11 hydraulic model and using the MIKE 11 for the required hydraulic analyses for this project.

The following sections and subsections summarize the approach implemented in developing, refining, and implementing hydrologic analysis in the MIKE 11 model. The detailed approach is outlined in Deliverable 4.2 of Phase 1 of the EAA RFS (Operating Strategy for Optimizing STA Performance with Existing EAA Canals, Final Report dated October 3, 2005). A copy of this report is included in Appendix B.

3.1.1 Model Provided by U.S. Army Corps of Engineers

The USACOE, as part of the EAA Storage Reservoirs PIR project, developed a MIKE SHE/MIKE 11 model for the EAA. This integrated surface/ground water continuous simulation model describes the full hydrologic cycle of the EAA including rainfall, evapotranspiration, infiltration, groundwater, runoff, canal hydraulics, and canal/aquifer exchanges. Structure details and operations of over 150 hydraulic control structures are handled by the surface water hydraulics model MIKE 11. The MIKE 11 hydraulic network is shown in Figure 3.1. The model represents 2004 conditions and included STA 3/4 with structures G-371 and G-373 on the North New River and Miami Canals, respectively. The MIKE SHE portion of the model (rainfall, overland flow, and groundwater model) was decoupled from the MIKE 11 model and not used. Rainfall and evapotranspiration can also be modeled in MIKE 11.

3.1.2 MIKE 11 Model Refinements

A number of refinements were made to the network to represent 2006 conditions and to improve hydraulic control structure operations to remove model instabilities. The refinements made to the model are as follows:

1. STA-1E was added to the MIKE 11 model so that the distribution of flows between STA-1E and STA-1W could be described at high flow conditions.
2. C-51W Canal was added to the MIKE 11 model using available canal cross sections.
3. G-341 Structure was added to the model using design drawings and has been programmed to open if water levels west of the structure exceed 12.5 ft-NGVD.
4. STA-2 Cell 4 was added based on design drawings obtained from Brown and Caldwell (2005).
5. STA 3/4 pump simulations were enhanced in accordance with design plans and STA 3/4 operation manual.
6. G-136 Structure simulation was improved to match current operation protocols.

7. STA 5 Flow-way 3 and associated improvements were added in accordance with draft BODR documents (URS, 2005a).
8. STA 6 Section 2 was added to the model in accordance with the draft BODR documents (URS, 2005b).
9. Simulation of "Confusion Corner" corner was enhanced using updated design plans and operational protocols.
10. The Rotenberger Tract and the Holeyland Wildlife Management Area were added to the MIKE 11 model to account for the overland flow component of these areas.
11. Model stability was enhanced my modifying the operation of STA 2 pumps and gates and the operation of the G-335 pump station.

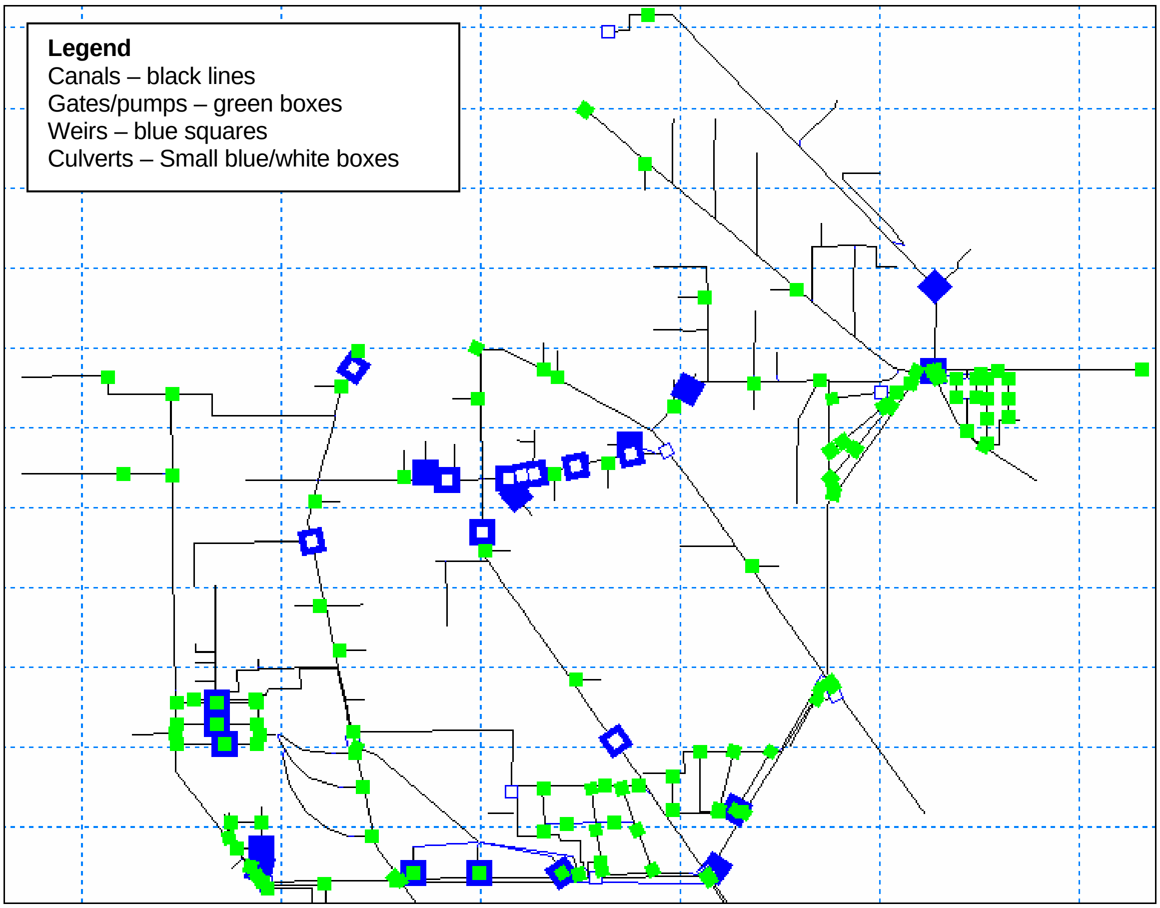

Figure 3.1 – EAA MIKE 11 Hydraulic Network

3.1.3 Hydrology

There are 226 farms in the EAA that have SFWMD permits to discharge to the main EAA canals. These permits are for specific farm areas and specific intake and discharge locations. The discharges are pumped outflows from the EAA farms, and the maximum flow for each pump is defined in the permit (there are 292 permitted pumps). Typically, the maximum pump discharge is equal to 1.5-inch per day, and the average permitted discharge is ¾-inch per day. The irrigation inflows are either pumped or are regulated by gated structures. The permits stipulate that farm runoff volume and TP concentration shall be measured using approved methods and reported to SFWMD. SFWMD maintains a data base of daily average discharge flows and discharge TP concentrations. EAA farms utilize best management practices (BMPs) to control the runoff with the intent of retaining at least 25% of the TP load on the farm. This is achieved by a variety of methods including in-canal retention upstream of the farm outflow pump station. When possible, EAA farms will not discharge any runoff for small storms and will use the runoff stored in internal canals for irrigation during periods following the runoff event. Some EAA farms are over 10,000 acres in size, and often experience heavy rainfall in one part of the farm while crop stresses are experienced in other fields due to low groundwater elevations. The net effect of the BMP program is a significant improvement in management of farm runoff that reduced TP loads to the STAs, however farm runoff is now very difficult to predict.

The analysis conducted for the alternative assessment assumed ¾ inch runoff from EAA farms. Runoff from approximately 200 farms was aggregated into runoff inputs from approximately 120 locations. Each of these locations represent runoff from one or more permitted EAA farms and/or water control districts. Runoff from the C-139 Basin, the C-139 Annex, C-51W Basin, and the L-8 was determined using alternative means. Simulated runoff as described in EAA RFS Phase 2 Deliverable 1.1.2 (see Appendix C), measured runoff as described in EAA RFS Phase 2 Deliverable 1.3.2 (see Appendix E) and permitted discharges from those basins were reviewed. The runoff rates presented in Table 3.1 were selected based on this review. Certain Chapter 298 Districts, shown in **Figure 2.2**, have historically discharged to Lake Okeechobee and have been partially re-directed to discharge to EAA canals. The runoff rates used for these Chapter 298 Districts have been based on permitted pump station capacities since runoff rates are higher than the ¾ inch rate assumed for most of the EAA. Table 3.2 presents the pump station capacities for the Chapter 298 Districts. The permitted pump station capacity flow rate was used as the inflow rate for the Chapter 298 Districts.

Table 3.1 – Runoff Rates Assumed for C-139, C-139 Annex, C-51W, and L-8 Basins

Basin	Runoff Rate (cfs)	Source
C-139	2,000	Burns & McDonnell, 2005a; URS, 2005
C-139 Annex	452	Burns & McDonnell, 2005a; URS, 2005
C-51W	2,000	Burns & McDonnell, 2005a
L-8	1,500	Burns & McDonnell, 2005a

Table 3.2 – Runoff Rates for Chapter 298 Districts and Receiving Water Body

298 District	Flow at ¾ inch Runoff (cfs)	Permitted Pump Capacity (cfs)
SSDD - Miami Canal	77	178
SFCD - Miami Canal	75	504
EBWCD #3 - WPB	206	338
ESWCD PS2 - Hillsboro	260	439

3.1.4 Boundary Conditions

MIKE 11 requires a boundary condition for the terminal end of each MIKE 11 branch. This boundary condition can be specified as zero flow, a specified constant head elevation, a specified constant flow, or a time series of head or flow. The L-8 and C-51W inflows were estimated based on an inspection of measured daily flows as part of the EAA RFS Phase 2

Deliverable 1.3.2 (See Appendix E). Precipitation and evaporation are included in the reservoir mass balance. ET values were taken from an ET station in WCA-1, and the rainfall values were taken from an October 2000 event at station ROTNWX (located in the Rotenberger Tract). The daily values for this event were adjusted down by 33% so that the total rainfall was equal to the average rainfall observed at Stations S-6, EAA5, NNRC, ROTNWX, and G-343.

3.2 TP Concentration and Loads Modeling

3.2.1 Inflow Volumes, TP Concentrations and TP Loads Baseline Data

Inflow volumes, TP concentrations and TP loads employed in the analysis of alternatives were developed in accordance with EAA RFS, Phase 2, Task 1. The overall objective of EAA RFS, Phase 2, Task 1 was to develop a revised Baseline Data for use in the EAA RFS consistent to the extent practicable with recent actual data and capable of acceptance by other agencies and parties (such as the United States Department of the Interior and the EAA Environmental Protection District) as being representative of inflow volumes and total phosphorus loads to the various stormwater treatment areas. Basins considered in EAA RFS, Phase 2, Task 1 include the following:

- *C-51 West Canal*
- *S-5A (West Palm Beach Canal)*
- *Chapter. 298 Districts*
- *East Beach Water Control District*
- *East Shore Water Control District*
- *715 Farms (State Lease No. 3420)*
- *South Shore Drainage District*
- *South Florida Conservancy District, Unit 5 (S-236 Basin)*
- *S2/S-6/S-7 (Hillsboro and North New River Canals)*
- *S-3/S-8 (Miami Canal)*
- *C-139 and C-139 Annex*
- *L-8 Canal*
- *Lake Okeechobee deliveries south to the STAs and Everglades*

The following subtasks were established in Work Order No. CN040912-WO04 as elements of the work necessary to achieve the overall objective of EAA RFS:

<u>Task 1.1</u> - Evaluation of the 2006 hydrologic simulation results for reasonableness, particularly as compared to recent (Water Year 1995-2004) actual data adjusted for significant changes in regional hydrology and water management operations over that period.

<u>Task 1.2A</u> - Evaluation of the 2010 to 2014 hydrologic simulation results for reasonableness, related primarily to changes from the 2006 simulation resulting from implementation of incremental significant changes to basin hydrography and regional water management operations.

<u>Task 1.3</u> - Development of inflow volumes and total phosphorus concentrations and loads segregated by source over Water Year (WY) 1995-2004, based on the SFWMD-furnished historic data. The intent of this activity is to develop relationships between discharge and total phosphorus concentration by source that can be subsequently applied to the 1965-2000 STA inflow simulation results.

Task 1.4 - Definition of a methodology for applying the relationships developed above to the simulated inflow data sets structured for use in the Dynamic Model for Stormwater Treatment Areas (DMSTA) analyses of the treatment areas.

Task 1.5 - On the basis of the methodology defined under Sub-task 1.4, development of inflow data sets for all six (6) STAs for each of the three (3) hydrologic simulations (2006, 2010, and 2015).

The reports associated with Sub-tasks 1.1 through 1.5 were completed in accordance with the following deliverables of Work Order No. CN040912-WO04 (EAA RFS, Phase 2) and are described below.

1. **Deliverable 1.1.2**: Task 1.1 - *Evaluation of 2006 Hydrologic Simulation Results*, Final Report dated June 27, 2005. A copy of this deliverable is included in Appendix C. Deliverable 1.1.2 presents a detailed comparison of the results of the 2006 South Florida Water Management Model (SFWMM) simulation to those considered in the October 2003 Everglades Protection Area Tributary Basins, Long-Term Plan for Achieving Water Quality Goals (the Long-Term Plan), and a March 2005 Draft Supplemental Analysis prepared for the Everglades Agricultural Area Environmental Protection District by Burns & McDonnell (the Supplemental Analysis). Volumes are compared by source both for average annual results, and for overlapping periods by Water Year (e.g., WY 1995-2000). This comparison is intended to identify any significant differences, and propose adjustments to the simulation data necessary to more closely parallel recent actual conditions, when appropriate. In the performance of this evaluation, due consideration has been given to defined changes from historic operations in system management.

2. **Deliverable 1.2A**: Task 1.2A - *Inflow Data Sets for the Period 2010-2014,* Draft Report dated September 29, 2005. A copy of this deliverable is included in Appendix D. Deliverable 1.2A summarizes the development and nature of projected discharges from the various basins and sources tributary to the STAs. The inflow data sets summarized are based primarily on the results of the 2010 hydrologic simulation and are considered specifically applicable to the period 2010-2014. As compared to the 2006 simulation, the most significant changes in the 2010 model are listed below.

    - Updated land-use assumptions from estimated 2000 conditions to projected 2010 conditions are representative.
    - The first phase of the EAA Storage Reservoir project will be complete and operational in Compartment A-1 (A-1 Reservoir).
    - STA-2 will be expanded to include all of Compartment B.
    - STA-5 and STA-6 will be expanded to incorporate the balance of Compartment C.

3. **Deliverable 1.3.2**: *Historic Inflow Volumes and Total Phosphorus Concentrations by Source,* Final Report dated June 27, 2005. A copy of this deliverable is included in Appendix E. As part of Deliverable 1.3.2, inflow volumes, and total phosphorus concentrations and loads to the STAs, segregated by source, from SFWMD-supplied data were developed. These historic volumes, concentrations and loads were developed for the 10-year period May 1, 1994, through April 30, 2004, or WY 1995–

2004. From these data on inflows and phosphorus loads, relationships between inflows and phosphorus loads were then investigated.

4. **Deliverable 1.4.2**: *Methodology for Development of Daily Total Phosphorus Concentrations,* Final Report dated June 30, 2005. A copy of this deliverable is included in Appendix F. For development of the May 2001 Baseline Data, the SFWMD estimated daily variations in total phosphorus concentrations as a function of discharge through development of a series of regression analyses. The SFWMD approach was in response to feedback on an earlier version of the Baseline Data in which it was suggested that capturing the variability of inflow phosphorus concentrations was of higher priority than preserving long-term flow-weighted mean total phosphorus concentrations. The resultant standard errors of estimate resulting from the regression analyses were relatively high, and the overall estimates of inflow loads varied from the historic data. Therefore, Deliverable 1.4.2 assessed the proposed phosphorus concentration methodology for one of the STAs, STA-1W, using the original inflow series for the 31-year period January 1, 1965, through December 31, 1995 as presented in the May 2001 Baseline Data through the DMSTA Versions 1 & 2. The analysis was conducted to assess the suitability for use of a time-period-average monthly TP concentration in subsequent tasks. It was determined that monthly average TP concentrations should be used for calculated daily and annual TP loads to the STAs.

5. **Deliverable 1.5.2**: *Inflow Data Sets for the Period 2006-2009,* Final Report dated August 9, 2005. A copy of this deliverable is included in Appendix G. Deliverable 1.5.2 summarizes the development and nature of projected discharges from the various basins and sources tributary to the STAs. The inflow data sets summarized are considered specifically applicable to the period 2006-2009. This period is assumed to follow the initial expansion of STA-2 and STA-5, and completion of STA-6, Section 2, but precede completion of Compartment A-1 of the Everglades Agricultural Area Storage Reservoir project (EAASR A-1). The inflow data summarized herein were used in the completion of Task 2, Phase 2 (Optimum Allocation of Hydraulic and Phosphorus Loading to the Existing STAs) and of Task 3, Phase 1 (Draft Operating Strategy for Optimizing STA Performance with Existing EAA Canals). For certain of the basins, the inflow data sets summarized were also considered applicable for analysis of the period 2010-2014 (following completion of the EAASR A-1 Project).

3.2.2 Methodology for Establishing Inflow TP Concentrations

The estimated performance of the various STAs in reducing total phosphorus concentrations presented in this document were developed employing the July 1, 2005 issue of the Dynamic Model for Stormwater Treatment Areas, Version 2 (DMSTA2), developed for the U.S. Department of the Interior and the U.S. Army Corps of Engineers by W. Walker and R. Kadlec. DMSTA2 is a complex empirical spreadsheet-based model that describes TP dynamics in STAs. Daily inputs are required for inflows, influent TP concentrations, ET, and rainfall. Outflow TP concentrations are calculated based on:

- daily input data,
- dynamically calculated internal parameters such as depth and time-of-travel,
- user-defined values such as vegetation type, short-circuiting coefficients, head loss, outflow structure types and dimensions, number of cells and parallel flow paths, seepage, etc.

- TP removal rates that are partially user-defined and partially determined based on extensive calibration to measured TP dynamics in many south Florida wetland treatment systems.

Additional information on DMSTA2 can be found on the Internet at: www.wwalker.net/dmsta.

As part of Deliverable 1.4.2 of the RFS Phase 2 (see Appendix F), an evaluation of the sensitivity of STA outflow TP concentrations projected were performed using DMSTA2 to the manner in which TP concentrations are assigned on a daily basis to basin runoff and other sources of inflow. The principal conclusion of that evaluation was that, at least with respect to long-term flow-weighted and geometric mean outflow concentrations, the analytical results are not significantly different when monthly flow-weighted mean concentrations are assigned in the following manners:

- On the basis of daily flow-dependent variations. The inflow time series used was based on an analysis of measured TP concentrations regressed against measured discharges, with the results of the regression analysis applied to an extended period of simulated flows to estimate daily concentrations;
- On the basis of monthly flow-weighted mean concentrations. The inflow time series based on the regression analysis was modified to attach TP concentrations on the basis of a flow-weighted mean TP concentration for each month of the year (e.g., for the full 31-years of the original time series, a flow-weighted mean TP concentration was developed for all inflows during each of the twelve months of the year).

Projected outflow concentrations varied by 0.2 ppb or less. Given that minor variability in the outflow results, it was concluded that it is suitable to assign TP concentrations to basin runoff and other sources of inflow on the basis of flow-weighted means that vary by month.

3.2.3 Monthly Flow-Weighted Mean TP Concentrations

As part of Deliverable 1.3.2 of the RFS Phase 2 (See Appendix E), an analysis of SFWMD-furnished data encompassing the period WY 1995-2004 (that is, May 1, 1994, through April 30, 2004). The principal purpose of that analysis was to, on the basis of historic data, develop estimated monthly flow-weighted mean TP concentrations in potential inflows from each basin or other source tributary to the STAs. It was determined in that analysis that the manner in which TP loads and concentrations associated with Lake Okeechobee flow-through releases are evaluated considerably influences the estimated TP concentrations and loads associated with basin runoff.

In general, it was observed that the TP concentration in Lake Okeechobee flow-through releases decreases as those releases travel through the primary canal system, being generally lower at the downstream end of the canals (at Pump Stations S-5A, S-6, S-7 and S-8) than the same-day concentrations at the points of release from the Lake. Deliverable 1.3.2 (Appendix E) analyses presents estimated flow-weighted mean TP concentrations in basin runoff computed after adjusting total discharge loads on the basis of both:

- TP concentrations and loads in Lake Okeechobee flow-through discharges measured at the point of release from the Lake;
- TP concentrations and loads in Lake Okeechobee flow-through discharges measured at the downstream point of release (e.g., point of discharge to either the Everglades Protection Area or to the STAs).

The first of those two methods is consistent with the manner in which TP loads in basin runoffs are computed under the EAA BMP rule (Chapter 40E-63, Florida Administrative Code). The second of these two methods is considered more applicable to assessing the influence of changes in Lake Okeechobee management and points of release on potential inflows to the STAs, and generally results in a more conservative estimate of inflow TP loads in basin runoff.

The inflow data sets summarized in this document are developed employing the second method (except as noted below), in which TP concentrations and loads are assigned based on water quality samples acquired at the downstream point of release. The daily flow-weighted mean TP concentrations in each source of runoff or potential inflow to the STAs are assigned on the flow-weighted mean for each of the twelve months of the year computed from the 10-year period of record encompassing WY 1995-2004.

There are two principal exceptions to the above statement. For the L-8 Basin, the average monthly concentrations in basin runoff were estimated using concentrations in flow-through volumes at the basin inlet. The second exception applies to runoff from the following basins, for which the STA inflow data sets are taken from the historic data. In those basins, the measured daily TP concentrations from the historic record are used in the analysis:

- The C-139 Basin (for those discharges to L-3/STA-5);
- The C-139 Annex;
- The former USSC Southern Division Ranch, Unit 2.

3.2.4 DMSTA 2 Parameters for Existing STAs

Basic physical parameters for the various existing STAs reflected in the DMSTA2 analyses reported in this document were taken from the BSFS Evaluation of Alternatives, with the following modifications:

- Marsh outflow coefficients (exponent and intercept) were modified to 4 and 1, respectively, consistent with basic guidance contained in the DMSTA2 documentation. They had previously been estimated on the basis of results taken from two-dimensional hydrodynamic analyses in certain of the STAs. It was concluded on the basis of trial runs that this change did not influence projected outflow concentrations, and modified peak and mean depths in the STAs resulting from the DMSTA2 by less than 5 centimeters.
- Seepage estimates were updated to reflect the results of water balance analyses prepared by the District for operating STAs. In addition, cell-to-cell seepage (at STA-1W and STA-1E) considered in the BSFS Evaluation of Alternatives was eliminated from this analysis due to its minor influence on the results and to improve the clarity of the estimates.

The most significant modification to DMSTA2 parameters, as compared to those considered in the BSFS Evaluation of Alternatives, was the use of updated calibration data sets for the performance of various vegetation types in reducing total phosphorus concentrations. Three basic vegetation calibrations were considered in this analysis:

- EMG_3: An updated calibration of the performance of emergent macrophyte vegetation, using data from full-scale STAs (replaced EMG in the 4/01/2002 version of DMSTA used in the BSFS Evaluation of Alternatives).

- SAV_3: An updated calibration of the performance of submerged aquatic vegetation, using data from full-scale STAs (replaced SAV_C4 and NEWS in the 4/01/2002 version of DMSTA used in the BSFS Evaluation of Alternatives).
- PEW_3 (Pre-Existing Wetland): A new calibration data set developed to reflect the performance of those cells in the operating STAs (and in other wetland data sets, such as WCA-2A) in which the wetland vegetation existed naturally. As applied to the existing STAs, the application of this data set is limited to Cells 1 and 2 of STA-2; STA-6 Section 1; and Cell 1B of STA-3/4.

Water quality improvement projections on which the Long-Term Plan was based were predicated on an ability to reproduce the performance of the best two years of operation of Cell 4 in STA-1W (SAV_C4) in those cells containing Submerged Aquatic Vegetation. A range in performance of those cells was also considered, employing the NEWS (Non-Emergent Wetland Systems) calibration data sets.

Comparison of summary data presented in Tables 2.4 and 2.6 of Deliverable 1.4.2 indicates (see Appendix F) that, for no other change in input data, the substitution of SAV_3 in DMSTA2 for SAV_C4 in the April 2002 version of DMSTA results in roughly a 20% increase in the projected flow-weighted mean TP concentration in outflows from STA-1W, following its enhancement as recommended in the Long-Term Plan, and roughly a 30% increase in the estimated geometric mean TP concentration in those outflows. However, the projected flow-weighted and geometric mean concentrations using the SAV_3 data set in DMSTA2 fall below those estimated using the NEWS calibration data set in the April 2002 version of DMSTA.

The net effect of this change in calibration data sets is to, as compared to projections considered in development of the Long-Term Plan and with all other inputs unchanged, result in higher projected outflow concentrations than the mean estimates considered in the Long-Term Plan, but still within the probable range of performance reported in the Long-Term Plan.

3.3 Alternative Evaluation Methodology

As part of the EAA RFS, Phase 2, Task 3 (Optimum Allocation of Phosphorus and Hydraulic Loading to the Existing STAs and A-1 Reservoir, and Optimum Canal Improvements Associated with Optimum Allocation), five (5) alternatives were evaluated to redistribute hydraulic and total phosphorus loads. The flows and loads will be discharged to the STAs (both existing STAs, currently planned STA-6 Section 2, and full conversion of Compartments B and C of the Talisman Land Exchange to use in STAs) to optimize TP reduction, given the presence of the Everglades Agricultural Area Storage Reservoir (EAASR) Compartment A-1. That evaluation was specific to the Period 2010-2014.

The results of the EAA Regional Feasibility Study Phase 2, Task 3 were used to evaluate the identified alternatives in accordance with the EAA RFS, Phase Task 2 (Evaluation Methodology and Evaluation Criteria). The evaluation methodology provides a common basis for evaluating the various alternatives that were developed as part of the EAA RFS and is comprised of three (3) evaluation criteria categories (see Appendix A): Technical Factors, Environmental Factors, and Economic Considerations. The evaluation criteria for each factor are summarized below and are described in the following subsections:

Technical Factors:
- Long-Term Phosphorus Concentration Achieved
- Flood impact analysis

- Operational flexibility
- Reservoir operation factors
- Implementation schedule including real estate acquisition

Environmental Factors:
- Redistribution of flows and TP loads to receiving waters
- Maintain desirable water levels in the Loxahatchee Wildlife Refuge

Economic Considerations:
- Probable Planning-level Opinion of Cost (50-Year Present Worth)
- Cash flow analysis

3.3.1 Technical Factors

Long-Term Phosphorus Concentration Achieved. This value is the projected long-term phosphorus concentration for the STA discharges as a flow-weighted mean for each alternative.

Flood Impact Analysis. If predicted water surface elevations are above the known critical Top-of-Canal elevations, modeling results show the linear feet of canal with stages above the critical Top-of-Canal elevations. If there is no flooding indicated in the model results, peak stages at critical locations were documented for each of the alternatives. Target canal stages during irrigation periods (these elevations are less than critical Top-of-Canal elevations) are known for EAA canals. The length of canals above those target stages was also documented. Below are the evaluation factors for the flood impact analysis.

Flood Impact Factor	Quantitative Measure
Flooding of farm fields	Feet of canal above critical Top-of-Canal Elevations
Canal Stage	Peak stage in each canal
	Miles above target stage in each canal

Operational Flexibility. The purpose of this evaluation criterion is to assess the potential for the alternative to add operational flexibility to the existing hydraulic conveyance system while still meeting treatment objectives. Operational flexibility will increase with the number of the anticipated EAA improvements. Examples include canal improvements, canal expansions, canal construction, and structure/pump station construction. Operational flexibility was evaluated by comparing the proposed system of pumps and canals to the existing system. The quantitative measures of operational flexibility will be:

Operational Flexibility Factor	Quantitative Measure (relative to existing conditions)
Structures/Pump Stations	% Increase in Number of pumps
Operational Modifications	Number of new flow routes
Canal Conveyance	% Increase in Canal Conveyance

Reservoir Operation Factors. Reservoir storage volume is only one measure of the utility of a given alternative. Examples of technical factors that influence the effective use of storage volume include the volume of average annual reservoir discharges, effect on peak flow reduction, and minimizing reservoir dry-out. This evaluation was based on output from the hydraulic analyses. The specific factors used are:

Effective Use of Storage Volume Factor	Quantitative Measure
Reservoir storage	Average annual reservoir discharge volume, acre-feet
Effect on peak flow reduction	Alternative Peak flow/base peak flow
Minimizing reservoir dry-out	Number of days with average depth < 1 foot

Implementation Schedule including Real Estate Acquisition. The purpose of this evaluation criterion is to evaluate the length of time required to design, construct, acquire land, and achieve full treatment capability, including any treatment start-up and stabilization time. The implementation schedule (in years from 2006 to full operation) for each of the alternatives was determined, and P3e schedules were developed for each alternative.

In general, it has been assumed that engineering design will start in February 2006, will take approximately one year, and right-of-way drawings will be delivered approximately six months after the beginning of design. Except for the Cross Canal, land acquisition will take two years starting in August 2006, and that canal enlargements will not proceed until the lands along a specific canal have been acquired. Except for the Cross Canal, it has been further assumed that major canal enlargements will take approximately two years, and that diversion gates (e.g. the West Palm Beach gate for Alternative 1) cannot proceed until the canals have been enlarged. It has been assumed that many canal enlargement projects will be taking place concurrently, however it has not been assumed that all canal enlargement projects can be completed within a two-year window following land acquisition.

Implementation schedules for the Cross Canal, Compartment B, and Compartment C have been developed by Acceler8 are reported herein without editing. The Cross Canal land acquisition will start in February 2006 and will be completed in one year. Contracting and construction for the Cross Canal, Compartment B, and Compartment C (including ordering and installation of pumps) will be completed by the end of 2008.

3.3.2 Environmental Factors

Redistribution of Flows and TP Loads to Receiving Waters. The proposed alternatives will deliver different flows to certain receiving waters in relation to existing conditions. The annual average discharge and total TP load from the STAs to each of the Water Conservation Areas (WCAs) were estimated for each of the alternatives, however it is important to understand that these flows and loads are not the total inflows to the WCAs. Fore example, even though one alternative may transfer water from an inflow to WCA-1 to an inflow to WCA-2A, the net change in inflow to WCA-2A may be zero, as a majority of the flows from WCA-1 enter WCA-2A. The annual loads to the WCAs were also estimated for each alternative. The analysis was documented in Phase 2, Deliverable 3 and is summarized below in Section 3.

Maintain Desirable Water Levels in the Loxahatchee Wildlife Refuge. The redistribution of flows to receiving waters may potentially result in different flows and water levels within the Refuge. There are existing concerns that high-hardness discharges from the EAA are impacting the ecology of the Refuge, which originally was a rainfall-driven system that exhibited low-hardness concentrations. Rainfall is still a major portion of the water balance for the Refuge, however significant EAA flows to the Refuge have likely affected hardness levels. The overall ecologic effects of higher levels of hardness associated with the EAA waters are not completely understood. While EAA runoff has introduced new waters to the Refuge, seepage from the Refuge to surrounding land is higher than historical rates and soil oxidation within the EAA has decreased the elevation of surrounding lands, resulting in increased seepage from the Refuge.

At the beginning of the EAA RFS, the Evaluation Methodology included an assessment methodology to quantify the effect of a given alternative on Refuge water levels and Refuge water hardness. The following text was presented in the Evaluation Methodology:

> *Water levels different from existing conditions were evaluated to determine if the change is beneficial, insignificant or adverse to Refuge habitat. Average water levels in the Refuge were not calculated, however a change in the annual discharge volume and the hydropattern of those discharges were used as a surrogate of a positive or negative impact to Refuge water levels. When deliveries were reduced, the regulation schedule for the Refuge were reviewed and it was determined if make-up waters can be treated and discharged to the Refuge to make-up for the reduction. If deliveries were increased, the regulation schedule for Refuge releases were reviewed to determine if additional releases are necessary to maintain desirable water levels within the Refuge.*
>
> *Decreases in hard-water discharges to the refuge may be beneficial. A general comparison was made to target hardness levels. Hardness impacts were assessed by calculating the average hardness level using average hardness levels from incoming sources (e.g. Lake Okeechobee, Dupuis Reserve, EAA runoff).*

This evaluation factor was discussed extensively at Long-Term Plan Technical Working Group meetings during the progress of the EAA RFS, and strong concerns were expressed that the above methodology was too simplistic to determine if an alternative would have either a positive or a negative impact on the Refuge. Accordingly, the Long-Term Plan Technical Working Group participants agreed later in the study that this evaluation factor would not accurately quantify the effect of alternatives on the Refuge and that instead additional analyses should be conducted to determine the relative effects of EAA RFS alternatives on the Refuge. District staff and management are currently coordinating to have these additional analyses completed using the SFWMM following the completion of the EAA Regional Feasibility Study.

It can be noted however that flows to the Refuge are estimated to be less than existing for all alternatives evaluated as part of the EAA RFS.

3.3.3 Economic Considerations

Probable Planning-level Opinion of Cost (50-year Present Worth). The purpose of this evaluation criterion is to determine the probable planning-level costs associated with each alternative. The total cost estimate for each alternative includes capital (design and engineering, equipment, land acquisition, construction and civil work), associated program management costs, and operation and maintenance costs. This cost will be reported as a present (2006 capital cost). A 50-year present worth cost analysis was performed. This cost was performed for the period of analysis. All design and engineering costs were escalated to the estimated center of the design and engineering phase, all land acquisition costs were escalated to the estimated center of the land acquisition phase, and all construction and program management costs were escalated to the estimated center of the construction period. Annual O&M costs were escalated to the year that they occur. The escalation rate was established at 3%, and the discount rate was established at 6-3/8%.

There have been numerous construction projects within the EAA in the past 10 years that provide an ample supply of construction unit costs. Unit costs reported in various recent planning and design documents such as the Revised Part 2 of the Long-Term Plan (November 2004), the Basis of Design Report prepared by Brown and Caldwell for STA-2 Cell 4, and the Basis of Design Reports prepared by URS Corporation for STA-5 Flow-way 3 and STA-6 Section 2, were also available references. Unit costs and adjustment factors for those unit costs were obtained from projects with similar construction elements to the work anticipated within the EAA. Operating costs were estimated in a similar manner. Costs of electricity, diesel, pump maintenance, levee maintenance are also documented in similar documents as described above.

Several key assumptions were implemented in establishing the capital costs. For excavation volumes, the volume was split into six cost categories in order to estimate costs for each construction method used based on soil type. The assumption of construction method used for each soil type for each canal excavated is summarized in **Table 3.3** below.

Table 3.3 - Excavation Percentage Based on Soil Type

Excavation Method Based on Soil Type	% of Volume
Rock Excavation	20
Backhoe Excavation and Load-Blasted Material	20
Light Excavation	20
Peat Excavation	20
Heavy Excavation	10
Spoil Excavation	10

The volume of excavated material was totaled and used for estimating the excavation cost. It was assumed that all the volume resulting from the excavation will be used for levee construction. However, this fill material to be used does not include the spoil nor peat material. Any excess material from excavation not being used for construction of levees will be stored or wasted on-site adjacent to the levee being constructed and additional right-of-way will be necessary to account for the excess material. This assumption was implemented, because it is anticipated that it will be more costly to haul the excess material offsite, than acquiring the additional required right-of-way.

Other assumptions per item for all alternatives are listed below:

- Excavated material will include a 10% swell factor
- Rip-Rap: Assume 30 CY for 80% of the proposed culverts
- Bulkhead: Assume 20% of the proposed culverts times the width of canal
- Tree Removal: Assume 2% of the clear and grubbing area
- Approach Reconstruction on Bridges: Assume 10 feet per bridge being obstructed
- Seeding: Assume 35% area of Levee width
- Equipment Demolition: Assume 95% of all new pumps
- Dewatering: Assume 100 feet of canal, 25 feet wide, 10 feet deep (dewatering will occur only at Hillsboro and West Palm Beach Canals). It was also assumed that dewatering would occur for 15 days for the assumed volume of water
- Engineering, planning and design cost 10% of construction cost
- Program management 2.5% of construction cost
- Construction management 7.5% of construction cost
- Land cost contingency 50% of land cost

- Land acquisition costs (appraisals, legal fee, negations, etc) 2.5% of land cost
- Overall cost contingency of 30%

The quantities for the extension of overhead power lines, including the poles, being relocated during the widening of the canals were quantified assuming that four power lines were being impacted per each farm pump station to be relocated because exact locations of the power lines could not be determined based on available aerial photographs. The only information available was for the Cross Canals, where photographs included in the Survey Reconnaissance Report for Cross Canal (JMJV, 2003) were used to determine the locations of each farm pump station to be impacted.

The cost for Compartment B was derived from the STA 2 Cell 4 Expansion portion of the Basis of Design Report. A prorated amount was used based on the area for STA 2 Cell 4 compared to the area of Compartment B.

The Compartment C cost was based on the Acceler8 Projects Update as of June 20, 2005 Report. The area calculated for the STA 5 Flow-way 3 Expansion is the same as that of STA 5 Flow-ways 4 and 5, therefore, the cost used for STA 5 Flow-way 3 was used for STA 5 Flow-ways 4 and 5. Additionally, the cost for STA 5 Flow-way 5 was derived using a prorated cost based on the area of STA 5 Flow-way 3 compared to that of the area of STA 5 Flow-way 5.

The area calculated for land acquisition was based on the widening of each canal, plus the levee on the side of the expansion and the additional volume of excavation not used for levee construction. **Table 3.4** below shows a list of canals with their corresponding cost for land acquisition per acre of land.

Table 3.4 - Land Acquisition Cost per Canal

Canal	Cost per acre
Alternative 1 and Sam Senter Canals	$ 8,000
Ocean, Hillsboro, NNR, and Cross Canals	$ 7,000
Manley Ditch (Alternative 3 only, see below)	$ 5,000

Operations and maintenance costs were estimated for each alternative, and are presented below in **Table 3.5**.

Cash Flow Analysis. A cash flow analysis was performed to determine the timing of cash outlays. Annual costs of project implementation were determined using the detailed information provided in the cost estimate and the implementation schedule. The timing of cash flow outlays will be compared to the anticipated revenue stream. Once available the alternatives that deviate significantly from the revenue stream will be noted.

Table 3.5 – Assumed Operation and Maintenance Cost Factors

Item	Cost	Contingency	Conditions	Source
Vegetation Maintenance of Canals	$30/Acre	30%	Apply only to expanded area of canal.	1
Vegetation Maintenance of STAs	$80/Acre	30%	Note Emergent cost is $50/Acre, $30/Acre more for SAV	1
Levee grading maintenance	$3,300/mile	30%		2
Pump power demands	$0.60/Acre-feet	30%		2
	$300/cfs	30%	Alternate method for estimating cost	2
Pump station bldg maintenance	$10,000/bldg	30%		2
Pump maintenance (per pump)	$2,500/pump	30%		2
Gate maintenance (test, oil, etc)	$8,000/gate	30%		2
O&M Staff (HQ)	$200,000	30%	Apply to each alternative for overall maintenance of the EAA RFS features	3
STA Site Manager	$125,000/STA	30%	Apply this cost to Compartment B and C	2
O&M Monitoring	$40,000/ structure	30%		2
Remit Compliance Monitoring	$45,000/ structure	30%		2

Sources:
1. Goforth and Piccone, 2002a
2. Burns & McDonnell, Oct 2003.
3. ADA best professional judgment

3.3.4 Overall Alternative Evaluation

Each alternative was evaluated according to the criteria listed above and entered into a criteria evaluation summary matrix (see **Table 3.6**).

Table 3.6 – Evaluation Criteria Quantitative Values

Evaluation Criterion	Quantitative Measure	Comment
Technical Factors		
1. Long-Term Phosphorus Concentration Achieved	Parts per billion (ppb) flow-weighted mean concentration	
2. Flood Impact Analysis		
• Flooding of Farm Fields	Feet of canal above critical Top-of-Canal stages	Provide by canal
• Canal Stage	Peak stage	Provide for each canal
• Canal Stage	Miles of canal above target irrigation stages	Provide for each canal
3. Operational Flexibility		
• Structures/Pump Stations	% Increase in Number of structures/pumps	
• Operational Modifications	Number of new flow routes	
• Canal Conveyance	% Increase in Canal Conveyance	
4. Reservoir Operation Factors		
• Reservoir Discharge Volume	Average Annual reservoir discharge volume, acre-feet	
• Effect on peak flow reduction	Alt. Peak flow/base peak flow	
• Minimizing reservoir dry-out	No. days with average depth < 1 foot	
5. Implementation Schedule including Real Estate	No. years to full treatment and operational capability	
Environmental Factors		
6. Redistribution of flows and loads	Report flows and loads to WCAs	
7. Impact to Refuge	Report changes in flow and hardness	Make-up waters will be identified if possible
Economic Considerations		
8. Capital & O&M Cost including Real Estate	$____ Present Worth	50-year Present Worth
9. Cash Flow Analysis	$ per year	

4.0 ANALYSIS OF EXISTING CONDITIONS 2006 – 2009

The following sections summarize the optimization of flows, loads and hydrologic/hydraulic analyses performance for the Period of 2006 – 2009 prior to the completion of EAA Canal Improvements, the A-1 Reservoir, and the build-outs of Compartments B and C.

4.1 Optimum Flows and Loads Distribution for Period of 2006 – 2009

The Baseline Data developed as part of the EAA RFS, Phase 2, Task 1 (see Section 2.2.1) was developed for use in determining the optimum allocation of phosphorus and hydraulic loads to the existing STAs including STA-6 Section 2, STA-2 Cell 4 and STA 5 third flow-way. The results of these analyses were developed in accordance with Task 2 of Work Order No. CN040912-WO04 (EAA RFS, Phase 2) and submitted as part of Deliverable 2.2: Optimum Allocation of Loads to the STAs for the Period 2006-2009, Final Report dated September 7, 2005. A copy of this deliverable is included in Appendix H.

A summary of the projected performance of the various stormwater treatment areas over the period 2006-2009 is presented in Table 4.1. That tabulation includes identification of the specific case for each STA considered as most applicable to this summary. That tabulation also summarizes all bypass volumes and TP loads. The results presented in Table 4.1 for STA-5 include the full range of uncertainty associated with the performance of the three downstream cells.

Table 4.1 Summary Projections for all STAs, for Period 2006-2009

Parameter	Units	Summary of DMSTA2 Results by Treatment Area and Case						
		STA-1W	STA-1E	STA-2	STA-3/4	STA-5*	STA-6	
		2006 Mod	2006 Mod	2006 Base	2006 Base	2006 Base	2006 Base	All
Effective Treatment Area	acres	6,670	6,175	8,140	16,543	6,167	2,197	45,892
Average Annual Inflow								
Volume	1,000 ac-ft	175.1	242.9	343.6	643.1	159.1	78.6	1642.4
TP Load	metric tons	37.7	41.16	43.3	64.94	39.14	8.30	234.52
FWM TP Concentration	ppb	174.3	137	102	82	199	86	116
Average Annual Outflow								
Volume	1,000 ac-ft	176.7	240.9	347.5	624.2	149.7	70.7	1609.7
FWM TP Concentration								
Upper Confidence Limit	ppb	16.7	19.3	17.1	16.2	16.7	11.8	16.8
Mean Estimate	ppb	20.3	25.2	21.0	20.1	39.7	14.3	22.6
Lower Confidence Limit	ppb	25.2	32.3	25.7	24.8	113.1	17.6	34.1
Geometric Mean TP Conc.								
Upper Confidence Limit	ppb	9.8	---	11.2	11.9	11.2	7.7	---
Mean Estimate	ppb	13.5	---	15.0	15.6	33.4	10.3	---
Lower Confidence Limit	ppb	18.5	---	19.7	20.1	66.7	13.7	---
TP Load (Using Mean FWM Conc.)	metric tons	4.43	7.48	8.90	15.46	7.3	1.25	44.84
Summary of Bypass Volumes and Loads								
Bypass Volume, TP Load and TP Concentration for each Treatment Area								
Volume	1,000 ac-ft	16.7	71.5	0.5	50.7	0.0	0.0	139.4
TP Load	metric tons	2.47	9.41	0.04	4.73	0.00	0.00	16.64
FWM TP Concentration	ppb	120	107	66	76	---	---	97

* At STA-5, upper confidence limit reported based on the assumption that the three downstream cells act as SAV_3; lower confidence limit reported based on the assumption that the three downstream cells act as EMG_3. Mean estimate of outflow concentration and outflow TP load taken as average of those two conditions

In the above table, bypasses at STA-1E are untreated bypass through S-155A. All other bypasses indicated in Table 4.1 consist of water supply releases bypassing the STAs.

The inflows to the six STAs in Table 4.1 are based on certain assumptions that are presented below.

- **STA 1W: 2006 Mod:** For this case, a modified distribution of discharges through G-302 and G-311 was assumed. Daily inflows to the STA-1 Inflow and Distribution Works were distributed 70% to STA-1W at G-302, and 30% to STA-1E at G-311. Those distributions closely parallel the relative capacities of G-302 and G-311.

- **STA 1E: 2006 Mod:** For this case, a modified distribution of discharges through G-302 and G-311 was assumed, consistent with Case "2006 Mod" for STA-1W. Daily inflows to the STA-1 Inflow and Distribution Works were distributed 70% to STA-1W at G-302, and 30% to STA-1E at G-311. Those distributions closely parallel the relative capacities of G-302 and G-311. For analysis of this case, the westerly flow path (Cells 5-7) was considered separately from the two easterly flow paths (Cells 1-4S). Analysis of the westerly flow path is included in **Case 5_7 2006 Mod.** Inflows to the westerly flow path were limited to discharges from G-311, which were assigned at 30% of the total inflow to the STA-1 Inflow and Distribution Works (approximately 75,100 acre-feet per year at a flow-weighted mean TP concentration of 174 ppb). Analysis of the two easterly flow paths (Cells 1-4S) is included in **Case 1_4 2006 Mod,** for which inflows were assigned at 100% of the inflow to STA-1E at S-319.

- **STA 2: 2006 Base:** This case varies from "Exist" only in that Cell 4 is considered complete and inflows to STA-2 are redistributed accordingly. Cell 4 was considered as developed in Submerged Aquatic Vegetation (SAV_3). Dimensional information on Cell 4 was taken from the BODR for STA-2 Cell 4. No other modifications to the existing cells of STA-2 were considered in the analysis.

- **STA 3/4: 2006 Base:** This case was developed upon the assumption that the inflows to STA-3/4 would be distributed to the three parallel flow paths in such a fashion as to result in essentially equal flow-weighted mean outflow concentrations.

- **STA 5: 2006 Base:** All inflows to the L-3 Borrow Canal from the C-139 Basin over Water Years 1995-2004 are assigned to STA-5 (e.g., no bypass). Inflow concentrations are assigned at 90% of those measured over WY 1995-2005. The BODR for STA-5 was generally silent on the amount of effective treatment area that would be added in the third flow-way. It was assumed for this analysis that the westerly part of the third flow path would be ineffective for treatment, similar to that for the two existing flow paths. In addition, the separation between Cells 3A and 3B was assigned at the location shown in the BODR, which is further east than the separation in the two existing flow paths. New Cell 3A (1,140 acres) was considered as emergent vegetation (EMG_3); New Cell 3B (917 acres) was considered as submerged aquatic vegetation (SAV_3).

- **STA 6: 2006 Base:** This case was developed to reflect the anticipated treatment area configuration and operation expected to exist over the Period 2006-2009. The analysis extends over the period WY 1998-2005 (no data for the Southern Division Ranch was available in WY 1997). For this analysis, the vegetation in Section 1 (Cells 3 and 5) was assigned as pre-existing wetland vegetation (PEW_3); the vegetation in Section 2 was assigned as SAV_3.

The total inflow volume shown in Table 4.1 varies from that reported in Table 7.1 of Deliverable 1.5.2 (see Appendix G) due primarily to:

- The addition of 27,500 acre-feet per year in STA-2 inflows due to seepage return to the STA-2 Supply Canal from the L-6 Borrow Canal and WCA-2A; and
- At STA-1E, the westerly flow path was analyzed separately from the easterly two flow paths. Seepage lost from the West Distribution Cell to the C-51 West Canal was added to the projected inflows to the easterly two flow paths – total outflow volumes from STA-1E were not affected by that assignment.

Review of the summary projections presented in Table 4.1 suggests that, for conditions expected to prevail over the period 2006-2009, there would be little value in attempting to redistribute the inflow volumes and TP loads to the various STAs, with one exception. That exception is for the combined operation of STA-1W and STA-1E. It would appear desirable to redistribute volumes and loads discharged from the STA-1 Inflow and Distribution Works, reducing the proportion delivered to STA-1W and increasing the proportion delivered to STA-1E, so that projected outflow concentrations from those two treatment areas are more closely in parallel. However, that redistribution, in and of itself, would not materially change the aggregate of total phosphorus loads delivered to the Loxahatchee National Wildlife Refuge.

However, the volumes and TP loads discharged to the Refuge are materially influenced by the assumption that volumes associated with L-8 Basin runoff will bypass both STA-1W and STA-1E, being delivered first through S-5AE to the C-51 West Canal and then discharged at Structure S-155A. It is not apparent that sufficient hydraulic capacity presently exists in the water control structures to effect that assumption. It would appear desirable that the potential need for increasing the capacity of S-5AE (and, potentially, S-155A) prior to the end of 2006 be evaluated in detail (note that hydraulic modeling of Alternatives for 2010 conditions assumed a doubling of the capacity of S-5AE.).

An interim operation of STA-1E, in which Cells 1 and 2 are considered to be off-line due to the construction and operation of the PSTA/SAV Demonstration Project by the Jacksonville District, U.S. Army Corps of Engineers, coupled with an increased bypass through S-155A, could be expected to:

- Reduce overall TP loads discharged to the Refuge;
- Result in a relatively close balance in the estimated TP concentrations in outflows from STA-1E and STA-1W;
- Increase volumes and TP loads bypassed to the C-51 East Canal through S-155A, but within the constraints permitted by the *(Draft) Water Control Plan* for STA-1E.

That interim operation could be considered to further delay realization of the full flood control benefits of the Central and Southern Florida Flood Control Project in the C-51 Basin, and would require additional analysis of the capacity and operations of S-155A.

Other key assumptions are listed below:

- Cessation of Lake Okeechobee regulatory releases to the Hillsboro Canal and STA 2 at Structure S-351;
- Water supply releases to the North New River Canal at S-351 destined for the Lower East Coast Service Area 2 would only be made when the stage of WCA 3A is at or below the floor of their regulation schedules and would bypass STA 3/4;
- Water supply releases to the Seminole Tribe's Big Cypress Reservation at S-354 would bypass STA 3/4.

4.2 Hydrologic/Hydraulic Analysis for Period of 2006 – 2009

As part of the EAA RFS, Phase 1, Task 3 (Deliverable 4.2: Operating Strategy for Optimizing STA Performance with Existing EAA Canals, Final Report dated October 3, 2005), a hydrologic/hydraulic analysis was performed to determine if there are possible operating strategy that could be implemented at this time for redistributing the inflows to the STAs to optimize TP reduction prior to the completion of EAA Canal Improvements, the A-1 Reservoir, and the build-outs of Compartments B and C (these improvements are anticipated to be completed by 2010). This report is included in Appendix B. Hydraulic modeling was conducted with the MIKE 11 model as described in Section 3.1 to define the capacity of existing EAA canals and to determine if operational changes could be employed to direct runoff from the S-5A and S-6 Basins to the S-7 Basin. A number of alternatives were simulated as follows:

- Alternative 1 - Existing Conditions, 3/8" runoff for entire EAA
- Alternative 2 - Existing Conditions, 3/4 inch runoff for S-5A and S-6 Basins
- Alternative 3 - Existing Conditions, 3/4 inch runoff for S-5A and S-6 Basins, No Cross bridges & culverts in the Bolles and Cross Canals
- Alternative 4 - Existing Conditions, 3/4 inch runoff for S-5A and S-6 Basins, No Cross bridges & culverts in the Bolles and Cross Canals

Alternative 1 - The MIKE 11 model was run with a uniform rate of runoff equal to 3/8" for all farms. Peak stages in the Ocean Canal west of G-341 remain below 12.5 ft NGVD, therefore G-341 remains closed. There is no flow into Lake Okeechobee through S-2 and S-3. Flows in the southern portions of the Hillsboro, North New River, and Miami Canals oscillate because basin runoff is in between the flow levels of S-6 (975, 1,950, and 2,925 cfs), and G-370 and G-372 (925, 1,850, and 2,775 cfs). Water levels are higher in the center of the Cross Canal than at the east and west ends of the canal, which results in westerly flow (negative flow) on the west end and easterly flow (positive flow)on the east end. Flow in the Bolles Canal is westerly (negative) at both ends because stages are lower in the Miami Canal than in the North New River Canal.

Alternative 2 - The MIKE 11 model was run with 3/4" of runoff in the S-5A and S-2/S-6 Basin and 3/8" runoff elsewhere in the EAA. The purpose of this simulation was to provide a base run to compare to simulations of minor canal improvements to the Cross Canal. This model run did not change the directions of flow in the Cross Canal. As with uniform runoff from all EAA farms, flows in the Cross Canal were easterly at the east end (225 cfs) and westerly on the west end (-68 cfs). As expected, there were higher flows to STA 1W and STA-2 with this model run. Runoff from the Gladeview Drainage District flowed primarily to STA-2, however there was 457 cfs of easterly flow through G-341 to STA 1W.

Alternative 3 - This alternative tested the effect of removing flow constrictions along the Cross Canal assuming higher runoff in the S-5A and S-6 Basins. Flow in the west side of the Cross Canal was -207 cfs, which is a discharge from the Cross Canal to the North New River. Flow from the Cross Canal to the Hillsboro Canal was 89 cfs. The flow in the west side of the Cross Canal was higher than Alternative 2 due to the removal of flow constriction in the east end of the Cross Canal.

Alternative 4 - This alternative is an extension of Alternative 3 with higher stages in the Hillsboro Canal to generate a greater head differential between the east and west side of the Cross Canal. The greater head differential was generated by decreasing S-6 Pump Station flow in the third pump station at S-6 from 975 cfs to 500 cfs. Flow in the west side of the Cross Canal was -314 cfs, which is a discharge from the Cross Canal to the North New River. Flow in the east side of the Cross Canal was -26 cfs, which indicates flow from the Hillsboro Canal to the Cross Canal.

The conclusion of these analyses indicate that it is possible to increase flows to the North New River by 107 cfs during a high runoff period where rainfall is higher in the S-5A and S-6 Basins if total S-6 flows are reduced by 475 cfs. However, there are some negative impacts with this alternative as follows:

- The peak stage in the Ocean Canal is 13.15 ft-NGVD, which could result in flooding of some farms along portions of the Ocean and Hillsboro Canals.
- The peak stage in the Ocean Canal will open G-341 on the Ocean Canal, thereby delivering flow from the Gladeview Drainage District to STA-1W (G-341 opens if stages west of G-341 are higher than 12.5 ft-NGVD).

Therefore, if it is decided to operate S-6 at a lower capacity during a large runoff event in the S-5A and S-6 Basins, it will be necessary to modify the gate operations at G-341 and levee heightening will be necessary at a number of low spots along the Ocean and Hillsboro Canals.

Based on the analysis of these alternatives, the flows from the Cross Canal to the North New River are relatively small for all alternatives that were simulated. Removing the Cross Canal culverts and bridges will not relieve the excess inflows to STA-1W. Alternative 4 was designed to evaluate if removal of Cross Canal obstructions and modification of S-6 pumping could re-direct flows from the S-5A and S-6 Basins to the North New River Canal Basin. This alternative increased flow to the North New River, however peak stages in the Ocean Canal were higher than with full S-6 operation. Accordingly, it does not appear that minor changes in the Cross Canal can re-direct flows to the North New River Canal. It appears that a more comprehensive suite of construction projects as described in Section 5 will be needed to improve the flow deliveries from the S-5A and S-6 Basins to STA-3/4.

5.0 ALTERNATIVE EVALUATION FOR PERIOD 2010 – 2014

The alternatives described below are intended to address Year 2010 conditions. Alternatives that appear to be feasible from a water quality and hydraulics perspective have been analyzed using the tools, evaluation methodology and evaluation criteria described in Section 3. The alternatives evaluation will also include assessment of project costs, land acquisition, and implementation schedules. This report presents a summary of results for hydraulic and water quality modeling of the proposed alternative modifications.

5.1 Alternative 1

The main purpose of this alternative is to re-direct runoff from the S-5A Basin to the S-2/S-7 basin. Components are summarized below and are shown in **Figure 5.1**:

1. Closing of the S-5AW structure and doubling the size of the S-5AE structure.
2. Addition of new gate in West Palm Beach (WPB) Canal to divert the northern S-5A Basin flows into S-2/S-6 Basin.
3. Addition of new Canal from WPB Canal to the Sam Senter Canal.
4. Expansion of the Sam Senter Canal.
5. Addition of new gate in the Hillsboro Canal south of the Cross Canal. This gate will divert a portion of S-2/S-6 flows to the Cross Canal and then to the North New River Canal.
6. Expansion of the Ocean Canal capacity from the Sam Senter Canal to the Hillsboro Canal.
7. Expansion of the of the Hillsboro Canal capacity from the Ocean Canal to the Cross Canal.
8. Expansion of the Cross Canal capacity and enlarging farm bridges along the Cross Canal.
9. Expansion of the North New River Canal (NNRC) capacity.
10. Addition of A-1 Reservoir and Compartment B with inflow pumps on the NNRC (3,000 cfs for A-1, 1,600 cfs for Compartment B).
11. The Compartment C STA receiving runoff from only C-139 and C-139 Annex.
12. Connection of STA-2 Cell 4 to Compartment B without connection Cells 1, 2, and 3 of STA-2.

Canal cross sections were modified a number of times in an attempt to minimize expansion while minimizing canal water levels during simulations. The resulting dimensions are presented in **Table 5.1.** Detailed description of the implementation of Alternative 1 is included in EAA RFS, Phase 2 Deliverable 3.2h (Final Optimum Allocation of Phosphorus and Hydraulic Loading to the Existing STAs, Compartment B & C, and the A-1 Reservoir, and Optimum Canal Improvements Associated with Optimum Allocation). This report is included in Appendix I.

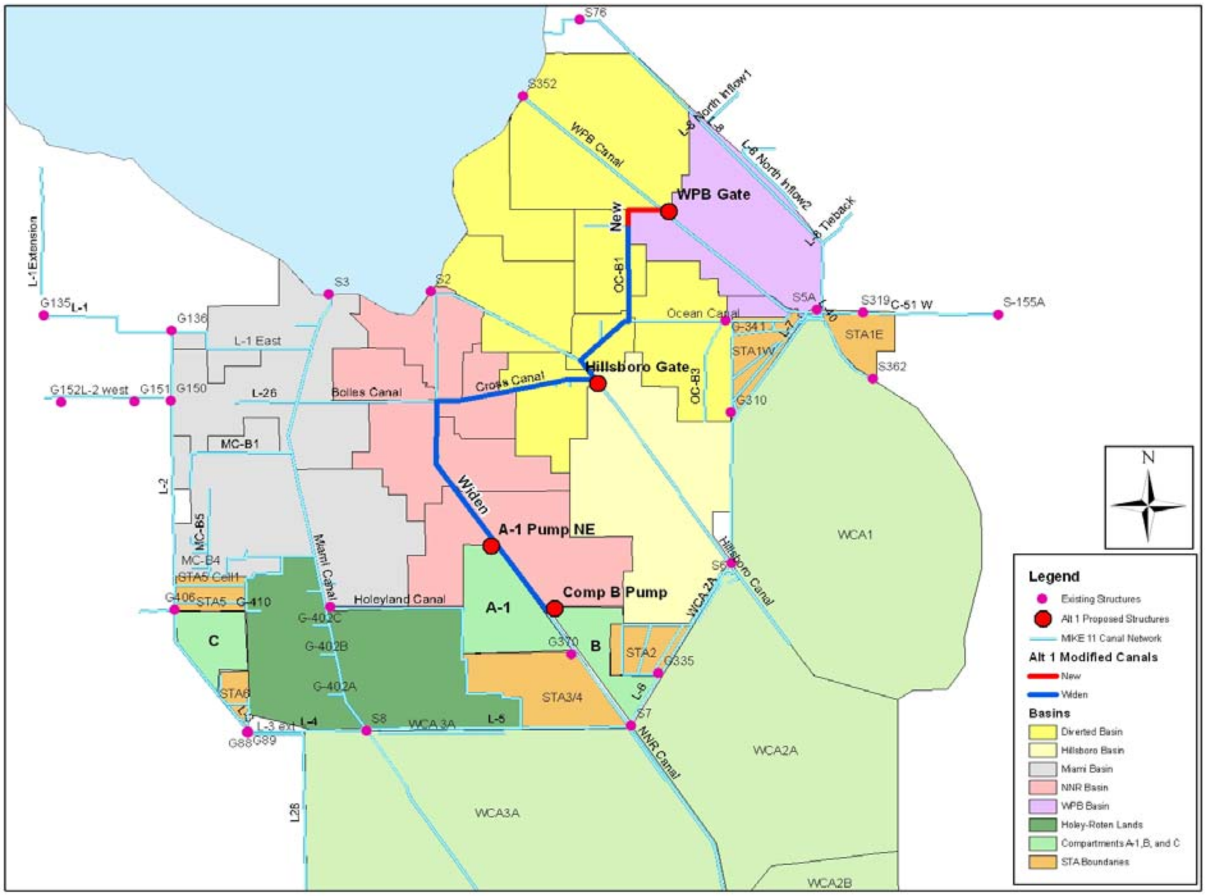

Figure 5.1 – Alternative 1

Table 5.1 – Alternative 1 Cross Section Dimensions (dimensions in feet)

Canal	Start Chainage	End Chainage	Bottom Width (feet)	Invert Elevation (ft-NGVD)	Side Slopes	Top-of-bank Elevation (ft-NGVD)
Alternative 1 (Connecting WPB Canal to Sam Senter Canal)	0	14350	95	-10.5	2.5	25
Sam Senter (OC-B1)	13138	41883	65	-10.0	2.5	25
Ocean Canal	0	18691	85	-10.0	2.5	25
Hillsboro Canal	48313	54313	100	-10.0	2.5	25
Cross Canal	0	46759	77	-10.0	2.5	25
North New River Run 36	33133	125889	110	-9.5	2.5	25
North New River Run 37	33658	125889	27.5	-15.0	2.5	25

5.1.1 Hydraulic Analysis

The dimensions of canal enlargements and the gate operations for the WPB and Hillsboro gates were selected to accomplish diversion of flows to achieve a balanced distribution of flows to the STAs. The diversions were based on an analysis of projected water quality conditions using DMSTA2 (see **Appendix J**). **Table 5.2** presents flows and canal stages for selected stations in the EAA for two options of Alternative 1. Run 36 assumes wider canals than Run 37 (see **Appendix I** for details). The target flows to be diverted and the Alternative 1 diversion flows are also presented below in **Table 5.2**. **Table 5.2** illustrates that Alternative 1 Run 37 comes closest to meeting the diversion requirements to balance flows and loads to the STAs, however Run 37 results in higher stages in the Ocean Canal near G-341 that results in eastward flows through G-341 toward pump station S-5A.

Table 5.2 - Flows and Stages for Existing Conditions and Alternative 1

PEAK FLOWS (cfs)		**Large Canals**	**Limited Widening, Deeper**	**Target Flows**
Station	**2006 EX**	**Run36**	**Run37**	
Cross Ch 100, West End	-525	-2,760	-2,380	
Cross Ch 20000, Middle	-216	-2,420	-2,036	-2,000
Cross Ch 45271, East End	161	-2,047	-1,690	
Ocean Ch 3400, Near Hillsboro	-561	-1,966	-1,526	
G-341 East Flow	770	0	71	
WPB 51430, U/S of New Gate	1493	1,484	1,500	
WPB 54740, D/S of New Gate	1493	880	1,237	
Sam Senter Ch 35368, near Ocean Canal	412	1,028	667	1,200
Bolles Ch 211, West End	-271	-102	-75	
Hillsboro Canal, Ch 54697, U/S of New Gate	675	674	670	
Hillsboro Canal, Just U/S of S-6	2728	2,723	2,722	
STA 1W Inflow Ch 100	3,208	2,783	2,952	
G-311, to STA 1E	0	0	0	
STA 1E S-319 Inflow Pump Station	1,800	1,900	1,900	
STA 2 Inflow Canal Ch 1100	3,300	3,201	3,203	
Comp B NNR Pump Station	0	1,146	700	1,600
A-1 Pump NE Pump Station	0	2,167	2,200	
STA 3/4 G-370 East Pump Station	2,742	2,578	2,566	
STA 3/4 G-372 West Pump Station	3662	3,645	3,646	
STA 5 (Cells 1-2, Compartment C cells)	1,724	2,803	2,803	
STA 6, Cells 3 and 5 (EX incl. Section 2)	1,285	184	184	
Sum of STA Inflows	20,449	17,624	17,202	
C-51W at S-155A (bypass flow)	830	1,367	1,401	
STAGES (ft-NGVD)				
Station	**2006 EX**	**Run 36**	**Run 37**	
NNR at A-1 Pump NE Pump Station	12.37	9.74	9.74	
NNR at Compartment B Pump Station	11.40	9.36	9.22	
NNR at G-370	9.78	9.21	9.02	
Cross Ch 200, West End	13.09	11.20	11.76	
Cross Ch 23622, Middle	14.32	11.33	11.89	
Cross Ch 43983, East End	15.14	11.48	12.00	
Ocean Ch 6800, halfway betw Hills & bend	14.62	11.58	12.05	
Ocean Ch 46400, at Gladeview Canal	14.68	12.15	12.50	
Sam Senter Ch 13139 (north end)	14.90	11.66	12.10	
WPB Ch 50000, U/S of new Gate	12.31	11.71	12.14	
Bolles Canal Ch 422, West End	12.91	12.15	12.50	
Target	12.50	12.50	12.50	

Note: U/S and D/S: Upstream and Downstream, Ch: chainage (canal location, feet from Lake Okeechobee). Highlighted cells exceed target flows and/or canal stages.

Because the diversion of flows is accomplished using new gates in the WPB and Hillsboro Canals, Alternative 1 water levels are compared to 2006 existing conditions water levels, as shown in **Table 5.2**. Run 37 results in opening of G-341, elevating flows to STA-1W. **Figure 5.2** illustrates the stages and flows at G-341.

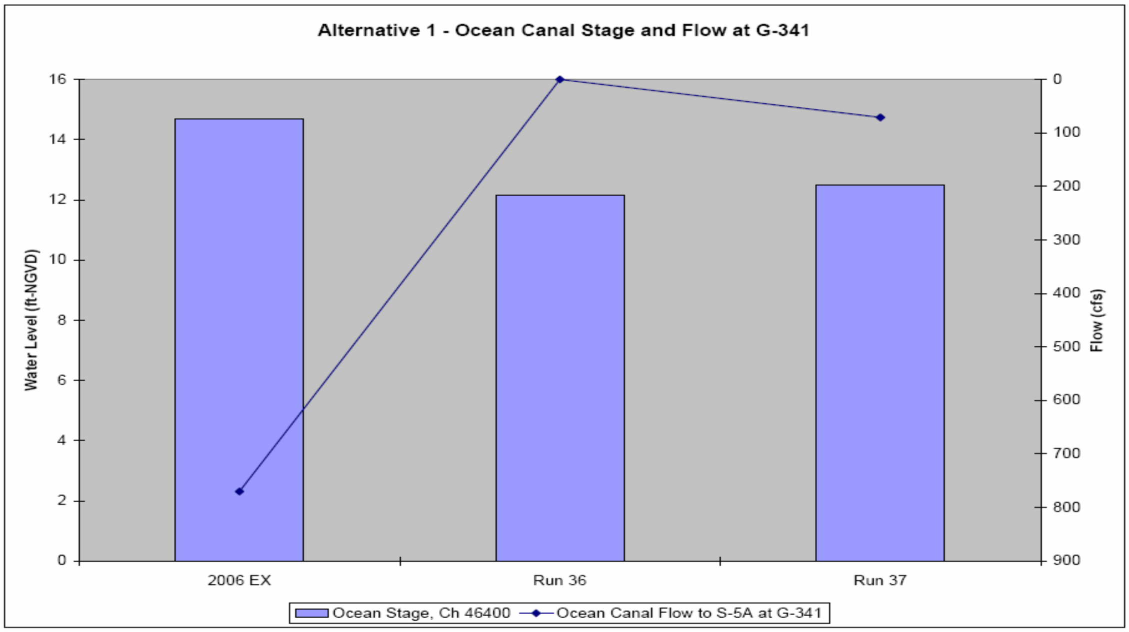

Figure 5.2 – Flows and Stages at G-341 in the Ocean Canal

Figures 5.3 and **5.4** present water levels in STA-2 and Compartment B. Water levels in STA-2 are within desired depths for 2006 conditions, yet are higher than desirable depths for the north cell of Compartment B. The desired flow in Compartment B is 1,600 cfs, yet the peak flow is only 1,084 cfs. Two-dimensional modeling conducted by Brown and Caldwell also indicated that the peak depth may be exceeded above 1,000 cfs (personal communication, Ms. Emily Mott, Brown and Caldwell, September 18, 2005). Further modeling may be appropriate to resolve this situation. The cross section file for Compartment B used in the MIKE 11 model were assumed as no detailed survey information was identified, and the assumptions made for this assessment should be verified.

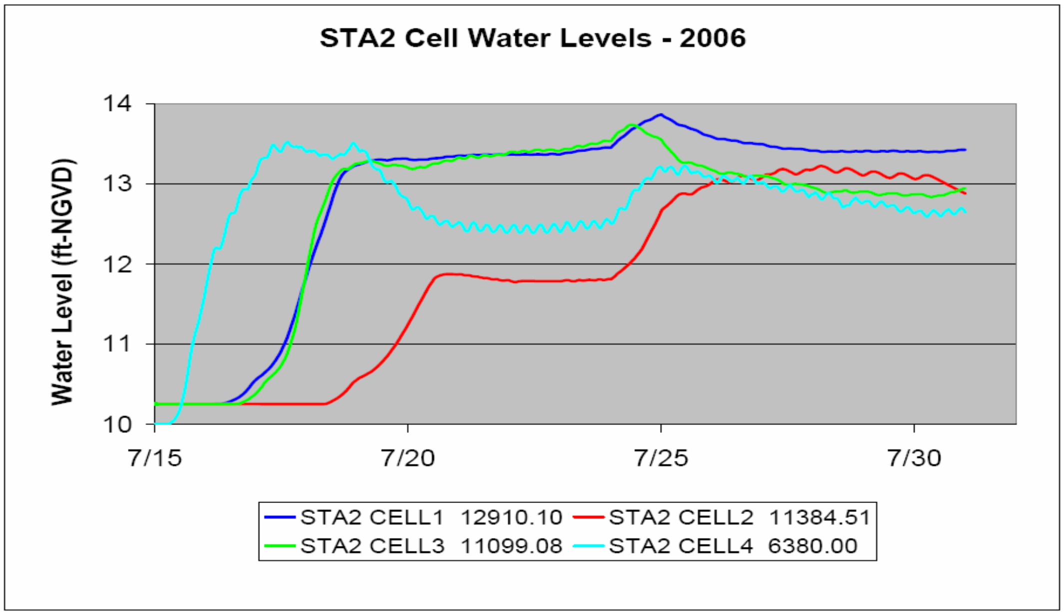

Figure 5.3 – Water Levels in STA 2 for 2006 Existing Conditions

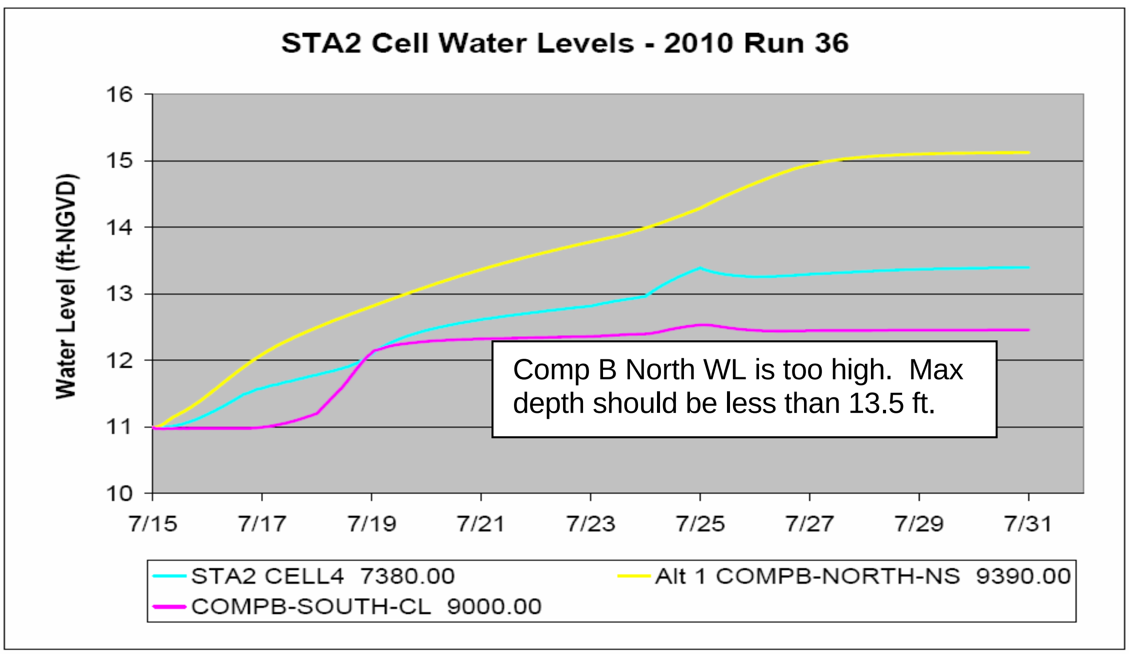

Figure 5.4 – Water Levels in Compartment B for 2010 Alternative 1 Run 36

One additional run was performed (Run 36a) that included deeper Cross Canal cross sections and this run appears to have performed as well as Run 36. Therefore, deeper Cross Canal cross sections will minimize right-of-way acquisition. Detailed cross sections of the recommended canal enlargements are presented in **Appendix M**.

5.1.2 TP Concentration and Load Analysis

Upon the full build-out of Compartments B and C of the Talisman Land Exchange, and completion of the EAASR Compartment A-1, substantial additional acreage of water management and treatment area will be added in the south central and western parts of the

EAA, suggesting that overall system performance during the period 2010-2014 would benefit from a redistribution of projected inflow volumes and TP loads. Alternative 1 is structured to redistribute inflow volumes and TP loads in order to take advantage of and more fully utilize those additional water management areas. Principal components of Alternative 1 are summarized above in Section 5.1.1 and indicated graphically in **Figure 5.1**. Additional details related to water quality are listed below:

1. The new WPB Canal control structure mentioned above will permit a partial diversion of runoff from roughly the northern half of the S-5A drainage basin and the East Beach Water Control District.
2. The new control structure in the Hillsboro Canal mentioned above will permit a partial diversion of runoff from the S-2/S-6 Basin (as well as runoff from the East Shore Water Control District/715 Farms, and additional inflows diverted from the S-5A Basin) to the Cross Canal and then to the NNRC.
3. STA-5, expanded to include the entire Compartment C of the Talisman Land Exchange (including that portion initially converted to use as STA-6 Section 2), is initially assumed to receive runoff from only the C-139 Basin.
4. STA-6 is initially assumed to receive runoff only from the C-139 Annex.
5. S-5AW will be closed, and the capacity of S-5AE will be increased as necessary to eliminate the discharge of L-8 Basin runoff to the STA-1 Inflow & Distribution Works.
6. There are no Lake Okeechobee regulatory releases at Structure S-352 directed to the STAs for treatment.
7. Water supply by-passes of STAs are permitted when the receiving WCA is below the floor of the regulation schedule and are therefore not treated.
8. Regulatory releases are eliminated from the LNWR through Structures S-5AS and S-5AE.
9. STA 1E will only treat runoff volumes equal to those from the C-51 West Basin and Basin B of the Acme Improvement District. Any inflows to the C-51 West Canal from the L-8 Basin will be bypassed through Structure S-155A.
10. STA-1W and -1E enhancements are complete. The East and West Distribution Cells of STA-1E are modeled as emergent vegetation with poor hydraulics (0.5 CSTRs in series).
11. STA-2 enhancements are not in place, and Cells 1 and 2 are analyzed as PEW_3 with Cell 3 analyzed as SAV_3.
12. Compartment B, Cell 1 will be EMG_3, and Cells 2-4 will be SAV_3.
13. STA-3/4 enhancements are completed including the conversion of Cell 1B to SAV.
14. STA-3/4 inflows come from the A-1 Reservoir, G-370 and G-372 on the Miami Canal. C-139 Basin runoff loads through G-136 were reduced 10% from historic levels as a result of ongoing BMP implementation in that basin.
15. The total effective treatment area of the fully expanded STA-5 considered in this analysis is 13,150 acres. The upstream cell in each of the six flow paths is assumed to be vegetated with emergent macrophytes (EMG_3); the downstream cell in each of the six flow paths is assumed to be vegetated with submerged aquatic vegetation (SAV_3).). C-139 Basin runoff loads were reduced 10% from historic levels in consideration of ongoing BMP implementation in the basin.

16. STA-6 is limited to the original Section 1 as STA 6, Section 2 is assumed to be Cell 6B of STA 5. Enhancements to STA-6, Section 1 are assumed to be complete.

A summary of the projected performance of the various stormwater treatment areas over the Period 2010-2014 is presented in **Table 5.3**. That tabulation includes identification of the specific case for each STA considered as most applicable to this summary. That tabulation also summarizes all bypass volumes and TP loads presented in earlier sections of this document. Lake Okeechobee discharges through S-2 and S-3 are assumed to continue, an assumption that differs from the hydraulic modeling. The results presented in **Table 5.3** for STA-5 include the full range of uncertainty associated with the performance of the six downstream cells.

Table 5.3 Summary Projections for all STAs, Alternative 1 for 2010-2014

In this table, one or more notes following the table are applicable to cells highlighted in green

Parameter	Units	Summary of DMSTA2 Results by Treatment Area and Case								
		STA-1W	STA-1E	STA-2	Comp. B	EAASR A-1	STA-3/4	STA-5	STA-6	
		2010 Alt 1	2010 Base	2010 Alt1	2010 Alt1	A1_2010	STA34_Alt1	2010 (Ave)	Sec1_USSO_SAV	All
Effective Treatment Area	acres	6,670	6,175	6240	8,940	16,000	16,543	13,150	897	58,615
Average Annual Inflow										
Volume	1,000 ac-ft	131.4	171.8	180.7	291.1	416.9	350.4	159.1	40.2	1741.7
TP Load	metric tons	25.8	27.03	20.3	44.1	50.0	42.59	39.14	4.88	253.78
FWM TP Concentration	ppb	160	128	91	123	97	99	199	98	118
Average Annual Outflow										
Volume	1,000 ac-ft	133.8	168.5	184.8	290.2	235.1	566.8	159.2	40.3	1543.6
FWM TP Concentration										
Upper Confidence Limit	ppb	16.6	10.1	14.5	12.6	73.4	15.3	8.2	14.1	---
Mean Estimate	ppb	18.9	13.3	16.9	16.5	80.5	18.6	15.3	17.1	17.1
Lower Confidence Limit	ppb	21.9	17.9	20.2	21.8	85.8	23.2	30.7	20.8	---
Geometric Mean TP Conc.										
Upper Confidence Limit	ppb	7.9	7.6	8.6	9.8	71.3	11.5	4.7	10.5	---
Mean Estimate	ppb	10.2	10.6	11.1	13.4	79.8	14.6	11.5	13.4	---
Lower Confidence Limit	ppb	13.4	15.0	14.3	18.6	86.3	18.9	26.5	17.2	---
TP Load (Using Mean FWM Conc.)	metric tons	3.11	2.77	3.86	5.89	23.33	12.99	3.01	0.85	32.48
Summary of Bypass Volumes and Loads										
Bypass Volume, TP Load and TP Concentration for each Treatment Area										
Volume	1,000 ac-ft	14.2	36.3	0.8	0.0	0.0	120.8	0.0	0.0	172.0
TP Load	metric tons	2.23	4.69	0.09	0.00	0.00	10.58	0.00	0.00	17.58
FWM TP Concentration	ppb	127	105	84	---	---	71	---	---	83

Notes:

(1) Surface area of EAASR Compartment A-1 excluded from computation of total effective treatment area

(2) Average annual inflows to STA-3/4 listed above include only direct inflow at G-370 and G-372; outlfow from EAASR Compartment A-1 also directed to STA-3/4

(3) Outflows from EAASR Compartment A-1 excluded from computation of total outlfows, as they are directed to STA-3/4

(4) At STA-1E and STA-2, FWM TP concentrations include estimates below the lower calibration range limit of 15 ppb for SAV_3

(5) At STA-5, upper confidence limit reported based on the assumption that the six downstream cells act as SAV_3; lower confidence limit reported based on the assumption that the six downstream cells act as EMG_3. Mean estimates of outflow concentrations and outflow TP load taken as the average of the estimates for those two conditions.

(6) STA-3/4 analyzed in DMSTA2 as a part of a network with the EAASR Compartment A-1. The 7/01/2005 version of DMSTA2 is not structured to compute the upper confidence limit of TP concentrations in a network simulation. The upper confidence limits for both FWM and Geometric mean TP concentrations were estimated as described in Part 8 of this document.

If STA-3/4 treats S-2 and S-3 bypasses, the flow-weighted mean (FWM) concentration range for the STA-3/4 discharge increases to 16.7 – 25.0 ppb, and the mean estimate is 20.3 ppb. The outflow load from STA-3/4 would increase from 12,990 to 14,900 Kg/yr. More details are provided in **Appendix J**. The FWM outflow concentrations range from 13.3 to 18.8 ppb, and the geometric mean concentrations range from 10.2 to 14.6 ppb. The outflow load is estimated to be 32,480 kg/yr.

The projections of treatment effectiveness are based on the following assumptions:

STA-1W – Alternative 1: Diversion of 800 cfs at the new control structure in the West Palm Beach Canal. All inflows to the STA-1 Inflow & Distribution Works are directed to STA-1W

STA-1E – 2010 Base: Cessation of Lake Okeechobee regulatory releases through the L-8 Borrow Canal to the C-51 West Canal, elimination of inflows from the STA 1 Inflow & Distribution Works, Elimination of LNWR regulatory releases through S-5AS and S-5AE, and by-pass of flows through S-155A equal to L-8 inflows. Runoff to STA 1E is from C-51W, Acme Basin B.

STA 2 – 2010 Alt 1: This case varies from “2010 Min” in that the new control structure in the Hillsboro Canal was considered to open under high rates of total inflow to the Hillsboro Canal at its confluence with the Cross Canal. A firm capacity for diversion of the accumulated Hillsboro Canal inflows at that point through the Cross Canal to the North New River Canal was assigned; daily inflows exceeding that assigned firm rate of diversion were considered discharged through the new control structure to Pumping Station S-6, and added to the inflows from the S-2/S-6 South Sub-basin in computation of the total inflows to STA-2. The firm rate of diversion through the Cross Canal to the North New River Canal was estimated through an iterative analysis in which the diversion rate was successively lowered until such time as the mean estimate of the long-term geometric mean TP concentration in discharges from STA-2 approached 10 ppb. The assigned firm rate of diversion resulting from that analysis is 2,000 cfs (e.g., all inflows to the Hillsboro Canal at its confluence with the Cross Canal equal to or less than 2,000 cfs were considered diverted through the Cross Canal to the North New River Canal; on those days when those inflows exceeded 2,000 cfs, the differential was assigned to STA-2).

Compartment B – 2010 Alt 1: The inflow to Compartment B is from the North New River, and the inflow pump station capacity is 1,600 cfs. STA-2, Cell 4 becomes part of Compartment B. The downstream cells are SAV.

STA-3/4 – Alt 1: A portion of Inflows to STA-3/4 are routed through the A-1 Reservoir. The inflow includes diverted flows from the S-5A and S-2/S-6 basins. Water supply releases to LEC and Big Cypress Reservation bypass STA 3/4.

STA-5 – Average of the two Cases. The two cases differ only in the assumed vegetation type that will be utilized in the downstream cells of STA-5. Average values presented are averages of the two cases. The ranges are the minimum and maximum values for either case.

STA-6 – 2010 Sec1_USSO_SAV: This case was structured on the basic assumption that STA-6, Section 1 would be dedicated to runoff from the C-139 Annex. Vegetation in Section 1 was considered as SAV_3. The analysis considers all available data at station USSO (Water Years 1997 – 2005).

5.1.3 Alternative 1 Evaluation

Alternative 1 is summarized above in Section 5.1.1. Additional clarifications on the water quality features of Alternative 1 are presented in Section 5.1.2. Alternative 1 was evaluated in accordance with the methodology and criteria outlined in Section 3.3. The following subsections provide a summary of the performance of each alternative in accordance with each of the evaluation criteria.

5.1.3.1 Long-Term Total Phosphorus Concentration Achieved

The long-term phosphorus removal performance of each alternative was evaluated using the Dynamic Model for Stormwater Treatment Areas, Version 2 (DMSTA 2). The results generated by the DMSTA 2 analysis of Alternative 1 are presented above in **Table 5.3**. The intent of **Table 5.3** is to show the performance of the individual STAs with respect to discharge of flows and loads to downstream Water Conservation Areas (WCAs). The tabulation includes information on the average annual inflow, average annual outflow, and a summary of bypass volumes and loads. For the purpose of this analysis, the range of STA outflow FWM concentration will be used to compare the alternatives. **Table 5.4** presents the FWM range for the STAs and the overall FWM concentration predicted for all the STAs. Ranges are provided due to uncertainties in vegetation succession in the STAs and anticipated evolution of the TP removal.

Table 5.4 – DMSTA2 Summary results of STA Outflow TP Concentrations

Alternative	TP Average Annual Outflow Mean (Range - ppb)
1	17.1 (13.3 – 18.9 ppb)

5.1.3.2 Flood Impact Analysis

The intent of the hydraulic analysis is to determine the flooding impact of the alternatives that have equal storm inflows from the EAA farms. The hydrologic and hydraulic modeling results provide predicted water levels at multiple locations along the Ocean, West Palm Beach, Hillsboro, Cross, Bolles, North New River, Miami, and the L Canals. **Table 5.2** presents the canal stages for selected stations in the EAA for two options of Alternative 1. In addition, this table shows the target flows to be diverted and Alternative 1 flows at key locations. Two runs were performed as part of the analysis: Run 36 assumes a wider canal scenario, and Run 37 assumes limited widening and deeper canal invert elevations. In Run 36, the results indicated that all identified stages are below the target elevation 12.50 ft-NGVD. The results generated for Run 37 identifies two stages (Ocean Channel 46400, at Gladeview Canal and Bolles Canal Channel 422, West End) with a canal stage of 12.50 ft-NGVD. Run 36 (with the wider canals) did not have any flooding of EAA canals. The Miami Canal at chainage 3914 had a peak stage of 12.4 ft-NGVD. Run 36A was conducted using the wide NNR cross sections and the deep narrow cross canal cross sections. This run had similar results to Run 36. Therefore, Run 36A was used in the cost estimate.

5.1.3.3 Operational Flexibility

Alternative 1 adds significant operational flexibility to EAA canal conveyance. The combination of a new canal connection from the West Palm Beach Canal to the Sam Senter Canal, enlarged canals, and 4,600 cfs of pump station capacity on the North New River increases Cross Canal flows at the North New River from 525 cfs to 2,760 cfs.

5.1.3.4 Reservoir Operation

Reservoir inflows and outflows were simulated by SFWMD employing v5.0 of the South Florida Water Management Model (SFWMM), with certain assumptions made specifically for the purposes of this analysis. The model run described conditions assumed to be present in 2010, including the A-1 Reservoir and Compartments B and C. Details on the results of this analysis are described in Appendix D and I of this document. Reservoir inflow for Alternative 1 is 416,580 ac-ft/yr and the TP load is 49,672 Kg/yr. Reservoir outflow to STA-3/4 is 235,100 ac-ft/yr, and the TP load is 23,330 Kg/yr. Irrigation outflows were 180,000 ac-ft/yr. The SFWMM representation of the reservoir is relatively simple, and more detailed assessments of the reservoir mass balance are being conducted separately.

The reservoir was modeled in MIKE 11 for the two-week long design storm period. Reservoir inflow during design storm conditions is 130,800 ac-ft.

5.1.3.5 Implementation Schedule

The implementation schedule for all alternatives includes real estate acquisition. The design, land acquisition, and construction for Alternative 1 will be completed in 2010. **Appendix M** includes a detailed implementation schedule for each alternative. The implementation duration included in these tables are in calendar days.

In general, it has been assumed that engineering design will start in February 2006, will take approximately one year, and right-of-way drawings will be delivered approximately six months after the beginning of design. Except for the Cross Canal, land acquisition will take one year starting in June, 2006, and that canal enlargements will not proceed until the lands along a specific canal have been acquired. Except for the Cross Canal, it has further been assumed that major canal enlargements will take approximately two years, and that diversion gates (e.g. the West Palm Beach gate for Alternative 1) cannot be used until the canals have been enlarged. It has been assumed that many canal enlargement projects will be taking place concurrently, however it has not been assumed that all canal enlargement projects can be completed within a two-year window following land acquisition.

Implementation schedules for the Cross Canal, Compartment B, and Compartment C have been developed by Acceler8 are reported herein without editing. The Cross Canal land acquisition will start in February 2006 and will be completed in one year. Contracting and construction for the Cross Canal, Compartment B, and Compartment C (including ordering and installation of pumps) will be completed by the end of 2009.

5.1.3.6 Re-distribution of flows and loads to receiving waters

The EAA has historically discharged to Lake Okeechobee, C-51W, WCA 1, WCA 2A, and WCA 3A. In turn, a portion of the water entering WCA-1 is discharged to WCA-2A through the S-10 structures, and a portion of WCA-2A is discharged to WCA-3A through the S-11 structures. The EAA RFS alternatives were reviewed to estimate if a given alternative would result in a shift to the balance of flows and loads to these receiving waters.

Lake Okeechobee. For 2006-2009, simulated back pumped volumes and loads from the EAA to Lake Okeechobee are as follows:

- Average annual volume = 42,554 ac-ft/yr, TP load = 4,640 kg/yr at S-2
- Average annual volume = 5,921 ac-ft/yr, TP load = 594 kg/yr at S-3

For 2010-2014, simulated back pumped volumes and loads from the EAA to Lake Okeechobee are as follows:

- Average annual volume = 24,946 ac-ft/yr, TP load = 2,822 kg/yr at S-2
- Average annual volume = 4,091 ac-ft/yr, TP load = 445 kg/yr at S-3

Hydraulic modeling results of 2010 – 2014 conditions suggest that back-pumping to Lake Okeechobee might be eliminated. While not reflected in the summary data being taken from the water quality analyses, this is an important distinction.

WCAs. Alternative 1 annual average flows to the WCAs are expected to be 1,543,600 ac-ft/yr (see Appendix J).

5.1.3.7 Maintain desirable water levels in the Loxahatchee Wildlife Refuge

Evaluation of this factor was not conducted for reasons discussed above in Section 3.3.2.

5.1.3.8 Probable Planning-level Opinion of Capital and O&M Cost Estimates

A summary of the estimated probable planning-level opinion costs for all improvements for each alternative are included in **Appendix M**. This appendix includes a summary of the cost for each alternative, a tabulation of cut/fill volume including the additional right-of-way required, and a detailed estimate per canal. The opinion of probable cost for Alternative 1 is:

Design Phase Cost	$ 20,299,464
Canal Improvements Cost	$ 51,962,976
Other Construction Cost	$ 63,916,398
Land Acquisition Cost	$ 15,869,688
Compartment B & C Construction Cost	$ 143,493,000
Annual O&M for B&C Only (2006 dollars)	$8,099,126
Annual O&M Cost with B&C (2006 dollars)	$ 8,573,512
Total 50-year Present Worth	$ 458,824,327

5.1.3.9 Cash Flow Analysis

A cash flow analysis was conducted for the opinion of probable cost presented above. The cash flow analysis apportioned costs for major project elements by year starting from design through completion of the construction phase. The schedule of Alternative 1 was used to apportion costs on a quarterly basis. Quarterly costs of all project elements were summed to generate an overall cost per quarter from early 2006 through completion in 2010. **Figure 5.5** provides the results of the Alternative 1 cash flow analysis. See **Appendix M** for additional details.

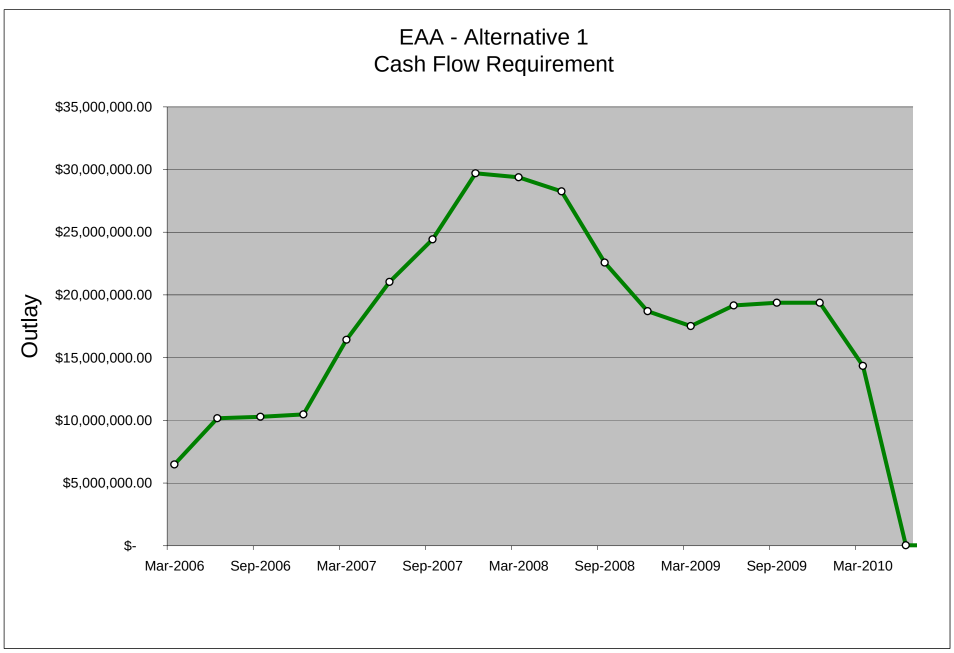

Figure 5.5 – Alternative 1 Cash Flow Analysis

5.2 Alternative 2

The purpose of this alternative is to minimize inter-basin transfers while achieving low TP concentrations in STA discharges. A summary of the components of this alternative is presented in **Figure 5.6** and is described below:

1. Enlargement of S-5AE to twice the existing capacity and close Structure S-5AW.
2. Enlargement of the L-7 Borrow Canal and separation of the Borrow Canal from the Loxahatchee National Wildlife Refuge (see figure below).
3. Installation of a gate on the east bank of L-7 near G-251 to allow STA 1W discharges to enter the north portion of the Refuge during periods when discharges are within acceptable concentration limits.
4. Replacement of G-338 (near S-6) with a new gated control structure that would allow L-7 flows to be delivered to the STA-2 Inflow Canal. (see **Figure 5.7** for a detail of the area around G-338 and S-6).
5. Construction of a new canal from the STA-2 Inflow Canal to Compartment B.
6. Removal of G-336G on L-6.
7. Enlargement of the Cross Canal and the North New River Canal.
8. A new inflow pumping station on the NNRC to the A-1 Reservoir. This is the pump station anticipated by Black & Veatch, however the pump capacity could be different than what is assumed by Black & Veatch.
9. STA-1 complex treats average annual amount of 35,000 ac-ft. L-8 runoff (approximate amount that historically discharged to the Refuge).
10. Hydraulic connection of the new STA-2, Cell 4 to the new Compartment B STA, i.e., no longer hydraulically connected to STA-2 Cells 1, 2, and 3.
11. Enlargement of the Ocean Canal and Hillsboro Canal.
12. Addition of a new gated structure on the Hillsboro Canal to limit flow into STA-2. This gate will close when the S-6 flow exceeds approximately 1300 cfs, such that the combined STA 2 inflow is no greater than 4720 cfs.
13. Modification of the operations of S-5A, G-300, G-370, G-335, G-302, and S-155A.
14. Modification length and cross sections of the STA 2 Cell 4 Discharge Canal.

Canal cross sections were modified a number of times in an attempt to minimize expansion while minimizing canal water levels during simulations. The resulting dimensions are presented in **Tables 5.5 and 5.6.** Detailed description of the implementation of Alternative 2 is included in EAA RFS, Phase 2 Deliverable 3.2h (Final Optimum Allocation of Phosphorus and Hydraulic Loading to the Existing STAs, Compartment B & C, and the A-1 Reservoir, and Optimum Canal Improvements Associated with Optimum Allocation). This report is included in Appendix I.

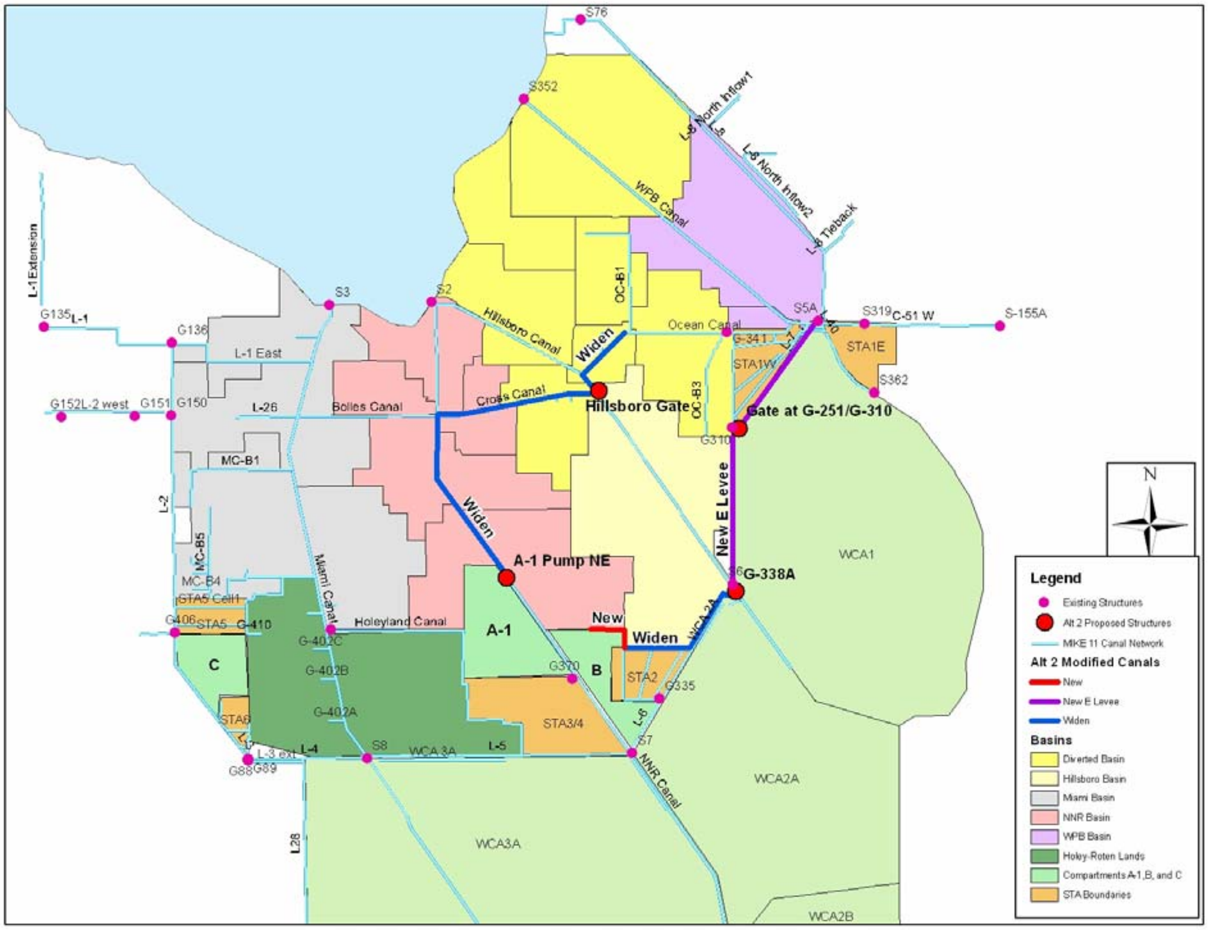

Figure 5.6 – Alternative 2 Features

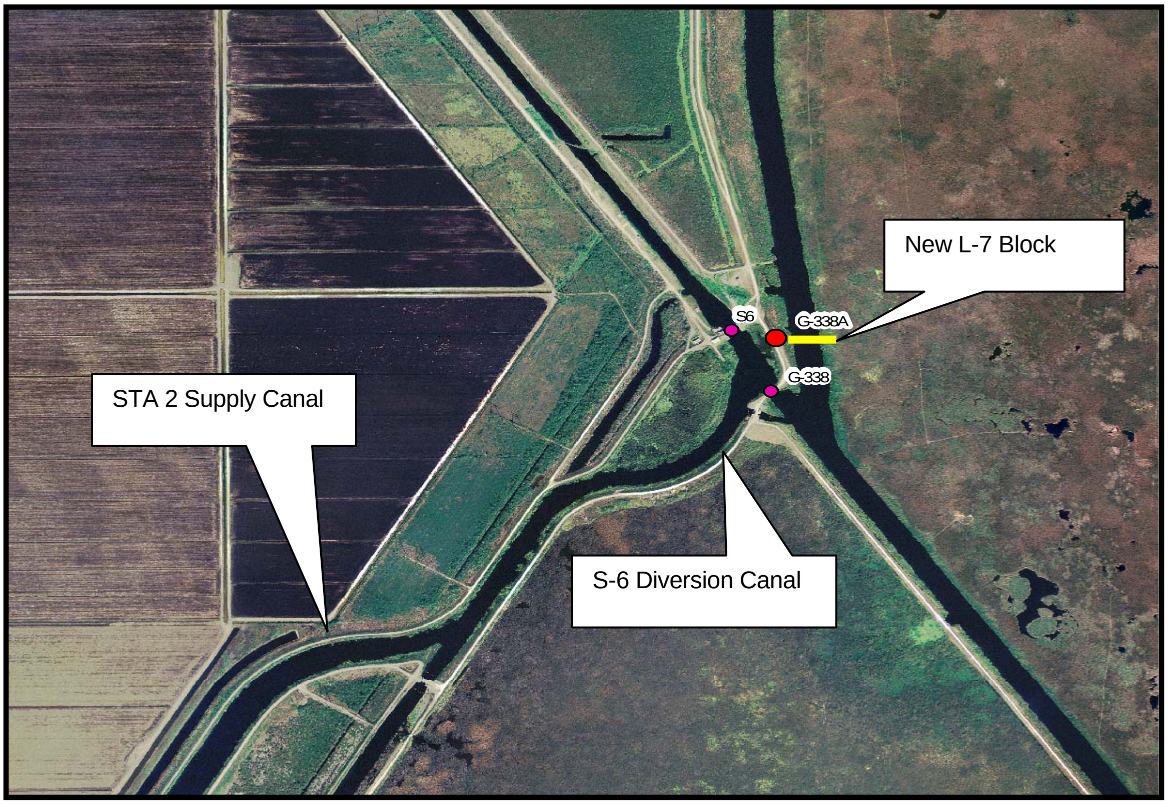

Figure 5.7 – Detailed View of S-6, L-7, and the STA 2 Supply Canal

Table 5.5 – Alternative 2 L-7 Cross Section Dimensions

Cross-Section Chainage (ft)	Existing Bottom Width (ft)	Proposed Bottom Width (ft)	Proposed East Top of Bank (ft-NGVD)
6416	100	160	20
6595	140	200	20
11594	70	130	20
16998	110	170	20
21597, 26496, 31596	120	180	20
36755, 43114	100	160	20
48519	70	130	20
53746, 58848, 64223	80	140	20
69540	90	150	20
74829	130	190	20
80016, 86438	140	200	20

Table 5.6 – Alternative 2 Miscellaneous Cross Section Dimensions

Canal	Start Ch (ft)	End Ch (ft)	Bottom Width (ft)	Invert (ft-NGVD)	Side Slopes H:1	Top-of-bank (ft-NGVD)
Ocean Canal	0	18,691	85	-10.0	2.5	18
Hillsboro Canal	48,313	54,313	100	-10.0	2.5	Existing
Cross Canal	0	46,759	140	-6.25	2.5	15
North New River Canal	33,133	125,889	110	-9.5	2.5	20
S-6 Diversion Canal	0	3,037	140	-4.0	Existing	Existing
STA 2 Supply Canal	0	17,953	140	-4.0	Existing	Existing
STA 2 Inflow Canal	0	30,000	100	-4.0	Existing	Existing
STA 2 Cell 4 Discharge	100	1,600	100	-4.0	Existing	Existing

5.2.1 Hydraulic Analysis

Development of the Alternative 2 hydraulic model preceded receipt of DMSTA analysis. This concurrent analysis was conducted because prior investigations conducted by others suggested that this alternative would be effective in achieving a balanced discharge from the EAA STAs without extensive inter-basin transfers. Initial hydraulic modeling results conducted as part of this assessment indicated that STA-2/Compartment B could handle the hydraulic inputs from STA-1W and the S-2/S-6 basin. As results of DMSTA modeling were received, it became apparent that modifications to this alternative would be required to deliver the appropriate flows to each STA. Numerous runs were conducted in an attempt to route the desired flows to the STAs and the A-1 Reservoir. Changes made to improve the performance of this alternative are summarized below:

A. The initial concept was to use STA-2 and Compartment B to treat the S-6 Hillsboro Basin and to further treat STA-1W discharges. A portion of this combined inflow to the STA-2/Compartment B inflow canal was routed around STA-2 and Compartment B North to avoid flow constrictions in Cell 4, the middle cell of Compartment B.
B. Cross sectional area of the North New River, Cross Canal, Hillsboro Canal, and the Ocean Canal were increased in increments to increase conveyance from the Hillsboro Canal to the North New River via the Cross Canal.
C. A gate was added to the Hillsboro Canal just south of the junction with the Cross Canal, and this gate was programmed to stay closed during the entire period of simulation.
D. Runoff from selected farm lands within the S-2/S-6 Basin that can discharge to both the Hillsboro and Cross Canal was routed to the Cross Canal, which reduced runoff to the Hillsboro Canal by 230 cfs.
E. Existing pump station S-6 operation was modified to reduce the inflow rate to STA-2 (this test was not successful due to high stages north of S-6).

After evaluation of model results for these tests, Alternative 2 incorporated items A-D listed above. This version is referred to as Run 51. Run 51 came close to meeting flow targets for the STAs but resulted in high stages in the Ocean Canal, Sam Senter Canal, Cross Canal, and portions of the Hillsboro Canal.

Due to the problems in Run 51, a number of additional tests were conducted modifying a variety of model parameters in an attempt to meet both the flow and the flood control targets. Changes included modifying flow distribution to STA 1E and -1W, using a number of different combinations of canal enlargements, and modifying the pump capacity for the A-1 Reservoir

NE pump station. Run 55 assumed that the A-1 NE pump station capacity would be 5,000 cfs rather than 3,000 cfs used for Alternative 1, and reduced the pump discharge capacity in STA-1W (G-251 was turned off). This run was able to achieve both the flow targets to the STAs and the flood control targets (stages less than 12.5 ft-NGVD in the Ocean, Sam Senter, Hillsboro, and Cross Canals). Stages and flows for Alternative 2, Run 51 and Run 55 are compared to existing conditions and target stages and flows in **Table 5.7**.

The dimensions of canal enlargements for L-7, Cross Canal, and NNR and the gate operations for the L-7 G-338A gate were selected to accomplish diversion of flows to achieve a balanced distribution of flows to the STAs. The diversions were based on an analysis of projected water quality conditions using DMSTA (see **Appendix K**). The target flows to be diverted and the Alternative 2 diversion flows are presented below in **Table 5.7**.

Alternative 1 inflows to STA 2 and Compartment B are compared to Alternative 2 Run 51 and 55 flows in **Figure 5.8**. **Figure 5.8** illustrates that the maximum inflow to STA-2/Compartment B for Alternative 2, Run 51 and Run 55 are above recommended levels. **Figure 5.9** illustrates that peak stages in Compartment B North are less for Alternative 2 because a portion of the STA 2 inflow is diverted around Compartment B North (see **Figure 5.10**). Numerous runs were conducted in an attempt to decrease the Hillsboro Canal peak inflow rate. This alternative was able to meet both the canal stage targets and STA flow distribution targets with the A-1 NE pump station capacity equal to 5,000 cfs (note that Alterative 1 A-1 NE pump station capacity is 3,000 cfs). Once it was apparent that Run 55 was providing both flow distribution and peak canal stage targets, it was re-run with narrow, deep cross sections in the Cross and North New River Canals (dimensions the same as shown for Alternative 1, Run 37). Higher stages were observed in the Cross and Ocean Canals with 550 cfs of easterly flow through G-341. Using the wider cross sections for Run 55 did not have flows through G-341.

Figure 5.11 illustrates flows out of STA-2 and Compartment B through G-335 and the new Compartment B outflow pump. It can be seen that G-335 does not begin discharges until the third day of the simulation, and the Compartment B pump station does not begin flow until G-335 is close to full capacity nine days after the beginning of the simulation. **Figure 5.12** illustrates that stages in the Ocean and Cross Canals are within target maximum stages and are lower than existing stages.

Table 5.7 - Flows and Stages for Existing Conditions and Alternative 2

PEAK FLOWS (cfs) Station	2006 EX	Run51	Run 55	Target Flows
Cross Ch 100, West End	-525	-2,593	-3,093	
Cross Ch 20000, Middle	-216	-2,286	-2,731	
Cross Ch 45271, East End	161	-1,631	-2,110	-1,460
Ocean Ch 3400, Near Hillsboro	-561	-856	-1,340	
G-341 East Flow	770	517	0	
Hillsboro Canal, Ch 54697, U/S of New Gate	675	-29	-30	
Hillsboro Canal, Just U/S of S-6	2728	1,754	1,825	
STA 1W Inflow Ch 100	3,208	2,775	2,492	3,250
G-311, to STA 1E	0	-970	-650	-1,000
STA 1E S-319 Inflow Pump Station	1,800	2,000	1,999	
STA 2 Inflow Canal Ch 1100	3,300	5,383	5,234	4,720
Comp B NNR Pump Station	0	0	0	
A-1 Pump NE Pump Station	0	3,000	4,480	
STA 3/4 G-370 East Pump Station	2,742	2,493	1,809	
STA 3/4 G-372 West Pump Station	3662	3,640	3,641	
STA 5 (Cells 1-2, Compartment C cells)	1,724	2,805	2,767	
STA 6, Cells 3 and 5 (EX incl. Section 2)	1,285	208	238	
Sum of STA Inflows	20,449	23,271	23,310	
C-51W at S-155A (bypass flow)	830	1,347	1351	
STAGES (ft-NGVD)				
Station	**2006 EX**	**Run 51**	**Run 55**	
NNR at A-1 Pump NE Pump Station	12.37	11.88	9.81	
NNR at Compartment B Pump Station	11.40	11.78	9.73	
NNR at G-370	9.78	11.66	9.65	
Cross Ch 200, West End	13.09	12.79	11.41	
Cross Ch 23622, Middle	14.32	12.90	11.60	
Cross Ch 43983, East End	15.14	12.97	11.76	
Ocean Ch 6800, halfway betw Hills & bend	14.62	12.96	11.81	
Ocean Ch 46400, at Gladeview Canal	14.68	13.00	12.31	
Bolles Canal Ch 422, West End	12.91	12.93	12.35	
Target	12.50	12.50	12.50	

Note: U/S and D/S: Upstream and Downstream, Ch: chainage (canal location, feet from Lake Okeechobee). Highlighted cells exceed target canal stages.

Table 5.8 – Alternative 2 Target Flows to Achieve Balanced Inflows and Predicted Flows from Hydraulic Modeling

Location	Target Flow cfs	MIKE 11 Flows, cfs	
		Run 51	Run 55
STA 1W Inflow	3,250	2,775	2,492
G-311 Inflow to STA 1E	1,000	970	650
STA 2/Compartment B Inflow	4,720	5,132	5,200
Flow from Hillsboro to NNR	1,460	1,614	2,065

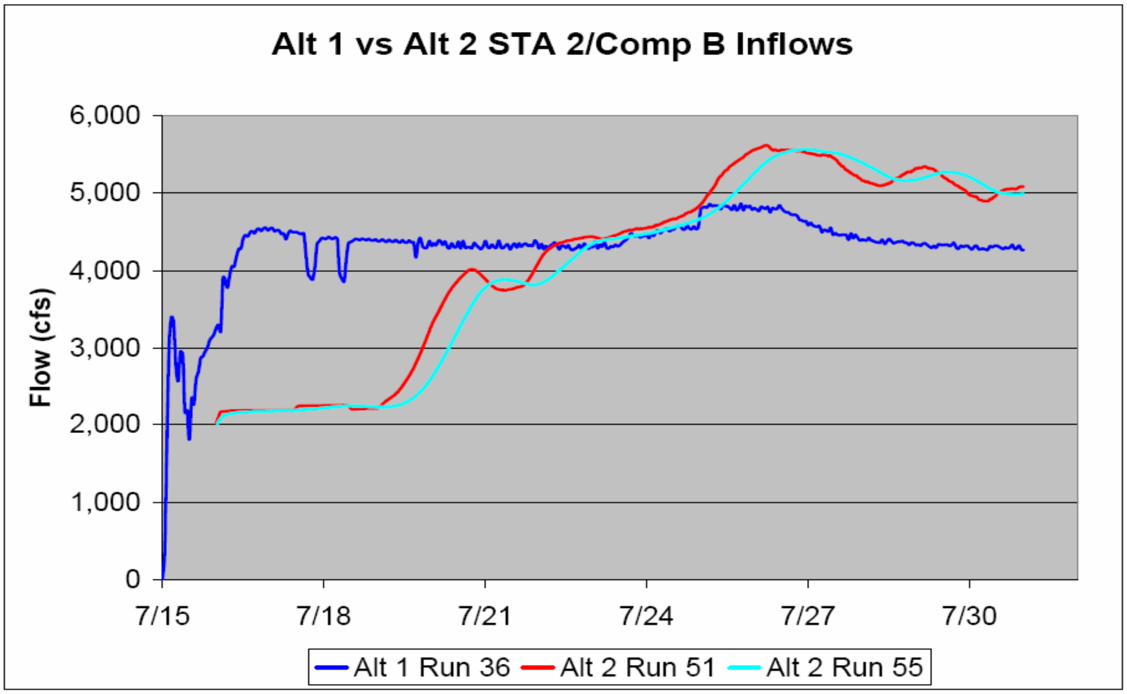

Figure 5.8 – Alternative 1 and 2 Inflows to STA 2 and Compartment B

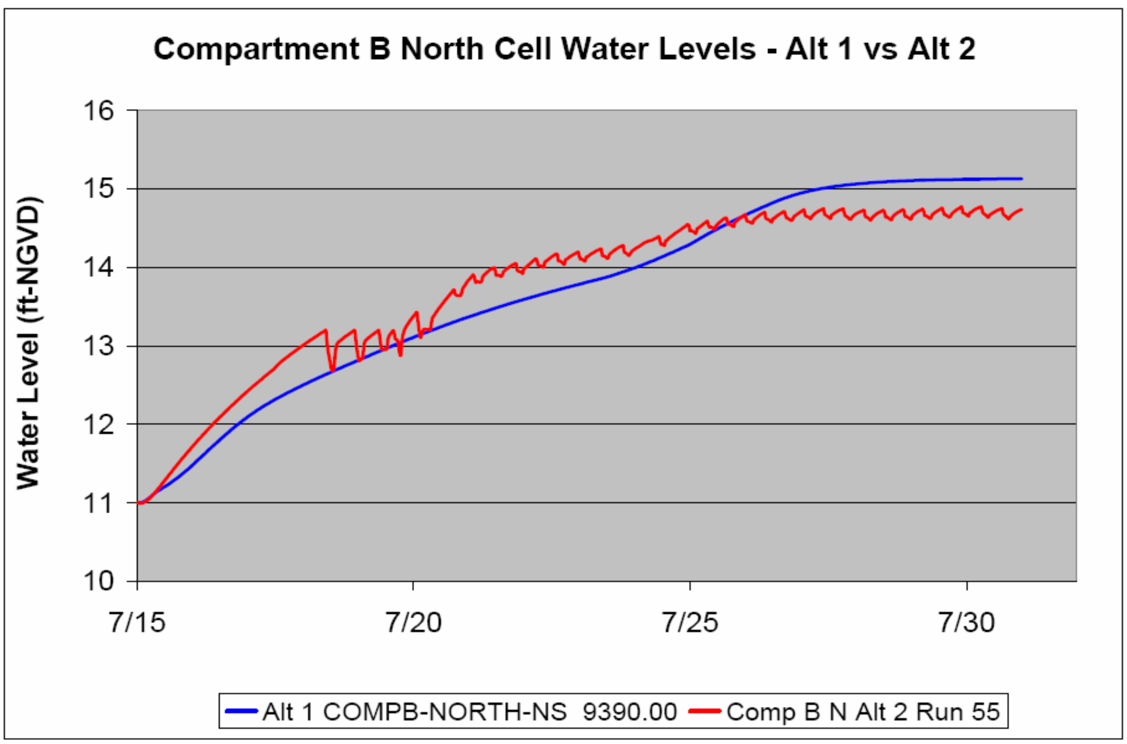

Figure 5.9 – Water Levels in Compartment B North for Alternatives 1 and 2

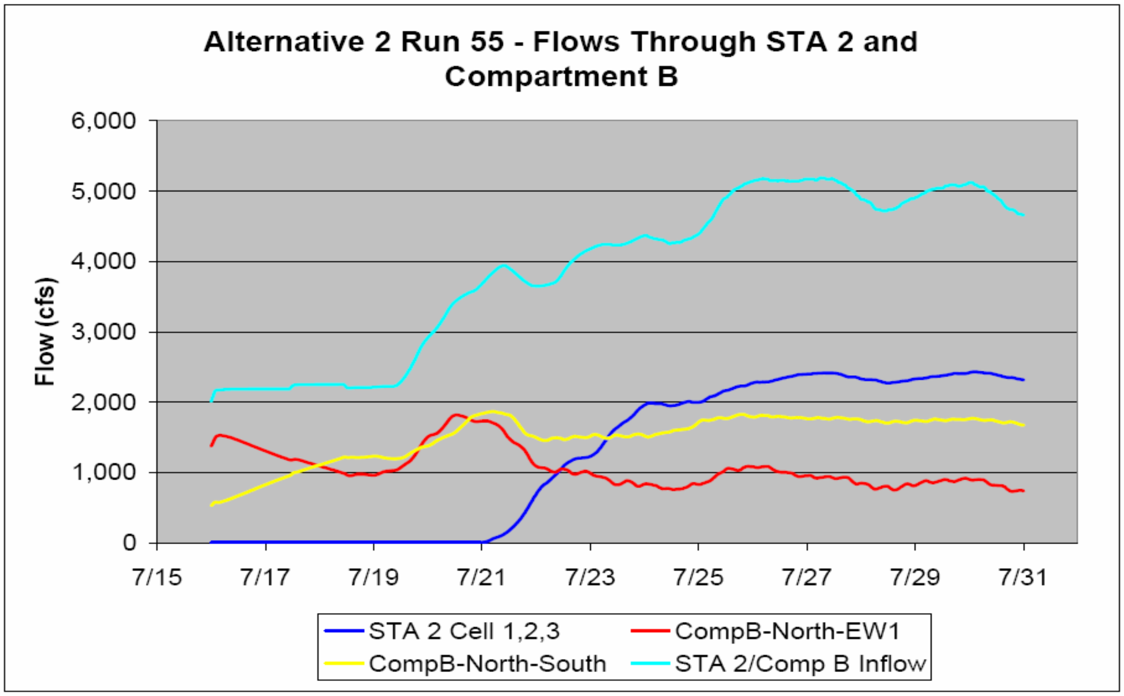

Figure 5.10 – Flows Through STA 2 and Compartment B

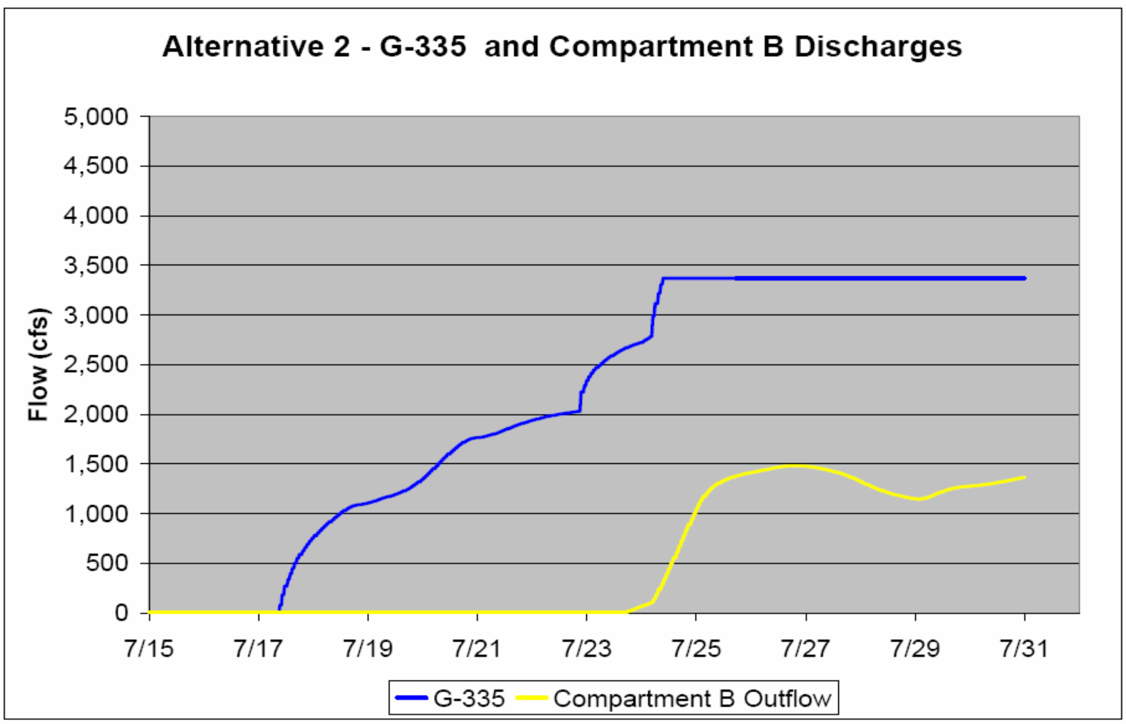

Figure 5.11 – Flows Leaving STA 2 and Compartment B

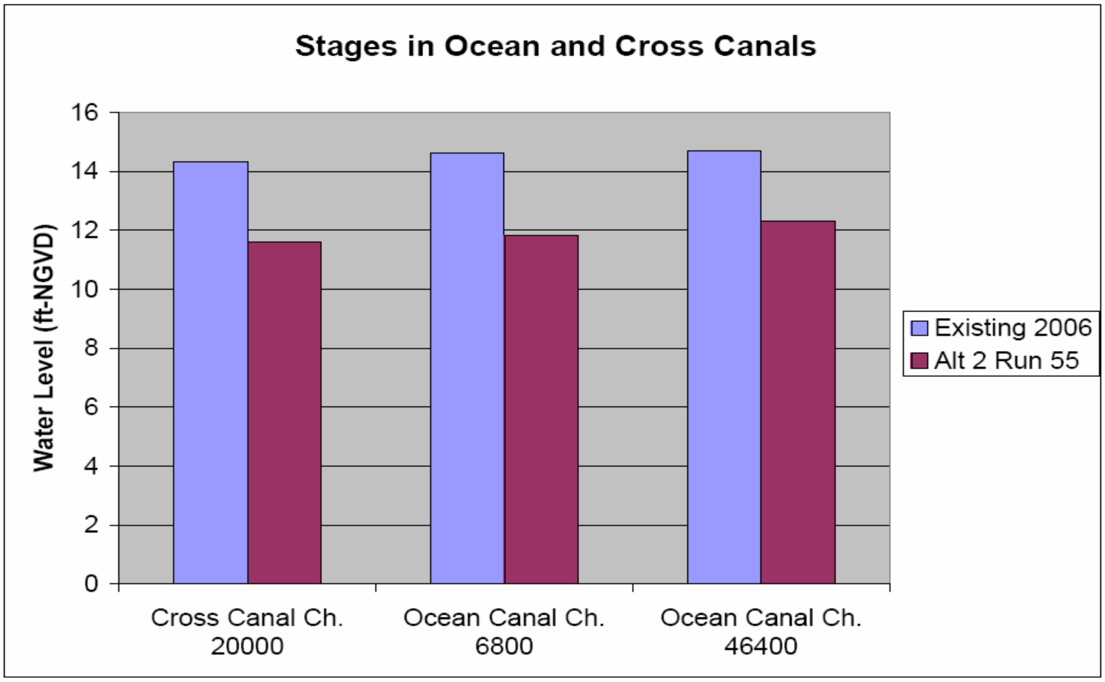

Figure 5.12 – Water Levels in the Cross and Ocean Canals for Alt 2 Run 55

A key feature of Alternative 2 is a larger pump station for the A-1 Reservoir. The required A-1 NE pump station capacity is 5,000 cfs, which is 2,000 cfs larger than the capacity assumed for Alternative 1. This larger capacity is needed for the following reasons:

1. In Alternative 2, STA 1W outflows are re-directed through new gate G-338A to the STA 2 Supply Canal via the S-6 Diversion Canal (see **Figure 5.7** shown above).
2. S-6 continues to pump into STA 2, however at **lower** rates than maximum capacity so that the combined inflow from S-6 and STA 1W via G-338A does not exceed 4,700 cfs. This maximum flow is derived from DMSTA 2 analysis of STA 2 and Compartment B. Decreased flows from the Hillsboro Canal to S-6 mean that all runoff from the Hillsboro Canal upstream of the proposed Hillsboro Gate is diverted to the North New River via the Cross Canal.
3. An inflow pump station to Compartment B on the North New River Canal is not needed due to Items 1 and 2 above. Therefore, G-370 and the A-1 NE Pump Station are the only withdrawals from the North New River. Simulations with a 3,000 cfs pump station resulted in flooding in the Ocean Canal.

Figure 5.13 illustrates that the 5,000 cfs pump station will operate for 7 days if the maximum reservoir elevation is 18 ft NGVD and 12 days if the maximum reservoir elevation is 22 ft-NGVD. The modeling conducted for this alternatives analysis assumed that all farms discharged 0.75 inches/day of runoff for 15 days. Historical flows from the EAA indicate that cumulative runoff from the EAA exceeded 0.75 inches/day for five days in November, 1998. No other event from 1990 through 2002 generated runoff in excess of 0.75 inches/day. This analysis indicates that the reservoir will be able to store North New River runoff from the largest 5-day event measured from 1990 through 2002.

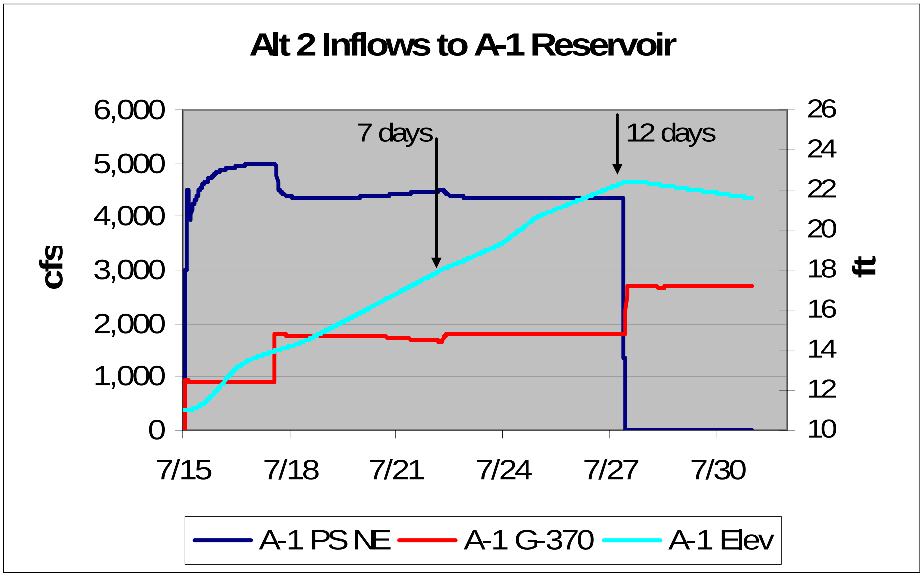

Figure 5.13 – Alternative 2 Flows to the A-1 Reservoir

Run 55 of Alternative 2 provided the best set of results for both flow distribution and peak stage reduction objectives. In summary, Alternative 2, Run 55 consists of:

- Expansion of the L-7 Canal and separation of the L-7 from the Refuge.
- Addition of a new gate near G-251 to allow STA 1W outflows to be delivered to the Refuge.
- Addition of a new gate G-338A.
- Expansion of the STA 2 Diversion, Supply, and Inflow Canals,
- Separation of Compartment B and Cell 4 (currently linked to STA-2) from STA-2.
- Addition of a new gate on the Hillsboro Canal south of the junction with the Cross Canal. This gate will be permanently closed during full flood conditions.
- Expansion of the Ocean Canal from the Sam Senter Canal to the Hillsboro Canal.
- Expansion of the Hillsboro Canal from the Ocean Canal to the Cross Canal.
- Expansion of the Cross and North New River Canals to the same dimensions recommended for Alternative 1.
- Addition of a 2,000 cfs capacity to the A-1 Reservoir NE pump station.

5.2.2 TP Concentration and Load Analysis

Alternative 2 involves the conveyance of STA-1W outflows to STA-2/Compartment B for further treatment. The lower portion of the S-6 Basin (generally south of the Cross Canal) would also be conveyed to STA-2/Compartment B. The assumptions used in analysis of water quality treatment of Alternative 2 are listed below:

STA1W – STA1W_Alt2: inflows to STA-1E from the C-51 West Canal at S-319 and at S-362 were assumed to be consistent with the summary data presented in **Table 4.1** of **Appendix K** (e.g., bypass of inflow volumes from the L-8 Basin, but before inclusion of inflows at G-311). This case is identical to that developed for Alternative 1, with the exception that projected diversions from STA-1W through G-311 are added to the STA-1E inflows.

STA1E_Alt2: This case was developed upon the assumption that all potential inflows to STA-2 listed in **Table 5.9 (Table 5.1 of Appendix K)** would be included in the inflow volumes and TP loads to STA-2, to the extent that hydraulic capacity is available in the expanded STA-2 to receive those inflows.

STA2_Alt2: This case was developed on the assumption that all potential inflows to STA-2 listed in **Table 5.9 (Table 5.1 of Appendix K)** would be included in the inflow volumes and TP loads to STA-2, to the extent that hydraulic capacity is available in the expanded STA 2 to receive those inflows.

Table 5.9 - Potential Average Annual Inflows to Expanded STA-2 (Table 5.1 of Appendix K)

Source	**Potential Average Annual Inflow, WY 1966-2000**			**Remarks**
	Volume (ac-ft)	**TP Load (kg)**	**TP Conc. (ppb)**	
S-2/S-6 Basin	236,624	28,327	97	Deliverable 1.2A, Table 3.3
ESWCD/715	29,818	4,588	125	Deliverable 1.2A, Table 2.6
Current S-5A Diversion	58,778	11,152	154	Deliverable 1.2A, Table 3.15
STA-1W Discharge	239,401	8,054	27.3	Table 3.2
Seepage from WCA-2A	27,500	509	15	See text
Lake Okeechobee	832	86	84	Water Supply to LEC SA2 (WL2351)
Total Inflow	592,953	52,716	72	
Assumed Bypass	832	86	84	Water Supply to LEC SA2 (WL2351)
Inflow to be Treated	**592,121**	**52,630**	**72**	

STA 3/4_Alt2: As taken directly from the information presented in Deliverable 1.2A (for that case, discharges from the reservoir are assigned TP concentrations equal to that in reservoir inflows, and thus would not reflect reductions due to passing through the reservoir). See Appendix D. As modified for Alternative 2, including those volumes and TP loads diverted from the Hillsboro Canal.

STA 5 and 6: Identical to Alternative 1.

The treatment performance of the STAs is presented in **Table 5.10**. Inflow volumes and loads are presented for each STA subject to the assumptions listed directly above. STA outflow FWM concentrations and upper and lower confidence limits are also presented. Geometric mean and confidence limits are presented. The outflow load using the geometric mean are presented. Bypass flows, concentrations, and loads are also given. In general, the assumptions listed above for Alternative 1 are incorporated into Alternative 2.

Table 5.10 – Summary Projections for all STAs, Alternative 2 for 2010 - 2014

Parameter	Units	Summary of DMSTA2 Results by Treatment Area and Case							
		STA-1W	STA-1E	STA-2	EAASR A-1	STA-3/4	STA-5	STA-6	
		STA1W_Alt2	STA1E_Alt2	STA2_Alt2	2010 Base	STA34_Alt2	2010 (Ave)	Sec1_USSO_SAV	All
Effective Treatment Area	acres	6,670	6,175	15180	16,000	16,543	13,150	897	58,615
Average Annual Inflow									
Volume	1,000 ac-ft	238.6	180.9	324.0	416.9	382.2	159.1	40.2	1742.0
TP Load	metric tons	51.3	29.05	41.5	46.8	40.98	39.14	4.88	253.72
FWM TP Concentration	ppb	174	130	104	91	87	199	98	118
Average Annual Outflow									
Volume	1,000 ac-ft	239.4	177.6	565.0	235.1	598.4	159.2	40.3	1540.5
FWM TP Concentration									
Upper Confidence Limit	ppb	22.1	11.9	12.2	71.7	15.0	8.2	14.1*	---
Mean Estimate	ppb	27.3	15.6	14.9	76.2	18.3	15.3	17.1	16.4
Lower Confidence Limit	ppb	34.2	20.6	18.5	81.1	22.6	30.7	20.8	---
Geometric Mean TP Conc.									
Upper Confidence Limit	ppb	17.2	8.4	9.2	68.9	11.3	4.7	10.5	---
Mean Estimate	ppb	22.1	11.8	11.8	74.4	14.2	11.5	13.4	---
Lower Confidence Limit	ppb	29.0	16.6	15.5	80.4	18.3	26.5	17.2	---
TP Load (Using Mean FWM Conc.)	metric tons	8.05	3.42	10.36	22.08	13.49	3.01	0.85	31.13
Summary of Bypass Volumes and Loads									
Bypass Volume, TP Load and TP Concentration for each Treatment Area									
Volume	1,000 ac-ft	14.2	36.3	0.8	0.0	120.8	0.0	0.0	172.0
TP Load	metric tons	2.23	4.69	0.09	0.00	10.58	0.00	0.00	17.58
FWM TP Concentration	ppb	127	105	84	---	71	---	---	83

Notes:

(1) Surface area of EAASR Compartment A-1 excluded from computation of total effective treatment area

(2) Average annual inflows to STA-3/4 listed above include only direct inflow at G-370 and G-372; outflow from EAASR Compartment A-1 also directed to STA-3/4

(3) Outflows from EAASR Compartment A-1 excluded from computation of total outlfows, as they are directed to STA-3/4

(4) At STA-1E,STA-2 and STA-5, FWM TP concentrations include estimates below the lower calibration range limit of 15 ppb for SAV_3

(5) At STA-5, upper confidence limit reported based on the assumption that the six downstream cells act as SAV_3; lower confidence limit reported based on the assumption that the six downstream cells act as EMG_3. Mean estimates of outflow concentrations and outflow TP load taken as the average of the estimates for those two conditions.

(6) STA-1W, STA-2, STA-3/4 analyzed in DMSTA2 as a part of a network with the EAASR Compartment A-1. The 7/01/2005 version of DMSTA2 is not structured to compute the upper confidence limit of TP concentrations in a network simulation. The upper confidence limits for both FWM and Geometric mean TP concentrations were estimated as described in Parts 3, 5, 6 and 7 of this document.

(7) Average annual inflows to STA-2 listed above include only direct inflow at S-6; outflow from STA-1W also directed to STA-2

(8) Outflows from STA-1W are excluded from total outflows, as they are directed to STA-2

The FWM outflow concentrations range from 14.9 to 18.3 ppb, and the geometric mean concentrations range from 11.5 to 14.2 ppb (STA 1W concentrations not used since the outflow from STA 1W is further treated in STA 2/Compartment B). The estimated outflow load for all STAs is 31,300 kg/yr.

5.2.3 Alternative 2 Evaluation

Alternative 2 is summarized above in Section 5.2.1. Additional clarifications on the water quality features of Alternative 1 are presented in Section 5.2.2. Alternative 1 was evaluated in accordance with the methodology and criteria outlined in Section 3.3. The following subsections provide a summary of the performance of each alternative in accordance with each of the evaluation criteria.

5.2.3.1 Long-Term Total Phosphorus Concentration Achieved

The long-term phosphorus removal performance of each alternative was evaluated using the Dynamic Model for Stormwater Treatment Areas, Version 2 (DMSTA 2). The results generated by the DMSTA 2 analysis of Alternative 2 were presented above in **Table 5.10**. The intent of **Table 5.10** is to show the performance of the individual STAs with respect to discharge of flows and loads to downstream Water Conservation Areas (WCAs). The tabulation includes information on the average annual inflow, average annual outflow, and a summary of bypass volumes and loads. For the purpose of this analysis, the overall FWM for all STAs and the range of STA outflow FWM concentrations will be used to compare the alternatives (see **Table 5.11)** Ranges are provided due to uncertainties in vegetation succession in the STAs and anticipated evolution of the TP removal.

Table 5.11 – DMSTA2 Summary results of STA Outflow TP Concentrations

Alternative	TP FWM Annual Outflow (Range - ppb)
2	16.4 (14.9 – 18.3 ppb)

5.2.3.2 Flood Impact Analysis

The intent of the hydraulic analysis is to determine the flooding impact of the alternatives that have equal storm inflows from the EAA farms. The hydrologic and hydraulic modeling results provide predicted water levels at multiple locations along the Ocean, West Palm Beach, Hillsboro, Cross, Bolles, North New River, Miami, and the L Canals. **Table 5.7** presents the canal stages for selected stations in the EAA for two options of Alternative 2. In addition, this table shows the target flows to be diverted and Alternative 2 flows at key locations. Two runs were performed as part of the analysis: Run 55 assumes a wider canal scenario while Run 51 assumes limited widening and deeper canal invert elevations. In Run 55, the results indicated that all identified stages except the Bolles Canal at the Miami Canal are below the target elevation 12.50 ft-NGVD. The results generated for Run 51 identifies numerous stations with canal stages exceeding 12.50 ft-NGVD. Run 55 (with the wider canals) has flooding of 4.8 miles of the Miami Canal. The Miami Canal at chainage 3914 had a peak stage of 12.93 ft-NGVD for Run 55.

5.2.3.3 Operational Flexibility

Alternative 2 adds significant operational flexibility to EAA canal conveyance. The combination of a new canal connection from the STA-1W via L-7 to STA 2, enlarged canals, and 5,000 cfs of pump station capacity on the North New River (note that this alternative does not meet flood control objectives unless the Alternative 1 A-1 NE pump station capacity is increased from 3,000 to 5,000 cfs). With the A-1 NE pump station capacity set at 5,000 cfs, Cross Canal flows at the North New River increase from 525 cfs to 3,100 cfs.

5.2.3.4 Reservoir Operation

Reservoir inflows and outflows were simulated by SFWMD employing v5.0 of the South Florida Water Management Model (SFWMM), with certain assumptions made specifically for the purposes of this analysis. The model run described conditions assumed to be present in 2010, including the A-1 Reservoir and Compartments B and C. Details on the results of this analysis are described in **Appendix D and K** of this document. Reservoir inflow for Alternative 2 is 416,900 ac-ft/yr and the TP load is 49,800 Kg/yr. Reservoir outflow to STA-3/4 is 235,100 ac-ft/yr, and the TP load is 23,330 Kg/yr. Irrigation outflows were 180,000 ac-ft/yr. The SFWMM representation of the reservoir is relatively simple, and more detailed assessments of the reservoir mass balance are being conducted separately.

The reservoir was modeled in MIKE 11 for the two-week long design storm period. Reservoir inflow during design storm conditions is 168,200 ac-ft.

5.2.3.5 Implementation Schedule

The implementation schedule for all alternatives includes real estate acquisition. The design, land acquisition, and construction for Alternative 2 will be completed in 2010. **Appendix M** includes a detailed implementation schedule for each alternative. The implementation duration included in these tables are in calendar days.

The Alternative 2 implementation schedule shows a completion date that is the same as the other alternatives. This completion date is based on the assumption that approvals needed to construct the levee inside the Refuge can be obtained through an amendment or revision to the existing 404 permit for STA-1W. The implementation schedule for design and construction for Alternative 2 is highly dependent on the length of time required for permitting of features within the Refuge. If this Alternative is selected a detailed schedule will be developed in consultation with appropriate agencies.

Implementation schedules for the Cross Canal, Compartment B, and Compartment C have been developed by Acceler8 are reported herein without editing. The Cross Canal land acquisition will start in February 2006 and will be completed in one year. Contracting and construction for the Cross Canal, Compartment B, and Compartment C (including ordering and installation of pumps) will be completed by the end of 2008.

5.2.3.6 Re-distribution of flows and loads to receiving waters

The EAA has historically discharged to Lake Okeechobee, C-51W, WCA 1, WCA 2A, and WCA 3A. In turn, a portion of the water entering WCA-1 is discharged to WCA-2A through the S-10 structures, and a portion of WCA-2A is discharged to WCA-3A through the S-11 structures. The EAA RFS alternatives were reviewed to estimate if a given alternative would result in a shift to the balance of flows and loads to these receiving waters.

Lake Okeechobee. For 2006-2009, simulated back pumped volumes and loads from the EAA to Lake Okeechobee are as follows:

- Average annual volume = 42,554 ac-ft/yr, TP load = 4,640 kg/yr at S-2
- Average annual volume = 5,921 ac-ft/yr, TP load = 594 kg/yr at S-3

For 2010-2014, simulated back pumped volumes and loads from the EAA to Lake Okeechobee are as follows:

- Average annual volume = 24,946 ac-ft/yr, TP load = 2,822 kg/yr at S-2
- Average annual volume = 4,091 ac-ft/yr, TP load = 445 kg/yr at S-3

Hydraulic modeling results of 2010 – 2014 conditions suggest that back-pumping to Lake Okeechobee might be eliminated. While not reflected in the summary data being taken from the water quality analyses, this is an important distinction.

WCAs. The Alternative 2 flows to the WCAs from the STAs is 1,540,500 ac-ft/yr.

5.2.3.7 Maintain Desirable Levels in the Loxahatchee Wildlife Refuge

Flows to WCA 1 will be less for all alternatives evaluated as part of this study. There are some existing concerns that high-hardness discharges from the EAA are impacting the ecology of WCA 1, which originally was a rainfall-driven system that exhibited low hardness concentrations. Rainfall is still a major portion of the water balance for WCA 1, however significant EAA flows to WCA have affected hardness levels. The overall ecologic effects of higher levels of hardness associated with the EAA waters are not completely understood. While EAA runoff has introduced new waters to WCA 1, seepage from WCA 1 to surrounding land is higher than historical rates. Soil oxidation within the EAA has decreased the elevation of surrounding lands, resulting in increasing seepage from WCA 1. Alternative 2 diverts STA-1W outflows and will decrease overall inputs of high-hardness waters to the EAA. Maintenance of higher elevations along the separated L-7 Canal will reduce net seepage from WCA 1, and to some degree will offset losses of direct discharges from STA-1W to WCA 1. The scope of the modeling work conducted as part of this feasibility study did not include quantifying the net effect of these two counteracting hydrologic influences. Further studies should be conducted to evaluate the net effect of Alternative 2, should that alternative appear to warrant further consideration. Regardless of the alternative, the net change to Refuge should be evaluated for each of the alternatives.

5.2.3.8 Probable Planning-level Opinion of Capital and O&M Cost Estimates

A summary of the estimated probable planning-level opinion costs for all improvements for each alternative are included in **Appendix M**. This appendix includes a summary of the cost for each alternative, a tabulation of cut/fill volume including the additional right-of-way required, and a detailed estimate per canal. The opinion of probable cost for Alternative 2 is:

Table 5.12 – Alternative 2 Summary of Probable Planning-Level Opinion of Capital Cost

Design Phase Cost	$ 22,132,405
Canal Improvements Cost	$ 57,910,397
Other Construction Cost	$ 90,527,883
Land Acquisition Cost	$ 11,142,077
Compartment B & C Construction Cost	$ 124,293,000
Annual O&M for B&C Only (2006 dollars)	$7,388,892
Annual O&M Cost with B&C (2006 dollars)	$ 9,901,013
Total 50-year Present Worth	$ 494,989,141

5.2.3.9 Cash Flow Analysis

A cash flow analysis was conducted for the opinion of probable cost presented above. The cash flow analysis apportioned costs for major project elements by year starting from design through completion of the construction phase. The schedule of Alternative 2 was used to apportion costs on a quarterly basis. Quarterly costs of all project elements were summed to generate an overall cost per quarter from early 2006 through completion in 2010. **Figure 5.14** provides the results of the Alternative 2 cash flow analysis.

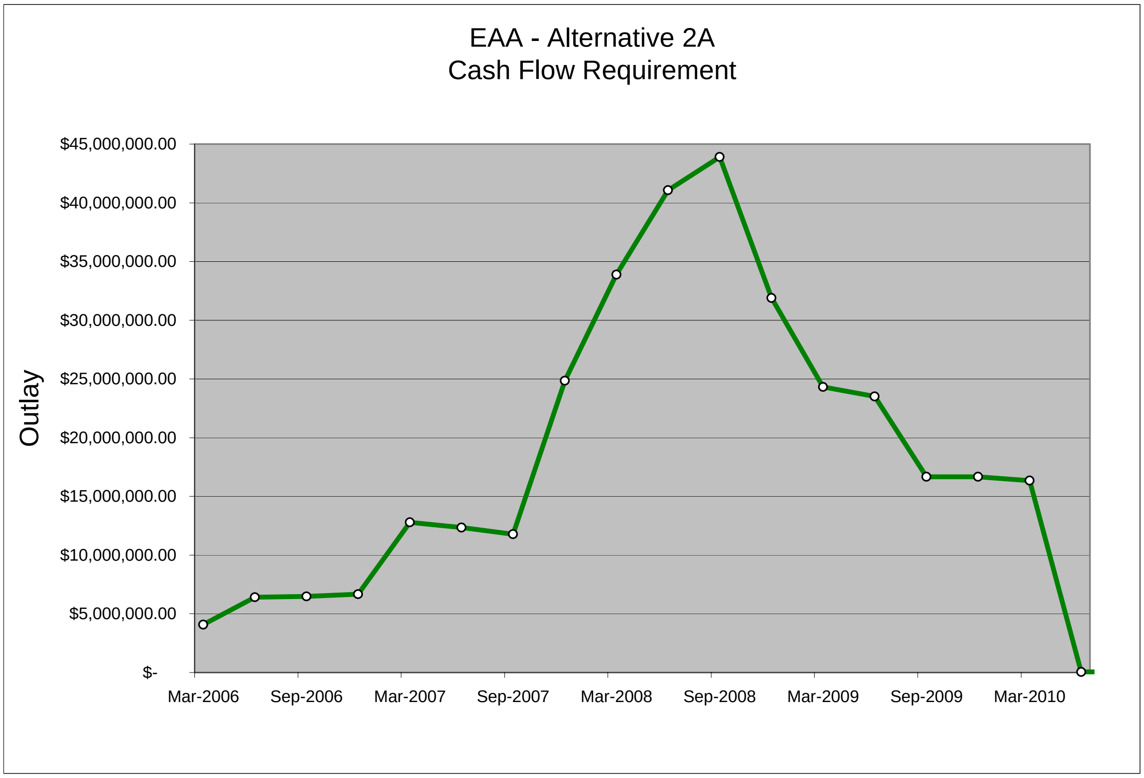

Figure 5.14 – Alternative 2A Cash Flow Analysis Results

5.3 Alternative 3

As concluded in Deliverable 2.2 (Optimum Allocation of Loads to the STAs for the Period 2006-2009) included in Appendix H, the overall performance of the various stormwater treatment areas is expected to be generally balanced over the period 2006-2009; no significant benefit would be expected to result from attempts to significantly redistribute inflow volumes and TP loads during that period. However, projected outflow concentrations from the STAs during the period 2006-2009 fall above long-term water quality goals.

Upon the full build-out of Compartments B and C of the Talisman Land Exchange, and completion of the EAASR Compartment A-1, substantial additional acreage of water management and treatment area will be added in the south central and western parts of the EAA, suggesting that overall system performance during the period 2010-2014 would benefit from a redistribution of projected inflow volumes and TP loads.

Both Alternative 1 and Alternative 2 were structured to redistribute inflow volumes and TP loads in order to take advantage of and more fully utilize those additional water management areas, and consisted of two fairly distinct alternatives for the overall system. In each, the projected performance of STA-5, expanded to include all lands in Compartment C of the Talisman Land Exchange was projected considering the full range of performance resulting from consideration of the downstream cells as both SAV_3 and EMG_3. Until such time as an improvement in the performance of the downstream cells is demonstrated, it is unclear that volumes and TP loads from sources other than the C-139 Basin should be included in the inflows to STA-5. Conversely, should it be found that, upon the reduced unit loading resulting from expansion of STA-5, the downstream cells perform more as SAV_3 than EMG_3, the (estimated) 13,150 acres of effective treatment area of the expanded STA-5 might well be substantially under-used.

Alternative 3 is structured upon the assumption that the downstream cells of STA-5 will, following its expansion to occupy all of Compartment C of the Talisman Land Exchange, perform as SAV_3. For this analysis, Alternative 3 is considered as an additional feature of Alternative 1; in practice, it could be considered equally applicable as an expansion of Alternative 2.

As indicated above, Alternative 3 is structured upon the assumption that the downstream cells of STA-5 will, following its expansion to occupy all of Compartment C of the Talisman Land Exchange, perform as SAV_3 (or, at a minimum, substantially improved from its actual performance to date). Should the performance of the downstream cells of STA-5 not improve markedly from that experienced to date, little benefit to the overall system would be expected to result from partial diversion of S-3/S-8 Basin runoff to the expanded STA-5.

Alternative 3 is a modification of Alternative 1 above. This Alternative includes all features of Alternative 1 (**see Figure 5.1 above**), but also includes a pump station in the Manley Ditch (called MC-B5 in the Mike 11 network) to convey additional water to L-2 just north of STA 5. **Figure 5.15** shows the STA 5/6 complex.

Alternative 3 was modeled with and without an outflow pump in the STA-6 Discharge Canal. Alternative 3A includes the pump while Alternative 3 does not. The purpose of this pump will be to enhance flow-through capacity of the STA-5/Compartment C/STA-6 complex. Detailed description of the implementation of Alternative 3 is included in Appendix L.

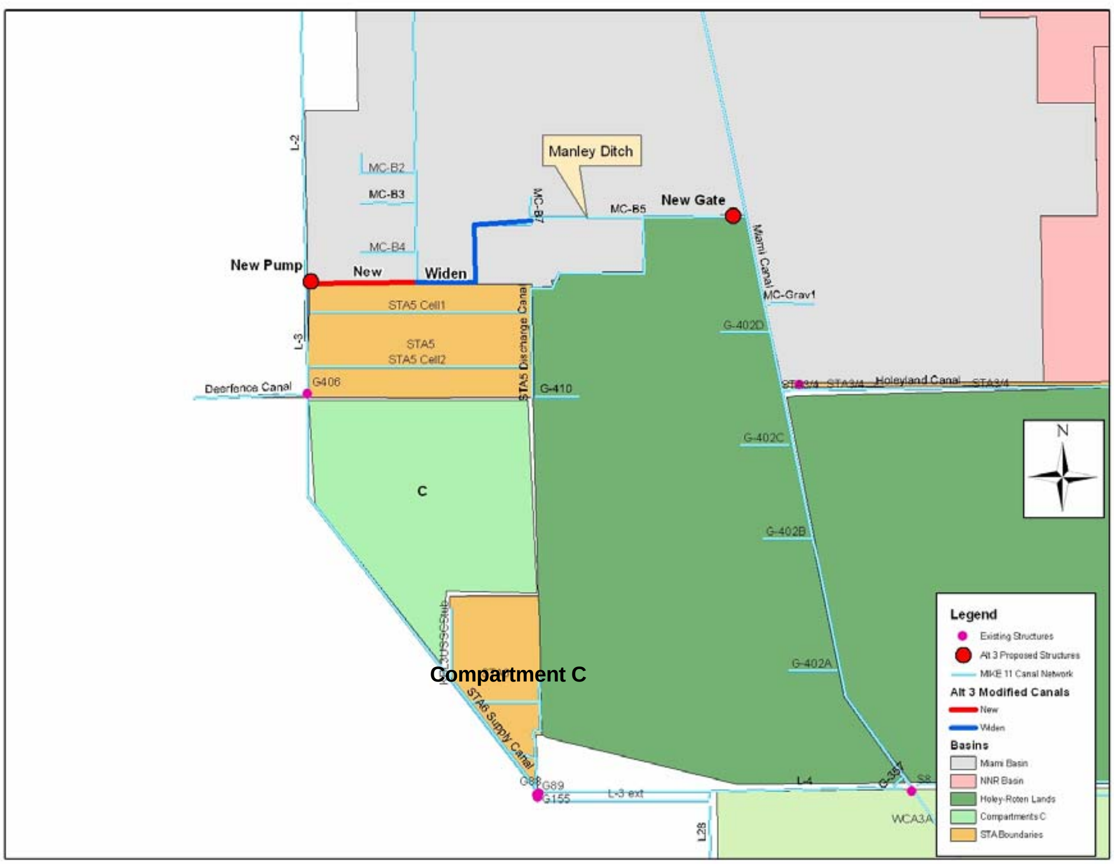

Figure 5.15 - Alternative 3 Manley Ditch Modifications

5.3.1 Hydraulic Analysis

Alternative 3 is a variant of Alternative 1. The only difference between the two alternatives is the destination of runoff from the Manley Ditch. Alternative 3 directs most of the Manley Ditch runoff to the L-2 Canal for subsequent treatment in STA-5/Compartment C/STA-6 (hereinafter called STA 5/6). This alternative would only be implemented if current scientific investigations being conducted by SFWMD indicate that TP removal capacity can be improved beyond historical levels. Should these investigations indicate that STA-5 removal rates will improve, then there will be sufficient capacity in STA-5/STA-6 for treatment of additional runoff. **Figure 5.16** indicates that Alternative 3 is effective in delivering additional flows to STA-5/6. **Figure 5.17** indicates that Alternative 3 results in lower discharges to STA-3/4 through existing pump station G-372. This reduction will improve efficiency of TP removal in STA-3/4. The one negative effect of Alternative 3 is higher stages in L-2 north of existing gate G-406, as shown in **Figure 5.18**.

Additionally, a pump station was added at the outflow of STA-6 (Alternative 3A) per prior conceptual descriptions of Compartment C and STA-6. There was a lower stage in the STA-6 discharge canal. However, the elevation in L-2 north of G-406 was not affected. It is expected that an inflow pump North of G-406 would have a more positive effect in reducing stages in L-2. Therefore, Alternative 3A was not evaluated further.

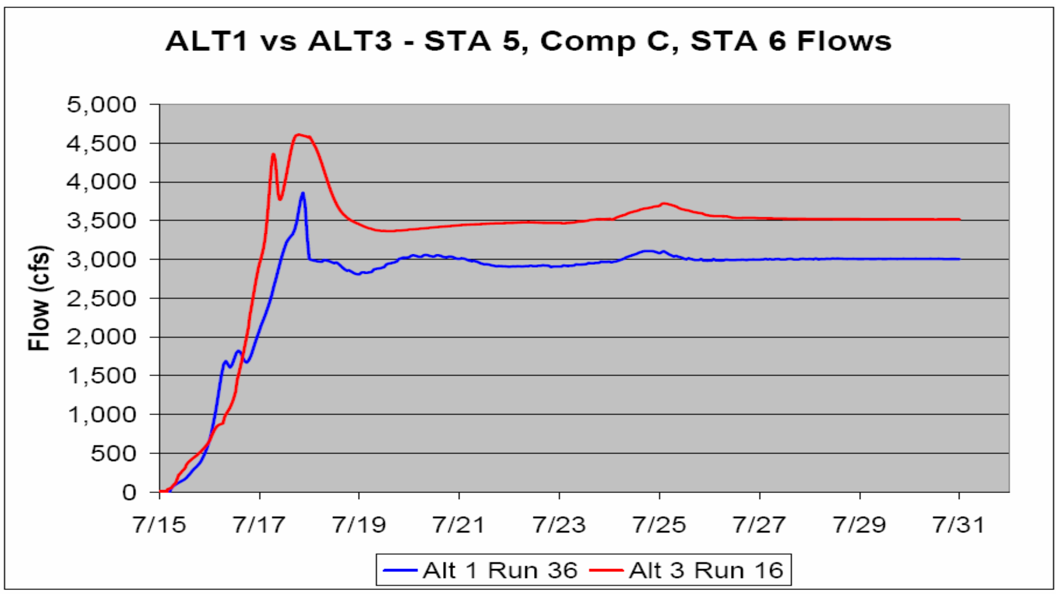

Figure 5.16 - Alternative 1 vs Alternative 3 Flows through STA 5, Compartment C, & STA 6

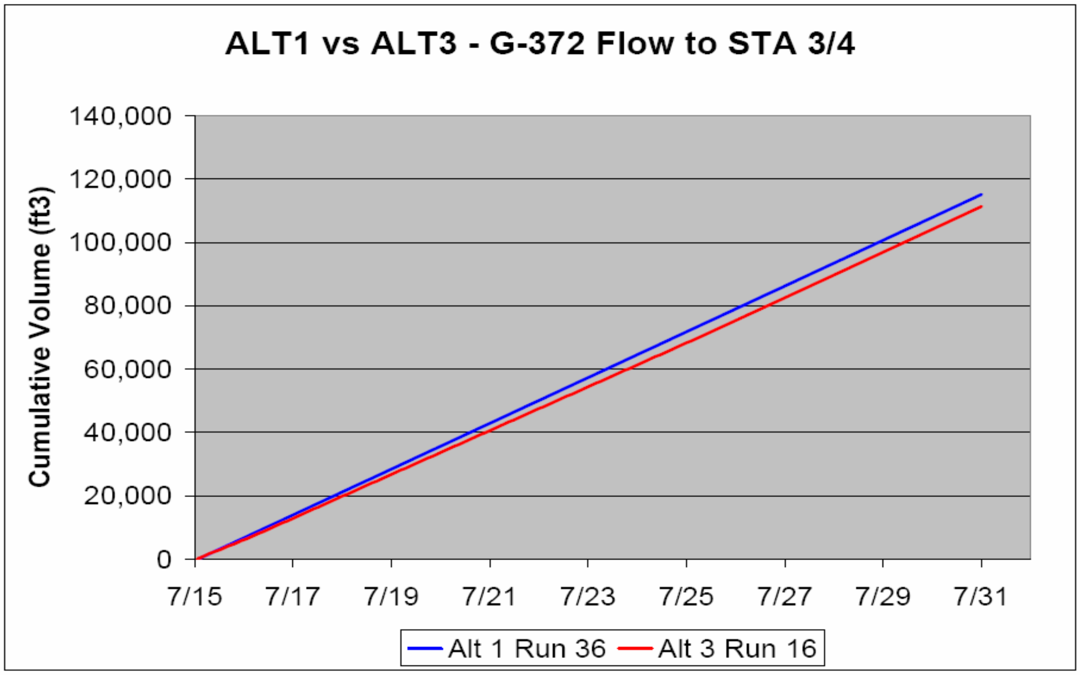

Figure 5.17 - Alternative 1 vs Alternative 3 Accumulated Volume to STA 3/4

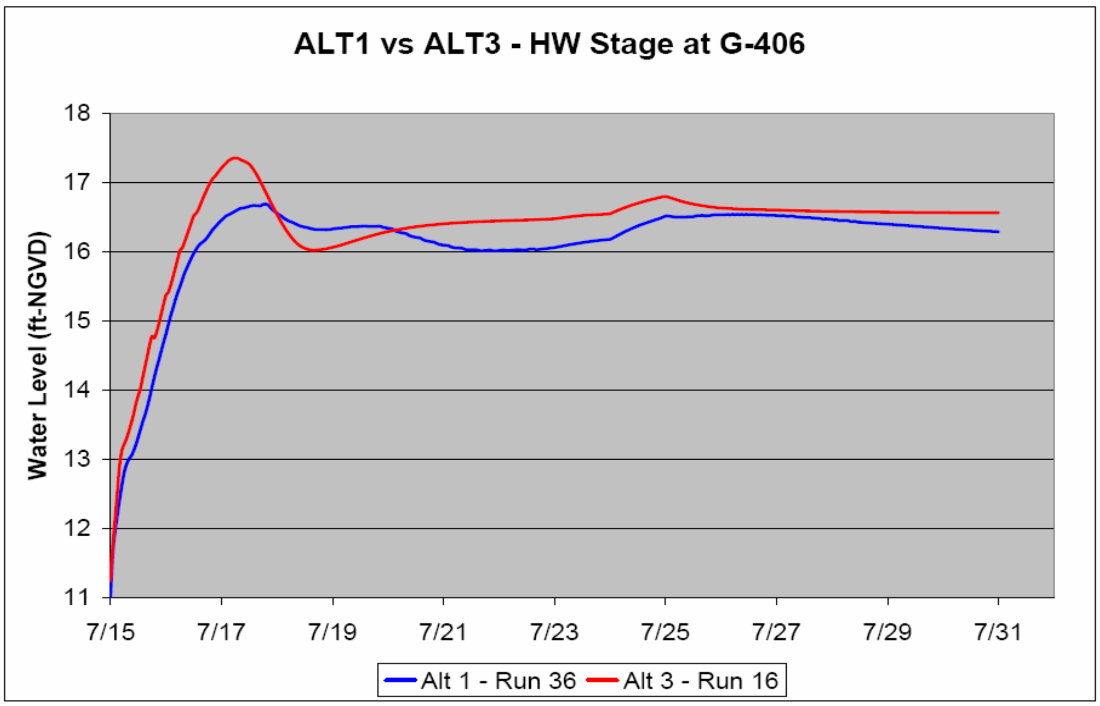

Figure 5.18 - Alternative 1 vs Alternative 3 Stages in L-2, North of G-406

5.3.2 TP Concentration and Load Analysis

Key assumptions for development of inflow loads to STA 3/4 and STA 5 are presented below:

- STA-3/4: Water supply releases to the North New River Canal at S-351 destined for the Lower East Coast Service Area 2 (terms “WL1351”and “WL3351” in the 2010 ECP simulation) would only be made when the stage in WCA-2A (for "WL 1351") or WCA-3A (for "WL-3351") is at or below the floor of their regulation schedules, and would bypass STA-3/4.

Water supply releases to the Seminole Tribe's Big Cypress Reservation at S-354 would bypass STA-3/4.

Runoff from the Manley Ditch would be removed from the STA-3/4 inflows. Miami Canal/ Manley Ditch flows less than 550 cfs would be diverted to L-2.

- STA-5: Runoff from the Manley Ditch would be redirected to the inflow of STA-5.

  STA-5 performance investigations confirm that treatment effectiveness of STA-5 will improve to the levels normally observed for SAV_3 in DMSTA2.

Two cases were considered for STA-3/4 in this Alternative 3 analysis. The first case (Alt1 w S2S3) is the same as analyzed for Alternative 2 assuming that there is not back-pumping from pump stations S-2 and S-3 to Lake Okeechobee. The second case (34 Alt3 w S2S3) assumes that runoff up to 550 cfs from the Miami Canal Basin is diverted to STA-5 and that there are no flows to Lake Okeechobee via S-2 and S-3.

Two cases were considered for STA-5 in this Alternative 3 analysis. The first case (STA5_Alt3_Base) assumes that STA-5 inflows remain the same and DO NOT have additional inflows from the Miami Canal Basin. The second case (STA5_Alt3) assumes that the inflow volume and load is increased to treat the runoff from the Miami Canal Basin. Tables 5.12 and 5.13 present the results of this analysis. STA 3/4 outflow concentrations stay within acceptable ranges with diversion of 550 cfs of Miami Canal, but are beyond acceptable ranges without diversion of Miami Canal runoff. The water quality analysis indicates that STA-5, assuming SAV_3, can easily assimilate the Miami Canal runoff and could readily accept additional diversions of Miami Canal Basin runoff. Alternative 3 would have a significant benefit to balancing flows and loads to downstream receiving waters and could eliminate the need to operate S-2 and S-3 to back-pump EAA runoff to Lake Okeechobee. NOTE THAT THIS ANALYSIS PRESUMES THAT STA 5 TREATMENT EFFICIENCY IS SIGNIFICANTLY IMPROVED.

Table 5.13 – Summary of DMSTA2 Analyses, STA 3/4, WY 1966-2000

Parameter	Units	Summary of Results by Case	
		Alt1_w_S2S3	**34_Alt3_w_S2S3**
Average Annual Inflow			
Volume	1,000 ac-ft	614.8	531.6
TP Load	metric tons	69.13	58.53
FWM TP Concentration	ppb	91	89
Average Annual Outflow			
Volume	1,000 ac-ft	595.9	513.0
FWM TP Concentration			
Upper Confidence Limit*	ppb	16.7	15.1
Mean Estimate	ppb	20.3	18.2
Lower Confidence Limit	ppb	25.0	22.3
Geometric Mean TP Conc.			
Upper Confidence Limit*	ppb	12.0	10.4
Mean Estimate	ppb	15.2	13.2
Lower Confidence Limit	ppb	19.7	17.1
TP Load (Using Mean FWM Conc.)	metric tons	14.90	11.53
For Detailed Results, See Appendix A		Table A.1	Table A.2
Summary of Bypasses and Diversions			
Water Supply Bypass			
Volume	1,000 ac-ft	120.8	120.8
TP Load	metric tons	10.6	10.58
FWM TP Concentration	ppb	71	71
Diversion from Miami Canal to STA-5			
Volume	1,000 ac-ft	0	83.3
TP Load	metric tons	0	10.60
FWM TP Concentration	ppb	---	103

* TP Concentrations for Upper Confidence Limits approximated, see text below

Note: Appendix A referenced in Table 5.12 is an Appendix of Appendix L.

Table 5.14 Summary of DMSTA2 Analyses, STA-5, W.Y. 1995-2000

Parameter	Units	Summary of Results by Case	
		STA5_Alt3_Base	STA5_Alt3
Average Annual Inflow			
Volume	1,000 ac-ft	160.7	266.9
TP Load	metric tons	34.33	47.61
FWM TP Concentration	ppb	173	145
Average Annual Outflow			
Volume	1,000 ac-ft	161.6	267.8
FWM TP Concentration			
Upper Confidence Limit	ppb	7.3*	9.4*
Mean Estimate	ppb	8.4*	11.9*
Lower Confidence Limit	ppb	10.2*	15.5
Geometric Mean TP Conc.			
Upper Confidence Limit	ppb	4.8	6.9
Mean Estimate	ppb	5.8	8.9
Lower Confidence Limit	ppb	7.4	12.5
TP Load (Using Mean FWM Conc.)	metric tons	1.68	3.93
For Detailed Results, See Appendix A		Table A.3	Table A.4

* Projected flow-weighted mean TP concentration in outflows less than calibration range lower limit of 15 ppb for SAV_3

Note: Appendix A referenced in Table 5.14 is an Appendix of Appendix L.

5.3.3 Alternative 3 Evaluation

Alternative 3 is summarized above in Section 5.3.1. Additional clarifications on the water quality features of Alternative 1 are presented in Section 5.3.2. Alternative 1 was evaluated in accordance with the methodology and criteria outlined in Section 3.3. The following subsections provide a summary of the performance of each alternative in accordance with each of the evaluation criteria.

5.3.3.1 Long-Term Total Phosphorus Concentration Achieved

The long-term phosphorus removal performance of each alternative was evaluated using the Dynamic Model for Stormwater Treatment Areas, Version 2 (DMSTA 2). Because this alternative is a variant of Alternative 1, results are taken from Alt 1 for STAs 1W, STA-1E, STA-2, and STA-6; and Alternative 3 results are used for STA-3/4 and STA-5. The results generated by the DMSTA 2 analysis of Alternative 1 were presented above in **Table 5.3**. For the purpose of this analysis, the range of STA outflow FWM concentration will be used to compare the alternatives. **Table 5.15** presents the FWM range for the STAs and the minimum and maximum confidence limit concentrations predicted for the STAs. The low value shown in the range is the lowest confidence limit predicted for any of the STAs. Ranges are provided due to uncertainties in vegetation succession in the STAs and anticipated evolution of the TP removal. As mentioned above, the values presented below in Table 5.14 assume that STA-5 performance improves significantly such that removal is best approximated by SAV_3 in DMSTA2.

Table 5.15 – DMSTA2 Summary results of STA Outflow TP Concentrations

Alternative	TP Average Annual Outflow (Range - ppb)
3	16.6 (13.3 – 18.9 ppb)

Note: The FWM concentration assumes STA 5 operates at an efficiency equal to STA 2 SAV_3.

5.3.3.2 Flood Impact Analysis

This alternative has similar flood control benefits to Alternative 1 except that there is improved flood control in the Miami Canal Basin. As discussed above in Alternative 1, Bolles Canal stages were in the range of 12.5 ft-NGVD, while the peak canal stage for the Bolles Canal for Alternative 3 is 11.5 ft-NGVD, 1 foot lower than for Alternative 1. No canals experience water levels above 12.5 ft-NGVD. The stage in the Miami Canal at chainage 3914 is 11.75 ft-NGVD.

5.3.3.3 Operational Flexibility

This alternative has all the operational flexibility of Alternative 1, plus it has lower stages in the Miami and Bolles Canals, thereby increasing operational flexibility. Flows to STA-3/4 are less, thereby further improving flexibility in this STA. Discharges to Lake Okeechobee via S-2 and S-3 are not necessary, either from a hydraulic or STA performance perspective.

5.3.3.4 Reservoir Operation

Reservoir operation is the same as for Alternative 1.

5.3.3.5 Implementation Schedule

The implementation schedule is the same as for Alternative 1. This project is estimated to be completed in 2010. The detailed implemented in the schedule is presented in Appendix M.

5.3.3.6 Re-distribution of flows and loads to receiving waters

The re-distribution of flows and loads to receiving waters is the same as for Alternative 1.

5.3.3.7 Maintain Desirable Levels in the Loxahatchee Wildlife Refuge

As discussed above in section 5.1.3.6, this evaluation was not conducted.

5.3.3.8 Probable Planning-level Opinion of Capital and O&M Cost Estimates

The probable planning-level opinion capital and O&M estimates for Alternative 1 were modified to account for acquisition of right-of-way for portions of the Manley Ditch, the Manley Ditch Extension, and portions of the STA 5 seepage canal. Excavation costs were added for expansion of these three canals, a 550 cfs pump station to L-2, and a discharge gate to the Miami Canal at the eastern end of the existing Manley Ditch. Finally, a farm pump station would be replaced so that a portion of farm land that currently discharges to the Miami Canal north of the Manley Ditch will discharge to the Manley Ditch. **Table 5.16** presents the probable planning level opinion of cost.

Table 5.16 – Alternative 3 Summary of Probable Planning-Level Opinion of Capital Cost

Design Phase Cost	$ 21,067,392
Canal Improvements Cost	$ 54,164,680
Other Construction Cost	$ 74,424,334
Land Acquisition Cost	$ 17,530,855
Compartment B & C Construction Cost	$ 143,493,000
Annual O&M for B&C Only (2006 dollars)	$8,099,126
Annual O&M Cost with B&C (2006 dollars)	$ 8,857,004
Total 50-year Present Worth	$ 479,633,158

5.3.3.9 Cash Flow Analysis

A cash flow analysis was conducted for the opinion of probable cost presented above. The cash flow analysis apportioned costs for major project elements by year starting from design through completion of the construction phase. The schedule of Alternative 3 was used to apportion costs on a quarterly basis. Quarterly costs of all project elements were summed to generate an overall cost per quarter from early 2006 through completion in 2010. **Figure 5.19** provides the results of the Alternative 3 cash flow analysis.

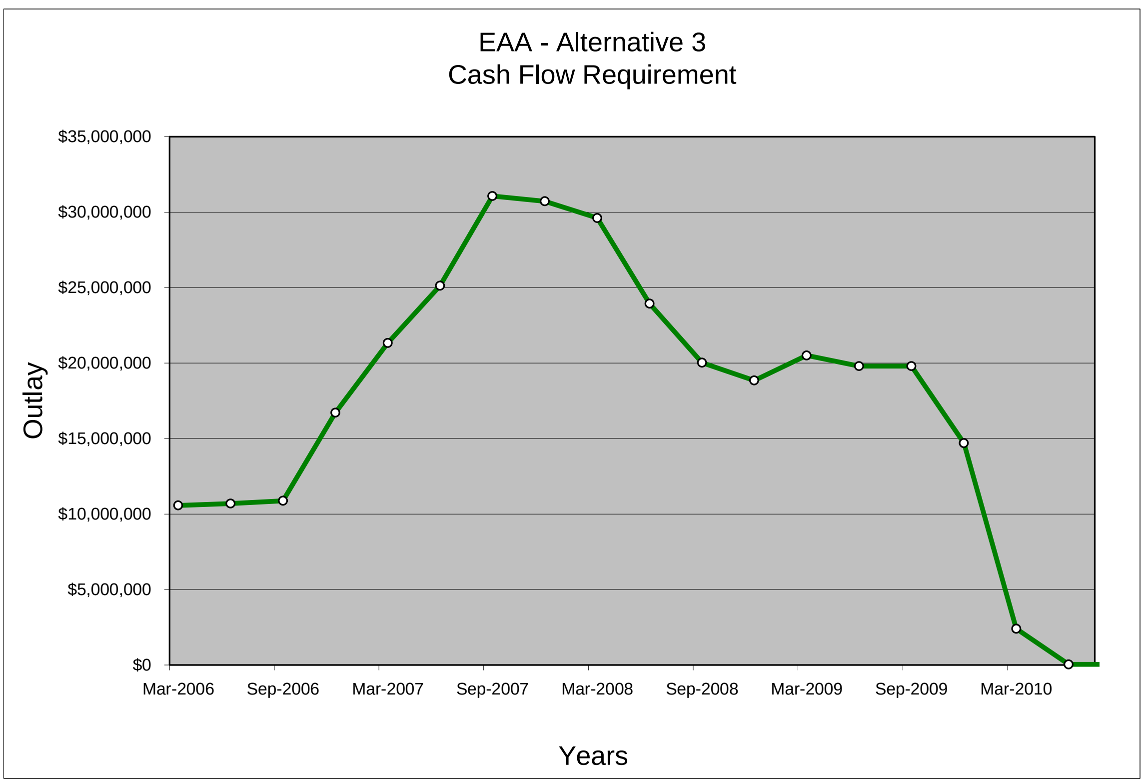

Figure 5.19 – Alternative 3 Cash Flow Analysis Results

5.4 Alternative 4

This alternative is comprised of a mix of components for Alternatives 1, 2, and 3. The objective of this alternative is to take the best features of previous alternatives to reduce the overall cost while maintaining desired nutrient removal performance. Details are presented below:

1. Enlargement of STA-1E to incorporate Section 24 of the Acme Improvement District.
2. Enlargement of the L-7 Borrow Canal and separation of the Borrow Canal from the WCA 1, the Loxahatchee National Wildlife Refuge (see **Figure 5.6**).
3. Addition of new gate in the Hillsboro Canal south of the Cross Canal. This gate will divert a portion of S-2/S-6 Basin flows to the Cross Canal and then to the North New River Canal.
4. Connection of the Manley Ditch to the STA-5 Seepage Canal and construct a 550 cfs pump station to increase runoff to the STA-5/Compartment C/STA-6 complex.
5. Enlargement Cross and Bolles Canals.
6. Limited widening of the North New River Canal.
7. Modifications to have the A-1 Reservoir receive water from existing G-370 and addition of new 3,000 cfs pump station on the NNRC.
8. Construction of a siphon from the A-1 Reservoir to Compartment C.

5.4.1 Hydraulic Analysis

Alternative 4 was intended to utilize the best features of Alternatives 1, 2, and 3 to meet project objectives while minimizing cost. Six different combinations of features from Alternatives 1 through 3 were tested. No combination provided an improvement over Alternatives 1 – 3. No combination of alternatives was found that would reduce project cost, therefore further assessment of Alternative 4 was abandoned.

5.5 Alternative 5

Alternative 5 is comprised of Alternative 1 with a modification of Compartment B internal flow patterns to keep STA-2, Cell 4 hydraulically linked to STA-2 Cells 1, 2, and 3, i.e., operating separately from the remainder of Compartment B. Detailed description of the implementation of alternative 5 is included in Appendix K.

5.5.1 Hydraulic Analysis

Head loss in the siphons was modeled using a specialty computer program from LMNO Engineering, Research, and Software, Ltd. (www.lmnoeng.com). The culverts were added to the MIKE 11 network and entrance coefficients were selected so that the head loss of the culverts in MIKE 11 was the same as simulated using the siphon program. The addition of the siphons for Alternative 5 resulted in Compartment B stages of 14 ft-NGVD on the North cell. The STA 2 Cells 1, 2, and 3 never exceeded water depths above 4 ft. However, the Alternative 1 accumulated volume in the North cell of Compartment B held approximately twice the amount as Alternative 5. **Figure 5.20** below illustrates the pumped volume into Compartment B from the NNR Canal. Inflows and water levels in the North cell of Compartment B are presented in **Figure 5.21**. It can be seen that the inflows to Compartment B begin at approximately 1,300 cfs and quickly drop to 400 cfs. There are significant instabilities in inflow pump rates to Compartment B with the siphons. These instabilities were not reduced because:

- the overall inflow rate to Compartment B was significantly less than for Alternative 1, and
- maintenance concerns are significant for inverted siphons.

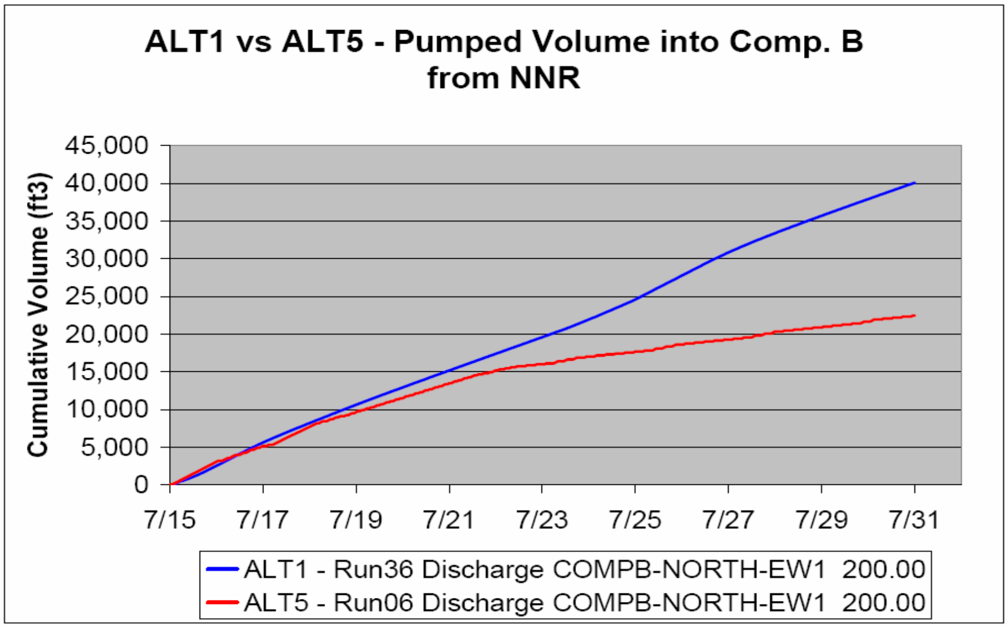

Figure 5.20 – Alternative 1 and Alternative 5 Accumulated Volume in Compartment B

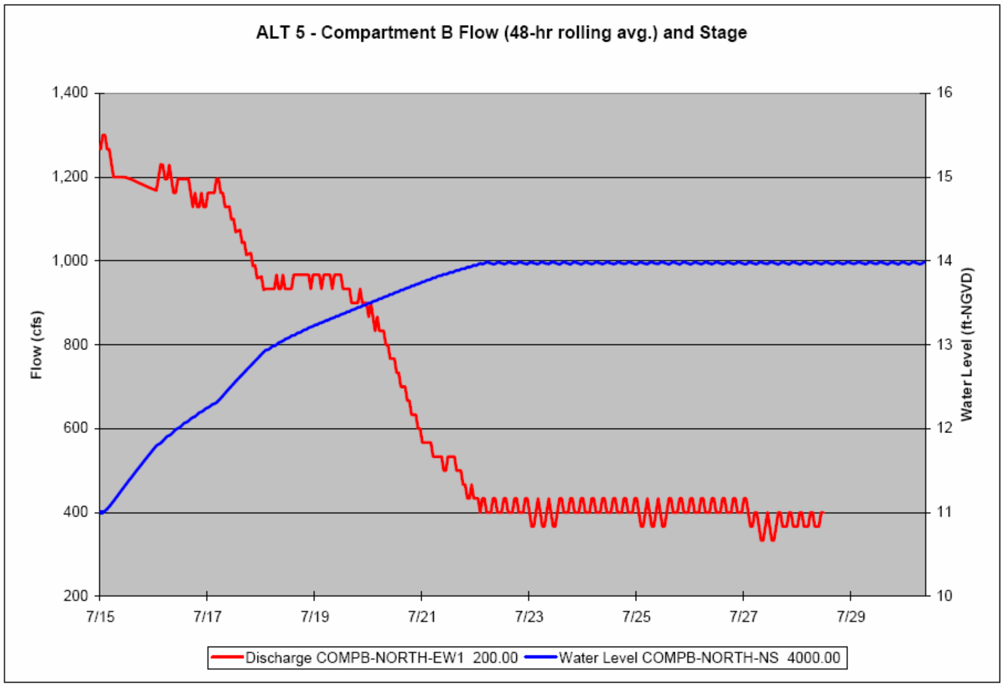

Figure 5.21 – Alternative 5 Compartment B Inflow Rates and North Cell Water Levels

5.5.2 TP Concentration and Load Analysis

A detailed flows and load analysis was not conducted for Alternative 5 because it is expected that overall flows and loads will be balanced across the STAs such that the overall average concentration discharged to the WCAs would be similar to Alternative 1. The restricted flow capacity of Compartment B due to the siphons would be further evaluated if this alternative received additional consideration such that the flow through Compartment B would likely increase. Accordingly, the results for Alternative 1 are felt to be appropriate for Alternative 5.

5.5.3 Alternative 5 Evaluation

5.5.3.1 Long-Term Total Phosphorus Concentration Achieved

As discussed above in Section 5.5.2, it is assumed that the long-term TP concentration achieved for Alternative 5 will be similar to the results for Alternative 1.

5.5.3.2 Flood Impact Analysis

Hydraulic modeling results indicate that the inflow to Compartment B will be less than for Alternative 1. If the head loss associated with the siphons cannot be reduced, Alternative 5 will have higher canal levels than Alternative 1. Hydraulic modeling results indicate that 4.8 miles of the Miami Canal will experience water levels above 12.5 ft-NGVD. The peak stage in the Miami Canal at chainage 3914 was 12.6 ft-NGVD.

5.5.3.3 Operational Flexibility

Decreased flow-through capacity of Compartment B reduces the operational flexibility of Alternative 5. Inverted siphons need high velocities to be self-flushing, and the projected velocities will be low. STAs produce significant amounts of vegetation, therefore cleaning of the siphons will be required on a frequent basis to assure proper operation of Compartment B with inverted siphons.

5.5.3.4 Reservoir Operation

Reservoir operation is expected to be similar to Alternative 1. Hydraulic modeling of high flow conditions indicates that the A-1 Reservoir would receive approximately 129,000 ac-ft of runoff during a two-week high flow condition.

5.5.3.5 Implementation Schedule

The implementation schedule for all alternatives includes real estate acquisition. The design, land acquisition, and construction for Alternative 5 will be completed in 2010. Note that the construction of the siphons will likely extend the construction schedule for Compartment B.

5.5.3.6 Re-distribution of flows and loads to receiving waters

The re-distribution of flows and loads to receiving waters is the same as for Alternative 1.

5.5.3.7 Maintain Desirable Levels in the Loxahatchee Wildlife Refuge

As discussed above in section 5.1.3.6, this evaluation was not conducted.

5.5.3.8 Probable Planning-level Opinion of Capital and O&M Cost Estimates

The probable planning-level opinion capital and O&M estimates for Alternative 5 is provided in Appendix M. The cost estimate for Alternative 5 is presented in Table 5.16. O&M cost was increased by $100,000/year to account for removal of debris from the siphons.

Table 5.17 – Alternative 5 Summary of Probable Planning-Level Opinion of Capital Cost

Design Phase Cost	$ 20,299,464
Canal Improvements Cost	$ 51,962,976
Other Construction Cost	$ 63,916,398
Land Acquisition Cost	$ 15,869,688
Compartment B & C Cost	$ 145,218,000
Annual O&M for B&C Only (2006 dollars)	$8,229,125
Annual O&M Cost with B&C (2006 dollars)	$ 8,703,512
Total 50-year Present Worth	$ 463,609,033

5.5.3.9 Cash Flow Analysis

A cash flow analysis was conducted for the opinion of probable cost presented above. The cash flow analysis apportioned costs for major project elements by year starting from design through completion of the construction phase. The schedule of Alternative 5 was used to apportion costs on a quarterly basis. Quarterly costs of all project elements were summed to generate an overall cost per quarter from early 2006 through completion in 2010. The cash flow analysis for Alternative 5 is presented below in **Figure 5.22**.

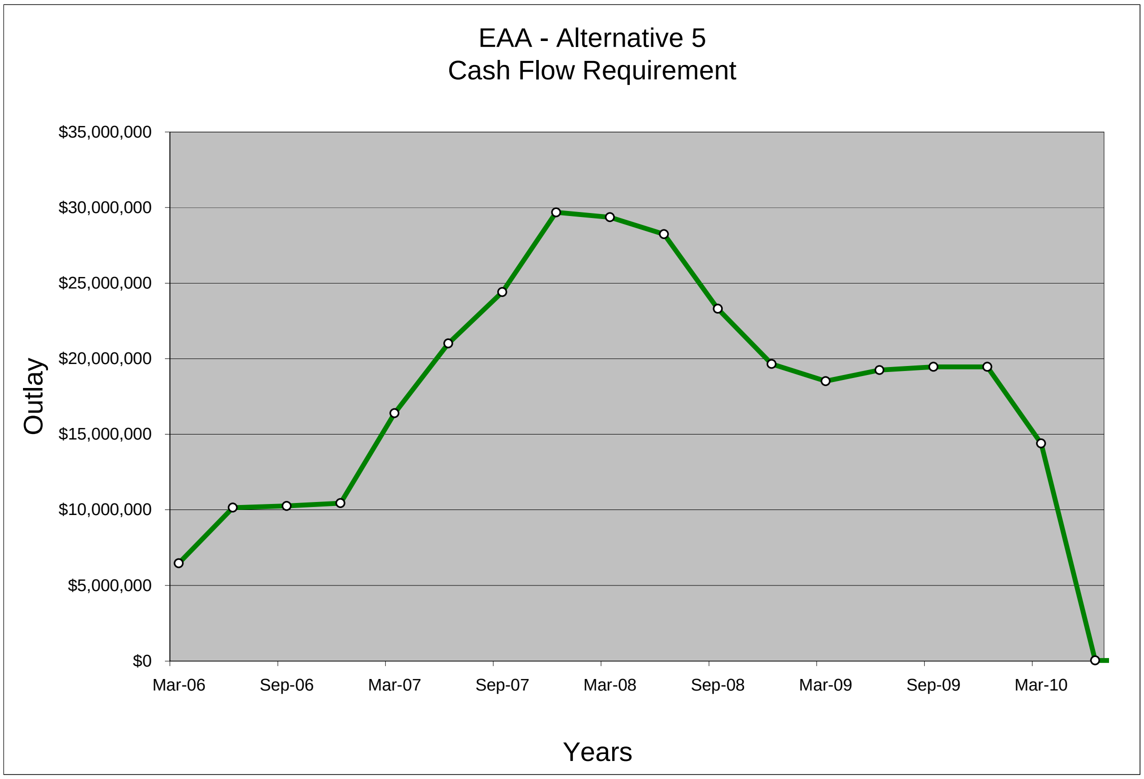

Figure 5.22 – Alternative 5 Cash Flow Analysis Results

6.0 ALTERNATIVE EVALUATION SUMMARY

The alternatives presented above accomplish, in varying degrees, the basic goals for achieving optimum flows and loads to the WCAs to the maximum extent possible. These alternatives were evaluated using criteria developed as part of the EAA RFS. **Table 6.1** presents a summary of those evaluations.

The alternatives presented above also meet the flood control peak canal stage objectives. The alternatives advantages and disadvantages are summarized below in **Table 6.2**. Project costs are summarized in **Table 6.3**.

Recommendations for further study are presented below:

1. If Alternative 3 is considered further, Manley Ditch should be surveyed so that the veracity of assumed cross sections can be confirmed or modified.

2. If Alternative 5 is considered further, the suitability of utilizing inverted siphons should be carefully evaluated. Inverted siphons in low-velocity environments, that are prevalent in south Florida, are prone to clogging. This assessment only assessed velocity of the siphons for extreme events.

3. Simulations should be conducted for runoff volumes lower than 3/4" to verify that the diversions are firm diversions for runoff events less than the events considered during the simulations described herein.

4. Simulations for certain alternatives (if recommended for further study) should be performed to refine structure operations during extreme events. The simulations described herein do not fully accomplish the diversions identified by the optimum flows and loads analysis.

5. Long-term simulations should be conducted with the hydraulic model utilized in this assessment for 1-2 years to verify the annual volumes delivered to the STAs.

6. An assessment should be conducted of the WCAs to determine the regional impact of inter-basin transfers on hydroperiods of WCA 1A, WCA 2A, and WCA 3A.

Table 6.1 - Summary Table of Alternatives Evaluation

Evaluation Criterion	Quantitative Measure (see note 1)			
	Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 5**
Technical Factors				
1. Long-Term Phosphorus Concentration Achieved (Flow-weighted mean value)	17.1 ppb (13.3 – 18.9)	16.4 (14.9 – 18.3)	See note 2 below	17.1 ppb (13.3 – 18.9)
2. Flood Impact Analysis				
• Flooding (>12.5 ft NGVD)	0.0 miles	4.8 miles	0.0 miles	4.8 miles
• Canal Peak Stage, Miami 3914	12.4 ft-NGVD	12.93 ft-NGVD	11.75 ft-NGVD	12.6 ft-NGVD
3. Operational Flexibility				
• Structures/Pump Stations	Two new gates, Two new pump stations	Two new gates, One new pump station	3 new gates, 3 new pump stations	Two new gates, Two new pump stations
• Operational Modifications	Two new flow routes	STA 1W to STA 2 via L-7	3 new flow routes	Two new flow routes
	2,760 cfs Cross to NNR	3,093 cfs Cross to NNR	2,760 cfs Cross to NNR	2,500 cfs Cross to NNR
• Operational Concerns		5,000 cfs A-1 PS required	Implement if STA 5 TP removal improves	Maintenance of siphons is difficult
4. Reservoir Operation Factors				
• Reservoir Avg Annual Inflow Vol.	416,800 ac-ft/yr	416,800 ac-ft/yr	416,800 ac-ft/yr	416,800 ac-ft/yr
• Reservoir Design Inflow Volume	130,800 ac-ft	168,200 ac-ft	130,800 ac-ft	130,800 ac-ft
• Irrigation Supply, Ac-ft/yr	180,000 ac-ft/yr	180,000 ac-ft/yr	180,000 ac-ft/yr	180,000 ac-ft/yr
5. Implementation Schedule including Real Estate (completion year)	2011	2014	2011	2011 (Comp B schedule after 2008)
Environmental Factors				
6. Redistribution of flows and loads	1,715,679 ac-ft/yr	1,540,500 ac-ft/yr	1,715,679 ac-ft/yr	1,715,679 ac-ft/yr
7. Impact to Refuge	See note 3.	See note 3.	See note 3.	See note 3.
Economic Considerations				
8. Opinion of Probable Planning Level Capital, Real Estate, & O&M Cost (50 yrs present worth)	$459 million	$495 million	$480 million	$464 million
9. Cash Flow Analysis (See note 4)	21 million / 3.25 yrs	26 million / 2.5 yrs	21 million / 3.25 yrs	24 million / 2 yrs

Notes:
1. Alternative 4 is not shown due to initial modeling results. See section 5.4.
5. Overall outflow concentration should be less if STA 5 performance improves. See section 5.3.
6. Further study required. See Section 3.2.2.
7. Duration given is the period of primary construction activity.

Table 6.2 – Advantages and Disadvantages of EAA RFS Alternatives

Alternative	Advantages	Disadvantages
1	• Fully achieved flow redistribution • Achieved flood control objectives • Allows for multiple flow paths for EAA runoff	• Significant canal enlargements • Requires acquisition of agricultural lands to construct the Sam Senter Canal extension to divert runoff from the WPB Canal to the Sam Senter Canal
2	• Achieved basic flow redistribution targets • Achieved flood control objectives • Allows for multiple flow paths for EAA runoff	• Significant canal enlargements • Requires dredging of protected wetlands within the Refuge • Requires acquisition of agricultural lands to divert runoff from the WPB Canal to the Sam Senter Canal
3	• Same as Alt 1, but has additional flood control benefits to the Miami Canal through diversion of Manley Ditch runoff to the L-2 Canal	• Same as Alt 1, but requires even more acquisition of agricultural lands to divert runoff from the Manley Ditch to L-2 • This alternative cannot proceed until on-going research demonstrates that STA 5 can assimilate additional flows beyond C-139 runoff
4	• No additional benefits beyond the benefits for Alt 1 and 2	• Has the largest number of new project features
5	• Same as Alt 1	• Reduced flows through Compartment B • Requires use of large inverted siphons which are maintenance intensive

Table 6.3 - Net Present Value Cost Estimates with Breakdown by Item

Cost Item	Alternative 1	Alternative 2	Alternative 3	Alternative 5
Design Phase Cost	$20,299,464	$22,132,405	$21,067,392	$20,299,464
Canal Improvements Cost	$51,962,976	$57,910,397	$54,164,680	$51,962,976
Other Construction Cost	$63,916,398	$90,527,883	$74,424,334	$65,641,398
Land Acquisition Cost	$15,869,688	$11,142,077	$17,530,855	$15,869,688
Compartment B & C Construction Cost	$143,493,000	$124,293,000	$143,493,000	$143,493,000
Overall Construction Cost	$295,541,526	$305,005,762	$310,680,261	$297,266,526
O&M Cost w/out B&C (2006 dollars)	$8,099,126	$7,388,892	$8,099,126	$8,099,126
Annual O&M Cost (2006 dollars)	$8,573,512	$9,901,013	$8,857,004	$8,703,512
Total 50-year Present Worth	$458,824,327	$494,989,141	$479,633,158	$463,609,033

REFERENCES

Brown and Caldwell, 2005. Draft Basis of Design Report – Stormwater Treatment Area 2 Expansion Cell 4. Prepared for SFWMD under Contract CN040935-WO04.

Burns & McDonnell, 1995. Everglades Construction Project General Design Memorandum – S-5A Basin Diversion, Volume I of II, November, 1995 submission to SFWMD.

Burns & McDonnell 2000. Addendum to Design Documentation Report (Revised Draft) Stormwater Treatment Area 1 East. Prepared for U.S. Army Corps of Engineers Jacksonville District.

Burns and McDonnell, 2003. Everglades Protection Area Tributary Basins Long-Term Plan for Achieving Water Quality Goals. October 27, 2003.

Goforth, G. and T. Piccone, 2002. Water Quality Improvement Strategies for the Everglades – Alternative Combinations for the ECP Basins. SFWMD, June 3, 2002.

Goforth, G. and T. Piccone, 2002a. Evaluation Methodology for the Water Quality Improvement Strategies for the Everglades. SFWMD, July 31, 2002.

Goforth, G. and T. Piccone. 2001. Baseline Data for the Basin-Specific Feasibility Studies to Achieve the Long-term Water Quality Goals for the Everglades. SFWMD, Everglades Construction Project Division.

JMJV, 2004. Preliminary Hydraulic Evaluation (Permitted Pump Flows & ¾" Runoff) Report For Bolles And Cross Canals, Submitted by the Jacobs MWH Joint Venture to SFWMD, June 15, 2004.

Nova, 2003. Hydrologic Assessment of S-5A Basin Diversion Project. Canals L-13 (Ocean Canal) and L-15 (Hillsborough Canal) Enlargement. Prepared by Nova Consulting, Inc. for SFWMD under contract C-15909-WO03, Task Order No. 3.

SFWMD, 1997. S-5A Diversion Structure G-341 Design Plans. Construction and Land Management Department Contract C-E202, Drawing DMOC-3.

SFWMD, 2001. Evaluation of Alternatives.

SFWMD, 2000, STA 1W, 2, 3/4, 5, and 6 Operating Plans (STA 5), 2001 (STA 2), 2004 (STA 1W, STA 3/4, STA 6).

SFWMD, 2004. S-5A Basin Diversion Structure G-341 Design Plans, Contract C-E202, Drawing DMOC-3.

SFWMD, 2005. STA 5 Outlet Canal Plans.

SFWMD, 2005 version. Structure Book. Prepared by SFWMD Operations Department, revised annually.

URS, April, 2005. Draft Basis of Design Report – Stormwater Treatment Area 5 Flow-way 3. Contract CN040936, Work Order 05.

URS, April, 2005. Draft Basis of Design Report – Stormwater Treatment Area 6 Section 2. Contract CN040936, Work Order 02.

Walker, W.W., Jr. R. Kadlec. Dynamic Model for Stormwater Treatment Areas, Aug, 2001. http://wwwalker.net/dmsta/index.htm.