Chapter 11: Kissimmee Basin

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SUMMARY

The Kissimmee Basin encompasses more than two dozen lakes in the Kissimmee Chain of Lakes (KCOL), their tributary streams and associated marshes, and the Kissimmee River and floodplain. The basin forms the headwaters of Lake Okeechobee and the Everglades; together they comprise the Kissimmee-Okeechobee-Everglades (KOE) system. In the 1960s, the Central and Southern Florida Flood Control (C&SF) Project modified the native KOE system extensively throughout South Florida, including construction of canals and water control structures to achieve flood control in the Upper and Lower Kissimmee basins.

Completed in 1971, the 56-mile-long C-38 canal in the Lower Kissimmee Basin channelized the Kissimmee River with profound ecological consequences, eliminating flow in the original river channel and preventing seasonal inundation of the floodplain. In the Upper Kissimmee Basin, C&SF Project modifications allowed lake stages to be regulated at reduced ranges of fluctuation, altering or eliminating much of the formerly extensive littoral zones around the lakes and the marshes between them. These and other environmental losses led to legislation authorizing the federal/state Kissimmee River Restoration Project, which includes the Kissimmee River Headwaters Revitalization Project.

The South Florida Water Management District's (SFWMD or District) Kissimmee Watershed Program was originally formed in the 1990s to coordinate and evaluate the restoration and associated projects. More recently, the program has worked to integrate management strategies for the Kissimmee Basin with the Kissimmee River Restoration Project. The primary goals of the Kissimmee Watershed Program are to (1) restore ecological integrity (i.e., an ecosystem comparable to the natural habitat of the region) (SFWMD, 2005a, Chapter 1) to the Kissimmee River and its floodplain; (2) conduct ecological monitoring programs for restoration evaluation; (3) develop a long-term management strategy for resolving water and other management issues in the Kissimmee Chain of Lakes; and (4) retain the existing level of flood control in the Kissimmee Basin. In addition to the Kissimmee River Restoration Project, major Kissimmee Basin initiatives designed to meet these program objectives are the Kissimmee Basin Modeling and Operations Study, the Kissimmee Basin Water Reservations, and the Kissimmee Chain of Lakes Long-Term Management Plan.

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Construction for the Kissimmee River Restoration Project is on schedule for completion in 2015. In Water Year 2009 (WY2009) (May 1, 2008–April 30, 2009), Phase IVB backfilling of the C-38 canal was initiated. Phase IVB is the northernmost phase of backfilling and involves filling 4 miles of the canal in Pool B and recarving 4 miles of river channel, which will reestablish flow to 6 miles of reconnected river channel. Completion is anticipated in early 2010. Other contract activity included the S-68 spillway addition (Lake Istokpoga outlet), S-83/S-84 spillway additions (between Lake Istokpoga and Pool E of the Kissimmee River), and Istokpoga Canal improvements, the latter of which included replacing a water control structure and constructing a public boat ramp. In the Upper Kissimmee Basin, the U.S. Army Corps of Engineer's contract to widen the C-37 canal was put on a fast track under funding available through the federal American Recovery and Reinvestment Act. As part of the Headwaters Revitalization Project, this project will provide greater conveyance capacity between Lake Hatchineha and Lake Kissimmee. This contract is scheduled to begin in 2010.

Other program activities included the development of Water Reservations for the Kissimmee Basin, continued ecological monitoring of Phase I responses, and the collection of baseline data for Phase II/III of the river restoration project. Work associated with evaluating modified structure operations and finalizing the management plan for the Kissimmee Chain of Lakes was put on hold to focus agency resources on the Water Reservations.

Because of rapid population growth in the Kissimmee Basin, the limit of sustainable water withdrawal from the Floridan aquifer is expected to be reached in 2013. At its June 2008 meeting, the District's Governing Board approved a resolution to begin rule development for the reservation of water necessary for the protection of fish and wildlife in the Kissimmee River, its floodplain, and the Kissimmee Chain of Lakes. In 2008–2009, the technical work to identify the water needed to protect fish and wildlife was completed for all eight reservation water bodies in the Kissimmee Basin. These eight reservation water bodies are the (1) Kissimmee River and floodplain, (2) Myrtle-Preston-Joel, (3) Hart-Mary Jane, (4) East Tohopekaliga, (5) Tohopekaliga, (6) Alligator Chain, (7) Gentry, and (8) Kissimmee-Cypress-Hatchineha. The document summarizing the technical work underwent an external peer review in April 2009, which concluded that the data and information used to develop the technical document "are technically sound, and inferences and assumptions made regarding the linkages between hydrology and the protection of fish and wildlife are based upon sound scientific information." The process to develop an administrative rule that incorporates the technical results into Consumptive Use Permit rule criteria is currently ongoing.

During WY2009, Kissimmee Basin environmental conditions were influenced by the two preceding years of drought, above-average rainfall during the wet season and below-average rainfall during the dry season. For WY2009, total rainfall was below average in both the Upper Kissimmee Basin (81 percent of normal) and the Lower Kissimmee Basin (87 percent of normal). At the beginning of the water year, rainfall was above average, causing water levels in the Upper Kissimmee Basin lakes to rise. This allowed small releases to be made to the Kissimmee River, which were increased in late July. In August, rainfall associated with Tropical Storm Fay caused water levels to rise and exceed the regulation schedules of the Upper Kissimmee Basin lakes. Water levels in the Kissimmee River also rose in response to this storm event and increased outflow from the Upper Kissimmee Basin. As inflow from the Upper Kissimmee Basin decreased, water levels in the river lowered rapidly and continued to decline during the dry season. After Tropical Storm Fay, there was not sufficient rainfall to refill the larger lakes to the high pool stage at the end of the wet season.

Monitoring of ecological responses to Phase I restoration construction continued in WY2009. This year's update from the Kissimmee River Restoration Evaluation Program focuses on a subset of studies with new data for the past year, including river channel and floodplain hydrology, river channel dissolved oxygen concentrations, phosphorus loads and concentrations, and wading bird and waterfowl densities. The discussion of mercury monitoring has been moved to Chapter 3B of this volume. Continuous inflow, which has not always been possible since the completion of Phase I, was maintained at low levels in WY2009 from the Upper Kissimmee Basin, except during the single major flow event associated with Tropical Storm Fay. The seasonality of flow continued to exhibit a more natural pattern with maximum monthly flows occurring in the wet season instead of the mid-dry season. Quantification of the Tropical Storm Fay event at multiple locations along the river showed that it was of long duration and had recession rates in the expected range. Analysis of water level fluctuation along the length of the river shows a complicated upstream-downstream pattern and the influence of a backwater effect caused by S-65C. Implementation of the Headwaters Revitalization Schedule or a revised water regulation schedule, projected for 2015, is expected to provide more operational flexibility to meet the hydrologic requirements of river and floodplain restoration.

Two components of the dissolved oxygen expectation (mean daytime wet and dry season dissolved oxygen concentrations) were above expected values as of WY2009. However, following a pattern seen in previous years since completion of Phase I, phosphorus loads and concentrations along the river have not declined relative to pre-Phase I values. Construction activity upstream of the Phase I restoration area provided newly available wading bird foraging habitat, which attracted flocks that might otherwise have foraged in the Phase I area; because the construction area is not within the Phase I area, these flocks were excluded from the evaluation of the Phase I wading bird expectation. Thus, construction likely contributed to the lower-than-expected densities of wading birds recorded in the Phase I area in the past year. Reduced waterfowl abundance in WY2009 may have been in response to below-average rainfall and water management regimes that gradually decreased water levels during the dry season.

This year's chapter includes a new assessment of the potential impacts of invasive, nonindigenous species on the Kissimmee River Restoration Project. This section evaluates the potential negative effects of invasive species in the Kissimmee River and floodplain on the outcome of the restoration project, with the broader objective of identifying species for which new or renewed attention is needed to avoid future negative impacts. Invasive species can disrupt the outcome of ecosystem restoration projects by changing the structure of native plant and animal communities or displacing native species. Of the 18 invasive plant species considered, 14 were judged to have little potential for impact on the Kissimmee River Restoration Project given existing control programs or because of changes in habitat conditions that will result from wetland restoration. For the three plant species judged to have current potential for impacts on restoration, new control strategies are actively under study. Of the seven invasive animals considered, only two were considered to have little potential for impact on the restoration project. Five invasive animals were judged to have potential for impact on the restoration project, primarily because effective control methods in natural systems are not available for these species. The evaluation shows good concurrence of invasive species of concern with existing District and regional invasive species control programs. Most species identified as potentially problematic for the restoration project are (1) already targeted by existing District or other regional agency control programs within the project area, (2) currently pose minimal risk to restoration due to past control efforts, (3) are considered high priorities by the District for development of control programs, or (4) are in the process of being evaluated in District field testing for development of best management practices.

The Kissimmee Watershed Program initiated a number of new studies in Fiscal Year 2009 (FY2009) (October 1, 2008–September 30, 2009). Program restoration evaluation scientists continued preparations for the next major phase of restoration reconstruction, Phase II/III, by initiating new monitoring studies that will provide baseline and post-restoration data for the evaluation of ecological responses to Phase II/III. A subset of metrics from these studies will be optimized for correlative analyses under the Phase II/III Integrated Studies. Monitoring to track responses to Phase II/III will include studies of hydrology, water quality (phosphorus and dissolved oxygen), geomorphology, river channel and floodplain vegetation, and aquatic invertebrate, herpetofauna, fish, and bird communities. Expansion of the Kissimmee River hydrologic monitoring network was completed, involving the installation of 16 new stage monitoring sites in Pool D, 13 of which are in the floodplain and three in remnant river channels; two of the three river channel sites also have flow monitoring capability. The enhanced hydrologic monitoring network will provide additional data for evaluation of the hydrologic restoration expectations and will support other evaluation studies, especially those associated with the Phase II/III Integrated Studies. The network will complement the existing Phase I network by extending hydrologic monitoring across the restoration project area. Another new effort initiated in 2009 is development of a plan for assessing the effect of the restoration project on phosphorus transport and retention.

In brief, the main accomplishments and findings of the Kissimmee Watershed Program in WY2009 are as follows:

- Phase IVB of backfilling for the Kissimmee River Restoration Project is nearly complete, and additions and improvements to the Istokpoga Canal and certain structures west of the river were completed. Widening of the C-37 canal in the Upper Kissimmee Basin will start in 2010.
- A technical document was completed and successfully peer-reviewed that identifies the water needed to protect fish and wildlife in the Kissimmee River and seven Lake Management Areas of the Kissimmee Chain of Lakes. The rule-making process for establishing Water Reservations for the river and lakes is under way, and the final rule is expected to be published in 2010.
- Operations under the interim water regulation schedule succeeded in maintaining continuous inflow to the Kissimmee River in WY2009.
- Monitoring of the environmental response to Phase I construction of the Kissimmee River Restoration Project continued. In WY2009, two components of the dissolved oxygen expectation exceeded expected values. However, phosphorus loads and concentrations have shown no declining trend since 2001. Densities of wading birds and waterfowl were lower than expected in WY2009.
- A new assessment of the potential impacts of invasive, nonindigenous species on the Kissimmee River Restoration Project found that District and regional control programs are addressing most invasive species of concern.
- New studies were initiated under the Kissimmee River Restoration Evaluation Program in preparation for evaluation of the next major phase of restoration construction (Phase II/III) in Pool D of the channelized river system. These studies will include monitoring of hydrology, water quality (phosphorus and dissolved oxygen), geomorphology, river channel and floodplain vegetation, and aquatic invertebrate, herpetofauna, fish, and bird communities.

INTRODUCTION AND BACKGROUND

Responding to the need for increased integration and coordination at basin and watershed scales, the South Florida Water Management District (SFWMD or District) has expanded the mission and geographic focus of the Kissimmee Watershed Program since the 1990s, when the program was formed primarily for the coordination and evaluation of the Kissimmee River Restoration Project (KRRP). Since then, following management and Governing Board direction, the Kissimmee Watershed Program has embarked on and participated in major projects to address basin- and watershed-level issues including (1) initiatives to address water supply and water quality issues, (2) development of regional modeling tools to enhance water management decisions, and (3) development of a long-term plan to address management of the Kissimmee Chain of Lakes (KCOL).

This chapter is an update to Chapter 11 of the *2009 South Florida Environmental Report* (SFER) – *Volume I* (SFWMD, 2009), and highlights (1) water year environmental conditions and their effects on the system; (2) newly available data from the Kissimmee River Restoration Evaluation Program (KRREP) studies; (3) descriptions of recent planning efforts; and (4) brief status updates on projects and other program activities during Water Year 2009 (WY2009) (May 1, 2008–April 30, 2009). The watershed, which includes the basins of the Kissimmee River in the Lower Kissimmee Basin and the KCOL in the Upper Kissimmee Basin, is depicted in **Figures 11-1** and **11-2**.

The chapter is organized into four main sections:

- The *Introduction and Background* section briefly summarizes the KRRP and other major projects taking place in the Kissimmee Basin. A description of the Kissimmee Basin and the history and background of the KRRP and KRREP are presented in the 2008 SFER (SFWMD, 2008a, Chapter 11).
- The second major section, *Cross-Watershed Activities,* describes the role of the Kissimmee Watershed Program in addressing issues that span the boundaries between the Kissimmee Basin and downstream ecosystems. This section includes subsections on (1) water management and operations, (2) development of Water Reservations for the Kissimmee River and Kissimmee Chain of Lakes, and (3) water quality programs in the Kissimmee Basin related to phosphorus management. Mercury is discussed in Chapter 3B of this volume.
- The third major section, *Kissimmee Basin Environmental Conditions*, summarizes environmental conditions in the Kissimmee Basin during WY2009. It emphasizes basin hydrologic conditions relative to water management decisions during the water year. During WY2009, hydrologic conditions in the Kissimmee Basin were strongly influenced by above-average wet season rainfall, especially associated with Tropical Storm Fay, and below-average dry season rainfall.
- The final major section, *Project Updates*, is devoted to presentations of monitoring data, status reports on ongoing projects, and descriptions of planning activities for new initiatives. This section includes (1) newly available Phase I restoration response data from the KRREP; (2) an evaluation of the potential effects of invasive species on the Kissimmee River Restoration Project; (3) progress on Phase II/III restoration evaluation studies and pilot studies; and (4) status updates on KRRP construction, the Kissimmee Basin Modeling and Operations Study (KBMOS), and other projects within the basin.

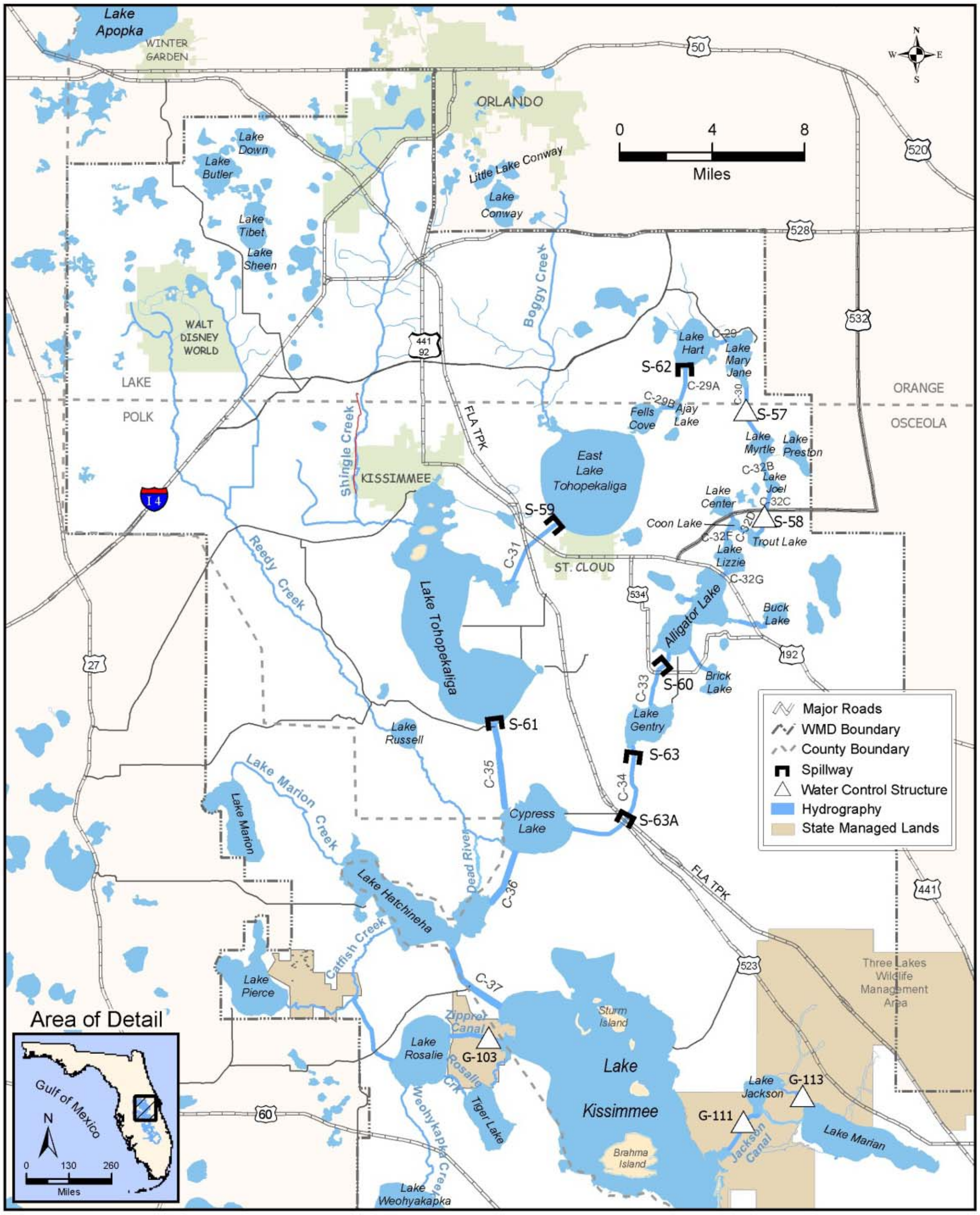


Figure 11-1. The Upper Kissimmee Basin.

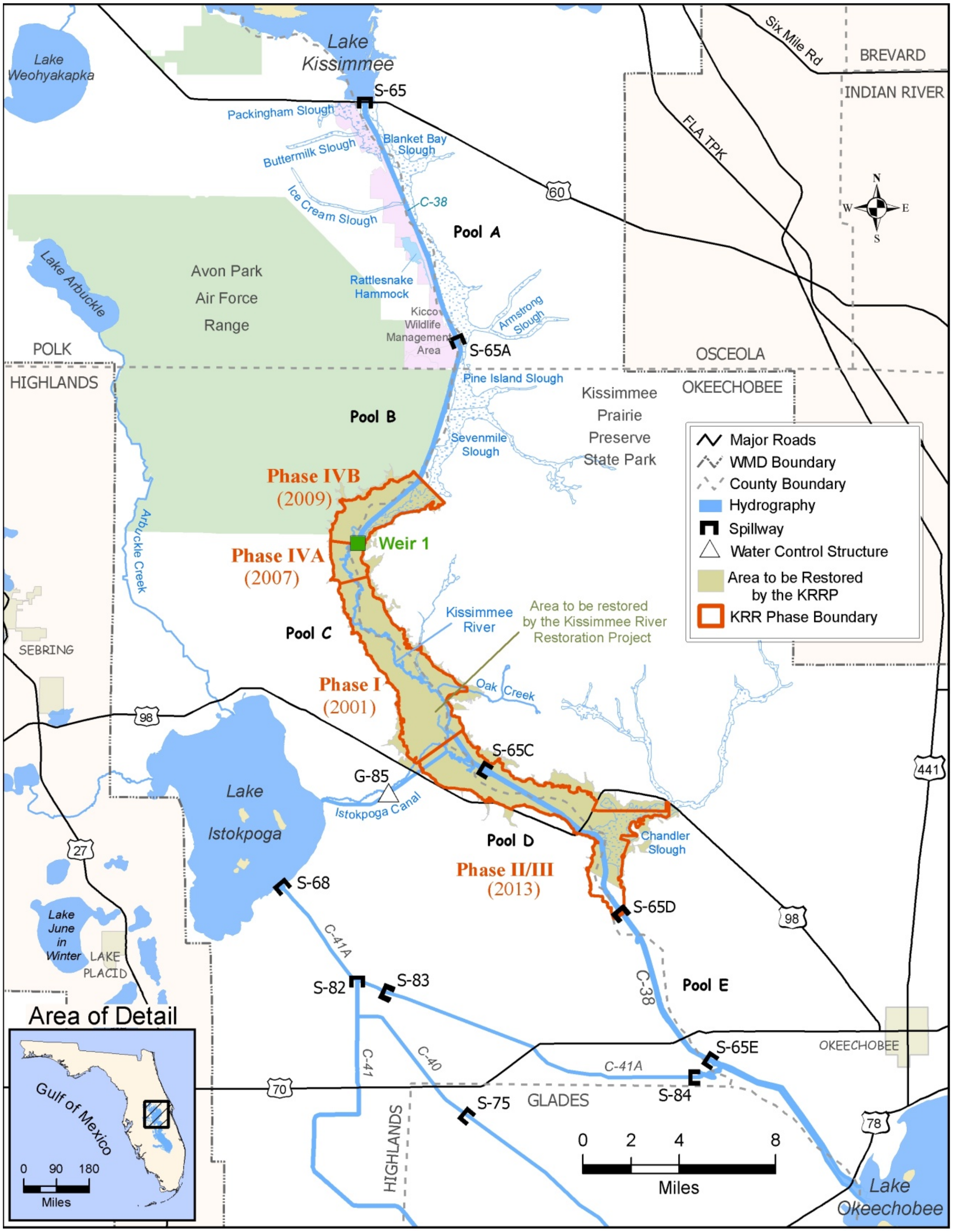


Figure 11-2. The Lower Kissimmee Basin.

KISSIMMEE RIVER RESTORATION PROJECT AND ASSOCIATED INITIATIVES

Concerns about environmental degradation and habitat loss in the Kissimmee Valley, and the potential contribution of the channelized river to eutrophication in Lake Okeechobee, were the impetus for the Kissimmee River Restoration Project. Successful restoration of the Kissimmee River depends largely on the reestablishment of hydrologic conditions similar to those of the pre-channelization period (Toth, 1990). The associated Kissimmee River Headwaters Revitalization Project (KRHRP) (USACE, 1996) is designed to provide sufficient storage in the headwater lakes in the Upper Kissimmee Basin to allow water regulation to approximate historical flow and volume characteristics in the Kissimmee River. An additional expected benefit is the improvement of the quantity and quality of lake littoral zone habitat in Lakes Kissimmee, Hatchineha, Tiger, and Cypress (USACE, 1996, Sections 1.3.2 and 5.1). Project modifications for the restoration will take place without jeopardizing existing levels of flood control in the Kissimmee Basin.

The KRHRP (organizationally, a component of KRRP) will culminate with the implementation of a new stage regulation schedule, called the Headwaters Revitalization Schedule, to operate the S-65 water control structure. The new schedule will allow water levels to rise 1.5 feet (ft) higher than the current schedule and will increase the water storage capacity of Lakes Kissimmee, Hatchineha, Cypress, and Tiger by approximately 100,000 acre-feet (ac-ft) [12,340 hectare-meters (ha-m)]. Approximately 97 percent of the 36,612 acres of land in the Upper Kissimmee Basin that will be impacted by the higher water levels have been acquired, and all projects to increase the conveyance capacity of canals and structures are in place to accommodate the larger storage volume except the C-37 widening project (see the *Kissimmee River Restoration Project Construction Activities* section of this chapter). The Headwaters Revitalization Schedule is scheduled for implementation in 2015, when the Lower Kissimmee Basin backfilling and other restoration construction are projected to be completed.

Because of the time lag between completion of the earliest phases of the construction project and the implementation of the Headwaters Revitalization Schedule, the U.S. Army Corps of Engineers (USACE) authorized the District to make releases from S-65 when the lake stage was in Zone B of the existing regulation schedule. Zone B allows for releases for environmental purposes when flood control releases are not needed, and is used to maintain flow in the reach of the restored river channel continuously through the year and to allow seasonal variability. Environmental releases according to this interim schedule began in July 2001 after Phase I construction for the KRRP had been completed and lake levels began to rise following the 2000–2001 drought. While the use of Zone B releases has been beneficial, it does not provide the full benefits of the Headwaters Revitalization Schedule (see the Kissimmee River Restoration Evaluation Program: Updates from the Phase I Monitoring Studies section of this chapter).

In the Lower Kissimmee Basin, the KRRP and KRHRP combined are expected to restore ecological integrity to approximately one-third of the river and floodplain, modifying a contiguous area of floodplain/river ecosystem of over 39 square miles (mi^2) [101 square kilometers (km^2)]. More than 20 mi^2 (52 km^2) of new wetlands will reestablish in areas that were drained by the canal, and 40 miles (mi) [64 kilometers (km)] of reconnected river channel will receive reestablished flow. In the Upper Kissimmee Basin, over 7,000 acres (ac) [2,800 hectares (ha)] of littoral marsh are expected to develop on the periphery of the four regulated lakes (USACE, 1996). The KRRP (including KRHRP and the KBMOS, described below) is funded under a 50/50 cost-share agreement between the SFWMD and the USACE. Engineering and construction components of the project are the responsibility of USACE, while the District's purview is land acquisition and ecological evaluation of the restoration project.

Restoration components encompass (1) acquiring 65,603 acres of land in the Lower Kissimmee Basin, of which approximately 98 percent have been acquired to date; (2) backfilling a total of approximately 22 mi (35 (km) of the C-38 canal (over one-third of the canal's length) from the lower end of Pool D north to the middle of Pool B; (3) reconnecting the original river channel across backfilled sections of the canal; (4) recarving sections of river channel destroyed during C-38 construction; and (4) removing the S-65B and S-65C water control structures and associated tieback levees. The material used for backfilling is the same material that was dredged during construction of the C-38 canal. Composed primarily of sand and coarse shell, this material was deposited in large spoil mounds adjacent to the canal.

Reconstruction of the river/floodplain's physical template is being implemented in four phases currently projected for completion by 2015 (**Table 11-1**). Phase I construction of the KRRP was completed in February 2001. Approximately 7.5 mi (12 km) of flood control canal were backfilled in Pool C and the southern portion of Pool B, nearly 1.3 mi (2 km) of river channel that had been obliterated during canal construction were recarved, and water control structure S-65B was demolished. These efforts reestablished flow to 14 mi (23 km) of continuous river channel and allowed for intermittent inundation of 5,792 ac (2,344 ha) of floodplain.

Table 11-1. Sequence of backfilling construction phases of the Kissimmee River Restoration Project (KRRP) with selected benefits.

Construction Sequence	Name of Construction Phase	Timeline	Backfilled Canal (miles)	River Channel Recarved (miles)	River Channel to Receive Reestablished Flow (miles)	Total Area (acres)	Wetland Gained (miles)	Location and Other Notes
1	Phase I Project Area	1999–2001 (complete)	8	1	14	9,506	5,792	Most of Pool C, small section of lower Pool B
2	Phase IVA Project Area	2006–2007 (complete)	2	1	4	1,352	512	Upstream of Phase I in Pool B to Wier #1
3	Phase IVB Project Area	2008–2010	4	4	6	4,183	1,406	Upstream of Phase IVA in Pool B (upper limit approx. at location of Wier #3)
4	Phase II/III Project Area	2012–2015	9	4	16	9,921	4,688	Downstream of Phase I (lower Pool C and Pool D south to the CSX Railroad bridge)
	Restoration Project Totals		**22**	**10**	**40**	**24,963**	**12,398**	

The second construction phase (Phase IVA) was completed in September 2007. This phase extends north into Pool B from the northern terminus of the Phase I project area (**Figure 11-2**). Phase IVA reconnected 4 miles of historical river channel by backfilling 2 miles of C-38, and is expected to recover 512 ac (207 ha) of floodplain wetlands. As of April 2009, Phase IVB, upstream of Phase IVA, was more than 40 percent complete and expected to be finished in early 2010. Phase II/III, the last phase of construction, is scheduled to begin in 2012 for completion by 2015. While the restoration phases were originally named in the order of expected completion, the sequence has changed over the years for logistical reasons (i.e., budgetary considerations, coordination with land acquisition, or ease of access). Upper and Lower Kissimmee Basin land acquisition for both the KRRP and KRHRP has been substantially completed.

A major component of the restoration project is the evaluation of restoration success through the KRREP, a comprehensive ecological monitoring program (SFWMD, 2007a; SFWMD, 2005a; SFWMD, 2005b). Evaluating the success of the KRRP is a requirement of the District's cost-share agreement with the USACE. Success is being tracked using 25 performance measures (SFWMD, 2005b) to evaluate how well the project meets its ecological integrity goal. Ecological integrity is defined as a reestablished river-floodplain ecosystem that is "capable of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region" (Karr and Dudley, 1981). The performance measures, called expectations, are based on estimated pre-channelized system reference conditions and have undergone an external peer-review process. Ongoing restoration evaluation status is reported in several ways, including conference presentations, peer-reviewed and District publications, and chapters in the annual SFER. A final evaluation of project success will be based on these data. The most current evaluation program data are reported in the *Project Updates* section of this chapter. Monitoring for ecological evaluation of restoration success will continue for at least five years after construction is completed or until ecological responses have stabilized.

A BASIN PERSPECTIVE

The District's Kissimmee Watershed Program was created in the early 1990s, originally to provide scientific expertise for coordination and ecological evaluation of the KRRP, including both the restoration project and the headwater lakes modifications included in the KRHRP. In recent years, the District has expanded the Kissimmee Watershed Program to encompass more of the Kissimmee Watershed, including 19 lakes in the KCOL, to more explicitly address hydrologic and management linkages between the Upper and Lower Kissimmee basins. The key strategic priority of the Kissimmee Watershed Program is to integrate management strategies in the Kissimmee Watershed with restoration of the Kissimmee River (SFWMD, 2006b). In line with this priority, the primary goals of the Kissimmee Watershed Program are restoration of ecological integrity to the Kissimmee River and its floodplain, and development of a long-term plan for addressing water and natural resource management issues in the KCOL, while retaining the existing level of flood control in the Kissimmee Basin.

In addition to the KRRP (**Figure 11-3**, panel A) and the KRHRP (**Figure 11-3**, panel B), coordinated initiatives designed to meet these program objectives include the interagency Kissimmee Chain of Lakes Long-Term Management Plan (KCOL LTMP) in the Upper Kissimmee Basin (**Figure 11-3**, panel C), the KBMOS (**Figure 11-3**, panel D), and the Kissimmee Basin Water Reservations. Activities associated with this suite of Kissimmee Watershed Program initiatives span ecosystem restoration, restoration evaluation, hydrologic management, modeling, aquatic plant management, land management, adaptive management of natural resources, water quality improvement, and water supply planning.

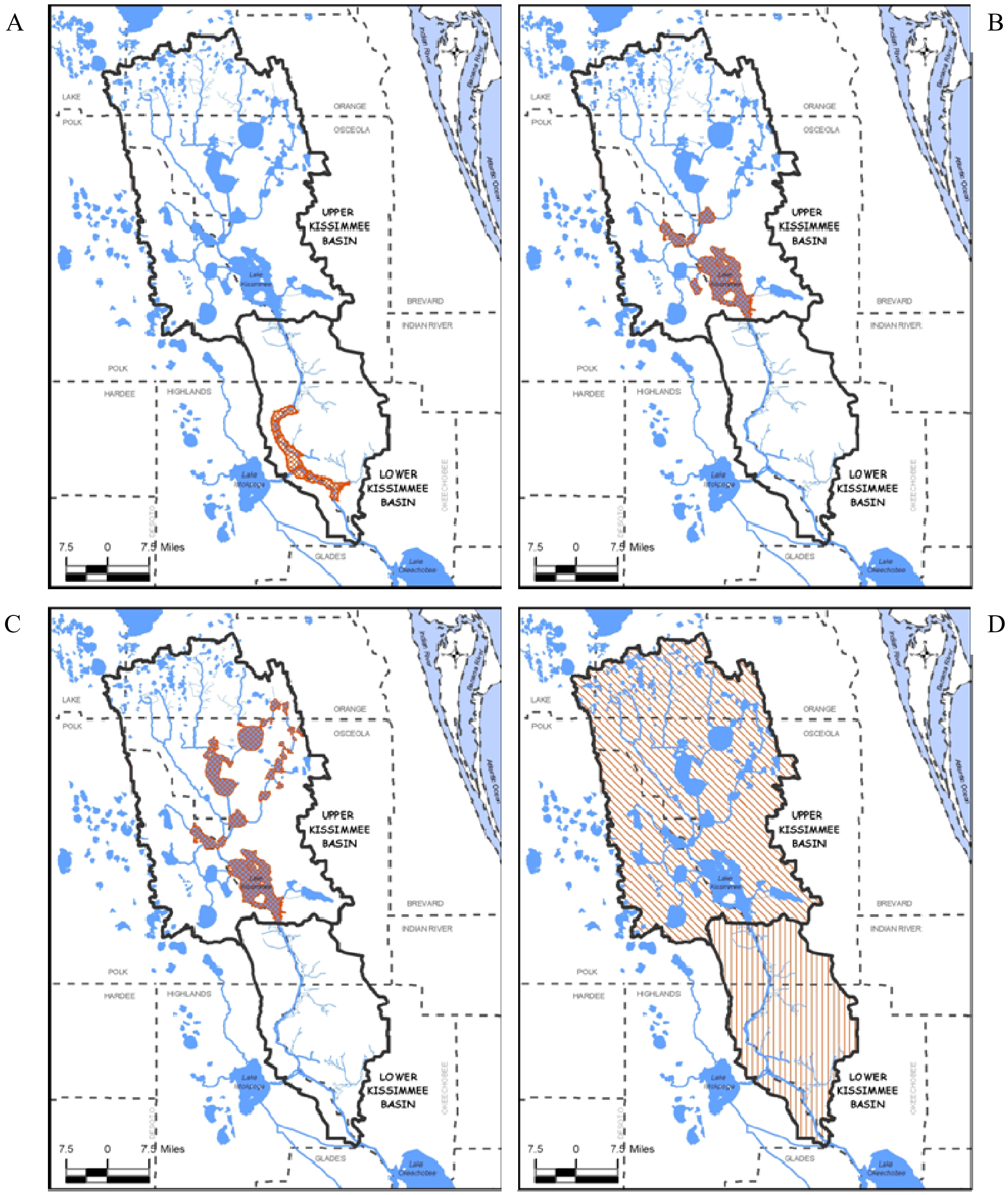


Figure 11-3. Geographic scopes (colored, hatched areas on maps) of major initiatives in the Kissimmee Basin including the (A) KRRP, (B) Kissimmee River Headwaters Revitalization Project, (C) Kissimmee Chain of Lakes Long-Term Management Plan, and (D) Kissimmee Basin Modeling and Operations Study.

CROSS-WATERSHED ACTIVITIES

Water-related issues with the potential for regional effects beyond the boundaries of individual basins and watersheds are a primary concern of the SFWMD, which works to ensure close coordination among related projects. The Kissimmee Watershed Program works both within the District and with other agencies to address watershed-scale water and natural systems issues in regions that are hydrologically connected to the Kissimmee Basin. In addition to the SFWMD's efforts, several other agencies are involved in the many construction, planning, monitoring, evaluation, and modeling projects needed to address watershed-scale issues. This section focuses on the Kissimmee Watershed Program's role and recent activities in addressing these far-reaching interactions, specifically in the areas of water management, water quality, and water supply.

WATER MANAGEMENT, OPERATIONS AND COORDINATION

Hydrologic conditions in the Kissimmee Basin are a function of natural hydrologic processes (e.g., rainfall, evapotranspiration) and management decisions that consider multiple needs. Much of the basin's 50 inches of annual rainfall is conveyed as surface water runoff through a network of canals that connects the Kissimmee Chain of Lakes (**Figure 11-1**). Outflow from Lake Kissimmee enters the channelized and reconstructed reaches of the Kissimmee River before continuing southward to Lake Okeechobee (**Figure 11-2**).

The movement of water through this network is regulated by 13 water control structures managed by the SFWMD in accordance with regulations prescribed by the USACE. Nine structures and seven regulation schedules maintain lake and canal stages in the KCOL. Four structures manage stages along the Kissimmee River. A fifth structure, S-65B, was demolished in 2000 as part of the KRRP. These canals and structures are part of the Central and Southern Florida (C&SF) Flood Control Project that provides flood control and water supply for the region. Operation of each structure is determined by a stage regulation schedule specifying the discharges that can be made through the structure, depending on the headwater stage at the structure and the time of year. The system is also operated with the intent to protect environmental values, particularly ecological integrity in the Kissimmee River.

The operation of water control structures in the Kissimmee Basin can influence the timing and volume of flows to downstream ecosystems. Water management operations in the Kissimmee Basin must be coordinated with the rest of the Kissimmee-Okeechobee-Everglades (KOE) system regulated by the C&SF Project. This coordination is achieved through weekly interagency meetings between the SFWMD staff and USACE to review recent rainfall data, the climatological outlook, water levels, and system operations in the various parts of the KOE system, and the overall condition of the entire system. Based on this information, environmental recommendations can be made to modify operations within existing operational flexibility. Second, flows in the Kissimmee River are formally considered by the interagency team in the decision making process for managing flows out of Lake Okeechobee. Third, an emergency modeling team is used to guide operations during flood events to minimize impacts on natural systems. Fourth, temporary deviations to the stage regulation schedules can be requested from the USACE to address specific issues. The development of a temporary deviation request involves support from an interdepartmental team as well as interagency review. Kissimmee Division staff was involved in temporary deviation requests for the extreme drawdown of Lake Tohopekaliga for fisheries habitat improvement in 2004, in modifying spring recessions in East Lake Tohopekaliga and Lake Tohopekaliga for snail kites (*Rostrhamus sociabilis*) in 2006, and in allowing water supply releases from Lake Istokpoga to downstream users during the recent drought if water levels fell below the low pool of the regulation schedule. Lastly, permanent revisions of the stage regulation schedules used for the C&SF Project structures in the Kissimmee

Basin consider the potential for impacts on downstream systems. The KBMOS is an example of such a regulation schedule review (see the *Introduction and Background* and *Project Updates* sections in this chapter).

KISSIMMEE BASIN WATER RESERVATIONS

The Central Florida region is experiencing rapid population growth, especially in the region of Orlando, Kissimmee, and St. Cloud. The population in the Kissimmee Basin Planning Area is projected to increase by approximately 150 percent from 2000–2025, growing from approximately 500,000 to more than 1.1 million residents (SFWMD, 2007b). One key factor that will control growth is availability of water to service the increasing population. The demand for public water supply is expected to double from almost 114 million gallons per day (mgd) (432,000 cubic meters per day) in 2000 to over 235 mgd (890,000 cubic meters per day) by 2025 (SFWMD, 2007b). In the Upper Kissimmee Basin, where 90 percent of the projected growth will occur, water supply for consumptive uses is withdrawn almost exclusively from the Floridan aquifer. The SFWMD, along with the two water management districts that abut this region — the St. Johns River Water Management District (SJRWMD) and Southwest Florida Water Management District (SWFWMD) — have determined that the limit of sustainable withdrawal from the Floridan aquifer will be reached in 2013, prompting the current investigation of alternative supplies, including withdrawals from surface waters. Potential withdrawal from the KCOL is of particular concern due to potential ecological impacts on the lakes and on Kissimmee River restoration.

At its June 2008 meeting, the SFWMD's Governing Board approved a resolution to begin rule development for the reservation of water necessary for the protection of fish and wildlife in the Kissimmee River, the river's floodplain, and the KCOL (eight water bodies in total). A Water Reservation is a tool provided by Section 373.223(4), Florida Statutes (F.S.), which allows the water necessary for the protection of fish and wildlife to be reserved from use by permit applicants through a formal rulemaking process. In 2008–2009, the technical work to identify the water needed to protect fish and wildlife was completed for all eight reservation water bodies in the Kissimmee Basin. This technical work was performed by District staff who relied heavily on previous work by the Kissimmee Watershed Program on the KRRP, the KRREP, the KBMOS, and the KCOL LTMP. It also made use of data published by the Florida Fish and Wildlife Conservation Commission (FWC) and the U.S. Fish and Wildlife Service (USFWS).

The technical work began by identifying eight reservation water bodies with important fish and wildlife resources in the Kissimmee Basin. The Kissimmee River and its floodplain were treated as a single reservation water body because of the close coupling of river channel and floodplain hydrology. The lakes in the KCOL were grouped into seven reservation water bodies. Each of these seven water bodies (also referred to as Lake Management Areas) consists of one or more lakes managed with the same regulation schedule (i.e., they have the same water levels). Therefore, all lakes within a reservation water body will experience the same change in water level from a withdrawal. These reservation water bodies are Lakes Myrtle-Preston-Joel, Hart-Mary Jane, East Tohopekaliga, Tohopekaliga, Alligator Chain, Gentry, and Kissimmee-Cypress-Hatchineha (**Figure 11-4**).

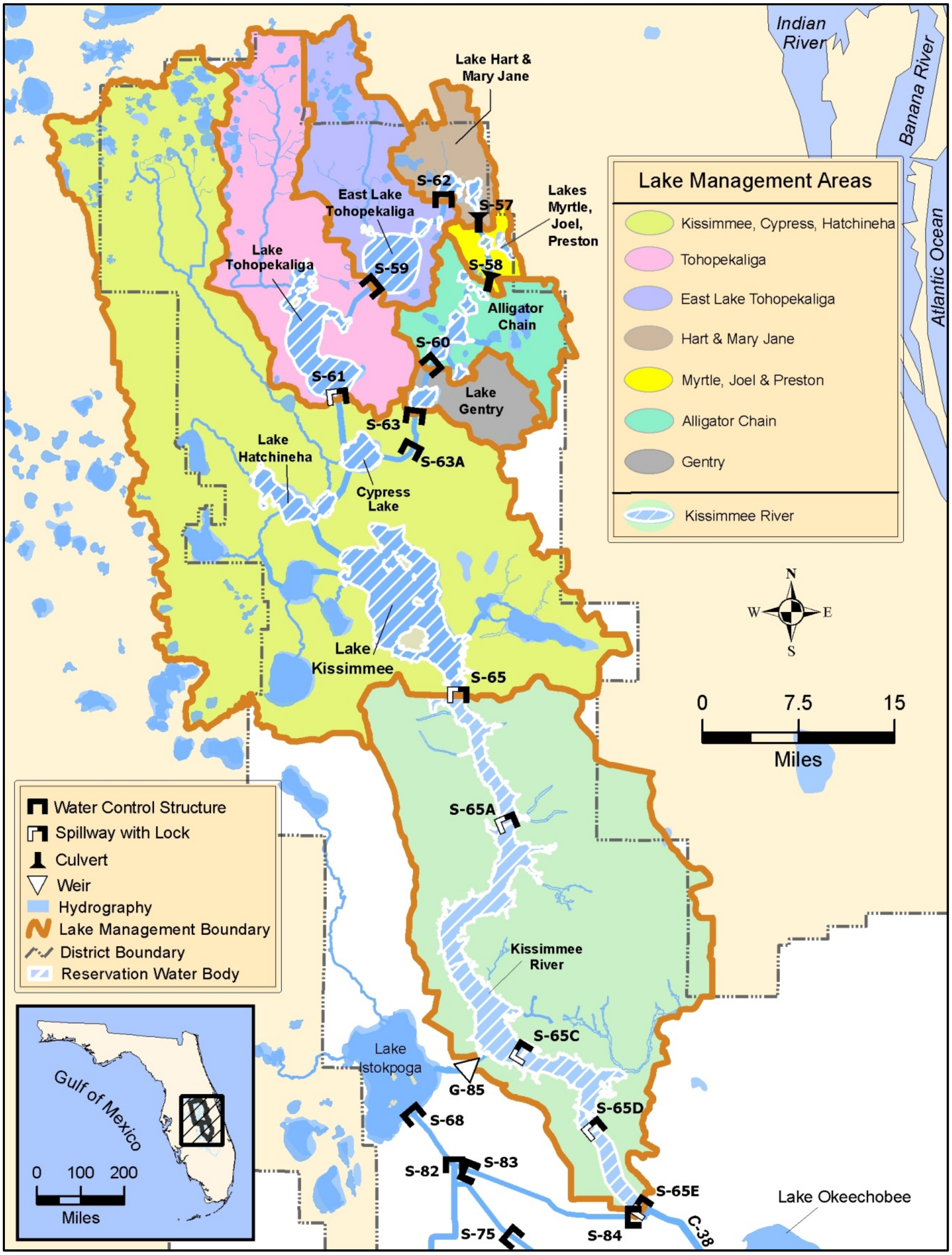


Figure 11-4. Location of the eight reservation water bodies in the Kissimmee Basin.

For each reservation water body, a comprehensive listing of the existing fish and wildlife resources was developed from the best available data on fish, amphibians, reptiles, birds, and mammals. This listing was developed from published studies, technical reports, and unpublished data, especially from the FWC and USFWS for the KCOL and from the SFWMD restoration evaluation program for the Kissimmee River. The comprehensive lists for each water body can be found in the technical document. In the KCOL, key groups of species included fish (45 species total with 26 common to all lakes, including largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*), the federally endangered snail kite and wood stork (*Mycteria americana*), the state-listed Florida sandhill crane (*Grus canadensis pratensis*), and water bird nesting colonies. In the Kissimmee River, key groups of species included fish (38 native species dependent on the inundated floodplain), amphibians and reptiles (24 species that may occur in broadleaf marshes), birds (66 wetland-dependent species including wading birds and waterfowl), and mammals (four species of wetland-dependent species).

An ecosystem approach was taken to identify hydrologic requirements. Stages or flows were identified that are needed to maintain important habitat (e.g., wetland plant community hydroperiod) for foraging and reproduction and to provide seasonal access to these habitats. For the Kissimmee River, hydrologic requirements were expressed as a set of performance measures that focused on seasonality of flow, variability of water level fluctuation, floodplain inundation, and recession events. The river performance measures were based on the analysis of measured flow and stage data collected before channelization. For each lake reservation water body, threshold criteria were identified that addressed recession rates, seasonal high and low water levels, and in some cases hydraulic criteria tied to special species needs. These performance measures were combined into the form of a target annual stage hydrograph threshold. Inter-annual variability was not explicitly incorporated into the initial reservations for the lakes, but it is being incorporated into criteria under development along with the KBMOS regulation schedule revisions underway by the USACE and the District.

The performance measures were used to develop target time-series of flow or stage that represented the water needed to protect fish and wildlife for each of the reservation water bodies. The target time-series were created by evaluating the performance measures against the output from a hydrologic/hydraulic model. The time-series were compared against the 41-year period of representative water levels and flows (1965–2005) to identify how much of the total flow was needed to protect existing fish and wildlife resources in the basin. The process for adjusting the model output time-series to create a target time-series is described in detail in the technical document. In April 2009, the technical document summarizing the science and modeling used to identify the water needed to protect fish and wildlife underwent an external scientific peer review by a panel of specialists with expertise in wetland plant communities, fish, wildlife (especially birds), hydrology, and hydrologic modeling. The panel concluded that the data and information used to develop the technical document "are technically sound, and inferences and assumptions made regarding the linkages between hydrology and the protection of fish and wildlife are based upon sound scientific information." A number of comments were provided by the peer-review panel and stakeholders. These comments were primarily for clarification and additional detail, and are being incorporated into the final document. The draft technical report and the peer-review panel comments are available on the District's web page at www.sfwmd.gov/watersupply.

Currently, an administrative rule is being developed that incorporates the technical results into consumptive use permit rule criteria. The rule development process has included a series of public workshops to provide the public and stakeholders with information about the Water Reservation process and results of the technical work. The first of these of workshops was held in December 2008. The rule development process will end with the adoption of a rule by the SFWMD's Governing Board.

WATERSHED WATER QUALITY

Lake Okeechobee Watershed

The Kissimmee Basin lies entirely within the Lake Okeechobee Watershed and is therefore within the geographic jurisdiction of the 2004 Lake Okeechobee Protection Act (LOPA), which requires that applicable water quality criteria be achieved and maintained in Lake Okeechobee and its tributary waters. The Lake Okeechobee Watershed Protection Plan (LOWPP), authorized under the LOPA to address water quality issues, evaluates nutrient effects on the lake from the Kissimmee and other tributary basins. The LOWPP includes among its four priority basins in the Lake Okeechobee Watershed the S-65D and S-65E sub-basins, which include the lowermost pools and still-channelized sections of the Kissimmee River. The LOPA requires that the LOWPP be reevaluated every three years to determine if further phosphorus load reductions are needed to achieve the Total Maximum Daily Load (TMDL). The last reevaluation report was completed in February 2007 and submitted to the Florida legislature in March 2007.

The Northern Everglades and Estuaries Protection Program (NEEPP) was created in 2007 by the Florida legislature, which expands upon the LOWPP to encompass the Caloosahatchee and St. Lucie rivers and estuaries as well as the Lake Okeechobee Watershed. In accordance with this legislation, the SFWMD and coordinating agencies developed a technical plan for Phase II of the Lake Okeechobee Watershed Construction Project and river watershed protection plans for the Caloosahatchee and St. Lucie watersheds (SFWMD et al., 2008; SFWMD et al., 2009a, b). These plans are intended to augment and enhance restoration currently under way in the remnant Everglades south of the lake. The NEEPP provides a vehicle for meeting the Kissimmee Basin's portion of the TMDL for Lake Okeechobee.

Kissimmee Basin

Monitoring of nutrient loading from the Kissimmee Basin to Lake Okeechobee is reported in Chapter 10 of this volume. Discharges and loads are divided among those originating in the Lower Kissimmee sub-watershed (between S-65 and S-65E) and those originating in the Upper Kissimmee sub-watershed (above S-65). (The geographical areas of these two sub-watersheds are identical to the areas referred to as the Upper and Lower Kissimmee basins in other parts of this chapter.) During WY2009, the entire Kissimmee Basin (both Upper and Lower sub-watersheds) contributed 169 metric tons (mt) of total phosphorus (TP) to Lake Okeechobee, or 26 percent of the total lake load of 656 mt (see Chapter 10 of this volume). This amount is equal to the average annual loading of 169 mt during the 1991–2005 LOWPP baseline period, which was 31 percent of the total lake load (549 mt) during that period (SFWMD et al., 2008).

Although the population of the Orlando-Kissimmee-St. Cloud region has grown rapidly, the Kissimmee Basin is still primarily rural. As of 2006 (SFWMD et al., 2008), only 5 percent of the Lower Kissimmee sub-watershed was urban and the rest was predominantly agricultural (45 percent), natural (34 percent), and woodland/rangeland (15 percent). In the Upper Kissimmee sub-watershed, urban areas comprised 20 percent of land use and most of the remaining area was agricultural (23 percent), natural (52 percent), and woodland/rangeland (4 percent). Most of the Upper Kissimmee sub-watershed is in Osceola County, where residential and commercial development is taking place on large tracts of agricultural land, most of which was used to graze cattle. Nonpoint-source runoff of nutrients and other contaminants is the main water quality concern arising from this urban development because municipal wastewater treatment effluents have been diverted away from the surface water system to reclamation and irrigation facilities, rapid infiltration basins, and land spreading operations. However, it should be noted that the 2007 unit load estimate for total phosphorus from urban land uses [0.66 pounds (lbs) TP/acre)] is not much different than the unit load for most agricultural land uses. For example, unit loading from pastures and rangeland ranges from 0.27–0.72 lbs/acre, and citrus is 1.62 lbs/acre. In comparison, loading from natural areas is 0.2 lbs/acre (SFWMD, 2007b).

Water Quality Management

Within the Kissimmee Basin, several agencies work to address water quality issues, including the Florida Department of Environmental Protection (FDEP), the Florida Department of Agriculture and Consumer Services (FDACS), the U.S. Environmental Protection Agency (USEPA), and the SFWMD. This section describes the current efforts of these agencies in the Kissimmee Basin.

As presented in more detail in Chapter 11 of the 2009 SFER (SFWMD, 2009), the FDEP has identified elevated nutrient concentrations as a principal water quality issue in the Kissimmee Basin and has verified 18 water bodies as impaired for nutrients (FDEP, 2006). The listing of verified impaired water bodies is the second of a five-phase TMDL process in the state of Florida (Chapter 403.067, F.S.; see www.dep.state.fl.us/water/tmdl/cycle.htm) and occurs after an initial basin assessment (the first phase). The FDEP also has been developing draft TMDLs for some water bodies listed as impaired, which is the third phase of the overall TMDL process. Currently, the FDEP is working on internal draft TMDL documents for Lake Marian, Lake Jackson, Lake Kissimmee, and Lake Cypress.

In general, the TMDL development involves determining the maximum amount of a given pollutant that a water body can assimilate and still meet its water quality standards. Water quality standards include a water body's designated use and the applicable numeric or narrative water quality criterion for pollutants. Water bodies in the Kissimmee Basin listed as impaired are designated as Class III water bodies and subject to those applicable state water quality criteria [see Chapter 62-302, Florida Administrative Code (FAC)]. The methodology for determining whether a water body is impaired is described in the Impaired Waters Rule (IWR, Chapter 62-303, F.A.C.).

Because restoration of natural filtration, reaeration, and biological processes in the Kissimmee River is expected to improve water quality with respect to nutrients and dissolved oxygen (DO), the restored area of the river is exempt from TMDL development according to the state's IWR. However, certain sections of the Lower Kissimmee sub-watershed outside of the restoration project area have been identified as impaired for nutrients and/or DO and will have TMDLs developed. These sections include Blanket Bay Slough (Pool A drainage), Oak Creek (Pool C drainage), an upland watershed in the Pool D drainage, and the S-154C sub-watershed below S-65E.

With the FDEP as the lead agency, the initial timeline for developing TMDLs for impaired waters is 2005–2011. One major factor influencing the TMDL developmental timeline is whether a water body is also on the USEPA's original 1998 list of impaired waters (see www.dep.state.fl.us/water/watersheds/assessment/docs/303(d)-2.pdf). Typically, waters existing on this original list have a higher priority on the FDEP's TMDL development schedule than waters not included on this list. Because of the amount of impaired listings in the state of Florida (both the current FDEP lists and USEPA's original 1998 list), it is probable that some TMDLs in the Kissimmee Basin may not be developed until after 2011.

After a TMDL is developed and adopted into rule (see Chapter 62-304, F.A.C.), the FDEP may develop and implement Basin Management Action Plans [(BMAPs), Phases 4 and 5 of the five-phase FDEP process] as a basis for reaching pollutant load reductions (Section 403.067, F.S.; see www.dep.state.fl.us/water/watersheds/bmap.htm). This process may include more detailed allocations among point and nonpoint sources of pollutant loading in the basin. In addition to any point and nonpoint sources of nutrients, allocations of nutrient loadings may be made to historical sources (e.g., the phosphorus-laden sediments within a water body) and upstream sources (e.g., those entering an impaired water body from upstream lakes). In the Kissimmee Basin, any sites found to be contributing excessive nutrient inputs will probably be categorized as nonpoint sources of pollution. The BMAPs will be developed with extensive stakeholder input and will contain final allocations, strategies for meeting the allocations, schedules for implementation, funding mechanisms, applicable local ordinances, and other elements.

The LOWPP and NEEPP identify areas for future legislative support to successfully implement the state's commitment to protect and restore Lake Okeechobee and to achieve its TMDL. Total phosphorus reductions and other water quality improvements are planned to be achieved through both the implementation of source controls, including Best Management Practices (BMPs), and regional projects such as Stormwater Treatment Areas (STAs). BMPs are mandatory unless an agricultural landowner monitors water quality and demonstrates that BMP implementation is not needed. In the Upper and Lower Kissimmee sub-watersheds, implementation of comprehensive source control measures is mandated by the LOWPP and provides for a cost-effective way to reduce nutrients discharged from both agricultural and non-agricultural land uses that are nonpoint source contributors. As required by the legislation, the coordinating agencies (FDACS, FDEP, and SFWMD) are expanding existing and developing new source control measures that include BMPs for agricultural and non-agricultural land uses, complementary to existing regulatory source control programs. Under the LOWPP, the SFWMD and FDACS initiated a coordinated effort to work with agricultural landowners within the Lower Kissimmee sub-watershed to implement BMPs. The FDACS is also making progress in the Upper Kissimmee sub-watershed. Landowners implementing conservation plans are being enrolled in the BMP program. In WY2009, the SFWMD continued to focus on rulemaking efforts that will expand the BMP rule to the Upper Kissimmee sub-watershed. For additional details, see Chapter 4 of this volume.

Ambient Water Quality Monitoring

Since 1981, the SFWMD has maintained a long-term water quality sampling program in five major lakes of the KCOL (East Lake Tohopekaliga, Lake Tohopekaliga, Cypress Lake, Lake Hatchineha, and Lake Kissimmee) and three main tributaries to these lakes (Boggy Creek, Shingle Creek, and Reedy Creek). Sampling is conducted monthly for TP, total nitrogen (TN), phytoplankton chlorophyll *a*, turbidity, water transparency, DO, and other constituents. One station is sampled at each tributary and up to three stations are sampled in each lake. Since 1973, the SFWMD also has sampled water quality in C-38 and/or lateral tributaries and remnant (non-flowing in the channelized system) and restored sections of river channel. In 2004, the SFWMD initiated additional sampling in the Kissimmee Basin under its Lake Okeechobee Watershed Assessment (LOWA) Program (see Chapter 10 of this volume). These stations are sampled for TP only. In the Upper Kissimmee sub-watershed, 12 stations have been added at lake tributaries, connecting canals, and water control structures. In the Lower Kissimmee sub-watershed, over 60 stations have been added within basins along the river.

Other sampling in the Kissimmee Basin has been conducted by the FWC, Florida Lakewatch, FDEP, USACE, U.S. Geological Survey (USGS), SWFWMD, Orange County, Polk County, Reedy Creek Improvement District, and City of Orlando. The FWC monitoring program includes the lakes sampled by the SFWMD plus Alligator Lake, Lake Gentry, Lake Jackson, and Lake Marian. Water quality is sampled for parameters similar to the SFWMD parameter list, but sampling is done quarterly instead of monthly. Florida Lakewatch samples 12 of the 19 lakes — Alligator Lake, Brick Lake, Lake Lizzie, Coon Lake, Lake Center, Ajay Lake, Fells Cove, Lake Gentry, East Lake Tohopekaliga, Lake Tohopekaliga, Cypress Lake, and Lake Kissimmee. Monitoring is conducted monthly for TP, TN, chlorophyll *a*, and Secchi depth. The FDEP utilizes the Florida STORET database (http://storet.dep.state.fl.us/WrmSpa/), which includes data from the FDEP and other sources, to prepare its water quality assessments. Data were compiled from all available sources for its 2006 water quality assessment of the Kissimmee Basin. The SFWMD supplied over half of the data used in that assessment. The FDEP conducts these assessments on a five-year cycle, and the next assessment is scheduled for 2010.

Further information about water quality monitoring in the basin can be found in SFWMD (2005a, Chapters 4 and 5), FDEP (2006), and SFWMD (2008b).

KISSIMMEE BASIN HYDROLOGIC CONDITIONS IN WATER YEAR 2009

RAINFALL

The drought conditions present in WY2007 and WY2008 continued into WY2009. Total rainfall was 40.00 inches (81 percent of normal) in the Upper Kissimmee Basin and 44.57 inches (87 percent of normal) in the Lower Kissimmee Basin. Rainfall followed a seasonal pattern with most precipitation occurring in the wet season months of June–October (**Figure 11-5**). Wet season rainfall totaled 33.85 inches in the Upper Basin and 38.35 inches in the Lower Basin. The total wet season rainfall exceeded long-term averages by 9 percent in the Upper Kissimmee Basin and 34 percent in the Lower Kissimmee Basin. The below-average water year rainfall totals resulted from below-average rainfall in every dry season month in both the Upper and Lower Kissimmee basins (**Figure 11-5**). The timing and quantity of rainfall was an important factor in determining water levels in and flows through the water bodies of the Kissimmee Basin.

TEMPORAL HYDROLOGIC PATTERNS

During WY2009, the seasonal fluctuation of water levels in the Upper Kissimmee Basin lakes was influenced by the timing and quantity of rainfall and the constraints imposed by regulation schedules. At the beginning of the water year, water was discharged from each group of lakes so that the water level declined with the regulation schedule line (**Figure 11-6**). For Lake Tohopekaliga, the water level followed the schedule line for a temporary deviation, which was described in detail in Chapter 11 of the 2009 SFER (SFWMD, 2009). After May 31, water levels were allowed to rise in response to early wet season rainfall until they reached the summer plateau of the regulation schedule. Water levels in all of the lakes rose rapidly above the regulation schedule when Tropical Storm Fay passed over the basin on August 20. At the S-65 structure on Lake Kissimmee, 7 inches of rainfall were recorded on August 20, and more than 12 inches were recorded for the August 15–24 time period (**Figure 11-7A**). By the end of the wet season on October 31, the smaller lakes (Hart-Mary Jane, Myrtle-Preston-Joel, and Alligator Chain of Lakes) in the KCOL refilled to the highest elevation of their regulation schedules. However, East Lake Tohopekaliga and Lake Tohopekaliga did not refill to the high stage of their regulation schedules (**Figure 11-6**).

Unlike the other lakes, the water level in Lakes Kissimmee, Cypress, and Hatchineha was also influenced by releases made to the Kissimmee River. Early in the wet season, rainfall (**Figure 11-7A**) caused the water level in Lake Kissimmee to increase (**Figure 11-7B**) and allowed low discharge of 200-300 cubic feet per second (cfs) to be maintained. The intense rainfall produced by Tropical Storm Fay caused water levels to rise above the regulation schedule lines in Lake Kissimmee (**Figure 11-7B**) and other lakes (**Figure 11-6**) for a short period of time, and releases were made to downstream water bodies. At S-65, the discharge peaked at 7,767 cfs on August 27. Discharge from each lake was rapidly reduced as water levels dropped below the regulation schedule lines. Because of the low rainfall in September and despite above-average rainfall in October, water levels in Lakes Kissimmee, Cypress, and Hatchineha did not reach the high stage of the regulation schedule. In these lakes, water levels fell gradually during the dry season (November–June) in response to below-average rainfall, evapotranspiration, and discharge to the Kissimmee River.

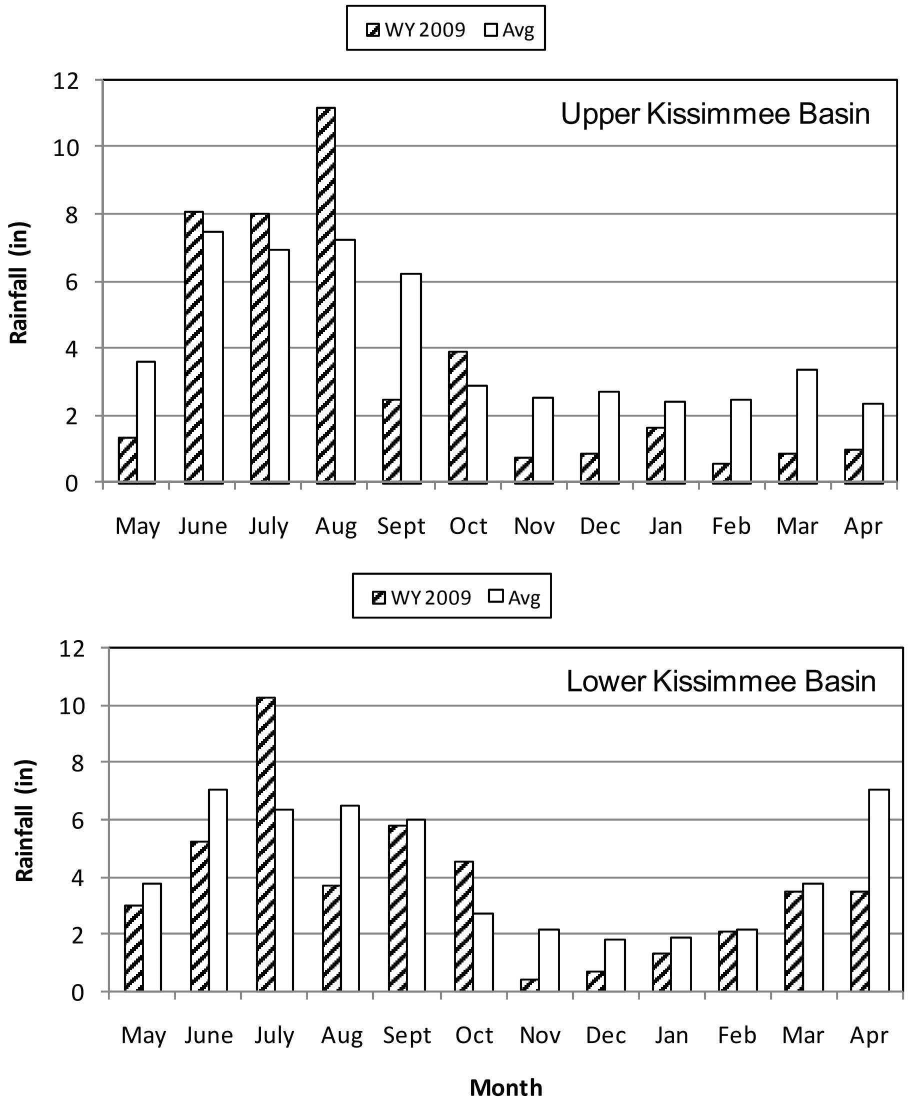


Figure 11-5. Monthly rainfall for Water Year (WY2009) (May 1, 2008–April 30, 2009) and average rainfall (1971–2000) over the Upper Kissimmee Basin (top) and the Lower Kissimmee Basin (bottom).

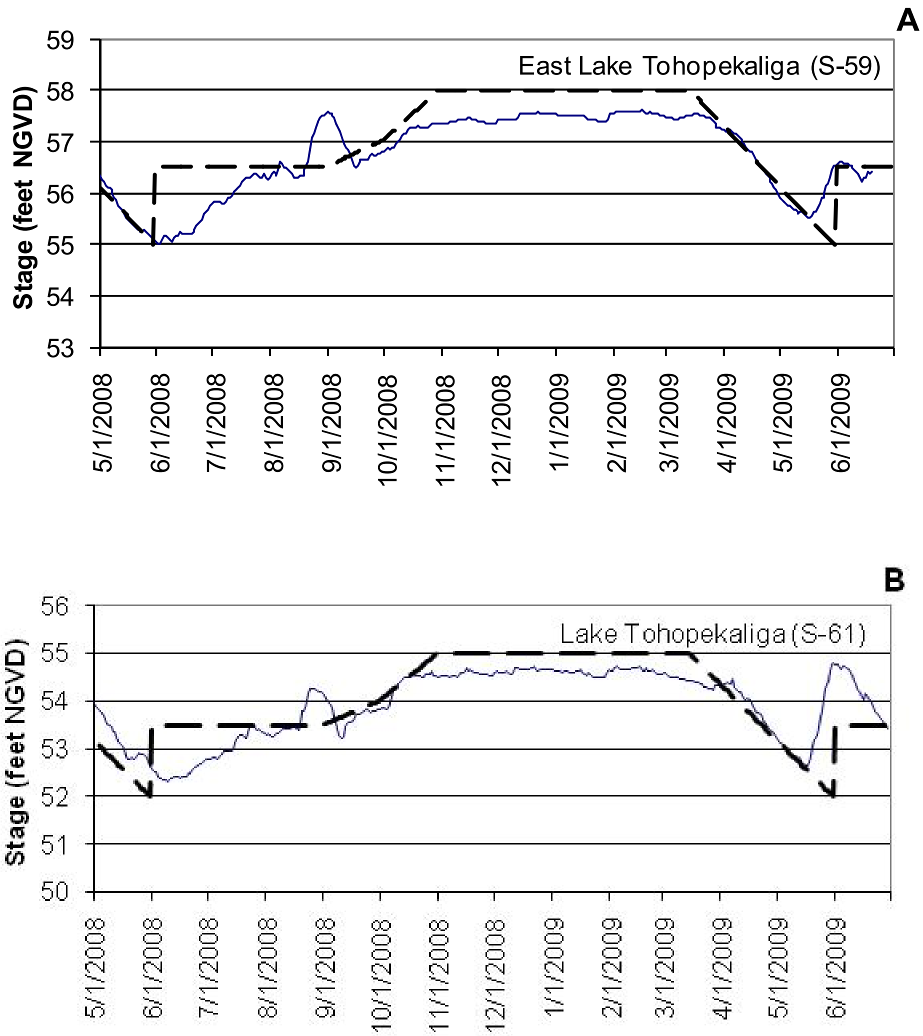


Figure 11-6. Regulation schedule (dashed line), water level (solid line) for East Lake Tohopekaliga (A) and Lake Tohopekaliga (B) during WY2009.

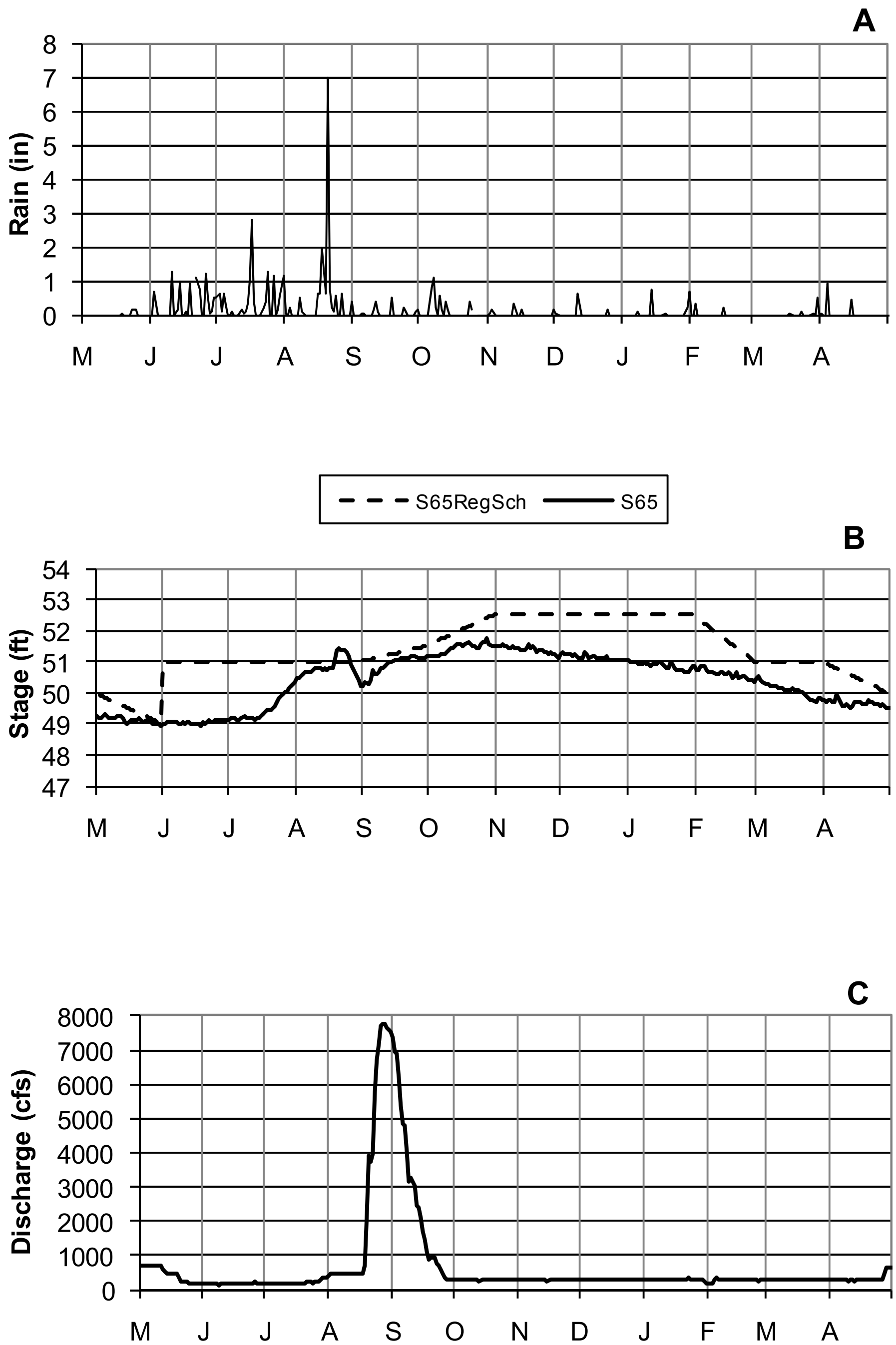


Figure 11-7. Rainfall (A), regulation schedule and water level (B), and discharge (C) at the outlet for Lake Kissimmee (S-65) for WY2009.

In addition to rainfall and runoff from the Lower Kissimmee Basin, hydrologic conditions in the Phase I restoration area of the Kissimmee River were influenced by the management of inflow from the Upper Kissimmee Basin at S-65 and outflow downstream at S-65C. At the beginning of WY2009, water levels at selected sites along the Kissimmee River decreased with the discharge at S-65 (**Figure 11-8**), then began to increase with rainfall and lower basin runoff during June. Water levels peaked in response to the rainfall associated with Tropical Storm Fay and the higher discharge at S-65, and decreased as the discharge at S-65 was reduced. At station PC61, located on the floodplain near the upper end of the Phase I restoration area (**Figure 11-9)**, the water level continued to decrease until it reached the bottom of the monitoring well at 36 ft National Geodetic Vertical Datum (NGVD). At station KRBN, located near the middle of the restoration area, the water level also declined, but more slowly than at PC61, until it reached the same elevation as the water level downstream at station PC11 and at the S-65C structure. Under low flow conditions, the water levels at PC61, KRBN, and PC11 are influenced by the elevation of water backing up at S-65C. In January 2009, the operation of S-65C was adjusted to allow the water level on the upstream side of the structure to decrease from 35 to 33 ft NGVD by May 15. Lowering the water level at the structure caused the water levels at upstream monitoring sites to decrease.

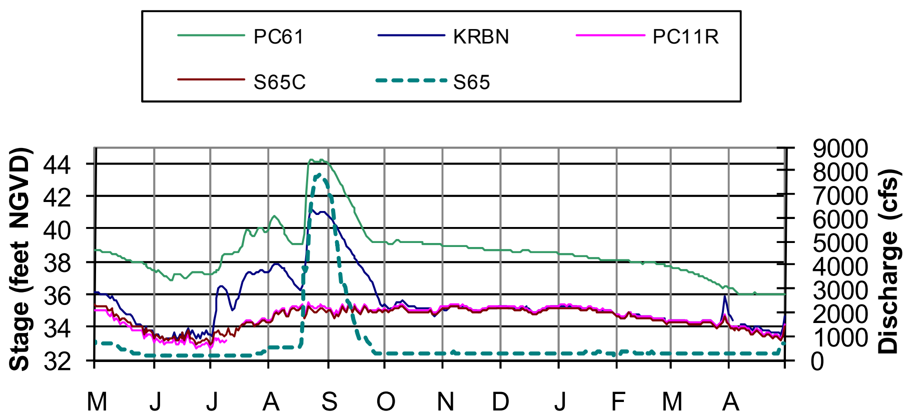


Figure 11-8. Mean daily stage at PC61, KRBN, PC11, and S-65C headwater in relation to mean daily discharge at S-65 during WY2009.

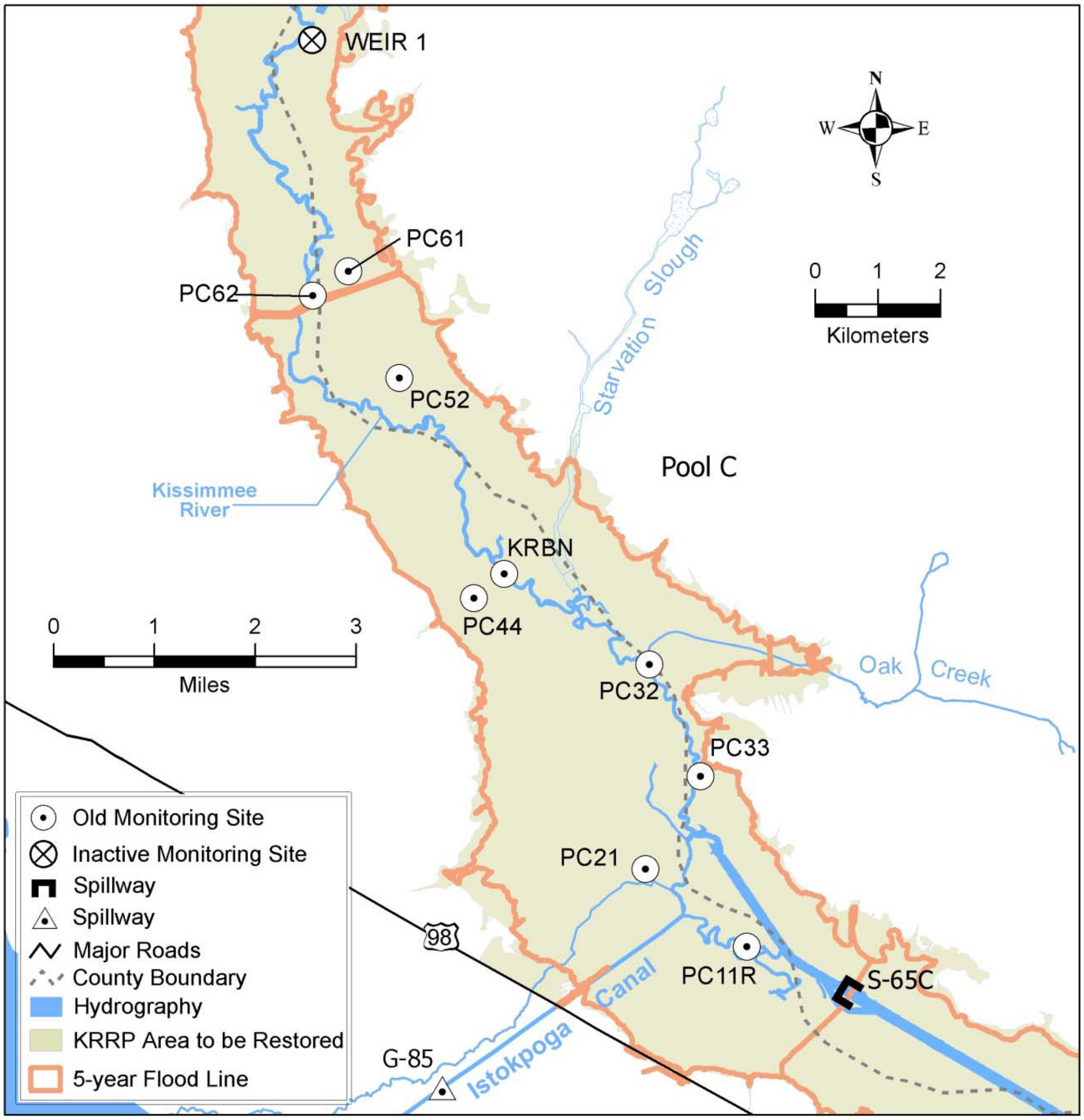


Figure 11-9. Location of hydrologic monitoring sites in Pool C used to guide operations and to evaluate restoration expectations.

PROJECT UPDATES

This section provides project and planning updates on the Kissimmee River Restoration Evaluation Program (KRREP); management of nonindigenous, invasive species; Kissimmee River Restoration Project (KRRP) construction activities; the Kissimmee Basin Modeling and Operations Study (KBMOS); and the Kissimmee Chain of Lakes Long-Term Management Plan (KCOL LTMP) and other projects taking place in the Upper Kissimmee Basin.

KISSIMMEE RIVER RESTORATION EVALUATION PROGRAM: UPDATES FROM PHASE I MONITORING STUDIES

With the completion of the KRRP Phase I construction in early 2001, restoration evaluation monitoring of the Phase I area entered the post-construction period. The first of four restoration construction stages, Phase I is being monitored by Kissimmee Watershed Program staff under the KRREP, as will selected successive phases of restoration (SFWMD, 2005a, Chapter 1). Many of the Phase I studies — which include assessments of hydrology, geomorphology, water quality, river channel and floodplain vegetation, aquatic invertebrates, herpetofauna, fish, and birds — already are indicating significant changes consistent with those predicted by the expectations (performance measures) developed for the KRREP (SFWMD, 2005b). As new data become available, results are reported in the SFER. The Phase I studies all used reference data to develop expectations. The reference data used to make these predictions were data from the pre-channelized Kissimmee River, published data from relatively undisturbed but similar systems elsewhere, or experimental studies.

A comprehensive update of the status of initial responses to Phase I reconstruction was published in the 2005 SFER – Volume I, Chapter 11 (SFWMD, 2005c), with additional updates from individual monitoring studies published in the 2006, 2007, 2008, and 2009 SFERs – Volume I (SFWMD, 2006a, 2007a, 2008a, 2009). The combined results for a suite of interrelated river channel studies were presented in the 2006 SFER – Volume I, Chapter 11. **Table 11-2** provides a directory of KRREP monitoring study updates since 2005. The monitoring results presented below provide the status of Phase I evaluation studies for which new data have been obtained since last year's report.

Table 11-2. Directory of Kissimmee River Restoration Evaluation Program Phase I restoration response monitoring study updates in the 2005–2010 SFERs – Volume I, Chapter 11.

		Page Number in SFER Volume I, Chapter 11					
KRREP Monitoring Study or Project	**Expectation #**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Kissimmee River Restoration Evaluation Program		11-8	11-37	11-22	11-28	11-36	11-26
Hydrology							
Stage-discharge relationships		11-20					
*Continuous river channel flow**	1	**[11-18]**				**[11-39]**	**[11-29]**
Variability of flow	2					**[11-40]**	**[11-31]**
Stage hydrograph	3	**[11-22]**				**[11-41]**	**[11-32]**
*Stage recession rate**	4	**[11-23]**	11-23	11-16	11-19	**[11-42]**	**[11-34]**
Flow velocity	5	**[11-25]**					**[11-35]**
Broadleaf marsh indicator	No expectation					**[11-43]**	
Geomorphology							
River bed deposits	6	**[11-26]**					
Sandbar formation	7	**[11-26]**					
Channel monitoring	No expectation					11-54	
Dissolved oxygen*	8	**[11-28]**	**[11-44]**	**[11-25]**	**[11-28]**	**[11-45]**	**[11-36]**
River channel metabolism	No expectation				11-35		
Phosphorus	No expectation	11-33	11-52	11-30	11-32	11-51	11-43
Turbidity	9	**[11-30]**	**[11-48]**	**[11-27]**			
Periphyton	No expectation	11-46					
River channel vegetation							
Width of littoral vegetation beds	10	**[11-36]**				**[11-59]**	
River channel plant community structure	11	**[11-37]**				**[11-59]**	
Floodplain vegetation							
Areal coverage of floodplain wetlands	12	**[11-39]**			**[11-35]**		
Areal coverage of broadleaf marsh	13	11-40			**[11-35]**		
Areal coverage of wet prairie	14	11-40			**[11-35]**		

Table 11-2. Continued.

Aquatic invertebrates							
Macroinvertebrate drift composition	15	**[11-45]**	11-57				
Snag invertebrate community structure	16	**[11-46]**	11-55			11-62	
Aquatic invertebrate community structure in broadleaf marsh	17		11-57				
Benthic invertebrate community structure	18	**[11-45]**	11-58			11-62	
Herpetofauna		11-48					
Floodplain reptiles and amphibians	19		Response data will be collected after implementation of headwaters reg. sched.				
Floodplain amphibian reproduction and development	20		Response data will be collected after implementation of headwaters reg. sched.				
Fish communities*							
Small fishes in floodplain marshes	21	11-50	After implementation of headwaters regulation schedule				
River channel fish community structure	22	11-52	**[11-59]**			**[11-66]**	
Mercury in fish	No expectation					**[11-20]**	
Floodplain fish community composition	23	11-50	Response data will be collected after implementation of headwaters reg. sched.				
Birds							
*Wading Bird Density**	24	**[11-58]**	**[11-71]**	**[11-32]**	**[11-44]**	**[11-72]**	**[11-50]**
Waterfowl	25		**[11-67]**	**[11-35]**		**[11-73]**	**[11-52]**
Shore birds	No expectation	11-57					
Wading Bird Nesting	No expectation		11-68		**[11-40]**	11-72	11-47
Threatened and endangered species	No expectation	11-60					

[xxx] bolded brackets indicate a major update in reference to the status of a restoration expectation (performance measure)
* = measures that are being used as Strategic Plan success indicators

Many of the restoration expectations, particularly those relating to floodplain responses, depend on full implementation of the revised water regulation schedule resulting from the KRHRP (USACE, 1996). Scheduled to be implemented in 2015, the KRHRP will provide the necessary storage volume in the KCOL to provide the volume and timing of water needed for the KRRP. The resulting Headwaters Revitalization Schedule will more closely simulate historical hydrology than is possible under the current interim schedule.

New data from several monitoring projects from the Phase I area are available for WY2009. Where applicable, these reports also evaluate the current status of the associated Phase I restoration expectations. Subsequent sections in this chapter include updates on *Hydrology*, two water quality studies (*Dissolved Oxygen* and *Total Phosphorus*), *Wading Bird Nesting Colonies*, *Wading Bird Densities*, and *Waterfowl Densities*.

Hydrology

The reestablishment of hydrologic conditions (water surface elevations and flow) comparable to those of the natural system is the driver for restoring ecological integrity to the Kissimmee River and its floodplain. Hydrologic conditions are being evaluated with five expectations for the restored hydrology of the river channel and floodplain, which reflect criteria that have guided the restoration project since its inception (SFWMD, 2005b). The ability to meet these expectations depends on the implementation of the Headwaters Revitalization Schedule (described above). Until this schedule is implemented in 2015, an interim regulation schedule for S-65 is providing the restoration project with flow that varies seasonally and with water levels in Lake Kissimmee.

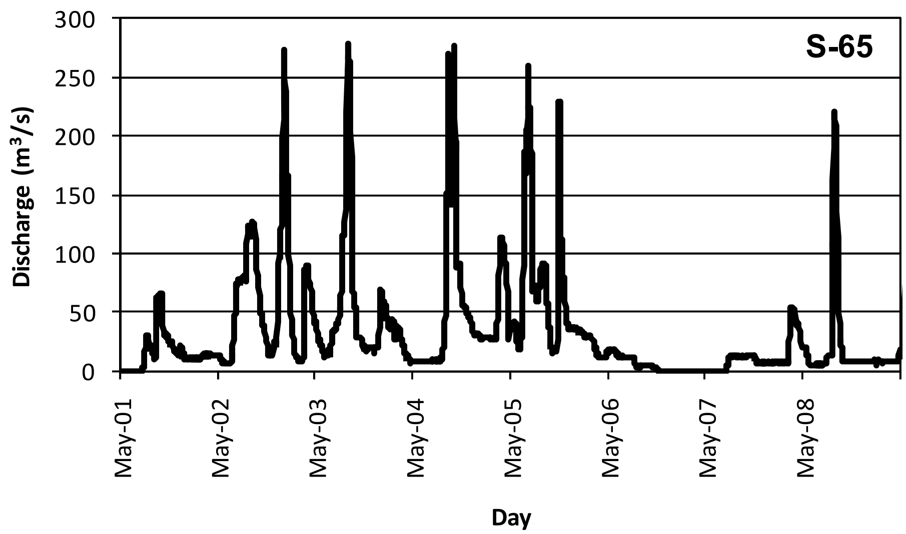
This update of the hydrologic conditions in Phase I (1) summarizes data for WY2002 through WY2009, (2) evaluates progress toward meeting the hydrologic expectations under the interim flow conditions, and (3) incorporates several changes from last year's report, including an update for all five hydrologic expectations. New evaluation locations are being used to replace Weir 1 (**Figure 11-9**) for water level fluctuation (**Expectation 3**) and for stage recession (**Expectation 4**). From upstream to downstream, these new sites are PC61, PC52, PC44, PC32, PC21, and PC11R (**Figure 11-9**). Monitoring at these locations will provide more insight into how conditions are changing along the length of the river. A candidate metric for a sixth expectation, which described the hydrologic requirements of long-hydroperiod marshes, was included last year but is not reported this year because it is still under review.

Expectation 1

The number of days that discharge is equal to 0 cubic meters per second (m^3/s) in a water year will be zero for restored river channels of the Kissimmee River (SFWMD, 2005b).

WY2009 was another year of continuous inflow (i.e., mean daily discharge exceeded 0 m3/s every day) (**Figure 11-10**). Discharge was low for most of the year with a single high discharge event in August–September associated with Tropical Storm Fay. With the inclusion of WY2009, the number of water years with continuous inflow from the Upper Kissimmee Basin increased to five of eight.

Inflow at S-65 from the Upper Kissimmee Basin has been continuous during WY2002–WY2009 except for portions of WY2002, WY2007, and WY2008 (**Figure 11-10**). In WY2002, there was no discharge at S-65 for the first 84 days of the water year because the basin was in a severe regional drought. A second time interval without inflow from the Upper Kissimmee Basin lasted 252 days between November 8, 2006, and July 18, 2007, because of another severe regional drought. This period of no inflow included portions of WY2007 (152 days) and WY2008 (79 days).



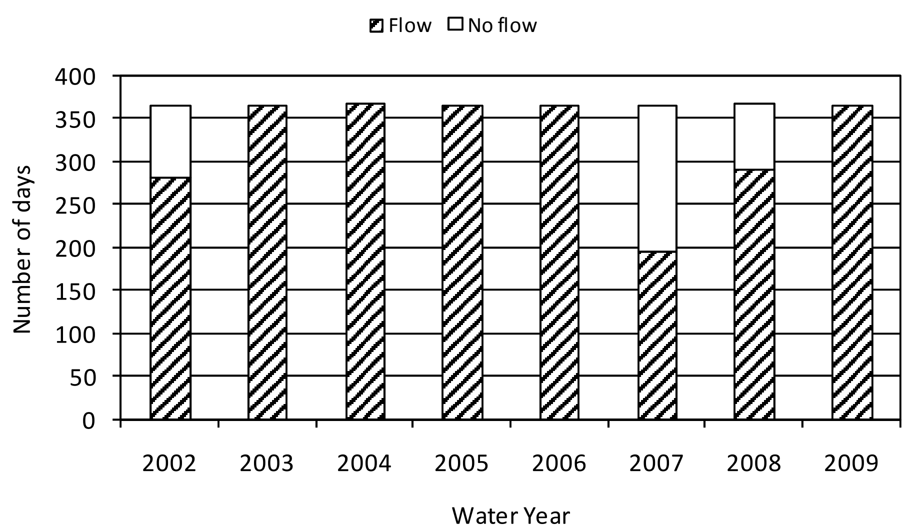


Figure 11-10. Mean daily flow [cubic meters per second (m^3/s)] at S-65, the outlet from the Upper Kissimmee Basin (top) and number of days with flow and no flow (bottom) for WY2002–WY2009.

Expectation 2

Intra-annual mean monthly flows will reflect historical seasonal patterns and have intra-annual variability (coefficient of variation) < 1.0 (SFWMD, 2005b).

Before channelization, the Kissimmee River exhibited a distinct seasonality of flow with mean monthly discharge being highest at the end of the wet season and lowest at the end of the dry season (**Figure 11-11**). In contrast, management of the channelized system resulted in peak flows in the dry season. Since the completion of Phase I, peak flows have occurred in the wet season, but a month earlier than in the reference period. The addition of data from WY2009 had little effect on the seasonal distribution of flow during the interim period. For WY2002–WY2009, the coefficient of variation for mean monthly discharge ranged from 0.74 to 1.50 across months. For five months (February, March, May, August, and September), it was less than 1.

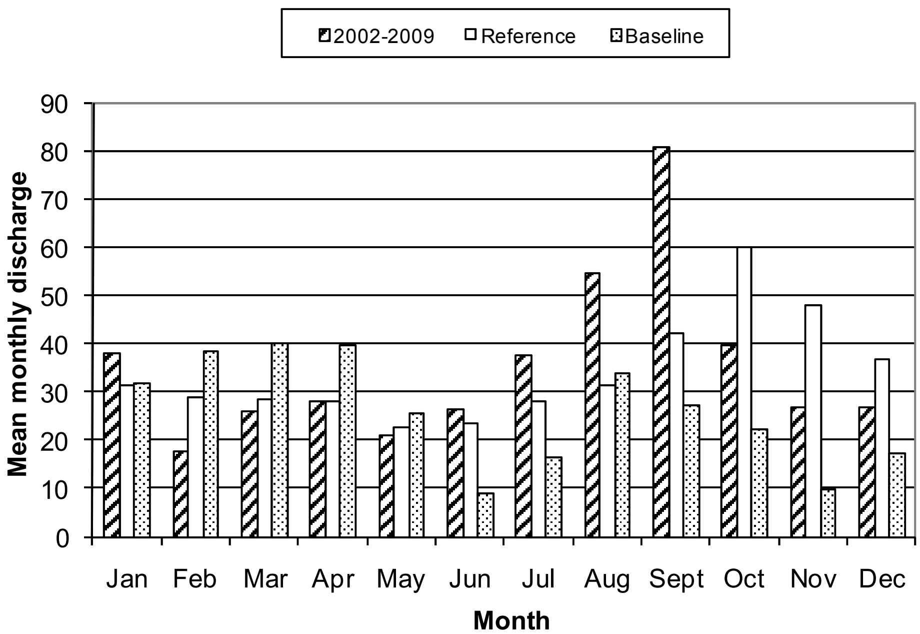


Figure 11-11. Seasonality of mean monthly discharge (m^3/s) at S-65 for the interim period (2001–2009), the reference period (1934–1962), and the baseline period (1963–2000). Note that for 2001, 0 values for the first six months were not included in the calculation of average discharge.

Expectation 3

River channel stage will exceed the average ground elevation for 180 days per water year and stages will fluctuate by at least 1.14 meters (m) (SFWMD, 2005b).

The change in stage for each water year (WY2002–WY2009) and the duration of water above ground level are reported for the new evaluation locations, which are from upstream to downstream PC61, PC52, PC44, PC32, PC21, and PC11R. The change in stage varies with water year and tends to decrease from upstream to downstream (**Figure 11-12**). The change in stage at the three most upstream sites exceeded the threshold target of 1.14 m for every water year. For the three sites located farther downstream, the change in stage exceeded the threshold target in some water years. The smaller changes in stage at the more downstream sites reflected the influence of water level regulation at S-65C. The duration of water level above ground level also varied with the location of the monitoring site (**Figure 11-12**). The duration at the most upstream site never exceeded the target threshold of 180 days. At the second-most upstream site, it exceeded the threshold in some years. At the four sites located downstream, durations exceeded the target threshold in every water year. The combination of the change in water level and inundation duration were best met at sites near the middle of the restoration project area.

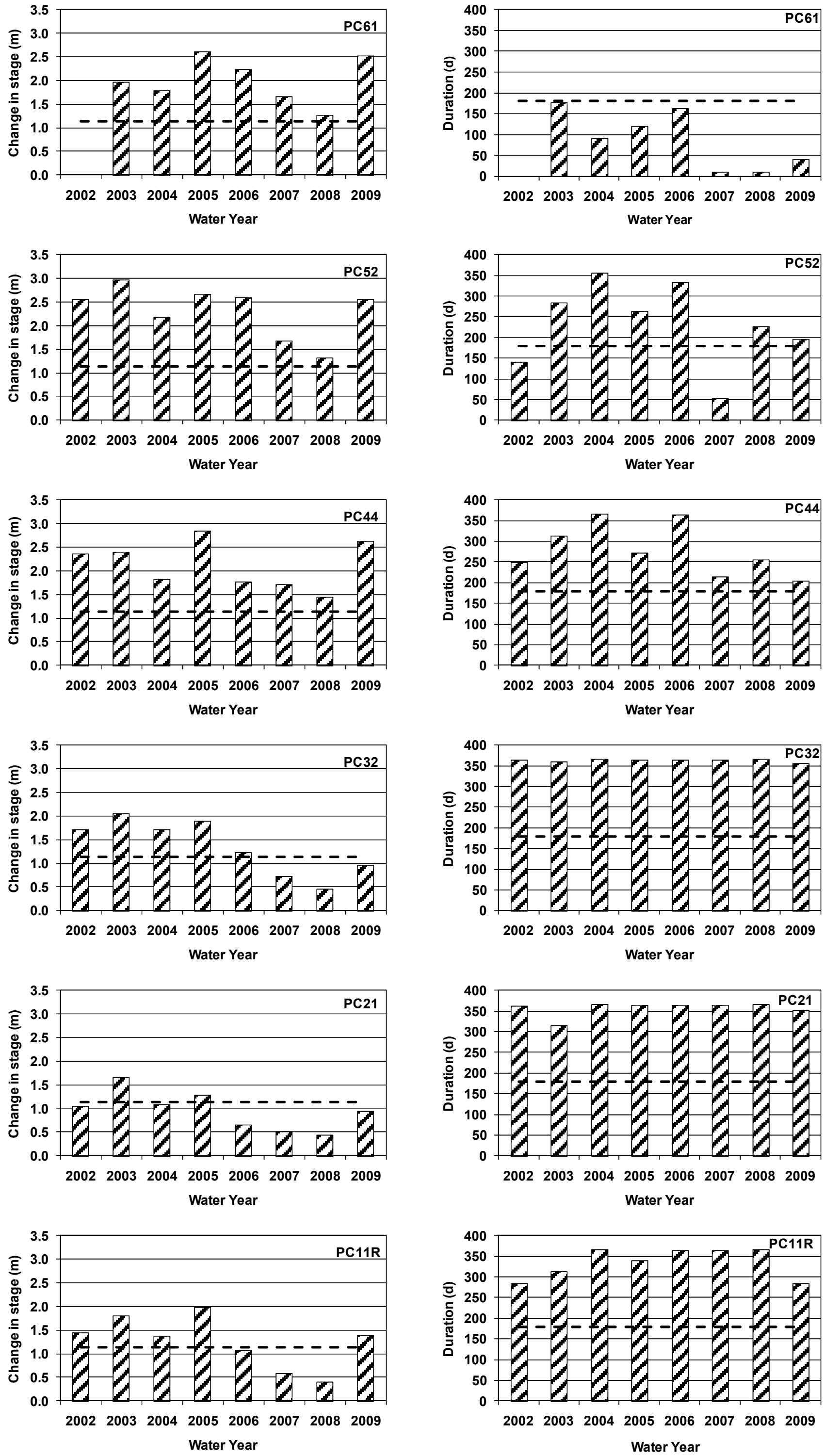


Figure 11-12. Water level fluctuation (left) and duration of inundation (right) at six locations for WY2002–WY2009. The dashed horizontal lines represent minimum change in water level fluctuation of at least 1.14 meters (m) per year (right) and a minimum duration of 180 days per year for stage exceeding floodplain ground elevation (left).

Expectation 4

An annual prolonged recession event will be reestablished with an average duration of > 173 days and with peak stages in the wet season receding to low stage in the dry season at a rate that will not exceed 0.3 m per 30 days (SFWMD, 2005b).

This expectation had been evaluated at Weir 1 in previous years, but is now being evaluated at the same six locations used for Expectation 3. In last year's update, 15 recession events had been identified since 2001 at Weir 1. Most years had more than one recession event, which had a shorter duration and a more rapid recession rate than desired. While the recession rates are still being evaluated for these earlier events, it is likely that similar results will be obtained at the new evaluation locations because the stage hydrographs for the sites tend to parallel one another. During WY2009, a recession event began in early August but was disrupted later in the month by high water levels caused by Tropical Storm Fay (**Figure 11-13**). For the event caused by Tropical Storm Fay, recession rates were calculated for six sites (**Table 11-3**). At all locations, the recession event exceeded the desired minimum duration of 173 days. The recession rates were 0.1-0.3 m/30 days and in the desired range. Recession rates were more rapid at the upstream sites, which had the larger changes in stage.

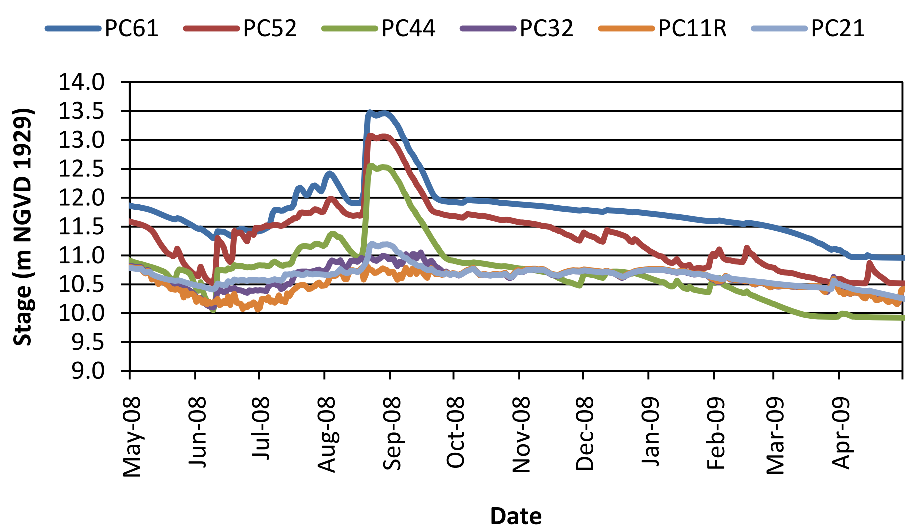


Figure 11-13. Water level (stage) at six locations in WY2009.

Table 11-3. Calculation of recession rate for the WY2009 event at six sites. Recession rate is calculated from the timing (T_{max}) and elevation (h_{max}) of the maximum stage for the event to the timing (T_{min}) and elevation (h_{min}) of the minimum stage. The recession rate (R) is calculated by dividing the change in water level elevation (Δh) by the change in time (Δt) and multiplying by 30 days.

Site	T_{max}	h_{max} (m)	T_{min}	h_{min} (m)	Δh (m)	Δt (d)	R (m/30d)
PC61	22-Aug-08	13.5	19-Apr-09	11.0	2.5	240	0.3
PC52	23-Aug-08	13.1	4-May-09	10.5	2.6	254	0.3
PC44	23-Aug-08	12.6	23-Apr-09	9.9	2.6	243	0.3
PC32	21-Aug-08	11.0	28-Apr-09	10.2	0.8	250	0.1
PC21	23-Aug-08	11.2	12-May-09	10.2	1.0	262	0.1
PC11R	21-Aug-08	10.8	24-Apr-09	10.2	0.6	246	0.1

Expectation 5

Mean velocities within the main river channel will range from 0.2 to 0.6 meters per second (m/s) during a minimum of 85 percent of the year (SFWMD, 2005b).

The expectation for mean channel velocity was evaluated using velocity estimates made during field flow measurements (i.e., stream gauging) at five locations in the river channel from upstream to downstream: PC62, KRDR, KRBN, PC33, and PC11R (**Figure 11-9**). Flow measurements were taken with an Acoustic Doppler Current Profiler, which was also used to measure the cross-sectional area of flow. Mean channel velocity was calculated by dividing the discharge by the cross-sectional area. Measurements were taken under a range of flow conditions beginning on Nov. 28, 2001, at all sites except PC62, which was not established until later (**Table 11-4**). When measurements began at PC62, they were discontinued at PC11R.

The percentage of mean channel velocity estimates in the desired range of 0.2-0.6 m/s was less than the desired value of 85 percent at all cross-sections except at KRDR (**Table 11-4**). The smaller percentage estimates in the desired range reflects a larger number of estimates < 0.2 m/s, which is a consequence of the extended periods of time with low discharge (e.g., **Figure 11-10 top panel**). Less than 10 percent of the velocity measurements at any cross-section exceeded 0.6 m/s. Mean channel velocities > 0.6 m/s corresponded to discharge measurements greater than 50-60 m^3/s.

Table 11-4. Summary of mean channel velocity estimates from stream gauging. Number of observations (n), the beginning and ending dates for the time period during which measurements were made, minimum (Q_{min}) and maximum (Q_{max}) discharge (m^3/s) during which measurements were made, and the number (percentage) of mean channel velocity estimates for five river channel stations. Values in parentheses are the percent of the total number of observations mode at a site.

						Mean Channel Velocity (m/s)		
Site	**n**	**Begin date**	**End date**	**Q_{min}**	**Q_{max}**	**<0.2**	**0.2-0.6**	**>0.6**
PC62	94	2/4/2004	6/4/2009	3.63	89.72	29(31)	61(65)	4(4)
KRDR	190	11/28/2001	6/4/2009	3.41	77.47	19(10)	167(88)	4(2)
KRBN	193	11/28/2001	6/4/2009	3.30	91.97	40(21)	144(75)	9(5)
PC33	198	11/28/2001	6/4/2009	3.42	129.39	85(43)	98(49)	15(8)
PC11R	94	11/28/2001	1/28/2004	6.37	403.93	70(74)	24(26)	0(0)

Water Quality

This year's report includes updates on DO and phosphorus. The results of mercury monitoring, which were presented in Chapter 11 of the 2009 SFER (SFWMD, 2009), have been updated and moved to Chapter 3B of this volume where mercury monitoring from other areas of the District is discussed.

Dissolved Oxygen

During the baseline period (1996–1999) DO was monitored continuously at a depth of approximately 1 m in two remnant river channel stations in Pool C. Sampled river channels were approximately 20–30 m wide and 2–3 m deep. DO also was sampled monthly within seven remnant river runs in Pools A and C. DO data were not collected prior to channelization; therefore, the reference condition was derived from data on seven free-flowing, blackwater streams in South Florida. Each stream had at least 11 samples collected over a minimum of one year and some streams were sampled for more than 10 years (**Figure 11-14**). The period of record for these reference data is 1973–1999. The mean daytime DO concentration in the reference streams was 4.2 milligrams per liter (mg/L) during the wet season and 6.1 mg/L during the dry season (**Figure 11-15**). In five of the seven streams, DO was > 5 mg/L in more than 50 percent of the samples. In seven of the eight streams, more than 90 percent of the samples had concentrations > 2 mg/L.

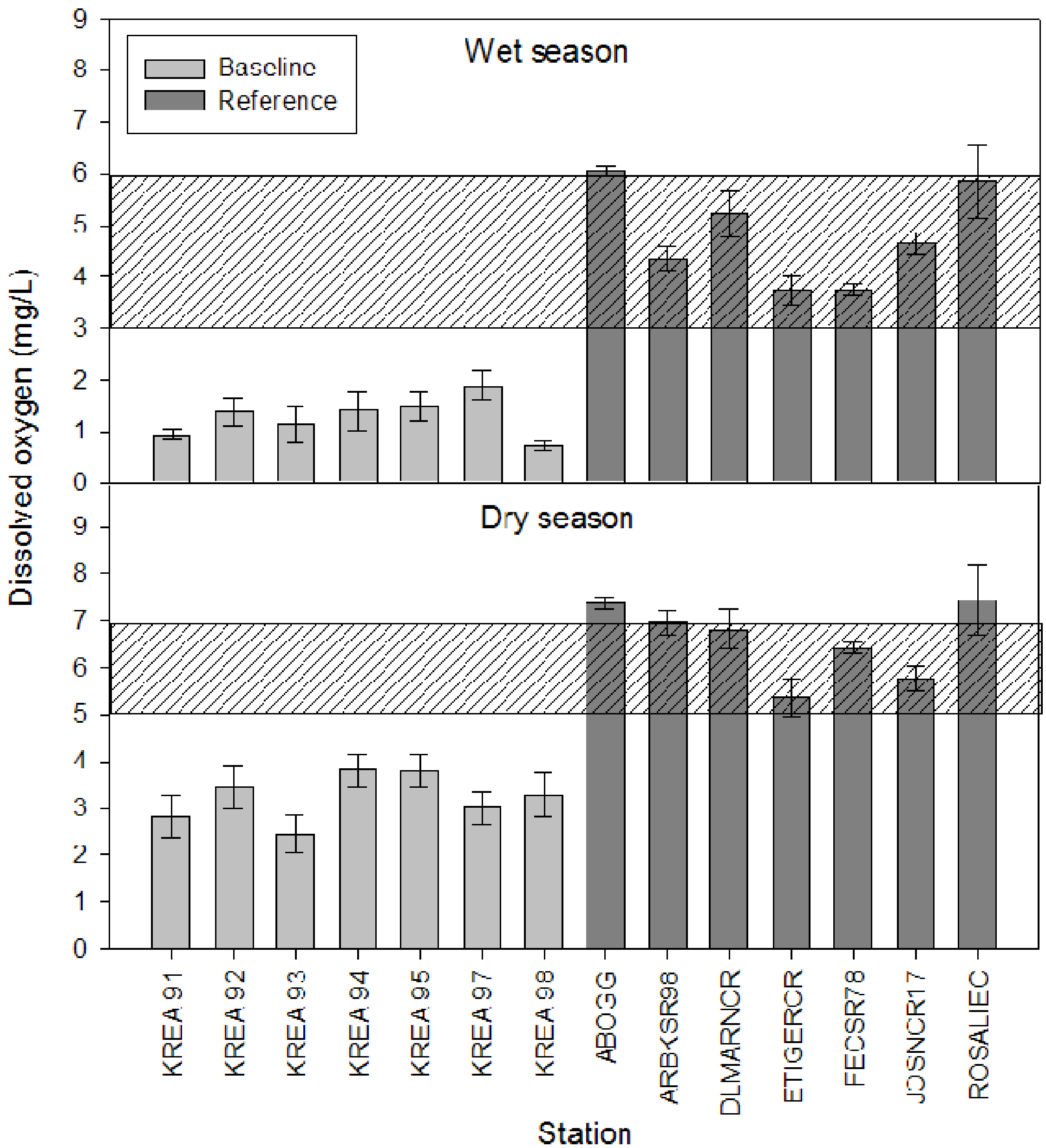


Figure 11-14. Mean [± standard error (S.E.) of the mean] dissolved oxygen (DO) concentrations in free-flowing, blackwater, South Florida streams and remnant runs of the channelized Kissimmee River during the wet (June-November) and dry (December-May) seasons. Shaded area represents expected range of DO concentrations in the Kissimmee River after restoration. Station names are from the SFWMD DBHYDRO database.

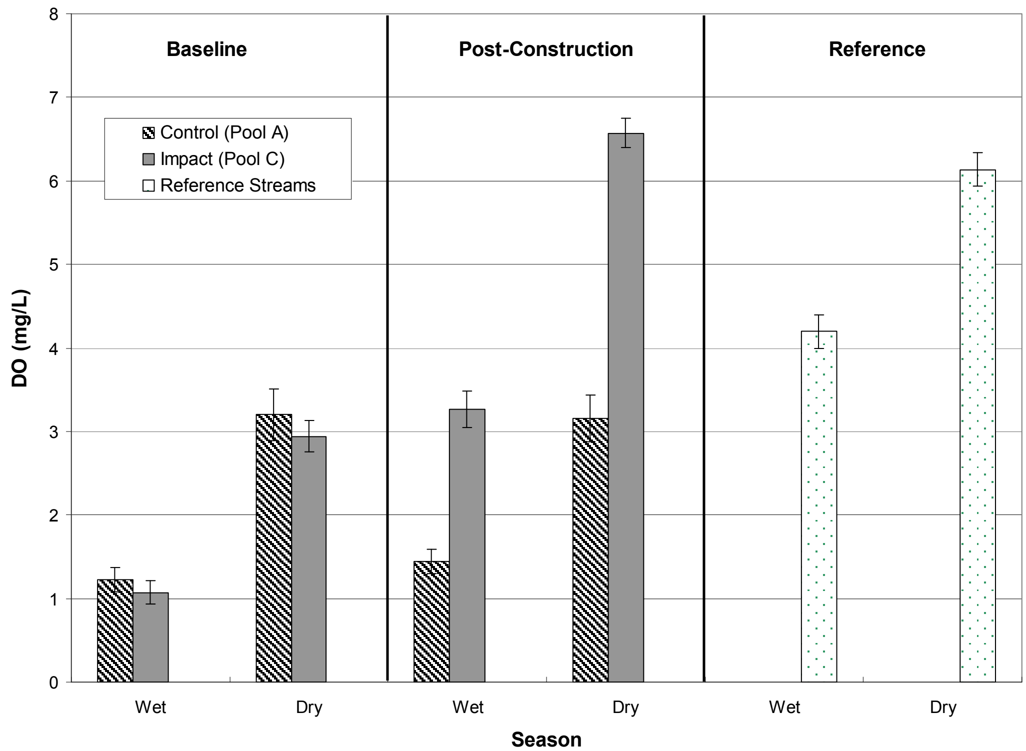


Figure 11-15. Mean (± S.E.) DO concentrations (mg/L) in reference streams (Period of record =1973–1999) and control and impact areas during the wet and dry season, during the baseline (1997–1999) and post-restoration (2001–present) periods.

Within the channelized river during the baseline period, DO concentrations were frequently below 1 mg/L throughout the water column at all times of day. A gradient in DO concentration, decreasing with depth, was observed during May–June 1999. DO concentrations near the surface could be as high as 4 to 5 mg/L, while concentrations near the bottom were lower than the detection limit (< 0.2 mg/L). During 1996–1999, mean DO concentrations in remnant river runs in Pool A and C were 1.2 mg/L and 1.1 mg/L, respectively, during the wet season, and 3.2 mg/L and 3.0 mg/L, respectively, during the dry season (**Figure 11-15**). DO concentrations exceeded 2 mg/L for 22 percent of the baseline period, and 5 mg/L for 6 percent of this period.

These reference and baseline data were used to develop the following four components of Expectation 8 (SFWMD, 2005b) to evaluate changes in DO as restoration proceeds:

1. Mean daytime concentration of DO in the river channel at 0.5–1.0 m depth will increase from < 2 mg/L to 3–6 mg/L during the wet season (June–October).
2. Mean daytime concentration of DO in the river channel at 0.5–1.0 m depth will increase from 2-4 mg/L to 5–7 mg/L during the dry season (December–May).
3. Mean daily DO concentrations in the river channel will be > 2 mg/L for more than 90 percent of the time (annually).
4. DO concentrations within 1 m of the channel bottom will be > 1 mg/L for more than 50 percent of the time annually.

Since continuous data (showing diel dissolved oxygen curves) were not available for the reference streams, a metric for minimum daily DO concentration was not developed. However, minimum and maximum daily DO concentrations were measured at the two previously mentioned stations within the restored channel from approximately 1997 to date. These data are used to help make weekly operational decisions as well as evaluate DO regimes in the restored portion of the river over the long term. Following completion of the first two phases of construction, DO concentrations within the restoration area (stations KRBN and PC62 continuous DO monitoring stations) averaged 3.3 mg/L during the wet season and 6.6 mg/L during the dry season (**Figure 11-15**). Post-construction DO concentrations in the control area (Pool A) averaged 1.4 and 3.2 mg/L during the wet and dry seasons, respectively (**Figure 11-15**).

Mean annual DO concentrations (continuous monitoring) in the restoration area (Pool C) increased from < 3.0 mg/L before construction to 5.8 mg/L in WY2009 (**Figure 11-16**). Mean daily water column DO concentrations were > 2.0 mg/L for 80 percent of the time in WY2009, and minimum daily concentrations were > 2.0 mg/L for 77 percent of the time. From May 1, 2008–July 4, 2008, DO concentrations were > 2.0 mg/L, and usually > 4.0 mg/L (**Figures 11-17** and **11-18**). On July 5, 2008, DO concentrations decreased to below 2.0 mg/L. From July 5, 2008, through September 22, 2008, DO concentrations were generally below 2 mg/L in the river channel except during August 19–21, 2008, when Tropical Storm Fay impacted Florida with torrential rains. Increased DO concentrations were likely associated with increased reaeration from high winds and heavy rainfall. A similar phenomenon was observed in 2004 when Hurricanes Francis and Jeanne passed close to the Kissimmee River. By the end of September 2008, DO concentrations increased to > 2.0 mg/L and by the middle of October 2008, concentrations were > 5.0 mg/L. Concentrations remained > 5.0 mg/L for the rest of WY2009.

Dissolved oxygen sags are common and likely a natural occurrence in South Florida streams during the wet season. Sometimes these events cause localized fish kills. Most of the time, fish and other mobile aquatic organisms are able to find refugia with slightly higher DO concentrations. On the Kissimmee River, DO sags often occur within the river channel while the floodplain of the river is inundated. Dissolved oxygen concentrations measured on the floodplain tend to be greater than river channel concentrations during these events. Therefore, fish and other aquatic organisms are hypothesized to use the floodplain as a refuge from low DO and high flow velocities.

Final evaluation of the restoration expectation for DO concentrations in the restored river channel will occur after implementation of the KRHRP regulation schedule. However, two of the four components used to evaluate DO response (components 1 and 2) were met under the interim regulation schedule through WY2009.

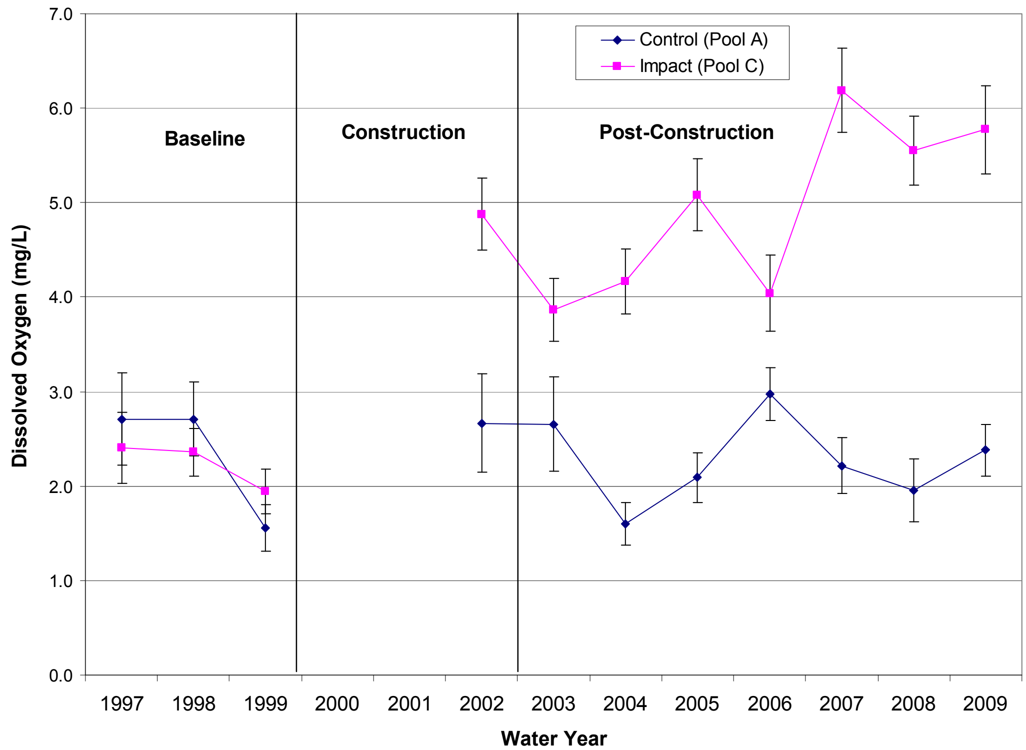


Figure 11-16. Mean DO concentrations (mg/L) in the Kissimmee River for each water year during the baseline and post-construction period.

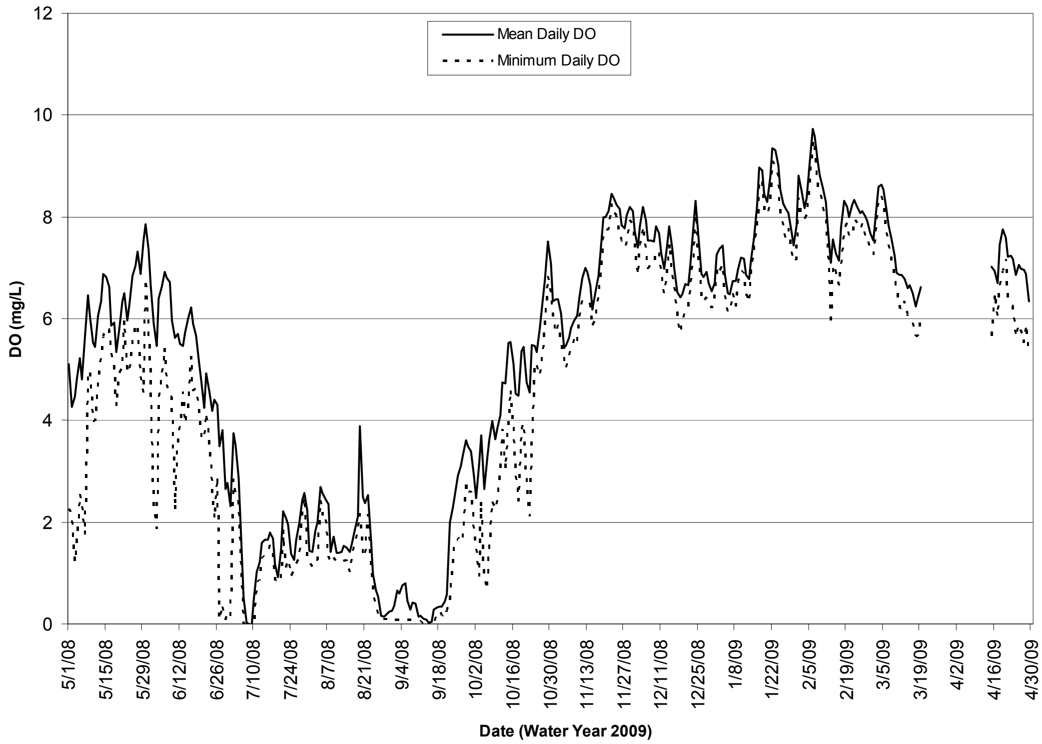


Figure 11-17. Mean (192 values per day) and minimum (lowest single value of 192 data points) daily DO concentrations (mg/L) at 0.5-1.0 m depth in the restored river channel at station KRBN during WY2009.

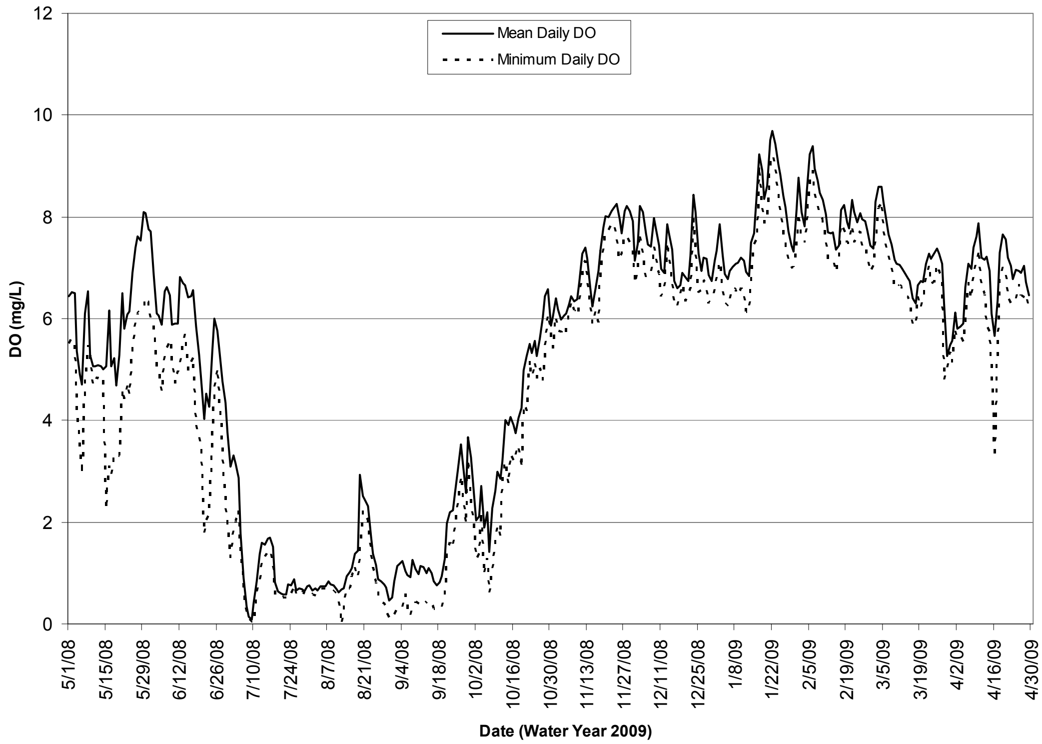


Figure 11-18. Mean (192 values per day) and minimum (lowest single value of 192 data points) daily DO concentrations (mg/L) at 0.5-1.0 m depth in the restored river channel at station PC62 during WY2009.

Total Phosphorus

As Lake Okeechobee's largest tributary, the Kissimmee River is a main contributor of phosphorus to the lake (see Chapter 10 of this volume). Construction of C-38 and lateral drainage ditches has presumably contributed to phosphorus loading from the Kissimmee Basin by facilitating downstream transport of phosphorus runoff and limiting opportunities for detention and assimilation in floodplain wetlands. Compared to the local drainages of Pools D and E, which have more intensive agricultural development, the drainages of Pools A, B, and C (**Figure 11-2**) are not major exporters of phosphorus. Nevertheless, restoration of the river and floodplain may eventually lead to lower inputs from these pools and reduced loading from the headwater lakes in the Upper Kissimmee sub-watershed. Restoration of sloughs and marshes along the river may increase the retention of phosphorus from tributary watersheds and headwater lakes as flow velocities decrease and phosphorus settles out or is assimilated by wetland vegetation. The filling of ditches and removal of cattle from the floodplain also may help to lower TP loads from lateral sources.

Baseline and post-construction TP data are obtained from routine monitoring at each C-38 water control structure. TP concentrations are determined at each structure from grab samples collected every two weeks, although sampling has ranged from weekly to monthly during portions of the period of record, and composite samples collected by auto-samplers. The auto-sampler gathers samples 10 times per day, which are combined into a single bottle collected on a weekly basis. Estimates of daily TP loads were computed from measured or interpolated TP concentrations and daily discharge data and then summed annually. Annual TP loads were divided by annual discharges to obtain flow-weighted mean (FWM) TP concentrations at each structure. Because TP loads can vary greatly between wet years and dry years, FWM concentrations provide a more useful metric for evaluating trends.

Calendar years 1974–1995, during which the C-38 canal was intact, were chosen as the baseline period of record. During those 22 years, TP loading averaged 51 metric tons per year (mt/yr) at S-65C and 83 mt/yr at S-65D (**Figure 11-19**). These amounts comprised 43 and 71 percent of the average load at S-65E, respectively. Annual FWM TP concentrations averaged 53 parts per billion (ppb) at S-65C (range of 33–87 ppb), and 78 ppb at S-65D (range of 47–141 ppb) (**Figure 11-20**). Concentrations were greater during years of lowest flow (1981 and 1985). At S-65, upstream of the restoration project area, the mean loading rate was 35 mt/yr (**Figure 11-19**), and the FWM TP concentration was 43 ppb (**Figure 11-20**).

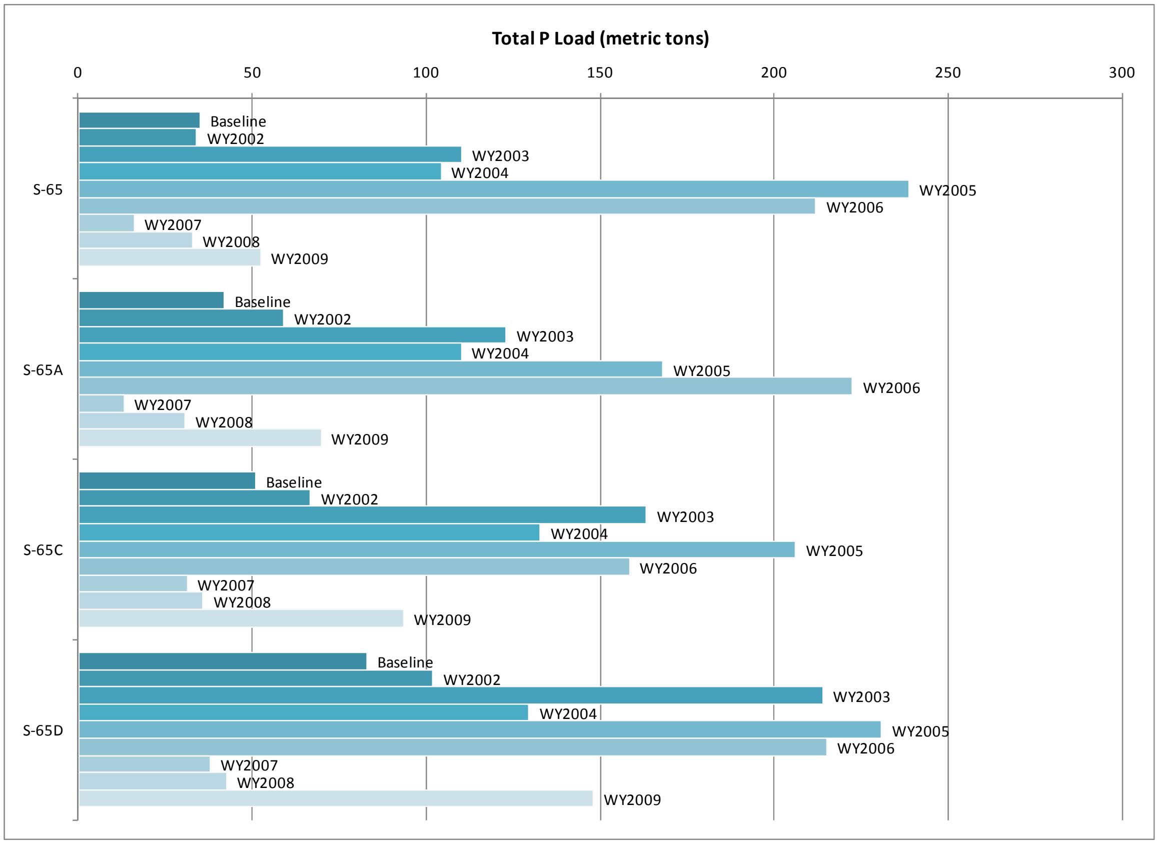


Figure 11-19. Annual total phosphorus (TP) loads (metric tons) from C-38 structures in comparison to baseline loads from 1974–1995. WY2002, WY2007, and WY2008 were drought years, and WY2005 was wet due to hurricanes.

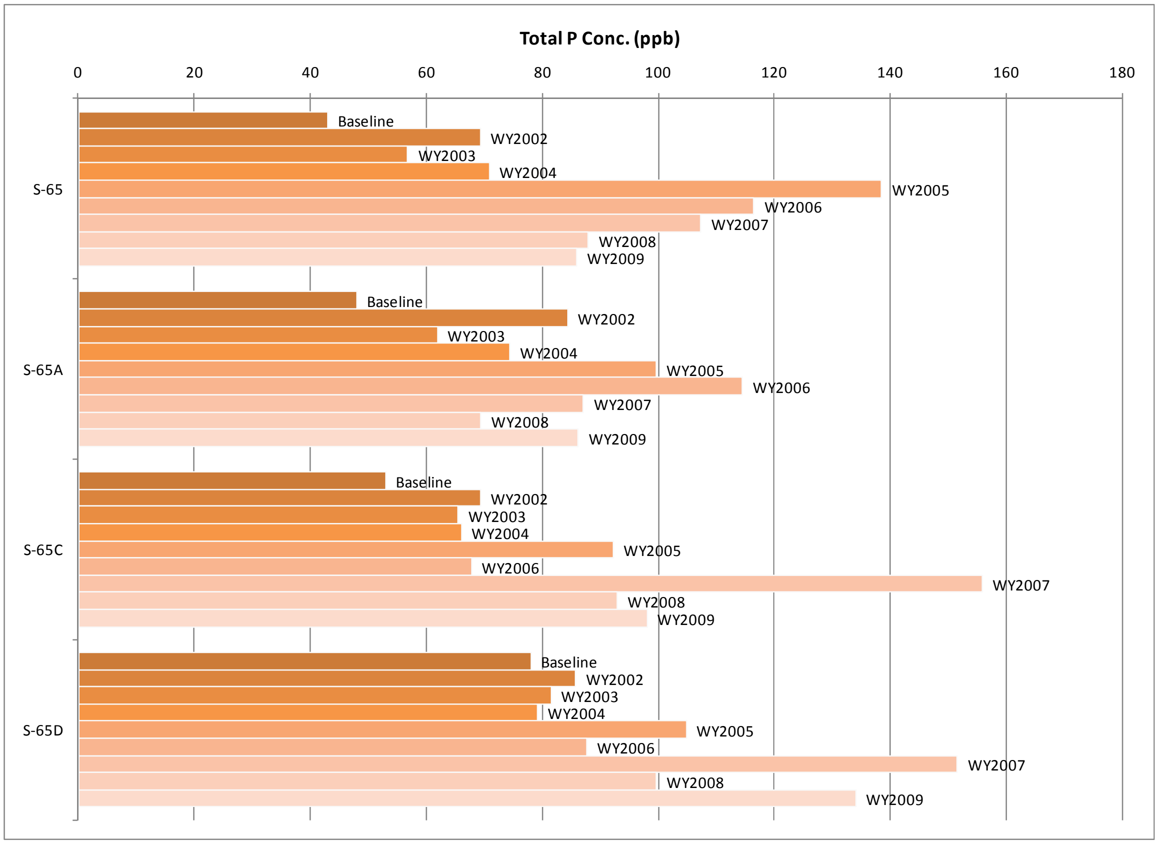


Figure 11-20. Annual flow-weighted mean TP concentrations in parts per billion (ppb) at C-38 structures in comparison to baseline concentrations (1974–1995).

Reference, pre-channelization conditions for TP loads and concentrations in the Kissimmee River cannot be determined with any certainty because phosphorus was not routinely monitored before channelization. Nevertheless, knowledge of former characteristics of the river and its floodplain and watershed make it reasonable to assume that concentrations were lower in the pre-channelized river (SFWMD, 2005a, Chapter 5). Restoration should tend to favor a return to lower concentrations when a more natural river-floodplain hydroperiod and stable wetland ecosystem become established. These conditions are expected to be achieved after the Headwaters Revitalization Schedule is implemented in 2015. In the meantime, TP concentrations may increase periodically as the nutrient runs off from former pastures and the floodplain transitions from terrestrial to wetland vegetation.

Under the interim regulation schedule, the floodplain in the Phase I restoration area has been inundated intermittently. Observational data and 2003 aerial photography indicate that wetland vegetation re-colonized the Phase I area to some extent following restoration (SFWMD, 2008a). However, the current (interim) regulation schedule has not allowed for the seasonal pattern of floodplain inundation that is expected when the KRHRP regulation schedule is implemented. Therefore, in the transitional years since Phase I was completed, the floodplain is unlikely to have assimilated phosphorus at its highest efficiency. This was especially true in WY2007 and WY2008, when there was little hydrologic interaction between the river channel and floodplain due to drought conditions.

Evaluation of TP loading trends from year to year is difficult because loading is highly dependent on the amount of discharge through the system. During WY2002–2006, discharge and loads at the C-38 structures were generally greater than the 1974–1995 baseline averages, but were much lower in the drought years of WY2007 and WY2008 (**Figure 11-19**). Annual discharges during WY2009 were higher than in the previous two years. Although low levels of flow occurred over most of the year, a significant amount of water passed through the system during August and September as a result of Tropical Storm Fay (**Figure 11-7C**). Total phosphorus loads at the C-38 structures were also higher than in WY2007–WY2008, but less than in WY2003–WY2006 (**Figure 11-19**). These WY2009 loads were roughly 50 to 80 percent higher than the baseline averages.

Flow-weighted mean TP concentrations have been higher at all structures since the baseline period (**Figure 11-20**), and they remained relatively high in WY2009. Although FWM TP concentrations have declined since WY2005 at S-65, the WY2009 concentration at S-65D was the second highest in the last eight years. Despite its recent decline, the FWM TP concentration at S-65 has generally increased since the mid-1990s and has had an effect on concentrations downstream in the canal. This increase is at least partially due to higher concentrations in Lake Kissimmee, possibly from hydrilla (*Hydrilla verticillata*) treatments that exposed more lake sediment to wind resuspension and allowed more growth of phytoplankton, and from the impact of hurricanes in 2004. The increase also may be due to greater inflows of phosphorus to the headwater lakes, possibly including local runoff near S-65, which so far has been difficult to document.

While the KRRP was not designed as a TP-removal project, there is considerable interest in how restoration of floodplain wetlands will influence the retention of phosphorus within the Kissimmee Basin. In WY2009, the SFWMD funded a study to evaluate existing data and water quality modeling further and develop a strategy to gather needed information to support better estimates of the restoration project's effect on phosphorus movement and retention, and its overall benefit to phosphorus control efforts. This study is described in the *Effects of the Kissimmee River Restoration Project on Phosphorus Transport* section of this chapter.

The Phase II/III evaluation will also monitor TP concentrations during construction in Pool D to determine if increased transport of phosphorus downstream to Lake Okeechobee occurs during construction. Additional sampling in Pool D is scheduled to be initiated in late 2009. An increase in phosphorus transport during construction work is not expected as the backfilling method is designed to isolate activity from the flow of the river (Colangelo and Jones, 2005).

Birds

Birds are integral to the Kissimmee River/floodplain ecosystem. While quantitative pre-channelization data are sparse, available data and anecdotal accounts indicate that the system supported an abundant and diverse bird assemblage (National Audubon Society, 1936–1959; FGFWFC, 1957). Restoration is expected to reproduce the necessary conditions to once again support such an assemblage. Further, since many bird groups (e.g., wading birds, waterfowl) exhibit a high degree of mobility, they are likely to respond rapidly to restoration of appropriate habitat (Weller, 1995; Melvin et. al., 1999). Detailed information regarding the breadth of the avian evaluation program and the initial response of avian communities to Phase I restoration can be found in the 2005 SFER (SFWMD, 2005c, Chapter 11). This section highlights portions of the avian program for which data were collected during WY2009.

Wading Bird Nesting Colonies

As part of the Kissimmee River Restoration Project evaluation program, SFWMD staff performed systematic aerial surveys (February 18, March 17, and April 28) to search for wading bird nesting colonies within the floodplain and surrounding wetland/upland complex of the Kissimmee River (i.e., approximately 3 km east and west of the 100-year floodline). Nesting colonies were also monitored, when encountered, during separate aerial surveys of foraging wading birds (January 13, February 10, March 10, April 14, May 12, and June 16). The number of nests reported represents the maximum number of nests for each species. Nesting success was not monitored, but ground surveys were conducted at the Pool C boat ramp (May 20) and Rabbit Island (June 3) colonies to obtain more accurate nest counts and determine the presence of less visible dark-colored species [i.e., little blue heron (*Egretta caerulea*) and tricolored heron (*Egretta tricolor*)].

Four colonies formed within the survey area during 2009 (**Table 11-5**; **Figure 11-21**). The largest colony — comprising 740 cattle egret (*Bubulcus ibis*), 150 great egret (*Ardea alba*), 87 tricolored heron, 75 white ibis (*Eudocimus albus*), 50 great blue heron (*Ardea herodias*), 42 little blue heron, 10 snowy egret (*Egretta thula*), 10 glossy ibis (*Plegadis falcinellus*), and three black-crowned night heron (*Nycticorax nycticorax*) nests — was first observed on February 18 on Rabbit Island in Lake Kissimmee. The largest colony to form along the Kissimmee River, comprising 240 cattle egret, 11 little blue heron, and three tricolored heron nests, was first observed on May 20, in the southern reach of MacArthur Run near the Pool C boat ramp. Two other colonies formed southwest of the Pool D floodplain on private property (Lykes Brothers, Inc.) comprising 126 great egret and 27 great blue heron nests. These nests were first observed on February 18; however, by March 17, approximately 50 great egret and seven great blue heron nests were abandoned between the two colonies. The remaining nests (96) appeared to have been abandoned between the March 17 survey and April 28.

Table 11-5. Peak numbers of wading bird nesting colonies inside or within 3 km of the Kissimmee River 100-year flood line between S-65 and S-65D structures. The surveyed area includes sections of floodplain that remain channelized and sections in which canal C-38 was backfilled by the first three phases of restoration construction, as well as adjacent lands that are beyond the restoration project boundary. Surveys were conducted March–June 2004, March–June 2005, February–June 2006, May–July 2007, January–May 2008, and February–April 2009.

Kissimmee River

Year	CAEG	GREG	WHIB	SNEG	GBHE	LBHE	TRHE	GLIB	BCNH	Total
2004	-	-	-	-	-	-	-	-	-	-
2005	400	81	-	-	5	-	-	-	-	486
2006	500	133	-	-	4	-	-	-	-	637
2007	226	-	-	-	-	-	1	-	-	227
2008	-	2	-	-	4	-	-	-	-	6
2009	240	126			27	11	3			407
Total	**1,366**	**342**			**40**	**11**	**4**			**1,763**

Lake Kissimmee

Year	CAEG	GREG	WHIB	SNEG	GBHE	LBHE	TRHE	GLIB	BCNH	Total
2009	740	150	75	10	50	42	87	10	3	**1,167**

CAEG = cattle egret
GREG = great egret,
WHIB = white ibis
SNEG = snowy egret,
GBHE = great blue heron
LBHE = little blue heron
TRHE = tricolored heron
GLIB = glossy ibis
BCNH = black-crowned night heron

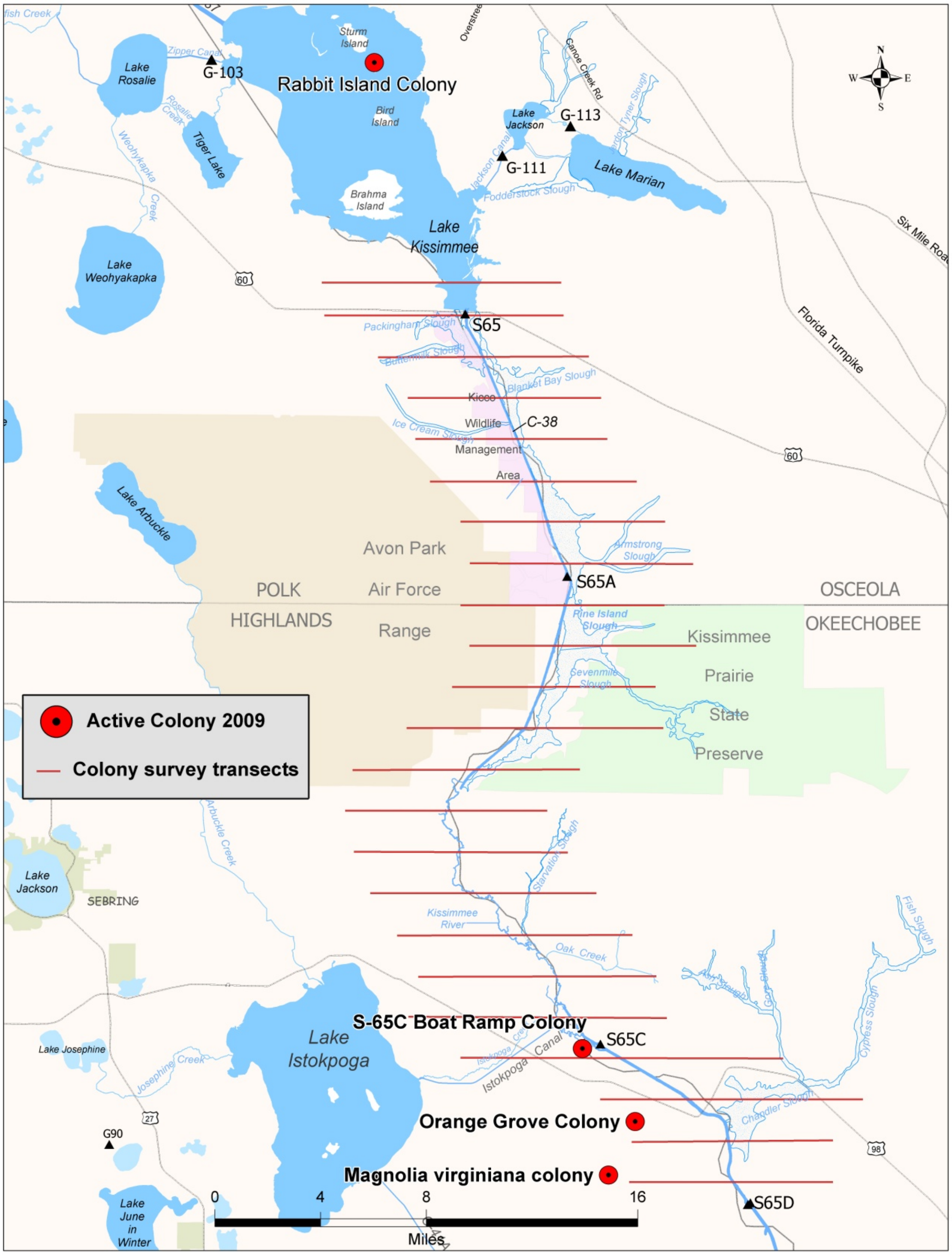


Figure 11-21. Aerial survey transect routes and locations of nesting colonies within the Kissimmee River floodplain and surrounding wetland/upland complex during 2009.

Based on two evenings of foraging flight-line counts near the colonies prior to abandonment, adult great egrets were observed returning to the breeding colonies from both the north-northwest and the east, indicating that some proportion of birds were likely foraging within the Phase I restoration area (north-northwest) as well as in isolated wetlands surrounding the Pool D floodplain (east). One possible explanation for the abandonment of the colonies was a significant reversal in stage (up to 2 feet) that occurred within portions of the restored Phase I floodplain in late April following several rainfall events and increased outflow from Pool A (S-65a). Additionally, rainfall events recorded at the S-65C lock on March 30 (0.32 inches) and April 1 (0.45 inches) may have caused water level reversals in isolated wetlands in Pool D and adjacent areas where a portion of these birds was also likely foraging. Reversal of water levels during the dry season is thought to decrease prey availability for wading birds by redistributing prey over a larger surface area and decreasing prey density, thereby leading to nest abandonment when sufficient food cannot be captured to feed young. However, due to limited access on private property, the colony was not monitored on a more frequent basis and the exact cause of abandonment remains uncertain.

Although this year's nesting effort was greater than last year, the abandonment of most nests by aquatic species (especially great egrets and great blue herons) indicates that prey availability on the floodplain was not sufficient to support the completion of breeding for these wetland-dependent species. Aquatic prey populations within the river may still need more time to recover to sufficient size to support more aquatic wading bird breeding after the drought years of 2006–2007 when much of the floodplain was completely dry. In contrast, most nests at the Pool C boat ramp colony were of the terrestrial cattle egret, which is indicative of the unrestored upland pasture habitat that dominates the Phase II/III area adjacent to the colony. Additionally, current water control operations do not allow optimal timing and magnitude of floodplain inundation and recession for rookery formation. Implementation of the regulation schedule for the Headwaters Revitalization Project in 2015 will allow water managers to more closely mimic the historical stage and discharge characteristics of the river, presumably leading to suitable hydrologic conditions for wading bird nesting colonies.

Wading Bird Densities

Monthly aerial surveys were used to measure the densities of foraging wading birds. Prior to Phase I construction (baseline period), mean annual dry season densities of long-legged wading birds in the Phase I area averaged [± standard error (S.E.)] 3.6 (± 0.9) birds/km² in 1997 and 14.3 (± 3.4) birds/km² in 1998. Since completion of Phases I and IVA, densities of long-legged wading birds have exceeded the restoration expectation of 30.6 birds/km² each year except 2007 and 2009, averaging 37.8 (± 15.4), 61.7 (± 14.5), 59.6 (± 24.4), 103.0 (± 31.5), 11.0 (± 2.1), 34.7 (± 6.4), and 18.6 (± 6.4) birds/km² in the dry seasons of 2002, 2004, 2005, 2006, 2007, 2008, and 2009, respectively (2003 data were not collected; **Figure 11-22**) (SFWMD, 2008a). Furthermore, the lower limit of the 95 percent confidence interval (C.I.) has exceeded the expectation in three of seven years.

Wading bird numbers within the restored portions of the river were roughly half of last year's mean of 34.7 birds/km². However, large numbers of wading birds (61.7 ± 26.8 birds/km²) were observed within the Phase IVB construction area immediately north of Phases I and IVA. This area was under construction during the time of the surveys and was not yet considered fully restored. Therefore, it was excluded from the data analysis. However, water levels were held significantly higher than average in portions of the construction area and large foraging flocks were attracted to the newly available habitats. It is likely that the large number of birds observed within the active construction area would otherwise have been foraging in the areas of Phase I and IVA in the absence of newly inundated floodplain in Phase IVB, and thus density estimates within these areas would likely have surpassed the restoration expectation of 30.6 birds/km² had the Phase IVB area been included in the analyses.

White ibis and great egrets dominated numerically, followed in order of abundance by great blue heron; small white heron (snowy egrets and juvenile little blue herons); small dark heron (tricolored herons and adult little blue herons); nearly equal numbers of wood storks, glossy ibis, and cattle egret; and several yellow-crowned night herons (*Nyctanassa violacea*).

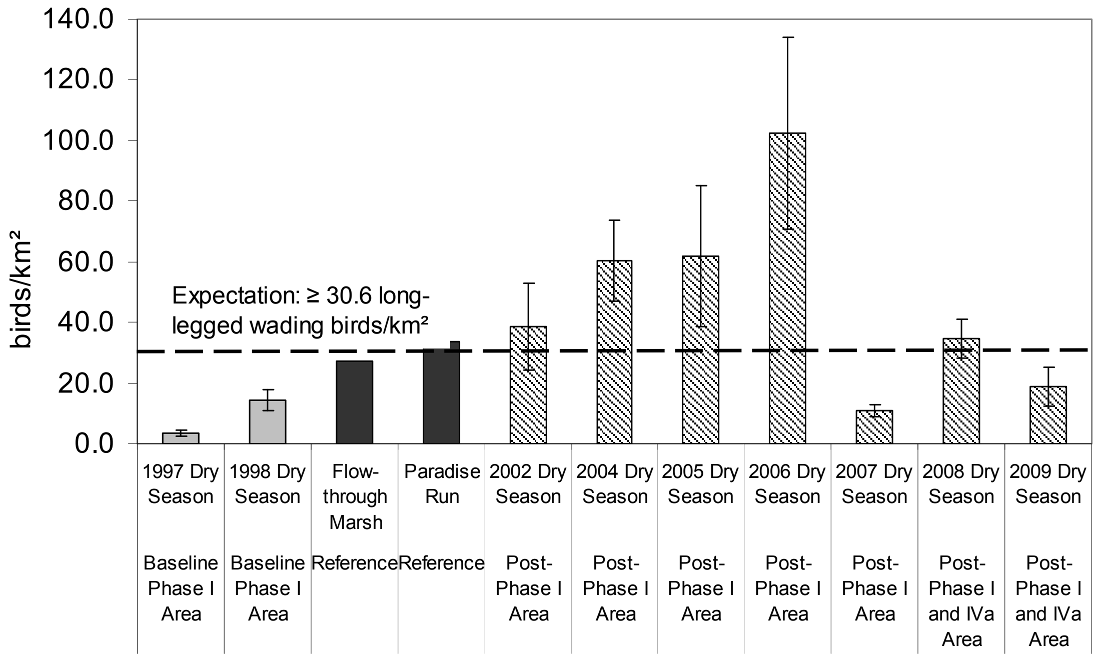


Figure 11-22. Baseline, reference, and post-Phases I and IVA densities (± S.E.) of long-legged wading birds [excluding cattle egrets (*Bubulcus ibis*)] during the dry season (December–May) within the 100-year flood line of the Kissimmee River. Baseline densities were measured in the Phase I area prior to restoration. Post-restoration densities were measured beginning approximately 10 months following completion of Phase I.

Waterfowl Densities

Four duck species, blue-winged teal (*Anas discors*), green-winged teal (*A. crecca*), mottled duck (*A. fulvigula*), and hooded merganser (*Lophodytes cullulatus*) were detected during baseline aerial surveys. During the same time period, casual observations of wood duck (*Aix sponsa*) were made during ground surveys for other projects (SFWMD, 2005a, Chapter 14). Mean annual density (± S.E.) was 0.4 ± 0.1 ducks/km² in the Phase I area, well below the restoration expectation of 3.9 ducks/km². Following completion of Phases I and IVA, average annual duck densities have exceeded the restoration expectation each year except 2007 and 2009, and the lower limit of the 95 percent C.I. has exceeded the expectation in five of eight years (**Figure 11-23**). Waterfowl densities this season (3.2 ± 1.5 birds/km²) were approximately half that of last year's mean of 7.6 birds/km². While densities within the Phase I area also may have been negatively affected by increased water levels in the active construction area (Phase IVB) (see *Wading Bird Densities* section of this chapter), the impact was likely minimal as density estimates within the construction area (3.5 ± 2.4) were also below the restoration target of 3.9 birds/km². Observed waterfowl densities below the restoration target may be due in part to the below-average rainfall received along the river during each month of the November–March survey period. Drier-than-average conditions may have led to an overall decrease in available shallow water foraging habitat within the floodplain. As overwintering and migrating waterfowl are highly mobile during the winter, many birds were likely selecting more suitable foraging areas outside of the Kissimmee River basin, such as Lake Okeechobee and the Water Conservation Areas of the Everglades to the south.

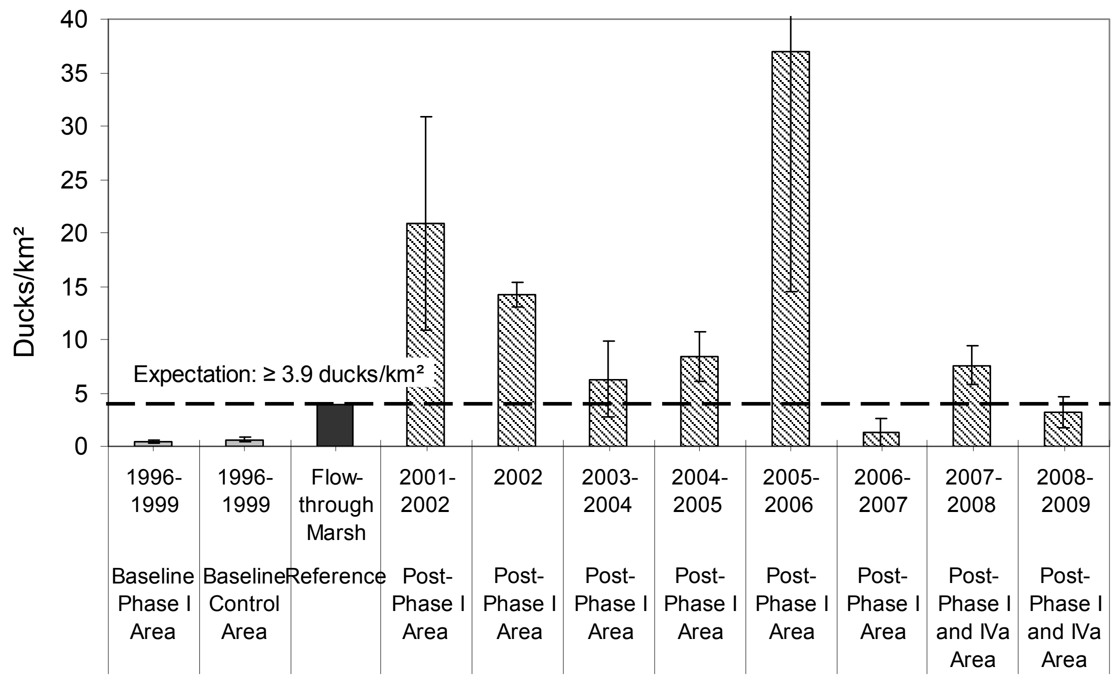


Figure 11-23. Baseline, reference, and post-Phases I and IVA densities (± S.E.) of waterfowl during winter (November–March) within the 100-year flood line of the Kissimmee River. Baseline densities were measured in the Phase I area prior to restoration. Post-restoration densities were measured beginning approximately nine months following completion of Phase I.

The American wigeon (*Anas americana*), northern pintail (*A. acuta*), northern shoveler (*A. clypeata*), ring-necked duck (*Aythya collaris*), and black-bellied whistling duck (*Dendrocygna autumnalis*) were not detected during baseline surveys, but have been present following restoration. However, these species are not regularly observed, and the restoration target for waterfowl species richness (≥ 13 species) has yet to be reached on an annual basis. Blue-winged teal and mottled duck remain the two most commonly observed species, accounting for over 95 percent of observations.

Restoration of the physical characteristics of the Kissimmee River and floodplain, along with the hydrologic characteristics of headwater inputs, is expected to produce hydropatterns and hydroperiods that will lead to the development of extensive areas of wet prairie and broadleaf marsh, two preferred waterfowl habitats (Chamberlain, 1960; Bellrose, 1980). Changes in the species richness and density of waterfowl within the restoration area are likely to be directly linked to the rate of development of floodplain plant communities and the faunal elements they support. Extrinsic factors, such as annual reproductive output on summer breeding grounds and local and regional weather patterns, also may play a role in the speed of recovery of the waterfowl community.

INVASIVE, NONINDIGENOUS SPECIES IN THE KISSIMMEE RIVER AND FLOODPLAIN

Introduction

This section presents an evaluation of nonindigenous, invasive species that occur in the Kissimmee River and floodplain, including the KRRP area in the Lower Kissimmee Basin (**Figure 11-3A**). The goal of this evaluation is to identify the potential negative effects of each species on the outcome of the restoration project, with the broader objective of identifying invasive species for which new or renewed attention is needed to avoid future negative impacts. Nonindigenous, invasive species can disrupt the outcome of ecosystem restoration by changing the structure of plant and animal communities or displacing native species.

The list of species was developed from Appendix 9-1, which identifies nonindigenous animal and priority plant species that occur in the Kissimmee Basin. The list was narrowed down by eliminating plant species that do not occur in the Kissimmee River and floodplain as well as animal species not considered to be problematic in this area. In some cases, plant species that are not District priority species (those species listed as Category I Invasives by the Florida Exotic Pest Plant Council) (FLEPPC, 2007) were added to the final list because they were identified as of concern in wetlands or uplands in the Kissimmee River and floodplain.

Eighteen invasive plant species and seven invasive animal species were considered. Biological scientists and land managers familiar with the river and floodplain evaluated each species for:

- Occurrence in the restoration project area.
- Known and possible impacts on native systems.
- Current status, existing control programs if any.
- Availability of effective control methods.
- The potential effects of the species on restoration efforts.

Recommendations were then made for what actions, if any, should be taken for each species in light of its possible effects on the Kissimmee River Restoration Project.

The resulting list and recommendations presented below show good concurrence with existing District and regional invasive species control programs. With few exceptions, most species identified as potentially problematic for the restoration project are (1) already targeted by existing District or other regional agency control programs within the project area, (2) currently pose minimal risk to restoration due to past and ongoing control efforts, (3) are considered high priorities by the District for development of control programs, or (4) are in the process of being evaluated in District field testing of BMPs or new control technologies.

Chapter 9 of this volume provides additional information about invasive species in the Kissimmee Basin.

The District's Role in Management of Invasive, Nonindigenous Species

The District has a robust vegetation management program, providing operational leadership on sovereign lands and waters within District boundaries including those in the Kissimmee Basin, and coordinates with inter-agency teams such as the Kissimmee Chain of Lakes Aquatic Plant Management Group and the Florida Hydrilla Management Summits.

For animal management, the FWC is the lead state agency, and the USFWS is the lead on federal lands; the District works in a supporting role with both agencies on District lands. For example, the District has provided assistance on programs targeting the Gambian pouch rat (*Cricetomys gambianus*) in the Florida Keys, purple swamphen (*Porphyrio porphyrio*) in the STAs and Water Conservations Areas (WCAs), and sacred ibis (*Threskironis aethiopicus*)and large constrictors in the Everglades, among others. Other than feral hog (*Sus scrofa*) management on District lands and a limited Burmese python (*Python molurus bivittatus*) management effort in the WCAs, the District does not directly manage any animal species. No agency in Florida actively manages established invasive fish populations in the wild.

The District and its partner agencies continue to seek the most current information on prevention and control methods by interacting with managers and researchers in the field of invasive species management. This is done through participation in groups such as the Florida Exotic Pest Plant Council (FLEPPC), the Florida Hydrilla Management Summit, the Everglades Cooperative Invasive Species Management Area (ECISMA), the Florida Invasive Animals Task Team (FIATT), and the South Florida Ecosystem Restoration Task Force, whose activities include prioritization of invasive species of concern and dissemination of recommendations and information on control methods. The District also is represented at regional and national conferences on species management and restoration, such as the Everglades Invasive Species Summit, Greater Everglades Ecosystem Restoration (GEER) conference, the Florida Lake Management Society (FLMS), the Society of Wetland Scientists (SWS), the Society for Ecological Restoration (SER), the North American Benthological Society (NABS), and the Ecological Society of America (ESA).

The District's Kissimmee River Restoration Evaluation Program (KRREP) includes faunal monitoring components that provide data used to evaluate trends in animal populations, including invasive fish, herpetofauna, and invertebrates. Indications of a trend of increase in the abundance of a species of concern can be elevated to the appropriate agency or task force for recommendations and development of a coordinated control strategy.

Invasive Plants

Brazilian Pepper (Schinus terebinthifolius)

- Listed as a Category I Invasive by FLEPPC.
- Forms a dense canopy, shading out native species.
- Occurs in the KRRP area primarily in spoil areas left by canal dredging. Also invades upland inclusions and wetlands within the Kissimmee River floodplain.
- Has been largely eliminated by inundation within much of the Phase I area of the KRRP.
- In 2008 and 2009, the District's Vegetation and Land Management Department aerially treated virtually all Brazilian pepper stands on the Kissimmee River, a total of over 1,500 acres, and the first time that this scale of treatment has been undertaken. Remaining small pockets will be treated by ground-based crews during *Lygodium* spp. and other exotic control work.
- Not a high priority in the KRRP project area in the past; however, it is now a District priority species. Stands are being treated as additional state funding becomes available from FWC.
- The SFWMD also provides funds for control of this species.

Prognosis for restoration impacts:

- Impact on the KRRP is unlikely given current control efforts.

Recommendations:

- Continue treatments as needed and as funds become available.

Caesar Weed (Urena lobata)

- Listed as a Category II Invasive by FLEPPC.
- Occurs primarily in uplands.
- Treated by the District's Vegetation and Land Management Department.

Prognosis for restoration impacts:

- Within the restoration area, much of the current and potential habitat of this species will be converted to wetlands.
- Although unlikely to significantly affect the KRRP, this species is of concern because of its impact on adjacent uplands.

Recommendations:

- Continue control efforts as needed.

Cogon Grass (Imperata cylindrica)

- Listed as a Category I Invasive by FLEPPC.
- Occurs primarily in disturbed uplands outside the KRRP restoration area and in areas of the channelized river/floodplain that will not be restored.
- Treated by the District's Vegetation and Land Management Department.

- A problematic species in Kissimmee Prairie Preserve State Park, a predominantly upland dry prairie state preserve on the east side of upper Pool B/C. Now a District priority species.

Prognosis for restoration impacts:

- Within the restoration area, much of the current habitat of cogon grass will be converted to wetlands.
- Although unlikely to significantly affect the KRRP, this species is of concern because of its impact on adjacent uplands.

Recommendations:

- Continue control efforts as needed.

Cuban Bulrush (Scirpus cubensis)

- This invasive, mat-forming rush has been virtually eliminated by District control efforts from the Phase I restoration project area where flow was reestablished in 2001. Not listed by FLEPPC.

Prognosis for restoration impacts:

- Given current status and control efforts, this species does not present a threat to the KRRP at this time.

Recommendation:

- Continue river channel monitoring under the restoration evaluation program littoral vegetation monitoring study.
- Treatment as needed.

Guava spp., Psidium guajava (Guava) and P. cattleianum (Strawberry Guava)

- Both species escaped from cultivation and occur primarily in upland hammocks.
- Treated by the District's Vegetation and Land Management Department.
- *P. guajava* is listed as a Category I Invasive by FLEPPC.

Prognosis for restoration impacts:

- Within the KRRP restoration area, much of the current and potential habitat of guava will be converted to wetlands by the restoration project.
- Although unlikely to significantly affect the KRRP, this species is of concern because of its impact on adjacent upland hammocks.

Recommendations:

- Continue control efforts as needed.

Hydrilla (Hydrilla verticillata)

- A prolific submergent species that forms dense mats at the water surface, hydrilla is an ongoing problem in Florida water bodies and a District priority species. In addition to its far-reaching ecological impacts, the species causes problems with water quality, recreation, and navigation.
- Listed as a Category I Invasive by FLEPPC.

- Hydrilla occurs in the Kissimmee River floodplain, becoming most evident under conditions of stabilized water levels and extended periods of inundation. During long periods of inundation of the floodplain, hydrilla has colonized large areas (e.g., the Oak Creek area on the east-central side of the floodplain) since completion of Phase I construction; these populations were reduced by prompt action. Continued rapid response by the District can control this species.
- In the Upper Kissimmee Basin headwaters lakes, hydrilla populations have developed a resistance to the systemic herbicide fluridone, formerly used extensively for whole-lake treatments. This development has reduced treatment options. However, treatments were conducted in 2008 with a new systemic herbicide, followed by application of a contact herbicide, with good success (see Chapter 9 of this volume).
- Seasonal reductions in floodplain water levels can help control hydrilla expansion. However, viable reproductive structures can lie dormant below ground during dry periods.
- Tropical storms and hurricanes can contribute to reduction of hydrilla coverage in lakes.
- A state-level hydrilla monitoring and control program is currently administered by FWC (formerly by the FDEP).

Prognosis for restoration impacts:

- Severe impacts on the KRRP are unlikely given the level of monitoring and vegetation management presence within the project area; infestations can be recognized early and addressed as needed.
- In the headwaters lakes, FWC monitoring and mapping of submergent vegetation is designed for early response to seasonal expansions of hydrilla populations.

Recommendations:

- In the Lower Kissimmee Basin, floodplain vegetation monitoring and timely response should continue.
- In Upper Kissimmee Basin lakes, hydrilla monitoring and aggressive control should continue.

Limpograss (Hemarthria altissima)

- An exotic grass introduced to the floodplain as cattle forage. Forms dense, almost monospecific stands.
- Listed as a Category II Invasive by FLEPPC.
- Experimental control efforts are in place and being closely monitored and evaluated.
- Studies were initiated in 2006 on the Kissimmee River floodplain. A 30-acre plot of *Hemarthria altissima* was established on the east-central side of the Phase I floodplain of Pool B/C to evaluate the potential efficacy of large-scale aerial herbicide treatments with two commonly used herbicides. Pre-treatment monitoring data on plant community structure were collected in this plot and an adjacent control plot in early May 2006. The herbicides imazapyr and glyphosate were applied by helicopter to separate 15-acre subplots. Subsequent monitoring indicated that these herbicides were equally effective in inducing almost 100 percent mortality of limpograss within the treated plots. Follow-up spot

treatments by ground applicators of limited regrowth within the 30-acre plot were conducted in 2007 and 2008. Post-treatment sampling to track the recovery of plant community structure and cover was conducted in summer and spring of 2007–2009 and is ongoing.

- Based on promising results from the aerial treatment, a larger 490-acre aerial application of glyphosate was carried out in fall 2007 to treat populations that had continued to spread in the restoration area floodplain. Ten 100 m^2 study plots were established to evaluate the effectiveness of the treatment in promoting reestablishment of a native wetland community. Community structure and cover data were collected from impact and control plots prior to the herbicide treatment, and semiannual measurements have continued since spring 2008 to monitor vegetation responses.

Prognosis for restoration impacts:

- This species has potential for negative impacts in the KRRP area floodplain.

Recommendations:

- Continue monitoring of treatment test plots with development of BMPs for control of this species.

Lygodium spp., Lygodium japonicum (Japanese Climbing Fern) and L. microphyllum (Old World Climbing Fern)

- Two species are present on the river. *L. japonicum* tends to be more prevalent in Pools A and B/C, and *L. microphyllum* is more prevalent in Pools D and E. Both species are present in Pool B/C, where the Phase I restoration area is located.
- Both species of *Lygodium* are listed as Category I Invasives by FLEPPC.
- Invasive wetland fern that climbs to the canopies of wetland trees and large shrubs, eventually killing host plants; a District priority species.
- Approximately 4,000 acres along the Kissimmee River, primarily wetland forest, are impacted by *Lygodium* spp.
- While treatment can reduce density and slow rates of infestation, maintenance control of this species with herbicides alone is not likely. New, small populations of *Lygodium* are discovered on the floodplain each year.
- An aerial treatment program in the Kissimmee River floodplain, administered by the District's Vegetation and Land Management Department, is in its eighth year. Density of infestation in treated (pre-2008) areas was reduced from high to moderate-low density at most sites over this period.
- Although more cost-effective than ground spraying, aerial treatments can kill host trees. A strategy has been developed for the Kissimmee River and floodplain that reserves a subset of ground-accessible native tree stands for ground treatment only.
- Larvae of the *Lygodium*-eating moth *Neomusotima conspurcatalis* were released in early 2009 in Pool D in a cooperative program between the District and the U.S. Department of Agriculture Agricultural Research Service. A 900-acre area surrounding the release site will not be treated this year so the area can be used as a nursery for the moths. Aerial and ground treatments will continue on other *Lygodium* populations.

Prognosis for restoration impacts:

- *Lygodium* infestations threaten wetland tree stands within the restoration area. Historically, stands of wetland trees were a small but important component of the floodplain vegetation mosaic.

Recommendation:

- Continue with a restrained program of aerial spraying, combined with ground treatment of selected infestations to avoid losses of wetland tree species.

Natal Grass (Rhynchelytrum repens)

- Occurring primarily in disturbed uplands, this species is treated by the District's Vegetation and Land Management Department.
- Listed as a Category I Invasive by FLEPPC.

Prognosis for restoration impacts:

- Within the KRRP restoration area, much of the current and potential habitat of this species will be converted to wetlands.
- Although unlikely to significantly affect KRRP, this species is of concern because of its potential for impact on adjacent uplands.

Recommendations:

- Continue control efforts as needed.

Paragrass (Urochloa mutica)

- Sparsely distributed patches occur on the restored floodplain and the backfilled canal, but populations are not believed to be significantly expanding.
- Listed as a Category I Invasive by FLEPPC.
- Occupies a floodplain niche similar to the native floodplain dominant, maidencane (*Panicum hemitomon*), and is difficult to distinguish from that species in aerial photography, making broad-scale monitoring difficult.
- Spot treatments of paragrass patches can avoid future expansion.

Prognosis for restoration impacts:

- Does not currently present a serious threat to the KRRP, but should be controlled as encountered.

Recommendations:

- Spot treatment should be undertaken as a complementary effort to treatments of other invasive grasses that occur on the floodplain.

Peruvian Primrose Willow (Ludwigia peruviana)

- This Category I invasive wetland shrub tends to be concentrated in the lower portions of pools above tieback levees, where water levels have remained relatively stable since channelization in 1971. It currently occurs in a large area of otherwise native floodplain marsh in the Phase I restoration area as well as along river channel edges.

- Primrose willow populations experience temporary frost impacts in very cold weather (e.g., winter 2009) but can quickly reestablish dense cover. Extended periods of deep inundation also cause dieback, but with rapid vegetative regrowth when water levels recede.
- May pose a threat to restoration of moderate-to-long hydroperiod native wetland marsh and shrub communities on the floodplain. The reestablishment of more-variable hydroperiods following the implementation of a revised water regulation schedule in 2015 may make conditions less favorable to this species.
- Experimental aerial control plots were established along the river channel in lower Pool B/C in fall 2008 and are being monitored.

Prognosis for restoration impacts:

- This species has potential to negatively impact the KRRP.

Recommendation:

- Continue monitoring and evaluation of experimental treatment plots for development of BMPs and the effects of herbicide treatments on reestablishment of associated native plants.

Smutgrass spp., Sporobolus indicus (small smutgrass) and Sporobolus indicus var. pyramidalis (giant smutgrass)

- Occurring primarily in uplands, these species are treated by the District's Vegetation and Land Management Department.

Prognosis for restoration impacts:

- Within the KRRP area, much of the current and potential habitat of this species will be converted to wetlands.
- Although unlikely to significantly affect the KRRP, these species are of concern because of their impact on adjacent uplands.

Recommendations:

- Continue control efforts as needed.

Torpedo Grass (Panicum repens)

- Although most commonly found in disturbed areas of the restoration project area (primarily in degraded spoil areas and the backfilled C-38 canal), *P. repens* occurs elsewhere at low levels; a District priority species.
- Treated by the District's Vegetation and Land Management Department
- Listed as a Category I Invasive species by FLEPPC.

Prognosis for restoration impacts:

- Given current maintenance, this species does not present a threat to the KRRP at this time.

Recommendations:

- Continue current program of treatment as needed.

Tropical Soda Apple (Solanum viarum)

- Occurs primarily in uplands on the margins of the restoration project area and in sections of the channelized river/floodplain that will not be restored.
- Listed as a Category I Invasive by FLEPPC.
- *Gratiana boliviana* beetles were released throughout the Kissimmee River area in 2007 from FDACS stocks. Some areas have seen good control.

Prognosis for restoration impacts:

- Within the restoration area, much of the current habitat of this species will be converted to wetlands.
- Although unlikely to significantly affect the KRRP, this species is of concern because of its impact on adjacent uplands.

Recommendations:

- Continue biocontrol and other control efforts as needed.

Water Hyacinth (Eichhornia crassipes) and Water Lettuce (Pistia stratiotes)

- Both of these invasive, floating exotics are listed as Category I Invasives by FLEPPC and are District priority species. They occur within the KRRP Phase I restoration area in remnant (non-flowing) river channels and channels with reestablished flow, as well as on the Phase I floodplain. Areas of open water that lack emergent vegetation are especially vulnerable for establishment and propagation of these species at the water surface, inhibiting development of native emergent communities.
- Low levels of these species are maintained in the river channel through a longstanding and successful District maintenance control program of periodic (usually semiannual) spray treatments.
- Water hyacinth has become a chronic problem on the floodplain in the Phase I restoration area. Large beds can establish on open water portions of the floodplain with sparse or immature emergent vegetation, and can expand with increasing stage and depths before native emergents can become established. The District conducts aerial treatment of these species on the floodplain.

Prognosis for restoration impacts:

- If uncontrolled, water hyacinth and water lettuce would have the potential to severely disrupt reestablishment of native patterns of vegetation, both in the river channel and the floodplain. Given current control program status, they pose little risk.

Recommendations:

- Continue maintenance control efforts in the river channel and on the floodplain.

West Indian Marsh Grass (Hymenachne amplexicaulis)

- Although present in the restoration area, this species occurs at low levels and is treated by the District's Vegetation and Land Management Department.

Prognosis for restoration impacts:

- Given current control efforts, this species does not at this time present a serious threat to the KRRP.

Recommendation:

- Continue treatments as needed.

Wright's Nut-rush (Scleria lacustris)

- This rapidly spreading species invades marshes and lake shorelines that experience seasonal water level fluctuation; listed as a Category II Invasive by FLEPPC.
- Treated by the District's Vegetation and Land Management Department.

Prognosis for restoration impacts:

- Not currently a serious problem, but recently recognized by the District as a priority species.

Recommendations:

- Continue monitoring for expansion and implement control efforts as needed.

Invasive Animals

Asian Clam (Corbicula fluminea)

- Common within the KRRP Phase I restoration area. Mean mid-river channel density in the Phase I area based on three years of post-construction data through 2004 was 1,585/m^2 in the Kissimmee River, higher than in other southeastern Coastal Plain rivers. Monitoring will resume in 2009 under the KRREP's macroinvertebrate monitoring program.
- Native mussels co-occur with the Asian clam in the restored river channel; it has not been determined to what extent, if any, this species is depressing native bivalve populations.
- Mechanical removal may be the only available control method and is unlikely to be effective in controlling populations.

Prognosis for restoration impacts:

- Competition with co-occurring native bivalves may impact the KRRP area.
- Effective control methods in natural systems are not available.

Recommendations:

- Continue the KRREP's macroinvertebrate monitoring program to track changes in status within the KRRP area.

Brown Hoplo (Hoplosternum littorale) and Vermiculated Sailfin Catfish (Pterygoplichthys disjunctivus)

- Both of these invasive fish species have increased in abundance since their introduction in the late 1990s and can be considered naturalized in the Kissimmee River ecosystem.

- Both species have potential to interfere with Centrarchid breeding success through predation of pit nests (based on feeding habits, Hoover et al., 2004) although this has not been documented in this region.
- Because vermiculated sailfin catfish construct nesting burrows, spawning colonies can degrade shoreline stability, increase erosion rates, and increase suspended sediment loads (Nico, 2000).
- No effective control methods have been demonstrated (Hoover et al., 2004). Some methods, e.g., bank armoring for vermiculated catfish, are inconsistent with restoration.

Prognosis for restoration impacts:

- Undetected negative impacts on native fish populations in the KRRP area may be occurring.
- Control of these species in natural systems is infeasible once populations have established (Hoover et al., 2004).

Recommendations:

- Continue monitoring as part of the KRREP's floodplain fish community studies.

Cane Toad (Marine Toad, Giant Toad) (Rhinella marina)

- Breeding populations have been established in the Kissimmee Basin since the early 1970s; however, the cane toad is mainly associated with disturbed, agricultural and residential areas.
- This species is a threat to native fauna. Its large size and aggressive nature allow the cane toad to out-compete and prey on native species. The toxicity of the cane toad makes it unpalatable to most potential predators; consequently, there is little predator control of the species.
- No formal control efforts are in place.
- Although cane toad has been observed in all counties within the Kissimmee basin, herpetofaunal sampling and incidental observations have not documented this species within the KRRP restoration area.

Prognosis for restoration impacts:

- Because of this species' habitat preferences, effects on the KRRP restoration area are not anticipated.

Recommendations:

- Control of this species is not a high priority within the KRRP restoration area.

Cuban Treefrog (Osteopilus septentrionallis)

- Cuban treefrog is established in all counties in the Kissimmee Basin and is a District priority species. The species has been recorded recently in aural and/or drift fence sampling in Pools A, D, and E of the Kissimmee River. It has not yet been recorded in comparable sampling in the Phase I restoration area.
- Has been observed to prey on native frogs and toads.
- The only known method of control is mechanical removal.

- No formal control efforts are in place, although the University of Florida has recently begun educating the public and encouraging euthanization of Cuban treefrogs captured by homeowners.

Prognosis for restoration impacts:

- The species has the potential to disrupt and displace native species in natural habitats and therefore is viewed as a potential problem for restoration of native herpetofaunal communities in the Kissimmee River and floodplain.
- While this species may become problematic, mechanical removal is likely to be ineffective for population control.

Recommendations:

- Continue the KRREP's herpetofaunal monitoring.
- Control options for this species should continue to be explored.

Feral Pig (Sus scrofa)

- Impacts are related to soil and vegetation disturbance through rooting, interspecific competition for resources, and predation of native flora and fauna.
- This species is present in the restoration project area, but avoids deep-water conditions on the floodplain; it is maintained at acceptable levels by hunts and removal programs.
- A feral pig removal program has been in place for five years.
- A popular FWC program that allows public hunts of the species has been expanded greatly since 1999.

Prognosis for restoration impacts:

- Given current control programs, this species is likely to have minimal overall impacts on restoration.

Recommendations:

- Continue existing programs.

Island Apple Snail (Channeled Apple Snail) (Pomacea insularum)

- A District Priority species known to be present in both the Upper and Lower Kissimmee Basins and Lake Okeechobee.
- Egg masses were recently observed in Pool E of the Kissimmee River within 3 miles of the upcoming KRRP Phase II/III restoration area.
- This species has potential to reduce abundance of the native Florida apple snail (*P. paludosa),* the primary food source of the endangered snail kite (Conner et al., 2008). Snail kites do not utilize the larger exotic species as effectively as they do *P. paludosa*.

Prognosis for restoration impacts:

- Potential impacts on the endangered snail kite by competition with native apple snails.

Recommendations:

- Control options for this species should continue to be explored.

Conclusions

Of the 18 invasive plant species considered in this subsection, 14 were judged to have little potential for impact on the KRRP, often because of past or ongoing effective control programs. For the three plant taxa judged to have current potential for impacts on wetland restoration, new control strategies are actively under study. These taxa are *Ludwigia peruviana*, *Hemarthria altissima*, and two species of *Lygodium*. Of the seven invasive animals considered, only two were judged to have little potential for impact on wetland restoration. Five invasive animals (Cuban tree frog, Asian clam, island apple snail, brown hoplo, and vermiculated sailfin catfish) were judged to have potential for impact. These are species for which control programs are not in place, primarily because effective methods of control in large natural systems are currently unknown.

PHASE II/III RESTORATION EVALUATION AND HEADWATER LAKES MONITORING

Phase II/III Integrated Studies and Monitoring

Several monitoring studies were implemented in WY2009 for evaluation of Phase II/III of the KRRP. These studies are collecting data to establish baseline conditions prior to the beginning of Phase II/III restoration construction, which is scheduled to start in 2011. Monitoring to track responses to Phase II/III will include studies of water quality (phosphorus and dissolved oxygen); geomorphology; river channel and floodplain vegetation; and aquatic invertebrate, herpetofauna, fish, and bird communities. Metrics collected by many of these studies are planned for coordinated analyses under the Phase II/III Integrated Studies. The goal of the Phase II/III Integrated Studies is to better identify relationships among individual components of the ecosystem. A better understanding of the relationships among monitoring studies will aid in adaptive management of the ecosystem during recovery. The Integrated Studies are using comparable designs that will be implemented using coordinated spatial and temporal sampling to enhance correlative analyses among studies, such as regressions, time-series analysis, and other methods. As in the Phase I evaluation studies, most of the Phase II/III studies will use a before-after-control-impact (BACI) design (SFWMD, 2005a, Chapter 1), with sampling conducted in control and impact areas before and after reconstruction of the project area.

Phase II/III Hydrology Network

Hydrologic monitoring is critical for evaluating the Kissimmee River Restoration Project. Hydrologic data are needed to evaluate restoration expectations for hydrology, which are described previously in the *Kissimmee River Restoration Evaluation Program: Updates from Phase I Monitoring Studies* section. Also, these data are needed to aid in the interpretation of responses by other ecosystem components (e.g., geomorphology, water quality, and animal and plant communities). Of particular importance is the ability to estimate the floodplain's hydroperiod characteristics to better understand the response by floodplain plant communities, fish, wading birds, and other wildlife that use the floodplain. Finally, hydrologic monitoring is needed to guide adaptive water management. In preparation for Phase II/III of construction for the restoration project, the hydrologic monitoring network in Pool D was expanded from six sites to 22 sites during 2008–2009.

The monitoring objectives for the Pool D network expansion are to establish flow and stage monitoring in reaches of the river that will be used for in-channel studies and to establish a stage monitoring network that can be used to evaluate hydroperiod characteristics across the floodplain. Also, the resulting stage monitoring network should (1) incorporate existing monitoring sites, (2) have a comparable site density to that in Pool BC, (3) link to the Pool BC network after S-65C is removed, and (4) be consistent with the layout described in the Integrated Feasibility Report/Environmental Impact Statement (IFR/EIS) for the KRRP (USACE, 1991).

The six previously existing sites are arranged from upstream to downstream (**Figure 11-23**) and include C38B, which was established in 1997, and five sites that were established in 2003 (PD01F, PD02R, PD03F, PD04F, and PD05F). The 16 new sites were located to create transects that are approximately perpendicular to the river similar to those used for Pool BC and to the network described in the IFR/EIS. Initial locations were determined from maps of topography and construction features. Sites were located near the outer edge of the floodplain and near the middle of the floodplain. Sites were also selected that would capture changes in water levels caused by discontinuities, such as changes in floodplain width, and obstructions to flow, such as the U.S. Highway 98 bridge. All sites were located on District-owned land. Final locations were adjusted based on site visits to address access issues, data transmission (line of sight to the nearest communication tower), and future site maintenance.

The 16 new sites (**Figure 11-24**) include stage recorders at 13 floodplain locations and three river channel locations. Two of the river channel sites have index velocity meters to provide information about discharge carried by the river channel. All 16 sites have been constructed and are being registered in the DBHYDRO database (**Table 11-6**).

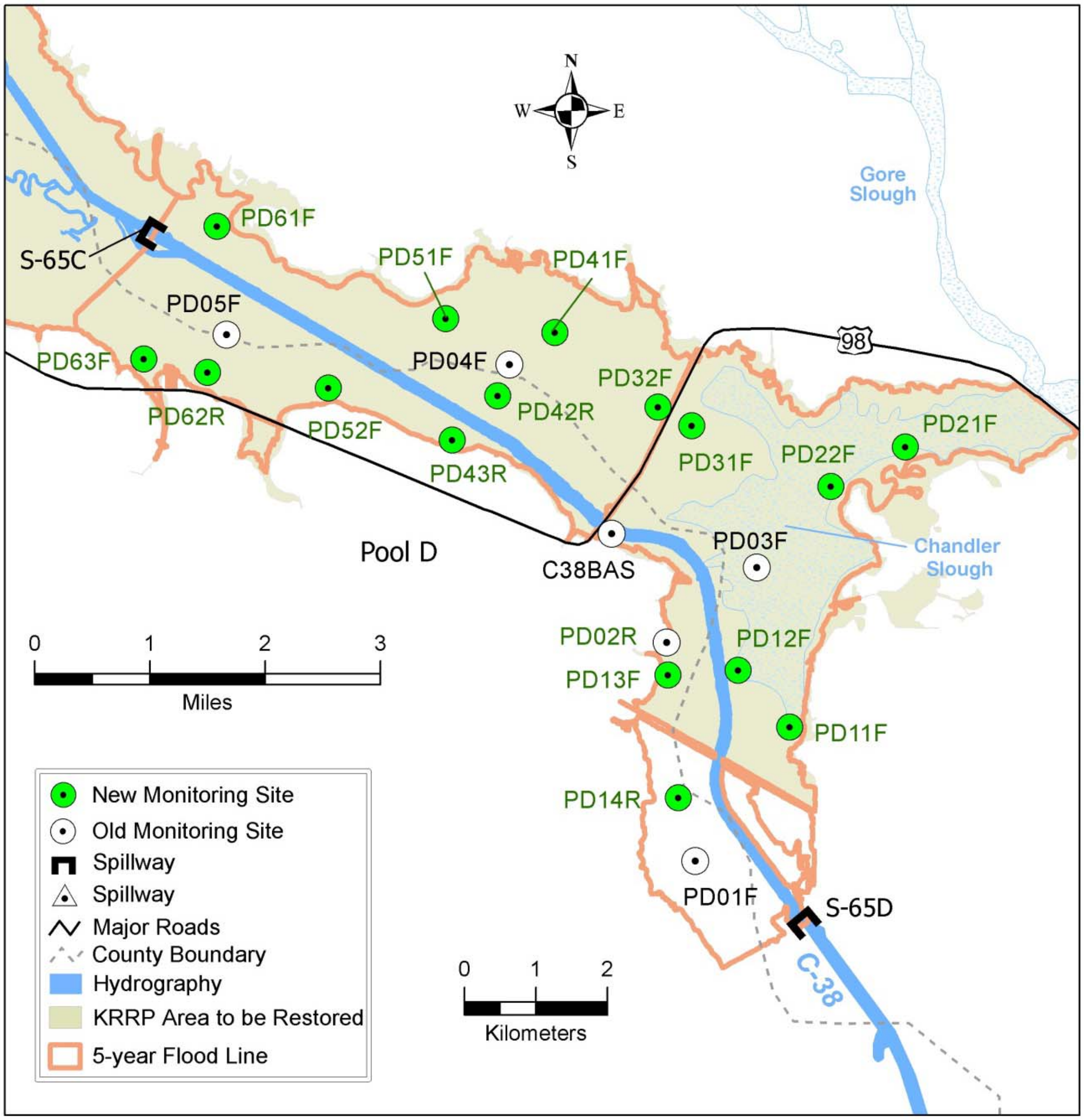


Figure 11-24. Location of new hydrologic monitoring sites (established in 2009) relative to old sites (established prior to 2009) in Pool D of the Kissimmee River that will be used to evaluate responses to Phase II/III of the Kissimmee River Restoration Project.

Table 11-6. New hydrologic monitoring sites in Pool D, Kissimmee River.

Site[1]	Data Type	DbKey		Start Date	Lat	Long	X-Coord	Y-Coord
PD11F	Stage	WF805		29-Jan-09	272020.611	810130.947	647965.27	1092425.162
PD12F	Stage	WF807		29-Jan-09	272046.320	810157.036	645613.326	1095021.814
PD13F	Stage	WN201		6-May-09	272044.185	810232.676	642399.499	1094807.167
PD14R	Stage	WN326			271947.871	810227.850	642832.522	1089120.925
PD21F	Stage				272227.590	810032.101	653272.575	1105246.474
PD22F	Stage				272209.750	810109.900	649864.523	1103445.269
PD31F	Stage	WN128		16-Apr-09	272237.139	810220.572	643494.592	1106212.752
PD32F	Stage	WN130		23-Apr-09	272245.686	810237.766	641944.902	1107076.438
PD41F	Stage	WN099		17-May-09	272319.454	810330.324	637208.642	1110488.231
PD42R	Stage	WN303			27 22 50.724	81 03 59.363	634590.401	1107587.037
	Flow							
PD43F	Stage	WN101			272230.577	810422.473	632505.279	1105555.118
PD51F	Stage	WN103		16-Apr-09	272325.767	810425.864	632202.891	1111128.38
PD52F	Stage	WN105		19-Apr-09	272254.268	810525.518	626823.636	1107951.11
PD61F	Stage	WN132			272407.471	810622.080	621731.247	1115347.209
PD62R	Stage	WN306			272301.183	810626.996	621282.298	1108653.49
	Flow							
PD63F	Stage	WN134		1-Apr-09	272307.222	810659.205	618379.651	1109266.22

[1]An F denotes site located on the floodplain; an R denotes the river channel.

Phase II/III Baseline Herpetofaunal Community Structure Study

The Phase II/III integrated study incorporates a new herpetological study that is closely integrated with hydrology, vegetation community structure, and food web dynamics. Beginning in WY2009, visual encounter surveys were conducted in forested upland habitat adjacent to the floodplain, and 300 meters of linear drift fences were installed on the outer fringe of the forested-edge of the unrestored floodplain to investigate seasonal patterns of breeding and foraging movements to and from the floodplain. The wet season of WY2009 also marked the initiation of larval throw trap sampling and Anuran call surveys to document baseline conditions for the Anuran breeding population and reproductive success in the floodplain of the channelized system. After the river restoration is complete, this baseline study will be used in assessing the success of restoration with regard to the herpetological component of ecological integrity. This herpetological study will continue until Phase II/III construction begins in 2012, and will resume following the completion of construction in 2015.

Headwaters Lakes Vegetation Monitoring

Monitoring of littoral zone vegetation began in WY2009 in the four headwaters lakes (Lakes Kissimmee, Cypress, Hatchineha, and Tiger) that are part of the Headwaters Revitalization Project. Data from this study will provide a baseline to evaluate species-level plant community changes in littoral zones that are expected as a result of increases in lake stages made possible by the Headwaters Revitalization Project.

In addition, the SFWMD and FWC entered into a partnership to map littoral vegetation in the four headwater lakes. The first phase of this mapping project began in April 2009 with the acquisition of digital aerial imagery over the lakes. The mapping phase of the project will begin in July 2009 and is expected to be finished by summer 2010, with final map data distributed to both agencies at that time. To expedite the project, scientists from the two agencies had to come to agreement over a number of issues, including a single classification system and mapping requirements for the project. The collaborative nature of this project can be a model for future partnerships between the agencies.

EFFECTS OF THE KISSIMMEE RIVER RESTORATION PROJECT ON PHOSPHORUS TRANSPORT

Phosphorus monitoring in the Kissimmee River has focused on the measurement of concentration and load at the water control structures. These measurements provide important information about changes over time. However, it is difficult to distinguish the effects of the restoration project from confounding effects such as changes in the watershed. Although the KRRP was not designed as a nutrient removal project, it is causing changes in the movement of water through the river-floodplain system that may increase the retention of phosphorus and reduce the river's phosphorus load to Lake Okeechobee. The restoration project is shifting the major flow path from the relatively deep and wide C-38 canal to the shallower and narrower river channel, which is expected to overflow and inundate its broad floodplain for extended periods of time. This change in the flow path should result in an increased opportunity for uptake of phosphorus by plants, algae, and soils. Changes in the management of flow through the system should also increase contact time by releasing more water at discharges less than those made for flood control. These changes include virtually continuous, variable flow through the system due to changes to the regulation schedule at structure S-65 (Lake Kissimmee) and movement of water through the river channel and re-inundated floodplain in the area where C-38 has been backfilled. Flow through the much shallower river channel and over the 1- to 3-mile-wide floodplain should create more opportunity for uptake and storage of phosphorus when compared to flow through the C-38 canal due to deposition and increased contact between the water flowing through the system and the river channel/floodplain vegetation and sediment/soil.

The goal of this project, which began in WY2009, is to provide an evaluation of existing data and develop a strategy/methodology for investigating the effect of the Kissimmee River Restoration Project on phosphorus transport and retention. This project was only funded for FY2009 with plans to seek funding in the future as needed. Tasks include (1) developing a framework for a phosphorus program for the KRRP; (2) summarizing existing data; (3) evaluating and further developing and expanding the Watershed Assessment Model (see Chapter 10 of this volume); (4) creating a format for reporting on the effects of the restoration project on phosphorus dynamics/loading; (5) writing status reports and annual reports on the phosphorus program; (6) enhancing the integration of phosphorus studies and reporting among SFWMD programs; and (7) identifying major uncertainties, data gaps, and additional monitoring and modeling needs, and (8) prioritizing recommendations for additional work.

KISSIMMEE RIVER RESTORATION PROJECT CONSTRUCTION ACTIVITIES

Hydrologic restoration continues on the $634 million restoration project, which is cost-shared equally by the USACE and the SFWMD. Since 1992, the SFWMD has invested approximately $341 million to acquire nearly all 102,061 acres needed for this restoration effort. Phase I and Phase IVA construction was completed in 2001 and 2007, respectively. To date, 10 of 22 miles of canal have been backfilled. Near-continuous water flow has been reestablished in the project area. Work is on schedule for completion in 2015. WY2009 contract activity included the S-68 spillway addition and Istokpoga Canal improvements. Also, backfilling for Phase IVB was initiated in WY2009.

S-68 Spillway and S-83/S-84 Spillway Additions

When Kissimmee River floodplain water levels restrict Lake Istokpoga Basin discharges via the Istokpoga Canal, the S-68 spillway addition will offset the loss of discharge capacity by re-routing flows down the C-41A canal. The project involved building an additional spillway structure adjacent to and northeast of the existing S-68 structure to increase conveyance capacity. This contract was completed in July 2009.

The S-83/S-84 spillway additions (located along the C-41A canal between Lake Istokpoga and Pool E of the Kissimmee River) are needed to increase the conveyance capacity of the C-41A canal located between Lake Istokpoga and the C-38 canal. These project features were completed in FY2008. The project activities at S-83 included excavating a new bypass channel, constructing a new spillway adjacent to and south of the existing spillway, and relocating a portion of the existing levee at that site. The project activities at S-84 included excavating a new bypass channel, constructing a new spillway north of the existing spillway, and relocating a portion of the existing levee at that site.

Istokpoga Canal Improvements

The general features under this contract limit construction to the south side of the canal to reduce the impact to high quality fish and wildlife habitat that exists along the north side of the canal. This contract included replacing the existing G-85 structure with a new water control structure (S-67), which has a 400 cfs capacity with culverts and riser gates. The contract also included dredging the canal to a 30-foot bottom width, removing a spoil mound from U.S. 98 to the river oxbow (MacArthur Run), constructing a tieback levee at S-67, constructing a public boat ramp and parking facility located east of U.S. 98 on the north side of the Istokpoga Canal, and constructing an access road from County Road 621 to 500 feet downstream of S-68. The canal improvements start at the confluence of the Istokpoga Canal and the historic Kissimmee River and extend to downstream of S-67.

Phase IVB Backfilling

Phase IVB backfilling is the northernmost section of C-38 scheduled for backfilling. Originally planned as the final section of C-38 to be backfilled, Phase IVB scheduling was altered due to logistics and is now actually the third backfilling contract to be executed. This phase is located between the Avon Park Bombing Range to the west and Kissimmee Prairie State Park to the east. The general features under this contract involve backfilling an additional 4 miles of the C-38 canal and recarving 4 miles of river channel. These activities should reestablish flow to an additional 6 miles of reconnected river channel. Phase IVB began in August 2008 and is scheduled for completion in February 2011. However, the contractor is approximately one year ahead of schedule and completion is anticipated in early 2010. Once the entire Kissimmee River Restoration Project is complete, the possibility of additional backfilling north of the Phase IVB area will be evaluated.

Canal C-37 Widening

The USACE's contract to widen the C-37 canal was selected under the American Recovery and Reinvestment Act of 2009 and put on a fast track in response to this federal funding. Part of the Headwaters Revitalization Project, this project will widen and deepen the C-37 canal between Lake Hatchineha and Lake Kissimmee by removing 780,000–1,000,000 cubic yards of material from C-37. The project will provide greater conveyance capacity of water between the two lakes to maintain the same level of flood control once the Kissimmee River Restoration Project is in place. This contract is scheduled to begin in 2010.

KISSIMMEE BASIN MODELING AND OPERATIONS STUDY

The KBMOS is a District initiative to identify alternative water control structure operating criteria for the Kissimmee Basin and its associated water resource projects. The KBMOS is independent of, but closely related to, the KCOL LTMP discussed below. The KBMOS will define the required water control structure operations needed to meet the hydrologic requirements of the river restoration project, while also achieving a more acceptable balance between water resource management objectives associated with flood control, water supply, aquatic plant management, and the natural resource requirements of the KCOL. In addition, the KBMOS will ensure that modified operations will not cause greater impacts on Lake Okeechobee from Kissimmee Basin inflows. These impacts will be evaluated relative to the desired stage envelope defined for Lake Okeechobee. The Northern Everglades and Estuaries Protection Program will address additional measures needed to meet the desired stage envelope because the KBMOS is intended only to refine operating criteria to effectively meet the above-stated objectives with complete reliance on the existing water management infrastructure and the land interests of the state of Florida and the SFWMD.

The KBMOS was initiated in September 2004. Since the previous reporting period, alternative plan screening has been completed. Four Computer-Aided Participation Workshops were held and 54 alternative plans were developed. These alternative plans were scored and ranked. All alternative plans performing better than the base condition were promoted to alternative plan formulation. These nine alternative plans are being refined and will be scored and ranked to identify the top performing alternative plans to promote to the final round of evaluation.

While the KBMOS was originally scheduled to be completed by June 2008, the completion date has been moved out to accommodate additional stakeholder involvement. The final deliverable will be modified interim and long-term operating criteria for Kissimmee Basin water control structures. Further information about the KBMOS is available at www.sfwmd.gov/watershed/.

UPPER KISSIMMEE BASIN AND TRIBUTARY PROJECTS

Kissimmee Chain of Lakes Long-Term Management Plan

The KCOL LTMP is a multiagency/stakeholder project that was initiated by the passage of the District's Governing Board Resolution 2003-468. This resolution directs SFWMD staff to work with the USACE and other interested parties to improve the health and sustainability of the KCOL by developing a long-term management plan for regulated lakes in the Upper Kissimmee Basin (**Figure 11-1** and **Figure 11-3**, panel C). The SFWMD is the lead agency responsible for coordinating the KCOL LTMP interagency activities and producing the plan. The other agencies/stakeholders include the FWC, FDEP, FDACS, USACE, USFWS, USEPA, local governments, community leaders, Lake Mary Jane Alliance, Audubon of Florida, Nature Conservancy, Alligator Chain of Lakes Home Owners Association, Alligator Chain Heritage Association, and other stakeholders. The purpose of the KCOL LTMP is to enhance and/or sustain lake ecosystem health by (1) providing the scientific and technical basis for assessing current and future environmental conditions relative to agreed-upon targets, and (2) developing collaborative strategies for identifying needs for management intervention or modification to achieve these targets. The KCOL LTMP is conceived as the collaborative framework upon which the partner agencies can manage the KCOL and adjacent/connected lands.

The draft version of the KCOL LTMP is currently on hold pending completion of other projects.

Three Lakes Wildlife Management Area Restoration

The FWC proposed the Hydrologic Restoration Project of the Three Lakes Wildlife Management Area (WMA) within the framework of the KBMOS. The project, which is being executed by the SFWMD in cooperation with the FWC, has the goal of restoring more natural hydrology and wetland function in the Three Lakes WMA, located near Lake Marian in the Upper Kissimmee Basin (**Figure 11-25**). The WMA encompasses 61,580 acres and supports one of the highest densities of bald eagles (*Haliaeetus leucocephalus*) in the lower 48 states. The project includes four phases:

- **Phase I – Hydrologic Assessment**: Compile data and prepare recommended modeling approach for the Three Lakes WMA (completed in February 2007).
- **Phase II – Modeling Work Plan Implementation**: Develop the modeling tool to formulate, evaluate, and rank alternatives; develop and evaluate alternative plans; and select the preferred alternative (completed in 2008).
- **Phase III – Project Design and Permitting**: Prepare design documents (plans and specifications) for the permitting and implementation of the preferred alternative (initiation has been delayed and activities are being restructured to allow a phased implementation of restoration project features).
- **Phase IV – Construction and Construction Support Services:** Implement the preferred alternative.

The contributing sub-watersheds within the Three Lakes WMA are hydraulically connected to Lake Kissimmee through the G-111 structure and the Jackson Canal. The major hydrologic components included in the study are Lake Marian, Lake Jackson, Fodderstack Slough, Parker Slough, Jackson Canal, and isolated wetlands connected to the system through the water table.

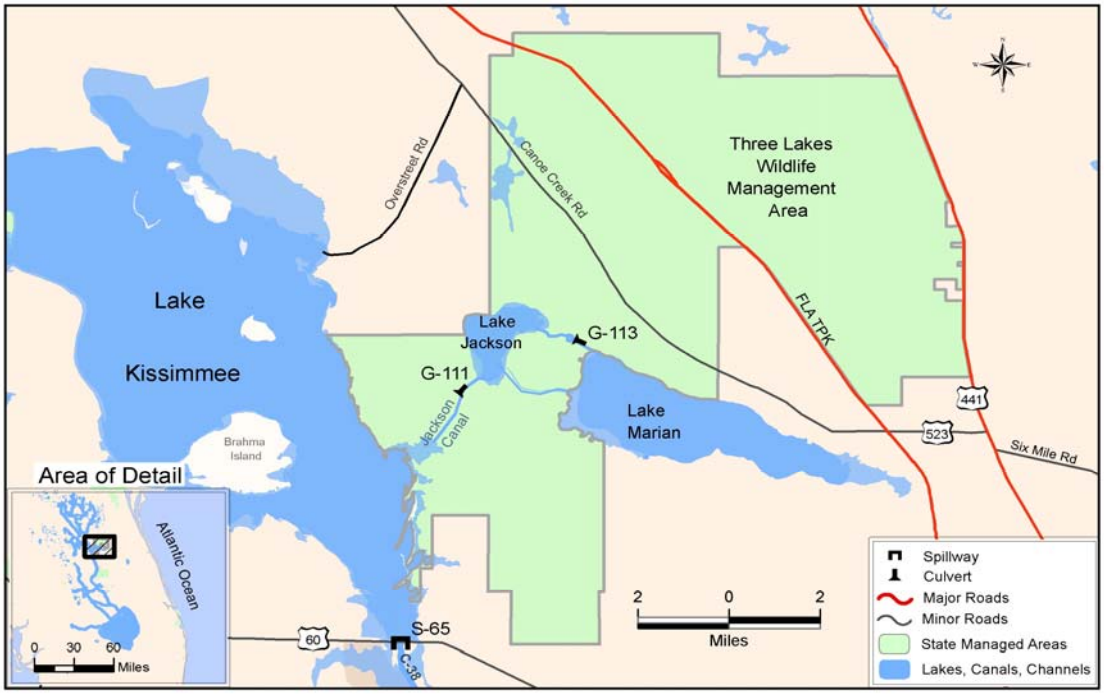


Figure 11-25. Boundaries of the Three Lakes Wildlife Management Area.

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