TECHNICAL DOCUMENT TO SUPPORT THE CENTRAL EVERGLADES PLANNING PROJECT EVERGLADES AGRICULTURAL AREA RESERVOIR WATER RESERVATION

Draft Report

June 2020

South Florida Water Management District
West Palm Beach, FL

EXECUTIVE SUMMARY

Authorized by Congress in 2016 and 2018, the Central Everglades Planning Project (CEPP) is one of many projects associated with the Comprehensive Everglades Restoration Plan (CERP) and provides a framework to address restoration of the South Florida Everglades ecosystem. As part of CEPP, the Everglades Agricultural Area (EAA) Reservoir was designed to increase water storage and treatment capacity to accommodate additional flows south to the Central Everglades (Water Conservation Area 3 and Everglades National Park). EAA Reservoir project features previously were evaluated to enhance performance of CEPP by providing an additional 240,000 acre-feet of storage. The additional storage will increase flows to the Everglades by reducing harmful discharges from Lake Okeechobee to the Caloosahatchee River and St. Lucie estuaries and capturing EAA basin runoff. The EAA Reservoir also enhances regional water supplies, which increases the water available to meet environmental needs.

The Water Resources Development Act of 2000 (Public Law 106-541) requires water be reserved or allocated as an assurance that each CERP project meets its goals and objectives. A Water Reservation is a legal mechanism to reserve a quantity of water from consumptive use for the protection of fish and wildlife or public health and safety. Under Section 373.223(4), Florida Statutes, a Water Reservation is composed of a quantification of the water to be protected, which may include a seasonal component and a location component. All surface water released from the EAA Reservoir through the S-624, S-625, and S-626 structures and directed to the Lower East Coast Everglades waterbodies will be reserved for the protection of fish and wildlife in the Central Everglades through adoption of a prospective Water Reservation rule.

This technical document summarizes the information and data collected and analyzed to support the EAA Reservoir Water Reservation rulemaking effort. It provides the best available information regarding the correlation between hydrology and biology, and it reserves a quantity of water needed for the protection of fish and wildlife. A description of the Water Reservation waterbody, an overview of CEPP, and a discussion of the project features and benefits associated with the EAA Reservoir are provided. Proposed hydrologic improvements within Water Conservation Area 3 and Everglades National Park are discussed. The conditions created by the EAA Reservoir will increase average depths and lengthen inundation durations in over-drained areas, while also reducing damaging peak water levels in ponded areas. The quantity, distribution, and timing of these hydrologic improvements are expected to restore multiple habitat types (e.g., tree islands, slough systems) that provide critical ecological functions for a multitude of fish and wildlife. Modeling information is included to show the expected hydrologic improvements associated with different habitat types and areas in the Central Everglades. Linkages are established between the hydrology and biology to show the expected benefits to fish and wildlife. Rehydration would facilitate transition from upland to wetland vegetation where submerged aquatic plants can provide structure for growth of periphyton, which are primary dietary components of invertebrates and small fishes. Thus, the expansion of rehydrated areas would increase prey availability, providing a long-term benefit to the spatial extent of suitable foraging and nesting habitat for higher trophic level species. These linkages are demonstrated by ecological models using key indicator species such as alligators, apple snails, wading birds, and small fish.

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ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

ac-ft	acre-feet
C&SF Project	Central and Southern Florida Flood Control Project
CEPP	Central Everglades Planning Project
CERP	Comprehensive Everglades Restoration Plan
cfs	cubic feet per second
CSSS	Cape Sable seaside sparrow
EAA	Everglades Agricultural Area
ECB	existing conditions baseline
ENP	Everglades National Park
F.S.	Florida Statutes
FEB	flow equalization basin
ft	foot
LOSA	Lake Okeechobee Service Area
m	meter
NESRS	Northeast Shark River Slough
NGVD29	National Geodetic Vertical Datum of 1929
PACR	Post Authorization Change Report
PIR	Project Implementation Report
RECOVER	Restoration, Coordination, and Verification program
RSM	Regional Simulation Model
RSM-GL	Regional Simulation Model – Greater Everglades and Lower East Coast Service Area
SFC	spatial foraging conditions
SFWMD	South Florida Water Management District
SRS	Shark River Slough
STA	stormwater treatment area
TFC	temporal foraging conditions
USACE	United States Army Corps of Engineers
WCA	water conservation area
WRDA	Water Resources Development Act

1 INTRODUCTION

1.1 Overview and Purpose

This document summarizes the technical and scientific data, assumptions, models, and methodology used to support rule development to reserve water for the protection of fish and wildlife in the Central Everglades (**Figure 1-1**). For the purposes of this document, and any subsequent rulemaking for this Water Reservation, the term "Central Everglades" means Water Conservation Area 3 (WCA-3) and Everglades National Park (ENP). Specifically, fresh water will be provided by the Everglades Agricultural Area (EAA) Reservoir as described in the Central Everglades Planning Project (CEPP) Post Authorization Change Report (PACR; South Florida Water Management District [SFWMD] 2018) and Final Environmental Impact Statement (United States Army Corps of Engineers [USACE] 2020). The EAA Reservoir is the main storage feature of CEPP, which also includes additional treatment and conveyance features that will improve the quantity, quality, timing, and distribution of flows to the Central Everglades, as described in the CEPP Project Implementation Report (PIR; USACE and SFWMD 2014) and PACR (SFWMD 2018). The meaning of "water needed to protect fish and wildlife" (i.e., ensuring the health and sustainability of fish and wildlife communities through natural cycles of drought, flood, and population variation) is discussed in **Chapter 2**.

The relationships and evaluations in the PIR (USACE and SFWMD 2014) and PACR (SFWMD 2018) form the basis of the proposed Water Reservation rules for the EAA Reservoir. The PACR established relationships among freshwater flows discharged from the EAA Reservoir and the downstream ecologic responses. Key information in this document is based on the PIR and PACR and provides:

- A basis for the Water Reservation rule;
- A description of the EAA Reservoir, the Central Everglades, and the watershed, which is discussed in **Chapter 3**;
- An overview of the ecosystem and improvements expected after construction and operation of the EAA Reservoir, as identified in the PACR, which is discussed in **Chapter 4**; and
- Identification of water to be reserved by rule in **Chapter 5**.

The Water Reservation rules will fulfill federal legal requirements for entering a Project Partnership Agreement with the USACE to construct the EAA Reservoir and other features. Section 601(h)(4) of the Water Resource Development Act of 2000 (WRDA 2000; Public Law 106-541) and the Programmatic Regulations for Implementation of the Comprehensive Everglades Restoration Plan (33 Code of Federal Regulations § 385.26-27) set implementation requirements for Comprehensive Everglades Restoration Plan (CERP) projects. These federal requirements ensure that each CERP project provides benefits for the natural system by protecting water through the SFWMD's reservation or allocation authority. The SFWMD elected to use its reservation authority pursuant to Section 373.223(4), Florida Statutes (F.S.), to protect water made available by the EAA Reservoir.

Water Reservation rules and accompanying water use criteria require water use permit applicants to provide reasonable assurances that their proposed use of water will not withdraw reserved water. The geographic scope of the analysis performed in the PACR and in this document includes surface water discharges from the EAA Reservoir to the Central Everglades.

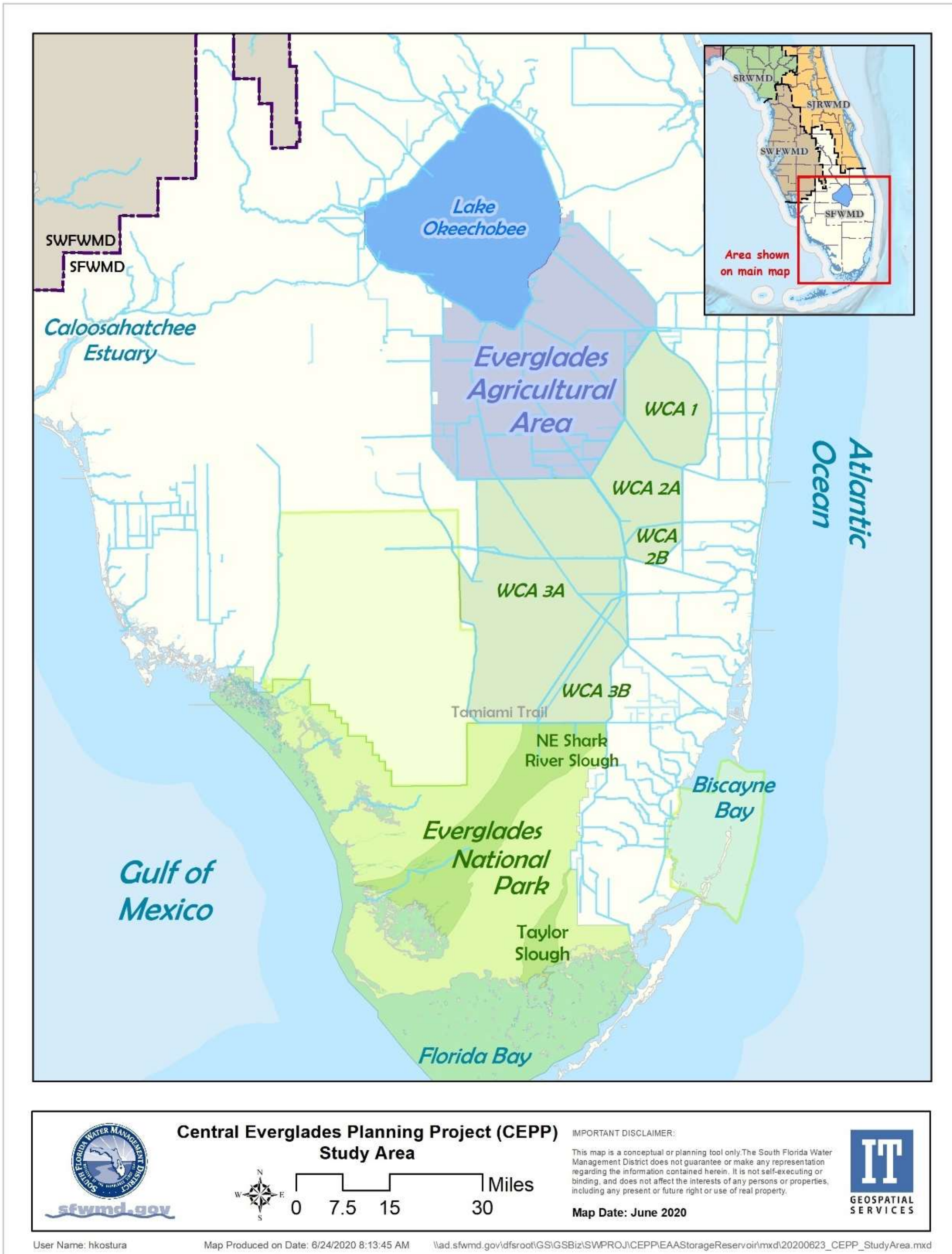

Figure 1-1. Location of the Central Everglades, encompassing Water Conservation Area 3 (3A and 3B) and Everglades National Park.

1.2 Identification of the Water Reservation Waterbody

The Water Reservation waterbody is the EAA Reservoir (**Figure 1-2**). The proposed aboveground reservoir will have a storage capacity of 240,000 acre-feet (ac-ft) and be designed with a normal full storage water depth of approximately 22.6 feet (ft). The project footprint is approximately 10,500 acres (16 square miles). Major features of the proposed EAA Reservoir are shown in **Figure 1-2**.

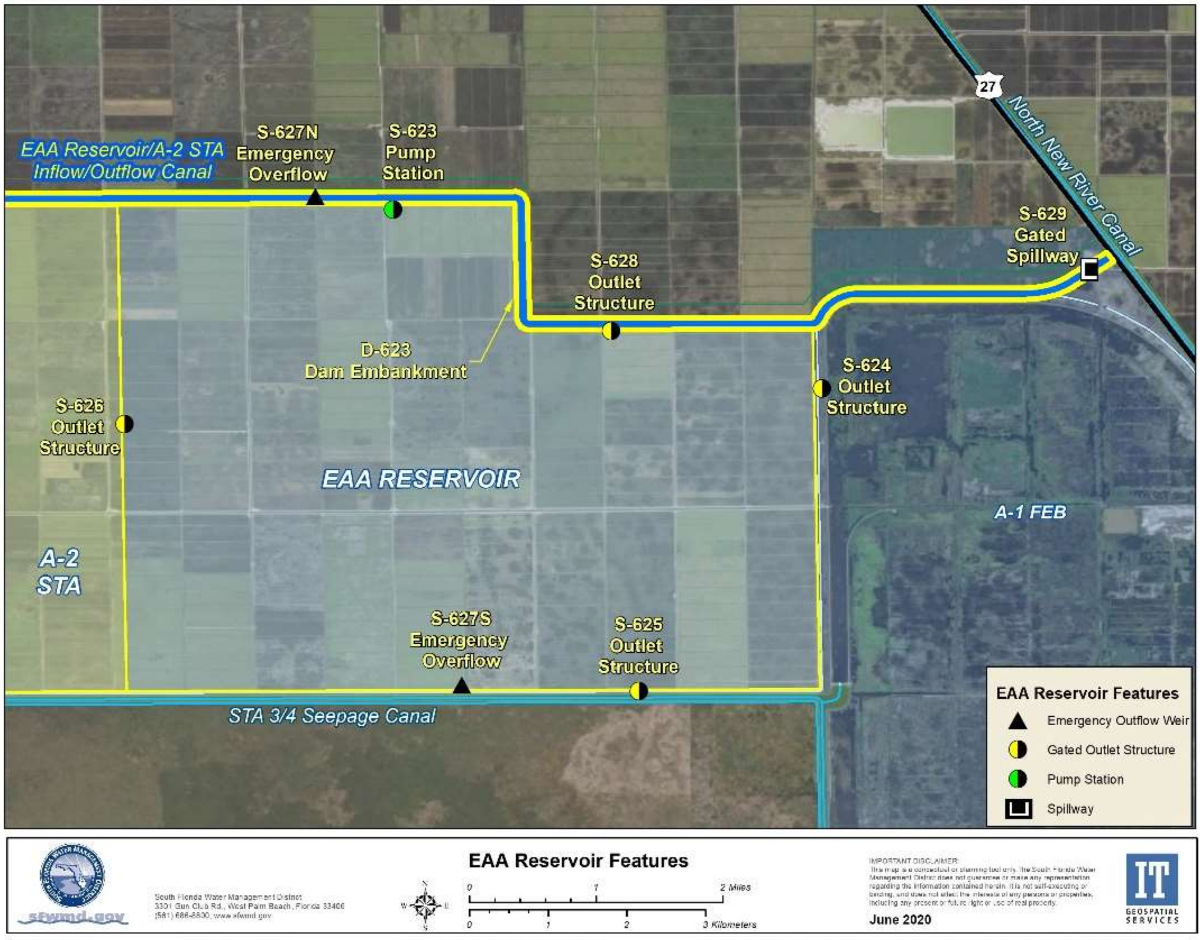

Figure 1-2. General features of the Everglades Agricultural Area Reservoir.

The EAA Reservoir will be adjacent to a stormwater treatment area (EAA A-2 STA), which also is recommended in the PACR. These features will work in conjunction with the existing A-1 Flow Equalization Basin (FEB), STA-2, and STA-3/4 to meet state water quality standards (**Figure 1-3**). The reservoir also will include additional conveyance capacity for the segments of the Miami Canal and the North New River Canal within the EAA. EAA Reservoir outflows may be sent to the new EAA A-2 STA (adjacent to and directly west of the reservoir), the existing A-1 FEB, STA-2, and/or STA-3/4. EAA Reservoir outflows also may be conveyed back to the Miami Canal or North New River Canal via the reservoir's inflow-outflow canal to supplement regional water supplies.

All surface water released via operation of the S-624, S-625, and S-626 structures in the EAA Reservoir is proposed for reservation from allocation for the protection of fish and wildlife in the Central Everglades. This is further described in **Chapter 5**.

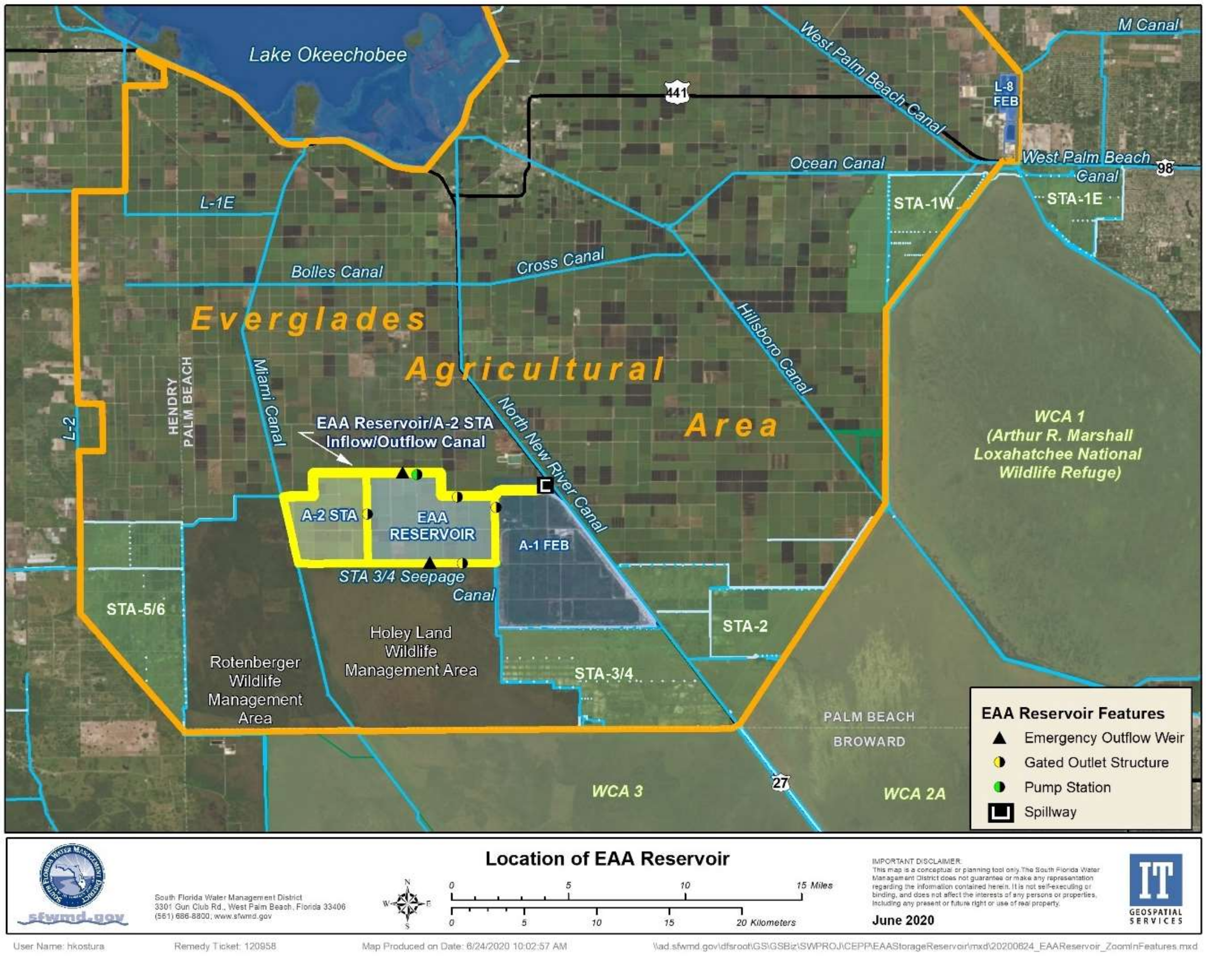

Figure 1-3. Location of the Everglades Agricultural Area Reservoir and Stormwater Treatment Area.

1.3 Comprehensive Everglades Restoration Plan

The Everglades ecosystem has been altered by 120 years of efforts to address flood protection and water supply needs in South Florida. Initiated in 1948, implementation of the federally authorized Central and Southern Florida Flood Control Project (C&SF Project) accelerated alterations to the ecosystem. As a result, the remaining Everglades ecosystem no longer exhibits the functionality, richness, and spatial extent that historically defined the system prior to the C&SF Project. The spatial extent of the Everglades has been reduced by almost 50% as a result of development and agriculture. Water management activities intended to provide flood protection and water supply to developed and agricultural areas resulted in ecosystem-wide changes south of Lake Okeechobee (**Figure 1-4**).

Water that once flowed from Lake Okeechobee south through the Everglades, down Shark River Slough (SRS), and to the southern estuaries has been impounded in the lake and discharged to the northern estuaries (i.e., Caloosahatchee River and St. Lucie estuaries) via regulatory releases through the C-43 and C-44 canals. Prolonged, high-volume discharges from Lake Okeechobee to the northern estuaries, coupled with high nutrient concentrations in Lake Okeechobee and downstream basin water, have resulted in damaging effects to plants and animals that inhabit estuarine environments. Damage to the ecosystem negatively affects the area's economy and takes years to correct. Additionally, discharges to the northern estuaries have significantly changed the hydrology south of Lake Okeechobee. The reduction in sheetflow across the Everglades has changed the landscape through the loss of peat, freshwater marshes, tree islands, and native flora and fauna, and through the proliferation of invasive species. Loss of freshwater inflow to Florida Bay, south of the Everglades, has increased the bay's salinity and caused adverse effects to estuarine species. Furthermore, South Florida agricultural practices have resulted in high nutrient concentrations in Lake Okeechobee and downstream basin water, causing additional damage to flora and fauna inhabiting these areas.

Condition	Acreage
Pre-Drainage	2,730,000
1940	2,220,000
~2003	1,540,000

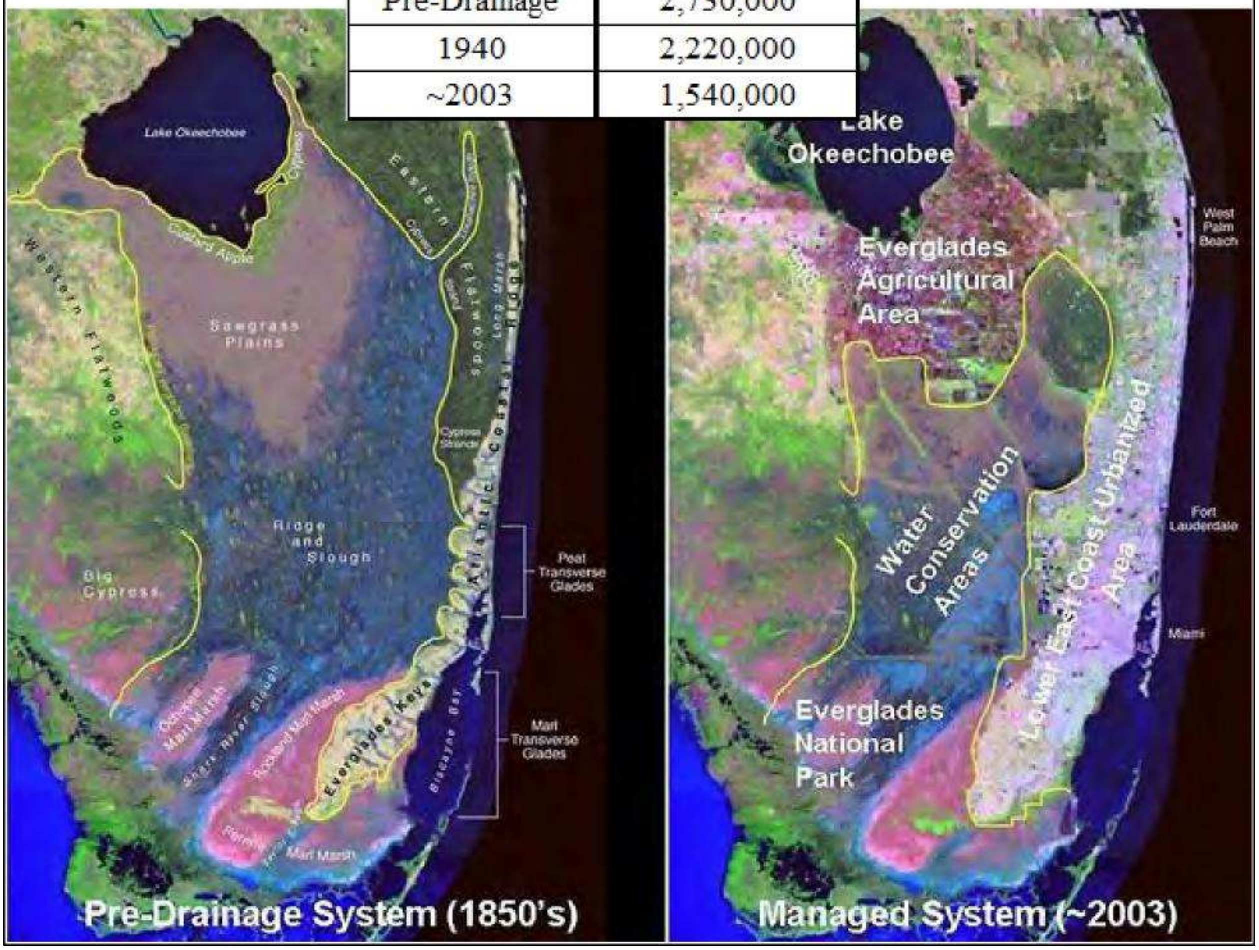

Figure 1-4. Land changes in the Everglades system over time (Modified from: McVoy et al. 2011).

CERP was approved by Congress as a framework for the restoration of the natural system under Section 601 of the WRDA 2000. CERP, as documented in the C&SF Project Comprehensive Review Study (USACE and SFWMD 1999), consists of 68 different components originally planned for implementation over an approximately 40-year period. The purpose of CERP is to modify structural and operational components of the C&SF Project to restore the South Florida ecosystem, including the Everglades, while providing for other water-related needs such as urban and agricultural water supply and flood protection. CERP was designed to restore more natural flows by redirecting water currently discharged to the Atlantic Ocean and Gulf of Mexico to a southern flow across the Everglades similar to pre-drainage conditions (**Figure 1-5**). The 68 components identified in the C&SF Project Comprehensive Review Study (USACE and SFWMD 1999), which include storage, treatment, seepage management, and conveyance modifications, among others, will work together to restore the ecological structure and function of more than 2.4 million acres of the South Florida ecosystem by improving and/or restoring the quantity, quality, timing, and distribution of water in the natural system from the Kissimmee Basin to Florida Bay. CERP also will address other concerns such as urban and agricultural water supply and maintain existing levels of service for flood protection in areas served by the project.

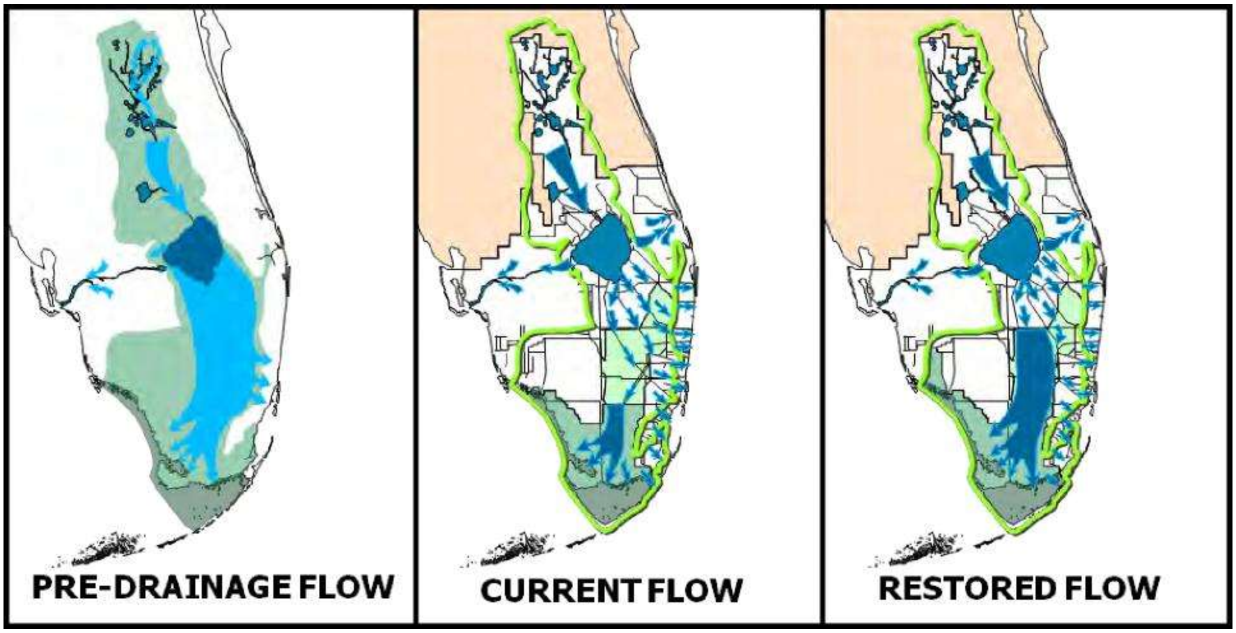

Figure 1-5. Pre-drainage, current, and restored flows to illustrate Comprehensive Everglades Restoration Plan (CERP) restoration.

Since authorization of CERP in the WRDA 2000:

- Three projects were authorized in the WRDA 2007 (Public Law 110-114) and proceeded into construction: Indian River Lagoon-South, Picayune Strand, and Site 1 Impoundment. A fourth project, Melaleuca and Other Exotic Plants Biological Controls, was implemented under the programmatic authority from the WRDA 2000.
- Four projects were authorized in the Water Resources Reform and Development Act of 2014 (Public Law 113-121). The Caloosahatchee River (C-43) West Basin Storage Reservoir, Biscayne Bay Coastal Wetlands Phase I Project, and C-111 Spreader Canal Western proceeded into construction, and detailed design began on the Broward County Water Preserve Area Project.
- CEPP was authorized in the Water Infrastructure Improvements for the Nation Act of 2016 (Public Law 114-322).
- The CEPP PACR was authorized in the America's Water Infrastructure Act of 2018 (Public Law 115-270).

1.4 Central Everglades Planning Project

The CEPP PIR was initiated by the USACE in 2011 in partnership with the SFWMD, the non-federal sponsor of CERP. The PIR was completed in December 2014, the Chief of Engineers report was signed on December 23, 2014, and CEPP was authorized by Congress in Section 1401(4) of the Water Infrastructure Improvements for the Nation Act of 2016 (Public Law 114-322). In 2018, Congress authorized the CEPP PACR in Section 1308(a) of the America's Water Infrastructure Act of 2018 (Public Law 115-270). The PACR modified CEPP to increase the storage, treatment, and conveyance of the new water component of the plan.

The overall purpose of CEPP is to develop a plan to restore water depth, duration, and distribution in WCA-3A, WCA-3B, and ENP to re-establish a landscape characteristic of the pre-drained system that would support a healthy mosaic of plant and animal life. The restored hydrology of the Everglades ecosystem would more closely resemble a naturally occurring, rainfall-driven system with wet and dry cycles essential to flora and fauna propagation. Improved water depth and sheetflow distribution would begin to re-establish the unique ridge, slough, and tree island microtopography that once sustained the vast diversity of species inhabiting the Everglades.

The following subsections describe the components of CEPP, which are organized into four geographic areas: the EAA; northern WCA-3A; southern WCA-3A, WCA-3B, and ENP; and the Lower East Coast protective levee (**Figure 1-6**). Additional information about CEPP is presented in the PIR (USACE and SFWMD 2014), PACR (SFWMD 2018), and Final Environmental Impact Statement (USACE 2020). Analyses of alternative plans in the PACR partially depended on hydrologic simulation models. The alternative selected to represent CEPP with the EAA Reservoir was called Alternative C240 in the PACR and the Final Environmental Impact Statement. This nomenclature can be found in the description of CEPP benefits in **Chapter 4**.

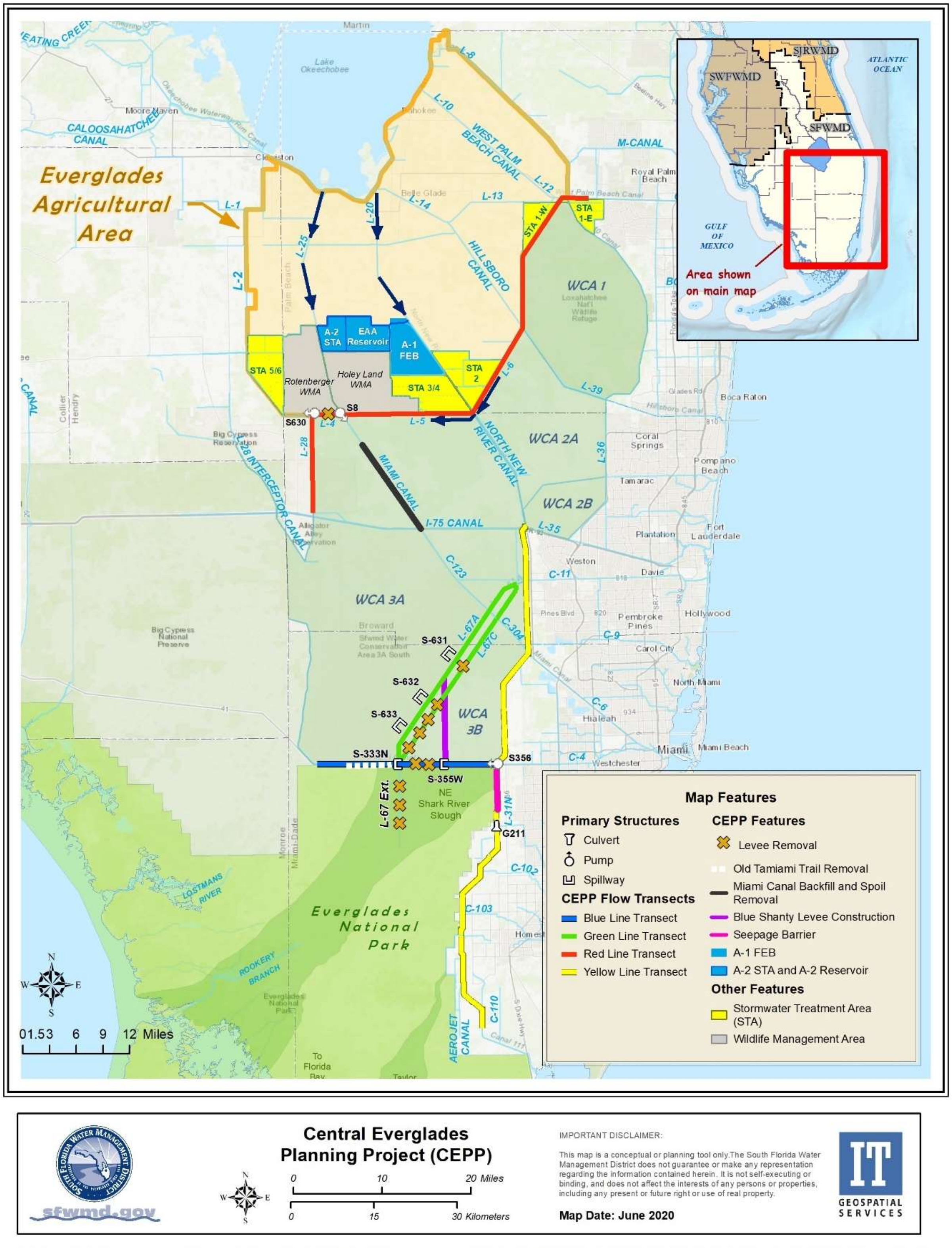

Figure 1-6. The authorized Central Everglades Planning Project components.

1.4.1 Everglades Agricultural Area

The EAA Reservoir and A-2 STA includes construction and operations to divert, store, and treat Lake Okeechobee regulatory releases. Once constructed, the EAA Reservoir will have a storage capacity of 240,000 ac-ft, and the STA will encompass 6,500 acres. These features will work in conjunction with the existing A-1 FEB (60,000 ac-ft), STA-2, and STA-3/4 to meet state water quality standards (**Figure 1-4**). The reservoir project increases conveyance capacity in segments of the Miami Canal and North New River Canal within the EAA by 1,000 and 200 cubic feet per second (cfs). EAA Reservoir outflows may be sent to the new EAA A-2 STA (adjacent to and directly west of the reservoir), the A-1 FEB, STA-2, and/or STA-3/4. EAA Reservoir outflows also may be conveyed to the Miami Canal or North New River Canal via the inflow-outflow canal to supplement regional water supplies for irrigation. The EAA Reservoir will store Lake Okeechobee water currently discharged to the northern estuaries and EAA basin runoff.

Additional water will be made available for restoration purposes through modified Lake Okeechobee operations and the efficient use of the EAA Reservoir and A-2 STA to improve the quantity, timing, and distribution of environmental deliveries to the WCAs and ENP during the wet and dry seasons. Operational changes to deliver this new water would be conducted in a manner consistent with stage, volume, and/or flow-based restoration targets by 1) treating and delivering water from Lake Okeechobee, water detained by CEPP PACR components, or a combination of both, and 2) providing temporary storage for releases from Lake Okeechobee to reduce the harmful effects of flood control releases on the St. Lucie and Caloosahatchee River estuaries. It should be recognized that most EAA flood control discharge currently sent to the WCAs is an important part of the water budget for those areas. Additionally, some regulatory releases from Lake Okeechobee to the WCAs are beneficial to the WCAs, provided the releases have water quality treatment sufficient to maintain compliance with legal and restoration goals. However, there are times when stages in the WCAs are higher than restoration targets. During those times, runoff and regulatory releases to the WCAs can exacerbate short- and long-term impacts due to high stages. The EAA Reservoir will provide an additional 240,000 ac-ft of effective detention volume to attenuate EAA runoff and lake water flows, thus avoiding sending water to the WCAs when they are not ready to receive additional water. The EAA Reservoir may be filled and emptied multiple times each year to handle flows to the STAs. As a general operational strategy, the EAA Reservoir will be operated to attenuate flows during the wet season and carry over water from September and October into the dry season when releases to the WCAs would be beneficial or cause less harm.

1.4.2 Northern Water Conservation Area 3A

Northern WCA-3A includes conveyance features to deliver and distribute existing flows and redirected Lake Okeechobee water through WCA-3A. The key features to ensure spatial distribution and flow directionality of water entering WCA-3A are 1) backfilling 13.5 miles of the Miami Canal between Interstate 75 and 1.5 miles south of the S-8 pump station, and 2) converting the L-4 Canal into a spreader canal by removing 2.9 miles of the southern L-4 levee.

Conveyance features to move water into and through the northwestern portion of WCA-3A include a gated culvert to deliver water from the L-6 Canal to the remnant L-5 Canal; a new gated spillway to deliver water from the remnant L-5 Canal to the western L-5 Canal (during L-6 diversion operations); a new gated spillway to deliver water from STA-3/4 to the S-7 pump station during peak discharge events (the eastern flow route typically is not used during normal operations), including L-6 diversion operations; 13.6 miles of conveyance improvements to the L-5 Canal; a new 360-cfs pump station within the L-4 Canal to retain existing functionality of STA-5 and STA-6 and to maintain water supply to existing legal users, including the Seminole Tribe of Florida; and new gated culverts and an associated new canal to deliver water from the Miami Canal (downstream of S-8, which pulls water from the L-5 Canal) to the L-4 Canal, along with potential design modifications to the existing S-8 and G-404 pump stations.

The Miami Canal would be backfilled to approximately 1.5 ft below the peat surface of the adjacent marsh. Spoil mounds on the east and west sides of the Miami Canal from S-8 to Interstate 75 would be used for backfill material. Refuge for mammals and other upland species would continue to be provided by retaining 22 of the highest priority Florida Fish and Wildlife Conservation Commission enhanced spoil mounds between S-339 (approximately 10 miles south of S-339) and Interstate 75 and by creating additional upland landscape (constructed tree islands) approximately every mile along the entire reach of the backfilled Miami Canal section where ridges and tree islands once existed.

1.4.3 Southern Water Conservation Area 3A, Water Conservation Area 3B, and Everglades National Park

As CEPP moves forward, WCA-3A and WCA-3B will include conveyance features to deliver and distribute water to ENP. The new Blue Shanty Levee (L-67D), extending from Tamiami Trail north to the L-67A Canal, would be constructed. The Blue Shanty Levee would divide WCA-3B into two subunits, a large eastern unit (3B-E) and a smaller western unit, the Blue Shanty Flow-way (3B-W). Hydrologic modeling indicated a new levee is the most efficient means to restore continuous southerly sheetflow through a practicable section of WCA-3B and alleviates concerns regarding effects to tree islands by maintaining lower water depths and stages in WCA-3B-E. The width of the Blue Shanty Flow-way is aligned to the width of the downstream 2.6-mile Tamiami Trail Next Steps bridge, optimizing the effectiveness of both the flow-way and bridge. In the Blue Shanty Flow-way, construction of two gated control structures on the L-67A Canal, removal of the L-67C and L-29 levees within the flow-way, and construction of a gated spillway in the L-29 Canal would enable continuous sheetflow of water from WCA-3A through WCA-3B-W to ENP. A third gated control structure in the L-67A levee and associated gap in the L-67C levee, both outside the flow-way, would improve the hydroperiod of WCA-3B-E. Spoil mounds along the northwestern side of the L-67A Canal, near the three new L-67A structures, would be removed to facilitate sheetflow connectivity with the WCA-3A marsh. An additional gated spillway (S-333N) adjacent to the S-333 structure at the terminus of the L-67A Canal, removal of 5.5 miles of the L-67 extension levee, and removal of approximately 6 miles of Old Tamiami Trail between ENP Tram Road and the L-67 extension levee would facilitate additional deliveries of water from WCA-3A directly to ENP.

1.4.4 Lower East Coast Protective Levee

The Lower East Coast protective levee includes features primarily for seepage management, which are required to mitigate for increased seepage resulting from additional flows into WCA-3B and ENP. A newly constructed 1,000-cfs pump station would replace the temporary S-356 pump station, and a 4.2-mile partial-depth seepage barrier would be built along the L-31N levee south of Tamiami Trail.

CEPP conservatively includes a 4.2-mile long, 35-ft deep tapering seepage barrier if necessary. Uncertainties remain regarding the effectiveness of the CEPP seepage cutoff wall in providing desired stages in ENP marshes while maintaining flood protection and canal stages to the east without limiting water availability to existing water users and Biscayne Bay. Additional analysis of the CEPP seepage cutoff wall would be conducted during the preconstruction engineering and design phase.

1.5 Benefits of the Central Everglades Planning Project

1.5.1 Meeting Comprehensive Everglades Restoration Plan Goals for Flows to Central Everglades

The original CEPP was the first incremental step in increasing average annual flows to the Central Everglades. It provided approximately 210,000 ac-ft on an average annual basis to the Central Everglades, which is approximately two-thirds of the CERP performance goal. Plan formulation for the PACR attempted to deliver the remaining one-third of new water essential to Everglades restoration consistent with the CERP performance goal by screening different storage features.

The screening analysis compared the pre-CERP baseline (USACE 2005) to the CERPA scenario—the model scenario from the Restoration, Coordination, and Verification program (RECOVER 2005) to update CERP—to establish the CERP goal for flow to the Central Everglades. This analysis identified the CERP goal flow target of approximately 300,000 ac-ft of new water on an average annual basis over the 36-year modeled simulation period (1965 to 2000) for restoration. Early screening suggested high potential for this project to meet or exceed the CERP goal of sending water to the Central Everglades.

The CERP goal flow target became the target for continued PACR plan formulation work. The most cost-effective alternative (R240A) was refined and modeled to optimize its performance based on the operational protocols included in Alternative C360C to become Alternative C240. The operations of Alternatives C360C and C240 broadened the reservoir's function from single-purpose to multi-purpose by conveying water to the Miami Canal and North New River Canal for regional water supplies. Alternative C240 achieved 97% of the CERP goal over the 36-year period of record available from RECOVER. Consistent with CEPP, Alternative C240 was modeled and analyzed over the longer 41-year period of record (1965 to 2005) to evaluate effects of the PACR. Alternative C240 provides an increase of approximately 370,000 ac-ft in average annual flow to the Central Everglades, exceeding the CERP goal of 300,000 ac-ft.

1.5.2 Benefits to the Northern Estuaries

One goal of CERP is to reduce damaging freshwater discharges to the northern estuaries by approximately 80%. In combination with the previously authorized projects, CEPP approaches this goal by providing a 55% flow reduction in damaging discharges and a 63% reduction in the number of mean monthly high-flow discharge events. CEPP helps restore the resiliency of the northern estuaries by reducing the number, duration, and frequency of harmful discharges from Lake Okeechobee. The supplemental storage and treatment proposed in the PACR would reduce the number of discharges by an additional 40% for the Caloosahatchee River Estuary and 55% for the St. Lucie Estuary, in addition to the benefits provided by CEPP. Salinity conditions in the estuaries are improved by reducing the number of discharge events that exceed the preferred salinity envelope by 45% in the Caloosahatchee River Estuary and by 39% in the St. Lucie Estuary.

1.5.3 Benefits to the Central Everglades

In addition to reducing damaging discharges to the northern estuaries, CEPP increases water deliveries to the Central Everglades to an average annual flow of approximately 370,000 ac-ft. This is essential to Everglades restoration and achieves the CERP goal for freshwater deliveries to the Everglades. CEPP also shifts the timing of deliveries, favoring flows during the dry season (November through May) when downstream infrastructure has adequate capacity to convey the increased flows (**Figure 1-7**). CEPP integrates the new EAA Reservoir and A-2 STA with the existing A-1 FEB, STA-2, and STA-3/4 to meet the project objectives. Under current conditions, STAs have little to no flow during the dry season, which can result in stagnant conditions. CEPP primarily uses STA capacity available during the dry season in STA-2 and STA-3/4. As expected, this results in higher average monthly inflows during dry season months compared to current conditions.

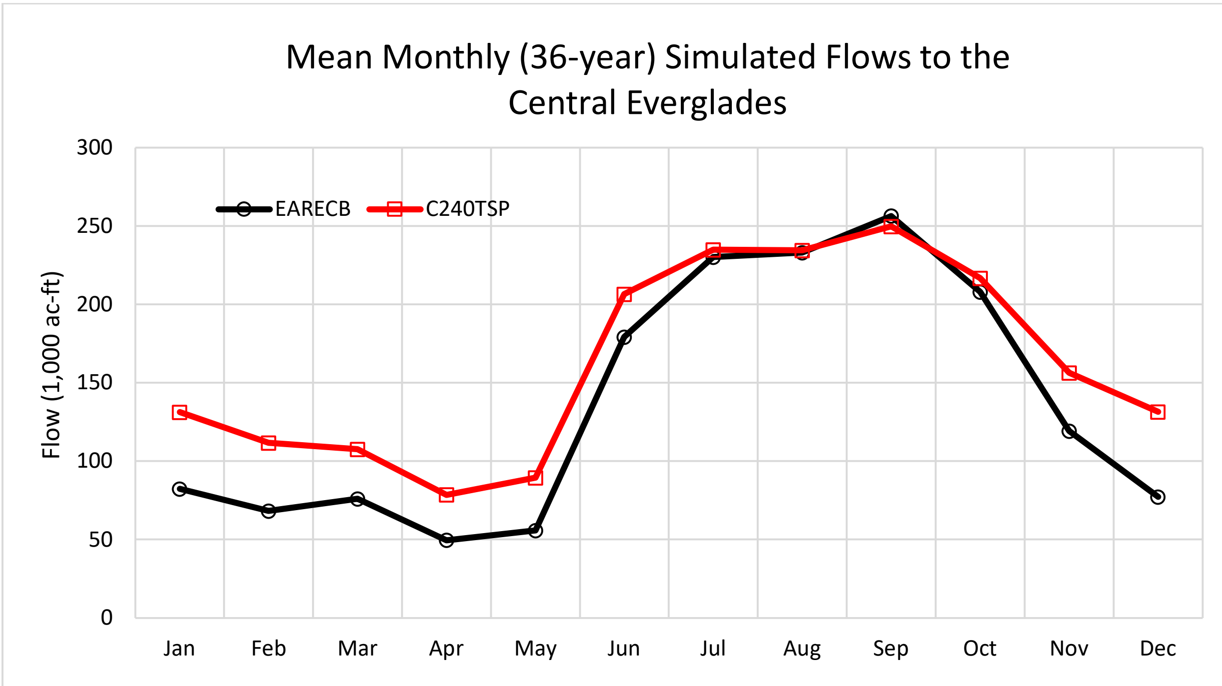

Figure 1-7. Timing of treated flows south into the Central Everglades with the Central Everglades Planning Project (C240TSP) compared to existing conditions (EARECB).

Additional flow will have the following ecological benefits to the Central Everglades:

- Additional water flowing into northern WCA-3A and ENP will help improve and/or restore vegetative communities and habitat for fish and wildlife.
- Additional flow will improve natural processes critical for development of peat soils and tree islands, which are essential features of the Everglades ridge and slough landscape.
- In northwestern WCA-3A, CEPP will improve slough vegetation depths, reducing the time that water ponding depth in the sloughs falls below zero (i.e., fewer dryouts).
- In northwestern WCA-3A, CEPP will provide longer durations (hydroperiods) when the CERP target ponding depths are achieved, which improves slough vegetation suitability.
- In northeastern WCA-3A, CEPP will improve slough vegetation by increasing the duration of beneficial water ponding depths.
- Overland flows will increase under Tamiami Trail and into the northern portions of ENP.
- Additional freshwater overland flow will be provided to central SRS and Taylor Slough and will improve the timing, distribution, and continuity of sheetflow across the Everglades ridge and slough landscape. The benefits of overland flow to central SRS are a continuation of the flows under Tamiami Trail.

2 BASIS FOR WATER RESERVATIONS

2.1 Definition and Statutory Authority

A Water Reservation is a legal mechanism to reserve a quantity of water from consumptive use for the protection of fish and wildlife or public health and safety.

Section 373.223(4), F.S., states the following:

> *The governing board or the department, by regulation, may reserve from use by permit applicants, water in such locations and quantities, and for such seasons of the year, as in its judgment may be required for the protection of fish and wildlife or the public health and safety. Such reservations shall be subject to periodic review and revision in the light of changed conditions. However, all presently existing legal uses of water shall be protected so long as such use is not contrary to the public interest.*

Per Florida Division of Administrative Hearings (2006) Case 04-000880RP, it is reasonable to interpret "protection" to mean ensuring the health and sustainability of fish and wildlife communities through natural cycles of drought, flood, and population variation.

When water is reserved pursuant to Section 373.223(4), F.S., it is unavailable for allocation to new or increased consumptive uses. However, existing legal uses of water are protected so long as such uses are not contrary to the public interest. An existing legal use is a water use that is authorized in a water use permit pursuant to Part II of Chapter 373, F.S., or is exempt from water use permit requirements.

It is equally important to understand the limitations of Water Reservations. Water Reservations do not drought-proof a natural system, ensure wildlife proliferation, or establish an operating regime. While Part II of Chapter 373, F.S., authorizes the SFWMD to permit consumptive uses and establish Water Reservations, it does not authorize the SFWMD to establish operating criteria for the C&SF Project system or CERP projects. The C&SF Project system and CERP project operating criteria are established by the USACE and implemented by the SFWMD through distinct federal and state authorities. C&SF Project and CERP project operating criteria affect the timing and availability of water in the SFWMD; therefore, the operating plans for CERP projects must be consistent with established Water Reservations and permitted water allocations.

The Florida Legislature gave broad discretion to the Governing Boards of Florida's five water management districts to exercise judgment in establishing Water Reservations, taking into consideration the water needs of fish and wildlife or public health and safety while also balancing the overall district missions. Water management districts are directed to periodically review and revise adopted Water Reservations as needed to achieve this balance.

The SFWMD has elected to use its Water Reservation authority conferred by Section 373.223(4), F.S., to reserve quantities of water in the EAA Reservoir for the protection of fish and wildlife through adoption of Water Reservation rules. The proposed Water Reservation rules also will support the overall restoration goals and objectives of CEPP. Rulemaking will be based on the technical information and recommendations in this document.

2.1.1 Prospective Water Reservation

Subsection 62-40.474(3), Florida Administrative Code, states that Water Reservations may be adopted prospectively for water quantities anticipated to be made available at a future date. Surface water from the EAA Reservoir will not be made available for the Central Everglades until the reservoir is constructed and operational. Therefore, this will be a prospective Water Reservation.

2.2 Water Reservation Rulemaking Process

General rulemaking requirements and procedures are described in Chapter 120, F.S., consistent with state law and SFWMD policy. The generalized process of Water Reservation rulemaking includes several steps (**Figure 2-1**). The following is a description of the steps completed thus far in the CEPP EAA Reservoir Water Reservation development process. On April 9, 2020, the SFWMD Governing Board authorized publication of a Notice of Rule Development for the CEPP EAA Reservoir Water Reservation. Modeling, analyses, and drafts of this technical document and Water Reservation rules were then completed. An independent scientific peer review was initiated by the SFWMD in April 2020; a public peer review session will be held on May 29, 2020; and a final peer review report will be completed in June 2020.

In addition to the SFWMD's recent peer-review process, a USACE Agency Technical Review/External Peer Review of the CEPP PIR was completed in October 2013 through collaboration with the USACE Planning Centers of Expertise in compliance with Engineer Circular 1105-2-408, Peer Review of Decision Documents, dated May 31, 2005. The PACR underwent an independent external peer review in accordance with the requirements in Engineer Circular 1165-2-214, Appendix D, and was completed in March 2018.

An overview of the proposed Water Reservation project will be presented at public workshops and meetings with key stakeholder groups in July and August 2020 to gain public input on the rulemaking process. Draft Water Reservation rules and revisions to applicable sections of the *Applicant's Handbook for Water Use Permit Applications in the South Florida Water Management District* (SFWMD 2015) will be completed in August 2020. Once the draft Water Reservation rules are finalized, they will be considered by the SFWMD Governing Board for adoption. The SFWMD encourages stakeholder review and comment on the draft Water Reservation rules prior to final rule adoption.

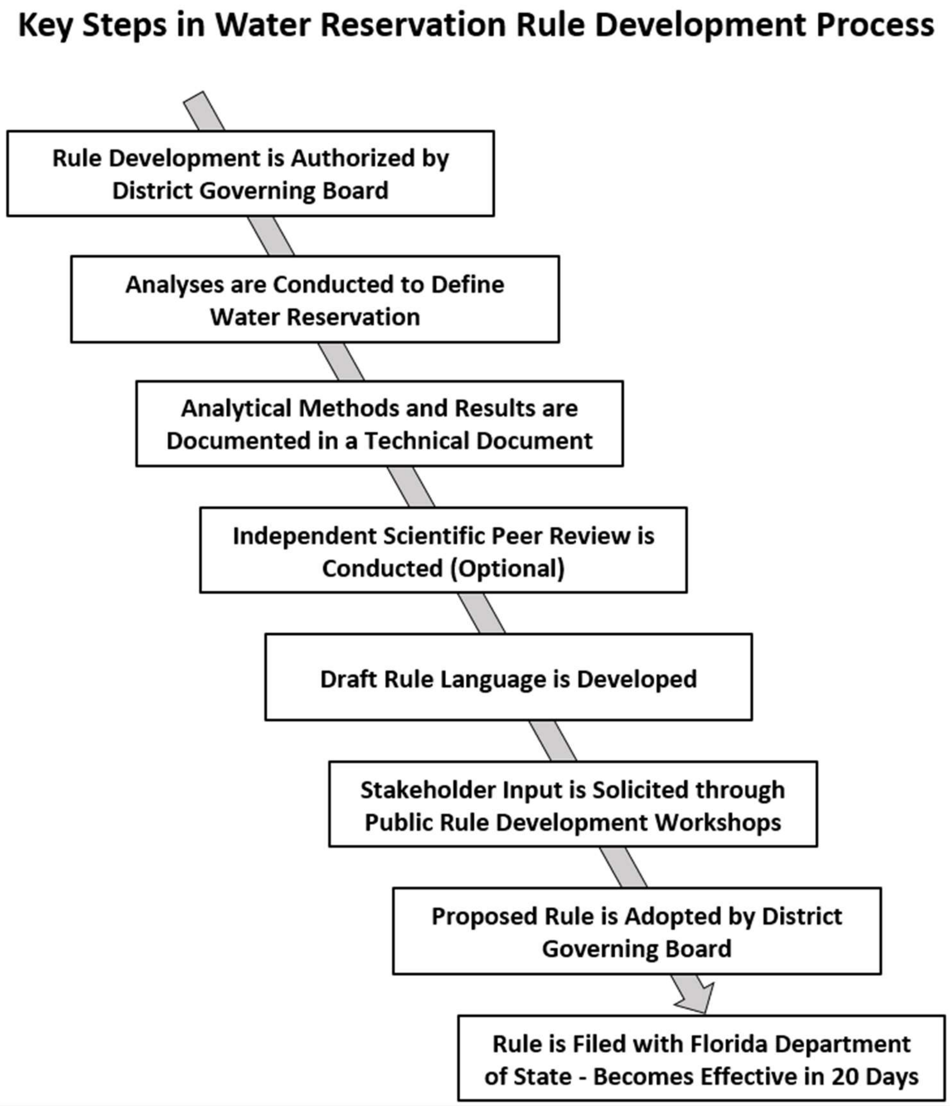

Figure 2-1. Water Reservation rule development process.

3 EXISTING CONDITIONS IN THE CENTRAL EVERGLADES WATERSHED

Current C&SF Project operations involve water supply and flood releases to manage stage levels in Lake Okeechobee, the WCAs, and ENP. Impoundment of the natural system, construction of drainage canals and conveyance features, and current C&SF Project operations have disrupted the seasonal pattern of rising and falling water depths in the Central Everglades. These hydrologic changes have contributed to degradation of sawgrass marshes, infilling of slough habitat, and loss of ecologically valuable tree islands. In short, the current system is too wet in some areas and too dry in others.

Additionally, conversion of natural areas for urban and agricultural uses and the network of C&SF Project canals have altered natural flow patterns, causing complete shifts in vegetative communities and dramatic reductions in fish and wildlife populations. The result is reduced water storage capacity in the remaining natural system and an unnatural mosaic of impounded, fragmented, over-inundated, and over-drained marshes.

3.1 Water Conservation Areas 3A and 3B

In response to expansive sheetflow from Lake Okeechobee, seasonal rainfall, and periodic fires, the pre-drainage landscape of WCA-3A and WCA-3B consisted of a complex mosaic of vegetative habitats interspersed on the flat peat bed that accumulated over the last 5,000 years. Construction and operation of the C&SF Project have had unintended and adverse effects on the ecosystems of WCA-3A and WCA-3B, which continue to decline. One of the most well documented effects of the C&SF Project has been the loss of native flora and fauna due to phosphorus enrichment of this naturally oligotrophic ecosystem (McCormick et al. 1996, 2009; Newman et al. 1998, 2004; Gaiser et al. 2005). However, Water Reservations are focused on hydrologic needs; therefore, while potential phosphorus effects are addressed, as appropriate, primary emphasis is on responses directly related to hydrologic changes and the benefits of Water Reservations to wildlife.

Northern WCA-3A has been over-drained and the natural hydroperiods shortened (**Figure 3-1**). Hydrologic changes have caused the loss of the historical ridge and slough patterned landscape (**Figure 3-1**), resulting in a loss of land surface elevation, principally through biochemical soil oxidation and peat fires. **Figure 3-2** displays estimated minimum and maximum changes in soil thickness from 1946 to 1996 (Scheidt et al. 2000). Calculations of soil thickness loss indicate northern WCA-3A lost between 39% and 65% of its organic soil depth during this 50-year period.

Decreased hydroperiods and fire in northern WCA-3A have facilitated a shift to plant communities dominated by sawgrass, cattail, and scattered shrubs that lack the structural diversity of native plant communities (**Figure 3-3**; Rutchey 2010). Vegetation and patterning in central WCA-3A most closely resemble pre-drainage conditions (McVoy et al. 2011) and represent some of the best examples of historical Everglades habitat left in South Florida (**Figures 3-1** and **3-3**). This region of the Everglades appears to have changed little since the 1950s (which was already post-drainage) and contains a mosaic of tree islands, wet prairies, sawgrass stands and ridges, and aquatic sloughs similar to those reported by Loveless (1959). Southern and eastern WCA-3A primarily is affected by high water, lack of seasonal variability, and prolonged periods of inundation (ponding) created by impoundment structures (i.e., L-67A, L-67C, and L-29 levees). Extended hydroperiods within southern and eastern WCA-3A have negatively impacted tree islands (**Figure 3-4**) and caused fragmentation of sawgrass ridges, resulting in the loss of historical landscape patterning.

Within WCA-3B, the ridge-slough-tree island structure has been severely compromised by the virtual elimination of overland sheetflow since construction of the L-67 Canal and levee system in the early 1960s (**Figure 3-1**). WCA-3B has become a primarily rain-fed compartment, experiencing very little overland flow. It primarily has turned into a sawgrass monoculture (**Figure 3-3**), where relatively few sloughs or tree islands remain (**Figure 3-4**).

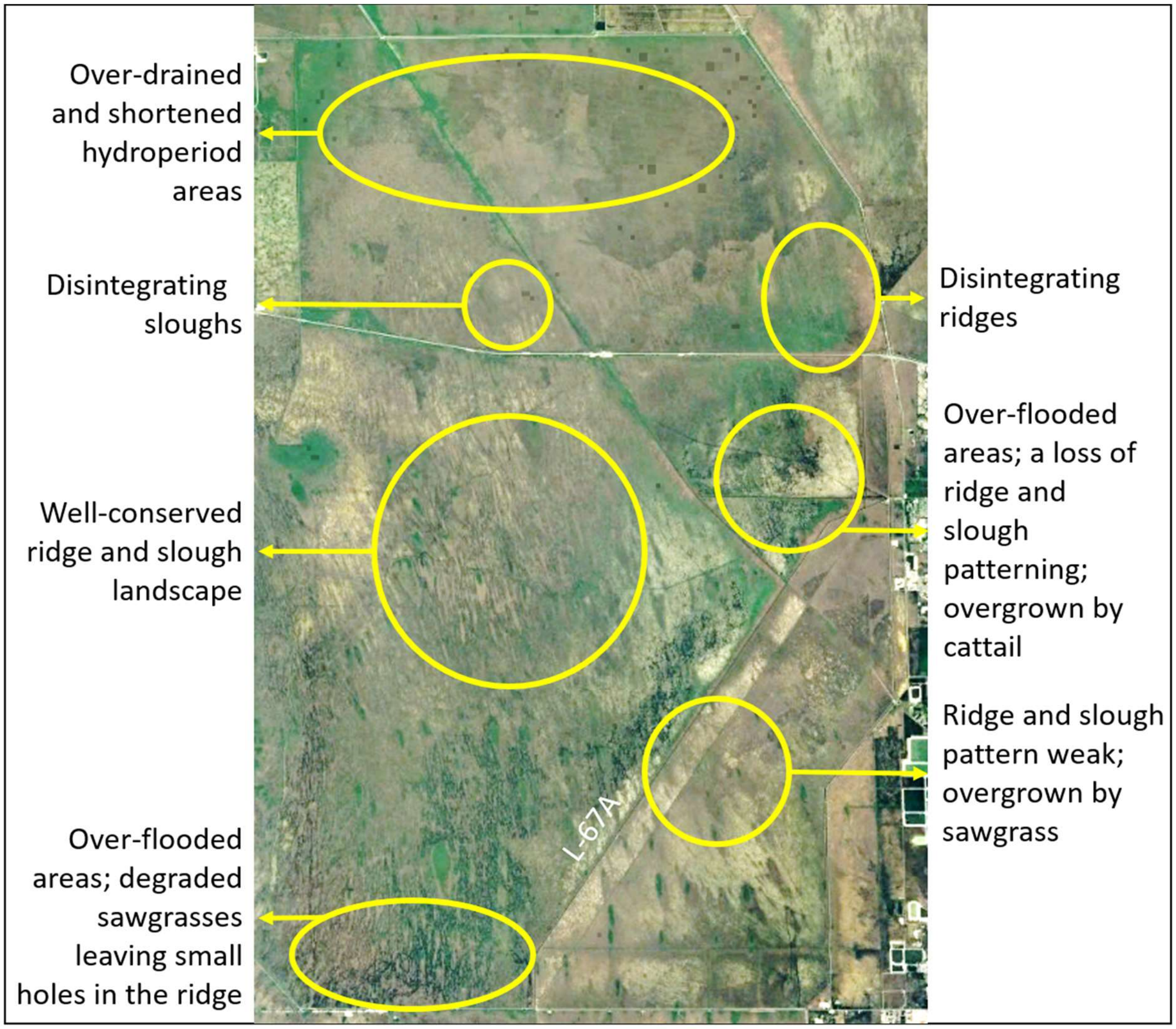

Figure 3-1. Water Conservation Areas 3A and 3B landscape vegetation conditions in August 2017 (Image from: Google Earth).

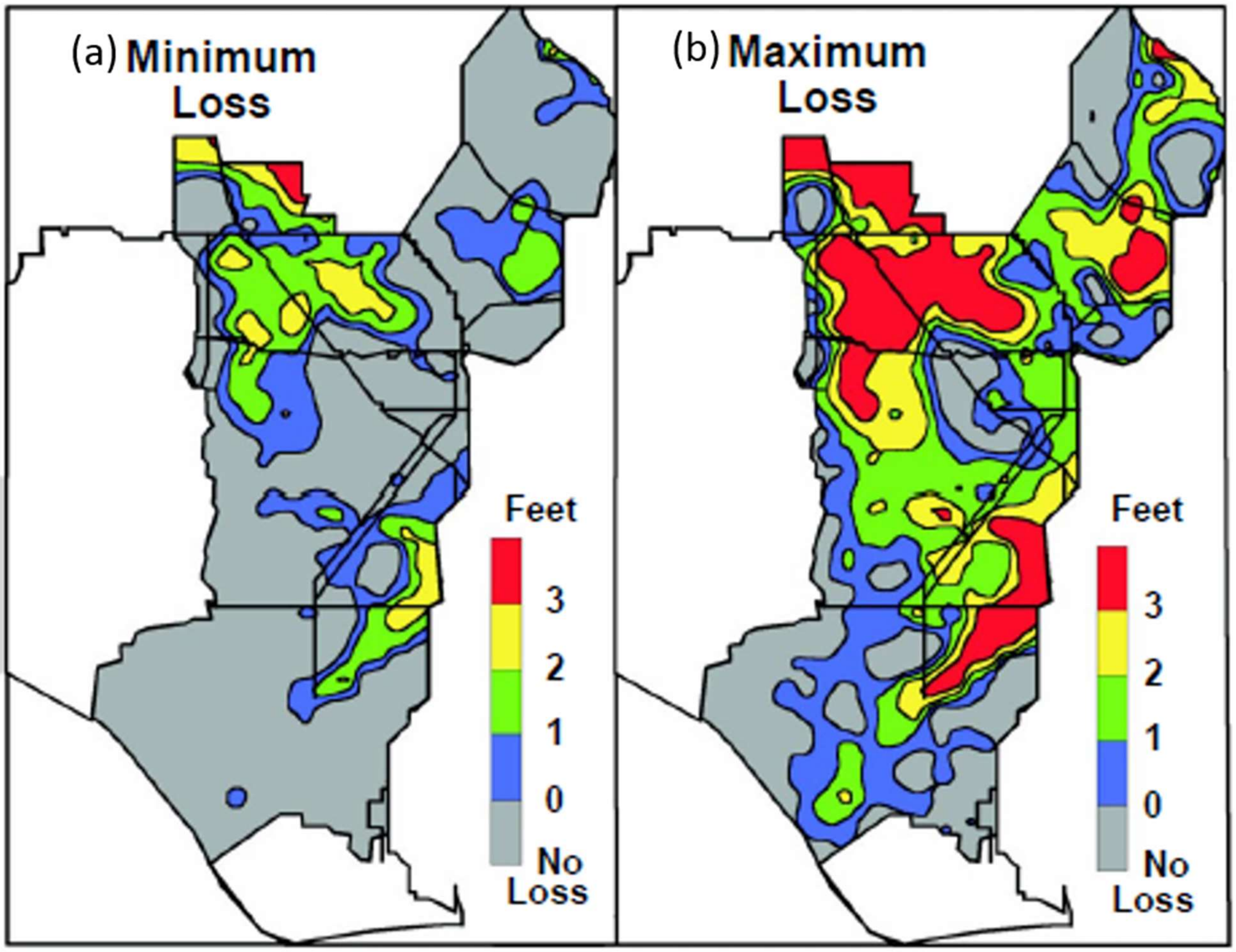

Figure 3-2. (a) Minimum and (b) maximum changes in soil thickness (feet) between 1946 to 1996 in the Central Everglades (From: Scheidt et al. 2000).

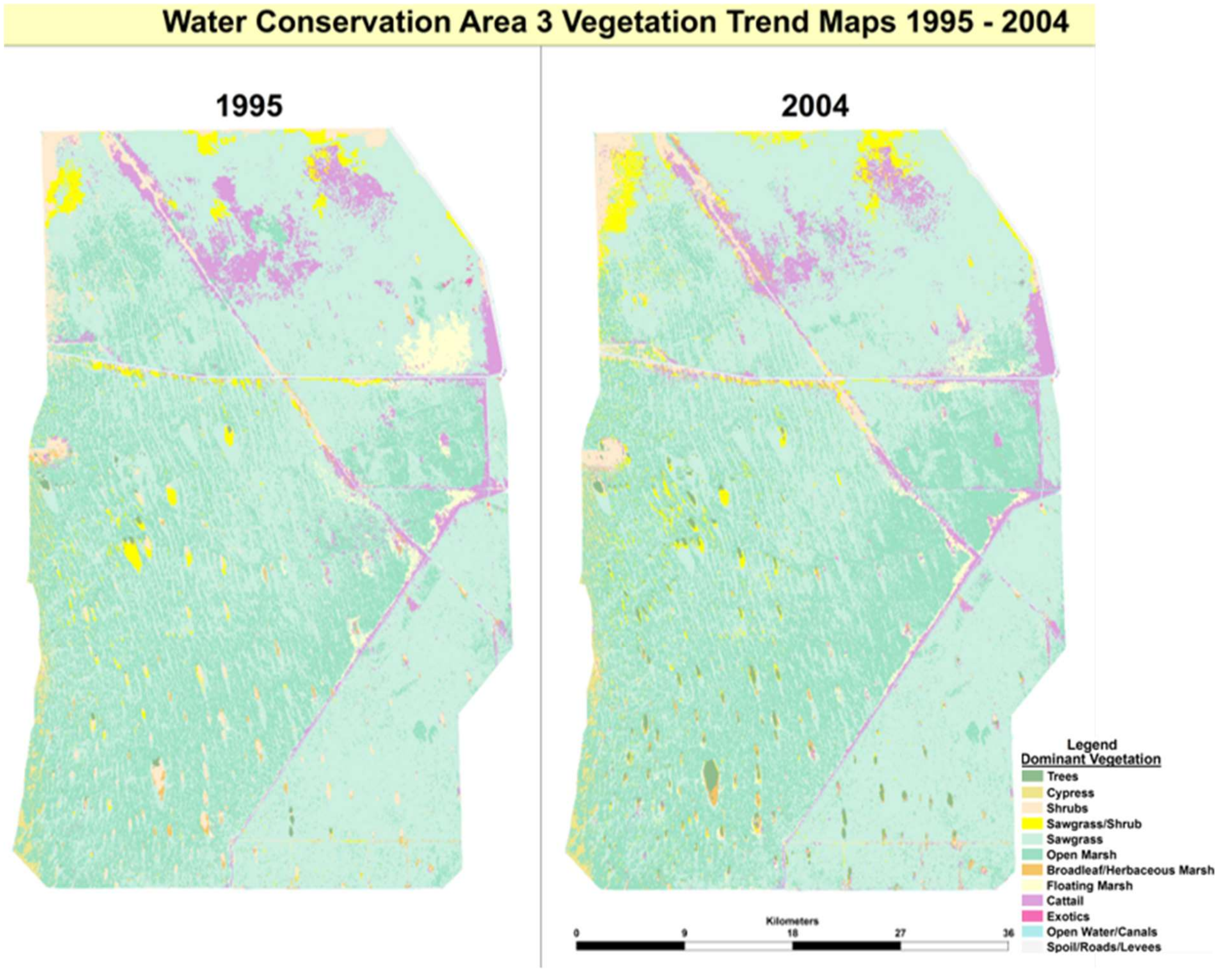

Figure 3-3. Changes in landscape vegetation patterns in Water Conservation Areas 3A and 3B between 1995 (left) and 2004 (right) (From: Rutchey et al. 2005).

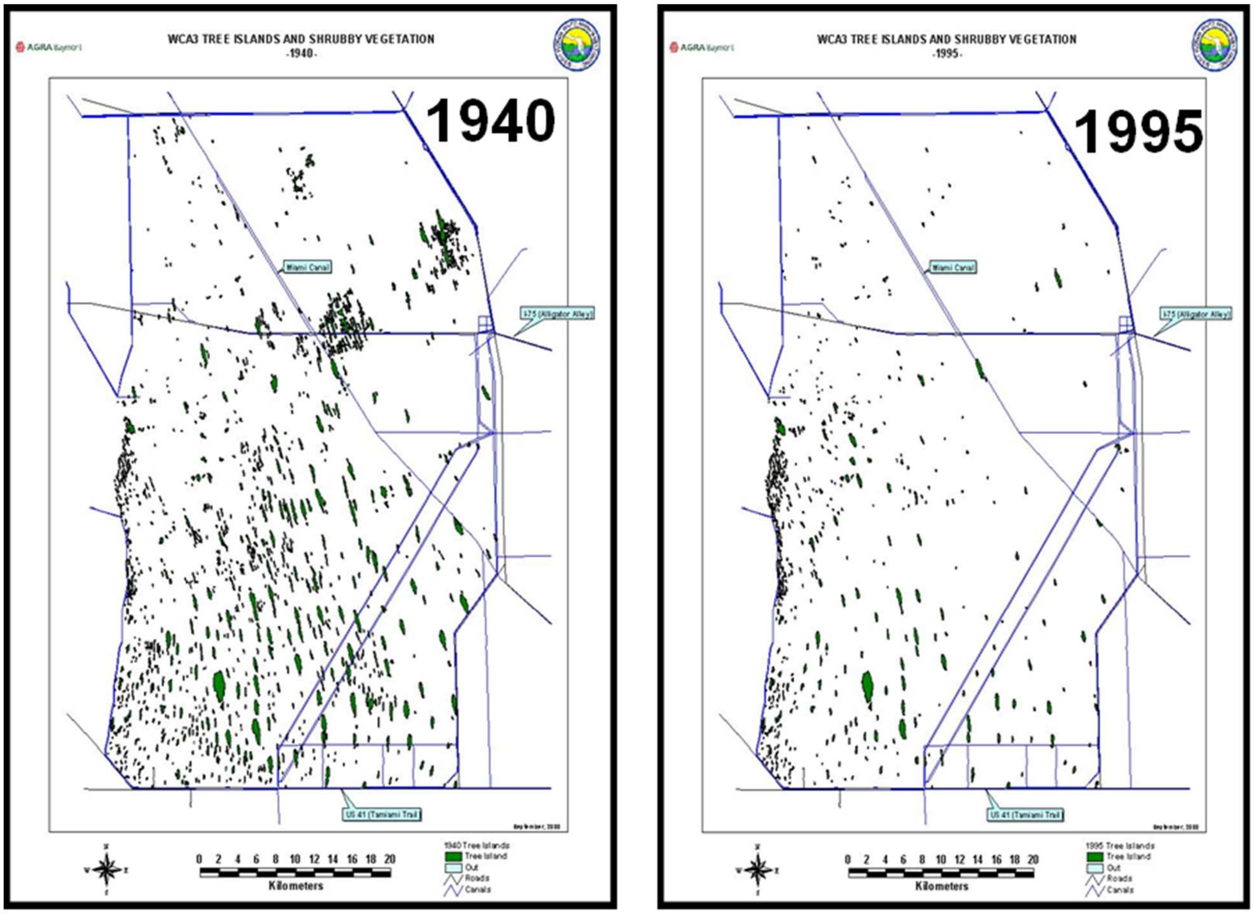

Figure 3-4. Tree island loss in Water Conservation Areas 3A and 3B from 1940 to 1995 (From: Patterson and Finck 1999).

3.2 Everglades National Park

ENP experiences many of the same environmental issues as WCA-3A and WCA-3B. One notable problem is the extreme drydowns (hydroperiod and ponding depth) that occur during many dry seasons. Although reduced rainfall is typical during the dry season, the historical Everglades system did not experience water levels below ground surface for many consecutive water years. The extreme drydowns occur because of the limited capability to store Lake Okeechobee outflows for delivery to the Central Everglades, current C&SF Project operations, and water loss through seepage along the eastern levees. The drydowns result in substantial peat subsidence, muck fires, reduced fish populations, loss of foraging habitats for wading birds, peat collapse due to saltwater intrusion, reduced biodiversity, and degradation associated with an onslaught of invasive plants and animals. Also, the United States Environmental Protection Agency found that from 1946 to 1996, more than 3 ft of peat soil was lost from Northeast Shark River Slough (NESRS), similar to southeastern WCA-3B, due to soil oxidation and peat fires (Scheidt et al. 2000) (**Figure 3-2**). Subsidence and fires damage the substrate, limit water retention, and alter vegetative communities, reducing the number of prey species available for breeding populations of wading birds.

4 IMPROVEMENTS TO HYDROLOGIC CONDITIONS, HABITATS, AND FISH AND WILDLIFE RESOURCES

This chapter discusses the predicted benefits of implementing the proposed CEPP EAA Reservoir Water Reservation (i.e., the authorized CEPP Alternative C240). The evaluation of benefits was based on the results of modeling simulations, environmental impact statements, scoping documents for similar projects, scientific literature, direct observation, project design reports, and reasonable scientific judgments. This chapter compares application of the SFWMD's Regional Simulation Model – Greater Everglades and Lower East Coast Service Area (RSM-GL) (version 2.3.2) for the simulation period (1965 to 2005) for Alternative C240 to the existing conditions baseline (ECB) assumptions, which represent the systemwide infrastructure and operations that were in place when the PACR was initiated by the SFWMD (2018).

The primary modeling for the CEPP PACR (SFWMD 2018) was evaluated based on outputs from the SFWMD's Regional Simulation Model (RSM) (SFWMD 2005a,b). The RSM is a robust and complex regional scale model that covers the entire South Florida system with two implementations: RSM-BN covers the northern part of the system and RSM-GL covers the southern extent (SFWMD 2010, 2011). The RSM Hydrologic Simulation Engine was peer reviewed in 2005 (Chin et al. 2005) and the Management Simulation Engine and revised Hydrologic Simulation Engine were peer reviewed again in 2019 (Bras et al. 2019). The RSM passed 25 verification tests (10 overland flow, 10 groundwater, and 5 mixed) and includes 83 benchmarks (West Consultants and CDM 2012). As part of the CEPP process, the RSM-BN and RSM-GL underwent USACE validation for engineering software and was classified as "allowed for use" for South Florida applications in August 2012. The RSM is the premier and most accepted tool for regional hydrologic simulation and planning in South Florida and has been used to plan for more than $20 billion of authorized capital infrastructure improvements and to support updates to operational permits and USACE water control plans. Recent projects supported by the RSM include the following:

- CEPP (2010-2012; PACR [2017-2018])
- Lake Okeechobee Watershed Restoration Project (2017-2019)
- Western Everglades Restoration Project (2017-2019)
- Everglades Restoration Transition Plan (2016)
- Combined Operational Plan (2018-2019)

Alternative C240 is expected to reduce damaging freshwater discharges from Lake Okeechobee to the northern estuaries and redirect this water south through EAA canals to the EAA Reservoir. The EAA Reservoir would provide storage capacity for attenuation of high flows to the EAA A-2 STA, which would reduce phosphorus concentrations in the water to meet required water quality standards. During the planning process, STAs are sized to meet a long-term flow-weighted mean average of 13 parts per billion of phosphorus using the Dynamic Model for Stormwater Treatment Areas across a wide range of hydrologic conditions, including wet years (Walker and Kadlec 2011). The treated water will be distributed across the northwestern boundary of WCA-3A to restore more natural quantity, timing, and distribution of waters through WCA-3A and WCA-3B to ENP.

Environmental impacts include both direct and indirect effects. Under Council on Environmental Quality regulations, direct effects are "caused by the action and occur at the same time and place," while indirect effects "are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 Code of Federal Regulations 1508.8). Under the National Environmental Policy Act, one purpose of an environmental impact assessment is to identify, at an early stage, the environmental issues deserving of study and de-emphasizing insignificant issues, narrowing the scope of the environmental impact statement accordingly (40 Code of Federal Regulations 1501.1). The resource conditions that were evaluated for the CEPP EAA Reservoir Water Reservation include hydrology, habitat, fish, and wildlife.

This document evaluates the hydrologic output of the RSM-GL and ecological output of the United States Geological Survey's Joint Ecosystem Model Program under the ECB and Alternative C240. All analyses compare the ECB to Alternative C240. The RSM-GL was used to verify the southern distribution and sheetflow improvements associated with Alternative C240 in the hydrologic model domains, including gauges, flow transects, and indicator regions (**Figure 4-1**). Annual transect flow is the long-term average of total overland flows across a lined landmark (e.g., T5 in northwestern WCA-3A), usually perpendicular to primary flow directions. The indicator region is a collection of cells that represent an area of ecologic interest. Also, indicator regions provide a visual reference for multiple performance measures. The calculation method and locations where the performance measure graphic applies were defined by RECOVER (2005). Hydrologic changes were assessed with normalized duration curves, average annual overland flows, and average annual water budgets. A normalized duration curve refers to a ponding duration curve relative to land surface elevation. When "ac-ft" are given in average annual overland flows and average annual water budgets, this refers to analysis of an average annual water budget over the 41-year period of hydrologic model simulation (1965 to 2005).

The ecological models developed by the Joint Ecosystem Model Program were used as evaluation tools to aid in the prediction and determination of an acceptable range of hydrologic factors as they relate to the persistence and success of key fish and wildlife species (Romañach et al. 2011a,b). The hydrologic and ecological outputs were evaluated for selected years representative of dry, average, and wet rainfall conditions. Analyses of rainfall data in Central and South Florida were fitted to annual rainfall for the entire project area using normal and log normal probability distributions. The results of the analysis indicate the SFWMD receives a regional annual average rainfall of 53.0 inches (134 centimeters), a dry annual average of 44.3 inches (112 centimeters), and a wet annual average of 62.5 inches (158 centimeters). Using the above statistics as a guide, representative years corresponding to annual SFWMD rainfall were selected (Sculley 1986, Alaa and Abtew 1999). In addition, annual rainfall for the antecedent year should be considered. In other words, the annual rainfall preceding the selected year should be consistent. In summary, 1978 was selected to represent an average rainfall year, 1989 a dry year, and 1995 a wet year.

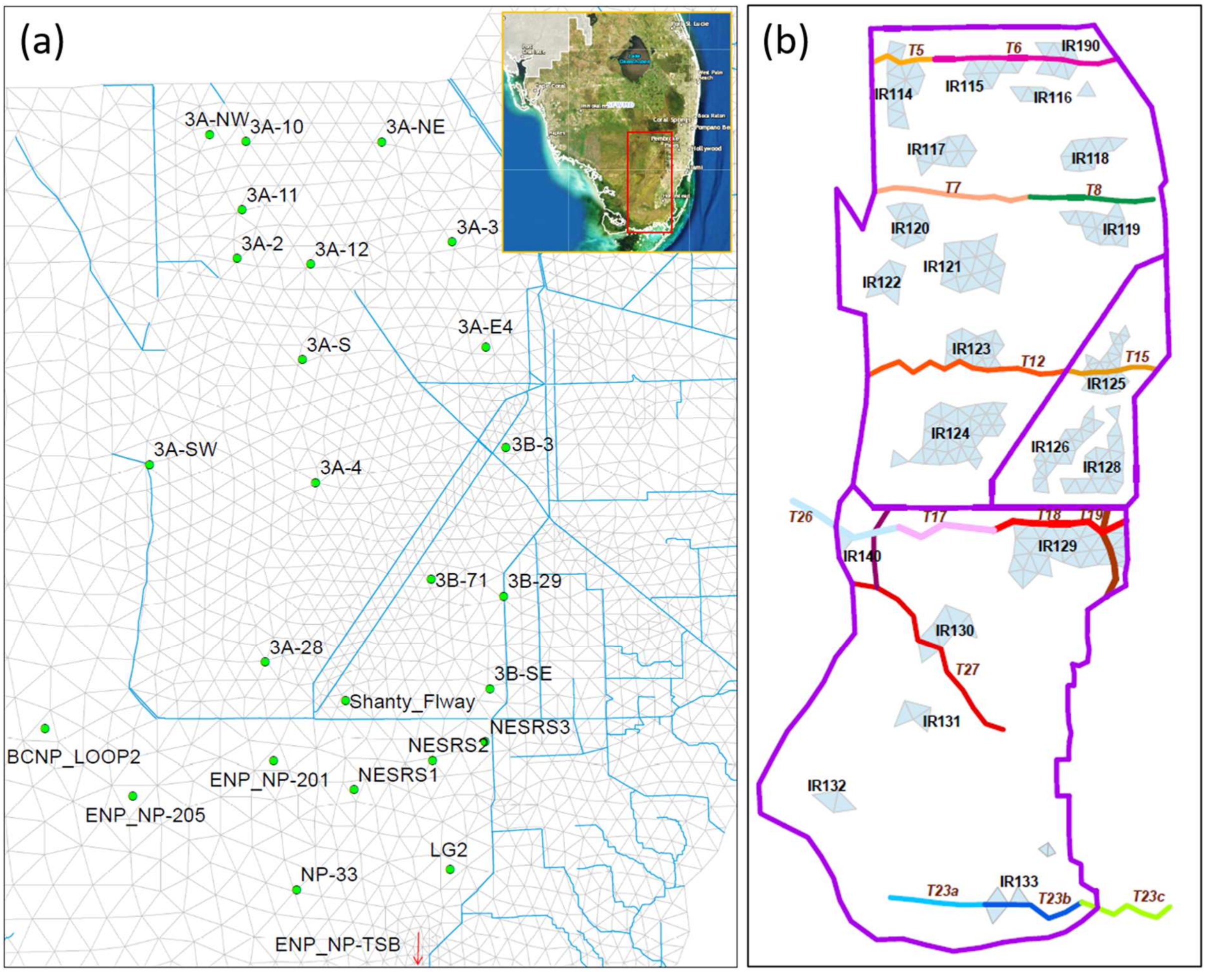

Figure 4-1. The Regional Simulation Model for the Greater Everglades and Lower East Coast Service Area (RSM-GL) domain with (a) gauges; and (b) flow transects (e.g., T5), and indicator regions (e.g., IR114).

4.1 Hydrologic Conditions

4.1.1 *Hydroperiod, Ponding Depth, and Overland Flow*

This section provides a general overview of regional hydrologic changes for Alternative C240 compared to the ECB. Hydrologic performance within a spatial area is the result of the combined effect of Alternative C240 components and operations identified throughout the project area. In general, the RSM-GL predicted significantly improved hydroperiods and ponding depths in both the long-term average (1965 to 2005) and dry (e.g., 1989) rainfall year conditions in northern WCA-3A and SRS (**Figures 4-2** and **4-3**). These changes are because Alternative C240 distributes almost all its additional water through the CEPP-designed L-4 spreader canal across northern WCA-3A (**Figure 4-4**). By contrast, hydroperiods increased (an improvement) in eastern WCA-3B and ponding depths decreased (neutral change) in northern WCA-3B long term (**Figures 4-2** and **4-3**). These changes in WCA-3B are caused by less water entering eastern WCA-3A from WCA-2A and the water routed to the Blue Shanty Flow-way and ENP.

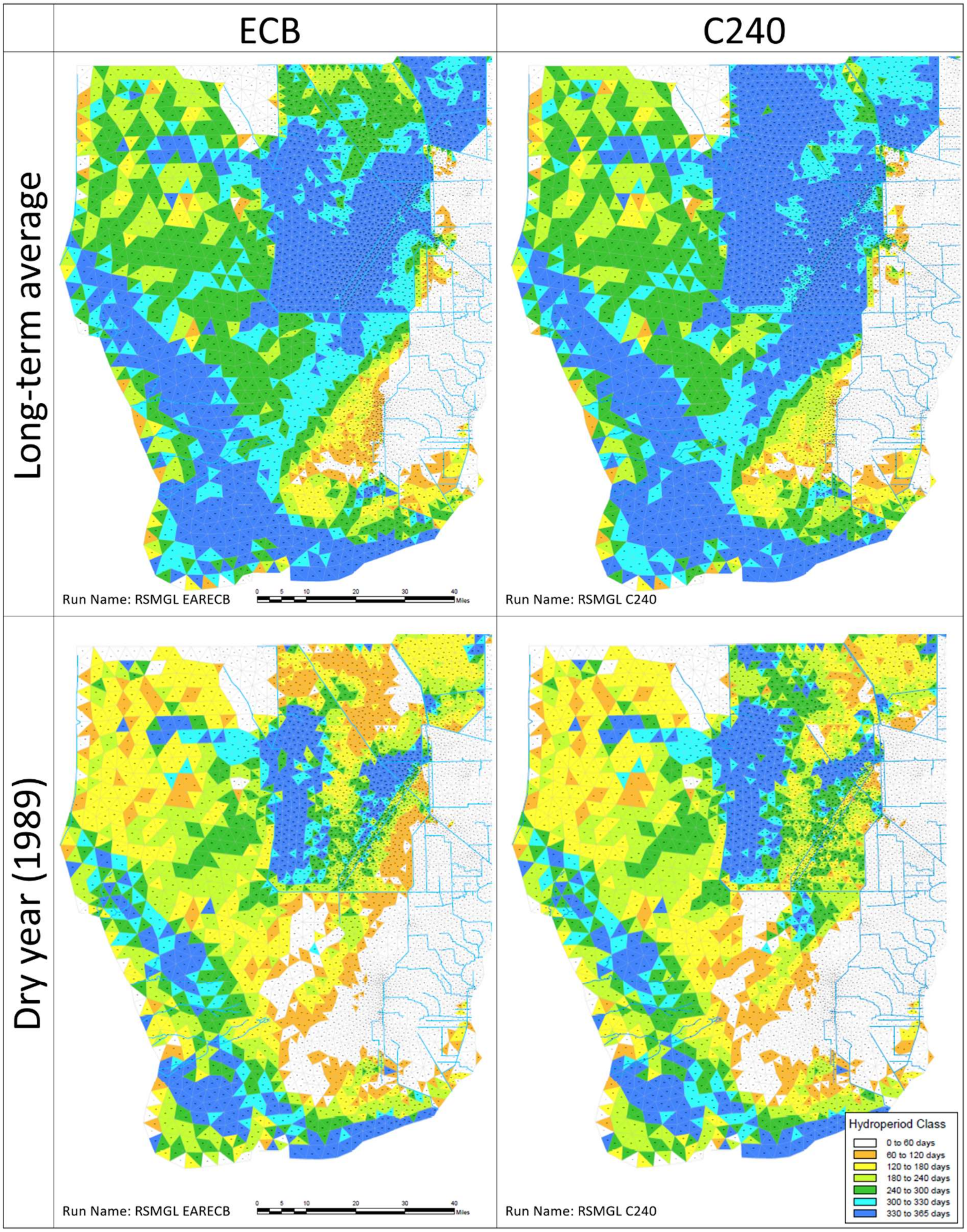

Figure 4-2. Modeled hydroperiod during long-term (1965 to 2005) average rainfall (top) and dry (bottom) year conditions for the existing conditions baseline (left) and Alternative C240 (right).

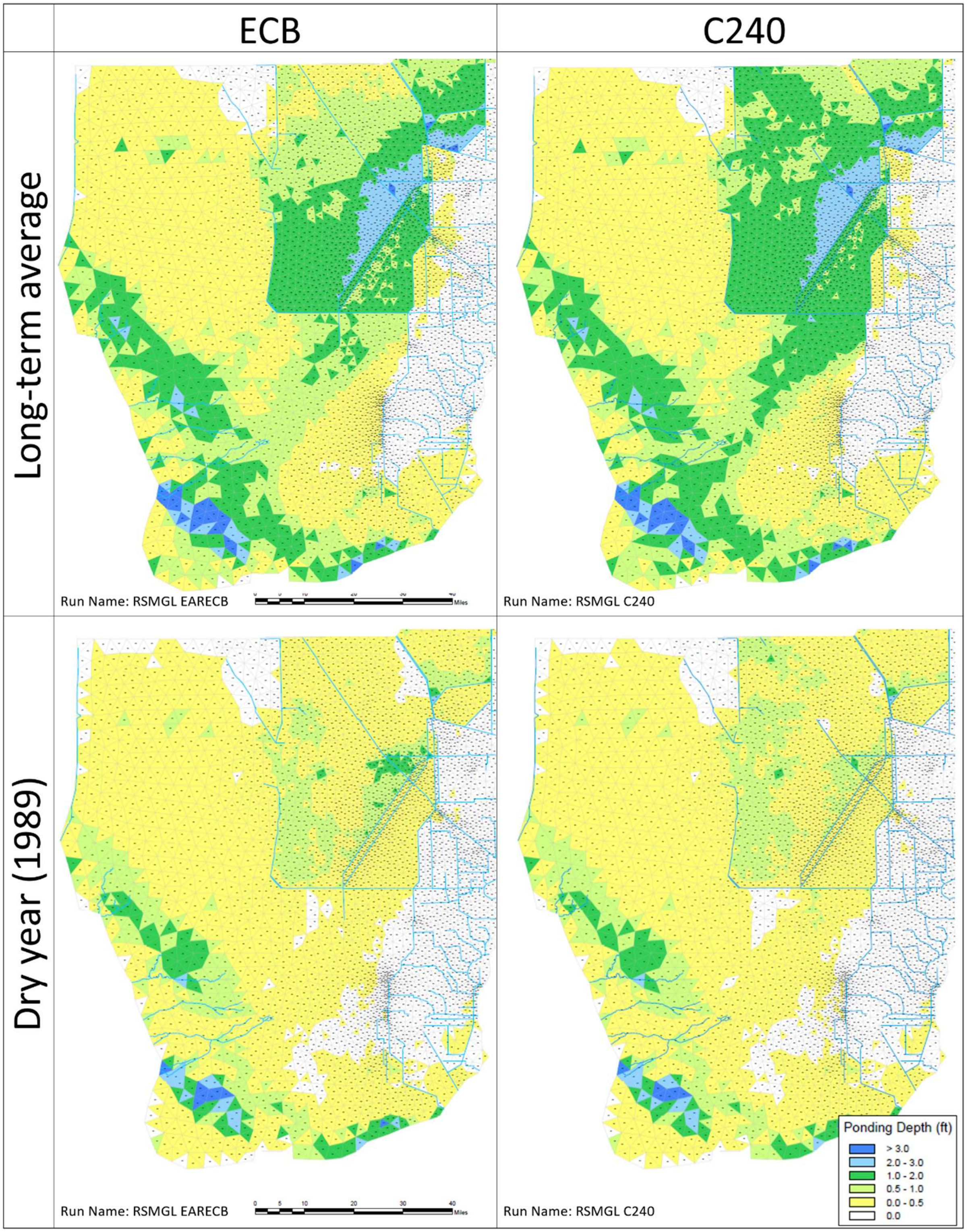

Figure 4-3. Modeled ponding depth during long term (1965 to 2005) average rainfall (top) and dry (bottom) year conditions for the existing conditions baseline (left) and Alternative C240 (right). The modeled ponding depth was computed by accumulating daily ponding depths for the water year and dividing by the number of days when the ponding depth was greater than zero.

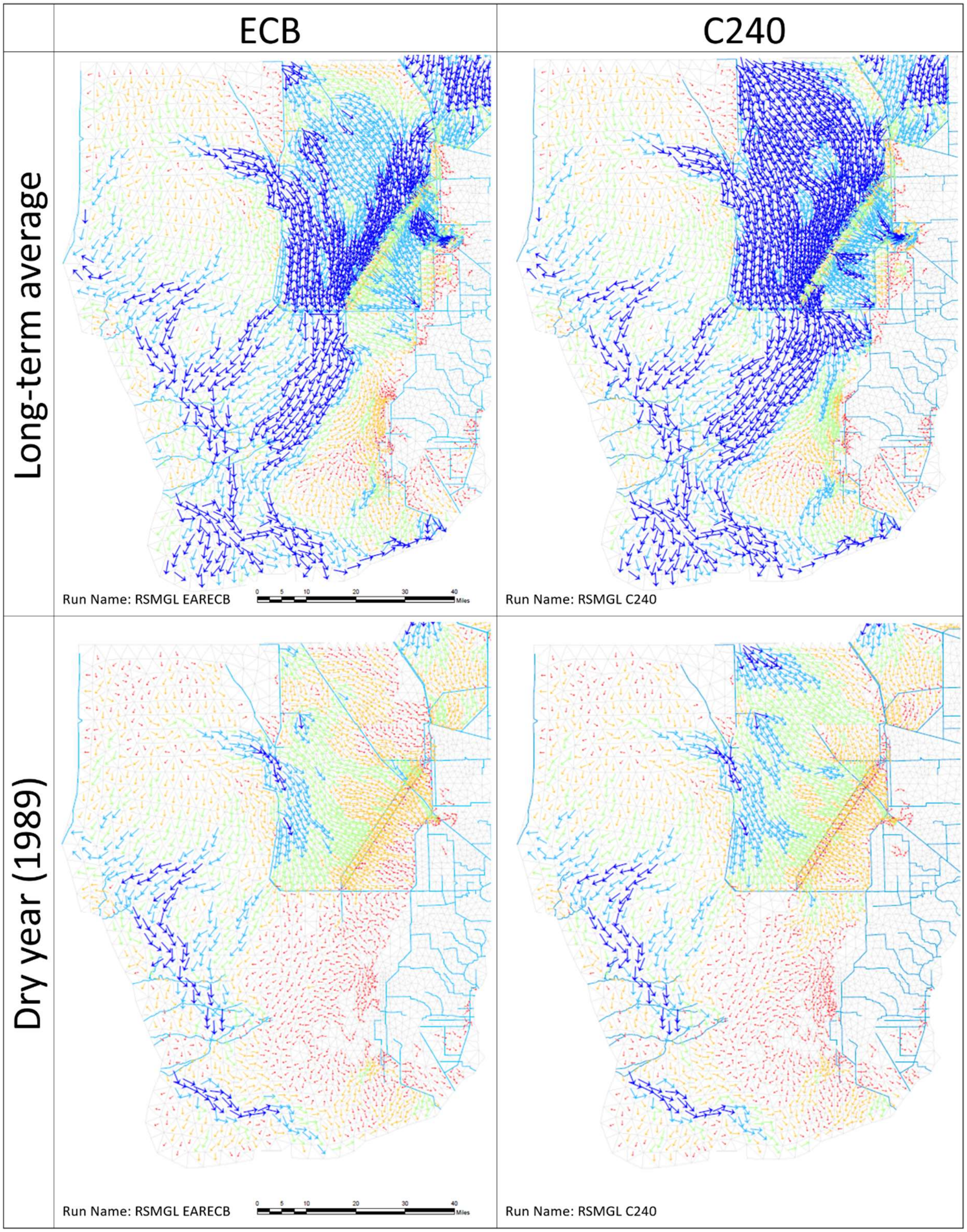

Figure 4-4. Modeled surface water flow vectors during long term (1965 to 2005) average rainfall (top) and dry (bottom) year conditions for the existing conditions baseline (left) and Alternative C240 (right). The vector plots are to provide the reader with overall flow directionality (arrow direction) and magnitude (arrow size and color) relative to other model cells.

4.1.2 Water Conservation Areas 3A and 3B

In general, hydrologic improvements associated with Alternative C240, including increased flows, longer hydroperiods, and less frequent marsh drydowns, result in improved habitats for fish and wildlife. Annual inflows to WCA-3A increase from approximately 1.8 million to 2.1 million ac-ft (19% increase) under Alternative C240 compared to the ECB (**Figure 4-5**). Annual outflows from WCA-3A also increase approximately 17% under Alternative C240 compared to the ECB, resulting in a net annual increase of 38,600 ac-ft under Alternative C240 (**Figure 4-5**). To avoid adverse increases to the frequency, duration, and peak stages of WCA-3A high-water conditions with this net increase in WCA-3A inflows, annual structural outflows from WCA-3A through S-151 (to WCA-3B), S-333 (to NESRS), S-12 (to western SRS), S-343/S-344 (to the Big Cypress National Preserve), and S-345D/S-345F/S-345G (to the Blue Shanty Flow-way), combined, increase from approximately 1.2 million ac-ft for the ECB to 1.5 million ac-ft for Alternative C240 (24% increase).

Because WCA-3A covers approximately 481,000 acres (752 square miles), hydrologic differences between the ECB and Alternative C240 are characterized at representative gauges throughout WCA-3A (**Figure 4-1a**). Within northwestern WCA-3A, by adding 0.7 ft of water during ponded times, the annual hydroperiod is extended 17% during drydowns, resulting in reduced soil oxidation for Alternative C240 (**Figure 4-6**). Within northeastern WCA-3A, enhanced inflows under Alternative C240 extend the annual hydroperiod by 26% during drydowns (**Figure 4-7**). Slightly lower increases in ponding depth and annual hydroperiod with Alternative C240 were observed for stages within east-central WCA-3A (**Figure 4-8**). Within eastern WCA-3A, ponding depths increased by approximately 0.1 ft during ponded times, but the annual hydroperiod decreased 5% (**Figure 4-9**). No significant depth or annual hydroperiod changes are expected within central (**Figure 4-10**) and southern WCA-3A (**Figure 4-11**).

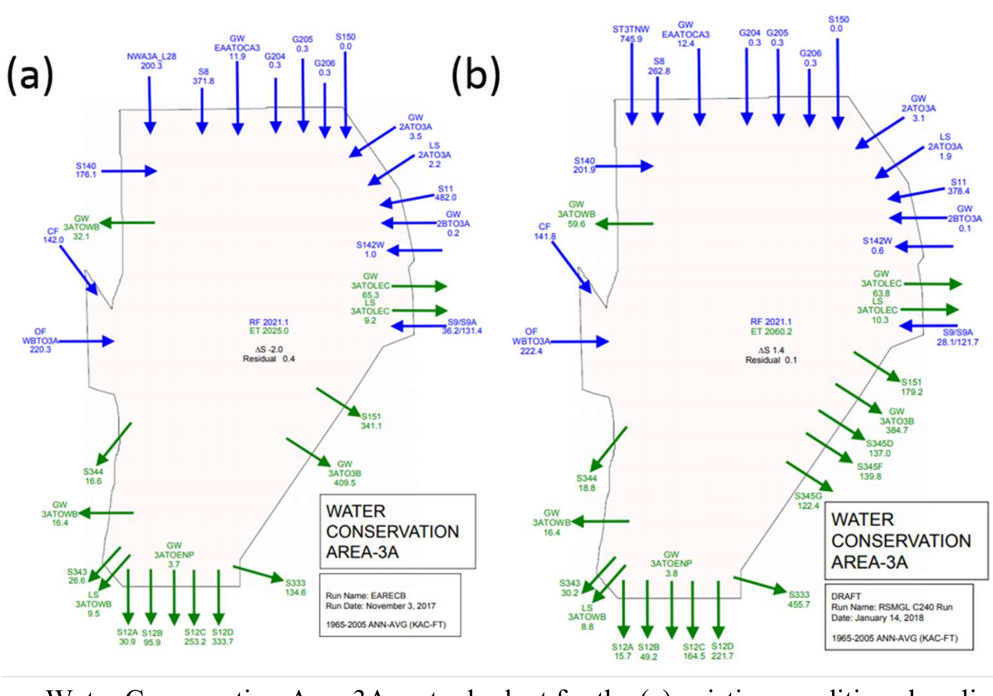

Figure 4-5. Water Conservation Area 3A water budget for the (a) existing conditions baseline and (b) Alternative C240. The arrows do not necessarily correspond to the locations of water control structures. Direction of the arrows represents the flow direction based on the annual average calculation. Structural flows can only go in one direction. For groundwater (GW) and levee seepage (LS) flows, it is possible, on a daily time step, for flows to go either direction, depending on the head difference (OF = overland flow).

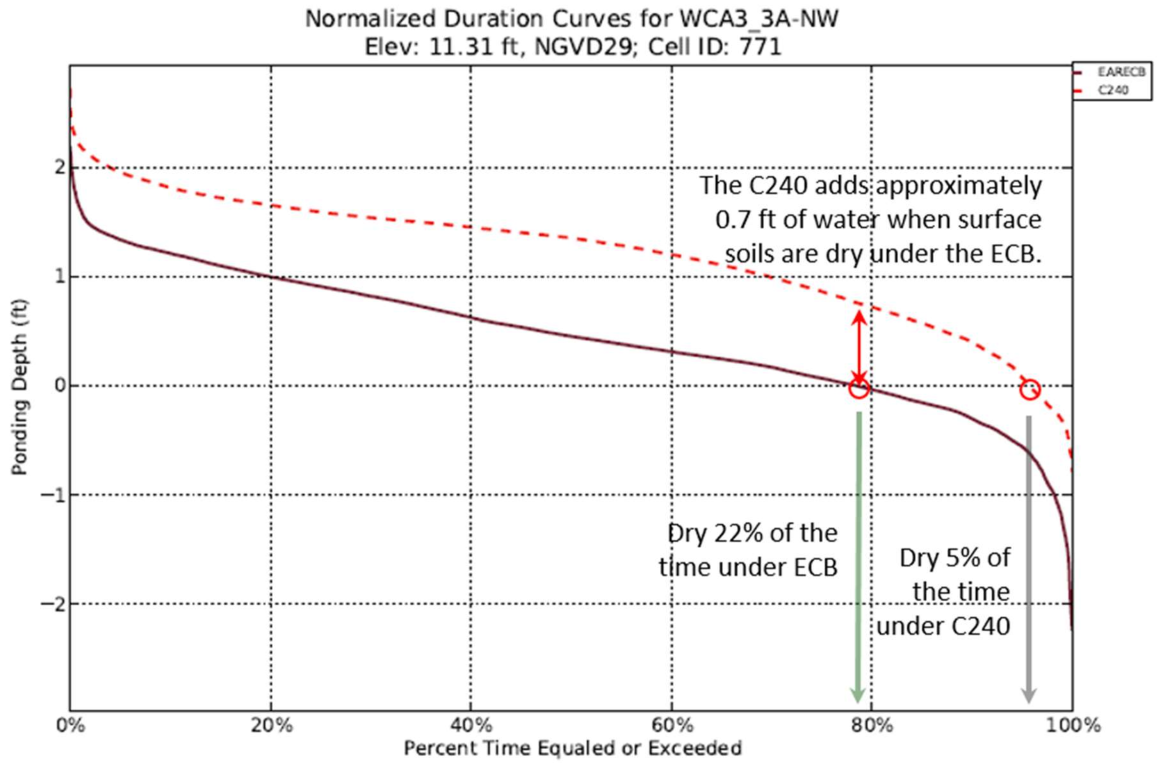

Figure 4-6. Northwestern Water Conservation Area 3A normalized duration curves.

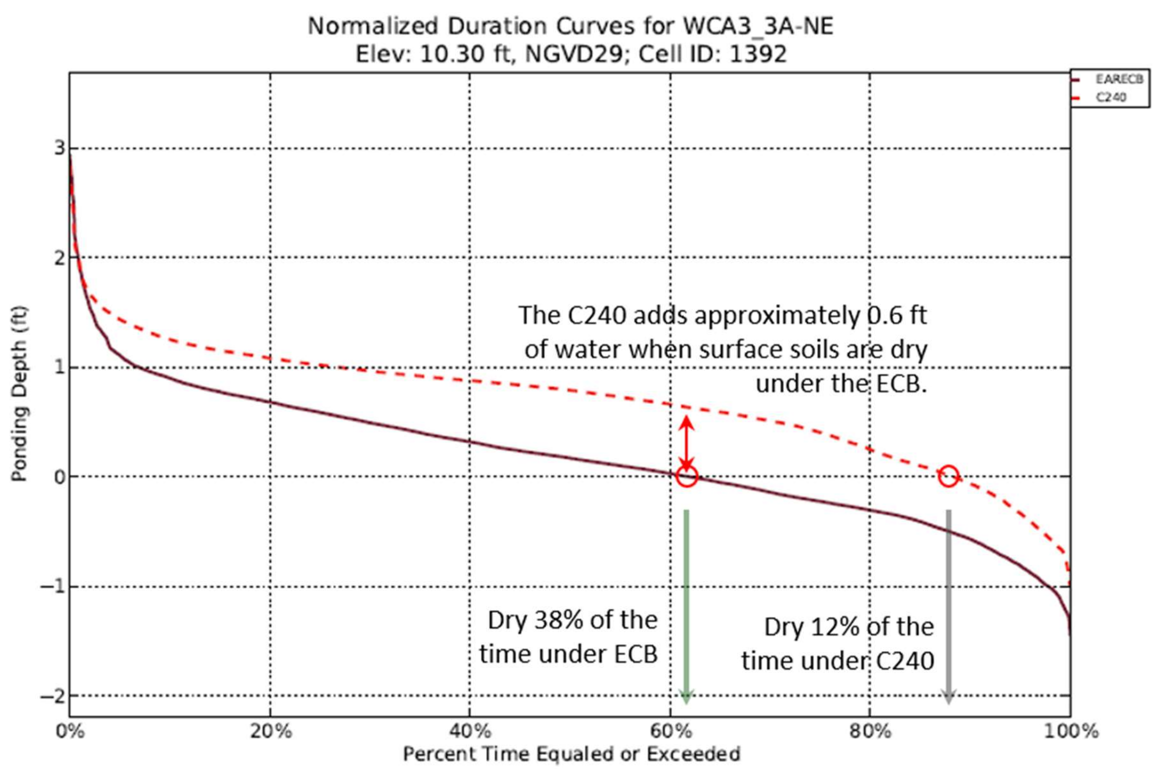

Figure 4-7. Northeastern Water Conservation Area 3A normalized duration curves.

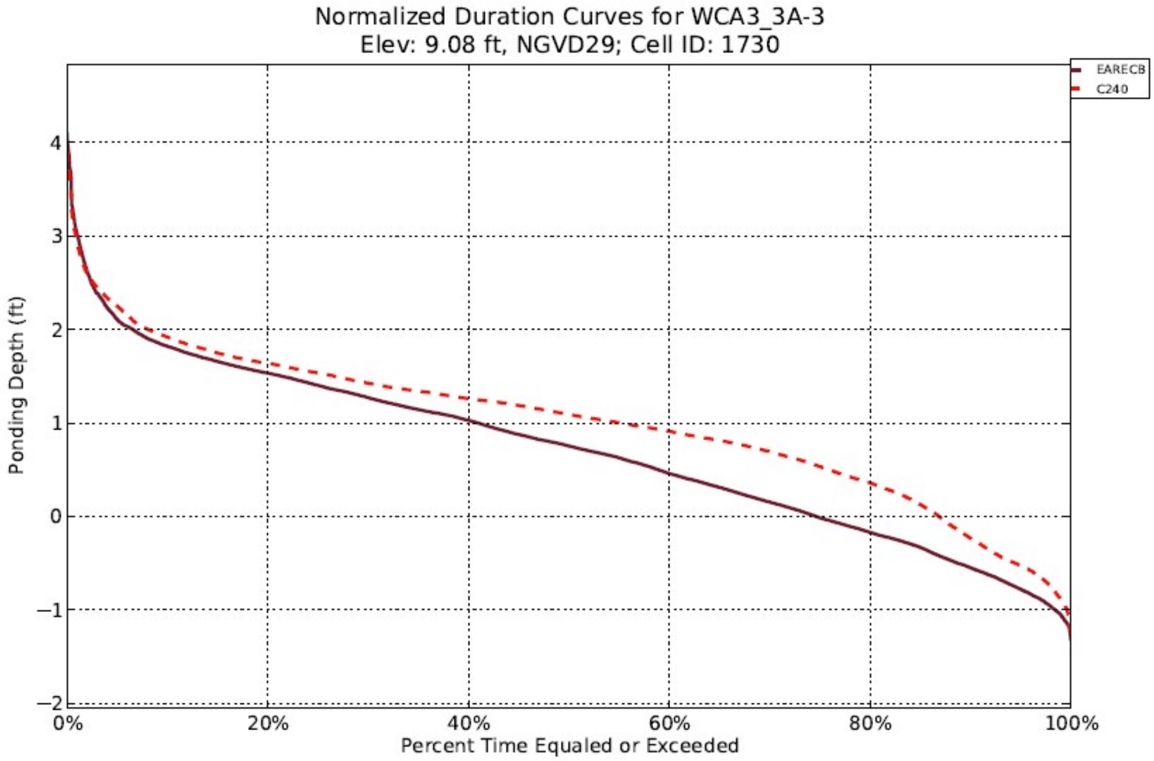

Figure 4-8. East-central Water Conservation Area 3A normalized duration curves.

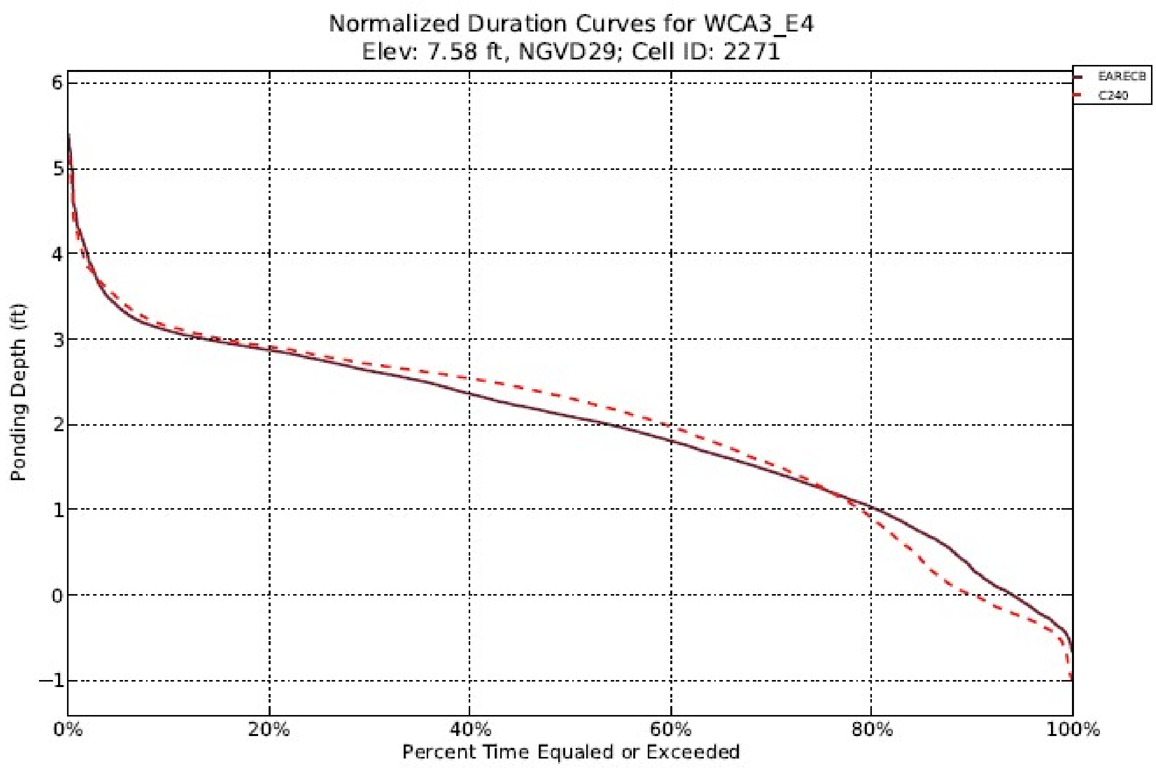

Figure 4-9. Eastern Water Conservation Area 3A normalized duration curves.

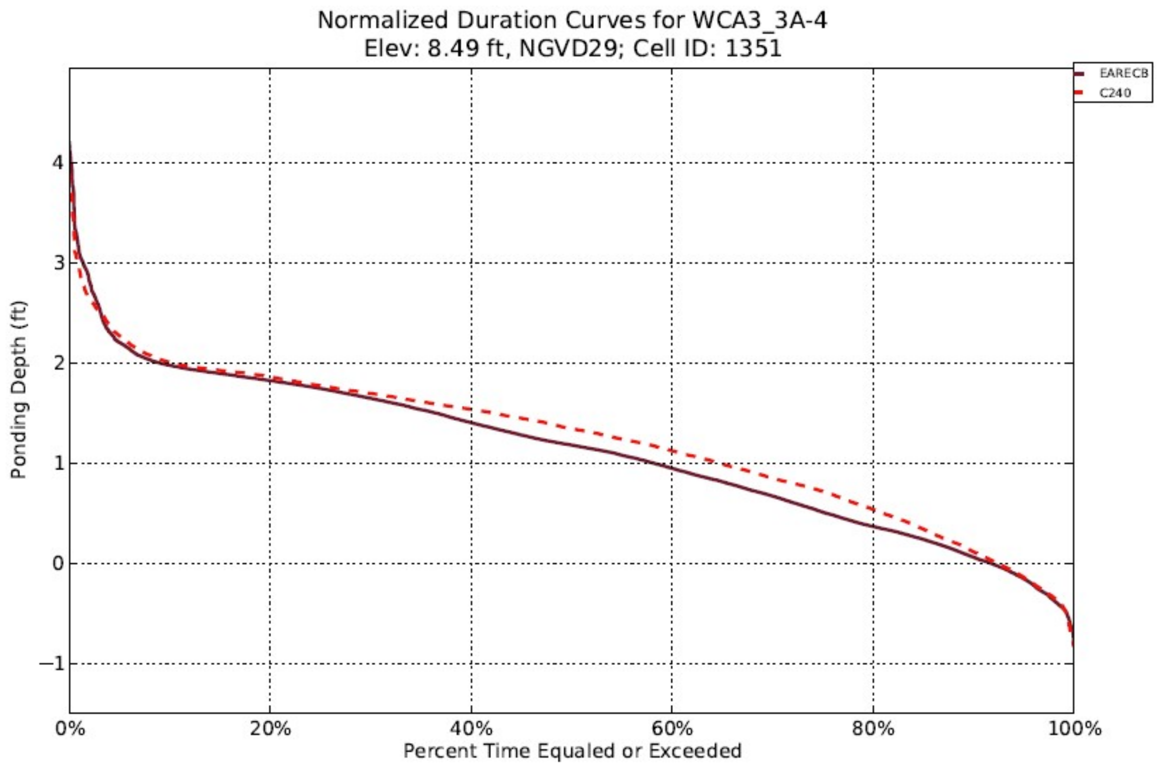

Figure 4-10. Central Water Conservation Area 3A normalized duration curves.

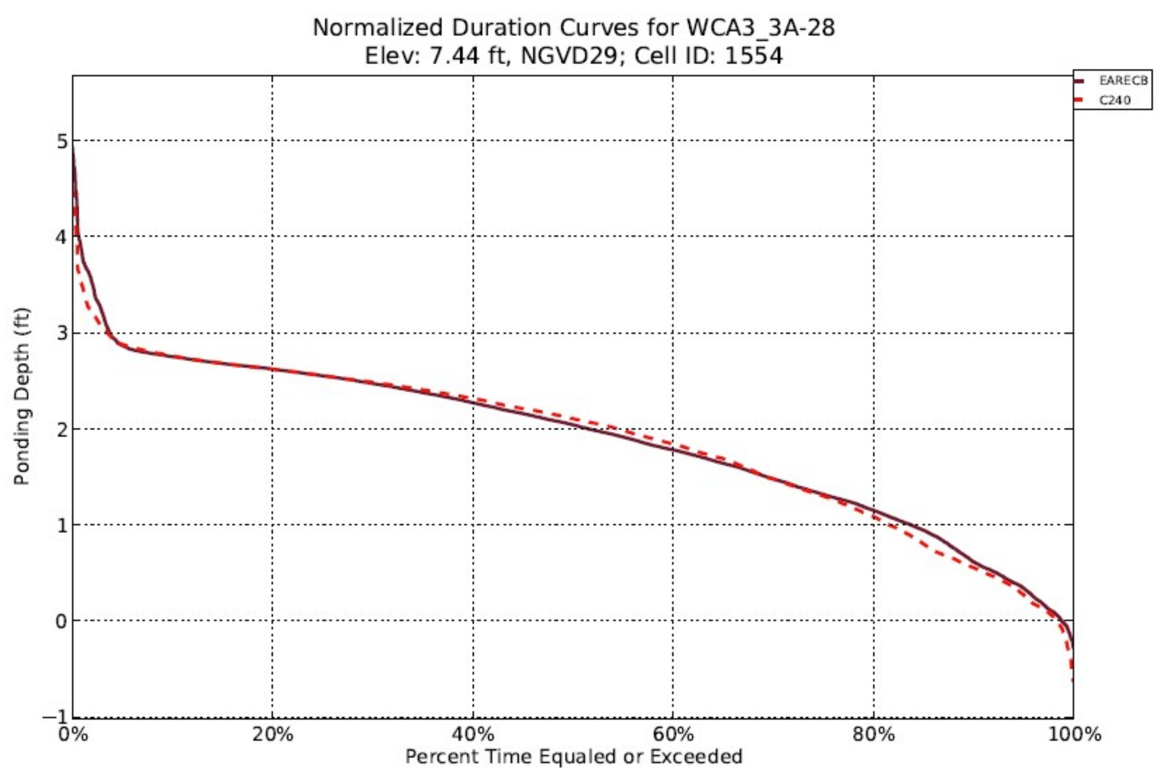

Figure 4-11. Southern Water Conservation Area 3A normalized duration curves.

Alternative C240 increases annual inflows from WCA-3A to WCA-3B from 751,000 to 976,000 ac-ft (30% increase) compared to the ECB (**Figure 4-12**). Annual outflows from WCA-3B to the L-29 Canal and NESRS increase from 42,000 to 259,000 ac-ft under Alternative C240 (approximately 500% increase) due to new overland flows of 255,000 ac-ft (**Figure 4-12**). Although annual structural outflows east from WCA-3B through S-31 and S-337 culverts decrease from 133,000 ac-ft for the ECB to 108,000 ac-ft for Alternative C240 (19% decrease), increased groundwater and levee seepage result in a small increase (1%) in outflows.

Under Alternative C240, the targeted inflows to eastern WCA-3B change ponding depths in northern (decrease) and central (increase) WCA-3B by approximately 0.2 ft for all hydrologic conditions, while there are no ecologically significant changes to annual hydroperiods (**Figures 4-13** and **4-14**). Within the Blue Shanty Flow-way and the downgradient L-29 Canal, ecologically significant increases in annual hydroperiods are not found, despite the addition of 0.3 to 0.7 ft of water during ponded times (**Figure 4-15**), because the inflows and outflows are relatively high and equal. Without Alternative C240, water levels drop to 0 ft approximately 4% of the time because the region is compartmentalized and rainwater has no outlet (**Figure 4-15**). With Alternative C240, water levels drop to 0 ft only 2% of the time because the inflows are high enough to keep the sloughs hydrated year-round (a critical performance measure). This is expected to improve conditions for fish and wildlife, especially during the dry season.

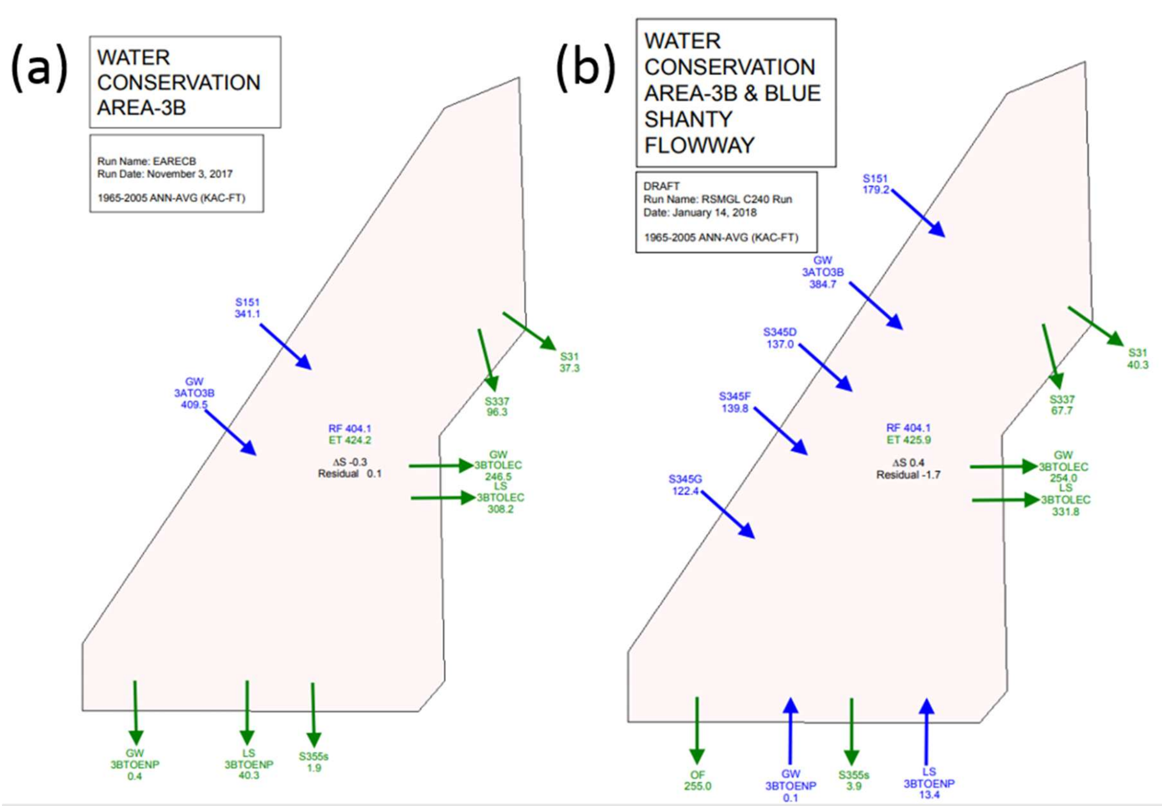

Figure 4-12. Water Conservation Area 3B water budget for the (a) existing conditions baseline and (b) Alternative C240. The arrows do not necessarily correspond to the locations of water control structures. The S-151 and S-345D structures discharge water north of the Blue Shanty Levee. The S-345F and S-345G structures discharge water into the Blue Shanty Flow-way.

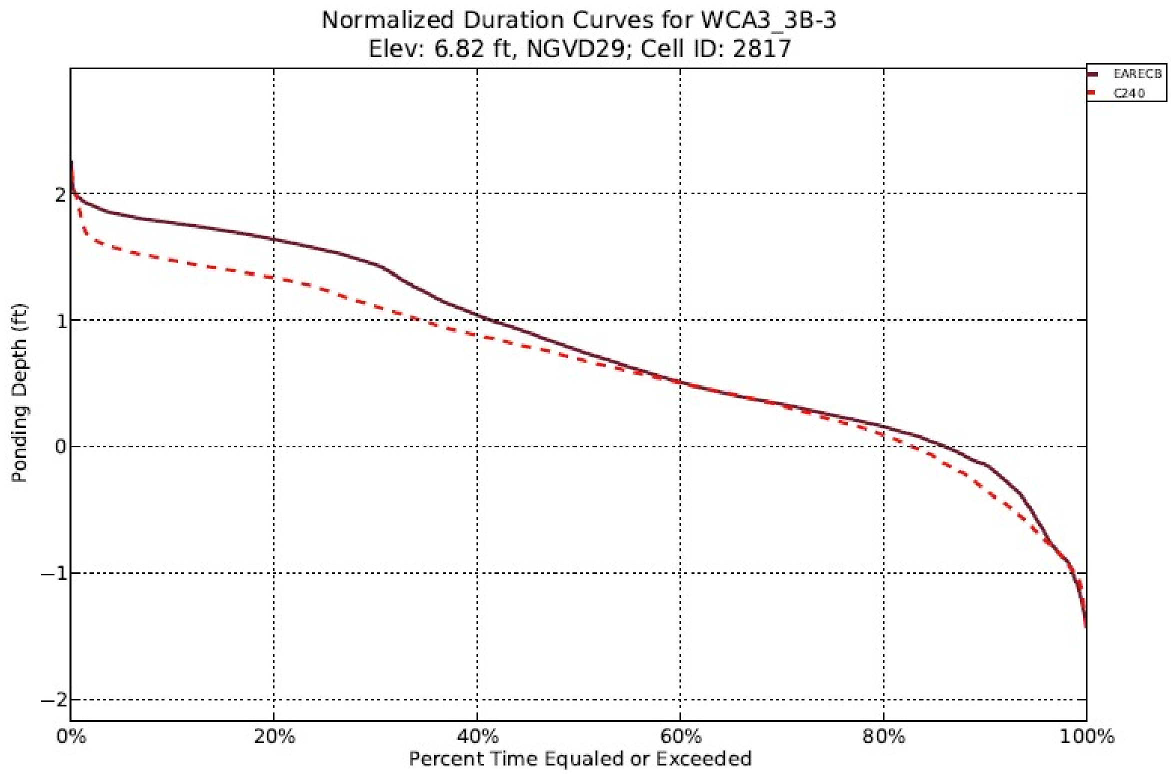

Figure 4-13. Northern Water Conservation Area 3B normalized duration curves.

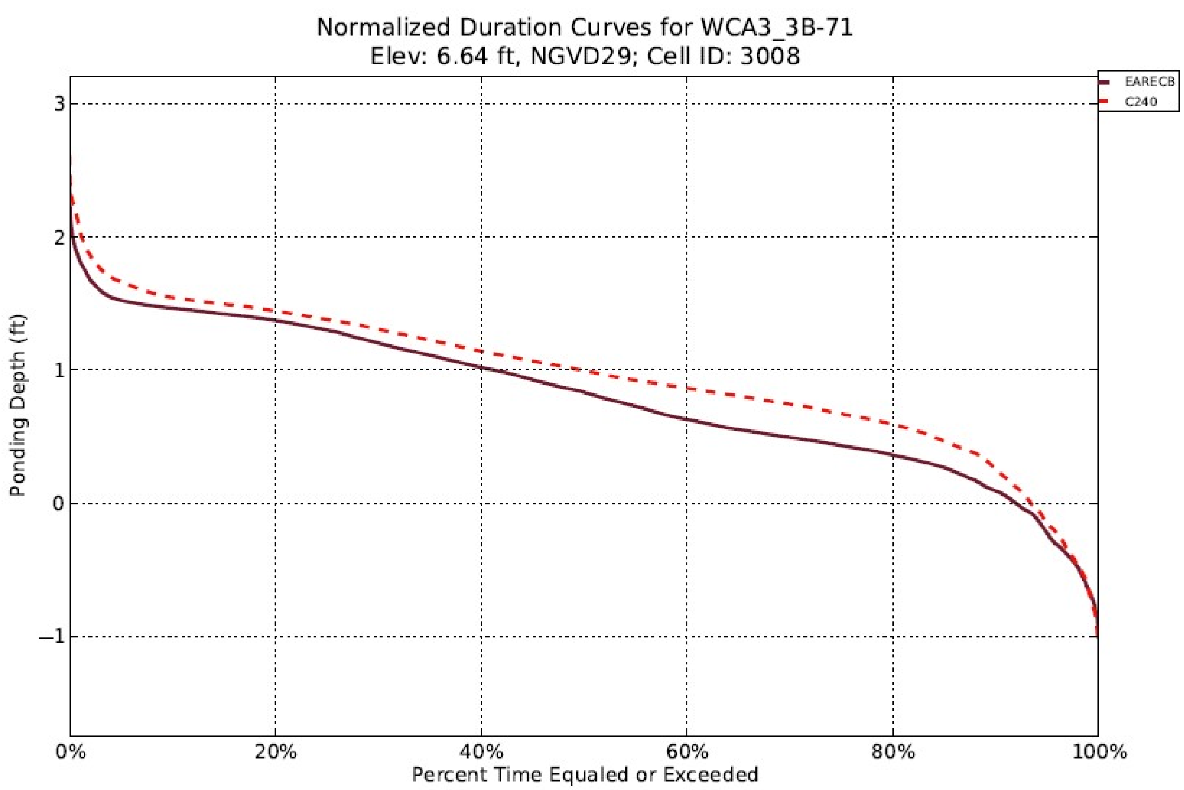

Figure 4-14. Central Water Conservation Area 3B normalized duration curves.

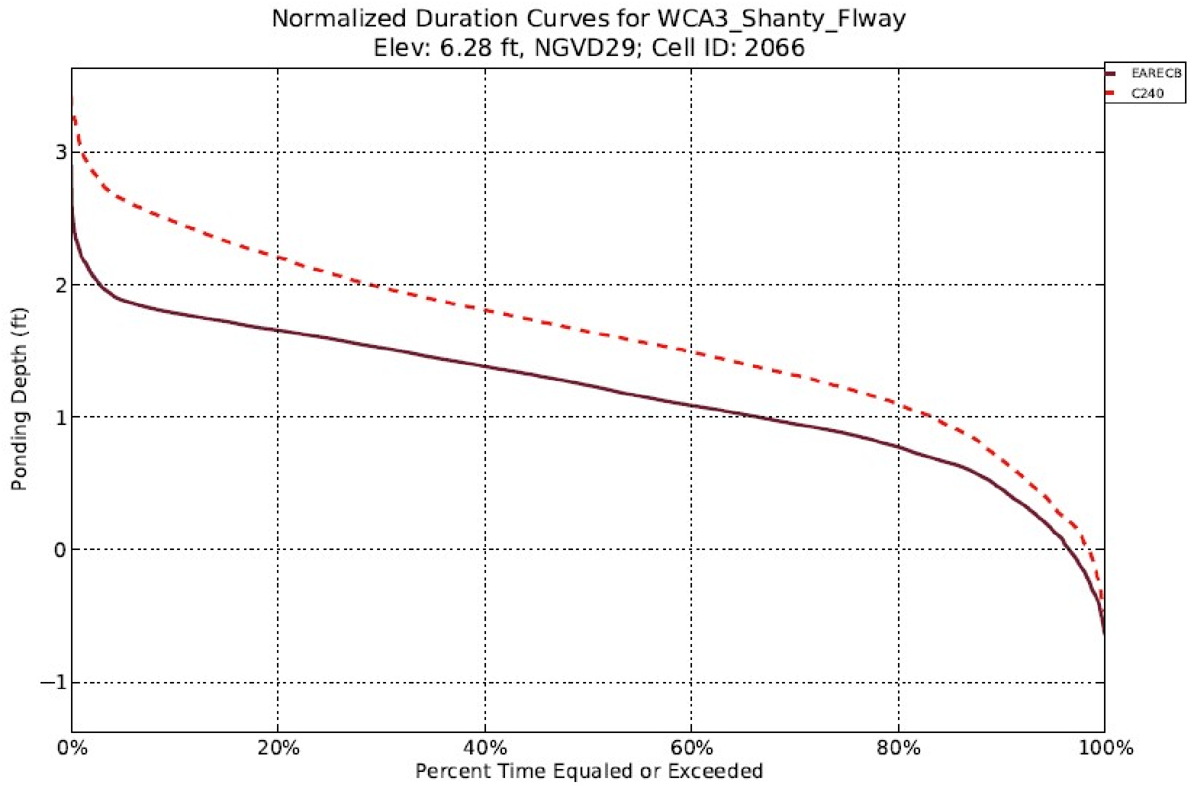

Figure 4-15. Water Conservation Area 3B Blue Shanty Flow-way normalized duration curves.

4.1.3 Northeast Shark River Slough

Annual overland inflows to NESRS (across Transect 18; **Figure 4-1b**) increase from 73,000 ac-ft (ECB) to 794,000 ac-ft under Alternative C240 (**Figure 4-16**), providing an ecological benefit for fish and wildlife species in areas currently experiencing extremely dry conditions for long periods. In addition to enhanced southward overland flows from WCA-3B (**Figure 4-12**), Alternative C240 increases annual inflows to NESRS by an additional 321,000 ac-ft from S-333 (originating from the L-67A Canal) and 67,900 ac-ft from S-356 (originating from the Tamiami Canal) to the L-29 Canal. Stage duration curves for the L-29 Canal are provided in **Figure 4-17**. The 9.7 ft National Geodetic Vertical Datum of 1929 (NGVD29) maximum operational limit prescribed for Alternative C240 is not constraining during any time within the model simulation period (1965 to 2005). L-29 Canal stages exceed 8.5 ft NGVD29 during only approximately 5% of the simulation period within the eastern L-29 Canal segment under Alternative C240. Within NESRS, by adding approximately 0.6 ft during ponded times, the annual hydroperiod is extended 11% during drydowns with Alternative C240 (**Figure 4-18**). Likewise, similar hydrologic improvements are observed farther south in SRS.

Increased water depths and hydroperiods within historically deepwater SRS are expected to alleviate severe drydowns in areas with shallow-water peripheral wetlands along the eastern boundary of the Everglades. Alternative C240 will substantially benefit vegetation by decreasing the amount of time water levels go below 0 ft by 19% and increasing water depths by approximately 1 ft when surface soils are dry under the ECB (**Figure 4-19**).

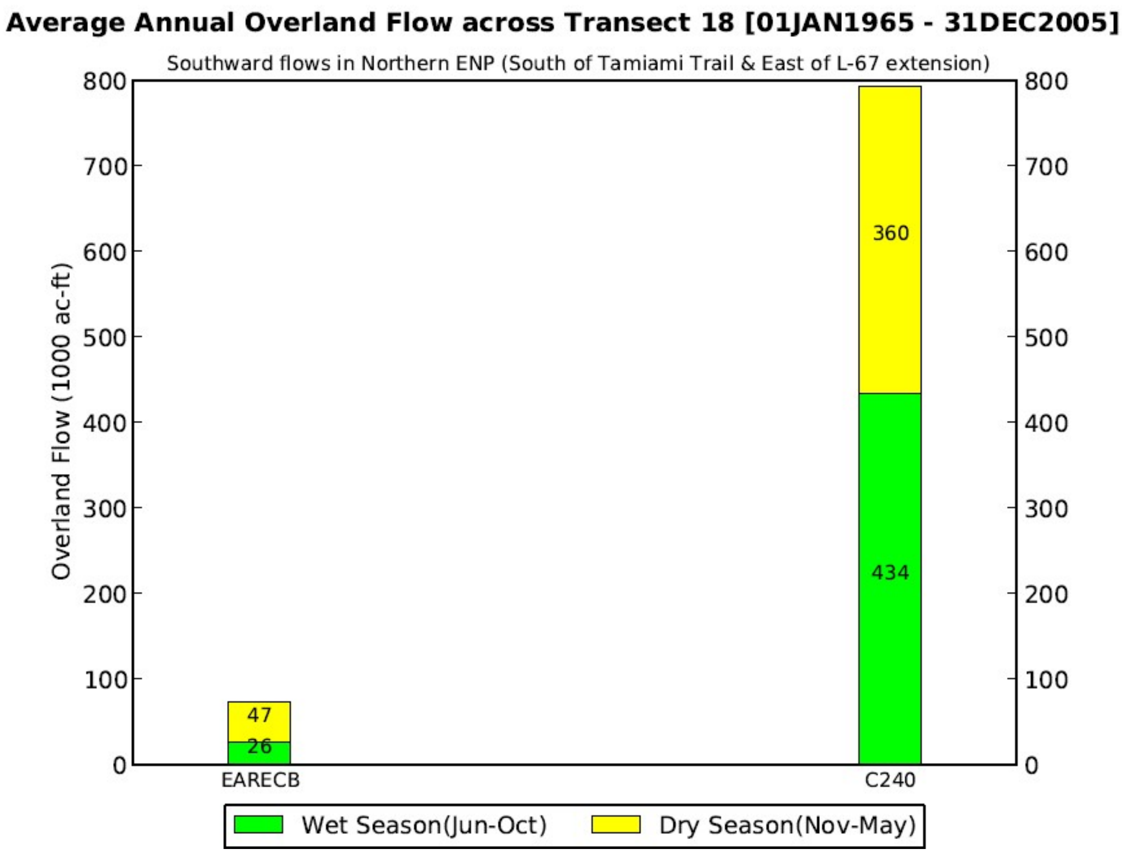

Figure 4-16. Average annual overland flow across Transect 18 in Northeast Shark River Slough.

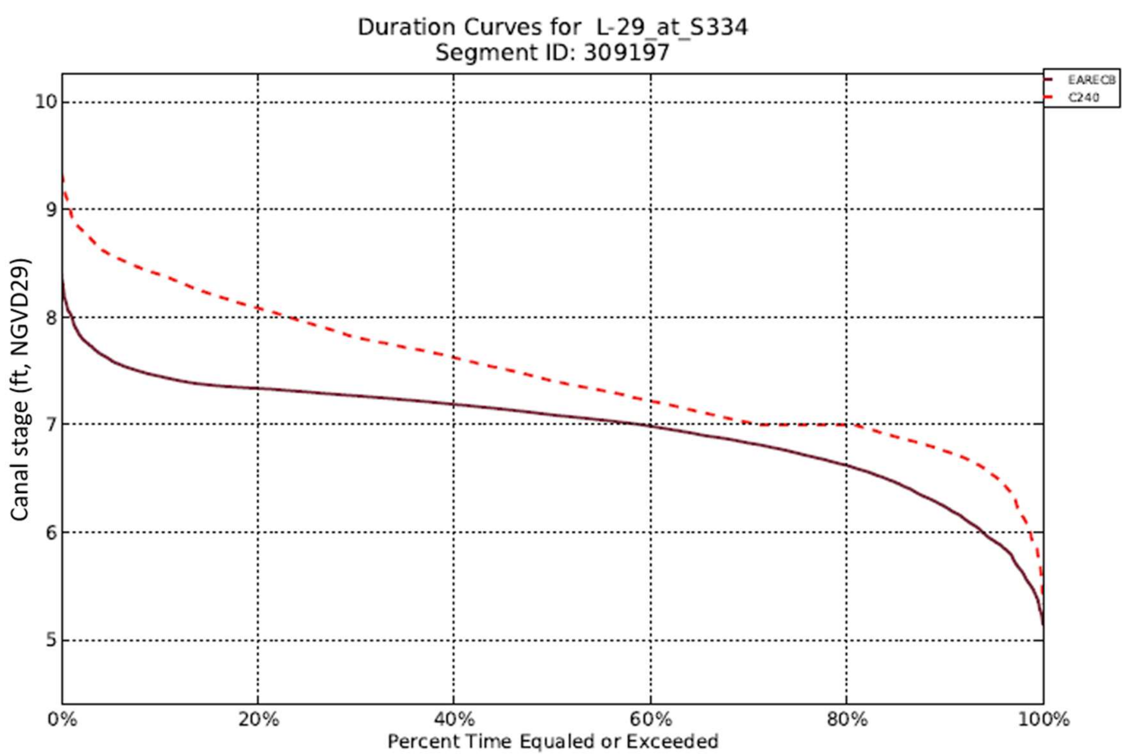

Figure 4-17. Water Conservation Area 3B Blue Shanty Flow-way stage duration curve.

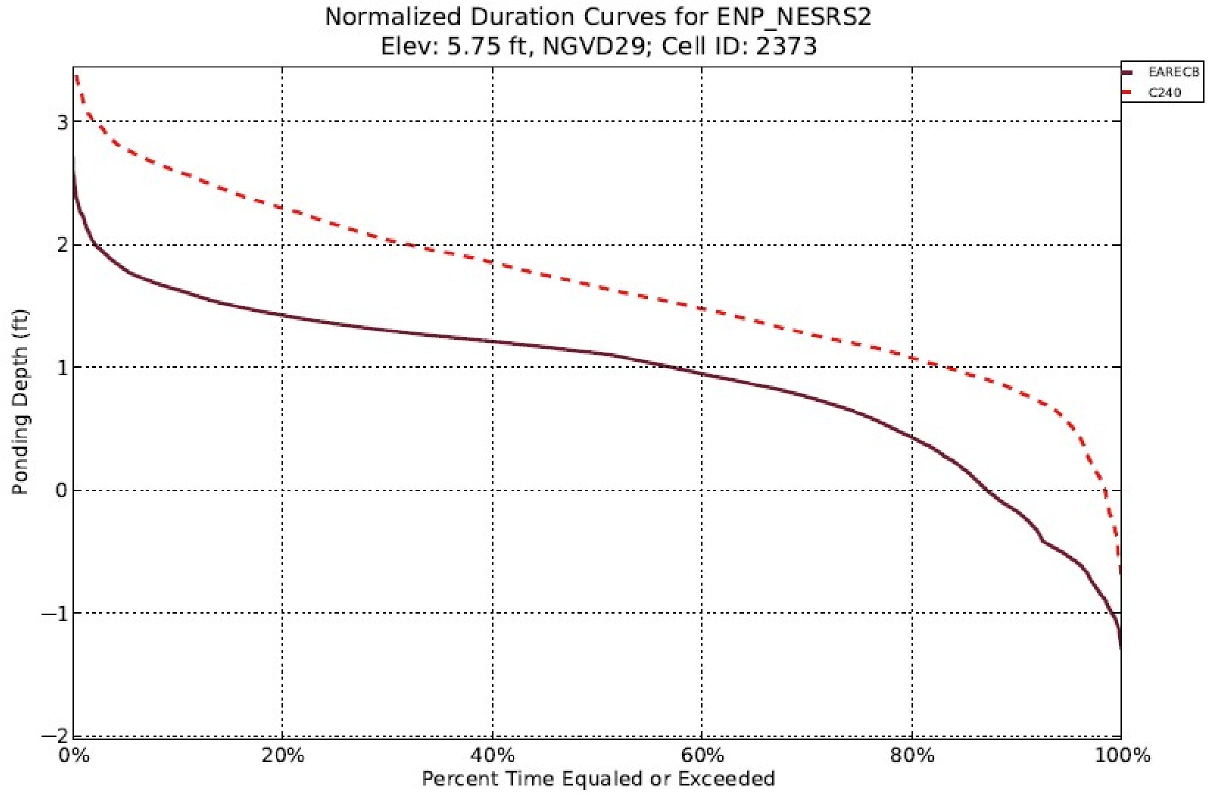

Figure 4-18. Northeast Shark River Slough normalized duration curves.

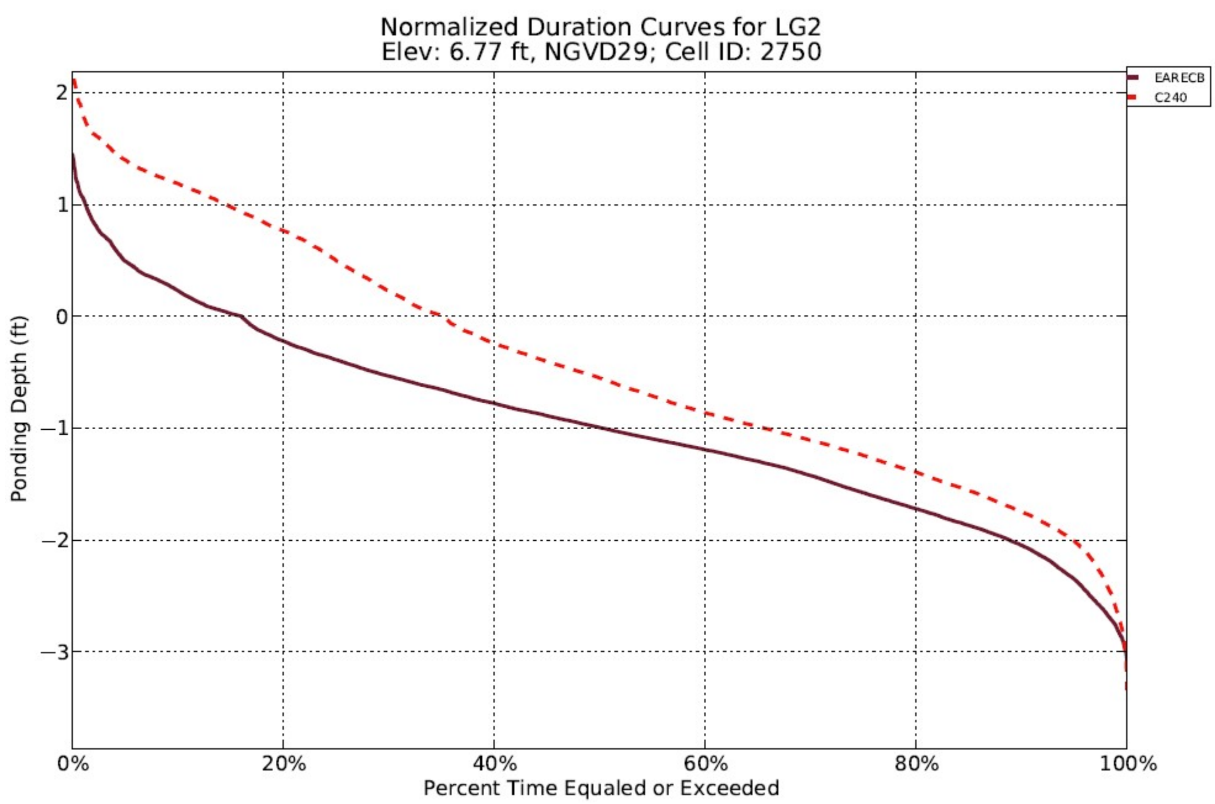

Figure 4-19. Eastern Everglades National Park normalized duration curves.

4.1.4 Western Shark River Slough

Located west of the L-67 extension levee and bounded to the north by Tamiami Trail, western SRS is influenced primarily by rainfall and water management operations at the S-12 structures. Under the Everglades Restoration Transition Plan, use of the S-12 structures and the seasonal sequential closure periods, beginning at S-12A (November 1 to July 14) and S-12B (January 1 to July 14), are meant to move water from WCA-3A into SRS while providing conditions for Cape Sable seaside sparrow (CSSS) Subpopulation A nesting and breeding. Modification to the Everglades Restoration Transition Plan seasonal closure periods for S-12A and S-12B was not considered during CEPP PACR preliminary screening and alternative formulation (SFWMD 2018), based on USACE consideration of the United States Fish and Wildlife Service (2016) Biological Opinion for the Everglades Restoration Transition Plan.

Annual overland flow to SRS from WCA-3A across RSM-GL Transect 17 (366,000 ac-ft) decreased 20,000 ac-ft (5%) with Alternative C240 relative to the ECB (**Figure 4-20**). Compared to the ECB, ponding depths within northern ENP (NP-201) are similar during 30% of deepest conditions for Alternative C240, while ponding depths decrease approximately 0.2 ft during 30% of shallowest conditions for Alternative C240 (**Figure 4-21**). Proceeding west, the NP-205 monitoring gauge (used as an indicator for CSSS Subpopulation A hydrology) similarly indicates a 0.1- to 0.3-ft decrease in ponding depth under all hydrologic conditions compared to the ECB (**Figure 4-22**), indicative of improved habitat for the CSSS.

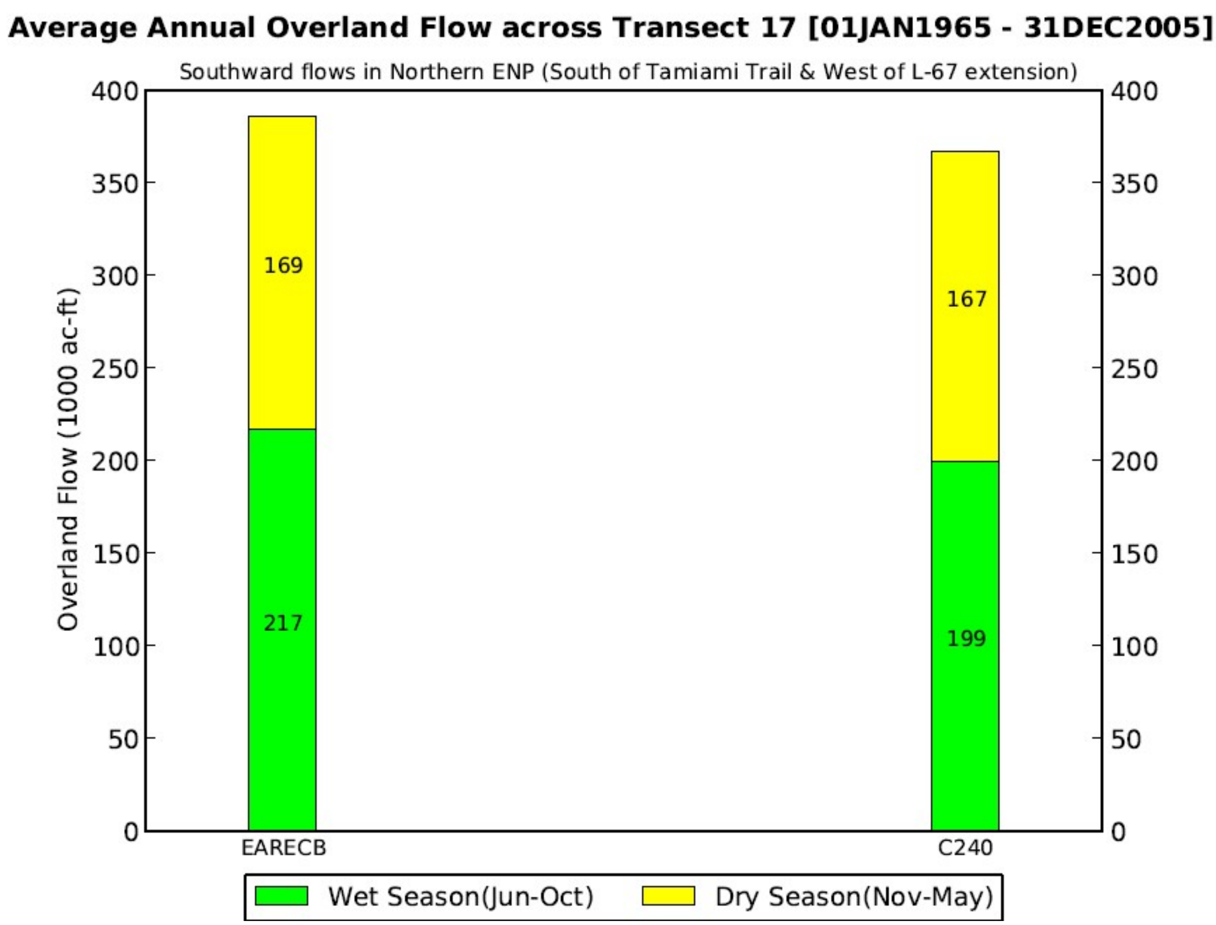

Figure 4-20. Average annual overland flow from WCA-3A to Shark River Slough across Transect 17.

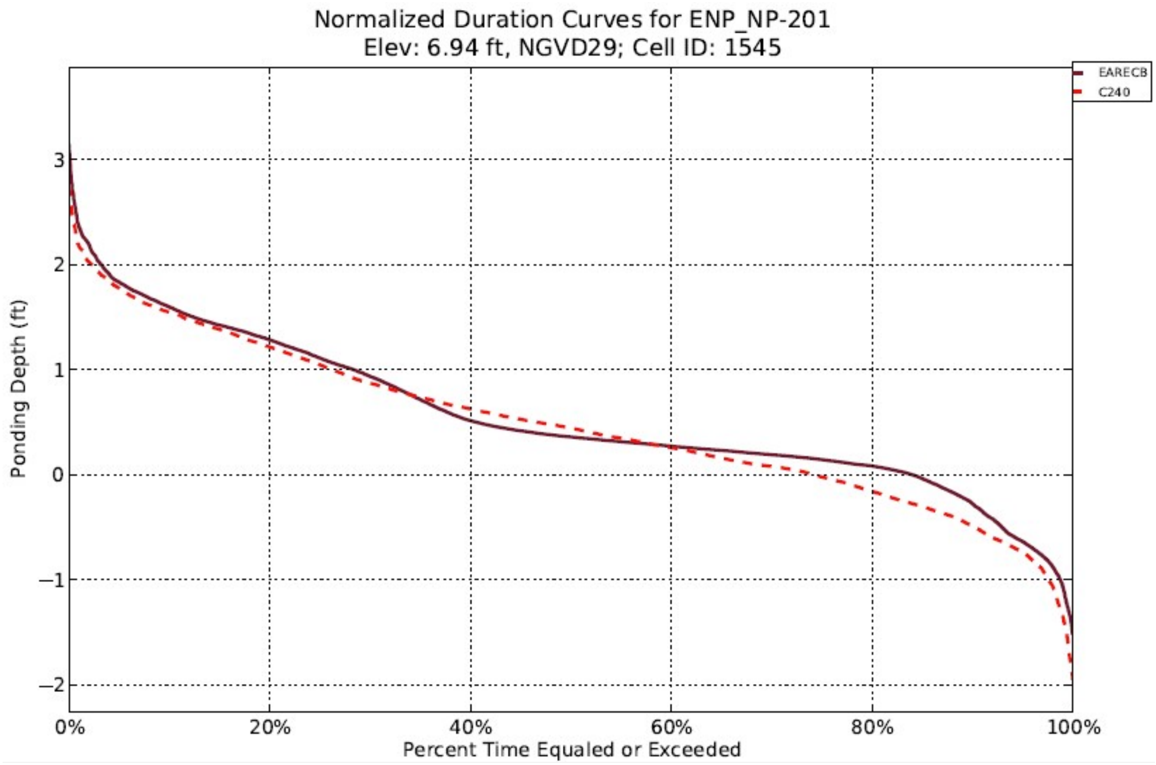

Figure 4-21. Northern Everglades National Park normalized duration curves.

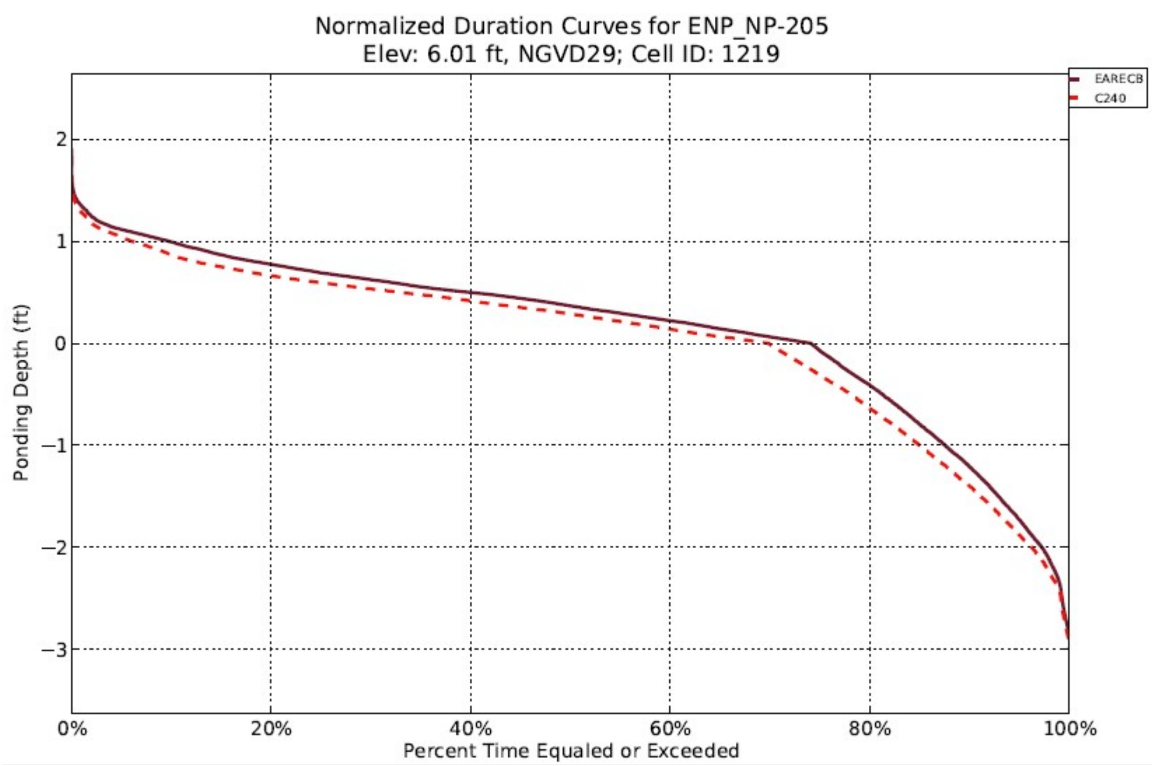

Figure 4-22. Northwestern Everglades National Park normalized duration curves.

In contrast, within central SRS, by adding 0.3 ft during ponded times, the annual hydroperiod is extended approximately 5% for Alternative C240 compared to the ECB (**Figure 4-23**), which indicates a potential degradation of CSSS habitat in the shallow-water edges of SRS. Ponding depths within central SRS demonstrate a combined response to the hydrologic changes previously indicated for NESRS and western SRS; the resultant combined annual transect flows within central SRS (Transect 27) increase from 618,000 ac-ft with the ECB to 828,000 ac-ft (34% increase) for Alternative C240 (**Figure 4-24**).

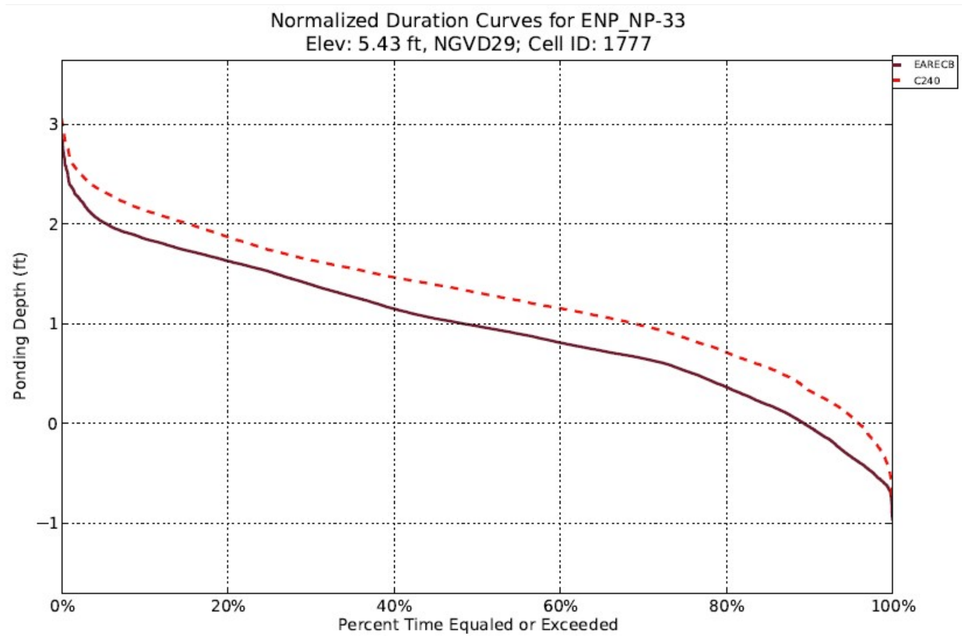

Figure 4-23. Central Everglades National Park normalized duration curves.

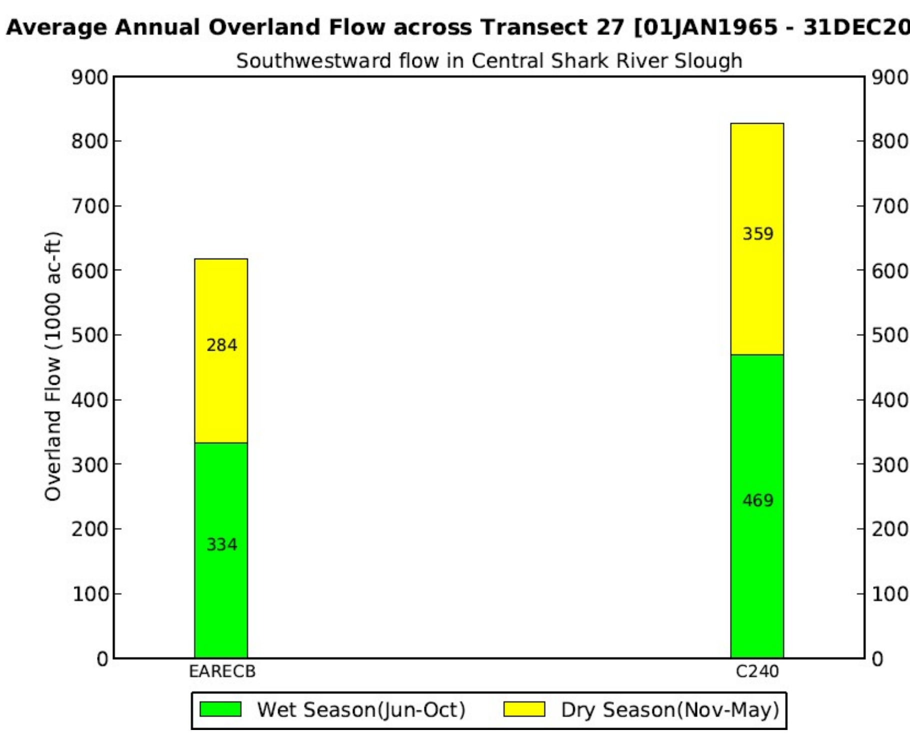

Figure 4-24. Average annual overland flow across Transect 27 in central Shark River Slough.

4.1.5 Taylor Slough

Ponding depths in Taylor Slough increased 0.1 to 0.3 ft during average hydrologic conditions, and annual hydroperiods extended approximately 10% for Alternative C240 compared to the ECB (**Figure 4-25**). Although these numbers are small compared to the large SRS and WCA-3A flows, they are ecologically significant when considering the importance of keeping these systems hydrated for as long as possible.

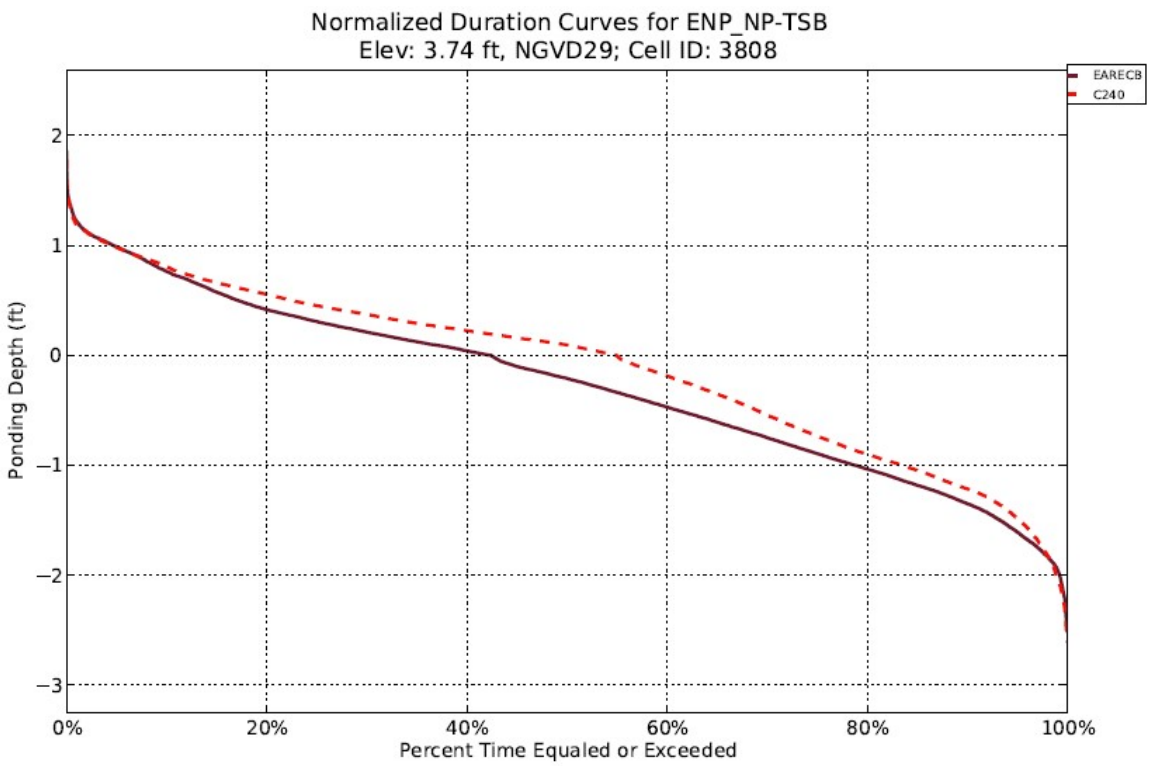

Figure 4-25. Taylor Slough normalized duration curves.

4.2 Habitats

4.2.1 Central Everglades

Alternative C240 provides demonstrably improved hydrologic conditions and is expected to benefit restoration objectives in the Central Everglades. Due to changes in the quantity, distribution, and timing of water entering the Central Everglades ecosystem under Alternative C240 (**Figures 4-2** to **4-4**), long-term improvements to wetland hydrology will enhance the sustainability of ridge and slough vegetation. Modeling results in northwestern and northeastern WCA-3A suggest Alternative C240 will decrease the amount of time water levels go below 0 ft by 21% and 17% and increase water depths by 0.7 ft and 0.4 ft, respectively, when surface soils are dry under the ECB (**Figures 4-26** and **4-27**). The extended hydroperiod will result in less soil oxidation across northern WCA-3A, thereby promoting wetland vegetation growth and peat accretion, while reducing the potential for high-intensity fires. According to the flow experiments in the Decomp Physical Model (Saunders et al. 2019), enhanced sheetflow in northwestern WCA-3A (approximately 340% increase; **Figure 4-28**) will help restore and sustain the microtopography, directionality, and spatial extent of ridges and sloughs and may improve the health of tree islands in the ridge and slough landscape (Wetzel et al. 2005).

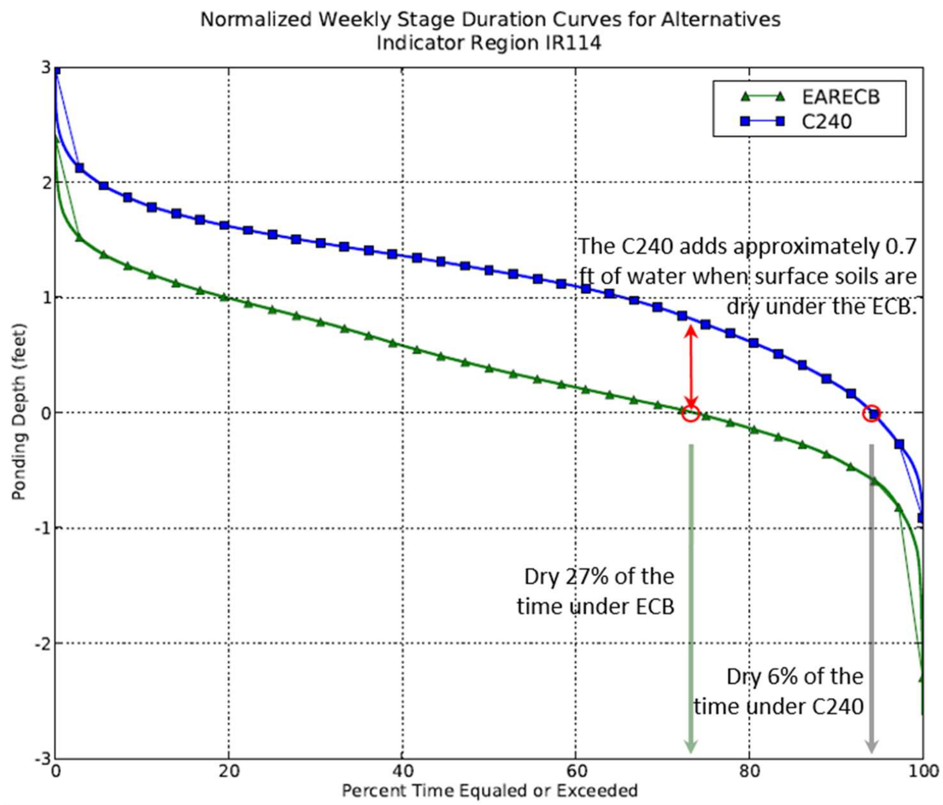

Figure 4-26. Normalized duration curves for northwestern Water Conservation Area 3A.

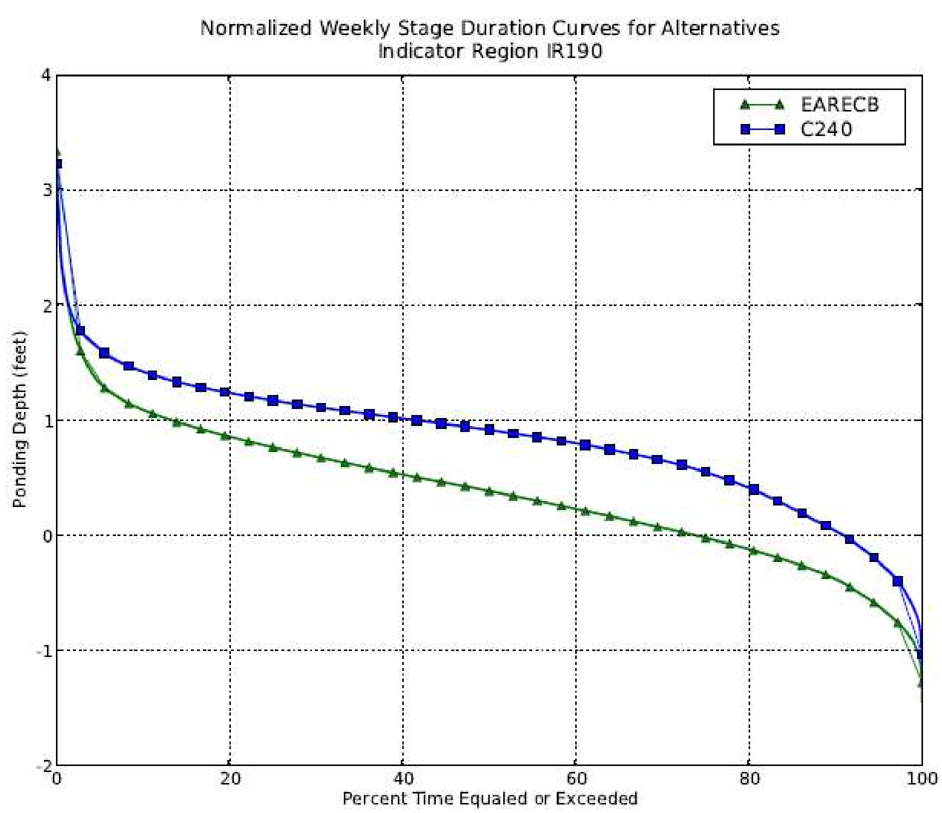

Figure 4-27. Normalized duration curves for northeastern Water Conservation Area 3A.

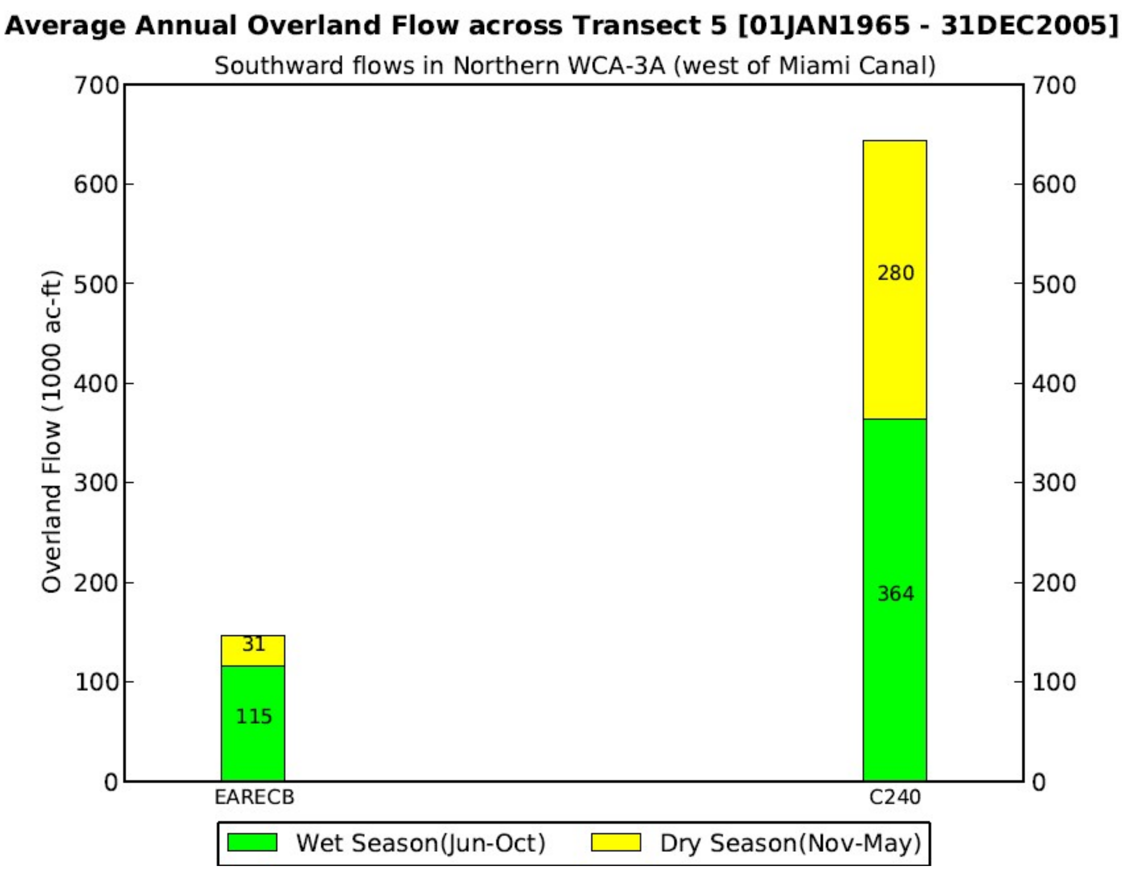

Figure 4-28. Average annual overland flow in northern Water Conservation Area 3A (west of the Miami Canal).

Alternative C240 is expected to have a moderate beneficial effect on vegetation in northern WCA-3A because of the enhanced sheetflow and extended hydroperiod. However, rehydration may result in expansion of cattail due the mobilization of phosphorus that occurs when peat soils are oxidized (Newman et al. 1998) as well as increased nutrient loads via overland flow. Nutrient loading may continue under Alternative C240. Although recent spatial sampling is unavailable to document changes in soil chemistry, the areas at greatest risk for phosphorus release upon rewetting are those closest to north-central WCA-3A near the Miami Canal, where increases in phosphorus per unit volume have occurred (Bruland et al. 2007). However, the long-term flow-weighted concentration of phosphorus is expected to be below 13 parts per billion, which is comparable to natural background levels. It is difficult to know exactly how vegetation in the northern region will respond to increased flows associated with Alternative C240; however, the risks associated with increased phosphorus concentrations are low compared to the benefits of the project.

Proceeding south approximately 10 miles, the amount of time water levels go below 0 ft decreases 11% and water depths increase 0.3 ft when ponding depths are approximately 1 ft for Alternative C240 compared to the ECB (**Figure 4-29**). Alternative C240 acts to rehydrate northern WCA-3A, promoting peat accretion, reducing the potential for high-intensity fires, and facilitating the transition from upland to wetland vegetation.

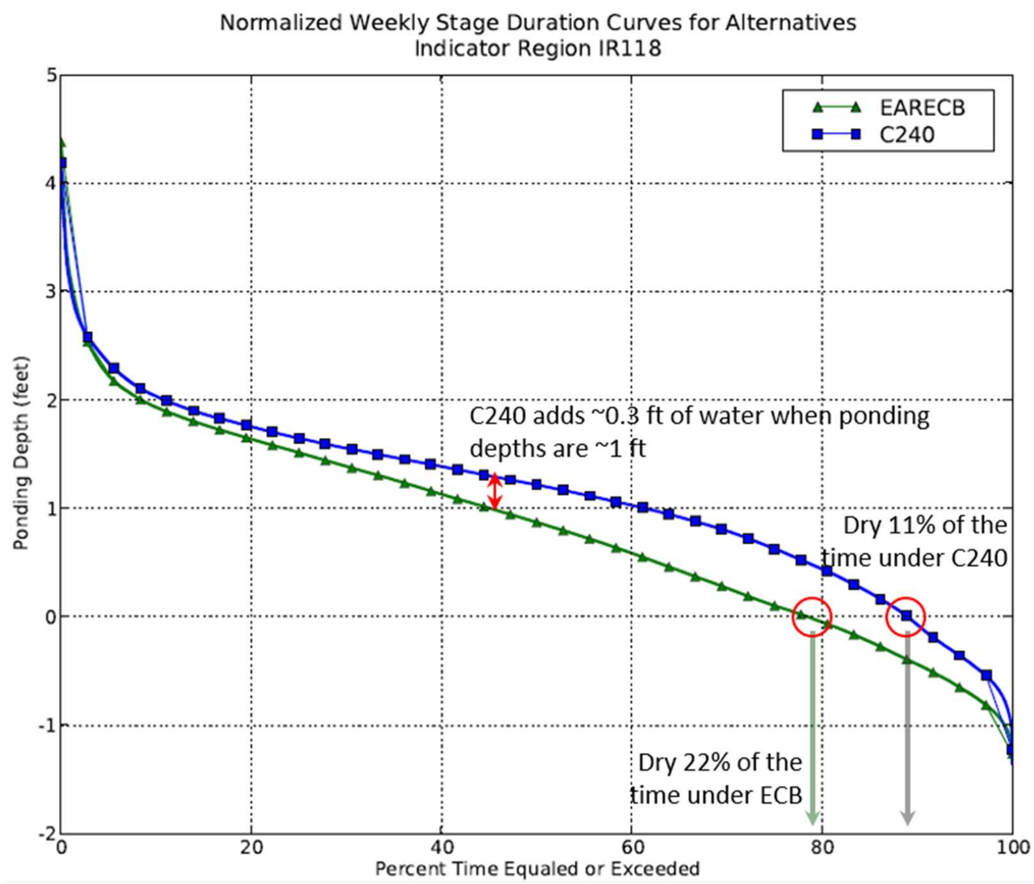

Figure 4-29. Normalized duration curves for northeastern Water Conservation Area 3A.

Rehydration of previously dry areas within north-central WCA-3A could temporarily mobilize nutrients within the water column; however, this is not expected to be a significant issue because portions of WCA-3A north of Interstate 75 experience annual dryout and rehydration with no significant downstream impact under the ECB. The introduction of phosphorus into previously unimpacted areas (i.e., central and southern WCA-3A) might cause vegetation shifts, providing a minor adverse effect. Chaing et al. (2000) suggested phosphorus loading can alter Everglades plant communities through increased plant productivity, tissue phosphorus storage, soil phosphorus enrichment, and shifts in plant species composition. Previous studies have shown that slough and sawgrass communities have been replaced by cattail-dominated communities when soil phosphorus concentrations increase, generally exceeding 500 milligrams per kilogram (Davis et al. 1994, Newman et al. 1998, Rutchey et al. 2008, McCormick et al. 2009). However, Craft et al. (1995) and Chaing et al. (2000) observed no significant change in macrophyte species diversity or expansion of cattails in study plots receiving nutrient additions during the 2 and 4 years, respectively, of their studies. Vegetation that can assimilate nutrients directly from the water column (e.g., periphyton-*Utricularia* complex) are the most sensitive to nutrient enrichment, and their communities shift in response to enrichment, as evidenced by the replacement of phosphorus-sensitive species with phosphorus-tolerant species (McCormick et al. 1996, Gaiser et al. 2005, Gaiser 2009, Newman et al. 2004).

Many areas of WCA-3A, particularly within central WCA-3A, still contain good quality wetland habitat, consisting of tree islands, sawgrass marshes, wet prairies, and aquatic sloughs. Vegetation and patterning in central WCA-3A most closely resemble pre-drainage conditions and represent some of the best examples of remnant Everglades habitat in South Florida. Although hydrology in these areas remains mostly unaffected by Alternative C240 compared to the ECB (**Figure 4-30**), maintenance of existing conditions within this region of the project area is desirable as ridge and slough habitat is well conserved.

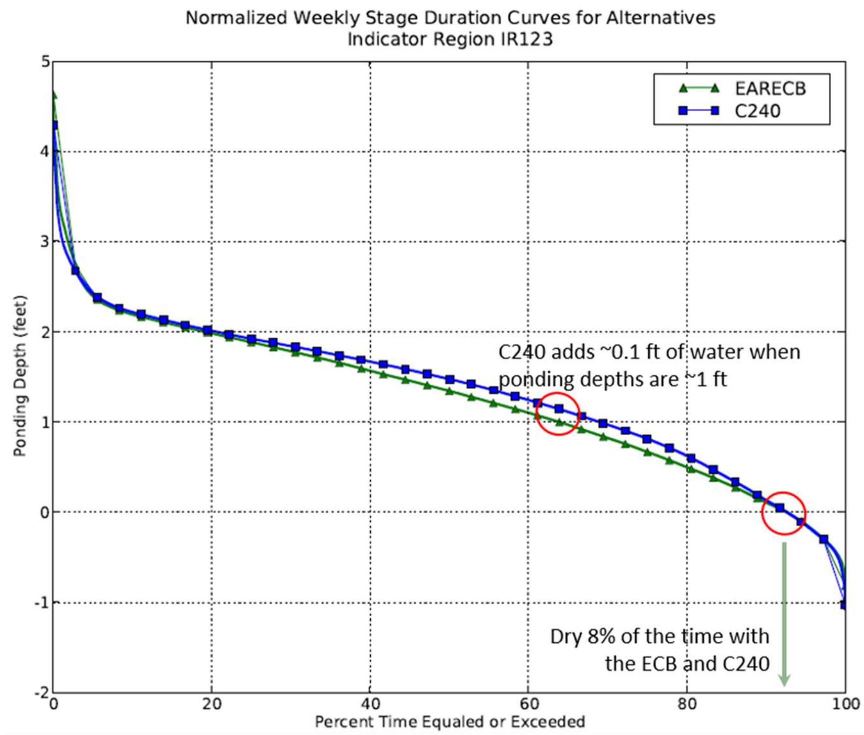

Figure 4-30. Normalized duration curves for central Water Conservation Area 3A.

High water levels during the wet season are essential to maintain quality wet prairie and emergent slough habitat. However, prolonged high water levels (i.e., during both the wet and dry seasons) and extended hydroperiods have resulted in vegetation shifts within southern WCA-3A, which negatively impact tree islands and fragment sawgrass ridges, resulting in loss of historical landscape patterning. Alternative C240 brings annual peak water levels down by 0.4 ft (**Figure 4-31**), which is expected to reduce the potential for flooding stress on tree islands. However, neither Alternative C240 nor the ECB reduce average water levels or duration in southern WCA-3A; therefore, major shifts in vegetation are not anticipated within this region, providing a negligible effect.

Typical Everglades vegetation, including tree islands, wet prairies, sawgrass marshes, and aquatic sloughs occurs throughout WCA-3B. However, within WCA-3B, the ridge and slough landscape has been severely degraded by the virtual elimination of overland sheetflow due to the L-67 Canal and levee system. WCA-3B has become a primarily rain-fed system with shorter hydroperiod sawgrass marshes and relatively few sloughs and tree islands. Loss of sheetflow to WCA-3B has accelerated soil loss, reducing elevations of the remaining tree islands and making them vulnerable to high water stages.

Compared to the ECB, Alternative C240 decreases ponding depths within central WCA-3B approximately 0.1 ft during 40% of deepest conditions and increases ponding depths approximately 0.1 ft during 30% of shallowest conditions (**Figure 4-32**). The seasonal decrease in ponding depths in central WCA-3B results from less water entering eastern WCA-3A (from WCA-2A), water routed to the Blue Shanty Flow-way and ENP, and a shift in flow timing. The timing shift refers to more water being stored in the EAA Reservoir for release during drier conditions. In contrast, Alternative C240 increases ponding depths approximately 0.1 ft in southern WCA-3B during all ponded times compared to the ECB (**Figure 4-33**). Although these changes could have positive (deeper water conditions during the dry season in central WCA-3B) and negative (flooding stress in southern WCA-3B) effects, the effects are not ecologically significant. As such, long-term shifts in vegetation, water quality, tree island sustainability, or use by wildlife are not anticipated in comparison to the ECB.

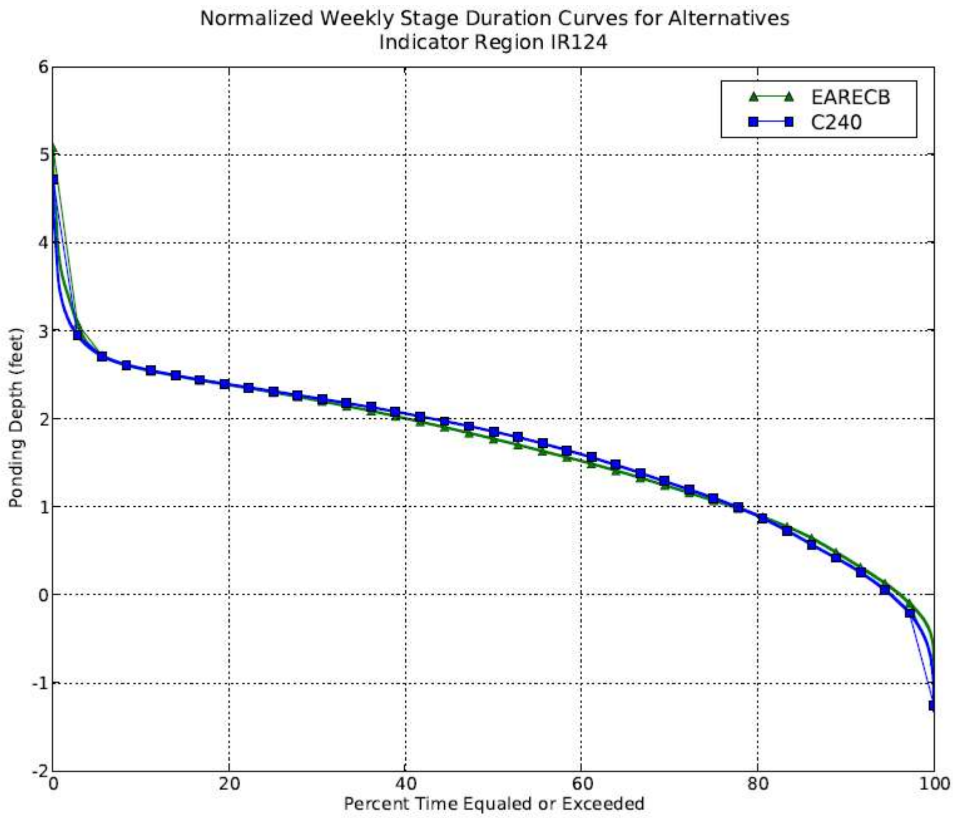

Figure 4-31. Normalized duration curves for southern Water Conservation Area 3A.

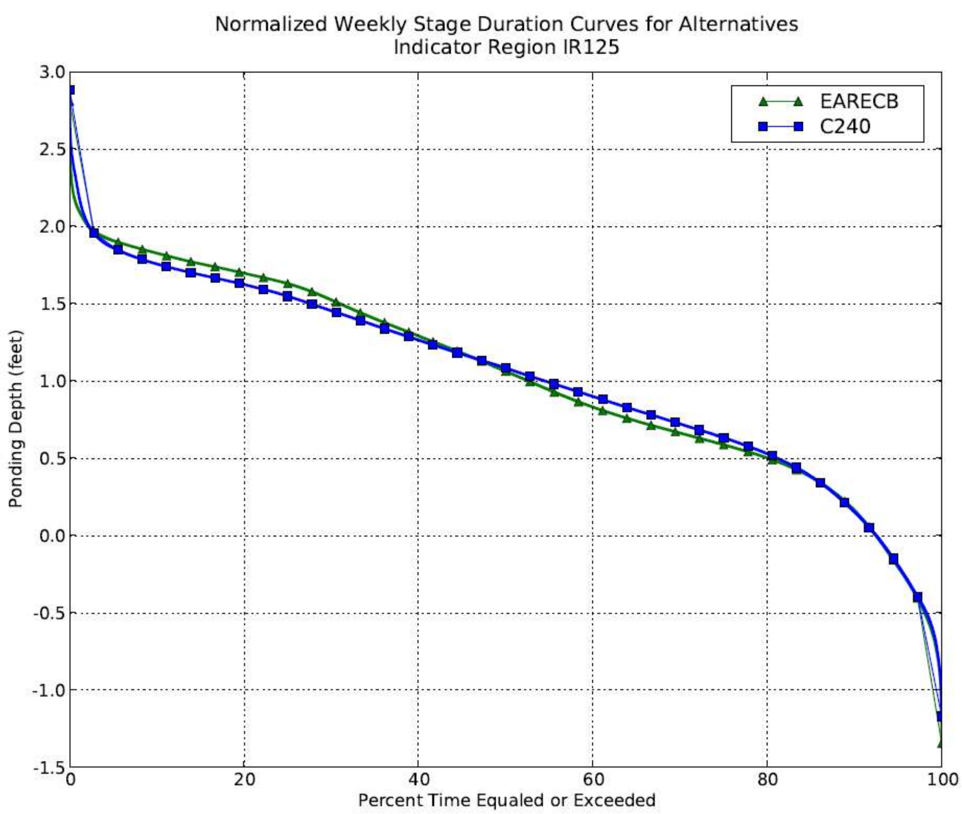

Figure 4-32. Normalized duration curves for central Water Conservation Area 3B.

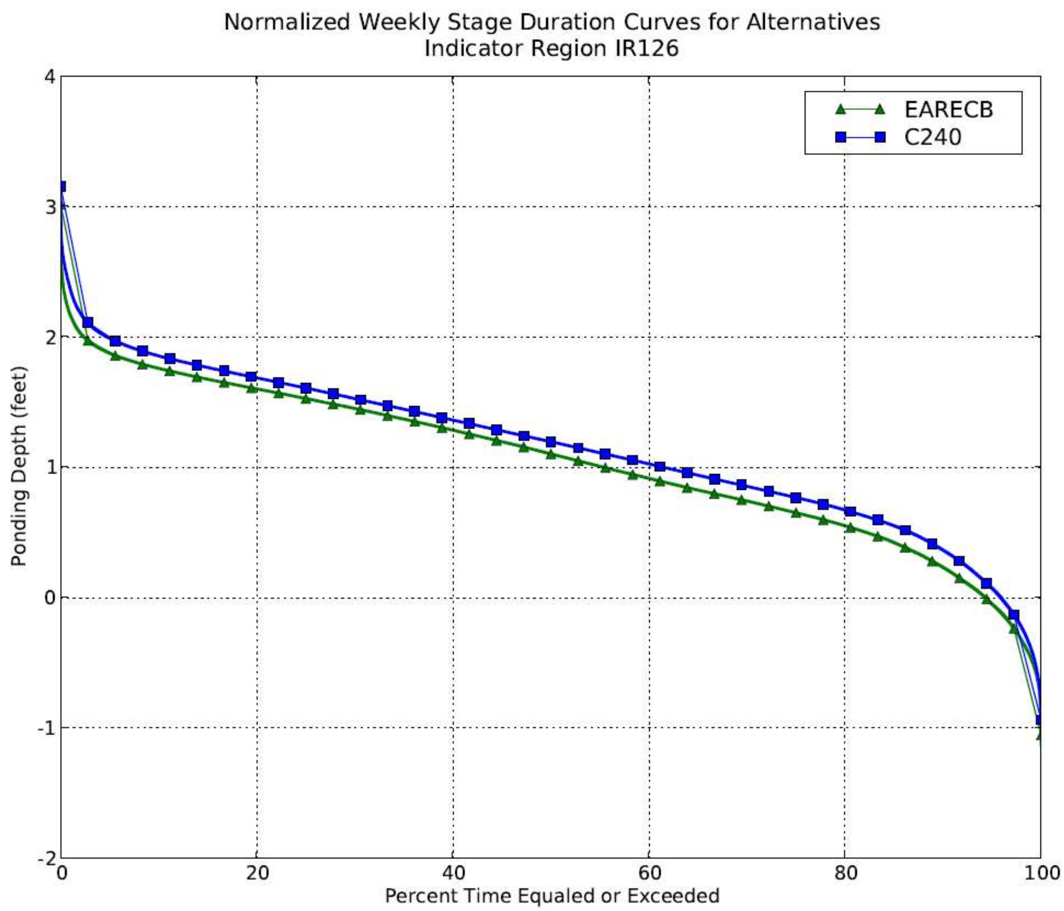

Figure 4-33. Normalized duration curves for southern Water Conservation Area 3B.

Existing compartmentalization and water management practices result in flows through NESRS that are significantly lower than pre-drainage conditions. The consequence of lower flows has been lower wet season depths, more frequent and severe drydowns in sloughs, and reduction in the extent of shallow-water edges. Over-drainage in peripheral wetlands along the eastern boundary of NESRS has caused shifts in community composition, invasion by exotic woody species, and increased susceptibility to fire. Implementation of Alternative C240 is expected to continue the benefit of rehydrating NESRS (**Figure 4-34**) by increasing annual overland flows to NESRS compared to the ECB (**Figure 4-16**), providing long-term ecological benefits. Resumption of sheetflow and related patterns of hydroperiod extension will help restore pre-drainage water depth patterns and the complex mosaic of the Everglades' vegetation communities.

Reduction in the number and duration of dry events in NESRS is a major environmental benefit because extended hydroperiods will reduce soil oxidation, decrease fire potential, promote peat accretion, and aid in the restoration of historical wetland vegetation communities. Alternative C240 will decrease the duration of dry events, calculated for the modeling period (1965 to 2005) along the SRS (indicator regions 129, 130, 131, and 132), to 13 weeks, which is 3 weeks shorter than the average duration of dry events for the ECB (**Figure 4-35**). Additionally, the results under Alternative C240 show similar performance in the average duration of dry conditions in four indicator regions of a pre-drained Everglades system (NSM462 in **Figure 4-35**). Therefore, Alternative C240 has fewer dry weeks than the ECB and has a similar extent of drydowns relative to a pre-drained Everglades, which achieves the project goal of rehydrating NESRS.

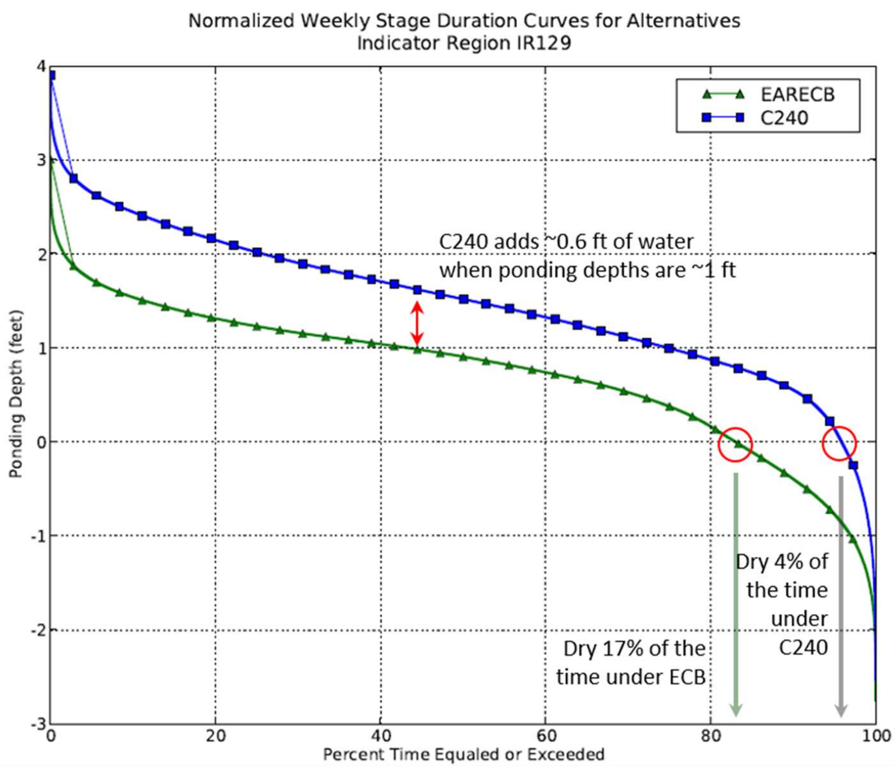

Figure 4-34. Normalized duration curves for Northeast Shark River Slough.

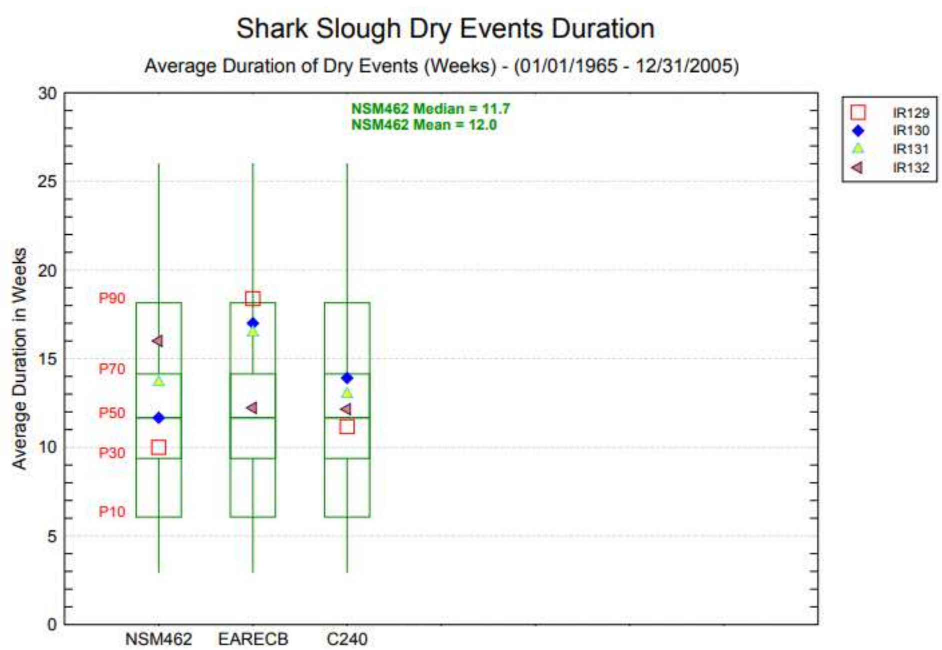

Figure 4-35. A weekly count of dry events in four indicator regions in Shark River Slough between 1965 and 2005 under a pre-drained hydrologic condition (NSM462), the existing conditions baseline (ECB), and Alternative C240 (C240). The box-whisker plot represents the Natural System Model (version 4.62) distributions for ridge and slough habitat south of Tamiami Trail. The model simulates the hydrologic response of a pre-drained Everglades system; it does not attempt to simulate the pre-drained hydrology. Instead, recent climatic data are used to simulate the pre-drained hydrologic response to current hydrologic input.

There is a long-term, moderate increase in the overland flow rates in NESRS and Taylor Slough. The added fresh water will lower the rate of saltwater intrusion in the mangroves of the southwestern coastal areas and Florida Bay. These flows will reduce coastal salinities and maintain hydrologic and ecological connectivity. Overland flows also help maintain the ridge and slough patterns in all of SRS. The average annual increase in sheetflow in central SRS (Transect 27) increases 210,000 ac-ft (34% increase) under Alternative C240 compared to the ECB (**Figure 4-24**). The average annual southward sheetflow to Taylor Slough in southern ENP (Transect 23B) increases 19,000 ac-ft (29% increase) for Alternative C240 compared to the ECB (**Figure 4-36**).

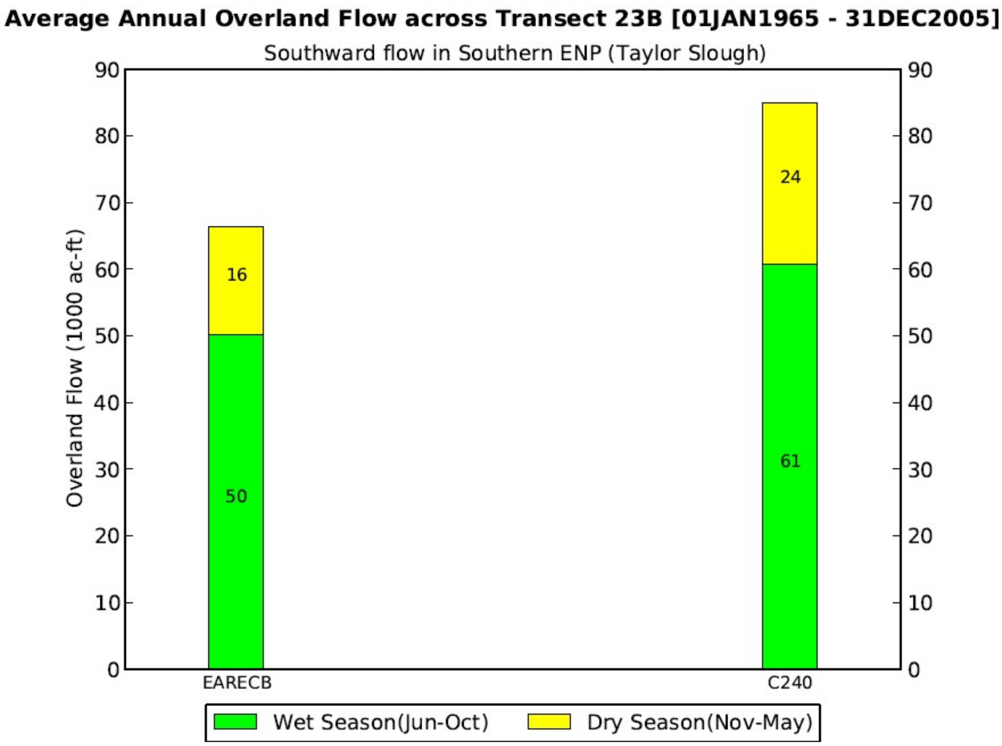

Figure 4-36. Average annual overland flow in southern Everglades National Park.

The Everglades, a phosphorus-limited system, historically received most phosphorus through rainfall, with average total phosphorus concentrations of less than 0.01 milligram per liter (McCormick et al. 1996). A rapidly growing population and industrial agriculture increased total phosphorus inputs in the WCAs and ENP; however, a series of STAs has removed phosphorus before it enters the ecosystem since 1993 and, recently, areas within ENP have shown total phosphorus concentrations of less than 0.01 milligram per liter (Julian et al. 2019). One concern is additional flow will provide greater phosphorus loads and could cause vegetation changes within NESRS. The periphyton-*Utricularia* complex will be the most sensitive to nutrient enrichment (Gaiser et al. 2005). Potential effects on vegetation and species community composition within NESRS and ENP cannot be fully determined at this time. Water quality in the study area will continue to be monitored.

Non-native and invasive plant infestations in the Central Everglades may be exacerbated by soil disturbance, increased nutrients, and hydrologic modification. Many non-native and invasive species are flourishing in a variety of habitats and negatively affecting the ecology throughout the Everglades. Non-native and invasive plant species most frequently are encountered in disturbed areas and areas where water quality has been impacted by increased nutrient loads. Construction or hydrologic modification under Alternative C240 is not expected to influence the spread or establishment of invasive and nuisance plant species.

4.2.2 Slough/Open Water Marsh

Deep slough communities occurred throughout the pre-drainage ridge and slough region of the Everglades (McVoy et al. 2011). Sloughs within the Central Everglades have been degraded by compartmentalization, resulting in reduced sheetflow, depths, and inundation durations; altered vegetation community structure; and expansion of wet prairie and sawgrass marsh communities. Overland sheetflow has been virtually eliminated from WCA-3B due to the L-67 Canal and levee system, resulting in loss of deep water sloughs and dominance of shorter hydroperiod, dense sawgrass marsh. Vegetative trends within ENP also include conversion of slough/open-water marsh communities to shorter hydroperiod sawgrass marshes (Davis and Ogden 1994, Davis et al. 1994, Armentano et al. 2006). Increases in SRS sheetflow under Alternative C240 (**Figure 4-16**) provide a long-term impact on the hydroperiod as the region will be dry only 4% of the time, compared to 17% under the ECB (**Figure 4-34**). With Alternative C240, much of NESRS will see substantial rehydration, which will promote sheetflow due to redistribution of flows from WCA-3A and WCA-3B to ENP. This will improve hydroperiods and water depths while reducing the frequency and severity of drydown events (**Figure 4-35**), which can cause a transition of shallower wet prairies to slough/open-water marsh communities.

4.2.3 Wet Marl Prairies

Wet marl prairies occur on marl soils and exposed limestone and experience the shortest hydroperiods of the slough/marsh/prairie wetland complex. Marl prairies occur in the southern Everglades along the eastern and western peripheries of SRS. Areas within the eastern marl prairies along the ENP boundary suffer from over-drainage, reduced water flow, exotic tree invasion, and frequent human-induced fires (Lockwood et al. 2003, Ross et al. 2006). To alleviate the perpetually drier conditions and associated problems, increased water flows are needed in this area. Alternative C240 provides long-term, moderate benefits to vegetation because increased hydroperiods within the eastern marl prairies may alleviate some of the problems associated with drier conditions and promote a shift in community composition (**Figure 4-19**).

Within the western marl prairies, decreased annual overland flows (**Figure 4-20**) and subsequent reductions in hydroperiod (**Figures 4-21** and **4-22**) would promote vegetation transition, increasing the area of marl prairie within CSSS Subpopulation A. Proceeding west to southern Big Cypress National Preserve, however, the vast majority of western marl prairies that currently are over-drained would experience no hydrologic changes, providing a negligible effect on the vegetation community under Alternative C240 compared to the ECB (**Figure 4-37**).

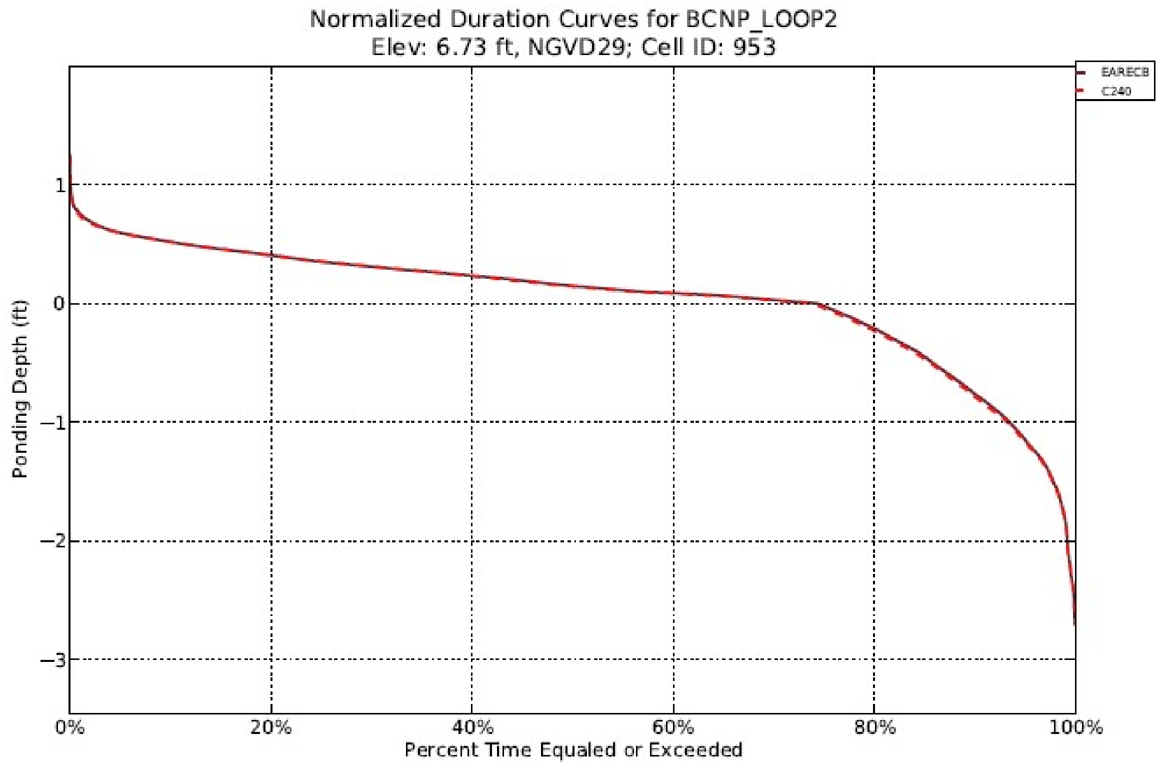

Figure 4-37. Normalized duration curves in southern Big Cypress National Preserve.

4.2.4 Tree Islands

Hydrologic restoration may not be conducive to new tree island creation in northeastern WCA-3A, where tree islands once were plentiful but now few remain. Despite beneficial effects of Alternative C240 reducing damaging drydown durations (26% increase in hydroperiod), adding approximately 0.4 ft water during the wettest 5% periods when deep water can stress vegetation on tree islands is a concern (**Figure 4-7**). However, because water depths on the marsh surface are predicted to be 1 ft or less 80% of the time for Alternative C240, this is beneficial to existing tree islands.

Proceeding south, central and southern WCA-3A are expected to respond similarly (**Figures 4-30** and **4-31**). Tree islands in central WCA-3A are in optimum hydrology. However, Alternative C240 does not lower the damaging ponding depths or improve the ecological condition of tree islands in southern WCA-3A compared to the ECB. Thus, benefits are deemed negligible.

Moving into WCA-3B (not including the Blue Shanty Flow-way), implementation of Alternative C240 will provide no improvement on the ecological condition of tree islands in central WCA-3B (**Figure 4-32**). In southeastern WCA-3B, Alternative C240 reduces damaging drydown durations approximately 7% by adding approximately 0.1 ft water during ponded times (**Figure 4-38**). Although these numbers are small compared to the area of major improvements (i.e., northern WCA-3A), given WCA-3B is compartmentalized and becomes a rain-fed system, even slight increases in hydroperiods associated with enhanced sheetflow will increase sediment redistribution to tree islands and ridges and help restore historical sloughs.

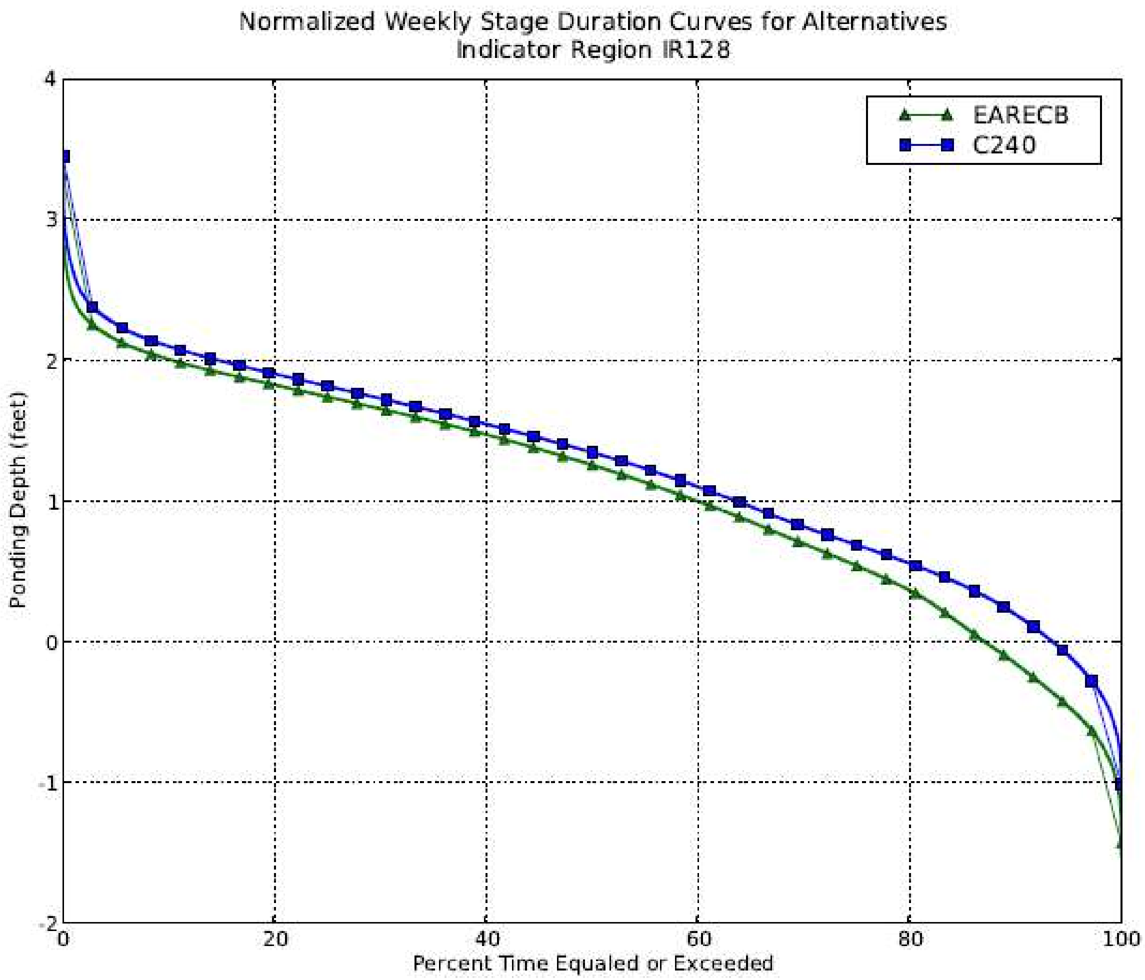

Figure 4-38. Normalized duration curves in southeastern Water Conservation Area 3B.

4.2.5 Shark River Slough

In SRS, where tree islands rise high above the surrounding marsh, the potential for flooding stress is practically nonexistent. Instead, ENP is faced with a reduction in tree islands due to intensive fires that move across the marshes and burn tree island peat soils, leaving only rocky outcroppings. The objective of Alternative C240 is to prevent extensive drydowns and extend hydroperiods. **Figure 4-39** shows a marsh surface hydrology for Alternative C240 that reduces drydown durations approximately 5% by increasing water depth approximately 0.2 ft during ponded times relative to the ECB, which provides rehydration benefits.

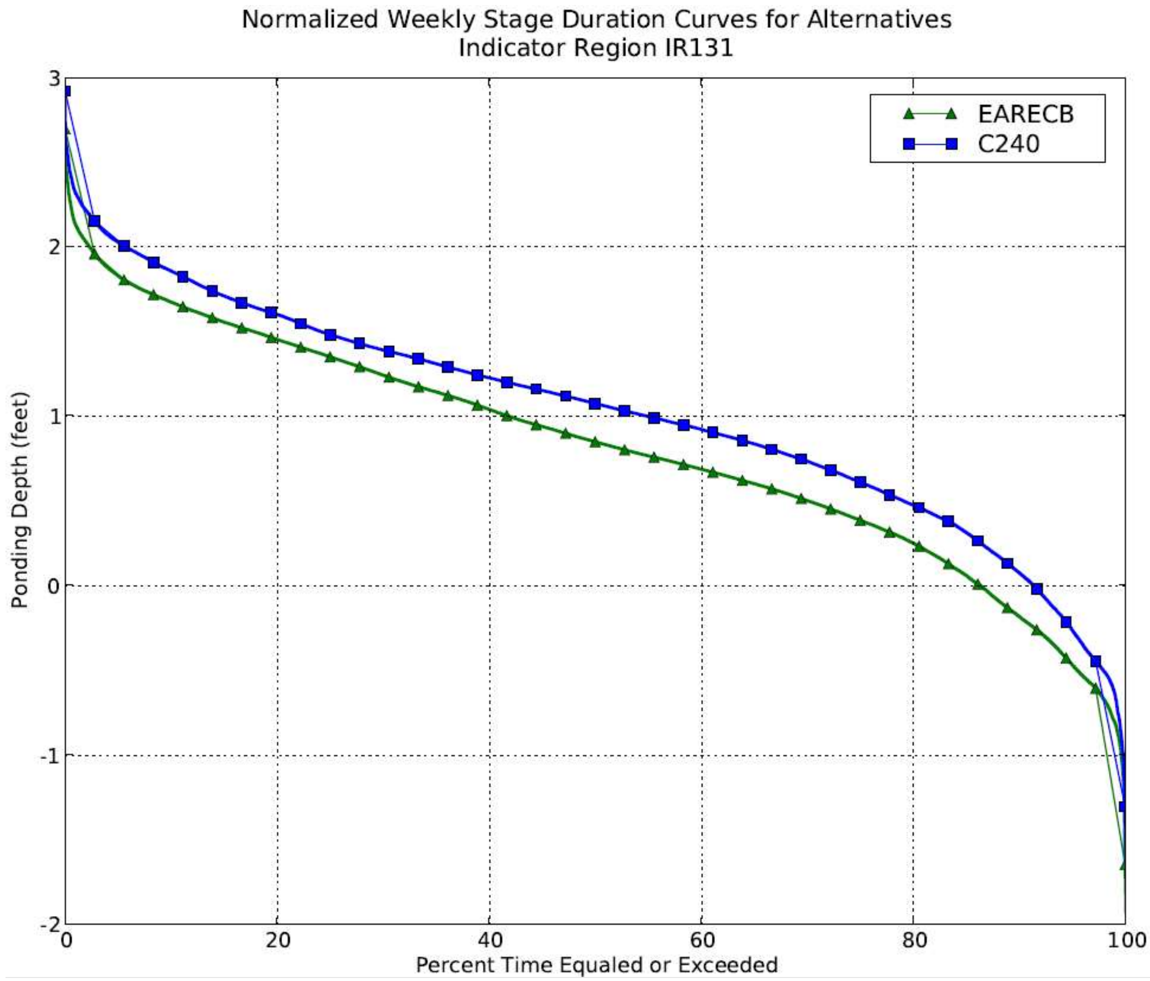

Figure 4-39. Normalized duration curves in Shark River Slough.

4.2.6 Hydrologic Summary

In this technical document, central WCA-3A (indicator region 123; **Figure 4-30**) serves as a reference location where the ridge-slough-tree island landscape is the most preserved. The current hydrology in this location is similar to the hydrology predicted by the Natural System Model and, as such, is more of a comparative reference site rather than a target. Because the Central Everglades was a rather uniform, spatially homogeneous ridge and slough landscape over WCA-3A and ENP, annual average depth, maximum depth, and hydroperiod in central WCA-3A are extrapolated across the project area (**Table 4-1**). Note that the goal of restoration is not to make water depths across the system as deep as central WCA-3A; however, that is one consideration that determines the composite picture of how the Everglades are to be restored.

A highly anticipated outcome of Alternative C240 is an increase water depths and hydroperiods in over-drained wetlands such as northern WCA-3A and NESRS (**Table 4-1**). The conditions created by Alternative C240 will considerably improve average water depths and hydroperiods, showing similar performance measures to central WCA-3A. Therefore, major hydrologic improvements are expected to produce long-term benefits to these areas and the fishes and wildlife living therein. The area northwestern portion of western marl prairies near the S-12 structures are at high risk for additional drying because there is less water sent to the S-12 structures under Alternative C240 (**Figure 4-5**). In the majority of the western marl prairies within northern ENP and southern Big Cypress National Preserve, no additional water is expected, and the area likely will remain over-drained and at risk from muck fires and further soil oxidation. On the contrary, a reduction in peak water levels and hydroperiods is expected to alleviate flooding stress in areas of excessive ponding, such as eastern and southern WCA-3A (**Table 4-1**). The new water routed to the Blue Shanty Flow-way from WCA-3A to ENP will moderately increase the drying out of northern and central WCA-3B but will lengthen hydroperiods and deepen water levels in southern WCA-3B (**Table 4-1**). As WCA-3B has become a primarily rain-fed system, returning to a flowing system in some areas can be considered a progressive step towards ecosystem restoration. In general, the overall impact of hydrologic changes to the landscape is expected to be small in WCA-3B. As a result of the negligible outcome, the CEPP adaptive management option to increase flows from the new S-633 structure into WCA-3B will assess an incremental increase in ponding depths over a 15- to 20-year interval to allow sloughs, ridges, and tree islands to re-establish microtopography.

Table 4-1. A summary comparison of hydrologic conditions under the existing conditions baseline and Alternative C240 across the project regions.

Region	Average Water Depth (ft)		Maximum Water Depth (ft)		Hydroperiod (days)		Figure
	ECB	C240	ECB	C240	ECB	C240	
Northwestern WCA-3A	0.4	1.2	2.3	3	262	338	4-26
Northeastern WCA-3A	0.4	0.9	3.4	3.2	270	332	4-27
Eastern WCA-3A	2.1	2.3	5.5	5.3	343	328	4-9
Central WCA-3A	1.3	1.5	4.6	4.3	337	338	4-27
Southern WCA-3A	1.8	1.9	5.1	4.7	350	346	4-28
Northern WCA-3B	0.8	0.7	2.3	2.2	313	302	4-12
Central WCA-3B	1.1	1.1	2.8	2.9	335	335	4-32
Southern WCA-3B*	1.2	1.6	2.9	3.4	350	357	4-14
Northeast SRS	0.9	1.5	3.0	3.9	302	350	4-30
Eastern ENP	-1.0	-0.5	1.5	2.1	58	128	4-19
Northwestern ENP	0.4	0.3	1.9	1.9	270	255	4-20
Southern BCNP	0.2	0.2	1.3	1.3	270	270	4-37

BCNP = Big Cypress National Preserve; C240 = Alternative C240; ECB = existing conditions baseline; ENP = Everglades National Park; ft = foot; SRS = Shark River Slough; WCA = Water Conservation Area.
* Within the Blue Shanty Flow-way.

4.3 Fish and Wildlife Resources

This section evaluates the fish and wildlife simulations from the United States Geological Survey Joint Ecosystem Model Program for the ECB and Alternative C240. Effects on key indicator species, including state and federally listed species, are summarized in **Table 4-2**. This table is based on a combination of the models presented in this technical document, model output from the PACR PIR (USACE and SFWMD 2014), an understanding of the biology and environmental requirements of each species, and the best professional judgement of federal and state ecologists working on Everglades restoration projects. Although changes in water quality could affect the prey forage base by altering vegetation composition or structure, modeling tools are not available to compare such changes under the ECB and Alternative C240. Instead, water quality will continue to be monitored, potential effects will be evaluated, and options in the CEPP adaptive management plan will be implemented, if necessary.

Table 4-2. Comparison of effects on key indicator species, including federally and state listed threatened and endangered species, under the existing conditions baseline and Alternative C240.

Species	Existing Conditions Baseline	Alternative C240
Crayfish	Crayfish production is greatly reduced from historical levels at sites where shortened hydroperiod and declined groundwater level decrease reproduction and growth but increase mortality of crayfish.	Extended hydroperiods will increase crayfish density in northern WCA-3A, WCA-3B, and portions of ENP, particularly within SRS.
American Alligator	Lack of water and a short hydroperiod within northern WCA-3A and NESRS are not suitable habitat for the American alligator.	Rehydration within northern WCA-3A and extended hydroperiods within NESRS increase spatial extent and quality of suitable habitat for the American alligator. Due to rehydration of previously drained areas, particularly in northern WCA-3A and northeastern ENP, implementation of Alternative C240 would greatly improve alligator habitat suitability.
Wood Stork	Support for improved ecological conditions for wood storks is hampered by short hydroperiods, shallow depths, or dense vegetation in ENP, northern WCA-3A, and WCA-3B.	Moderate beneficial effects for habitat and foraging conditions for wood storks throughout portions of the Central Everglades are expected. An analysis by the South Florida Natural Resources Center (Beerens 2013) of wood stork foraging potential indicated improved foraging conditions in northern WCA-3A, WCA-3B, and ENP due to improved fish abundance, vegetation, and hydrology.
Tricolored Heron, Little Blue Heron, and Reddish Egret	Population declines of these species are attributed to loss and degradation of suitable habitat due to short hydroperiods, shallow depths, or dense vegetation.	Extended hydroperiods in the WCAs and ENP are expected to have moderate beneficial effect on these species through improved fish abundance and altered vegetation composition or structure.
Roseate Spoonbill	Roseate spoonbills lost historical nesting ground along the southwestern coast of the Everglades in the SRS and Lostman's Slough estuaries. Since completion of the South Dade Conveyance System in 1982, altering water deliveries to Taylor Slough and northeastern Florida Bay, roseate spoonbill nesting effort has shifted to the northwestern region of Florida Bay.	A small but long-term improvement to the spatial extent of suitable nesting and foraging habitat for roseate spoonbills is anticipated due to the southern distribution and sheetflow improvements associated with Alternative C240 in the mainland estuary zones of ENP.
Snail Kite	Lack of water and undesirable vegetation within northern WCA-3A, WCA-3B, and ENP are not suitable habitat for apple snails (main prey of snail kites). Southern WCA-3A would continue to experience extended hydroperiods due to ponding along the L-67A and L-29 levees. High water levels and extended hydroperiods have resulted in vegetation shifts within WCA-3A, degrading snail kite critical habitat.	Longer hydroperiods and desirable vegetation shifts within northwestern WCA-3A are expected to increase suitable habitat for apple snails, thereby increasing spatial extent of suitable foraging opportunities for snail kites, providing a beneficial effect. Alternative C240 produces greater depths and hydroperiods in northwestern WCA-3A relative to the existing conditions baseline.

Species	Existing Conditions Baseline	Alternative C240
Cape Sable Seaside Sparrow	Disruption of the seasonal pattern of rising and falling water depths has resulted in up to 60 consecutive dry days during the CSSS nesting season (March 1 to May 15) for 3 or more consecutive years, degrading the CSSS critical habitat in wet marl prairies along the eastern and western edges of SRS and along the eastern edge of Taylor Slough in southeastern ENP.	A mixed effect for CSSS nesting and habitat conditions is expected in critical habitat areas. An overall decline on marl prairie hydrologic suitability within designated subpopulation regions could lead to long-term adverse effects on CSSS habitat suitability under Alternative C240. However, habitat improvements in adjoining areas may warrant further consideration as the Joint Ecosystem Model results illustrate the complexity of marl prairie hydrologic suitability.
Eastern Indigo Snake	High terrestrial levees along the Miami Canal have become artificial refuge for the eastern indigo snake.	Habitat loss from backfilling the Miami Canal and removal of 50% of its adjacent levees in northern WCA-3A is expected to be mitigated by the restoration of tree islands and construction of new tree islands in northern WCA-3A.
Florida Panther	High terrestrial levees along the Miami Canal have become refuge and hunting ground for the Florida panther.	Habitat loss from backfilling the Miami Canal and removal of 50% of its adjacent levees in northern WCA-3A is expected to be mitigated by the restoration of tree islands and construction of new tree islands in northern WCA-3A.
Everglades Mink	Lack of water and a short hydroperiod limit the range of Everglades mink to the shallow freshwater marshes and swamps of ENP, near Tamiami Trail. Shortened hydroperiods decrease the distribution and abundance of small fish species upon which the Everglades mink feeds.	A minor beneficial effect for habitat and foraging conditions for Everglades mink is expected because of extended hydroperiods within northern WCA-3A and ENP, particularly within marl prairies.

CSSS = Cape Sable seaside sparrow; ENP = Everglades National Park; NESRS = Northeast Shark River Slough; SRS = Shark River Slough; WCA = water conservation area.

The following subsections discuss the model output of key indicator species under the ECB and Alternative C240 in the Central Everglades (**Table 4-3**). The period of model simulation captures a range of climatic events in the Central Everglades, including the 1970-1975 droughts and the brief El Niño (wet period) in 1972. Other notable drought years captured include 1985, 1988, 1989, 1998-1999, 2001, and 2004. This simulation period also captures significant rainfall years, including 1969, 1983, 1994-1995, 1997 (the highest El Niño event on record), and the 2005 hurricane season. The population density of apple snails was simulated for 1995 to 2005 because the model was developed with daily water depth and temperature provided by the Everglades Depth Estimation Network starting in 1992. All the modeling for this technical document should be consistent with models in the PIR (USACE and SFWMD 2014) and PACR (SFWMD 2018). As such, the discussion of crayfish responses were not modeled but are based on an understanding of the ecological and environmental requirements of the species.

Table 4-3. A comparison of ecological model output and simulation period.

Section	Taxa	Model Output	Simulation Period	Representative Rainfall Year
4.3.1	Small Fish	Population density	1965 to 2005	1989 (dry), 1978 (average), 1995 (wet)
4.3.3	Alligators	Habitat suitability index	1966 to 2005	1989 (dry), 1978 (average), 1995 (wet)
4.3.4	Wading Birds	Spatial foraging condition, temporal foraging condition	1975 to 2005	Not applicable
4.3.5	Apple Snail	Population density	1995 to 2005	2004 (dry), 2000 (average), 1995 (wet)
4.3.6	Cape Sable Seaside Sparrow	Habitat suitability index	1965 to 2005	Not applicable

4.3.1 Small Fish

High densities of small fish characterized the pre-drainage Everglades ecosystem; thus, maximizing small fish densities is an objective of Everglades restoration. Because fish dominate the prey community in both biomass and abundance, they are an important energy source for higher trophic levels such as wading birds, alligators, and larger fish. Estimations of prey fish can be used as a general measure of trophic conditions in the Everglades.

The density of small (i.e., <8 centimeters) freshwater fish is assessed primarily for livebearers and killifishes using a statistical relationship between hydrologic parameters and the small fish monitoring data collected from 1996 through 2006 within WCA-3A, WCA-3B, SRS, and Taylor Slough (Trexler and Goss 2009, Donalson et al. 2010). Under the ECB, projected densities range from 12 to 17 fish per square meter in the central and southern portions of WCA-3A and WCA-3B, while densities are less than 8 fish per square meter in ENP during an average rainfall year (**Figure 4-40a**). Implementation of Alternative C240 is expected to have a negligible effect on small fish species throughout much of the Central Everglades (**Figure 4-40b**). However, in northern WCA-3A and SRS, small fish densities increase 78% to 100% and 10% to 78%, respectively, under Alternative C240 due to enhanced overland flows and fewer drydown events (**Figure 4-40c**). The average of daily percent differences in small fish density for the entire model domain increases approximately 68%, 186%, and 29% during an average rainfall (1978), a dry (1989), and a wet (1995) year, respectively (**Figure 4-40c**,**d**,**e**), providing the benefit of enhanced prey density for higher trophic level predators, such as wading birds. For all years of the model simulation period (1965 to 2005), implementation of Alternative C240 increased small fish density by approximately 130% compared to the ECB. Introduction or expansion of non-native fish species due to changes in water distribution is not likely to occur; however, the extent of invasion is uncertain at this time.

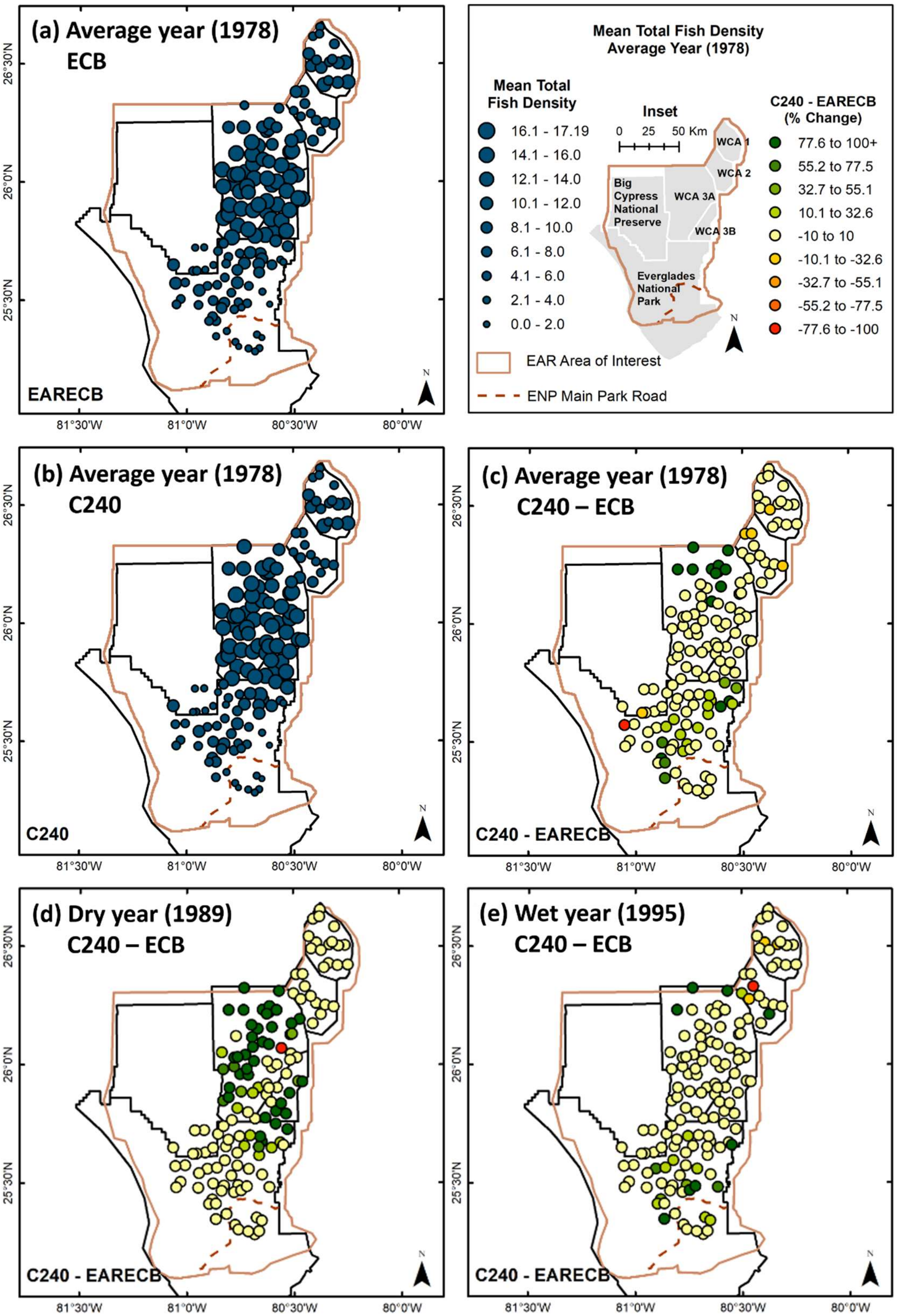

Figure 4-40. Mean total fish density is presented for (a) the existing condition baseline and (b) Alternative C240, and (c) percent differences between Alternative C240 and the existing conditions baseline for an average rainfall year. Only percent differences between the models are presented for (d) a dry year and (e) a wet year.

4.3.2 Crayfish

Everglades crayfish (*Procambarus alleni*) and slough crayfish (*Procambarus fallax*) are critically important components of the Everglades food web, serving as primary dietary components of higher trophic level species, including fish, amphibians, alligators, wading birds, and mammals such as raccoons and river otters (Kushlan and Kushlan 1979). White ibis depend heavily on crayfish species during nesting; therefore, the production and availability of crayfish are important components for white ibis recovery (Dorn et al. 2011).

Crayfish species composition and abundance within the Central Everglades are linked to hydroperiod and ponding depth (Acosta and Perry 2001), with both species being most abundant in marshes that dry seasonally. The Everglades crayfish commonly is found in marshes with a hydroperiod of 7 to 9 months, while the slough crayfish prefers marshes with slightly longer hydroperiods of 10 to 11 months but also is found in perennially flooded habitats. Populations of both species are strongly limited by predatory fishes and can exhibit significant population growth after periodic dry disturbances (Dorn and Cook 2015).

Because the Joint Ecosystem Model Program does not have a crayfish model, crayfish responses to hydrologic improvements presented herein are based on hydrological evaluations (**Table 4-1**) and an understanding of the environmental ecology requirements of the species. Even slight increases in hydroperiods in sloughs with shallow to moderate water depths and occasional dry conditions associated with Alternative C240 likely would increase slough crayfish production within the over-drained northern WCA-3A and eastern WCA-3B. Everglades crayfish production would increase if hydroperiods within ENP marl prairie were extended by 3 to 4 months (Acosta and Perry 2002). However, Alternative C240 would not extend hydroperiods by this duration; therefore, Everglades crayfish population growth would remain limited by short hydroperiods. Slight declines in hydroperiod under Alternative C240 would further limit Everglades crayfish production in western marl prairies near the S-12 structures. Also, Alternative C240 likely would have a negligible effect on crayfish production in the southern Big Cypress National Preserve based on hydrological evaluations. It has become evident in recent years that the western marl prairies are disproportionally important for wading bird foraging (Cook and Baranski 2019, Cocoves et al. in review) and might be critical for supporting coastal supercolonies, a major CERP objective; however, Alternative C240 will provide no improvement in this respect. Therefore, the overall effect of Alternative C240 on crayfish production, when comparing the combined spatial region, appears marginally positive.

4.3.3 Alligators

A keystone species in the Everglades ecosystem, the American alligator (*Alligator mississippiensis*) depends on spatial and temporal patterns of water fluctuations that affect courtship and mating, nesting, and habitat use (Brandt and Mazzotti 2000). Historically, American alligators were most abundant in peripheral Everglades marshes and freshwater mangrove habitats but are now most abundant in canals and the deeper slough habitats of the Central Everglades. Water management practices, including drainage of peripheral wetlands and elevated salinity in mangrove wetlands as a result of decreased freshwater flows, have limited occurrence of alligators in these habitats (Craighead 1968, Kushlan 1990, Mazzotti and Brandt 1994).

A habitat suitability index developed by RECOVER for the American alligator (Shinde et al. 2014) can predict the potential effects of Alternative C240 and the ECB (**Figure 4-41**). The habitat suitability index measures habitat suitability annually for five components of alligator production: 1) land cover suitability, 2) breeding potential (female growth and survival from April 16 of the previous year to April 15 of the current year), 3) courtship and mating (April 16 to May 31), 4) nest building (June 15 to July 15), and 5) egg incubation (nest flooding from July 1 to September 15) (South Florida Natural Resources Conservation Center 2013). The results show that alligator habitats are limited to the relatively wet areas of central and southern WCA-3A, WCA-3B, NESRS, and coastal areas of ENP under the ECB (**Figure 4-41a**), while the habitat suitability scores notably increase in northern WCA-3A and NESRS under Alternative C240 (**Figure 4-41b**).

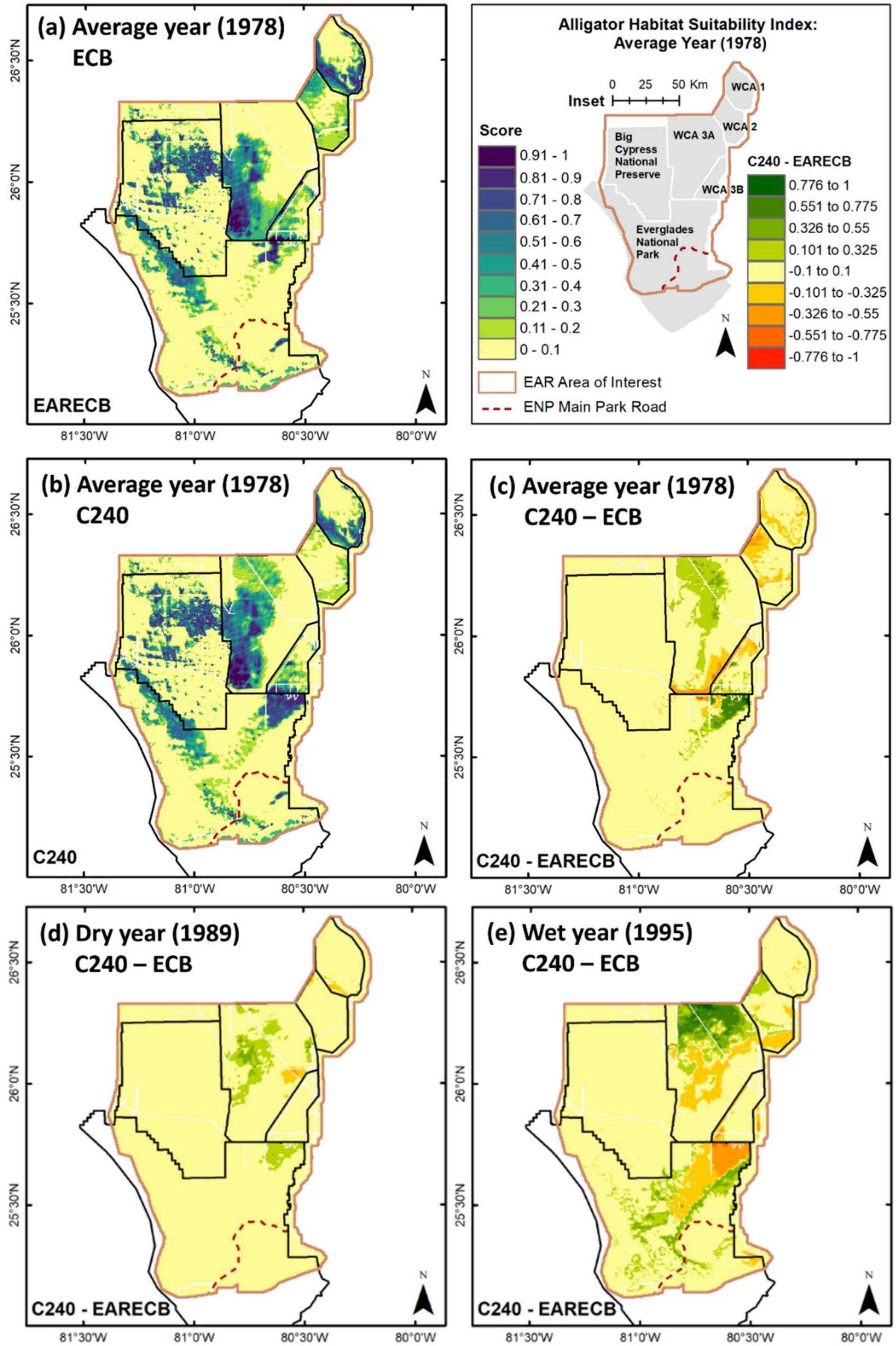

Figure 4-41. Habitat suitability index score for (a) the existing condition baseline and (b) Alternative C240, and (c) habitat suitability index differences between Alternative C240 and the existing conditions baseline for an average rainfall year. Only differences in the habitat suitability index between the models are presented for (d) a dry year and (e) a wet year.

Comparison between the models shows the lift (Alternative C240 minus ECB > 0) of an index of alligator growth and survival at sites in northern and central WCA-3A and NESRS during an average rainfall year (**Figure 4-41c**). The average of percent differences in the habitat suitability index for the entire model domain increases approximately 6%, 18%, and 7% during an average rainfall (1978), a dry (1989), and a wet (1995) year, respectively (**Figure 4-41c**,**d**,**e**), providing a moderate benefit during dry conditions. This habitat suitability index captures spatial shifts. It increases in 197,407 acres (308 square miles) but also decreases in 138,616 acres (217 square miles) during an average rainfall year (1978), resulting in a net increase of habitat suitability in 58,791 acres (91 square miles). For all years in the model simulation period (1966 to 2005), Alternative C240 increased habitat suitability by 20% compared to the ECB, indicating an overall benefit to alligator production.

The decline of habitat suitability for an average rainfall year with Alternative C240 occurs in portions of northern WCA-3B and southeastern WCA-3A against the L-67A and L-29 levees (**Figure 4-41c**) due to decreases in ponding depth and hydroperiod. The reduced inflows from WCA-3A (**Figure 4-12**) decrease ponding depths and hydroperiods in northern WCA-3B (**Figure 4-13**). Enhanced continuous sheetflow from WCA-3A through WCA-3B as a result of Blue Shanty Flow-way operation also shortens hydroperiods in southeastern WCA-3A (**Figure 4-2**). For a wet hydrologic year (e.g., 1995), large areas of central WCA-3A and SRS become too wet for alligator breeding and nesting, reducing alligator habitat suitability for Alternative C240 compared to the ECB (**Figure 4-41e**). However, American alligators are mobile and will move in response to unfavorable high-water conditions from flooded habitats to open-water/slough and wet prairies due to the enhanced hydrologic connectivity. Therefore, hydroperiod improvements within WCA-3A and ENP are expected to have a very valuable and long-term benefit on the spatial extent and quality of suitable habitat for the American alligator.

4.3.4 Wading Birds (White Ibis, Wood Stork, and Great Egret)

Historically, the short hydroperiod wetlands within ENP have been important for wading bird foraging during the early breeding season, with birds shifting to longer hydroperiod wetlands as the dry season progresses. Hydrological patterns that produce a maximum number of patches with high prey availability (i.e., high water levels at the end of the wet season and low water levels at the end of the dry season) are necessary for high reproductive outputs for wood storks and other wading birds (Gawlik 2002, Gawlik et al. 2004, Boyle et al. 2014). Therefore, restoration of sheetflow and historical hydropatterns would provide long-term improvement to wetland habitats (elevation and microtopography) that would support prey densities conducive to successful wading bird foraging and nesting.

The Wader Distribution Evaluation Model (Beerens et al. 2015), a tool to predict how white ibis (*Eudocimus albus*), wood stork (*Mycteria americana*), and great egret (*Ardea alba*) distributions respond to prey resources linked to hydrologic variables, was used to evaluate and predict changes to wading bird foraging habitat in the Central Everglades. The model determines spatially explicit changes in foraging conditions for wading birds relative to baseline scenarios from bird and hydrological data collected during surveys between 2000 and 2009. Using a multi-model approach, a wading bird foraging index was produced from a spatial foraging conditions (SFC) model and a temporal foraging conditions (TFC) model. The SFC model predicts wading bird patch abundance over time at a fixed spatial scale (400 m), while the TFC model predicts daily abundance across space (patch quality). The resulting indices represent proxies for different components of patch dynamics: patch abundance (i.e., the spatial area of suitable foraging patch) is reflected by the SFC model, and patch quality (i.e., temporally in terms of how many birds use a patch) within suitable foraging depths (e.g., white ibis: -4.9 to +32 centimeters, wood stork: -8.7 to +45 centimeters, great egret: -1.7 to +41 centimeters) is reflected by the TFC model. The product of these two indices (i.e., SFC × TFC) is a foraging index to account for both processes.

The results show that areas with high abundance of foraging patches are limited to the relatively wet areas in central and southern WCA-3A, WCA-3B, SRS, and coastal ENP under the ECB for both the white ibis (**Figure 4-42a**) and wood stork (**Figure 4-43a**). In contrast, the abundance of foraging patches is lower in areas with conditions that are too dry (northern WCA-3A and the eastern boundary of the ENP for both the white ibis and wood stork) or too wet (eastern WCA-3A along the L-67A Canal for the wood stork). The perpetually drier areas make tree islands, which are used by large numbers of wading birds for nesting, extremely vulnerable to fires and nesting predation. For example, the Alley North colony in northeastern WCA-3A (proximate to indicator region 118; **Figure 4-29**) is one of the largest nesting aggregations of wading birds in North America, capable of supporting more than 50,000 nests when hydrologic conditions are appropriate. However, under the ECB, the area is prone to drying early in the nesting season, which can reduce the colony's attractiveness to nesting birds, allow mammalian predators (i.e., raccoons) access to the colony, and cause large-scale nest abandonment. Relatively wet conditions are good for wading bird foraging and nesting because they would restore spatial extent of ridges and sloughs and could improve the health of tree islands in the ridge and slough landscape. However, increasing flooding also may create more frequent water level reversals during critical wading bird foraging periods, causing declines in nesting success for wading birds.

Implementation of Alternative C240 would provide long-term, improved foraging conditions for wading birds in northern WCA-3A, southeastern WCA-3B, and northeastern ENP, particularly in NESRS (**Figures 4-42c** and **4-43c**), due to improved hydrology, prey abundance, and changes to vegetation structure. Under Alternative C240, abundance of white ibis foraging patches (i.e., SFC) in March and April from 1975 to 2005 increases in approximately 264,000 acres (413 square miles) of northern WCA-3A and NESRS but decreases in 70,000 acres (109 square miles) of eastern WCA-3A against the L-67A levee compared to the ECB (**Figure 4-42c**). The abundance of wood stork foraging patches for the same period increases in approximately 297,000 acres (464 square miles) of northern WCA-3A, NESRS, and southeastern WCA3B but decreases in 135,000 acres (211 square miles) of southeastern WCA-3A (**Figure 4-43c**). Increased use of southeastern WCA-3B by wood storks and the eastern marl prairies by both white ibis and wood storks appears to be associated with increased hydroperiods (**Figures 4-38** and **4-19**). However, the predicted declines in eastern WCA-3A against the L-67A levee do not make intuitive sense given what is known of wading bird foraging ecology. Specifically, the predicted decline in hydroperiods in the ponded areas of eastern WCA-3A under Alternative C240 (**Figure 4-9**) would be expected to improve foraging patches for wading birds, yet the model forecasts a 10% to 32% decrease in foraging patch abundance. This might be because the hydrologic conditions and wading bird distributions that were used to create the model (from 2000 to 2009 surveys) did not include some of the unique conditions expected with restoration, such as areas with relatively long hydroperiods (greater prey production) that also have relatively shallow depths (increased prey availability). Between 2000 and 2009, these two conditions did not exist together; thus, the benefits of such conditions to foraging birds might not be recognized in the current model output.

Over the entire simulation period (1975 to 2005), implementation of Alternative C240 increased the quality of white ibis foraging patches (TFC) by 3.5% but decreased wood stork foraging indices (SFC × TFC) by 2.1% compared to the ECB. The quality of great egret foraging patches (TFC) decreased 1.1% for Alternative C240 compared to the ECB. These results suggest implementation of Alternative C240 will have a negligible effect on foraging patch quality throughout much of the Central Everglades.

A key CERP goal is to re-establish historical wading bird foraging and colonial nesting habitats in the mainland estuary zones of ENP. An evaluation of hydropatterns during the 2018 nesting season suggests that dry marl prairies during the previous dry season preceding extended flooding during the early dry season resulted in early nesting, extended periods of optimal foraging conditions, and formation of large colonies in coastal areas (Cook and Baranski 2019). While redirected and enhanced inflows to NESRS from the Blue Shanty Flow-way would help improve habitat suitability for CSSS in the western marl prairie, the same change in timing and magnitude of inundation and recession likely would further limit prey availability for wading birds in this critical area (**Figure 4-40c**). An expected outcome of Alternative C240 is to slightly decrease hydroperiods and provide a slight negative effect on wading birds in the western prairies (**Figures 4-42c** and **4-43c**). As such, Alternative C240 alone will not provide the hydrologic and foraging conditions needed to recover historical coastal populations of wading birds.

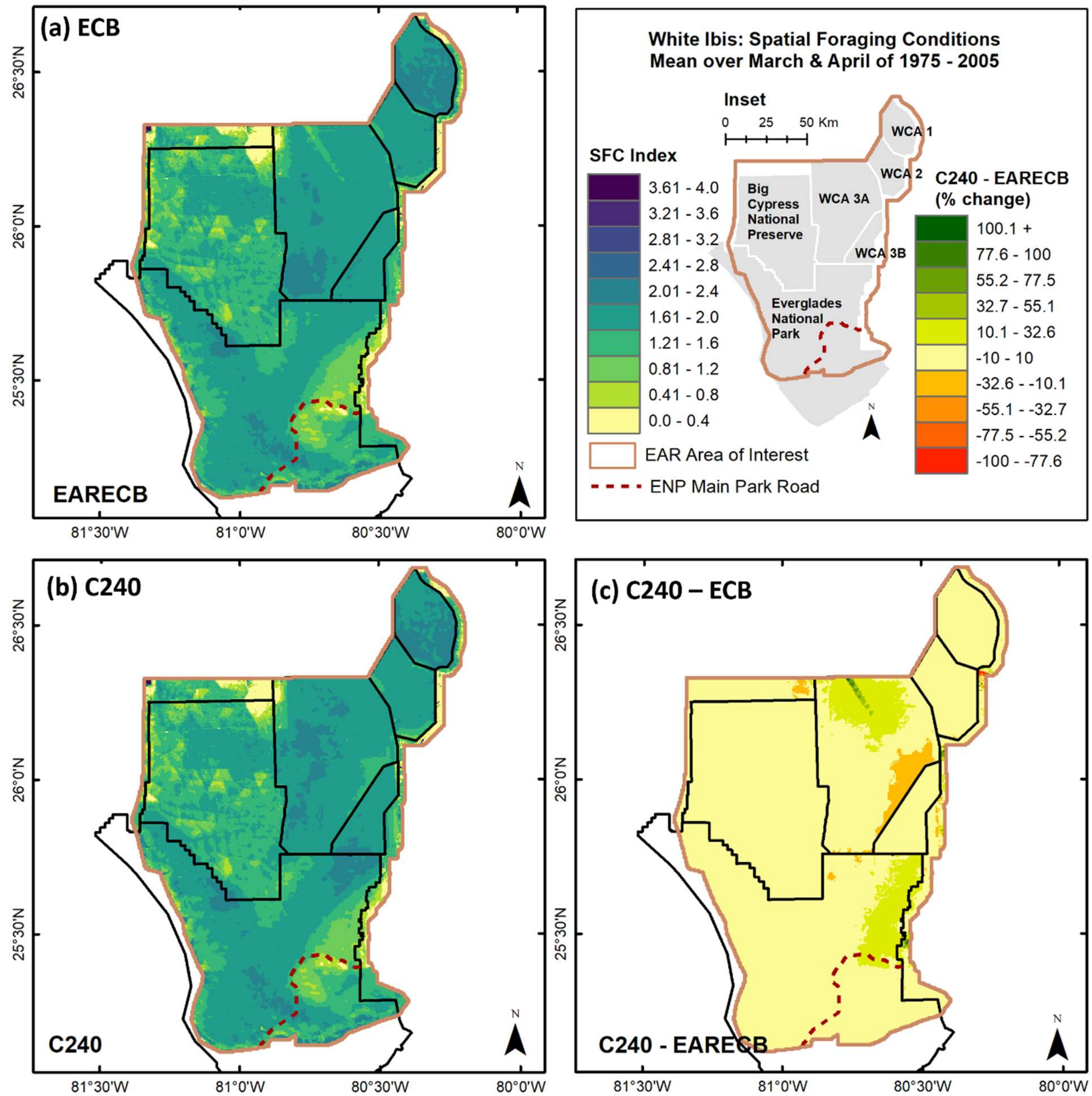

Figure 4-42. White ibis spatial foraging conditions is presented for (a) the existing condition baseline and (b) Alternative C240, and (c) percent differences in spatial foraging conditions indices between Alternative C240 and the existing conditions baseline in March and April from 1975 to 2005.

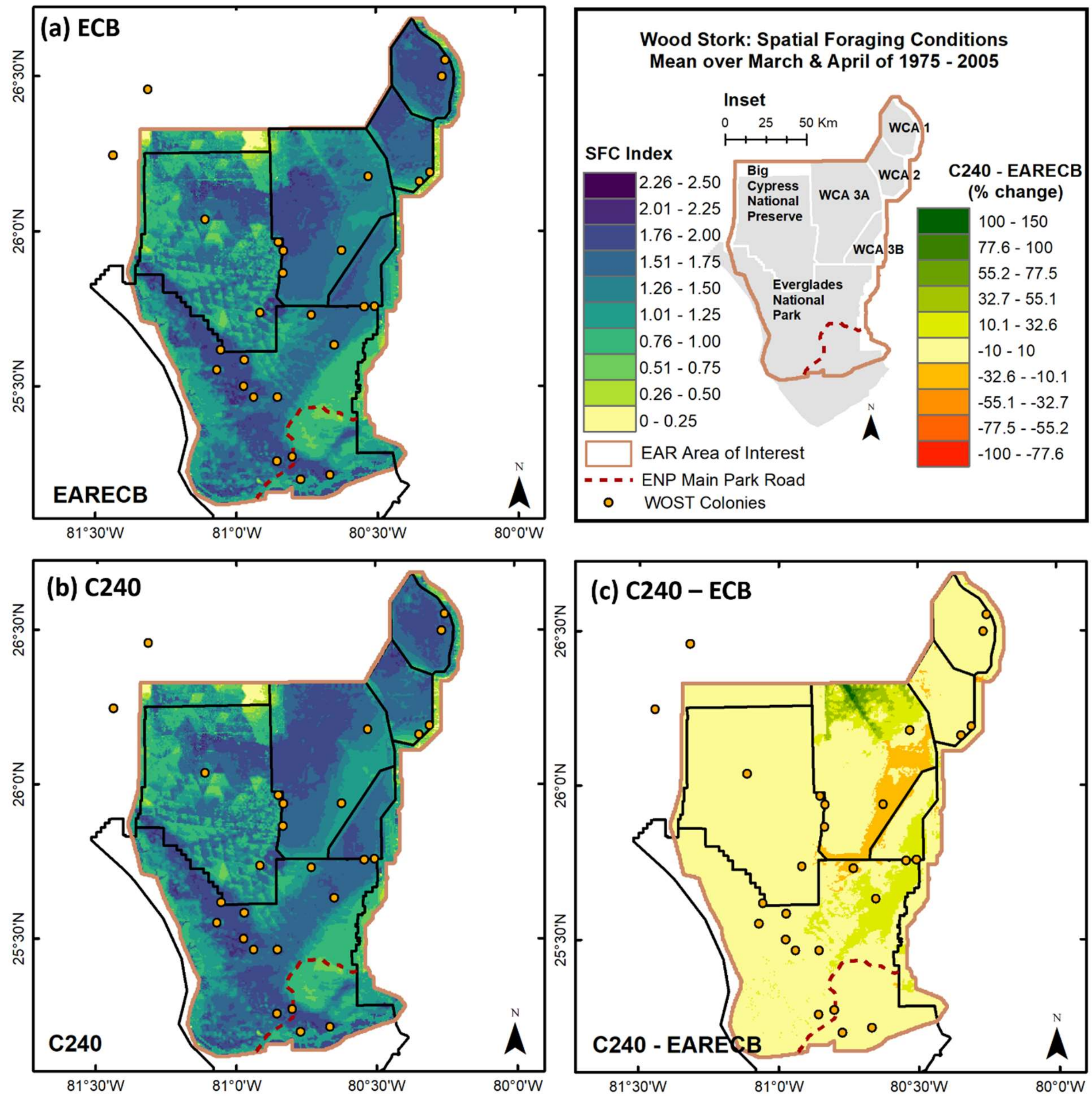

Figure 4-43. Wood stork spatial foraging conditions for (a) the existing condition baseline and (b) Alternative C240, and (c) percent differences in spatial foraging conditions indices between Alternative C240 and the existing conditions baseline in March and April from 1975 to 2005.

4.3.5 Apple Snail

The snail kite (*Rostrhamus sociabilis*) has a highly specialized diet composed almost entirely of apple snails (*Pomacea paludosa*), which are found in palustrine, emergent, long-hydroperiod wetlands. As a result, the snail kite's survival directly depends on the hydrology and water quality of its habitat (United States Fish and Wildlife Service 1999). Suitable foraging habitat for the snail kite typically is a combination of low-profile marsh and shallow open water clear enough to visually search for apple snails. Areas of sparse emergent vegetation enable apple snails to climb near the surface to feed, breathe, and lay eggs, while also making them easily seen from the air by foraging snail kites.

The purpose of the apple snail population model is to describe the dynamics of the apple snail population as a function of hydrology and temperature (Darby et al. 2015). The abundance and size distribution of snails are simulated and can be calculated for any day with input data. Adult snail population size during a given year is a product of egg production, and thus environmental conditions, from the previous year. The model was developed using the Everglades Depth Estimation Network and outputs begin in 1992. Results are shown for adult snails (larger than 20 millimeters) in 160,000 m^2 cells (400-m × 400-m model grid) during the spring (April 20), before that year's reproductive period (**Figure 4-44**). End of spring results are shown because that is the population of snails of the size class consumed by the endangered snail kite.

The results show that areas with high apple snail densities (0.56 to 0.87 snails per square meter) are limited to relatively wet areas in central and southern WCA-3A, WCA-3B, NESRS, and coastal ENP under the ECB (**Figure 4-44a**). In contrast, apple snails are virtually absent (fewer than 0.09 snails per square) in areas with conditions that are too dry (northern WCA-3A and marl prairies in ENP) or too deep (eastern WCA-3A along the L-67A Canal) , as approximately 0.2 snails per square meter are necessary to support snail kite foraging (Darby et al. 2012). Estimates of apple snail densities can be linked to local abundance of snail kite nests within a 2-kilometer radius from the sampling site (Cattau et al. 2014), and according to modeling, the relative wet areas can support approximately 9 to 12 snail kite nests.

Rehydration and vegetation shifts within northwestern WCA-3A and marl prairies in ENP, combined with decreases in the frequency and duration of extremely low water stages in these areas, are expected to increase the abundance of adult apple snails under Alternative C240 compared to the ECB (**Figure 4-44c**). Comparison between the models shows the lift (Alternative C240 minus ECB > 0) of apple snail densities at sites in northern and central WCA-3A, SRS, and coastal areas during an average rainfall year (**Figure 4-44c**). The models indicate that as apple snail densities increase by 0.69 to 0.78 snails per square meter, the probability of local abundance of snail kite nests increases by a factor of approximately 2.5 (Cattau et al. 2014). In contrast, a decline of apple snail densities in the deeper-water edges within eastern WCA-3A appears to be caused by increases in average ponding depth by approximately 0.2 ft (**Figures 4-9** and **4-10**). The average of the percent differences in apple snail density for the entire model domain increases approximately 47%, 61%, and 19% during an average rainfall (2000), a dry (2004), and a wet (1995) year, respectively (**Figure 4-44c**,**d**,**e**), providing a moderate benefit during dry conditions. On average, apple snail densities increase in approximately 471,000 acres (735 square miles) but decrease in 153,000 acres (239 square miles) during dry and wet years, resulting in a net increase of apple snail densities in 318,000 acres (496 square miles) of the Central Everglades. For all years of the model simulation period (1995 to 2005), implementation of Alternative C240 increased apple snail population density by 41% compared to the ECB, thereby increasing the spatial extent of suitable foraging opportunities and enhanced prey density for snail kites.

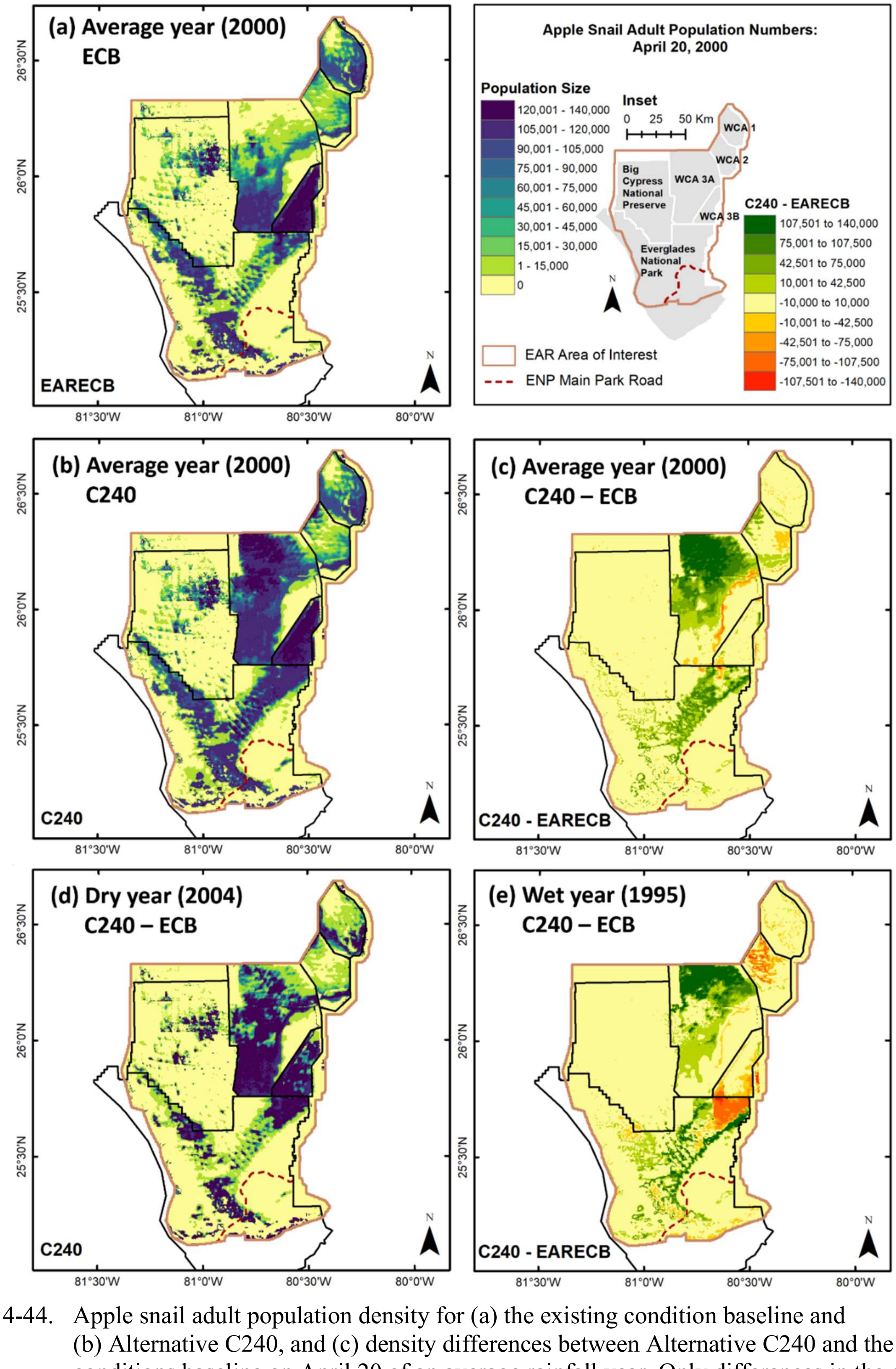

Figure 4-44. Apple snail adult population density for (a) the existing condition baseline and (b) Alternative C240, and (c) density differences between Alternative C240 and the existing conditions baseline on April 20 of an average rainfall year. Only differences in the densities between the models are presented for (d) a dry year and (e) a wet year.

4.3.6. Cape Sable Seaside Sparrow

Presently, the known distribution of the CSSS is restricted to two areas of marl prairies east and west of SRS within ENP and Big Cypress National Preserve and the edge of Taylor Slough in the Southern Glades Wildlife and Environmental Area in Miami-Dade County. CSSS surveys resulted in a range map that divided the CSSS into six separate subpopulations (A through F; **Figure 4-45a**), with Subpopulation A as the only subpopulation west of SRS (Curnutt et al. 1998).

The CSSS builds nests low to the ground, 14 to 17 centimeters above the substrate. Male CSSS call for mates and set up territories when water levels drop below ground surface. Breeding behavior can be interrupted when water levels rise above ground surface. Therefore, it is important to maintain water levels below ground surface for at least 60 days during CSSS nesting season (March 1 to July 15). To compare Alternative C240 to the ECB, a habitat suitability index for marl prairie was used. The CSSS marl prairie model is a temporally and spatially explicit ecological planning tool that simulates hydrologic suitability of marl prairie habitats based on CSSS survey presence data threshold ranges (Pearlstine et al. 2016). The CSSS marl prairie model evaluates hydrologic suitability with four metrics: 1) average wet season (June to October) water depths, 2) dry season (November to May) water depths, 3) discontinuous annual hydroperiod (May to April of the following year), and 4) maximum continuous dry days during the nesting season (March 1 to July 15). Output is provided as a percent-to-target met by the hydrologic scenario.

When comparing Alternative C240 with the ECB, there are negligible changes (±10 differences in habitat suitability index) within 68% of critical CSSS habitat areas. Improvements to marl prairie hydrologic suitability are found within Subpopulations A, northern AX, B, C, and F, where habitat suitability scores increase in 17,969 acres (28 square miles) (**Figure 4-45c**). Enhanced inflows into SRS will alleviate some of the problems associated with extremely dry conditions in the eastern boundary of the Everglades (e.g., drought, fire, invasion of woody plants) and promote a shift in vegetation communities to marl prairies by increasing hydroperiods (**Figure 4-19**). In contrast, the lift in northern Subpopulations A and AX within the western counterparts is caused by decreases in hydroperiod under Alternative C240 compared to the ECB (**Figures 4-21** and **4-22**), which would reduce the potential for water level reversals drowning CSSS nests. Enhanced inflows into SRS also would reduce the extent of shallow-water edge in areas adjacent to SRS. Moderate declines in hydrologic suitability would occur along the shallow regions of southern Subpopulations AX and E that abut SRS, where habitat suitability scores decrease in 37,695 acres (58 square miles) under Alternative C240 compared to the ECB (**Figure 4-45c**).

The increased distances between Subpopulation A and other eastern subpopulations might be a problem given the limited dispersal capacity of the CSSS (Van Houtan et al. 2010). Some loss in habitat quality will occur west of Subpopulations E and F, which will increase the isolation of Subpopulation A. This effect likely is negligible, however, because there already appears to be little migration between the eastern and western marl prairies. Therefore, the overall negative impact on marl prairie hydrologic suitability from Alternative C240 relative to the ECB of the combined spatial regions within designated CSSS subpopulations appears relatively minor (19,726 acres [30 square miles]). Hydrologic suitability for marl prairie and the CSSS also expands along the expanded hydrologic fronts to the East in the eastern prairies and to the North in the western prairies. Therefore, habitat improvements in adjoining areas will result in overall positive effects on CSSS habitat suitability.

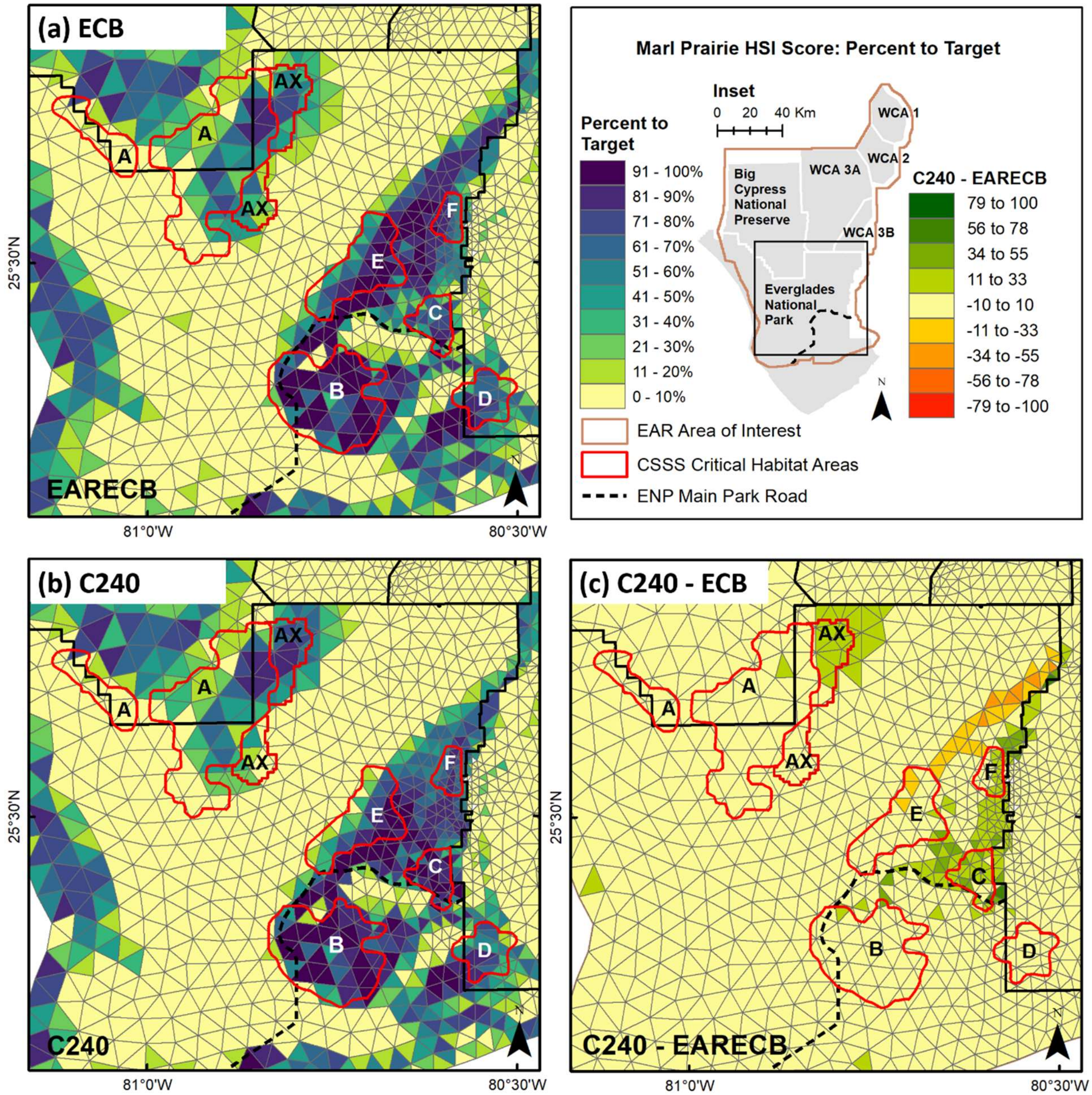

Figure 4-45. Marl prairie habitats and locations of the Cape Sable seaside sparrow subpopulations (A, AX, B, C, D, E, and F). The habitat suitability index score, expressed as percent to target, is presented for (a) the existing conditions baseline, (b) Alternative C240, and (c) raw habitat suitability index differences between the existing conditions baseline and Alternative C240.

4.3.7. Ecologic Summary

Additional water flowing into northern WCA-3A from the EAA Reservoir would help restore aquatic habitat for fish and wildlife, while improving natural processes critical for the development of peat soils and tree islands. Improved overland flows into northern ENP and related patterns of increased water depths and shorter drydowns would help restore a historically deepwater habitat such as SRS. Expansion of wet prairies along the eastern boundary of ENP would reduce the potential for high-intensity fires and exotic tree invasion while promoting hydrologic and ecologic connectivity. Thus, due to changes in quantity, distribution, and timing of water entering the Central Everglades, long-term improvements to wetland hydrology and desirable vegetation shifts would improve essential habitat for Everglades fish and wildlife populations.

Depending on elevation and microtopography, enhanced sheetflow would produce a variety of wetland habitats capable of supporting prey densities conducive to successful foraging and nesting of large predators. Aquatic invertebrates, such as apple snails and crayfish, would rapidly colonize newly rehydrated areas under Alternative C240, providing minor to moderate beneficial effects within northern WCA-3A and NESRS. Similarly, moderate percentage gains in fish density are expected to occur within northern WCA-3A and NESRS due to rehydration. Other areas within and adjacent to SRS also are expected to experience appreciable gains in apple snail and fish density due to extended hydroperiods. Increases in stages and hydroperiods in rehydrated areas would facilitate transition from upland to wetland vegetation through contraction of sawgrass marshes and expansion of wet prairies and, in deeper regions, to sloughs. Submerged aquatic plants are associated with sloughs and provide structure for growth of periphyton, a primary energy source of invertebrates and small fishes.

The EAA Reservoir, will provide long-term beneficial effects to wetland vegetation communities and perform well overall for higher trophic level species. Extended hydroperiods are good for foraging and nesting of wading birds and alligators because they would restore the spatial extent of ridges and sloughs, increasing the abundance of suitable habitat. In addition, an increase in density of important prey populations will directly benefit wading birds and alligators. Negative responses in foraging condition (wading birds) and habitat suitability (alligators) were found in southeastern WCA-3A because of shortened hydroperiods. However, the negative impact on foraging and habitat conditions from Alternative C240 relative to the ECB of the combined spatial regions appears relatively small compared to the net overall benefits, particularly in northern WCA-3A and SRS. Improved water depth and sheetflow distribution also will enhance habitat connectivity of highly mobile species that can avoid unfavorable conditions. Therefore, hydroperiod improvements in over-drained portions of WCA-3A, ENP, and adjoining shallow-water areas are expected to provide long-term benefit to the spatial extent of suitable foraging and nesting habitat for higher trophic level species.

5 IDENTIFICATION OF WATER TO BE RESERVED

5.1 Water Made Available by the Project

A component of establishing a Water Reservation pursuant to Section 373.223(4), F.S., is the identification of locations and seasonal quantities of water, which in the judgment of the applicable water management district governing board, may be required for the protection of fish and wildlife or public health and safety. Rules that withhold such waters from allocation are drafted when there is a reasonable expectation that demands for waters from the identified source(s) will occur at a time of year and in an amount, singularly or cumulatively, to reduce the availability of water needed for the protection of fish and wildlife. This section identifies the water associated with the EAA Reservoir project that is needed for the protection of fish and wildlife.

The CEPP EAA Reservoir Water Reservation will reserve from allocation all surface water released, via operation, from the EAA Reservoir that is directed to the Lower East Coast Everglades waterbodies through the S-624, S-625, and S-626 structures for the protection of fish and wildlife. State regulatory rules allow for Water Reservations to be adopted prospectively for water anticipated to be made available from a project to be constructed in the future. The water to be reserved prospectively for the EAA Reservoir is consistent with the fish and wildlife benefits outlined in **Chapter 4**, the PIR (USACE and SFWMD 2014), the PACR (SFWMD 2018), and the USACE (2020) Final Environmental Impact Statement. Protection of project waters under state regulatory authority is a prerequisite of a Project Partnership Agreement, which is needed for authorization and appropriation of a CERP project component.

5.1.1 Water Stored Within the Reservoir and Conveyed to the Natural System

The major facilities contained in the PACR consist of the EAA Reservoir and A-2 STA (**Figure 5-1**). Total reservoir storage capacity is approximately 240,000 ac-ft. The PACR provides an increase of approximately 370,000 ac-ft in average annual flow to the Central Everglades, which exceeds the CERP goal of 300,000 ac-ft. The EAA Reservoir and A-2 STA will be located north of the Holey Land Wildlife Management Area and west of the A-1 FEB. The EAA Reservoir has a project footprint of approximately 10,500 acres and the A-2 STA will cover 6,500 acres to the west, abutting the Miami Canal. Average ground elevation is approximately 10.0 ft NGVD29, and the maximum operational depth for the reservoir is 22.6 ft. The purpose of the EAA Reservoir is to capture EAA runoff and regulatory releases from Lake Okeechobee for delivery to the Central Everglades (WCA-3A, WCA-3B, and ENP), while maintaining the pre-project capability to provide flood control and water quality treatment for existing EAA basin runoff and a portion of Lake Okeechobee regulatory releases. The EAA Reservoir also enhances regional water supplies, which increases the water available to meet environmental needs. During the preconstruction engineering, and design phase, the EAA Reservoir components will be assessed in further detail (as described in Appendix A, Section A.10.1.5 of the PACR [SFWMD 2018]).

Additional "new" water provided by the PACR will not be available until the facility is constructed and operational. Operation of the EAA Reservoir will improve the quantity, timing, and distribution of environmental water deliveries to WCA-3A, WCA-3B, and ENP during the wet and dry seasons. Operational changes to deliver this new water would be conducted in a manner consistent with stage, volume, and/or flow-based restoration targets by treating and delivering water from Lake Okeechobee, water detained by PACR components, or a combination of both and by providing temporary storage for releases from Lake Okeechobee to reduce the harmful effects of flood control releases on the Caloosahatchee River and St. Lucie estuaries.

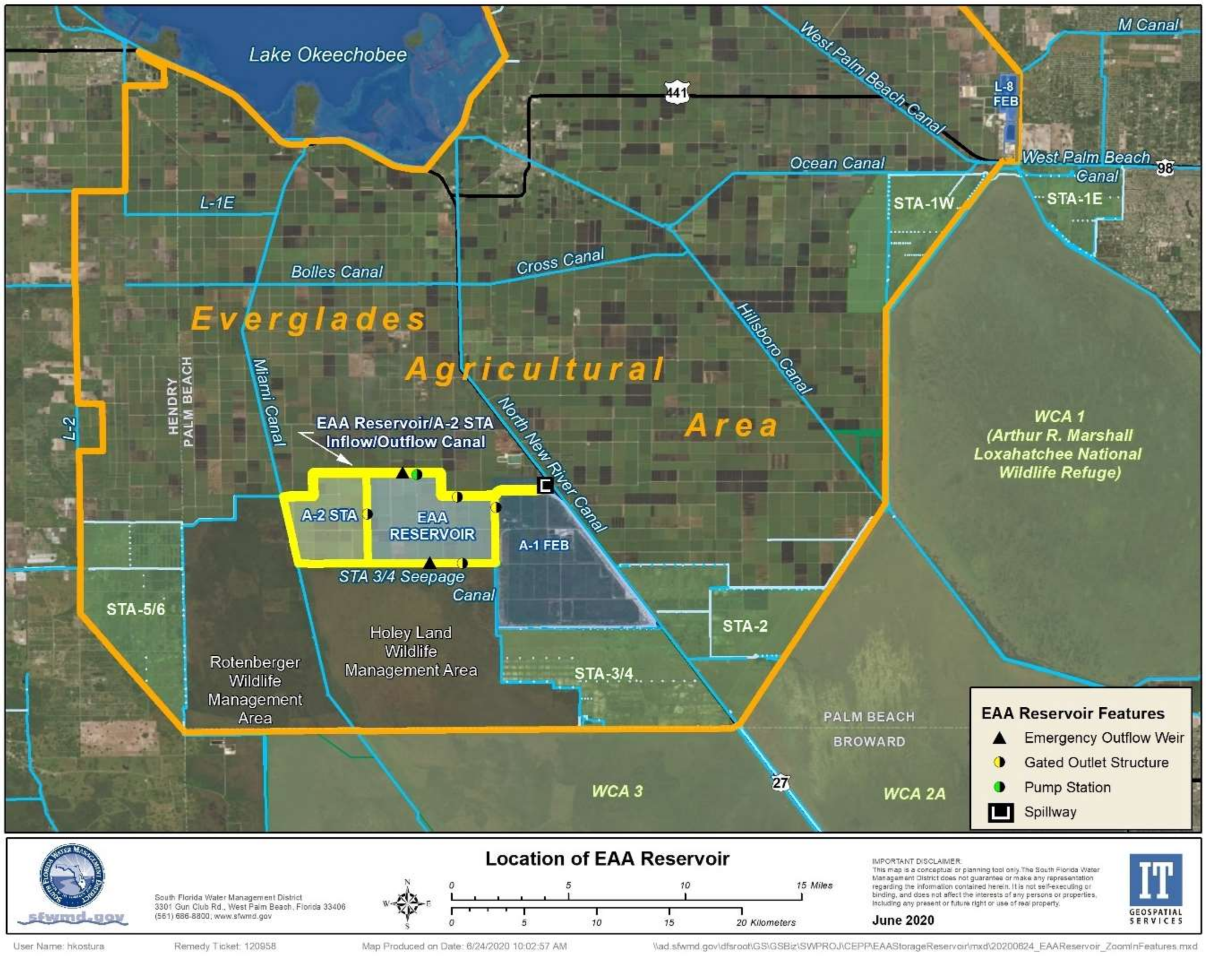

Figure 5-1. Proposed location of the Everglades Agricultural Area Reservoir and A-2 Stormwater Treatment Area as well as existing adjacent facilities.

To identify the quantity, timing, and distribution of water for the natural system, a probabilistic approach was selected during the PIR planning process. This approach used a volume probability curve based on the period of record (1965 to 2005). With the Alternative C240 model simulation, a volume probability curve of the EAA Reservoir (**Figure 5-2**) shows the annual outflow volumes from the reservoir through the S-624, S-625, and S-626 structures are directed to the EAA A-2 STA, STA-2, STA-3/4, or A-1 FEB, then discharged to the Lower East Coast Everglades waterbodies. Model simulations of the EAA Reservoir, together with existing and planned infrastructure, indicate the EAA Reservoir could convey 825,000 ac-ft of surface water, on an average annual basis, to the existing STAs, EAA A-2 STA, and A-1 FEB.

The EAA Reservoir provides an additional 240,000 ac-ft of effective detention volume to attenuate EAA basin runoff and Lake Okeechobee regulatory releases, rather than sending the water to the WCAs when they are not ready to receive additional water. As a general operational strategy, the EAA Reservoir would be operated to attenuate flows during the wet season and carry over water into the dry season when releases to the WCAs would be beneficial or cause less harm. The full suite of environmental benefits to downstream fish and wildlife occurs when the EAA Reservoir is filled and emptied multiple times throughout the year. Periodically, water from the EAA Reservoir may be released from the S-628 structure to the EAA via the inflow-outflow canal to the Miami Canal and North New River Canal. This water is not reserved for fish and wildlife.

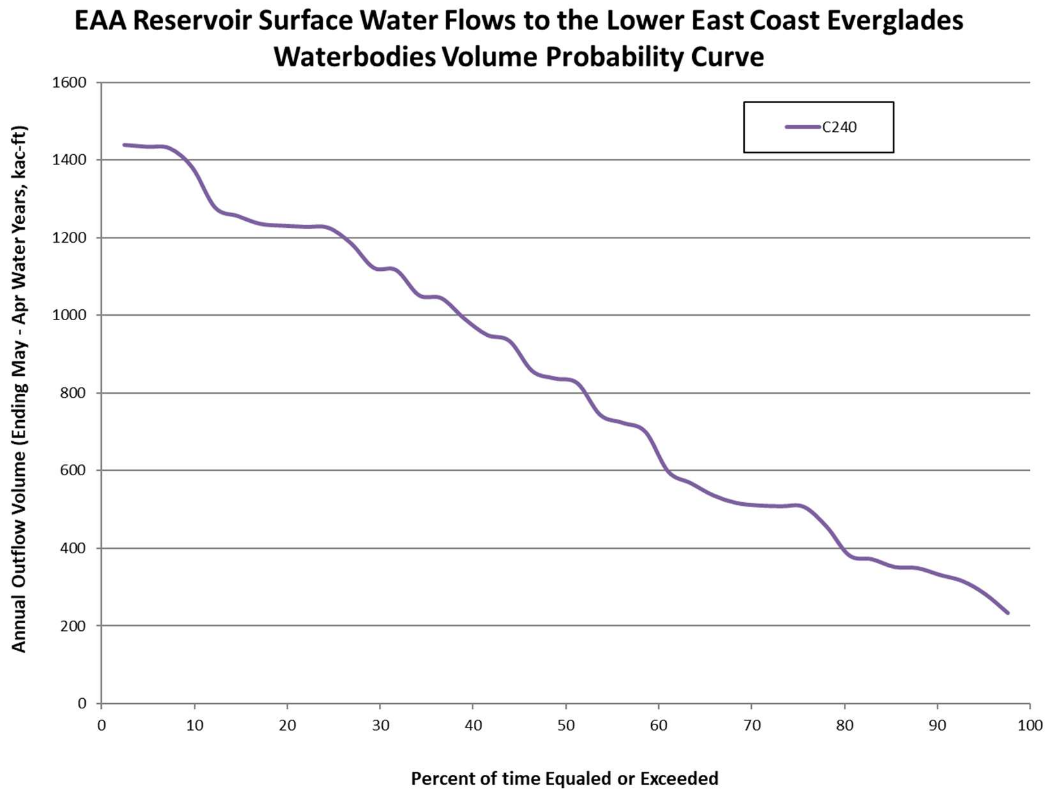

Figure 5-2. Everglades Agricultural Area Reservoir outflow volume probability curve through Structures S-624, S-625, and S-626 from the Alternative C240 model simulation.

The operational strategies are intended to meet the goals, purposes, and benefits outlined in the PACR by improving the quantity, quality, timing, and distribution of water for the natural system while providing for other water-related needs and meeting the requirements for protection of public health and safety. These goals, purposes, and benefits will not be fully realized until completion of construction and implementation of the CEPP and PACR components. These components will be phased in as they become operational. Interim operations have not yet been developed.

The A-1 FEB is an existing storage facility east of the proposed EAA Reservoir. Upon completion of the EAA Reservoir, the reservoir complex will operate in conjunction with the A-1 FEB and existing STAs. As additional details are developed during the design phase, the operational criteria for the EAA Reservoir will become more refined. The following initial guidance is based on the results of the optimization for the CEPP PACR hydrologic modeling:

- The EAA Reservoir accepts EAA basin runoff when the reservoir depth is below 22.6 ft.
- The EAA Reservoir accepts Lake Okeechobee water when the reservoir depth is below 20.0 ft.
- The EAA Reservoir could provide water to the Miami Canal and North New River Canal when excess capacity is available beyond restoration flows, if the reservoir depth is higher than 8.2 ft.
- EAA Reservoir discharges discontinue when the reservoir depth is below 0.5 ft.
- No supplemental water supply is provided to the EAA Reservoir to prevent dryout.

Initial operation of the EAA Reservoir will be monitored for embankment and structural stability, especially during initial filling operations. In addition, the quality of the water discharged from the EAA Reservoir would be monitored to ensure compatibility with the inflow assumptions and discharge requirements for STA-3/4, STA-2, the EAA A-2 STA, and the Central Everglades. Operational decisions regarding the volume of EAA Reservoir discharges sent to STA-3/4, STA-2, and the EAA A-2 STA would consider the vegetative health as well as the maximum monthly and annual limitations of the receiving treatment cells.

The final Project Operating Manual assumes completion of all CEPP components. The manual will undergo several updates and refinements over time, as explained in Section 6 and Annex C of the PACR (SFWMD 2018). The triggers, thresholds, and knowledge gained over time will be used in future modeling and updates, and the Project Operating Manual will be developed in coordination with, and consistent with, the CEPP Adaptive Management Plan. Modifications and/or revisions to the manual will occur during subsequent project phases. Development of the Project Operating Manual is an iterative process that will continue throughout the life of the project. The manual will be updated at periodic intervals during the detailed design, construction, operational testing, and monitoring phases of the project. Refinements to the operating criteria in the manual will be made as more project design details, data, operational experience, and general information are gained during these project phases.

5.2 Effects of the Proposed Everglades Agricultural Area Reservoir on Existing Legal Users

When establishing a Water Reservation, all existing legal users of water shall be protected so long as such use is not contrary to the public interest [Section 373.223(4), F.S.]. To analyze seepage from the EAA Reservoir complex, several modeling scenarios were performed, including three-dimensional MIKE SHE/MIKE 11 modeling, two-dimensional SEEP/W groundwater modeling, and a three-dimensional MODFLOW model recalibration of the A-1 test cells. A passive management modeling scenario that included a cutoff wall, at a depth of -34.1 ft North American Vertical Datum of 1988 (NAVD88), showed that without the EAA Reservoir inflow-outflow seepage pumping, a difference of more than 0.25 ft, determined to be an impact threshold, would extend approximately 2.7 miles north of the project boundary and 2.6 miles south into Holey Land Wildlife Management Area under steady-state conditions. There are no existing legal users of groundwater within those distances. The existing legal users of surface water within those distances are provided in **Table 5-1**. The existing legal users of surface water withdraw from the Miami Canal and North New River Canal, which have water level elevations maintained by the SFWMD. The water elevations remain the same under Alternative C240; therefore, no impacts to the availability of water are expected for existing legal users.

Table 5-1. Existing legal users surrounding the Everglades Agricultural Area Reservoir site.

Project	Water Use Permit	Application	Surface Water Source in the Area of Interest	
			L-19 Canal	L-23/L-24 Canal
Star Ranch Enterprises	50-00045-W	101012-1	X	
Star Farms Corporation	50-00191-W	101011-24	X	
Okeelanta Corporation	50-00656-W	190725-16	X	X
Halasco	50-08963-W	140513-6	X	
Sugar Farms Co-Op	50-08986-W	181001-16	X	X
ECP and Non-ECP Components	50-11070-W	160520-28		X
Star Ranch Enterprises West Farm	50-00092-W	190619-5	X	

The project is underlain by naturally occurring hydrogeologic formation water (connate water) with chloride ion concentrations that progressively increase with depth (Reese and Wacker 2009). To prevent mounding of water table elevations and to minimize the transport and/or upconing of chloride ion concentrations as a result of the project, active seepage scenarios were performed, including depth increases to the cutoff wall and EAA Reservoir inflow-outflow canal on the northern boundary of the reservoir and stage control in the reservoir's inflow-outflow canal (via three 200-cfs seepage pumps). Active management modeling scenarios indicate seepage from the EAA Reservoir can be fully captured, mitigating any potential seepage impacts. To further minimize water level impacts north of the EAA Reservoir, the SFWMD and USACE jointly recommend inclusion of an additional seepage canal within the EAA Reservoir and A-2 STA (Alternative 3 of the USACE [2020] Final Environmental Impact Statement) to increase operational flexibility within the EAA Reservoir inflow-outflow canal during pumping operations.

5.2.1 Water Not Reserved for the Protection of Fish and Wildlife

Water was not quantified for other water-related needs in the Lake Okeechobee Service Area (LOSA), which includes the EAA. However, water stored in the EAA Reservoir may be provided to the Miami and/or North New River canals within the EAA to maintain canal stages used for supplemental irrigation. Discharges may be made from the EAA Reservoir through the S-628 structure to the Miami and/or North New River canals via the reservoir's inflow-outflow canal. According to the Draft Project Operating Manual (Annex C of the PACR [SFWMD 2018]), water stored in the EAA Reservoir can be used for water supply deliveries to meet EAA irrigation needs only when the reservoir stage is above 8.2 ft and the Miami and/or North New River canal stages are below their maintenance stages.

Any withdrawal of water from the Miami and North New River canals must be consistent with allocations in existing water use permits. Based on the additional water stored in the EAA Reservoir, the Draft Project Operating Manual, and modeling conducted for the PACR, 82,000 ac-ft of water on average annually (**Figure 5-3**) could be conveyed through the S-628 structure to the Miami and/or North New River canals to maintain canal stages in the EAA. This amount represents approximately 9% of the total discharge from the EAA Reservoir while exceeding the CERP target flow goal to the Central Everglades. Water discharged from the EAA Reservoir will be available to water users in in the EAA in addition to water stored in Lake Okeechobee. Section 6.9.1.3 and Annex C of the PACR (SFWMD 2018) contain additional information.

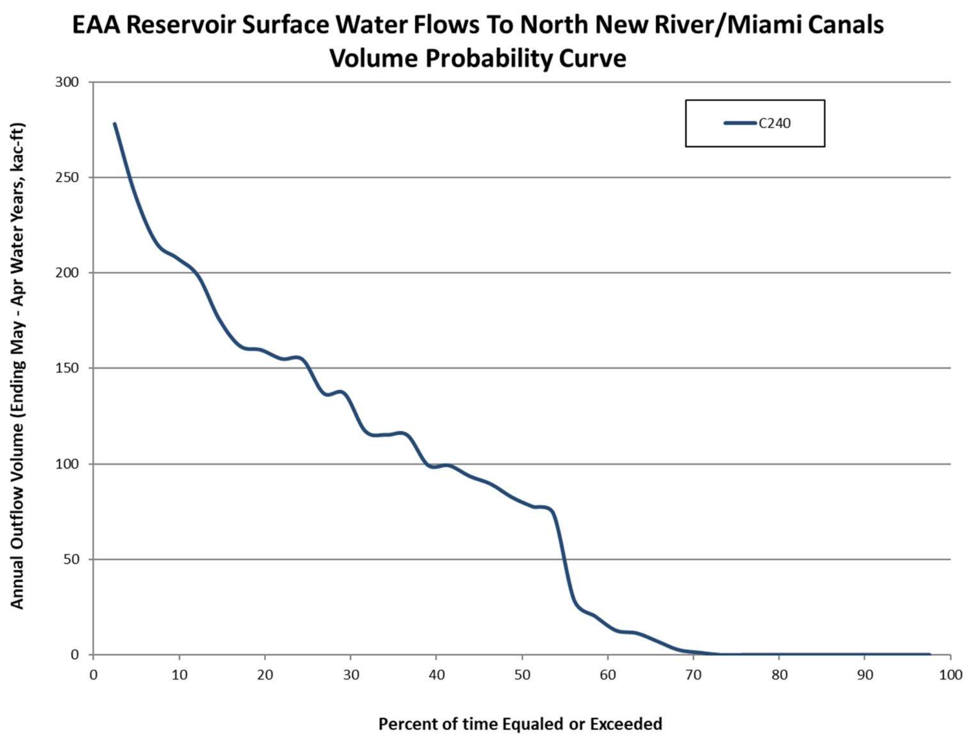

Figure 5-3. Everglades Agricultural Area Reservoir flow volume probability curve from the Alternative C240 model simulation.

5.3 Protection of Project Waters

To evaluate the protection of project water and the risk associated with consumptive uses, the following areas were evaluated to determine if project waters would be diminished: 1) the surrounding upstream watershed, including surface water and groundwater withdrawals in the vicinity of the project, 2) waters reserved within the EAA Reservoir for the natural system, and 3) waters downstream of the EAA Reservoir discharge structures.

5.3.1 Upstream Watershed Evaluation

Water use rules were used to evaluate the potential risk of future increases in consumptive uses. The use of surface water from Lake Okeechobee is capped at a base condition established between April 1, 2001 and January 1, 2008 within LOSA. The water use rules generally are referred to as the LOSA Rule. The LOSA Rule is the regulatory component of the Lake Okeechobee Minimum Flow and Minimum Water Level (MFL) recovery strategy. **Figure 5-4** depicts the geographic region of the LOSA Restricted Allocation Area. Section 3.2.1F of the *Applicant's Handbook for Water Use Permit Applications in the South Florida Water Management District* (SFWMD 2015) contains the full scope of the LOSA Rule.

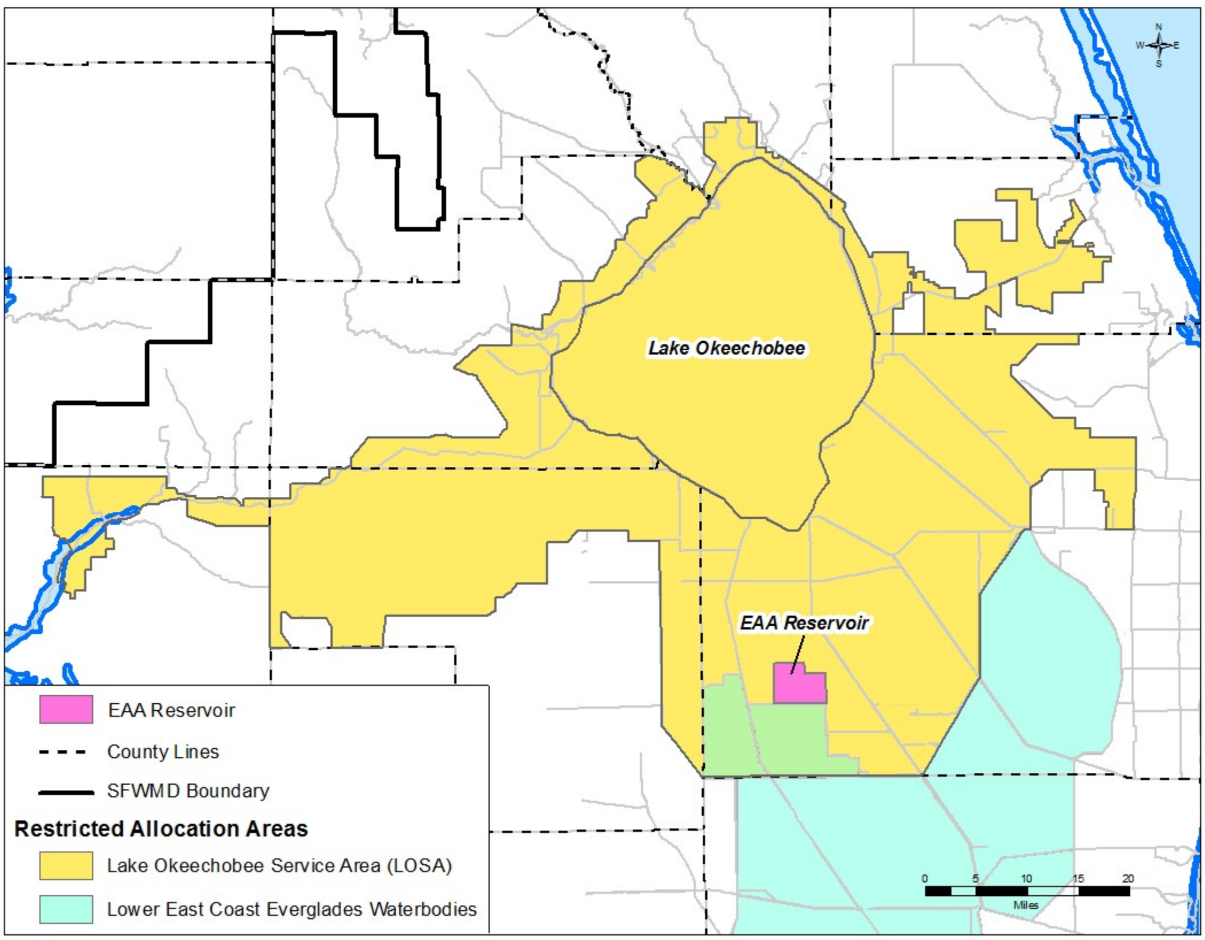

Figure 5-4. The Restricted Allocation Area for Lake Okeechobee and the Lake Okeechobee Service Area.

The upstream evaluation considered a smaller subbasin within the EAA and LOSA that includes the area immediately south of Lake Okeechobee between the Miami and North New River canals and the areas surrounding the EAA Reservoir (**Figure 5-5**). Existing surface water withdrawals identified near the EAA Reservoir are shown in **Figure 5-5** and listed in **Table 5-1**. Adjacent existing legal users rely solely on surface water from the Miami and/or North New River canals, which are maintained by the SFWMD through current operations. New allocations or increases in the current allocation to existing legal users are not expected due to the existing LOSA Restricted Allocation Area rule. There are no existing legal users withdrawing groundwater in the area. Additional information about impacts to existing legal users is provided in the **Appendix**.

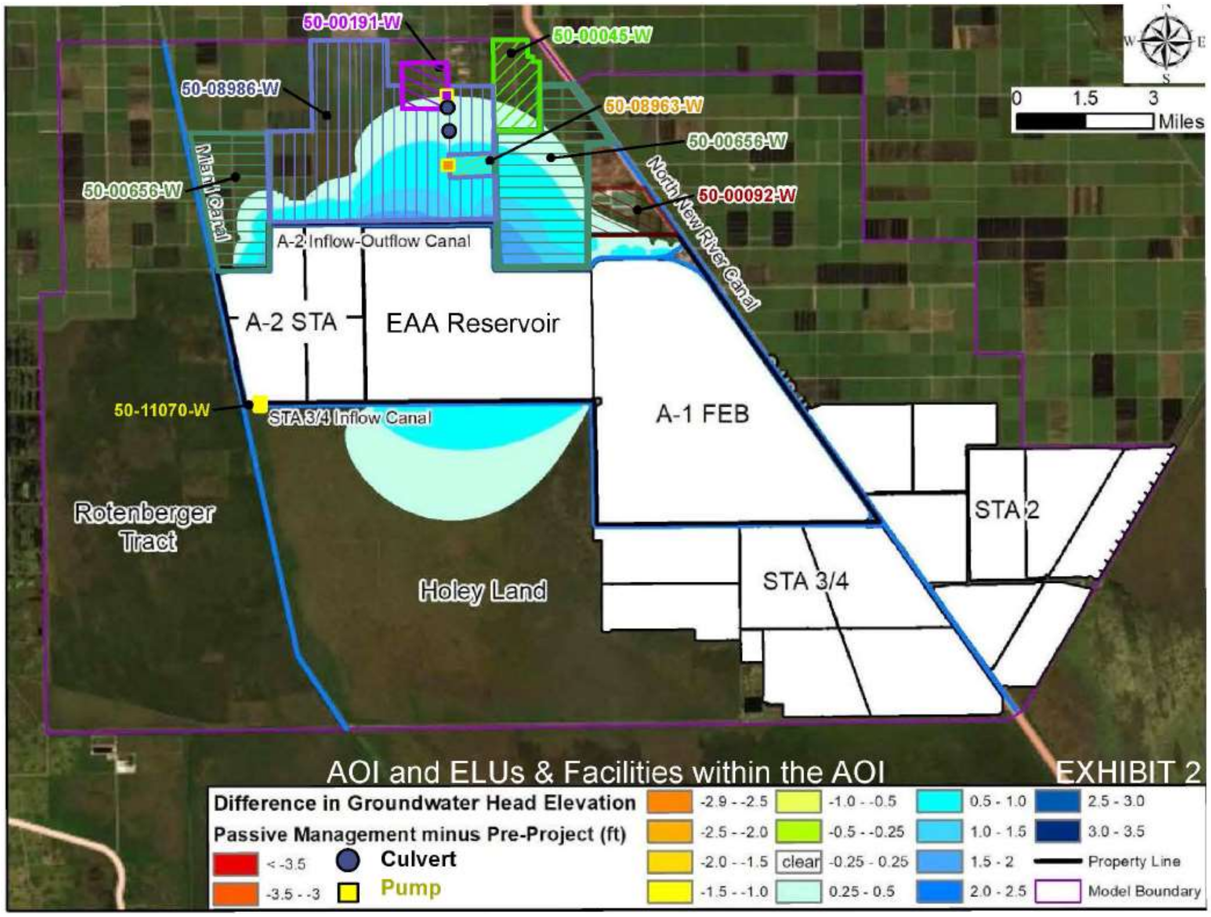

Figure 5-5. Existing legal users within the area surrounding the Everglades Agricultural Area Reservoir site.

5.3.2 Water Stored Within the Everglades Agricultural Area Reservoir

The CEPP EAA Reservoir Water Reservation rule will reserve from allocation all project water directed to the Lower East Coast Everglades waterbodies through the S-624, S-625, and S-626 structures. Any new water use permit application, or existing permittee seeking an increase in allocation, would have to comply with the LOSA Rule described above and the provision in the conditions for permit issuance described in Rule 40E-2.301, Florida Administrative Code, which requires an applicant to demonstrate they are not withdrawing reserved water.

5.3.3 Downstream Watershed Evaluation

The potential risk of future consumptive uses downstream of the EAA Reservoir discharge structures were evaluated. Waters stored within the EAA Reservoir will flow south to the Lower East Coast Everglades waterbodies via outflow structures from the EAA A-2 STA, A-1 FEB, STA-2, or STA-3/4. Surface water discharged from the EAA A-2 STA, A-1 FEB, STA-2, or STA-3/4 for the protection of fish and wildlife will be directed to lands in public ownership, including WCA-3A, WCA-3B, and ENP.

There is another Restricted Allocation Area rule south of the EAA Reservoir, the Lower East Coast Regional Water Availability Rule, which covers the Lower East Coast Everglades waterbodies (**Figure 5-6**) and is contained in Subsection 3.2.1.E of the *Applicant's Handbook for Water Use Permit Applications in the South Florida Water Management District* (SFWMD 2015). The Lower East Coast Regional Water Availability Rule is a component of the Everglades Minimum Flow and Minimum Water Level (MFL) recovery strategy, set forth in Chapter 40E-8, Florida Administrative Code, and assists in implementing the SFWMD's objective to ensure that water necessary for Everglades restoration is protected from consumptive uses. The Lower East Coast Regional Water Availability Rule was established in 2007 and covers more than 1.5 million acres, including WCAs 1, 2A, 2B, 3A, and 3B; the Holey Land and Rotenberger wildlife management areas; and the freshwater portions of ENP. The Lower East Coast Regional Water Availability Rule also includes the integrated conveyance systems that are hydraulically connected to and receive water from the Lower East Coast Everglades waterbodies, such as C&SF Project primary canals and the secondary and tertiary canals that derive water from the primary canals. Net increases in volume or changes in timing on a monthly basis of direct surface water and indirect groundwater withdrawals from the Restricted Allocation Area are prohibited over that resulting from base condition uses permitted as of April 1, 2006. Allocations over the base condition water use are allowed only through sources detailed in Subsection 3.2.1.E.5 of the Restricted Allocation Area rule, such as certified project water, implementation of offsets, alternative water supply, terminated or reduced base condition water use that existed as of April 1, 2006, or available wet season water.

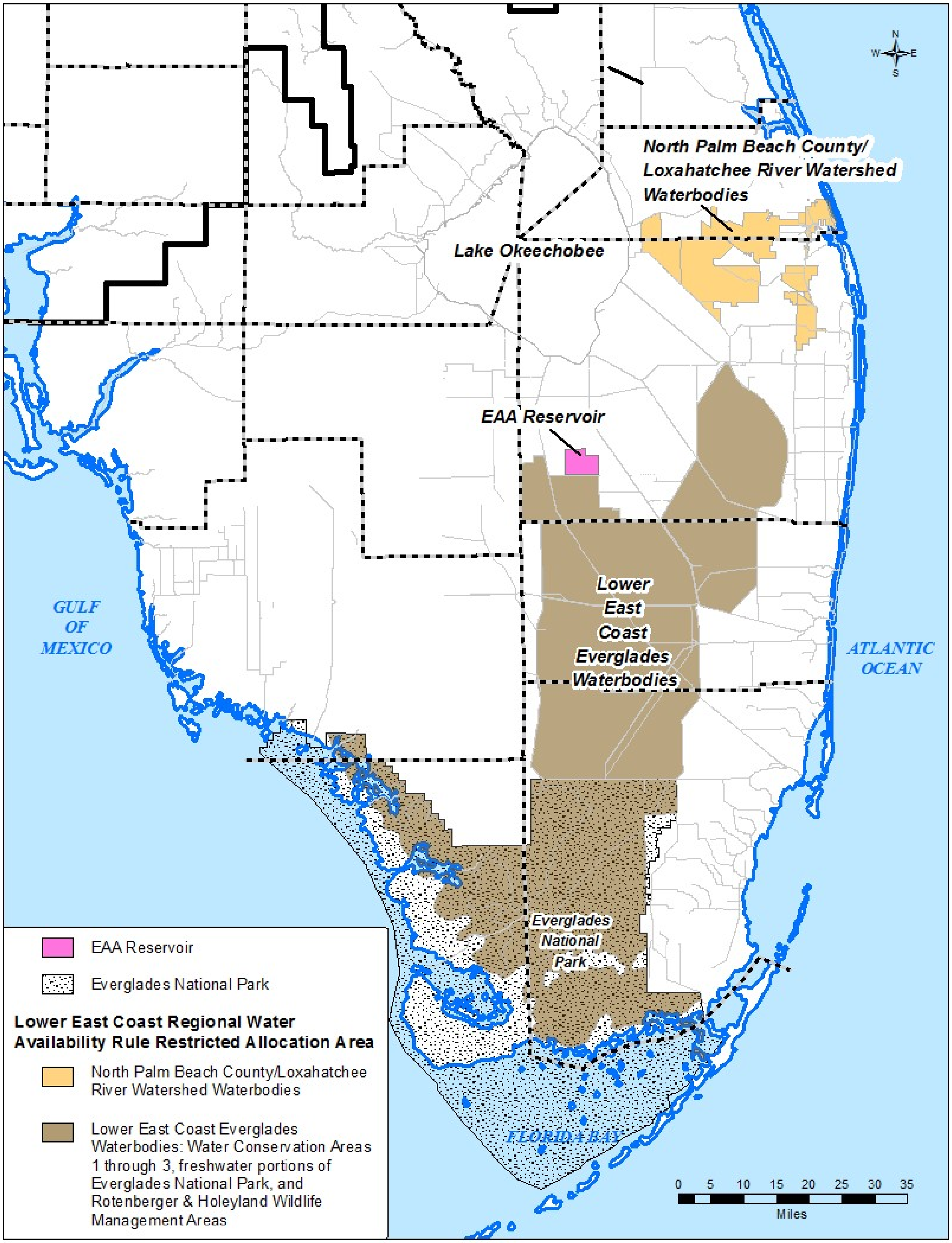

Figure 5-6. Lower East Coast Everglades waterbodies and major integrated conveyance canals.

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APPENDIX: EVALUATION OF IMPACTS TO WATER SOURCES FOR EXISTING LEGAL CONSUMPTIVE USERS DUE TO THE EVERGLADES AGRICULTURAL AREA RESERVOIR AND A-2 STORMWATER TREATMENT AREA

PURPOSE

This appendix briefly describes and analyzes the possible effects of operating the Everglades Agricultural Area (EAA) Reservoir and A-2 Stormwater Treatment Area (STA) on the water sources of existing legal consumptive users. **Figure A-1** is an aerial photograph of the EAA Reservoir and A-2 STA site.

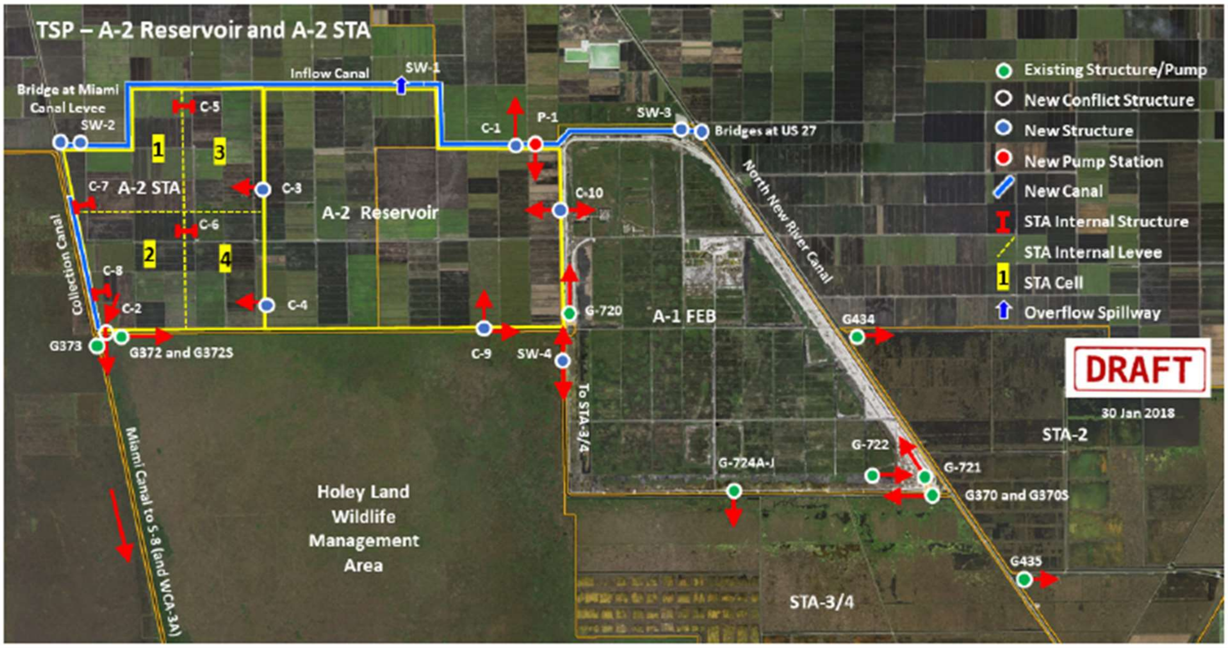


Figure A-1. Location of the Everglades Agricultural Area Reservoir and A-2 Stormwater Treatment Area.

PROJECT AREA HYDROLOGY AND HYDROGEOLOGY

The EAA Reservoir and A-2 STA are within the southern portion of the EAA. The site is bisected by the Miami Canal Basin and the North New River and Hillsboro Basin (**Figure A-2**). The North New River Canal (L-18/L-19) and Miami Canal (L-24/L-23) are located east and west of the reservoir, respectively. East of the reservoir is the A-1 Flow Equalization Basin, and west of the reservoir is the proposed EAA A-2 STA. South of the reservoir is the Holey Land Wildlife Management Area and STA-3/4. The L-21 Canal and STA-3/4 discharge canal are the nearest regional canals to the north and south, respectively.

The EAA Reservoir will be hydrogeologically connected to the surficial aquifer system (SAS), which primarily is an unconfined aquifer. However, the SAS comprises three main hydrostratigraphic units, or permeable zones, separated by partial confinement. Zone 1, the shallowest zone, is of Pleistocene age and includes the Anastasia and Fort Thompson formations. The lithology of Zone 1 consists of cemented and loosely cemented shell that can be highly permeable. Zone 2, located at intermediate depth, is of Pliocene age and includes the Pinecrest Sand member of the Tamiami formation. Zone 2 consists of shelly, highly permeable, well-cemented, gray limestone and sandstone and can be semi-confined from Zone 1. Zone 3, the deepest zone, also is of Pliocene age and includes the Ochopee Limestone member of the Tamiami formation. Zone 3 commonly includes gray, sandy lime rudstone (a carbonate grain-supported rock) and sandstone. In southwestern Palm Beach County, Zone 3 is called the gray limestone aquifer.

The EAA Reservoir and A-2 STA are in an area where groundwater is known to be saline at depth (Reese and Wacker 2009). The saline groundwater originated from seawater present during deposition (i.e., connate water) of the Late Miocene and Pliocene Epochs (approximately 3 to 7 million years ago) or upwelling of saline water from deeper saline aquifers. Nearby monitor wells indicate the chloride ion concentrations in Zones 1 and 2 vary from 100 to 180 milligrams per liter (mg/L). However, below Zone 3 (approximately -80 feet (ft) North American Vertical Datum of 1988 [NAVD88]), the chloride ion concentration is 3,000 mg/L.

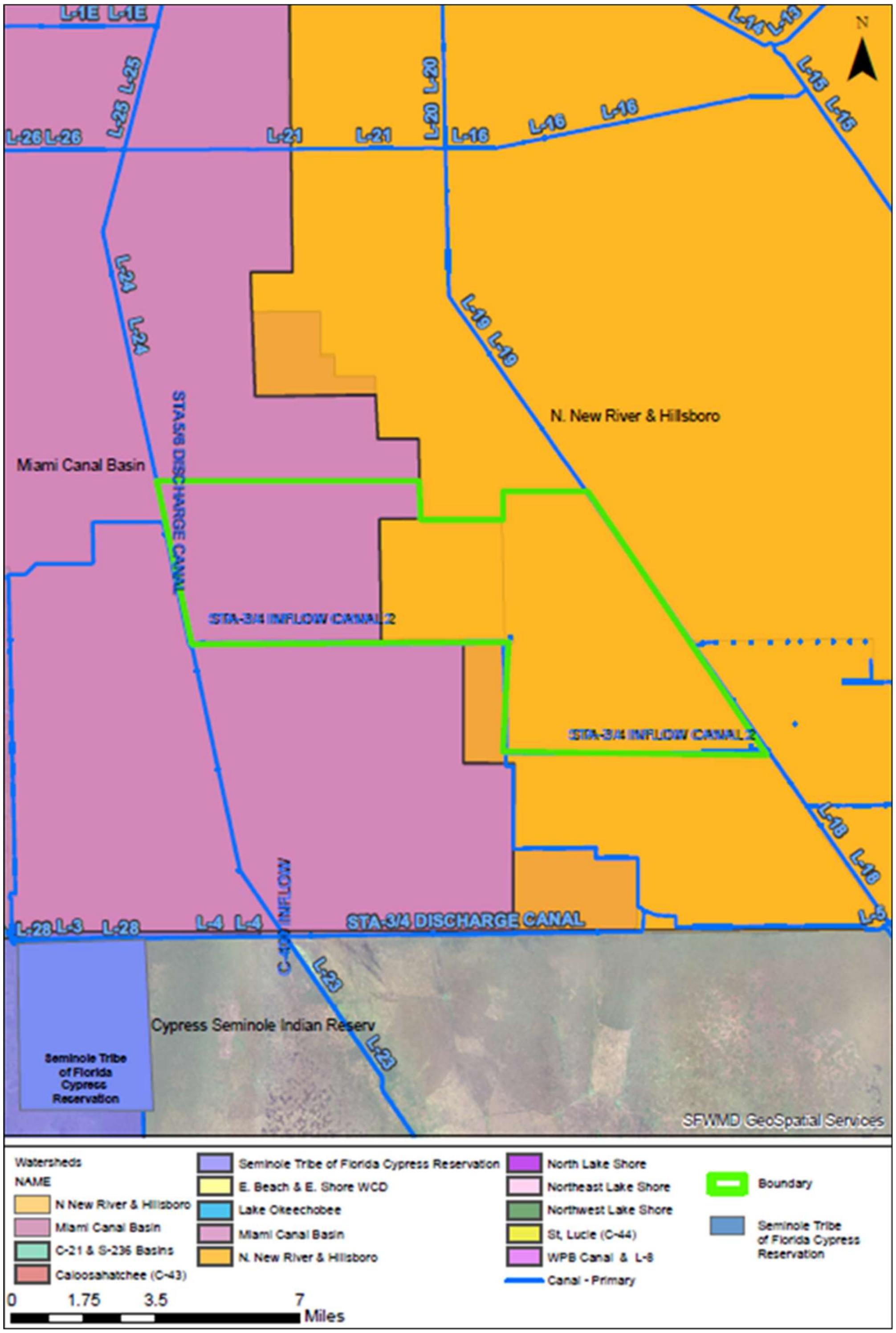


Figure A-2. Hydrology map of the Everglades Agricultural Area Reservoir.

MODELING RESULTS AND WATER SOURCES OF EXISTING LEGAL USERS

The EAA Reservoir and A-2 STA were evaluated with integrated groundwater and surface water modeling software called MIKE SHE (DHI 2019). The model was verified and calibrated using SEEP/W, which is a finite element model used for seepage analysis as a function of time. The SEEP/W model used a finer discretization and telescoped to the model domain near the cut-off wall and reservoir. In the model, Zone 1 was represented by a layer thickness ranging from 8.0 to 20.7 ft, with a hydraulic conductivity of 900 ft/day. Zones 2 and 3 were combined in the model and represented by a layer thickness ranging from 129 to 143 ft, with a hydraulic conductivity of 30 ft/day.

An impermeable 3-ft thick wall (i.e., cutoff wall) is proposed to be constructed below the embankments that surround the EAA Reservoir to a depth of -34.1 ft NAVD88 (located within the Caloosahatchee formation) and next to the northern inflow-outflow canal as an active control for seepage. The MIKE SHE and SEEP/W models were used to simulate the effects of the cutoff wall and the inflow-outflow canal on groundwater seepage. The seepage analysis quantified the amount of seepage loss from the reservoir to determine whether various proposed seepage management alternatives would effectively mitigate impact to surrounding areas and to quantify impacts, if any, to lands surrounding the reservoir and A-2 STA.

A baseline model without the EAA Reservoir and A-2 STA was compared to a second model with the reservoir and STA using conservative parameters that maximized the amount of seepage that could occur. The normal full storage elevations of 31.1 and 12.5 ft NAVD88 of the EAA Reservoir and A-2 STA, respectively, were used in a steady-state condition model. The cut-off wall was included in the model run but the inflow-outflow canal was set at an elevation equivalent to the regional canals (8.9 ft NAVD88) to represent only passive control. The difference in water elevations between the baseline model and the with-reservoir model using only passive controls demonstrates the limits of the area of influence (AOI; **Figure A-3**). The AOI is defined by the 0.25-ft mounding contour, which extends approximately 2.7 miles north of the EAA Reservoir and A-2 STA. Mounding as high as 2 ft could be expected immediately north of the reservoir. Due to the length of the model run to steady-state conditions and the full water elevations of the EAA Reservoir and A-2 STA, the parameters were chosen to represent a conservative estimate of the AOI. The existing legal users and their commensurate withdrawal facilities within the AOI are shown in **Figure A-3**, and those permittees and their water sources are listed in **Table A-1**.

The primary land use in the EAA is agriculture, and the dominant crop is sugarcane within the AOI. All existing legal users' water sources are directly or indirectly conveyed from the Miami Canal or North New River Canal, which are owned and operated by the South Florida Water Management District. Therefore, existing legal users should have no impact to the EAA Reservoir and A-2 STA. Furthermore, there are no users of groundwater from the SAS; therefore, consumptive use of groundwater within the AOI will have no impact to the reservoir and STA. Sugar Farms Co-Op and Florida Crystals Corporation have agricultural operations under Water Use Permits 50-08986-W and 50-0656-W, respectively, that encroach on the reservoir area. Both permits will need to be modified to remove the irrigated acreage contained within the EAA Reservoir and A-2 STA (17,917 acres).

Modeling that used active controls for seepage adjusted the stage elevation within the inflow-outflow canal based on: 1) the design stage of the canal (4.5 ft NAVD88), 2) the proposed capacity of the pumps (total of 600 cubic feet per second) that will move water from the canal to the reservoir, and 3) two alternative depths of the north cut-off wall (-34.1 and -65 ft NAVD88). The deeper cut-off wall reduced seepage by half, and the stage elevation range for the inflow-outflow canal can either fully intercept seepage (and cause drawdown north of the canal) by maintaining stage elevations at 4.5 ft NAVD88 or allow seepage up to the passive model by maintaining stage elevation at 8.9 ft NAVD88. The results of the active controls range from mounding, as shown previously with no active controls (passive), to drawdowns as large as 3 ft north of the EAA Reservoir and A-2 STA (**Figure A-4**). A canal elevation between these two limits will be used to minimize drawdown and mounding north of the EAA Reservoir and A-2 STA. A model using the shallower cut-off wall and stage elevation of 6.8 ft NAVD88 for the inflow-outflow canal was presented as the optimal active control design. As shown in **Figure A-5**, minimal impacts occur north of the EAA Reservoir and A-2 STA using these parameters.

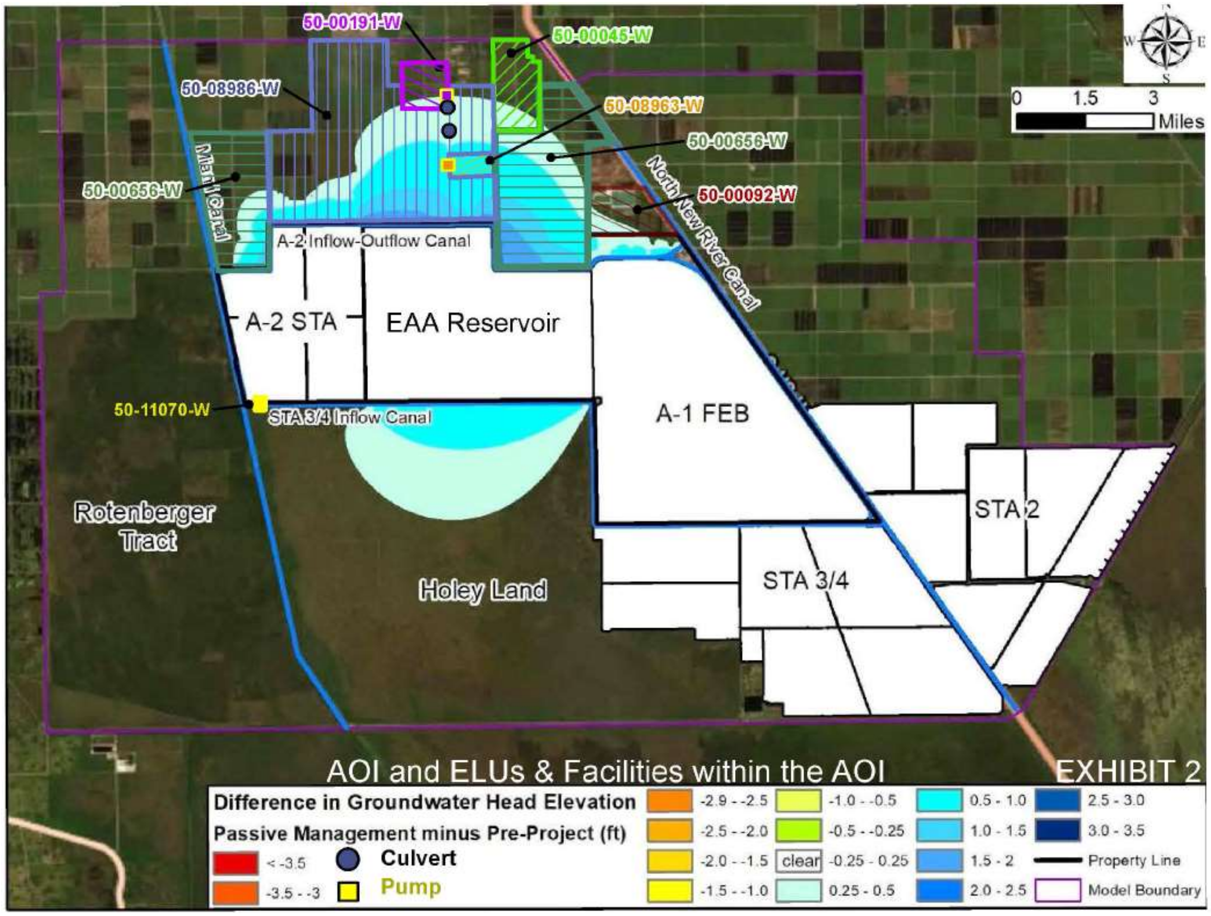
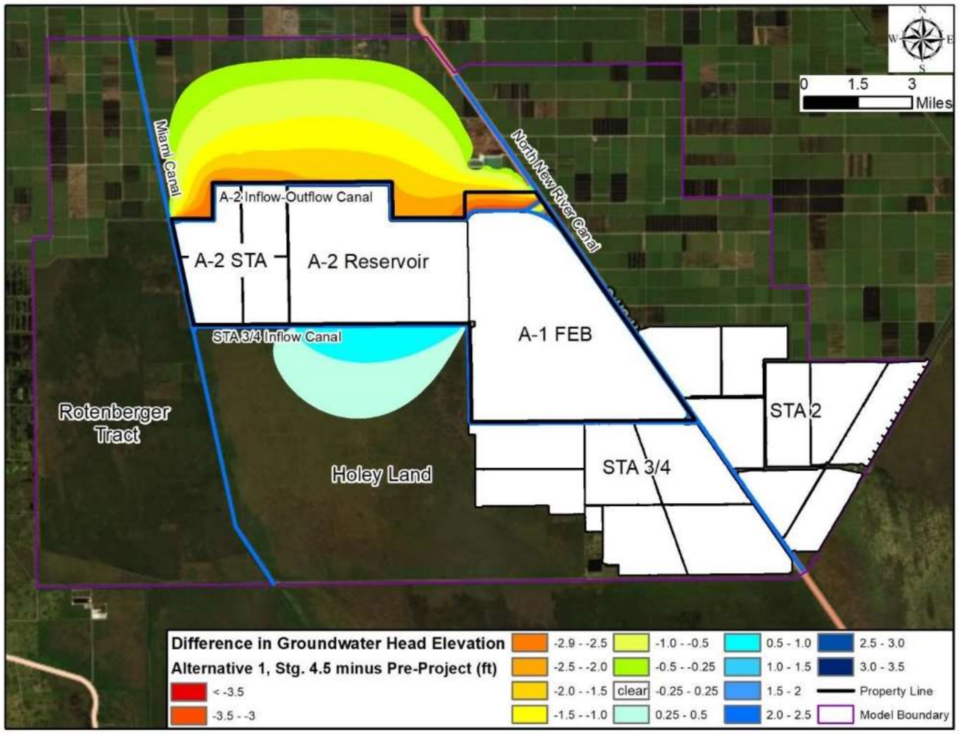


Figure A-3. Area of influence and existing legal user facilities.

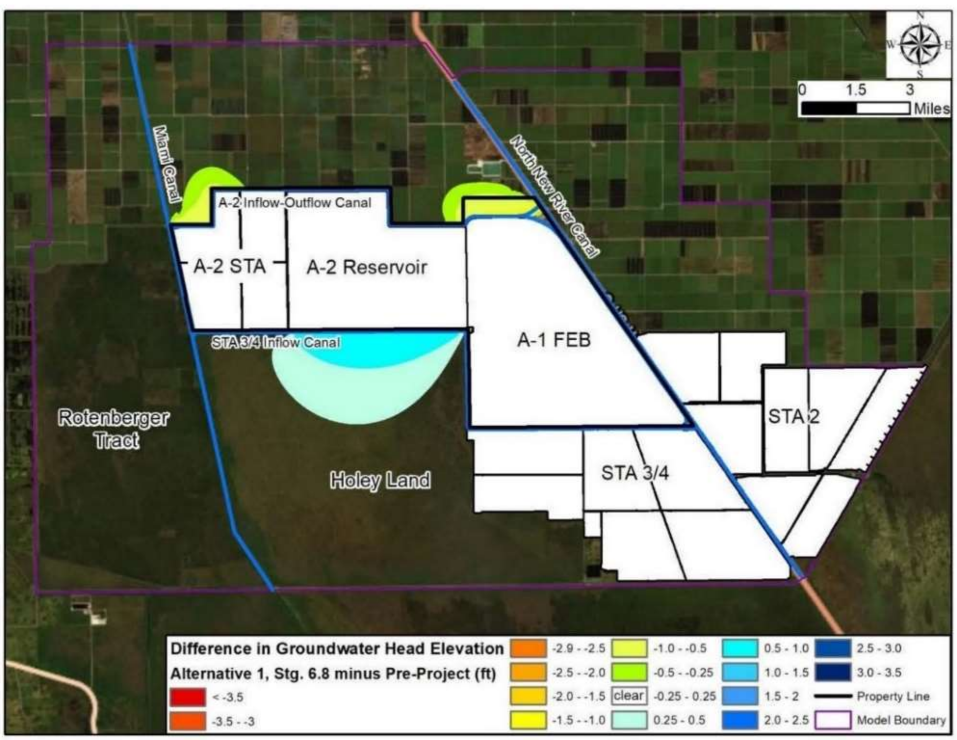
Table A-1. Existing legal uses surrounding the Everglades Agricultural Area Reservoir and A-2 Stormwater Treatment Area.

Project	Water Use Permit	Application	Surface Water Source in the Area of Interest	
			L-19 Canal	L-23/L-24 Canal
Star Ranch Enterprises	50-00045-W	101012-1	X	
Star Farms Corporation	50-00191-W	101011-24	X	
Okeelanta Corporation	50-00656-W	190725-16	X	X
Halasco	50-08963-W	140513-6	X	
Sugar Farms Co-Op	50-08986-W	181001-16	X	X
ECP and Non-ECP Components	50-11070-W	160520-28		X
Star Ranch Enterprises West Farm	50-00092-W	190619-5	X	



Inflow-Outflow Canal maintained at 4.5 feet NAVD EXHIBIT 3

Figure A-4. Difference in water table elevations in the immediate vicinity of the project when the inflow-outflow canal stage is maintained at 4.5 feet NAVD88.



Inflow-Outflow Canal maintained at 6.8 feet NAVD EXHIBIT 4

Figure A-5. Difference in water table elevations in the immediate vicinity of the project when the inflow-outflow canal stage is maintained at 6.8 feet NAVD88.

FINDINGS AND RECOMMENDATIONS

Modeling demonstrated active control of stage elevation in the inflow-outflow canal can minimize potential mounding or drawdown effects to existing legal users north of the EAA Reservoir and A-2 STA. Additionally, because there are no consumptive uses of groundwater and the use of surface water by existing legal users is from regional canals maintained by the South Florida Water Management District, the potential for harmful impacts to the EAA Reservoir and A-2 STA as a result of the continued use of surface water by existing legal users, including seepage, is considered minimal.

Impounding water with or without the use of a cut-off wall or seepage barrier results in alterations to groundwater flow, which may affect water quality. Water quality impacts due to the reservoir and cut-off wall should be addressed in light of recent data and preliminary findings of ongoing investigations performed for the Herbert Hoover Dike Major Rehabilitation Project and Water Conservation Areas 1 and 2A (United States Army Corps of Engineers 2015). The altered circulation of groundwater flow could cause upwelling of connate saline water, where present. This is exacerbated when a seepage barrier is installed. Monitoring conducted at the Herbert Hoover Dike indicated changes in salinity occurred when the seepage barrier depth was close to the saline water interface (1,000 mg/L in this study), which caused upconing of the saline water interface and fresh or brackish water above the interface to become more saline, while groundwater at depths of up to three times the depth of the seepage barrier became less saline. The cut-off wall has a proposed depth of -34.1 ft NAVD88, and the saline water interface is estimated at approximately -80 ft NAVD88. For Lake Okeechobee, which has the same hydrostratigraphic units as the EAA Reservoir, Reese and Wacker (2009) and Prinos and Valderrama (2014) demonstrated the effects of a seepage barrier reached three times the depth of the impermeable wall. The saline water interface at the reservoir site is estimated to be well within this range.

Therefore, to provide assurances that harmful mounding/drawdown and/or saline upconing is not occurring to existing legal users north of the EAA Reservoir, it is recommended that a groundwater and saline water monitoring program be implemented. Monitor wells traversing north and south and background wells to the north (beyond the AOI) should be installed and regularly sampled for groundwater elevation and chloride ion concentrations at various depths. Monitor wells close to and/or deeper than the seepage barrier can serve as sentinel wells. If saline water is being discharged from the inflow-outflow canal or if there is upwelling of saline groundwater into the canal (base flow), existing legal users downstream of the Miami Canal and North New River Canal should be protected by sampling the chloride ion concentration in the canals. Groundwater elevation and chloride ion concentration data should be evaluated for trends and used to provide feedback for operational purposes and maintenance of optimal stage elevations for the inflow-outflow canal to balance the need to protect existing legal users and environmental features and to provide flood protection during various hydrologic and seasonal conditions.

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