BASIN-WIDE WATER BUDGETING USING AN INTEGRATED MODEL

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Abstract. Integrated surface water/groundwater models have been used extensively for water budgeting and water resource allocation projects in Florida. Is a similar modeling approach viable in Georgia?

The Caloosahatchee River Basin is a river system that is used heavily by agriculture and is under intense urban development pressure and drains to an important saltwater estuary. Water managers are faced with the challenge of providing sufficient freshwater for competing (irrigation, potable water, and ecological) water needs. Future plans suggest that the volume of surface water and ground water historically used to meet these needs will be greatly reduced in the future. How will water managers meet the challenge?

The South Florida Water Management District (SFWMD) has utilized the integrated surface water/groundwater model, MIKE SHE, to evaluate water demands and budgets for existing and future conditions. This tool gives the SFWMD the ability to evaluate the impact of alternative water management strategies within a single computational environment.

This tool has been used to answer many questions within the Caloosahatchee River Basin. Typical questions include:

1) If we reduce flows to the Caloosahatchee River, can we still provide enough water to the estuary?
2) If we build a reservoir, what impacts would we expect to see in the groundwater and the surrounding stream network?
3) If we add an irrigation pump to this stream, will it impact the nearby wetlands?
4) What is the irrigation return flow to streams from irrigation wells?
5) How can we manage water so we don't cause flooding in urban areas?
6) What is the hydro-period of the wetland restoration project we are implementing?

BACKGROUND

The major flow ways in the Caloosahatchee River (C-43) Basin consist of a number of creeks that meander through broad floodplains and an intricate network of man-made canals. For agricultural uses, water is back-pumped from the C-43 into the canal network where it is held behind weirs and gated structures to meet irrigation needs. Releases from Lake Okeechobee provide much of the water flowing through and utilized within the watershed.

As part of an assessment and plan developed to restore the Florida Everglades, the Central and Southern Florida Project Comprehensive Review Study (Restudy) stated that "extreme fluctuations between too much and too little freshwater discharge into the Caloosahatchee and St. Lucie estuaries resulting in detrimental salinity conditions and physical alterations of fish and wildlife habitat" (USACE, 1999).

Among the many recommendations included in the plan is development of the C-43 Basin Storage Reservoir Project. The purpose of the reservoir, as described in the plan is:

The C-43 Basin Storage Reservoir Project will capture local basin runoff and releases from Lake Okeechobee (Figure 1). Water from the reservoir will be used to provide environmental deliveries to the Caloosahatchee Estuary and to meet demands in the C-43 Basin. Lake Okeechobee water will also be used to meet any remaining local basin demands subject to supply-side management. The operation of project components in the C-43 Basin will significantly improve regional water managers' abilities to meet local basin agricultural/urban demands as well as the environmental needs of the downstream estuary. (USACE, 1999)

The South Florida Water Management District hired Stanley Consultants, Inc to design the C-43 West Storage Reservoir, a component of the C-43 Basin Storage Reservoir Project. DHI Water and Environment provided modeling expertise to support the reservoir design.

Project Goals

The goal of the design project is to design an above ground reservoir with a storage capacity of approximately 170,000 acre-feet. The success of the reservoir design project will, for the most part be judged by how well the performance measures are met (Stanley,

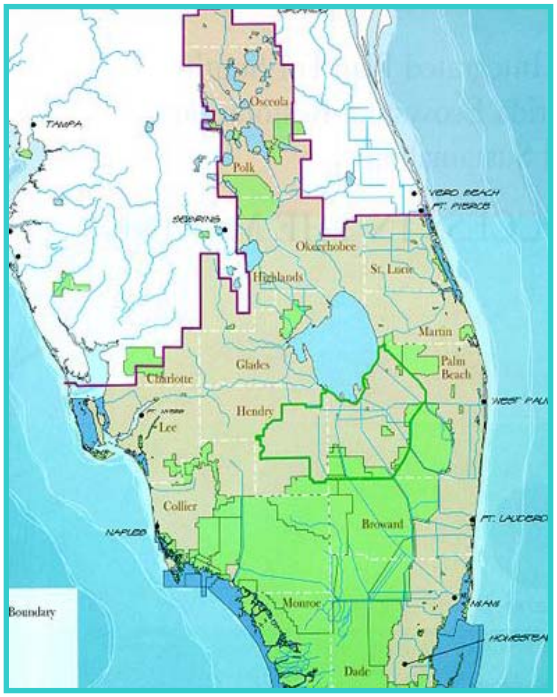


Figure 1. Project Location

2005). The primary performance measure for the West Reservoir is a more natural flow through the Franklin Lock (S-79) that separates the freshwater portion of the watershed from the tidal portion of the watershed. This Performance Measure was defined in 2005 and specified a distribution of mean monthly flows through the lock. Stated simply, the reservoir will be used to capture excess flows during the wet season, store the water, and release it during the dry season to meet the specified flow requirements at the S-79 structure. The flow distribution is shown in Table 1.

Table 1. Target flow distribution at S-79

Discharge Range; Mean Monthly Flow From S-79 (cfs)	Percent Distribution Of Flows From S-79
0 to 450	0%
450 to 500	42.8%
500 to 800	31.7%
800 to1500	19.2%
1500 to 2800	5.6%
2800 to 4500	0.7%
>4500	0%

Model Development and Calibration

A model of the freshwater Caloosahatchee River basin was developed and calibrated based on the MIKE SHE modeling system developed by DHI Water and Environment. The MIKE SHE modeling system is an integrated hydrologic tool that describes the entire land phase of the hydrologic system including coupled surface and groundwater systems. Components of the model that are particularly useful in the C-43 Basin include the structure operations module in the river network model, the 2-dimensional overland flow module, and the irrigation module.

The model was calibrated to match stage (12 locations) and flow (4 stations) within the river system network. In addition, the model was calibrated to match groundwater elevations at more than 40 well locations distributed among three aquifers. Irrigation was calibrated to represent seasonal and annual irrigation patterns based on land use type. Hydro-period maps were generated to ensure that wetland areas were properly represented within the model. (DHI, 2005)

Alternatives Analysis

The calibrated model was modified to evaluate flows in the C-43 Basin resulting from land use changes and construction of the reservoir. Multiple reservoir designs, including 2-cell and 3-cell configurations were evaluated. Each design considered the benefits of a single pump station or multiple pump stations.

These alternatives were evaluated on cost-effectiveness and hydrologic benefit. A 2-cell reservoir was selected for the project. (SFWMD 2006). Figure 2 shows the proposed reservoir design features.

Subsequent analyses were completed to evaluate different inflow pump sizes. Four pump sizes were considered. The evaluated pump capacities were: 1,500; 2,000; 2,500; and 3,800 cubic feet per second (cfs).

As a result of this analysis, the SFWMD elected to move forward with design of a 2-cell, 170,000 acre-foot reservoir, utilizing a single 1,500 cfs pump.

Figure 3 shows the "best" result for each of the pump size simulations completed. At least 10 runs were completed for each alternative pump size.

Additional Results

In addition to evaluating flow at S-79, the model was used to evaluate:

- potential changes in wetland hydro-period associated with reservoir construction;
- potential modifications to groundwater levels;
- water levels in streams surrounding the reservoir;
- the availability of water for irrigation needs; and
- the effect of a breach of the reservoir embankment.

The initial results of these additional analyses indicate negative impacts in the area around the reservoir. As an example, Figure 4 provides a comparison of water levels in the LPDD Header located just east of the reservoir and the C43S14 structure shown in Figure 2.

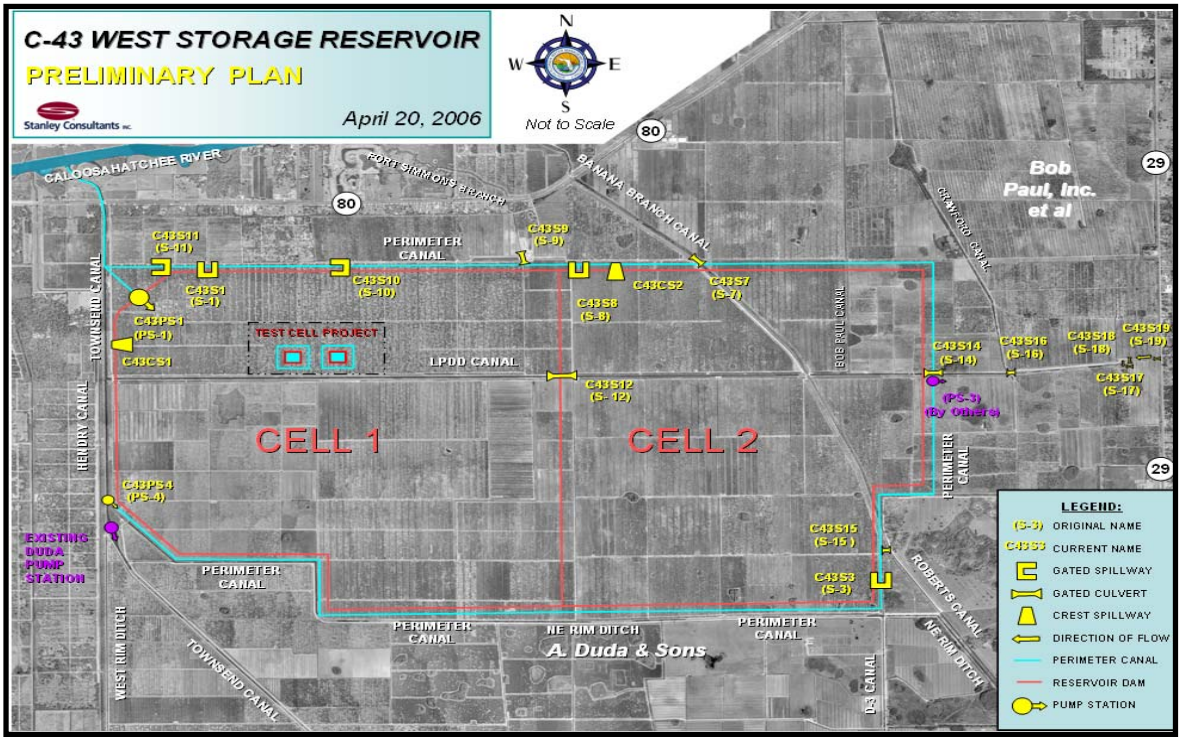
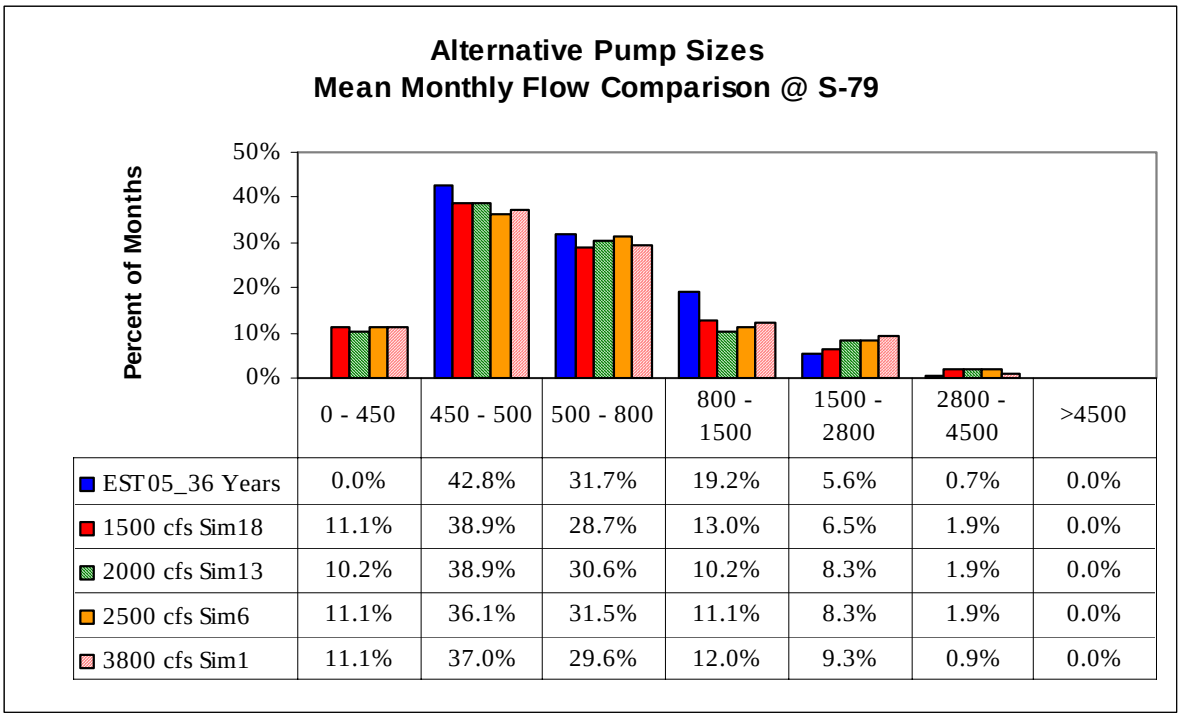


Figure 2. Proposed Reservoir Design

Figure 3. Results of Pump Size Analysis



	0 - 450	450 - 500	500 - 800	800 - 1500	1500 - 2800	2800 - 4500	>4500
EST05_36 Years	0.0%	42.8%	31.7%	19.2%	5.6%	0.7%	0.0%
1500 cfs Sim18	11.1%	38.9%	28.7%	13.0%	6.5%	1.9%	0.0%
2000 cfs Sim13	10.2%	38.9%	30.6%	10.2%	8.3%	1.9%	0.0%
2500 cfs Sim6	11.1%	36.1%	31.5%	11.1%	8.3%	1.9%	0.0%
3800 cfs Sim1	11.1%	37.0%	29.6%	12.0%	9.3%	0.9%	0.0%

Figure 4 shows a period of extreme draw down in the stream during 1982. Several structures are included in the project design to maintain a relatively constant water level in this stream. The result indicates that the operational controls currently defined in the model must be revised in order to meet irrigation demands on the LPDD Header Canal

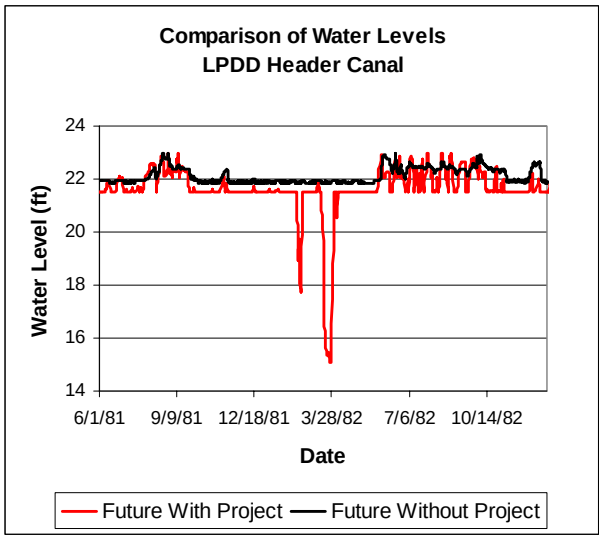


Figure 4. Stage Comparison in the LPDD Header Canal

CONCLUSION

The results of the modeling completed to date indicate that the reservoir will provide a significant benefit to the downstream estuary. The additional analyses indicate that the operational plan for several structures must be modified to reduce, or eliminate negative impacts to surrounding areas.

LITERATURE CITED

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