# Stormwater Master Planning Case Studies in Florida

***Brian W. Mack, Joel G. Jordan, Charles E. Cook, Theresa Heiker, and Mark Flomerfelt***

Successful stormwater master planning efforts have several key elements including goal setting, problem identification and assessment (flooding, water quality, and ecological considerations), development of prioritized solutions, and public involvement. This article presents two case studies that include these key elements. For brevity, select details of these general elements have been highlighted. These details include goal setting, stormwater modeling efforts (highlighting the importance of model calibration) for planning and design, and improved operation and maintenance.

## Case 1: Leon County—Lake Munson Restoration Project

In 1997, Leon County contracted with Camp Dresser & McKee, Inc., to provide engineering services for the Lake Munson Restoration Project. The county's long-term goal was to restore the lake, to the extent possible, to its original functionality to reduce flooding, revitalize wetland treatment systems, and control sediment loading to the lake. CDM has developed a phased program, which includes management of sediment loads and increased flood protection. Phase I involves the restoration of Lake Henrietta upstream of Lake Munson to a combination wetland/open water body system that will be used for sediment control and flood control; removal of the delta at the inflow point to Lake Munson; enhancement the flood conveyance capacity between Lake Henrietta and Lake Munson; development of a sediment disposal site: and the identification of a management plan for the restored system. Phase II will involve the restoration of Lake Munson itself.

This case study summarizes the surface water modeling component of this project including model development and calibration for the 72-square mile Lake Munson basin, which includes the majority of downtown Tallahassee. The development of a sound and justified regional model was necessary to support the analysis of alternatives to the local and state permitting agencies.

The general modeling approach was to use previous modeling efforts to the extent practicable to develop a single regional model for the Lake Munson basin. Previous models included the stormwater models developed by NWFWMD and models developed for portions of the system within the city. The models selected for this effort were the RUNOFF (hydrology) and EXTRAN (hydraulics) blocks of EPA's Stormwater Management Model (SWMM) Version 4.4.

The major refinements to the previous hydrologic evaluations were the identification of closed subbasins and off-line storage within the Lake Munson basin and refinement of the hydraulic representation of the existing system using new data gathered as part of this modeling effort. Several of the planning level models previously developed for the basin did not account for all of the existing storage within the basin. Therefore, CDM delineated subbasins (hydrologic units) at a higher level of detail than previously done. A total of 245 hydrologic units were delineated as part of the refinement process. Because hydrologic units were redefined, all of the hydrologic parameters (land use, soils, infiltration parameters) were recalculated.

For efficiency, CDM used the county's existing GIS data to develop all of the appropriate hydrologic parameters, specifically the following: parcel specific land use data provided by the Tallahassee-Leon County Planning Department, digital SCS soils data, and level III Florida Land Use/Cover Classification System data provided by NWFWMD. These coverages were inported into the GIS software package ArcView along with the revised subbasin delineations. The appropriate acreage coverages by subbasin were calculated for each data type necessary to determine the hydrologic parameters needed by the RUNOFF model.

After updating the hydrology, CDM combined the previously developed hydraulic models into one regional model, which was reviewed for computational stability and proper hydraulic representation. The model was further refined with new data.

The regional model was then calibrated by simulating Tropical Storm Josephine (October 6-8, 1996) using the extensive network of rainfall and stream stage gages in the basin maintained by NWFWMD and the city of Tallahassee. The calibrated regional stormwater model was used to predict flood stages and flows within the basin and to show the resulting flood mitigation benefits of the proposed restoration efforts which will assist the county with its federal, state, and local permitting requirements.

Model calibration refers to the adjustment of model parameters within reasonable limitations so that the model results (e.g. flood stages) are in reasonable agreement with a set of measured data. A reasonable range of values for the adjustment of parameters is established through review of the hydrologic literature. Adjustments outside those ranges are only made if some unusual hydrologic condition exists. For this study, the model was considered well calibrated when the resulting stages were in reasonable agreement with the data measured/recorded at the existing gaging stations and measured high water marks. Calibration serves as a "reality check" of the model and improves the accuracy and confidence in model results.

The two primary data requirements for model calibration are gaged rainfall and runoff for the study area. When selecting a calibration storm, the rainfall and runoff data must be sufficiently documented in appropriate time intervals so that variations in rainfall intensity and the associated runoff can be described. Data should be recent to represent current conditions in the study area. Additionally, to account for the spatial distribution inherent in Florida rainfall, data should be available at various rainfall stations throughout the study area. Stage and rainfall data from an extensive network of rainfall and stage gages maintained by NWFWMD and the city within the Lake Munson basin are readily available.

Eight rainfall gages were selected that provide excellent coverage of the study area. For stage data, records were obtained from twelve streamgages. Data at each of the gages are measured in 5-minute intervals.

Leon County selected Josephine for the model calibration process because it produced an average of 7.5 inches of rainfall, with a minimum recording of 5.45 inches rainfall and a maximum of 8.99 inches, and created several documented flooding problems within the basin. Rainfall was fairly uniform over the entire basin. The hydrologic units in the basin were assigned a raingage based on the nearest neighbor approach. In addition to the rainfall and streamgage data, historical flooding records were obtained for use in the model calibration process. CDM obtained field photographs and a survey of high water marks at several locations in the basin that occurred during the storm.

Most of the input data are used simply to describe the geometry and size of the hydraulic and hydrologic units of the subdivided study area. These data, such as the areas, widths, and lengths of catchments, are known quantities and are subject to very little interpretation. A few of the input requirements, however, are not derived from directly measurable qualities of the catchments. These data, referred to as calibration parameters, include:

- The maximum and minimum infiltration rates for pervious areas;
- The total infiltration volume capacity;
- The pervious and impervious depression storage volumes;
- The channel and overland flow roughness coefficients; and
- Initial water surface elevations in the lakes without stage gages.

These parameters were first approximated with values derived from local data (e.g., aerial topographic photographs and soil surveys), but final values were ultimately determined through model calibration.

The first step in the calibration procedure was to estimate values for the calibration parameters and run the model for the October 6-8, 1996, storm event. The peak stage values of the calculated and measured hydrographs for the twelve stage gages and seven road flooding locations were compared. If they did not agree, successive runs were made varying the values for the parameters, identified above, until the predicted values were close to the measured values.

The initial model runs indicated that the total volume of runoff was being over-predicted. Therefore, the soil storage values were adjusted to reflect a dry antecedent moisture condition (AMC-I). It is important to note that for this calibration effort, the Horton infiltration parameters were varied with in a range of accepted I values for dry antecedent moisture conditions (AMCs). The maximum soil storage values representative of dry conditions were deemed acceptable based on discussions with county and NWFWMD staff, which indicated that many of the existing lakes and depressional areas in the Lake Munson Basin were on the low side, indicating a dry AMC. Further support was provided by the lower rainfall volumes recorded in the basin by NWFWMD during the previous three-month period. For the design storm analysis, the maximum soil storage values were set within the normal range of AMC values.

The next step in the calibration process was to try to match the recorded peak shape and timing. This was accomplished by adjusting the values for the Manning's roughness coefficients of the numerous open channels in the system. Particular attention was paid to the values of the overbank roughness coefficients since Tropical Storm Josephine caused many of the streams to overflow their normal, well-defined banks. The overbank roughness coefficients were raised to reflect the dense vegetation normal to streams that flow through swampy areas. This had the effect of delaying the peak stage. In a few locations, the main channel and overbank roughness coefficients were slightly lowered to have the predicted peak stage arrive early to match the recorded data.

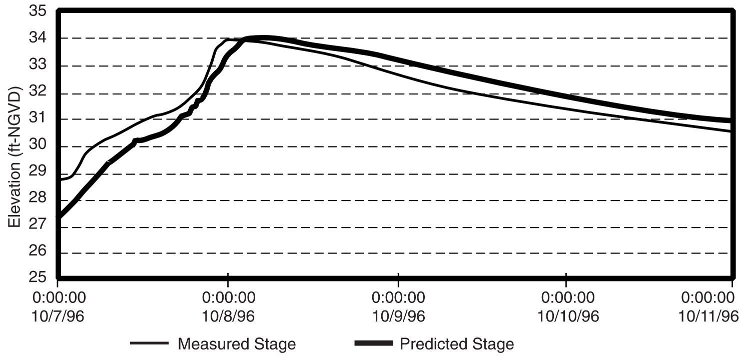
After the flow and stage values of the observed and calculated hydrographs were in relative agreement, they were checked for timing and general shape. Final adjustments in timing were achieved by varying roughness coefficients and/or the depression storage for the impervious areas. The peak stages used for calibrated and the global Horton infiltration parameters used to reach these calibration points, are presented in the accompanying table. As can be seen from the table, predicted peak stages were between 0.1 and 0.8 feet of measured peak stages, with the majority of the differences being between 0.0 and 0.5 feet. Additionally, the accompanying figure shows plots of the recorded and simulated storm elevation versus time plots for streamgage S-3, the most critical gauge for calibration because it is within the project site. The plots show there is an excellent correlation between the model results and the historical record. The recorded 33.9 feet National Geodetic Vertical Datum (NGVD) peak water surface elevation is only 0.1 feet higher than the simulated peak water surface elevation. Besides the peak elevations matching well, the predicted peak timing, and total flow volume also were excellent fits to the measured data.

After calibration, a critical event duration analysis was performed. The 1-hour, 2-hour, 4-hour, 8-hour, 24-hour, 3-day, 7-day, and 10-day 25-year design storms were run to determine which produced the highest stages in the Lake Henrietta area. The 24-hour storm was determined to produce the highest peak stages, so simulations were performed for the 2-year/24-hour, 25-year/24-hour, and 100-year/24-hour design storm events for both present and future land use. A normal AMC-II was used for the soil storage for these simulations rather than the dry AMC-I that was used for the calibration event.

The calibrated regional stormwater model was used

**Lake Munson Restoration Project Model Calibration —Design Storm Simulation Results, Oct. 6-8, 1996**

| High Water Mark Location 8-Oct-96 | Site Number | Measured Peak stage (ft-NGVD) | Simulated Peak Stage (ft-NGVD) | Delta (ft) |
|---|---|---|---|---|
| Munson Slough - Springhill Rd | 1 | 35.9 | 35.2 | -0.7 |
| East Drainage Ditch | 2 | 37.2 | 37 1 | -0 1 |
| Munson Slough - Crawfordville Rd | 3 | 25.5 | 25.6 | 0.1 |
| Central Drainage Ditch - Lake Bradford Rd | 4 | 57.7 | 57.4 | -0.3 |
| Munson Slough - Orange Avenue | 5 | 37.6 | 37.8 | 0.2 |
| West Branch Gum Creek - Blountstown Hwy | 6 | 53.7 | 53.8 | 0.1 |
| North Branch Gum Creek - Tennessee St | 7 | 67.6 | 68.1 | 0.5 |
| NWFWMD Stage Recorder S-3, SW Capital Cir | | 33.9 | 34.0 | 0.1 |
| NWFWMD Stage Recorder S-4 Aenon Church Rd | | 42.0 | 41.5 | -0 5 |
| NWFWMD Stage Recorder S-6 - Tennessee St | | 59.6 | 59.2 | -0.4 |
| NWFWMD Stage Recorder S-19 - Lake Bradford Rd | | 38.9 | 38.9 | 0.0 |
| NWFWMD Stage Recorder S-20, Roberts Avenue | | 46.9 | 47.1 | 0.2 |
| NWFWMD Stage Recorder S-22, Wahnish Way | | 72.1 | 72.2 | 0.1 |
| NWFWMD Stage Recorder S-39, Lakeview Drive | | 33.4 | 34.1 | 0.7 |
| City of Tallahassee SMDRG104, Elanor Drive Pond | | 86.4 | 86.9 | 0.5 |
| NWFWMD Stage Recorder S-70, Gum Swamp | | 53.3 | 54.0 | 0.8 |
| NWFWMD Stage Recorder S-128, Adams St | | 49.2 | 48.7 | -0.5 |




*NWFWMD Stage Recorder S-3 (EP070)*

as one of the tools to evaluate various stormwater management options to meet the goals of providing a mechanism for sediment management. flood control, and wetland restoration. The stormwater model was used to help the restoration design team quantify flood stages, flow rates, and flow volumes through the project area.

Once the response of the river system to various design storm events was evaluated, the design team identified potential areas within "Old Lake Henrietta" that could be retrofitted for improved stormwater and sediment management. The area identified, on the northern end of the historical lake area, encompasses about 30 acres of uplands and failed wetlands. The calibrated stormwater model was used to accomplish reduction in downstream flood levels and restoration of wetlands that have had their hydroperiods significantly altered by sedimentation and channelization. The proposed 30-acre flood attenuation area was designed with an average depth of 7 feet and a forebay area for sediment management. Flows resulting from the 2-year design storm are diverted into the pond while flows from the larger design storms bypass the facility. Discharge from the pond is controlled by a spillway and bleed-down device and by equalization pipes between the pond and the existing river (Munson Slough). Modeling shows that the proposed pond reduces downstream flood levels by as much as 1 foot under the 25-year design storm event. Based on sediment loading, it was estimated the sediment management area of the proposed facility could store between 5 and 10 years of sediment generated from surface water runoff and erosion.

In addition to sediment control and flood protection, the calibrated stormwater model was used to identify structural improvements for reducing fluctuation in the hydroperiod resulting from channelization. Low flow weirs with bleedown devices were strategically located downstream of the proposed pond site (located using stormwater model) in order to maintain ordinary high water levels within the failing wetland systems surrounding the project area. Maintaining ordinary high water levels increases the duration of inundation within the surrounding wetlands, thus restoring historical hydroperiods as much as possible.

The pond was also designed to significantly reduce sediment loads that have historically been transported downstream to Lake Munson. The pond's detention time will promote sediment deposition in the forebay areas of the proposed pond.

## Case 2: Seminole County—Pond Operation and Maintenance

For the NPDES municipal separate storm sewer permit, Seminole County identified a need to address typical shortcomings of data intensive storage resulting from paperwork generated from the inspection, maintenance, and certification of its stormwater ponds. The county inspects and maintains over 325 stormwater ponds that provide both flood attenuation and water quality treatment.

The first and most critical step in the development of a database was the identification of existing maintenance procedures. The county's maintenance activities fall into two general categories: routine maintenance operations and complaint response generated maintenance. Routine maintenance, performed on a 3-month cycle, includes sideslope mowing, debris removal, herbicide and pesticide application to control aquatic vegetation, and mechanical harvesting. Maintenance crews document any structural problems, such has bank erosion and/or control structure failures. At the end of the day, field crews submit paper logs of work performed or work needed to the field operations team leader who compiles and files them according to existing protocol. For major repair work, the team leader takes the necessary steps (described below) to issue a corrective action work order.

Complaint-response-generated maintenance investigations typically originate from the general county information operator. The operator who receives a complaint completes a job assignment form (complaint type, contact person) that is routed to the appropriate county department. In the case of stormwater pond maintenance issues, the field operations team leader assigns a field crew to investigate the complaint and determine what corrective actions are warranted. If corrective action items are warranted, the field operations team leader identifies the type of corrective action needed. To make corrective actions that are in compliance with local and state permits, the field operations team leader researches as-built construction drawings and existing permit requirements for the facility. This effort can be a time-consuming effort for maintenance staff. As with many municipalities, as-built construction drawings and permits are kept at an off-site storage site and are more difficult to locate over time. If not found in storage, copies of construction drawings and permits may have to be requested from the water management district. It is not uncommon to spend between 1 and 3 days locating these types of data (if found at all). Once construction drawings and permits are found, the field operations team leader identifies the plan to correct the structural deficiency back to its as-built and permitted condition, issues the work order and once work is completed, signs off on the job assignments form which is then filed.

Once procedural actions were identified through client interviews, CDM conducted several meetings with the field operations team leader and the Stormwater Programs Manager reviewing paper maintenance tracking forms and the types of data reported on each form. During the process, county and CDM staff identified historically tracked data that was beneficial for maintenance and additional data types that, if accessible, would make their efforts more efficient. This was especially true in light of their expected EPA NPDES permit maintenance reporting requirements. Compiling daily maintenance records (paper copies) and assimilating the information in sufficient detail to generate their federally mandated maintenance activity report was viewed as a very labor-intensive effort.

Given these parameters, CDM's Orlando Applications Development Team designed "Pond Explorer," a Microsoft ACCESS database than can access specific pond information, Pond Explorer provides a powerful interface for managing maintenance items, permits, as-built drawings, and digital photographs, as well as scheduling of pond recertification activities. Digital information maintained within the database includes general pond specific data, on-site digital photographs, digital as-built drawings, St. Johns River Water Management District permits and design requirements, public reported problems, completed maintenance activities and repairs, maintenance summary reports, and a pond recertification schedule report.

Pond Explorer addressed the typical shortcomings of intensive data storage (i.e., as-built drawings, permits, etc.) by providing an understandable, user-friendly interface to access critical information instantly.

Databases are often designed to store data without any regard to ease of use. To simplify the user inter-face, CDM designed a tree structure from which the user can use a mouse to select a pond and information of interest. The tree structure resembles and operates in a similar fashion as the Explorer standard with the Microsoft Windows95 operating system. It is always visible in the interface. Saving information, viewing scanned as-built constructions drawings, scanned permits, digital photographs, job assignments, and historical maintenance records all use identical interfaces. Only the information itself changes. This allows the user to develop familiarity of the system almost immediately. Online help provides the user with all the information needed to use the application.

In addition to the tree structure interface, an overall aerial photograph of the county is included. It shows the general location of each pond. The user can click on the location of each pond on the aerial photograph and automatically open the types of data available for the selected pond within the tree structure. Also, there are search and sorting tools within the database that are button driven (e.g., list all ponds with drainage areas over 100 acres).

The reporting features of Pond Explorer are similar to those used in Microsoft applications. A report wizard guides the user through a simple report type selection process, allowing the user to summarize data in a matter of minutes. For example, the standard annual NPDES maintenance report can be selected, which will summarize all maintenance activities (i.e., chemical types and quantities, sediments removed, mowing efforts, rehabilitation efforts, etc.) for the period of interest which can be directly inserted into their annual compliance report. This report generation method takes minutes instead of months (if done from paper trails). Other time-saving advantages of Pond Explorer include access of as-built construction drawings, permits, digital photographs, and complaint response efforts in minutes versus several days.

## References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Brian W. Mack, P.E., Joel G. Jordan, P.E., and Charles E. Cook, P.E., are with Camp Dresser & McKee Inc. Theresa Heiker, P.E., is with Leon County. Mark Flomerfelt, P.E., is with Seminole County.


### Glossary of Common Terms Used in this publication

| | | | |
|---|---|---|---|
| AWT, AWWT | advanced wastewater treatment | gpm | gallons per minute |
| AWWA | American Water Works Association | hp | horsepower |
| BPR | Florida Dept. of Business & Professional Regulation | MGD | million gallons per day |
| | | mg/l | milligrams per liter |
| BOD | 5-day biochemical oxygen demand | NPDES | National Pollutant Discharge Elimination System |
| $BOD_x$ | BOD test based on other than 5 days | | |
| COD | chemical oxygen demand | POTW | public-owned treatment works |
| CWA | Clean Water Act | ppm | parts per million |
| DEP | Florida Department of Environmental Protection | psi | pounds per square inch |
| | | SJRWMD | St. Johns River Water Mangement District |
| EIS | Environmental Impact Statement | | |
| EPA | U.S. Environmental Protection Agency | SFWMD | South Florida Water Management District |
| FAC | Florida Administrative Code | SRWMD | Suwannee River Water Management District |
| FSAWWA | Florida Section of AWWA | | |
| FWEA | Florida Water Environment Association | SWFWMD | Southwest Florida Water Management District |
| FWPCOA | Fla. Water & Pollution Control Operators Association | TDS | total dissolved solids |
| | | TSS | total suspended solids |
| GIS | Geographic Information System | USGS | United States Geological Survey |
| gpcd | gallons per capita per day | WRF | Water Reclamation Facility |
| gpd | gallons per day | WTP/WWTP | Water/Wastewater Treatment Plant |