COMPREHENSIVE EVERGLADES RESTORATION PLAN

LAKE OKEECHOBEE WATERSHED RESTORATION PROJECT

FINAL INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

August 2020

Appendix C

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APPENDIX C
ENVIRONMENTAL AND CULTURAL RESOURCES

Part 1: Existing and Future Without Project Conditions

Part 2: Effects of the Alternatives and Optimized Tentatively Selected Plan

Part 3: Pertinent Correspondence Information

Part 4: Environmental Compliance Information

Part 5: Cultural Resources Consultation Information

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C ENVIRONMENTAL AND CULTURAL RESOURCES

This appendix consists of 5 parts:

1. Existing and Future Without Project Conditions
2. Effects of the Alternatives and Tentatively Selected Plan
3. Pertinent Correspondence Information
4. Environmental Compliance Information
5. Cultural Resources Consultation Information

Each part has a cover page, with its own table of contents.

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PART 1: EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS

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C.1 Existing and Future Without Project Conditions

This appendix provides a detailed discussion of the existing condition baseline (ECB) and considers the environmental conditions in the affected regions without the proposed action, known as the Future Without Project (FWO). The resource conditions that were evaluated include climate; geology; soils; vegetation; wildlife; hydrology; water quality; flood control; air quality; hazardous, toxic, and radioactive waste (HTRW); noise; aesthetics; land use; agriculture; socioeconomics; environmental justice; recreation; cultural resources; and invasive species.

C.1.1 Existing Conditions of Resources

The study area of the Lake Okeechobee Watershed Restoration Project (LOWRP) covers a portion of the Lake Okeechobee Watershed (LOW), Lake Okeechobee, and the Caloosahatchee and St. Lucie estuaries (collectively known as the Northern Estuaries).

The LOW, as defined hydrologically, spreads over approximately 8,687 square miles (mi^2), almost 13 times the area of the lake itself (Flaig and Havens, 1995). The LOW is a shallow trough that drains south from Orlando to the Florida Everglades and is bounded by sand hills of the Lake Wales Ridge on the west and upland marshes of the Osceola Plain to the east (Parker et al., 1955). Characterized by low-gradient, poorly drained landscapes with many marshes and sloughs, it includes all major basins and sub-basins that are direct tributaries to the lake, including those that are hydrologically upstream and/or those from which water is released or pumped into the lake on a regular basis. Four distinct tributary systems (basins) drain naturally into Lake Okeechobee: the Kissimmee River Valley, Lake Istokpoga-Indian Prairie/Harney Pond, Fisheating Creek, and Taylor Creek/Nubbin Slough. With the exception of Fisheating Creek, all major inflows to Lake Okeechobee are controlled by gravity-fed or pump-driven water control structures. The four major basins of the LOW are generally bounded by the drainage divides of the major water bodies and are further divisible into smaller sub-basins based on hydrology and geography. The existing conditions are presented in a regional or area-specific content, depending on the nature of the resource or the anticipated effect of that resource. Existing conditions are summarized in **Section 2.0** of the main report.

Lake Okeechobee, a central part of the south Florida watershed, is the largest lake in the southeastern United States. The lake provides water supply to urban areas, agriculture, and downstream estuarine ecosystems during the dry season (November-May) and is used for flood control during the wet season (June-October). In the Lake Okeechobee Service Area (LOSA), the Okeechobee Utility Authority is the only remaining public water supply (PWS) utility using water directly from the lake. Clewiston, South Bay, Belle Glade, and Pahokee discontinued the use of Lake Okeechobee as their supply source. Since 2008, they use Floridan Aquifer water, treated by reverse osmosis, for all of their PWS. The Okeechobee Intracoastal Waterway (OIWW) provides economically and politically important commerce between the eastern and western coasts of Florida. A congressionally authorized project, the OIWW connects the Atlantic Intracoastal Waterway to the Gulf Intracoastal Waterway, with depths and operations required for efficient navigation on the system. The authorized Central and Southern Florida (C&SF) Project depths for Lake Okeechobee navigation are based on 12.56 ft. National Geodetic Vertical Datum of 1929 (NGVD29).

C.1.1.1 Climate

The Lake Okeechobee watershed is in the transition zone between a tropical (to the south) and humid subtropical (to the north) climate. Both climates are dominated by hot, humid summers and mild-to-warm

winters. The subtropical climate of south Florida, with its distinct wet and dry seasons, high rate of evapotranspiration, and climatic extremes of floods, droughts, and hurricanes, represents a major physical driving force that sustains the Everglades while creating water supply and flood control issues in the agricultural and urban segments.

Global climate change and variability, particularly at regional levels, are not completely understood. Over the last two decades, the South Florida Water Management District (SFWMD) scientists have investigated how natural, global climatic patterns such as the El Niño/La Niña Southern Oscillation and the Atlantic Multidecadal Oscillation (AMO) are linked to South Florida's weather and climate.

Since 1900, there have been two cool phases and two warm phases of the AMO cycle; each phase lasted approximately 20-40 years. The exact year of the phase start and finish is an estimate as each phase goes through a "transition period" of a few years. South Florida was in a much drier regime from 1965 to the early 1990s when the AMO transitioned from the cool phase to the warm phase. South Florida experienced more droughts and dry weather during the cool phase. High-water events (some extreme) have been more frequent during the current warm phase. South Florida has been in a "wetter" regime since the early 1990s, mostly due to the AMO. With the AMO phases lasting typically 20-40 years, the current AMO warm phase has likely peaked. Thus, the generally wetter-than-normal conditions that Florida has experienced since the early 1990s should begin to slowly decline and we will see continually cooler conditions over the next 10-20 years, with an increase in dry years compared to wet years as we move into the next cool phase. However, low-frequency dry years can still occur during this warm phase due to other events such as La Niña, which can occur every 2-7 years, on average.

Seasonal rainfall patterns in south Florida resemble the wet and dry season patterns of the humid tropics more than the winter and summer patterns of temperate latitudes. Recorded annual rainfall averages 53 inches per year in south Florida. Recorded extremes range 37-106 inches. Of the average annual rainfall that south Florida receives, 75% falls during the wet season, May through October. During the wet season, thunderstorms that result from easterly tradewinds and land-sea convection patterns occur almost daily. Wet-season rainfall follows a bimodal pattern, with peaks during mid-May through June and September through mid-October. Tropical storms and hurricanes also provide major contributions to wet-season rainfall with a high level of interannual variability and low level of predictability. During the dry season (November- April), rainfall is governed by large-scale winter weather fronts that pass through the region approximately weekly. However, due to the variability of climate patterns (La Niña and El Niño), dry periods may occur during the wet season and wet periods may occur during the dry season. Multi-year high and low rainfall periods often alternate on a time scale approximately on the order of decades. These interannual extremes in rainfall result in frequent years of flood and drought (USACE 1999).

Mean annual temperature for the south Florida ecosystem range from 72° Fahrenheit (F) (22° Celsius (C)) in the northern Everglades to 76° F (24° C) in the southern Everglades (Thomas 1974). Mean monthly temperatures range from a low of 63° F (17° C) in January to a high of 85° F (29° C) in August (Thomas 1974).

High evapotranspiration rates in south Florida roughly equal annual precipitation. Evapotranspiration removes from 70% to 90% of the rainfall in undisturbed south Florida wetlands (Duever et. al. 1994). Evaporation from open water surfaces peaks annually in the late spring when temperatures and wind speeds are high and relative humidity is low. Evaporation is lowest during the winter when the temperatures and wind speeds are low (Duever et. al. 1994).

Regional climate studies of observed air temperature trends show an increase in temperature with a general consensus in an increase in minimum and maximum temperatures. Observed precipitation show no discernible trends in annual/seasonal precipitation but shows an increase in the frequency and intensity of extreme precipitation events. Heavy precipitation events in most parts of the United States have increased in both intensity and frequency since 1901. Extreme precipitation events are generally observed to increase in intensity by about 6% to 7% for each degree Celsius of temperature increase (USGCRP 2017). The annual frequency of hurricanes has remained relatively stable throughout the 20th and early 21st centuries; however, hurricane rainfall is expected to increase for Florida as the climate continues to warm. No trend in observed streamflow was found.

Sea-level change has been a persistent trend for decades in the United States and elsewhere in the world. Observed and reasonably foreseeable global sea level rise means that local sea levels will continue to rise beyond the end of this century. This trends evaluation will be further discussed in subsection **C.1.3.1**.

C.1.1.2 Physical Landscape

The most common landscapes of the LOW are the wet prairies near Lake Okeechobee and at lower elevations, and the dry prairies and pine flatwoods that occur in an upland setting (McVoy et al., 2011). Aerial imagery of the Indian Prairie and Istokpoga areas show relict ridge-and-slough geomorphology that characterizes the Greater Everglades topography. Depressional wetlands also appear in areas that are not over-drained. The C-41A and C-40 canals and the Kissimmee River are the primary drains of the project area. Elevations in the watershed generally range 13–55 ft. NGVD and gradually decrease in a southeasterly direction to approximately 13 ft. NGVD.

The shallow subsurface geology of the LOW consists of unconsolidated fluvial sediments of the Kissimmee River floodplain and freshwater wetland soils of Holocene age, which overlie Quaternary marine sediments, primarily sand and silt with clay lenses (Klein et al., 1964). These sediments are underlain by a thick (greater than 1,000 ft.) sequence of Cenozoic marine limestones.

C.1.1.2.1 Geology

The deepest lithologic unit of interest in southern Highlands and Glades counties is the Avon Park Formation (mid-to-late Eocene). This unit is encountered at depths of 790–840 ft. below land surface (bls) in the northern portion of the project area, and dips to approximately 1,220 ft. in the southeast near Lake Okeechobee (Campbell, 1990; CH2MHill, 2004, 2008). The Avon Park Formation consists of fine-grained, micritic to fossiliferous limestone, dolomitic limestone, and dolostone (Reese and Richardson, 2008).

The Ocala Limestone (late Eocene) overlies the Avon Park Formation in Glades County. This unit is a chalky to fossiliferous, mud-rich to calcarentic limestone (Reese and Richardson, 2008). Near the project area, the top of the Ocala Limestone is encountered at depths that range between 540 ft. bls (Kissimmee River Aquifer Storage and Recovery (KRASR) System, CH2MHill, 2004) and 650 ft. bls (Paradise Run, CH2MHill, 2008; Brighton Reservation; Missimer Groundwater Science, 2007), and generally dips to the south. The upper contact of the Ocala limestone shows significant—as much as 200–300 ft.—topographic variation (Reese, 2014); this may have implications for ASR well construction. The Ocala Limestone thickness ranges approximately 200–400 ft. in the project area.

The Suwannee Limestone (early Oligocene) is a pale orange-to-tan, fossiliferous, medium-grained calcarenite. This formation occurs at depths of 750 to 950 ft. bls (Reese and Richardson, 2008), and thins

to the east. The Suwannee Limestone is not easily recognized in cores east of Glades County and is absent in exploratory boreholes at the Brighton Reservation (Missimer Groundwater Science, 2007) and KRASR (CH2MHill, 2004). However, the Suwannee Limestone was shown at depths of approximately 850–950 ft. bls in an exploratory borehole at Moore Haven (GLF-6, southwest of the project area; Reese and Richardson, 2008), and at 550–610 ft. in an exploratory borehole for HIF-42 at Paradise Run (Highland County; CH2MHill 2008).

Hawthorn Group (late Oligocene-Miocene) sediments overlie the Suwannee and Ocala Limestones throughout south Florida, including Glades County (Scott, 1988; Missimer, 2002). The Hawthorn Group consists of two formations, the Arcadia Formation and the overlying Peace River Formation. Hawthorn Group sediments are distinguished from underlying limestones by their high and variable siliciclastic and phosphatic content, gray-green coloration, and gamma-ray log response (Reese and Richardson, 2008). The basal Hawthorn unit is phosphate-rich and shows pronounced gamma-ray log responses that contrast with low response in the phosphate-poor Ocala Limestone. Clays occur within the Arcadia Formation; dolomite is the primary carbonate mineral (Scott, 1988). The Arcadia Formation/basal Hawthorn Group lies unconformably on the Ocala Limestone in the project area.

The Peace River Formation overlies the Arcadia Formation throughout south Florida. The Peace River Formation consists of interbedded quartz sands, clays, and carbonates, with quartz sands dominating the formation (Scott, 1988). Undifferentiated Hawthorn Group sediments occur at depths of 178 ft. to 650 ft. at the Brighton Reservation (Missimer Groundwater Science, 2007), from 140 ft. to 550 ft. at Paradise Run (CH2MHill, 2008), and 170 ft. to 562 ft. bls at KRASR (CH2MHill, 2004).

Undifferentiated shelly marine sands (Pliocene-Pleistocene) overlie Hawthorn Group sediments throughout the project area (Scott et al., 2001). West of the Kissimmee River alluvial floodplain, nearshore marine sediments are exposed at the surface. During the Holocene (starting at approximately 10,000 years BCE), the Kissimmee River floodplain developed, initiating deposition of fluvial and freshwater wetland sediments on surficial marine sands. The thickness of the unconsolidated marine and freshwater sediments is 178 ft. at the Brighton Reservation (Missimer Groundwater Science, 2007), 140 ft. at Paradise Run (CH2MHill, 2008), and 170 ft. at KRASR (CH2MHill, 2004).

C.1.1.2.2 Soils

Surface soils in the Lake Okeechobee region are grouped based on distinctive patterns of composition, relief, drainage, and natural landscape. These soils developed in response to climate and drainage during the Holocene Epoch. Holocene soils developed on Quaternary marine sands and silts that serve as parent material. Sandy marine sediments are clearly identified at relatively shallow depths beneath the Holocene soils and alluvium of the Kissimmee River. Two general soil types characterize the project area: upland flatwoods soils and slough and freshwater marsh soils.

Upland flatwoods soils in the project area are primarily fine sands and are mapped as Immokalee sand, Basinger fine sand, and Piñeda fine sand (**Figure C-1;** NRCS, 2018).

- The Immokalee sand is the most widely occurring soil in the project area. This soil occurs in upland flatwoods environments on marine terraces (light green units in the figure).
- The Basinger fine sand commonly occurs in depressions on marine terraces (yellow and light blue units in the figure).

- The Piñeda fine sand occurs in upland drainages in flatwoods environments and marine terraces (dark blue units in the figure).

The slough and freshwater marsh soils consist of fine sand and are often organic-rich. These hydric soils develop in depressional wetlands, sloughs, and the Kissimmee River alluvial floodplain. They are mapped as Tequesta muck and Floridana fine sand (NRCS, 2018).

- The Tequesta muck is an organic rich soil of the Kissimmee River alluvial floodplain (red units in the figure).
- The Floridana fine sand is found in low-lying areas that are ponded frequently, or in former natural drainages (also light green units in the figure, generally in depressional wetlands).

Slough and freshwater marsh soils consist of fine sands, silts, and organics. These soils generally are poorly drained and frequently ponded. These are hydric soils, found in areas with longer hydroperiods (typically 9–12 months) and greater maximum depths of flooding.

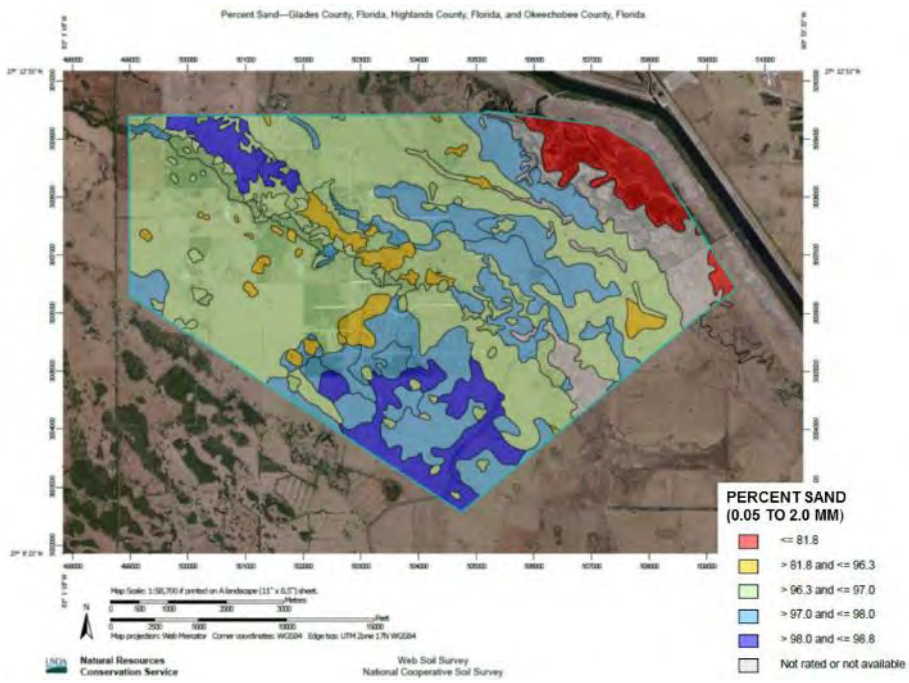


Figure C-1. Soil map showing percent sand in surface soils (NRCS, 2018).

C.1.1.2.3 Aquifers

The lithologic units described in **subsection C.1.1.2.1** include permeable zones known as aquifers and low-permeability zones that are confining units. The aquifer systems are the Surficial Aquifer System (SAS), the Intermediate Aquifer System (IAS), and the Floridan Aquifer System (FAS) (Miller, 1990). The SAS (or water table aquifer) in the project area is unconfined and is included in the Pliocene-Pleistocene marine sands. The base of the SAS corresponds with the upper surface of the Hawthorn Group sediments, which also serves as the upper surface of the Intermediate Confining Unit (ICU).

The ICU may include one or more permeable zones that qualify as aquifers, particularly in the western portion of the project area. Lithologic heterogeneity of Hawthorn Group sediments results in permeable zones in quartz sand units, bounded by clay-rich confining units. The Sandstone Aquifer and the Mid-Hawthorn Aquifer together comprise the IAS in west-central Florida (Reese and Richardson, 2008). An exploratory borehole at the Brighton Reservation yielded a productive coarse sand aquifer at depths of 250–340 ft. bls, but it is not clear if this permeable zone is correlative with the Sandstone Aquifer defined farther west (Missimer Groundwater Science, 2007). IAS/ICU is recognized at Paradise Run (CH2MHill, 2008) at depths of 140–550 ft., but discrete permeable zones and confining units are not defined. At KRASR, the ICU is recognized at depths of 150–540 ft. and consists of the Peace River Formation and the Arcadia Formation (CH2MHill, 2004).

The FAS, one of the most productive aquifers on Earth, consists of highly permeable zones and confining units in a thick sequence of marine limestones. In the project area, the FAS consists of the UFA, a middle confining unit, the Avon Park Permeable Zone (APPZ) (Reese and Richardson, 2008), and the Lower Floridan Aquifer (LFA). Only the UFA and APPZ are relevant to the project because they are considered the primary targets for ASR wells.

The UFA is included in the Suwannee Limestone (where present) and the Ocala Limestone throughout the project area. A preferential flow zone is often observed at the unconformable contact between the Arcadia Formation/basal Hawthorn unit and the uppermost Ocala Limestone (Reese, 2014). The preferential flow zone occurs at or near the top of the UFA and is a regional feature, as it appears in the Brighton exploratory well, at KRASR, and farther eastward from the project area (Reese, 2014). Groundwater flow logging indicated that this flow zone accounts for 80% of the artesian flow from the UFA at KRASR (Mirecki et al., 2013).

The Middle Confining Unit 1 (MCU1) separates the UFA from the underlying APPZ. In the project area, the MCU1 is regarded as a “leaky” confining unit that separates the lower portions of the UFA from the APPZ. The top of the MCU1 occurs at depths of approximately 850 ft. in the project area (Reese and Richardson, 2008).

The APPZ occurs between the MCU1 and the deeper Middle Confining Unit 2 (MCU2), within the upper portions of the Avon Park Formation throughout south Florida. The APPZ is primarily fracture-dominated, resulting in a confined aquifer that shows high transmissivity (Reese and Richardson, 2008). The APPZ is tentatively identified throughout the project area (Reese and Richardson, 2008; Reese, 2014) with the deepest occurrence in western Glades County (Brighton exploratory borehole, 1,700 ft.; Missimer Groundwater Geoscience, 2007).

C.1.1.3 Vegetative Communities

The vegetation within the Lake Okeechobee region has been greatly altered during the last century. Historically, the natural vegetation was a mix of wet and dry prairies, freshwater marshes, hardwood swamps, cypress swamps, mesic temperate hammock, and pine flatwoods. Although some of these natural areas still exist, the introduction of controlled drainage for agriculture and land development has resulted in a significantly different set of land cover types. North of Lake Okeechobee, improved pasture and rangeland comprises about half of the study area. Other agricultural uses include citrus, cropland, dairies, silviculture, and sugarcane. Natural lands and open water occupy approximately 34% of the landscape. Urban and residential land areas occupy about 5% of the study area. Today’s native vegetative

communities in the watershed include primarily cabbage palm and oak hammocks, pine flatwoods, and freshwater marsh. Lesser amounts of wet prairie, cypress, and other swamps are also present.

C.1.1.3.1 Lake Okeechobee Watershed

The conversion of natural areas for urban and agricultural uses and the network of C&SF Project canals have altered the natural system, causing complete shifts in vegetative communities. Historically, the LOWRP project area was composed of approximately 40% wetlands, consisting of cypress and bay tree forests, inland swamps, freshwater marsh, wet prairie, and sawgrass marsh (Davis, 1943). Currently, only 15% of the original habitat remains within the LOWRP area. This substantial reduction in the spatial extent of watershed wetlands (approximately 330,000 acres) is exacerbated by a reduction in the function of the remaining wetlands, as many of them have lost vital hydrologic connections. 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.

C.1.1.3.1.1 Upland Communities

In this subsection, five types of upland communities are discussed.

Mesic Temperate Hammock: Mesic temperate hammocks (also known as upland hardwood forest, upland mixed forest, prairie hammock, and xeric and hydric hammock) are temperate, broad-leaved, evergreen forests. These forested communities are common throughout the project watershed. They are floristically transitional between the tropical forest of southern Florida and the southern mixed hardwood forest of north Florida (Greller, 1980). Mesic temperate hammocks are generally closed-canopy forests, dominated primarily by live oak (*Quercus virginiana*) and cabbage palm (*Sabal palmetto*). Moist soils have a dense litter layer but are seldom inundated. They are naturally protected by fire because of their transitional position in the landscape. They occur as generally small islands in expanses of dry prairie composed of saw palmetto and graminoid species (FNAI, 1995; Hilsenbeck and Hedges, 1994).

No federally listed plant species inhabit the mesic temperate hammocks, but two state listed species, wild coco and twisted air plant, may be present. The wild coco is a terrestrial orchid occurring primarily in the dry prairies and mesic temperate hammock islands. The twisted air plant is an epiphytic bromeliad that grows on trees in mesic hammocks, swamps, hydric pine flatwoods, and xeric hammocks.

Mesic Pine Flatwoods: The mesic pine flatwoods (also known as pine savanna, cabbage palm savanna, and pine barrens) are open canopied forests of pines with a dense groundcover of herbs and shrubs. Within the Lake Okeechobee watershed, this community type is found primarily in portions of Glades and Highlands counties. They provide essential forested upland habitat, furnishing refuge and cover in the form of tree canopy, tree cavity, and nesting. The Florida Natural Areas Inventory (FNAI) characterizes mesic flatwoods as flatland with a sand substrate visited by annual or frequent fires. Characteristic vegetation includes a slash pine (*Pinus elliotti*) or longleaf pine (*Pinus palustris*) overstory with an understory/groundcover consisting of saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), and/or wiregrass (*Aristida beyrichiana*) or cutthroat grass (*Panicum abscissum*). These flatwoods provide the principal dry ground in the watershed.

One federal/state-listed endangered plant, Carter's mustard, occurs in the watershed in Highlands County primarily in dry, shrub-dominated habitat. It is a fire-dependent, annual, fall-flowering herb. Additional state-listed plant species include pinewood bluestem, hartwrightia, thick-leaved water willow, southern red lily, and yellow fringeless orchid.

Hydric Pine Flatwoods: The hydric pine flatwoods (also known as low flatwoods, moist pine barren, hydric flatwoods, and cabbage palm/pine savanna) are seasonally inundated wet flatwoods that function as both a wetland and an upland. Hydric pine flatwoods contain the highest plant species diversity of any habitat in south Florida. They are dominated by a slash pine overstory with a wetland plant understory.

Dry Prairie: The dry prairie community (also known as palmetto prairie, saw-palmetto prairie, and wiregrass prairie) is endemic to central peninsular Florida. The loamy to clayey subsoils are saturated in the wet season, providing substrate for both upland and wetland plant species. This treeless, fire-maintained landscape is dominated by wiregrass, saw palmetto, and runner oak (*Quercus minima*). Harshberger (1914), Harper (1927), and Davis (1943) identified extensive areas of dry prairie in the south-central peninsula, encompassing portions of the lower Kissimmee River, Fisheating Creek, and lower Peace River watersheds. No federally listed plant species are known from the dry prairie; the many-flowered grass-pink is the only state endangered plant species that may occur.

Cutthroat Grass Communities: Cutthroat grass communities (also known as cutthroat seeps, cutthroat grass seasonal ponds, and cutthroat grass flatwoods, and swale) are dominated by cutthroat grass (*Panicum abscissum*) and exist almost exclusively within Polk and Highlands counties in association with the sideslope seepages of the central Florida ridges. These diverse communities vary by topography, hydrology, soils, and vegetation, but they are all fire-dependent, graminoid-dominated communities (Abrahamson et al., 1984). Cutthroat grass is a state-listed endangered species (Coile, 2000) and is ranked as imperiled at the global and state levels by FNAI (Marois, 1997). The Highlands County soil survey (Carter et al., 1989) recognizes the Basinger-St. Johns-Placid complex as a specific soil-mapping unit corresponding to cutthroat seeps in the county. The greatest extent of cutthroat grass communities on the Lake Wales Ridge is on the eastern slope of the ridge in the northwestern fringe of the Lake Okeechobee Watershed. It is also present to a lesser degree along Bootheel Creek in the Fisheating Creek Basin. A diverse array of state-listed plant species is quite common in the cutthroat grass community, including cutthroat grass, many-flowered grass-pink, Edison's ascyrum, *Lilium catesbaei*, *Pinguicula caerulea*, *P. lutea*, *Platanthera blephariglottis* var. *conspicua*, *P. integra*, *P. ciliaris*, *P. cristata*, and *Sarracenia minor*.

C.1.1.3.1.2 Wetland Communities

In this subsection, five types of wetland communities are discussed.

Freshwater Marshes and Wet Prairies: In the Lake Okeechobee watershed, freshwater marshes and wet prairies are found as zones along topographical gradients throughout the entire watershed. The higher-elevation wetlands with shorter hydroperiods and shallower flooding are classified as wet prairies. The lower-elevation wetlands with long hydroperiods are designated as freshwater marshes. Freshwater marshes include the sawgrass marshes, cattail marshes, flag marshes, sloughs, mixed emergent grass/sedge marshes, open-water marshes, submerged vegetation marshes, and floating vegetation marshes. Freshwater marshes are vegetated primarily with sawgrass (*Cladium jamaicense*) and scattered clumps of Carolina willow (*Salix caroliniana*), sweetbay (*Magnolia virginiana*), and cypress (*Taxodium* spp.). The wet prairies include sawgrass prairies, wiregrass prairies, and savannas. The distribution of

dominant vegetative species in wet prairies and freshwater marshes is dependent on soil type, depth, and hydrological conditions (Kushlan, 1990). Most of these plant associations are found in the Kissimmee River floodplain and Lake Okeechobee perimeter marshes. These Lake Okeechobee communities are frequently the littoral zones associated with lakes, creeks, and rivers. Soils have changed with shifts in water management practices in Lake Okeechobee; this is reflected in variations in hydrology and vegetative decomposition rates (Brown et al., 1990).

Flowing Water Swamps: Flowing water swamp communities (also known as floodplain swamp, slough, and strand swamp) are seasonally inundated, forested wetlands associated with drainage channels. These communities are generally deep swamps with long-term flooding. They are often degraded by silviculture/agriculture drainage-control activities and agricultural/urban runoff pollution. Exotic species control is also a major concern. Kissimmee River, Fisheating Creek, Taylor Creek, and Nubbin Slough are lined with floodplain swamps.

Pond Swamps: Pond swamps (also known as basin swamps, dome swamps, cypress swamp, and cypress ponds) are seasonally inundated forested wetland depressions. This includes the swamps associated with lake borders as well as smaller cypress domes and gum ponds. Dome swamps typically appear in sinkhole depression landscapes with peat soils, while larger basin swamps are common in landscape depressions with acidic, nutrient-poor peats with an overlying clay lens or other impervious layer. Sugarcane planting destroyed the pond apple swamp that historically bordered the southern edge of Lake Okeechobee. Continuing soil oxidation has further degraded this system. Many other systems have been destroyed/degraded by silviculture, drainage, impoundment, or pollution. The Cypress Creek/Trail Ridge is another example of pond swamp mosaic in the watershed. Typical dome swamp plants include pond cypress (*Taxodium ascendens*), red maple (*Acer rubrum*), dahoon holly (*Ilex cassine*), swamp bay (*Persea palustris*), sweet bay (*Magnolia virginiana*), wax myrtle (*Myrica cerifera*), buttonbush (*Cephalanthus occidentalis*), St. John's wort (*Hypericum* spp.), chain fern (*Woodwardia* spp.), and fireflag (*Thalia geniculata*). Basin swamp plants include blackgum (*Nyssa sylvatica*), cypress, slash pine, red maple, swamp bay, sweet bay, loblolly bay (*Gordonia lasianthus*), and Virginia willow (*Itea virginica*). A federally endangered plant species, the Okeechobee gourd (*Cucurbita okeechobeensis* ssp *okeechobeensis*), was once common in the pond apple swamp along the southern edge of Lake Okeechobee. This gourd now occurs sporadically inside the levee that encircles Lake Okeechobee (southern end and western littoral marsh) (USFWS, 1995).

Seepage Swamps: Seepage swamps (also referred to as hydric hammock, baygall, bog, wetland hardwood hammocks, shrub bog, and sweetbay swamp) are characterized by their saturated soils. They include baygalls and hydric hammocks on low sand or limestone rises within ephemeral wetland systems. These systems burn only every 50 to 100 years because of their hydrology. Baygalls once fringed the Lake Wales Ridge but were cleared for caladium/gladiola farms. Seepage swamps are degraded by hydrological alterations and agricultural/urban runoff. Cabbage palms in hydric hammocks have been removed in large numbers for use in landscaping. Baygalls occur at the base of a slope that has a saturated peat substrate. Bog bayheads occur in peat soil depressions. Hydric hammocks occur on flat, wet, limestone-surfaced sandy lowlands. Baygalls and bayheads are composed of evergreen hardwoods including sweetbay, swamp bay, red bay (*Persea borbonia*), and loblolly bay with sphagnum moss/fern groundcover. Hydric hammocks are dominated by cabbage palms, laurel oaks (*Quercus laurifolia*), and other hardwoods with minimal groundcover. Some important seepage slopes in the Okeechobee watershed include Cypress Creek/Trail Ridge at SR 70 and the Bluefield Road area, and the seepage swamps of Fisheating Creek. Imperiled plants include star anise (*Illicium parviflorum*), hand fern (*Cheiroglooa palmata*), and auricled spleenwort (*Asplenium auritum*).

Open Water: Open-water habitats in the project watershed consist primarily of the aquatic communities in the Kissimmee Waterway (C-38), Fisheating Creek, Taylor Creek, Harney Pond Canal (C-41), Indian Prairie Canal (C-40), and the many other canals in the project watershed. The invasion of exotic vegetation has rapidly expanded throughout these areas. Included among these troublesome species are water hyacinth (*Eichornia crassipes*), water lettuce (*Pistia stratiotes*) and hydrilla (*Hydrilla verticillata*).

C.1.1.3.2 Lake Okeechobee

The majority of the surface of Lake Okeechobee (450,000 acres) is not vegetated; it provides open water (pelagic and nearshore) habitat. Open water habitat within Lake Okeechobee covers about 75% of the lake's surface area.

A 100,000-acre (157-square-mile) littoral zone is found mostly along Lake Okeechobee's northwestern and western edge and on the islands in its southern shore (Kraemer Island, Torry Island, and Ritta Island, which together encompass 4,000 acres). There also is a small amount of littoral zone on the northeastern edge of the lake. The extended drought in 2007-08 resulted in the littoral zone spreading offshore into most of South Bay. Since the high water levels in the winter of 2016 and fall of 2017, the edge of this portion of the littoral zone has moved toward the southern shoreline. The littoral zone supports more than 50 species of emergent, submerged, and floating-leaf plants. Emergent vegetation within the littoral zone is dominated by herbaceous species such as cattail (*Typha* spp.), spike rush (*Eleocharis cellulosa*), and the invasive exotic torpedo grass (*Panicum repens*). Other emergent vegetation includes giant bulrush (*Schoenoplectus californicus*), sawgrass, pickerelweed (*Pontederia cordata*), duck potato (*Sagittaria* spp.), beakrushes (*Rhynchospora* spp.), wild rice (*Zizania aquatica*), arrowhead (*Sagittaria latifolia*), buttonbush (*Cephalanthus occidentalis*), sand cordgrass (*Spartina bakeri*), umbrella-grass (*Fuirena scirpoidea*), southern cutgrass (*Leersia hexandra*), maidencane (*Panicum hemitomon*), white vine (*Funastrum clausum*), dogfennel (*Eupatorium capillifolium*), and mikania (*Mikania scandens*). Woody vegetation consists of primrose willow (*Ludwigia* spp.), Carolina willow, and the invasive exotic melaleuca (*Melaleuca quinquenervia*). Over the years, there has been an ongoing effort to eradicate melaleuca in the Lake Okeechobee region. The eradication effort has been extremely effective.

Submerged vegetation within Lake Okeechobee is composed primarily of the invasive exotic species hydrilla (*Hydrilla verticillata*), eelgrass (*Vallisneria americana*), pondweed (*Potamogeton illinoensis*), bladderwort (*Utricularia* spp.), muskgrass (*Chara* spp.), and coontail (*Ceratophyllum demersum*).

The floating component of the littoral zone vegetation consists of lotus lily (*Nelumbo lutea*), fragrant water lily (*Nymphaea odorata* and *N. mexicana*), the invasive exotic water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), duckweed (*Lemna* spp.), coinworts (*Hydrocotyle* spp.), and primrose willow (*Ludwigia* spp.).

C.1.1.3.3 Northern Estuaries

Submerged aquatic vegetation (SAV), which includes seagrass and macroalgae, is one of the most important vegetation communities of the St. Lucie River, Indian River Lagoon, and the Caloosahatchee River and Estuary (IRL CCMP 1996). These communities are highly productive, providing food and habitat for fish, sea turtles, manatees, a myriad of invertebrates, and other species. Seagrass meadows improve water quality by removing nutrients, dissipating the effects of waves and currents, and stabilizing bottom habitats (thereby reducing suspended solids). Seagrass beds support some of the most abundant and diverse fish populations. Many commercial and recreational fisheries (e.g. clams, shrimp, lobster, and fish)

are associated with healthy seagrass beds (USFWS 1999). Currently, many SAV beds are stressed. Where not completely eliminated, they have been reduced by extreme salinity fluctuations, increased turbidity, sedimentation, dredging, damage from boats, and nutrient enrichment which causes cyanobacteria blooms that, in turn, restrict light penetration.

C.1.1.3.3.1 Upper Caloosahatchee River and Estuary

In terms of distribution and abundance, tape grass has been the dominant species in the upper Caloosahatchee River and Estuary, colonizing fresh water and oligohaline littoral zones in water less than one meter deep (Chamberlain and Doering 1998a). In the early 1990s, tape grass covered approximately 1,000 acres and about 60% of the coverage occurred within an 8-kilometer (km) stretch between Beautiful Island and the Fort Myers Bridge (Hoffacker 1994). Total longitudinal cover ranged from 14 to 32 km upstream from Shell Point (Chamberlain and Doering 1998b). Tape grass can typically tolerate salinities of 3 to 5 practical salinity units (psu) with few long-term effects if light conditions are sufficient (Haller et al. 1974, French and Moore 2003, Jarvis and Moore 2008). Declines in tape grass began in 2000 as a result of salinities exceeding the species' tolerance (Doering et al. 2001). There was some recovery by 2006; however, dramatic declines were observed beginning in late 2006 as a result of high salinities (RECOVER 2009). During this period, widgeon grass (*Ruppia maritime*) was the dominant species, although it never achieved even the minimum abundance recorded for tape grass (Burns et al. 2007).

The effects of hurricane water high flows in 2005 resulted in decreased plant cover and density at some sites in the latter half of 2005. Compounding the high turbidity effects from freshwater high flows in 2005, drought conditions caused precipitous increases in salinities beginning in October 2006. Salinity levels went from 10 to 25 psu from November 2006 through April 2008. During the period December 2005 to April 2006, lower water clarity due to high turbidity was associated with lower shoot density and cover. The loss of plants was quite rapid with, a significant end-of-year dieback in 2006 followed by no regrowth in spring 2007. Salinities finally declined between April and October 2008, but tape grass recovery has been slow. This may be related to a lack of propagules, as nearly all the tape grass was lost during the late 2006 to 2008 high salinity period. It may also be related to herbivory or other impacts on the initial recolonization of recruits into the area, as leaves were sometimes noted as missing their tips (RECOVER 2009).

C.1.1.3.3.2 Lower Caloosahatchee River Estuary

Historically, several species of SAV have been routinely reported during surveys in the lower Caloosahatchee River Estuary upstream of Shell Point. These include shoal grass (*H. wrightii*) and turtle grass (*Thalassia testudinum*) (Chamberlain and Doering 1998a, Wilzbach et al. 2000, Burns et al. 2007). In more recent reports, manatee grass (*Syringodium filiforme*) has been reported in San Carlos and Tarpon Bays (Wilzbach et al. 2000, Burns et al. 2007). Shoal grass coverage, described as abundant, has been at 300 acres; about 75% of this occurred between 2 and 8 km upstream of Shell Point (Chamberlain and Doering 1998b).

From 2004 to 2008, the lower estuary was dominated by shoal grass. Although widgeon grass was observed occasionally (Burns et al. 2007), only very low densities were found in the lower estuary when surveys were searching specifically for it. High salinity fluctuations with tides and shading by shoal grass may limit its growth. Low salinities during higher rainfall periods and high flow events observed since 2004 likely prevented the survival of seagrass species such as turtle grass (Burns et al. 2007). Water clarity was

poor in 2004 and 2005, preventing SAV growth in waters greater than 0.7 meter deep. Water clarity conditions improved in 2007 and were sufficient for growth down to 1.2 meters.

Hurricane effects lowered SAV abundance in 2005 and 2006, but subsequent shoal grass recovery in 2007 was evident, with cover in 2007 exceeding 2004 levels. Salinities of 1 psu or less occurred each year from 2004 to 2006 due to high rainfall within the watershed.

C.1.1.3.3.3 St. Lucie Estuary

The outer St. Lucie Estuary and Southern Indian River Lagoon support six species of seagrass: shoal grass, manatee grass, turtle grass, paddle grass, star grass *(Halophila engelmannii*), and the threatened Johnson's seagrass (*Halophila johnsonii*). Johnson's seagrass was listed as threatened under the Endangered Species Act (ESA) in 1998, and critical habitat was designated in 2000. The species has a very limited distribution along the east coast of Florida from central Biscayne Bay to Sebastian Inlet. Major threats include propeller scarring, dredging, sedimentation, and degraded water quality. Shoal grass and manatee grass are the dominant canopy species in the lagoon (Thompson 1978, Dawes et al. 1995, Morris et al. 2000). While all of these species are most successful in salinities greater than 20 psu, *s*hoal grass can tolerate a wide range of salinity and salinity variations. However, manatee grass is not as tolerant of low or widely varying salinities (Irlandi 2006).

The SAV distribution has been mapped in the outer St. Lucie Estuary and the Southern Indian River Lagoon every two to three years since 1986, including annual mapping from 2005 through 2007 to help assess hurricane impacts. In 2007, very sparse SAV (< 10% cover in most areas) was present in the lower and middle estuary (RECOVER 2009). Three seagrass species occurred within the estuary: shoal grass, Johnson's seagrass, and paddle grass. The majority of the SAV occurred in small isolated patches. The dominant SAV species in 2007 was Johnson's seagrass. It also extended farther upstream than any other SAV species (RECOVER 2009).

This region was impacted by hurricanes and associated freshwater high flow events in 2004 and 2005. Following the hurricanes, observed impacts to southern Indian River Lagoon SAV communities included large coverage and density declines, and smaller direct impacts due to burial by shifting bottom sediments. Lush manatee grass beds were documented through 2004; however, low salinities and associated poor water quality following the 2004 and 2005 hurricanes greatly impacted manatee grass in the area. The hurricanes also altered bathymetry on the east and west edges of the lagoon, covering seagrasses. The steepest decline in percent occurrence of manatee grass occurred in 2005 after Hurricane Wilma. Johnson's seagrass, followed by shoal grass, colonized the former manatee grass habitat and recruited throughout the site.

C.1.1.4 Threatened and Endangered Species

The U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and State of Florida have designated certain species of fish, amphibians, reptiles, birds, mammals, gastropods, and plants and lichens in Okeechobee, Highlands, Glades, Lee, Martin, and St. Lucie counties as threatened or endangered. Several of these listed species have been observed within the project area. Additional detail can be found in the Biological Assessment (BA) included in **Annex A**.

C.1.1.4.1 Federally Protected Species

The U.S. Army Corps of Engineers (USACE) has coordinated the existence of federally listed species with the USFWS and NMFS, as appropriate. Federally listed threatened and endangered species are either known to exist or potentially exist within the project area; subsequently, they may be affected by the proposed project. Many of these species have been previously affected by habitat impacts resulting from uplands conversion, wetland drainage, alteration of hydroperiods, wildfire, and water-quality degradation. For a complete list of federally threatened and endangered species, their critical habitat, and candidate species, refer to the Biological Assessment (BA) included in **Annex A**. The BA also includes descriptions for each species.

C.1.1.4.1.1 Florida Grasshopper Sparrow

The Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) is a subspecies of grasshopper sparrow that is endemic to the dry prairie of central and southern Florida. This subspecies is extremely habitat-specific and relies on fire every two to three years to maintain its habitat. This species was listed as endangered by the State of Florida in 1977. The USFWS listed the Florida grasshopper sparrow as endangered in 1986 because of habitat loss and degradation resulting from conversion of native vegetation to improved pasture and agriculture. Today, this species is the most endangered bird in North America and is represented by less than 100 individuals, with about half of the population in captive breeding. Critical habitat has not been designated for this species.

The sparrow is so highly endangered due in large part to its exclusive dependence upon Florida dry prairie habitat, more than 85% of which has been destroyed. Some prairie habitat may have disappeared due to infrequent burn regimes from fire prevention, or from planting slash pine, but most prairie loss has resulted from conversion to domestic pasture grasses, which support more cattle per acre and can support some species of prairie wildlife, but not this sparrow. This “improved pasture” lacks the structure that these birds need. Research indicates the sparrows need native prairie in prime condition—it should burn every two years and as a result have virtually no brush or trees. Burns at the end of the dry season (April-June) are considered better than other times of the year.

Figure C-2 shows locations of potential Florida grasshopper sparrow habitat in the project area. Such habitat consists of large (greater than 50 hectares), treeless, relatively poorly drained grasslands with a history of frequent fires (USFWS 1988, Delany 1996). The Florida grasshopper sparrow occurs in prairies dominated by saw palmetto (*Serenoa repens*) and dwarf oaks (*Quercus minima*) ranging from 30 to 70 cm in height. Bluestem grasses (*Andropogon* spp.), St. John’s wort (*Hypericum* spp.), and wiregrasses (*Aristida* spp.) are also components of grasshopper sparrow habitat (Delany et al. 1985, USFWS 1988). These dry prairies are relatively flat and are moderately to poorly drained. The soils typically consist of 0.3 to 1.0 m of acidic, nutrient-poor quartz sands overlying a high clay subsoil or organic hardpan (spodic horizon) (FNAI and FDNR 1990, Abrahamson and Hartnett 1990). Both the heavy subsoil and hardpan reduce the movement of water below and above their surfaces (FNAI and FDNR 1990). Thus, dry prairies may become flooded for short periods during the rainy season, but remain dry for the remainder of the year. The water table in these prairies is normally found between several centimeters and a meter below the soil surface.

The main difference between dry prairies and pine flatwoods is that pines and palms are absent or at a density below one tree per acre. Grasshopper sparrows, however, cannot tolerate tree densities as high as one tree per acre. Some dry prairies may be artifacts of clearcutting, unnaturally frequent burning,

livestock grazing, and alteration of hydrology which provide habitat for the sparrow (Abrahamson and Hartnett 1990).

Despite much understanding of their habitat requirements, sparrow populations have declined on all three conservation lands where they remain, with 2016 reporting the lowest counts in history. Unfortunately, reasons for the decline are unknown but suspects include suboptimal habitat management, fire ants and other predators destroying nests, diseases, and genetic problems.

The Avon Park Bombing Range sub-population dropped from about 130 singing males in 1999 to only 10 in 2004. In recent years, only a few singing males and a handful of successful nests have been detected. In a similar fashion, the counts of singing males at Kissimmee Prairie Preserve State Park declined from 150 a decade ago to only a few found on the entire 50,000-acre property. At Three Lakes Wildlife Management Area, where as many as 140 singing males have been counted, recent counts have been fairly stable at about 60 singing males, but still seem to be sliding downward. The populations at Three Lakes Wildlife Management Area and Kissimmee Prairie Preserve State Park now have fewer birds than were recorded at Avon Park prior to its rapid population crash. At these population levels, genetic problems become a major concern.

Figure C-2. Florida grasshopper sparrow potential habitat (USFWS 2017).

C.1.1.4.1.2 Northern Crested Caracara

The raptor northern crested caracara (*Polyborus plancus audubonii*, family Falconidae), federally listed as threatened, is found primarily in Florida, Texas, and New Mexico (although only the Florida population is listed under the ESA). In Florida, it occurs as an isolated population in the south-central region of the state. They are found in greatest abundance in five counties north and west of Lake Okeechobee (Glades, Desoto, Highlands, Okeechobee, and Osceola). They forage in the wet and dry prairies, improved pastures, rangeland, and other open areas of the watershed, nesting primarily in cabbage palms surrounded by low herbaceous vegetation, including the cabbage palm/live oak "islands" of mesic temperate hammocks. This

raptor has been found almost exclusively in cabbage palms found on improved or semi-improved pastures on privately owned cattle ranches in the south-central part of the state. Northern crested caracaras utilize pine flatwoods during the cooler months, particularly in the Highlands County portion of the watershed. Mesic cabbage palm clusters are of primary importance for seasonal foraging of this raptor.

Available evidence suggests that the most serious threat to Florida's caracara population is loss or degradation of nesting and feeding habitat. Such loss is most commonly due to conversion of pasture and other grassland habitats and wetlands to citrus, sugar cane, other agriculture, and urban development.

Figure C-3 shows northern crested caracara nests around Lake Okeechobee. **Figure C-4** shows the potential habitat within the proposed reservoir locations.

Figure C-3. Caracara nests and observations (from 1992-2014) around Lake Okeechobee. Source: USFWS 2015.

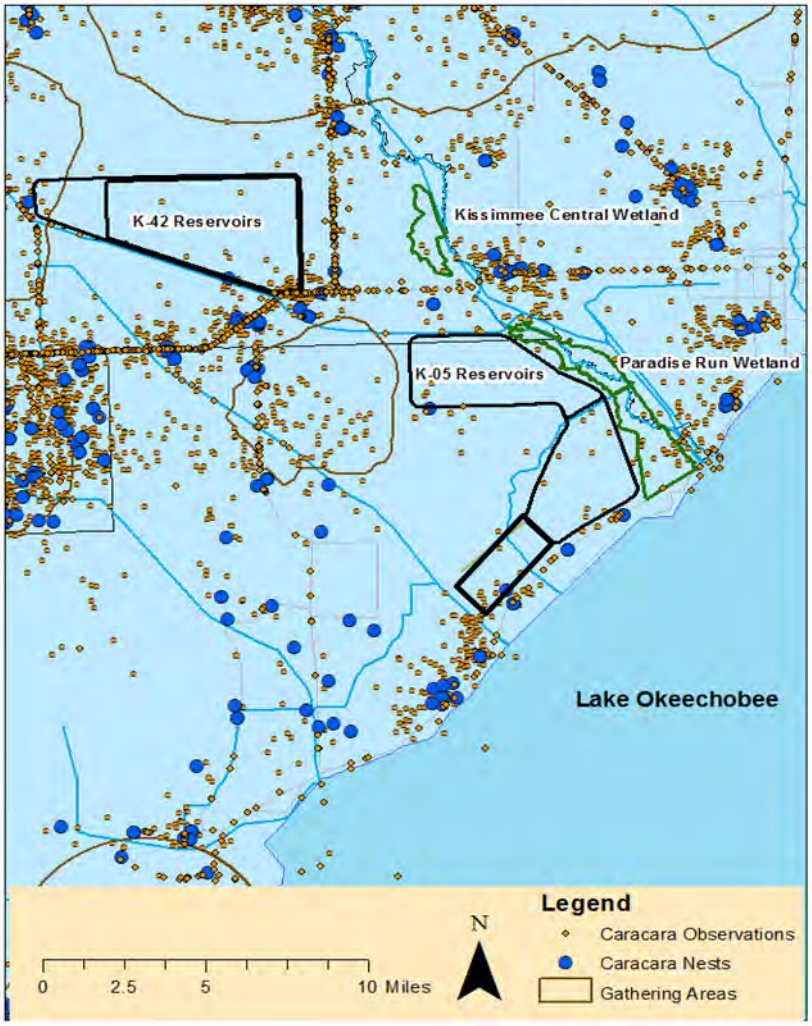


Figure C-4. Caracara nests, gathering areas, and observations (1994-2017, including eBird database observations from January 2010 to May 2017 around Lake Okeechobee). Source: USFWS 2018.

C.1.1.4.1.3 Florida Bonneted Bat

The endangered Florida bonneted bat (*Eumops floridanusis*) is Florida's only endemic bat, as well as its largest, weighing approximately 1.1-2.0 ounces, with a 19-21 inch wingspan, and a body length of 5.1-6.5 inches. They have dark brown fur and large broad ears that join together and slant forward over the eyes.

Relatively little is known regarding the ecology and habitat requirements of this species. In general, bats will forage over ponds, streams, and wetlands. They are nocturnal insectivores that rely on echolocation to navigate and detect prey. They require roosting habitat for daytime roosting, protection from predators, and rearing of young (FFWCC 2011). Florida bonneted bats roost in tree cavities, rocky outcrops, and dead palm fronds. In residential communities, the bats roost in Spanish tile roofs, but they have also been found in attics, and in rock or brick chimneys and fireplaces of old buildings (FFWCC 2011). Colonies are small, with the largest reported numbering just a few dozen individuals. Females give birth to a single pup from June through September (FFWCC 2011); however, limited data suggests that a female may undergo a second birthing season, possibly in January or February.

The range of this species is limited to southern Florida, including two locations within the Kissimmee River Wildlife Management Area north of Lake Okeechobee in 2008. Records indicate that it was once common in the 1950s and early 1960s near Coral Gables and Miami (Belwood 1992). The Florida bonneted bat has been documented in only 10 locations within Florida:

- Coral Gables
- Homestead
- Naples
- Everglades City
- North Fort Myers
- Big Cypress National Park
- Fakahatchee Strand Preserve State Park
- Kissimmee River Wildlife Management Area
- Babcock Ranch
- Fred C. Babcock/Cecil M. Webb Wildlife Management Area

Figure C-5 shows the consultation and focus area of the Florida bonneted bat. Due to the species' small range, the greatest threats to Florida bonneted bats are loss of habitat, including the destruction of natural roost sites, and natural disasters such as hurricanes, since the impact could occur throughout its entire range. Other perceived threats include pesticide and herbicide use, which decreases the population of insects, the bats' primary prey. Critical habitat has not yet been designated for this species.

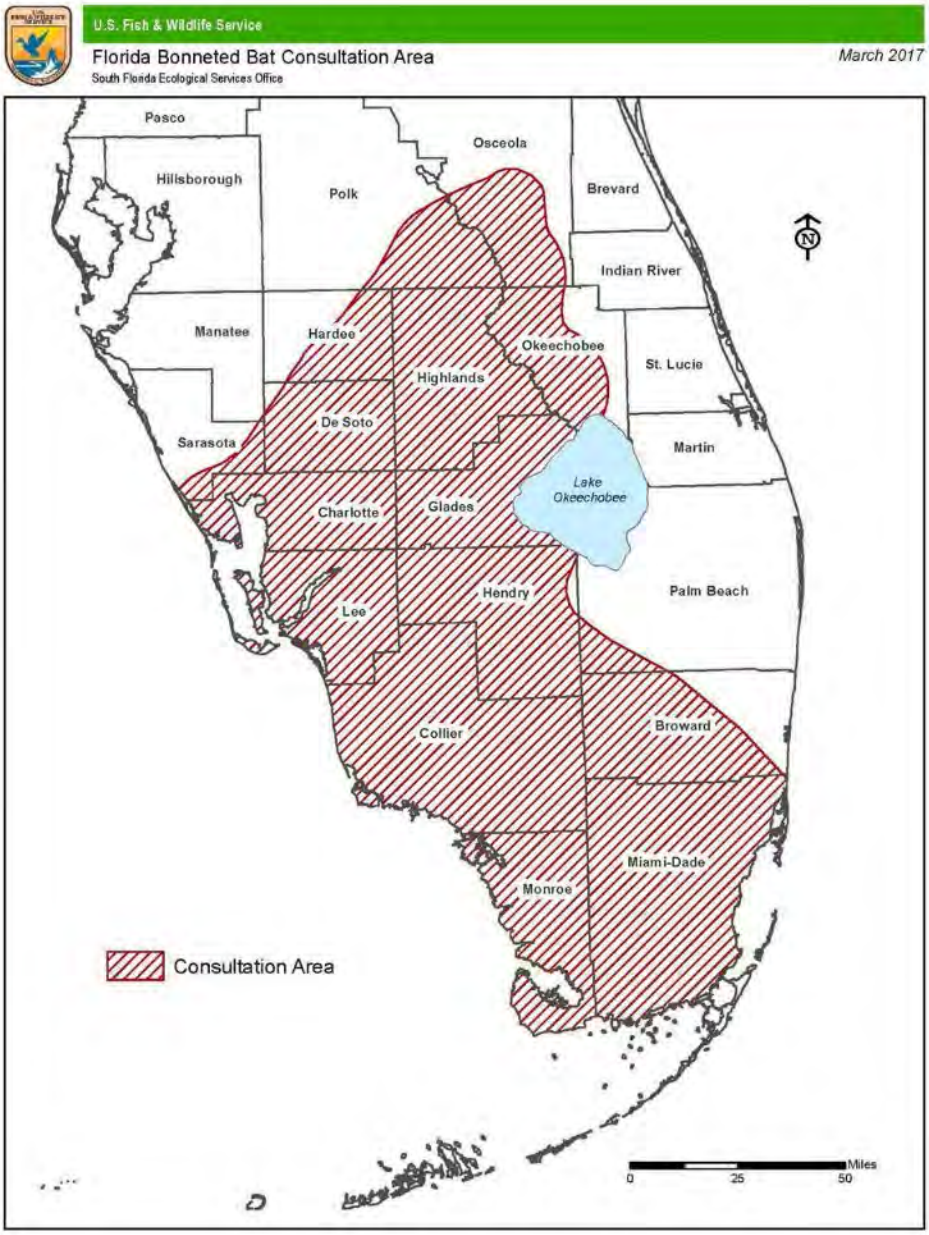


Figure C-5. 2017 Florida bonneted bat (FBB) consultation and focal area (USFWS 2017).

C.1.1.4.1.4 Everglade Snail Kite

The Everglade snail kite (*Rostrhamus sociabilis plumbeus*) is listed as an endangered species by both the USFWS and the State of Florida. Although previously located in freshwater marshes over a considerable area of peninsular Florida, the range of the snail kite is now limited to central and southern portions of Florida. Six large freshwater systems are located within the current range of the snail kite: Upper St. Johns marshes, Kissimmee Chain of Lakes (KCOL), Lake Okeechobee, Loxahatchee Slough, the Everglades, and the Big Cypress basin. Other habitats that have historically supported snail kites include the East Orlando Wilderness Park, the Blue Cypress Water Management Area, the St. Johns Reservoir, and the Cloud Lake, Strazzulla, and Indrio impoundments. In the KCOL, snail kites may occur within most of the lakes and adjacent wetlands, with the majority of snail kite nesting occurring within Lake Kissimmee, Lake

Tohopekaliga, and East Lake Tohopekaliga. Snail kites have also nested in lower numbers on Lakes Hatchineha and Jackson, as well as periodically on Lake Istokpoga since about 2001.

Lake Okeechobee and the surrounding wetlands represent significant historic snail kite nesting and foraging habitats. Lake Okeechobee is of particular importance because it serves as a critical stopover point as snail kites traverse the network of wetlands within their range. A loss of suitable habitat and refugia, especially during droughts in the lake, may have significant demographic consequences. Lake Okeechobee is critical to the snail kite's long-term population persistence, especially given the susceptibility of juvenile snail kites in the Kissimmee River Valley to an increased frequency of local disturbance events due to cold weather and the treatment of hydrilla. The Everglades snail kite apple snail diet is dependent on the hydrology and water quality of the watersheds. Foraging habitat requires shallow open-area ponds with low marsh areas; nesting/roosting sites are located over water. Foraging conditions have expanded recently due to the increase in exotic apple snail population (since about 2010). As a result, the Everglade snail kite breeding season has lengthened (sometimes into fall) and some previous unsuitable foraging areas now have the more robust exotic apple snail and are being utilized by snail kites.

Snail kites nest in both woody and herbaceous vegetation in the Lake Okeechobee littoral zone. Nine critical habitat units were designated in 1977: two small reservoirs, the littoral zone of Lake Okeechobee, and areas of the Everglades' marshes within the water conservation areas (WCA) and Everglades National Park (ENP). Since this designation, the utilization of these units by snail kites as productive nesting areas has varied significantly. In 2012, the KCOL, Lake Tohopekaliga in particular, supported the greatest percentage of snail kites in Florida, while in 2016 they were clustered in Lake Okeechobee and in 2018 in the Everglades region. While the KCOL is now considered an important habitat for the snail kite, this was not the case when critical habitat was designated in 1977, and the KCOL was not included in the original designation. And while the St John's Reservoir critical habitat in Indian River County does not seem to be used, across the street (SR 60), the St. John's Marsh (not critical habitat) was used in most years (from 1996 to 2016) by nesting snail kites. **Figure C-6** shows critical habitat in the project area (USFWS 2015); **Annex A** has more information. **Figure C-7** through **Figure C-9** show snail kite nests around Lake Okeechobee**.**

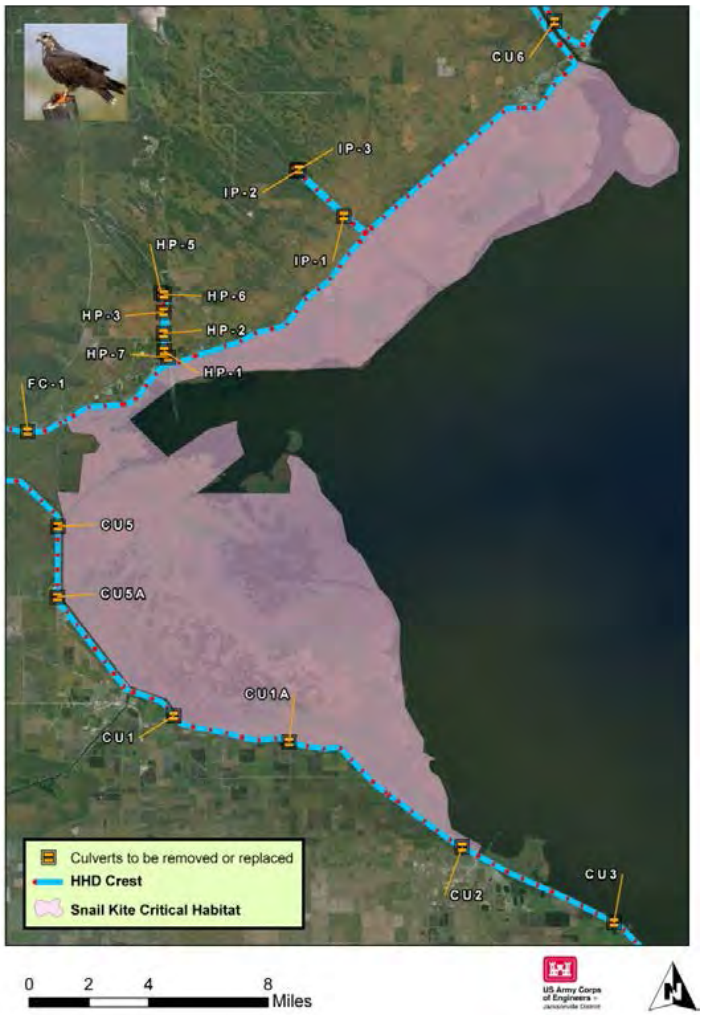


Figure C-6. Snail kite critical habitat. Source: USFWS 2015

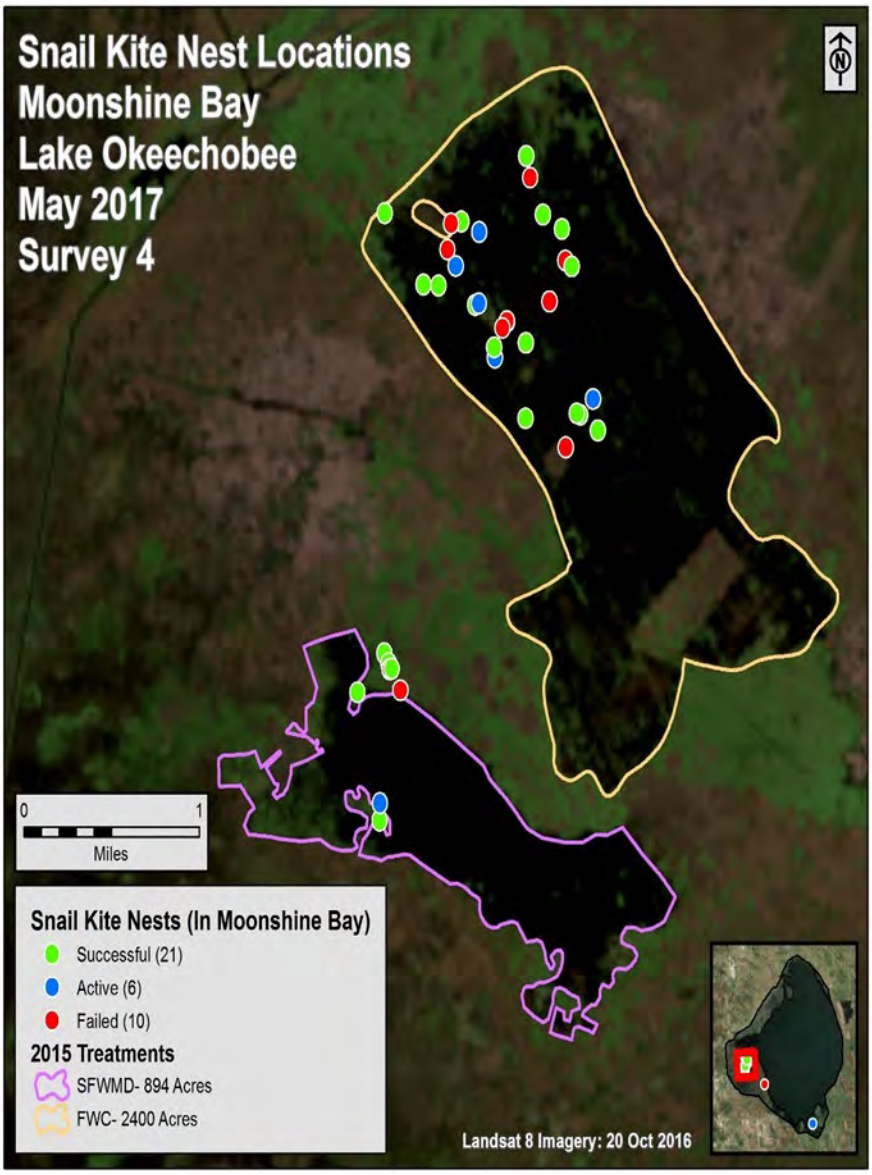


Figure C-7. Snail kite nests in Moonshine Bay.

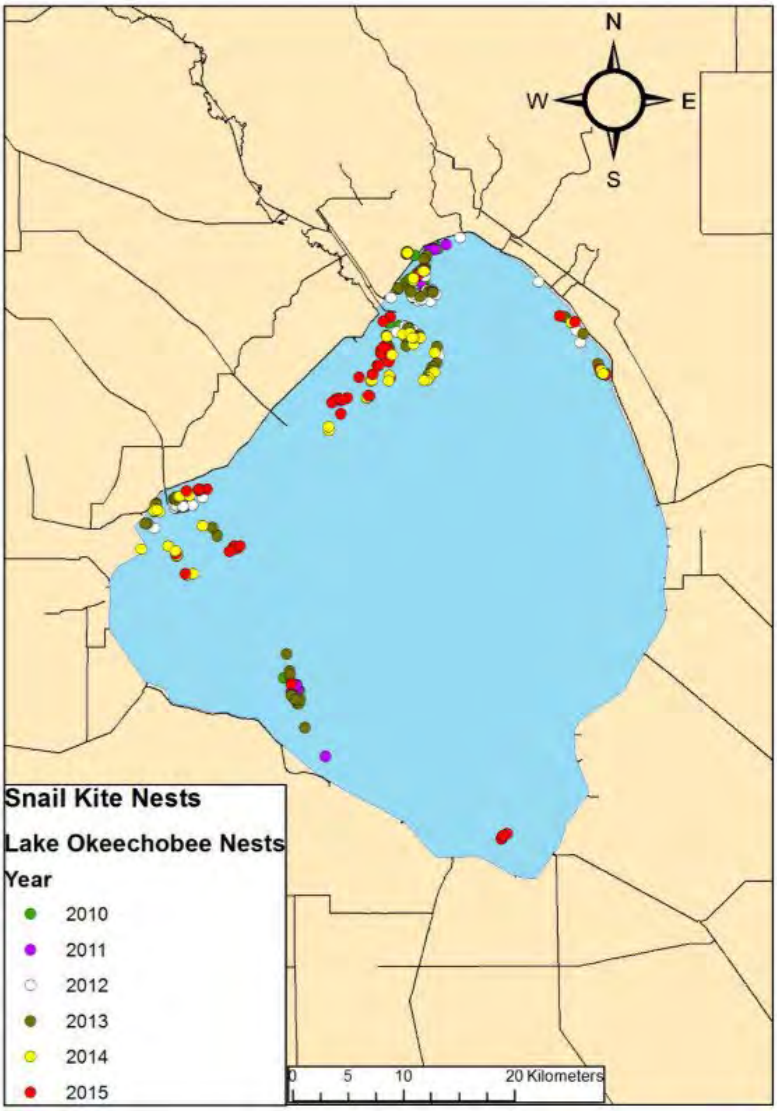


Figure C-8. Snail kite nest locations from 2010-2015 (active nests only). Source: USFWS 2015.

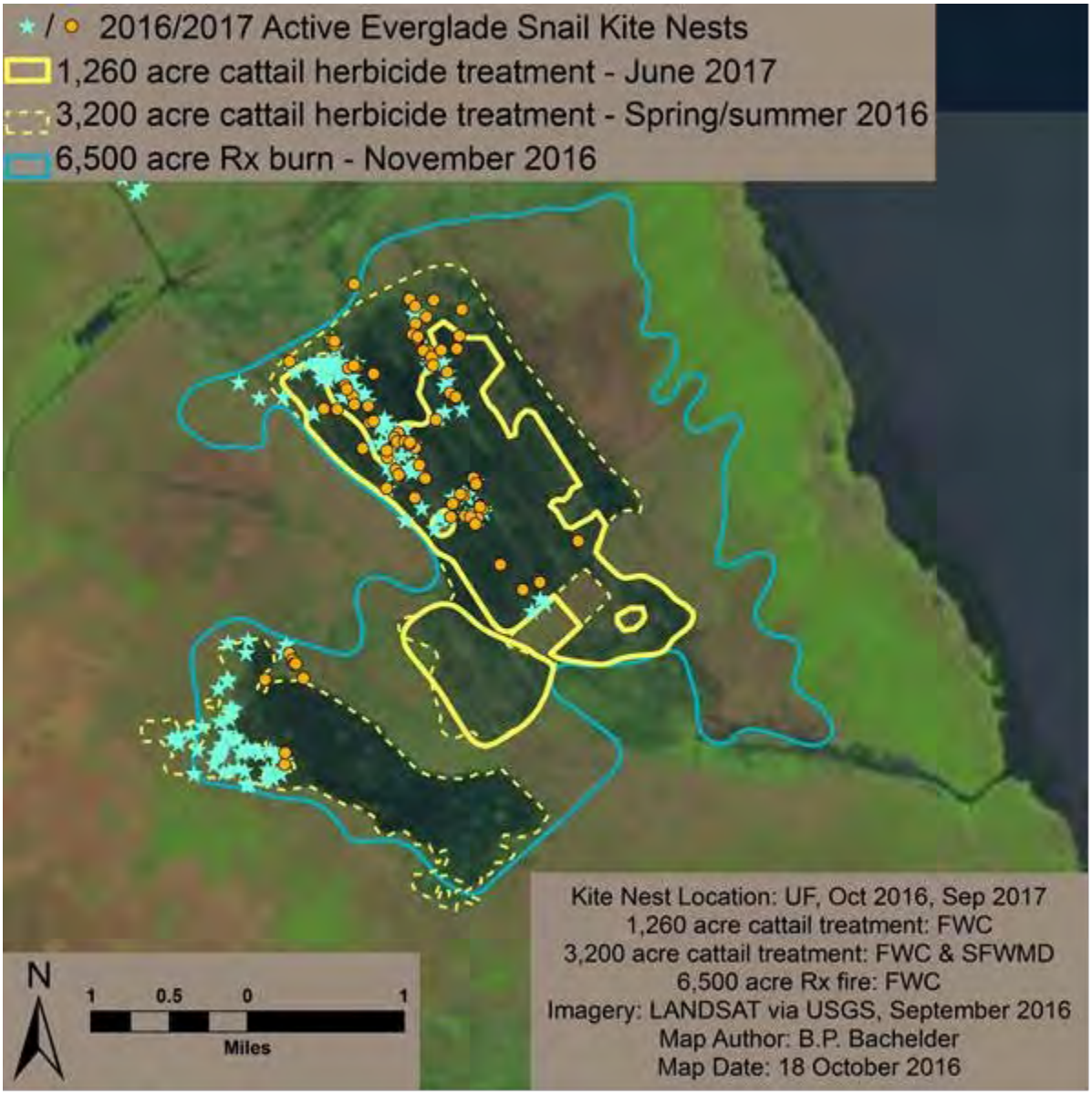


Figure C-9. Active snail kite nests in 2016/2017.

C.1.1.4.1.5 Wood Stork

The wood stork (*Mycteria americanais*) is a large, white, long-legged wading bird that relies upon shallow, freshwater wetlands for foraging. Black primary and secondary feathers, a black tail, and a blackish, featherless neck distinguish the wood stork from other wading bird species. This species was federally listed as endangered under the ESA on February 28, 1984. No critical habitat has been designated for the wood stork.

In the United States, wood storks were historically known to nest in all coastal states from Texas to South Carolina (Wayne 1910; Bent 1926; Howell 1932; Oberholser 1938). Dahl (1990) estimates these states lost about 38 million acres, or 45.6%, of their historic wetlands between the 1780s and the 1980s. However, it is important to note wetlands and wetland losses are not evenly distributed in the landscape. Hefner et

al. (1994) estimated 55% of the 2.3 million acres of the wetlands lost in the southeastern United States between the mid-1970s and mid-1980s were located in the Gulf-Atlantic coastal flats. These wetlands were strongly preferred by wood storks as nesting habitat. Currently, wood stork nesting is known to occur in Florida, Georgia, South Carolina, and North Carolina from March to late May. However, in south Florida, wood storks lay eggs as early as October and fledge in February or March. Breeding colonies of wood storks are currently documented in all southern Florida counties except for Okeechobee County. Within the study area, the principal habitat for the wood stork is within the littoral zone of Lake Okeechobee (USFWS 2001). **Figure C-10** shows known nesting colonies.

The wood stork population in the southeastern United States appears to be increasing. Preliminary population totals indicate that the wood stork population has reached its highest level since it was listed as endangered in 1984. In all, approximately 11,200 wood stork pairs nested within their breeding range in the southeastern United States. Wood stork nesting was first documented in North Carolina in 2005 and wood storks have continued to nest in this state through 2009. This suggests that the northward expansion of wood stork nesting may be continuing.

The primary cause of the wood stork population decline in the United States is loss of wetland habitats, or loss of wetland function resulting in reduced prey availability. Almost any shallow wetland depression where fish become concentrated, either through local reproduction or receding water levels, may be used as feeding habitat by the wood stork during some portion of the year, but only a small portion of the available wetlands support foraging conditions (high prey density and favorable vegetation structure) that wood storks need to maintain growing nestlings. Browder et al. (1976) and Browder (1978) documented the distribution and the total acreage of wetland types occurring south of Lake Okeechobee, Florida, for the period 1900 through 1973. They combined their data for habitat types known to be important foraging habitat for wood storks (cypress domes and strands, wet prairies, scrub cypress, freshwater marshes and sloughs, and sawgrass marshes) and found these habitat types had been reduced by 35% since 1900.

Wood storks forage primarily within freshwater marsh and wet prairie vegetation types, but can be found in a wide variety of wetland types, as long as prey are available and the water is shallow and open enough to hunt successfully (Ogden et al. 1978; Browder 1984; Coulter 1987; Gawlik et al. 2004; Herring and Gawlik 2007). Calm water, about 5 to 25 centimeters in depth, and free of dense aquatic vegetation is ideal; however, wood storks have been observed foraging in ponds up to 40 centimeters in depth (Coulter and Bryan 1993; Gawlik 2002). Typical foraging sites include freshwater marshes, ponds, hardwood and cypress swamps, narrow tidal creeks or shallow tidal pools, and artificial wetlands such as stock ponds; shallow, seasonally flooded roadside or agricultural ditches; and managed impoundments (Coulter et al. 1999; Coulter and Bryan 1993; Herring and Gawlik 2007). During nesting, these areas must also be sufficiently close to the colony to allow wood storks to efficiently deliver prey to nestlings.

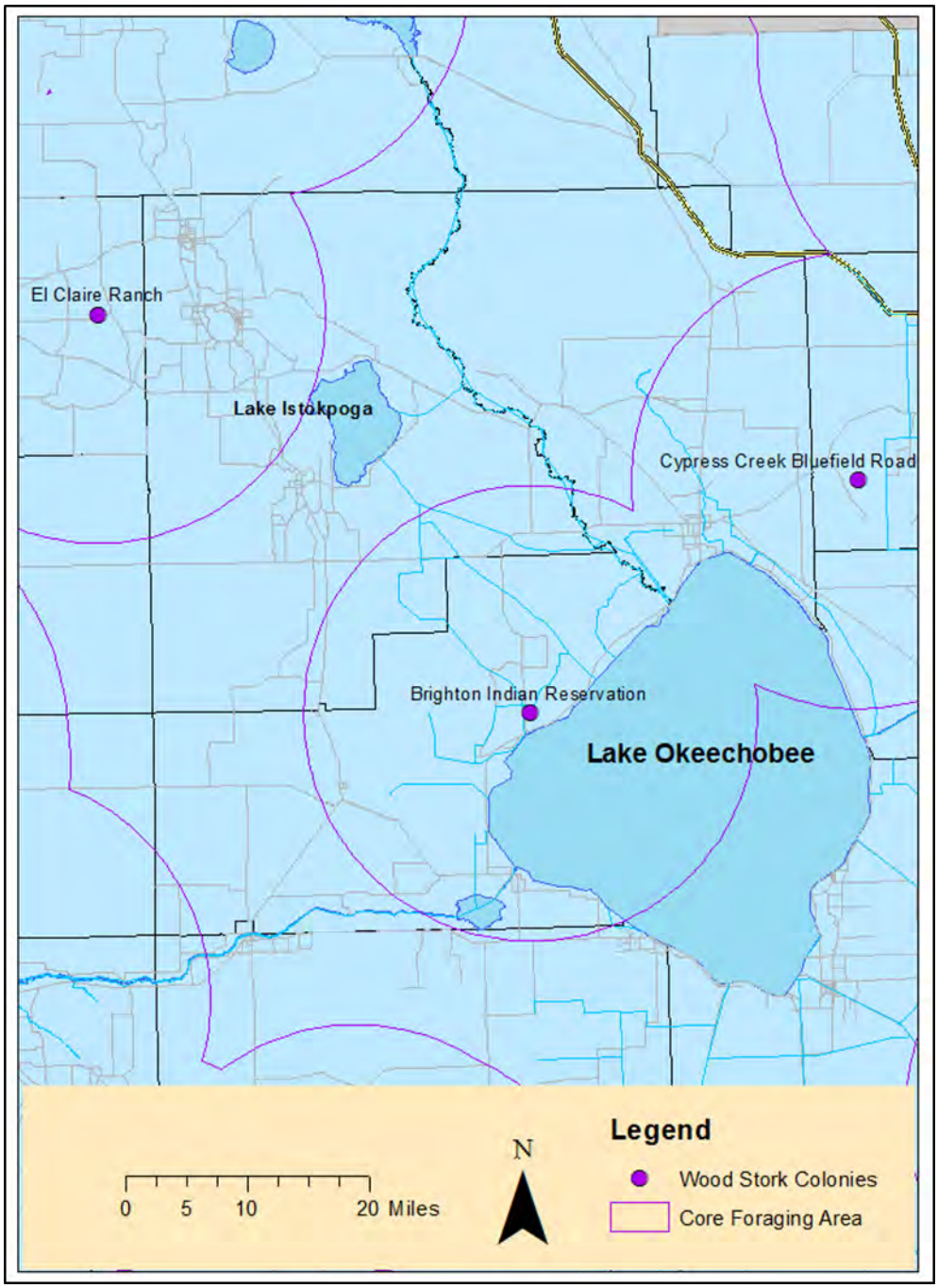


Figure C-10. Wood stork colonies active in 2016 near Lake Okeechobee. Source: USFWS 2018.

C.1.1.4.1.6 Eastern Indigo Snake

The threatened Eastern indigo snake (*Drymarchon couperiis*) is the largest native, non-venomous snake in North America. It is an isolated subspecies occurring in southeastern Georgia and throughout peninsular Florida. They prefer drier habitats, but may be found in a variety of habitats from xeric sandhills, to cabbage palm hammocks, to hydric hardwood hammocks (Schaefer and Junkin 1990). They have also been found in citrus groves and sugar cane. They need relatively large areas of land to maintain their population, making them especially vulnerable to habitat fragmentation that makes travel between

suitable habitats difficult. The main reason for the Eastern indigo snake's decline is habitat loss due to development. As habitats become fragmented by roads, they also become increasingly vulnerable to highway mortality as they travel through their large territories (Schaefer and Junkin 1990).

In south Florida, the Eastern indigo snake is thought to be widely distributed. They are found in a variety of upland and wetland communities in the watershed, including mesic hammocks. Given their preference for upland habitats, they are not commonly found in great numbers in wetland complexes, though they have been found in pinelands, tropical hardwood hammocks, and mangrove forests in extreme south Florida (Duellman and Schwartz 1958; Steiner *et al*. 1983). Within the range of the gopher tortoise, tortoise burrows are favorite refugia for indigo snakes. They are also known to use burrows made by cotton rats and land crabs, hollows at bases of trees and stumps, ground litter, trash piles, and rock piles lining banks of canals and pipes or culverts.

Sexual maturity appears to occur around 3-4 years of age. In north Florida, breeding occurs November to April with females laying 4-12 eggs in May to June (Moler 1992). Most egg hatching occurs August to September, with yearling activity peaking in April to May (USFWS 1999). Limited data on reproduction in south Florida indicate the breeding season is extended: breeding occurs from June to January, egg deposition is April to July, and hatchlings are born through early fall (USFWS 1999).

C.1.1.4.1.7 West Indian Manatee

The West Indian manatee (*Trichechus manatus)*, known locally as the Florida manatee, is a large, plant-eating aquatic mammal that can be found in the rivers, springs, and shallow coastal waters of Florida. The Florida manatee was listed as endangered throughout its range for both the Florida and Antillean subspecies (*T. manatus latirostris* and *T. manatus manatus*) in 1967 (32 FR 4061) and received federal protection with the passage of the ESA in 1973. Because the manatee was designated as an endangered species prior to enactment of the ESA, there was no formal listing package identifying threats to the species, as required by section 4(a)(1) of the Act.

Florida manatees can be found throughout the southeastern United States; however, within this region, they are at the northern limit of their range (Lefebvre et al. 2000). Because they are a subtropical species with little tolerance for cold, they remain near warm water sites in peninsular Florida during the winter. During periods of intense cold, Florida manatees tend to congregate in warm springs and outfall canals associated with electric generation facilities (Florida Power and Light 1989). During warm interludes, Florida manatees move throughout the coastal waters, estuaries, bays, and rivers of both coasts of Florida and are usually found in small groups. During warmer months, Florida manatees may disperse great distances. Florida manatees have been sighted as far north as Massachusetts and as far west as Texas, and in all coastal states in between (Rathbun et al. 1983; Fertl et al. 2005). Warm weather sightings are most common in Florida and coastal Georgia. They will once again return to warmer waters when the water temperature is too cold (Hartman 1979; Stith et al. 2006). Florida manatees live in freshwater, brackish, and marine habitats, and can move freely between salinity extremes. They can be found in both clear and muddy water, preferring depths of at least 3 to 7 feet (1 to 2 meters). They avoid flats and shallows unless they're adjacent to deeper water.

Over the past centuries, the principal sources of Florida manatee mortality have been opportunistic hunting by man and unusually cold winters. As of March 2010, the Florida Fish and Wildlife Conservation Commission (FWC) reported 431 Florida manatee deaths, more than the total number of deaths reported in 2009, related to the prolonged cold-water conditions in the winter of 2009-2010. Today, poaching is

rare, but high mortality rates from human-related sources threaten the future of the species. The largest single mortality factor is collision with boats and barges. Florida manatees also are killed in floodgates and canal locks, by entanglement or ingestion of fishing gear, and through loss of habitat and pollution.

The manatee is known to inhabit Lake Okeechobee (USFWS, 2001) and, at times, the lower Kissimmee River (C-38 Canal) and the C-43 and C-44 canals (**Figure C-11**). In March 2017, the manatee was reclassified from "endangered" to "threatened" due to habitat improvements and population expansion; the existing federal protections remain in place. Critical habitat for the Florida manatee was designated in 1976 (50 CFR §17.95[a]). No specific primary or secondary constituent elements were included in the critical habitat designation. However, experts agree that essential habitat features for the manatee include SAV or seagrasses for foraging, shallow areas for resting and calving, channels for travel and migration, warm-water refuges during cold weather, and fresh water for drinking (Service 2001). Although there is no designated manatee critical habitat within Lake Okeechobee, critical habitat is designated in the St. Lucie and Caloosahatchee Estuaries.

Designated critical habitat includes the Caloosahatchee River downstream from the Florida State Highway 31 bridge, Lee County; all U.S. territorial waters adjoining the coast and islands of Lee County; all U.S. territorial waters adjoining the coast and islands and all connected bays, estuaries, and rivers from Gordon's Pass, near Naples, Collier County, southward to and including Whitewater Bay, Martin and West Palm Beach Counties; that section of the intracoastal waterway from the town of Sewalls Point, Martin County, to Jupiter Inlet, Palm Beach County; and the entire inland section of water known as the Indian River, from its northernmost point immediately south of the intersection of U.S. Highway 1 and Florida State Highway 3, Volusia County, southward to its southernmost point near the town of Sewalls Point, Martin County. **Figure C-12** shows critical habitat areas for the Florida manatee**.**

C.1.1.4.1.8 Florida Panther

One of 30 cougar subspecies, the endangered Florida panther (*Puma concolor coryi*)—also known as cougar, puma and catamount—is tawny brown on the back and pale gray underneath, with white flecks on the head, neck, and shoulder. The species was once the most widely distributed mammal (other than humans) in North and South America, but it is now virtually exterminated in the eastern United States. Habitat loss in Florida drove this subspecies south of the Caloosahatchee River. Only recently have adult female panthers been recorded north of the Caloosahatchee River.

Figure C-11. Canals that Florida manatee have access to within LOWRP action area.

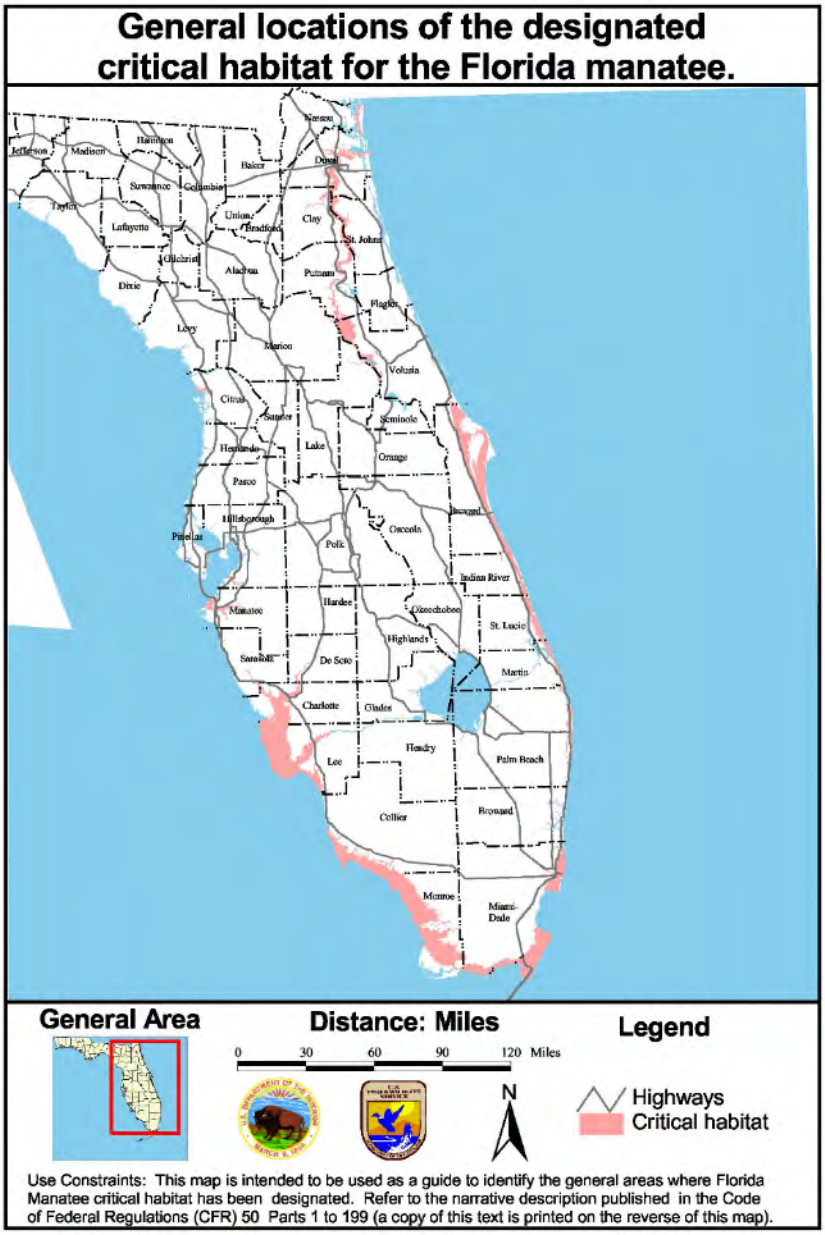


Figure C-12. Designated critical habitat for the West Indian manatee.

Male panthers weigh up to 130 pounds and females reach 70 pounds. Preferred habitat consists of cypress swamps, pine and hardwood hammock forests. The main diet of the Florida panther consists of white-tailed deer, rabbit, raccoon, armadillo, birds, and sometimes wild hog. Present population estimates range from 80 to 100 individuals. Florida panthers are solitary, territorial, and often travel at night. Males have a home range of up to 400 square miles and females about 50 to 100 square miles. Florida panther primary, secondary, and dispersal zones are shown in **Figure C-13**. Female panthers reach sexual maturity at about 3 years of age. Mating season is December through February. Gestation lasts about 90 days, resulting in 2 to 6 kittens. Juvenile panthers stay with their mother for about 2 years; females do not mate again until their young have dispersed. The main survival threats to the Florida panther are habitat loss

due to human development and population growth, collision with vehicles, and parasites, as well as feline distemper, feline alicivirus (an upper respiratory infection), and other diseases (USFWS 1999).

The Florida panther has been found in almost all Lake Okeechobee watershed ecological communities, including mesic temperate hammocks (Humphrey 1992). The Florida panther utilizes mesic pine flatwoods in combination with other forested communities. Foraging, breeding, and wildlife corridors are provided for the panther and its prey. Mesic flatwoods are associated with natural drainage patterns defining travel corridors. There is no designated critical habitat for the Florida panther.

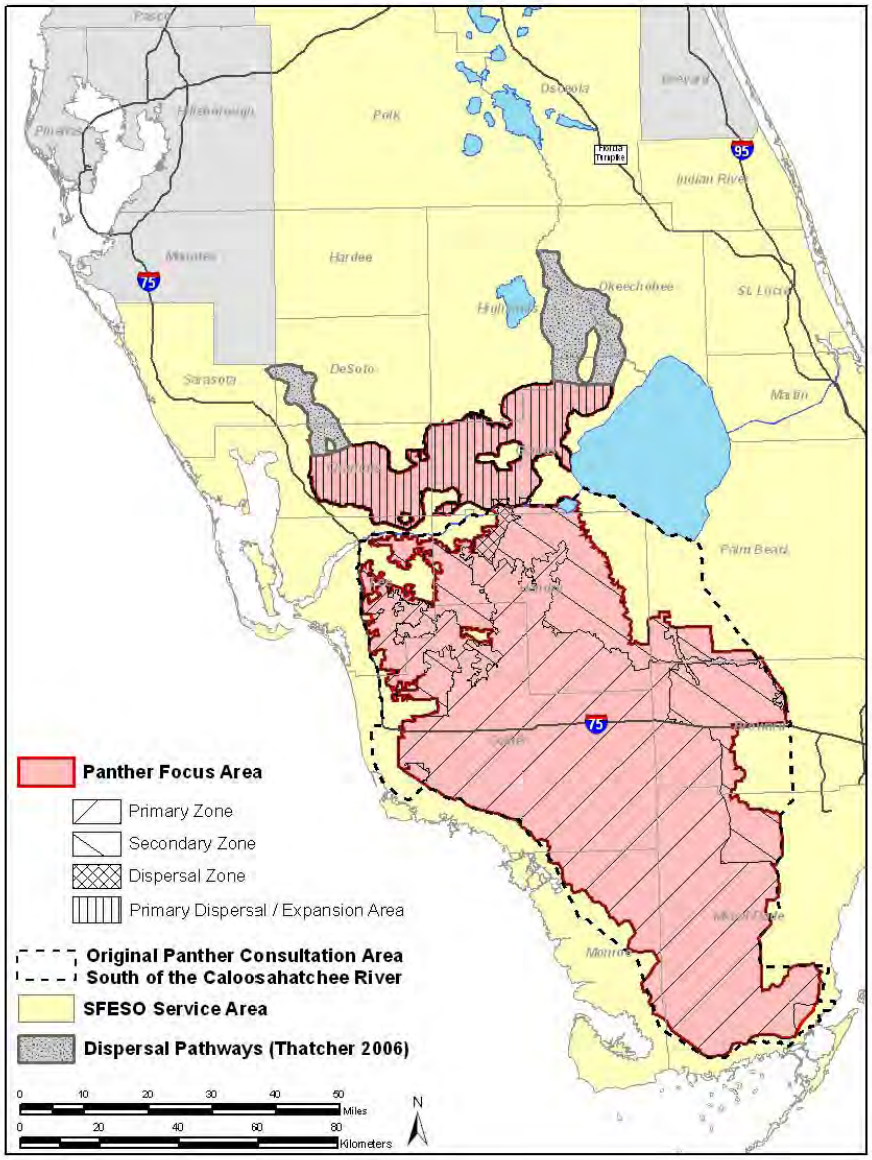


Figure C-13. Florida panther zones in south Florida.

C.1.1.4.1.9 Okeechobee Gourd

The Okeechobee gourd (*Cucurbita okeechobeensisis*) is an annual or perennial, fibrous rooted, high-climbing vine with tendrils. The Okeechobee gourd possesses heart to kidney-shaped leaf blades, with 5 to 7 angular, shallow lobes, and irregularly serrated margins. Young leaves are covered with soft hairs. The cream-colored flowers are bell-shaped. The light green gourd is globular or slightly oblong, with 10 indistinct stripes, and hard-shelled with bitter flesh. The seeds are gray-green and flat (USFWS 1999). The Okeechobee gourd was historically found on the southern shore of Lake Okeechobee, in Palm Beach County, and formerly in the Everglades (USFWS 1999). In recent surveys, the species has been found to be restricted to sites along the middle St. Johns River in Volusia County and around Lake Okeechobee in Glades and Palm Beach counties (USFWS 2009). It has been recently documented along the southern shore of the Lake Okeechobee Rim Canal and the southeastern shore of Lake Okeechobee, including Torry Island, Ritta Island, and Kreamer Island (USFWS 2009). The documented population of the Okeechobee gourd around the southeastern shore of Lake Okeechobee is strongly associated with Torry muck, a soil formed in the extensive pond apple forests that once surrounded the lake. However, successful growth and reproduction of the gourd under cultivation suggests that the species can grow in a wider range of soils (USFWS 1999).

Around Lake Okeechobee, the gourd relies on pond apple trees to support its vines above rising water levels during the wet season. Other trees and shrubs, such as willow (*Salix caroliniana*) and cypress (*Taxodium distichum*), may also provide suitable support for the vines. Along the St. Johns River, Okeechobee gourds are most typically found growing on elderberry and common reed (*Phragmites* spp.). The Okeechobee gourd also seems to readily germinate on alligator nests around Lake Okeechobee, which provide suitably elevated soil berms in full sun, with no competition from other plants. These disturbed sites provide areas where competition is reduced and elevated areas that promote the growth of elderberry, button bush, and other erect bushes and shrubs (USFWS 1999).

The decline of the plant is largely attributable to conversion of swamp forests to agriculture and water level management in Lake Okeechobee. For the gourd to maintain viable healthy populations, fluctuations in lake level are necessary. High lake levels facilitate dispersal and inundate and destroy aggressive weeds in local habitats. As lake levels decrease, the cleared open habitats allow the quickly germinating Okeechobee gourd seeds to sprout and begin climbing before they have to compete with other pioneer species. Water regulation practices can greatly influence the timing and duration of flooding and drying cycles across remnant areas of suitable elevation and soils around Lake Okeechobee. Permanent inundation of suitable soils is detrimental to the plant. Another potential threat to this plant is the proliferation of exotic plant species around the edges of Lake Okeechobee (USFWS 1999). There is no designated critical habitat for the Okeechobee gourd.

C.1.1.4.1.10 Gopher Tortoise

The gopher tortoise (*Gopherus polyphemus*), an upland dwelling reptile, is currently listed as a candidate species in the eastern U.S. by the USFWS (USFWS 2013). It is a dark-brown to grayish-black terrestrial turtle with large hind feet, shovel-like forefeet, and a shell that measures from 5.9 to 14.6 inches long (Ernest and Barbour 1972). In Florida, individuals from coastal areas are generally darker than those from more central populations. Gopher tortoises excavate deep burrows that provide shelter from weather extremes and refuge from predation (Diemer 1989). The gopher tortoise commonly occupies habitats with a well-drained sandy substrate, ample herbaceous vegetation for food, and sunlit areas for nesting. Diemer (1989) found that gopher tortoise activity increased in April, peaked in July, and remained high

through October. Many vertebrate and invertebrate species are known to seek refuge in gopher tortoise burrows, including protected species like the Eastern indigo snake.

C.1.1.4.1.11 Florida Scrub-Jay

The Florida scrub-jay (*Aphelocoma coerulescens*), a threatened species, is present in limited areas of scrub habitat in the study area. It is a relict species of fire-dominated oak scrub habitat that occurs on well-drained sandy soils in peninsular Florida. Scrub-jays are extremely habitat-specific, sedentary, and territorial. Florida scrub-jays form family groupings; fledglings remain with their parents in their natal territory as helpers. The Florida scrub-jay is listed as a threatened species because of loss, fragmentation, and degradation of scrub habitats throughout Florida, due primarily to urbanization, agriculture, and fire suppression. During the last 10 to 23 years, the population has declined by an estimated 25-50%, and they have been extirpated from seven counties statewide.

C.1.1.4.1.12 Red-Cockaded Woodpecker

One of 22 species of woodpeckers native to North America, the red-cockaded woodpecker (*Picoides borealis*) was listed as threatened in 1970. Its historic range encompasses the southeastern United States from eastern Texas to Oklahoma to New Jersey, and it was characterized as "abundant" in the 19th-century literature. Throughout the 20th century, however, the species' distribution within its historic range has become fragmented, and total population numbers have decreased dramatically due to habitat destruction. Although south Florida is not a designated recovery population for the red-cockaded woodpecker, the area contains significant support populations for recovery of the species in the southeast. Additional population surveys and research on habitat requirements within the hydric pine flatwoods of south Florida are needed to assess the current status of the birds and to adapt conservation measures used elsewhere to the distinct conditions in this area. The nearest documented red-cockaded woodpecker population occurs approximately 25 miles west of the K-05 footprint and 20 miles from the K-42 footprint (FWC data).

C.1.1.4.1.13 Smalltooth Sawfish

Smalltooth sawfish (*Pristis pectinata*) juveniles inhabit coastal areas such as estuaries, river mouths, and bays year-round. They have been recorded in a variety of habitat types, including unvegetated mud and sand bottoms, especially along red mangrove shorelines, as well as creeks and canals that connect to the main stem of rivers as habitat (Poulakis et al. 2010, 2011). Juveniles typically inhabit salinities between 18 and 30 psu, sometimes miles up rivers (Poulakis et al. 2010, 2011; Simpfendorfer et al. 2011). Adult smalltooth sawfish are typically found in open water habitats. The smalltooth sawfish population has been reduced to a small section of Florida's southern coast; their core range used to reach in the U.S. from North Carolina to Texas (NMFS 2009a). Historical threats have included unintentional overfishing associated with commercial fisheries, trophy fishing associated with recreational fisheries, and habitat destruction. Presently, fishing gear entanglements and habitat destruction are the main threats as the amount of recreational and commercial fishing has increased, and the development along Florida's coast has caused damage to mangrove forests that serve as nursery areas for juveniles (Seitz and Poulakis 2006; NMFS 2009a).

C.1.1.4.1.14 Green Sea Turtle

The green sea turtle (*Chelonia mydas*), which weighs approximately 150 kilograms as an adult, lives in tropical and sub-tropical waters. Areas that are known as important feeding areas for the green turtles in Florida are the Indian River Lagoon, the Florida Keys, Florida Bay, Homosassa, Crystal River and Cedar Key. Green turtles occupy three habitat types: high-energy oceanic beaches, convergence zones in the pelagic habitat, and benthic feeding grounds in relatively shallow, protected waters. Females deposit eggs on high-energy beaches, usually on islands, where they can dig a deep nest cavity above the high water line. Hatchlings leave the beach and move into the open ocean. Green sea turtles forage in pastures of seagrasses and/or algae, but small ones can also be found over coral reefs, worm reefs, and rocky bottoms.

C.1.1.4.1.15 Leatherback Sea Turtle

The leatherback sea turtle (*Dermochelys coriacea*) is the largest living turtle, reaching up to 700 kilograms. The leatherback lives in tropical and sub-tropical waters. Habitat requirements for juvenile and post-hatchling leatherbacks are virtually unknown. Nesting females prefer high-energy beaches with deep unobstructed access. Leatherbacks feed primarily on jellyfish.

C.1.1.4.1.16 Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle (*Lepidochelys kempii*) is the smallest of all sea turtles, reaching only 45 kilograms. This species is a shallow water benthic feeder, consuming mainly algae and crabs. Juveniles grow rapidly. Juveniles and sub-adults have been found along the eastern seaboard of the United States and in the Gulf of Mexico. However, the major nesting beach for the Kemp's ridley sea turtle is on the northeastern coast of Mexico. This species occurs mainly in coastal areas of the Gulf of Mexico and in the northwestern Atlantic Ocean. The post-pelagic stages are commonly found dwelling over crab-rich sandy or muddy bottoms. Juveniles frequent bays, coastal lagoons, and river mouths.

C.1.1.4.1.17 Loggerhead Sea Turtle

Loggerhead sea turtles (*Caretta caretta*) inhabit the continental shelves and estuarine environments along the margins of the Atlantic, Pacific, and Indian Oceans. Females select high-energy beaches on barrier strands adjacent to continental land masses for nesting, favoring steeply sloped beaches with gradually sloped offshore approaches. After leaving the beach, hatchlings swim directly offshore and eventually are found along drift lines. They migrate to the near-shore and estuarine waters along the continental margins and utilize those areas as the developmental habitat for the sub-adult stage. Loggerheads are predators of benthic invertebrates.

C.1.1.5 State-listed Species

The LOWRP project area contains habitat suitable for the presence, nesting, and/or foraging of 12 state-listed threatened and endangered species and one species of special concern.

C.1.1.5.1 State-listed Beach-nesting Birds (American oystercatcher, black skimmer, least tern)

The American oystercatcher (*Haematopus palliatus*), black skimmer (*Rynchops niger*) and least tern (*Sternula antillarum*) nest directly in sand, shell, or small gravel in coastal areas; in shallow scrapes in sand,

shell, or gravel along the coast; near bodies of fresh water; and occasionally on flat, gravel-covered rooftops. Major threats to these species include:

- Habitat loss and degradation, largely due to coastal development and incompatible recreational use
- Disturbance during breeding, causing nest failure and resulting in loss of eggs and/or chicks
- Changes to water quality that impact bivalves (e.g., pollution, turbidity, depth, and temperature)
- Predation that is magnified by human disturbance

C.1.1.5.2 Burrowing Owl

The burrowing owl (*Athene cunicularia*) occurs throughout the state although its distribution is considered local and spotty. The presence of burrowing owls is primarily dependent upon habitat. Humans have created new habitat for burrowing owls by clearing forests and draining wetlands. Burrowing owls inhabit open native prairies and cleared areas that offer short groundcover, including pastures, agricultural fields, golf courses, airports, and vacant lots in residential areas. Historically, they occupied the prairies of central Florida. The drainage of wetlands, although detrimental to many organisms, increases the areas of habitat for the burrowing owl. Recently, central Florida populations have decreased because of disappearing habitat, while populations in south Florida coastal areas have increased due to modification of habitat by humans creating new habitat.

Burrowing owls live as single breeding pairs, or in loose colonies consisting of two or more families. They use burrows year-round: for roosting during the winter and for raising young during the breeding season (February–July). Burrows extend 4 to 8 ft. underground and are lined with materials such as grass clippings, feathers, paper, and manure (www.myfwc.com 2014). Although they typically dig their own burrows, they will also use gopher tortoise or armadillo burrows.

C.1.1.5.3 Florida Sandhill Crane

The Florida sandhill crane (*Grus canadensis pratensis*) is a non-migratory that inhabits prairies, improved pastures, and freshwater marshes. They occur throughout peninsular Florida and north to the Okefenokee Swamp in southern Georgia. Degradation or direct loss of habitat due to wetland drainage or conversion of prairie for development or agricultural use is the primary threat that they face. The prairies, improved pastures, and freshwater marshes on which the species depends are especially vulnerable to overgrowth, development, and alteration. Predation and road mortality are exacerbated by habitat fragmentation as cranes travel farther between breeding and foraging areas. The proximity of wetlands to upland areas is key to crane survival.

C.1.1.5.4 State-listed Wading Birds (little blue heron, roseate spoonbill, tricolored heron)

The state- listed wading bird species in the project area include the little blue heron (*Egretta caerulea*), roseate spoonbill (*Platalea ajaja*), and tricolored heron (*Egretta tricolor*). These wading birds prey on small fishes, aquatic crustaceans, amphibians, snakes, and insects. Though their diets are diverse, they do require shallow wetlands for foraging. Threats to these species include habitat degradation, including diversion of natural water flow, altered levels of water fluctuation, lower water tables, and nutrient enrichment in waters; loss of suitable foraging and breeding areas due to human disturbance, especially during key phases of reproduction (e.g., continued disturbance near nesting colonies); increased presence

of predators that cause nest failure; and magnified vulnerability to pesticides, heavy metals, and other environmental contaminants.

C.1.1.5.5 Southeastern American Kestrel

The southeastern American kestrel (*Falco sparverius paulus*) is a non-migratory subspecies of the American kestrel closely tied to sandhills in the southeastern U.S with preferred habitat consisting of open fields, grasslands, savannas, or other habitats that contain widely scattered trees or similar perches. Population declines of southeastern American kestrels in Florida have been largely attributed to clearing of older pine forests and conversion of sandhill and other upland habitats for agriculture and urban development. Kestrels are secondary cavity nesters, and suitable nest sites can be a limiting factor for kestrel populations (Smallwood and Collopy 2009). In addition to a lack of natural nesting sites and loss of suitable foraging habitat, environmental contaminants also pose a threat to the species.

C.1.1.5.6 Florida Pine Snake

The Florida pine snake (*Pituophis melanoleucus mugitus*) is found in the project area. They prefer habitats with well-drained, sandy soils and moderate to open canopy cover (Franz 1992, Ernst and Ernst 2003). The most common natural habitat of pine snakes in Florida is sandhill, but they also are found in scrub, xeric hammock, scrubby flatwoods, and mesic pine flatwoods and dry prairie with dry soils (Allen and Neill 1952, Enge 1997, Franz 2005). Florida pine snakes are fossorial, spending approximately 80% of their time in underground retreats, primarily burrows of the southeastern pocket gopher (*Geomys pinetis*) (Franz 2005, Miller 2008), as well as other retreats such as stumpholes, mole runs, and burrows of gopher tortoises (*Gopherus polyphemus*), ninebanded armadillos (*Dasypus novemcinctus*), and mice (Franz 2005, Miller 2008). Threats to the Florida pine snake include habitat loss, fragmentation, and degradation from the loss of dry uplands and fire suppression; roads, which fragment habitat and may contribute to reduced genetic diversity and mortality; operations that result in stump removal, soil compaction, and root removal; predation by domestic pets and other nonnative species; and intentional killing by humans.

C.1.1.5.7 Big Cypress Fox Squirrel

Big Cypress fox squirrels (*Sciurus niger avicennia*) are large tree squirrels. Primarily a ground-dwelling species, they inhabit stands of cypress, slash pine savanna, mangrove swamps, tropical hardwood forests, live oak woods, coastal broadleaf evergreen hammocks, and suburban habitats, including golf courses, city parks, and residential areas (Hafner et al. 1998; Humphrey and Jodice 1992; Jansen 2008; Munim et al. 2007; Williams and Humprey 1979). Optimum habitat for *S. n. avicennia* includes an open understory free of bushes and undergrowth (Hafner et al. 1998). The status of Big Cypress fox squirrels in the core of their range in Big Cypress National Preserve and the Everglades is largely unknown because of the difficulty of studying and observing squirrels in such habitat (Jansen 2008; Jodice and Humphrey 1992; Jodice and Humphrey 1993; Maehr 1993). Isolation of Big Cypress fox squirrel populations has occurred in western Lee and Collier counties due to rapid urbanization (Ditgen and Shepherd 2007; Endries et al. 2009; Kellam and Jansen 2010). The biggest threat to Big Cypress fox squirrels on the periphery of their range is destruction of habitat and habitat fragmentation due to encroaching development (FWC 2005; FWC 2008; Jansen 2008; Jodice and Humphrey 1992; Munim et al. 2007; Koprowski 1994; Zwick and Carr 2006). Rapid urbanization has isolated Big Cypress fox squirrel populations in fragmented habitat in western Lee and Collier counties (Ditgen and Shepherd 2007). Although urban greenspaces, such as golf courses, may provide suitable habitat if the understory is open and there is abundant food supply, mortality due to vehicle collision is high, and these areas may act as population sinks (Munim et al. 1997).

C.1.1.5.8 Sherman's Fox Squirrel

Sherman's fox squirrel (*Sciurus niger shermani*) is a species of special concern. These large tree squirrels inhabit mature, open, fire-maintained longleaf pine (*Pinus palustrus*) and turkey oak (*Quercus laevis*) sandhills and flatwooods. To accommodate the large home ranges and fluctuating food resources, suitable habitat also includes more productive lower slopes of sandhills (Kantola 1992). This species also inhabits mixed hardwood pine, mature pine forests, cypress domes, pastures, the ecotone between bayheads and pine flatwoods, and other open habitats with pines and oaks (summarized in Endries et al. 2009; Florida Natural Areas Inventory 2001). Habitat loss has been significant; it is estimated that only 10-20% of original Sherman's fox squirrel native habitat is still intact, most of it having been logged, converted to pasture, degraded by lack of fire, or used for agriculture, commercial, and residential development. (Bechtold and Knight 1982 as cited in Kantola 1992). Improperly burned longleaf pine communities also affect the fox squirrel's population because this prevents longleaf pine seeds from properly reproducing in the bare ground. This species also has an increased chance of getting hit by a vehicle due to their typically slow gait.

C.1.1.6 Fish and Wildlife

A great diversity of fish and wildlife species occur throughout the Lake Okeechobee Watershed and in Lake Okeechobee. Important fish and wildlife resources in the project area include aquatic macroinvertebrates, small freshwater marsh fishes, larger sport fishes, amphibians and reptiles, birds, including raptors and wading birds, and mammals. Much of the native habitats in the watershed has been replaced by agricultural uses; approximately 65% of historic wetland habitats have been converted. The creation of ditches, canals, and the flooding of fallow agricultural fields provides some lower quality habitat for fish and wildlife, particularly during the rainy season. The ecological character of the watershed is the sum of its diverse mosaic of ecological communities and the variety of wildlife species for which the communities provide food, cover, roosting, and nesting. Some communities are inherently rich in wildlife diversity and also differ broadly according to community quality and size just as species vary diversely in community use; some species are extremely narrowly habitat-specific (e.g., the Florida grasshopper sparrow uses only the wet and dry prairies), while others (e.g., Florida panther, Florida black bear, and bald eagle) use a broad array of habitats as they move through their extensive ranges.

C.1.1.6.1 Freshwater Fish

Small freshwater marsh fishes provide an important food source for wading birds, amphibians, and reptiles. Marsh fishes are also important processors of algae, plankton, macrophytes, and macroinvertebrates. Common species include the native and introduced golden topminnow (*Fundulus chrysotus*), least killifish (*Heterandria formosa*), Florida flagfish (*Jordenella floridae*), golden shiner (*Notemigonus crysoleucas*), sailfin molly (*Poecilia latipinna*), bluefin killifish (*Lucania goodei*), oscar (*Astronotus ocellatus*), eastern mosquitofish (*Gambusia holbrookii*), and small sunfishes (*Lepomis* spp.) (USACE 1999). The density and distribution of marsh fish populations fluctuate with seasonal changes in water levels. Populations of marsh fishes increase during extended periods of continuous flooding during the wet season. As marsh surface waters recede during the dry season, marsh fishes become concentrated in areas that hold water through the dry season. Concentrated dry season assemblages of marsh fishes are more susceptible to predation and provide an important food source for wading birds (USACE 1999).

Within Lake Okeechobee, numerous sport fishes and larger predatory fishes occur. Common species include largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis*

microlophus), speckled perch (black crappie, *Pomoxis nigromaculatus*), Florida gar (*Lepisosteus platyrhincus*), threadfin shad (*Dorosoma petenense*), gizzard shad (*Dorosoma cepedianum*), yellow bullhead (*Ameiurus natalis*), white catfish (*Ameiurus catus*), bowfin (*Amia calva*), and tilapia (*Tilapia* spp.) (USACE 1999). Larger fishes are an important food source for wading birds, alligators, otters, raccoons, and mink.

C.1.1.6.2 Amphibians and Reptiles

The freshwater wetland complex supports a diverse assemblage of amphibians and reptiles. Common amphibians include the greater siren (*Siren lacertina*), Everglades dwarf siren (*Pseudobranchus striatus*), two-toed amphiuma (*Amphiuma means*), pig frog (*Rana grylio*), southern leopard frog (*Rana sphenocephala*), Florida cricket frog (*Acris gryllus*), southern chorus frog (Pseudacris nigrita), squirrel tree frog (*Hyla squirela*), and green tree frog (*Hyla cinerea*) (USACE 1999). Amphibians represent an important forage base for wading birds, alligators, and larger predatory fishes (USACE 1999).

Common reptiles of freshwater wetlands include the American alligator (*Alligator mississippiensis*), snapping turtle (*Chelydra serpentina*), striped mud turtle (*Kinosternon bauri*), mud turtle (*Kinosternon subrubrum*), cooter (*Chrysemys floridana*), Florida chicken turtle (*Deirochelys reticularia*), Florida softshell turtle (*Trionys ferox*), water snake (*Natrix sipidon*), green water snake (*Natrix cyclopion*), mud snake (*Francia abacura*), and Florida cottonmouth (*Agkistrodon piscivorus*) (USACE 1999).

The Eastern indigo snake (*Drymarchon corais couperi*; federally listed as threatened) utilizes many watershed communities including year-round habitation of moist areas of pine flatwoods due to the availability of a diet of amphibian and reptilian fauna. They also utilize the burrows of the gopher tortoise in the well-drained soil areas with open, herbaceous groundcover. The gopher tortoise forages on the grasses, herbs, fruits, and berries of the fire-maintained pine flatwoods. The gopher frog also utilizes gopher tortoise burrows and other animal burrows in mesic pine flatwoods. Gopher frogs find breeding habitat in shallow vegetated ephemeral ponds of the flatwoods adjacent to xeric scrub habitats.

C.1.1.6.3 Birds

Wading and secretive marsh birds frequent the littoral zone in the lake, and migratory birds heavily use Lake Okeechobee throughout the year, as well as during the migratory season as a resting and foraging stop. Common wading birds include the white ibis (*Eudocimus albus*), glossy ibis (*Plegadus falcenellus*), great egret (*Casmerodius albus*), great blue heron (*Ardea herodius*), little blue heron (*Egretta caerulea*), tricolored heron (*Egretta tricolor*), snowy egret (*Egretta thula*), green-backed heron (*Butorides striatus*), cattle egret (*Bubulcus ibis*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nycticorax violacea*), roseate spoonbill (*Ajaia ajaja*), and wood stork (*Mycteria americana;* federally listed as threatened) (USACE 1999). Common secretive marsh birds include moorhen (recently renamed common gallinule: (*Gallinula chloropus*), purple gallinule (*Porphyrio martinicus*), least bittern (*Ixobrychus exilis*), limpkin (*Aramus guarauna*), king rail (*Rallus elegans*), and black rail (*Laterallus jamaicensis*). Wood storks utilize wetland habitats for nesting, roosting, and foraging. These storks forage in shallow water areas with highly concentrated prey and breed in colonies with other wetland-dependent birds including little blue heron, snowy egret, and tri-colored heron.

Migratory birds and waterfowl utilize the marsh zone and adjacent wetlands as a major resting area along the Atlantic flyway (SFWMD, 1997). Bald eagles are commonly found in the watershed nesting near open water areas where they feed primarily on fish and water-dependent birds. Nesting is prevalent along the

Kissimmee River Valley. Distribution is influenced by availability of suitable nest and perch sites near open water bodies, but eagles clearly adapt to a wide variety of habitat conditions and use most of the upland and wetland ecological communities in the watershed. Northern crested caracaras (*Caracara cheriway*; federally listed as threatened) inhabit open pastures and prairies with cabbage palms that are suitable for nesting. Open-canopied mesic pine flatwoods adjacent to emergent wetlands and open water areas provide nesting and foraging habitat for sandhill cranes. Large mature pine trees provide nesting habitat for bald eagles, particularly pine flatwoods located adjacent to lakes and rivers. They often remain in the flatwoods year-round. The red-cockaded woodpecker has a relatively small disjunctive population in the western portion of the watershed. The woodpecker nests and roosts in excavated old- age pines, preferably longleaf pine. Low or sparse understory is a necessity.

C.1.1.6.4 Mammals

Mammals that are well-adapted to the aquatic and wetland conditions of the freshwater marsh complex include the rice rat (*Oryzomys palustris natator*), round-tailed muskrat (*Neofiber alleni*), and river otter (*Lutra canadensis*). Additional mammals that may utilize freshwater wetlands on a temporary basis include the white-tailed deer (*Odocoileus virginianus*), Florida panther (*Puma concolor coryi*; federally listed as endangered), bobcat (*Lynx rufus*), and raccoon (*Procyon lotor*). In Lake Okeechobee and the connected canals, West Indian manatees (*Tricheus manatus*) may be found especially outside of the winter months (when they tend to stay near the coasts). The Northern Estuaries are also home to marine mammals such as the Atlantic bottlenose dolphin (*Tursiops truncatus*).

The upland habitats provide food, cover, roosting, and nesting sites to a wide variety of wildlife. Hardwood mast (e.g., acorns, fruit, or nuts) makes the island hammocks attractive to birds and mammals, including a number of rare, threatened, and endangered animal species. The Florida panther has been found in almost all Lake Okeechobee watershed ecological communities, including mesic temperate hammocks (Humphrey 1992). White-tailed deer and feral pigs, the primary prey of panthers, are abundant in these hammocks. The Florida black bear also uses large tracts of land that include cabbage palm and mixed hardwood hammocks, particularly those adjoining large forested wetlands. These hammocks provide the black bear diet of berries, acorns, saw palmetto, and cabbage palm. Large, relatively undisturbed tracts of pine flatwoods, in combination with other upland forested communities and major wetland systems, provide the principal habitat of the Florida black bear. Bears have seasonal preferences for available foods, much of which is produced in the mesic flatwoods community. The mesic flatwoods and mixed flatwoods-hardwood riverine forests are primary habitats for Sherman's fox squirrel, where they forage on pine cones, acorns, cabbage palm fruits, bromeliad buds, and insects. Nesting also occurs here.

C.1.1.6.5 Aircraft Wildlife Strike Hazard Assessment

Aircraft-wildlife strikes pose risks to safe aviation and wildlife conservation. The 2013 Memorandum of Agreement (MOA) between the Federal Aviation Administration (FAA), the U.S. Air Force, USACE, EPA, USFWS, and the U.S. Department of Agriculture – Wildlife Services established procedures necessary to coordinate their agency missions to more effectively address existing and future environmental conditions contributing to aircraft-wildlife strikes throughout the United States. These efforts are intended to minimize wildlife risks to aviation and human safety, while protecting the nation's valuable environmental resources (FAA 2013). The National Plan of Integrated Airport Systems (NPIAS) encompasses approximately 3,400 airports in the national network of airports and the national airport plan, which identifies existing and proposed new airports to serve commercial and general aviation needs. The NPIAS contains all commercial service airports, all reliever airports, and selected general aviation airports.

Specific criteria were established to meet national aviation needs at a reasonable cost. These criteria considered the number of based aircraft and annual operations, scheduled air carrier service, and proximity to other airports in the national plan. Airports that met special needs, such as access to remote populations, could also be included.

There are three airports within the LOWRP project area. Of these, the Okeechobee County Airport (Okeechobee Jet Center; KOBE) is a NPIAS airport. Because the other two airports, River Acres Airport (FAA ID FD70) and River Oak Airport (FAA ID OOFL) are not in the NPIAS system, they do not require analysis pursuant to the MOA. River Acres Airport and River Oak Airport are both private, short, grass landing strips within airpark neighborhoods; both are general aviation or civilian airports that handle private aircraft and small-aircraft charter operations rather than scheduled passenger service.

C.1.1.6.6 Estuarine and Riverine Fish and Invertebrates

The Northern Estuaries are also home to fish and wildlife species found in estuarine and marine habitats. Seagrasses and other submerged aquatic vegetation within the Northern Estuaries provide important habitat and nursery grounds for several fish species. Many fish species spend part or all of their life in the estuary. Common recreational and commercial fish species include mutton snapper (*Lutjanus analis*), yellowtail snapper (*Ocyurus chrysurus*), lane snapper (*Lutjanus synagris*), yellowtail parrot fish (*Sparisoma rubripinne*), gag grouper (*Mycteroperca microlepis*), pinfish (*Lagodon rhomboids*), tarpon (*Megalops atlanticus*), common snook (*Centropomus undecimalus*), crevalle jack (*Cranx hippos*), spotted sea trout (*Cynoscion nebulosus*), redfish (*Sciaenops ocellatus*), mullet (*Mugil* spp.), and sheepshead (*Archosargus probatocephalus*).

In addition to finfish, the estuaries support a variety of shellfish. Blue crabs (*Callinectes sapidus*), stone crabs (*Menippe mercenaria*), hard clams (*Mercenaria mercenaria*), and oysters (*Crassostrea virginica*) are important estuarine commercial species. The open bottom habitats in the tidal Caloosahatchee and St. Lucie estuaries are composed of mixtures of sand, mud, shell, and bedrock. Mollusks compose one the larger groups of macroinvertebrates within the Northern Estuaries ecosystems. The wedge clam (*Rangia cuneata*) and marsh clam (*Polymesoda carolineata*) are commonly found associated with mud and sandy bottoms in the Northern Estuaries. The common oyster (*Crassostrea virginica*) is the dominant species in the oyster reef community. Oyster bars serve as a food source and provide habitat for many estuarine species, including other mollusks, polychaete worms, decapod crustaceans, and various boring sponges. The more common shrimp species include the pistol (*Alpheus* spp.), ghost (*Palaemonetes* spp.), grass (*Hippolyte* spp.), and broken-back (*Hippolyte pleuracantha*). The fisheries for the blue crab (*Callinectes sapidus*) are the largest year-round fisheries in the upper and middle portion of the Caloosahatchee River. Other crab species occurring within the region are the spider (*Libinia emarginata*), fiddler (*Uca* spp.), horseshoe (*Limulus polyphemus*), stone (*Menippe mercenaria*), and hermit (*Pagurus* spp.). Sand dollar (*Echinarachnius* spp.) and starfish (*Solaster* spp., *Crossaster* spp., and *Ophioderma* spp.) are predatory invertebrates also found within the Northern Estuaries.

C.1.1.7 Essential Fish Habitat

Essential fish habitat (EFH) located within the area affected by LOWRP occurs within the St. Lucie River and Indian River Lagoon and the Caloosahatchee River and Estuary (NMFS 2000).

C.1.1.7.1 Caloosahatchee River and Estuary

This portion of the study area is within the jurisdiction of the Gulf of Mexico Fishery Management Council (GMFMC) and is located in areas designated as EFH for juvenile brown shrimp, juvenile gray snapper, juvenile pink shrimp, adult and juvenile redfish, adult and juvenile Spanish mackerel (*Scomberomorus maculatus*), and juvenile stone crab. Downstream habitats include oyster reefs and seagrass.

C.1.1.7.2 St. Lucie River and Indian River Lagoon

This portion of the study area is within the jurisdiction of the South Atlantic Fishery Management Council (SAFMC) and is located in areas designated as EFH for wormrock, live bottom habitat, for the American oyster, pink shrimp (*Penaeus duorarum*), white shrimp (*Penaeus* sp.), brown shrimp (*Penaeus aztecus*), redfish , grouper (*Epinephelus* spp.), gray snapper (*Lutjanus griseus*), white grunt (*Haemulon plumieri*), red porgy (*Pagrus pagrus*), spiny lobster (*Panulirus argus*), and the snapper-grouper complex. In addition, the nearshore hardbottom habitat outside of the St. Lucie Estuary is designated as EFH-Habitat Areas of Particular Concern (EFH-HAPC) for the snapper-grouper complex.

C.1.1.8 Hydrology

The major characteristics of south Florida's hydrology are (1) local rainfall, (2) evapotranspiration, (3) canals and water control structures, (4) flat topography, and (5) the highly permeable surficial aquifer along a thirty to forty mile-wide coastal strip. Local rainfall is the source of all of south Florida's fresh water. The surface water that is not removed from the land by evapotranspiration and seepage to the underlying aquifer is drained to the Atlantic Ocean, Florida Bay, or the Gulf of Mexico by very slow, shallow sheetflow through wetlands or relatively quickly through man-made canals.

The LOWRP study area can be hydrologically divided into four drainage basins: Fisheating Creek, Indian Prairie, Lower Kissimmee (S-65D and S-65E) and Taylor Creek/Nubbin Slough (**Figure C-14**). Each basin has a major tributary that historically drained south into the Lake Okeechobee via meandering rivers and extensive floodplains. The introduction of ditches, berms, and canals into this rain-driven system disrupted the natural flow path of water, leading to current restoration efforts. The subsections that follow describe all four listed drainage basins and Lake Okeechobee.

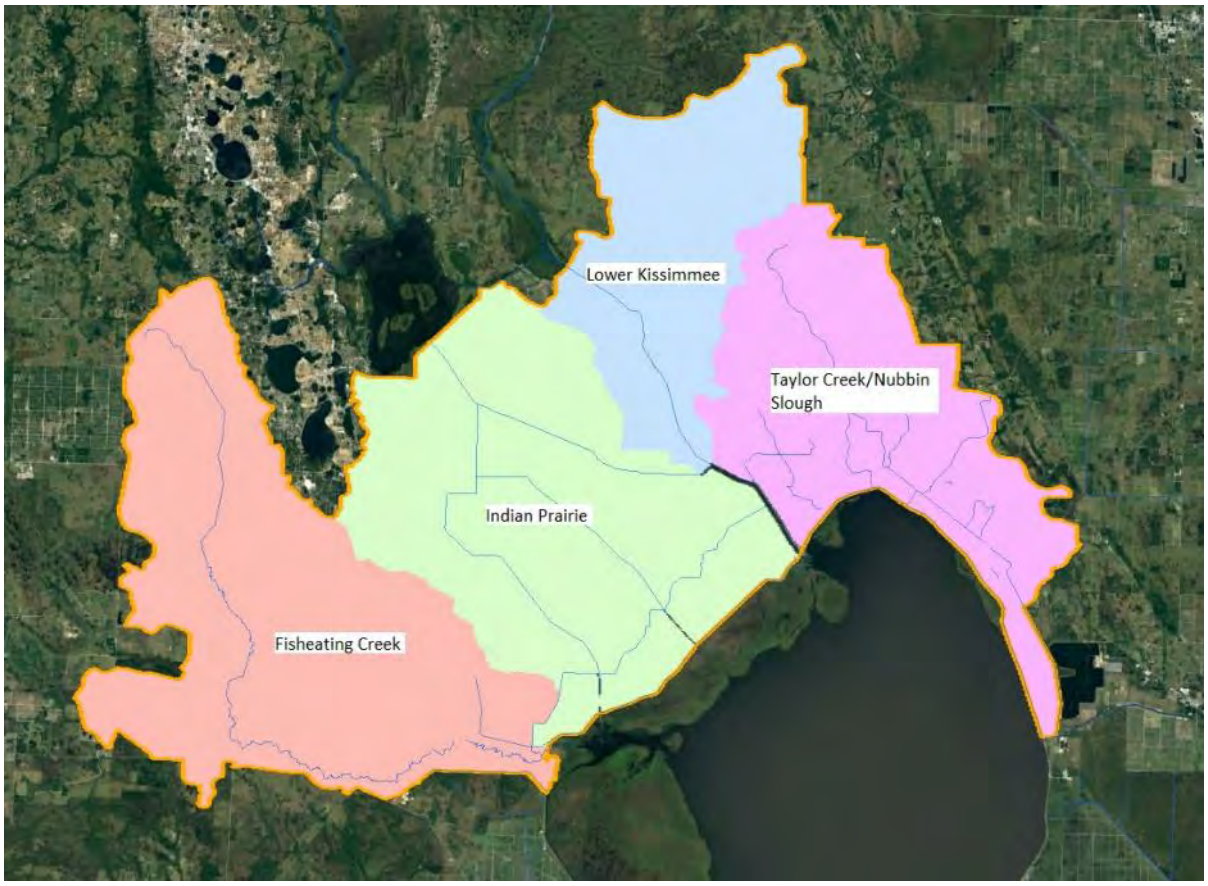


Figure C-14. LOWRP four major drainage basins: Fisheating Creek, Indian Prairie, Lower Kissimmee (S-65D and S-65E), and Taylor Creek/Nubbin Slough.

C.1.1.8.1 Fisheating Creek

Fisheating Creek is located principally in the western portions of Highlands and Glades counties, with the western boundary extending into the easterly edges of Hardee, DeSoto, and Charlotte counties. The drainage area is adjacent to the Peace Creek Basin to the west and northwest, the Lake Istokpoga-Indian Prairie and Harney Pond Canal areas to the north and northeast, and Nicodemus Slough to the south. Fisheating Creek drains an L-shaped area of about 550 square miles. From the headwaters near Lake Josephine, the creek flows uncontrolled south for 32 miles, then east for 23 miles into Lake Okeechobee.

Monthly average flows for 2001 to November 2017 from Fisheating Creek to Lake Okeechobee show that the September monthly average flows (1,144 cubic feet per second [cfs]) were highest and the May monthly average flows (76 cfs) were the lowest. Monthly average Kissimmee River flows at S-65E were also highest during September (3,557 cfs) and lowest (735 cfs) during December; both averages were higher than the Fisheating Creek monthly average flows.

C.1.1.8.2 Indian Prairie

The Indian Prairie drainage basin borders the northwest shore of Lake Okeechobee from Kissimmee River (C-38) to Fisheating Creek, encompassing about 622 square miles. Levees isolate the two main canals, Indian Prairie Canal (C-40) and Harney Pond Canal (C-41), from the watershed. The outflow from Lake

Istokpoga enters C-41A at S-68. After approximately four miles, the flow divides into three canals (C-40, C-41, and C-41A). C-41A flows southeast to the Kissimmee River and joins it near S-65E. The Indian Prairie Canal (C-40) lies in the middle. The Harney Pond Canal (C-41) flows to the west, entering Lake Okeechobee midway between C-40 and Fisheating Creek. Outflow from Lake Istokpoga also occurs in the Istokpoga Canal that connects to the Kissimmee River upstream of S-65C.

Annual average flows for canals C-40, C-41, and C-41A at SFWMD respective control structures S-75, S-82 and S-83 are recorded daily. Flow data from 2002 to November 2017 indicates that the average outflow from Lake Istokpoga to C-41A (through control structure S-68) for the 15-year period was 438 cfs, and the combined flow from the three canals to Lake Okeechobee was 6,433 cfs. These data indicate that, during the 15-year period, 70% of the flow from the canal system to Lake Okeechobee originated in Lake Istokpoga, while 30% of the flow was from runoff in the intervening basins.

C.1.1.8.3 Lower Kissimmee

The Lower Kissimmee drainage basin encompasses about 1,805 square miles and extends from the S-65A location southward to Lake Okeechobee at the mouth of the Kissimmee River (C-38). The basin handles the largest source of surface water flow to Lake Okeechobee with the inflow from C-38 controlled at SFWMD structure S-65E.

The Kissimmee River (C-38) flows south to Lake Okeechobee through basins S-65A, S-65D, and S-65E. The overall average flows for 1998 to November 2017 at monitoring stations S-65A, S-65D, and S-65E are 1,234 cfs, 1,377 cfs and 1,564 cfs, respectively. The additional flow in S-65D may be associated with flow from the Istokpoga Canal, which enters the Kissimmee River upstream of S-65C's old location. Note that the estimation of runoff in this analysis does not take into account additional sources such as evapotranspiration.

C.1.1.8.4 Taylor Creek/Nubbin Slough

The Taylor Creek/Nubbin Slough drainage area bordering the north and northeast shores of Lake Okeechobee encompasses about 309 square miles and extends from the Kissimmee River (C-38) to the St. Lucie River (C-44). All inflow from this watershed is controlled. Annual average flows at S-133 and S-191 for the 2002 to Nov 2017 period shows that the 15-year average flow from the Taylor Creek (measured at S-133) was 28 cfs and from the Nubbin Slough (measured at S-191) be 121 cfs. The recent historical annual average flow from these interconnected basins to Lake Okeechobee is 149 cfs.

C.1.1.8.5 Lake Okeechobee and the Northern Estuaries

Lake Okeechobee is managed as part of the C&SF Project for water supply and flood protection. The Herbert Hoover Dike (HHD) and several water control structures allow management of Lake Okeechobee to meet project purposes, which include flood control, water supply, navigation, recreation, and environmental enhancement. Inflows to Lake Okeechobee average 2.1 million acre-feet per year. Nearly half the inflow to Lake Okeechobee is through the Kissimmee River. The Upper and Lower Kissimmee River watersheds cover more than 2,300 square miles of central Florida. The remaining inflow to Lake Okeechobee is received from Lake Istokpoga, Fisheating Creek, the Taylor Creek/Nubbin Slough Basin, and reverse flows from the Caloosahatchee River, the St. Lucie Canal, and the Everglades Agricultural Area (EAA).

The primary outflows from Lake Okeechobee are east to the St. Lucie Canal and west to the Caloosahatchee River. The main outflows south are through the L-8 Canal, Miami Canal, North New River Canal, Hillsborough Canal, and the West Palm Beach Canal. Inflows to Lake Okeechobee frequently exceed total outflow capacity.

The approximately 35-mile St. Lucie Canal, part of the Okeechobee Waterway, is the main eastern flood control outlet for Lake Okeechobee. The St. Lucie Estuary is located within portions of both Martin and St. Lucie counties on the southeast coast of Florida. The two forks of the St. Lucie Estuary, the North Fork and South Fork, flow together near the Roosevelt Bridge at the City of Stuart, and then flow eastward approximately six miles to the Indian River Lagoon and Atlantic Ocean at the St. Lucie Inlet. The Caloosahatchee River, part of the Okeechobee Waterway, is the only flood control outlet leading west from Lake Okeechobee. Extending approximately 70 miles from Lake Okeechobee, through the Caloosahatchee Estuary, to the lower Charlotte Harbor Basin at San Carlos Bay, the Caloosahatchee River passes through parts of Glades, Hendry, and Lee counties. Combined with the St. Lucie Canal and Lake Okeechobee, it completes the only navigable passage between the Gulf of Mexico and the Atlantic Ocean.

C.1.1.9 Regional Water Management (Operations)

This subsection describes current regional water management operations.

C.1.1.9.1 Kissimmee-Istokpoga Regulation Schedule

A general plan for flood damage prevention in the Kissimmee basin was incorporated into the comprehensive plan that was presented to Congress in 1948. Project works in the basin were authorized for construction by Congress in 1954. The inclusion of the Kissimmee Basin in the comprehensive plan was directly pursuant to Public Law No. 534.1947. However, earlier Congressional Acts in 1937, 1939, and 1946 had directed that studies on regulating the Kissimmee River and its tributaries be made at the request of state interests. It is important to mention that all the project works located within the Kissimmee River and Lake Istokpoga Basins are operated and maintained by the SFWMD. The USACE serves in an advisory capacity regarding the inspection, operation, regulation, maintenance, improvements, or alterations to any of the structures or facilities within the Kissimmee River and Lake Istokpoga basins.

The purpose of the general plan was to relieve flooding and minimize flood damages, largely in the upper Kissimmee basin. This was to be accomplished partially by flood storage in the lakes of the upper basin and partially by providing the capability to more rapidly remove the floodwater from the basin, when necessary. The report to Congress clearly stated that complete flood protection could not be provided, but that reasonable flood protection would result from such a plan.

The project (C-38) also provides the congressionally authorized 3-foot navigation project (PL-56-154) and now permits year-round navigation from Lake Kissimmee to Lake Okeechobee. The regulation schedules have been developed for flood control, navigation, agricultural water supply, and environmental enhancement. The regulation schedule essentially represents the seasonal and monthly limits of storage, which guides the regulation of the project for the plan purposes. The regulation schedule varies from high stages in the late fall and winter to low stages at the beginning of the wet season. **Figure C-15** shows a map of the Kissimmee River Basin. **Figure C-16** shows the current Kissimmee regulation schedule related to the LOWRP**.**

The Lake Istokpoga Project works were primarily designed to protect lands adjacent to the lake from flooding by lake waters and provide water supply for agricultural use in areas around the lake and in the Indian Prairie area (**Figure C-17**). At the same time, project works maintain the lake at a desirable level for fish and wildlife, navigation, and recreational purposes. The Lake Istokpoga Project generally consists of an outlet canal (C-41A), S-66, S-68, and three associated downstream canals: Indian Prairie (C-40), Slough Canal (C-41A), and Harney Pond Canal (C-41). Lake Istokpoga is regulated in accordance with the regulation schedule shown in **Figure C-18**.

Figure C-15. Lower Kissimmee River Basin.

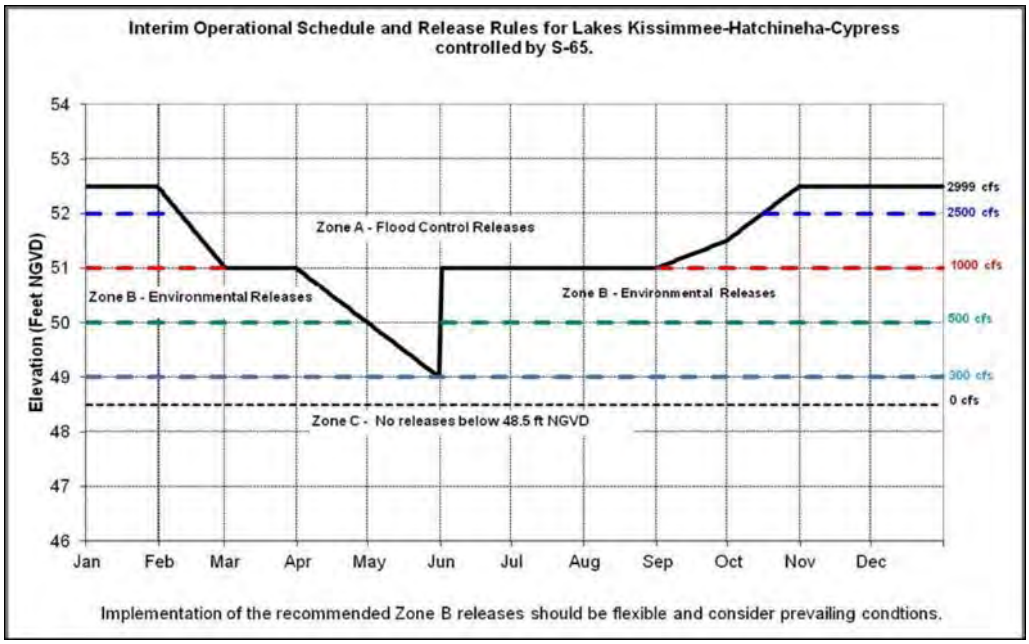


Figure C-16. The Interim Regulation Schedule for S-65 (ca 2006), as updated by water managers to improve the zoned release schedule in Zone B to address floodplain inundation needs for the KRR Project until Headwaters Revitalization Schedule implementation.

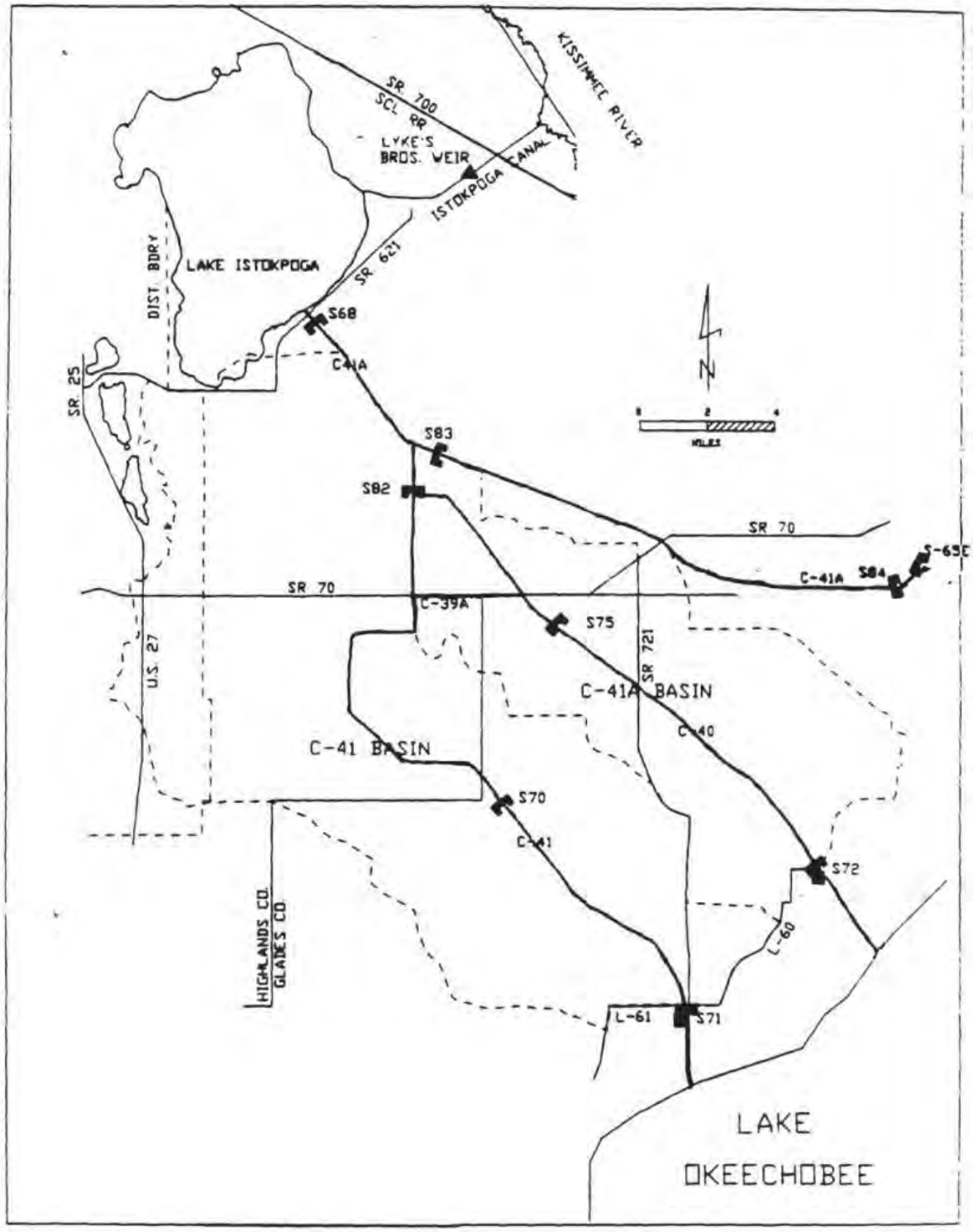


Figure C-17. Indian Prairie Basin.

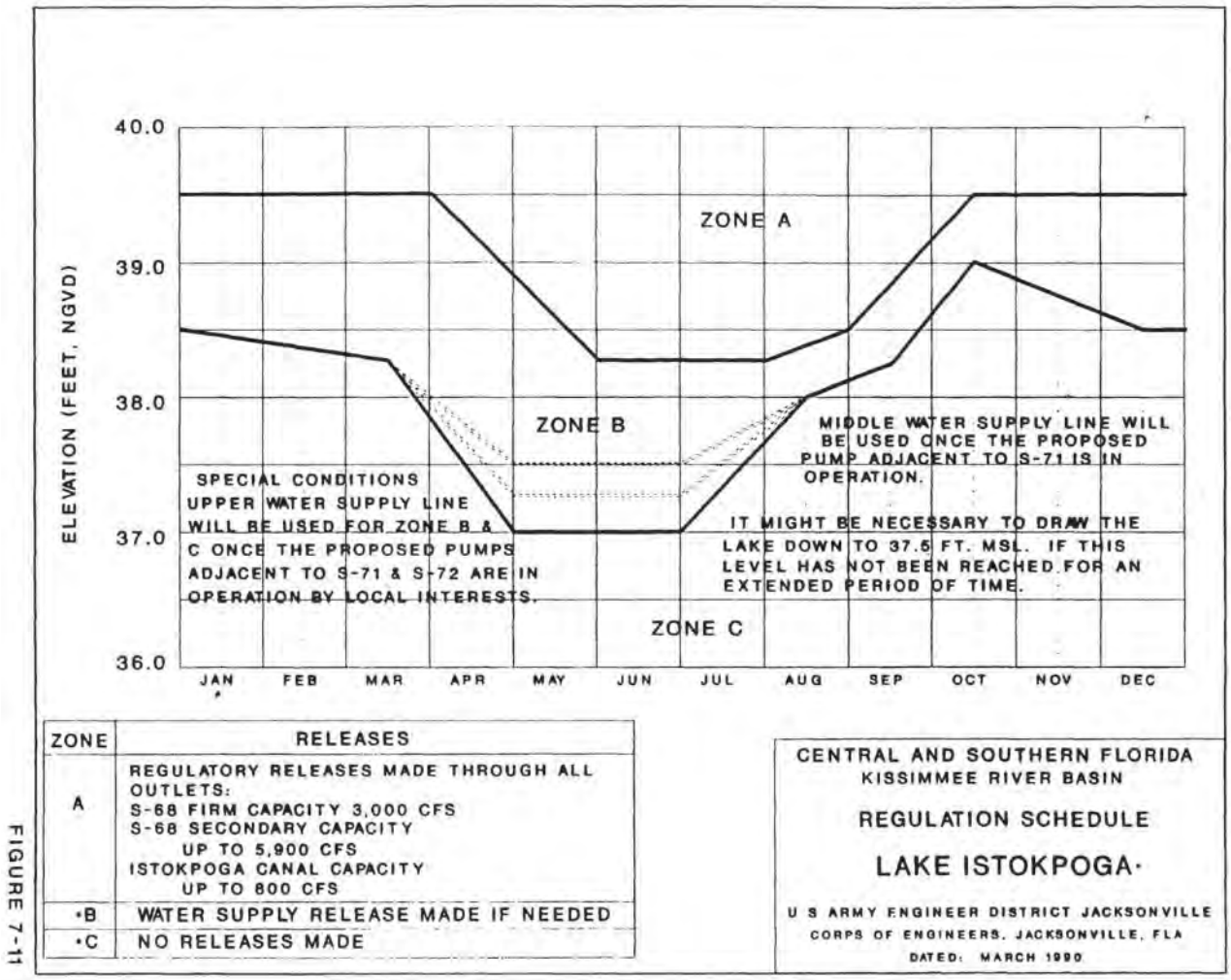


Figure C-18. Istokpoga regulation schedule.

C.1.1.9.2 Lake Okeechobee

The USACE is responsible for management of the water resources contained within HHD and for the development of regulations concerning operation of Lake Okeechobee's outlet structures. Water management operations at Lake Okeechobee are performed to ensure that congressionally authorized project purposes are met. The congressionally authorized project purposes for Lake Okeechobee include flood control; navigation; water supply for ENP, salinity control, regional groundwater control, agricultural irrigation, municipalities, and industry; and enhancement of fish and wildlife; and recreation. Since April 2008, Lake Okeechobee has been operated in accordance with the 2008 Lake Okeechobee Regulation Schedule (2008 LORS; refer to **Figure C-19** through **Figure C-23**); for additional details and complete documentation, refer to the USACE November 2007 Lake Okeechobee Final Supplemental Environmental Impact Statement (EIS). Changes to the Lake Okeechobee Regulation Schedule with the 2008 LORS are included in the revised March 2008 USACE Lake Okeechobee and Everglades Agricultural Area Water Control Plan (WCP). The WCP, which codifies the water management operational guidance included in the November 2007 Final Supplemental EIS, defines allowable flows to the Water Conservation Areas (WCAs) and to tide (estuaries). From July 2000 to April 2008, Lake Okeechobee operations were managed under

the "Water Supply and Environment (WSE) Regulation Schedule." **Table C-1** summarizes the history of the different Lake Okeechobee Regulation Schedules.

Table C-1. Lake Okeechobee regulation schedules throughout history.

YEAR	Water levels in feet NGVD29	Water levels in feet NAVD88
1948	12.56 to 15.56	11.26 to 14.26
1974	14.5 to 16	13.2 to 14.7
1978	15.5 to 17.5	14.2 to 16.2
1994-2000 Run25/WSE	Max. stage 17-18.5	Max. stage 15.7-17.2
2008 LORS	Max. stage 17.25	Max. stage 15.95

The regulation schedule is a tool used by water managers to meet congressionally authorized project purposes. A regulation schedule attempts to meet all functional objectives of the particular project, acting separately or in combination with other projects in a system. The regulation schedule has been, and will continue to be, designed to balance multiple, and often competing, project purposes and objectives. Managing for better performance of one objective often lessens the effectiveness of performance of competing objectives. For example, higher regulation schedules tend to benefit water supply, but may increase the risk to public health and safety, and can harm the ecology of the lake. Lower lake schedules may produce lake levels more desirable for the lake ecology and improved flood protection, but reduce water supply potential. Lower lake schedules may also harm the ecology of the lake during extended dry periods and downstream estuaries during extended wet periods. The regulation schedule contains bands that vary with the time of year. High volume flows from Lake Okeechobee are outlined by flowcharts that define the allowable flows by structure within each band.

Though water supply is a project purpose, water supply flow volumes are not prescribed by this regulation schedule. However, water supply flows are made to meet downstream demands that can include agricultural irrigation, municipal and industrial needs, estuary needs, and other environmental water supply needs.

The 2008 LORS operational study was initiated to address high lake levels, high estuarine flows, estuary ecosystem conditions, and lake ecology conditions that occurred during the 2003 to 2005 time period. The study considered the back-to-back historically significant 2004 and 2005 hurricane seasons' effects on the recognized structural integrity issues of HHD, along with effects to other project purposes. The 2008 LORS was identified to be effective at decreasing the risk to public health and safety, reducing the number of high-volume flows to the estuaries, and providing critical flexibility to perform water management operations (November 2007 Final Supplemental EIS).

Under the 2008 LORS, management of Lake Okeechobee water levels and determination of Lake Okeechobee flows to the WCAs and to tide (estuaries) is based on seasonally varying lake elevations divided into three bands as shown on the proposed 2008 Lake Okeechobee Interim Regulation Schedule Part A (**Figure C-19**). These bands include "High Lake Management," "Operational," and "Water Shortage Management." The High Lake Management Band is meant to address public health and safety, especially related to the structural integrity of HHD, by providing the ability to make flows up to the maximum capacity lake outlets will allow; Lake Okeechobee outlet canals may be maintained above their optimum

water management elevations. The Operational Band is meant to facilitate authorized project purposes by providing the ability to make fresh water flows of various volumes, including no flow; Lake Okeechobee outlet canals should be maintained within their optimum water management elevations. The Water Shortage Management Band pertains to low lake levels which necessitate rationing water supplies; Lake Okeechobee outlet canals may be maintained below their optimum water management elevations. The water supply fresh water flows made within this band are made according to the SFWMD's Lake Okeechobee Water Shortage Management Plan (LOWSM). The 2008 Lake Okeechobee Interim Regulation Schedule Part B (**Figure C-20**) further defines the bands of the regulation schedule. In Part B, the Operational Band is further subdivided into sub-bands that are directly related to defining allowable Lake Okeechobee flows to the WCAs and to tide (estuaries). In general, as lake levels rise through the higher sub-bands, the allowable flow rates increase. Refer to **Figure C-21** through **Figure C-23** for more details.

The 2008 LORS EIS analysis demonstrated that the then-proposed regulation schedule flows to the WCAs and to the estuaries would reduce the likelihood of lake levels that could increase the probability of a breach of the HHD and also contribute to poor ecological conditions within Lake Okeechobee. For Lake Okeechobee, a high lake level can lead to the decline of emergent and submerged vegetation which is essential habitat for the lake's fish and wildlife populations. The 2008 LORS provides the ability to make long-term, low-volume flows to the Caloosahatchee Estuary, St. Lucie Estuary, and WCAs. These flows include low-volume pulse flows and base flows to the Caloosahatchee and St. Lucie estuaries that allow Lake Okeechobee to be maintained at more desirable levels throughout the year. A pulse flow attempts to simulate a natural rainstorm event within the basins. The receiving body would respond to the pulse flow in a similar fashion as if a rainstorm had occurred in the upstream watershed. Although an average flow rate is targeted for the duration of the pulse flow, daily flows vary. The pulse flow and base flows are intended to regulate lake levels and reduce the potential for future prolonged high-volume flows to the estuaries. The base flows also provide a benefit of maintaining desirable salinity levels in the estuaries.

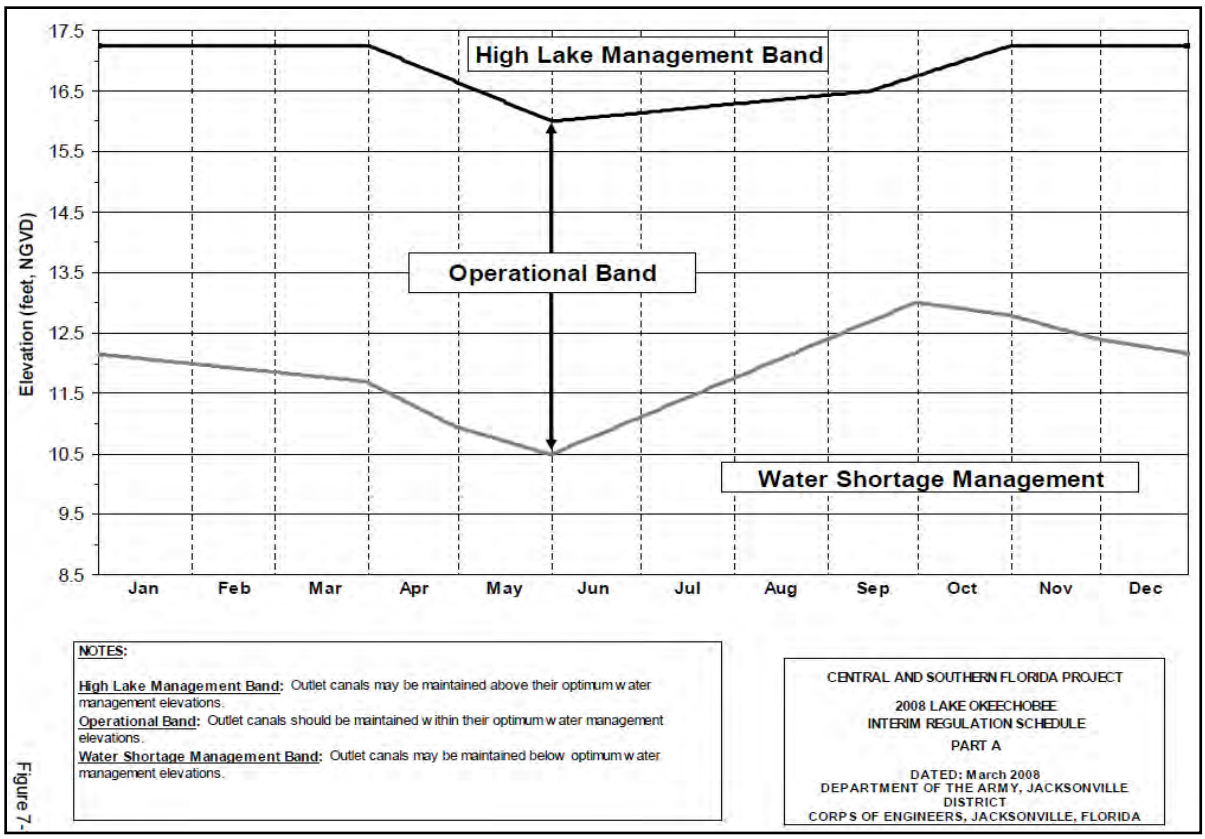


Figure C-19. 2008 Lake Okeechobee Regulation Schedule Part A.

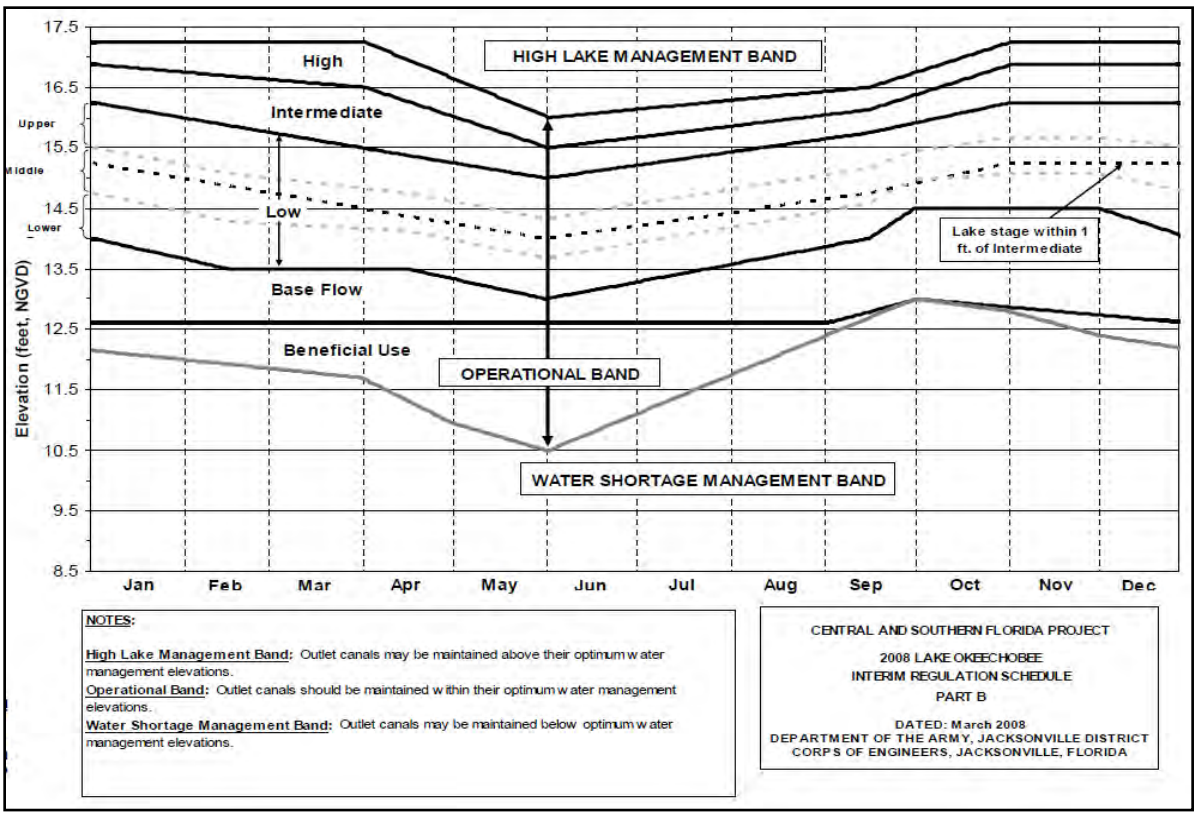


Figure C-20. 2008 Lake Okeechobee Regulation Schedule Part B.

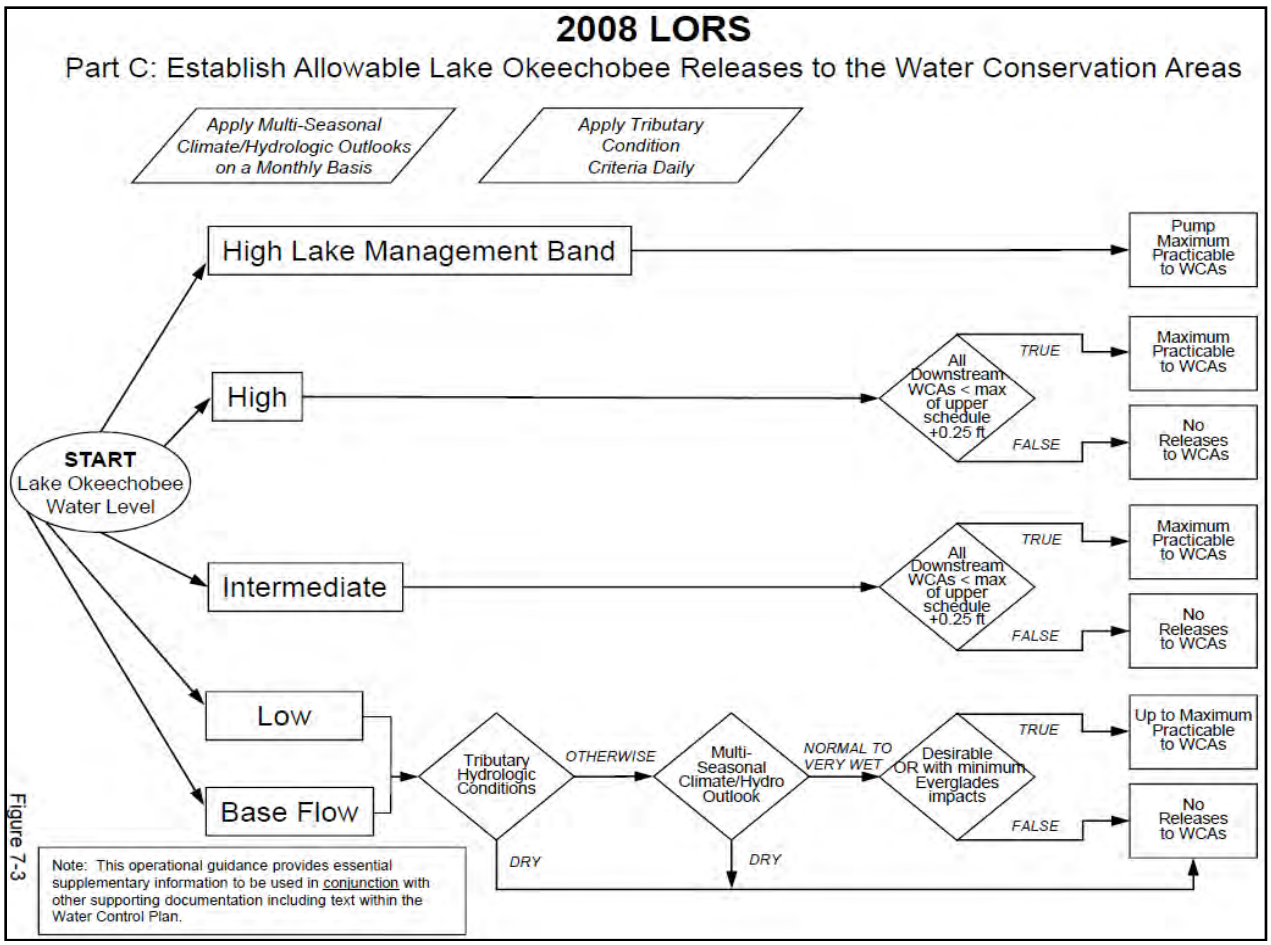


Figure C-21. 2008 Lake Okeechobee Regulation Schedule Part C.

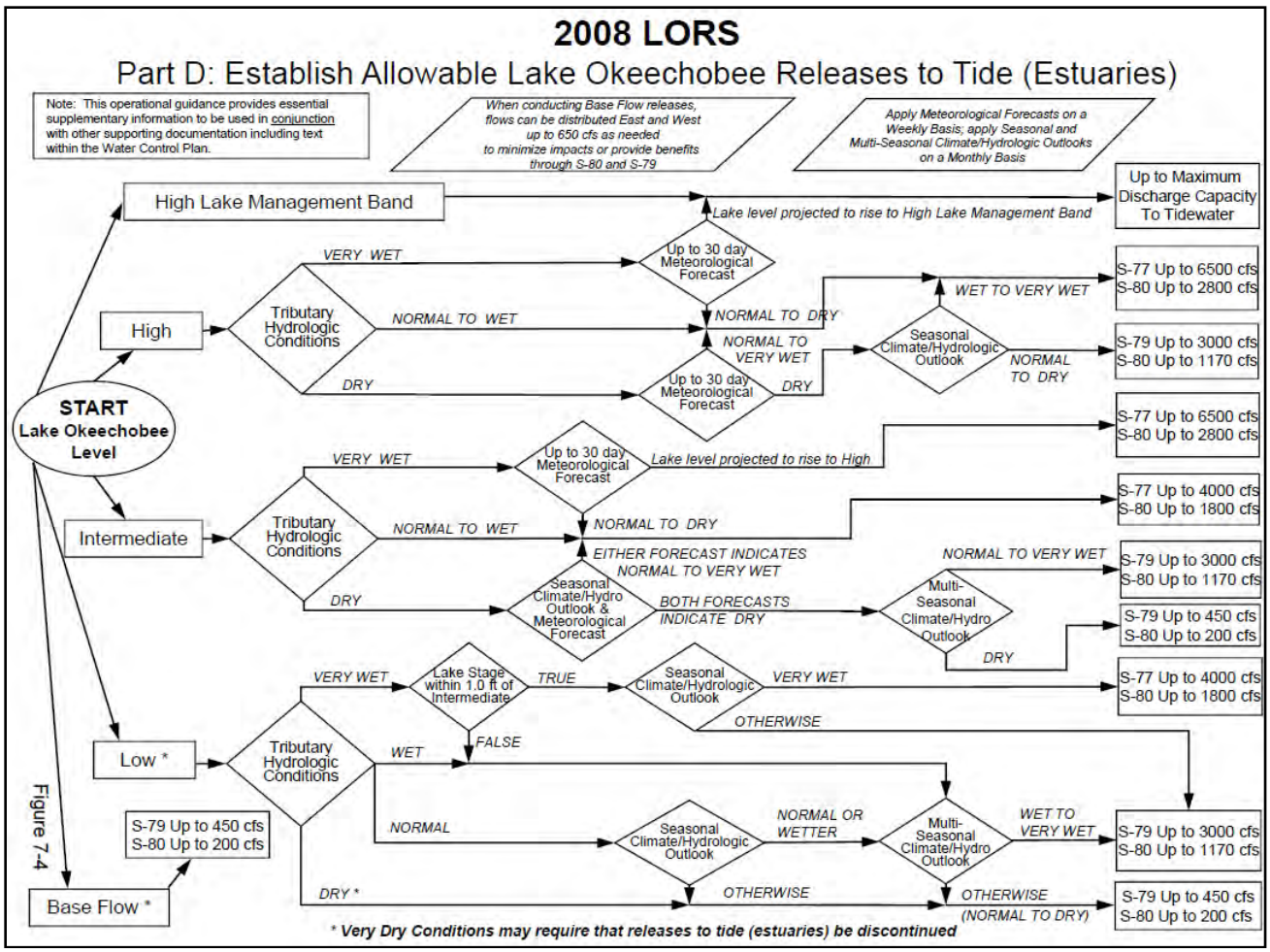
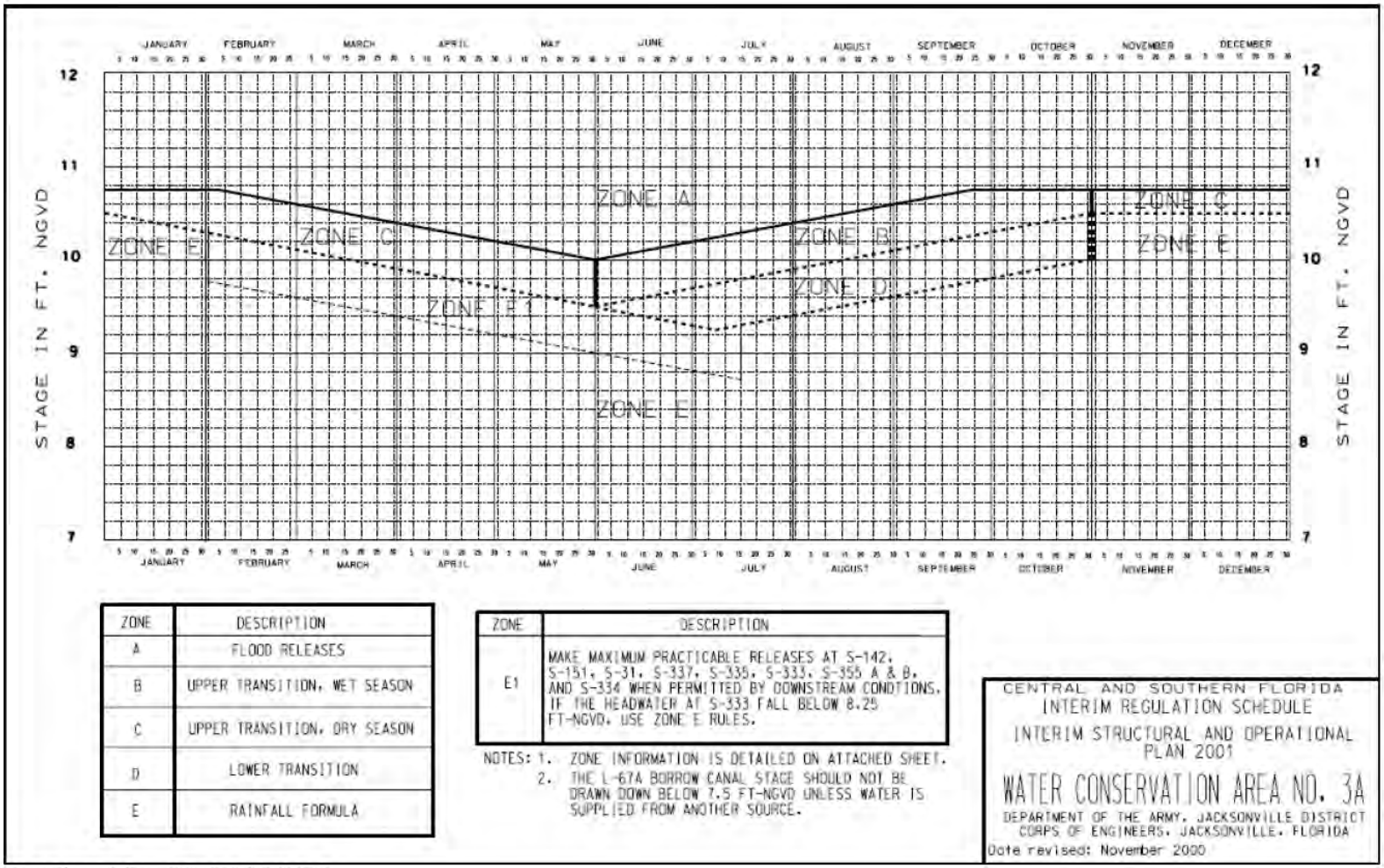


Figure C-22. 2008 Lake Okeechobee Regulation Schedule Part D.



ZONE	DESCRIPTION
A	FLOOD RELEASES
B	UPPER TRANSITION, WET SEASON
C	UPPER TRANSITION, DRY SEASON
D	LOWER TRANSITION
E	RAINFALL FORMULA

ZONE	DESCRIPTION
E1	MAKE MAXIMUM PRACTICABLE RELEASES AT S-142, S-151, S-31, S-337, S-335, S-333, S-355 A & B, AND S-334 WHEN PERMITTED BY DOWNSTREAM CONDITIONS. IF THE HEADWATER AT S-333 FALL BELOW 8.25 FT-NGVD, USE ZONE E RULES.

NOTES: 1. ZONE INFORMATION IS DETAILED ON ATTACHED SHEET.
2. THE L-67A BORROW CANAL STAGE SHOULD NOT BE DRAWN DOWN BELOW 7.5 FT-NGVD UNLESS WATER IS SUPPLIED FROM ANOTHER SOURCE.

CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE
INTERIM STRUCTURAL AND OPERATIONAL PLAN 2001
WATER CONSERVATION AREA NO. 3A
DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
Date revised: November 2000

Note: Figure 9 from 2002 IOP Final SEIS.

Figure C-23. IOP Water Conservation Area 3A Interim Regulation Schedule Part A.

C.1.1.10 Groundwater Resources

Groundwater resources that underlie the LOWRP are the unconfined SAS and the confined FAS. These two aquifers are separated by a thick sequence of marine sediments of the Hawthorn Group, which serves as a laterally extensive confining unit (Reese and Richardson, 2008). Both aquifer systems are used for irrigation and drinking water supply in the LOWRP, primarily for self-supply agricultural demands (SFWMD, 2014). Groundwater resources of the SAS are utilized currently by the Okeechobee Utility Authority (1 MGD) and the Seminole Tribe of Florida's Brighton Reservation (1 MGD). Groundwater resources of the UFA are utilized for agricultural and ranchland water supply. The UFA will serve as a drinking water supply source after treatment by reverse osmosis at the Brighton Reservation.

The Surficial Aquifer System (or water table aquifer) is included in the marine and alluvial deposits that overlie Hawthorn Group sediments in the project area. Measurements of hydrologic characteristics (hydraulic conductivity, transmissivity, and storativity) in the area of K-05 are limited. A single pump test was conducted near Moore Haven, southwest of the project area, and yielded moderate transmissivity value of 110,000 gallons per foot per day (gpd) (Klein et al., 1964). Recharge of the SAS in the project area is from local rainfall. Flows occurs locally as outflow to drainage canals, or regionally to Lake Okeechobee.

It is necessary to define the hydrogeologic setting of lithologic units and aquifers below the SAS because ASR is proposed to augment storage at the K-05 reservoir footprint. A generalized hydrogeologic diagram is shown in **Figure C-24.**

Hawthorn Group (late Oligocene-Miocene) sediments overlie the Suwannee and Ocala Limestones throughout south Florida, including Glades County (Scott, 1988; Missimer, 2002). The Group consists of two formations: the Peace River Formation, which overlies the Arcadia Formation. The Peace River Formation consists of interbedded quartz sands, clays and carbonates, of which quartz sands dominate the formation composition particularly in the western portions of the LOW (Scott, 1988). Undifferentiated Hawthorn Group sediments occur at depths of 178 ft. to 650 ft. at the Brighton Reservation (Missimer Groundwater Science, 2007), from 140 ft. to 550 ft. at Paradise Run (CH2MHill, 2008), and 170 ft. to 562 ft. bls at Kissimmee River ASR system (KRASR; CH2MHill, 2004).

Hawthorn Group sediments are distinguished from underlying limestones by their high and variable siliciclastic and phosphatic content, gray-green coloration, and gamma-ray log response (Reese and Richardson, 2008). The basal Hawthorn unit is phosphate-rich and shows pronounced gamma-ray log responses that contrast with low response in the phosphate-poor Ocala Limestone. Clays occur within the Arcadia Formation, and dolomite is the primary carbonate mineral (Scott, 1988). The Arcadia Formation/basal Hawthorn Group lies unconformably on the Ocala Limestone in the project area. In the LOW, Hawthorn Group sediments serve as a thick, laterally extensive confining unit (CU, **Figure C-24**). West of the LOW, Hawthorn Group sediments are more permeable, and include the Intermediate Aquifer (IA, **Figure C-24**).

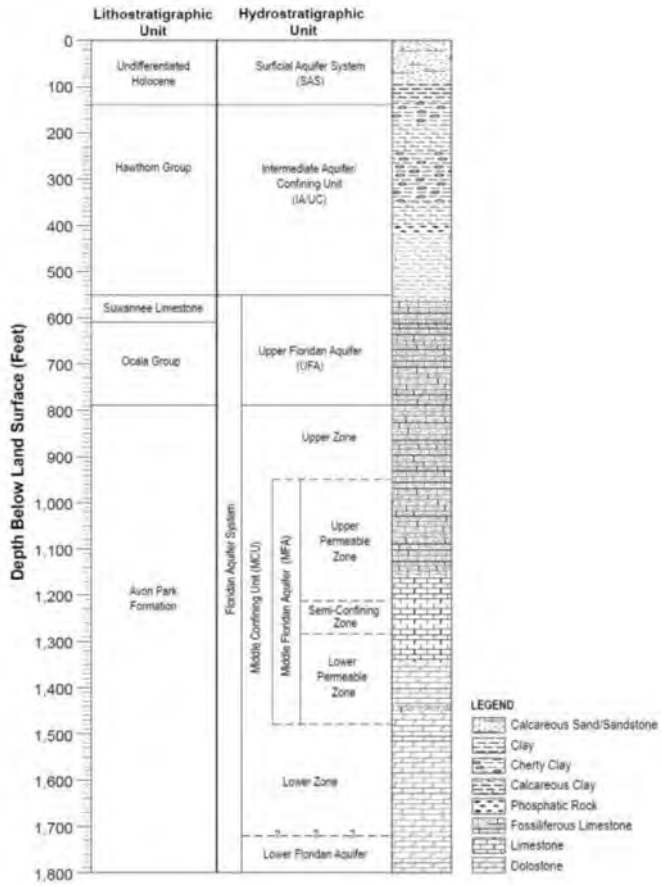


Figure C-24. Generalized hydrogeologic framework for the project area. From CH2MHill (2008).

The Ocala Limestone (late Eocene) overlies the Avon Park Formation in Glades County. This unit is a chalky-to-fossiliferous, mud-rich-to-calcarentic limestone (Reese and Richardson, 2008). Near the project area, the top of the Ocala Limestone is encountered at depths that range between 540 ft. bls (KRASR; USACE, 2013; CH2MHill, 2004) and 650 ft. bls (Paradise Run, CH2MHill, 2008; Brighton Reservation; Missimer Groundwater Science, 2007), and generally dips to the south. The upper contact of the Ocala limestone shows significant topographic variation (as much as 200–00 ft.; Reese, 2014), and this topographic variation may have implications for ASR well construction. The Ocala Limestone thickness ranges approximately 200–400 ft. in the project area.

The Suwannee Limestone (early Oligocene) is a pale orange-to-tan, fossiliferous, medium-grained calcarenite. This formation occurs at depths of 750–950 ft. bls (Reese and Richardson, 2008), and thins to the east. The Suwannee Limestone is not easily recognized in cores east of Glades County and is absent in exploratory boreholes at the Brighton Reservation (Missimer Groundwater Science, 2007) and KRASR (CH2MHill, 2004). However, the Suwannee Limestone was shown at depths of approximately 850–950 ft. bls in an exploratory borehole at Moore Haven (GLF-6, southwest of the project area; Reese and Richardson, 2008), and at 550–610 ft. in exploratory borehole for HIF-42 at Paradise Run (Highland County; CH2MHill 2008). The uppermost permeable zone of the FAS is the UFA and occurs primarily in the Ocala Limestone in the LOW project area.

The deepest lithologic unit of interest in southern Highlands and Glades Counties is the Avon Park Formation (mid-to-late Eocene). This unit is encountered at depths of 790–840 ft. below land surface (bls) in the northern portion of the project area, and dips to approximately 1,220 ft. in the southeast near Lake Okeechobee (Campbell, 1990; CH2MHill, 2004, 2008). The Avon Park Formation consists of fine-grained, micritic to fossiliferous limestone, dolomitic limestone, and dolostone (Reese and Richardson, 2008). The APPZ (Reese and Richardson, 2008) occurs within the Avon Park Formation, and was known formerly as the middle Floridan aquifer. A leaky confining unit separates the lower portion of the UFA from the APPZ. A geologic map of the thickness of the APPZ is presented in **Figure C-25**.

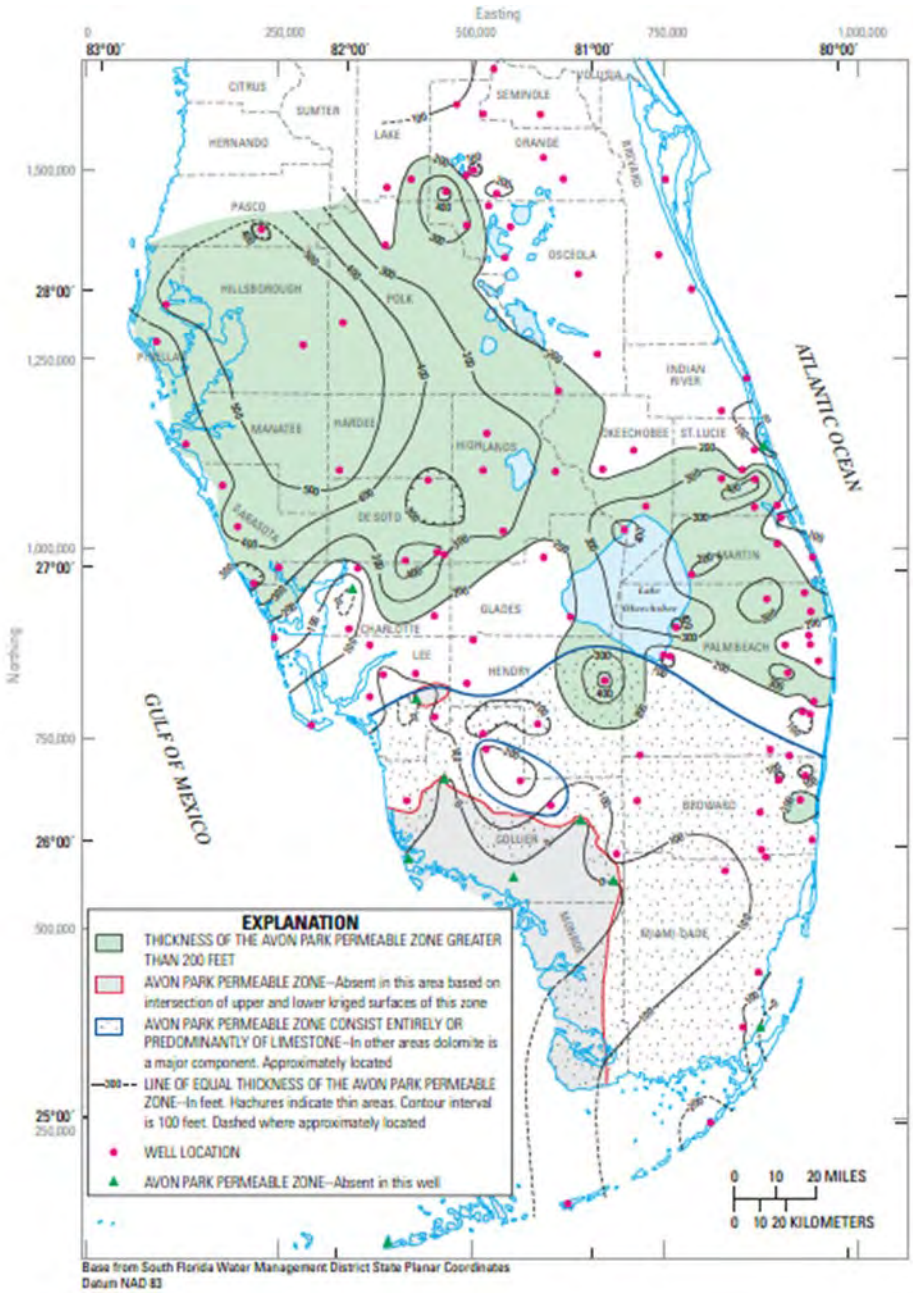


Figure C-25. Geologic map of the thickness of the APPZ (Reese and Richardson, 2008).

Groundwater quality in the upper portions of the SAS is fresh, because recharge infiltrates primarily from rainfall. Groundwater quality becomes increasingly saline toward the base of the SAS due to mixing of fresh groundwater with relict seawater (Reese and Wacker, 2009). SAS groundwater quality (approximately 130 ft.–140 ft. bls) at the Kissimmee River ASR system is brackish, showing chloride concentrations that range between 630–720 mg/L, and total dissolved solids concentrations ranging 1700–2000 mg/L.

Groundwater quality characteristics of the UFA are defined using data from exploratory boreholes and ASR wells at KRASR, Paradise Run, and Brighton Reservation. Native groundwater in the UFA at KRASR is generally fresh, showing chloride concentrations that range 150–280 mg/L, and total dissolved solids concentrations that range 540–810 mg/L (USACE, 2013). Chloride concentration (190 mg/L) and total dissolved solids concentration (680 mg/L) measured in the UFA at Paradise Run also indicate generally fresh groundwater (CH2MHill, 2008). At the Brighton Reservation, chloride concentrations in the UFA (634–1,200 ft. bls) actually decreased with depth, from 1,700 mg/L (640–936 ft. bls) to 655 mg/L (640–1,216 ft. bls) indicating fresher groundwater in lower portions of the UFA (Missimer Groundwater Science, 2007). Overall, groundwater quality in the UFA at the LOW project site is generally fresh, which suggests the likelihood of high percent volume recoveries during ASR system cycle tests.

The APPZ is a thick, transmissive aquifer that occurs below the UFA throughout south Florida (Reese and Richardson, 2008). Groundwater quality characteristics of the APPZ are defined from the same exploratory boreholes used for UFA characterization. Native groundwater in the APPZ generally is more saline than UFA groundwater. At KRASR, chloride (356 mg/L) and total dissolved solids (902 mg/L) reflect water quality at the uppermost portion of the APPZ, and probably are not representative of the entire aquifer. Chloride concentration (8,600 mg/L) and TDS concentration (3,600 mg/L) indicate brackish groundwater quality in the APPZ (1,310–1,530 ft. bls) at the Paradise Run exploratory borehole (CH2MHill, 2008). At the Brighton Reservation, chloride was measured during aquifer performance testing range 740–1,040 mg/L. To the west of the LOW project area, the APPZ occurs at greater depths. Well GLF-6 near Moore Haven, the APPZ shows chloride concentrations that range 1,711–1,811 mg/L, and total dissolved solids concentrations that range 3,549–4,164 mg/L. Groundwater quality of the APPZ varies considerably across the project area, but it is reasonable to expect that brackish water will be encountered. ASR percent volume recoveries will be low during early ASR cycle tests, and large recharge volumes will be required to freshen the APPZ.

C.1.1.11 Surface Water Quality

Water quality in the study area is significantly influenced by development. The C&SF Project led to significant changes in the landscape by opening large land tracts for urban development and agricultural uses, and by the construction of extensive drainage networks. Natural drainage patterns in the region have been disrupted by the extensive array of levees and canals which has resulted in further water quality degradation. The surface water quality of the study area is largely controlled by inflows from the Kissimmee River and Lake Okeechobee. Lake Okeechobee feeds downstream sub-basins such as the St. Lucie and Caloosahatchee River Estuaries, including Indian River Lagoon and Charlotte Harbor. Water quality impairment within the study area can generally be attributed to nutrients and bioavailable forms of mercury. A short discussion of each of these water pollutants is provided below followed by a geographically referenced review of surface water quality within the study area.

C.1.1.11.1 Nutrients

Nutrients such as phosphorus and nitrogen compounds are a concern in the estuaries, LOW, and Lake Okeechobee since they result in an imbalance of flora and fauna. To address nutrients, the Florida Department of Environmental Protection (FDEP) has recently established surface water quality numeric nutrient criteria for Florida water bodies and Total Daily Maximum Loads (TMDLs) for many watersheds with excessive nutrient pollution. TMDLs for phosphorus and/or nitrogen currently exist for Lake Okeechobee, the St. Lucie Estuary, and the Caloosahatchee Estuary. Lake Okeechobee phosphorus TMDL is routinely exceeded by a factor of approximately 3-4 times. Additional information on the status and implementation of TMDLs within the study area can be found at http://www.dep.state.fl.us/water/tmdl/.

Land use changes as well as changes to the hydrology of the system have contributed to increase nutrients in the Lake Okeechobee Watershed. As improvements to drainage were made, nutrient-enriched runoff from agriculture and urban activities within the watershed flowed to the lake. Phosphorus is the limiting nutrient for Lake Okeechobee; nitrogen is generally considered to be the limiting nutrient for the marine waters of south Florida. Prior to 1970, the background TP in-lake concentration was less than 0.040 mg/l while the 5-year average (WY2013 – WY2017) was 0.129 mg/l, and the WY2017 value was 0.150 mg/l (SFWMD 2018).

Nitrogen is generally not considered to be a problem within the Everglades landscape, but is elevated in Lake Okeechobee and its watershed. The 5-year average TN concentration (WY2013 – WY2017) for the pelagic area of Lake Okeechobee was 1.41 mg/l (SFWMD 2018). In the Caloosahatchee and St. Lucie estuaries, excess nutrients may contribute to cause cyanobacteria blooms and depressed oxygen conditions. The Caloosahatchee and St. Lucie Estuaries are generally considered to be nitrogen limited with inorganic forms of nitrogen such as nitrate causing the most harm. The concentration of nitrogen in the fresh water flows from the C-43 and C-44 canals into the Northern Estuaries is approximately 1.5 mg/l with approximately 0.5 mg/l provided by the highly bioavailable inorganic forms such as nitrate and nitrite. Lake Okeechobee provides approximately 60% of the freshwater flows at the S-79 structure which is the upstream end of the Caloosahatchee Estuary. Detailed information on Lake Okeechobee's contribution to the Caloosahatchee Estuary can be found below in **Section C.1.1.11.5**. In the St. Lucie Estuary, 31.9% of the historic TN load comes from the lake and 17.9% of the historic TP load comes from the lake (SFER 2019). Detailed information on Lake Okeechobee's contribution to the St. Lucie Estuary can be found below in **Section C.1.1.11.6**.

C.1.1.11.2 Mercury

Mercury (Hg) in south Florida aquatic systems including Lake Okeechobee is 90-95% from eastern regional atmospheric deposition (SFWMD 2002, Burger et al 2004) as inorganic Hg. Significant local sources include coal-burning power plants, cement kilns, and incinerators (FDEP, 2013). In the Everglades, the conversion of inorganic Hg to organic methylmercury (MeHg) is facilitated by naturally occurring sulfate-reducing bacteria. This conversion of inorganic Hg to MeHg is one of the important steps in the bioaccumulation of Hg as it greatly increases toxicity and potential for accumulation in aquatic biota. Mercury has been monitored in the lake from 1990 to 2000, the Kissimmee River S65E structure from 1979 to 2000, and the Taylor Creek STA from 2007 to 2016.

STAs are monitored for mercury based on A Protocol for Monitoring Mercury and Other Toxicants (Protocol; FDEP and SFWMD 2018) and the Comprehensive Everglades Restoration Plan Guidance

Memorandum 42.02 (CGM-42.02; USACE and SFWMD 2018) which serve as guides for the design of monitoring and assessment plans for mercury, pesticides, and other toxicants for South Florida Water Management District (SFWMD or District) and United States Army Corps of Engineers projects permitted by the Florida Department of Environmental Protection (FDEP or Department). Data collection consists of surface water, fish tissue, and sediment.

The Protocol uses a phased, multi-tiered approach and covers two phases of a project: (1) Baseline Collection and Assessment and (2) Monitoring during the Five-Year Stabilization and Routine Operational Period. The Protocol includes decision criteria and adaptive management strategies to respond to different scenarios. If an identified threshold of concern is exceeded, then Tier 2 expanded monitoring and risk assessment would be triggered to determine the cause and guide appropriate adaptive management decision making regarding short-term corrective actions and long-term operational optimization. The intent of this approach is to allow monitoring efforts to smoothly ramp down or up, as appropriate.

Results from the monitoring and assessment plan are intended to provide state and federal regulatory and trust oversight agencies with reasonable assurance that the project will not cause or contribute to an unacceptable increase in the risk of toxic effects to aquatic or terrestrial resources.

Human exposure to Hg is primarily through the consumption of fish and shellfish containing MeHg. Exposure to Hg causes neurodevelopmental delays in children. Wildlife exposure to MeHg through the consumption of fish results in reproductive, neurological, and immune system problems (Fleming et al. 1995; Tchounwou et al. 2003). However, contaminated fish is not the only pathway for bioaccumulation of Hg.

The United States Environmental Protection Agency (USEPA) has established that a concentration of Hg in fish tissue in excess of 0.3 mg/Kg is detrimental to human health. Water quality impairment for Hg is also measured by the incidence of gamefish tissue with Hg in excess of 0.3 mg/Kg. Twenty species of Florida freshwater fish and over 60 species of marine fish are under consumptive advisory (FDOH 2013).

Methylmercury also poses a threat to fish-eating wildlife and species that prey on them such as wading birds, ospreys, eagles, otters and panthers. The elevated concentrations of MeHg in fish have been correlated with elevated concentrations in wildlife, including state and federally listed endangered species. Total Mercury concentrations in panther hair ranged from 0.092–67 mg/Kg; in wood stork chicks ranged from 5.2 to 10.8 mg/kg, at coastal ENP colonies; in great egrets ranged from 2.5 to 20 mg/Kg, from several colonies in the EPA (2013 and 2014 SFER, SFWMD). Three types of Florida gar fish tissues (gonads, muscle and liver) were monitored at three locations in Lake Okeechobee, near the mouth of the Kissimmee River, in Moonshine Bay on the western side and near Torry, Kreamer and Ritta islands at the south end, between 1998 and 2000. The amount of Hg was significantly higher in the fish tissues at the northern site, with a decreasing north to south gradient. The highest level at the northern site may have been caused by runoff from cattle ranches into the Kissimmee River (Burger et al 2004). Like many of Florida's freshwater lakes, Lake Okeechobee is impaired for mercury due to elevated levels of mercury found in fish. The 2017 Florida Department of Health (FDOH) guidelines call for not eating any fish from the Kissimmee River near Lake Okeechobee and from the lake more than once or twice a week or once a month, depending on your gender, age and the type of fish and for Largemouth bass, depends on the fish size.

C.1.1.11.3 Lake Okeechobee Watershed

Water quality conditions have continued to exceed the total maximum daily load (TMDL) of 140 metric tons (MT), 105 MT for surface water inflow and 35 MT for rainfall, of total phosphorus (TP) annually, by a factor of approximately 3-4 times. During WY 2017, the watershed TP loading to the lake was 484 MT, including the assumed 35 MT of rainfall contribution, which was 11% less than the WY 2016 amount but still 344 MT higher than the TMDL target. The lower load was also attributed to 17% lower flows, due to an extremely dry November to April period (SFWMD 2018). The five-year average TP loading to the lake over WY 2013-2017 was 531 MT, including the rainfall contribution, which was a 21 MT increase over the WY2012-2016 loading, and 391 MT higher than the TMDL target.

The watershed-wide load of TP averaged 0.29 pounds per acre (lb./ac or 0.32 kilogram per hectare [kg/ha]) in WY2017, a 9% decrease compared with the WY2016 value of 0.32 lb./ac (0.36 kg/ha). The drainage basin with the highest load of TP in WY2017 was the L-59W basin (3.57 lb./ac or 3.40 kg/ha) in the Indian Prairie subwatershed, followed by the S-154C (2.13 lb./ac or 2.39 kg/ha) and S-191 (1.32 lb./ac or 1.48 kg/ha) basins in the Taylor Creek/Nubbin Slough subwatershed. The S-154C Basin had the highest flow-weighted-mean TP concentration value (787 ppb), followed by the S-154 (683 ppb) and S-191 (665 ppb) basins in the Taylor Creek/Nubbin Slough subwatershed during WY2017 (SFWMD 2018).

C.1.1.11.4 Lake Okeechobee

Lake Okeechobee is considered to be the hydrologic heart of south Florida; it is a multipurpose reservoir that used to provide drinking water for urban areas, but still provides irrigation water for agricultural lands, recharge for aquifers, freshwater for the Everglades, habitat for fish and waterfowl, flood control, navigation, and many recreational opportunities. Lake Okeechobee has been designated by the FDEP as a Class I water body (drinking water supply). The surface water in the HHD toe ditch and nearby canals meets most Class III water quality standards (recreation and maintenance of healthy fish and wildlife populations). However, the water in Lake Okeechobee and canals has elevated concentrations of nutrients (primarily phosphorus and nitrogen). The Clean Water Act requires states to classify their surface waters according to designated uses and to develop water quality standards. If water bodies are not meeting the standards, states are required to develop Total Maximum Daily loads (TMDLs). The TMDLs establish the maximum amount of a pollutant that a water body can assimilate without causing an exceedance of water quality standards. Nutrient loads within the Lake Okeechobee Basin are regulated under the Northern Everglades and Estuaries Protection Program (NEEPP). The NEEPP specifies the implementation of Basin Management Action Plans (BMAPs). The Lake Okeechobee BMAP was adopted in December 2014 and allocated the TMDL to the entire Lake Okeechobee Watershed which includes all nine-sub watersheds to the north, south, east and west. The plans contain a schedule for subsequent phases of phosphorus load reduction consistent with the TMDLs and milestones must be set. The FDEP has a five-year cycle for setting and updating TMDLs and BMAPs. Florida statutes require agricultural and non-agricultural non-point source releases located in areas within a BMAP to implement best management practices (BMPs) or monitor to demonstrate compliance with state water quality standards. Revisions to the NEEPP were enacted in January 2016 and became effective July 1, 2016. Over the past 30 or more years, state and federal agencies have been working to reduce nutrient loading associated with agricultural operations in the Lake Okeechobee basin and downstream. Back-pumping agricultural storm runoff into the lake has been significantly curtailed and that has also improved lake water quality. A reduction in Lake Okeechobee phosphorus is desired, in part, to reduce the occurrence of blue-green cyanobacteria blooms in the lake, and to reduce the adverse effects of phosphorus on downstream systems, including the Caloosahatchee

River Basin and the St. Lucie River Basin. During high lake stages conditions, large volumes of water flow from Lake Okeechobee and sent to the Northern Estuaries. These large flow events reduce the salinity in the downstream estuaries (USACE 2007d).

Water quality in the lake has been greatly impacted over the long-term by agricultural operations in the Kissimmee Basin to the north and the EAA to the south, storing an estimated 30,000 MT of TP in the lake sediments and the large watershed inflow north of the lake. The FDEP has established a TP loading TMDL for Lake Okeechobee with a target annual load of 140 MT per year and a target in-lake TP concentration of 40 ppb. The 40 ppb TP target was established as the level of phosphorus necessary to reduce algal blooms to less than 10% of the time (Havens, K.E. & Walker, W. W. 2002). Control of nitrogen inputs has not been the focus in the Lake Okeechobee basin to date and there is no set goal. The FDEP has determined that the lake is impaired for nutrients and mercury in fish tissue.

In-lake TP concentrations declined from a high of 233 ppb in WY2005 to 93 ppb in WY2012 (SFWMD 2018). In WY2017, the in-lake TP concentration was 150 ppb, which is about 27% higher than the WY2016 value of 118 ppb. These in-lake TP concentration values exceed the TP in-lake goal of 40 µg/L by 3-4 times. The current five-year moving (WY2013–WY2017) average TP concentration is 129 ppb, which is near the upper value of the pre-hurricane (pre-2004) range of 57–127 ppb.

C.1.1.11.5 Caloosahatchee River and Estuary

Water quality conditions are degraded in the upper and lower areas of the Caloosahatchee River basin due to agricultural and urban runoff, respectively. The channelized section of the river also shows degraded water quality conditions, due to agricultural inputs, as compared to tributaries lying in less developed areas of the basin. Problems associated with the degraded areas of the basin are typified by low dissolved oxygen levels, elevated conductivity, decreased biodiversity, and mercury methylation / bioaccumulation. Conditions in the urbanized sections of the basin are influenced by non-point stormwater flows and are manifested in the river by elevated chlorophyll levels, cyanobacteria blooms, periodic fish kills, and low dissolved oxygen levels. Although wastewater releases remain a problem, the estuary is presently more seriously affected by high nutrient waters from the river and tributaries, and stormwater runoff from cities. Nutrient and chlorophyll can be elevated, and small cyanobacteria blooms occur regularly.

Lake Okeechobee provides approximately 60% of the freshwater flows at the S-79 structure which is the upstream end of the Caloosahatchee Estuary. The remaining volume of freshwater comes from Caloosahatchee River basin runoff. FDEP has identified mercury in fish tissue, nutrients, and dissolved oxygen as verified impairments to the main stem of the Caloosahatchee Estuary. Approximately two-thirds of the nutrient load to the Caloosahatchee Estuary is contributed from sources within the basin with the remaining fraction coming from Lake Okeechobee. Given that the estuary is nitrogen limited, FDEP has focused on controlling nitrogen loads to improve water quality. FDEP has developed a TMDL for TN in the estuary that requires a reduction in load of 23% relative to the current average annual load of 5,900 MT per year. FDOH has a fish mercury consumption advisory for the Caloosahatchee River and Estuary.

C.1.1.11.6 St Lucie River and Estuary

Water quality conditions along the St. Lucie River are rated as good in less developed areas of the basin. However, conditions are degraded in urbanized areas and along the extensive network of canals that drain this area. The worst water quality conditions in Martin and St. Lucie Counties are reported in the St. Lucie River and the canals leading from the EAA. Approximately 33% of total freshwater flow to the St. Lucie Estuary is provided by flows from Lake Okeechobee through the C-44 Canal. In the St. Lucie Estuary, 31.2% of the historic TN load comes from the lake and 17.4% of the historic TP load comes from the lake (SFER 2018). FDEP has determined that the St. Lucie River is impaired for Biochemical Oxygen Demand (BOD), TP, and TN. For the C-44 canal, FDEP established TMDL's for BOD, TP, and TN that require a reduction in load of 70, 55, and 51%, respectively from current conditions. Upstream portions of the St. Lucie River (north and south forks) are impaired for mercury; however, the main portion of the St. Lucie Estuary is not included in the FDOH list of fish consumption advisories for mercury.

C.1.1.12 Flood Control

Water management and flood control is achieved in south Florida through a variety of canals, levees, pumping stations, and control structures. This is also true within the LOWRP study area. The regulation schedules for Lake Okeechobee, Kissimmee, and Istokpoga Basins contain instructions and guidance on how to protect infrastructure within their area of influence. The regulation schedules represent the seasonal and monthly limits of storage which guides project regulation for the authorized purposes. In general, the schedules vary from high stages in the late fall and winter to low stages at the beginning of the wet season. These regulation schedules must take into account various, and often conflicting, project purposes.

In the Kissimmee River Basin, the net hydrologic effect of the canal and control structures was to shorten the residence time of water in the basin during periods of high water (floods) and to increase the residence time during low-flow (drought) periods.

Based upon a review of historical U.S. Geological Survey Data, under similar hydrologic conditions, the overall volume of waters delivered to Lake Okeechobee from the Lower Kissimmee River Basin via the completed project was found to be relatively the same as those volumes experienced under pre-project conditions. The timing of those water deliveries has been changed, however, which is reflective of the current water management practices for flood control and water conservation purposes within the basin. Although the project achieved flood reduction benefits, it also harmed the river-floodplain ecosystem.

After extensive planning, construction for the Kissimmee River Restoration Project began in 1999. The project is now nearly complete. In the lower Kissimmee River Basin, Reach 1 construction was completed in 2001 and Reach 4 was completed in 2010, restoring continuous water flows to approximately 24 of 40 miles of the Kissimmee River. Reaches 2 and 3, now underway, include backfilling the C-38 canal, and restoring flow to 16 miles of the river. Approximately 99% of lands needed to complete Kissimmee River Restoration (KRR) have been acquired — a total of 100,316 acres. More than 13 of 22 miles of canal have been backfilled and over 7,700 acres of floodplain wetlands have been restored. The response of the natural system has exceeded expectations.

It must be emphasized that in Lake Istokpoga area, the project design does not prevent State Road 621 from being overtopped by floodwaters from Lake Istokpoga during large events. Flooding of State Road

261 during large events is expected and provides Lake Istokpoga with additional outlet capacity. The best method for the reduction of flood hazard in this area is the modification of flood damage susceptibility and the regulation of the use of the zone of potential flooding. Such measure could promote optimum economic utilization of the Lake Istokpoga shores.

C.1.1.13 Water Supply

C.1.1.13.1 Lake Okeechobee

As one of the federally authorized project purposes, Lake Okeechobee supplies water for agricultural irrigation, municipalities, industry, and ENP, and for regional groundwater and salinity control. The primary water supply uses of Lake Okeechobee are to provide water supply for adjacent agricultural lands and to serve as a backup water supply for the Lower East Coast Service Area (LECSA) and west coast Florida counties when rainfall is insufficient and during dry periods (**Figure C-26**).

Lake Okeechobee and its connected conveyance system are the most significant surface water sources for the LOSA, which includes the EAA. Surface water from the lake and runoff from the EAA supply water to the regional system via canals and provide recharge to the Surficial Aquifer System. Agriculture in the LOSA covered approximately 255,500 acres outside of the EAA and the 460,000 acres within EAA in 2010 (most recent data available) and is the predominate user of lake water. Agricultural water supply demands equate to approximately 480,000 acre-feet per year for LOSA, which includes 303,000 acre-feet per year for just the EAA.

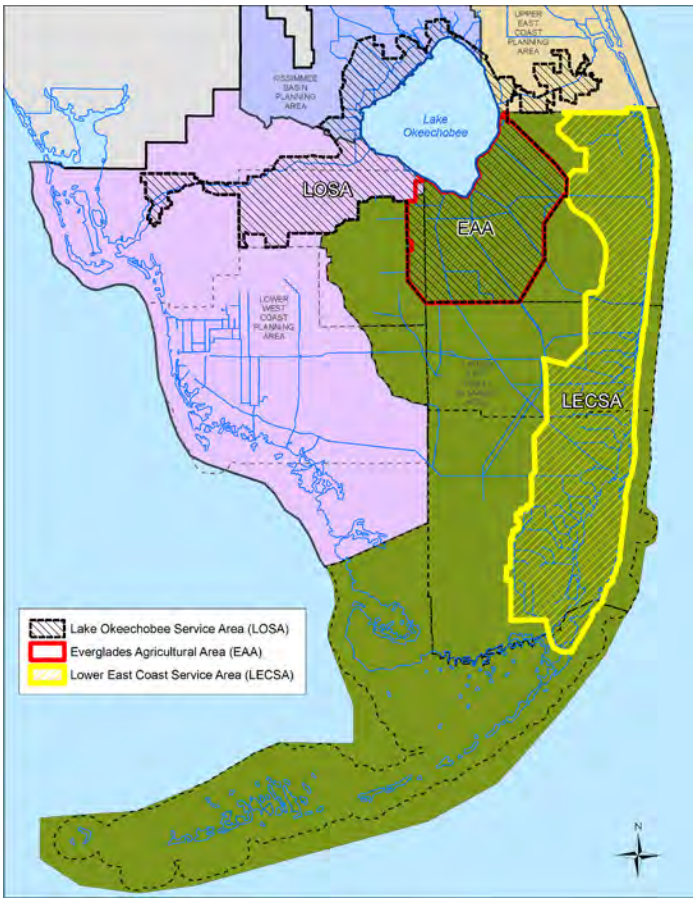


Figure C-26. Map of LOSA, EAA, and Lower East Coast Service Area.

In 2008, the USACE implemented the 2008 Lake Okeechobee Regulation Schedule (2008 LORS). The 2008 LORS provides operational flexibility to make Lake Okeechobee fresh water flows to meet project purposes as specified in the Water Control Plan. SFWMD also provides recommendations for USACE consideration regarding high volume flows to the Everglades or the Northern Estuaries for Lake Okeechobee flows within the low, base-flow or beneficial use sub-bands of the 2008 LORS (**Figure C-27**).

The right to use water within the LOWRP project area is authorized by a permit issued by the SFWMD. The conditions of permit issuance are more specifically enumerated in Chapter 40E-2 of the Florida Administrative Code (F.A.C.), which also incorporates by reference the current SFWMD Applicant's Handbook (SFWMD 2015). In order to provide reasonable assurances that the conditions of permit issuance are met, applicants must meet consumptive use permitting criteria. Technical criteria are used to evaluate the purpose, quantity, and source of proposed water to prevent harm including the following: (1) saltwater intrusion, (2) wetland and other surface water body impacts, (3) pollution, (4) impacts to off-site land uses, (5) interference with existing legal users, and (6) minimum flows and levels.

Water supplies allocated from Lake Okeechobee and its connected conveyance systems are primarily for supplemental irrigation to the LOSA agricultural areas. In the LOSA, the Okeechobee Utility Authority is the only remaining Public Water Supply (PWS) utility using water directly from Lake Okeechobee. The Okeechobee Utility Authority relies on Lake Okeechobee for part of its PWS supply with the balance coming from a surficial aquifer wellfield. Clewiston, South Bay, Belle Glade, and Pahokee discontinued the

use of Lake Okeechobee as their supply source in 2005 and now use Floridan Aquifer water treated by reverse osmosis to meet their PWS demand.

Water shortages are declared by the SFWMD Governing Board when available groundwater or surface water is not sufficient to meet users' needs or when conditions require temporary reduction in total use within the area to protect water resources from serious harm. The SFWMD's Water Shortage Plans are contained in Chapters 40E-21 and 40E-22, F.A.C. The purposes of the plans are to protect the water resources of the State from serious harm; assure equitable distribution of available water resources among all water users during times of shortage, consistent with the goals of minimizing adverse economic, social, and health related impacts; provide advance knowledge of the means by which water apportionments and reductions will be made during times of shortage; and promote greater security for consumptive use permittees. The current SFWMD water shortage management plan for Lake Okeechobee, known as the Lake Okeechobee Water Shortage Management (LOWSM) Plan was implemented in November 2007. It requires various actions to be taken according to the severity of the actual and projected lake water levels. The basis of this plan is an allocation scheme that equitably divides available lake water based on a percentage of the 1-in-10 water demand. If the lake level continues to fall, the percentage of water restrictions increases. If the water level at the beginning of the dry season is low, then the likelihood of water restrictions is greater.

In October 2008, the SFWMD adopted Restricted Allocation Area criteria for the LOSA as part of the Minimum Flow and Minimum Water Level (MFL) recovery strategy for Lake Okeechobee following an extended drought and USACE implementation of the 2008 LORS, which generally lowered the water levels by one foot in Lake Okeechobee. According to the SFWMD, without modification to the current LOWSM, the frequency of water shortage restrictions is expected to increase from 1-in-10 years to experiencing restrictions 1-in-6 years while the lake is being operated under the 2008 LORS. Because of the impacts to water supply, the SFWMD enacted rules to limit future additional withdrawals from Lake Okeechobee in order to prevent further degradation of the level of certainty for existing legal users and to avoid exceeding the MFL criteria. Also, based on MFLs, Section 373.709, F.S. requires development of water supply plans which include water recovery, large-decrease-prevention strategies, water resource development, and water supply development projects necessary to achieve compliance with the MFLs during project planning phases. Implementing these projects will enable the replacement or an increase in current water sources with other supplies to help provide sufficient water amounts for beneficial use as stated in Section 373.0421, F.S. When these projects are finished, the District will certify the amount of available water as defined in subsection 40E-8.021(5), F.A.C. The SFWMD permitting rules also ensure that water necessary for Everglades restoration is not allocated for consumptive use. The regulatory criteria limit allocations from Lake Okeechobee and connected surface waters, including the Caloosahatchee River and St. Lucie River (C-44 canal), to base condition water uses as defined within the SFWMD *Applicant's Handbook for Water Use Permit Applications* for the period from April 1, 2001 to January 1, 2008 (SFWMD 2015).

C.1.1.13.2 Seminole Tribe of Florida Water Supply

The STOF has six reservations located in Florida. The reservations include Brighton, Tampa, Fort Pierce, Immokalee, Hollywood, and Big Cypress. Hollywood is the headquarters location for the Seminole Tribe of Florida.

Two reservations of the Seminole Tribe of Florida rely on Lake Okeechobee as a secondary supplemental irrigation supply source for their surface water, with specific volumes of water identified for this purpose for the Seminole Tribe of Florida's Big Cypress Reservation and an operational plan addressing drought-water shortage operations for the Brighton Reservation.

The Seminole Tribe of Florida has surface water entitlement rights pursuant to the 1987 Water Rights Compact between the Seminole Tribe of Florida, the State of Florida, and the SFWMD. (Public Law No. 100-228; 101 Stat. 1566 and Chapter 87-292 Laws of Florida as codified in section 285.165, [Fla. Stat.]). Additional documents addressing the Water Rights Compact entitlement provisions have since been executed. These documents include Agreements between the Tribe and SFWMD and a SFWMD Final Order. Of particular interest in this regard is the 1996 Agreement which commits the SFWMD to mitigate impacts to the Tribe's ability to obtain surface water supplies at both the Brighton and Big Cypress Reservations, which may be diminished as a result of various activities.

For the Big Cypress Reservation, the SFWMD has installed forward pumps to deliver water from Lake Okeechobee at lower stages to the Miami Canal. This option remains a part of drought management alternatives. Also, real-time operational decisions made during a declared drought event include recognition of the Tribe's water rights. These decisions remain a part of the SFWMD drought management operations.

For the Brighton Reservation, various options of securing both short and long-term water supply deliveries to agricultural operations in the Southern Indian Prairie Basin are being evaluated extensively and implemented where possible. For example, other water source and conveyance options, including deviations to the Lake Istokpoga Regulation Schedule (USACE 1994) to provide for additional water supply and modifications to the C-40 canal to augment the pump station G-208 capability, continue to be explored.

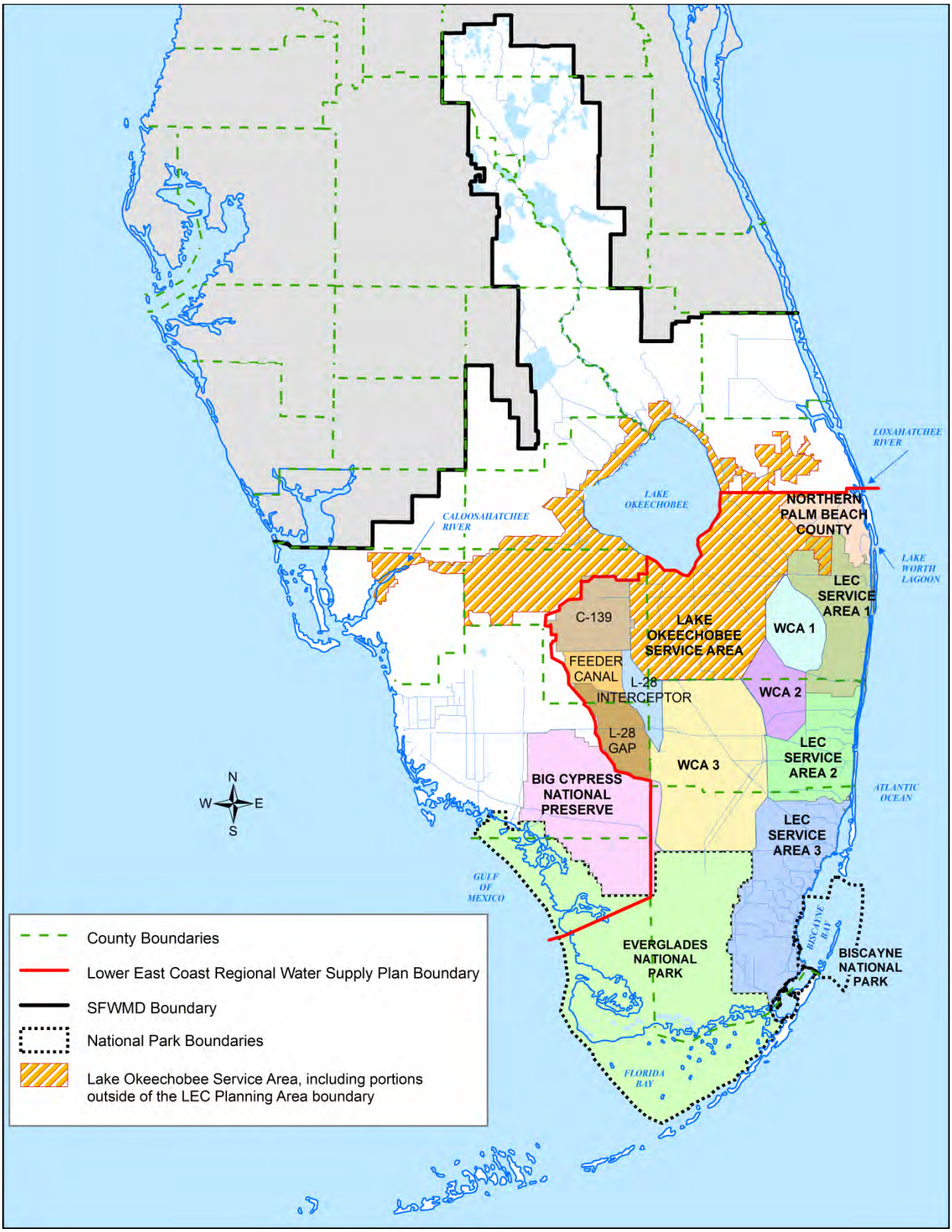


Figure C-27. Map of South Florida Water Management lower east coast service area.

C.1.1.14 Air Quality

According to the Florida Department of Environmental Protection (FDEP) Division of Air Resource Management – Office of Air Monitoring's 2012 Air Monitoring Report, all counties in the project area are in attainment for all criteria pollutants (carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide, and particle pollution). This is the most recent data available on the FDEP website (confirmed by personal communication March 2018). The U.S. Environmental Protection Agency's (EPA) AirData database contains measurements of air pollutant concentrations for the entire United States. The measurements include both criteria air pollutants and hazardous air pollutants and are compared against the National Ambient Air Quality Standards (NAAQS) specified by the EPA. The AirData database was queried for air quality data between 2002 and 2006 (newest comparison information available) within the project area. The data show that Glades, Hendry, Martin, Okeechobee, and Palm Beach counties are currently in attainment for all six criteria air pollutants. The AirData database also provides annual summaries of Air Quality Index (AQI) values for counties or metropolitan areas. The AQI is an approximate indicator of overall air quality, because it takes into account all of the criteria air pollutants measured within a geographic area. The AQI summary values include both qualitative measures (i.e., days of the year having "good" air quality) and descriptive statistics (i.e., median AQI value). The AQI for Palm Beach County, the most developed portion of the study area indicates that air quality is generally good, with no periods when air quality is classified as unhealthy for sensitive groups. Of the six criteria air pollutants, ozone and particulate matter of 2.5 millimeters or less are most likely to occur within this county. However, the air quality is within NAAQS limits for these parameters.

C.1.1.15 Hazardous, Toxic or Radioactive Wastes

Engineering Regulation (ER) 1165-2-132 states that "construction of Civil Works projects in HTRW contaminated areas should be avoided where practicable." Compliance with the requirements of ER 1165-2-132 for the planning phase is demonstrated in this report. The USACE and SFWMD will continue to document HTRW conditions on the project lands such that the project will be in compliance with the ER and other applicable HTRW policies. In order to comply with the requirements of ER 1165-2-132, human health risks are typically evaluated by comparing chemical concentrations in all media (e.g., soil, groundwater, surface water, sediment) to human health-based cleanup target levels (CTLs) promulgated by FDEP in Chapter 62-777, F.A.C. Ecological risks are typically evaluated by comparing chemical concentrations to the Sediment Quality Assessment Guidelines (SQAGs) developed by the FDEP for inland waters and to ecological restoration targets established by the USFWS. If warranted, lands within the project boundary are investigated in accordance with the jointly developed (the FDEP, USFWS, and SFWMD) protocol entitled "Protocol for Assessment, Remediation and Post-remediation Monitoring for Environmental Contaminants on Everglades Restoration Projects" (SFWMD 2008). The protocol, which is commonly referred to as the Ecological Risk Assessment (ERA) Protocol, is intended to provide guidance on conducting environmental site assessments on agricultural lands proposed for use in projects to be inundated with water, such as for conversion to storm water treatment areas, wetlands, reservoirs, and other aquatic features.

The ERA Protocol requires that relevant data collected during the Phase II ESA initially be compared to the human health Soil Cleanup Target Levels (SCTLs) from 62-777 F.A.C. and the ecological risk SQAG thresholds. While the SCTL's are promulgated standards under Florida law, the SQAG guidelines are not

standards as defined in Section 403.803, F.S. where the results exceed the SCTLs, a risk-based approach is used by the regulator to determine if corrective action is required or if an alternative target level is appropriate based on projected exposure. Where the results exceed the SQAG screening criteria, a Screening Level Ecological Risk Assessment (SLERA) is performed as part of the Phase II ESA. The purpose of the SLERA is to evaluate potential ecological risks to benthic invertebrates and higher trophic species, particularly USFWS trust species protected under the Endangered Species Act or the Migratory Bird Treaty Act, associated with exposure to the chemicals present in the soils, after the project is constructed and the property is inundated.

HTRW personnel worked with the South Florida Water Management District to identify and review available environmental assessments and documentation associated with the parcels contained within the LOWRP footprint. At a minimum for screening and budgetary purposes, a desktop screening-level environmental site assessment should be conducted for each parcel to identify activities or conditions adverse to the project's water quality. The desktop review includes the analysis of current and historical aerial photography, a regulatory database search as listed in ASTM-E1527-13 and 40 CFR Part 312 Standards and Practices for all Appropriate Inquiries, and a review of available regulatory records on the FDEP OCULUS database management system. Emphasis should be given to identification of potential "point sources" of contamination such as current/former agricultural areas, including agricultural fields, pump stations, maintenance areas, fueling facilities, and pesticide/herbicide mix/load/rinse/storage areas. The regulatory database search includes the following:

- Federal National Priorities List (NPL)(1 mile radius)
- Federal Delisted National Priorities List (0.5 mile radius)
- Federal Superfund Environmental Management System (SEMS) (former Comprehensive Environmental Response, Compensation and Information System [CERCLIS] list) (0.5 mile radius)
- Federal SEMS – Archive [former CERCLIS NFRAP list] (0.5 mile radius)
- Federal Resource Conservation and Recovery Act (RCRA) Corrective Action Report (CORRACTS) list (1 mile radius)
- Federal RCRA non-CORRACTS Treatment, Storage and Disposal (TSD) list (0.5 mile radius)
- Federal RCRA Generators list (property and adjoining properties only)
- Federal institutional control/engineering control registries (property only)
- Federal Emergency Response Notification System (ERNS) list (property only)
- State and tribal equivalent cleanups (1 mile radius)
- State and tribal equivalent CERCLIS (0.5 mile radius)
- State and tribal landfill and/or solid waste disposal site lists (0.5 mile radius)
- State and tribal equivalent Leaking Underground Storage Tank (LUST) list (0.5 mile radius)
- State and tribal registered storage tank lists (property and adjoining properties only)

- State and tribal institutional control/engineering control registries (property only)
- State and tribal voluntary cleanup sites (0.5 mile radius)
- State or tribal brownfield sites (0.5 mile radius)

If HTRW issues are identified in the desktop screening-level environmental site assessment, then a Phase I and possibly a Phase II environmental site assessment should be completed to understand the nature and extent of any contaminants of concern. Should remediation of HTRW contamination be required, it is the responsibility of the SFWMD, the non-federal sponsor and is not a creditable cost to the project. Real Estate section personnel provided lists of parcels contained within the reservoir and wetlands footprints but a list of parcels contained within the ASR footprints has not been generated to date. Regardless of whether a parcel has been assessed to date, the SFWMD practice is to conduct environmental assessments, or updates to environmental assessments, to confirm historical conditions and ensure all HTRW conditions have been identified and resolved prior to project construction.

Available environmental assessments and documentation associated with the parcels contained within the footprint of the various component features that make up the focused array of alternatives is shown in **Figure C-28** and are inventoried and discussed below.

C.1.1.15.1 Kissimmee River–Center and Paradise Run Wetland Sites

The Kissimmee River–Center and Paradise Run wetland features are included in all of the focused array of alternatives. USACE-SAJ HTRW personnel worked with the SFWMD to identify and review available environmental assessments and documentation associated with the parcels contained within the footprint of the Kissimmee River Center and Paradise Run Wetland Sites shown in **Figure C-29.**

Inspection of **Figure C-29** indicates the Kissimmee River–Center and Paradise Run Wetlands footprints contain 43 privately owned and 20 SFWMD/State owned parcels of land for a total of 63 parcels. At a minimum and regardless of previous environmental investigations, a desktop screening-level environmental site assessment should be conducted for each parcel to provide additional budgetary and screening information to help refine and confirm alternative selection decision making. The cost to complete these assessments for the 63 parcels located within the Kissimmee River Central and Paradise Run Wetlands footprints is approximately $63,000.

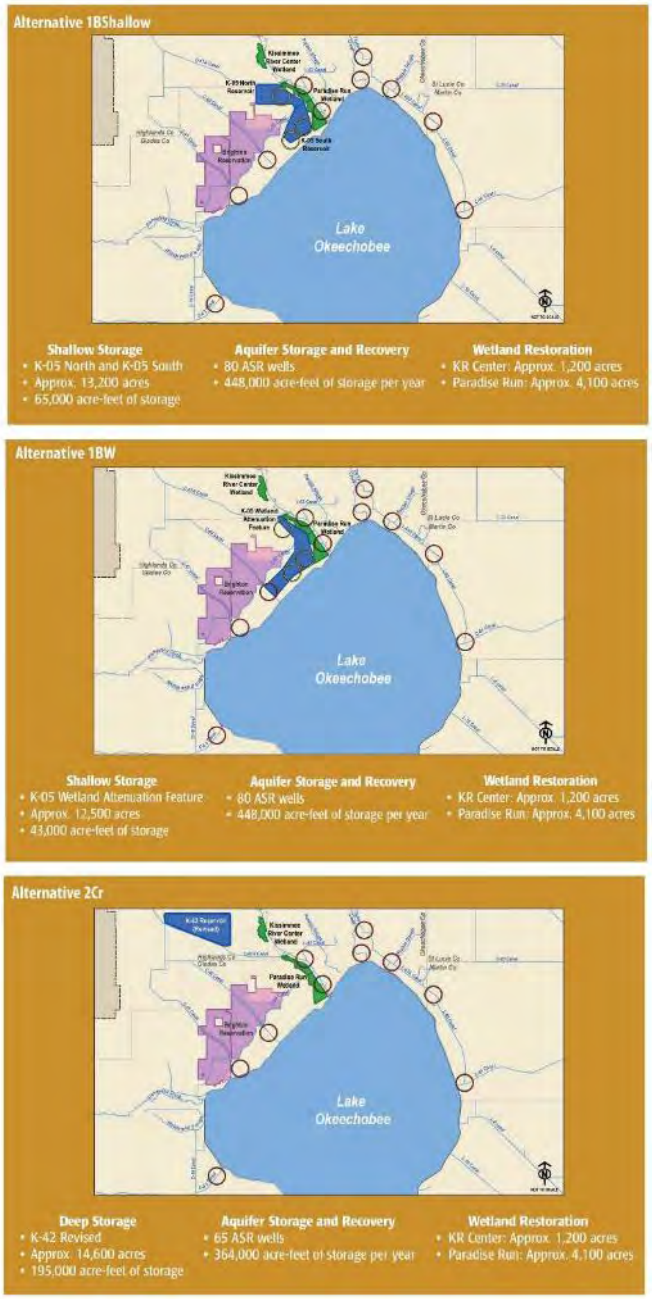


Figure C-28. Focused array of alternatives with component features.

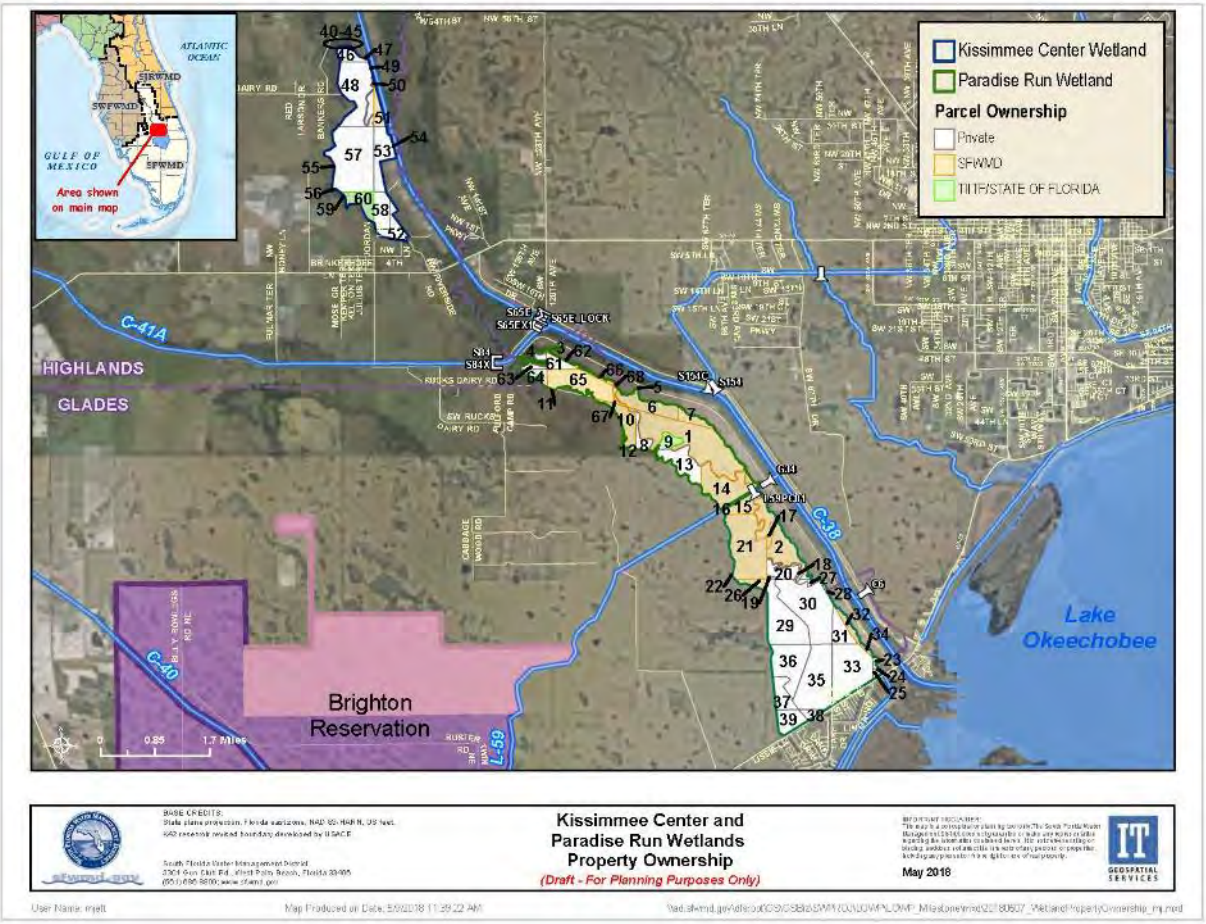


Figure C-29. Kissimmee River–Center and Paradise Run wetland sites and parcels.

Prior to acquisition of parcels that are not screened out, a Phase I environmental site assessment should be completed to ensure the identification and resolution of any HTRW sites prior to project construction. The cost to complete Phase I environmental site assessments for all of the 63 parcels contained in these footprints is approximately $157,500. Phase II environmental assessments or remediation efforts other than those described later in **Annex G** will not be defined well enough to develop a reasonably accurate cost estimate until the Phase I environmental site assessments are complete. Known conditions within the Kissimmee River Central and Paradise Run Wetlands footprints include the following:

Property 1. Among a number of relatively low-risk conditions, a cattle pen(s) operation was identified within the Paradise Run Wetland footprint which will require additional assessment and potentially remediation.

Property 2. An underground gasoline storage tank, an aboveground diesel storage tank, and 55-gallon drums of hydraulic fluid were identified. The size of the tanks and the number of drums is unknown but no large signs of spillage were observed on the surface. Phase II environmental assessment and, potentially, remedial action will be required to address the tanks and drums observed on the property.

Under circumstances where remediation of HTRW contamination is required, it is the responsibility of the SFWMD, the non-federal sponsor, and is not a creditable cost to the project.

C.1.1.15.2 ASR Systems

Aquifer Storage and Recovery Systems (ASRs) are included in all of the Focused Array of Alternatives. ASR cycle testing has shown increased arsenic concentrations in recovered water at many ASR systems currently in operation throughout Florida. Increased arsenic results from a reaction of dissolved oxygen in recharge water, which oxidizes the mineral pyrite (iron sulfide) that commonly occurs in marine limestones that include the FAS. Arsenic concentrations can exceed the maximum contaminant level (10 µg/L) in recovered water, which violates the Safe Drinking Water Act. The surface water quality arsenic criterion (50 µg/L; Florida Administrative Code 62-302.530) can also be exceeded. The CERP Kissimmee River and Hillsboro ASR pilot project systems (USACE, 2013) successfully demonstrated arsenic release and subsequent attenuation during ASR cycle testing in the UFA when lightly treated surface water is recharged into the aquifer. Groundwater quality conditions in Okeechobee and Glades counties are similar so that arsenic attenuation is likely at LOW ASR systems. Regarding contaminated media, the ASR system conceptual footprints contain at least 8 parcels of land. There is no available parcel or ownership information other than the conceptual ASR well field layouts shown in **Figure C-28**. Actual ASR wellfields can be sited and expanded upon completion of exploratory programs. Well-siting and ASR well cluster configurations will preliminarily be based on available state or federally owned land.

At least 8 parcels will require a desktop ESA and if Phase I's are complete then the associated costs are estimated to be $8,000 and $20,000, respectively. HTRW section personnel will review available SFWMD environmental documentation generated for parcels contained within the ASR footprints to identify HTRW sites; potential HTRW impacts; and sites with the potential for agricultural chemical contamination once these parcels are identified.

Phase II environmental assessments or remediation efforts other than those described later in **Annex G** will not be defined well enough to develop a reasonably accurate cost estimate until the Phase I environmental site assessments are complete.

C.1.1.15.3 K-42 Reservoir Revised

The K-42 Reservoir component feature is included only in the 2Cr alternative of the focused array of alternatives. The K-42 Reservoir Revised footprint contains six parcels of land that are privately owned and there are no available environmental assessments or environmental documentation from the SFWMD regarding the HTRW status of these parcels. The SFWMD has no available environmental documentation describing the presence or non-presence of HTRW conditions on these parcels. The parcels contained within the boundaries of the K-42 Revised Reservoir footprint are shown in **Figure C-30**.

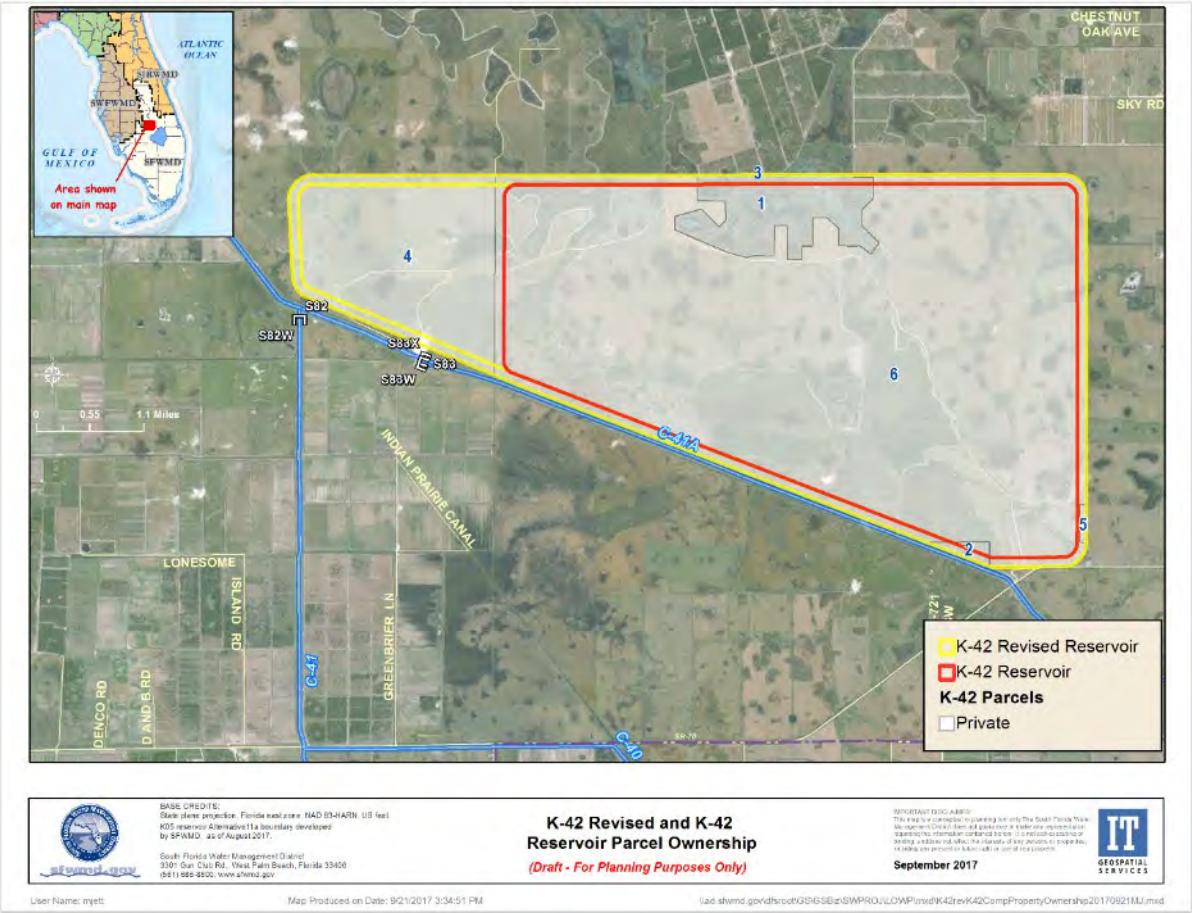


Figure C-30. K42 revised parcel ownership & location map.

The 6 parcels will require a desktop ESA and if Phase I's are complete then the associated costs are estimated to be $6,000 and $18,000, respectively.

Phase II environmental assessments or remediation efforts other than those described later in **Annex G** will not be defined well enough to develop a reasonably accurate cost estimate until the Phase I environmental site assessments are complete.

C.1.1.15.4 K-05 (North & South) Boomerang Reservoir

The K-05 Boomerang Reservoir feature is included only in the 1Bshlw alternative of the focused array of alternatives. HTRW section personnel reviewed available SFWMD environmental documentation generated for parcels contained within the K-05 Boomerang Reservoir footprint to identify HTRW sites; potential HTRW impacts; and sites with the potential for agricultural chemical contamination. The K-05 Boomerang Reservoir footprint contains 98 privately owned and 29 SFWMD/state-owned parcels of land for a total of 127 parcels. Privately owned parcels contained within the boundaries of the K-05 Boomerang Reservoir footprint are shown in white and SFWMD-owned parcels are shown in beige (**Figure C-31**).

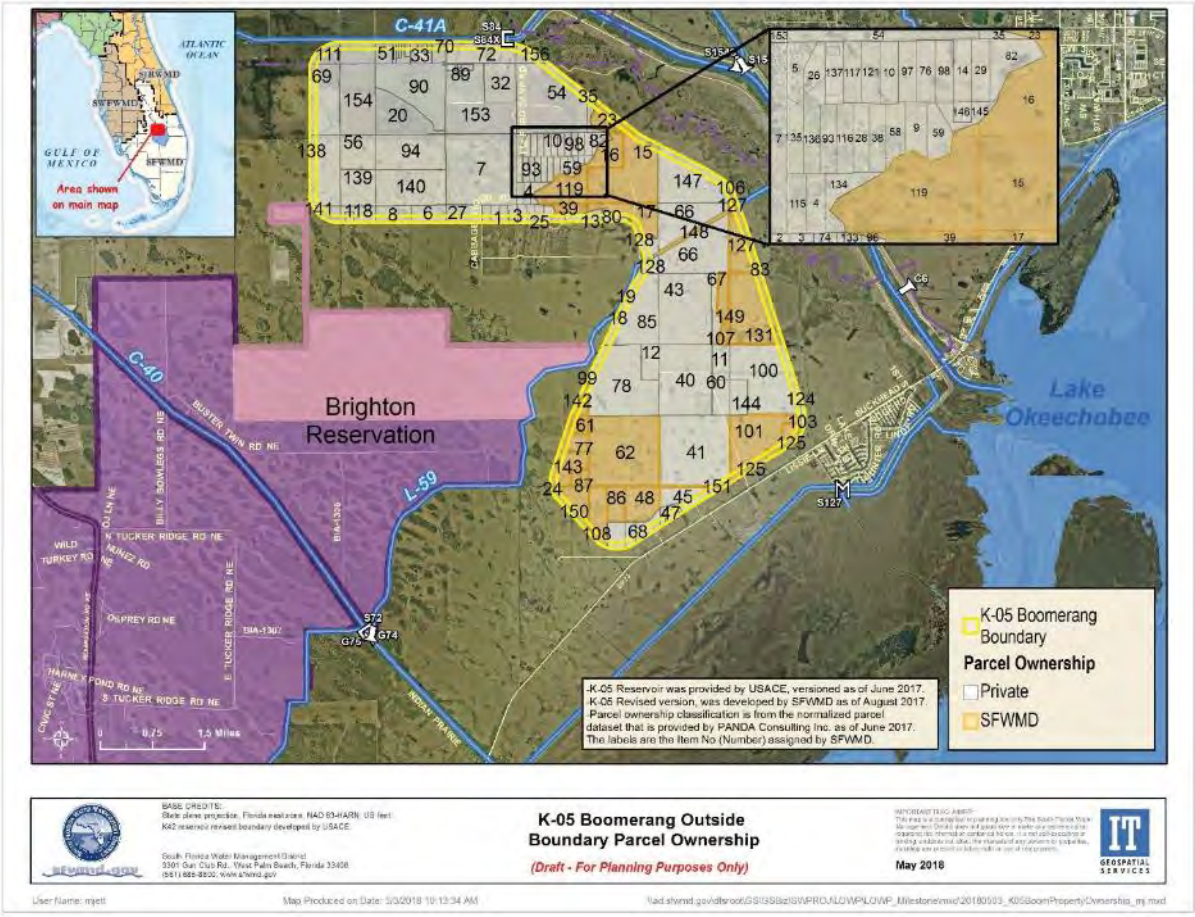


Figure C-31. K-05 Boomerang Reservoir parcel ownership and location map.

Although there are some dated environmental assessments and environmental documentation available from the SFWMD regarding the HTRW status for some of their parcels described below, all of the parcels within the K-05 Boomerang Reservoir footprint will require environmental assessments or significant updates.

The 127 parcels will require a desktop ESA and if Phase I's are complete then the associated costs are estimated to be $127,000 and $317,500, respectively.

Phase II environmental assessments or remediation efforts other than those described later in **Annex G** will not be defined well enough to develop a reasonably accurate cost estimate until the Phase I environmental site assessments are complete.

The P1 Properties

The P1 Properties include seven SFWMD Tracts within the K-05 Reservoir footprint. The SFWMD commissioned Environmental Consulting & Technology, Inc. (ECT) to complete a Phase I/Phase II environmental assessment in 2006 for the P1 properties shown in **Figure C-32** and listed in **Table C-2**. Available portions of the ECT report are provided **Annex G**.

The following excerpt from the ECT report describes the issues affecting these parcels:

> "Soil and groundwater analytical results from the Phase II investigation were reviewed to evaluate the necessity for and estimated costs of corrective actions. Based upon areas of concern identified during the Phase II ESA, an ecological risk assessment was performed.
>
> "DDE has been identified as chemicals of potential ecological concern (COPECs). The presence of DDE is not considered to preclude the use of the property except in the context of the levels within the areas designated as TCASB-23, TCASB-25, TCASB-26, TCASB-27, TCASB-28, TCASB-30, TCASB-37 and TCASB-38, which is estimated to encompass approximately 400 acres.
>
> "Outside of these areas and the identified point sources on the P1, little to no potential adverse ecological effects would be predicted, and as such, would not preclude the use of the property as a water retention reservoir or other water control structure."
>
> "On the basis of the information obtained from the Phase II ESA, ECT recommends the implementation of corrective action activities be conducted, at point sources and areas TCASB-23, TCASB-25, TCASB-26, TCASB-27, TCASB-28, TCASB-30, TCASB-37 and TCASB-38, as provided in Sections 8 and 9 of this report. The estimated cost to implement the investigation and corrective action activities is $566,753.60. It is ECT's opinion that the investigation and correction activities can be completed within a one to two year period."

At the request of the SFWMD, ECT evaluated the recommended corrective actions, as they would relate to 2 proposed future land uses. The first land use would be the property's continued agricultural use, or conversion to residential or industrial land uses and the second would consist of the property's proposed future land use as a surface water impoundment.

The costs associated with the proposed future land use as an agricultural, residential or industrial property were calculated based upon the contaminants of concern, identified on the property, at concentrations, which exceed the FDEP Soil Cleanup Target Levels [SCTLs (Chapter 62-777, FAC)].

Notwithstanding the corrective actions described in Section 8.0, there are no other identified regional environmental conditions that would inhibit the property from being utilized for its projected land use as a water storage impoundment structure."

A SFWMD commissioned study completed in 2006 by ECT for the P1 Properties including seven SFWMD Tracts indicated that DDE (dichlorodiphenydichloroethylene) contamination exists within the K-05 Reservoir footprint requiring remediation via soil inversion. DDE is a breakdown product of the insecticide DDT (dichlorodiphenyltrichloroethlyene). The cost to complete remedial activities related to the DDE and other point sources of contamination related to the P1 Properties within the K-05 South Reservoir footprint is estimated in 2017 dollars to be $1,014,489 and is estimated at a minimum to require up to two years to complete. The remaining 21 SFWMD Tracts were apparently acquired prior to the practice of conducting environmental assessments.

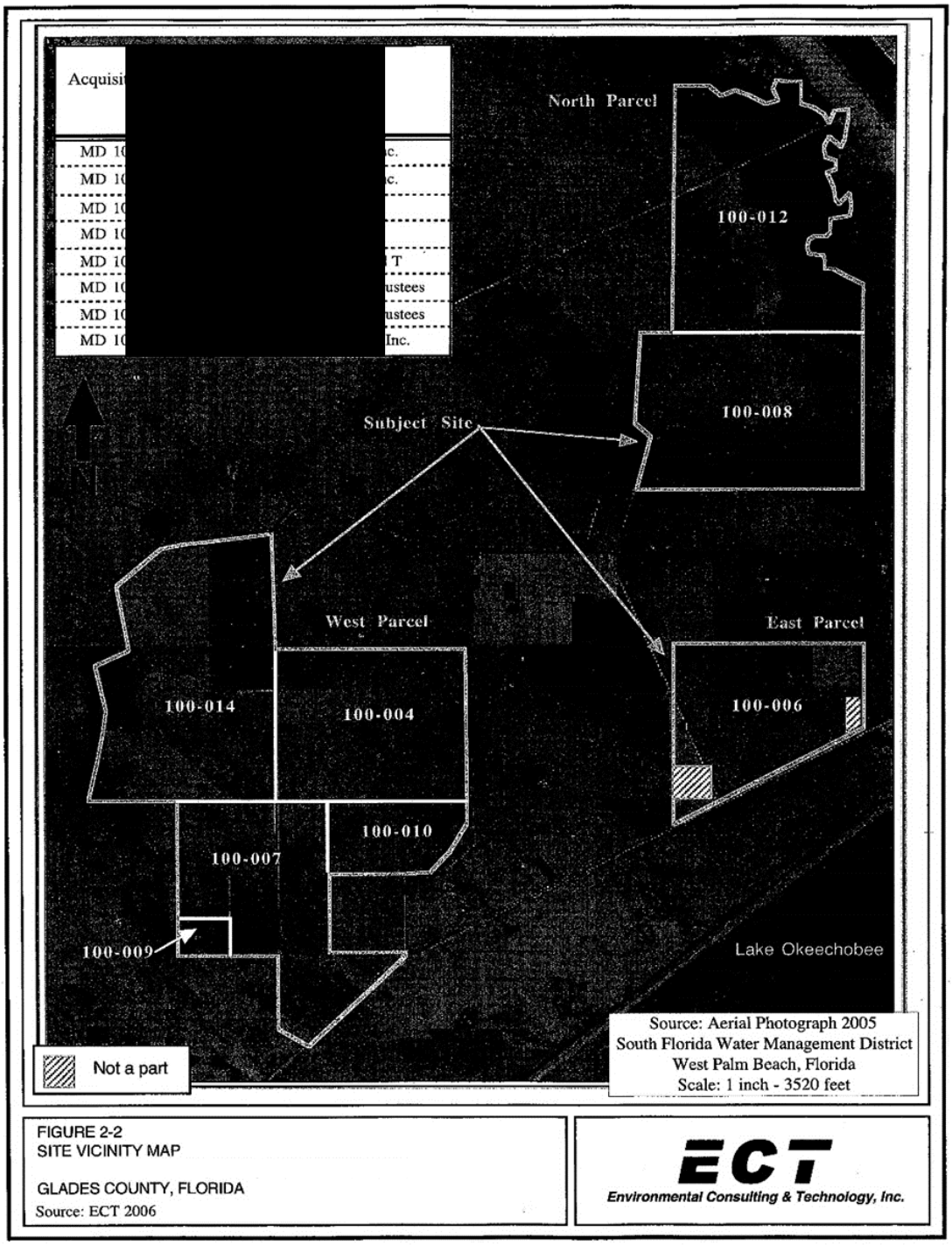


Figure C-32. P1 properties location map.

Table C-2. P1 properties.

TRACT NO.	ACREAGE
MD 100-004	734.46
MD 100-006	567.97
MD 100-007	605.47
MD 100-008	1,374.78
MD 100-009	40.75
MD 100-010	189.75
MD 100-012	283.97
MD 100-014	922.70

The P2 Properties

The P2 Parcel is included in the K-05 Boomerang Reservoir footprint. SFWMD personnel conducted an inspection of the properties on 25 October 1999 and then conducted a subsequent inspection to confirm the presence of a cattle vat that was completed on 8 November 1999. The general location of the P2 parcel cattle vat is shown in **Figure C-33**. By inspection, the cattle vat shown in **Figure C-33** is contained within the boundary of the K-05 Boomerang Reservoir footprint. The following is an excerpt from a memorandum provided in Attachment 2 from Robert Kukleski, Environmental Engineer, REC, Water Resource Management, to Blair LittleJohn, Director, Real Estate Division, REC, Water Resource Management, dated 13 January 2000:

"It is recommended that the characterization phase of the remedial strategy for cattle dipping vat sites that was developed in conjunction with the Florida Department of Environmental Protection (DEP) be implemented at this location. This strategy has been successfully implemented at 15 District sites. The initial investigation will delineate the extent of the contaminated area and will evaluate remedial measures (with associated costs.) The degree of remedial effort would be consistent with projected future land use (Water Retention Reservoir/STA.) The cost associated with the characterization phase is estimated at approximately $56,000. The cost of the subsequent remedial effort is dependent upon the results of the characterization work."

The estimated cost to characterize and remediate this cattle vat is approximately $310,855 in 2018 dollars. Under circumstances where remediation of HTRW contamination is required, it is the responsibility of the SFWMD, the non-federal sponsor, and is not a creditable cost to the project.

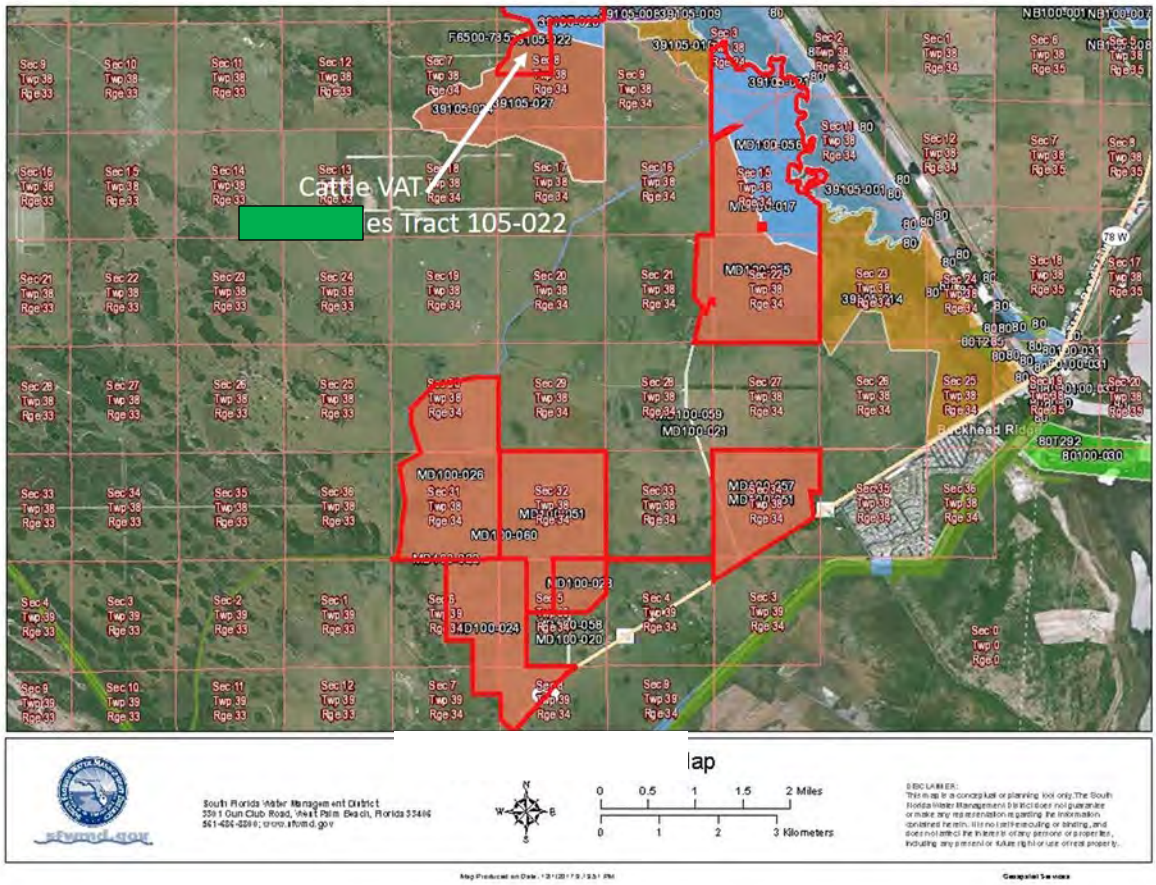


Figure C-33. SFWMD TRACT- state plain location map, P2 parcel - tract 105-022.

C.1.1.15.5 K05 Wetland Attenuation Feature (K-05 Alt 1BW)

The K-05 WAF is included only in the 1BW alternative of the Focused Array of Alternatives. HTRW section personnel reviewed available SFWMD environmental documentation generated for parcels contained within the K-05 Alt 1BW footprint to identify HTRW sites; potential HTRW impacts; and sites with the potential for agricultural chemical contamination. The K-05 Alt 1BW footprint contains 65 privately owned and 35 SFWMD/State owned parcels of land for a total of 100 parcels. Privately owned parcels contained within the boundaries of the K-05 Alt1 BW footprint are shown in white and SFWMD/State owned parcels are shown in beige on **Figure 34**.

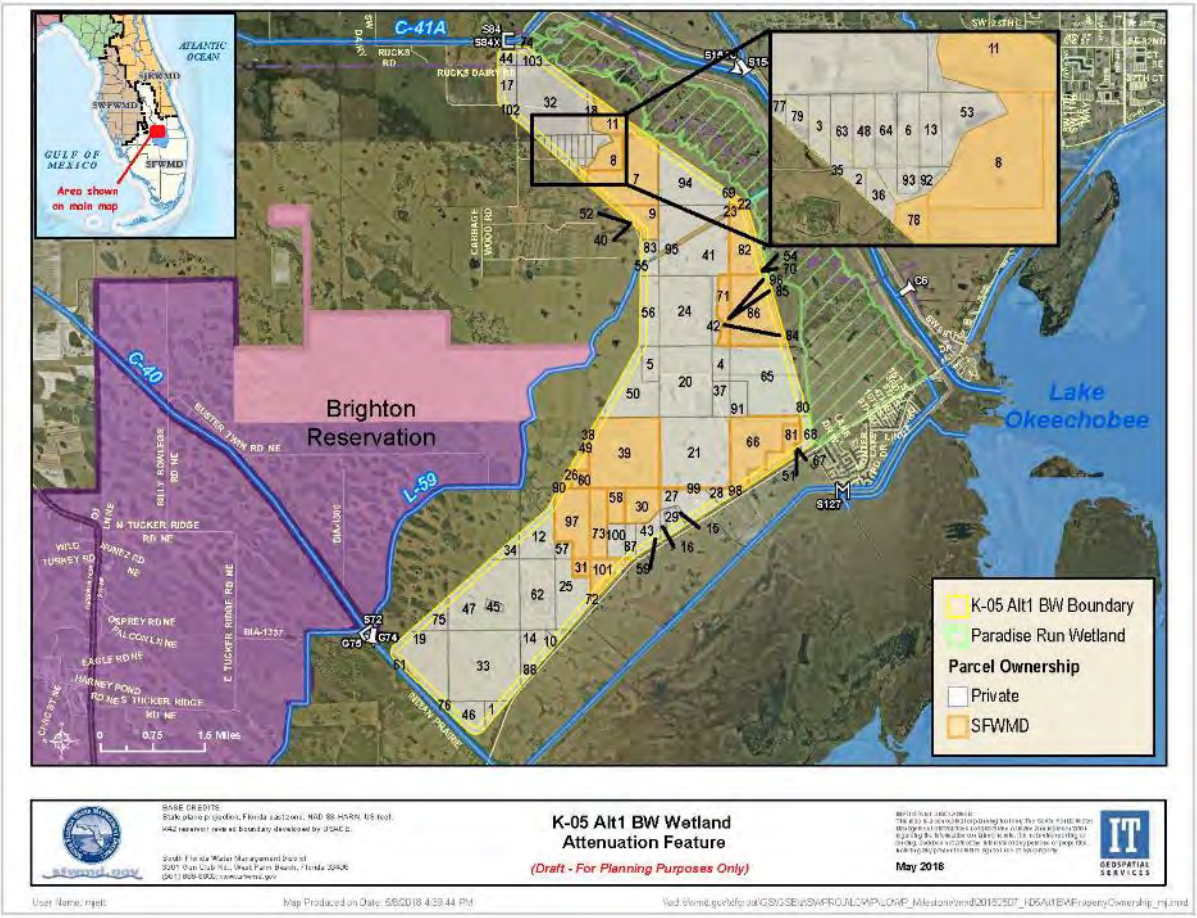


Figure 34. K-05 Alt1 BW WAF parcel and location map.

Although there are some dated environmental assessments and environmental documentation available from the SFWMD regarding the HTRW status for some of the same parcels previously described for the K05 Boomerang Reservoir footprint, all of the parcels within the K-05 Alt 1BW footprint will require environmental assessments or significant updates.

The 100 parcels will require a desktop ESA. If Phase I assessments are also completed then the associated costs are estimated to be $100,000 and $250,000, respectively.

Phase II environmental assessments or remediation efforts other than those described later in **Annex G** will not be defined well enough to develop a reasonably accurate cost estimate until the Phase I environmental site assessments are complete.

C.1.1.16 Noise

Noise levels are associated with surrounding land use. Within the major natural areas of south Florida, external sources of noise are limited and of low occurrence. There is no significant noise generating land users within these areas. Existing sources of noise are limited to the vehicular traffic travelling on roads adjacent to and cutting through the project area. Other sources of noise which may occur within these

natural areas include air boats, off road vehicles, swamp buggies, motor boats, and occasional air traffic. Sound levels are typically in the range of 85 to 105 decibels (dB) for motorboats and air boats, respectively. Wilderness ambient sound levels are typically in the range of 35 dB and should not be an issue for wildlife.

Along Lake Okeechobee there are a number of existing sources currently contributing to the overall ambient noise level. The more predominant of these sources include: vehicular traffic on U.S. 27 and other local roadways, boat traffic along the rim canal and on the outside edge of the littoral zone, small industry (i.e., produce processing and distribution), urban activities in Moore Haven, Clewiston, Pahokee, Okeechobee, and Belle Glade, agricultural equipment (tractors, trucks, etc.), and pumping stations.

Rural areas typically have noise levels of 35-55 decibels. Sound levels along transportation arteries are typically in the range of 70 decibels. According to the FDOT State Environmental Management's Office, no known ambient noise monitoring has been conducted in the project area; consequently, no quantitative data on noise levels within the project area are available for analysis.

C.1.1.17 Aesthetics

The visual characteristics of south Florida can be described according to the three dominant land use categories: natural areas, agricultural lands, and urban areas. The natural areas consist of a variety of upland and wetland ecosystems, including lakes, ponds, vast expanses of marsh and wet prairie, with varying vegetative components. Uplands are often dominated by pine, although other sub-tropical and tropical hardwoods such as Brazilian pepper, fig, gumbo limbo, oak and cypress do occur. These areas are more fully described in **Section C.1.1.1**. Overall, the land is extremely flat, with few natural topographic features such as hills or other undulations. Much of the visible topographic features within the natural areas are man-made, including canals and levees. Additional man-made features include pump stations, navigation locks, secondary and primary roads, highways, electrical wires, communication towers, occasional buildings, borrow pits and other features which may or may not detract from the regional aesthetic. Visual aesthetics when possible from a high perspective such atop a levee, offer pleasant and unspoiled perspectives of Everglades marsh with numerous birds and other wildlife. Agricultural lands are cultivated for cattle ranching, citrus, and greenhouse/nursery. Visual aesthetics are marginal. Development is typically immediately adjacent to or nearby protected natural areas. These areas are more fully described in **Section C.1.1.18**.

There are many public access points to view Lake Okeechobee from the HHD elevated vantage point and scenic trail (LOST), which runs atop the HHD approximately 110 miles around the entire lake.

The HHD crest affords panoramic views of the flat agricultural (mostly sugarcane) fields and rim canal to the south, southwest, and southeast. The extensive littoral zone on the west side of the lake's perimeter can be viewed from HHD. The littoral zone plant community is composed of a mosaic of emergent and submerged plant species. Emergent vegetation within the littoral zone is dominated by cattail, beak rush/spike rush, and willow.

C.1.1.18 Land Use

The LOWRP study area is approximately 1,450,000 acres and is comprised of portions of the Lake Okeechobee, St. Lucie, and Caloosahatchee River watersheds (**Figure C-35)**. The project area is a portion of the study area where project feature placement was considered. The project area is comprised of approximately 920,000 acres and includes four major drainage basins: Fisheating Creek, Indian Prairie,

Taylor Creek/Nubbin Slough, and Lower Kissimmee (S-65D and S-65E). The land use within the study area varies widely from wetlands to upland hardwood forests and from agriculture to high density residential land use. The majority of the lands in the study area are pasture, wetlands and agricultural crops such as citrus and row crops. The various categories of land use types can be shown on **Figure C-35**.

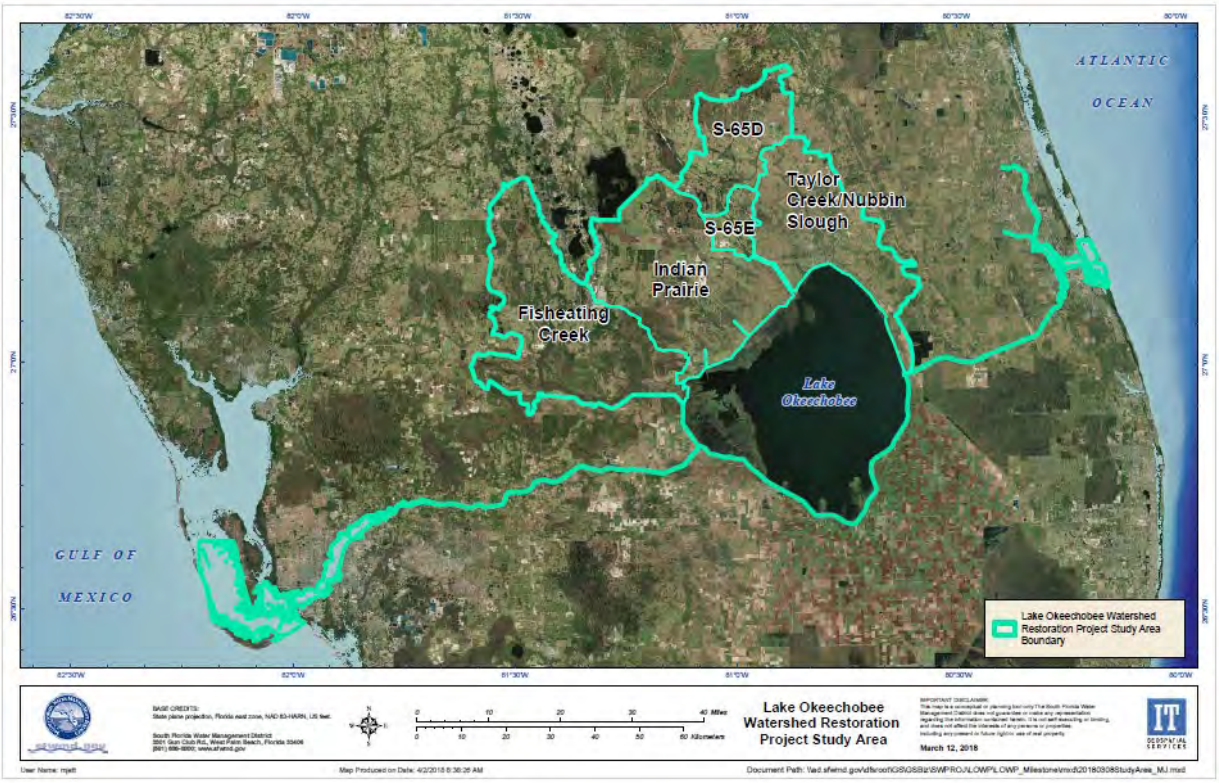


Figure C-35. LOWRP study Area.

The LOWRP study area contains Lake Okeechobee and peripheral lands collectively equating to 450,000 acres (approximately 720 square miles). Lake Okeechobee is comprised of approximately 350,000 acres of fresh water and 100,000 acres of wetlands, freshwater marshes, and wetland forests. The remaining 3,299 acres of land in this basin are a combination of barren lands, parks and recreational areas, and commercial land use. Lake Okeechobee acts as a reservoir that provides drinking water for nearby urban areas, is a source for multiple fisheries, and is utilized for recreation.

The Fisheating Creek Drainage Basin consists of approximately 298,379 acres. Over 56% of the lands are utilized as pasture predominantly for cattle grazing, and 24% of the land in this area is comprised of freshwater marshes and wetlands. Less than 2% of the lands in this area are utilized for residential, commercial, and industrial purposes. This drainage basin contains a stream that is the only remaining natural-flowing watercourse feeding into Lake Okeechobee.

The Indian Prairie Drainage Basin consists of approximately 276,507 acres. The lands in this sub-watershed are used primarily for pasture (60%) and citrus (11%). Less than 2% of the lands in this sub-watershed are categorized as residential, commercial, and industrial land uses. The Brighton Indian Reservation belonging to the Seminole Tribe of Florida consists of 36,000 acres and is located within this sub-

watershed. The lands belonging to the Seminole Tribe are used for various purposes including residential, cattle operations, agricultural purposes, and commercial businesses including restaurants and a casino.

The S-65D and S-65E basins of the Lower Kissimmee Drainage Basin are comprised of approximately 145,586 acres. The S-65D basin is approximately 116,590 acres where 65% of the lands are used for pasture and rangeland. Nearly 20% of this area is classified as fresh water, marshes, and wetland forests. S-65E is the smallest basin with approximately 28,997 acres of land. Over 66% of the land use is pasture and rangeland, 15% is used for agricultural purposes such as row crops, citrus, and dairies, and the remaining land use is a mix of residential, forests, freshwater marshes, and wetlands. Both basins have less than 2% residential land use. These basins were specifically named in the Northern Everglades and Estuaries Protection Program (NEEPP) statute (373.4595 Florida Statutes) as priority basins for the Lake Okeechobee Watershed Construction Project.

The Taylor Creek/Nubbin Slough Drainage Basin consists of approximately 197,796 acres where 63% of the lands are used for pasture cattle grazing. Of the four sub-watersheds, Taylor Creek/Nubbin Slough has the most residential land use of 8% as is contains the city of Okeechobee. Additionally, this drainage basin contains a large portion of wetlands and freshwater marshes comprising almost 10% of the landscape. The Taylor Creek/Nubbin Slough Drainage Basin also contains the S-191 and S-154 basins which were also identified as priority basins per the NEEPP statute.

The Caloosahatchee River and its associated estuaries included in the study area consist of approximately 75,412 acres, with over 95% saltwater and freshwater bodies. The remaining area is comprised of a mix of wetlands, marshes, residential, and commercial land use. The St. Lucie River and its associated estuaries included in the study area are comprised of 14,794 acres consisting of approximately 94% saltwater and freshwater bodies and nearly 5% are wetlands, mangroves, and marshes. The remaining acres are a mix of pasture, citrus and row crops, upland forests, residential and urban land use. The land use categories for the watersheds and drainage basins of the LOWRP study area are summarized in **Table C-3.**

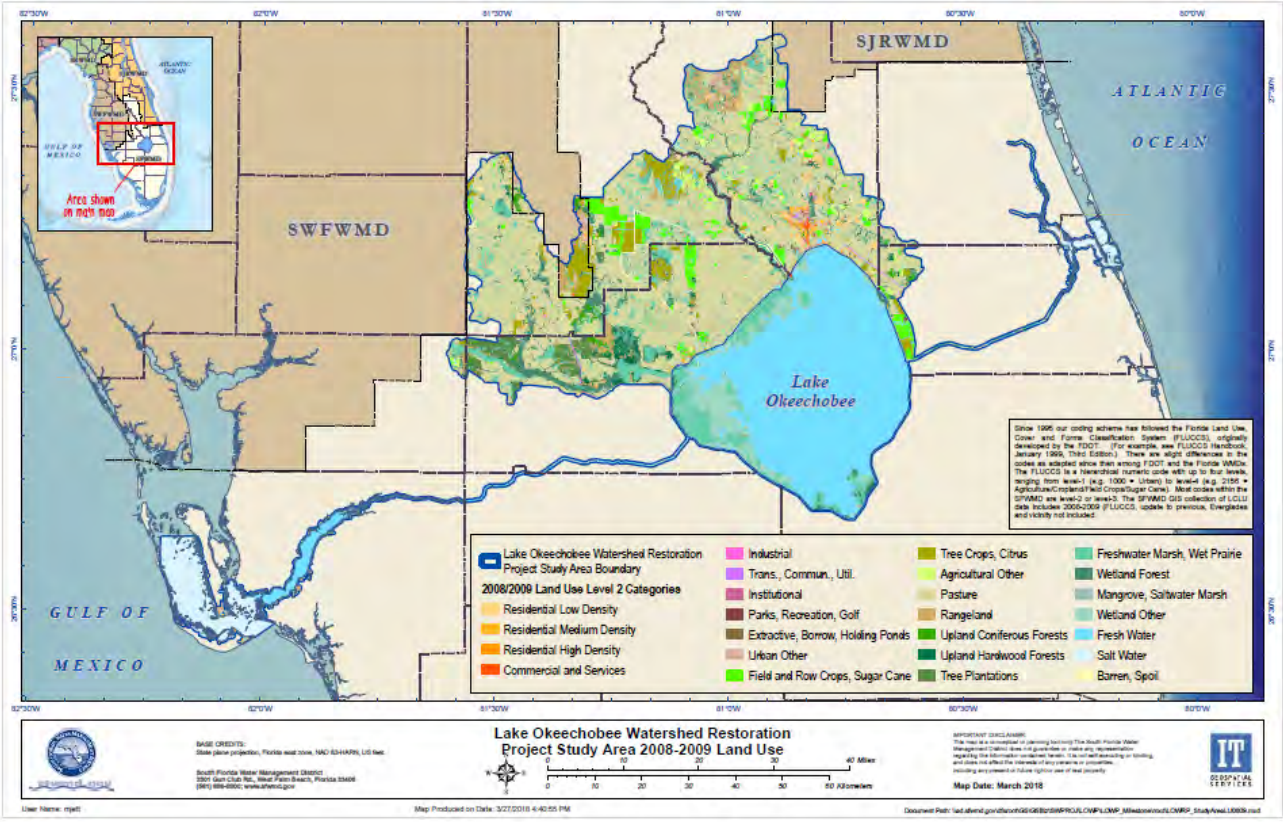


Figure C-36. Study area land use (2008-2009).

Table C-3. Summary of land use (by acreage) in the study area (watershed and drainage basins).

Land Use Category	Caloosahatchee River	Fisheating Creek	Indian Prairie	Lake Okeechobee	S-65D	S-65E	St Lucie River	Taylor Creek/ Nubbin Slough	Total Acreage for each Land Use Category
Agricultural Other	6	830	1,636	0	4,264	1,884	12	6,249	**14,881**
Barren, Spoil	47	1,100	3,680	2,448	486	152	6	1,587	**9,505**
Commercial and Services	13	221	205	230	37	0	4	1,435	**2,146**
Extractive, Borrow, Holding Ponds	0	0	0	0	0	0	0	537	**537**
Field and Row Crops, Sugar Cane	1	1,489	20,769	0	5,894	1,706	3	11,665	**41,526**
Fresh Water	18,037	808	2,887	350,000,	1,145	716	2,067	2,469	**377,983**
Freshwater Marsh, Wet Prairie	0	42,714	28,573	100,000	13,502	2,373	0	10,335	**142,609**
Industrial	0	4	18	0	0	0	0	171	**193**
Institutional	0	30	93	5	0	0	0	860	**989**
Mangrove, Saltwater Marsh	998	0	0	0	0	0	20	0	**1,017**
Parks, Recreation, Golf	54	0	0	70	10	0	6	467	**607**
Pasture	2	153,639	166,737	0	59,784	18,417	6	124,615	**523,200**
Rangeland	21	13,608	5,691	290	16,482	738	27	2,882	**39,740**
Residential High Density	23	0	0	0	17	0	6	60	**107**
Residential Low Density	70	2,275	1,874	0	1,446	545	38	8,218	**14,465**
Residential Medium Density	229	168	1,048	11	73	124	31	4,965	**6,648**
Salt Water	54,354	0	0	0	0	0	11,779	0	**66,134**
Transportation, Communications, Utilities	8	624	146	0	28	0	4	831	**1,641**
Tree Crops, Citrus	2	8,109	30,453	0	1,963	748	8	6,076	**47,359**
Tree Plantations	0	19,718	404	0	9	18	0	55	**20,204**
Upland Coniferous Forests	0	8,713	969	0	105	84	4	1,325	**11,200**

Land Use Category	Caloosahatchee River	Fisheating Creek	Indian Prairie	Lake Okeechobee	S-65D	S-65E	St Lucie River	Taylor Creek/ Nubbin Slough	Total Acreage for each Land Use Category
Upland Hardwood Forests	20	14,703	2,407	240	1,715	196	76	3,478	**22,837**
Urban Other	10	575	1,764	5	2,092	0	2	1,594	**6,041**
Wetland Forest	13	28,914	6,588	3,779	7,270	1,270	77	7,763	**55,674**
Wetland Other	1,504	137	566	45,321	270	25	619	156	**48,598**
Total Acreage for each Basin	75,412	298,379	276,507	450,000	116,590	28,997	14,794	197,796	**1,455,840**

C.1.1.19 Recreation

There are many recreational opportunities throughout south Florida; however, with the dense urban surroundings demand often exceeds availability. Recreational resources in the Lake Okeechobee region are primarily water based. Lake Okeechobee and the Okeechobee Waterway provide approximately 154 miles of navigable waterway for commercial navigation and many more for recreational boating. Lake Okeechobee is recognized as supporting one of the best recreational fisheries in the nation. Several major sport-fishing tournaments are held on the lake annually, bringing significant revenues to the surrounding area. Recreational areas are located around Lake Okeechobee offering day-use facilities, campgrounds, hiking and biking trails, and boat ramps. The LOST is designated as a segment of the Florida National Scenic Trail, encompassing 110 miles of the lake atop HHD. Heavy seasonal waterfowl utilization of Lake Okeechobee attracts hunters and recreational enthusiasts, as well. Lake Okeechobee has also been a popular destination for airboat rides. Lake Okeechobee offers alligator hunting and is subdivided into four Alligator Harvest Units.

Recreation opportunities in the northern estuaries include easy access to fresh, estuarine, and marine resources for fishing, boating, swimming, diving, camping, and sightseeing. Numerous recreation areas, such as the Ortona Lock Recreation Area, Caloosahatchee Regional Park, and W.P. Franklin Lock Recreational Area are extensively used.

Recreational opportunities are also present within the Kissimmee River Public Use Area, PUA, and are open to public access year round. Primary recreational opportunities include hunting, fishing, camping, hiking, and bicycling. Game species occurring in the PUA include white-tailed deer, common snipe (*Gallinago gallinago*), feral hog (*Sus scrofa*), marsh rabbit (*Sylvilagus palustris*), blue-winged teal (*Anas discors*), mottled ducks (*Anas fulvigula*), and other game. Alligator hunting is also currently administered by the Florida Fish and Wildlife Conservation Commission, FWC, in the Kissimmee River area and is divided into multiple Alligator Harvest Units on the River and adjacent lakes.

The 2013 State Comprehensive Outdoor Recreation Plan (SCORP) is a reliable source to determine if Florida residents and tourists need additional facilities to support outdoor recreation. Surveys determined the user rates for 26 different outdoor activities within eight regions of Florida (**Figure C-37**).

The SCORP divides all activities into either resource based or user based. Below is a table from Florida's 2013 SCORP showing each region and the level of service provided as either above or below the state average for surveyed activities. A close review of the table shows that canoeing and kayaking is not listed. The SCORP did survey this popular activity and found participation rates similar to motorized boating. The SCORP found the high user rates are where the available resource has been developed for this outdoor activity. The SCORP did not assess the level of service due to the abundance of available water, but encourages the provision of facilities and designating canoe trails. These projects primarily provide opportunities for resource based activities.

The natural features of the Kissimmee River and Lake Okeechobee form county lines and also form the boundaries for four SCORP regions. This project location on those natural features would draw users from these four SCORP regions: Central, Central East, Southwest, and Southeast.

Comparing Regional Levels of Service to Statewide Median*

● Level of Service **Above** Statewide Median ○ Level of Service **Below** Statewide Median

Resource-Based Activities	Region							
	NW	NC	NE	CW	C	CE	SW	SE
Saltwater Beach Activities	●	○	●	○	NA	●	●	○
Freshwater Beach Activities	●	●	○	○	○	●	○	●
Saltwater Fishing Non-boat	●	○	○	○	NA	●	●	●
Freshwater Fishing Non-boat	○	●	○	●	●	○	●	○
Saltwater Boat Ramp	●	●	○	○	NA	●	●	○
Freshwater Boat Ramp	●	●	●	○	○	●	○	○
Bicycling Paved	○	●	○	●	○	●	●	○
Bicycling Unpaved	○	●	●	○	○	●	●	○
Hiking	●	●	○	○	○	●	●	○
Horseback Riding	○	●	●	○	○	●	●	○
Off-Highway Vehicle Driving	●	●	○	○	○	●	●	○
Nature Study	●	●	●	○	○	●	○	○
Picnicking	○	●	○	○	○	●	●	●
Visiting Historical or Archaeological Sites	○	●	●	○	○	●	●	○
Tent Camping	●	●	●	○	○	○	●	○
RV or Trailer Camping	○	●	○	●	○	●	●	○
Hunting	●	●	○	○	○	○	●	●

User-Oriented Activities	Region							
	NW	NC	NE	CW	C	CE	SW	SE
Swimming in Public Outdoor Pool	○	●	○	○	○	●	●	●
Baseball or Softball	●	●	●	○	○	●	○	○
Outdoor Basketball	○	●	●	●	○	●	○	○
Outdoor Tennis	○	●	○	○	○	●	●	●
Soccer	●	●	●	○	○	●	○	○
Football	●	●	●	○	○	●	○	○
Golf	○	○	●	○	○	●	●	●

* Table shows SCORP planning regions as either above or below the statewide median level of service, per activity.
See Appendix G for regional level of service calculations per activity.

Figure C-37. Regional Levels of Service for Outdoor Recreation 2013.

C.1.1.20 Socioeconomics

This section describes the socioeconomics in the project area.

C.1.1.20.1 Economic Activities In and Around Lake Okeechobee

The primary economic activity throughout the study area is agriculture. The EAA, located directly south of Lake Okeechobee, consists of approximately 500,000 acres of highly productive agricultural land, the vast majority of which is under active sugarcane cultivation. In addition to sugarcane, crops grown in the EAA include an array of winter vegetables including sweet corn, green beans, all varieties of lettuce, radishes, celery, rice and sod. This region of Palm Beach County is the nation's top producer of sugar, sweet corn, radishes and number two in winter vegetables. The economic value of these crops exceeds $3 billion annually (FDACS 2016) and provide employment for more than 12,000 people in the sugar sector alone (LMC Internation-2011). The agricultural operations are vertically integrated and there are four raw sugar mills, two sugar refineries, a rice mill, eight vegetable packing houses and distribution centers, and a renewable energy power plant. Other agricultural activities in the Lake Okeechobee watershed include citrus, pasture, livestock and dairy operations.

A second major economic activity is recreation. Lake Okeechobee and its associated waterways, shoreline, and the LOST on top of the dike provide a wide variety of water-based recreation activities for local residents and tourists, including fishing, boating, picnicking, sightseeing, camping, swimming, birding, hunting, biking, horse-back-riding, roller blading, air boating and hiking. Recreation facilities associated with Lake Okeechobee include: 37 picnic sites, 309 individual camp sites, 4 playgrounds, 1 public swimming area, 1 marina with 41 boat slips, 29 boat ramps, 12 general recreation areas, and hundreds of acres open to hunting. Annual visitation based on a five-year average (2006-2010), amounts to 5,616,000 recreation visits per year. Data for specific recreation activities in these years were obtained from the Institute for Water Resources (IWR) "Lakes Gateway" website. According to the IWR 2010 *Lake Level Report*, it is estimated that visitors to Lake Okeechobee spend approximately $172 million per year, directly supporting more than 1,800 local jobs.

Additionally, Lake Okeechobee supports an active commercial and recreational fishing industry. This includes several different types of commercial fishing operations and landside support activities, such as marinas and wholesale and retail distribution facilities. There are commercial fisheries on Lake Okeechobee that harvest the American alligator. Alligators are harvested from the lake population to supplement the stock in alligator farming operations. Recreational fishing tournaments are held on the lake multiple times a year.

The depth of Lake Okeechobee also makes commercial navigation on the lake possible. There are two navigation routes in Lake Okeechobee, including Route 1 through the center of the lake and Route 2 along the south shore of the lake. Only Route 1 is fully maintained at its authorized depth for commercial navigation. Petroleum products, including distillate fuel oil residual fuel oil, and liquid natural gas, comprise the majority of tonnage shipped. Other commercial navigation includes fleets of day/dinner cruise vessels that operate from Pahokee during the tourist season. The Okeechobee Waterway (OWW) allows passage of boats between the Atlantic Ocean and the Gulf of Mexico through Lake Okeechobee.

Other than agriculture, recreation, tourism, commercial fishing, and navigation, secondary economic activities include: services (banking, insurance, etc.) healthcare, education, and government activities. Examples of the above include the Lakeside Medical Center, and the University of Florida- Everglades Research and Education Center, Palm Beach State College, Belle Glade Campus and the Dolly Hand Cultural Arts Center; Glades Day School serving students Pre-K-12; seven public elementary schools, two middle schools and two high schools as well as the West Technical Training and Education Center. The City of Clewiston is a major center of the agricultural community around the lake. Known as the "Gateway to Lake Okeechobee" it has many of the above activities. Also, the Town of Moore Haven is the seat of government for Glades County, so there are several public buildings in the town.

C.1.1.20.2 Demographics

Demographically, the communities around Lake Okeechobee are highly diverse. The demographic characteristics of the study area include:

- Below-average Income levels in most communities
- Lower than average levels of formal education
- Relatively high percentage of minority populations
- Relatively large number of households for which English is not the first language

In addition to these characteristics, which were measured in the 2010 Census and 2015 American Community Survey, two other characteristics are not captured in the census data:

- Relatively high number of undocumented residents
- Relatively high seasonal population ("snowbirds")

The undocumented residents are associated with migrant labor camps that support sugarcane production. The seasonal population is associated with recreational opportunities in the tourist season. Many seasonal residents spend the winter months in these communities due to mild winter climate. Some mobile home RV parks cater to seasonal residents, and several of these parks are adjacent to HHD.

The majority of the study area is rural and agricultural. However, there are a number of towns and cities located in close proximity to Lake Okeechobee (see **Figure C-38** and **Table C-4**). In most of these communities, homes, businesses, and public buildings can be found within 100 feet of the dike. The largest of the communities is Belle Glade, located near the Hillsboro Canal with a population of more than 17,000 people. The study area also includes the Brighton Seminole Indian Reservation in Glades County, which is home to approximately 600 people.

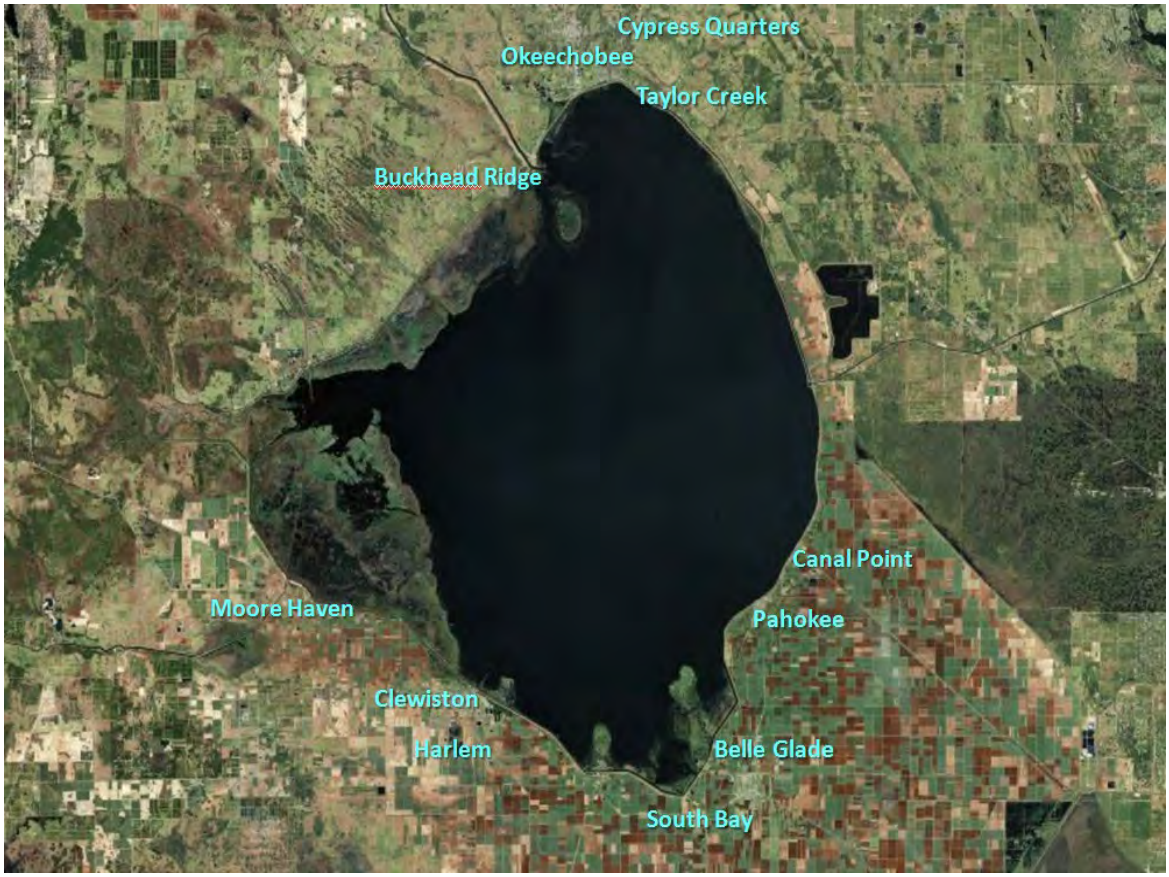


Figure C-38. Major cities in study area considered in demographics study.

Table C-4. Major population centers. *

City / Town	County	2010 Population
Pahokee	Palm Beach	5,649
Belle Glade	Palm Beach	17,467
South Bay	Palm Beach	4,876
Clewiston	Hendry	7,155
Harlem	Hendry	2,658
Moore Haven	Glades	1,680
Buckhead Ridge	Glades	1,450
Okeechobee	Okeechobee	5,621
Taylor Creek	Okeechobee	4,348
Cypress Quarters	Okeechobee	1,215

*Please note: Population estimates in this table do not include very small towns (Canal Point, Lake Harbor, Bryant, Lakeport, etc.) in the inundation zones or population at risk in unincorporated areas of Palm Beach, Martin, Hendry, Glades, and Okeechobee counties. The table also does not include population associated with the Brighton Indian Reservation in Glades County.

In general, these are diverse, relatively low-income communities. Hendry, Glades, and Okeechobee counties all have median household incomes that are less than the state average. They also have a relatively high proportion of households below the poverty line (**Table C-5**). Palm Beach County has an above average median income, but the communities in the county near Lake Okeechobee (Pahokee, Belle Glade, and South Bay) have socioeconomic characteristics much more similar to Hendry and Glades counties.

Table C-5. Economic characteristics of counties adjacent to Lake Okeechobee.

	Median Household Income	Persons below poverty line
State of Florida	$47,827	14.70%
Hendry County	$37,989	26.00%
Glades County	$39,611	19.50%
Okeechobee County	$36,929	23.70%
Palm Beach County	$52,951	13.30%

C.1.1.21 Environmental Justice

Environmental justice (EJ) is addressing, as appropriate, disproportionately high and adverse human health or environmental effects of Federal programs, policies, and activities on minority and/or low-income populations. The Executive Order (EO) 12898 on EJ requires an analysis of environmental effects, including human health, economic and social effects, of Federal actions, including effects on minority and/or low-income communities, when such analysis is required by the NEPA. The intent of EJ is that no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental, and commercial operations or policies. This section identifies minority, low income, and Native American Tribal populations that exist within the LOWRP area of

potential effect and evaluates whether the environmental impacts of each alternative would result in a disproportionately high and adverse impact on minority, low-income, and Native American Tribal populations (EO 12898, February 11, 1994). See **Section C.1.2**, Existing Conditions of Native Americans, for a detailed description of tribal history, and **Section C.2.1.18**, Cultural and Historic Resources, for additional discussion of other cultural, tribal, and religious freedom issues. See **Section C.2.1.8**, Water Supply/Water Rights, for a discussion of water rights in the area of analysis.

This section examines, consistent with the NEPA regulations and guidelines, the Proposed Action's potential impacts on minority and low-income people. Impacts were assessed to determine if any community would bear a disproportionate share of the potentially adverse environmental consequences resulting from the Proposed Action.

C.1.1.21.1 Area of Analysis

For the environmental justice, data from all 2015 census block groups within a two-mile radius of proposed LOWRP features in the focused array are included. A two-mile radius was chosen as an initial estimate of project siting and potential effects to facilitate the EJ analysis. The K-05 reservoir, Paradise Run wetland, and the majority of the Kissimmee River Center wetland are in Glades County, FL. A small portion of the Kissimmee River Center wetland and the K42 reservoir footprint are in Highlands County, FL. Conceptual locations for ASR wells are located throughout the watershed on either Lake Okeechobee tributaries or on the perimeter of the K05 reservoir in Highlands, Glades, Okeechobee, and Martin Counties. Although there are no project features proposed within the STOF Brighton Reservation, it is included in this analysis due to the proximity to the LOWRP features and potential impacts to the Tribal Reservation. The block group locations are summarized in **Table C-6**. Data pertaining to these block groups will be identified and used as available. In cases where block group information has not been compiled by the census bureau, data pertaining to census tracts to which they belong will be substituted.

Table C-6. Socioeconomic Study Area

County	Census Tract	Block Group
Glades	1	1
Glades	1	2
Glades	2	1
Glades	2	4
Glades	2	5
Glades	3	1
Glades	3	2
Highlands	9615	1
Highlands	9617	4
Okeechobee	9101.01	1
Okeechobee	9103	2
Okeechobee	9104.01	1
Okeechobee	9104.01	2
Okeechobee	9104.02	1
Okeechobee	9104.03	1

County	Census Tract	Block Group
Okeechobee	9104.03	2
Okeechobee	9105	1
Okeechobee	9105	2
Okeechobee	9105	3
Okeechobee	9106.02	1
Okeechobee	910101	2
Okeechobee	910101	3
Okeechobee	910201	1
Okeechobee	910202	1
Okeechobee	910202	2
Okeechobee	910202	3
Okeechobee	910300	1
Okeechobee	910601	3
Okeechobee	910601	4
Okeechobee	910601	5
Martin	18.02	1
Martin	18.02	2

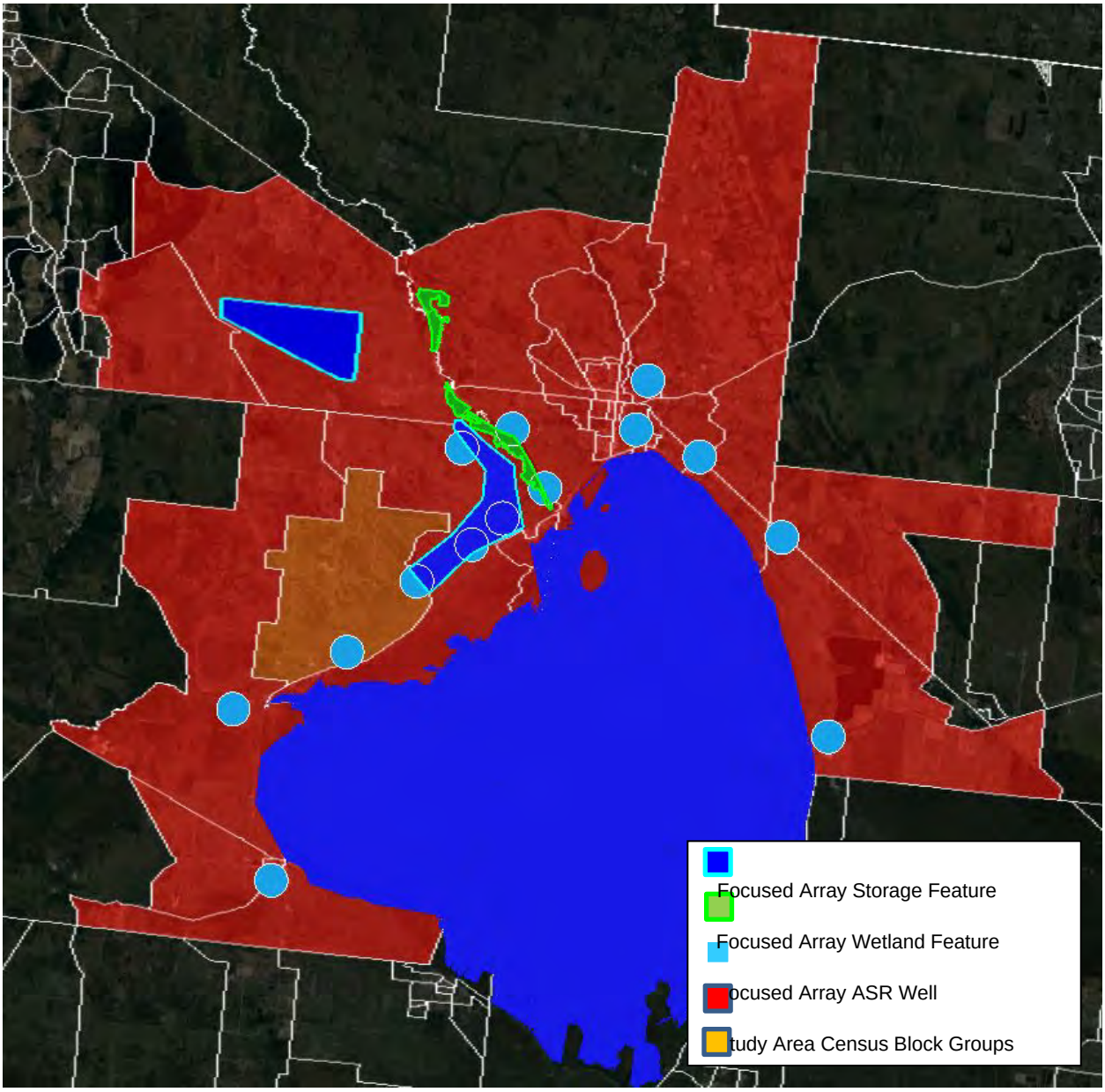


Figure C-39. Socioeconomic study area.

C.1.1.21.2 Scoping to Identify Environmental Justice and Socio-economic Issues

Numerous methods of engagement were employed as part of the LOWRP study to engage minority, low-income, and Native American Tribes. **Table C-7** summarizes overall engagement efforts with stakeholders on the project.

Table C-7. Summary of LOWRP stakeholder engagement meetings.

Engagement Type	Date	Stakeholders
Notice of Intent Mailing	June 28, 2016	All interested agencies, tribes, and parties in area.
Scoping Meetings	July 26, 2016	Presentations on scope of study
PDT Meetings	Webinars:13 In person:3	Agencies and tribes participate directly; public and NGOs participate with questions and comments.
Landowner Meetings	2	Engaged landowners in project footprint or immediate area of effect.
Government to Government with Tribes	12	Number of meetings to engage Seminole Tribe of Florida;
STOF Community Meeting	November 28, 2017	Met with STOF Tribal members to hear comments/concerns about project.

C.1.1.21.3 Existing Conditions/Affected Environment

This section provides a description of existing conditions within the study area as they relate to issues of environmental justice.

- **Unique characteristics of the geographic area.** According to CEQ's regulation on EJ (40 CFR §1508.27), unique characteristics of the geographic area could include proximity to distinctive features such as historic or cultural resources, prime farmlands, wetlands, ecologically critical areas. The STOF Brighton Reservation falls under this category and has been given special consideration when assessing the intensity of impacts listed below.
- **Aesthetics.** Current aesthetics reflect a pastoral and rural landscape viewshed in most of the landscape that is farm and ranchland. Several communities, roads, and canals bisect the project area with the most populous urban area being the town of Okeechobee. The Herbert Hoover Dike earthen levee to the south of the LOWRP represents the tallest feature viewable from the ground within 1 mile. Numerous tree lines and hammocks disrupt direct viewing of the HHD or other parts of the landscape based on their scattered nature throughout the landscape.
- **Noise.** Noise is relatively low in rural pastoral areas. Noise is loudest near roads and canals used for boat traffic. Agricultural and ranching activities also increase noise periodically to manage lands with heavy machinery. Average background noise for agricultural lands is about 40 decibels, but can range up to 90 decibels near working machinery (e.g., tractor).
- **Light pollution.** Light pollution is minimal from lights marking existing roads, existing water management infrastructure, rural houses, trailer parks, and other residential developments. Most light pollution would be in the town of Okeechobee vicinity near the main streets.
- **Air quality.** Minor, short-term air quality issues occur from burning of agricultural material or land management activities. Otherwise air quality is relatively good. According to the Florida Department of Environmental Protection (FDEP) Division of Air Resource Management – Office

of Air Monitoring's 2012 Air Monitoring Report, all counties in the project area are in attainment for all criteria pollutants (carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide, and particle pollution). This is the most recent data available on the FDEP website (confirmed by personal communication March 2018).

- **Cultural and historic resources.** Burial resources are highly likely to be found in mounds and earthwork sites throughout the region. There exists the possibility of mortuary ponds (cemeteries) located within one or more ponds within the project boundary. Burials can also be found associated with traditional pre-contact archaeological sites.
- **Economic impacts.** Socioeconomic statistics of the human population in this area are described in the next sections of the EJ analysis. The following are key issues that will need to be considered in the EJ analysis with respect to potential socio-economic impacts.
    - *Displacement of listed threatened and endangered species* to local properties and potential for increased compliance costs and/or loss of economic use of lands.
    - *Maintain water supply* for agricultural, Tribes, and utilities as it relates to surficial aquifer wells, canals, and Lake Okeechobee. Hydrologic modeling is used to explain comparison of water supply existing conditions with alternatives.
    - *Seepage and Restricted Drainage*. Ground water and surface water levels can be affected by water storage features seepage. Excess seepage from project features and canals can affect agricultural land productivity by limiting drainage from farmlands and in extreme cases limit drainage from home and residential areas which could lead to risk of flooding.
    - *Land acquisition*. Most of the land being considered for project features includes land in public ownership. However, all alternatives require some private land acquisition for project features. During project planning, land values were assumed to be equal throughout the study area to ensure no disproportionate impacts to low income communities by removal of lower cost living areas or sources of jobs from agriculture and ranching. Project alternative lands include a mix of willing sellers, unwilling sellers, and undecided/undetermined sellers.
- **Human Health and Safety**
    - *Drinking water quality*. Drinking water for many residents in the project area is obtained from the surficial aquifer (land surface to 170 ft. below land surface) in the project area. Surface water quality in the Kissimmee Basin and Lake Okeechobee is sufficient to meet drinking water standards with minimal treatment.
    - *Subsistence and recreational fishing and hunting*. Recreational fishing is plentiful in the Kissimmee River, Canals, and Lake Okeechobee. Hunting is limited to those who have access to private lands in the area with some hunting in Lake Okeechobee. Hunting is available to the STOF hunting on Tribal Reservation lands for subsistence, and public lands like Lake Okeechobee are available for hunting water fowl and fishing under applicable state regulations. Project features that convert land to built environment, or change upland to deep water can limit types of terrestrial based hunting.
    - *Life safety*. Project features that store large amounts of water with levees determined to be high hazard dams can pose a risk to immediate residential communities downstream of potential dam breaks. The incremental life loss risk from a reservoir failure will be

evaluated to ensure lower than the tolerable risk limits described in ER 1110-2-1156, Safety of Dams - Policy and Procedures.

C.1.1.21.4 Race and Ethnicity – Identification of Minority Populations

American Community Survey 2015 5-year estimates concerning population race or Hispanic origin are presented in **Table C-8**, **Table C-9** and **Figure C-40**. Data for the study area is related via the census block groups identified in **Table C-6.**

Table C-8. Racial composition.

	Project Area	Brighton Reservation	Glades County	Highlands County	Okeechobee County	Martin County
Total Population	46,911	662	13,272	98,328	39,255	151,586
White	38,621	139	10,601	81,651	33,535	132,047
	82.3%	*21.0%*	*79.9%*	*83.0%*	*85.4%*	*87.1%*
Black or African American	5,585	7	1,729	9,400	3,536	8,482
	11.9%	*1.1%*	*13.0%*	*9.6%*	*9.0%*	*5.6%*
American Indian or Alaska Native	5,585	453	530	157	368	631
	11.9%	*68.4%*	*4.0%*	*0.2%*	*0.9%*	*0.4%*
Asian	328	7	56	1,479	380	1,689
	0.7%	*1.1%*	*0.4%*	*1.5%*	*1.0%*	*1.1%*
Native Hawaiian or Other Pacific Islander	0	0	0	120	0	10
	0.0%	*0.0%*	*0.0%*	*0.1%*	*0.0%*	*0.0%*
Some Other Race	1,474	20	222	3,703	1,076	6,187
	3.1%	*3.0%*	*1.7%*	*3.8%*	*2.7%*	*4.1%*
Two or More Races	34,658	36	134	1,818	360	2,540
	73.9%	*5.4%*	*1.0%*	*1.8%*	*0.9%*	*1.7%*
Hispanic or Latino (Any Race)	12,253	44	2,817	17,963	9,799	19,491
	26.1%	*6.6%*	*21.2%*	*18.3%*	*25.0%*	*12.9%*

Source: U.S. Department of Commerce, Bureau of the Census

Table C-9. Racial composition – combined counties, state, and national figures.

	Counties Combined	State of Florida	United States
Total Population	302,441	19,645,772	316,515,021
	-	-	-
White	257,834	14,934,702	232,943,055
	85.3%	*76.0%*	*73.6%*
Black or African American	23,147	3,171,108	39,908,095
	7.7%	*16.1%*	*12.6%*

	Counties Combined	State of Florida	United States
American Indian or Alaska Native	1,686	54,569	2,569,170
	0.6%	*0.3%*	*0.8%*
Asian	3,604	509,085	16,235,305
	1.2%	*2.6%*	*5.1%*
Native Hawaiian or Other Pacific Islander	130	11,024	546,255
	0.0%	*0.1%*	*0.2%*
Some Other Race	11,188	493,202	14,865,258
	3.7%	*2.5%*	*4.7%*
Two or More Races	4,852	472,082	9,447,883
	1.6%	*2.4%*	*3.0%*
Hispanic or Latino (Any Race)	50,070	4,660,733	54,232,205
	16.6%	*23.7%*	*17.1%*

Source: U.S. Department of Commerce, Bureau of the Census

- The largest racial group in the study area was White, with an estimated 38,621 people or 82.3% of the population claiming ancestry. This is well above the national and state respective averages of 73.6 and 76.0%. White was likewise the largest racial group in Glades, Highlands, Okeechobee, and Martin Counties, where it was estimated to constitute 79.9, 83.0, 85.4, and 87.1% of the population, respectively. Only in the Brighton Indian Reservation, where 21.0% of the population claims sole ancestry, was White not the largest racial group.
- The second largest racial group in the study area was Black or African American, which had an estimated 5,585 or 11.9% of the population claiming ancestry. This is below the national and state respective averages of 16.1 and 12.6%. Black or African American was likewise the second largest racial group in Glades, Highlands, Okeechobee, and Martin Counties, constituting 13.0, 9.6, 9.0, and 5.6% of the population respectively.
- Hispanic or Latino ancestry is non-specific in terms of race. In the study area, an estimated 12,253 or 26.1% of the population fell into this group. This falls between the national and state respective averages of 17.1 and 23.7%.
- In the Brighton Indian Reservation, the largest racial group was American Indian or Alaska Native, where 453 people or 68.4% of the population claimed ancestry.

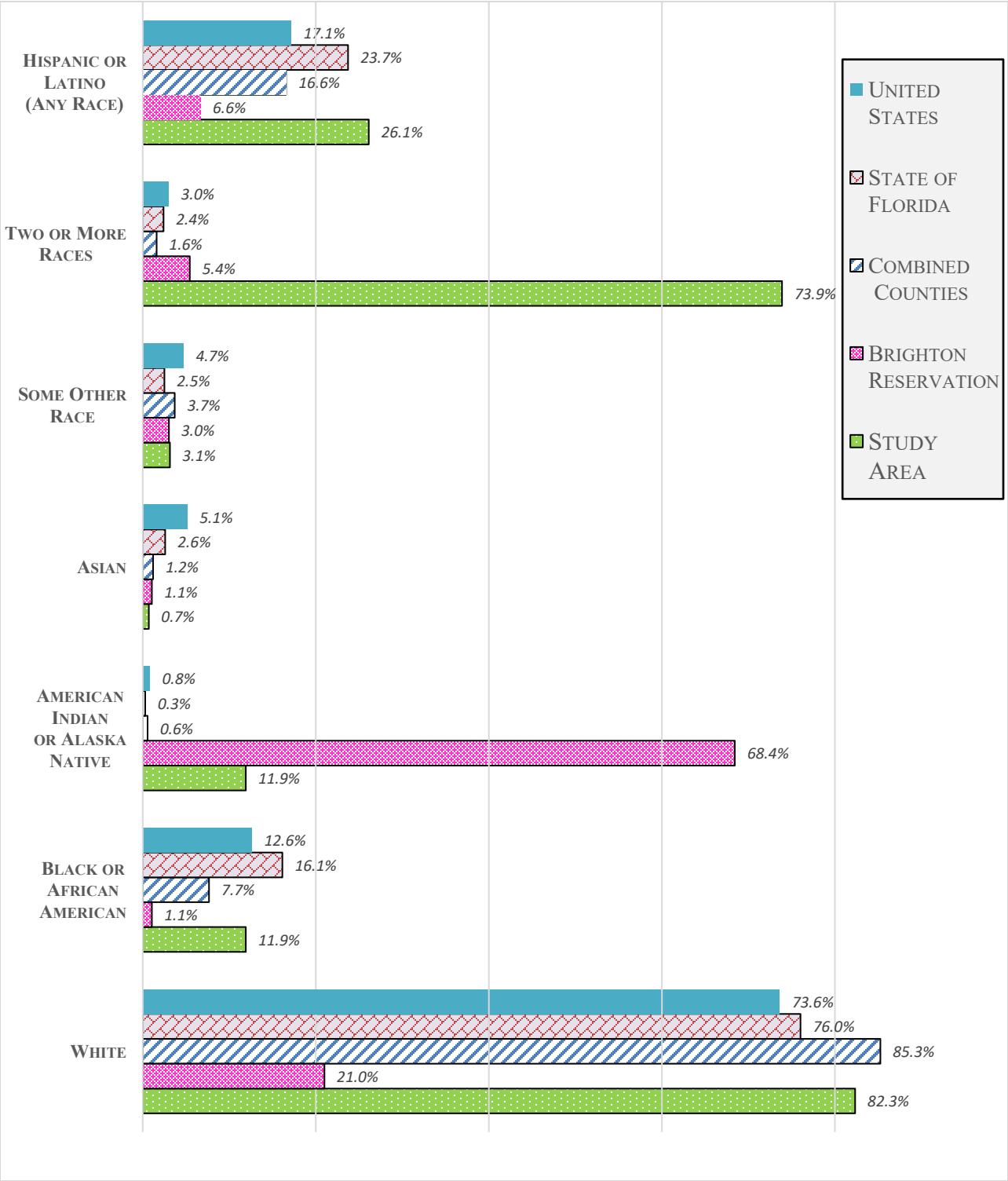
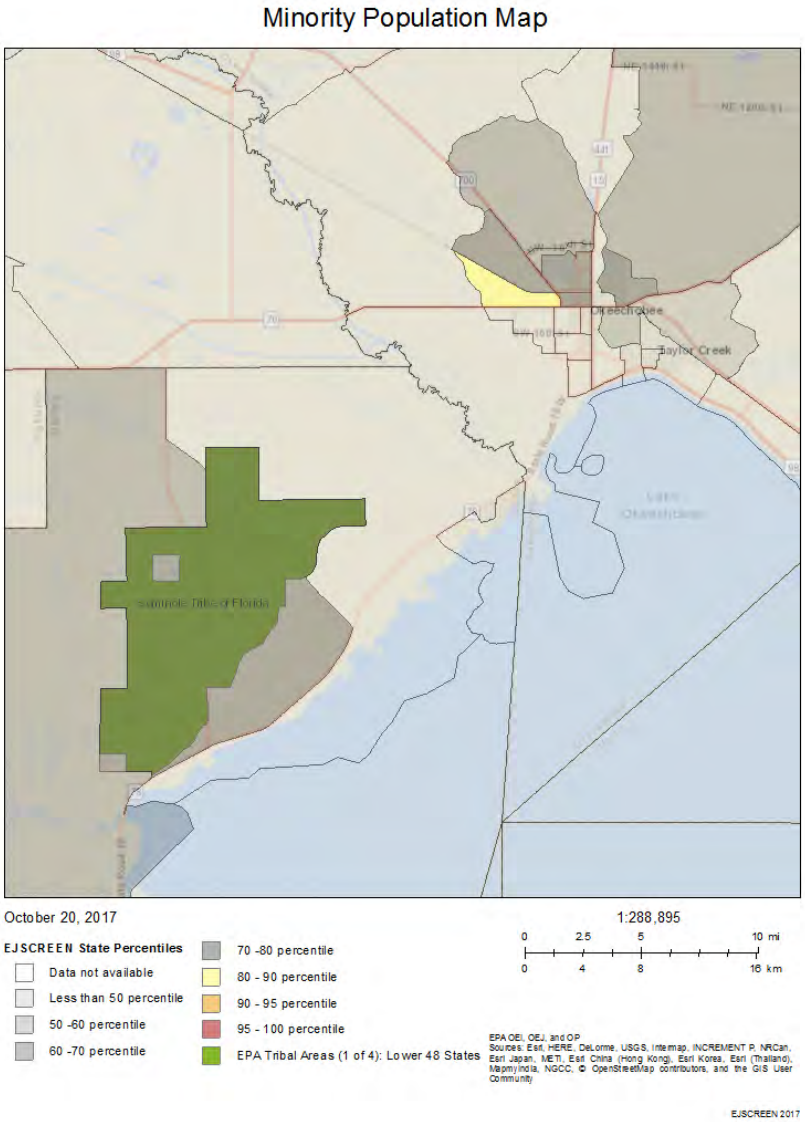


Figure C-40. Racial composition.



Note: This analysis uses any percentiles over 70% representing a higher degree of minority population compared to state average.

Figure C-41. Minority population compared to the state percentiles.

In summary, one minority group that could potentially be impacted by the LOWRP is the STOF Brighton Reservation. The minority population north of the city of Okeechobee is just outside the area of potential effect for the remaining alternatives.

C.1.1.21.5 Unemployment

Table C-10 provides labor force characteristics concerning employment status for the study area as estimated by the 2015 American Community Survey. Data for the study area is related via the census block groups identified in **Table C-6**. The unemployment rate is an economic indicator that is commonly used to describe an area. It is calculated as the percentage of the civilian labor force that is unemployed.

Table C-10. Labor force characteristics.

	Project Area	Brighton Reservation	Glades County	Highlands County	Okeechobee County	Martin County
Civilian Labor Force	10,969	192	4,247	35,895	14,993	67,754
Employed	9,367	156	3,701	31,131	13,227	61,157
Unemployed	1,602	36	546	4,764	1,766	6,597
Unemployment Rate	*14.6%*	*18.8%*	*12.9%*	*13.3%*	*11.8%*	*9.7%*
Counties Combined Unemployment Rate	*11.1%*					
State of Florida Unemployment Rate	*9.7%*					
United States Unemployment Rate	*8.3%*					

Source: U.S. Department of Commerce, Bureau of the Census

The study area had a labor force of 10,969, which represents 38.3% of the population aged sixteen years and over. This falls below the percentage of the population above sixteen years in the labor force in Brighton Reservation, which amounted to 44.0%. It likewise falls below that same percentage for Glades, Highlands, Okeechobee, and Martin Counties, which came to 38.2, 43.4, 47.6, and 52.4%, respectively. At 58.8% for Florida and 63.2% for the United States, state and national averages exceeded all locations examined.

A total of 1,602 members of the civilian labor force in the study area were unemployed in 2015, amounting to an unemployment rate of 14.6%. This exceeds the national and state unemployment rates of 8.3% and 9.7% by a considerable amount. Unemployment rates in the surrounding counties likewise exceeded state and national averages. Brighton Reservation was the only area examined with a higher unemployment rate than the study area. In Brighton Reservation, 36 people or 18.8% of the civilian labor force were unemployed in 2015.

C.1.1.21.6 Per Capita & Mean Household Income

Table C-11 and **Figure C-42** provide 2015 per capita income characteristics for the study area based on 2015 American Community Survey data. National, state, and surrounding county information is included for the purpose of comparison. Data for the study area is related via the census block groups identified in **Table C-6**.

Table C-11. Per capita income (2015 inflation-adjusted dollars).

	Project Area	Brighton Reservation	Glades County	Highlands County	Okeechobee County	Martin County
Population	46,911	662	13,272	98,328	39,255	151,586
Per Capita Income	$16,298	$42,724	$17,879	$21,117	$16,931	$34,742
Counties Combined Per Capita Income	$27,261					
State of Florida Per Capita Income	$26,829					
United States Per Capita Income	$28,930					

Source: U.S. Department of Commerce, Bureau of the Census

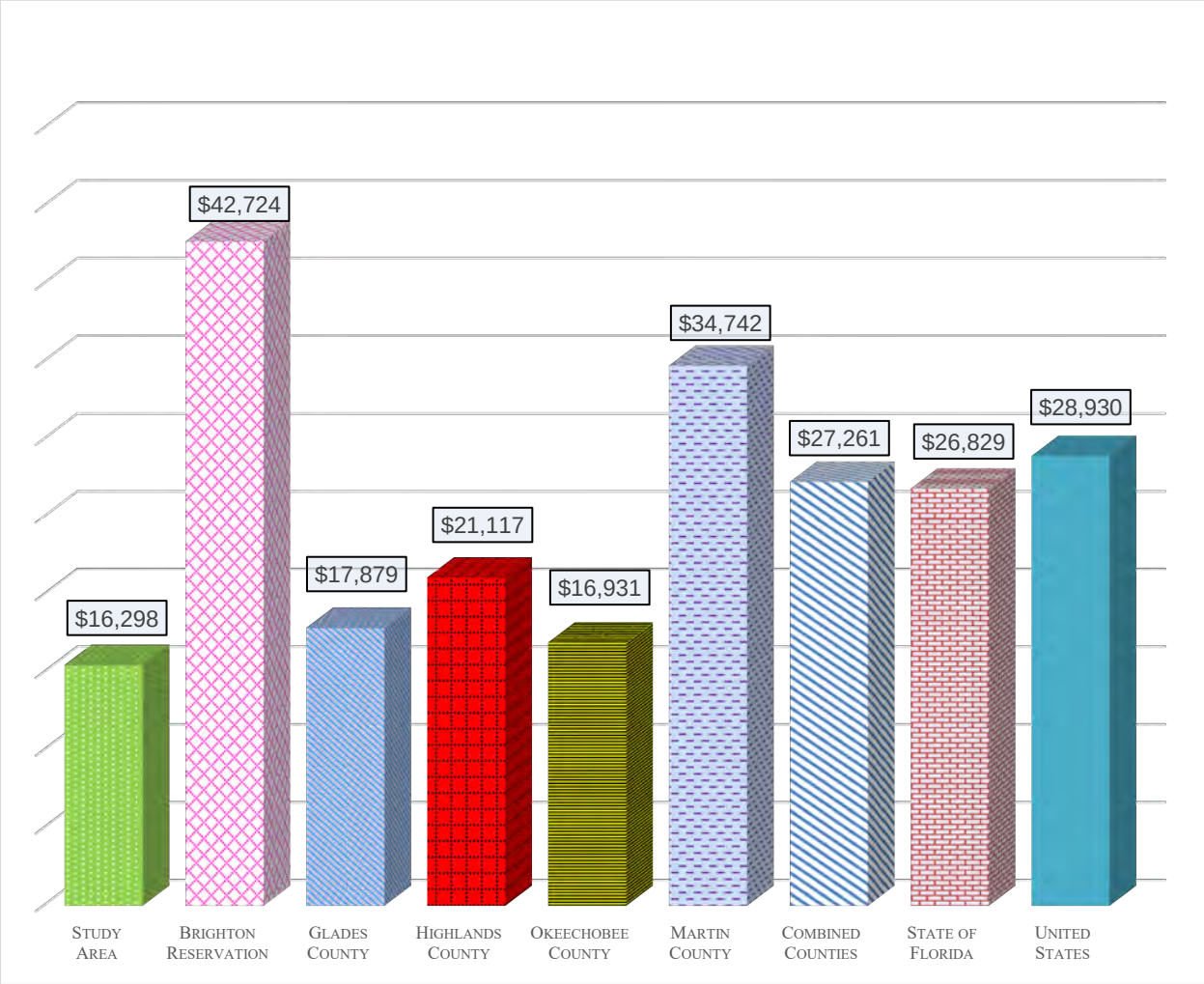


Figure C-42. Per capita income (2015 inflation-adjusted dollars).

Per capita income in the study area was $16,298 in 2015 inflation adjusted dollars. This is $12,600 or 43.3% below the national average of $28,930. It falls nearly as short of the per capita income for the state of Florida, where it is 39.3% or $10,530 below the average.

Of the counties examined, Martin had the highest per capita income at $34,740. Over $13,500 separated the Martin County 2015 per capita income from that of Highlands County, which had the second highest of the counties examined. Highlands, Glades, and Okeechobee Counties each fell within $4,200 of one another.

At $42,724, Brighton Reservation had the largest per capita income of any area examined. Brighton Reservation's per capita income was 175.7% above that of the study area, 47.7% above the national average, 59.3% above the Florida state average, and 56.7% above the combined averages of Glades, Highlands, Okeechobee, and Martin counties.

Table C-12 provides 2015 mean household income characteristics for the study area based on 2015 American Community Survey data. National, state, and surrounding county information is included for the purpose of comparison, as is data concerning Brighton Indian Reservation. Data for the study area is related via the census block groups identified in **Table C-6**.

Table C-12. Mean household income.

	BG Area	Brighton Reservation	Glades County	Highlands County	Okeechobee County	Martin County
Total Households	8,810	184	3,920	40,397	13,046	61,952
Mean Household Income	$44,138	$102,747	$45,321	$48,516	$47,483	$81,104
Counties Combined Mean Household Income	*$65,219*					
State of Florida Mean Household Income	*$67,975*					
United States Mean Household Income	*$75,558*					

Source: U.S. Department of Commerce, Bureau of the Census

Mean household income in the study area was $44,138 in 2015 inflation adjusted dollars. This is $31,420 or 41.6% below the national average of $75,558. It is below the mean household income of the state of Florida by $23,840, or 35.0%.

Martin County had the highest mean household income of any county examined. At $81,100, Martin County's mean household income was 7.3% above the national average and 19.3% above the Florida state average.

The study area's mean household income was within at least $4,400 dollars of that of Glades, Highlands, and Okeechobee counties.

At $102,750, Brighton Reservation has the highest mean household income of any area examined. Brighton Reservation's mean household income was 132.8% above that of the study area, 36.0% above the national average, 51.1% above the Florida state average, and 57.5% above the combined averages of Glades, Highlands, Okeechobee, and Martin counties.

C.1.1.21.7 Poverty

Table C-13 displays the poverty characteristics of the study area population based on 2015 American Community Survey data. **Figure C-43** is included for the purpose of comparison. Data for the study area is related via the census block groups identified in **Table C-6**.

Table C-13. Individual poverty.

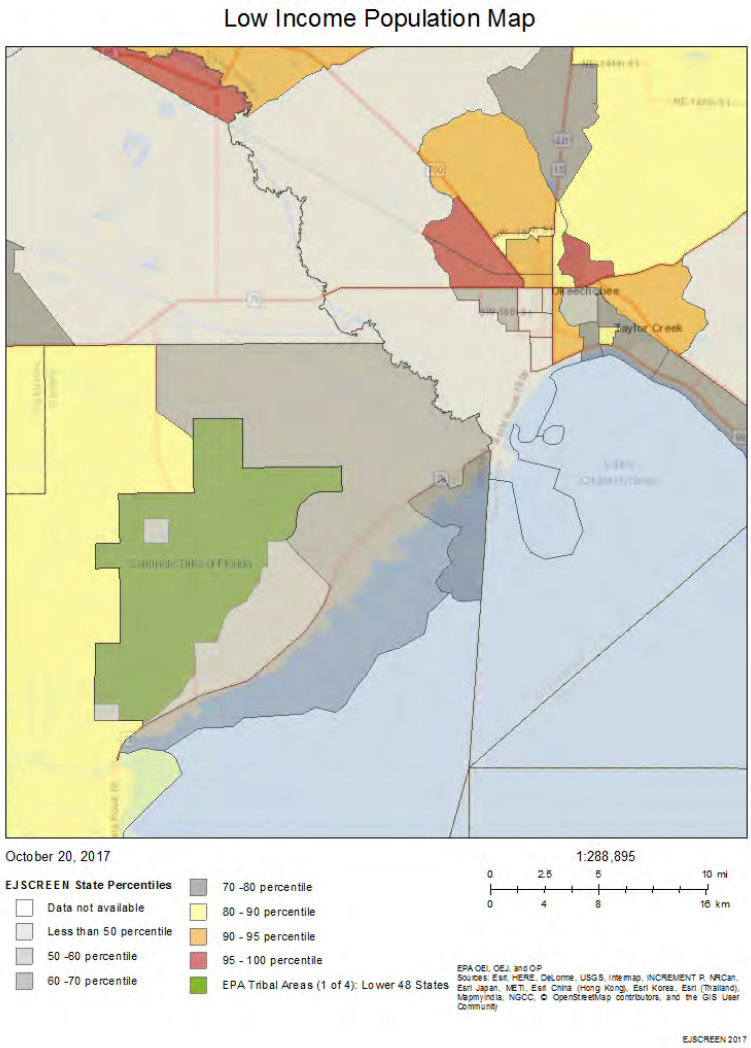
	Project Area	Brighton Reservation	Glades County	Highlands County	Okeechobee County	Martin County
Eligible PSD Population*	40,912	660	11,916	97,095	35,911	148,615
Total Below Poverty Threshold	11,691	186	2,408	18,863	9,965	17,965

	Project Area	Brighton Reservation	Glades County	Highlands County	Okeechobee County	Martin County
Percent Below Poverty Threshold	*28.6%*	*28.2%*	*20.2%*	*19.4%*	*27.7%*	*12.1%*
Counties Combined Percent Below Poverty Threshold			*16.8%*			
State of Florida Percent Below Poverty Threshold			*16.5%*			
United States Percent Below Poverty Threshold			*15.5%*			

*Population eligible for poverty status classification under U.S. census guidelines.

Source: U.S. Department of Commerce, Bureau of the Census

- A total of 11,691 people in the study area fell below the poverty threshold. This constitutes 28.6% of the population eligible for poverty status classification under census guidelines. This is higher than the percent below poverty level within Glades, Highlands, Okeechobee, and Martin counties, which were respectively estimated to be 20.2, 19.4, 27.7, and 12.1%. It is also above the 28.2% estimated for Brighton Reservation.
- The percentage below poverty threshold in the study area was considerably higher than state and national figures, which came to 16.5 and 15.5%.



Note: This analysis uses populations with in the 70th percentile of the state average to represent vulnerable populations.

Figure C-43. Low-income population compared to state percentiles.

C.1.1.21.8 Summary of Environmental Justice Communities

Low-income population concerns associated with the project relate to human health and safety, potential loss of affordable housing, loss of recreational fishing/hunting, and loss of job opportunities in the area where they live.

The major minority population in the project area is the STOF and to a lesser extent, the MTIF. The tribes' potential concerns are explained below.

C.1.1.21.9 Tribal Environmental Justice Concerns

Today most of the MTIF lives within the confines of the reservation located along the forty mile bend of Tamiami Trail more commonly known as the Miccosukee Reserve Area (MRA). In addition to the federal

reservation, the MTIF has also established a perpetual lease to large portions of the WCA 3A area. The STOF members live on various reservations properties, with the largest being those of Big Cypress, Hollywood, and Brighton Reservations. The STOF has an easement within the northwestern portion of WCA 3A. Members of both tribes maintain a traditional life style that is intricately connected to the Everglades. Traditional practices of hunting, fishing, frogging, trapping, and general living are still maintained, along with modern entrepreneurship through various enterprises such as cattle ranching and with tourism related businesses along Tamiami Trail. Today, both tribes have vibrant, thriving culture based within the Everglades region. These practices continue to tie the tribes to the Everglades in such a way that careful consideration of effects on Tribal cultural, well-being, and way of life is warranted.

Members of both tribes continue to rely upon the Everglades to support their cultural, medicinal, subsistence, and commercial activities. The specific issues impacting each Tribe have been different over the last few decades, but they are all related to impacts from man-made changes to the Everglades ecosystem. The MTIF's focus has been on the detrimental ponding of water on tribal leased lands in WCA 3A, which affects subsistence practices and increases inundation risks to islands that they use. The MTIF has also voiced concerns with regards to the impacts of nutrient pollution in the natural system both above and below ground. The STOF's focus has been on the detrimental drainage of water from the western basin and their Big Cypress Reservation, in addition to the impacts of nutrient pollution on the delicate Everglades system.

Numerous government-to-government consultations, along with other outreach efforts, were conducted with the STOF and MTIF to solicit input from the tribal governments regarding their assessment of effects on Indian trust resources, tribal rights to use those resources, other resources traditionally used by tribes, and cultural values related to those resources and rights within the area resulting from the implementation of one of the LOWRP alternatives. (The reader should note that inclusion of any claims and assertions put forth by these tribes does not necessarily imply that the Federal Government endorses those views.) The STOF and MTIF were also engaged in presenting alternative plans to meet project objectives.

C.1.1.22 Cultural Resources

Within the larger region that includes the Everglades and the study area, there are numerous recorded archeological sites indicative of Native American habitation. Prior to European contact, the Everglades were a heavily populated area. Native Americans traveled via canoe and on foot through the saw grass and inhabited many of the tree islands that dot the landscape. The earliest known habitation sites date to the Early Archaic period (7,500 BC) when the Everglades were much drier. However, within the larger area of south Florida, evidence of Paleo-Indian (12,000- 7,500 BC) habitation has also been recorded [Warm Mineral Springs (8SO18) and Little Salt Spring (8SO79) (Griffin 1988)]. During the Archaic period (ca. 7500 B.C. - ca. 500 BC), a wider range of resources was exploited and may have led to a more sedentary existence. Some of the Early Archaic habitation sites have only recently been rediscovered as the result of managed drainage programs in south Florida. As the climate warmed and sea level rose, many Native Americans abandoned the lowest of the tree islands as they became submerged. This process continued through what is known as the Middle Archaic, until climate conditions stabilized around 300 BC at the start of the Late Archaic. Today many sites from both the Early and Middle Archaic periods are no longer submerged and may have more modern Native American use.

After the Archaic period, the Okeechobee Basin became incorporated into what is known as the Glades region and remained inhabited until European contact, when Old World diseases and slave raiding heavily

reduced the Native populations during the late 1500s to 1700s. Many of the tree islands through this portion of the Everglades have sites associated to the Glades period. This period has been broken down into successive stages starting with Glades I, which dates from 500 BC to 750 AD, Glades Period II dating from 750 to 1,200 AD, and Glades Period III dating from 1,200 AD to European contact in the 1,500s. Bell Glades sites include black earth middens, low sand mounds, and circular and linear earthworks.

During the early historic period, beginning with the first Spanish colonial period (1513 - 1763), the Calusa, a native tribe, inhabited southern Florida. Their population was decimated by European-introduced diseases, warfare, enslavement, and migration out of Florida. After European contact, Native American populations in the region continuously declined and remained at low levels until Miccosukee and Seminole tribal groups moved into the area while fleeing the U.S. Army and U.S. Governments' forced relocation program. Many sites associated with both the Miccosukee and Seminole tribes are known to exist throughout the region. The Miccosukee and the Seminole migrated into Florida in the 18th and 19th centuries from Georgia and Alabama. Throughout the mid-1800s, the U.S. relentlessly pursued a policy of Indian removal in Florida, and the Seminole, resisting removal, eventually established themselves in the Everglades, Big Cypress Swamp, and the Ten Thousand Islands. Today, many sites associated with the MTIF and STOF are known to exist throughout the region. Refer to Section 2.6 for more information.

Several important battles of the Seminole Wars occurred around Lake Okeechobee including the largest and bloodiest battle of the Second Seminole War, the Battle of Okeechobee on Christmas Day in 1837. The Okeechobee Battlefield site is located at the north end of Lake Okeechobee and is a National Historic Landmark site. Other Seminole battle and habitation sites, predominantly on tree islands, are located near Lake Okeechobee. Numerous tree island sites have been identified on nearby Brighton Reservation. Similar tree island sites may also be present within several of the proposed the project alternatives. Many tree islands are midden sites, which represent the accumulation of daily life activities. Material on these sites stretches from the surface to well over one meter below the surface on certain islands. Native American burials can also be found on these sites (Milanich 1994).

American settlement around Lake Okeechobee began in earnest in the late 19th century when efforts to drain and reclaim the Everglades began. Agriculture began in the Everglades, south of Lake Okeechobee after drainage projects of the 1906-1927 era. By 1921, there were 16 settlements on or near Lake Okeechobee, with a total estimated population of 2,000. By the 1940s, a number of homes had been built in this area forming historic districts that are potentially eligible for listing in the National Register of Historic Places (NRHP).

Areas around Lake Okeechobee and the Brighton Reservation have been subjected to cultural resources surveys; however, few investigations have focused on the area of the proposed alternatives. A review of the Florida Master Site File (FMSF) lists both prehistoric and historic archeological sites located in the vicinity of Lake Okeechobee. Prehistoric Native American sites consist of middens, mounds, and earthworks. Historic sites include buildings, shipwrecks, canoes, cemeteries. FMSF data and recently completed USACE surveys have identified 11 archaeological sites present within the focused array of alternatives. The majority of lands within the array locations have not been previously surveyed for the presence of cultural resources. There is a high probability that significantly larger numbers of unrecorded archaeological sites are located within each of the proposed alternatives. Several known prehistoric mounds and earthworks complexes are also located within or close proximity to the LOWRP project features including the Kissimmee Circle Earthworks Site (8GL39), the Spivey Site (8GL72) and the Mulberry Mound Site (8GL77). The Mulberry Mound Site is eligible for listing in the NRHP and has a high potential for containing burial resources.

C.1.1.23 Invasive and Exotic Species

EO 13112, entitled Invasive Species, states an "invasive species means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." Alien species (exotic) means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores or other biological material capable of propagating that species and is not native to that ecosystem. Invasive species are broadly defined and can be a plant, animal, fungus, plant disease, livestock disease or other organism. A native species is defined as a species that historically occurred or currently occurs in a particular ecosystem and is not the result of an introduction.

Significant scientific evidence and research document invasive non-native plants are degrading and damaging south Florida natural ecosystems (Doren and Ferriter 2001). Many species are causing significant ecological impacts by crowding out and displacing native plants, altering soil types and soil/water chemistry, altering ecosystem functions such as carbon sequestration, nutrient cycling and fire regimes, and reducing gene pools and genetic diversity. Non-native invasive animal distribution, extent and impacts are not well understood, however implications of invasive animals are apparent in south Florida. In addition to environmental impacts, invasive species impact human health, reduce agricultural production and property values, degrade aesthetic quality, decrease recreational opportunities and threaten the integrity of human infrastructure such as waterways/navigation channels, locks, levees, dams and water control structures.

Florida is particularly vulnerable to the introduction, invasion, and naturalization of non-native species. This is due to several factors including a subtropical climate, dense human population centers, major ports of entry and the pet, aquarium and ornamental plant industries. Major disturbance to the landscape has also increased Florida's vulnerability to invasive species. Alteration of the landscape for urban development, flood control, and agricultural uses has exacerbated non-native plant and animal invasions. On average, 10 new organisms per year are introduced into Florida that are capable of establishing and becoming invasive and causing environmental harm. Approximately 90% of the plants and animals that enter the continental United States enter through the port of Miami (JP Cuda, 2009a). Stein, Kutner & Adams (2000) estimated that over 32,000 exotic species (25,000 plants and 7,000 animals) have been introduced into Florida. There are approximately 4,000-5000 native species of plants and animals in Florida. The number of non-native species that have been introduced is eight times the total number of native species in the entire state.

The Guide to the Vascular Plants of Florida (Wunderlin, 1998) documented 3,834 plant species in Florida. Of the 3,834 plant species, 1,180 were considered non-native and were naturalized (freely reproducing) populations. The Florida Exotic Pest Plant Council (FLEPPC) identifies 81 of the 1,180 species of non-native plants as Category I species and 87 as Category II species in the 2017 Invasive Plant List. Searches through existing data and resources indicate 74 non-native plant species have been documented to occur within the project area (See **Annex F, Table 1**). Other non-native species are probably present; however, documented citations could not be located. Of the 74 species of plants documented to occur within the project area, there are 44 FLEPPC Category I species, 12 FLEPPC Category II species and 15 Florida Noxious Weed species.

Within the project area, non-native invasive plant species of concern include Australian pine (*Casuarina equisetifolia*), Old World climbing fern (*Lygodium microphyllum*), melaleuca (*Melaleuca quinquenervia*), Brazilian pepper (*Schinus terebinthifolius*), cogongrass (*Imperata cylindrical*), water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), Cuban bulrush (*Oxycaryum cubense*), and creeping water

primrose (*Ludwigia* spp.). Other non-native plant species of concern within the larger project area include torpedo grass (*Panicum repens*), tropical American water grass (*Luziola subintegra*) and Writes nutrush (*Scleria lacustris*).

A primary native nuisance species within the project area is cattail (*Typha* spp.). Many areas within the project area have been invaded by cattails. This is attributed to water with increased phosphorus being delivered to these areas which began in the late 1950's. Areas where water control structures, conveyance features, and levees exist provide a suitable habitat for invasion and expansion of cattail.

Searches through existing data and resources indicate 51 animal species have been documented to occur within the project area (See **Annex F**). Other non-native animal species are probably present however documented citations could not be located. Information regarding species presence and distribution is largely incomplete for most taxonomic groups of animals. Not all of the 51 non-native animal species identified and documented to occur in the LOWRP area will have a significant impact on the ecosystem.

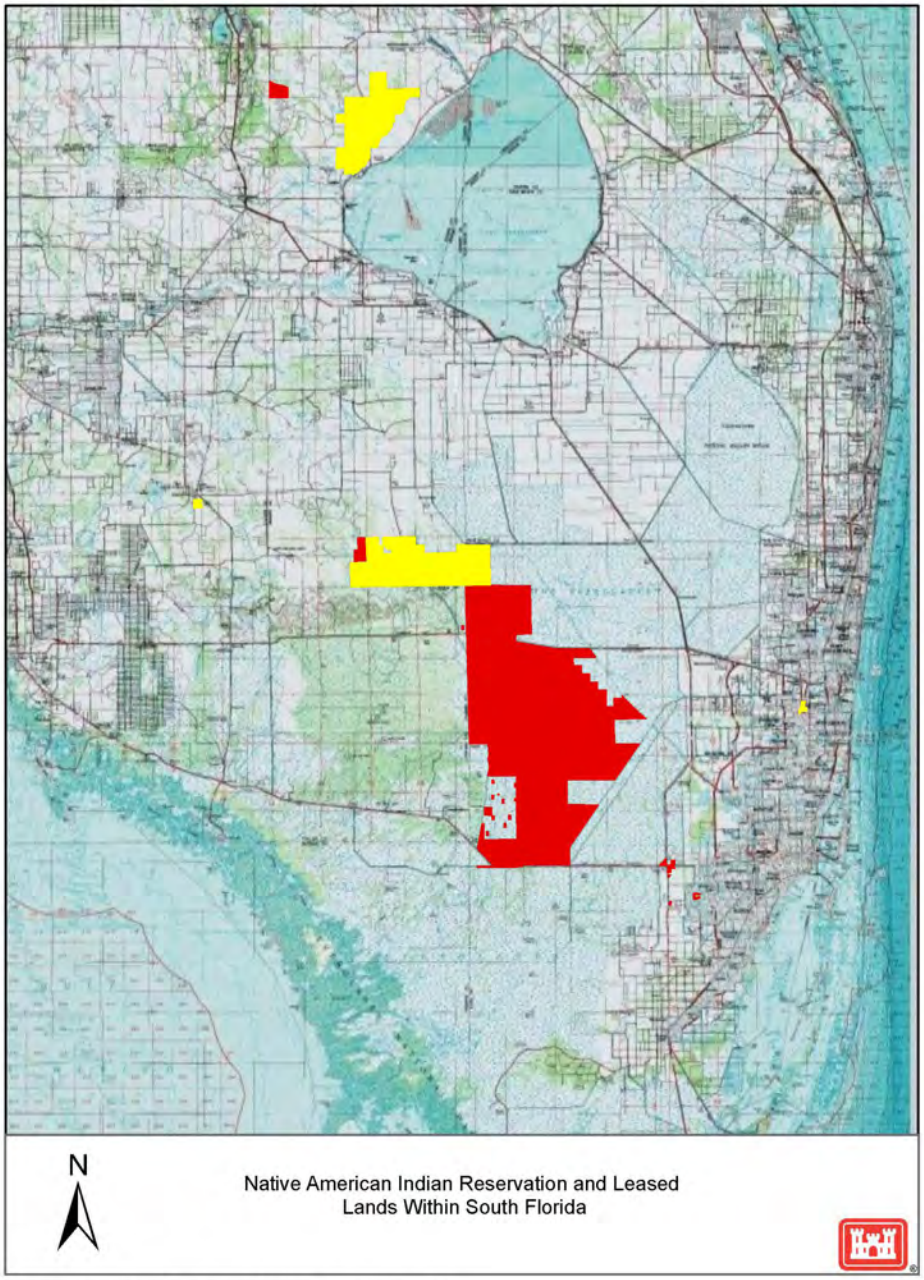
Key species of carnivorous reptiles, such as the Burmese python (*Python molurus bivittatus*) and the Nile Monitor (*Varanus niloticus*) have been located within the project area. At present time these occurrences have been isolated but there is concern regarding further spread of these species from south of the project area. These species have potential to cause significant impacts to the ecosystem and are among south Florida's most threatening invasive animals. These species are considered top predators and increase additional pressures on native wildlife populations, particularly threatened and endangered species (SFER 2013). Other species of concern include the island apple snail (*Pomacea insularum*), purple swamphen (*Porphyrio porphyrio*), feral pig (Sus scrofa) and redbay ambrosia beetle (*Xyleborus glabratus*) and associated fungus (*Raffaelea lauricola*).

C.1.2 Existing Conditions of Native Americans

There are two federally recognized tribes—the MTIF and STOF—that currently live adjacent to the project area and have a long history of occupying the region (**Figure C-44**). Both tribes have historically utilized the project area and maintain a strong connection to the region through continued use and regard the indigenous populations of Florida as their ancestors. Both tribes moved into the region during the eighteenth and nineteenth centuries from Georgia and Alabama. Fleeing the U.S. Army and the forced relocation policies of the Indian Removal Act (1830), the Miccosukees and Seminoles were part of Native American groups commonly referred to as Seminoles; however, there are references to some of the groups involved in the conflict as Mikasuki which supports the later reasons for separations of the two groups (Weisman 1999). Many of these groups fled into the swamp areas of south Florida and made their homes within the Everglades and other remote areas of region. The coming of the Civil War led to the abandonment of the removal efforts and the various Native American groups were largely left alone until the late nineteenth century. In 1928 the Tamiami Trail opened, cutting through the Everglades and bringing along with it tourists and explorers into the region, and, for the first time, bringing complete access for the various tribes to participate in the larger economy that was growing in south Florida.

Before the 1930s, the Seminoles inhabited camps scattered across Florida where the Federal Government started to bring services. Between 1935 and 1938, 35,279 acres of land were set aside to begin consolidating the Seminole camps into a reservation at Brighton. Some of the groups relocated and started to receive federal aid, while some groups resisted government intrusion into their lives and remained in various traditional areas that now include sites along Tamiami Trail (Weisman 1999). Today, Brighton is one of six Seminole reservations; approximately 637 people live there. They continue to rely

on the water from Lake Okeechobee as water supply and a secondary irrigation supply for water shortages on the reservation. The STOF also has access to and uses the HHD and Lake Okeechobee for hunting, fishing, and recreational activities.



Source: ESRI Maps - Online Access 8 January 2013

Figure C-44. Map outlining the location of the tribal reservations and leased lands.

C.1.3 Future Without Project Conditions of Resources

The FWO condition for the 50-year planning horizon assumes the construction and implementation of authorized CERP and non-CERP projects, and other Federal, state and local projects constructed or approved under existing governmental authorities that occur in the LOWRP study area (**Table C-14**). Under NEPA the **No Action Alternative** (herein called the FWO) needs to be evaluated. This subsection describes the projected physical, ecological, and socioeconomic conditions within the study area in the year 2072. The FWO conditions are also summarized in **Section 2.0** of the main report. Refer to **Appendix A** for further information on how project features in **Table C-14** were represented in the hydrologic model simulation of the LOWRP FWO baseline, where applicable.

Table C-14. Status of related reports, projects, and operational plans affecting plan formulation.

	EXISTING CONDITIONS	FUTURE WITHOUT-PROJECT CONDITIONS	RELATIONSHIP TO LOWRP
Pre-CERP	Kissimmee River Restoration (KRR) under construction	KRR construction complete	KRR has been restoring portions of the historic floodplains and oxbows north of the S65E structure, thereby slowing flows from the Kissimmee River into Lake Okeechobee
	Kissimmee River Headwaters Revitalization Project	Kissimmee River Upper Basin (real estate acquisition and operations)	See above
	Herbert Hoover Dike (HHD) Dam Safety Modification Report	Complete, features operational	LOWRP management measures may alleviate some of the risks associated with higher lake levels during peak water years
CERP	Lake Okeechobee Watershed Project June 2003 Watershed Assessment Report; December 2004 Development of Alternative Plans: Part 1 – Storage and Water Quality, and Part 2: Wetland Restoration	LOWRP features not complete	Previous LOWRP Planning Documents
	IRL-S under construction	Complete, features operational	Provides alternate storage downstream from Lake O, partially protecting the St Lucie Estuary from flows from the C-44, C-23, C-24, and C-25 basins. The IRL-S C-44 reservoir may receive limited inflows from Lake O if capacity is available
	C-43 West Basin Storage authorized	Complete	Provides alternate storage downstream from Lake Okeechobee, partially protecting the Caloosahatchee estuary from high volume flows from the lake

	EXISTING CONDITIONS	FUTURE WITHOUT-PROJECT CONDITIONS	RELATIONSHIP TO LOWRP
	CEPP Authorized	Complete	When completed, CEPP components would allow approximately 200,000 acre-feet of water to be delivered to the Everglades that would otherwise be retained within Lake Okeechobee or flowed to the Northern Estuaries
Other Related Projects	Natural Resource Conservation Service (NRCS) WRP-WRE	Complete	Wetland restoration projects within the LOWRP footprint to consider in FWO conditions and when siting project features
	U.S. Fish and Wildlife Service (USFWS) Refuge project	Complete	Restoration project within the LOWRP footprint to consider in FWO conditions and when siting project features
	2007 Feasibility Study of Deep Injection to Assist Management of Surface Water Releases to Lake Okeechobee	Not applicable, this is a study	Provides more detail on deep injection wells, a measure that was screened out of LOWRP alternatives
	LOW Protection Plan and LOW Phase II Technical Plan	Not applicable, this is a study	Provides more information on deep injections wells
	Florida Department of Protection (FDEP) Basin Management Action Plans (BMAPs)	Complete	To satisfy State water quality (WQ) requirements
Operational Plans	Lake Okeechobee Regulation Schedule (LORS) 2008	2008 LORS + CEPP refinements	Lake Okeechobee stage influenced primarily by LORS

C.1.3.1 Climate

During the period between the present and 2072, south Florida should experience a full multi-decadal cycle of Atlantic hurricane activity. Currently the area is in an active phase of this cycle that started in 1995. This active phase followed a 25-year period of low hurricane activity. This suggests that between the present and year 2072, the area would complete this active phase, pass through another low activity period, and begin another active phase. There is now evidence of anthropogenic changes to global climate patterns that will likely have an impact on south Florida in terms of rainfall, evapotranspiration, and temperature (Intergovernmental Panel on Climate change 2007). Climatologists predict air temperatures will increase, with projections of summer temperatures being up to 3–7°F warmer by 2100 (Twilley et.al. 2001, Union of Concerned Scientists 2008). Increases in air temperature, solar radiation, and water vapor deficit due to climate change are expected to increase evapotranspiration. Models used by Calanca et al. (2006) predict a 20% increase in evapotranspiration if summer temperatures increase from 4–7°F.

Other sources of climate modeling predict a 1.5°C increase of temperatures in the Everglades and +/-10% change in precipitation by 2060 (Obeysekera et al. 2011). The temperature change equates to a 7% increase in evapotranspiration. Unless precipitation increases similarly (+7% to +10%), then drought frequency is expected to increase in the Everglades. As a peat soil ecosystem, increasing drought would reduce available water to keep the soils wet, resulting in higher peat oxidation and loss of soil elevations in the freshwater wetlands (FAU 2013). Hydrological modeling indicates that surface water duration may decrease by 10-50% in the Everglades by 2060 (FAU 2013). In parts of northern WCA 3A, peat depths are less than 10 cm above bedrock (Johnson 2012), so loss of peat may produce bedrock protrusions in these areas within this time frame.

Regional surface water storage systems (lakes, rivers, canals, reservoirs, water conservation areas) will most likely experience more rapid water loss when compared to current levels, ultimately impacting availability of water supplies. Increased evapotranspiration may increase water demand for irrigation and natural wetlands areas. In addition, accelerated evaporation losses from stormwater treatment areas could impact their phosphorus removal performance, increasing the need for supplemental water for these facilities.

The Florida Oceans Council (2009) predicts more frequent intense rainfall events will occur coupled with longer dry periods in between. The SFWMD data indicate that there has been an increase in heavy downpours in many parts of the region, while the percentage of the region experiencing moderate to severe drought increased over the past three decades. While periodic heavy downpours may increase overall precipitation totals, much of the water may be runoff that is eventually lost to the Atlantic Ocean and Gulf of Mexico. The environmental impact of changes to floods and droughts depends on the relationship between the climate extremes. If flooding and drought frequency increase together, the Everglades may return to a more natural slough-ridge-island landscape because the floods would redistribute soils and sediments onto ridges and the droughts would allow recruitment of trees on islands. More droughts, without an increase in flooding conditions, pose a threat to the entire South Florida system. They would likely cause large shifts in community structure due to saltwater intrusion into freshwater habitats, drying of inland wetlands, disappearance of ridge and slough microtopography, and an increase in frequency of fires (both terrestrial and wetland). Without the ability to maintain minimum flows and water levels in South Florida, agriculture and public water supply well fields may not be able to function as designed. In addition, well fields may be contaminated by saltwater intrusion and higher salt levels in coastal waters may limit the usefulness of currently installed desalinization plants. More flooding may be good for the Everglades ecosystem because it would stimulate ridge-slough development and restore historic salinity regimes in Biscayne Bay and Florida Bay. However, increasing flooding alone may also create more frequent water level reversals during critical wading bird foraging periods, thus causing further declines in nesting success for wading birds.

Current research indicates overall storm frequency may decrease, while the number of strong hurricanes (due to warmer temperatures) is expected to increase. Tropical storms and hurricanes provide huge amounts of rain for the area. The loss of storm-associated rainfall could have significant implications for the SFWMD regional water supplies. If a decrease in the number of storms does occur, there may be significant changes to the distribution of rainfall, which will affect the water supply and natural ecology of South Florida. Less rainfall may mean the region is under drought conditions more often. If tropical storms and hurricanes become more intense, the potential damage to levees, canals, and other water control structures may also increase – resulting in an increased likelihood of flooding on a local and regional scale. Water supply and water quality may also be adversely affected by this extreme.

Sea level change is one of the more certain consequences of climate change, and because it affects the land/ocean interface, it has the potential for environmental impacts on coastal areas. Various sites along the east coast of Florida indicate that the sea level is rising at a rate above the global average (Maul and Martin 1983). USACE sea level change projections for the period from 2015 to 2065 for Daytona Beach Shores, Florida (Tailwater of S-80) and Fort Myers, Florida (Tailwater of S-79) area for historic, intermediate, and high rates of future sea level rise are described in **Table C-15**.

The regional hydrologic models used to simulate with and without project conditions require climatic and tidal data as boundary conditions. Given the uncertainty in future climatic conditions, the historic climate conditions used in the period of record are assumed to represent conditions that are expected to occur in the study area in the future. Simulation model tidal boundary conditions that reflect future sea level change were not available for the range of potential sea level change expected. However, the impact of sea level change on project benefits is assessed for the FWO and FWP conditions per USACE guidance ER 1110-2-8162, *Incorporating Sea Level Change in Civil Works Programs* and Engineer Technical ETL 1100-2-1, *Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation*. Future rates of sea level change are expected to result in significant impacts on coastal canals and communities, with loss of flood protection and increased saltwater intrusion being the primary effects. Additionally, coastal ecosystems and estuaries are expected to be adversely affected and require additional deliveries of freshwater to maintain desirable salinity patterns and healthy ecosystems. Sea level change is discussed in more detail in **Annex H**.

Table C-15. Estimated USACE Low, Intermediate, and High sea level change projections at Fort Myers, Florida and Daytona Beach Shores, in feet relative to NAVD88 for years 1992, 2028, 2078, and 2128 .

	Fort Myers, Florida Gauge: 8725520 Rate: 0.00787 feet/yr, NAVD88 (S-79 Tailwater in the Caloosahatchee Canal)			Daytona Beach Shores, Florida Gauge: 8721120 Rate: 0.00761 feet/yr, NAVD88 (S-80 Tailwater in the St. Lucy Canal)		
Year	Low	Intermediate	High	Low	Intermediate	High
1992	-0.41	-0.41	-0.41	-0.79	-0.79	-0.79
2028	-0.13	-0.01	0.35	-0.52	-0.40	-0.04
2078	0.27	0.93	3.01	-0.14	0.52	2.61
2128	0.66	2.31	7.52	0.25	1.89	7.10

C.1.3.2 Physical Landscape

During the period between the present and 2072, lands within the project area would be disposed and developed consistent with surrounding land use patterns. Within the Greater Everglades, continued loss of organic soils would continue as a result of oxidation. It has been observed throughout the Greater Everglades that peat loss is associated with changes in water deliveries that reduce water depths and hydroperiods. Canal construction and drainage have led to increased drought intensity and a resultant loss of peat soils. As soil subsides, a minor lowering of topography would be expected. Characteristics of the physical landscape are not expected to change significantly from existing conditions.

C.1.3.2.1 Geology

There are no active mining operations in the LOWRP project area. The only active mine is in western Glades County near Palmdale. The Cemex plant supplies materials for ready-mix concrete. Mining activities are not expected to change significantly from existing conditions in the LOW project area.

C.1.3.2.2 Soils

Soils within the project area are primarily sands in the upland dry prairies, and fine sands and silt in the alluvial floodplain and depressional wetland areas. Without the project, the landscape and soils are likely to remain over-drained until converted from ranch and agricultural lands to developed areas.

C.1.3.2.3 Aquifers

Agricultural and ranchland water supply represent the primary water use category in the LOW project area. As population increases with development, there will be additional pressure on SAS and UFA to provide alternate water supply sources. Use of brackish groundwater coupled with reverse osmosis treatment is a method already in use at coastal municipalities, and may be applied in the interior of the state to augment surface water supplies.

C.1.3.3 Vegetative Communities

The once vast, naturally connected landscape has been cut into a mosaic of various-sized habitat patches. The canals throughout the project area will likely continue to serve as an effective barrier to wildlife movement, interfering with, or preventing, the life functions of many native wildlife species. Possible future development, changes in the availability and distribution of freshwater, and further disruption of natural sheet flow from discontinuities in hydrology due to construction of levees, roads, canals, etc. could exacerbate the fragmentation of wetland communities. However, ongoing restoration activities within the watershed, including the KRR, Natural Resource Conservation Service (NRCS) wetland restoration projects, and the USFWS refuge project, are restoring functionality to historic wetlands.

C.1.3.4 Lake Okeechobee Watershed

Based on the 2060 Florida Report (Zwick and Carr, 2006), between 2005 and 2060, Florida's population is projected to double from approximately 18 to 36 million people. However, due to the relative remoteness to the coasts, and the presence of the Seminole Tribe's Brighton Reservation, the LOWRP study area (specifically Glades, Highlands, and Okeechobee Counties) is expected to retain their rural and agricultural characteristics under FWO conditions. Some areas (e.g., City of Okeechobee and along SR 78 which runs along the northwest shoreline of Lake Okeechobee) are predicted to experience a small increase in residential land uses (Zwick and Carr, 2006). Upland and wetland areas that are currently under conservation (e.g., portions of Fisheating Creek and along the Kissimmee River) are expected to stay in conservation. However, without the project, the wetlands along Paradise Run and Kissimmee River would not be restored, and those native vegetative communities would stay "as is" or possibly deteriorate (colonized by invasive species). As agriculture and improved pasture occupies a large percentage of the existing watershed, we do not anticipate a substantial change to land use or vegetation communities under FWO conditions. One uncertainty is the future degree of agricultural land use change. Conversion to different agricultural uses could affect vegetative patterns. Another potential change in the watershed under FWO conditions is the conversion of agricultural lands to dispersed water storage areas. At this time

it is unclear which vegetative communities would colonize these water storage features which we expect to have an annual hydroperiod that varies from dry to 4 ft. deep.

C.1.3.5 Lake Okeechobee

The majority of the surface of Lake Okeechobee is not vegetated and currently provides open (pelagic) habitat. Littoral vegetation occurs along much of Lake Okeechobee's perimeter, but is most extensive along the southern, northwest, and western borders. Under FWO conditions, the continued use of Lake Okeechobee to store water for agricultural and flood control needs would likely continue to result in high water levels within the lake. High water levels within the lake would continue to adversely affect shallow littoral zone habitat, and deeper littoral zones would remain without vegetation. In addition, even with state BMP's and other projects to improve water quality within the watershed, due to legacy effects, it is anticipated that the continued storage of nutrient-rich waters would maintain reduced water clarity that in turn adversely affects nearshore emergent and SAV areas. Vegetative communities in Lake Okeechobee are not expected to change significantly from existing conditions unless the regulation schedule is updated.

C.1.3.6 Northern Estuaries

The SAV is one of the most important vegetation communities of the Caloosahatchee River and Estuary and St. Lucie River and Estuary (including the Indian River Lagoon). Currently, SAV beds have been reduced or eliminated from their former areas by extreme salinity fluctuations, increased turbidity, sedimentation, dredging, damage from boats, and nutrient enrichment which causes cyanobacteria blooms that, in turn, restrict light penetration. Continued flood control freshwater flows from Lake Okeechobee to the Northern Estuaries would continue to cause salinities to drop below preferred ranges for estuarine biota. High-level freshwater flows during the wet-season would continue to result in increases in nutrient inflows and turbidity to the estuaries, thereby adversely affecting sea grasses. Some level of improvement is expected to occur during the period between the present and 2072 as a result of implementation of projects within the study area with the capability of improving the timing, quantity, and quality of freshwater flow to the Northern Estuaries. Improvements in water quality and salinity levels within the estuaries as a result of the C-43 West Basin Storage Reservoir Project (USACE 2010), Indian River Lagoon South Project (USACE 2004a) and the CEPP (USACE 2013) would reduce stress to SAV and aid in long-term health of estuarine habitat and biota.

C.1.3.7 Threatened and Endangered Species

Federally listed threatened and endangered species are either known to exist or potentially exist within the project area. Under FWO conditions, we predict that the study area's rural and agricultural nature will remain largely intact. We expect an increase in water management features (i.e., dispersed water projects) that are not part of the LOWRP, as water supply become scarcer, or at least less reliable. The potential conversion from pasture to other types of agriculture (e.g., sugar cane or other crops) may result in a loss of habitat for species like the crested caracara. In the Northern Estuaries, benefits to Florida manatees or smalltooth sawfish from a more natural hydroperiod would not be realize under FWO conditions. Future Federal actions unrelated to the proposed action but located in the study area, will require separate consultations pursuant to Section 7 of the ESA. For further information pertaining to potential impacts to federally listed threatened and endangered species as a result of changes that occur between the present and the future without project condition please see the BA included in **Annex A.**

C.1.3.8 State-listed Species

State listed threatened and species of special concern are either known to exist or potentially exist within the project area. Under FWO conditions, we predict that the study area's rural and agricultural nature will remain largely intact. We expect an increase in water management features (i.e., dispersed water projects) that are not part of the LOWRP, as water supply become scarcer, or at least less reliable. The potential conversion from pasture to other types of agriculture (e.g., sugar cane or other crops) may result in a loss of habitat for species like the Florida burrowing owl.

C.1.3.9 Fish and Wildlife

The project area supports a variety of fish and wildlife resources. Disruption of the natural hydrology has resulted in aquatic vegetation community changes and a resultant disruption of aquatic productivity and function that has had repercussions through the food web, including effects on wading birds, larger predatory fishes, reptiles, and mammals. Under FWO conditions, a further reduction in habitat function is possible, albeit to a lesser rate than in the past. In this event, it would likely result in a decrease in the abundance and diversity of fish and wildlife resources on non-protected lands.

In the FWO, continued artificially high water levels within the lake would reduce the availability of bedding habitat for fishes and change the extent and composition of the emergent and submergent vegetation communities. Lower water levels could provide opportunities for foraging for wading birds and other birds dependent upon aquatic prey species by concentrating prey and exposing additional shallow water habitat; however, under FWO conditions, drought conditions would be ecologically worse without additional water storage to offset low lake levels.

Fish and wildlife resources inhabiting the Northern Estuaries would continue to be impacted by high volume freshwater flows from Lake Okeechobee. Annual variability in flow would lead to salinity extremes outside the tolerance ranges of many fish and wildlife resources resulting in decreased species diversity. Further declines in estuarine habitat (SAV and oysters) would continue to result in additional declines in the species that utilize these habitats. Seagrass communities within the Northern Estuaries provide critical refugia for juvenile fish. The long-term loss of nursery habitat will result in population declines for many species of estuarine and marine fishes and macroinvertebrates, including those whose young of the year use fresher habitats. Waterfowl and wading birds are also expected to decrease under FWO conditions as estuarine habitat quality continues to decline. Some level of improvement is expected to occur as a result of implementation of projects within the study area with the capability of improving the timing, quantity, and quality of freshwater flow to estuarine systems and coastal areas (i.e., C-43 West Basin Storage Reservoir Project (USACE 2010), Indian River Lagoon South Project (USACE 2004a) and the CEPP (USACE 2013)).

C.1.3.10 Essential Fish Habitat

Estuarine systems and coastal areas within the project area support fishery resources of recreational and commercial importance. At least 70% of Florida's recreationally or commercially sought fishes depend on estuaries for at least part of their life histories. Current disruptions caused by flood control high volume freshwater flows would continue to reduce salinities in the estuarine systems and coastal areas during the period between the present and 2072. The absence of freshwater flow into estuarine systems and coastal areas would continue to promote conditions that are likely to result in a decrease in the abundance and diversity of species within those habitats. High-volume freshwater flows during the wet season would

continue to negatively impact species utilizing essential fish habitat. Some level of improvement is expected to occur as a result of implementation of projects within the study area with the capability of improving the timing, quantity, and quality of freshwater flow to estuarine systems and coastal areas (i.e., C-43 West Basin Storage Reservoir Project (USACE 2010), Indian River Lagoon South Project (USACE 2004a) and the CEPP (USACE 2013)).

C.1.3.11 Hydrology

Hydrologic modeling simulations of the existing condition baseline (ECB) and the FWO condition were developed with the RSM-BN sub-regional modeling tool, to provide baseline conditions for plan formulation, the assessment of LOWRP project benefits (comparisons against FWO), and the assessment of LOWRP alternative performance for the level-of-service for flood protection and water supply (comparisons against ECB). The ECB was developed to represent the system-wide infrastructure and operations that were in place at the time LOWRP plan formulation was initiated, approximately in year 2016. The FWO for LOWRP assumes the construction and implementation of currently authorized CERP and non-CERP projects, and other Federal, state or local projects constructed or approved under existing governmental authorities that occur in the LOWRP study area. The LOWRP FWO therefore included first generation CERP projects already authorized and under construction (Indian River Lagoon South Project, Picayune Strand Restoration Project, Site 1 Impoundment Project), second generation CERP projects that are authorized (Biscayne Bay Coastal Wetlands Project, Broward County Water Preserve Areas Project, Caloosahatchee River (C-43) West Basin Storage Reservoir, C-111 Spreader Canal Western Project, Ten Mile Creek Reservoir and STA Preliminary Operation Plan, Holey Land G200 structure, Central Everglades Planning Project (CEPP), and non-CERP projects currently in progress (SFWMD Restoration Strategies, C&SF C-51 West End Flood Control Project, the C-111 South Dade Project, the KRR Project, Modified Water Deliveries, and the DOI Tamiami Trail Modifications Next Steps Project). Note RSM-BN model domain south of the lake is spatially limited and some of the projects listed above might have no influence to the LOWRP area. Refer to Appendix A Engineering Appendix for more details about model domain.

Operations protocols for the first and second generation CERP projects were modeled consistent with the draft Project Operating Manuals, as documented in the respective PIRs. The completed KRR project included the Headwaters Revitalization Schedule for the Kissimmee Chain of Lakes as defined for the Upper Kissimmee Chain of Lakes Routing (UKISS) modeling conducted by the Kissimmee River project team.

The extensive list of first- and second-generation CERP projects and non-CERP projects that are included in the LOWRP FWO will result in hydrologic interactions between the projects. Due to the CERP PIR sequencing and the project-specific assumptions for related projects that were defined in each CERP PIR, the hydrologic interactions observed for the LOWRP FWO are likely unique to the LOWRP PIR. Based on these considerations, the summary of regional hydrology for the LOWRP FWO includes quantitative comparisons with the LOWRP ECB based on the RSM-BN and RSM-GL CEPP modeling representations of these baselines. The baseline RSM-BN modeling outputs represent the ECB and FWO scenarios and these scenarios have also been used in the three rounds of model output to compare these conditions to potential reservoir and ASR-well alternatives.

C.1.3.11.1 Lake Okeechobee and the Northern Estuaries

The FWO assumption for the operation of Lake Okeechobee is the 2008 LORS, plus refinements to the LORS in anticipation of implementing authorized projects such as CEPP by 2050 were included in the

model runs. Independent of LOWRP implementation, there is an expectation that revisions to the 2008 LORS will be needed following the execution of other CERP projects and HHD infrastructure remediation.

Compared to the ECB, the FWO follows the expected trend of increasing the stage due to the incorporation of projects such as IRL, C-43, and A1-FEB. Notice criteria like reduction on high-flow durations per event results in an improvement toward the Caloosahatchee Estuary baseflow but increases lake stage from ECB. **Figure C-45** shows increases in stage of roughly 0.3 ft., primarily between 14–16.5 ft. NGVD, though slight increases also occur between 10–13.5 ft. NGVD as well. Overall, lake stages in both the ECB and the FWO are within the ecologically beneficial envelope for almost the same amount of time (57.4% vs 56.6%, respectively), though the FWO exceeds the upper boundary more frequently while the ECB exceeds the lower boundary more frequently. Ecologically, higher stage exceedances are considered more detrimental than lower stage exceedances.

For the Caloosahatchee Estuary, compared to the ECB, mean monthly flows above 2800 cfs and 4500 cfs are reduced by 24 and 13 months, respectively (25% and 30% reductions, respectively; **Figure C-46**. Mean monthly flows less than 450 cfs are reduced by 93 months (80%) with operation of the C-43 Reservoir (**Figure C-47**).

For the St. Lucie Estuary, compared to the ECB, mean monthly flows above 2000 cfs and 3000 cfs are reduced by 18 and 17 months, respectively (36% and 40% reductions, respectively; **Figure C-48**). Mean monthly flows less than 350 cfs are increased by 12 months (13%) with operation of the C-44 Reservoir (**Figure C-49**).

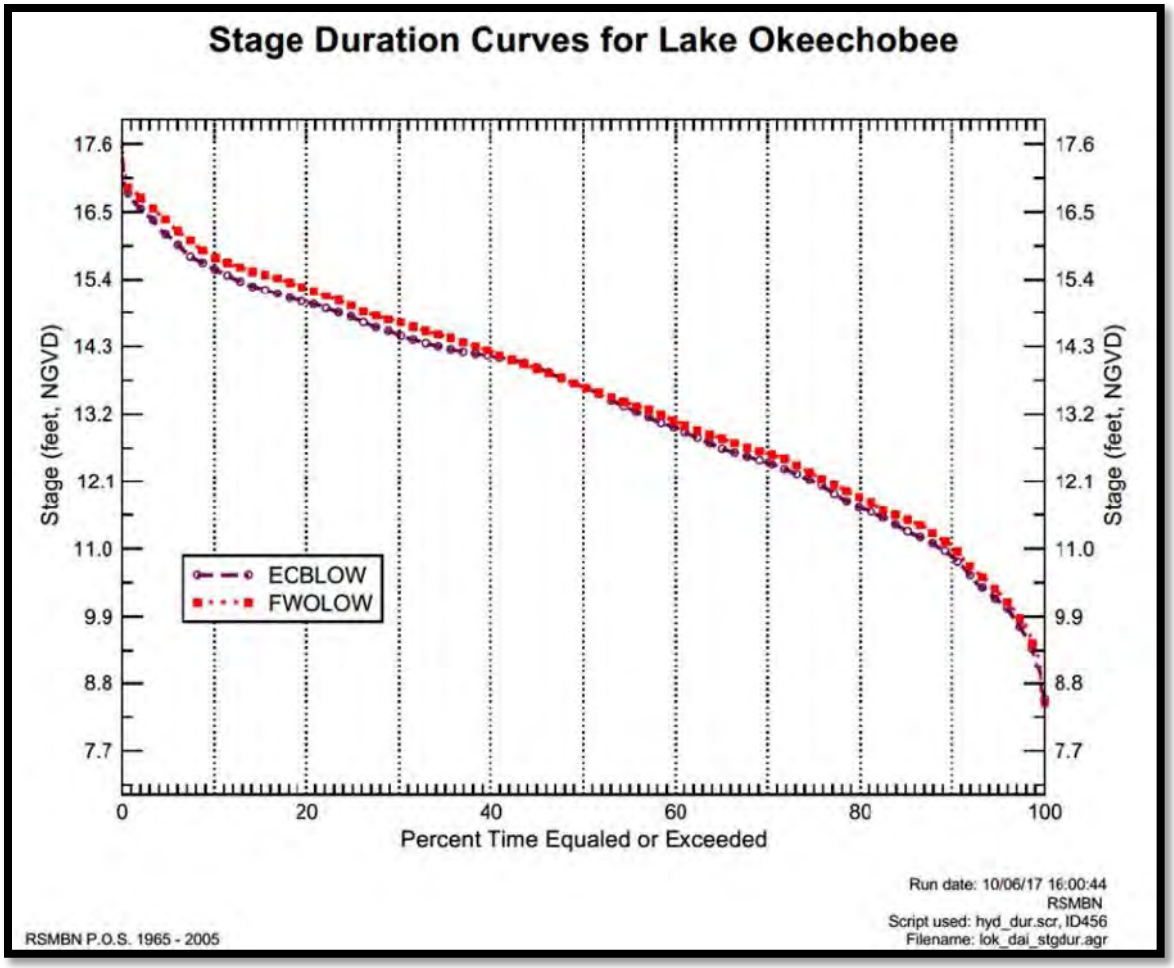


Figure C-45. Lake Okeechobee ECB and FWO stage duration curves.

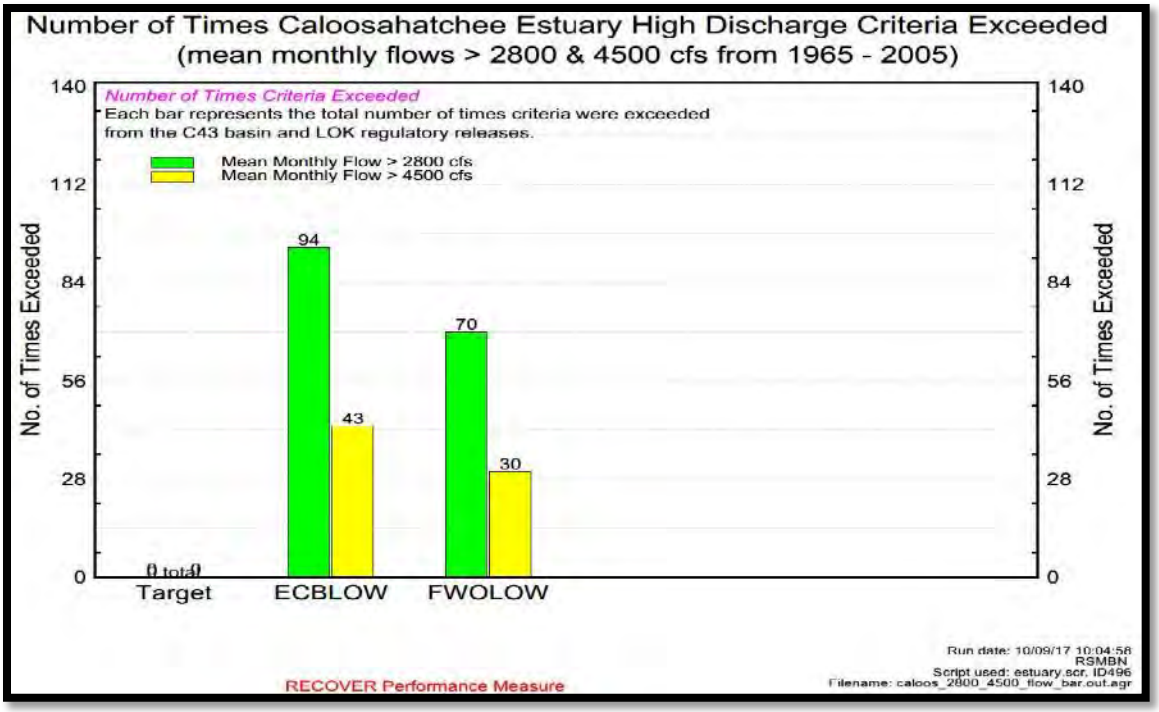


Figure C-46. Caloosahatchee high-flow criteria exceeded.

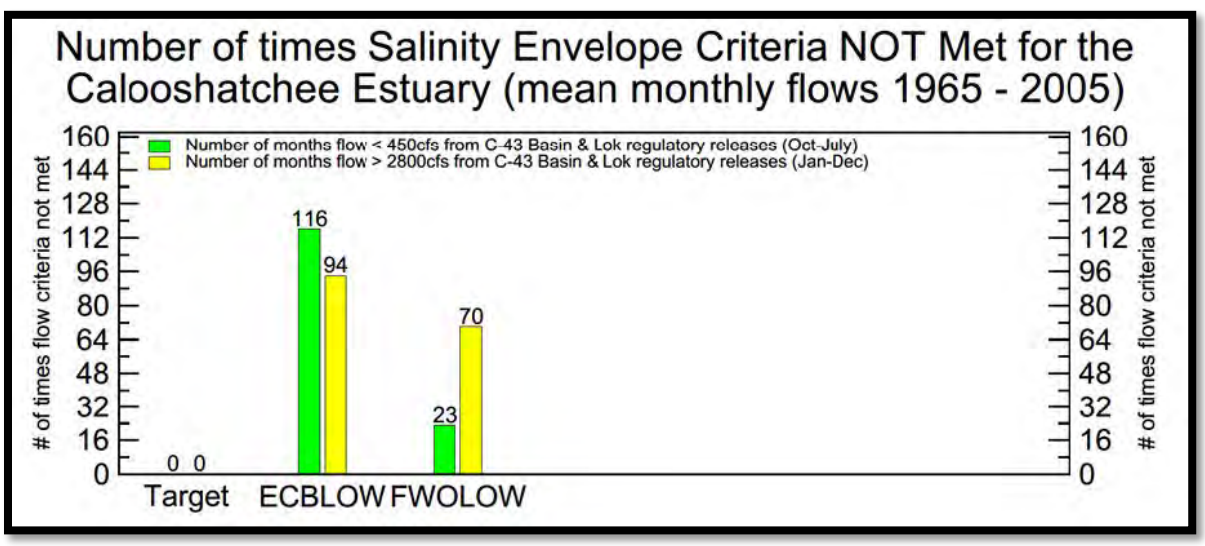


Figure C-47. Caloosahatchee salinity envelope criteria not met.

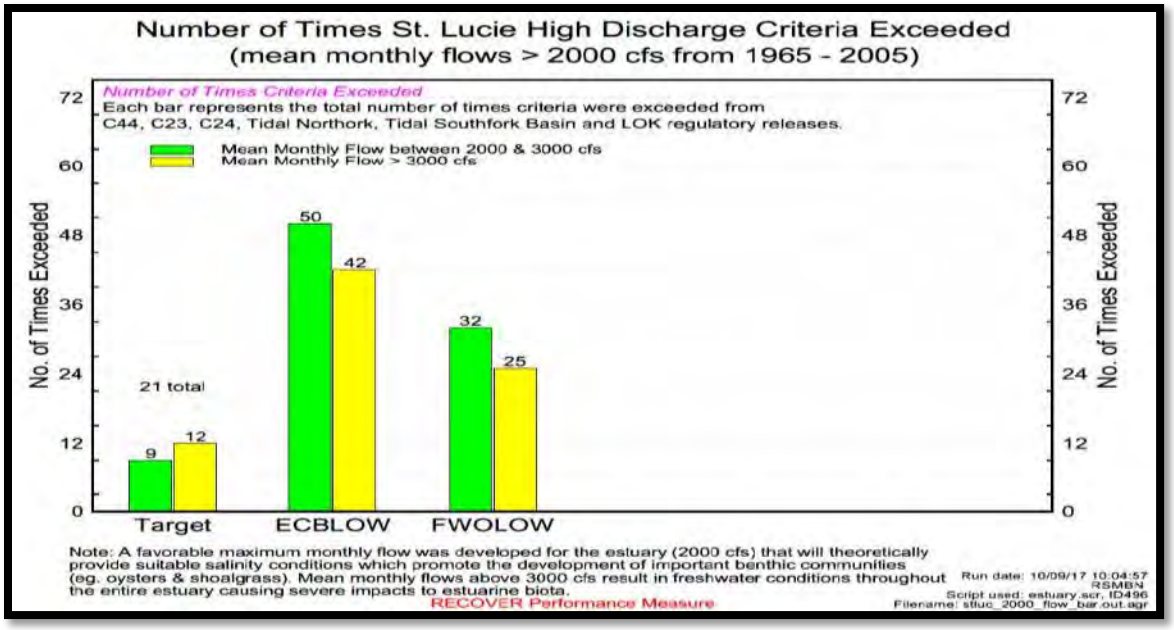


Figure C-48. St. Lucie high-flow criteria exceeded.

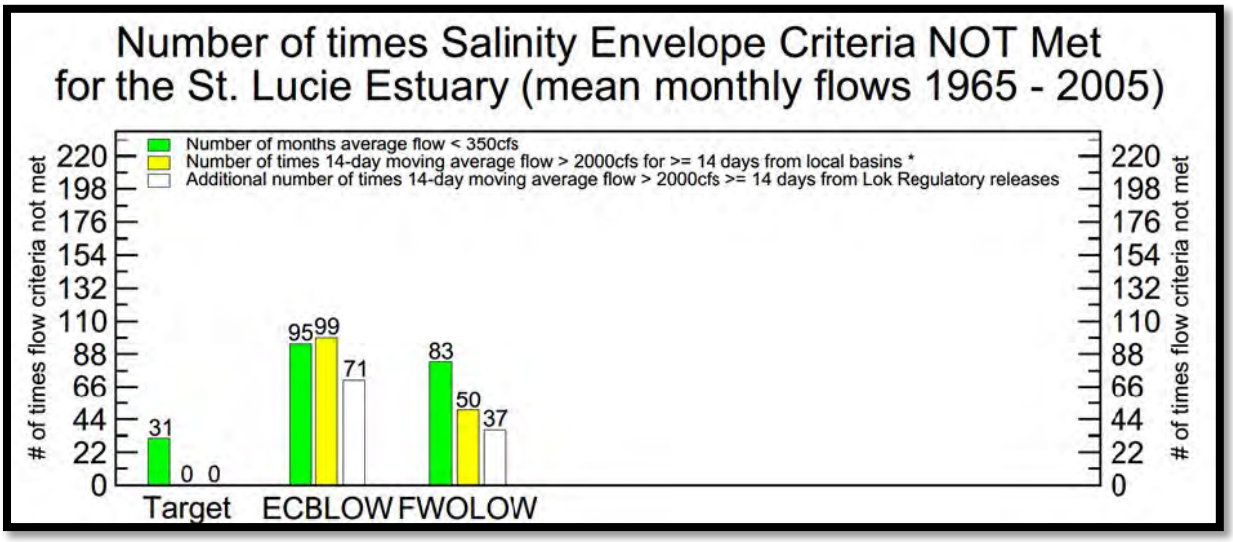


Figure C-49. St. Lucie salinity envelope criteria not met.

C.1.3.12 Regional Water Management (Operations)

The FWO for the LOWRP assumes the construction and implementation of currently authorized CERP and non-CERP projects, and other Federal, state, or local projects constructed or approved under existing governmental authorities that occur in the LOWRP study area; the LOWRP FWO therefore included first generation CERP projects already authorized and under construction (Indian River Lagoon-South Project), second generation CERP projects that are authorized (Central Everglades Planning Project (CEPP),

Caloosahatchee River (C-43) West Basin Storage Reservoir), and non-CERP projects currently in progress (the KRR Project, Natural Resource Conservation Service WRP-WRE, and USFWS Refuge Project).

For the LOWRP modeling of the FWO with the RSM-BN model, operations protocols for the first- and second-generation CERP projects were modeled consistent with the draft project operating manuals, as documented in the respective PIRs. The completed KRR project includes the Headwaters Revitalization Schedule for the Kissimmee Chain of Lakes as defined for the UKISS modeling conducted by the Kissimmee River project team. Although the 2008 LORS was assumed to remain in place during the ECB conditions, (**subsection C.1.1.9)**, the FWO assumes a subsequent schedule to accommodate the operational protocols specified in the documentation for the projects listed above.

C.1.3.13 Lake Okeechobee Regulation Schedule

The ECB scenario for the operation of Lake Okeechobee is based on the 2008 LORS regulation schedule. The LOWRP team recognizes that when it was approved, 2008 LORS was identified as an interim schedule and that a subsequent schedule would be considered after the repairs to the HHD were completed. Although a new operating schedule is expected to be developed under a different, future study, 2008 LORS is the best estimate for operations under existing conditions. However, the LOWRP FWO scenario is based on a subsequent LORS regulation schedule that results in additional occurrences of higher lake stages than the current 2008 LORS regulation schedule estimates.

The LOWRP FWO modeling assumed operation of Lake Okeechobee with the other specified adjacent FWO projects (Kissimmee River Restoration, Caloosahatchee River (C-43) west basin and St. Lucie River (C-44) storage reservoirs, IRL-S project) in place and operational. Lake Okeechobee FWO operations assume the 2008 LORS regulation schedule with modifications developed during CEPP for future flows. Effects on Lake Okeechobee are described in Appendix C, Part 2, **subsection C.2.3.3.**

C.1.3.13.1 Kissimmee River Regulation Schedule

In the LOWRP FWO, the Kissimmee River Basin is partitioned into three major sub-watersheds: Pool A, BCD (Pool BC & Pool D combined into Pool BCD) and Pool E. The stage-volume and stage-area relationships were updated for Pool BCD. Also, the structure S-65C is removed from this scenario, as intended in the Kissimmee River Restoration Project. The FWO Kissimmee regulation schedule used for LOWRP is found on **Figure C-50**.

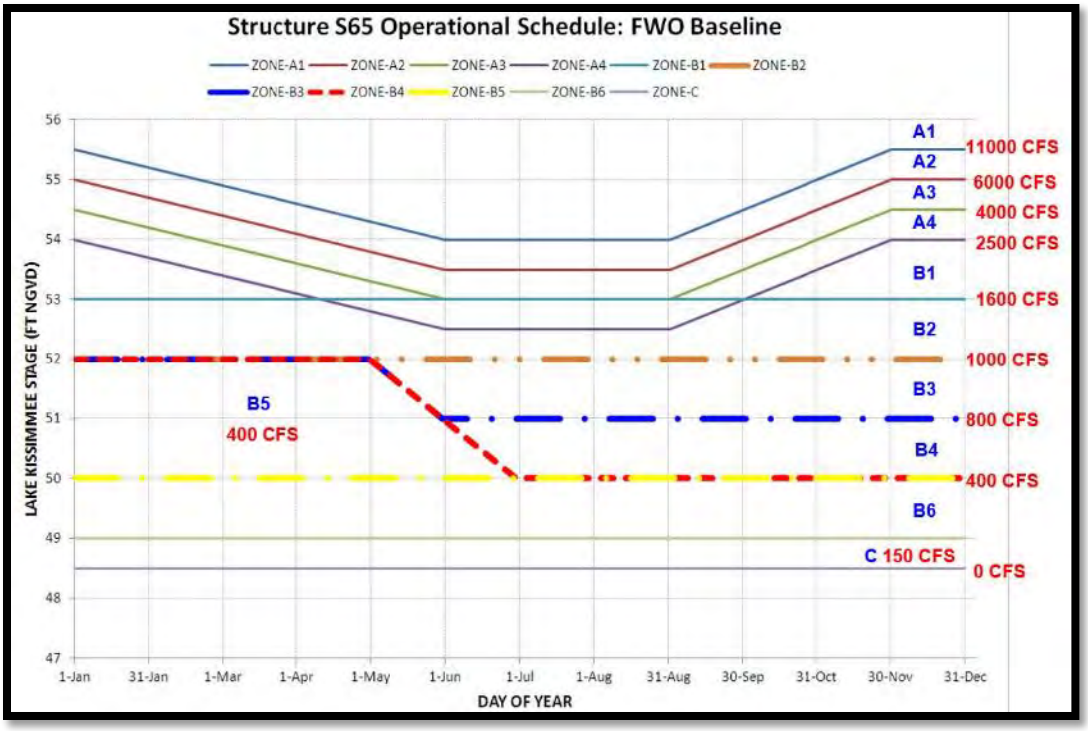


Figure C-50. Kissimmee River Basin FWO regulation schedule.

C.1.3.14 Groundwater Resources

Planning for future groundwater supply demands in the LOW is described in the Lower Kissimmee Basin water supply plan (SFWMD, 2014). Total water demand is expected to increase by 15% to 222 million gallons per day by 2035, of which agricultural self-supply is the largest water use category. This demand is met using both surface and groundwater resources. Municipal and tribal groundwater resources of the surficial aquifer are utilized currently by the Okeechobee Utility Authority (1 MGD) and the STOF's Brighton Reservation (1 MGD).

The Intermediate Aquifer/Confining Unit is not a significant water supply source in the project area. However, a permeable quartz sand unit was described at depths of 250–340 ft. below land surface at the Brighton Reservation (Missimer Groundwater Science, 2007). If sufficiently productive, this aquifer could serve as a limited groundwater supply source.

The UFA serves as the most reliable source for agricultural water supply and some public water systems in the LOW. The UFA groundwater is fresh in the LOW project area, but becomes brackish toward Moore Haven and Port Mayaca on Lake Okeechobee (USACE, 2013). Estimated future demands on the UFA groundwater may be limited near the Lake Wales Ridge in order to maintain minimum flows and levels in adjacent lakes (SFWMD, 2014). However, sufficient confinement separates Lake Istokpoga and Lake Okeechobee from the UFA, so increased demands are unlikely to affect water levels in these lakes.

The APPZ is not a water supply source due to greater salinity compared to the UFA, and greater depth. It is unlikely that the APPZ will provide drinking water or agricultural irrigation supplies in the future.

C.1.3.15 Water Quality

The two most significant water quality issues within the study area are associated with nutrient pollution and the bioaccumulation of mercury by fish and birds. General discussion of the phosphorus issues within the basin are provided here. Details of the nutrient issues were discussed in **subsection C.1.1.11**.

C.1.3.15.1 Lake Okeechobee Watershed

Watershed nutrient runoff is being addressed by an interagency basin management action plan (BMAP) set of projects. These projects are designed to reduce nutrient loading from the runoff at individual properties in the sub basins. The goal is to meet the TMDL of 140 MT of phosphorus loading into the lake on an annual basis, which is currently being exceeded by a factor of approximately 3-4 times the TMDL.

C.1.3.15.2 Lake Okeechobee

Water quality in Lake Okeechobee should improve under the FWO condition relative to the existing conditions as a result of implementation of TMDLs and associated BMAPs within the Upper Kissimmee River Basin as well as lake basin. The State of Florida has committed to achieving the phosphorus TMDL for the lake by implementing a series of source controls and treatment facilities within the basin. Achieving the TP load TMDL for the lake of 140 MT/year will result in improved dissolved oxygen conditions and reduced incidence of cyanobacteria blooms after internal TP loading events start to decrease. Mercury methylation conditions within the lake should improve due to the implementation of the proposed mercury TMDL for Florida; however, the greatest reduction in total mercury due to atmospheric deposition will only come about through international controls on atmospheric emissions of mercury related to the combustion of coal and other fuels. Although atmospheric loading is often the dominant proximate source of inorganic Hg to many water bodies, the complication lies in the relationship between influx of inorganic Hg and the amount that is converted to MeHg by sulfate-reducing bacteria (SRB) or potentially other groups of bacteria such as iron-reducing bacteria and methanogens following deposition.

C.1.3.15.3 Northern Estuaries

Nutrient and dissolved oxygen conditions should improve during the wet season within the Caloosahatchee River and Estuary given the reduction in high flow events due to implementation of the C-43 Reservoir Project (USACE 2010) and the CEPP (USACE 2013). The frequency of dry season algal events within the upper estuary may decrease as a result of increased dry season flows through the S-79 structure during the late spring should occur due to implementation of the C-43 Reservoir Project (USACE 2010).

Nutrient and dissolved oxygen conditions should improve during the wet season within the St. Lucie Estuary given the reduction in high flow events due to implementation of the Indian River Lagoon South Project (USACE 2004a) and the CEPP (USACE 2013). Low-flow event conditions do not change significantly within the St. Lucie for the FWO conditions; therefore no change to water quality is expected during the dry season. Mercury methylation conditions within the estuaries should improve due to the implementation of the proposed mercury TMDL for Florida; however, the greatest reduction in methylated mercury will only come about through international controls on atmospheric emissions of mercury related to the combustion of coal and other fuels.

C.1.3.16 Flood Control

The negative effects associated with flooding are expected to increase during the period between the present and the year 2072. As agricultural and urban development continues, the volume, duration, and frequency of floodwaters may increase, and the actual levels of service for flood control may decline in some areas. If sea level change continues as predicted, it is foreseeable that the Biscayne aquifer is likely to experience greater intrusion of saltwater possible rendering some of the current water supply well fields unusable due to contamination. Higher groundwater stages in the project area would reduce the ability of water managers to store rainfall runoff wither within wetlands or the surficial aquifer, resulting in increased intensity of stormwater flows through the primary canals. Reduced water storage reduces the capacity of the flood control system to accommodate runoff and would likely lead to increased frequency of flooding events. Sea level change may also impact flood control effectiveness as rising tail water conditions at the coastal canal structures reduce the effective maximum release rates. As additional information becomes available, these structures may be modified or replaced with pumps to ensure continued effective flood control. This may also require the implementation of forward pumping to maintain the existing level of flood protection in the future. An analysis of sea level change on the optimized TSP is discussed in **Section 6** and **Annex H**. Sea level change is not included in the FWO modeling for LOWRP.

Future non-CERP projects, implemented through the USACE and/or SFWMD may potentially alter the levels of service for flood control within the LOWRP project area, including but not limited to: potential Lake Okeechobee Regulation Schedule changes, SFWMD Restoration Strategies, C&SF C-51 West End Flood Control Project, the C-111 South Dade Project, the KRR Project, Modified Water Deliveries, and other potential future C&SF operational plan studies. Potential flood control affects, including improved or reduced levels of service, would be thoroughly assessed through the public NEPA process. To the extent that these projects have been identified and defined, these non-CERP projects have been included in the LOWRP FWO modeling assumptions; potential future operational plans for Lake Okeechobee, implementation of the Modified Water Deliveries and C-111 South Dade projects, and other potential future C&SF operational plan studies are therefore not able to be included in the LOWRP FWO modeling.

The Water Resources Development Act of 2000 (section 601 of WRDA 2000) approved the CERP Plan contained in the "Final Integrated Feasibility Report and Programmatic Environmental Impact Statement" dated April 1, 1999. As stated in section 601(h) of WRDA 2000, "the overarching objective of the Plan is the restoration, preservation, and protection of the south Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection." Section 601 of WRDA 2000 required the Secretary of the Army, with the concurrence of the Secretary of the Interior and the Governor of Florida, and after notice and opportunity for public comment, to promulgate Programmatic Regulations to ensure that the goals and purposes of the Plan are achieved and to establish the processes necessary for implementing the Plan. The final Programmatic Regulations became effective on 12 November 2003 as 33 CFR Part 385.

Identifying if an elimination or transfer of existing legal sources of water will occur as a result of implementation of CERP and whether levels of service for flood protection will be reduced by implementation of CERP is required by section 601(h)(5) of WRDA 2000. The WRDA 2000 Savings Clause requires that "Implementation of the Plan shall not reduce levels of service for flood protection that are:

(i) in existence on the date of enactment of this Act [11 December 2000]; and (ii) in accordance with applicable law." Consistent with the Savings Clause requirements, each CERP project included in the

LOWRP FWO (IRL-S, Picayune Strand Restoration, Site 1 Impoundment, Biscayne Bay Coastal Wetlands, Broward County Water Preserve Areas, Caloosahatchee River (C-43) West Basin Storage Reservoir, C-111 Spreader Canal Western) must independently demonstrate in the respective PIRs that implementation of these CERP projects would not adversely impact the levels of service for flood protection. Operations protocols for the first- and second-generation CERP projects were modeled in the LOWRP FWO consistent with the draft project operating manuals, as documented in the respective PIRs.

C.1.3.17 Water Supply

Future non-CERP projects within the LOWRP project area, implemented through the USACE and/or SFWMD may potentially partially or entirely eliminate water supply sources or transfer water supply to new sources.

C.1.3.18 Air Quality

During the period between the present and 2072, air quality is expected to be degraded due to increased populations and urbanization. Air quality is expected to comply with air quality standards; however it is possible that regions of the project area may be classified as air quality non-attainment zones.

C.1.3.19 Hazardous, Toxic and Radioactive Wastes

The HTRW conditions under the future without project condition are expected to be very similar to the present condition. Farming operations and the accompanying HTRW contamination would continue on for the foreseeable future until the overlying peat soils are exhausted due to oxidation. HTRW contamination and cleanup will continue at present rates given continued agricultural, residential, and commercial use of other lands within the study area.

C.1.3.20 Noise

Sources of noise associated with surrounding land use are expected to be similar to those described in existing conditions. During the period between the present and the year 2072, noise within the major natural areas of south Florida would continue to be limited and of low occurrence. Noise levels would be expected to change where land use is projected to change. Within rural municipalities and urban areas, sound levels would be expected to be of greater intensity, frequency, and duration as areas are further developed in 2072 from agricultural to residential/commercial due to increased noise from traffic, construction associated with development, and increased operations at commercial and industrial facilities.

C.1.3.21 Aesthetics

Sources of visual aesthetics are expected to be similar to those described in existing conditions. Visual characteristics would be expected to change where land use is projected to change. During the period between the present and the year 2072 the visual environment within the major natural areas of south Florida, is expected to decline as changes in the availability and distribution of freshwater would further exacerbate changes occurring in fish and wildlife resources and vegetative communities as described in **Sections C.1.1.3** and **C.1.1.6**. Within rural municipalities and urban areas, the occurrence of visible topographic features would be expected to be of greater occurrence as areas are further developed in 2072 from agricultural to residential/commercial. Increased occurrence of visible topographic features (i.e., heavily used roads, highways, single-family homes, high rises, commercial and industrial facilities)

may detract from the regional aesthetic. . Conversely, if the 2014 Florida Land and Water Conservation Initiative, Amendment 1, receives more funding in the future, regional aesthetic features may increase.

C.1.3.22 Land Use

The region, including cities within the study area, is expected to grow slightly both in population and in development to meet population demands. Florida is expected to grow exponentially exceeding the national expected growth rate; however, the growth rate is not as inflated for Glades, Highlands, and Okeechobee counties in comparison to other counties in Florida (U.S. Census Bureau, 2010 Census of Population and Housing, CPH-2-11). Much of the land in the study area is currently zoned for agricultural use. As growth continues, rezoning of lands for commercial and industrial use is likely to occur. Development pertaining to increased population includes the demand for additional infrastructure of roads, fire districts, schools, recreation facilities, stormwater management, water and sewer system and other facilities the developer may require. Agriculture is expected to remain a strong economic driver within the study area. It is not anticipated that land use acreages will increase or decrease substantially based on future population projections.

C.1.3.23 Recreation

In general, the variety of recreational interests in the United States appears to be increasing along with recreational participation rates. As future recreation needs and interests develop, it is important to recognize that participation in specific types of recreational activities is often linked to demographic factors such as age and income. For example, participation in activities requiring vigorous exercise is considerably higher for young people than for senior citizens. However, the elderly population is increasing recreation participation because of the growing awareness of the importance of physical fitness. Participation in most activities is low for those with family incomes below $25,000 per year. Interestingly, participation is low for those with family incomes greater than $100,000 per year. Most outdoor recreational activities appear to be enjoyed largely by the middle class, those with family incomes between $25,000 and $75,000 per year.

The 2013 SCORP is a reliable source to determine if Florida residents and tourists need additional facilities to support outdoor recreation. Surveys determined the user rates for 26 different outdoor activities within 8 regions of Florida.

Figure C-51 below from SCORP 2013 predicts population growth in all regions. All regions are expected to have significant increases in demands for the selected recreation activities with a commensurate need to increase development of the regions' recreation resources and facilities.

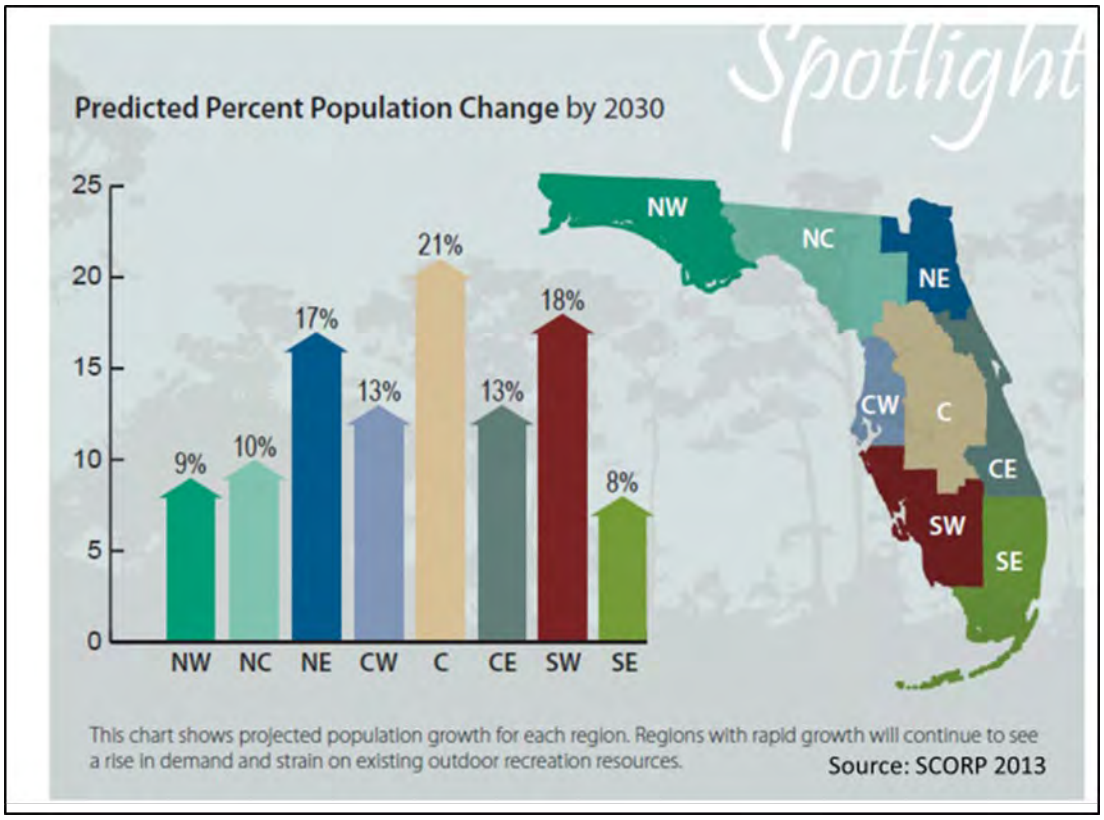


Figure C-51. Projected population growth by 2030.

C.1.3.24 Socioeconomics

The 2010 Census count of total population as reported by the United States Census Bureau is the basis for the 2010 population estimates as reported by the University of Florida's Bureau of Economic and Business Research (BEBR). The 2010 BEBR estimates for permanent resident population (BEBR 2011) are the basis for estimating 2030 populations for each county in the LEC. **Table C-16** provides BEBR population projections for the low, medium, and high ranges for 2015–2040 for the LEC Planning Area.

Table C-16. BEBR population projections for the LEC planning area for 2010-2040.

	Projections					
	2015	2020	2025	2030	2035	2040
Palm Beach County						
Low	1,342,600	1,367,700	1,383,900	1,389,700	1,384,900	1,370,900
Medium	1,394,300	1,482,900	1,568,500	1,648,000	1,720,000	1,786,000
High	1,454,500	1,605,600	1,761,400	1,919,200	2,077,300	2,236,700
Broward County						
Low	1,736,800	1,726,300	1,710,600	1,689,000	1,661,600	1,632,900
Medium	1,788,200	1,834,500	1,877,700	1,916,200	1,949,700	1,982,500
High	1,844,200	1,946,700	2,048,900	2,149,600	2,248,100	2,349,700

	Projections					
	2015	2020	2025	2030	2035	2040
Miami-Dade County						
Low	2,528,700	2,564,400	2,590,900	2,606,400	2,610,300	2,604,100
Medium	2,600,900	2,722,900	2,841,400	2,952,800	3,055,100	3,150,200
High	2,685,100	2,891,800	3,103,400	3,317,200	3,531,500	3,747,400

C.1.3.25 Environmental Justice

The conditions under the FWO conditions are expected to be very similar to the existing conditions.

C.1.3.26 Cultural Resources

There are hundreds of previously identified archeological sites within the region. Future economic growth within the study area may lead to population increase and development of agricultural lands. Future development and expansion of infrastructure has the potential to adversely impact cultural resources during construction of roads, sewer systems, and other facilities; however, all applicable state and federal regulations that consider cultural resources would still apply.

C.1.3.27 Invasive and Exotic Species

Since the climate of south Florida is subtropical, it presents a hospitable environment for non-native species to invade and become established. Currently, many non-native invasive species are thriving and negatively affecting the ecology throughout the project area. During the period between present and 2050, it is expected that anthropogenic effects will continue to negatively impact the project area therefore it is expected new invasions and expansion of current invasive species will continue in the future. Many factors affect the future expansion and reduction of invasive species currently present within the project area. In addition, there are numerous factors that affect new introductions of invasive species. This constrains the ability to predict the populations, new introductions and expansion and reduction of invasive species. Each species has a diverse and intricate biological heritage which influences their ability to inhabit and thrive in areas outside of their native range. Factors that affect invasive species introductions are presented below.

Canals within the project area provide deep-water refugia for species of tropical fish and serve as pathways for invasive species to travel and expand into previously uninhabited areas. Currently, drier conditions within the project area are being experienced due to compartmentalization and diversion of water. The historically wetter areas that are now experiencing drier conditions will continue to shift in vegetation composition. Woody shrubs such as willow and invasive species such as melaleuca will continue to expand in these areas. Continued deliveries of nutrient rich water to the project area will further promote the expansion of cattail. Sea level rise is expected in the future which will allow saltwater species to invade further inland.

Environmental manipulation and construction activities, urban development, and agriculture will continue to provide disturbance within south Florida. Natural weather events, such as floods, droughts and hurricanes, will also provide disturbance and avenues for invasive species introduction and expansion. Disturbance of any type promotes the establishment and expansion of invasive species.

Management of invasive species within the project area is conducted by several agencies. The magnitude of the control programs within the project area is dependent upon the level of funding available. Portions of allocated funding for these programs have been and potentially will be redirected to other programs in the future. Management activities vary in effectiveness which also influences species control and spread within the project area. Management components will be incorporated into CERP projects which will reduce some species within those projects. This will reduce sources for invasions into other areas. Little is known about control and management measures for the majority of species already present, therefore these species will perpetuate and spread to other areas.

The large aquarium, pet, and ornamental plant industries import new non-native species into Florida on a regular basis. Therefore, new invasive species introductions will continue to occur. On average, each year 10 new non-native organisms are introduced into Florida that are capable of establishing, becoming invasive, and causing environmental harm. New imported non-native species introductions will occur through intentional and unintentional fresh water flows. Educational efforts may slightly reduce the number of intentional fresh water flows.

The deeper navigation channels and expansion of ports in Florida, such as Miami and Port Everglades, will provide new trade opportunities for the state. Deeper channels will allow larger container cargo vessels to enter the ports. As a result, it is expected the Port of Miami will double its cargo traffic over the next several years. With the completion of the projects and as cargo traffic increases, it is expected the number of non-native species introductions into Florida will likely increase. The ships, barges, and goods coming into these ports come from all over the world. Ports are known points for species to be introduced from native to non-native locations.

C.1.4 Future Without Project Conditions of Native Americans

The Brighton Reservation on the northwest side of Lake Okeechobee would still exist under the FWO. It is expected that the STOF would continue to use the areas around the Brighton Reservation for hunting and fishing. The MTIF owns one property located within the LOWRP study area approximately 8 miles west of the Brighton Reservation. In the FWO, tribal properties would remain unaffected. Members of both tribes continue to rely upon the areas off the reservations to support their cultural, medicinal, subsistence, and commercial activities. Future economic growth within the study area may lead to population increase and development of agricultural lands.

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PART 2: EFFECTS OF THE ALTERNATIVES AND THE RECOMMENDED PLAN

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C.2 Effects of the Final Array of Alternatives and the Recommended Plan

This section provides a detailed discussion of the potential environmental effects, which can be either positive or negative, that could result from implementation of the LOWRP alternatives. The evaluation of the effects was based on results of modeling simulations, current information including scientific literature, direct observation, project design reports, reasonable scientific judgment, the NEPA scoping processes, and information contained within other Environmental Impact Statement (EIS) documents for similar projects. The no-action alternative is always considered and carried forward as a requirement of NEPA; it forms the basis of comparison and evaluation of alternatives. The NEPA no-action alternative (referred to as the future without project [FWO]) considers the environmental conditions in the affected regions without the proposed action.

Environmental impacts include both direct and indirect effects. Under the Council on Environmental Quality (CEQ) 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 CFR § 1508.8). Under NEPA, one purpose is to identify at an early stage the significant environmental issues deserving of study, and deemphasizing insignificant issues, narrowing the scope of the EIS accordingly (40 CFR § 1501.1).

The resource conditions that were evaluated include climate; geology; soils; vegetation; wildlife; hydrology; water quality; flood control; air quality; hazardous, toxic, and radioactive waste (HTRW); noise; aesthetics, land use; agriculture; socioeconomics; environmental justice (EJ); recreation; cultural resources; and invasive species.

The features of the Recommended Plan are described in **Section 6**, with specific features located in **Figure 6-1**. The LOWRP Recommended Plan will improve the quantity, timing, and distribution of water entering Lake Okeechobee, provide for better management of lake water levels, reduce high volume flows to the Caloosahatchee and St. Lucie estuaries (collectively referred to as the "Northern Estuaries") from Lake Okeechobee, improve system-wide operational flexibility, and will restore portions of the historic Kissimmee River channel and floodplain. Better managing Lake Okeechobee stage levels within ecologically preferred stage envelope benefits plant and animal communities of Lake Okeechobee by concentrating prey resources in the littoral zone where wading birds forage; providing optimal light levels for photosynthesis in the summer months to benefit submerged plants and bulrush; favoring development of a diverse emergent plant community; and providing water supply benefits to Lake Okeechobee Service Area (LOSA) existing legal users. Reducing the return frequency, volume, and duration of Lake Okeechobee flows to the Northern Estuaries will improve salinity and turbidity conditions, as well as benefit seagrass beds and the animals that inhabit them. The restoration of historic Kissimmee River sites would result in improved connectivity, more natural hydrologic conditions, and improved habitat for fish and wildlife resources. The flow-through wetland attenuation feature (WAF) will create emergent wetland habitat, resulting in improved connectivity, more natural hydrologic conditions, and improved habitat for fish and wildlife resources. Additional refinements were made to Alternative 1BW to account for additional input from the stakeholders. This alternative is now referred to as Alternative 1BWR. Alternative 1BWR is the Recommended Plan.

C.2.1 Climate

Climate change is expected to be similar in the FWO and future with project (FWP) alternative conditions.

Implementation of any of the LOWRP action alternatives would have a short-term, regionally negligible, and less-than-significant effect on climate within the action area. Minor, localized effects to microclimate may occur under all LOWRP action alternatives as a result of redistribution of water and shifts in vegetation. Potential effects may include increases in evapotranspiration, increases in localized rainfall, and temperature changes. Refer to **subsection C.1.1.1** in **Appendix C, Part 1,** for a summary of the FWO condition, and **Annex H** for a detailed overview of the projected impact of climate change within the LOWRP area.

C.2.2 Physical Landscape

Under the FWO condition, it is likely that the lands within the project area will remain over-drained. The existing alluvial wetlands at Paradise Run and Kissimmee River–Center would exhibit hydroperiods that reflect changes in river stage and precipitation. The physical landscape in upland portions of the project area would change with development patterns.

Implementation of all LOWRP action alternatives would result in rehydration of Paradise Run wetland, primarily due to eastward-flowing seepage from the aboveground storage feature in Alternatives 1 Bshlw and 1BW. The Kissimmee River–Center wetland also would be rehydrated due to higher stages in Kissimmee River Pool D that result from construction of a submerged weir. Wetlands that currently exist in the footprints of the shallow storage features in Alternatives 1 Bshlw and 1BW would be submerged. The physical landscape at the K-42 deep storage footprint is mostly under cultivation, with a few relict depressional wetlands. These wetlands would be submerged in Alternative 2Cr. Construction of ASR systems would have a negligible effect on the physical landscape due to the limited area that these features would occupy at any given site. Aboveground storage-assisted ASR systems would be constructed proximal to the shallow storage features in Alternatives 1 Bshlw and 1BW, so piping, wellheads, and appurtenances would coexist near the toe of the shallow storage embankment.

C.2.2.1 Geology

Geologic changes are unlikely in the FWO condition or the LOWRP action alternatives due to the limited depth of excavation of the shallow storage features in Alternatives 1 Bshlw and 1BW, or the deep storage feature in Alternative 2Cr.

C.2.2.2 Soils

Under the FWO condition, muck soils of Paradise Run and Kissimmee River–Central sites located adjacent to the levees of the Kissimmee River would remain over-drained. Currently, the Paradise Run area consists of approximately 93% of surface soils show hydric characteristics, although oxbows and interfluves of the former Kissimmee River channel are not well-vegetated (**Figure C.2-1**). As the physical landscape of the wetlands is restored, so will the acreage of hydric soils increase.

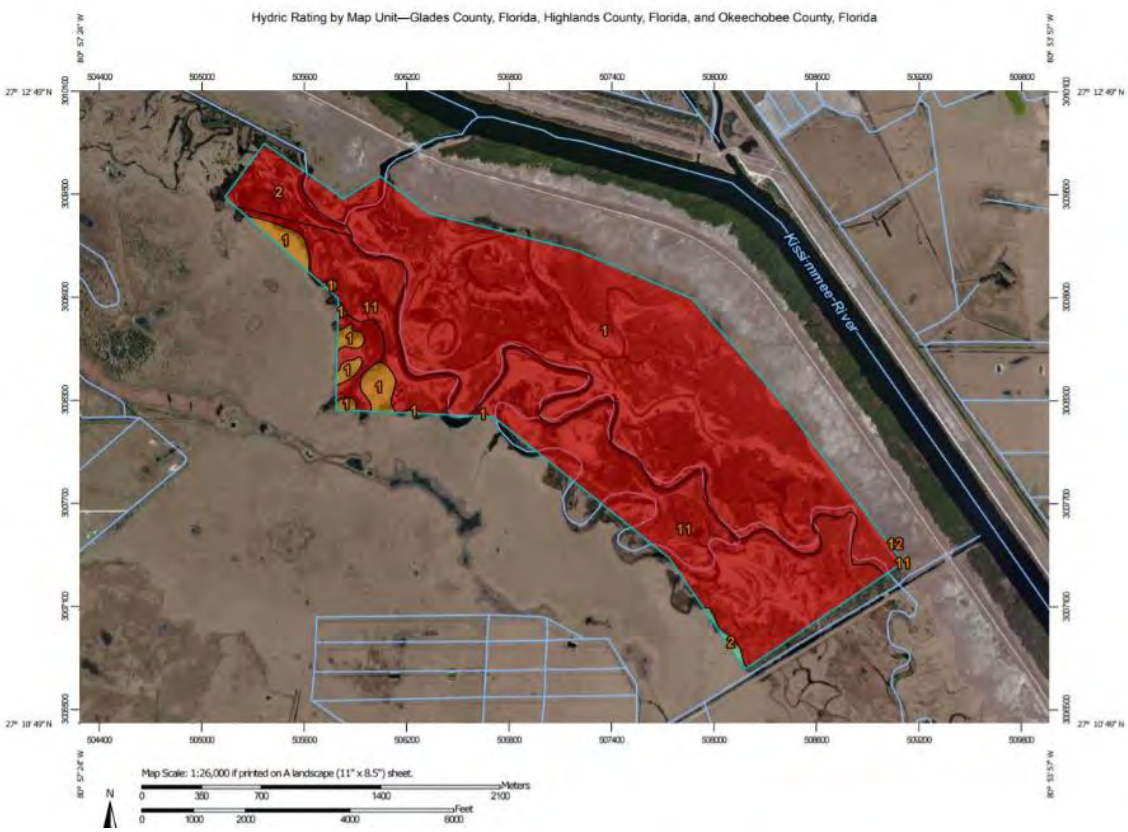

Figure C.2-1. Upper image shows proportion of surface soils (shaded red) that exhibit 90-100% of hydric soil characteristics in the Paradise Run area. Lower image shows poorly vegetated oxbows and tributaries of the former Kissimmee River at Paradise Run (both NRCS, 2018).

C.2.3 Vegetative Communities

The effects of the final array of alternatives on the vegetative communities is documented below and compared to the FWO.

C.2.3.1 Lake Okeechobee Watershed

Under the FWO condition, as discussed in **subsection C.1.4**, the lands within the project area would be developed consistent with surrounding land-use patterns and local growth management plans. The surrounding areas are predicted to maintain their agricultural and rural nature up to 2070. Upland and wetland areas that are currently under conservation (e.g., portions of Fisheating Creek and along the Kissimmee River) are expected to stay in conservation. However, without the project, the wetlands along Paradise Run and Kissimmee River would not be restored, and those native vegetative communities would stay as-is or possibly deteriorate (colonized by invasive species). Because agriculture and improved pasture occupy a large percentage of the existing watershed, we do not anticipate a substantial change to land use or vegetation communities under the FWO conditions. **Table C.2-1** shows the existing conditions baseline (ECB) land use by number of acres per FLUCCS code description in the two wetland restoration sites, Kissimmee River–Center and Paradise Run, with the combined total acres per land use type. The acreages and values presented in this table are planning level for alternative comparative purposes and are subject to revision during later detailed design.

Table C.2-1. Estimated ECB land-use acreage by FLUCCS code description.

FLUCCS Code Description	Kissimmee River–Center	Paradise Run	Total Wetlands in Recommended Plan
Improved Pastures	796	1,286	**2,082**
Unimproved Pastures	64	0	**64**
Herbaceous Rangeland	3	19	**22**
Shrub and Brushland	0	17	**17**
Mixed Rangeland	0	40	**40**
Upland Hardwood Forest	4	35	**39**
Live Oak	3	0	**3**
Oak - Cabbage Palm Forest	1	0	**1**
Cabbage Palm	0	3	**3**
Streams and Waterways	19	76	**95**
Channelized waterways, canals	3	2	**5**
Reservoirs	5	0	**5**
Slough Waters	0	146	**146**
Mixed Wetland Hardwoods	0	32	**32**
Mixed Wetland Hardwoods - Mixed Shrubs	159	185	**344**
Cabbage Palm Savannah	4	15	**19**
Freshwater Marshes	55	493	**548**
Wet Prairies	41	840	**881**

FLUCCS Code Description	Kissimmee River–Center	Paradise Run	Total Wetlands in Recommended Plan
Emergent Aquatic Vegetation	40	885	**925**
Spoil Areas	0	10	**10**
Total Acres	**1,197**	**4,084**	**5,281**

Under all alternatives, aboveground storage with associated seepage canals and embankments would be constructed, ASR wells would be installed, and two restored wetland areas would be created. For Alternatives 1Bshlw and 2Cr, most existing plant cover within the reservoir footprint will be removed, representing a significant impact to existing plant communities. Alternative 1BW has a WAF rather than a reservoir; therefore, the feature will contain wetland plant species. **Table C.2-2** shows the area of the aboveground storage feature for each action alternative. The majority of the storage sites are improved and unimproved pastures.

Table C.2-2. Planning-level Existing land use acres in the storage footprint for each alternative.

FLUCCS Code Description	1Bshlw	1BW	2Cr
Improved Pastures	11,213	11,051	8,185
Unimproved Pastures	266	135	2,659
Citrus Groves	34	13	0
Herbaceous Rangeland	20	27	313
Shrub and Brushland	43	59	0
Palmetto Prairies	0	0	5
Upland Hardwood Forest	0	0	0
Brazilian Pepper	0	0	319
Oak - Cabbage Palm Forest	150	89	138
Cabbage Palm	452	326	54
Channelized waterways, canals	0	2	1
Reservoirs	24	6	371
Mixed Wetland Hardwoods	5	3	0
Mixed Wetland Hardwoods - Mixed Shrubs	43	16	135
Cabbage Palm Savannah	0	0	155
Freshwater Marshes	966	662	1,937
Sawgrass	0	0	38
Wet Prairies	44	103	269
Emergent Aquatic Vegetation	0	0	17
Total Storage Area	**13,260**	**12,492**	**14,596**

Table C.2-3 shows the acreage of native uplands and wetlands (according to the FLUCCS codes) within the aboveground storage footprint for each alternative that will be removed. Implementation of Alternatives 1Bshlw and 2Cr result in a loss of both upland and wetland communities within the reservoir footprints;

however, inclusion of wetland restoration sites within Kissimmee River–Center and Paradise Run will restore a total of 5,279 acres of wetlands, offsetting the wetland losses in the reservoir footprints. Alternative 1BW will create an additional 5,417 acres of wetlands in the storage footprint.

Table C.2-3. Acreages of native uplands and wetlands within the storage footprints for each alternative.

Acres of native uplands or wetlands	1Bshlw	1BW	2Cr
Uplands	666	501	510
Wetlands	1,058	785	2,551

In general, construction will largely replace existing upland and wetland plant communities with aquatic habitat (water-covered reservoir areas) or maintained uplands (embankments, roads, berms). Aquatic plant species that may colonize the area include sawgrass (*Cladium jamaicense*) and scattered clumps of Carolina willow (*Salix caroliniana*), sweetbay (*Magnolia virginiana*), cypress (*Taxodium* spp.), pond cypress (*Taxodium ascendens*), red maple (*Acer rubrum*), dahoon holly (*Ilex cassine*), swamp bay (*Persea palustris*), sweet bay (*Magnolia virginiana*), wax myrtle (*Myrica cerifera*), buttonbush (*Cephalanthus occidentalis*), St. John's wort (*Hypericum* spp.), chain fern (*Woodwardia* spp.), and fireflag (*Thalia geniculata*). The construction of a reservoir and seepage canal may provide some deepwater refugia and/or littoral habitat. Alternative 2Cr would likely experience wide-ranging depth and duration fluctuations throughout the year ranging from complete dry down to full capacity (e.g., 5-15 ft. above soil surface) on an annual basis. Alternative 1Bshlw would likely experience similar fluctuations between 0-5 ft. above soil surface. This would potentially impact the survival of any wetland species and provide limited benefits to opportunistic plants that could adapt to such environmental dynamics.

The interior of the reservoir would have minimal productive littoral zone because of the necessity to construct relatively steep sides to maximize water storage capacity. The design for the perimeter canals, however, includes littoral areas in the corners and along some of the banks. Exotic plant species are not expected to be a problem under any of the alternatives, as appropriate construction and maintenance procedures would be established to deter and control exotic establishment at the project site. ReleaseRelease of recovered water from the ASR systems is not expected to have a deleterious effect on aquatic vegetation in the impoundments.

C.2.3.2 Wetlands

While the majority of the storage feature sites in each alternative are improved and unimproved pastures, there are some wetlands in each FWP alternative that will be removed in the construction of the storage feature. **Table C.2-4** shows the acres of wetland in each storage feature footprint by FLUCCS code description. While these wetlands will be lost in Alternatives 1Bshlw and 2Cr, each FWP alternative also includes the restoration of the Kissimmee River–Center wetland and the Paradise Run wetland, totaling 5,279 acres of wetlands. All alternatives significantly increase the acreage and quality of wetlands in the project area (**Table C.2-5**). Alternative 1BW has the largest net gain of wetlands at 9,911 acres including the wetlands created in the WAF footprint, followed by Alt 1Bshlw with a net gain of 4,221 acres of wetlands and then Alt 2Cr with a net gain of 2,728 acres of wetlands.

The Kissimmee River–Center and Paradise Run sites are being restored for the sole purpose of wetland restoration, giving them a habitat quality of 1.0 (**Table C.2-1.**). A 1.0 habitat quality score means that it is a high-quality, functioning wetland.

Table C.2-4. Estimated acres of wetlands in each storage feature footprint by FLUCCS code description.

FLUCCS Code Description	Alt 1Bshlw	Alt 1BW	Alt 2Cr
Mixed Wetland Hardwoods (acres)	5	3	0
Mixed Wetland Hardwoods - Mixed Shrubs (acres)	43	16	135
Cabbage Palm Savannah (acres)	0	0	155
Freshwater Marshes (acres)	966	662	1,937
Sawgrass (acres)	0	0	38
Wet Prairies (acres)	44	103	269
Emergent Aquatic Vegetation (acres)	0	0	17
Total Acres of Existing Wetlands in Storage Feature Footprints	**1,058**	**785**	**2,551**

Table C.2-5. Estimates net acres of wetlands acres for each alternative.

	1Bshlw	1BW	2Cr
Acres of Wetlands Removed	-1,058	-785	-2,551
Acres of Wetlands Restored (1.0 value)	5,279	5,279	5,279
Total Wetlands Offset (acres)	**4,221**	**4,494**	**2,728**

C.2.3.3 Lake Okeechobee

Beneficial effects to Lake Okeechobee's littoral vegetation are anticipated as a result of any of the action alternatives, relative to the FWO. The overall effect of the alternatives is to stabilize water levels; maintaining lake stage within the ecologically preferred seasonal stage envelope (12.5-15.5 ft. NGVD) more frequently than the FWO (**Table C.2-6** and **Figure C.2-2** to **Figure C.2-4)**. The increase in time that stages were within the envelope varied from 4.2% to 6.2% increase over FWO for Alternatives 1BW and 2CR, respectively. This was primarily from reductions in the frequency of low (<12.5 ft. NGVD) and extreme low (<10.0 ft. NGVD) stages compared to FWO. For example, the frequency of stages below the envelope was reduced by 2.7 and 3.6% for Alternatives 1Bw and 2Cr, respectively, while the frequency of stages above the envelope was only reduced by 2.1 and 2.7% in Alternatives 1Bshlw and 2Cr, respectively. However, all action alternatives reduced the frequency of stages at the upper end of the stage envelope between approximately 14.5 and 15.5 ft. NGVD, which will help to offset reductions in the frequency of stages at the lower end between approximately 12.5 and 13.5 ft. NGVD (**Figure C.2-5**).

There were also different effects on extreme low vs extreme high lake stages for all alternatives. The frequency of extreme low stages was reduced from the FWO by 1.3 to 1.6%, while the frequency of extreme high lake stages (>17.0 ft. NGVD) slightly increased compared to the FWO, from 0.6 to 1.2% (**Table C.2-6**). There may be some concern that reducing the frequency of lower lake stages while also slightly increasing the frequency of extreme high lake stages could have a compounding effect, affecting the ability of marsh and SAV communities to recover at lower elevations after extreme high lake stages occur. However, the overall occurrence of extreme high stages was still very low—less than 2.0% for any of the alternatives—while the return frequency of low lake stages was still at least 5% higher than the RECOVER target for any of the alternatives (**Table C.2-6**). The Lake Stage Performance Measure for RECOVER suggested a duration of 2.5% for stages <11.0 ft. NGVD (3 months per decade) (RECOVER 2007), and Alternatives 2Cr and 1BW had durations of 6.7 and 7.8%, respectively. While still considerably higher than the target, they represent improvements from the FWO frequency of 9.7%. This suggests that return frequencies of low lake stage events should be sufficient to offset slight increases in extreme highs, especially given the reduced frequencies of moderately high lake stages (14.5-15.5 ft. NGVD) under any of the alternatives versus FWO.

The overall effect of stabilizing lake stages should improve vegetation in the upper and lower marshes by reducing the intra- and inter-annual variation that leads to encroachment of woody vegetation and exotic species at high elevations, and conversion of submerged aquatic vegetation (SAV) beds to emergent marsh at low elevations. For example, following drying events in the upper marsh, exotic species like torpedograss (*Panicum repens*) can displace spikerush (*Eleocharis* spp.) prairies, a valuable, critical habitat for the endangered snail kite. These invasions can persist indefinitiely and require expensive chemical and/or physical treatments to restore the prairie (Smith et al 2009). Woody species like wax myrtle (*Myrica cerifera*) and willow (*Salix caroliniana*) can invade spikerush prairies, sawgrass marshes (*Cladium jamaicense*), and broadleaf marsh habitats during low water, eventually shading out and displacing marsh with forested wetlands. Extreme low lake stages allow large-scale displacement of SAV communities with invasive emergent species like cattail (*Typha* spp.); such an event occurred in southern portions of the lake following the 2007-2008 drought and subsequent record low water levels.

High lake stages have similar negative effects; promotes monotypic stands of dense cattail; increased mixing of turbid pelagic water with clearer nearshore water decreases light levels at lower elevations, reducing SAV and emergent marsh coverage; all ultimately reducing the quantity and quality of littoral habitat (Havens 2002, Havens et al. 2005).

Because the action alternatives increase the frequency of moderate lake stages (time inside the preferrred ecological envelope), the impacts described above should be less frequent or at short enough durations to be offset by the benefits of more stablized water levels overall. These benefits are evident in the potential habitat unit (HU) lift for the alternatives relative to FWO; 2,811 HU lift for Alt 1Bshlw, 3,399 HU lift for Alt 1BW and 6,664 HU lift for Alt 2Cr.

Table C.2-6. Amount of time each alternative is within the Lake Okeechobee Stage envelope.

Lake Okeechobee Stage Levels		Future Without Project	ALT 1Bshlw	ALT 1BW	ALT 2Cr
% Time Inside Ecologically Preferred Stage Envelope	% TIME between 12.5 ft. and 15.5 ft.	27.7%	32.3%	31.9%	33.9%
%Time Above Stage Envelope	% TIME above 15.5 ft.	29.9%	27.8%	28.4%	27.2%
%Time Below Stage Envelope	% TIME below 12.5 ft.	42.4%	39.9%	39.7%	38.8%
% Time Below Navigational Min. Stage	% TIME < 12.5 ft.	29.8%	26.7%	26.9%	25.0%
Extreme High Stage	% TIME > 17 ft.	0.4%	1.6%	1.4%	1.0%
Extreme Low Stage	% TIME < 10 ft.	3.3%	2.0%	2.0%	1.7%
RECOVER Low Stage Target (2.5% Time < 11 ft)	% TIME < 11 ft.	9.7%	7.5%	7.8%	6.7%

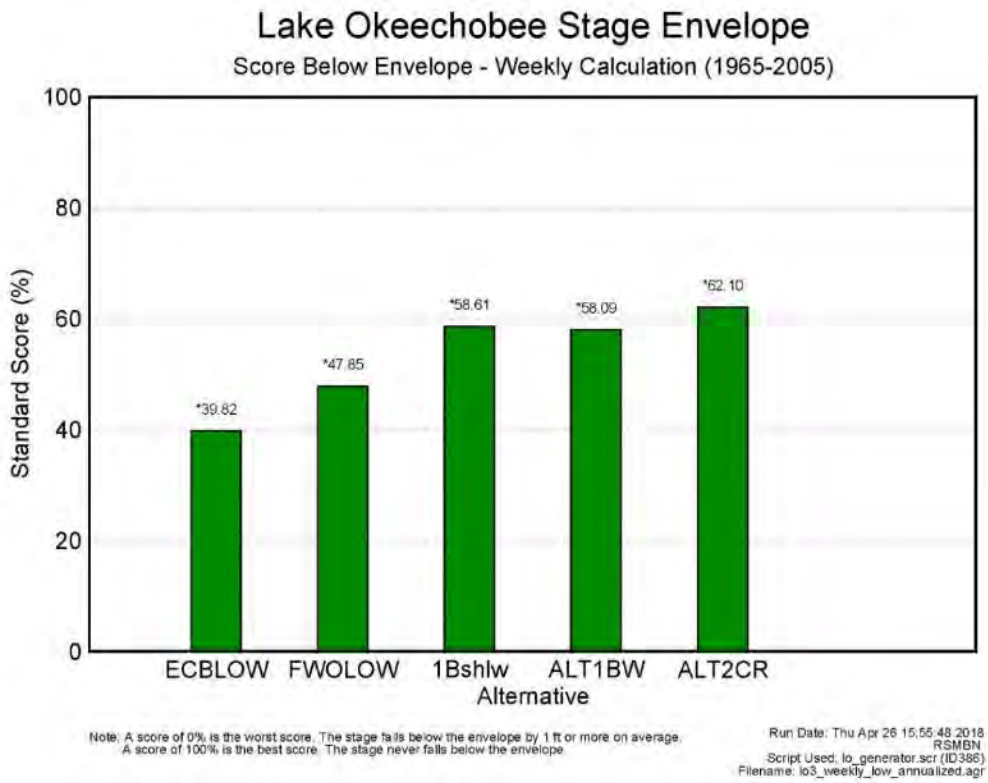

Figure C.2-2. Lake Okeechobee stage envelope, time above the low-stage envelope.

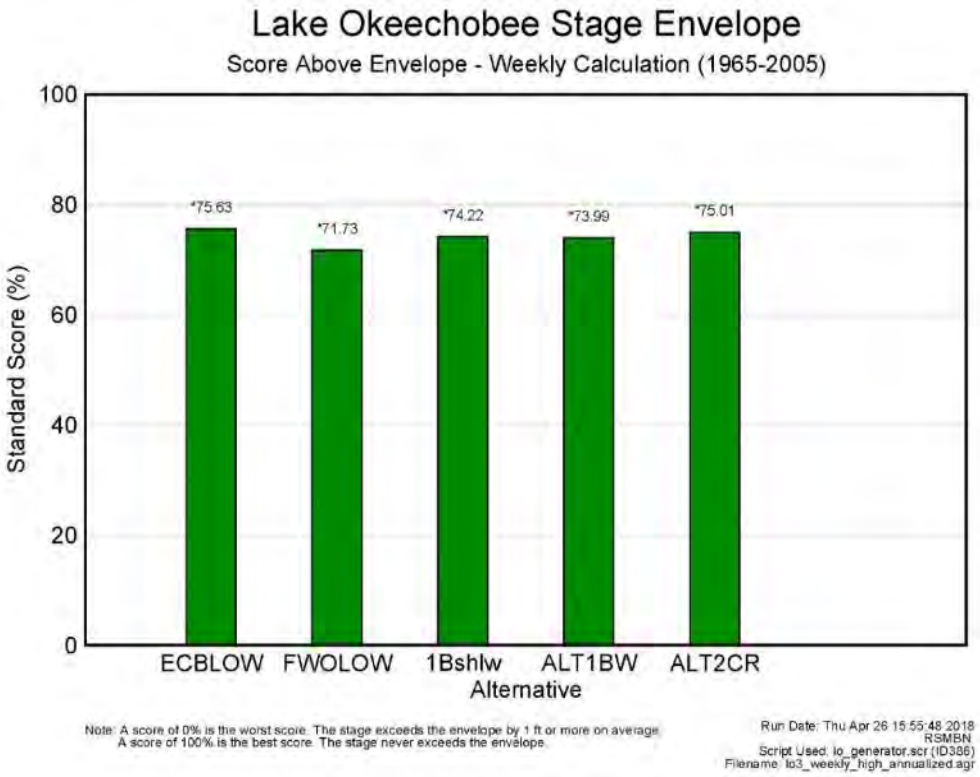

Figure C.2-3. Lake Okeechobee stage envelope, time below the high-stage envelope.

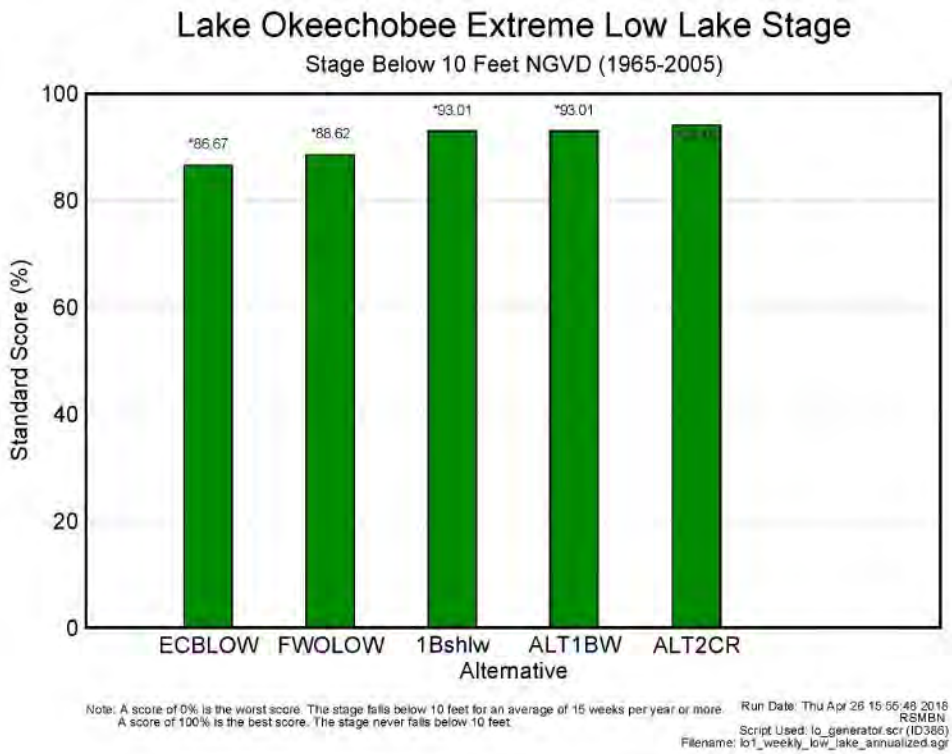

Figure C.2-4. Lake Okeechobee extreme low lake stage, time above extreme low lake levels (< 10 ft).

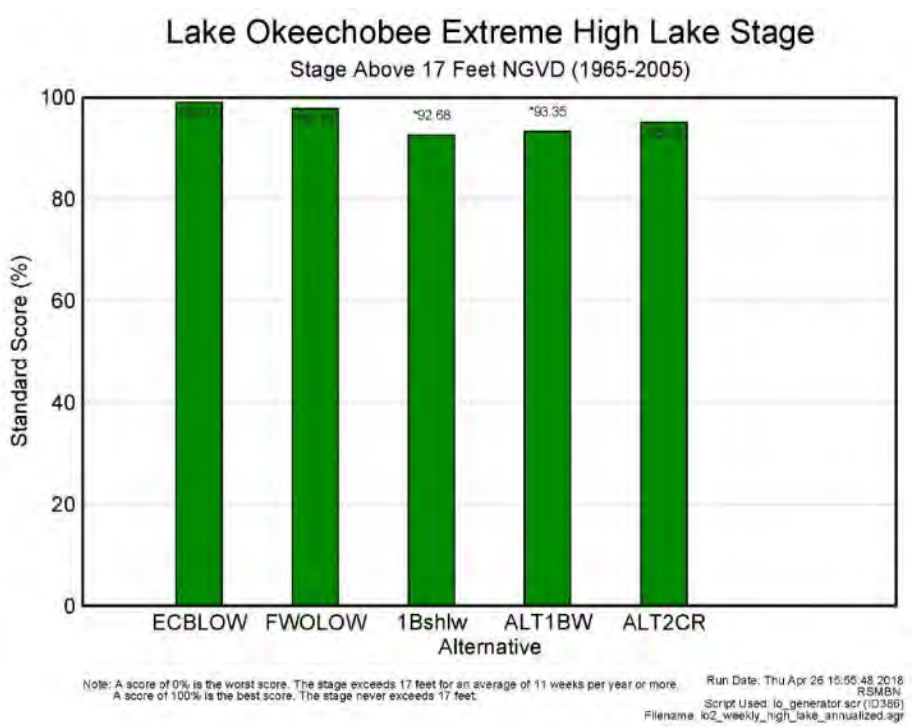

Figure C.2-5. Lake Okeechobee extreme high lake stage, time below extreme high lake levels (> 17 ft).

The combined scores for the ecological indicators (*Chara*, cyanobacteria, epipelon, epiphytes, panfish, and vascular SAV) also show overall benefits under each of the action alternatives, but the effects varied by individual indicator (**Figure C.2-6**). For example, since all alternatives reduce the occurrence of lake stages below the beneficial envelope, indicators that perform well under low-water conditions scored considerably lower than ECB and similar or worse than FWO; while indicators that perform well when stages are within the beneficial envelope all fare similar or better than FWO. *Chara* and epipelon both benefit from increased light penetration in the nearshore zone, especially at lake stages below the stage envelope; and cyanobacteria blooms tend to occur less frequently when summer lake stages are rather low; these indicators all have lower scores than the ECB, which is the driest condition, and similar to or lower than FWO as well. This is to be expected given that all action alternatives, and even the FWO, reduce the frequency of low lake stages, both within and below the stage envelope, as compared to ECB. However, these performance measures do not take into account the return frequency of such events, which are critical at higher elevations in regards to invading woody and exotic species, fire frequency, aquatic fauna, etc. Therefore, it is important to weigh these indicators against those that perform well under average conditions, or lake stages within the beneficial envelope. The epiphytes and panfish indicators, for example, benefit from moderate stages in the spring and fall and score substantially better than FWO under all action alternatives. Because of the importance of having low return frequencies for extreme low stages, it is anticipated that the ability of all alternatives to maintain stages within the envelope more than FWO should result in benefits to the overall lake ecology. As for individual alternatives, Alt 2Cr had the highest combined indicator score, driven by epiphytes and panfish scores, while Alt1Bshlw scored the lowest, due primarily to its panfish score (**Table C.2-7**). Alt 2Cr also had the worst score among alternatives for cyanobacteria, which scores highest when average May water levels are actually lower than the preferred stage envelope. In essence, because Alt 2Cr has the largest storage available, it can result in a lower cyanobacteria score by holding lake stage within the beneficial envelope during droughts, versus falling to lower stages. This is also evident by the much higher scores for Alt 2Cr in both the epiphyte and panfish indicators, which do well when lake stages are within the stage envelope in spring and/or fall seasons.

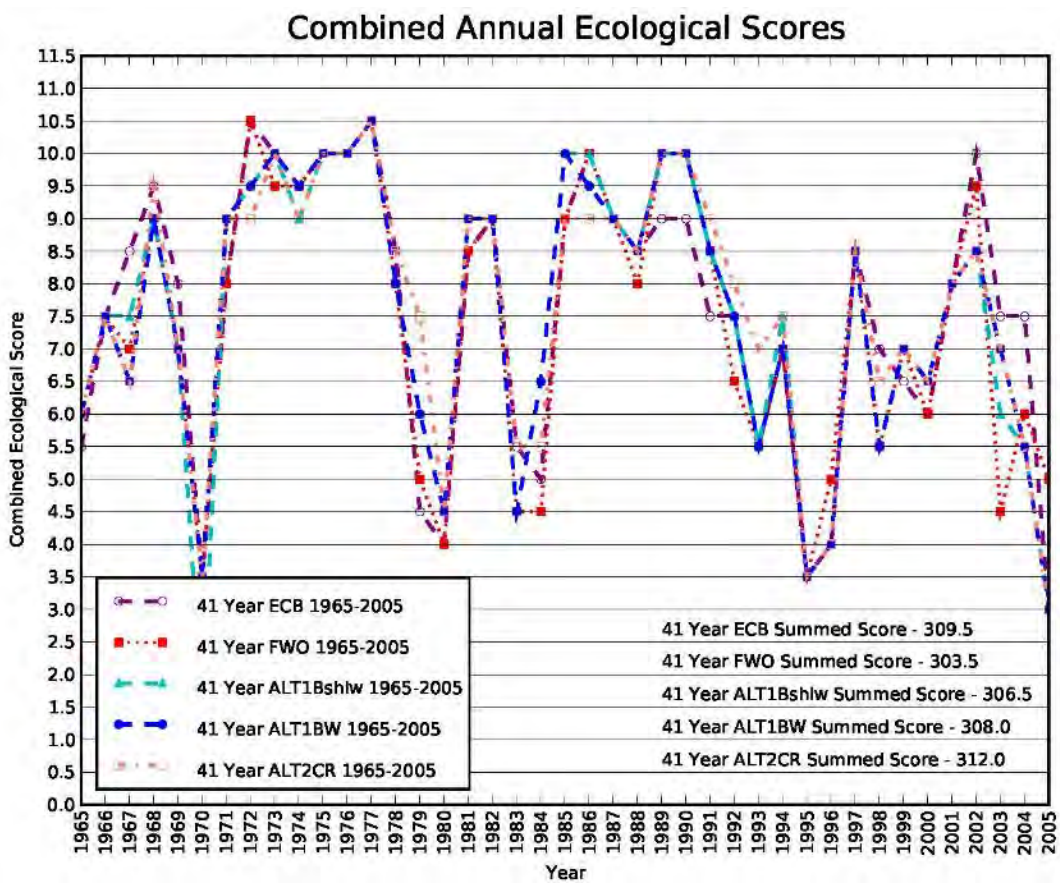

Figure C.2-6. Lake Okeechobee Ecological Indicator Combined Period of Record Performance Measure Scores for the Final Array of Alternatives.

Table C.2-7. Lake Okeechobee individual ecological indicator performance measure scores for the ECB, FWO and final array of alternatives. The time period assessed for the abundance of each indicator is noted in the title, e.g. Summer or January + February.

	Summer *Chara*	Summer Cyanbacteria	Spring+Fall Epipelon	Spring+Fall Epiphytes	January+February Panfish	Summer Vascular SAV	Combined Ecological Score
ECB	54	49	37.5	53	53	63	309.5
FWO	55	49	34.5	50	49	66	303.5
Alt 1Bshlw	51	49	36	53.5	51	66	306.5
Alt 1BW	52	48	36.5	52.5	52	67	308.0
Alt 2Cr	52	45	36	56	56	67	312.0

C.2.3.4 Northern Estuaries

Currently, many SAV beds are stressed and have been reduced or eliminated from their former areas by extreme salinity fluctuations, increased turbidity, sedimentation, dredging, and damage from boats that, in turn, restrict light penetration. All LOWRP alternatives are designed to store water north of Lake Okeechobee, thereby reducing the volume of water that in the FWO would flow to the Atlantic Ocean and Gulf of Mexico. Therefore as compared with the FWO, all the LOWRP action alternatives show a slight performance improvement within the Northern Estuaries as indicated by fewer high volume flow months, providing a minor beneficial effect. Reduction in high flows and accompanying flow velocities would result in lower suspended solid loading and decreased concentration of colored dissolved organic matter, thereby allowing greater light penetration to promote growth of SAV. In addition, reduction in high volume flows from Lake Okeechobee would reduce extreme salinity fluctuations associated with such events. Although some SAV are tolerant of a wide range of salinity levels, a reduction in high volume flows would reduce stress to SAV and aid in long-term health of estuarine habitat and biota. For low-flow events, the alternatives perform the same as the FWO or slightly worse than the FWO. Implementation of any LOWRP alternative would help to maintain the target frequency and duration of water flows to the Northern Estuaries and would help curtail continued habitat loss and allow the recovery of more desirable vegetative communities. Alt 1BW captures an estimated 76,400 acre-feet of water from being lost to the Gulf of Mexico in the Caloosahatchee (32% increase relative to the FWO) and 31,500 acre-feet from being lost to the Atlantic Ocean in the St. Lucie on average annually (24% increase relative to the FWO).

C.2.3.4.1 Caloosahatchee River Estuary

Negligible and less than significant effects are predicted for all alternatives for the low flows into the Caloosahatchee estuary. The FWO and Alt 2Cr have the same number of months where the low-flow criteria are not met (**Figure C.2-7**). Alt 1Bshlw and Alt 1BW perform worse than the FWO with an additional two months and one month, respectively, where low flows are below 450 cubic feet per second (cfs). A mean monthly inflow of at least 450 cfs is needed from S-79 to ensure that the average monthly salinity at Ft. Myers (Yacht Basin) is < 10 psu (target maximum salinity for tape grass). An important upper estuarine feature is the freshwater-brackish submerged grass, *Vallisneria americana* (tape grass), which when present is located near the shoreline in the upper estuary to a depth of about 1.0 m. Its greatest coverage occurs from Beautiful Island to just past the Ft. Myers bridges (Hoffacker et al. 1994, Chamberlain and Doering 1998b). During times of extended low inflow conditions, when salinity is too high, this grass becomes very sparse and can disappear completely (Chamberlain et al. 1995, Doering et al. 2002, SFWMD 2000). For high- flow events, all LOWRP action alternatives performed better than the FWO having fewer months where flows were greater than 2800 cfs. Alt 1Bshlw has 10 fewer months of high flows than the FWO, Alt 1BW has 7 fewer months and Alt 2Cr has 6 fewer months of high flows than the FWO. The model output shows that of the number of months flow > 2800 cfs from the C-43 Basin and Lake Okeechobee regulatory flows, 47 of those months are a results of basin runoff. Therefore, flows greater than 2800 cfs from direct Lake Okeechobee flows go from 23 in the FWO to 13 in Alt 1Bshlw, 16 in Alt 1BW and 17 in Alt 2Cr (**Table C.2-8, Figure C.2-8**). For extreme high flow events (mean monthly flow > 4500 cfs), all alternatives perform better than the FWO that had 30 months where the mean monthly flow was greater than 4500 cfs. The number of mean monthly flows greater than 4500 cfs were reduced to 25 for Alt 1BW, 26 for Alt 1Bshlw, and 27 for Alt 2Cr (**Figure C.2-9**). All alternatives provide minor beneficial effects in the reduction of high flows into the Caloosahatchee Estuary which are beneficial to the SAV in the estuaries.

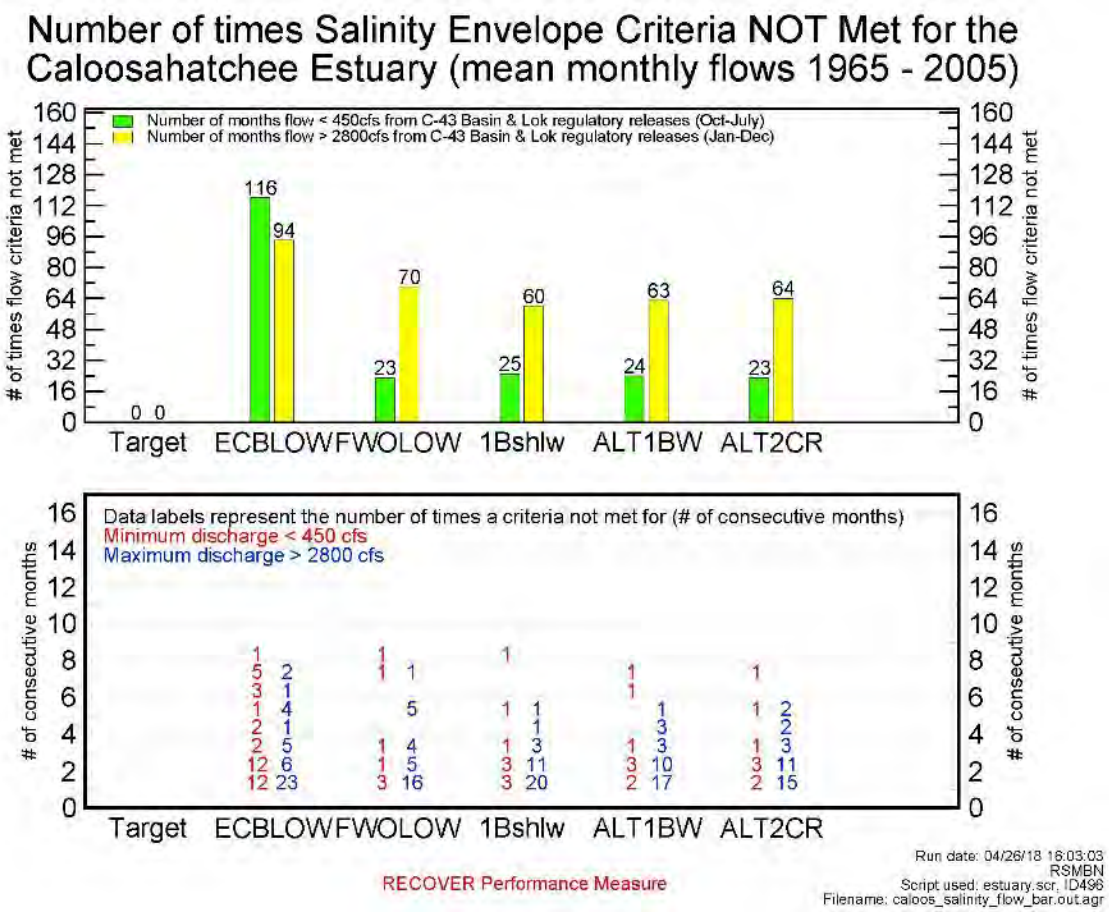

Figure C.2-7. Flow results for the Caloosahatchee Estuary.

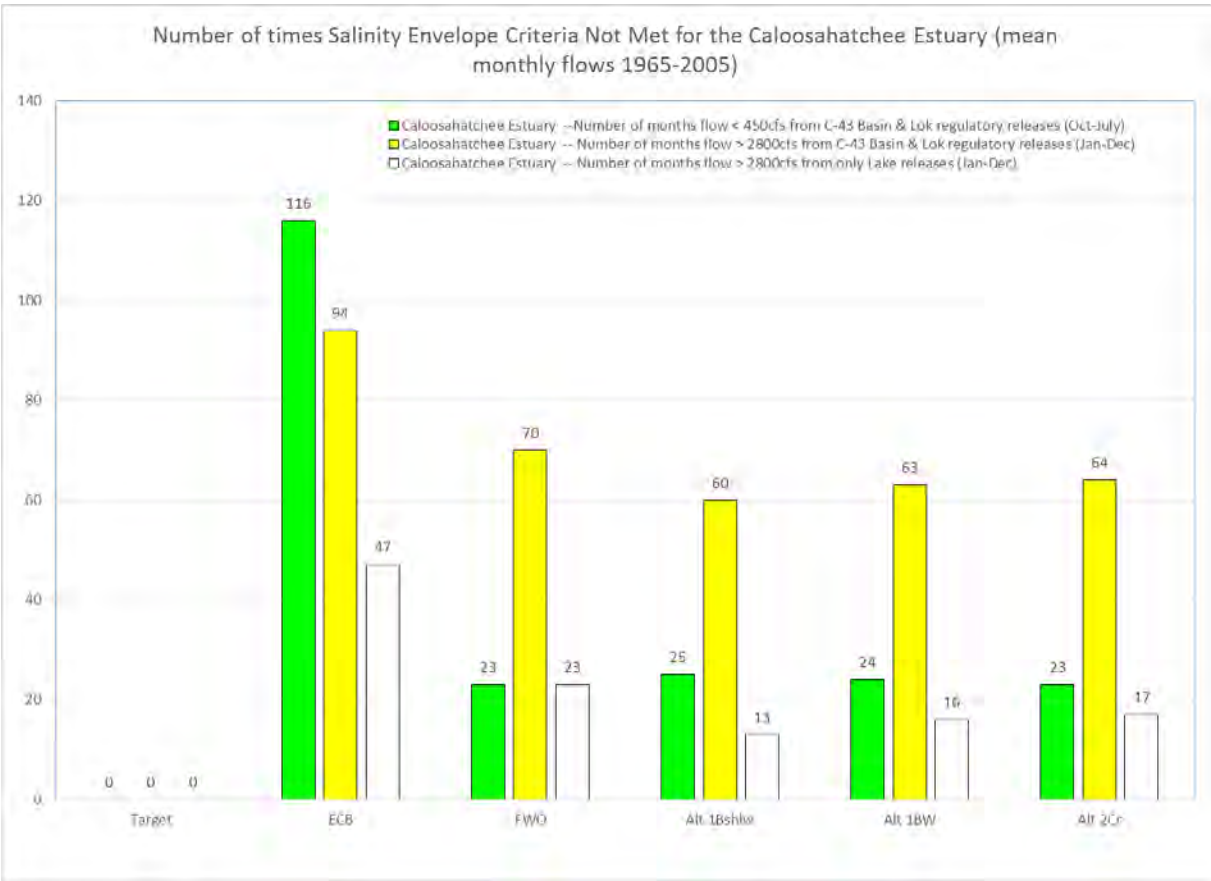

Figure C.2-8. Caloosahatchee Estuary flow results that include the number of high-flow events only from Lake Okeechobee.

Table C.2-8. Flow results for the Caloosahatchee Estuary for the final array of alternatives.

	FWO	Alt 1Bshlw	Alt 1BW	Alt 2Cr
Number of months flow < 450 cfs	23	25	24	23
Mean Monthly Flow > 4500 cfs	30	26	25	27
Number of months flow > 2800 cfs from Lake O flows	23	13	16	17
Average Annual Flow (acre-ft)	235,824	149,410	159,430	152,721

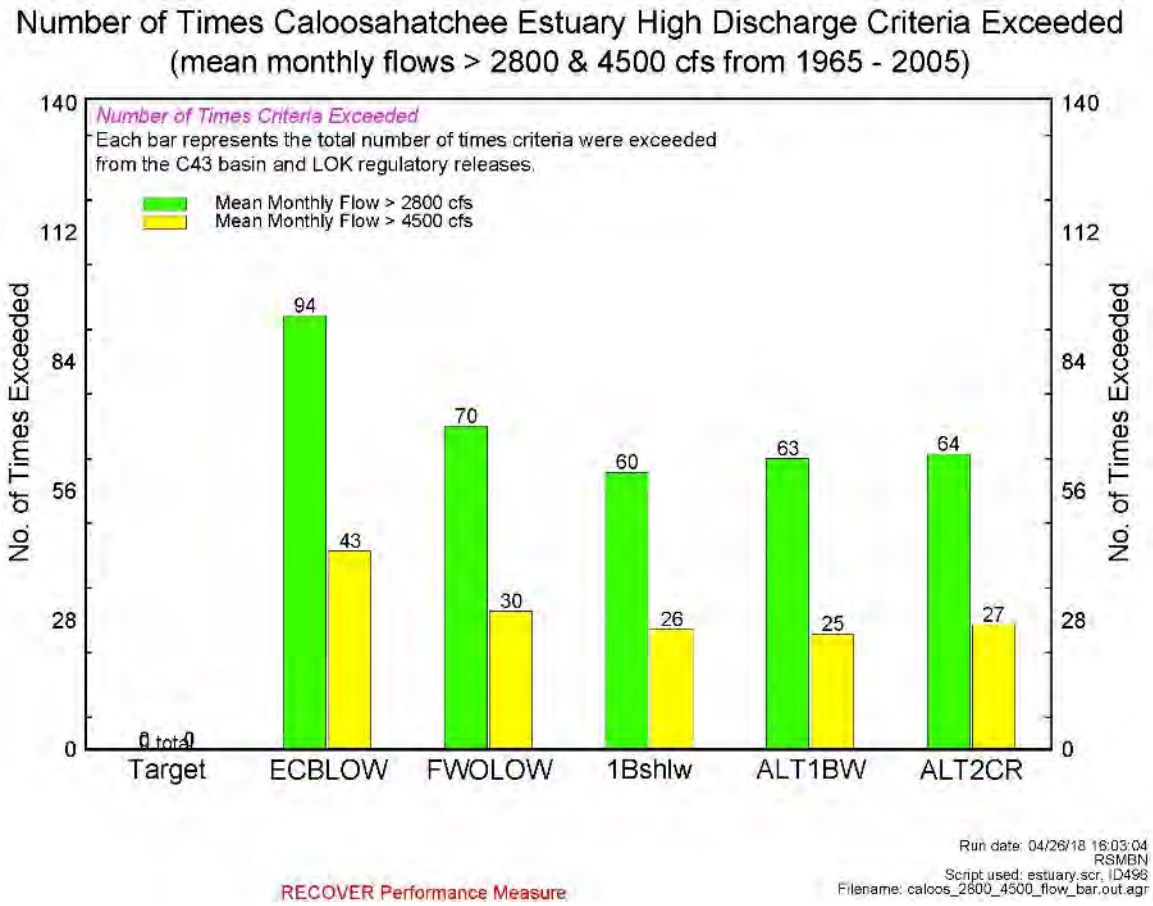

Figure C.2-9. Extreme high-flow events in the Caloosahatchee Estuary.

C.2.3.4.2 St. Lucie Estuary

Negligible and less than significant effects are predicted for all alternatives for the low flows into the St. Lucie estuary. The FWO and all alternatives have the same number of months were the low flow criteria is not met (**Figure C.2-10, Table C.2-9**). For high flow events, all LOWRP action alternatives performed better than the FWO having fewer times where the 14-day moving average flow was greater than 2000 cfs from Lake Okeechobee regulatory flows. Alternatives 1Bshlw and 1BW performed the best with a reduction to 20 times when the high flow criteria was not met compared to 37 times in the FWO. Alt 2Cr had a reduction to 24 times when the high flow criteria were not met compared to the 37 times in the FWO. For extreme high flow events (mean monthly flow > 3000 cfs), all alternatives perform better than the FWO that had 25 months where the mean monthly flow was greater than 3000 cfs. The number of mean monthly flows greater than 3000 cfs were reduced to 21 for Alt 1Bshlw, 22 for Alt 1BW and 23 for Alt 2Cr (**Table C.2-9**, **Figure C.2-11**). For the St. Lucie estuary, Alt 1Bshlw provides the greatest reduction of extreme high flow events, followed by 1BW and then 2Cr. Alternative 1BW captures 31,500 acre-feet from being lost to the Atlantic Ocean in the St. Lucie on average annually (24% increase relative to FWO). All alternatives provide significant beneficial effects for the reduction of high flow events which are beneficial for the SAV in the estuaries.

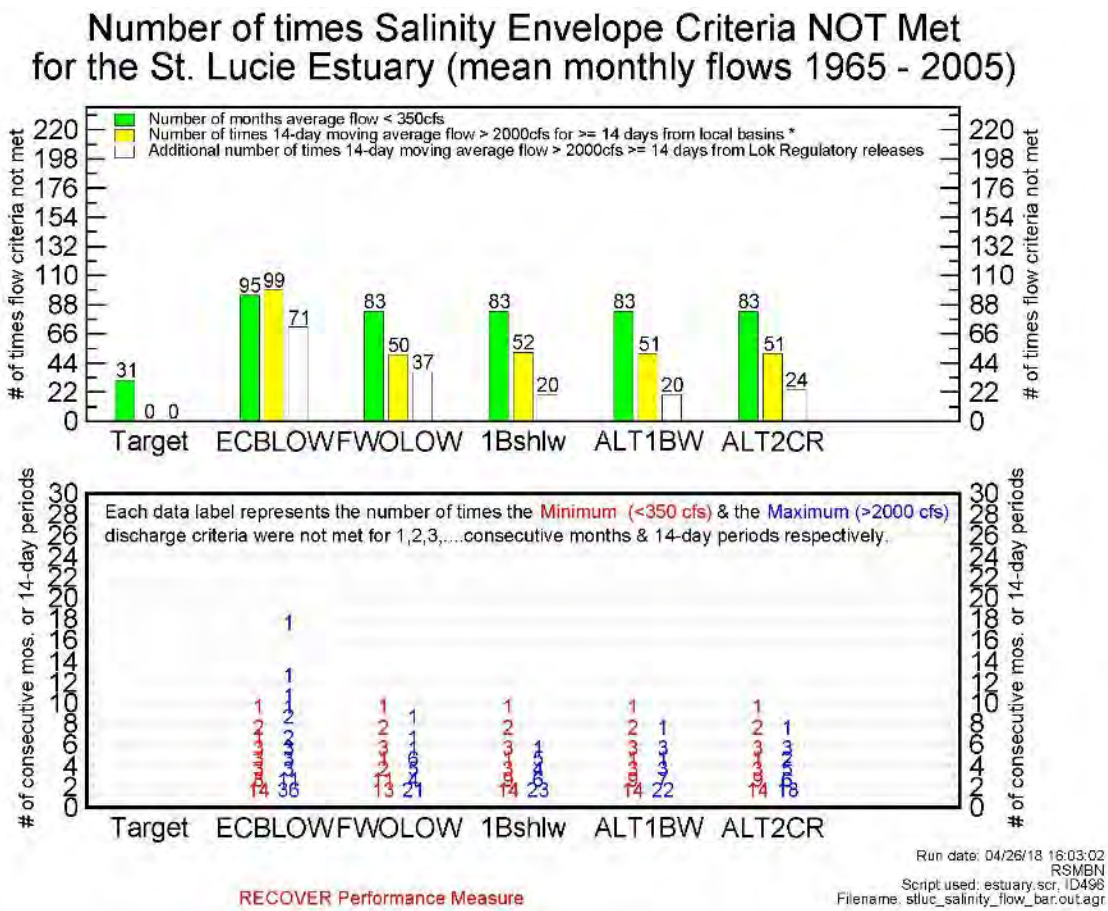

Figure C.2-10. Flow results for the St. Lucie Estuary.

Table C.2-9. Flow results for the St. Lucie estuary for the final array of alternatives.

	FWO	Alt 1Bshlw	Alt 1BW	Alt 2Cr
Number of months flow < 350 cfs	83	83	83	83
Number of times flow > 2000 cfs from Lake O flows	37	20	20	24
Average Annual Flow (acre-ft)	129,501	97,345	98,054	115,939

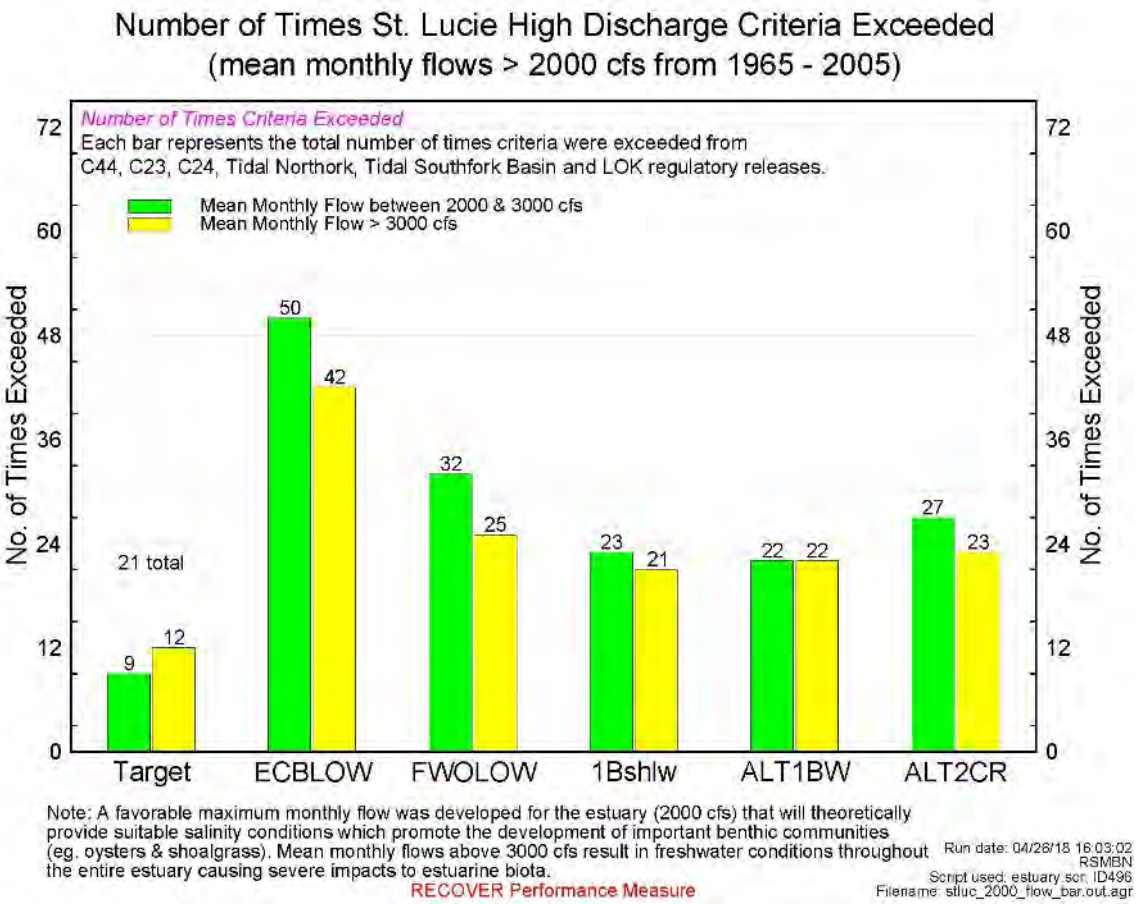

Figure C.2-11. Extreme high-flow events in the St. Lucie Estuary.

Ecological Benefits to the Northern Estuaries

High flows to the St. Lucie Estuary of more than 2,000 cfs reduce salinities for oysters and submerged aquatic vegetation to salinities outside the preferred salinity envelope. In comparison, the high flows to the Caloosahatchee Estuary are considered at or above 2,800 cfs at the S-79 structure that reduce salinities outside the preferred salinity envelope. All alternatives help restore the resiliency of the Northern Estuaries by reducing the number, duration, and frequency of flows from Lake Okeechobee. Evaluation of the alternatives showed significant reductions in the number, duration, and frequency of high flows to the estuaries, including:

- 55-58% reduction in high flow volumes from Lake Okeechobee to the Northern Estuaries, in conjunction with authorized projects as defined in the FWO.
- 63-70% reduction in the number of high flow events from Lake Okeechobee to the Northern Estuaries, in conjunction with authorized projects as defined in the FWO.

C.2.4 Threatened and Endangered Species

The overall objective of LOWRP is to increase water storage capacity in the watershed, improve the quantity and timing of flows to the Caloosahatchee and St. Lucie estuaries, and restore wetlands. Federally and state- listed threatened, endangered, and candidate species may occur within the study area (**Table**

C.2-10). Species described in the following section were determined by the USACE to potentially be affected by the project. No-effect species determinations are described in **Annex A**, LOWRP Biological Assessment, and the CERP Programmatic Biological Assessment for NOAA NMFS.

Table C.2-10. List of threatened, endangered, and candidate species know to occur in Okeechobee, Highlands, Charlotte, Glades, Martin, and St. Lucie counties. State-listed species of special concern (SSC) are also listed.

Scientific Name	Common Name	Federal Status	State Status	Alternatives 1Bshwl, 1BW, 2Cr Determinations
Reptiles				
Caretta caretta	Loggerhead sea turtle	Threatened	Threatened	May Affect Not Likely to Adversely Affect
Chelonia mydas	Green sea turtle	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Dermochelys coriacea	Leatherback sea turtle	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Drymarchon couperi	Eastern indigo snake	Threatened	Threatened	May Affect
Eumeces egregius lividus	Bluetail mole skink	Threatened	Threatened	No Effect
Gopherus polyphemus	Gopher tortoise	Not listed	Threatened	May Affect
Lepidochelys kempii	Kemp's Ridley sea turtle	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Neoseps reynoldsi	Sand skink	Threatened	Threatened	No Effect
Pituophis melanoleucus mugitus	Florida pine snake	Not listed	Threatened	May Affect
Birds				
Ammodramus savannarum floridanus	Florida grasshopper sparrow	Endangered	Not Listed	May Affect Not Likely to Adversely Affect
Aphelocoma coerulescens	Florida scrub jay	Threatened	Not Listed	No Effect
Athene cunicularia	Burrowing owl	Not listed	Threatened	May Affect
Egretta caerulea	Little blue heron	Not listed	Threatened	No Effect
Egretta tricolor	Tricolored heron	Not listed	Threatened	No Effect
Falco sparverius paulus	Southeastern American kestrel	Not listed	Threatened	No Effect
Grus Americana	Whooping crane	Experimental Population non-essential	Not Listed	No Effect

Scientific Name	Common Name	Federal Status	State Status	Alternatives 1Bshwl, 1BW, 2Cr Determinations
Grus canadensis pratensis	Florida sandhill crane	Not listed	Threatened	May Affect
Haematopus palliates	American oystercatcher	Not listed	Threatened	No Effect
Mycteria americana	Wood stork	Endangered	Not Listed	May Affect Not Likely to Adversely Affect
Picoides borealis	Red-cockaded woodpecker	Endangered	Not Listed	No Effect
Platalea ajaja	Roseate spoonbill	Not listed	Threatened	No Effect
Polyborus plancus audubonii	Northern crested caracara	Threatened	Not listed	May Affect
Rostrhamus sociabilis plumbeus	Everglade snail kite	Endangered	Not Listed	May Affect Not Likely to Adversely Affect
Rychops niger	Black skimmer	Not listed	Threatened	No Effect
Sterna antillarum	Least tern	Not Listed	Threatened	No Effect
Mammals				
Eumops floridanus	Florida bonneted bat	Endangered	Not Listed	May Affect
Puma concolor coryi	Florida panther	Endangered	Not Listed	May Affect Not Likely to Adversely Affect
Sciurus niger avicennia	Big Cypress Fox Squirrel	Not Listed	Threatened	May Affect
Sciurus niger shermani	Sherman's Fox Squirrel	Not Listed	Not Listed	May Affect
Trichechus manatus	Florida manatee	Endangered	Not Listed	May Affect Not Likely to Adversely Affect
Plants and Lichens				
Asimina tetramera	Four-petal pawpaw	Endangered	Endangered	No Effect
Cladonia perforata	Florida perforate cladonia	Endangered	Endangered	No Effect
Cucurbita okeechobeensis	Okeechobee gourd	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Dicerandra immaculate	Lakela's mint	Endangered	Endangered	No Effect
Halophila johnsonii	Johnson's seagrass	Threatened	Threatened	No Effect
Jacquemontia reclinata	Beach jacquemontia	Endangered	Endangered	No Effect
Liatrus ohlingerae	Scrub blazing star	Endangered	Endangered	No Effect
Panicum abscissum	Cutthroat grass	Not Listed	Endangered	No Effect
Paronchia chartacea	Papery whitlow-wort	Threatened	Endangered	No Effect
Polygala lewtonii	Lewton's polygala	Endangered	Endangered	No Effect

Scientific Name	Common Name	Federal Status	State Status	Alternatives 1Bshwl, 1BW, 2Cr Determinations
Polygala smallii	Tiny polygala	Endangered	Endangered	No Effect
Warea carteri	Carter's mustard	Endangered	Endangered	No Effect
Critical Habitat				
Rostrahamus sociabilis plumbeus	Everglade snail kite	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Trichechus manatus	West Indian Manatee	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Chelonia mydas	Green sea turtle	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Halophila johnsonii	Johnson's seagrass	Threatened	Threatened	May Affect Not Likely to Adversely Affect

ASR Effects

Aquifer Storage and Recovery Wells have the potential to affect methyl mercury bioaccumulation downstream. Recovered water may have higher sulfate concentrations than surface water. Increased sulfate may accumulate in lake sediments, reduce to hydrogen sulfide, and result in a sedimentary geochemical environment that can favor mercury methylation. All alternatives include ASR wells so there may be a risk for snail kites, wood storks, the Florida panther, and wading birds. An earlier study at Kissimmee River ASR System (Krabbenhoft and Sunderland 2013) demonstrated that mercury methylation does not occur during storage in the Upper Floridan Aquifer (UFA), and extensive monitoring during KRASR cycle testing showed that mercury and methylmercury concentrations were not releasereleased in recovered water (USACE, 2013).

C.2.4.1 Florida Grasshopper Sparrow

The Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) is a subspecies of grasshopper sparrow that is endemic to the dry prairie of central and southern Florida. This subspecies is extremely habitat specific and relies on fire every two to three years to maintain its habitat. The endangered Florida grasshopper sparrow is restricted to the dry prairie ecosystem of central and south Florida.

The sparrow is highly endangered (i.e., less than 100 individuals) due in large part to its exclusive dependence upon Florida dry prairie habitat, more than 85% of which has been destroyed. Most prairie loss has resulted from conversion to domestic pasture grasses, which support more cattle per acre and can support some species of prairie wildlife, but not Florida Grasshopper Sparrows. This "improved pasture" lacks the structure that these birds need. Research indicates the sparrows need native prairie in prime condition—it should burn every two years and as a result have virtually no brush or trees. Burns at the beginning of the dry season (January - March) are considered better than other times of the year.

Florida grasshopper sparrow habitat consists of large (greater than 50 ha), treeless, relatively poorly drained grasslands that have a history of frequent fires (FWS 1988, Delany 1996). The Florida grasshopper sparrow occurs in prairies dominated by saw palmetto (*Serenoa repens*) and dwarf oaks (*Quercus minima*) ranging from 30 to 70 cm in height. Bluestem grasses (*Andropogon* spp.), St. John's wort (*Hypericum* spp.), and wiregrasses (*Aristida* spp.) are also components of grasshopper sparrow habitat (Delany et al. 1985, FWS 1988). These dry prairies are relatively flat and are moderately to poorly drained. There is potential Florida grasshopper sparrow habitat in the project area (**Figure C.2-12**).

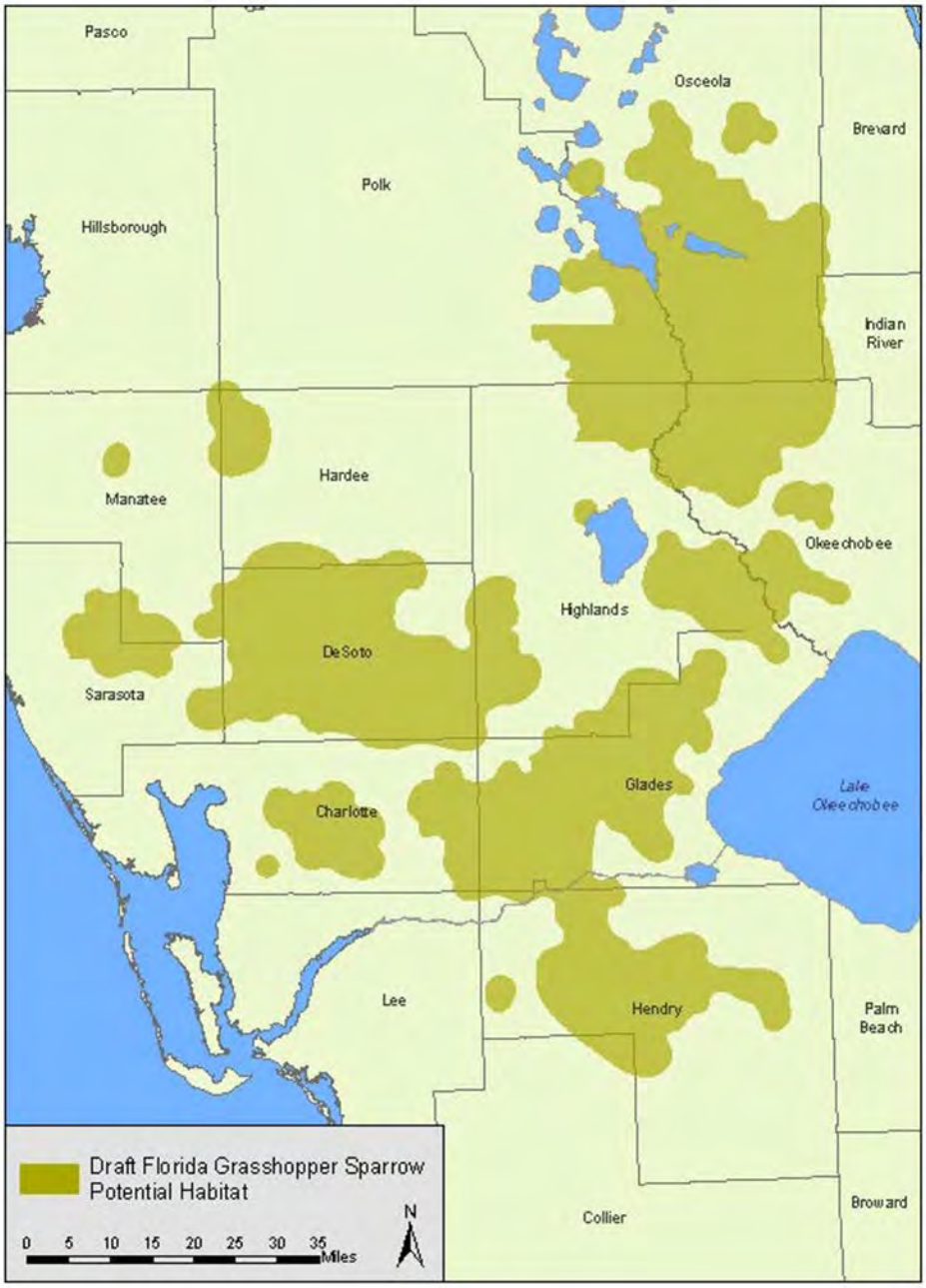

Figure C.2-12. Draft Florida grasshopper sparrow potential habitat (USFWS 2017).

C.2.4.1.1 Wetland Restoration Sites

The wetland restoration sites are the same for all alternatives. For the Paradise Run wetland site, there is no potential grasshopper sparrow habitat within the footprint (**Figure C.2-13**). For the Kissimmee River–Center wetland site, the entire site is within the area of potential grasshopper sparrow habitat (**Figure C.2-13**). However, based on the existing conditions, most of the site is improved pastures and wetlands (**Table C.2-11**), therefore, it is unlikely that there is actual grasshopper sparrow habitat within this footprint. However, surveys would be conducted during the Preconstruction Engineering and Design (PED) phase of the project to confirm there is no potential sparrow habitat within the Kissimmee River–Center wetland restoration site. The wetland restoration sites for all alternatives may affect, but is not likely to adversely affect grasshopper sparrows.

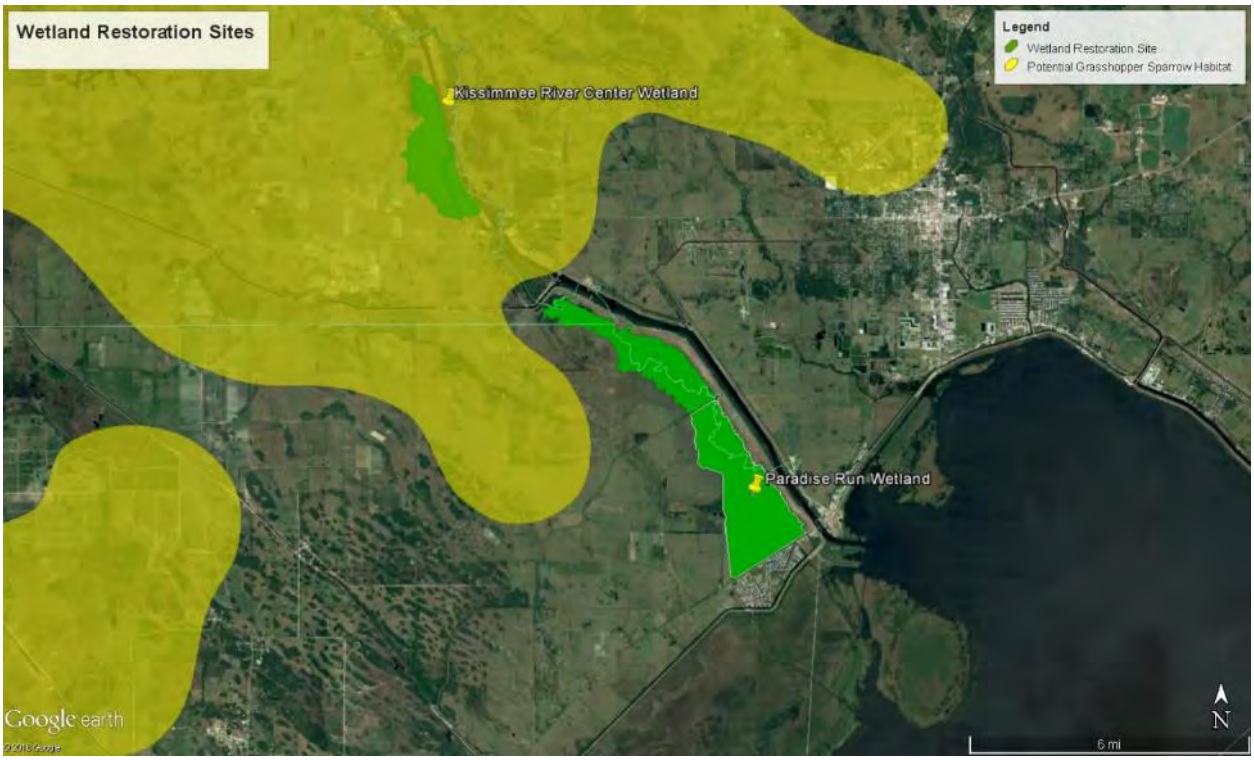

Figure C.2-13. Potential grasshopper sparrow habitat within the wetland restoration site footprints.

Table C.2-11. Existing land use in the Kissimmee River–Center wetland restoration site footprint.

FLUCCS Level 4 Code	FLUCCS Code Description	Area (acres)
2110	Improved Pastures	796
2120	Unimproved Pastures	64
3100	Herbaceous Rangeland	3
4200	Upland Hardwood Forest	4
4270	Live Oak	3
4271	Oak - Cabbage Palm Forest	1
5110	Streams and Waterways	19
5120	Channelized waterways, canals	3
5300	Reservoirs	5
6172	Mixed Wetland Hardwoods - Mixed Shrubs	159
6180	Cabbage Palm Savannah	4
6410	Freshwater Marshes	55
6430	Wet Prairies	41
6440	Emergent Aquatic Vegetation	40
n/a	**Total Area**	**1197**

C.2.4.1.2 Alternative 1Bshlw

37% (approximately 4,800 acres) of the K-05 reservoir footprint in Alternative 1Bshwl contains potential grasshopper sparrow habitat (**Figure C.2-14**). Most of the K-05 reservoir footprint is improved pastures and freshwater marshes, habitat that is not suitable for the grasshopper sparrow (**Table C.2-12**). However, there is a potential that some of the habitat could be grasshopper sparrow habitat so surveys will be conducted during PED phase to determine if the reservoir footprint contains potential grasshopper sparrow habitat. Alternative 1Bshlw will not affect grasshopper sparrows because there is minimal potential for suitable habitat to occur within the footprint.

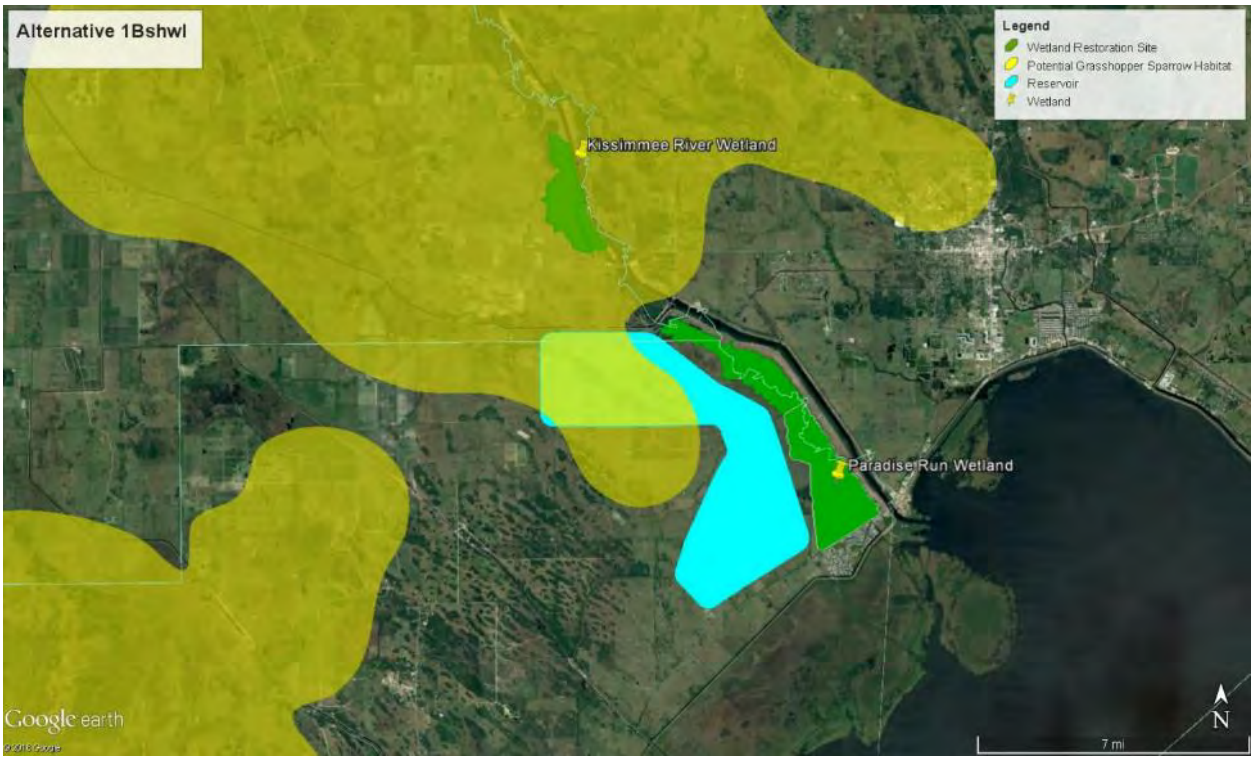

Figure C.2-14. Potential grasshopper sparrow habitat within the Alternative 1Bshlw footprint.

Table C.2-12. Existing land use in the K-05 reservoir footprint in Alternative 1Bshlw.

FLUCCS Level 4 Code	FLUCCS Code Description	Acres
2110	Improved Pastures	11,213
2120	Unimproved Pastures	266
2210	Citrus Groves	34
3100	Herbaceous Rangeland	20
3200	Shrub and Brushland	43
4271	Oak - Cabbage Palm Forest	150
4280	Cabbage Palm	452
5300	Reservoirs	24
6170	Mixed Wetland Hardwoods	5
6172	Mixed Wetland Hardwoods - Mixed Shrubs	43
6410	Freshwater Marshes	966
6430	Wet Prairies	44
n/a	**Total Acres**	**13,260**

C.2.4.1.3 Alternative 1BW

There is no potential grasshopper sparrow in the WAF footprint in Alternative 1BW (**Figure C.2-15**). Alternative 1BW will not affect grasshopper sparrows because there is no potential suitable habitat to occur within the footprint.

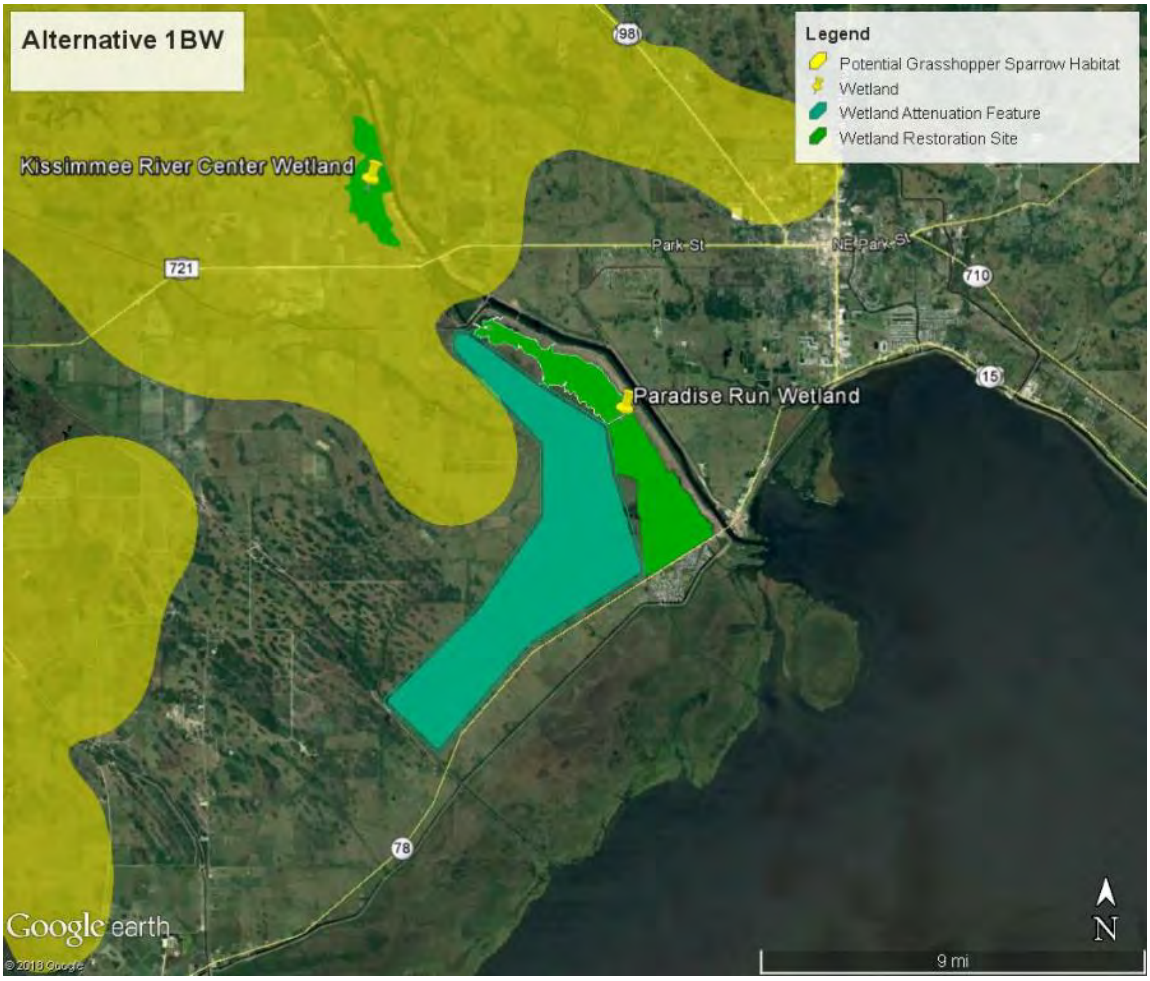

Figure C.2-15. Potential grasshopper sparrow habitat within the Alternative 1BW footprint.

C.2.4.1.4 Alternative 2Cr

The entire K-42 Revised reservoir footprint (14,600 acres) contains potential grasshopper sparrow habitat (**Figure C.2-16**). The K-42 Revised reservoir footprint contains mostly improved pastures, unimproved pastures and freshwater marshes (**Table C.2-13**). The K-42 reservoir footprint may contain potential grasshopper sparrow habitat and surveys would need to be completed during PED phase. Because Alt 2Cr contains the K-42 Revised reservoir that is entirely within the potential grasshopper sparrow habitat and it is 3,200 acres larger than the original K-42 reservoir, there would be a greater potential impact to the grasshopper sparrow habitat as compared to Alternatives 1Bshlw and Alt 1BW.

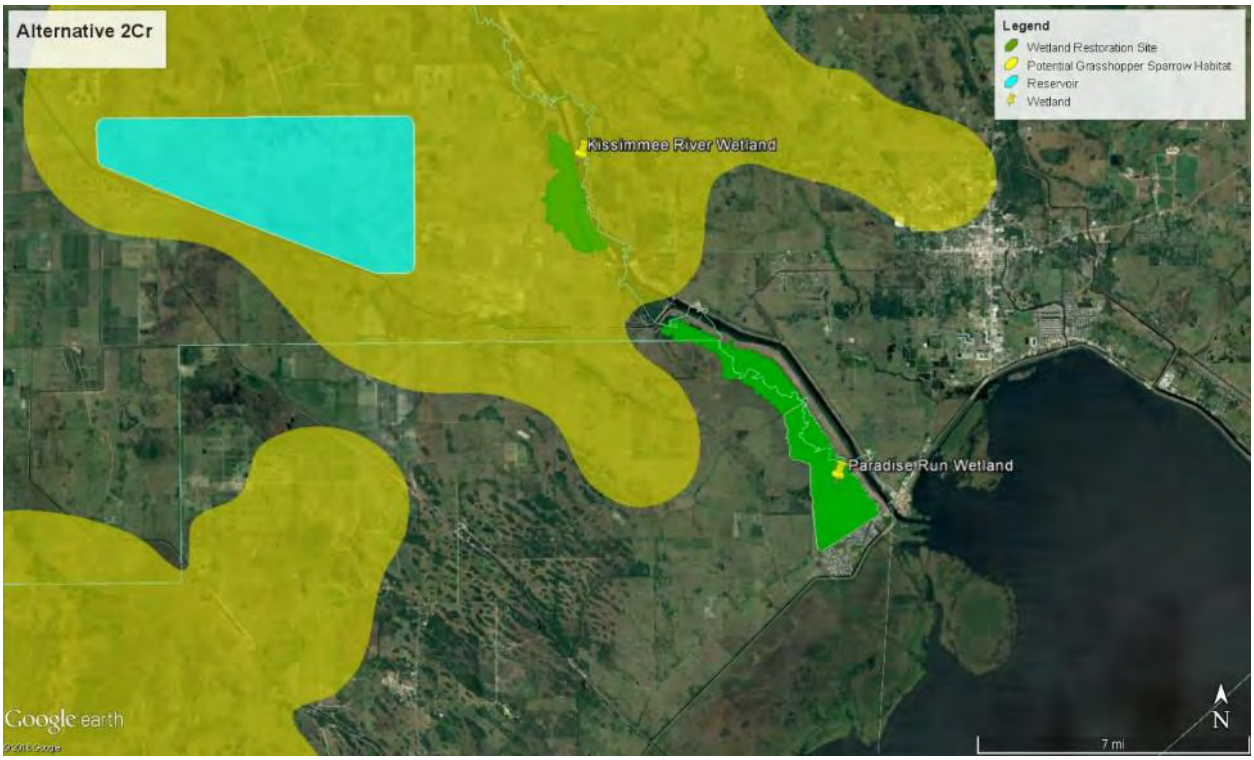

Figure C.2-16. Potential grasshopper sparrow habitat within the Alternative 2Cr footprint.

Table C.2-13. Existing land use in the K-42 Revised reservoir footprint in Alternative 2Cr.

FLUCCS Level 4 Code	FLUCCS Code Description	Acres
2110	Improved Pastures	8,185
2120	Unimproved Pastures	2,659
3100	Herbaceous Rangeland	313
3210	Palmetto Prairies	5
4220	Brazilian Pepper	319
4271	Oak - Cabbage Palm Forest	138
4280	Cabbage Palm	54
5120	Channelized waterways, canals	1
5300	Reservoirs	371
6172	Mixed Wetland Hardwoods - Mixed Shrubs	135
6180	Cabbage Palm Savannah	155
6410	Freshwater Marshes	1,937
6411	Sawgrass	38
6430	Wet Prairies	269
6440	Emergent Aquatic Vegetation	17
n/a	**Total Acres**	**14,596**

C.2.4.1.5 Recommended Plan

There is no potential grasshopper sparrow habitat within the Paradise Run wetland restoration footprint or the WAF. However, for the Kissimmee River–Center wetland restoration site, the entire footprint is located within potential habitat (**Figure C.2-14**). Within the Kissimmee River–Center wetland site, the majority of the acreage in FLUCCS classification includes improved pastures (796 acres), mixed wetland hardwoods/mixed shrubs (159 acres), and unimproved pastures (64 acres). Based upon the existing conditions of the wetland restoration sites and lack of suitable sparrow habitat in the WAF, the grasshopper sparrow is not likely to use the current area. Within the proposed footprints of the ASR wells, no potential grasshopper sparrow habitat is present. Construction and use of the ASRs are not expected to affect the grasshopper sparrow. Preconstruction surveys will be conducted prior to building all features to confirm there are no grasshopper sparrows present. If Florida grasshopper sparrows are encountered during the pre-construction surveys, the USACE will work closely with USFWS to identify options to eliminate or minimize any potential effects. The Recommended Plan may affect, but is not likely to adversely affect, Florida grasshopper sparrows.

C.2.4.2 Northern Crested Caracara

There are known and suspected caracara territories within the storage feature footprints for all with-action alternatives. There is additional caracara foraging habitat with both wetland sites. **Figure C.2-17** shows the reported caracara nest locations and other caracara observations in the US FWS's database. Due to the lack of public access, parts of the study area have not been surveyed for caracaras. This is

especially true for the interior of the proposed storage feature footprints. As a result, there are likely more caracara nests than depicted on **Figure C.2-17**. Given the amount of overall pasture habitat in the study area, the direct effect of habitat loss on caracaras from any with-action alternative would be proportional to the size of the management measure; therefore, larger storage features will likely have a larger adverse effect on the species. Alternative 2Cr would likely have the greatest impact due to size, followed by Alt 1Bshlw and then Alt 1BW. ASRs generally have smaller surface footprints, so there may not be any substantial adverse effects of ASR construction and operation on caracaras. A follow-up assessment will be needed once specific ASR sites are selected. For the wetlands, pasture conversion to deep wetlands may displace caracaras, but conversion to short-hydroperiod wetlands may not. Additionally, the anticipated increase in wetland-based prey items associated with restored wetlands is likely to increase foraging opportunities and may benefit the caracara. Caracaras may forage along future storage feature levees and seepage control features. As a result, all with-action project features would likely need surveys to identify caracara nests and better define the magnitude of adverse and potentially beneficial effects. A biological opinion exempting incidental take of caracaras will likely be needed for any with-action alternative. The Recommended Plan removal of upland habitat may affect caracaras.

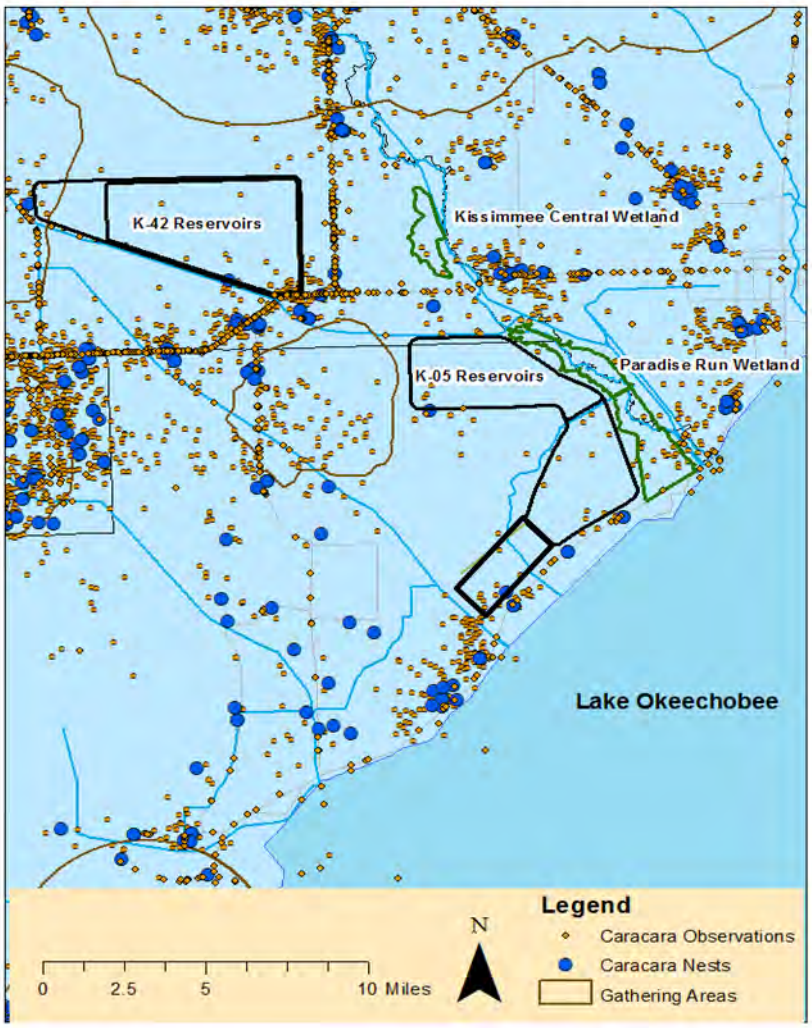

Figure C.2-17. Caracara nests, gathering areas, and observations (1994-2017, including eBird database observations from January 2010 to May 2017 around Lake Okeechobee). Source: USFWS 2018.

C.2.4.3 Florida Bonneted Bat

The Florida bonneted bat consultation area includes Glades, Highlands, and Okeechobee counties, which are within the project area (**Figure C.2-18**). The project area does not include the 2013 bonneted bat focal area as described by FWS (2013). This species forages for insects at night while flying over water; therefore, all of the alternatives provide benefits of increased wetlands and storage features for foraging. However, the wetland and storage sites contain uplands that may contain roosting trees, thus all alternatives may be removing roosting habitat. Alt 1Bshlw has the most potential habitat for trees that are suitable for roosting, followed by Alt 2Cr and then Alt 1Bw (**Table C.2-14**). Acoustic surveys to detect bats should be completed prior to construction so that if bats are encountered, the USACE will coordinate measures with FWS to minimize or avoid potentially adverse effects. Because the LOWRP is within the Florida bonneted bat consultation area and contains trees in which bats could potentially roost, the USACE has determined that the Recommended Plan may affect the Florida bonneted bat.

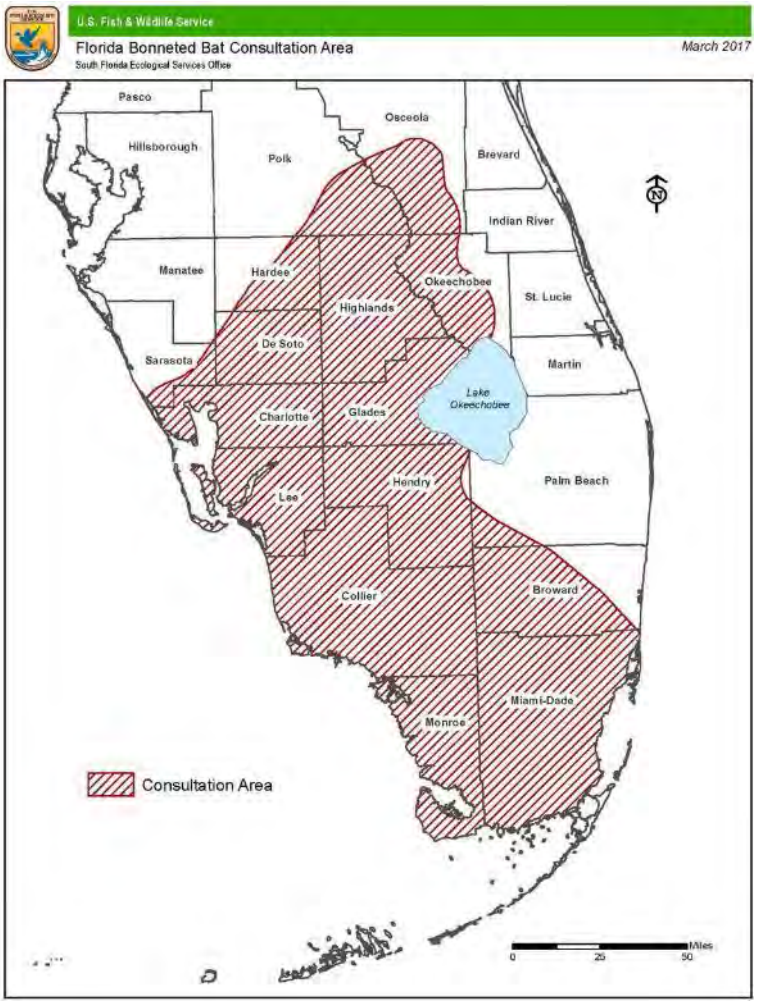

Figure C.2-18. 2017 Florida Bonneted Bat (FBB) Consultation and Focal Area (USFWS 2017).

Table C.2-14. Acres where potential bonneted bat tree roosts may be present in each storage feature footprint and in the restored wetland sites.

	1Bshlw	1BW	2Cr
Acres of uplands in storage footprint	666	442	510
Acres of uplands in wetland restoration footprint	2,146	2,146	2,146
Total acres of uplands lost	**2,812**	**2,588**	**2,656**

C.2.4.4 Everglades Snail Kite

Snail kites are known to nest and forage in and around Lake Okeechobee during most non-drought years (**Figure C.2-19**). They may also occupy Lake Istokpoga and the Kissimmee River floodplain as hydrologic conditions and availability of apple snails (the kite's main prey item) allow. In recent years, the introduction and expansion of the exotic apple snail (*Pomacea maculata*) population has, in turn, expanded both the areas in which snail kites may forage and nest as well as prolonged the nesting season in some years from the spring into the summer and sometimes fall. We expect that all alternatives that either restore or increase the spatial extent of wetlands could benefit the snail kite if apple snails and/or nesting substrate become present in those wetlands. The creation of storage features has the potential to benefit snail kites if the hydrology allows for creation and maintenance of apple snail populations or if nesting substrate is available. However, there is greater uncertainty that storage features will provide snail kite habitat compared to restored wetlands. All alternatives restore 5,279 acres of wetlands along the Kissimmee River floodplain (**Table C.2-5**), significantly increasing the spatial extent of suitable foraging opportunities for snail kites.

Water storage provided by implementation of any of the with-action alternatives is likely to improve overall lake levels and moderate stage fluctuations. This may increase suitable habitat for apple snails, thereby increasing spatial extent of suitable foraging opportunities for snail kites. Minor beneficial effects to vegetation (including vegetation used for snail kite nesting) within Lake Okeechobee's extensive littoral zone are also anticipated as a result of any of the alternatives. These ecological benefits are a result of the small increase in amount of time within the beneficial stage envelope and less time in the extremely low stages (<10 ft, NGVD) and above the stage envelope for any of the alternatives compared to the FWO (**Figure C.2-2** to **Figure C.2-4**). Conversely, also as compared with the FWO, all LOWRP action alternatives reveal the potential for short-term minor adverse effects to the ecological indicators and littoral and nearshore aquatic vegetation due to a slight increase in the amount of time that lake stages in the extremely high stages (>17 ft. NGVD) might occur (**Figure C.2-5**).

The Recommended Plan includes increasing wetland acreage in the LOW by approximately 18,000 acres, and creating storage with ASR, which will help regulate water levels within the lake and south of the lake. The increase in wetland acreage would significantly increase the spatial extent of suitable foraging habitat and opportunities for snail kites. The change in lake stages does not appear to result in many occurrences of time the lake is above or below the optimal stage envelope for vegetation as compared to the current conditions. The effects of lake stages on snail kites are outlined and discussed in the LORS Biological Opinion, with actions to minimize any potential effects. This project would also follow those guidelines. Rapid recession rates during the dry (breeding) season and associated low water levels can allow nests to become accessible to land-based predators, resulting in decreased nest success (Beissinger 1986; Sykes 1987b). The potential for this effect is greater for snail kites nesting near land (i.e., in lakes or reservoirs)

compared to those nesting in expansive marsh systems such as Water Conservation Area 3A (WCA-3A). While recession rates were not analyzed specific to LOWRP effects on Lake Okeechobee stage, LOWRP provides additional capability to moderate Lake Okeechobee stages particularly in the dry season, which may or may not reduce high recession rates (>0.16 ft. per week, Fletcher et al. 2017). The USACE has determined that the Recommended Plan may affect, but is not likely to adversely affect, Everglade snail kites.

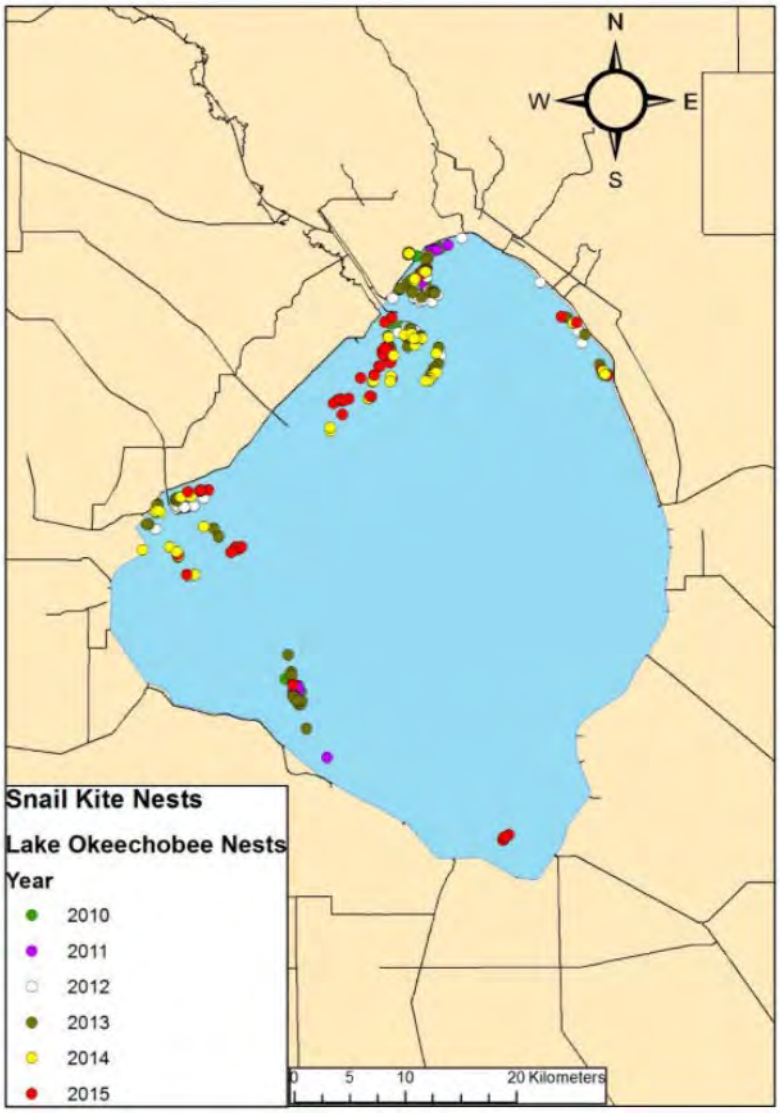

Figure C.2-19. Everglade snail kite nest locations from 2010-2015 (*active nests only). Source: USFWS 2015.

C.2.4.5 Everglades Snail Kite Critical Habitat

Based on the description in the Federal Register (1977), snail kite critical habitat in Lake Okeechobee is located in the western parts of Glades and Hendry Counties, extending along the western shore to the east of the dike system and the undiked high ground at Fisheating Creek, and from the Hurricane Gate at Clewiston northward to the mouth of the Kissimmee River, including all the spike rush (*Eleocharis* sp.) flats of Moonshine Bay, Monkey Box, and Observation Shoal, but excluding the open water north and west of the northern tip of Observation Shoal, north of Monkey Box and east of Fisheating Bay.

The project benefits described above for vegetation within the Lake Okeechobee littoral zone are mostly within the designated snail kite critical habitat (**Figure C.2-20**). Therefore, snail kite critical habitat in Lake Okeechobee should benefit by implementation of the project, particularly by reducing the frequency of extreme low lake stages. Due to these anticipated beneficial effects on Lake Okeechobee's littoral vegetation, the USACE has determined that implementation of the Recommended Plan may affect, but will not likely adversely affect, Everglade snail kite critical habitat.

Figure C.2-20. Snail kite critical habitat located in Lake Okeechobee.

C.2.4.6 Wood Stork

Implementation of all action alternatives would be expected to improve conditions for wood storks throughout much of the project area. Rehydration and vegetation shifts within the Lake Okeechobee Watershed (i.e., restored project wetlands) and lake levels (via additional project storage) are likely to increase the spatial extent of suitable foraging opportunities and nesting habitat for wood storks providing a moderate beneficial effect (**Figure C.2-21**). Minor beneficial effects to vegetation within Lake Okeechobee's extensive littoral zone are anticipated as a result of any of the action alternatives. These ecological benefits are a result of the small increase in amount of time within the beneficial stage envelope and less time in the extremely low stages (<10 ft. NGVD) and above the stage envelope for any of the alternatives compared to the FWO (**Figure C.2-2** to **Figure C.2-4**). This increase in time in the beneficial stage envelope improves the foraging habitat in the littoral zone of Lake Okeechobee for wood storks. Conversely, also as compared with FWO, all LOWRP action alternatives reveal the potential for short-term minor adverse effects to the ecological indicators and littoral and nearshore aquatic vegetation due to a slight increase in the amount of time that lake stages in the extremely high stages (>17 ft. NGVD) might occur (**Figure C.2-5**) which may affect foraging habitat for wood storks.

All alternatives restore 5,279 acres of wetlands along the Kissimmee River floodplain (**Table C.2-5**), significantly increasing the spatial extent of suitable foraging opportunities and nesting habitat for wood storks. These benefits should offset the adverse impacts to existing foraging habitat (wetlands) currently within the potential storage footprints.

The Recommended Plan would be expected to improve conditions for wood storks throughout much of the project area, including the littoral community within Lake Okeechobee due to the increased amount of time the water levels would be within the beneficial stage envelope. This would allow for a greater opportunity for wood stork foraging. Rehydration and vegetation shifts within the LOW (i.e., wetland restoration sites) and lake levels (via additional project storage) are likely to increase the spatial extent of suitable foraging opportunities and nesting habitat for wood storks, which would provide a moderate beneficial effect.

The Recommended Plan proposes to restore 5,279 acres of wetlands along the Kissimmee River floodplain (this includes the Paradise Run wetland site) and 13,000 acres of the WAF. This significantly increases the spatial extent of suitable foraging opportunities and nesting habitat for wood storks. These benefits should offset the adverse effects to existing foraging habitat (i.e., wetlands) currently within the potential storage footprints. Therefore, the USACE has determined that the Recommended Plan may affect, but is not likely to adversely affect, wood storks.

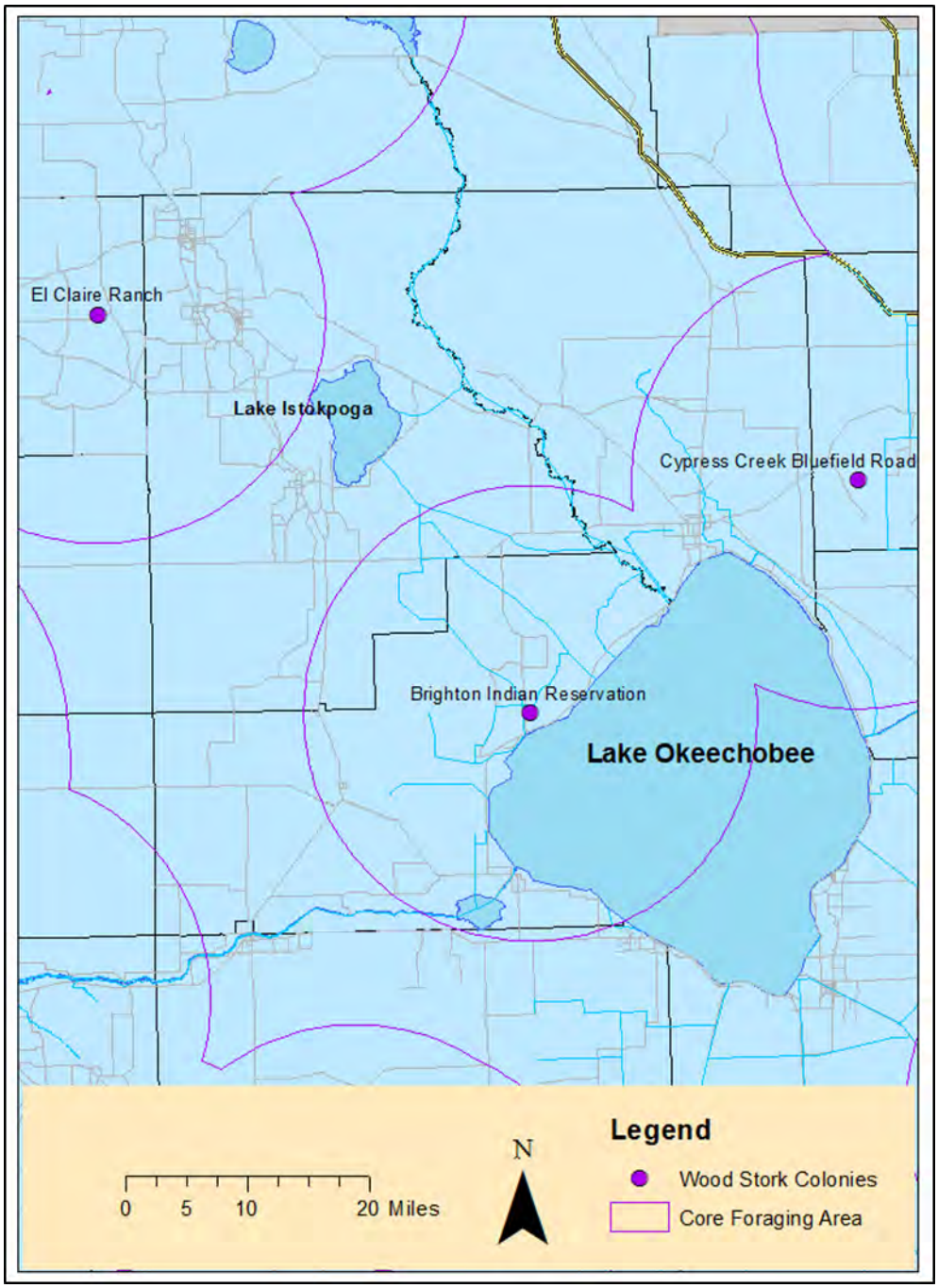

Figure C.2-21. Wood stork colonies active in 2016 near Lake Okeechobee. Source: USFWS 2018.

C.2.4.7 Eastern Indigo Snake

All LOWRP alternatives include storage features that will convert uplands and wetlands to deep-water or wetland habitat and wetland restoration sites that will convert some uplands to wetlands. For all with action alternatives, the majority of the current land uses in the storage features and wetland restoration footprints are improved and unimproved pastures. **Table C.2-15** shows the amount of uplands and pastureland that will be converted to deep-water habitat or wetlands for each alternative. Eastern indigo snakes have a high probability of occurrence within all proposed storage and wetland restoration

footprints based on the acreage of the potential project component and the available potential snake habitat. As a result of construction, the species is likely to be displaced or possibly killed. Alt 1Bshlw would remove approximately 14,451 acres of potential habitat, Alt 1BW would remove approximately 13,913 acres of potential habitat, and Alt 2Cr would remove approximately 13,626 acres of potential habitat. All alternatives are likely to have unavoidable adverse effects on Eastern indigo snakes.

The Recommended Plan includes wetland restoration sites that will convert some uplands to wetlands. The majority of the current land uses in the wetland restoration footprints are improved and unimproved pastures. **Table C.2-15** shows the amount of uplands and pastureland that will be converted to wetlands, with a total of 13,913 acres. Eastern indigo snakes have a high probability of occurrence within all proposed wetland restoration footprints based on the acreage of the potential project component and the available potential snake habitat. The Recommended Plan is likely to have unavoidable adverse effects on Eastern indigo snakes due to removal of pasturelands and uplands. The USACE will utilize Standard Protection Measures for Eastern Indigo snakes throughout project design and construction in order to minimize any potential adverse effects to the extent practicable. The USACE has determined that the Recommended Plan may affect Eastern indigo snake.

Table C.2-15. Acres of potential upland habitat in each storage feature footprint and in the restored wetland sites.

	1Bshlw	1BW	2Cr
Acres of uplands in storage feature footprint	666	442	510
Acres of pasture in storage feature footprint	11,513	11,199	10,844
Acres of pasture in wetland restoration footprint	2,146	2,146	2,146
Acres of non-pasture uplands in wetland restoration footprint	126	126	126
Total acres of uplands and pasturelands lost	**14,451**	**13,913**	**13,626**

C.2.4.8 Florida Manatee

The Florida manatee is a large, plant-eating aquatic mammal that can be found in Lake Okeechobee and its rim canal, the Kissimmee River below S65-E, and the shallow coastal waters, rivers, and springs of Florida. Florida manatees live in freshwater, brackish, and marine habitats, and can move freely between salinity extremes. They move from the inland locations to warmer coastal waters in winter. Any "with-action" alternative is not likely to adversely impact the overall manatee foraging habitat within Lake Okeechobee, local canals, or the Northern Estuaries; the latter includes designated manatee critical habitat. All LOWRP action alternatives show a slight performance improvement within the Northern Estuaries as indicated by fewer high volume flow months, providing a minor beneficial effect to SAV. Reduction in high flows and accompanying flow velocities would result in lower suspended solid loading and decreased concentration of colored dissolved organic matter, thereby allowing greater light penetration to promote growth of SAV. In addition, reduction in high volume flows from Lake Okeechobee would reduce extreme salinity fluctuations associated with such events. Although some SAV are tolerant of a wide range of salinity levels, a reduction in high volume flows would reduce stress to SAV and promote increases in seagrass shoots and have the potential to increase foraging opportunities for manatees in this region and provide a minor beneficial effect. All alternatives provide significant beneficial effects for the reduction of high flow events which are beneficial for the SAV in the estuaries (refer to **Northern Estuaries** for further information).

In the Caloosahatchee Estuary, Alternatives 1Bshlw had 10 fewer months of high flows than the FWO, Alt 1BW had 7 fewer months of high flows and Alt 2Cr has 6 fewer months of high flows than the FWO. The model output shows that of the number of months flow > 2800 cfs from the C-43 Basin and Lake Okeechobee regulatory flows, 47 of those months are a results of basin runoff. Therefore, flows greater than 2800 cfs from direct Lake Okeechobee flows go from 23 in the FWO to 13 in Alt 1Bshlw, 16 in Alt 1BW and 17 in Alt 2Cr (**Table C.2-8**). For extreme high flow events (mean monthly flow > 4500 cfs), all alternatives perform better than the FWO that had 30 months where the mean monthly flow was greater than 4500 cfs. The number of mean monthly flows greater than 4500 cfs were reduced to 25 for Alt 1BW, 26 for Alt 1Bshlw, and 27 for Alt 2Cr (**Figure C.2-9**). In the St. Lucie estuary, Alt 1Bshlw and Alt 1BW provides the greatest reduction of high flow events (reduced from 37 to 20 events compared to FWO), followed by 2Cr (reduced to 24 events) (**Table C.2-9**, **Figure C.2-10**).

Florida manatees also depend upon canals as a source of freshwater and resting sites. It is highly likely that Florida manatees also depend on the deep canals as a cold-weather refuge. The relatively deep waters of the canals respond more slowly to temperature fluctuations at the air/water interface than the shallow bay waters. Thus, the canal waters remain warmer than open bay waters during the passage of winter cold fronts. **Figure C.2-22** illustrates canals that Florida manatees have access to within LOWRP action area. Within Lake Okeechobee, minor beneficial effects to vegetation within Lake Okeechobee's extensive littoral zone are anticipated as a result of any of the alternatives. These ecological benefits are a result of the small increase in amount of time within the beneficial stage envelope and less time in the extremely low stages (<10 ft. NGVD) and above the stage envelope for any of the alternatives compared to the FWO (**Figure C.2-2** through **Figure C.2-4**). This increase in time in the beneficial stage envelope improves the foraging habitat in Lake Okeechobee for manatees.

In addition to the Endangered Species Act, the manatee is also protected by the Marine Mammal Protection Act, and as such, incidental take of manatees cannot be exempted for federal actions. Therefore, any alternative with ASRs that release to waters inhabited by manatees will need to maintain the thermal profile in the receiving stream if manatees are present. This will preclude entrapment of manatees in temporary warm water ASR plumes (expected to be 75° F) when ambient water temperatures are below 60° F. This concern could be remediated by having alternative ASR release points to areas not inhabited by manatees and avoid any identified refugium.

The Recommended Plan would improve the overall manatee foraging habitat within Lake Okeechobee, local canals, and the Northern Estuaries; the latter includes designated manatee critical habitat. Within Lake Okeechobee, modeling shows a minor beneficial effect to vegetation within Lake Okeechobee's extensive littoral zone that will improve the foraging habitat in Lake Okeechobee for manatees. The modeling shows performance improvements within the Northern Estuaries as indicated by fewer high-volume flow months, providing a beneficial effect to SAV. Reduction in high flows and accompanying flow velocities would result in lower suspended solid loading and decreased concentration of colored dissolved organic matter, thereby allowing greater light penetration to promote growth of SAV. In addition, reduction in high-volume flows from Lake Okeechobee would reduce extreme salinity fluctuations associated with such events. Although some SAV are tolerant of a wide range of salinity levels, a reduction in high volume flows would reduce stress to SAV and promote increases in seagrass shoots and have the potential to increase foraging opportunities for manatees in this region and provide a minor beneficial effect.

Florida manatees also depend upon canals as transit from one habitat to another, a source of freshwater, and resting sites. Standard manatee protection guidelines will be used during construction along

canals/rivers accessible to manatees to avoid effects. It is highly likely that Florida manatees also depend on the deep canals as a cold-weather refuge. The relatively deep waters of the canals respond more slowly to temperature fluctuations at the air/water interface than the shallow bay waters. Thus, the canal waters remain warmer than open bay waters during the passage of winter cold fronts. **Figure C.2-22** illustrates the canals that Florida manatees have access to, some of which are within the LOWRP action area.

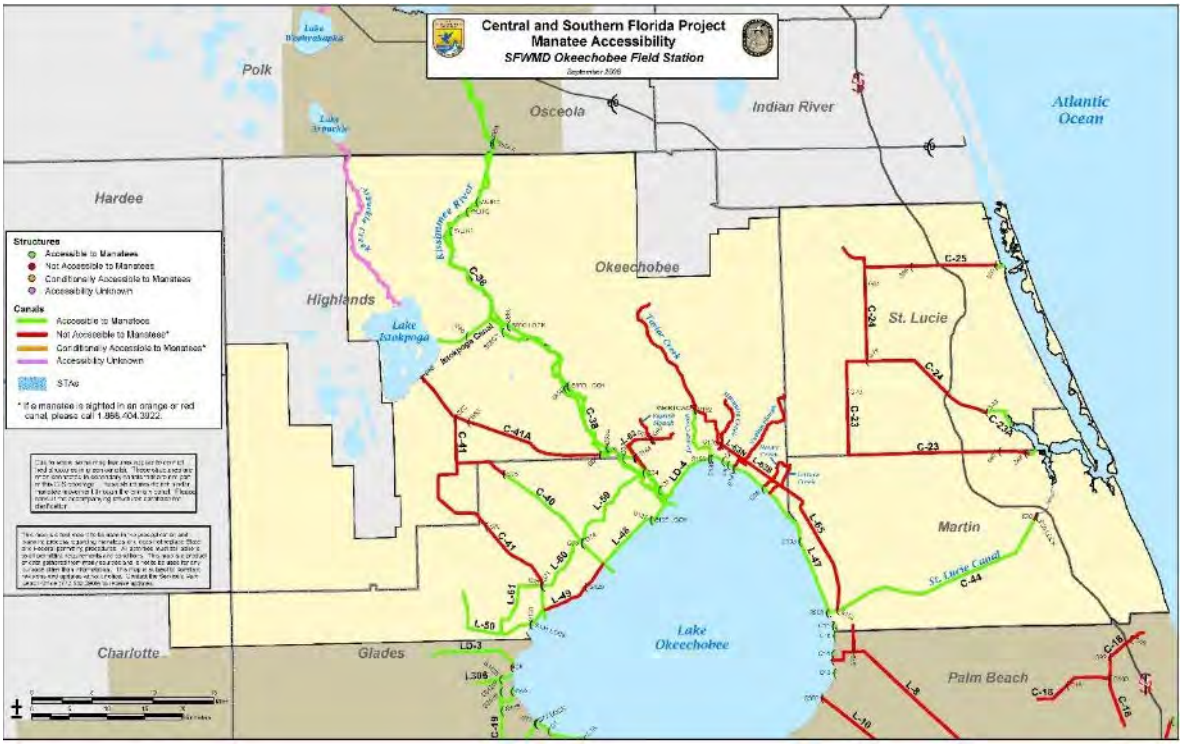

Figure C.2-22. Canals that Florida manatee have access to within LOWRP action area.

The ASRs are not likely to negatively affect manatee with releasing warmer waters (Ecological Risk Assessment from the Aquifer Storage and Recovery Regional Study Technical Data Report, pages 165-166, May 2015). The typical duration of water releases from ASR wells would likely not be enough water to provide prolonged warm water habitat, as the water is likely to dissipate into the canals without changing the thermal temperature significantly. ASRs that release to waters inhabited by manatees will need to maintain the thermal profile in the receiving stream if manatees are present. This will preclude entrapment of manatees in temporary warm water ASR plumes (expected to be 75° F) when ambient water temperatures are below 60° F. This concern could be remediated by having alternative ASR release points to areas not inhabited by manatees. In order to avoid potential effects to manatee, the timing of water releases into the canals could be conducted during non-critical times manatee would be present. This concern of change in thermal profile while manatees are in the waters could also be reduced by having alternative ASR release points to areas not inhabited by manatees. With careful planning on timing of releases and placement of ASRs, the USACE has determined that the Recommended Plan may affect, but is not likely to adversely affect Florida manatee.

C.2.4.9 Florida Manatee Critical Habitat

Critical habitat for the Florida manatee was designated in 1976 (50 CFR §1 7.95[a]). Critical habitat for the West Indian manatee is shown in **Figure C.2-23**.

No specific primary or secondary constituent elements were included in the critical habitat designation. However, experts agree essential habitat features for the manatee include SAV or seagrasses for foraging, shallow areas for resting and calving, channels for travel and migration, warm-water refuges during cold weather, and fresh water for drinking (Service 2001). Designated critical habitat includes the Caloosahatchee River downstream from the Florida State Highway 31 bridge, Lee County; all U.S. territorial waters adjoining the coast and islands of Lee County; all U.S. territorial waters adjoining the coast and islands and all connected bays, estuaries , and rivers from Gordon's Pass, near Naples, Collier County, southward to and including Whitewater Bay, Martin and West Palm Beach Counties; that section of the intracoastal waterway from the town of Seawalls Point, Martin County to Jupiter Inlet, Palm Beach County; the entire inland section of water known as the Indian River, from its northernmost point immediately south of the intersection of U.S. Highway I and Florida State Highway 3, Volusia County, southward to its southernmost point near the town of Sewalls Point, Martin County.

The Recommended Plan is not likely to adversely affect the overall manatee foraging habitat within the designated manatee critical habitat. The Recommended Plan modeling shows a slight performance improvement within the Northern Estuaries as indicated by fewer high volume flow months, which provides a minor beneficial effect to SAV. Reduction in high flows and accompanying flow velocities would result in lower suspended solid loading and decreased concentration of colored dissolved organic matter, thereby allowing greater light penetration to promote growth of SAV. In addition, reduction in high volume flows from Lake Okeechobee would reduce extreme salinity fluctuations associated with such events. Although some SAV are tolerant of a wide range of salinity levels, a reduction in high volume flows would reduce stress to SAV and promote increases in seagrass shoots and have the potential to increase foraging opportunities for manatees in this region and provide a minor beneficial effect. Therefore, the Recommended Plan may affect, but is not likely to adversely affect, Florida manatee designated critical habitat.

C.2.4.10 Florida Panther

The Florida panther is a wide-ranging species, with the majority of project area sightings west of Lake Okeechobee, along the Caloosahatchee River. Female panthers have only recently been recorded north of the Caloosahatchee River. Primary dispersal/expansion area lies north of the river, and the Thatcher dispersal pathways lie north of there (see **Figure C.2-24**). The Thatcher dispersal pathways were not identified as being used by panthers; rather they represent a least-cost pathway for panthers to move north based on the available habitat in 2006.

All action alternatives have the potential to convert wetland and upland habitat in the Thatcher Dispersal Pathway to aboveground storage. However, the lower water depth in Alternate 1BW will not be a geographic barrier as panthers could still traverse the WAF. In addition, as lands within project area become restored to their more historic natural values, the concomitant improved prey base would result in greater use of these areas by the Florida panther.

It has yet to be determined if the panther population will substantially expand beyond the primary expansion area. In the event it does, the FWP levees, associated seepage canals, and restored wetlands

would provide permanent panther prey and dispersal pathways. Because panthers are not using these areas now, it is difficult to say if any of the action alternatives will adversely affect the Florida panther, but the Recommended Plan, Alternative 1BW, would have the least impact of all alternatives. Based on this information, the Recommended Plan may affect the Florida panther.

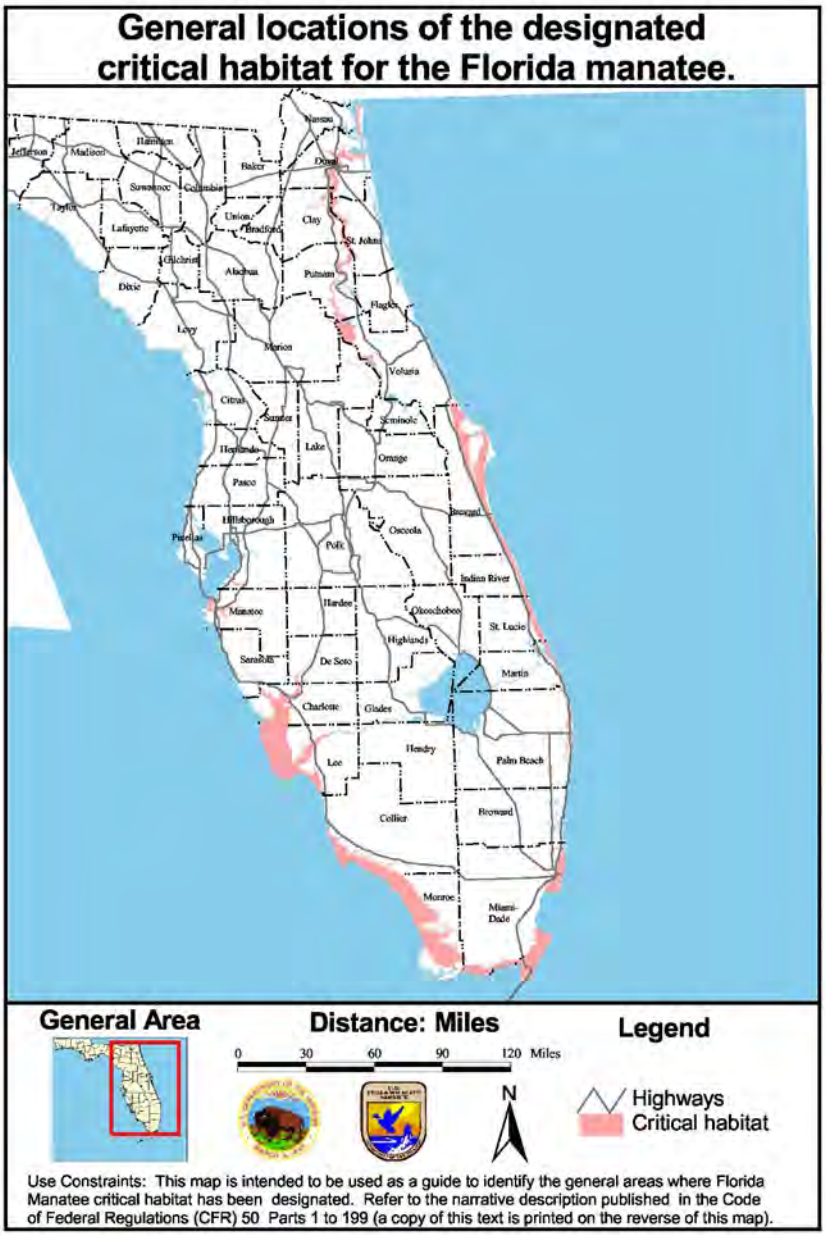

Figure C.2-23. Designated critical habitat for the West Indian Manatee.

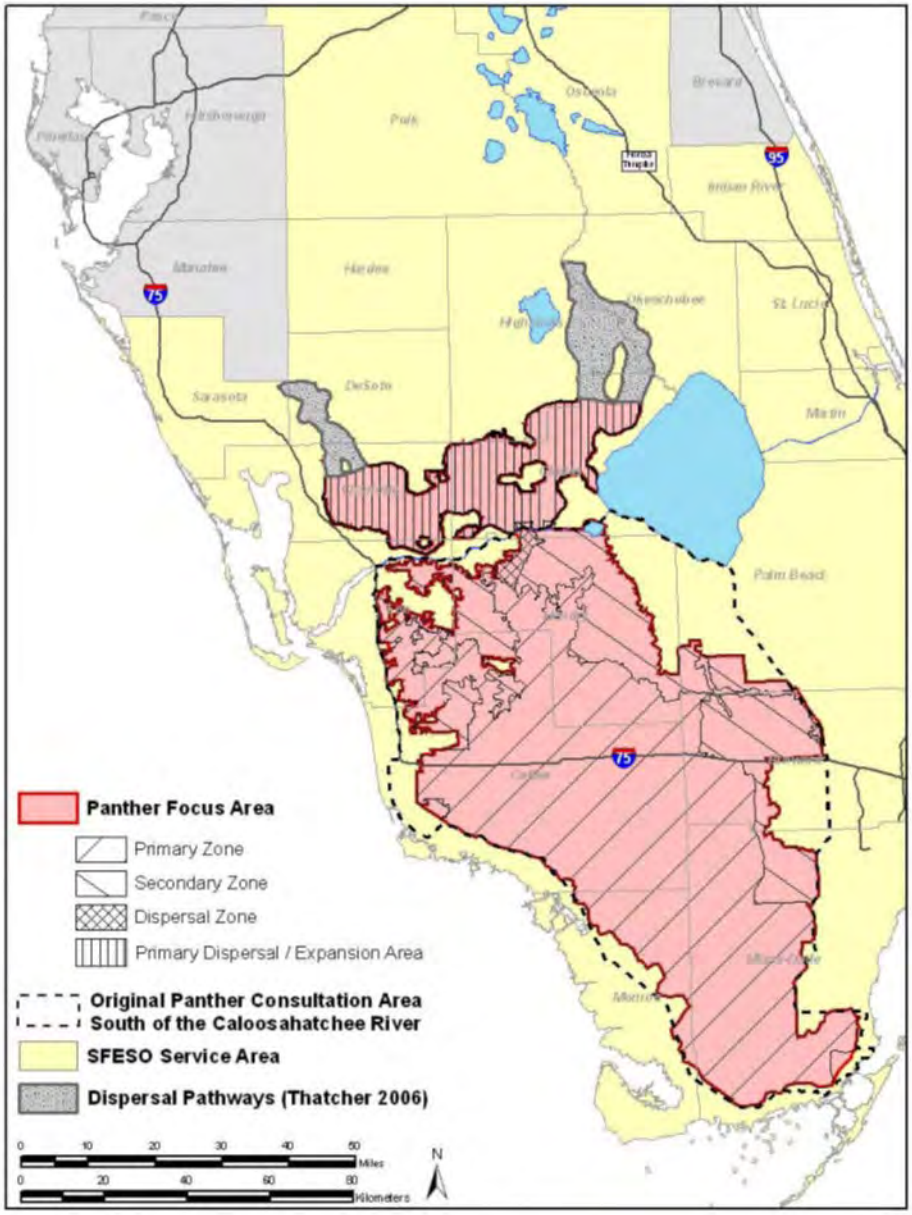

Figure C.2-24. Florida panther zones in South Florida. Source: USFWS 2015.

C.2.4.11 Okeechobee Gourd

Around Lake Okeechobee, the gourd relies on pond apple trees to support its vines above rising water levels during the wet season. Other trees and shrubs, such as willow (*Salix caroliniana*) and cypress (*Taxodium distichum*), may also provide suitable support for the vines. Along the St. Johns River, Okeechobee gourds are most typically found growing on elderberry and common reed (*Phragmites spp.*). The Okeechobee gourd also seems to readily germinate on alligator nests around Lake Okeechobee, which provide suitably elevated soil berms in full sun, with no competition from other plants. These disturbed

sites provide areas where competition is reduced and elevated areas that promote the growth of elderberry, button bush, and other erect bushes and shrubs (USFWS 1999).

The decline of the plant is largely attributable to conversion of swamp forests to agriculture and water level management in Lake Okeechobee. For the gourd to maintain viable healthy populations, fluctuations in lake level are necessary. High lake levels facilitate dispersal and inundate and destroy aggressive weeds in local habitats. As lake levels decrease, the cleared open habitats allow the quickly germinating Okeechobee gourd seeds to sprout and begin climbing before they have to compete with other pioneer species. Water regulation practices can greatly influence the timing and duration of flooding and drying cycles across remnant areas of suitable elevation and soils around Lake Okeechobee. Permanent inundation of suitable soils is detrimental to the plant. Another potential threat to this plant is the proliferation of exotic plant species around the edges of Lake Okeechobee (USFWS 1999). As a result, any alternative that increases the amount of time that lake stages are within the desired stage envelope will benefit the gourd. Therefore, all with-action alternatives are better than the FWO. Based on **Figure C.2-2** and **Figure C.2-3**, Alternative 2Cr is likely to provide the most benefits to the gourd, followed by Alternative 1Bshlw, then Alternative 1BW. Negative adverse effects to the gourd are not anticipated with any action alternative. Due to the changes in Lake Okeechobee stages and the increased amount of time that water levels are within the beneficial stage envelopes for the Recommended Plan, the USACE has determined that there may be slight beneficial effects to the Okeechobee gourd.

C.2.4.12 Gopher Tortoise

The gopher tortoise, an upland dwelling reptile, is currently listed as a candidate species in the Eastern U.S. by the USFWS (USFWS 2013). The gopher tortoise commonly occupies habitats with a well-drained sandy substrate, ample herbaceous vegetation for food, and sunlit areas for nesting. Many vertebrate and invertebrates species are known to seek refuge in gopher tortoise burrows, including protected species like the Eastern indigo snake and the Florida pine snake. All LOWRP alternatives include storage features that will convert uplands to deep-water or wetland habitat and wetland restoration sites that will convert uplands to wetlands. For all alternatives the majority of the current land use in the storage feature footprints is improved and unimproved pastures. **Table C.2-15** shows the amount of uplands and pastureland that will be converted to deep-water habitat or wetlands for each alternative. Gopher tortoises have a high probability of occurrence within all proposed storage feature and wetland restoration footprints and as a result of construction are likely to be displaced. Alt 1Bshlw would remove approximately 14,451 acres of potential habitat, Alt 1BW would remove approximately 13,913 acres of potential habitat, and Alt 2Cr would remove approximately 13,626 acres of potential habitat. Prior to construction, gopher tortoise surveys will be conducted and any tortoises will be relocated to minimize the impact of the project. As needed, the USACE will coordinate with the FWC on appropriate gopher tortoise impact avoidance, minimization, and/or mitigation measures. All with action alternatives may have unavoidable adverse effects.

C.2.4.13 Smalltooth Sawfish

All action alternatives have the potential to benefit the smalltooth sawfish by reducing excessive freshwater flows and improving the salinity regime throughout the Caloosahatchee estuary and provide minor beneficial effects. Discharging large volumes of freshwater from Lake Okeechobee to the Caloosahatchee River during the wet season significantly reduces salinities which has a profound adverse effect on estuarine flora and fauna. As a result, the smalltooth sawfish may benefit from the project's

ability to reduce excessive freshwater flows by improving the salinity regime throughout the Caloosahatchee estuary.

C.2.4.14 Green Sea Turtle

Although green sea turtles are expected to be found foraging in nearshore seagrass habitats within the St. Lucie estuary, the decreased freshwater flows associated with all action alternatives may alter seagrass species composition but should have a negligible and less than significant effect on the overall biomass available for sea turtle feeding habits. Additionally, no green sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the USACE has determined green sea turtle may be affected, but is not likely to be adversely affected, by the proposed project.

C.2.4.15 Leatherback Sea Turtle

Although leatherback sea turtles are expected to be found foraging in nearshore seagrass habitats within the St. Lucie estuary, the decreased freshwater flows associated with all action alternatives may alter seagrass species composition but should have a negligible and less than significant effect on the overall biomass available for sea turtle feeding habits. Additionally, no green sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the USACE has determined green sea turtle may be affected, but is not likely to be adversely affected, by the proposed project.

C.2.4.16 Kemp's Ridley Sea Turtle

Although Kemp's ridley sea turtles could be found foraging in nearshore habitats within the St. Lucie and Caloosahatchee estuaries, this species is not expected to be found within the direct area of influence associated with LOWRP. Additionally, no Kemp's ridley sea turtles would attempt to utilize areas for nesting purposes since their main nesting location is on a single stretch of beach on the Gulf Coast of Mexico. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the USACE has determined Kemp's ridley sea turtle may be affected, but would not likely be adversely affected, by the proposed project.

C.2.4.17 Loggerhead Sea Turtle

Although loggerhead sea turtles are expected to be found foraging in nearshore habitats within the St. Lucie and Caloosahatchee estuaries, the decreased freshwater flows associated with all action alternatives may increase nearshore salinity concentrations but should have a negligible and less than significant effect on crustaceans, mollusks or other invertebrate food sources utilized by this species. Additionally, no loggerhead sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea

Turtle and Smalltooth Sawfish Construction Conditions, the USACE has determined loggerhead sea turtle may be affected, but would not likely be adversely affected, by the proposed project.

C.2.4.18 Johnson's Seagrass

Johnson's seagrass (*Halophila johnsonii*) was listed as threatened under the Endangered Species Act (ESA) in 1998, and critical habitat was designated in 2000. The species has a very limited distribution along the east coast of Florida from central Biscayne Bay to Sebastian Inlet. All action alternatives have the potential to benefit Johnson's seagrass by reducing excessive freshwater flows and improving the salinity regime throughout the St. Lucie estuary and provide minor beneficial effects. Discharging large volumes of freshwater from Lake Okeechobee to the St. Lucie estuary during the wet season significantly reduces salinities which has a profound adverse effect on estuarine flora and fauna. As a result, the Johnson's seagrass may benefit from the project's ability to reduce excessive freshwater flows by improving the salinity regime throughout the St. Lucie estuary. All action alternatives have the potential to benefit Johnson's seagrass and its designated critical habitat in the St. Lucie inlet by reducing excessive freshwater flows and improving the salinity regime throughout the St. Lucie Estuary. Based on the information in **Table C.2-9**, Alt 1Bshlw and Alt 1BW provides the greatest reduction of high-flow events (reduced from 37 to 20 events compared to FWO), followed by 2Cr (reduced to 24 events). Negative adverse effects to Johnson's seagrass are not anticipated with any action alternative.

C.2.5 State-listed Species

The LOWRP project area contains habitat suitable for the presence, nesting, and/or foraging of 12 state-listed threatened species and 1 species of special concern. Threatened animal species include the American oystercatcher (*Haematopus palliatus*), black skimmer (*Rynchops niger*), least tern (*Sternula antillarum*), Florida burrowing owl (*Athene cunicularia*), Florida sandhill crane (*Grus canadensis pratensis*), little blue heron (*Egretta caerulea*), roseate spoonbill (*Platalea ajaja*), Southeastern American kestrel (*Falco sparverius paulus*), tricolored heron (*Egretta tricolor*), gopher tortoise (*Gopherus polyphemus*), Florida pine snake (*Pituophis melanoleucus mugitus*) and Big Cypress fox squirrel (*Sciurus niger avicennia*). The species of special concern is Sherman's fox squirrel (*Sciurus niger shermani*).

C.2.5.1 State-listed Beach-Nesting Birds (American oystercatcher, black skimmer, least tern)

The state listed beach-nesting birds include the American oystercatcher (*Haematopus palliatus*), black skimmer (*Rynchops niger*) and least tern (*Sternula antillarum*). These species nest directly in sand, shell, or small gravel in coastal areas, in shallow scrapes in sand, shell, or gravel along the coast, near bodies of fresh water and occasionally on flat, gravel-covered rooftops. Threats to these species include habitat loss and degradation, largely due to coastal development and incompatible recreational use, disturbance during breeding, causing nest failure and resulting in loss of eggs and/or chicks, changes to water quality that impact bivalves (e.g., turbidity, depth, and temperature) and predation that is magnified by human disturbance. All LOWRP action alternatives show a slight performance improvement within the Northern Estuaries as indicated by fewer high volume flow months, providing a minor beneficial effect to beach-nesting birds. Reduction in high flows and accompanying flow velocities would result in reductions in salinity fluctuations, lower suspended solid loading, and decreased concentration of colored dissolved organic matter and would likely benefit the bivalves, small fish, and other prey items within the estuaries.

C.2.5.2 Burrowing Owl

The burrowing owl occurs throughout the state although its distribution is considered spotty. The presence of burrowing owls is primarily dependent upon habitat. Burrowing owls inhabit open native prairies and cleared areas that offer short groundcover including pastures, agricultural fields, golf courses, airports, and vacant lots in residential areas. All LOWRP alternatives include storage features that will convert uplands to deep-water or wetland habitat and wetland restoration sites that will convert uplands to wetlands. For all alternatives the majority of the current land use in the storage feature and wetland restoration footprints are improved and unimproved pastures. **Table C.2-15** shows the amount of uplands and pastureland that will be converted to deep-water habitat or wetlands for each alternative. Florida burrowing owls have a high probability of occurrence within all proposed storage features and wetland restoration footprints and as a result of construction are likely to be displaced. Alt 1Bshlw would remove approximately 14,451 acres of potential habitat, Alt 1BW would remove approximately 13,913 acres of potential habitat, and Alt 2Cr would remove approximately 13,626 acres of potential habitat. The USACE will coordinate with the Florida Fish and Wildlife Conservation Commission (FWC) on mitigation measures as well as a secure a permit for relocation. Prior to construction, burrowing owl surveys will be conducted and if burrows are found will be relocated to minimize the impact of the project. All action alternatives may have an unavoidable adverse effect. As needed, the USACE will coordinate with the FWC on appropriate burrowing owl impact avoidance, minimization, and/or mitigation measures.

C.2.5.3 Florida Sandhill Crane

Florida sandhill cranes are non-migratory and inhabit prairies, improved pastures, and freshwater marshes. They occur throughout peninsular Florida north to the Okefenokee Swamp in southern Georgia. Degradation or direct loss of habitat due to wetland drainage or conversion of prairie for development or agricultural use is the primary threat that they face. All LOWRP alternatives include storage features that will convert uplands to deep-water or wetland habitat and wetland restoration sites that will convert uplands to wetlands. For all alternatives, the majority of the current land use in the storage features and wetland restoration footprints are improved and unimproved pastures. **Table C.2-15** shows the amount of uplands and pastureland that will be converted to deep-water habitat or wetlands for each alternative. Florida sandhill cranes may occur within all proposed storage features and wetland restoration footprints and as a result of construction may be displaced from storage features and to a lesser extent from wetlands. Alt 1Bshlw would remove approximately 14,451 acres of potential habitat, Alt 1BW would remove approximately 13,913 acres of potential habitat, and Alt 2Cr would remove approximately 13,626 acres of potential habitat. All alternatives restore 5,279 acres of wetlands along the Kissimmee River floodplain. Alternative 1BW has the largest net gain of wetlands at 9,911 acres, followed by Alt 1Bshlw with a net gain of 4,221 acres and then Alt 2Cr with a net gain of 2,728 acres of wetlands (**Table C.2-5**). All alternatives provide a benefit to the Florida sandhill crane. Prior to construction, Florida sandhill crane surveys will be conducted. As needed, the USACE will coordinate with the FWC on appropriate Florida sandhill crane impact avoidance, minimization, and/or mitigation measures.

C.2.5.4 State-listed Wading Birds (little blue heron, roseate spoonbill, tricolored heron)

The state-listed wading bird species in the project area include the little blue heron (*Egretta caerulea*), roseate spoonbill (*Platalea ajaja*), and tricolored heron (*Egretta tricolor*). Implementation of all action alternatives would be expected to significantly improve conditions for wading birds throughout much of the project area. Rehydration and vegetation shifts within the Lake Okeechobee Watershed and lake levels are likely to increase the spatial extent of suitable foraging opportunities and nesting habitat for

wading birds provides a moderate beneficial effect. Minor beneficial effects to vegetation within Lake Okeechobee's extensive littoral zone are anticipated as a result of any of the alternatives. These ecological benefits are a result of the small increase in amount of time within the beneficial stage envelope and less time in the extremely low stages (<10 ft. NGVD) and above the stage envelope for any of the alternatives compared to the FWO (**Figure C.2-2** to **Figure C.2-4**). This increase in time in the beneficial stage envelope improves the foraging habitat in Lake Okeechobee for wading birds. Conversely, also as compared with FWO, all LOWRP action alternatives reveal the potential for short-term minor adverse effects to the ecological indicators and littoral and nearshore aquatic vegetation due to a slight increase in the amount of time that lake stages in the extremely high stages (>17 ft. NGVD) might occur (**Figure C.2-5**).

All alternatives restore 5,279 acres of wetlands along the Kissimmee River floodplain. Alternative 1BW has the largest net gain of wetlands at 9,911 acres, followed by Alt 1Bshlw with a net gain of 4,221 acres and then Alt 2Cr with a net gain of 2,728 acres of wetlands. All alternatives significantly increase the spatial extent of suitable foraging opportunities and nesting habitat for wading birds (**Table C.2-5**).

C.2.5.5 Southeastern American Kestrel

The southeastern American kestrel (*Falco sparverius paulus*) is a non-migratory subspecies of the American kestrel closely tied to sandhills in the southeastern U.S with preferred habitat consisting of open fields, grasslands, savannahs, or other habitats that contain widely scattered trees or similar perches. Population declines of southeastern American kestrels in Florida have been largely attributed to clearing of older pine forests and conversion of sandhill and other upland habitats for agriculture and urban development. Kestrels are secondary cavity nesters, and suitable nest sites can be a limiting factor for kestrel populations (Smallwood and Collopy 2009). All LOWRP alternatives include storage features that will convert uplands to deep-water or wetland habitat and wetland restoration sites that will convert uplands to wetlands. For all alternatives the majority of the current land uses in the storage feature footprints are improved and unimproved pastures. **Table C.2-15** shows the amount of uplands and pastureland that will be converted to deep-water habitat or wetlands for each alternative. Southeastern American kestrels have a high probability of occurrence within all proposed storage feature and wetland restoration footprints and as a result of construction are likely to be displaced and nesting sites lost. Alt 1Bshlw would remove approximately 14,451 acres of potential habitat, Alt 1BW would remove approximately 13,319 acres of potential habitat and Alt 2Cr would remove approximately 13,626 acres of potential habitat. All alternatives may have an unavoidable adverse effect. Prior to construction, southeastern American kestrel surveys will be conducted. As needed, the USACE will coordinate with the FWC on appropriate southeastern American kestrel impact avoidance, minimization, and/or mitigation measures.

C.2.5.6 Florida Pine Snake

The Florida pine snake (*Pituophis melanoleucus mugitus*) is found in the project area and prefers habitats with well-drained, sandy soils and moderate to open canopy cover (Franz 1992, Ernst and Ernst 2003). The most common natural habitat of pine snakes in Florida is sandhill, but they also are found in scrub, xeric hammock, scrubby flatwoods, and mesic pine flatwoods and dry prairie with dry soils (Allen and Neill 1952, Enge 1997, Franz 2005). Florida pine snakes are fossorial, spending ca. 80% of their time in underground retreats, primarily burrows of the southeastern pocket gopher (Geomys pinetis) (Franz 2005, Miller 2008) as well as other retreats such as stumpholes, mole runs, and burrows of gopher tortoises (Gopherus polyphemus), nine banded armadillos (Dasypus novemcinctus), and mice (Franz 2005, Miller 2008). All LOWRP alternatives include storage features that will convert uplands to deep-water or wetland

habitat and wetland restoration sites that will convert uplands to wetlands. For all alternatives the majority of the current land use in the storage feature footprints are improved and unimproved pastures. **Table C.2-15** shows the amount of uplands and pastureland that will be converted to deep-water habitat or wetlands for each alternative. Florida pine snakes have a high probability of occurrence within all proposed storage feature and wetland restoration footprints and as a result of construction are likely to be displaced. Alt 1Bshlw would remove approximately 14,451 acres of potential habitat, Alt 1BW would remove approximately 13,913 acres of potential habitat, and Alt 2Cr would remove approximately 13,626 acres of potential habitat. Prior to construction, Florida pine snake surveys will be conducted. As needed, the USACE will coordinate with the FWC on appropriate Florida pine snake impact avoidance, minimization, and/or mitigation measures.

C.2.5.7 Big Cypress Fox Squirrel

Big Cypress fox squirrels (*Sciurus niger avicennia*) are large tree squirrels and are a primarily ground-dwelling species that inhabits stands of cypress, slash pine savanna, mangrove swamps, tropical hardwood forests, live oak woods, coastal broadleaf evergreen hammocks, and suburban habitats including golf courses, city parks, and residential areas (Hafner et al. 1998; Humphrey and Jodice 1992; Jansen 2008; Munim et al. 2007; Williams and Humprey 1979). Optimum habitat for S. n. avicennia includes an open understory free of bushes and undergrowth (Brown 1978 as cited in Hafner et al. 1998). All LOWRP alternatives include storage features that will convert uplands to deep-water or wetland habitat and wetland restoration sites that will convert uplands to wetlands. For all alternatives the majority of the current land use in the storage feature and wetland restoration footprints are improved and unimproved pastures. **Table C.2-15** shows the amount of uplands and pastureland that will be converted to deep-water habitat or wetlands for each alternative. The Big Cypress fox squirrel may occur within all proposed storage feature and wetland restoration footprints and as a result of construction are likely to be displaced. Alt 1Bshlw would remove approximately 14,451 acres of potential habitat, Alt 1BW would remove approximately 13,913 acres of potential habitat, and Alt 2Cr would remove approximately 13,626 acres of potential habitat. Prior to construction, Big Cypress fox squirrel surveys will be conducted. As needed, the USACE will coordinate with the FWC on appropriate Big Cypress fox squirrel impact avoidance, minimization, and/or mitigation measures.

C.2.5.8 Sherman's Fox Squirrel

Sherman's fox squirrel is a species of special concern and are large tree squirrels that inhabit mature, open, fire-maintained longleaf pine (*Pinus palustrus*) - turkey oak (*Quercus laevis*) sandhills and flatwooods. To accommodate the large home ranges and fluctuating food resources, suitable habitat also includes more productive lower slopes of sandhills (Kantola 1992). This species also inhabits mixed hardwood pine, mature pine forests, cypress domes, pastures, the ecotone between bayheads and pine flatwoods, and other open habitats with pines and oaks (summarized in Endries et al. 2009; Florida Natural Areas Inventory 2001). All LOWRP alternatives include storage features that will convert uplands to deep-water habitat and wetland restoration sites that will convert uplands to wetlands. For all alternatives the majority of the current land use in the storage feature and wetland restoration footprints are improved and unimproved pastures. **Table C.2-15** shows the amount of uplands and pastureland that will be converted to deep-water habitat or wetlands for each alternative. Sherman's fox squirrel may occur within all proposed storage feature and wetland restoration footprints and as a result of construction are likely to be displaced. Alt 1Bshlw would remove approximately 14,451 acres of potential habitat, Alt 1BW would remove approximately 13,913 acres of potential habitat, and Alt 2Cr would remove approximately 13,626 acres of potential habitat. Prior to construction, Sherman's fox squirrel surveys will be conducted. As

needed, the USACE will coordinate with the FWC on appropriate Sherman's fox squirrel impact avoidance, minimization, and/or mitigation measures.

C.2.6 Fish and Wildlife

A comparison of the FWO and LOWRP action alternatives and their potential effects on fish and wildlife within the LOWRP action area are summarized below. Effects to state and federally listed species are described in further detail in **subsection C.2.4** and in **Annex A**. Implementation of LOWRP action alternatives would benefit most fish and wildlife resources within the LOWRP project area. These benefits are described in greater detail in the sections below.

C.2.6.1 Invertebrates

Within the Lake Okeechobee Watershed and restored wetlands, invertebrates would rapidly colonize newly created and restored aquatic habitat with implementation of any LOWRP action alternative providing a moderate beneficial effect, directly benefitting invertebrates within the action area. Increases in stages and hydroperiods within the restored wetlands would promote wetland vegetation transition through contraction of marshes and expansion of wet prairies, and in deeper regions, sloughs. In Alt 1BW, approximately 12,500 acres of a WAF will provide emergent vegetation that will provide habitat for a diverse population of invertebrates and provide major beneficial effects to the aquatic community on the watershed. Within the storage feature footprints of Alternatives 1Bshlw and 2Cr a diverse population of invertebrates is not expected, due largely to a lack of emergent vegetation and water level fluctuations.

The intakes for the storage features as well as the ASR wells may cause the entrainment and impingement of aquatic invertebrates during operation. See **subsection C.2.6.2**for the analysis of "with-project" effects on aquatic invertebrates and fish.

Minor beneficial effects to the aquatic invertebrate community within Lake Okeechobee are anticipated under any LOWRP action alternative. All alternatives increase emergent and submerged aquatic vegetation which provides a beneficial effect to invertebrate habitat. Due to the increased potential habitat, the invertebrate diversity and abundance is expected to increase in the pelagic, nearshore and littoral zones.

As compared with the FWO, all LOWRP action alternatives show a minor beneficial effect with performance improvement within the Northern Estuaries as indicated by fewer high volume flow months. Reductions in high volume flows and salinity fluctuations would likely benefit oysters and other associated invertebrates (e.g., crabs, shrimp, snails, sea stars) within the Northern Estuaries. Reduction in high flows and accompanying flow velocities would help lessen the current problem of flushing of oyster spat into outer areas of the Northern Estuaries that experience high salinities levels during the dry season resulting in increased predation and disease in the oyster population.

C.2.6.2 Fish

Fish are found within the Lake Okeechobee watershed, Lake Okeechobee itself and in the Northern Estuaries.

C.2.6.2.1 Lake Okeechobee Watershed

The construction of a storage features, seepage canals, and perimeter canals may provide some deepwater refugia and/or littoral habitat for use by fish and amphibian species when the storage feature is drawn down. Alternative 1BW contains a WAF that will be operated for storage and wetland habitat, Therefore, the deeper natural sloughs in the footprint will remain hydrated creating a refugia for fish during drier times providing a major beneficial effect in the watershed. The operational plan for the aboveground storage in Alternatives 1Bshlw and 1BW, in order to meet the project objectives, constrains the ability of the project site (either storage feature or seepage canal) to be optimized for management as habitat for fish and wildlife. Small areas of existing open water habitat (i.e., deeper than natural wetlands) would be lost under the storage feature construction footprint. Once the storage feature is filled, aquatic (open water) habitat will substantially increase. The reservoir is Alt 1Bshlw will be approximately13,000 acres, the WAF in Alt 1BW will be approximately12,500 acres and the reservoir in Alt 2Cr will be approximately14,600 acres. The open water storage features will likely harbor fish typical of nearby canals. Water would be conveyed to the storage features by these canals which also act as conduits for the introduction of many aquatic organisms, including fish. Due to the operation of the pumps there will likely be some entrainment and impingement of fish and other aquatic organisms. Some of these organisms may survive the pumping process, others may be killed or disoriented enough that they become easy prey for other animals inside the storage features (wading birds, alligators, turtles, or other fish). Species that will likely inhabit the storage features include: largemouth bass, black crappie, gar, red ear sunfish, bluegill, and mosquitofish, among others including exotic species such as armored catfish and cichlids. Shallow water fish bedding and rearing habitat will be limited to the margins of the reservoirs in Alternatives 1Bshlw and 2Cr. The design of the seepage canal, however, includes littoral areas for fish and wildlife use.

Storage-assisted ASR wells will recharge from, and recover into, the shallow storage features of Alternatives 1 Bshlw and 1BW. Watershed ASR systems will have site-specific intake and outflow structures. Because watershed ASR systems are associated with canals, it is likely that the ecological impacts from recharge and recovery will not be significant. Pump stations located on or near the Kissimmee River have the potential to impact fish and aquatic invertebrates through entrainment and impingement. The larval and post-larval stages of black crappie (*Pomoxis nigromaculatus*) are especially at risk because after the channelization of the Kissimmee River, C-38 South of S-65E became a favorite spawning location for this species. The typical spawning period for black crappie at this location occurs from January through May. Adults prefer to nest in colonies in shallow water near aquatic vegetation. A few days after hatching, post-larvae disperse from the nest area and eventually move to deeper water near the middle of the channel. Fry move vertically throughout the water column primarily to forage on other planktonic species and secondarily to avoid predation. They follow the currents downstream into Lake Okeechobee. The black crappie spawning requirements increase the likelihood that in the lower Kissimmee River, which is contiguous with Lake Okeechobee, nest sites will be near intakes (assuming that these structures will also be near or on the stream bank). The larval and post-larval stages are poor swimmers and would be unable to escape intake velocities (0.25 ft./sec) once drawn into the water intake flow-field. This is important to note not only for those fish hatching near the shoreline, but also for those that may be drifting down from upstream spawning locations (including open-water spawners like threadfin or gizzard shad). Shad entrainment and impingement has been a major concern with many water withdrawal systems because shad are the primary forage food for many predators, and locally are nearly the sole food source of adult black crappie (FWC 2017). Many other species of fish spawn during the same period as black crappie (**Table C.2-16**) and they could experience similar effects and have similar

risks. For those species that spawn in the summer (shiners) or fall (some sunfishes, *Lepomis* species) the predicted effect may be similar to speckled perch.

Table C.2-16. Spawning months for critical species in the lower Kissimmee River (FWC 2017).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Black crappie	X	X	X	X	X	-	-	-	-	-	-	-
Sunfish species	-		X	X	X	X	X	X	X	-	-	-
Threadfin and Gizzard Shad	X	X	X	X	X	X	X	X	X	-	-	-
Shiners	-	-	X	X	X	X	X	X	-	-	-	-

Figure C.2-25 shows the potential risks to fisheries in the Lake Okeechobee watershed. **Table C.2-17** denotes the specific canal and waterbody locations and the associated risk. The highest risk areas (red) are in the lower Kissimmee River, south of S-65E, is contiguous with Lake Okeechobee and is a critical spawning area for black crappie and several sunfishes (**Figure C.2-25**). Moderate risk areas (yellow) are further from the critical fish spawning areas and are located along the rim canal (**Figure C.2-25**). The lowest risk areas are furthest from the critical fish spawning areas and do not have a direct connection to Lake Okeechobee and are located above S-65E (**Figure C.2-25**).

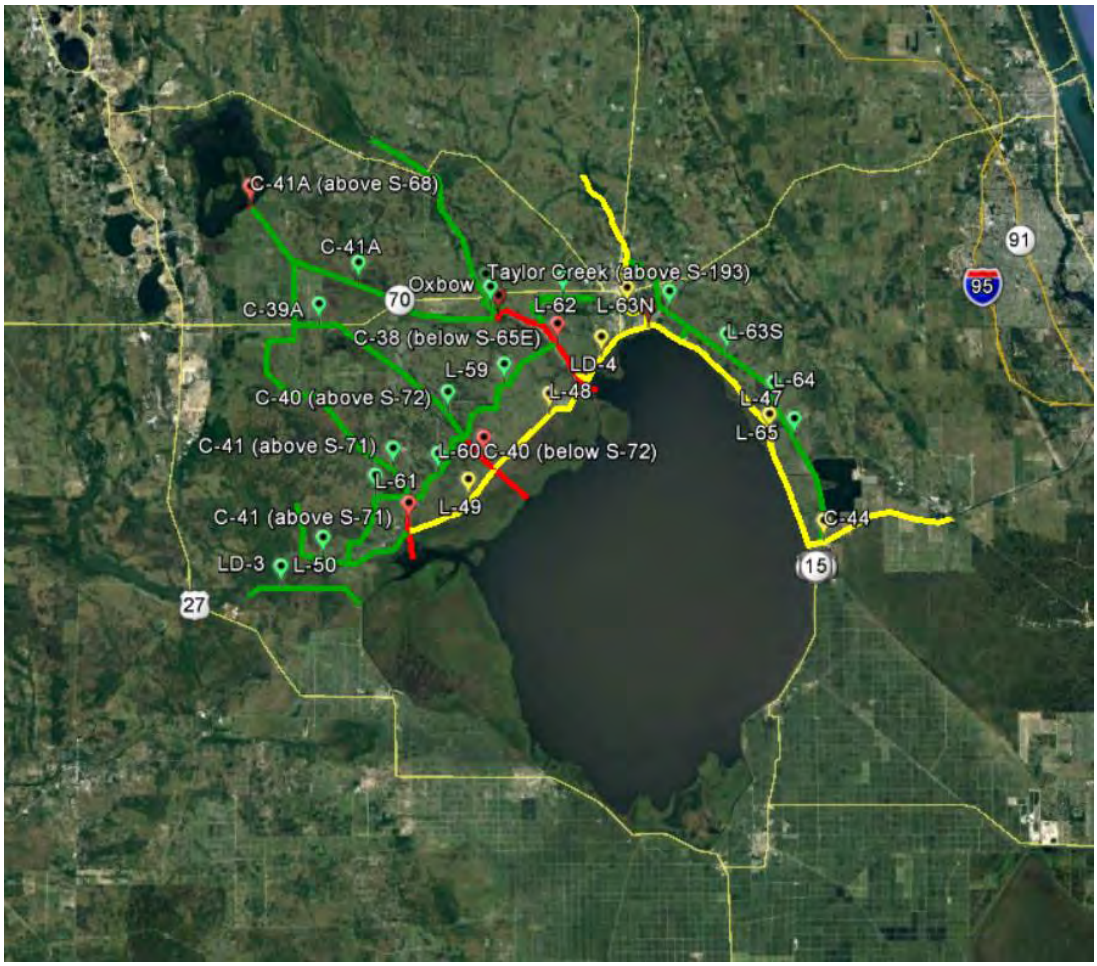

Figure C.2-25. Risk level associated with entrainment and entrapment for different canal segments in the Lake Okeechobee watershed. Red canal segments are the highest risk category, yellow moderate, and green have the lowest risk (FWC 2017).

Table C.2-17. Risk of entrainment and entrapment of fish and aquatic invertebrates during operation of storage features and ASR in the Lake Okeechobee watershed (FWC 2017).

Waterbody or Canal Segment	Risk to Fisheries
C-38 (below S-65E; lower Kissimmee River) C-41A (below S-84) C-41A (above S-68) C-40 (below S-72) C-41 (below S-71) Taylor Creek (below S-193)	**Highest Risk (red)**
LD-4 (Rim Canal North) L-48 and L-49 (Rim Canal West) C-44 Taylor Creek (above S-193) L-47 (Rim Canal East)	**Moderate Risk (yellow)**

Waterbody or Canal Segment	Risk to Fisheries
C-38 (above S-65E) C-41A L-62 L-59, L-60 and L-61 C-40 (above S-72) C-41 (above S-71) C-39A L-50 LD-3 L-63N L-63S L-64 and L-65	**Lowest Risk (green)**

C.2.6.2.1.1 ASR Wells

There are eight tentative locations for ASR fields (**Figure C.2-26**). The number of ASR wells in each location has not been determined. The following is numbered from west to east. (Lake O) indicates a connection in a canal downstream of any structures, which effectively draws water from Lake Okeechobee.

1. ASRs C-41: Intakes on the C-41 canal downstream of S-71 (Lake O), FWC High Risk.
2. ASRs C-40: Intakes on the C-40 canal downstream of S-72 (Lake O), FWC High Risk.
3. ASRs C-38 North Field: Intakes on the C-38 canal downstream of S-65E (Lake O), FWC High Risk-recharge and rec over into/from the WAF – reduces risk to fishery
4. ASRs C-38 South Field: Intakes on the C-38 canal downstream of S-65E (Lake O), FWC High Risk - recharge and rec over into/from the WAF – reduces risk to fishery
5. ASRs L-63N: Intakes on the L-63N canal. There are no structures in L-63N. It connects downstream with C-59. S-191 is on C-59 upstream of Lake O, FWC Low Risk.
6. ASRs Taylor Creek: Intakes on Taylor Creek downstream of S-192 and upstream of S-193, which connects to Lake O, FWC Moderate Risk.
7. ASRs Nubbin Slough: Intakes on Nubbin Slough upstream of the L-63N/L-63S/C-59 confluence. There are no structures in Nubbin Slough, FWC Low Risk.
8. ASRs L-64: Intakes on the L-64 canal. There are no structures in L-64. It connects with L-63S to the north and L-65 to the south. S-153 is on L-65 south of L-64 and connects L-65 with C-44, FWC Low Risk.

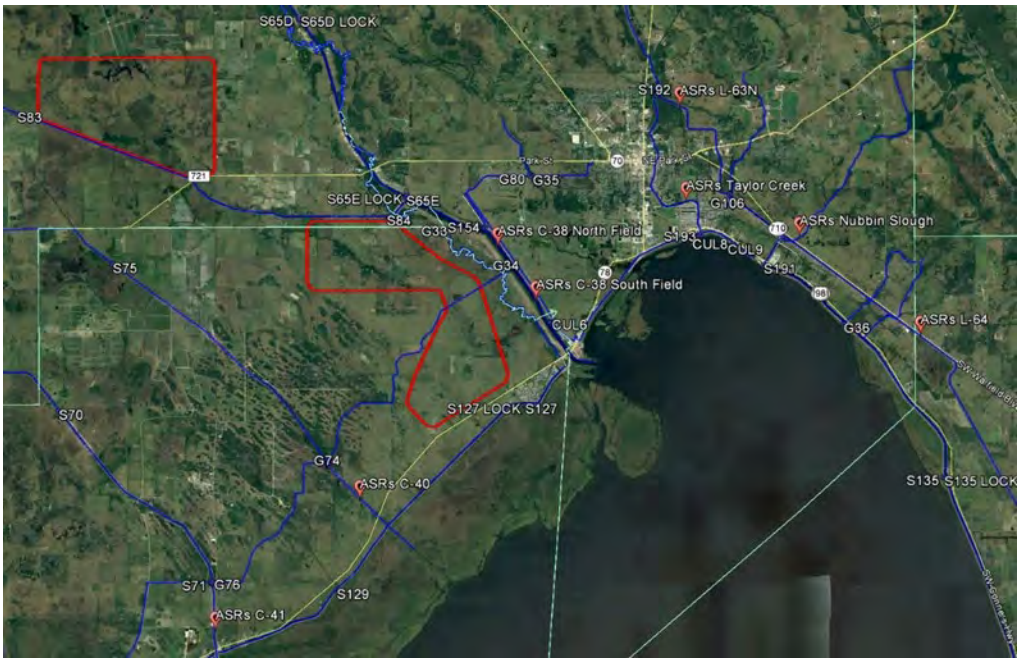

Figure C.2-26. Location of the eight tentative ASR fields.

While each alternative has high risk ASR locations (**Table C.2-18**) and some high-risk storage feature locations (**Table C.2-19**), those are also the locations that have the water availability for the storage features and ASR wells. After consultation with FWC on a site visit, it was determined that within the stretch between S-84 and S-65E is a lesser "high risk" of all because the two drops produce turbulence that fish do not like.

Table C.2-18. FWC fisheries risk at the eight tentative ASR fields and the ASR fields included in each LOWRP alternative (red = highest risk category, yellow = moderate risk, and green= lowest risk).

Alternative	ASRs C-41	ASRs C-40	ASRs C-38 North Field	ASRs C-38 South Field	ASRs L-63N	ASRs Taylor Creek	ASRs Nubbin Slough	ASRs L-64
1Bshlw (80 ASRs)	X (red)	X (red)	X (red)	X (red)	X (green)	X (yellow)	X (green)	N/A
1BW (80 ASRs)	X (red)	X (red)	X (red)	X (red)	X (green)	X (yellow)	X (green)	X (green)
2Cr (65 ASRs)	X (red)	X (red)	X (red)	X (red)	X (green)	X (yellow)	X (green)	X (green)

Table C.2-19. FWC fisheries risk for the storage features included in each LOWRP alternative.

Alternative	K-05 North and South	K-42 Revised
1Bshlw	X (red)	NA
1BW	X (red)	NA
2Cr	NA	X (green)

C.2.6.2.1.2 Alternative 1Bshlw and Alternative 1BW

Alternatives 1Bshlw and 1BW contain the K-05 reservoir or WAF that has an intake on the C-41A canal downstream of S-84 with uncontrolled access to the C-38 canal downstream of S-65E which is considered by FWC to be high risk for fisheries (**Figure C.2-25**, **Figure C.2-27**, **Figure C.2-28**, and **Table C.2-17**). Alternatives 1Bshlw and 1BW have 80 ASR wells with intakes listed in **Table C.2-18** in the high-, moderate-, and low-risk areas.

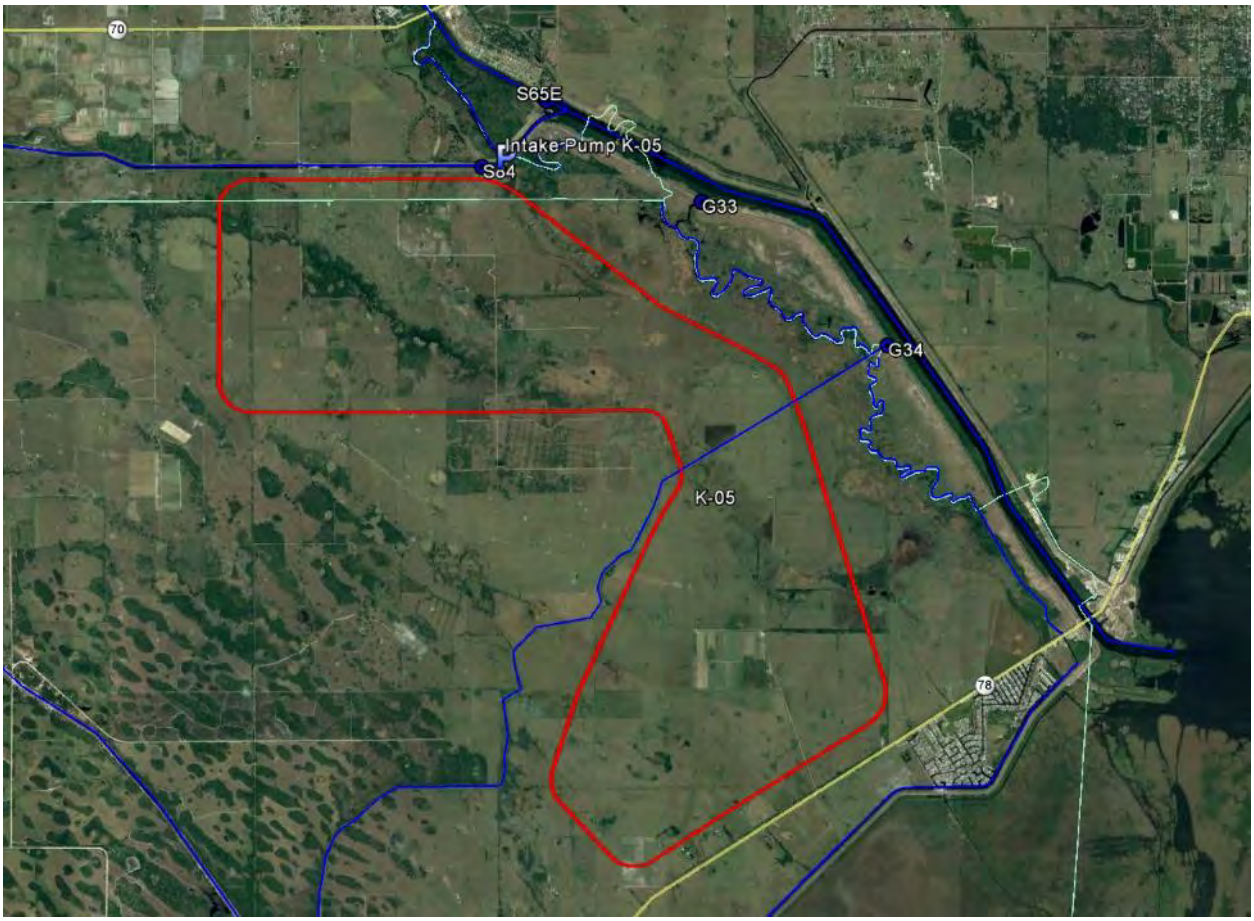

Figure C.2-27. Intake on the reservoir in Alternative 1Bshlw.

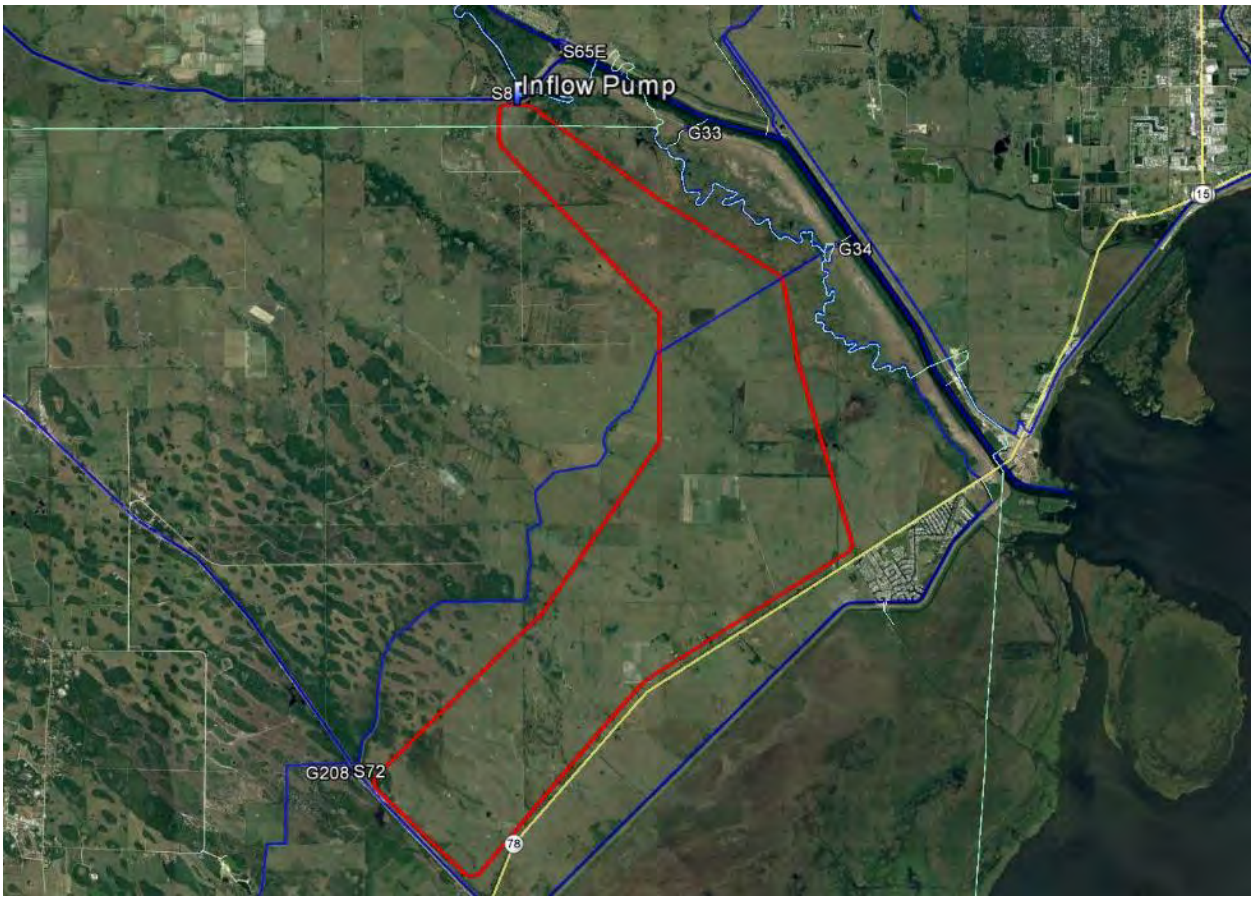

Figure C.2-28. Intake on the storage feature in Alternative 1BW.

C.2.6.2.1.3 Alternative 2Cr

Alternative 2Cr contains the K-42 Revised reservoir with intake on the C-41A canal downstream of S-84 with uncontrolled access to the C-38 canal downstream of S-65E and with additional intake pump in the C-41A canal to pump into the reservoir (**Figure C.2-29**). The K-42 Revised reservoir is considered to be low risk to fisheries (**Table C.2-19**). Alternative 2Cr has 65 ASR wells with intakes listed in **Table C.2-18** in the high-, moderate-, and low-risk areas.

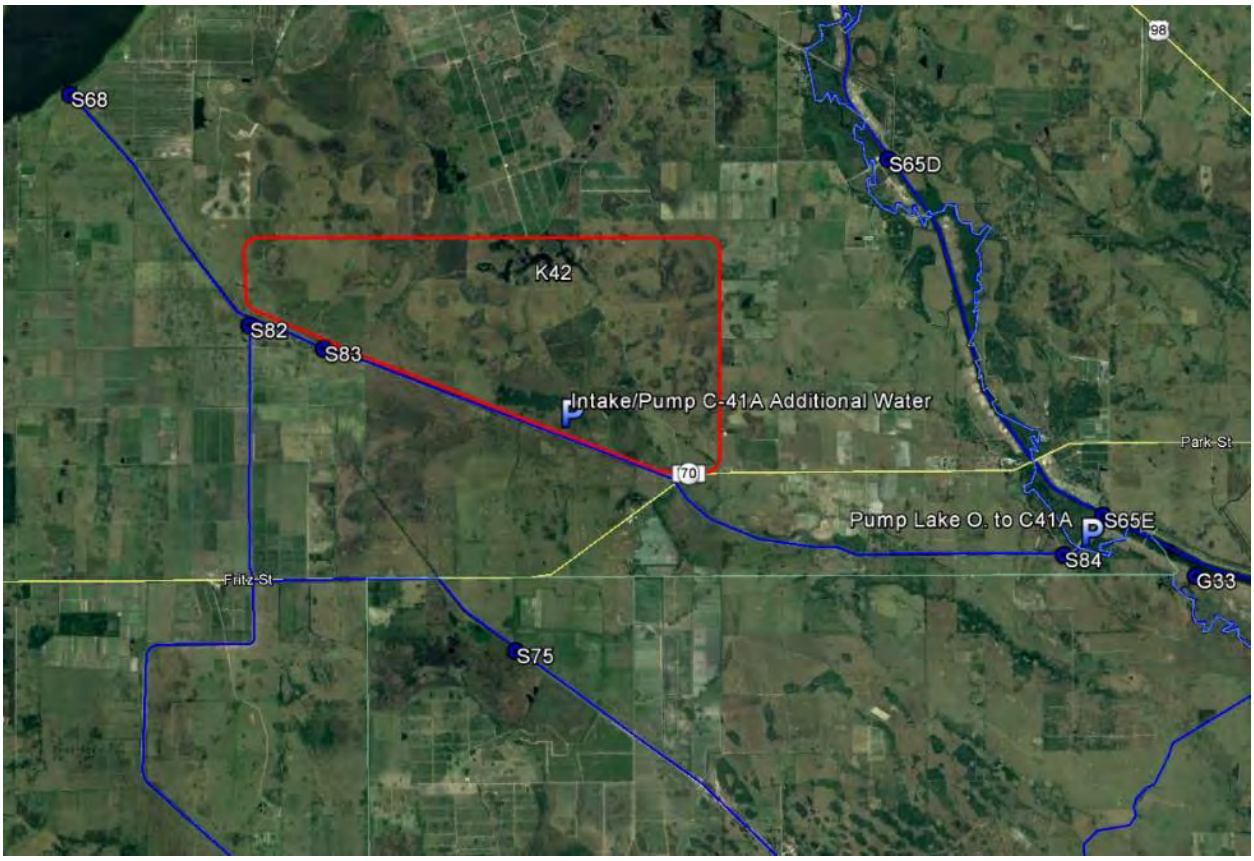

Figure C.2-29. Intake on the K-42 Revised reservoir in Alternative 2Cr.

All alternatives may have a significant impact on the entrainment and impingement of fish and aquatic invertebrates if they operate at times of the year when these organisms are present in the surface water. All alternatives have ASR wells that are in areas that have been identified by FWC as high risk for larval fish entrainment and impingement. Alternative 2Cr has the fewest ASR wells with 65 and thus will have the lowest impact on fisheries due to ASR wells. Both Alt 1Bshlw and 1BW have 80 ASR wells (**Table C.2-18**). To minimize the impact, where ASR wells will be co-located with storage features, the ASR pumps pull water from the storage features and not the canals to minimize the entrainment and impingement of fish and invertebrates. In locations where the ASR wells will pull directly from canals, the intake will be designed to limit impingement and entrainment by installing screens with a pore size of 1 mm and an anticipated intake velocity at the screen face of 0.25 ft./sec. with screen setting depth below the zones that fish larvae inhabit and/or installing a wildlife exclusion barrier curtain. Alternative 2Cr has the lowest reservoir impact to fisheries due to the intake of the K-42 revised reservoir (**Table C.2-19**). Alternatives 1Bshlw and 1BW have the potential to significantly impact the fisheries due to high-risk location of the intake pump for any of the K-05 storage features. As with the ASR locations, the intake pumps will be designed to limit impingement and entrainment by installing screens with a pore size of 1mm and an anticipated intake velocity at the screen face of 0.25 ft./sec. or installing a wildlife exclusion barrier curtain. Also, the impact may be limited due to the fact that the stretch between S-84 and S-65E is a lesser "high risk" because the two drops produce turbulence that fish do not like. The USACE will continue to coordinate with FWC to minimize risks. During PED, the USACE will look to minimize risks by considering installing gravity flow intake systems at C-41A and upstream of S-65E to feed into the northern boundary of the K-05 storage feature; determine storage feature and well intake operations based on results from

the potential risk assessment and population studies; consider installing in-bank filtration system adjacent to the Kissimmee River to minimize the risk to fisheries and recreation; consider installing more than one intake system for each storage feature or well to reduce intake velocities and the size of the intake cone; and consider using storage feature water and collocating with facilities with planned storage features.

C.2.6.2.2 Lake Okeechobee

All alternatives will help improve conditions for fish in Lake Okeechobee by increasing the amount of time water levels are in the beneficial stage envelope. Alternative 2Cr performs the best for keeping the lake in the beneficial stage envelope, followed by Alt 1Bshlw and then Alt 1BW (**Figure C.2-2** and **Figure C.2-3**). The same performance of the alternatives occurs for the extreme low lake stage (**Figure C.2-4**). The increase in time in the beneficial stage envelope will help to increase the emergent and submerged aquatic vegetation habitat that the fish use in the nearshore and littoral zones. An increase in invertebrate and plankton populations and diversity will also benefit fish in the lake as an increased food source. The ecological indicator performance measure combined scores indicate that some ecological benefits are anticipated to occur under any of the alternatives (**Figure C.2-6**). Alternative 2Cr scored the highest while Alt1Bshlw scored the lowest for the alternatives, although they all scored higher than the FWO scenario (**Table C.2-7**). The individual ecological PM POR scores indicate that the panfish community will improve in abundance for all alternatives, with Alt 2Cr scoring the highest and Alt 1Bshlw scoring the lowest (**Table C.2-7**).

C.2.6.2.3 Northern Estuaries

All action alternatives improve conditions for estuarine and marine resources throughout the Northern Estuaries by restoring more natural timing, volume, and duration of freshwater flows to the Caloosahatchee and St. Lucie estuaries, providing minor beneficial effects for the fish. In the Caloosahatchee Estuary, for high flow events, all LOWRP action alternatives performed better than the FWO having fewer months where flows were greater than 2800 cfs. Alternatives 1Bshlw has 10 fewer months of high flows than the FWO, Alt 1BW has 7 fewer months and Alt 2Cr has 6 fewer months of high flows than the FWO. The model output shows that of the number of months flow > 2800 cfs from the C-43 Basin and Lake Okeechobee regulatory flows, 47 of those months are a results of basin runoff. Therefore, flows greater than 2800 cfs from direct Lake Okeechobee flows go from 23 in the FWO to 13 in Alt 1Bshlw, 16 in Alt 1BW and 17 in Alt 2Cr (**Table C.2-8**). For extreme high-flow events (mean monthly flow > 4500 cfs), all alternatives perform better than the FWO that had 30 months where the mean monthly flow was greater than 4500 cfs. The number of mean monthly flows greater than 4500 cfs were reduced to 25 for Alt 1BW, 26 for Alt 1Bshlw, and 27 for Alt 2Cr (**Figure C.2-9**). All alternatives provide minor beneficial effects in the reduction of high flows and the duration of high flow events into the Caloosahatchee Estuary which are beneficial to the fish in the estuaries. In the St. Lucie Estuary, Alternatives 1Bshlw and 1BW provide the greatest reduction of high flow events (20 times flow is greater than 2000 cfs from Lake Okeechobee flows compared to 37 in the FWO), followed by Alt 2Cr with 24 times (**Figure C.2-10**). All alternatives provide significant beneficial effects for the reduction of high flow events and the duration of the high flow events which are beneficial for the fisheries in the estuaries.

C.2.6.3 Amphibians and Reptiles

The construction of a storage feature and seepage canal may provide some deepwater refugia and/or littoral habitat for use by fish and amphibian species when the storage feature is drawn down. The operational plan for the storage feature, in order to meet the project objectives, constrains the ability of

the project site (either storage feature or seepage canal) to be optimized for management as habitat for fish and wildlife, except in Alt 1BW with the WAF.

Amphibians and aquatic reptiles including frogs, turtles, snakes, and alligators will likely inhabit the reservoirs in alternatives 1Bshlw and 2Cr with minor beneficial effects to amphibian and reptile communities anticipated. Alternative 1BW will provide additional wetland habitat for amphibians and reptiles and provide major beneficial effects. Rehydration within previously dry areas within the watershed would increase spatial extent of suitable habitat for aquatic amphibian species in this area. Increase in forage prey availability (e.g., crayfish and other invertebrates, fish) in areas rehydrated by LOWRP implementation will also directly benefit amphibian and reptiles species. There would also be a loss of habitat within reservoir footprints for upland herps (e.g., toads, certain snakes, and box turtle), and through wetland conversion (i.e., for tree frogs or other aquatic/semi-aquatic herps). Alt 1Bshlw would remove approximately 14,451 acres of potential habitat, Alt 1BW would remove approximately 13,913 acres of potential habitat, and Alt 2Cr would remove approximately 13,626 acres of potential habitat.

Submerged aquatic vegetation and algal communities are also common foraging areas for the green sea turtle. Reductions in high flow events within the Northern Estuaries reduce stress on SAV and promote increases in seagrass shoots that have the potential to increase foraging opportunities for green sea turtles in this region.

C.2.6.4 Birds

The freshwater wetlands of the Everglades are noted for their abundance and diversity of colonial wading birds. Implementation of Alternatives 1Bshlw and 2Cr are anticipated to show a moderate beneficial effect on nesting and foraging activities of resident bird species, while the WAF of Alt 1BW is anticipated to show a major beneficial effect on nesting and foraging activities of resident bird species. All alternatives will benefit wading birds by increasing foraging and nesting habitat in the wetland sites. Impacts to the grasshopper sparrow, snail kite, and wood stork are further discussed in **subsection C.2.4** and in **Annex A**. Ducks may also use the reservoirs, but the emergent vegetation associated with the WAF will increase the habitat value over the reservoirs in Alternatives 1BShlw and 2Cr. The reservoirs in 1Bshlw and 2Cr may create foraging habitat for osprey, bald eagle, terns, cormorant, and other aquatic birds that feed on fish, and the WAF in 1BW is expected to provide significant foraging habitat. Forested or upland bird species (turkey, bobwhite quail, and songbirds) may lose habitat within the storage footprints.

As predicted by the Trophic Hypothesis (RECOVER 2004) an increase in density of small fishes would directly benefit higher trophic level predators such as wading birds. Therefore, it is predicted that the Alt 1BW will provide the greatest benefit to small fishes as described in **subsection C.2.6.2**, and also perform best overall for wading birds. All action alternatives have to potential to have an adverse impact on overwintering, nesting, or foraging songbirds that utilize the uplands in the storage feature and wetland restoration site footprints.

C.2.6.5 Mammals

As compared with FWO, potential minor beneficial effects to mammals within the LOWRP action area are anticipated with implementation of any LOWRP action alternative. Small mammals including raccoons and river otters would benefit from increased small prey fish biomass in rehydrated areas within the watershed along the Kissimmee River. Effects to state and federally listed species are described in further

detail in **subsection C.2.4** and in **Annex A**. Mammals in the storage features will likely be limited to river otter.

LOWRP implementation, however, could have a significant and adverse effect on mammals dependent upon upland habitat (e.g., deer, armadillos, opossum, skunks, woodrats, and raccoons). Due to the storage feature footprints and wetlands being restored, triggering a vegetation transition from upland to deep water and wetland habitat. Although, mammals occurring within the action area are adapted to the naturally fluctuating water levels in the Everglades; there is an increased potential for this vegetation transition to negatively affect mammals utilizing upland habitat.

C.2.6.6 Airport Wildlife Strike Hazard Assessment

Aircraft-wildlife strikes pose risks to safe aviation and wildlife conservation. The 2013 Memorandum of Agreement (MOA) between the Federal Aviation Administration (FAA), the U.S. Air Force, USACE, EPA, USFWS, and the U.S. Department of Agriculture - Wildlife Services established procedures necessary to coordinate their agency missions to more effectively address existing and future environmental conditions contributing to aircraft-wildlife strikes throughout the United States. These efforts are intended to minimize wildlife risks to aviation and human safety, while protecting the Nation's valuable environmental resources (FAA 2013). The National Plan of Integrated Airport Systems (NPIAS) encompasses approximately 3,400 airports in the national network of airports and the national airport plan, which identifies existing and proposed new airports to serve commercial and general aviation needs. The NPIAS contains all commercial service airports, all reliever airports, and selected general aviation airports. Specific criteria were established to meet national aviation needs at a reasonable cost. These criteria considered the number of based aircraft and annual operations, scheduled air carrier service, and proximity to other airports in the national plan. Airports that met special needs, such as access to remote populations, could also be included.

There are three airports within the LOWRP project area (**Figure C.2-30**). Of these, the Okeechobee County Airport (Okeechobee Jet Center; KOBE) is a NPIAS airport. The other two airports, River Acres Airport (FAA ID FD70) and River Oak Airport (FAA ID OOFL) are not in the NPIAS system and, therefore, do not require analysis pursuant to the MOA.

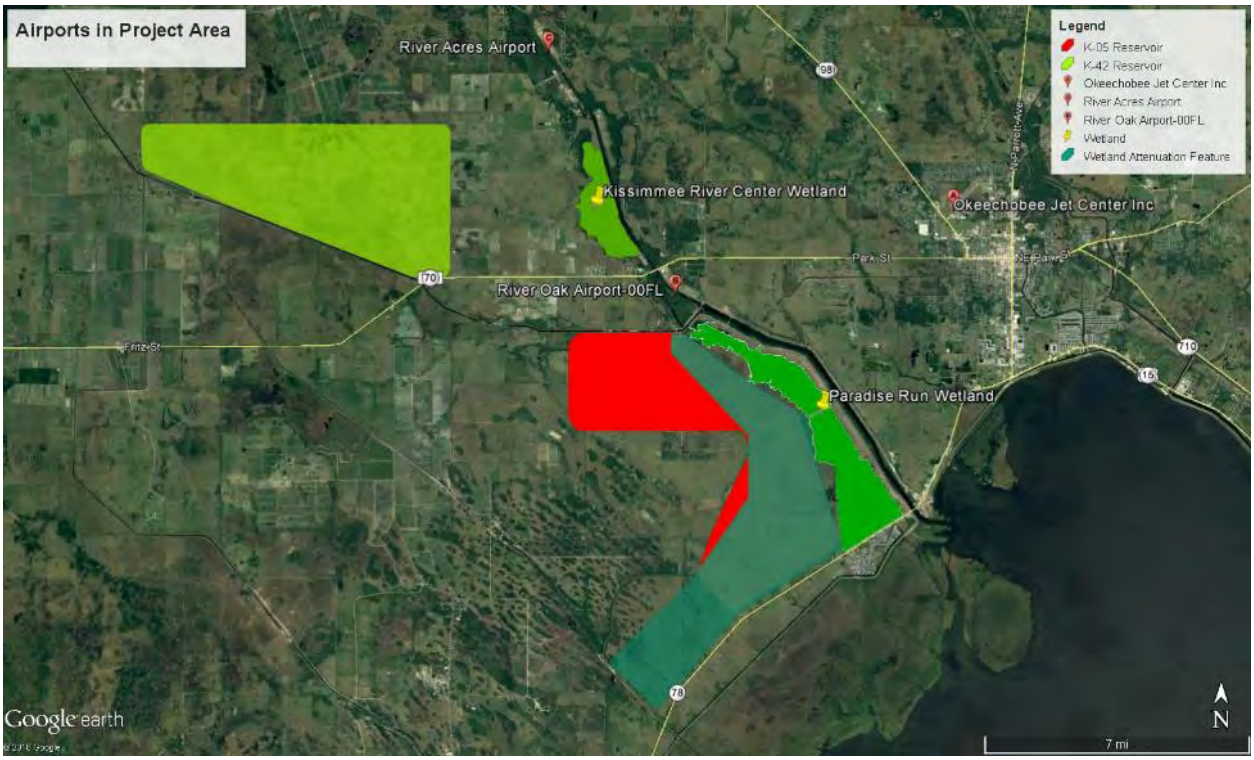

Figure C.2-30. Airport locations within the LOWRP project area.

River Acres Airport and River Oak Airport are both private short grass landing strips within airpark neighborhoods; both are general aviation airports or civilian airports that do not serve scheduled passenger service and usually serve private aircraft and small aircraft charter operations.

The FAA MOA requires an analysis of project effects within the separation distances of 5,000 feet (airports serving piston-powered, e.g., propeller aircraft), 10,000 feet (airports selling Jet-A fuel, e.g., serving turbine-powered aircraft) and 5 miles (airspace). For all airports, the FAA recommends a distance of 5 statute miles between the farthest edge of the airport's airport operations area (AOA) and a hazardous wildlife attractant if the attractant could cause hazardous wildlife movement into or across the approach or departure airspace. The basis for the separation criteria is found in existing FAA regulations. The separation distances are based on (1) flight patterns of piston-powered aircraft and turbine-powered aircraft, (2) the altitude at which most strikes happen (78% occur under 1,000 ft. and 90% occur under 3,000 ft. above ground level), and (3) National Transportation Safety Board (NTSB) recommendations (FAA 2007, AC150/5200-33B).

The Okeechobee Jet Center is 5.4 miles from the Paradise Run Wetland site in all alternatives, 6.2 miles from the K-05 reservoir in Alt 1Bshlw and the WAF in Alt 1BW, 8.1 miles from the Kissimmee River Center Wetland site in all alternatives and 13.1 miles from the K-42 reservoir in Alt 2Cr. ASR well clusters will negligibly change the existing ruderal herbaceous habitat conditions and, therefore, will not increase the risk of strike hazards. In all alternatives, the wetland sites and the storage sites are located greater than the 5-mile separation distance from the Okeechobee Jet Center and, thus, no discussion of mitigation recommendations is required. Although analysis of the two non-NPIAS airports is not required per the MOA, the 5,000-foot separation distance from project features was evaluated for both. River Acres Airport is 2.6 miles from the Kissimmee River Center wetland in all alternatives, 3.3 miles from the K-42 reservoir

in Alt 2Cr, 7.4 miles from the K-05 reservoir in Alt 1Bshlw, 8.2 miles from the WAF in Alt 1BW, and 8.1 miles from the Paradise Run Wetland site in all alternatives. River Oak Airport is 1.0 miles from the K-05 reservoir in Alt 1Bshlw, the WAF in Alt 1BW and the Paradise Run Wetland site in all alternatives, 1.3 miles from the Kissimmee River Center Wetland site in all alternatives and 6.0 miles from the K-42 reservoir in Alt 2Cr.

C.2.7 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act, 16USC 1801 et seq. Public Law 104-208 reflects the Secretary of Commerce and Fishery Management Council authority and responsibilities for the protection of essential fish habitat (EFH). Federal agencies that fund, permit, or carry out activities that may adversely impact EFH are required to consult with the National Marine Fisheries Service (NMFS) regarding the potential effects of their actions on EFH. In conformance with the 1996 amendment to the Act, the information provided in this Integrated Environmental Impact Statement (EIS) will comprise the required EFH assessment and has been coordinated with NMFS.

Consultation for the Lake Okeechobee Watershed Restoration project (LOWRP) was initiated on June 28, 2016 through a NEPA scoping letter. The NMFS has indicated that beneficial effects to fish resources and EFH may occur as a result of this project. The NMFS requested an evaluation of potential impacts to living marine resources, including mangroves, seagrasses, live bottom communities, and the marine/estuarine water column that may be impacted by activities or operations of the project action alternatives. The preparation of an EFH assessment will be contained within the project PIR/EIS, and submitted to the NMFS for coordination.

C.2.7.1 Essential Fish Habitat in the Project Area

The project area includes two distinct regional estuarine and nearshore coastal systems: the Northern Estuaries including the Caloosahatchee River and the St. Lucie Estuary. Lake Okeechobee flows into the two Northern Estuaries. The St. Lucie Canal feeds into the St. Lucie Estuary, and the Caloosahatchee Canal/River feeds into the Caloosahatchee Estuary to the west.

C.2.7.1.1 Caloosahatchee River

The Caloosahatchee River estuary contains EFH for juvenile brown shrimp (*Penaeus aztecus*), juvenile gray snapper (*Lutjanus griseus*), juvenile pink shrimp (*Penaeus duorarum*), adult and juvenile red drum, (*Sciaenops ocellatus*), adult and juvenile Spanish mackerel (*Scomberomorus maculatus*), and juvenile stone crab (*Menippe mercenaria*). Downstream habitats include oyster reefs and seagrass beds (submerged aquatic vegetation).

C.2.7.1.2 St. Lucie Estuary

The proposed project is within the jurisdiction of the South Atlantic Fishery Management Council (SAFMC) and is located in areas designated as EFH for wormrock, live bottom habitat, for the American oyster (*Crassostrea virginica*); pink shrimp (*Penaeus duorarum*); white shrimp (*Penaeus* sp.) and brown shrimp (*Penaeus aztecus*); Florida red drum (*Sciaenops ocellatus*); grouper (*Epinephelus* spp.); gray snapper (*Lutjanus griseus*); white grunt (*Haemulon plumieri*); red porgy (*Pagrus pagrus*); spiny lobster (*Panulirus argus*); and the snapper-grouper complex. In addition, the nearshore hardbottom habitat outside of the St. Lucie Estuary is designated as Essential Fish Habitat-Habitat Areas of Special Concern (EFH-HAPC) for the snapper-grouper complex.

C.2.7.2 Assessments of Effects on Essential Fish Habitat

Aquatic habitats within the Caloosahatchee Basin have been altered through the channelization of the river. Nevertheless, the basin continues to support fishery resources of some recreational and commercial importance. Seagrass communities within the Caloosahatchee Estuary provide critical refugia for juvenile fishes such as redfish, grouper, snook, and spotted seatrout. The decline in juvenile abundance and distribution of these and other species, along with an overall decrease in species richness may be related to the loss of seagrass habitat and/or a result of alterations in the salinity regime and the timing of the freshwater flows from the S-79 structure. The model output shows that of the number of months flow > 2800 cfs from the C-43 Basin and Lake Okeechobee regulatory flows, 47 of those months are a results of basin runoff. Therefore, flows greater than 2800 cfs direct from Lake Okeechobee flows go from 23 in the FWO to 13 in Alt 1Bshlw, 16 in Alt 1BW and 17 in Alt 2Cr (**Table C.2-8**). For extreme high-flow events (mean monthly flow > 4500 cfs), all alternatives perform better than the FWO that had 30 months where the mean monthly flow was greater than 4500 cfs. The number of mean monthly flows greater than 4500 cfs were reduced to 25 for Alt 1BW, 26 for Alt 1Bshlw, and 27 for Alt 2Cr (**Figure C.2-9**). Therefore, Alt 1Bshlw is anticipated to have the greatest beneficial effect on EFH followed by Alt 1BW and then Alt 2Cr. Implementation of the project would reduce the frequency of high volume freshwater flows during the wet season, ultimately resulting in minor beneficial effects to EFH within the Caloosahatchee Estuary.

Another primary goal of this project is to reduce high freshwater flows to the St. Lucie estuary. Implementation of the project would reduce the frequency of high volume freshwater flows during the wet season, ultimately resulting in minor beneficial effects to EFH within the St. Lucie estuary. For high flow events, all LOWRP action alternatives performed better than the FWO having fewer times where the 14-day moving average flow was greater than 2000 cfs from Lake Okeechobee regulatory flows. Alternatives 1Bshlw and 1BW performed the best with a reduction to 20 times when the high flow criteria was not met compared to 37 times in the FWO. Alt 2Cr had a reduction to 24 times when the high flow criteria were not met compared to the 37 times in the FWO. For extreme high flow events (mean monthly flow > 3000 cfs), all alternatives perform better than the FWO that had 25 months where the mean monthly flow was greater than 3000 cfs. The number of mean monthly flows greater than 3000 cfs were reduced to 21 for Alt 1Bshlw, 22 for Alt 1BW and 23 for Alt 2Cr (**Figure C.2-11**). Therefore, based on these reductions in flow, Alt 1Bshlw is anticipated to have the greatest beneficial effect on EFH, followed by 1BW and then 2Cr. Increases in seagrass and oyster reef would provide a large number of benefits to the EFH species. The proposed project may increase the acres of SAV, oyster, and healthy benthic habitat.

C.2.7.3 Conclusion

The Caloosahatchee and St. Lucie estuaries both receive excessive flows from Lake Okeechobee as well as their local basins during wet years, and suffer from too little flow on excessively dry years.

Restoration goals in the Caloosahatchee estuary include; re-establishment of a salinity range favorable to juvenile marine fish, shellfish, oysters and submerged aquatic vegetation (SAV), re-establishment of seasonally appropriate freshwater flows of favorable quality that maintain low salinities in the upper estuary and re-establishment of more stable salinities and ranges in the lower estuary. Restoration goals for the St. Lucie estuary include maintaining a salinity range favorable to fish, benthic invertebrates, oysters, and SAV. This requires a reduction of high volume, long duration flow events from Lake Okeechobee, the C-44, C-23 and C-24 watersheds.

In summary, LOWRP may improve conditions for estuarine and marine resources throughout the Northern Estuaries by restoring more natural timing, volume, and duration of freshwater flows to the Caloosahatchee and St. Lucie estuaries and provide minor beneficial effects. It has the potential to provide a more appropriate range of salinity conditions by reducing extreme salinity fluctuations and durations. The improvement of estuarine conditions will ultimately have a significant beneficial effect to EFH resources.

C.2.8 Hydrology

Hydrologic modeling simulations of the existing condition baseline (ECB) and the LOWRP FWO condition were developed with the RSM-BN sub-regional modeling tool, to provide baseline conditions for plan formulation, the assessment of LOWRP project benefits (comparisons against FWO), and the assessment of LOWRP alternative performance for the level-of-service for flood protection and water supply (comparisons against ECB). The ECB was developed to represent the system-wide infrastructure and operations that were in place at the time LOWRP plan formulation was initiated, approximately June 2016. The FWO for LOWRP assumes the construction and implementation of currently authorized CERP and non-CERP projects, and other Federal, state or local projects constructed or approved under existing governmental authorities that occur in the LOWRP study area. Selection of the Recommended Plan is conducted based on comparisons between the LOWRP action alternatives and the LOWRP FWO. The reader should refer to **Section 2** of the LOWRP PIR main report and **Appendix C**, **subsection C.1.1.8 and C.1.2.8** for additional documentation of the ECB and FWO conditions.

C.2.8.1 Lake Okeechobee Watershed

The management measures proposed in LOWRP will improve the system performance, primarily measured in the Lake Okeechobee and Northern Estuaries. **Section 4** covers the modeling results of the Lake Okeechobee and Northern Estuaries compared to the FWO condition. At regional level, the system will experience a moderate improvement to hydrology: 1) wetlands tend to decrease local temperature, atmospheric circulation, duration, and seasonality of flooding; 2) reservoirs will capture high peak flows adding more flexibility into the system and 3) ASR wells will provide additional long-term storage to replenish the system as needed.

C.2.8.2 Lake Okeechobee and the Northern Estuaries

For the modeling of the final array of alternatives, operational changes to Lake Okeechobee were limited to changes within the flexibility of the 2008 LORS, with no adjustments to the defined LORS zones. Lake Okeechobee operational assumptions were adjusted per alternative for the final array modeling. These adjustments included changes to the decision tree outcome maximum allowable flows dependent on Lake Okeechobee inflow forecasts, time of year (wet season or dry season), stage level (regulation zone), and/or stage trends (receding or ascending). The changes are all assumed to occur within the flexibility of LORS 2008 (Regulation Schedule zones unchanged), for the purpose of increasing LOWRP potential benefits. Details pertaining to the proposed LOWRP operations for Lake Okeechobee are separately addressed in the draft Project Operating Manual (refer to **Annex C**).

Compared to the FWO, Lake Okeechobee stages are increased by 0.2-0.6 feet for the upper 50% of the % time exceeded of the stage duration curve, excluding extreme wet hydrologic conditions (**Figure C.2-31**). Peak lake stage is 17.65 ft. in the FWO, and ranges 17.57–18.25 ft. NGVD29 in the alternatives (**Table C**.2-20).

For the Lake Okeechobee mean daily stages greater than 16 ft. NGVD29 (**Figure C.2-32**) and (**Table C.2-21**) are changed compared to the FWO as follows:

- ALT1Bshlw, days in the POR with:
    - LO mean daily stage > 17.25 = 65; increase by <1% from FWO
    - LO mean daily stage > Zone A = 98; increase by <1% from FWO
    - LO mean daily stage > 16 = 1,167; increase by <1% from FWO
- ALTBW, days in the POR with:
    - LO mean daily stage > 17.25 = 55; increase by <1% from FWO
    - LO mean daily stage > Zone A = 83; increase by <1% from FWO
    - LO mean daily stage > 16 = 1,181; increase by <1% from FWO
- ALT2CR
    - LO mean daily stage > 17.25 = 41; increase by <1% from FWO
    - LO mean daily stage > Zone A = 46; no change from FWO
    - LO mean daily stage > 16 = 1,120; decrease by <1% from FWO

For the Caloosahatchee Estuary, compared to the FWO, mean monthly flows above 2800 cfs and 4500 cfs (**Figure C.2-33**) are reduced per alternative by:

- Alt 1Bshlw – 10 and 4 months (14% and 13%) respectively
- Alt 1BW – 7 and 5 months (10% and 17%) respectively
- Alt 1BCr – 6 and 3 months (9% and 10%) respectively

Mean monthly flows less than 450 cfs (**Figure C.2-34**) were increased by:

- Alt 1Bshlw – 2 months (8%)
- Alt 1BW – 1 month (4%)
- Alt 1BCr – 0 months (0%)

For the St. Lucie Estuary, compared to the FWO, mean monthly flows between 2000/3000 cfs and mean monthly flows above 3000 cfs (**Figure C.2-35**) are reduced per alternative by:

- Alt 1Bshlw – 9 and 4 months (28% and 16%) respectively
- Alt 1BW – 10 and 3 months (31% and 12%) respectively
- Alt 1BCr – 5 and 2 months (16% and 8%) respectively

Mean monthly flows less than 350 cfs (**Figure C.2-36**) did not changed for all with project alternatives.

The hydrologic effects to Lake Okeechobee and Northern Estuaries would be roughly the same for all the future with project alternatives. A summary can be found in **Table C.2-22**.

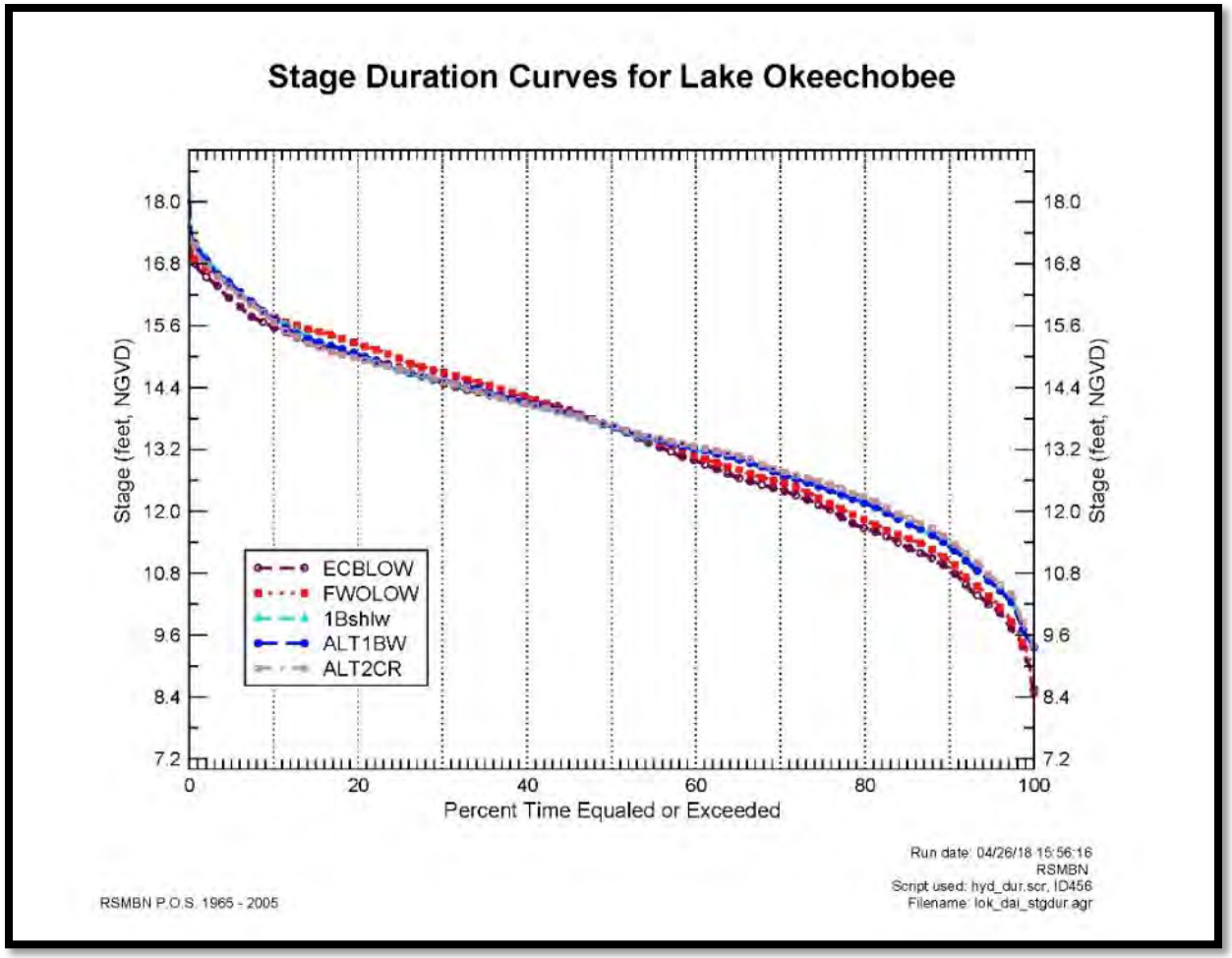

Figure C.2-31. Lake Okeechobee ECB and FWO stage duration curves.

Table C.2-20. Peak Stage in Lake Okeechobee comparisons between alternatives and baselines.

Area	Criteria	ECB	FWO	Dif. FWO vs ECB	Alt 1Bshlw	Dif. 1Bshlw vs FWO	Alt 1BW	Dif. 1BW vs FWO	Alt 2Cr	Dif. 2CR vs FWO
Lake Okeechobee	Peak Stage (in feet NGVD29)	17.58	17.65	<0.1	18.25	0.6	18.05	0.4	17.57	<0.1

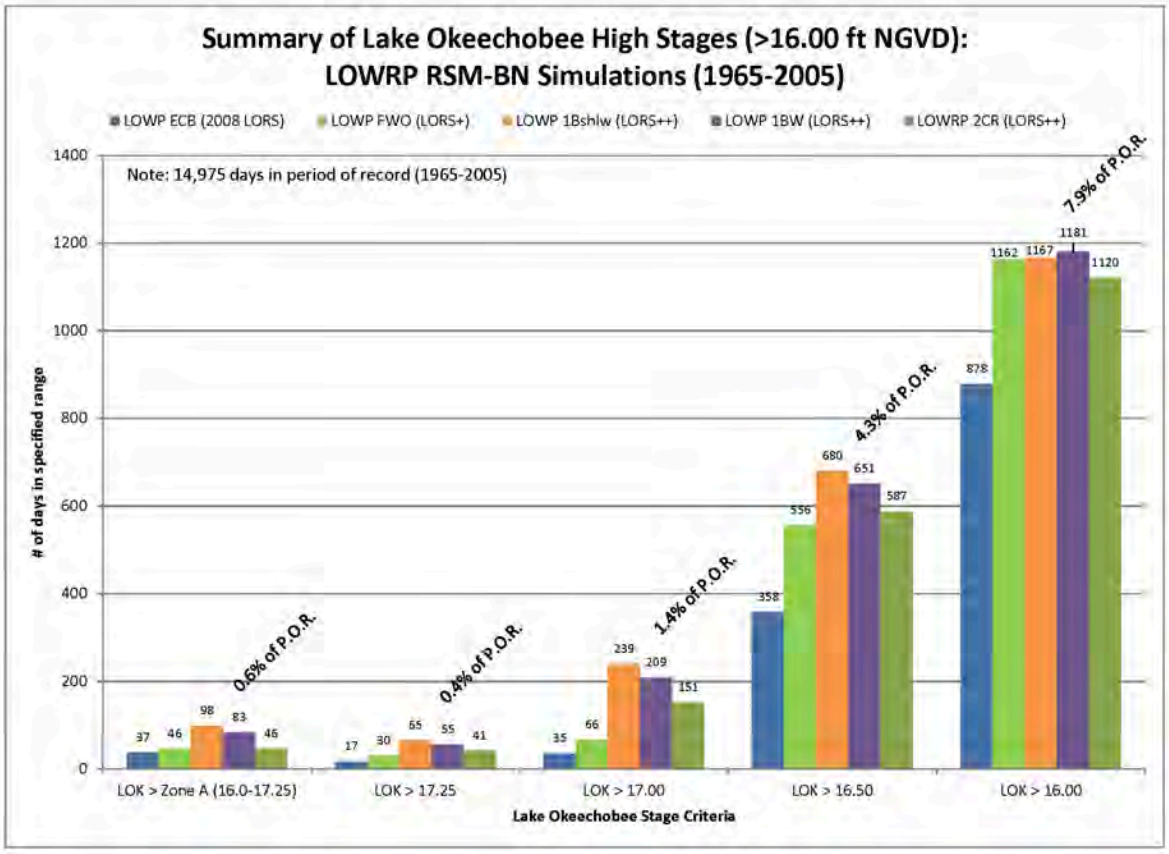

Figure C.2-32. Lake Okeechobee high stages (>16.00 ft. NGVD): LOWRP RSM-BN simulations (1965-2005).

Table C.2-21. Summary and comparison between Lake Okeechobee High Stages (>16.00 ft. NGVD29): LOWRP RSM-BN Simulations (1965-2005) alternatives and baselines.

Criteria	ECB (Days)	FWO (Days)	FWO vs ECB (% in POR)	1Bshlw (Days)	1Bshlw vs FWO (% in POR)	1BW (Days)	1BW vs FWO (% in POR)	2CR (Days)	2CR vs FWO (% in POR)
LO Mean Daily Stage > 17.25	17	30	0.1	65	0.2	55	0.2	41	0.1
LO Mean Daily Stage > Zone A	37	46	0.1	98	0.3	83	0.2	46	0
LO Mean Daily Stage > 16.00	878	1162	2	1167	0	1181	0.1	1120	-0.3

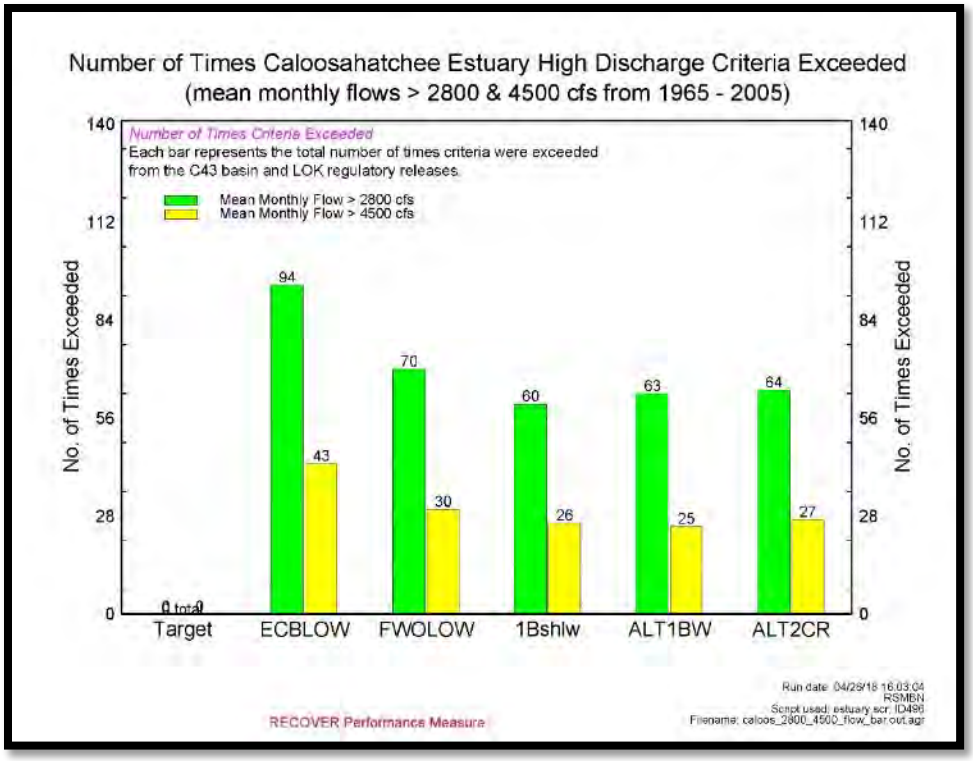

Figure C.2-33. Caloosahatchee high release flow criteria exceeded.

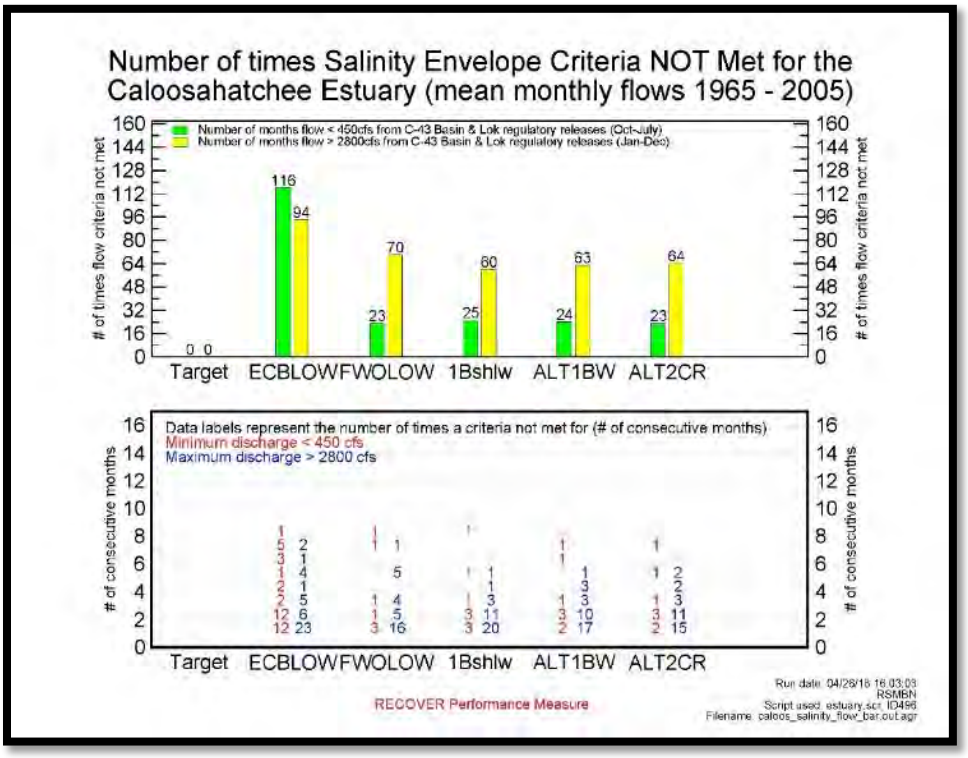

Figure C.2-34. Caloosahatchee salinity envelope criteria not met.

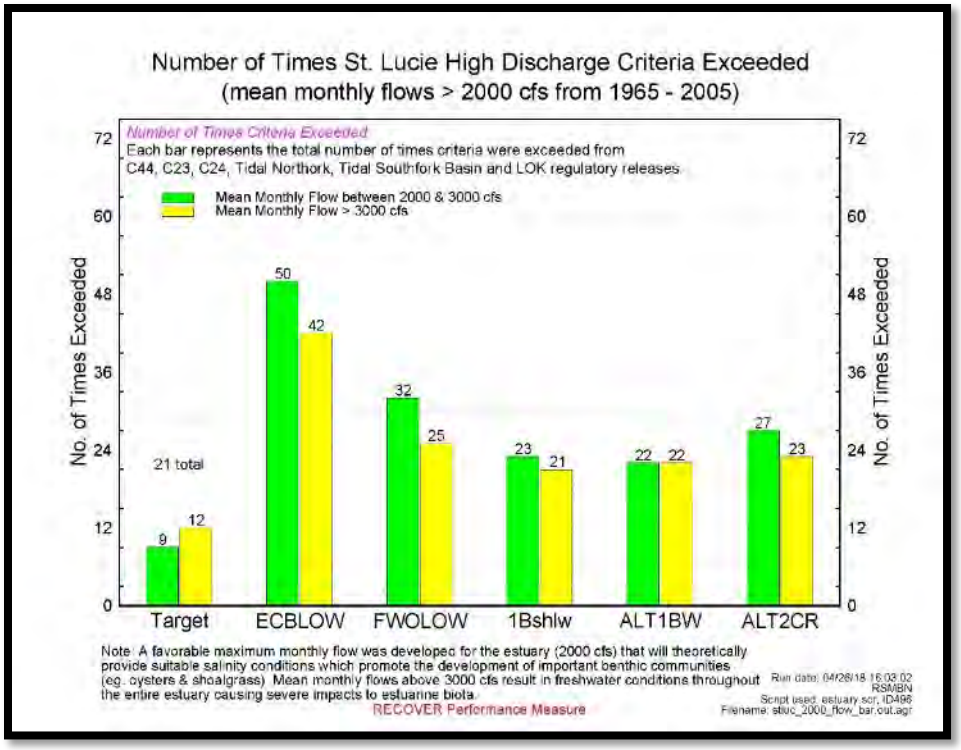

Figure C.2-35. St. Lucie high releaseflow criteria exceeded.

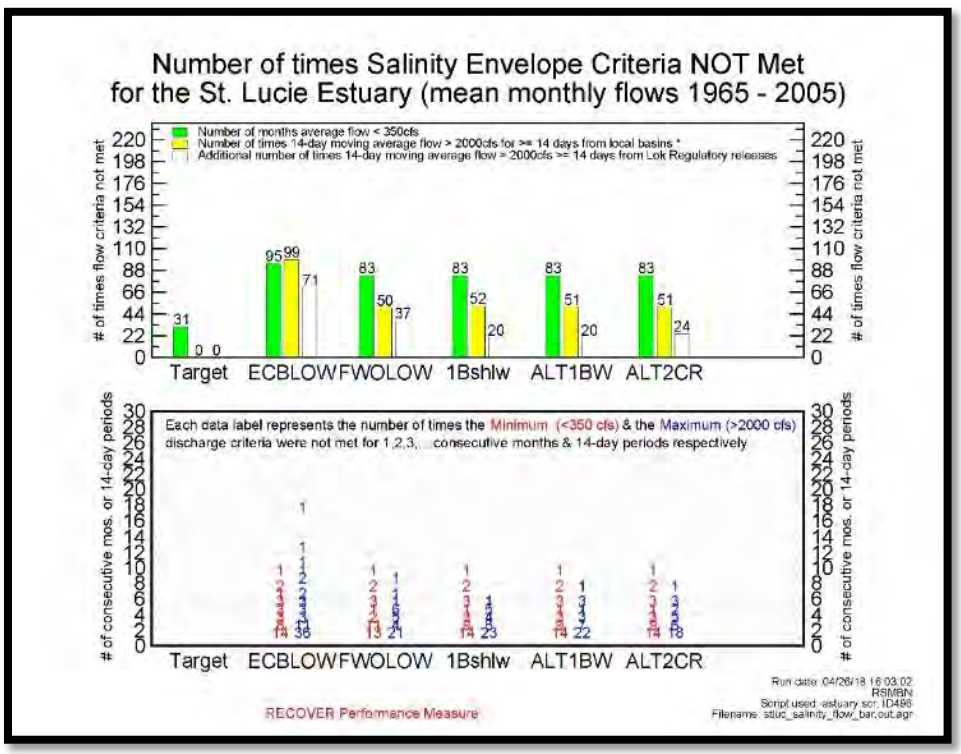

Figure C.2-36. St. Lucie salinity envelope criteria not met.

Table C.2-22. Summary of Caloosahatchee and St. Lucie estuaries flow.

Estuary	Criteria	ECB	FWO	Alt 1Bshlw	Alt 1BW	Alt 2Cr
Caloosahatchee	Number of months flow < 450cfs from C-43 Basin & Lake Okeechobee regulatory flows (Oct-July)	116	23	25	24	23
	Number of months flow > 2800cfs from C-43 Basin & Lake Okeechobee regulatory flows (Jan-Dec)	94	70	60	63	64
St. Lucie	Number of months average flow < 350cfs	95	83	83	83	83
	Number of times 14-day moving average flow > 2000cfs for >= 14 days from local basins*	99	50	52	51	51
	Additional number of times 14-day moving average flow > 2000cfs >= 14 days from Lok Regulatory flows	71	37	20	20	24

C.2.8.3 Aquifers

Three aquifers are affected in the FWO condition and implementation of LOWRP action alternatives: the unconfined surficial aquifer system (SAS), the confined UFA) and the confined APPZ. In the project area, the UFA occurs at depths of 372–525 ft. below land surface (Sunderland et al., 2011). The APPZ occurs at depths of 1150–1468 ft. below land surface (Sunderland et al., 2011).

Under the FWO condition, SAS groundwater levels are affected primarily by rainfall in the Kissimmee River basin. Regional recharge occurs in the upland areas, and groundwater flows downgradient to release into the Kissimmee River and Lake Okeechobee. The primary use of SAS groundwater is to satisfy agricultural demands, which are expected to increase by 15% by 2035. Under LOWRP action alternatives, SAS groundwater levels are expected to increase as a result of seepage from the shallow or deep storage features and wetland restoration activities.

Under the FWO condition, UFA groundwater levels are affected locally by agricultural pumping stresses. There are few UFA wells in the project area that monitor groundwater levels continuously. One such is OKF-105 (Sunderland et al., 2011) is located near the S-65C structure (now removed), on the Kissimmee River near the border between Highland and Glades counties (**Figure C.2-37**). Groundwater level variations of up to 6 ft. reflect pumping stresses during the dry season for agricultural demands. The UFA in this location is fresh. Chloride concentrations are below the drinking water maximum contaminant level (250 mg/L), ranging 79–153 mg/L (n=3, SFWMD DBHydro, 2018).

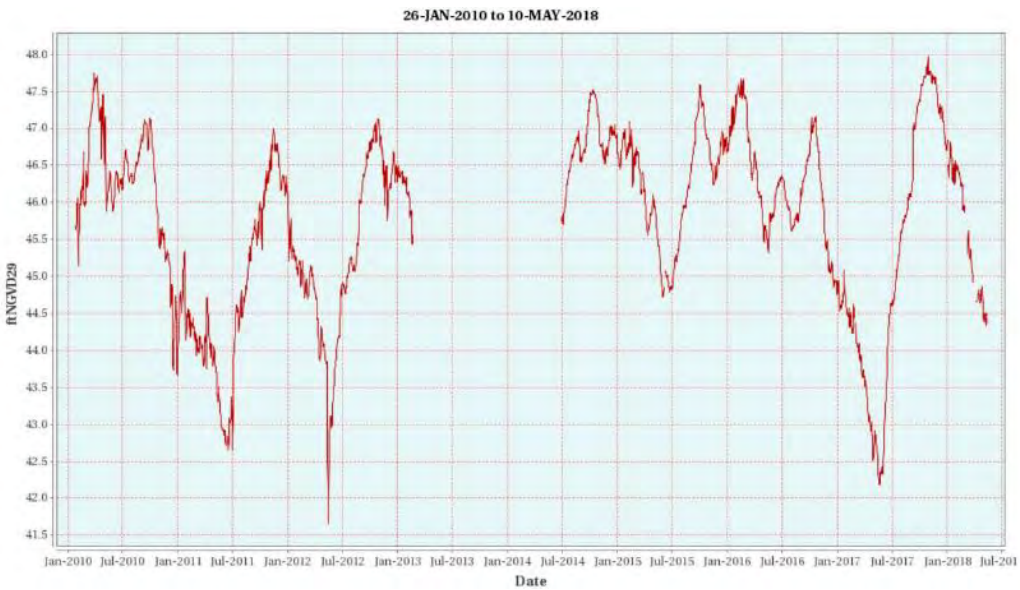

Figure C.2-37. Average daily groundwater level measurements at UFA well OKF-105U (POR January 2010 through May 2018).

Under the FWO condition, APPZ groundwater levels also respond to pumping stresses, most likely from pumping in the UFA. The maximum range in the APPZ groundwater levels is approximately 5 ft., and variations are synchronous with those in the UFA (**Figure C.2-38**). The APPZ in this location is slightly brackish. Chloride concentrations exceed the drinking water maximum contaminant level (250 mg/L), ranging 495–536 mg/L (n=4, SFWMD DBHydro, 2018). Higher chloride concentrations suggest that APPZ groundwater is not suitable for agricultural water supply.

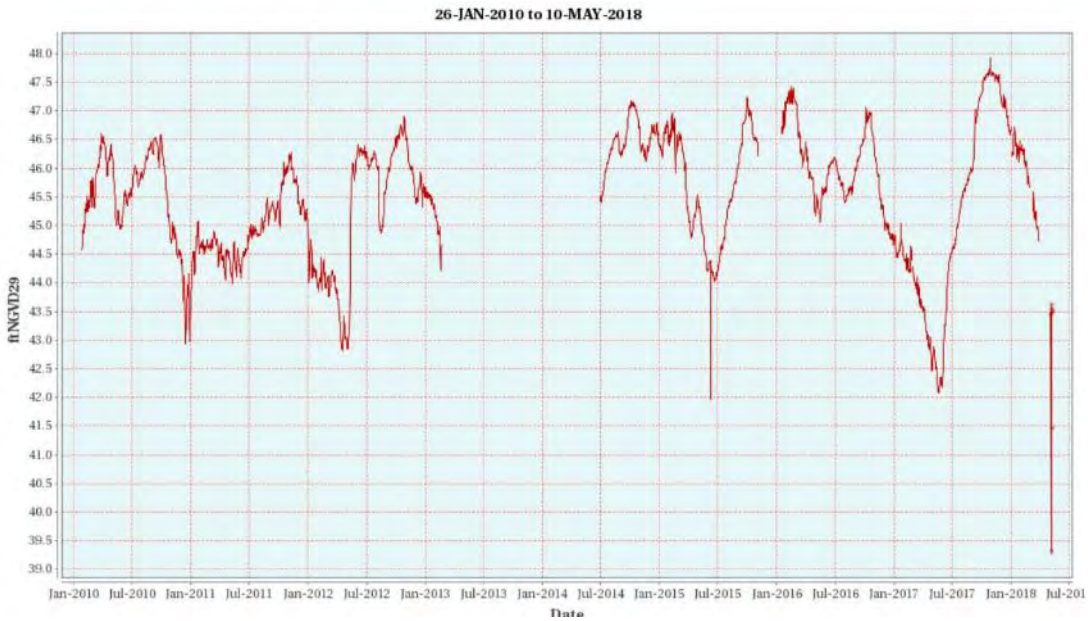

Figure C.2-38. Average daily groundwater level measurements at APPZ well OKF-105M (POR January 2010 through May 2018).

All LOWRP action alternatives include an ASR component, in which surface water will be recharged into, and recovered from, the UFA and the APPZ. Storage-assisted ASR wells are conceptualized to store water in both the UFA and APPZ with co-located well pairs. Because chloride concentrations in the UFA and APPZ generally are low, it is anticipated that recovery efficiencies will exceed 40% by volume. Also, storing surface water in the APPZ will freshen the aquifer, leading to improved recovery efficiencies over time.

C.2.9 Regional Water Management (Operations)

Every alternative run was adjusted to achieve project goals of minimizing high flows to the northern Estuaries and improving Lake Okeechobee water levels while reducing water supply cutbacks. This was achieved by adjusting the operating parameters for the proposed management measures in relationship with the Lake regulation schedule. See **Appendix A – Annex A3** for modeling details.

In general, water management operations on Lake Okeechobee may be optimized to account for available storage within LOWRP project features. Changes to the Lake Okeechobee Regulation Schedule (LORS) can only occur after great consideration and required NEPA analysis and the operation of the project features in any of the alternatives will not directly trigger any changes in the LORS. No changes to the operations on the Kissimmee are anticipated at this time due to any of the alternatives.

The LOWRP team identified Alternative 1BW as the Tentative Selected Plan (TSP). The ALT 1BW primary feature is the wetland attenuation facility. The WAF is primarily used for surface water storage to attenuate peak flows into Lake Okeechobee from the Kissimmee River Basin. Although a WAF allows for aboveground storage like a reservoir, water levels may be suitable for growth of wetland vegetation due to the water depths typically realized through operation of the facility (see **Figure C.2-39**). Storage-assisted ASR wells will rehydrate habitat during dry times to encourage wetland conditions within the WAF footprint without sacrificing desired regional benefits for Lake Okeechobee and the Northern Estuaries. The WAF footprint, including the embankments, seepage canal, and other perimeter features, is approximately 12,500 acres with a storage capacity of approximately 43,000 ac-ft. A pump station located downstream of the existing S-84 structure on the C-41A canal serves as the water source for the proposed WAF. The pump draws water from the downstream area that is considered to be part of Lake Okeechobee. The engineering design and construction of the WAF will follow state of the practice methods for design and construction of pertinent features of the plan. U.S. Army Corps of Engineers ER 1110-2-1150, “Engineering and Design for Civil Works Projects,” and ER 1110-2-1156, “Engineering and Design Safety of Dams – Policy and Procedures,” along with various other site/structure specific-regulations, will be adhered to prior to and during the PED phase.

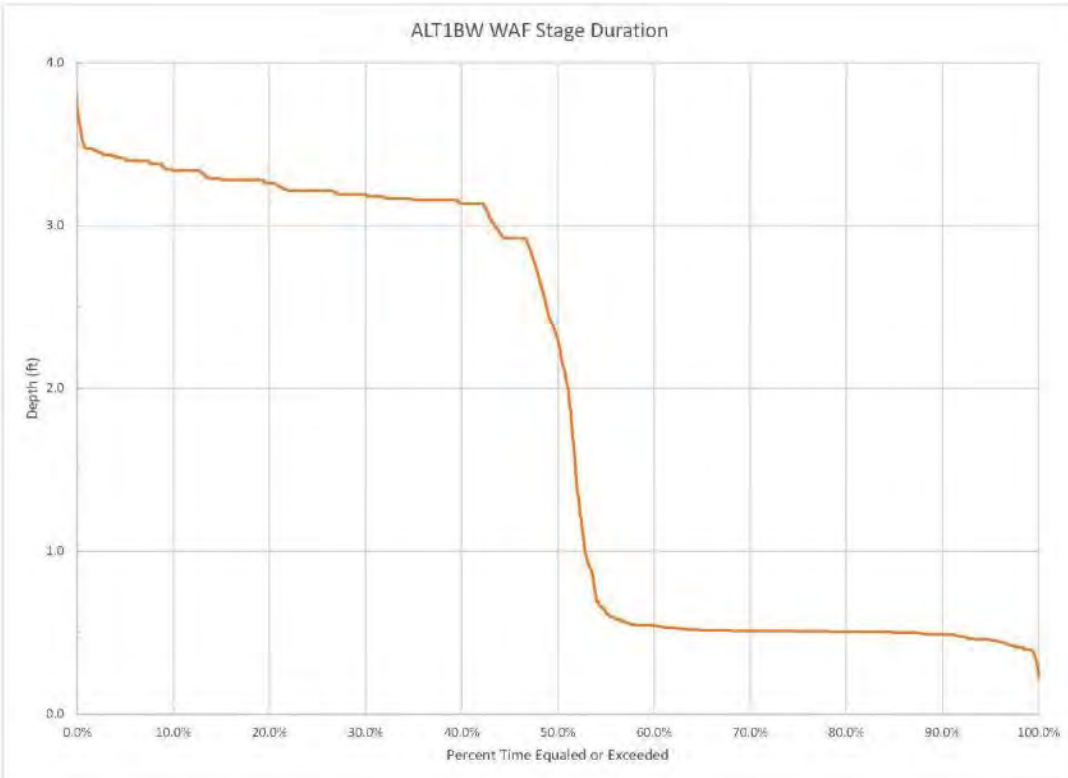

Figure C.2-39. Stage duration curve for ALT1BW wetland attenuation facility.

C.2.10 Groundwater Resources

The LOWRP project area is within the SFWMD Lower Kissimmee River Water Supply Planning Area (SFWMD, 2014a). In conjunction with this planning effort, the Lower Kissimmee River Basin groundwater model was updated (SFWMD, 2014b). The UFA is the main groundwater supply source in the Lower Kissimmee Basin. Objectives of the updated groundwater flow model include evaluation of UFA groundwater withdrawals in the future (2035), which applies to the FWO condition of the LOWRP. A second objective is to evaluate potential impacts to minimum flows and levels in lakes along the Lake Wales Ridge due to UFA groundwater withdrawals within the SFWMD and the SWFWMD boundaries. Modest increases in water demand are projected in the basin with public water supply and domestic self-supply sources increased from 4.9 MGD to 6.0 MGD in 2035 (SFWMD, 2014a). Pumping of the UFA is predicted for agricultural and public water supply in both SFWMD and SWFWMD areas. However the 2035 simulations suggest that UFA water levels show a rebound or no significant effect beneath minimum flows and levels lakes given projected increases in UFA pumpage and model uncertainty.

Storage-assisted ASR systems located proximal to the shallow impoundment are unlikely to affect existing agricultural users to the north in Highlands County, although this will need further investigation during the UIC permitting process. There are a few existing users of the UFA within the impoundment footprint for Alternatives 1Bshlw and 1BW (**Table C.2-23).** The abundant number of permitted users north of the K-42 footprint (Alternative 2Cr) indicates that UIC permitting of storage-assisted ASR systems at K-42 is unlikely to be successful. ASR systems at K-42 would likely impact groundwater levels in the wells of adjacent users. **Table C.2-23** describes the groundwater resources for each alternative.

Table C.2-23. Groundwater resources for the Final Array of Alternatives and the Recommended Plan.

Aquifer	FWO	Alt 1Bshlw	Alt 1BW	Alt 2Cr
Surficial Aquifer System (SAS)	Total water demand is expected to increase by 15% by 2035, mostly due to agricultural demands. Surficial aquifer pumping will meet part of those demands. Extensive pumping of the SAS can potentially affect regional water levels in this unconfined aquifer.	On completion of the K-05 reservoir construction, seepage will occur locally from the impoundment. Eastward flowing seepage from K-05 will hydrate the northern portions of the Paradise Run alluvial plain.	On completion of the K-05 WAF construction, seepage will occur locally from the impoundment. Eastward flowing seepage from K-05 will hydrate the northern portions of the Paradise Run alluvial plain.	On completion of the K-42 reservoir construction, seepage will occur locally from the impoundment. Existing permeability data suggest that seepage losses from the K-42 reservoir may be significant and may require mitigation during design phase.
Upper Floridan Aquifer (UFA)	Estimated future demands on UFA groundwater may be limited near the Lake Wales Ridge in order to maintain minimum flows and levels in adjacent lakes. However, sufficient confinement separates Lake Istokpoga and Lake Okeechobee from the UFA, so increased demands are unlikely to affect water levels in these lakes.	Construction of 80 ASR wells (approximately 50 open to the UFA) will increase regional storage by 448,000 acre-feet per year. Fully implemented ASR will reduce flows to the estuaries and will augment lake levels during drought. Most ASR systems will be constructed in the watershed, with 25 ASR facilities associated with the K-05 reservoir.	Construction of 80 ASR wells (approximately 50 open to the UFA) will increase regional storage by 448,000 acre-feet per year. Fully implemented ASR will reduce flows to the estuaries and will augment lake levels during drought. Most ASR systems will be constructed in the watershed, with 25 ASR facilities associated with the K-05 WAF.	Construction of 65 ASR wells total (approximately half open to the UFA) will increase regional storage by 364,000 ac-ft per year. Fully implemented ASR will reduce flows to the estuaries and will augment lake levels during drought. All ASR systems will be constructed in the watershed, with no facilities associated with the K-42 reservoir.
Avon Park Permeable Zone (APPZ)	The APPZ is not a water supply source due to greater salinity compared to the UFA, and greater depth. It is unlikely that the APPZ will provide drinking water or agricultural irrigation supplies in the future.	Approximately 30 ASR wells in the APPZ will augment storage in this deeper transmissive aquifer. APPZ wells will be paired with UFA wells.	Approximately 30 ASR wells in the APPZ will augment storage in this deeper transmissive aquifer. APPZ wells will be paired with UFA wells.	Approximately 30 ASR wells in the APPZ will augment storage in this deeper transmissive aquifer. APPZ wells will be paired with UFA wells.

C.2.11 Water Quality

The alternatives selected for the final array may provide minor improvements to water quality. The section below outlines the effects of the final array on water quality.

C.2.11.1 Lake Okeechobee Watershed

In comparison to the FWO, implementation of any of the action alternatives may result in some minor improvement in the water quality of the Lake Okeechobee watershed. The wetland restoration components will provide increased hydroperiods and retention times of watershed runoff, and both the wetland features and reservoirs/WAFs will result in direct conversion of pasture and upland to wetland and/or reservoirs in the footprints. This combination of increased wetland quantity and quality may result in minor local improvements to portions of the watershed water quality.

Inflows to Lake Okeechobee may contain nutrients such as nitrogen and phosphorus from surrounding uplands. If this upland flow can travel through wetlands prior to entering Lake Okeechobee, there would be greater opportunity for retention and storage of nutrients within these wetland systems (Reddy et al. 1996). The ability of wetlands and streams to assimilate nutrients such as phosphorus depends on physical, chemical, and biological characteristics of each system. Many case studies have shown wetlands as net assimilators of nutrients, including phosphorus.

Wetlands assist to improve water quality by removing nutrients such as nitrogen, phosphorus, and pesticides from agricultural and municipal runoff. Wetlands remove nutrients from the surface water and transfer them to the sediment, wetland plants, or the atmosphere. In addition, wetlands act as water storage features further improving water quality. By holding water, a wetland allows sediment and large particles to settle on the wetland bottom and thus act as a sediment trap to prevent translocation of the sediments and nutrients. The root systems of wetland plants then absorb nutrients from the sediment. There may also be differences related to season. During the growing season, in the summer and early fall, emergent and submerged aquatic plants take up large quantities of nutrients from water and sediment. Algae and floating plants absorb nutrients from surface water. These plants essentially convert the wetland into a "nutrient sink," by taking nutrients from the water and sediment and retaining them as plant material. By taking up and holding nutrients during the summer, wetlands decrease the possibility of contamination downstream (Johnston 2009; Reddy et. al 2010; Miller 2014). Based upon the spatial extent of wetlands created within each alternative, wetlands within Alternative 1BW would provide the greatest potential benefit to water quality, followed by 1Bshlw and 2Cr as compared with the FWO.

C.2.11.2 Lake Okeechobee

Relative to the FWO option, implementation of any of the action alternatives may result in some improvement in Lake Okeechobee water quality due primarily to reduced flow volume into Lake Okeechobee and thus nutrient load (**Figure C.2-41)**. However, the expected improvement in Lake Okeechobee water quality will likely be small, since nutrient (phosphorus) loads will be slightly less compared to FWO project conditions.

To evaluate the alternatives compared to the FWO option, loads were estimated by phosphorus loading spreadsheet model (PLSM James 2017) for the three sub-watersheds directly affected by this project (Kissimmee River, Taylor Creek/Nubbin Slough and Indian Prairie/Istokpoga). The PLSM used daily flow estimates from the RESOPS model (Modeling Section 2013) and a constant baseline concentration applied

to all inflows prior to entering project features. The PLSM demonstrated a slight load reduction compared to the FWO option **(Figure C.2-40** and **Figure C.2-41**).

As discussed in the FWO conditions section for Lake Okeechobee, there is an existing total maximum daily load (TMDL) for phosphorus (Florida Department of Environmental Protection (FDEP) 2001). This TMDL requires a reduction in annual phosphorus loading from more than 500 metric tons per year to 140 metric tons per year. Concentration estimates to reach these loadings range from 25 to 114 μg P l^{-1}, for the Kissimmee and the Taylor Creek/Nubbin Slough subwatersheds. To reflect this variation in ranges and account for the sum of load and flow contributions from the sub-watersheds, results were estimated from the PSLM using a range of concentrations from 40 to 100 μg P l^{-1} (James 2017). This analysis compared the effect of variation of phosphorus concentration on the overall load reduction for each alternative. This sensitivity analysis indicated that the with-project action alternatives may result in reductions of phosphorus loads between 4 and 12% (**Figure C.2-42**).

The annual TMDL phosphorus load release to the lake from each alternative and at each baseline concentration also is predicted to be a bit lower than the FWO load predictions (**Figure C.2-43**).

The existing condition average annual load from the Kissimmee River, Taylor Creek/Nubbin Slough and Indian Prairie/Istokpoga sub-watersheds using water years 2012 to 2015 was 374 metric tons per year (Sharfstein and Zhang 2017). The future without condition is estimated as 80.2 metric tons/yr (James 2017) to 200.5 metric tons/yr at the highest baseline.

C.2.11.2.1 Alternative 1Bshlw vs. FWO

Alternative 1Bshlw showed reductions in phosphorus loadings to the lake between 9 to 12% over the FWO condition, depending on assumed baseline concentrations (**Figure C.2-42**). This would equate to predicted flowreleases of 73 to 177 metric tons/yr for baseline concentrations of 40 to 100 μg P L^{-1} (**Figure C.2-43**).

C.2.11.2.2 Alternative 1BW vs. FWO

This alternative's water quality performance may reduce the phosphorus loadings to the lake by 9 to 12% over the FWO, depending on assumed baseline concentrations (**Figure C.2-42**). This would equate to predicted flowreleases of 73 to 177 metric tons/yr for baseline concentrations of 40 to 100 μg P L^{-1} (**Figure C.2-43**).

C.2.11.2.3 Alternative 2Cr vs. FWO

This alternative's water quality performance may reduce the phosphorus loadings to the lake by 5% to 7% over the FWO, depending on assumed baseline concentrations (**Figure C.2-42**). This would equate to predicted flowreleases of 76 to 187 metric tons/yr for baseline concentrations of 40 to 100 μg P L^{-1} (**Figure C.2-43**).

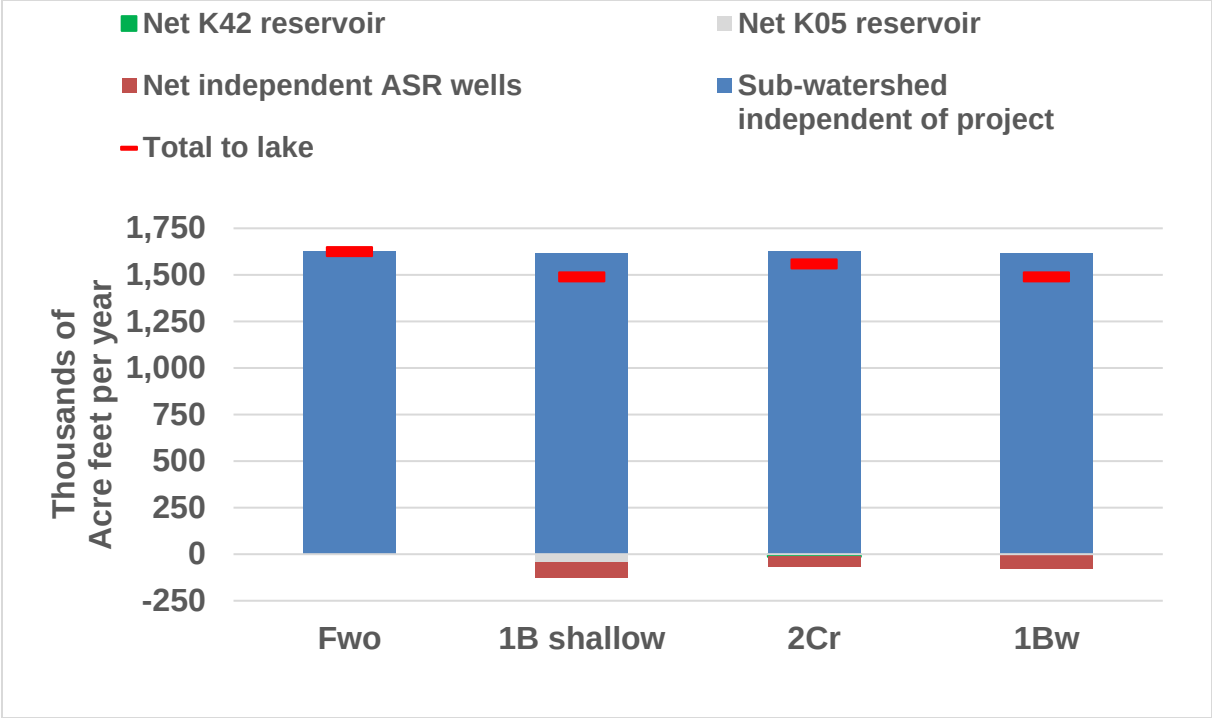

Figure C.2-40. Estimated yearly total flow to Lake Okeechobee from the Taylor-Creek/Nubbin Slough, Indian Prairie/Istokpoga, Kissimmee watersheds and net flow from ASR Wells and storage features included in the alternatives.

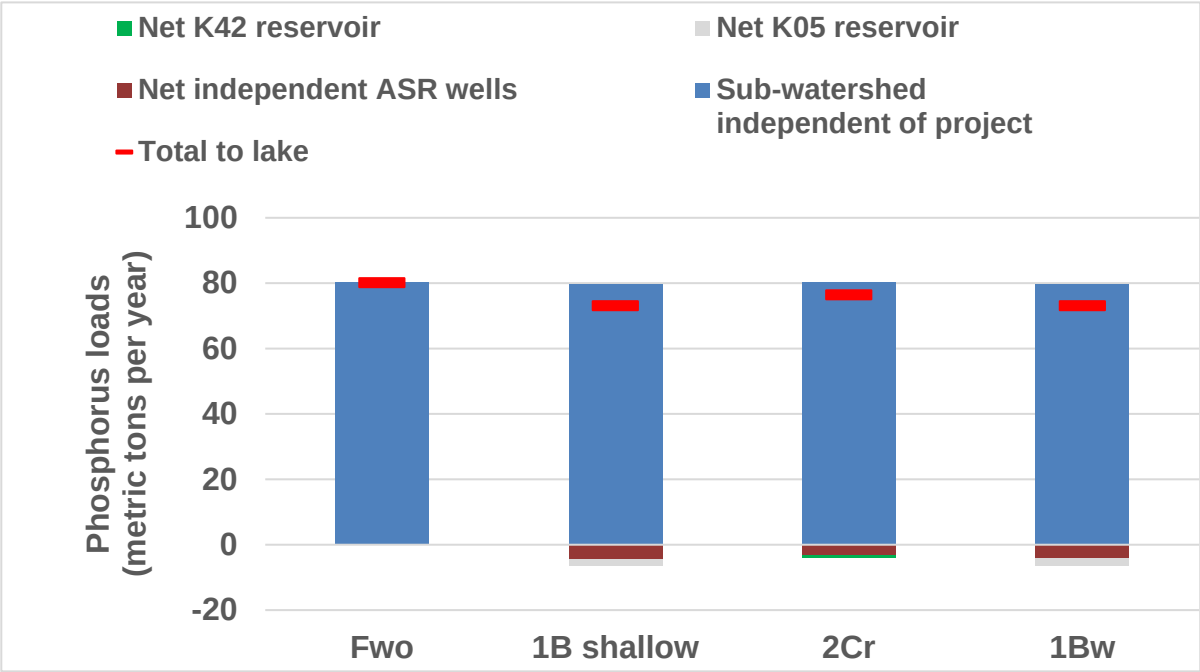

Figure C.2-41. Estimated yearly load to Lake Okeechobee from the Taylor-Creek/Nubbin Slough, Indian Prairie/Istokpoga, Kissimmee watersheds and net loads from ASR Wells and storage features included in the alternatives assuming a base flow concentration of 40 µg l^{-1}.

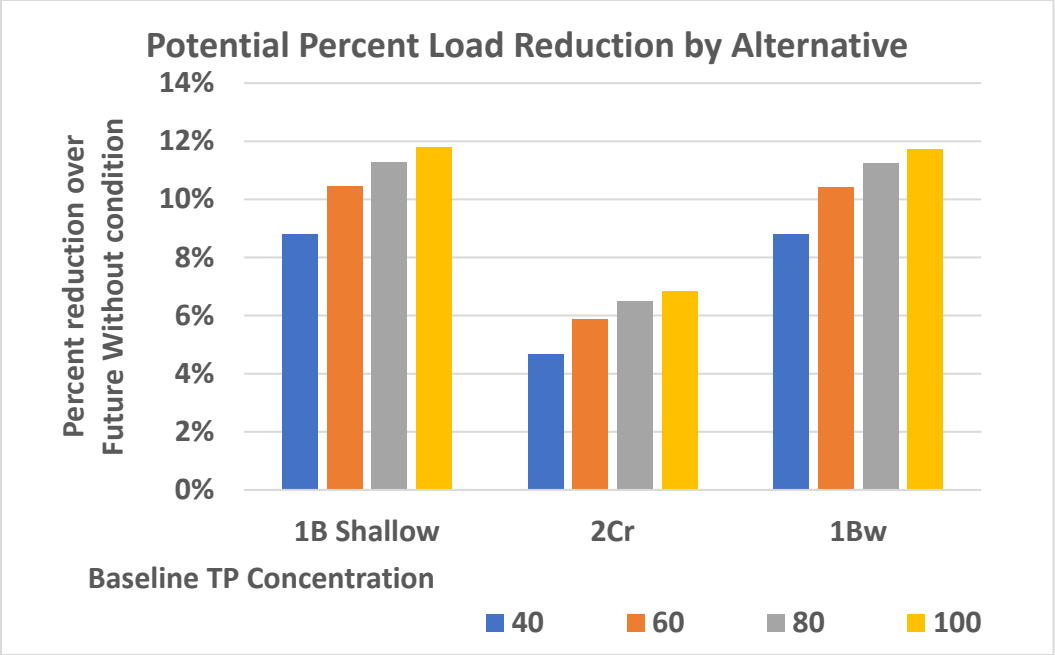

Figure C.2-42. Potential Percent reduction of loads from to Lake Okeechobee from the Taylor-Creek/Nubbin Slough, Indian Prairie/Istokpoga, Kissimmee watersheds By alternative and for different baseline TP concentrations.

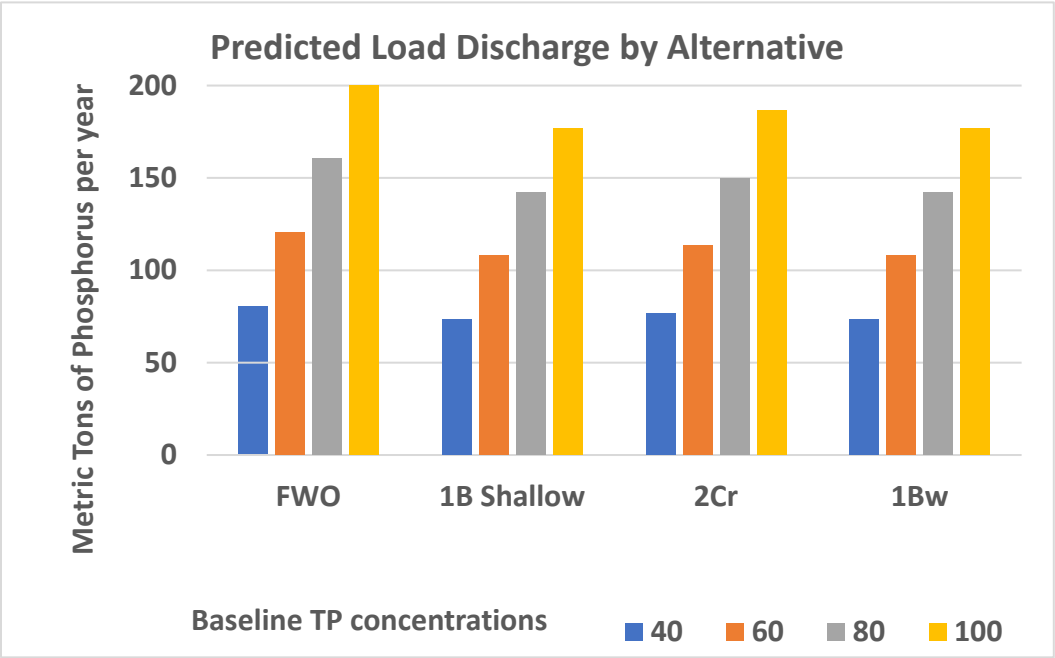

Figure C.2-43. Predicted POSSIBLE annual TP metric ton load releaseflows to Lake Okeechobee from the Taylor-Creek/Nubbin Slough, Indian Prairie/Istokpoga, Kissimmee watersheds by alternative and for different baseline TP concentrations.

C.2.11.3 Northern Estuaries

Caloosahatchee Estuary: Improved salinity conditions may occur within this estuary as a result of a reduction in the number of high flow events and a reduction in the number of extreme low flow events as characterized by flows through the S-79 structure. Salinity and dissolved oxygen conditions should improve during the wet season within the estuary given the reduction in high flow events.

St. Lucie Estuary: Improved salinity conditions may occur within this estuary as a result of a reduction in the number of high flow as characterized by flows through the S-80 structure. Salinity and dissolved oxygen conditions should improve during the wet season within the estuary given the reduction in high flow events.

C.2.12 Flood Control

To address the Savings Clause requirements for CERP, the LOWRP PIR includes an analysis of potential effects of the LOWRP TSP, where applicable, to existing legal sources for water supply and/or the levels of service for flood protection. Refer to **Section 6** of the PIR main report for summary information and **Annex B, Analysis Required by WRDA 2000 and Florida State Law,** for the complete analysis. However, it was determined that the implementation of the alternatives as well as the TSP will not degrade the existing level of flood protection offered by various components of the C&SF Project for this area. Further, the future LOWRP Recommended Plan will ensure flood protection of the area through engineering design and construction following state of the practice methods for design and construction of pertinent features of the plan. U.S. Army Corps of Engineers ER 1110-2-1150, *Engineering and Design for Civil Works Projects*, and ER 1110-2-1156, *Engineering and Design Safety of Dams – Policy and Procedures*, along with various other site/structure-specific regulations, will be adhered to prior to and during the PED phase.

C.2.13 Water Supply

The water supply performance of the TSP (Alt 1BW) and other alternatives in the final array (Alt 1Bshlw and Alt 2Cr) were simulated in model runs of RSMBN. Water supply performance is quantified for LOSA and for the Seminole Tribe of Florida Brighton and Big Cypress Reservations. Water supply in the ECB and FWO project condition are quantified and displayed for comparison to the final array of alternatives.

C.2.13.1 Lake Okeechobee

Each of the alternatives in the final array improve water supply for existing legal users in LOSA compared the future without project (FWO). For the eight years with the largest water supply cutbacks within the LOSA, the water supply cutback percentage is reduced for seven of the eight years, compared to the FWO (**Figure C.2-44**). Based on the LOWRP alternative modeling assumptions and the resulting moderate stage increase within Lake Okeechobee, the average annual percentage of water supply demand not met is projected to decrease in LOSA including the EAA (**Figure C.2-45**). Each of the alternatives in the final array improve or maintain water supply compared to the FWO project condition. In the EAA the TSP (Alt 1BW) reduces the percentage of unmet demands to 5%, down from 6% in the future without project condition (**Figure C.2-45**).

Following completion of the HHD remediation of Reaches 1, 2, and 3, the degree to which higher maximum lake stages and increased frequency and duration of high lake stages would be accepted, if at

all, will be contingent on the conclusions identified in the USACE 2014 Dam Safety Modification Report (DSMR) for the HHD. Any changes to the LORS would be analyzed and coordinated with the public through the NEPA process.

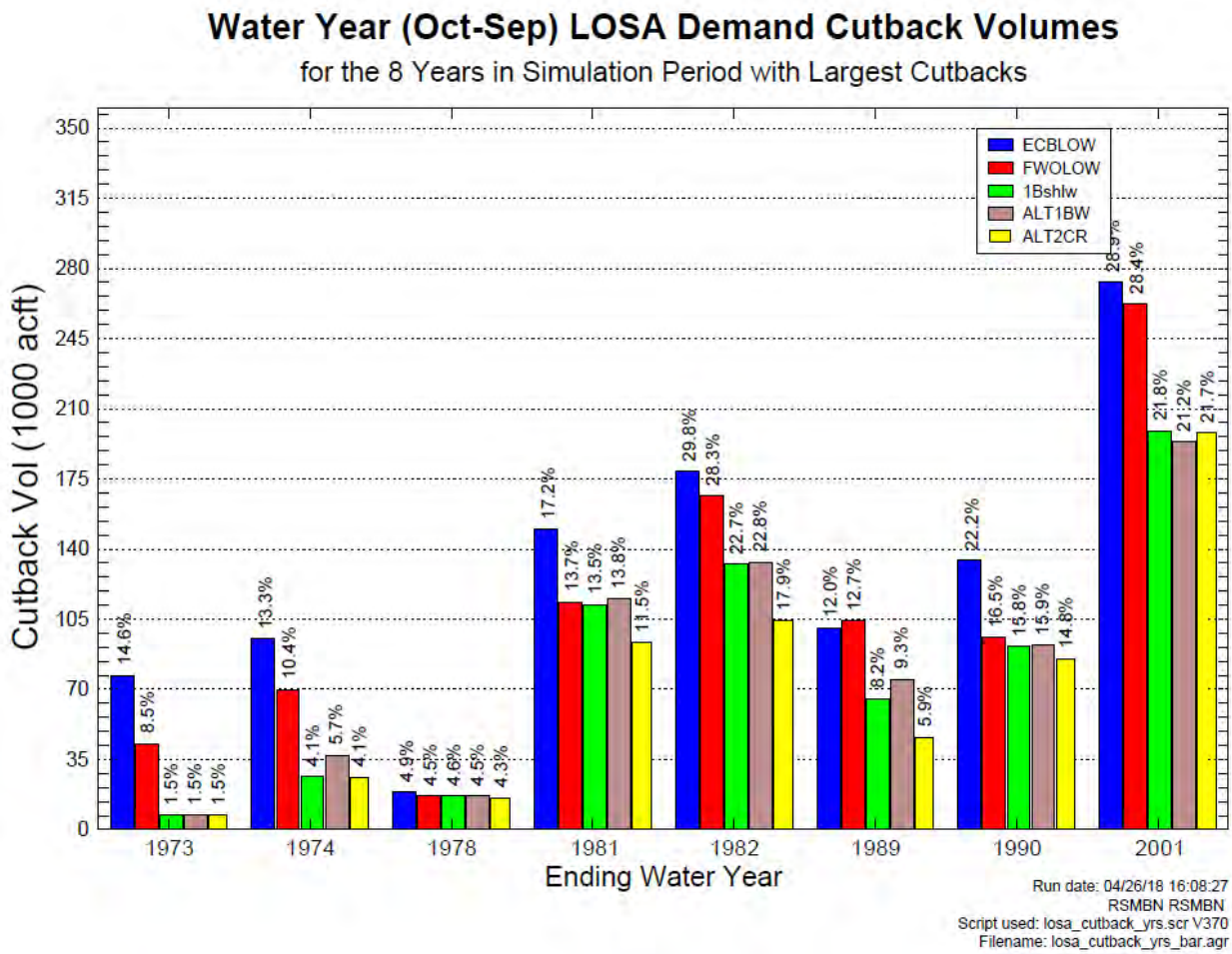

Figure C.2-44. LOSA demand cutback volumes for the 8 years with the largest cutbacks.

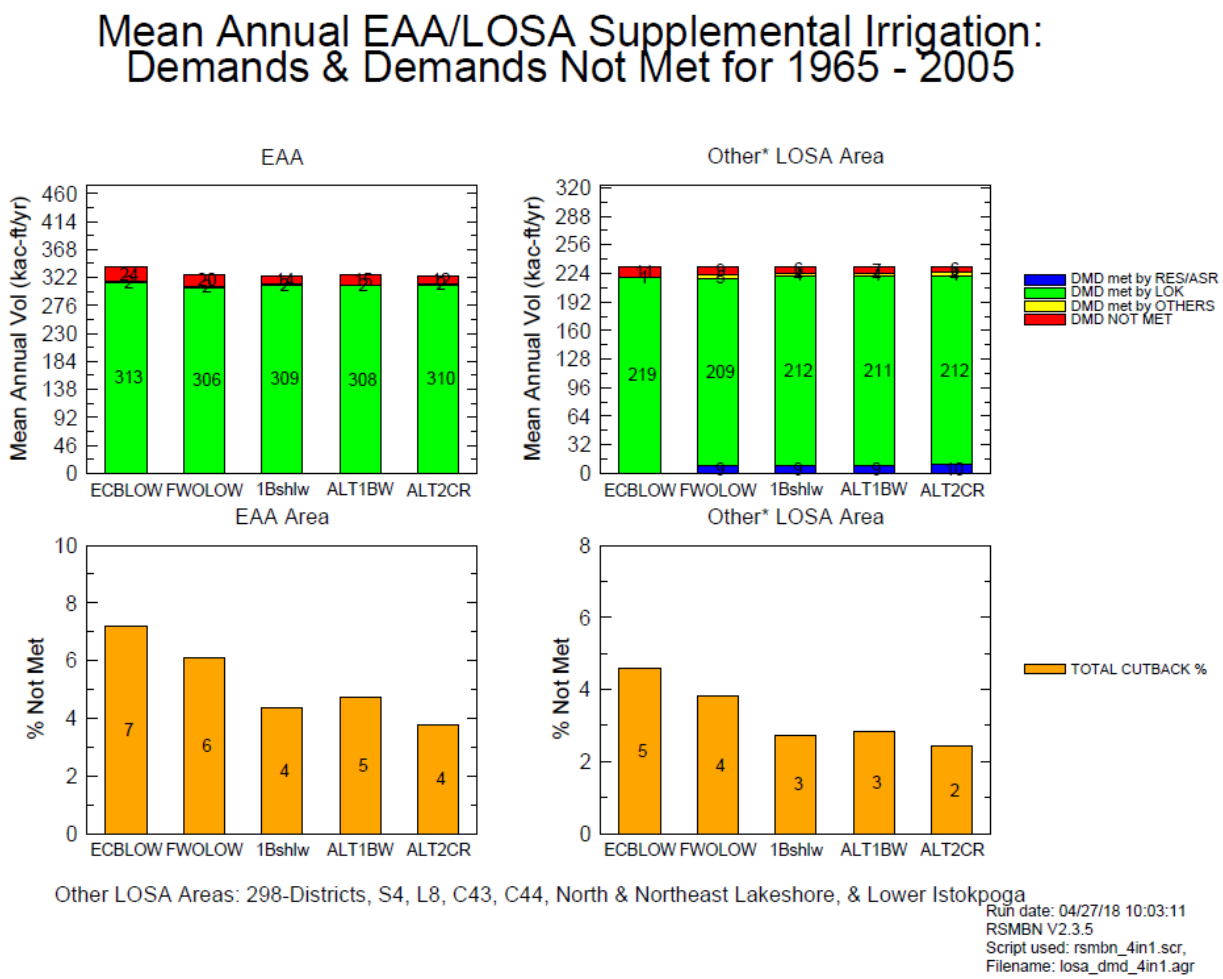

Figure C.2-45. Mean annual EAA/LOSA supplemental irrigation: demands & demands not met for 1965–2005.

As measured by RECOVER Performance Measure WS-1 (**Table C.2-24**), the frequency and severity of water restrictions in LOSA is reduced by all alternatives in the final array compared to the FWO project condition. The TSP (Alt 1BW) reduces the severity score from 12 in the FWO project condition to 7.

Table C.2-24. RECOVER Performance Measure WS-1: Frequency and Severity of Water Restrictions for Lake Okeechobee Service Area.

Simulation	POR	*Cutback Total (kaf)	Frequency	Severity Score	Number of WYs with at Least 1 Cutback
ECB	1965-2005	857	8	13	8
FWO	1965-2005	688	8	12	8
Alt 1Bshlw	1965-2005	446	6	6	6
Alt 1BW	1965-2005	461	6	7	6
Alt 2CR	1965-2005	384	6	4	6
*Computed using monthly cutbacks > 18k **Cutback report tabulated by calendar Year					

C.2.13.2 Seminole Tribe of Florida

The STOF has surface water entitlement rights pursuant to the 1987 Water Rights Compact and subsequent entitlement provisions executed between the Seminole Tribe of Florida, the State of Florida, and the SFWMD. Impacts are not expected for the LOWRP action alternatives based on the hydrologic modeling.

Based on LOWRP alternative modeling, the percentage of water supply demand not met for the Brighton Reservation is shown to be slightly reduced in all alternatives compared to the FWO (**Figure C.2-46**). The percentage of water supply demand not met for the TSP (Alt 1BW) is 2.4% compared to 3.3% in the future without project condition (FWO).

The percentage of water supply demand not met for the Big Cypress Reservation is shown to be slightly reduced in all alternatives compared to the FWO (**Figure C.2-47**). The percentage of water supply demand not met for the TSP (Alt 1BW) is 3.1% compared to 3.7% in the future without project condition (FWO).

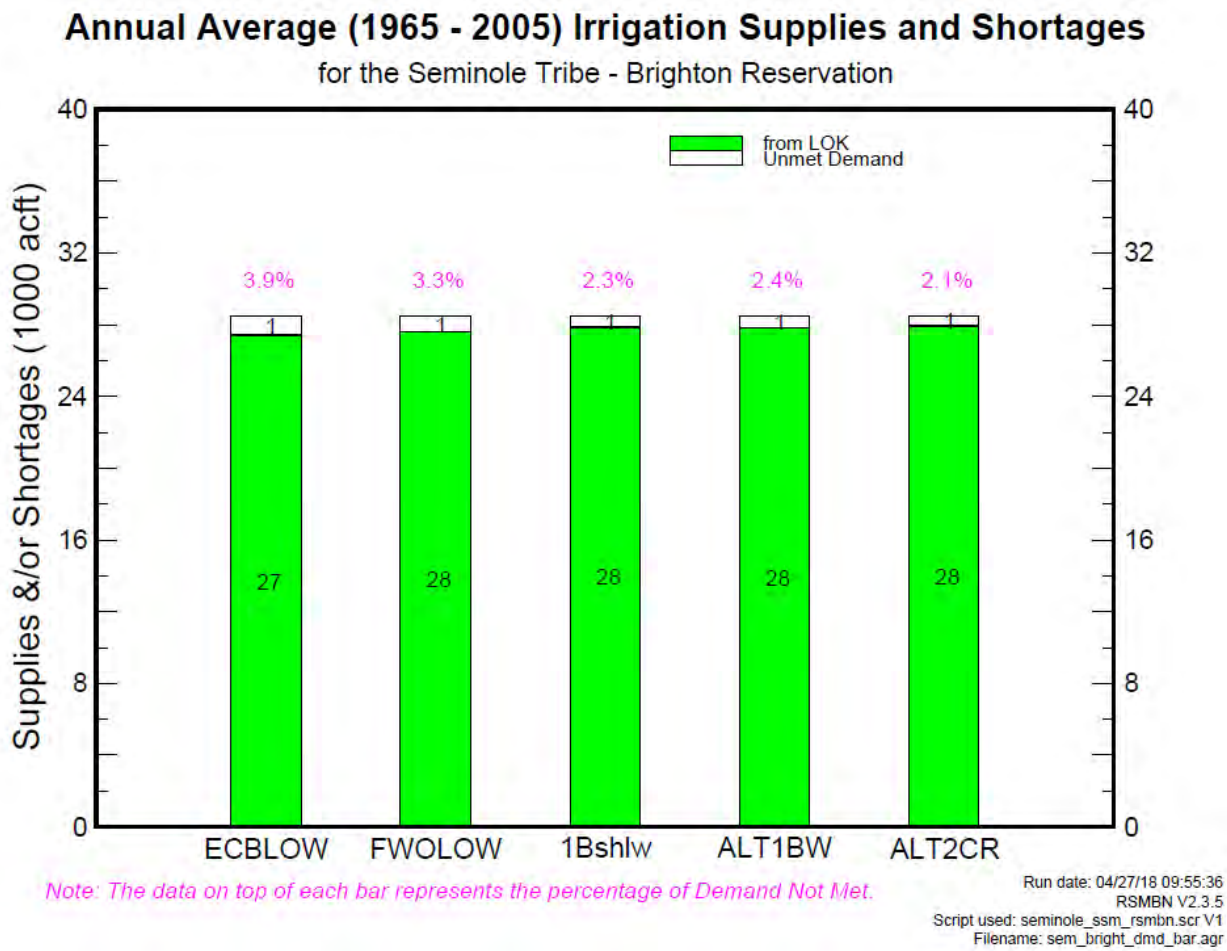

Figure C.2-46. Annual average (1965–2005) irrigation supplies and shortages for the STOF Brighton Reservation.

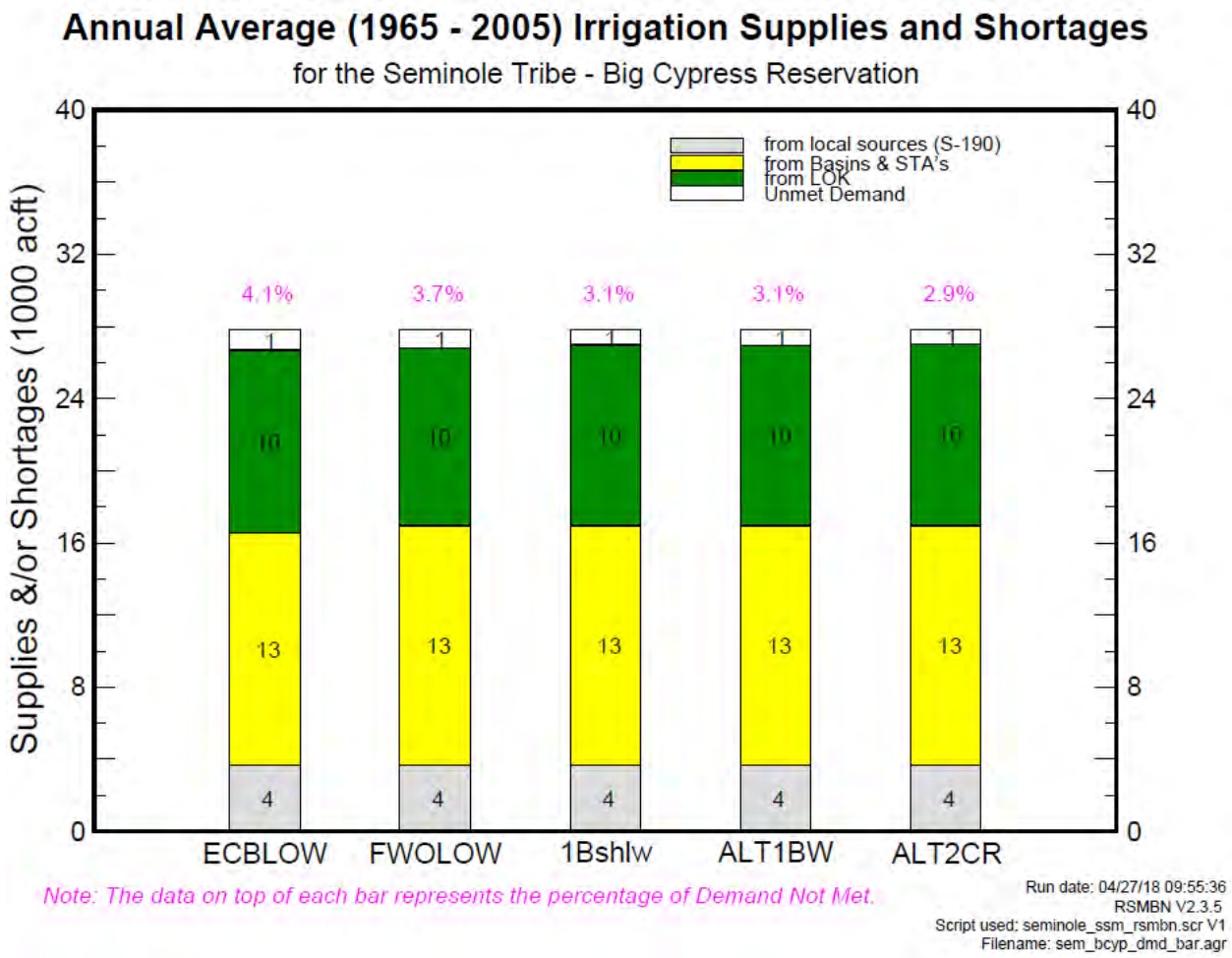

Figure C.2-47. Annual Average (1965–2005) irrigation supplies and shortages for the STOF Big Cypress Reservation.

C.2.14 Air Quality

Direct emissions from the proposed construction of the LOWRP project features would be confined to exhaust emissions of labor transport equipment, and construction equipment (dump trucks, excavators, graders, bulldozers, etc.). Clean Air Act pollutants considered in this air quality assessment are SOx; volatile organic compounds (VOCs); nitrogen oxides (NOx), CO, PM10, and PM2.5. Greenhouse gas emissions are also considered. Volatile organic compounds, sulfur oxides, and nitrogen oxides are important since they are precursors to ozone generation. These criteria pollutants are generated by the construction and operational activities associated with the proposed action alternatives.

In Lake Okeechobee and the Northern Estuaries, population growth in the area is expected in the FWO condition relative to existing conditions baseline, representing the potential for an increase in air pollution. However, air quality compliance is expected. All action alternatives are expected to have no change relative to FWO conditions in Lake Okeechobee and the Northern Estuaries. Reduction in ranching equipment used on the reservoir lands in FWO condition will be offset by increase in air pollutants from new pump stations and ASR wells. A detailed analysis of air quality impacts has been prepared for the TSP

in **Section 6**. The air quality analysis done for the TSP is applicable for Alternatives 1Bshlw and 2Cr given their similarities to Alt 1BW.

C.2.15 Hazardous, Toxic, and Radioactive Waste

The FWO and with-project alternative conditions will have similar HTRW conditions in the future with the exception of the lands used for the WAF and, Kissimmee River–Central & Paradise Run wetlands. Under the FWO condition, the WAF, Kissimmee River–Central & Paradise Run wetlands lands will likely continue to be farmed which will result in the additional application of agricultural pesticides in the cultivated portions of this property and the inadvertent release of petroleum and pesticides in operation and maintenance areas. During the construction of project features, it is possible that undiscovered HTRW contamination will be found. Per EC 1165-2-132, the non-federal sponsor will be required to remediate these sites at their sole expense. There is also the potential for HTRW release associated with the operation of project pump stations; however, with modern facilities and best management practices, this presents a minor risk to the environment.

C.2.15.1 Residual Agricultural Chemicals

The USACE HTRW policy (ER 1165-2-132) directs that Construction of Civil Works projects in HTRW-contaminated areas should be avoided where practicable. In September 2011, the ASA (CW) provided an exception to this HTRW policy for CERP Projects (Memorandum for Deputy Commanding General for Civil and Emergency Operations, Subject: Comprehensive Everglades Restoration Plan (CERP) – Residual Agricultural Chemicals, Dated September 14, 2011). If specific criteria are met, this policy memorandum allows residual agrichemicals to remain on project lands and allows the USACE or SFWMD to integrate response actions directly into the construction plan.

This section of the LOWRP PIR will partially fulfill the requirements established in the aforementioned policy for the WAF, Kissimmee River–Central & Paradise Run wetlands, and up to 80 ASR locations of the LOWRP. The Jacksonville District will seek conditional but not final approval of the application of the Ag-chem policy from HQ USACE. Final approval will be requested prior to design of the K-05 WAF, Kissimmee River–Central & Paradise Run wetlands, and up to 80 ASR locations of the LOWRP when it is expected that supplemental information will be available to completely fulfill the policy requirements.

C.2.15.2 Recommendation

The WAF, Kissimmee River–Center and Paradise Run wetlands, and up to 80 ASR locations of the LOWRP project feature require the land conversion from agricultural production to aquatic restoration which inundates the land with water. The avoidance of lands containing residual agricultural chemicals is not practicable.

Environmental Conditions that indicate likely HTRW issues including ag-chemicals have been identified via prior Pre-Acquisition Environmental Due Diligence completed by the non-federal sponsor at relatively localized areas situated within the limited subset of previously acquired properties within the Project footprint. These HTRW issues remain currently unabated. Prior to construction, these HTRW issues will be satisfactorily addressed by the non-federal sponsor. In addition, all additional properties to be acquired will be evaluated via current Pre-Acquisition Environmental Due Diligence requirements to identify any additional Recognized Environmental Conditions and/or HTRW issues. Additionally, due to the time that has elapsed since the acquisition of selected properties within the project footprint, these properties will

be evaluated consistent with current requirements to ensure that no HTRW issues remain outstanding. Prior to construction and during operation, the USACE and the non-federal sponsor will comply with applicable requirements.

Specifically, unabated HTRW issues are associated with the former P1 Property (current Tract Nos. MD 100-060, MD 100-057, and MD 100-055) and the former P2 Property (Tract No. 39 105-022). These properties are situated within the revised current configuration of the WAF. A Phase I/II Environmental Assessment of the P1 Property was completed in January 2006, and a Phase I Environmental Assessment of the P2 Property was completed in January 2000.

When the WAF, Kissimmee River–Central & Paradise Run wetlands, and up to 80 ASR locations of the LOWRP lands are set for construction Phase I & if required Phase II assessments will be performed to determine the presence of any potential sources of HTRW in the cultivated areas at selected locations. The results of these audits will be provided to the FDEP and USFWS for their review, comment, and concurrence regarding the need for remedial actions. The project must have concurrence from the USFWS and the FDEP waste cleanup section that the lands are suitable for project use before construction can proceed.

The non-federal sponsor will be 100% responsible for the cost of actions taken due to the presence of residual agricultural chemicals, at no expense to the Federal Government. Any future costs associated with the presence of residual agricultural chemicals at the Federal project site will be 100% non-federal sponsor cost and responsibility. The costs for characterization of the project lands in preparation for conducting a response action for the residual agricultural chemicals and removal of soils that are hazardous waste will be included as 100% non-federal sponsor responsibility. The CESAJ will not conduct actions to address residual agricultural chemicals for the SFWMD during the OMRR&R phase of the project.

C.2.16 Noise

For the action alternatives there would be minor short term and less than significant increases in noise during construction activities. All LOWRP action alternatives include additional pump stations which would result in long-term, localized increases in noise. Since Alternatives 1Bshlw and 1BW adds the fewest number of pump stations (one), it would have the least effect with Alt 2Cr that adds 2 additional pump stations having the greatest effect. Pumps associated with ASR wells would also result in long-term localized increases in noise. Alt 2Cr adds the fewest ASR wells (65 wells), followed by Alternatives 1Bshlw and 1BW with 80 ASR wells each. ASR pumps are electric, which run much quieter than diesel powered engines. The turbines are submerged to a depth of 30 ft. below the surface, so sound is damped. Compressor for the airburst system (to clean intake screen) runs infrequently for 5 minutes. There will be some noise during the day from the drill rig during well construction (duration approximately 1 month per well). Hospital-grade mufflers will be included in design.

C.2.17 Aesthetics

Aesthetic effects refer generally to impacts on the visual qualities of the environment. Restoration of the south Florida ecosystem is expected to result in a healthier environment that would support vigorous plant communities; larger fish and aquatic animal populations; large numbers of wading birds; alligators; and sustainable populations of wide-ranging mammals, in a natural setting, in perpetuity. People value viewing wildlife, wetlands, and open, relatively pristine spaces, as supported by tourism statistics for south

Florida. During construction of all features there will be a temporary short-term significant impact to aesthetic values in the construction areas. All action alternatives show a significant increase in aesthetic value over the FWO due to restoration of wetlands in the Lake Okeechobee watershed and provide a minor beneficial effect. The restoration of wetlands provides additional habitat for native plants and animals and opportunities for wildlife viewing. Alternative 1BW will have the greatest increase in aesthetics due to the WAF and the addition of wetland vegetation habitat on the storage footprint. The proposed reservoirs in Alt 1Bshlw and Alt 2 Cr will provide some potential habitat for fish and wildlife that will enhance the aesthetics of the area. There will be temporary, short-term significant adverse impact to aesthetic values in the construction areas during construction. For the reservoirs and WAF there will be a long-term, major adverse impact in reservoir areas due to levees in line of sight. An earthen dam will be visible on the rise, but covered in grass to minimize the aesthetics impact. There will be a moderate adverse impact with the addition of a pump stations, ASR wells, and reservoirs by adding man-made features in the natural landscape. All alternatives will have a minor effect to the night sky resource (nightscape) within and vicinity of this project due to increased light pollution. The light pollution concern includes light pollution at pump stations and ASR wells at night in an otherwise dark landscape. ASR systems and pump stations will be designed to have a minimum number of fully shielded LEDs for exterior lighting. Floodlights used for security during construction will be minimized. All alternatives will have minor effects after minimizing light type, number, direction of orientation, and location compared to residential areas. There are no affects to public parks, conservation areas, or refuges in the project area.

There would be negligible and less than significant effects due to LOWRP in Lake Okeechobee. In the Northern Estuaries, the action alternatives would increase the aesthetic value due to decreased high-flow events and provide minor beneficial effects. Reductions in high volume flows to the estuaries would result in lower suspended solids, increased water clarity, and the correct salinity envelope that maintain healthy SAV beds. These benefits could also and lead to an increase in wildlife viewing opportunities (Orth et al., 2006).

C.2.18 Land Use

The LOWRP project area consists of a mixture of private and public land ownership. The public lands belong to the South Florida Water Management District (SFWMD) and the State of Florida. Publicly owned lands in the Paradise Run and K-05 footprints (Alt 1Bshlw and Alt 1BW) are currently being leased for cattle grazing. The publicly owned lands in the Kissimmee River–Center Wetlands boundary are currently vacant. The K-42 Revised footprint (Alt 2Cr) consists of all privately owned lands which are predominantly used as pasture. The parcel map showing land ownership types are shown in **Figure C.2-48**.

C.2.18.1 Wetlands and Uplands

All of the alternatives consist of aboveground storage and wetland components. The same wetland components will apply to each alternative and are referred to as the Kissimmee River–Center and the Paradise Run Wetlands. In the footprint of the Kissimmee River–Center Wetland, approximately 89% of the lands are privately owned and the remaining 11% are publicly owned (**Figure C.2-48**). In the Paradise Run Wetland footprint, the land ownership types are comparable with approximately 50% in both public and private ownership. For the aboveground storage components in the Final Array of Alternatives there are three alternatives proposed, Alt1BShlw, Alt1BW, and Alt2Cr which consist of two footprints, K-05 and K-42. There is a combination of public and private lands in the K-05 footprint. The K-42 footprint consists of all privately owned lands. The parcel map showing land ownership types are shown in **Figure C.2-48**.

Much of the land proposed to be used for the future development of the aboveground storage components is currently in agricultural use.

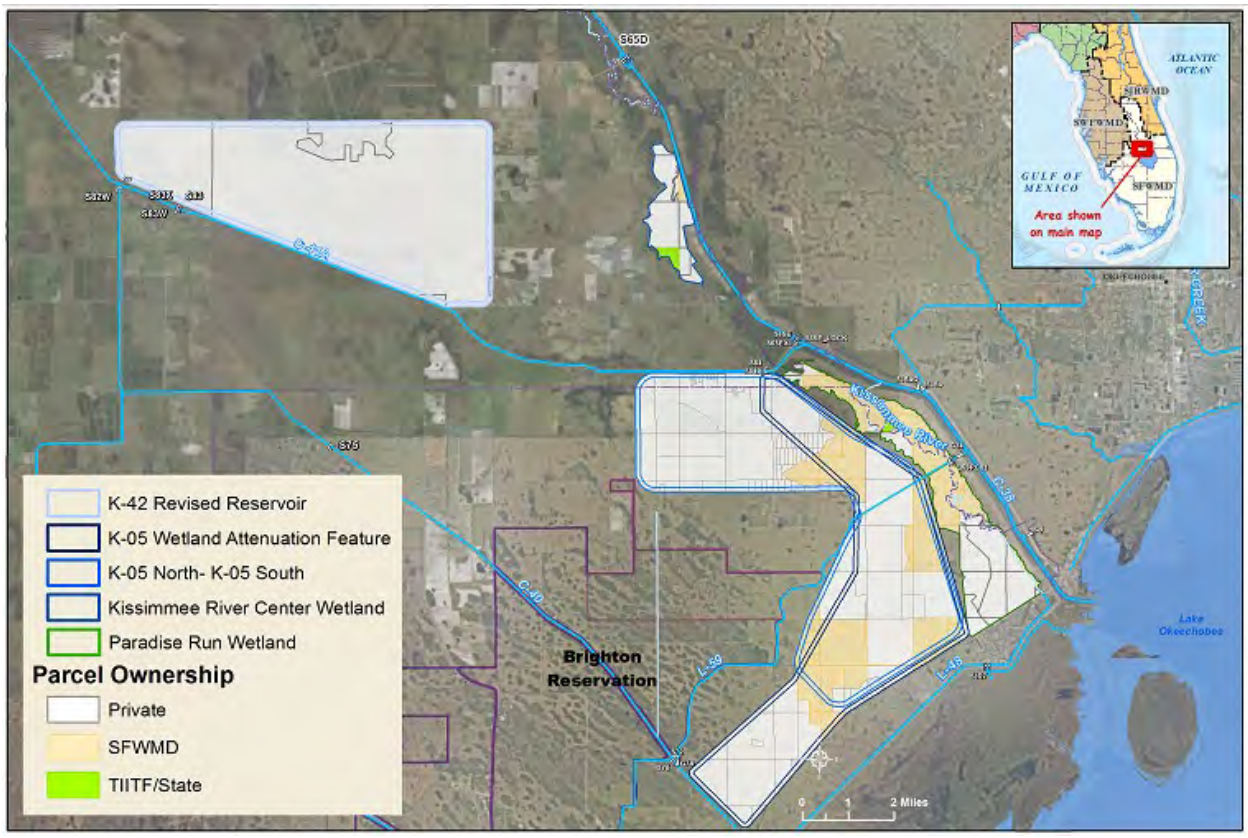

Figure C.2-48. Public and private parcels in the alternative footprints.

The Kissimmee River–Center wetland and Paradise Run wetland footprints were formerly the floodplain and wet marshes for the meandering Kissimmee River. Currently, approximately 13% of the lands in the Kissimmee River–Center wetland are existing fresh water, marshes, wetlands, or wetland forests. The remaining 87% of the lands are uplands or pasturelands that will be restored into inland wetlands. The Paradise Run wetland footprint would need much less restoration in comparison to the Kissimmee River–Center wetland footprint. Currently, approximately 61% of the lands in the Paradise Run wetland are fresh water, marshes, wet prairies, or wetlands. The remaining 39% of the lands are uplands or pasturelands that will require restoration to have inland, wetland landscapes features. The land use categories for each component of the alternatives are summarized in **Table C.2-25**.

Alternative 1Bshlw contains the K-05 North and K-05 South aboveground storage footprints. These footprints are comprised of approximately 14,800 acres of land that are predominantly used for pasture. Agricultural pasturelands dominant the landscape by 87%, the next significant land use category are freshwater marshes and wet prairies comprising 8% of the landscape. Approximately 1,127 acres of freshwater marshes and wetland forests will be impacted as a result of this alternative.

Table C.2-26 summarizes the impacts to wetlands for the final array of alternatives. Additionally, 75% of the lands in this footprint are in private ownership and the remaining 25% of the lands are publicly owned lands. This alternative's footprint is located the closest to the STOF Brighton Reservation.

Similar to Alternative 1Bshlw, Alternative 1BW contains portions of both the K-05 North and K-05 South aboveground storage footprints, but it is positioned 0.5 miles away from the STOF Brighton Reservation. This footprint is comprised of approximately 12,500 acres of land that are predominantly used for pasture. Although uplands of pasture and rangelands dominant the landscape by 94%, the next significant land use category are freshwater marshes and wetland forests comprising 6% of the landscape. Approximately 793 acres of freshwater marshes and wetland forests will be impacted as a result of this alternative. This alternative contains the most public owned lands at 31%. The remaining 69% of the lands in this footprint are privately owned.

Alternative 2Cr contains the K-42 Revised aboveground storage footprint, which is approximately 14,600 acres in size and predominantly used for agriculture. Although pasture dominants the landscape by 81%, the next significant land use category is freshwater marshes or wet prairies comprising 17% of the landscape. This alternative would impact more than twice the amount of acreages of freshwater marshes and wetland forests compared to the other alternatives resulting in impacting approximately 2,416 acres of existing wetlands. Additionally, all the lands in this alternative are privately owned.

Table C.2-25. Land use in the wetland and storage features.

Land Use Category	Wetland or Aboveground Storage Component				
	Kissimmee River–Center	Paradise Run	K-05 North and K-05 South (Storage component for Alt1BShlw)	Portions of K-05 North and K-05 South (Storage component for Alt1BW)	K-42 Revised (Storage component for Alt2Cr)
Cabbage Palm	0	3	491	320	54
Cabbage Palm Wetland	4	15	0	0	155
Channelized Waterways, Canals	2	2	0	1	1
Citrus Groves	0	0	49	0	0
Emergent Aquatic Vegetation	39	885	0	0	17
Freshwater Marshes / Graminoid Prairie	55	493	1,032	691	1,937
Freshwater Marshes-Sawgrass	0	0	0	0	38
Herbaceous (Dry Prairie)	3	19	27	26	311
Improved Pastures	792	1,286	12,514	11,038	8,184
Live Oak	3	0	0	0	0
Mixed Rangeland	0	40	0	0	0
Mixed Shrubs	159	184	45	17	135
Mixed Wetland Hardwoods	0	32	7	4	0
Natural River, Stream, Waterway	8	76	0	0	0
Oak - Cabbage Palm Forest	0	0	159	61	138
Palmetto Prairies	0	0	0	0	5
Reservoirs	5	0	24	7	371
Slough Waters	0	146	0	0	0
Spoil Areas	0	10	0	0	0

Land Use Category	Wetland or Aboveground Storage Component				
	Kissimmee River–Center	Paradise Run	K-05 North and K-05 South (Storage component for Alt1BShlw)	Portions of K-05 North and K-05 South (Storage component for Alt1BW)	K-42 Revised (Storage component for Alt2Cr)
Unimproved Pastures	64	0	300	120	2,659
Upland Hardwood Forests	0	35	0	0	319
Upland Shrub and Brushland	0	17	54	62	0
Wet Prairie	41	840	71	98	269
Woodland Pastures	5	0	0	0	0
Total Acres	**1,181**	**4,083**	**14,774**	**12,446**	**14,594**

Table C.2-26. Impacts to wetlands and uplands for the final array of alternatives.

Impacts to Wetlands/Uplands (acres) for each project feature for each alternative. Project Feature	FWO Acres of Wetland, Gain (Loss)	Alternative 1BShlw, Acres of Wetland Gain (Loss)	Alternative 1BW, Acres of Wetland Gain (Loss)	Alternative 2Cr, Acres of Wetland Gain (Loss)
Kissimmee Center Wetland	0	1,181	1,181	1,181
Paradise Run Wetland	0	4,083	4,083	4,083
K-05 North and K-05 South (Alt1Bshlw)	0	(1,134)	0	0
Portions of K-05 North and K-05 South (Alt1BW)	0	0	(793)	0
K-42 Revised (Alt2Cr)	0	0	0	(2,415)
Total Net Change [i1]	0	4,130	4,471	2,849

All alternatives show a significant and major beneficial effect with an increase in wetland habitat compared to the future without (FWO). Alt 1BW provides the greatest increase in wetland acreage with 4,471 acres followed by Alt 1BShlw with 4,130 acres, and Alt 2Cr provides the least with 2,849 acres. There is approximately 341 acres of wetland benefit difference between Alt1Bshlw and Alt1BW since they are in the same general vicinity, located northwest of Lake Okeechobee, west of the Kissimmee River, and

[1] All of the land use footprints of the alternatives are estimates until detailed design is complete. Differences in estimated acreages can be altered by different project features, construction of features, and topography for sheetflow to restore the wetlands.

east of Brighton Reservation. Alt1BW is unique due to its proposed shallow water depth. When the aboveground storage component is a shallow wetland feature, having ASR assisting the facility ensures that wetland conditions will be maintained within the project footprint when the water is held between 0.5-3 ft. This alternative will have additional wetland benefits within its aboveground storage feature. Alt2Cr is further north in the watershed and contains much more acres of existing wetlands predominantly located along the C-41A canal. The objective for the LOWRP was to restore a minimum of 3,500 acres of wetlands, and Alt2Cr falls short of this goal by approximately 650 acres. All of the other alternatives meet this project objective.

C.2.18.2 Agriculture

The LOWRP area consists of a mixture of private and public land ownership. Each component in the Final Array of Alternatives will have an impact on agricultural lands. Each alternative would convert approximately 13,000-15,000 acres of agricultural lands to either wetlands or aboveground storage due to the construction of project features. **Table C.2-27** summarizes the impacts to agricultural lands for each component in the Final Array of Alternatives. Coordination with the USDA and NRCS to meet the requirements of the Farmland Protection Policy Act, is ongoing. When detailed design information that locates each of the plan components is completed, it can then be determined how many acres of unique farmland would be affected by the Project. (Refer to **Part 4**).

Table C.2-27. Impacts to agriculture lands.

Impacts to agriculture lands (acres) for each project feature or aboveground storage component for each alternative.	Alternative 1BShlw, acres	Alternative 1BW, acres	Alternative 2Cr, acres
Kissimmee Center Wetland	861	861	861
Paradise Run Wetland	1,326	1,326	1,326
K-05 North and K-05 South (Alt1Bshlw)	12,814	0	0
Portions of K-05 North and K-05 South (Alt1BW)	0	11,158	0
K-42 Revised (Alt2Cr)	0	0	10,843
Total Agriculture Acres Loss	15,001	13,345	13,030

C.2.19 Recreation

There will be no impacts to recreational navigation with this project. All alternatives may provide enhanced fishing opportunities due to better salinity conditions in the Caloosahatchee and St. Lucie estuaries. Reductions in high flows to the Northern Estuaries would enhance fish populations and subsequently improve related recreational opportunities such as fishing, boating and kayaking.

A Recreation Plan is included in **Appendix F**.

C.2.20 Socioeconomics

The counties containing the LOWRP study area are expected to increase in population by 18.2% from 2016 to 2045, with Martin and Highlands counties attracting the greatest number of new residents. Glades and Okeechobee counties are expected to increase by only 2,253 and 5,094, respectively. When aggregated, the total population is projected to increase by 25,416 people. This rate of growth is consistent with that projected previously in CERP planning efforts. Population projections are not anticipated to differ between the FWO and alternative conditions.

There will be no impacts to Lake Okeechobee commercial navigation with this project. The hydrologic modeling conducted for all LOWRP alternatives to optimize system-wide performance incorporated the current Regulation Schedule management bands of the 2008 LORS. The hydrologic modeling of the LOWRP alternatives included proposed revisions to the 2008 LORS flow chart guidance of maximum allowable flows, which are dependent on the following criteria:

- Class limits for Lake Okeechobee inflow and climate forecasts, including tributary hydrologic conditions, seasonal climate outlook, and multi-seasonal climate outlook
- Stage level, as delineated by the Regulation Schedule management bands
- Stage trends (whether water levels are receding or ascending)

Most of the 2008 LORS refinements applied in the LOWRP modeling lie within the bounds of the operational limits and flexibility available in the current 2008 LORS, with the exception of the adjustments made to the class limits for the Lake Okeechobee inflow and climate forecasts. Under some hydrologic conditions, the class limit adjustments made to the Lake Okeechobee inflow and climate forecasts reduced the magnitude of allowable flows from the lake, thereby resulting in storage of additional water in the lake in order to optimize system-wide performance and ensure compliance with Savings Clause requirements. However, these class limit changes represent a change in the flow chart guidance that extends beyond the inherent flexibility in the current 2008 LORS. Additional information and documentation of the LOWRP TSP modeling assumptions for Lake Okeechobee operations are found in the Appendix A. The authorized C&SF project depths for Lake Okeechobee navigation are based on 12.56 ft. NGVD. Effects are provided in the main report in **Section 5.**

C.2.21 Environmental Justice

The effects of the final array of alternatives and the TSP on the EJ communities are described below.

C.2.21.1 EJ Aesthetics

Aesthetic effects refer generally to impacts on the visual qualities of the environment. Restoration of the south Florida ecosystem is expected to result in a healthier environment that would support vigorous plant communities; larger fish and aquatic animal populations; large numbers of wading birds; alligators; and sustainable populations of wide-ranging mammals, in a natural setting, in perpetuity. There is concern from the STOF and local communities that the proposed levees will block the current unobstructed view of the landscape. The WAF in Alt 1BW will have a levee height of 15.5 ft. The shallow reservoir in Alt 1Bshlw will have a levee height of 15-16 ft. The deep reservoir in Alt 2Cr will have a levee height of 27.5 ft. The geographic area of the LOWRP is that it is relatively flat with no significant change in topography which magnifies the aesthetic impact in the surrounding area. However, the proposed levees will be significantly lower than the existing HHD levees with a levee height of 20–25 ft. and is located in the

project area. The levee will be visible on the rise, but covered in grass to minimize the aesthetics impact and could be surrounded by trees to provide screening, a more natural look, and provide habitat for wildlife. Alternative 1Bshlw features are located 0.2 miles or more from the STOF Brighton Reservation and tribal owned lands, Alt 1BW features are located 0.5 miles or more from the STOF Brighton Reservation and tribal owned lands and Alt 2CR features are located 2.5 miles or more from the STOF Brighton Reservation and tribal owned lands.

All alternatives significantly increase the acreage and quality of wetlands in wetland restoration sites which will provide a long-term, significant, beneficial impacts in aesthetic value in the Kissimmee River–Center and Paradise Run wetland restoration sites. All alternatives will have a temporary, short-term, significant adverse impact to aesthetic values in the construction areas during construction. Alternative 1BW will have a levee height of 15.5 ft. and will have a long-term minor adverse impact in the K-05 footprint due to 15.5-ft. levees in the line of sight. However, the WAF is located at least 0.5 mile from tribal lands. Alt 1BW will also have a minor adverse impact with the addition of a pump station, 80 ASR wells, and a WAF by adding man-made features in the natural landscape. The WAF will contain wetland vegetation, thus providing additional habitat for native plants and animals and opportunities for wildlife viewing. Alternative 1Bshlw will have long-term minor adverse impact in the reservoir area due to a 15-16 ft.-levee in the line of sight for K-05. Alternative 1Bshlw will also have minor adverse impact with the addition of a pump station, 80 ASR wells and one reservoir by adding man-made features in the natural landscape. Alternative 2Cr will have long-term moderate adverse impact in the K-42 revised reservoir area due to 27.5-ft. levees in the line of sight. Alternative 2Cr will also have minor adverse impacts with the addition of two pump stations, 65 ASR wells, and a reservoir in the K-42 revised footprint by adding man-made features in the natural landscape.

C.2.21.2 EJ Noise

The noise concern includes noise during construction and noise of pump operations in an otherwise quiet landscape with only periodic noise from roads and agricultural/ land management activities. All alternatives would have a minor short term and less than significant increase in noise during construction activities. All alternatives include additional pump stations which would result in long-term, localized increases in noise. Since Alternatives 1Bshlw and 1BW add the fewest number of pump stations (one), they will have the least effect with Alt 2Cr that adds 2 additional pump stations having the greatest effect. Pumps associated with ASR wells would also result in long-term, localized, increases in noise. Alt 2Cr adds the fewest ASR wells (65 wells), followed by Alternatives 1Bshlw and 1BW with 80 ASR wells. ASR pumps are electric, which are much quieter than diesel powered engines. The turbines are submerged to a depth of 30 ft. below the surface, dampening radiated noise. Compressors for the airburst system (to clean intake screen) runs infrequently for 5 minutes. There will be some noise during the day from the drill rig during well construction (duration approximately 1 month per well). Hospital grade mufflers will be included in the design.

C.2.21.3 EJ Light Pollution

The light pollution concern includes light pollution at pump stations and ASR wells at night in an otherwise dark landscape. ASR systems and pump stations will be designed to have a minimum number of fully shielded LEDs for exterior lighting. Floodlights used for security during construction will be minimized. All alternatives will have minor effects after minimizing light type, number, direction of orientation, and location compared to residential areas.

C.2.21.4 EJ Air Quality

The air quality concern includes pollutants and smog in the air near the local community and the STOF's Brighton Reservation from pump station and ASR use. The ASR system is powered by electricity (no diesel engines), so has no local air quality impacts. All alternatives will have minor, short-term adverse effect in direct emissions from the construction of project features (exhaust emissions of labor transport equipment, and construction equipment (dump trucks, excavators, graders, bulldozers, etc.). Alternatives 1Bshlw and 1BW will have long term, minor, localized adverse effects in air quality from pump stations and ASR wells (1 pump station, 80 ASR wells). Alternative 2Cr will have long term, minor, localized adverse effect in air quality from pump stations and ASR wells (2 pump stations, 65 ASR wells).

C.2.21.5 EJ Wetlands

The wetland concern includes the loss of wetlands in the aboveground storage footprints. While the majority of the aboveground storage sites in each alternative are improved and unimproved pastures, there are some wetlands in each project alternative that will be removed in the construction of the reservoir or WAF. **Table C.2-4** shows the acres of wetland in each reservoir footprint. While these wetlands will be lost in Alternatives 1Bshlw and 2Cr, each alternative also includes the restoration of the Kissimmee River–Center wetland and the Paradise Run wetland. This wetland alternative restores 5,279 acres of wetlands along the Kissimmee River floodplain. Alternative 1BW has the largest net gain of wetlands at 9,911 acres, followed by Alt 1Bshlw with a net gain of 4,221 acres and then Alt 2Cr with a net gain of 2,728 acres of wetlands. All alternatives significantly increase the acreage and quality of wetlands in the project area (**Table C.2-5**).

C.2.21.6 EJ Cultural and Historic Resources – Kissimmee Circle Earthworks

The Kissimmee Circle Earthworks site (8GL39), which is adjacent to Alternative 1BW, will likely be eligible for listing in the National Register of Historic Places (NRHP). To avoid impacting this site, the K-05 WAF boundary was relocated to avoid adverse effect to this site. The boundary of Alternative 1Bshlw was also relocated to avoid impacting this site. Alternative 2Cr is located several miles away and will have no effect to his site.

C.2.21.7 EJ Cultural and Historic Resources – Burial Resources

Prehistoric burial resources have been reported within the final array of alternatives. The STOF have expressed concerns that burial resources could be inundated by the construction of aboveground storage features or impacted by wetland restoration. Burial resources are highly likely in mounds and earthwork sites throughout the region. There is also some potential for mortuary ponds (cemeteries) that could be located within one or more ponds within the project boundary. Burials can also be found associated with traditional pre-contact archaeological sites. Burial resource patterns are likely to reflect the demographics of pre-contact Native American demographics and cluster near ceremonial/ ritual areas. Areas with dense pre-contact populations are more likely to contain more burial resources while low density and or nomadic human populations are likely to produce fewer burial resources. Alternatives 1Bshlw and 1BW are adjacent to the Kissimmee Circle Earthworks and which has a high potential for the presence of burial resources in the area. If burials are identified during the project the procedures stipulated within the Burial Resource Agreement (BRA) between the STOF and SAJ will ensure meaningful consultation with respect to burial resources. Although not signatories of the Burial Resources Agreement, the presence of burial resources will also require consultation with the Miccosukee Tribe of Indians of Florida and other

appropriate federally recognized Tribes pursuant to Section 106 of the National Historic Preservation Act (NHPA), the USACE Trust Responsibility, and other federal regulations, executive orders, and departmental policies, including the 2008 CERP Policy on Human Remains. There are no known burial resources within the footprints of the K42 reservoir; however, one previously identified site with reported burial resources was identified within the Paradise Run restoration area and is part of each alternative. There is a high potential for the presence of burial resources associated with 8GL77 within Alternative 1BW WAF. Additional cultural resource investigations will be required during design.

C.2.21.8 EJ Cultural and Historic Resources – NRHP Eligible Sites

Archaeological sites are likely present in every alternative; archaeological surveys are limited in this area. The larger the footprint, the greater likelihood of impacting more NRHP eligible archaeological sites. There is one previously identified archaeological site (8GL77) which has been formally evaluated and is eligible for listing in the NRHP. A reconnaissance survey of approximately 1350 acres of SFWMD-owned lands within the 1Bshlw and 1BW footprints identified two new archaeological sites that are potentially eligible for listing in the NRHP. The investigation also identified two cultural sites within the Paradise Run wetland restoration area. Alternative 2Cr has no known NRHP eligible sites within the footprint of the K42 reservoir; however, there are multiple sites present within the Paradise Run. Only one Cultural Resource Assessment Survey (CRAS) has been completed within a portion of the K42 reservoir area. In all alternative, additional investigations will be required during PED to identify archaeological sites within areas that have not been surveyed, and evaluate the NRHP eligibility of all identified archaeological sites which may be impacted by the project.

C.2.21.9 EJ Cultural and Historic Resources – Impacts to Traditional Cultural Properties

The concern is there are traditional cultural properties (TCP) that may be eligible for inclusion in the NRHP based on associations with cultural practices, traditions, beliefs, ways of life, arts, crafts, or social institutions of a living community including the STOF and MTIF in the project area. The close proximity of Alternatives 1Bshlw and 1BW to the Brighton Reservation may increase the potential likelihood of the presence of TCPs. National Register Bulletin 38 describes traditional cultural properties as properties that are eligible for inclusion in the NRHP because of their association with cultural practices or beliefs of a living community that is rooted in that community's history, and is important in maintaining the continuing cultural identity of the community (Parker and King 1998). While there is an increased chance of TCPs within the final array of alternatives due to the proximity of Brighton Reservation, the presence of private property around the reservation is likely to limit STOF access to these areas. A TCP must meet specifically defined criteria and any potential TCPs identified within the TSP will require evaluation and consultation. At this time, there are no known TCPs located within the final array or TSP. TCPs are frequently identified and evaluated through ethnographic investigations and such a study has been initiated to be utilized during PED.

C.2.21.10 EJ Economics – Displacement of Endangered Species

The concern is displacement of species from project footprints to adjacent lands that could increase ESA compliance costs and limit the range of economic activities on lands. Of the number of species identified in the ESA species list (Annex A), the best candidate for dispersal is northern crested caracara and the Eastern indigo snake. For all alternatives species assessments on the project footprint would be required to determine the abundance of threatened and endangered species. Upland species could be planted next to the aboveground storage features and the restored wetland site to replace upland habitat that is

affected by project. USFWS can coordinate with the STOF to develop safe harbor agreements that ensures STOF can still pursue economic activities and traditional practices on their land.

Alternative 1Bshlw

There may be minimal increase in Eastern indigo snakes on STOF lands due to proximity to K-05 reservoir. Much of the K-05 area is pasture habitat that is not suitable for Eastern indigo snakes. It is unlikely that any displaced caracaras will successfully nest on the Brighton Reservation unless it displaces a current pair or new caracara habitat is created. There is already a surplus of adults without territories in the population, so if new habitat is created anywhere, a pair may move in regardless of it being a pair displaced from a LOWRP aboveground storage feature. There may be minimal to no increase in Florida grasshopper sparrows (FGSP) on STOF lands. The previous 2 Biological Opinions (BOs) for the Brighton Reservation (2010 and 2013) did not identify FGSP as a species of concern. The entire sparrow population has only gone down since then, so it is not likely that FGSP exist on the Reservation or the K-05 footprint or that habitat is present on the Reservation. There is a potential increase in Florida bonneted bat to STOF lands due to proximity to K-05 reservoir and loss of habitat, due to limited trees in the area. There is an opportunity to put up bat houses or roost structures for any bats that might be in the K-05 footprint in order to keep them near the reservoir after construction. There may be a minimal negative impact to primary dispersal areas of the Florida panther. The K-05 footprint is limited by Lake Okeechobee to the south and the Kissimmee River to the east so it is a limited panther corridor. No panthers are currently on the Reservation or any aboveground storage footprint. There is potential for panthers to occupy the Reservation in the future, but this would be independent of the LOWRP as they would be coming from the south, and their use of the Reservation would be dependent on the habitat on the Reservation. K-05 has less of a potential impact than K-42 on potential panther dispersal pathways.

Alternative 1BW

There may be minimal increase in Eastern indigo snakes on STOF lands due to proximity to K-05 WAF. Much of the K-05 area is pasture habitat that is not suitable for Eastern indigo snakes. It is unlikely that any displaced caracaras will successfully nest on the Brighton Reservation unless it displaces a current pair or new caracara habitat is created. There is already a surplus of adults without territories in the population, so if new habitat is created anywhere, a pair may move in regardless of it being a pair displaced from a LOWRP aboveground storage feature. There will be no impact to STOF lands for the Florida grasshopper sparrow for Alt 1BW because there is no potential FGSP habitat in the 1BW footprint. There is a potential increase in Florida bonneted bat to STOF lands due to proximity to the WAF and loss of habitat, due to limited trees in the area. There is an opportunity to put up bat houses or roost structures for any bats that might be in the WAF footprint in order to keep them near the WAF after construction. There may be a minimal negative impact to primary dispersal areas of the Florida panther. The K-05 WAF is limited by Lake Okeechobee to the south and the Kissimmee River to the east so it is a limited panther corridor. No panthers are currently on the Reservation or any aboveground storage footprint. There is potential for panthers to occupy the Reservation in the future, but this would be independent of the LOWRP as they would be coming from the south, and their use of the Reservation would be dependent on the habitat on the Reservation. K-05 has less of a potential impact than K-42 on potential panther dispersal pathways.

Alternative 2Cr

There may be minimal-to-no potential increase in Eastern indigo snakes on STOF lands due to proximity to K-42 reservoir and roads creating a barrier. The K-42 reservoir has better Eastern indigo habitat and therefore density could be higher, but it is farther away from Reservation, so it is not likely that any displaced Eastern indigo snakes would make it to the Reservation. It is not likely that any displaced caracaras will successfully nest on Reservation unless it displaces a current pair or new caracara habitat is created. There is already a surplus of adults without territories in the population, so if new habitat is created anywhere, a pair may move in regardless of it being a pair displaced from a LOWRP reservoir. There may be minimal to no increase in Florida grasshopper sparrows on STOF lands. The previous 2 BOs for the Reservation (2010 and 2013) did not identify FGSP as a species of concern. The entire sparrow population has only gone down since then, so it's not likely that FGSP exist on the Reservation or the reservoir footprints or that habitat is present on the Reservation. There is a potential increase in Florida bonneted bat to STOF lands due to proximity to K-42 reservoir and loss of habitat, limited due to trees in the area. There is an opportunity to put up bat houses or roost structures for any bats that might be in the reservoir in order to keep them near the reservoir after construction. There may be a moderate negative impact to primary dispersal areas of the Florida panther. The K-42 is in the primary dispersal area and may negatively affect the panther's corridors. No panthers are currently on the Reservation or any reservoir footprint. There is potential for panthers to occupy the Reservation in the future, but this would be independent of the LOWRP as they would be coming from the south, and their use of the Reservation would be dependent on the habitat on the Reservation.

C.2.21.11 EJ Economics – Water Supply Entitlement

The concern is losing access and volume of water that the STOF has reserved as part of three party water compact. The Seminole Tribe of Florida has surface water entitlement rights pursuant to the 1987 Water Rights Compact and subsequent entitlement provisions executed between the Seminole Tribe of Florida, the State of Florida, and the SFWMD. Impacts are not expected for the LOWRP action alternatives based on the hydrologic modeling. Based on LOWRP alternative modeling, the percentage of water supply demand not met for the Brighton Reservation is shown to be slightly reduced in all alternatives compared to the FWO (**Figure C.2-46**). The percentage of water supply demand not met for the TSP (Alt 1BW) is 2.4% compared to 3.3% in the future without project condition (FWO).

C.2.21.12 EJ Economics – Water Supply Entitlement

The concern is for existing users of Lake Okeechobee and other surface and ground water sources to maintain existing permitted withdrawals. Each of the alternatives in the final array improve water supply for existing legal users in LOSA compared the future without project (FWO). For the eight years with the largest water supply cutbacks within the LOSA, the water supply cutback percentage is reduced for seven of the eight years, compared to the FWO (**Figure C.2-44**). Based on the LOWRP alternative modeling assumptions and the resulting moderate stage increase within Lake Okeechobee, the average annual percentage of water supply demand not met is projected to decrease in LOSA including the EAA (**Figure C.2-45**). Each of the alternatives in the final array improves or maintains water supply compared to the FWO. In the EAA, the TSP (Alt 1BW) reduces the percentage of unmet demands to 5%, down from 6% in the FWO condition (**Figure C.2-45**).

C.2.21.13 EJ Economics – Ranching Impacts

The concern is impacts to ranching due to seepage and potential dam break due to aboveground storage. For all alternatives a seepage canal will be designed to limit seepage outside the WAF or reservoir and there will be no discernible impact to ranching from seepage. Groundwater effects will be modeled during PED. Deep reservoirs that were determined to be close to or over tolerable risk limits for dam breach consequences were removed from the final array. Formal dam safety risk assessments were not performed at this stage of the planning process. However, a desktop evaluation of all alternatives in the final array indicates that the alternatives are well within tolerable risk limit guidelines. Additional dam breach analysis will be performed during PED.

C.2.21.14 EJ Economics – Restricted Drainage of Brighton Reservation

The concern is that the aboveground storage features will restrict drainage patterns on the Brighton Reservation. Reservoirs could block drainage canals near the perimeter of project and plugged drainage could cause flooding on adjacent STOF lands if not avoided and minimized. For all alternatives the design of WAF and reservoirs will maintain existing drainage patterns outside the reservoir. Existing drainage patterns outside of reservoir footprints will be maintained as part of savings clause analysis.

C.2.21.15 EJ Health – Water Supply Well Contamination

The concern is with ASR water mixing in with water used for water supply bringing up drinking water concerns, especially with sources of drinking water that are in closer to proximity to the ASR wells than the general population. Since there are unknown effects on the environment from the ASR, these uncertainties have the potential to impact drinking water supplies, as well as traditional drinking water practices in the vicinity of the ASR wells. Drinking water supply is obtained mostly from the surficial aquifer (land surface to 170 ft. below land surface) in the project area. The ASR storage zone is 550 ft. to 1100 ft. below land surface in the project area. The surficial aquifer and ASR storage zone are separated by approximately 330 ft. of Hawthorn Group sands and clays, which form the intermediate confining unit. There is no possibility that the groundwater in the ASR storage zone will contaminate the surficial aquifer during normal ASR operations. FDEP UIC permitting process requires that ASR systems will not impact existing users. All alternatives will not affect drinking water.

Water supply from the UFA by existing users is unlikely to be contaminated or affected by LOW ASR wells. Previous testing at the KRASR facility (USACE, 2013) showed that the maximum lateral extent of the recharged water volume during the largest volume recharge event (1 billion gallons over 6 months) was less than 2,350 ft away from the KRASR recharge/recovery well. Storage-assisted ASR wells at the WAF are at least 3 miles away from the nearest UFA production well, and so will not be affected by project ASR testing.

C.2.21.16 EJ Health – Fish and Wildlife (Food) Contamination

The concern is mercury bioaccumulation in fish and wildlife due to ASR storage. Earlier studies have shown that mercury methylation does not occur during ASR storage in the Upper Floridan Aquifer. Earlier testing shows that mercury concentrations are lower in recovered water than in recharge water. Sulfate in recovered water has a low to moderate risk of enhancing mercury methylation in downstream sediments. ASR system operation can be performed to minimize sulfate in recovered water and mercury and sulfate

concentration analysis in test wells will be done during design. All alternatives will not affect fish and wildlife (food) contamination.

C.2.21.17 EJ Health – Dam Breach Impacting Property and Life

The concern is the impact to life and property in the event of a dam breach in the aboveground storage features. Deep reservoirs that were determined to be close to or over tolerable risk limits for dam breach consequences were removed from the final array. The risk of impacts to environmental justice communities is extremely low due to the low probability of reservoir/WAF breach for any alternative.

C.2.21.18 EJ Cultural Practices – Access to Sacred/Ceremonial Sites

The concern is that access to sacred/ceremonial sites will be impacted by the alternatives. At this time the majority of project lands are under private ownership and access may currently be restricted. An ethnographic study on what and where sacred ceremonial sites are located is currently being conducted in order to identify the sites and the potential impact.

C.2.21.19 EJ Cultural Practices – Hunting and Fishing Impacts

The concern is that traditional hunting and fishing grounds will be impacted by the alternatives. Aboveground storage feature will limit habitat for upland species. Wetland attenuation features and restored wetland sites will increase fishing opportunities in the project area. Waterfowl hunting will likely increase in the WAF and wetlands as well. All alternatives have the potential to increase in fishing due to increased access to wetland restoration sites and aboveground storage sites. All alternatives have the potential to negatively impact fishing due to impingement of larval fish at K-05 reservoir/WAF and ASR wells. However, this impact can be mitigated by location of pump stations, distance from Lake Okeechobee and the Kissimmee River, operations and installment of screens. All alternatives will reduce upland game species on those lands (that are mostly private and probably not open to the public for hunting), but may increase game species on surrounding properties. Alt 1BW contains approximately 14,869 acres of upland habitat, Alt 1Bshlw contains approximately 14,451 acres of upland habitat and Alt 2Cr contains approximately 13,626 acres of upland habitat This represents a potential loss to hunting if there is current access to these properties. However, there is a potential increase to hunting if upland species are relocating to different areas due to habitat loss in WAF, reservoir, and wetland site footprints.

C.2.21.20 Summary of EJ Effects and Determination

LOWRP would provide benefits to quality of life by improving Lake Okeechobee ecology, improving the estuarine environment and contribute to hydrological improvements in the historic Everglades. These wetland and estuarine habitat improvements would benefits fish and wildlife species abundance for recreation and subsistence fishing/hunting, as well as aesthetic existence value. In addition, the project would have incidental water supply improvements by minimizing the number and severity of Lake Okeechobee Service Area cutbacks.

Several EJ communities were identified in the project area as having a potential to be affected. Low-income communities located west of the Kissimmee River and surrounding Lake Okeechobee have income significantly lower than state/national averages and unemployment rates that are also higher than the state and national averages. Another EJ community that could be affected by the project is the STOF's Brighton Reservation, which represents Tribal National lands that are geographically fixed in position. Based on the above analysis, no disproportionately high and adverse impacts or benefits are imparted

upon the STOF and/or lower income communities. Any remaining minimal impacts will be further avoided, minimized, and/or mitigated, as described above.

C.2.21.21 Cumulative Effects for EJ

Cumulative environmental justice effects are associated primarily with effects on public health and safety, air quality, traffic and noise, and socioeconomics from implementation of LOWRP and other past, present and reasonably foreseeable actions. The timeframe will extend beyond the construction period indefinitely because impacts on socioeconomics and county revenues are long term and can continue to occur after construction. LOWRP is expected to contribute to a net beneficial cumulative impact on the regional ecosystem and public health. While the spatial extent of natural plant communities would not be restored to historic proportions, the quality of vegetative communities would be improved and habitat improvement efforts are anticipated to benefit fish and wildlife resources. Cumulative effects to historic properties and culturally significant sites will potentially be long-term adverse effects if not avoided. Mitigation measures for effects to historic properties could potentially reduce the cumulative effect to minor long-term adverse effects. Mitigation measures for culturally significant sites are unknown. While anthropogenic effects on water quality are unlikely to be eliminated, water quality is expected to slowly improve over existing and recent past conditions. During detailed planning and design, the USACE and SFWMD are committed to ensuring that project feature implementation will not result in violations of water quality standards. While effects on water supplies are unlikely to improve, water supplies available for agricultural and urban users are expected to remain stable until additional storage mechanisms are implemented.

C.2.22 Cultural Resources

The project study area consists of the Lake Okeechobee Watershed and includes 5 sub-basins (totaling approximately 920,000 acres) within portions of Glades, Highlands, Okeechobee, St. Lucie, and Martin counties and the STOF's Brighton Reservation. The majority of the LOWRP project features are located within the Indian Prairie sub-basin, although there are proposed ASR wells located around Lake Okeechobee.

The LOWRP study area has been impacted by human agricultural activities for over a hundred years. A review of the Florida Master Site Files (FMSF) indicate that there are previously recorded cultural resource sites and resource groups within the LOWRP study area that may be eligible for listing in the National Register of Historic Places (NRHP); however, the entire study area has not been subject to a systematic archaeological assessment. Three previous cultural resource investigations have been completed within portions of the areas the final array of alternatives.

In 2011, Wampler et al. (2011) completed a cultural resource survey within portions of Alternative 2Cr. This survey identified no new cultural resources within the surveyed portions of the alternative. However, an intensive cultural resource survey that was completed on property located adjacent to the 2Cr reservoir identified ten new archaeological sites, including six that were potentially eligible for listing on the NRHP (Ambrosino 2016). In 2009, Wayne and Dickinson (2009) completed a cultural resource reconnaissance survey of approximately 564 acres located entirely within Alternative 1 Bshlw. The investigation identified one new site. In 2014, Dunn (2014) completed a cultural resource investigation within portions of Alternative 1BW WAF. The investigation failed to identify any new cultural resources; however, one previously identified site 8GL77 was revisited and determined eligible for listing on the NRHP.

Due to the large area considered in the alternative, and the high probability of identifying properties eligible for inclusion in the NRHP within the LOWRP area of potential effects (APE), the USACE will employ a phased process in the identification and evaluation of historic properties and an assessment of effects through the execution of a programmatic agreement (PA) as provided in 36 CFR § 800.4[b][2]. The PA was executed among the USACE, SHPO, and Advisory Council on Historic Preservation (ACHP) and outlines the process in which the USACE will identify historic properties within the APE, determine effects of the undertaking to historic properties if present, and avoid, minimize, or mitigate adverse effects during the PED phase. Pursuant to Section 106 of the NHPA, consultation on LOWRP and the execution of a PA was undertaken with the STOF's Tribal Historic Preservation Office (THPO), the MTIF NAGPRA Representative, the Florida SHPO, the Seminole Nation of Oklahoma THPO, the ACHP, the Thlopthlocco Tribal Town THPO, and the public.

Engineering Regulation (ER) 1105-2-100 Appendix C, paragraph C-4(d)(6)(a) states that results of cultural resources investigations conducted during the feasibility phase and if needed, the PED phase will "serve as the basis for formulation of plans for management of historic properties prior to or during the construction and operational stages of projects". At which time, as required under ER 1105-2-100 Appendix C, paragraph C-4 (d)(6)(b) the PED phase will be utilized to complete historic property inventories, seek determinations of eligibility for the NRHP, determine effects of the project to historic properties, determine the need to mitigate adverse project effects on National Register and eligible properties, develop plans and cost estimates for such mitigation, and serve as the basis for negotiation of a Memorandum of Agreement with the appropriate parties specifying actions which will be taken by the USACE prior to or during the project construction period to mitigate adverse effects on National Register and eligible properties.

Post project authorization, each suite of features in the TSP will be subject to separate consultation and consideration of effects during PED as the APE may be subject to change based on final designs or modifications of project features. As outlined in the PA, supplementary cultural resources assessments will be conducted in areas that have not been previously surveyed. During PED and prior to construction, these surveys and a final determination of effects for any historic properties within the APE will be coordinated with the appropriate interested parties. Pursuant to Section 106 of the National Historic Preservation Act (54 U.S.C. 306108), the project design would be modified to avoid impacting significant historic properties and culturally significant sites where possible. Avoidance of adverse effects to cultural resources is the USACE preference, therefore, throughout the planning process for LOWRP, the project archaeologist, engineers, and plan formulators have worked closely to determine alternatives and features of alternatives that reduce or eliminate impacts to cultural resources. Where avoidance is not possible, other mitigation measures would be considered, which could include, but are not limited to, data recovery excavations. Mitigation measures would be developed in consultation with the SHPO, the ACHP, the appropriate federally recognized tribes, THPOs, and other interested parties as established in implementing regulations for Section 106 of the NHPA (36 CFR 800). This PIR/EIS meets cultural resources requirements as specified under NEPA. The LOWRP will remain in compliance with the Section 106 of the NHPA pre and post construction.

C.2.22.1 Area of Potential Effect

The area of potential effect (APE) for cultural resources differs greatly from the overall LOWRP study area. For this project, the APE for cultural resources covers many of the same features in each alternative. The Paradise Run Wetland Restoration Area, Kissimmee Center Wetland Restoration Area, and nine of the ASR well clusters are nearly identical. The differences between the alternatives is the result of variations

between the footprints of the different reservoir and wetland attenuation features and possible ASR well clusters that will be co-located within them. The location of the APE will continue to be refined during PED.

C.2.22.2 Evaluation Criteria Specific to Cultural Resources

Impacts to cultural resources vary by individual components within the alternatives. Therefore, impact evaluations were based on a review of the individual components of each Alternative to determine if actions would potentially result in impacts to significant cultural resources (which include sites eligible or potentially eligible for listing in the NRHP) described below. Throughout the development and selection of the components measures to eliminate or lessen adverse cultural resource effects were utilized.

The following significance thresholds have been used in determining whether components proposed for each Alternative would result in a significant impact to cultural resources. The use of the term cultural resources includes historic properties eligible or potentially eligible for listing in the NRHP and culturally significant sites. A cultural resource impact is considered significant if implementation of a component of an Alternative would result in any of the following when compared to FWO:

- Result in a change in the significance or NRHP eligibility of a historical property, including but not limited to any contributing elements.
- Disturb any human remains, including but not limited to those outside of formal cemeteries.*
- Disturb memorials determined to hold public significance regardless of age.
- Result in adverse changes to sites identified through consultation with Native American Tribes as having cultural significance.

* The Jacksonville District has implemented a Burial Resources Agreement (BRA) with the Seminole Tribe of Florida which serves as the basis for consultation regarding the presence of burial resources and sets forth procedures that will ensure the culturally sensitive treatment of burial resources pursuant to the USACE Trust Responsibility. The 2008 CERP Policy on Human Remains also applies to the current study and is only superseded by the BRA for consultation regarding burial resources with the STOF.

C.2.22.3 Comparison of Proposed Action Alternatives and Future Without Conditions

The project schedule (**Section 6.7 and 6.11.2.3**) allows for a phased approach to Section 106 compliance, in that each suite of features will be consulted on as they arise. This will ensure that the most up to date information will be considered in the determination of effect. Also, based on final designs or modifications of the project features, additional work may be required for compliance with the NHPA. *While the USACE is currently in compliance with the procedural requirements of the NHPA through execution of a PA, the USACE recognizes that additional cultural resource surveys, NRHP evaluations, and determination of effects made in consultation with the SHPO, appropriate federally recognized tribes, and other interested parties will be required in PED.*

Based on the stipulations of the PA, consideration of effects and potential mitigation of effects will be finalized during PED; therefore the effects associated with each Alternative have only been preliminarily considered for this feasibility study. A final identification, evaluation of historic properties, and determination of effects, as required under Section 106 of the NHPA, will not be made until the project is authorized and project features are sited during the subsequent PED phase.

For each component discussion below, the environmental effect is determined when compared to the FWO conditions. *This is a preliminary review of potential effects of the undertaking and should not be considered final. For this document, the use of the term "cultural resources" includes significant historic properties that are determined eligible or potentially eligible for NRHP listing and culturally significant sites. See* ***Section 10*** *in the Main Document for definitions of terms*.

C.2.22.3.1 Lake Okeechobee Watershed

C.2.22.3.1.1 Kissimmee River–Center (KRC)

The KRC wetland restoration area is located on the west bank of the C-38 canal and is approximately 1,200 acres in size. Plans call for placing a submerged weir in the C-38 canal, which will divert water into the old channel. Approximately 21,500 linear feet of silted channel will be excavated at various locations to clear the channel and reopen flow. The water will flow through this channel and reenter the C-38 canal through a culvert that will be placed at the southern end of the old channel. When water is available it will stage up and fill the entire wetland footprint. This flooding is intended to restore the wetlands to natural conditions. No cultural resource surveys have been completed and no known cultural resource sites have been identified within the KRC Wetland restoration area.

Anticipated ground disturbances include the construction of a new weir within the C-38 canal and the construction of a culvert at the southern end of the channel. No containment berm will be constructed around the wetlands to contain the water. The exact placement of the constructed features and associated access and work areas has not been determined. The removal of silt during this project will be confined to the old channel remnants as much as possible to minimize the impact to previously disturbed sediments. Some areas may require new excavations to connect isolated channel segments. Cultural resource surveys will be necessary in areas of proposed construction and adjacent to areas along restored river channels that may potentially be subject to heightened erosion from flooding caused through the restoration.

Additional cultural resource surveys and evaluations will be necessary, specifically during the detailed design phase for construction, when feature designs are finalized and construction staging areas determined.

C.2.22.3.1.2 Paradise Run (PR)

The PR wetland restoration area is approximately 4,100 acres located on the west bank of the C-38 canal between the Kissimmee River South and Buckhead Ridge. The wetland restoration requires the installation of a pump station on the C-41A canal downstream of S-84 to pump water over HHD into the historic Kissimmee River channel. This pump may be collocated with the K-05W inflow pump. Approximately 24,500 linear feet of remnant oxbow channel excavations will be excavated in locations where it has silted. The water will flow through the channel and reenter a canal at the southern end. A levee notch will be cut in the L-59 canal to allow flow from the northern to southern parts of Paradise Run. There will also be stage control at the existing structures G-33 and G-34. The water will stage up and fill the entire wetland footprint when water is available. There are no perimeter berms.

Prior to this project, no cultural resource surveys have been conducted in the Paradise Run wetlands although five cultural sites had been previously recorded in this wetlands area (8GL72, 8GL492, 8OB360, 8OB361, and 8OB364). Based on this information, the USACE conducted a reconnaissance survey of within

a 900-acre portion of the Paradise Run wetlands (Carlson and Barnett 2018). The survey identified three new cultural sites 8GL496, 8GL499, and 8OB365 within the Paradise Run wetlands and conducted supplemental investigations at 8GL492. Based on consultation with the FLSHPO sites 8OB360, 8OB361 and 8GL499 are 20th century canals which are not eligible for listing on the NRHP. Sites 8GL72, 8GL492 8GL496, 8OB364, 8OB365 are all potentially eligible for listing in the NRHP and require additional investigations. Site 8GL72 is a prehistoric midden and burial mound site with reported burial resources. The site has reportedly been looted in the past.

Additional cultural resource surveys and evaluations will be necessary, specifically during the detailed design phase for construction, when feature designs are finalized and construction staging areas determined.

C.2.22.3.1.3 Alternate 1BW Wetland Attenuation Feature (WAF)

The WAF is located in the K05B footprint within the Indian Prairie sub-watershed west of the C-38 canal, north of SR 78, east of the STOF Brighton Reservation, and south of the C-41A canal. The WAF footprint, including the embankments, seepage canal, and other perimeter features, is approximately 12,500 acres. The WAF is used for surface water storage to attenuate peak flows into Lake Okeechobee from the Kissimmee River Basin. Storage-assisted ASR wells will rehydrate habitat during dry times to ensure that wetland conditions are maintained within the WAF footprint. A pump station will be located downstream of the existing S-84 structure on the C-41A canal and will serve as the water source for the proposed WAF. The pump draws water from the downstream area that is considered to be part of Lake Okeechobee.

The majority of Alternate 1BW WAF has not been previously surveyed for cultural resources. In 2014, NRCS completed a reconnaissance survey of a portion of the area containing the WAF. This previous survey identified no new cultural sites; however, it did re-investigate previously identified site 8GL77 (Dunn 2014). This site, called the Mulberry Mound, is a Belle Glades period site with dense midden deposits. The limited investigation expanded the size of the original site and determined it is eligible for listing in the NRHP. The site also yielded a single human tooth and it is likely that Burial Resources are present in this site which would make it a culturally significant resource to the STOF and the MTIF.

In support of this study, a CRAS of portions of the Alternative 1 Bshlw and Alternative 1BW study area was completed to identify historic and cultural sites within lands owned by SFWMD. The survey consisted of a Phase I archaeological survey within portions of the proposed KO5 footprint and reconnaissance level investigations within the Paradise Run wetland restoration area (Carlson and Barnett 2018). Pursuant to the Burial Resources Agreement, the CRAS methodology/approach was coordinated with the STOF's THPO on October 27, 2016. As a result of this survey two new Belle Glades period cultural resource sites 8GL494 and 8GL495 were identified within the Alternate 1BW WAF. Both sites 8GL494 and 8GL495 are considered potentially eligible for listing in the NRHP and will require Phase II evaluations for a final determination of eligibility for listing in the NRHP.

The results of the CRAS survey demonstrated that that additional surveys will be needed to identify and evaluate cultural resources within the remaining un-surveyed portions of the TSP. These surveys and evaluations will be necessary, specifically during the detailed design phase for construction, when feature designs are finalized and construction staging areas determined. Due to the lack of information about these sites, Phase II Investigations are recommended at site 38GL77 to identify the boundaries of the site and to determine whether additional potential Burial Resources are present. Phase II investigations are also recommended for 8GL494 and 8GL495 to determine their eligibility for listing on the NHRP. Mitigation

of effects for these sites are unknown at this time and will be determined through consultation with the SHPO and appropriate federally recognized tribes once the Phase II evaluations have been completed.

C.2.22.3.1.4 Alternate 1Bshlw Reservoir

The shallow reservoir is located in the K05A footprint within the Indian Prairie subwatershed west of the C-38 canal, north of SR 78, east of the STOF Brighton Reservation, and south of the C-41A canal. The average pool depth of the reservoir will be about 5 feet. This reservoir will be operated to capture flows into Lake Okeechobee from the Kissimmee River Basin and maximize regional benefits, meaning operations will not be constrained to maintain habitat within this feature. The reservoir footprint, including the embankments, seepage canal, and other perimeter features, is approximately 14,800 acres. A pump station located downstream of the existing S-84 structure on the C-41A canal serves as the water source for the proposed shallow reservoir. The pump draws water from the downstream area that is considered to be part of Lake Okeechobee.

One previous cultural resource survey was completed within a portion of the proposed K-05 reservoir. In 2009, Wayne and Dickinson (2009) completed a cultural resource reconnaissance survey of approximately 564 acres located entirely within Alternative 1 Bshlw K-05 footprint. The investigation identified one cultural site 8GL455. This site consists of the remains of a 1930s aircraft wreckage. This site is unlikely to be eligible for listing in the NRHP. In support of this study, a CRAS of portions of the Alternative 1Bshlw and Alternative 1BW study area was completed to identify historic and cultural sites within lands owned by SFWMD. The survey consisted of a Phase I archaeological survey within portions of the proposed KO5 footprint and reconnaissance level investigations within the Paradise Run wetland restoration area (Carlson and Barnett 2018). Pursuant to the Burial Resources Agreement, the CRAS methodology/approach was coordinated with the STOF's THPO on October 27, 2016. As a result of this survey two new Belle Glades period cultural resource sites 8GL494 and 8GL495 were identified within the Alternate 1Bshlw Reservoir. Both site 8GL494 and 8GL495 are considered potentially eligible for listing in the NRHP and will require Phase II evaluations for a final determination of eligibility.

The results of the CRAS survey demonstrated that that additional surveys will be needed to identify and evaluate cultural resources within the remaining un-surveyed portions of the reservoir. These surveys and evaluations will be necessary, specifically during the detailed design phase for construction, when feature designs are finalized and construction staging areas determined. Due to the lack of information about previously identified sites, Phase II Investigations are recommended at sites 8GL494 and 8GL495 to determine their eligibility for listing on the NHRP. Mitigation of effects for these sites are unknown at this time and will be determined through consultation with the SHPO and appropriate federally recognized tribes once the Phase II evaluations have been completed and the project is implemented. Additional cultural resource surveys and evaluations will be necessary, specifically during the detailed design phase for construction, when feature designs are finalized and construction staging areas determined.

C.2.22.3.1.5 Alternative 2Cr K-42 Deep Reservoir

Alternative 2Cr includes a deep reservoir in the K-42 footprint which including the embankments, seepage canal, and other perimeter features, is approximately 14,600 acres. The average pool depth is about 15 feet deep and the total storage capacity is about 195,000 acre-feet. There will be two pumps used for inflow in order to access water in the C-38 canal downstream of S-65E. The first pump is located downstream of S-84 and moves water into the C-41A canal. The second pump is located on the C-41A

canal between S-83 and S-84 and pumps directly into the reservoir. The most likely location for an outflow culvert is back into the C-41A canal between S-83 and S-84.

In 2011, Wampler et al. (2011) completed a cultural resource survey within the boundary of portions of the K-42 reservoir of Alternative 2CR. This survey investigated multiple high probability areas within the reservoir boundary. The survey identified no new cultural resources within the surveyed portions of the alternative. However, an intensive cultural resource survey that was completed on property located adjacent to the 2Cr reservoir identified ten new archaeological sites, including six that were potentially eligible for listing in the NRHP (Ambrosino 2016). Based on the results of these surveys additional surveys will be needed to identify and evaluate cultural resources within the remaining un-surveyed portions of the reservoir footprint.

Additional cultural resource surveys and evaluations will be necessary, specifically during the detailed design phase for construction, when feature designs are finalized and construction staging areas determined.

C.2.22.3.1.6 Aquifer Storage and Recovery Wells

A total of 80 ASR wells are proposed in 12 clusters in various locations throughout the watershed and around Lake Okeechobee. The number of wells in each location has not yet been determined

Storage-assisted ASR Wells: Storage-assisted ASR wells are co-located within Alternative 1Bshlw reservoirs and the Alt 1BR WAF feature to increase the total storage capacity. There are three well clusters (25 wells) co-located with the WAF and the 1 Bshlw reservoir configuration.

Watershed ASR wells: The remaining 55 ASR wells are located throughout the watershed.

- One proposed cluster is located adjacent to the C-44 canal in Port Mayaca. This would flow out of the C-44 into Lake Okeechobee or to the St. Lucie River Estuary.
- Three potential cluster areas are located in the S-191 subwatershed. The wells will be adjacent to the L-63N, L-63S, or L-64 canals that can flow to Lake Okeechobee.
- One cluster is located along Taylor Creek, downstream of S-192 and upstream of the S-133 pump station which flow to Lake Okeechobee.
- Two potential clusters are located adjacent to the C-38 canal downstream of S-65E that can flow back into the C-38 canal.
- There is a well cluster along C-40 canal downstream of S-72 that can flow to Lake Okeechobee.
- There is a well cluster along C-41 canal downstream of S-71 that can flow to Lake Okeechobee.
- There is a well cluster along the C-43 canal in Moore Haven that can flow to Lake Okeechobee or the Caloosahatchee River.

The footprint of each ASR well is approximately 3 acres in size. Additional cultural resource surveys and evaluations may be will be necessary at the final ASR locations, specifically during the detailed design phase for construction, when feature designs are finalized and construction staging areas determined. In most instances the current ASR well locations are tentative and could be moved to avoid and minimize adverse effects to significant cultural resources.

C.2.22.3.2 Lake Okeechobee

There are no changes from the future without conditions for this component of LOWRP. Effects: There will be no adverse effect to cultural resources for Alternatives 1Bshlw, Alt 1BW, and through Alt 2Cr.

C.2.22.3.3 Northern Estuaries

This component of LOWRP proposes to redirect a percentage of water currently flowing from Lake Okeechobee into the eastern and western Northern Estuaries, south into the Miami Canal and the North New River Canal. Effects: This decrease of freshwater into the estuaries will have no effect to cultural resources for Alternatives 1Bshlw, 1BW, and 2Cr.

C.2.23 Invasive and Exotic Species

All of the alternatives have the potential and likelihood for establishment and spread of non-native invasive and native nuisance species. Proposed restoration activities may affect ecosystem drivers that directly or indirectly influence the invasiveness of non-native species. These factors may affect invasive species positively or negatively, depending on the unique characteristics of individual species and the environmental conditions for a given biological invasion (Doren et al. 2009). For example, shortened surface water drawdowns may reduce the recolonization rates of melaleuca in marshes while increasing habitat suitability for Old World climbing fern in other areas. Many of the areas where features are proposed are currently inhabited by non-native invasive and native nuisance species. Construction of the proposed features has the potential to spread the existing non-native invasive and native nuisance species on site as well as introduce new invasive species via contaminated equipment. Disturbed areas resulting from construction are likely to become established with non-native invasive and native nuisance species. New flows created by operations of the proposed features may serve as vectors to spread invasive and native nuisance species into new areas. The large number of existing and potential invasive plant and animal species and the often-incomplete knowledge of invasive mechanisms for each species create moderate to high uncertainty in this evaluation. Long-term monitoring in an adaptive management framework is critical to ensure efficient management of the most threatening non-native invasive species in the restoration footprint.

C.2.23.1 Lake Okeechobee Watershed

All the alternatives have the potential and likelihood for increasing or decreasing the establishment and spread of non-native and native nuisance species. The establishment of both shallow and deep-water reservoirs could potentially decrease terrestrial invasive species present however, the addition of the reservoirs will likely increase emergent and/or submersed non-native and potentially native nuisance species such as cattail. In addition, new flows created by the connecting the features could serve as pathways for new plant and animal non-native invasive species introductions.

C.2.23.2 Lake Okeechobee

All the alternatives have the potential and likelihood for increasing or decreasing the establishment and the spread of non-native and native nuisance species. Decreasing the duration of very low lake stages should reduce the spread of non-native invasive plants species such as torpedograss and melaleuca, and native nuisance species such as saltbush, willow, and wax myrtle. An increased duration of higher lake stages may increase the spread of some littoral zone non-native invasive species such as water lettuce and water hyacinth, and native nuisance species such as cattail and water lily. However, given the

tendency for all action alternatives to reduce lower lake stage frequency (<13.5 ft. NGVD), it is anticipated that there will be beneficial reductions in invasions from species like torpedograss, willow, saltbush, and wax myrtle, which should offset potential minor increases in species like cattail and water lily. Long-term monitoring and employing an adaptive management plan will help enable management of the non-native invasive and native nuisance species in the littoral zone.

C.2.23.3 Northern Estuaries

All of the alternatives would reduce freshwater flows from Lake Okeechobee to the Northern Estuaries, allowing for slightly higher salinity levels to persist in the estuaries. The reduced freshwater outflows are not expected to have an impact on non-native invasive or native nuisance species. Existing invasive species under active management are expected to persist at baseline levels if current funding levels are sustained (e.g., melaleuca, lionfish). Existing species not under active management or which are ineffectively controlled are expected to increase in abundance and spatial extent (tropical American water grass). New invasions of non-native plant and animal species are expected but estimates of species number and severity of impacts are conjectural.

C.2.24 Effects of the Final Array and TSP on Native Americans

The MTIF and the STOF rely upon the Everglades in its natural state to support their cultural, subsistence, and commercial activities. The STOF's Brighton Reservation lands are situated immediately adjacent to LOWRP project features. Subsistence activities for members of the both the MTIF and the STOF include gathering of materials, hunting, trapping, frogging, and fishing.

C.2.24.1 Miccosukee Tribe of Indians of Florida

General background information on the MTIF is provided in Section 2.6 Native Americans. No portion of the proposed action is located within or adjacent to known MTIF -owned lands, reservation lands, or Traditional Cultural Properties. Pursuant to Section 106 of the NHPA (54 U.S.C. §306101 et. seq.) and obligations regarding USACE Trust Responsibilities to federally recognized Native American Tribes, consultation with the MTIF is detailed in **Appendix C**, **Part 5**. Representatives for the MTIF have indicated that they have significant concerns over the use of ASR wells for water storage for all alternatives under consideration.

The MTIF does not support ASR wells and desires alternatives that maximize the amount of aboveground storage without negatively impacting the STOF. The MTIF are concerned about the disproportionate impacts to both the Indian prairie and the MTIF. The MTIF prefer twice the area of surface water storage within reservoirs which are half the depth of those that were proposed by the USACE. The shallower depths are preferred to remove additional phosphorous from the water. Water quality is one of the highest priorities of MTIF concerns and they desire that water be treated to drinking water standards before injecting the water into the aquifer, and before discharging the water back to the surface. The MTIF prefer shallow storage alternatives that will do more to improve water quality. The MTIF have some concerns about the flushing effect associated with initially rehydrating the wetland restoration areas. The concern is primarily associated with water quality issues; however, the long-term improvements in environmental quality to the wetlands outweigh those concerns. The MTIF would like to see the restoration of as much naturally occurring wetlands as possible.

C.2.24.2 Seminole Tribe of Florida

General background information on the STOF is provided in Section 2.6. Portions of the proposed action are located adjacent to known STOF's Brighton Reservation lands. Pursuant to Section 106 of the NHPA (54 U.S.C. §306101 et. seq.), obligations regarding USACE Trust Responsibilities to federally recognized Native American Tribes, and in consideration of the Burial Resources Agreement between USACE and the STOF, USACE has consulted with the STOF. The Seminole have provided comments during government-to-government consultation which are applicable to the entire project and comments that are specific to individual project features and/or individual alternatives. The STOF presented two modifications to the WAF footprint to avoid impacts to 8GL77.

C.2.24.2.1 Paradise Run and Kissimmee River–Center Wetland Sites

The locations of the proposed features for PR and KRC wetland restoration areas are nearly identical for each alternative. STOF leadership supports wetland restorations in in the proposed KRC and PR footprints. There may be potential adverse effects to cultural resources within the wetland restoration areas; however, these impacts will be avoided, minimized, and/or mitigated during the PED phase of this project. Additional cultural resource surveys of the wetland restoration areas will be necessary to identify and avoid impacting historic properties that are of importance to the STOF and MTIF.

C.2.24.2.2 ASR Wells

The STOF are concerned that the proximity of ASR wells and well clusters should be located outside the zone of influence of reservation lands so STOFs groundwater resources on Brighton are not affected. The STOF are concerned about ASR well seal failure, failure in the associated confining layers which may impact STOF access to groundwater. Additionally, the STOF have questioned the impact of ASR well clusters on the quality of the underlying aquifer, and the quality of the water when it is returned to surface water systems. There is a potential to adversely affect cultural resources during ASR well construction; however, these impacts will be avoided, minimized, and mitigated during the PED phase of this project. Additional cultural resource surveys of the ASR well locations will be necessary to identify and avoid impacting historic properties that are of importance to the STOF and MTIF.

C.2.24.2.3 Alt 1BW

The STOF are concerned with the physical proximity of reservoirs to the Brighton Reservation and tribal owned lands. Many of the concerns about potential effects to Native Americans that were provided by the STOF are greatly reduced in Alternative 1BW. Redesigns of this alternative moved the WAF feature to a distance that is approximately 0.5 mile from Brighton Reservation and tribal owned lands. The relocation of this major feature and its corresponding reduction in the operationally maintained depth greatly reduced the volume of surface water for storage in the WAF. The increased distance from the Brighton Reservation and water depth reduces the impacts from seepage, flood risk, impact to the cultural landscape, and slightly reduces the probability of displacement of endangered species from the footprint of the WAF. The impacts to cultural resources appear potentially higher within this proposed alternative due to the proximity of tree islands located on Brighton Reservation. Site 8GL77 (the Mulberry Mound site), is eligible for listing in the NRHP. Site 8GL77 also has a high potential for containing burial resources. Two other cultural sites identified within the Alt 1BW footprint (8GL494 and 8GL495) are both potentially eligible for listing in the NRHP and may impacted by this alternative if they are determined NRHP eligible. Alt 1BW has a slightly elevated potential to contain additional sites in the southern part of the WAF. The

close proximity of Alternatives 1BW to the Brighton Reservation may increase the potential likelihood of the presence of TCPs. TCPs identified within the TSP will require evaluation and consultation. At this time, there are no known TCPs located within the final array or TSP. This alternative was developed in consultation with the STOF leadership. Additional cultural resource surveys of the 1BW WAF will be necessary to identify and avoid impacting historic properties that are of importance to the STOF and MTIF. These impacts will be avoided, minimized, and mitigated during the PED phase of this project.

C.2.24.2.4 Alt 1Bshlw

STOF are concerned with the physical proximity of Alt 1Bshlw reservoir to the Brighton Reservation and tribal owned lands. Portions of the Alt 1Bshlw reservoir are located within 1000 feet of the STOF owned tribal land with seepage canals located within approximately 500 feet of tribal owned lands. The close distance to the Brighton Reservation potentially increases impacts of seepage, flood risk, impacts to the cultural landscape, and slightly increases the risk of displacement of endangered species from the footprint of the Alternative 1Bshlw reservoir to the Brighton Reservation. Two cultural sites identified within the Alternative 1Bshlw reservoir footprint (8GL494 and 8GL495) are both potentially eligible for listing in the NRHP and may be impacted by this alternative. Cultural resources survey of portions of the reservoir footprint indicates a high potential for identifying additional cultural resources in the reservoir. The close proximity of Alternatives 1Bshlw reservoir to the Brighton Reservation may increase the potential likelihood of the presence of TCPs. TCPs identified within Alt 1Bshlw will require evaluation and consultation. At this time, there are no known TCPs located within the final array or TSP. Additional cultural resource surveys of the 1Bshlw reservoir will be necessary to identify and avoid impacting historic properties that are of importance to the STOF and MTIF These impacts will be avoided, minimized, and/or mitigated during the PED phase of this project.

C.2.24.2.5 Alt 2Cr

Alt 2Cr removes many of the STOF concerns about the 2Cr proximity of K42 reservoir to the Brighton Reservation and tribal owned lands. Many of the concerns about potential effects to Native Americans that were provided by the STOF are greatly reduced in Alternative 2Cr. This alternative removes the proposed K42 reservoir feature to a distance that is approximately 5.0 miles from Brighton Reservation and tribal owned lands and it also is separated from Brighton Reservation by the C-41A canal. This location greatly reduces the potential of impacts from seepage, flood risk, impacts to the cultural landscape, and may reduce the probability of displacement of endangered species from the footprint of the reservoir. The impacts to cultural resources appear slightly reduced over other alternatives. A limited archaeological survey of portions of the proposed K42 reservoir location identified no cultural resources within the proposed footprint. Despite the lack of previously recorded cultural resources, this reservoir location has the potential to adversely affect cultural resources during construction. At this time, there are no known TCPs located within the final array or TSP. Additional cultural resource surveys of the K42 reservoir will be necessary to identify and avoid impacting historic properties that are of importance to the STOF and MTIF. These impacts will be avoided, minimized, and/or mitigated during the PED phase of this project.

C.2.25 Effects of the Recommended Plan

This section provides a detailed discussion of the potential environmental effects, which can be either positive or negative, that could result from implementation of the LOWRP Recommended Plan. The evaluation of the effects was based on results of modeling simulations, current information including scientific literature, direct observation, project design reports, reasonable scientific judgment, the NEPA

scoping processes, and information contained within other EIS documents for similar projects. The no-action alternative is always considered and carried forward as a requirement of NEPA and it forms the basis of comparison and evaluation of alternatives. The NEPA No Action Alternative (referred to as the FWO) considers the environmental conditions in the affected regions without the proposed action.

Environmental impacts include both direct and indirect effects. Under the Council on Environmental Quality (CEQ) 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 CFR 1508.8). Under NEPA, one purpose is to identify at an early stage the significant environmental issues deserving of study and deemphasizing insignificant issues, narrowing the scope of the environmental impact statement accordingly (40 CFR Sec 1501.1).

The resource conditions that were evaluated include climate, geology, soils, vegetation, wildlife, hydrology, water quality, flood control, air quality, HTRW, noise, aesthetics, land use, agriculture, socioeconomics, environmental justice, recreation, cultural resources, and invasive species.

The features of the Recommended Plan are described in **Section 6** of the main report with specific features located in Figure 6-1. The Recommended Plan, ALT1BWR, is the modified ALT1BW described in more detail in Sections 4 and 5. The footprint was revised based on feedback from stakeholders, including adding buffer zones between the WAF and Paradise Run wetland site from State Road 78, along with more detailed design optimizations to increase the cost-effectiveness of the LOWRP. The eastern boundary of the WAF was moved to the east to eliminate a gap between the WAF and Paradise Run that is now incorporated into the project footprint. This resulted in an increase in the WAF area and a decrease in the Paradise Run area. The WAF boundary and the Paradise Run boundary are now contiguous on the entire east side of the WAF. The WAF boundary area changed from 12,500 acres to 13,600 acres. The Paradise Run area changed from 4,100 acres to 3,600 acres. All of the WAF infrastructure was developed from the conceptual level. This included the addition of internal embankments, tree islands, ungated auxiliary spillways, gated spillways, and culverts. The location of the outlet to HHD was moved to the north. The intake for the Kissimmee River Center wetland was changed from a submerged weir to a pump station. The LOWRP Recommended Plan will improve the quantity, timing, and distribution of water entering Lake Okeechobee, provide for better management of lake water levels, reduce high volume flows to the Caloosahatchee and St. Lucie estuaries from Lake Okeechobee, improve system wide operational flexibility, and will restore portions of the historic Kissimmee River channel and floodplain. Better managing Lake Okeechobee stage levels within ecologically preferred stage envelope benefits plant and animal communities of Lake Okeechobee by concentrating prey resources in the littoral zone where wading birds forage, providing optimal light levels for photosynthesis in the summer months to benefit submerged plants and bulrush by and favoring development of a diverse emergent plant community, along with providing water supply benefits to Lake Okeechobee Service Area (LOSA) existing legal users. Reducing the return frequency, volume, and duration of high volume flows to the Northern Estuaries will improve salinity and turbidity conditions and benefit seagrass beds and the animals that inhabit them. The restoration of historic Kissimmee River sites would result in improved connectivity, more natural hydrologic conditions, and improved habitat for fish and wildlife resources. The flow-through WAF will create emergent wetland habitat, resulting in improved connectivity, more natural hydrologic conditions, and improved habitat for fish and wildlife resources. The Recommended Plan is referenced throughout the document as Alternative 1BWR (Alt 1BWR).

C.2.25.1 Climate

Implementation of the LOWRP Recommended Plan would have a short-term, regionally negligible, and less than significant effect on climate within the action area. Minor, localized effects to microclimate may occur under the Recommended Plan as a result of redistribution of water and shifts in vegetation. Potential effects may include increases in evapotranspiration, increases in localized rainfall and temperature changes. Refer to **Section C.1.1.1** in **Appendix C, Part 1** for a summary of the FWO conditions and **Annex H** for a detailed overview of the projected impact of climate change within the LOWRP area.

C.2.25.2 Physical Landscape

Under the FWO condition, it is likely that the lands within the project area will remain over-drained. The existing alluvial wetlands at Paradise Run and Kissimmee River–Center would exhibit hydroperiods that reflect changes in river stage and precipitation. The physical landscape in upland portions of the project area would change with development patterns. Implementation of all LOWRP action alternatives would result in rehydration of Paradise Run wetland, primarily due to eastward-flowing seepage from the WAF. The Kissimmee River–Center wetland also would be rehydrated due to higher stages in Kissimmee River Pool D that result from construction of a submerged weir. The storage in the Recommended Plan is a flow-through WAF used for surface water storage to attenuate peak flows and stages in adjacent areas. Although a WAF allows for aboveground storage like a reservoir, water levels may be suitable for growth of wetland vegetation due to the water depths typically realized through operation of the facility. Construction of ASR systems would have a negligible effect on the physical landscape due to the limited area that these features occupy at any given site. Storage-assisted ASR systems would be constructed proximal to the WAF in Alternatives 1BWR, to ensure that piping, wellheads and appurtenances will coexist near the toe of the shallow storage embankment.

C.2.25.2.1 Geology

Geologic changes are unlikely in the FWO condition or the LOWRP Recommended Plan due to the limited depth of excavation of the WAF.

C.2.25.2.2 Soils

Under the FWO condition, muck soils of Paradise Run and Kissimmee River–Central sites located adjacent to the levees of the Kissimmee River would remain over-drained. Currently, the Paradise Run area consists of approximately 93% of surface soils show hydric characteristics, although oxbows and interfluves of the former Kissimmee River channel are not well-vegetated (**Figure C.2-49**). As the physical landscape of the wetlands is restored, so will the acreage of hydric soils increase.

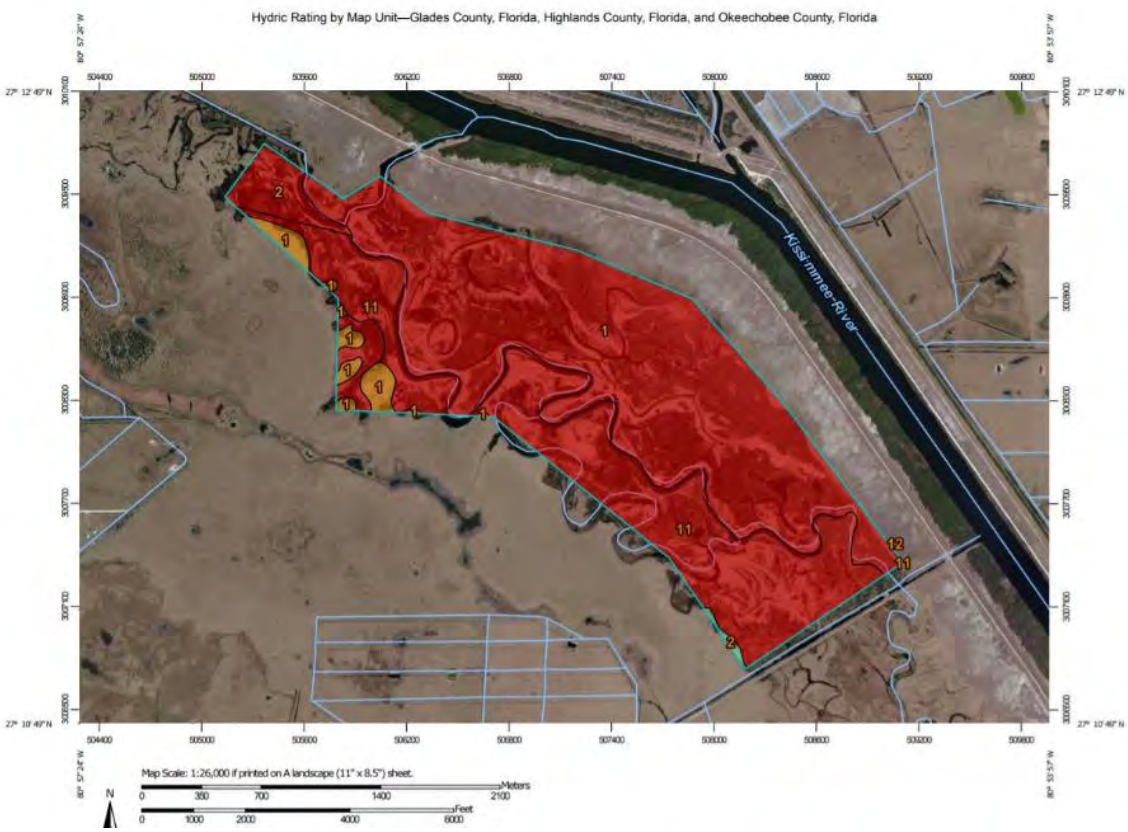

Figure C.2-49. Image showing proportion of surface soils that exhibit 90 to 100% of hydric soil characteristics (red, above) in the Paradise Run area. Lower image shows poorly vegetated oxbows and tributaries of the former Kissimmee River at Paradise Run (both NRCS, 2018).

C.2.25.3 Vegetative Communities

The effects of the Recommended Plan on the vegetative communities is documented below and compared to the FWO.

C.2.25.3.1 Lake Okeechobee Watershed

Under the FWO condition, as discussed in **subsection C.1.25**, the lands within the project area would be developed consistent with surrounding land use patterns and local growth management plans. The surrounding areas are predicted to maintain their agricultural and rural nature to 2070. Upland and wetland areas that are currently under conservation (e.g., portions of Fisheating Creek and along the Kissimmee River) are expected to stay in conservation. However, without the project, the wetlands along Paradise Run and Kissimmee River would not be restored, and those native vegetative communities would stay as-is or possibly deteriorate (colonized by invasive species). As agriculture and improved pasture occupies a large percentage of the existing watershed, we do not anticipate a substantial change to land use or vegetation communities under FWO conditions. **Table C.2-28** shows the current land use in the two wetland restoration sites, Kissimmee River–Center and Paradise Run.

Table C.2-28. Land use codes for the wetland restoration footprints for the Recommended Plan and acreages for ECB.

FLUCCS Level 4 Code	FLUCCS Code Description	Paradise Run Area (acres)	Kissimmee River–Center Area (acres)	Total Wetland Restoration Recommended Plan (acres)
2110	Improved pastures	836	796	1,632
2120	Unimproved pastures	0	64	64
2130	Pasture	1	5	6
3100	Herbaceous rangeland	23	3	26
3200	Shrub and brushland	10	0	10
3300	Mixed rangeland	40	0	40
4200	Upland hardwood forest	35	0	35
4270	Live Oak	0	3	3
5110	Streams and waterways	76	19	95
5120	Channelized waterways, canals	0	3	3
5300	Reservoirs	146	5	151
6170	Mixed wetland hardwoods	32	0	32
6172	Mixed wetland hardwoods - mixed shrubs	182	159	341
6180	Cabbage palm savannah	7	4	11
6410	Freshwater marshes	402	55	457
6430	Wet prairies	830	41	871
6440	Emergent aquatic vegetation	909	40	949
7430	Spoil areas	53	0	53
	TOTAL AREA (acres)	**3,583**	**1,196**	**4,779**

Under the Recommended Plan, the WAF with associated seepage canals and embankments would be constructed, ASR wells will be installed and two restored wetland areas will be created. Alternative 1BWR has a WAF as the storage feature, therefore the feature may contain wetland plant species. **Table C.2-29** shows the area of the WAF and the existing land use. The majority of the WAF is improved and unimproved pastures. **Table C.2-30** shows the acreage of native uplands and wetlands (according to the FLUCCS codes) within the WAF footprint. The WAF contains 67 acres of uplands and 976 acres of wetlands that may provide wetland habitat that can tolerate a 1-4 ft water depth. Inclusion of wetland restoration sites within Kissimmee River–Center and Paradise Run will restore a total of 4,779 acres of wetlands. Due to wetland restoration components, the wetland losses in the WAF footprint will be offset since the with-project condition will be the full footprint with a wetland land use. Alternative 1BWR will have a net gain of 3,803 acres of wetlands.

Table C.2-29. Existing land use acres in the WAF footprint for the Recommended Plan.

FLUCCS Code Description	1BWR (acres)
Improved Pastures	12,432
Unimproved Pastures	120
Citrus Groves	1
Shrub and Brushland	67
Channelized waterways, canals	1
Reservoirs	7
Mixed Wetland Hardwoods - Mixed Shrubs	38
Freshwater Marshes	813
Wet Prairies	124
Emergent Aquatic Vegetation	1
Spoil Areas	28
Total Storage Area (acres)	**13,632**

Table C.2-30. Acreages of native uplands and wetlands within the WAF footprint.

Acres of native uplands or wetlands	1BWR
Uplands	67
Wetlands	976

In general, construction will largely replace existing upland and wetland plant communities with aquatic habitat (water-covered reservoir areas) or maintained uplands (embankments, roads, berms). Aquatic plant species that may colonize the area include sawgrass (*Cladium jamaicense*) and scattered clumps of Carolina willow (*Salix caroliniana*), sweetbay (*Magnolia virginiana*), cypress (*Taxodium* spp.), pond cypress (*Taxodium ascendens*), red maple (*Acer rubrum*), dahoon holly (*Ilex cassine*), swamp bay (*Persea palustris*), sweet bay (*Magnolia virginiana*), wax myrtle (*Myrica cerifera*), buttonbush (*Cephalanthus occidentalis*), St. John's wort (*Hypericum* spp.), chain fern (*Woodwardia* spp.), and fireflag (*Thalia geniculata*). The construction of a WAF and seepage canal may provide some deepwater refugia and/or littoral habitat.

The interior of the WAF will have minimal productive littoral zone because of the necessity to construct relatively steep sides to maximize water storage capacity. The design for the perimeter canals, however, includes littoral areas in the corners and along some of the banks. Exotic plant species are not expected to be a problem under the Recommended Plan, as appropriate construction and maintenance procedures would be established to deter and control exotic establishment at the project site. Release of recovered water from the ASR systems is not expected to have a deleterious effect on aquatic vegetation in the impoundments.

C.2.25.3.2 Wetlands

While the majority of the lands in the Recommended Plan are currently improved and unimproved pastures, there are some wetlands that will be removed in the construction of the WAF**. Table C.2-31**shows the acres of wetland in the WAF footprint. Although the WAF allows for aboveground storage like a reservoir, water levels may be suitable for growth of wetland vegetation due to the water depths typically realized through operation of the facility. The Recommended Plan also includes the restoration of the Kissimmee River–Center wetland and the Paradise Run wetland restoration sites. These wetlands restore 4,779 acres of wetlands. The Recommended Plan will have a net gain of 3,803 acres of wetlands. The Recommended Plan increases the acreage and quality of wetlands in the project area (**Table C.2-32**).

Table C.2-31. Wetlands in the WAF footprint.

FLUCCS Code Description	Alt 1BWR
Mixed Wetland Hardwoods - Mixed Shrubs (acres)	38
Freshwater Marshes (acres)	813
Wet Prairies (acres)	124
Emergent Aquatic Vegetation (acres)	1
Total Acres of Existing Wetlands in Storage Feature Footprints	**976**

Table C.2-32. Net acres of wetlands acres for the Recommended Plan.

	1BWR
Acres of Wetlands Removed	-976
Acres of Wetlands Restored (1.0 value)	4,779
Total Wetlands Offset (acres)	**3,803**

C.2.25.3.3 Lake Okeechobee

Beneficial effects to Lake Okeechobee's littoral vegetation are anticipated as a result of the Recommended Plan relative to FWO. The overall effect of the Recommended Plan is to stabilize water levels; maintaining lake stage within the ecologically preferred stage envelope (12.5–15.5 ft. NGVD) more frequently than the FWO (**Table C.2-33, Figure C.2-50** to **Figure C.2-53)**. This was primarily from reductions in the frequency of low (<12.5 ft. NGVD) and extreme low (<10.0 ft. NGVD) stages compared to FWO. The Recommended Plan does reduce the frequency of stages at the upper end of the stage envelope between

approximately 14.5-15.5 ft. NGVD, which will help to offset reductions in the frequency of stages at the lower end between approximately 12.5-13.5 ft. NGVD (**Figure C.2-5**).

The frequency of extreme low stages was reduced from FWO by 1.1%, while the frequency of extreme high lake stages (>17.0 ft. NGVD) slightly increased compared to FWO by 0.8% (**Table C.2-33**). There may be some concern that reducing the frequency of lower lake stages while also slightly increasing the frequency of extreme high lake stages could have a compounding effect; affecting the ability of marsh and SAV communities to recover at lower elevations after extreme high lake stages occur. However, the overall occurrence of extreme high stages was still very low; while the return frequency of low lake stages was still at least 5% higher than the RECOVER target for any of the alternatives (**Table C.2-33**). The Lake Stage Performance Measure for RECOVER suggested a duration of 2.5% for stages <11.0 ft. NGVD (3 months per decade) (RECOVER 2007), and the Recommended Plan had durations of 8.4%. While still considerably higher than the target, they represent improvements from the FWO frequency of 9.7%. The return frequencies of low lake stages was improved by 1.3% when compared to the RECOVER target for the FWO.

The overall effect of stabilizing lake stages should improve vegetation in the upper and lower marshes by reducing the intra- and inter-annual varation that leads to encroachment of woody vegetation and exotic species at high elevations and conversion of SAV beds to emergent marsh at low elevations. For example, following drying events in the upper marsh, exotic species like torpedograss (*Panicum repens*) can displace spikerush (*Eleocharis* spp.) prairies; a valuable, critical habitat for the endangered snail kite. These invasions can persist indefinitiely and require expensive chemical and/or physical treatments to restore (Smith et al 2009). Woody species like wax myrtle (*Myrica cerifera*) and willow (*Salix caroliniana*) can invade spikerush prairies, sawgrass (*Cladium jamaicense*), and broadleaf marsh habitats during low water, eventually shading out and displacing marsh with forested wetlands. Extreme low lake stages allow large-scale displacement of SAV communities with invasive emergent species like cattail (*Typha* spp.); such an event occurred in southern portions of the lake following the 2007-2008 drought and subsequent record low water levels.

High lake stages have similar negative effects; promotes monotypic stands of dense cattail; increased mixing of turbid pelagic water with clearer nearshore water decreases light levels at lower elevations, reducing SAV and emergent marsh coverage; all ultimately reducing the quantity and quality of littoral habitat (Havens 2002, Havens et al. 2005).

Because the Recommended Plan increases the frequency of moderate lake stages (time inside the preferrred ecological envelope), the impacts described above should be less frequent or at short enough durations to be offset by the benefits of more stablized water levels overall. These benefits are evident in the potential habitat unit (HU) lift for the Recommended Plan relative to FWO; 2,674 HU lift for Alt 1BWR.

Table C.2-33. Amount of time each alternative is within the Lake Okeechobee Stage envelope.

Lake Okeechobee Stage Levels		Future Without Project	ALT 1BWR
% Time Inside Ecologically Preferred Stage Envelope	% TIME between 12.5 ft and 15.5 ft.	27.7%	31.2%
%Time Above Stage Envelope	% TIME above 15.5 ft.	29.9%	28.1%
%Time Below Stage Envelope	% TIME below 12.5 ft.	42.4%	40.7%
% Time Below Navigational Min. Stage	% TIME < 12.5 ft.	29.8%	27.5%
Extreme High Stage	% TIME > 17 ft.	0.4%	1.2%
Extreme Low Stage	% TIME < 10 ft.	3.3%	2.2%
RECOVER Low Stage Target (2.5% Time < 11 ft)	% TIME < 11 ft.	9.7%	8.4%

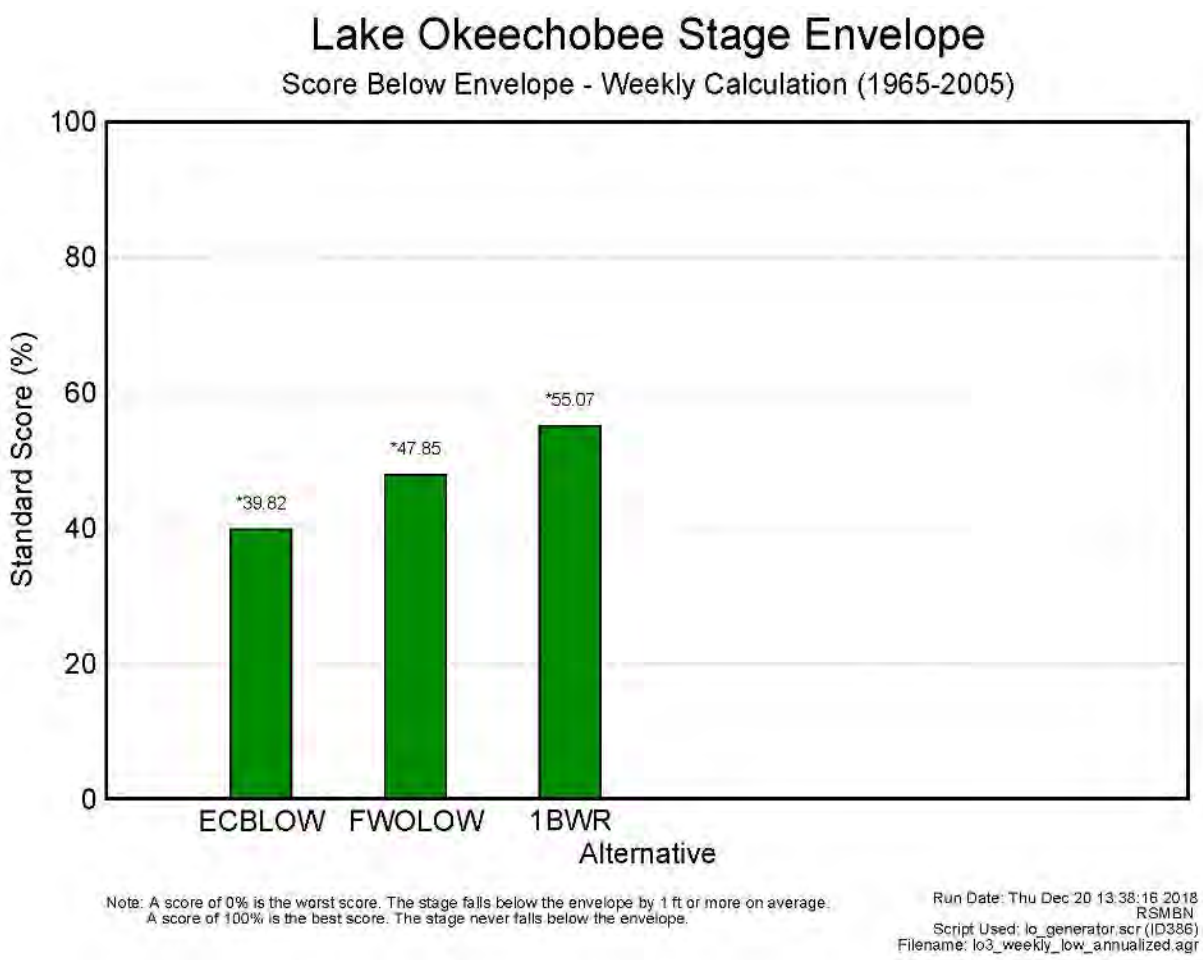

Figure C.2-50.Lake Okeechobee stage envelope, time above the low-stage envelope.

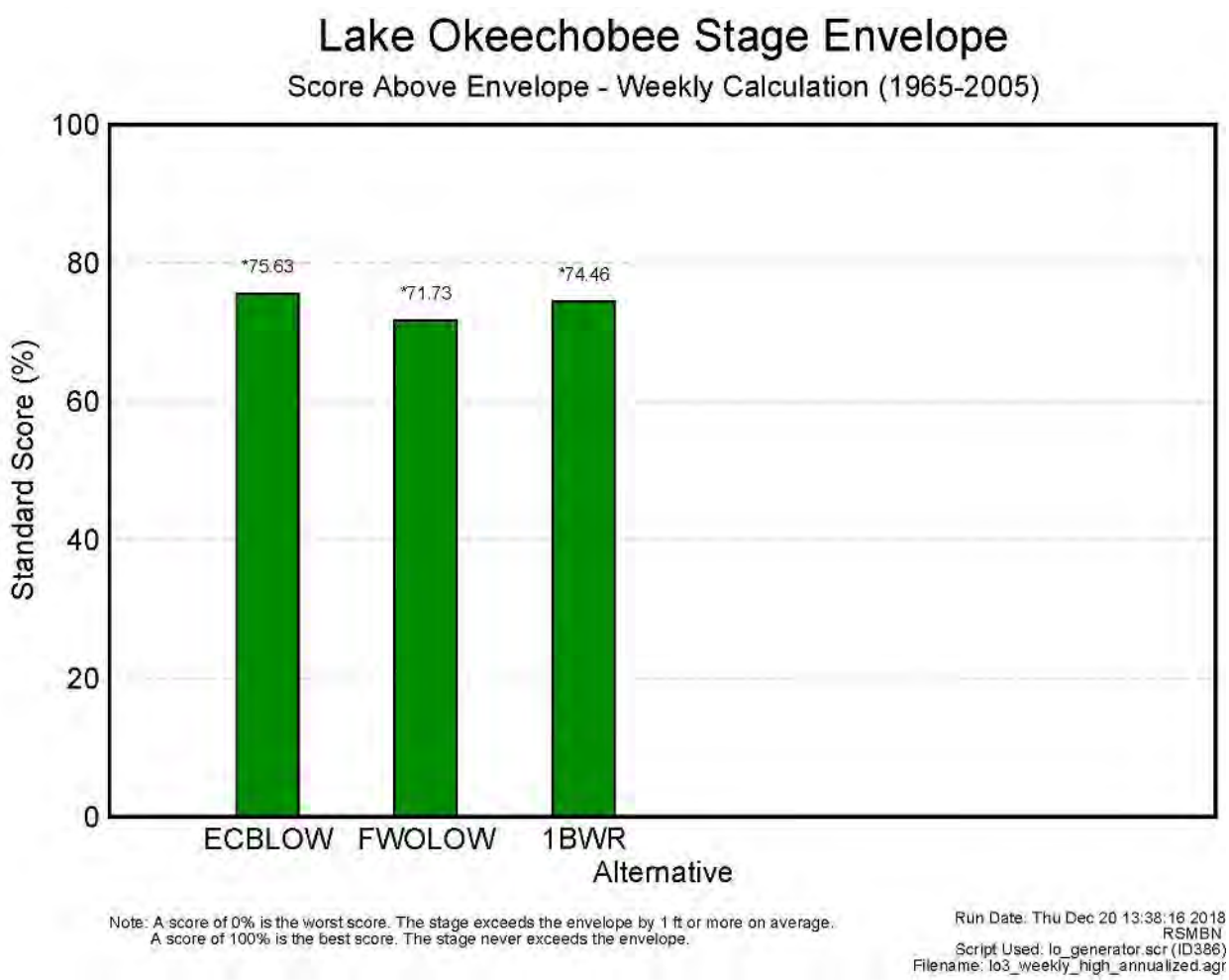

Figure C.2-51. Lake Okeechobee stage envelope, time below the high-stage envelope.

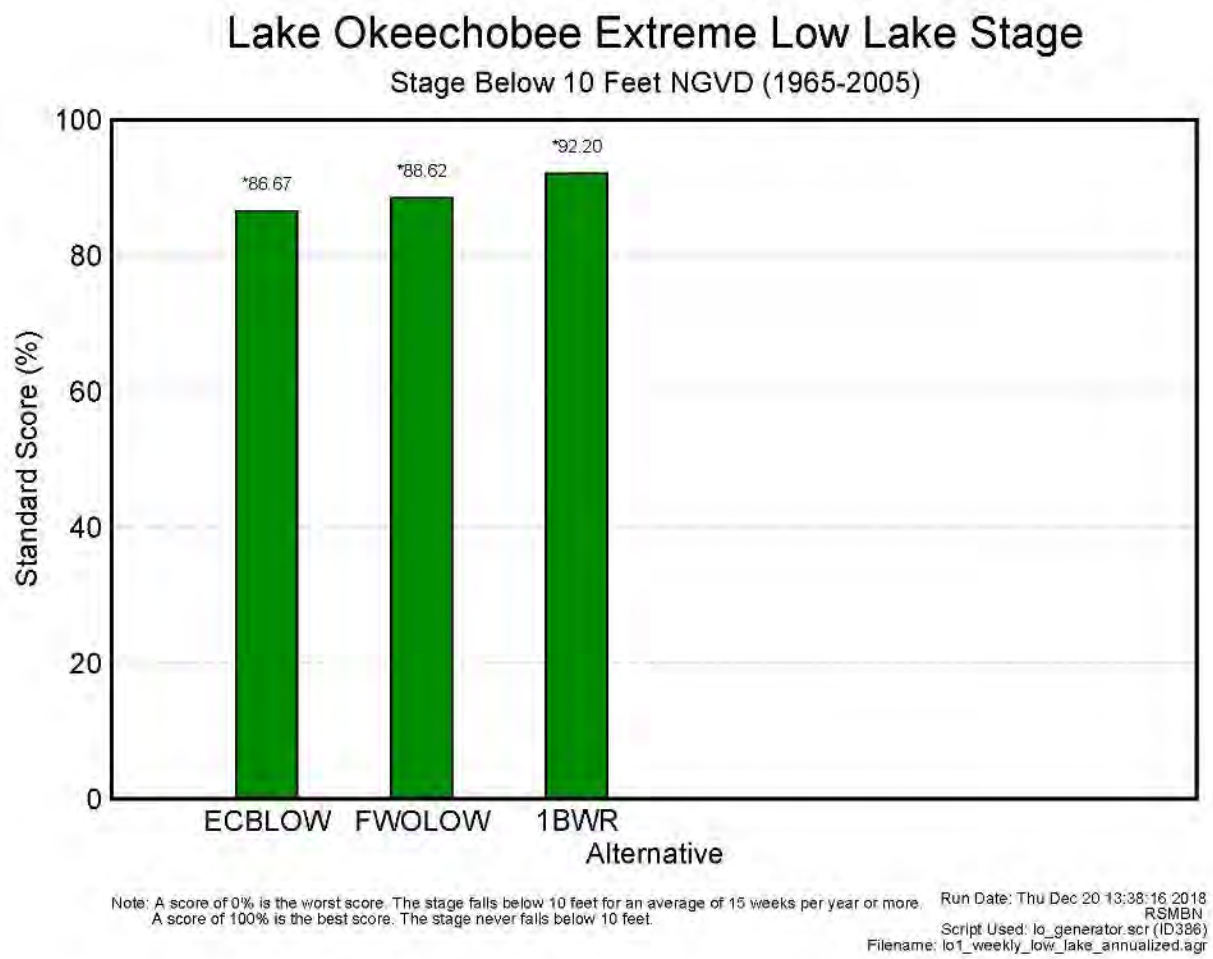

Figure C.2-52. Lake Okeechobee extreme low lake stage, time above extreme low lake levels (< 10 ft).

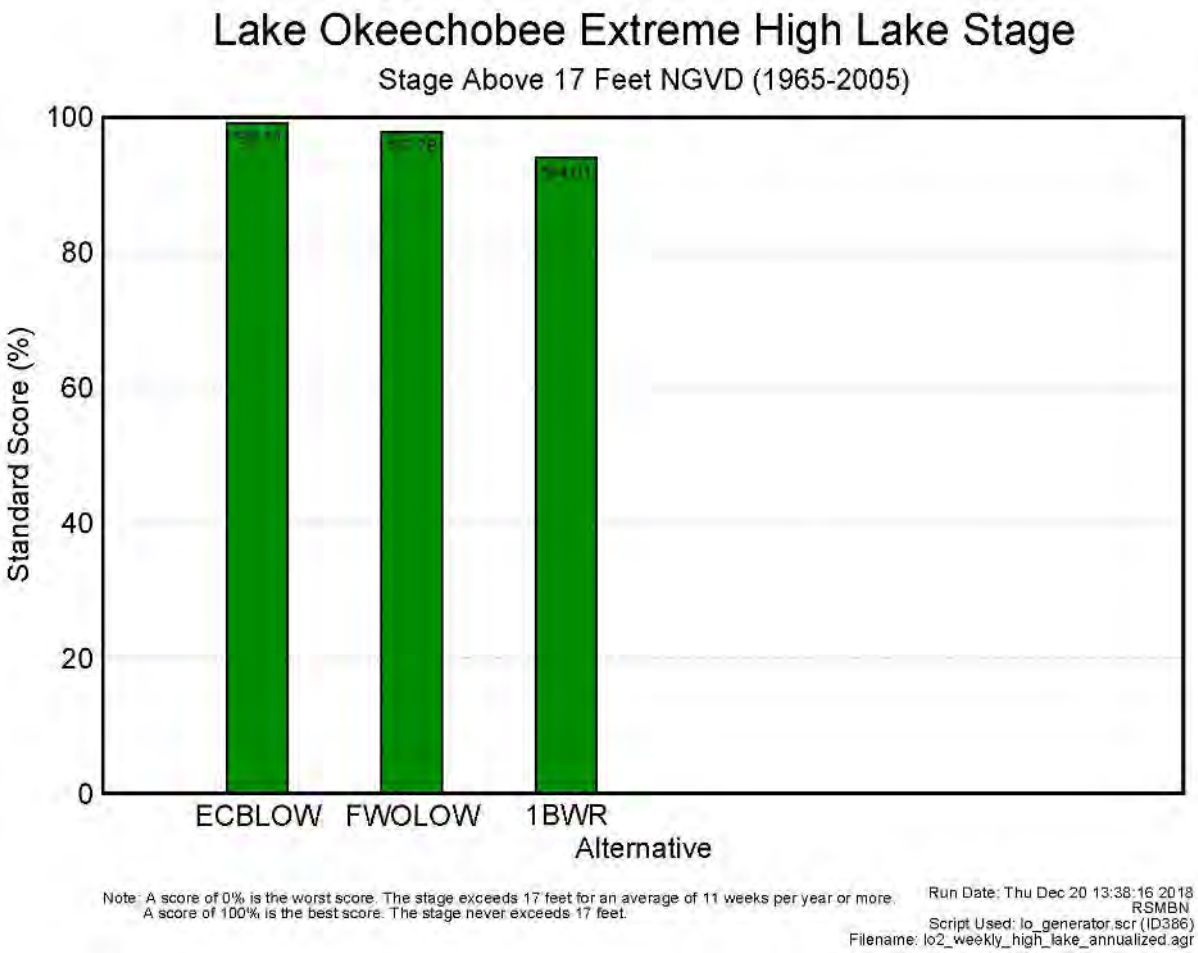

Figure C.2-53. Lake Okeechobee extreme high lake stage, time below extreme high lake levels (> 17 ft).

The combined scores for the ecological indicators (*Chara*, cyanobacteria, epipelon, epiphytes, panfish, and vascular SAV) also show overall benefits under the Recommended Plan, but the effects varied by individual indicator (**Figure C.2-54**). For example, the Recommended Plan reduces the occurrence of lake stages below the beneficial envelope, indicators that perform well under low-water conditions scored worse than FWO; while indicators that perform well when stages are within the beneficial envelope all fare similar or better than FWO (**Table C.2-34**). *Chara* and epipelon both benefit from increased light penetration in the nearshore zone, especially at lake stages even below the stage envelope; and cyanobacteria blooms tend to occur less frequently when summer lake stages are rather low; these indicators all have lower scores than the ECB, which is the driest condition, and similar to or lower than FWO as well. This is to be expected given that the Recommended Plan, and even the FWO, reduces the frequency of low lake stages, both within and below the stage envelope, as compared to ECB. However, these performance measures do not take into account the return frequency of such events, which are critical at higher elevations in regards to invading woody and exotic species, fire frequency, aquatic fauna, etc. Therefore, it is important to weigh these indicators against those that perform well under average conditions, or lake stages within the beneficial envelope. The epiphytes and panfish indicators, for example, benefit from moderate stages in the spring and fall and score substantially better than FWO under the Recommended Plan. Because of the importance of having low return frequencies for extreme

low stages, it is anticipated that the ability of the Recommended Plan to maintain stages within the envelope more than FWO should result in benefits to the overall lake ecology.

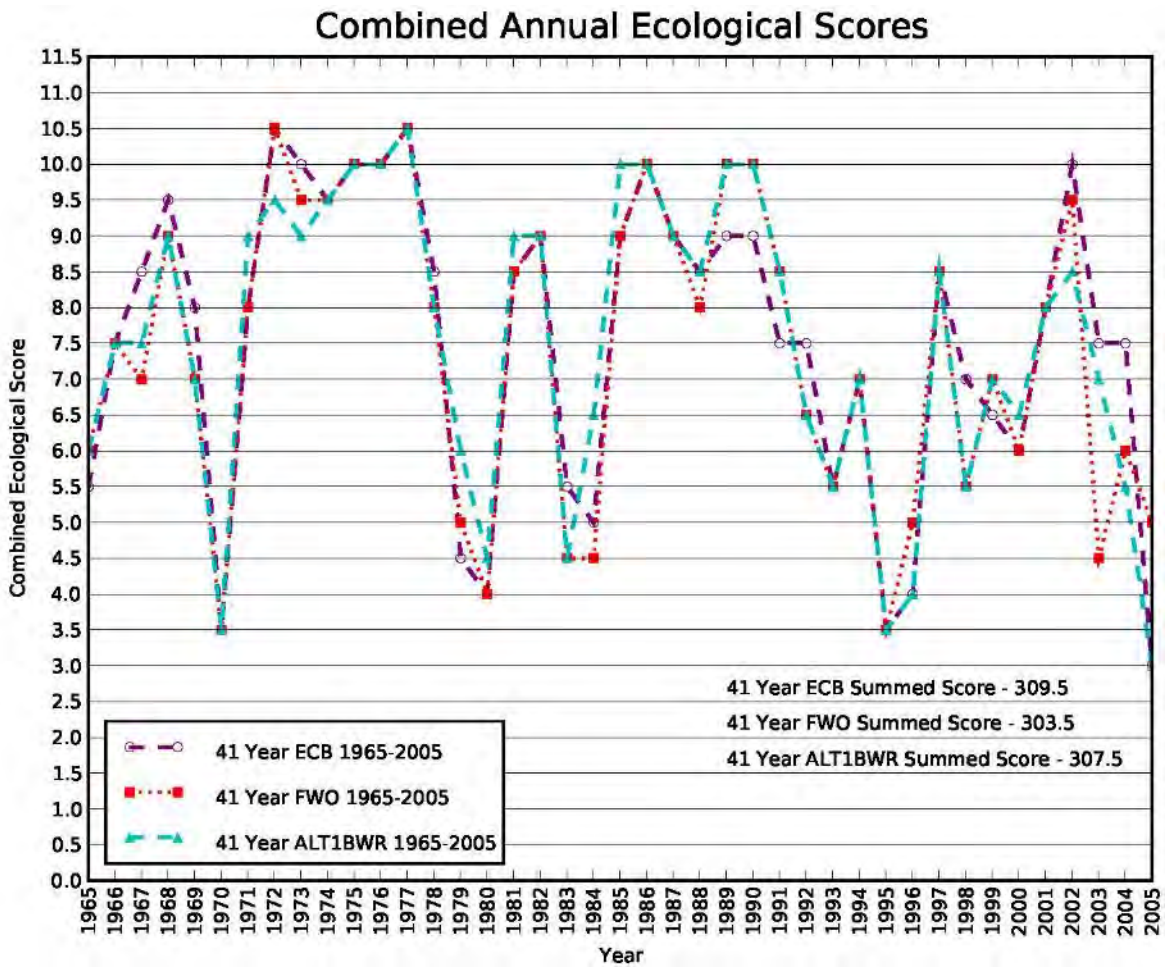

Figure C.2-54. Lake Okeechobee Ecological Indicator Combined Period of Record Performance Measure Scores for the Recommended Plan.

Table C.2-34. Lake Okeechobee individual ecological indicator performance measure period of record scores for the Recommended Plan.

	Summer *Chara*	Summer Cyanbacteria	Spring+Fall Epipelon	Spring+Fall Epiphytes	January+February Panfish	Summer Vascular SAV	Combined Ecological Score
ECB	54	49	37.5	53	53	63	309.5
FWO	55	49	34.5	50	49	66	303.5
1BWR	52	49	36.5	53	50	67	307.5

C.2.25.3.4 Northern Estuaries

Currently, many SAV beds are stressed and have been reduced or eliminated from their former areas by extreme salinity fluctuations, increased turbidity, sedimentation, dredging, and damage from boats that, in turn, restrict light penetration. The LOWRP Recommended Plan is designed to store water north of Lake Okeechobee, thereby reducing the volume of water that in the FWO would flow to the Atlantic Ocean and Gulf of Mexico. Therefore as compared with FWO, the Recommended Plan shows a slight performance improvement within the Northern Estuaries as indicated by fewer high volume flow months, providing a minor beneficial effect. Reduction in high flows and accompanying flow velocities would result in lower suspended solid loading and decreased concentration of colored dissolved organic matter, thereby allowing greater light penetration to promote growth of SAV. In addition, reduction in high volume flows from Lake Okeechobee would reduce extreme salinity fluctuations associated with such events. Although some SAV are tolerant of a wide range of salinity levels, a reduction in high volume flows would reduce stress to SAV and aid in long-term health of estuarine habitat and biota. For low flow events, the Recommended Plan performs the same as the FWO or slightly worse than the FWO. Implementation of the LOWRP Recommended Plan would help to maintain the target frequency and duration of water flows to the Northern Estuaries and would help curtail continued habitat loss and allow the recovery of more desirable vegetative communities. The LOWRP Recommended Plan captures an estimated 86,012 acre-feet of water from being lost to the Gulf of Mexico in the Caloosahatchee (36.5% increase relative to the FWO) and 22,385 acre-feet from being lost to the Atlantic Ocean in the St. Lucie on average annually (17.3% increase relative to FWO).

C.2.25.3.4.1 Caloosahatchee River Estuary

Negligible and less than significant effects are predicted for the Recommended Plan for the low flows into the Caloosahatchee estuary. The Recommended Plan performs worse than the FWO with an additional month where the low flow criteria is not met **Figure C.2-55**). A mean monthly inflow of at least 450 cfs is needed from S-79 to ensure that the average monthly salinity at Ft. Myers (Yacht Basin) is < 10 psu (target maximum salinity for tape grass). An important upper estuarine feature is the freshwater-brackish submerged grass, *Vallisneria americana* (tape grass), which when present is located near the shoreline in the upper estuary to a depth of about 1.0 m. Its greatest coverage occurs from Beautiful Island to just past the Ft. Myers bridges (Hoffacker et al. 1994, Chamberlain and Doering 1998b). During times of extended low inflow conditions, when salinity is too high, this grass becomes very sparse and can disappear completely (Chamberlain et al. 1995, Doering et al. 2002, SFWMD 2000). For high flow events, the Recommended Plan performed better than the FWO having fewer months where flows were greater than 2800 cfs. Alt 1BWR had 10 fewer months of high flows than the FWO. The model output shows that of the number of months flow > 2800 cfs from the C-43 Basin and Lake Okeechobee regulatory flows, 47 of those months are a results of basin runoff. Therefore, flows greater than 2800 cfs from direct Lake Okeechobee flows go from 23 in the FWO to 13 in Alt 1BWR (**Table C.2-35**, **Figure C.2-56**). For extreme high flow events (mean monthly flow > 4500 cfs), the Recommended Plan performs better with 25 months where the mean monthly flow was greater than 4500 cfs compared to the FWO that had 30 months (**Figure C.2-57**). Alt 1BWR captures an estimated 86,012 acre-feet of water from being lost to the Gulf of Mexico in the Caloosahatchee (36.5% increase relative to the FWO). The Recommended Plan provides minor beneficial effects in the reduction of high flows into the Caloosahatchee Estuary which are beneficial to the SAV in the estuaries.

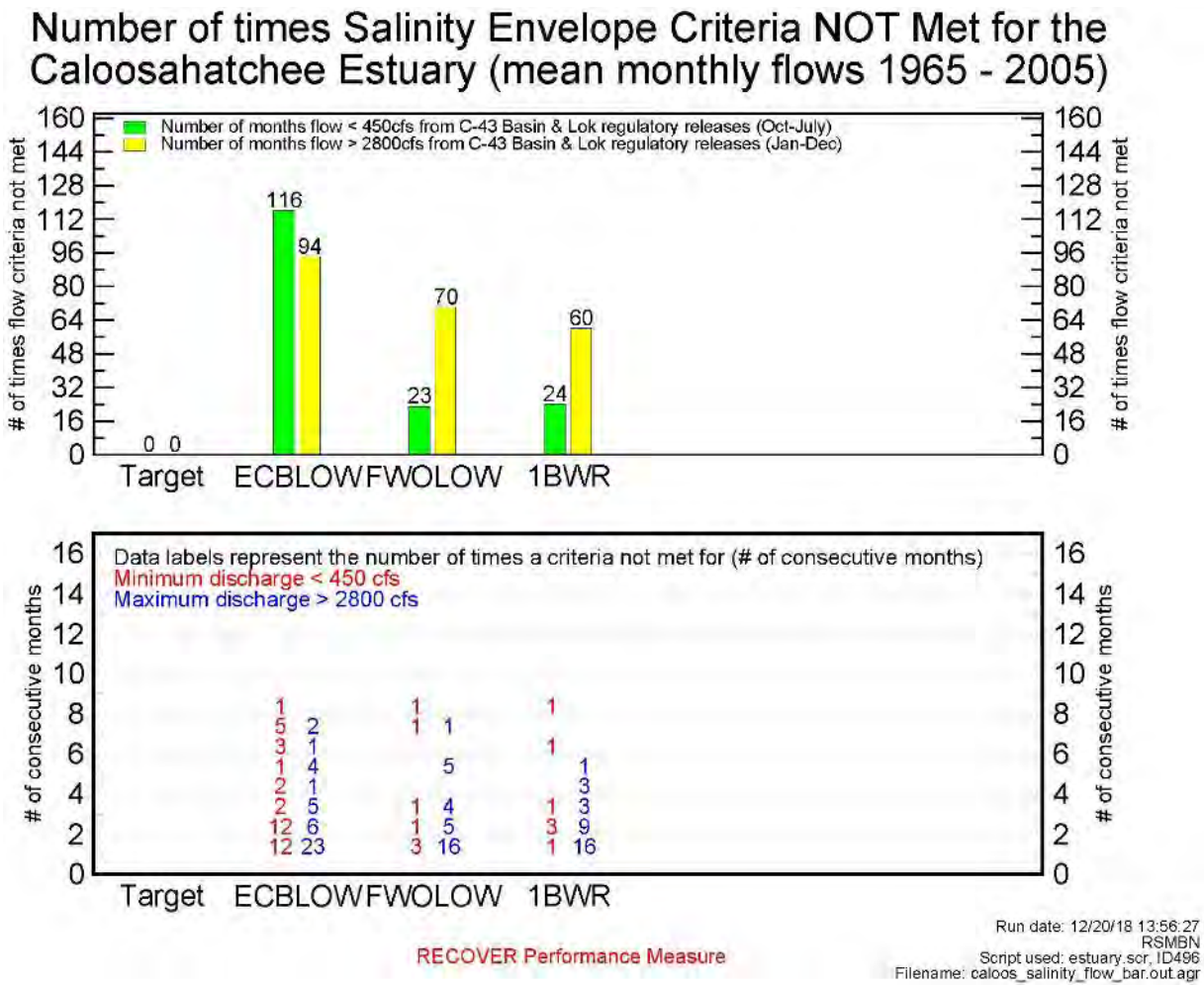

Figure C.2-55. Flow results for the Caloosahatchee Estuary.

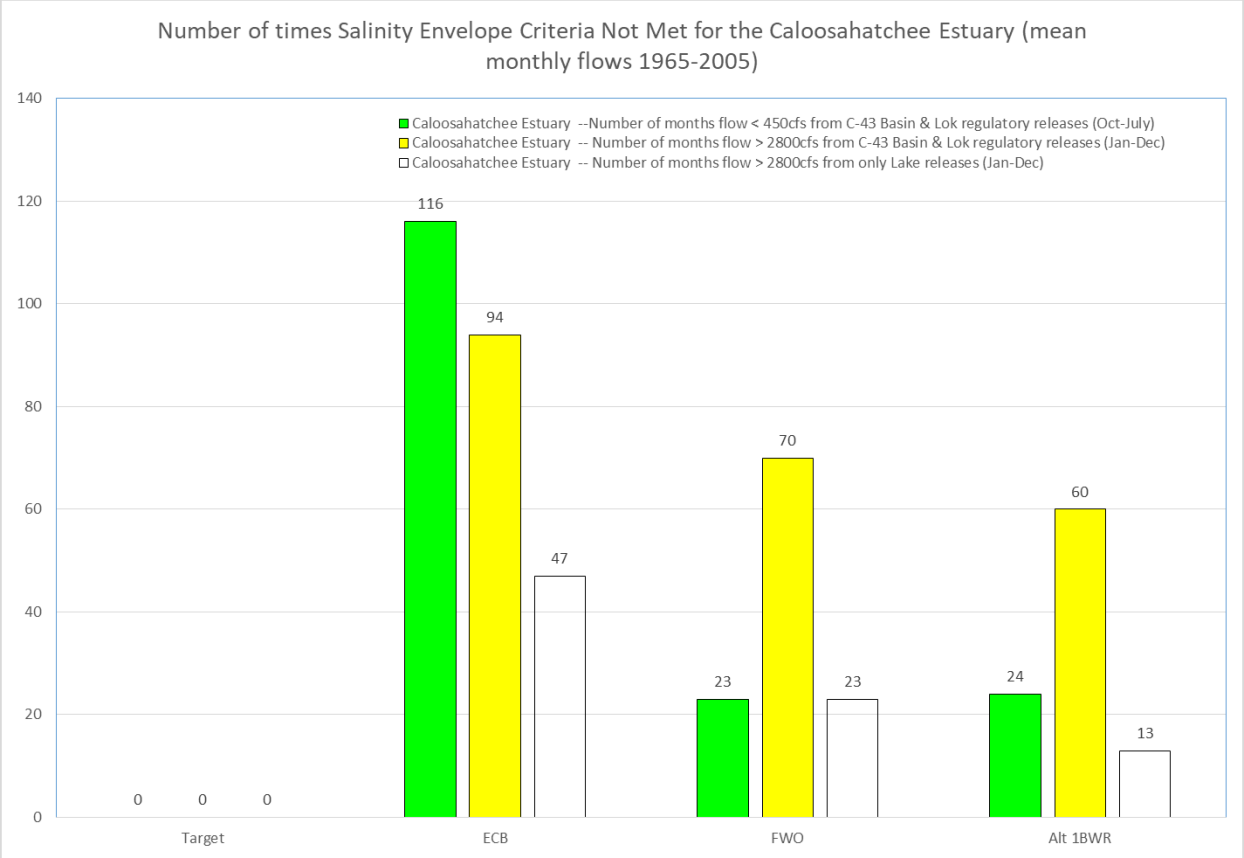

Figure C.2-56. Flow results for the Caloosahatchee Estuary that include the number of high-flow events only from Lake Okeechobee.

Table C.2-35. Flow results for the Caloosahatchee Estuary for the Recommended Plan.

	FWO	Alt 1BWR
Number of months flow < 450 cfs	23	24
Mean Monthly Flow > 4500 cfs	30	25
Number of months flow > 2800 cfs from Lake O flows	23	13
Average Annual Flow (acre-ft)	235,824	149,810

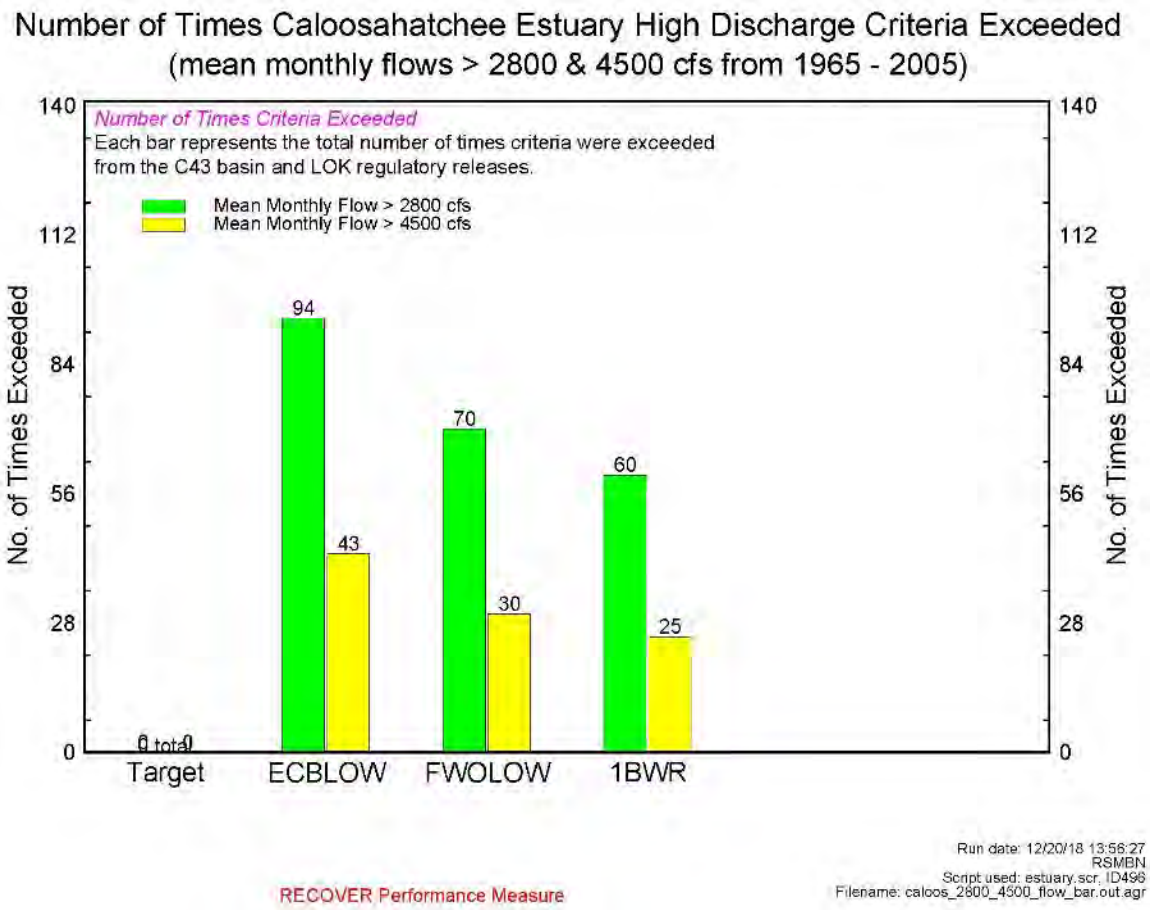

Figure C.2-57. Extreme high-flow events in the Caloosahatchee Estuary.

C.2.25.3.4.2 St. Lucie Estuary

Negligible and less than significant effects are predicted for the Recommended Plan for the low flows into the St. Lucie estuary. The FWO and the Recommended Plan have the same number of months were the low flow criteria is not met (**Figure C.2-58**, **Table C.2-36**). For high flow events, the LOWRP Recommended Plan performed better than the FWO having 18 fewer times where the 14-day moving average flow was greater than 2000 cfs from Lake Okeechobee regulatory flows. Alt 1BWR had 19 times when the high flow criteria was not met compared to 37 times in the FWO. For extreme high flow events (mean monthly flow > 3000 cfs), the Recommended Plan perform better than the FWO that had 25 months where the mean monthly flow was greater than 3000 cfs and Alt 1BWR had 22 months (**Table C.2-36**, **Figure C.2-59**). Alternative 1BWR captures 22,385 acre-feet from being lost to the Atlantic Ocean in the St. Lucie on average annually (17.3% increase relative to FWO). The Recommended Plan provides significant beneficial effects for the reduction of high flow events which are beneficial for the SAV in the estuaries.

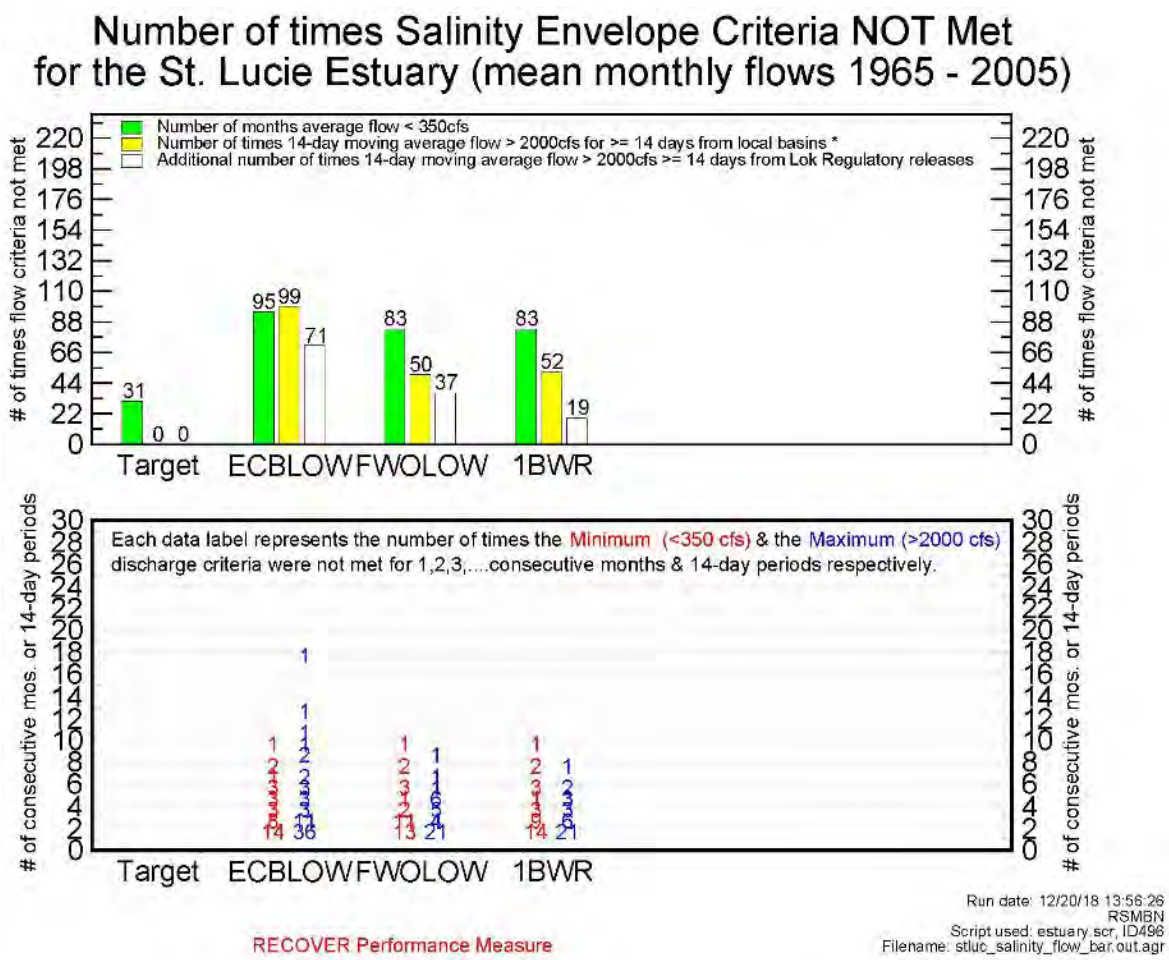

Figure C.2-58. Flow results for the St. Lucie Estuary.

Table C.2-36. Flow results for the St. Lucie estuary for the Recommended Plan.

	FWO	Alt 1BWR
Number of months flow < 350 cfs	83	83
Number of times flow > 2000 cfs from Lake O flows	37	19
Average Annual Flow (acre-ft)	129,501	107,116

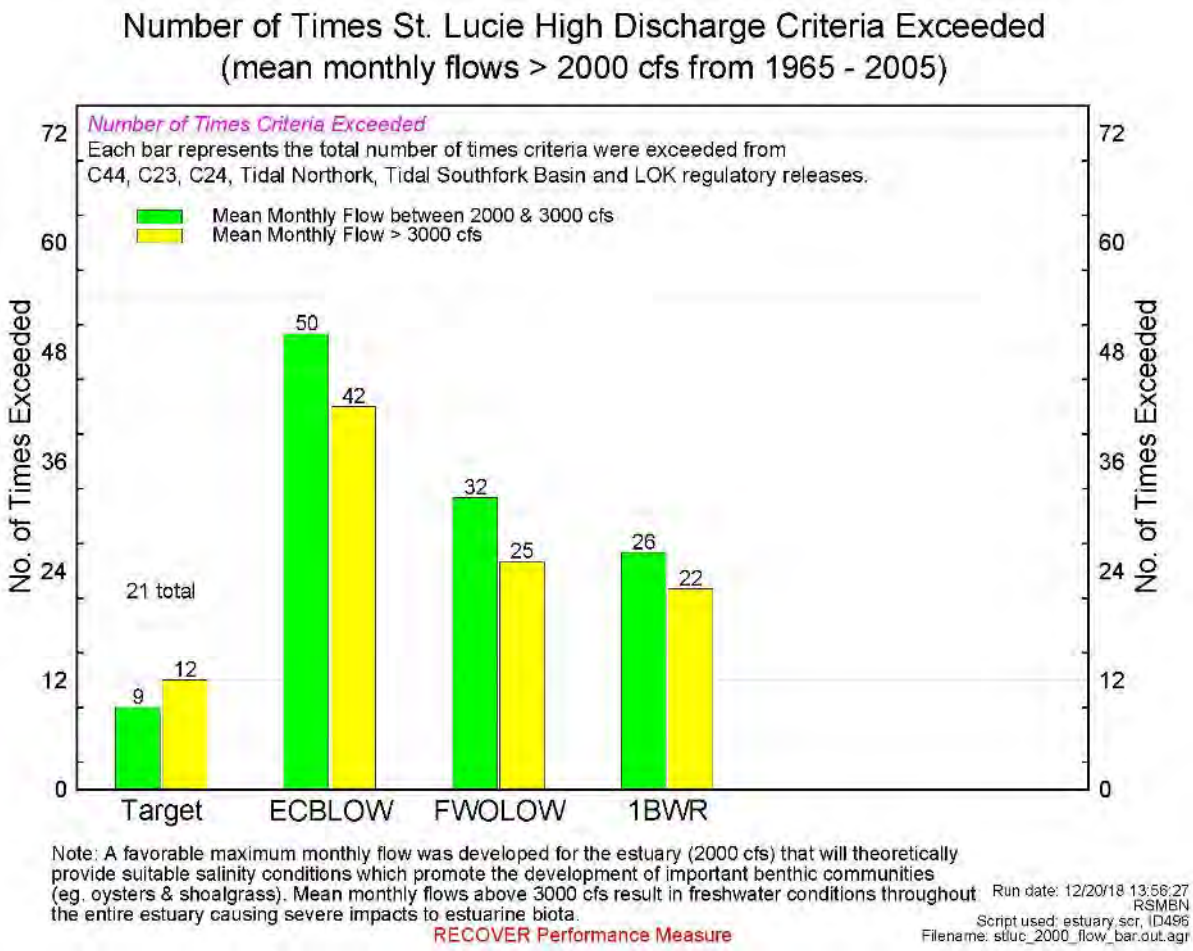

Figure C.2-59. Extreme high-flow events in the St. Lucie Estuary.

Ecological Benefits to the Northern Estuaries

High flows to the St. Lucie Estuary of more than 2,000 cfs are reduce salinities for oysters and submerged aquatic vegetation to salinities outside the preferred salinity envelope. In comparison, the high flows to the Caloosahatchee Estuary at or above 2,800 cfs at the S-79 structure reduce salinities to outside the preferred salinity envelope. The LOWRP Recommended Plan helps restore the resiliency of the Northern Estuaries by reducing the number, duration, and frequency of flows from Lake Okeechobee. Evaluation of the alternatives showed significant reductions in the number, duration, and frequency of high flows to the estuaries, including:

18-37% reduction in flow volumes from Lake Okeechobee to the Northern Estuaries, in conjunction with authorized projects as defined in the FWO.

43-49% reduction in the number of flows from Lake Okeechobee to the Northern Estuaries, in conjunction with authorized projects as defined in the FWO.

C.2.25.4 Threatened and Endangered Species

The overall objective of LOWRP is to increase water storage capacity in the watershed, improve the quantity and timing of flows to the Caloosahatchee and St. Lucie estuaries, and restore wetlands. Federally and state listed threatened, endangered, and candidate species may occur within the study area (**Table C.2-37**). Species described in the following section were determined by the USACE to potentially be affected by the project. No effect species determinations are described in **Annex A**, LOWRP Biological Assessment and the CERP Programmatic Biological Assessment for NOAA NMFS. With continued coordination with USFWS, it was determined that a supplemental Biological Assessment was not needed based on coordination of the Recommended Plan with the USFWS. Effects determinations on federally listed species in the BA submitted concurrent with the Draft Integrated Project Implementation Re-port and Environmental Impact Statement (PIR/EIS) remained the same. Direct and/or indirect impacts within the action area resulting from the Recommended Plan remained the same. Recommended Plan.

Table C.2-37. List of threatened, endangered, and candidate species know to occur in Okeechobee, Highlands, Charlotte, Glades, Martin, and St. Lucie counties. State-listed species of special concern (SSC) are also listed.

Scientific Name	Common Name	Federal Status	State Status	Alternative 1BWR Determinations
Reptiles				
Caretta caretta	Loggerhead sea turtle	Threatened	Threatened	May Affect Not Likely to Adversely Affect
Chelonia mydas	Green sea turtle	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Dermochelys coriacea	Leatherback sea turtle	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Drymarchon couperi	Eastern indigo snake	Threatened	Threatened	May Affect
Eumeces egregius lividus	Bluetail mole skink	Threatened	Threatened	No Effect
Gopherus polyphemus	Gopher tortoise	Not listed	Threatened	May Affect
Lepidochelys kempii	Kemp's Ridley sea turtle	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Neoseps reynoldsi	Sand skink	Threatened	Threatened	No Effect
Pituophis melanoleucus mugitus	Florida pine snake	Not listed	Threatened	May Affect
Birds				
Ammodramus savannarum floridanus	Florida grasshopper sparrow	Endangered	Not Listed	May Affect Not Likely to Adversely Affect
Aphelocoma coerulescens	Florida scrub jay	Threatened	Not Listed	No Effect

Scientific Name	Common Name	Federal Status	State Status	Alternative 1BWR Determinations
Athene cunicularia	Burrowing owl	Not listed	Threatened	May Affect
Egretta caerulea	Little blue heron	Not listed	Threatened	No Effect
Egretta tricolor	Tricolored heron	Not listed	Threatened	No Effect
Falco sparverius paulus	Southeastern American kestrel	Not listed	Threatened	No Effect
Grus Americana	Whooping crane	Experimental Population non-essential	Not Listed	No Effect
Grus canadensis pratensis	Florida sandhill crane	Not listed	Threatened	May Affect
Haematopus palliates	American oystercatcher	Not listed	Threatened	No Effect
Mycteria americana	Wood stork	Endangered	Not Listed	May Affect Not Likely to Adversely Affect
Picoides borealis	Red-cockaded woodpecker	Endangered	Not Listed	No Effect
Platalea ajaja	Roseate spoonbill	Not listed	Threatened	No Effect
Polyborus plancus audubonii	Northern crested caracara	Threatened	Not listed	May Affect
Rostrhamus sociabilis plumbeus	Everglade snail kite	Endangered	Not Listed	May Affect Not Likely to Adversely Affect
Rychops niger	Black skimmer	Not listed	Threatened	No Effect
Sterna antillarum	Least tern	Not Listed	Threatened	No Effect
Mammals				
Eumops floridanus	Florida bonneted bat	Endangered	Not Listed	May Affect
Puma concolor coryi	Florida panther	Endangered	Not Listed	May Affect Not Likely to Adversely Affect
Sciurus niger avicennia	Big Cypress Fox Squirrel	Not Listed	Threatened	May Affect
Sciurus niger shermani	Sherman's Fox Squirrel	Not Listed	Not Listed	May Affect
Trichechus manatus	Florida manatee	Endangered	Not Listed	May Affect Not Likely to Adversely Affect
Plants and Lichens				
Asimina tetramera	Four-petal pawpaw	Endangered	Endangered	No Effect
Cladonia perforata	Florida perforate cladonia	Endangered	Endangered	No Effect
Cucurbita okeechobeensis	Okeechobee gourd	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Dicerandra immaculate	Lakela's mint	Endangered	Endangered	No Effect

Scientific Name	Common Name	Federal Status	State Status	Alternative 1BWR Determinations
Halophila johnsonii	Johnson's seagrass	Threatened	Threatened	No Effect
Jacquemontia reclinata	Beach jacquemontia	Endangered	Endangered	No Effect
Liatrus ohlingerae	Scrub blazing star	Endangered	Endangered	No Effect
Panicum abscissum	Cutthroat grass	Not Listed	Endangered	No Effect
Paronchia chartacea	Papery whitlow-wort	Threatened	Endangered	No Effect
Polygala lewtonii	Lewton's polygala	Endangered	Endangered	No Effect
Polygala smallii	Tiny polygala	Endangered	Endangered	No Effect
Warea carteri	Carter's mustard	Endangered	Endangered	No Effect
Critical Habitat				
Rostrahamus sociabilis plumbeus	Everglade snail kite	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Trichechus manatus	West Indian Manatee	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Chelonia mydas	Green sea turtle	Endangered	Endangered	May Affect Not Likely to Adversely Affect
Halophila johnsonii	Johnson's seagrass	Threatened	Threatened	May Affect Not Likely to Adversely Affect

ASR Effects

Aquifer Storage and Recovery Wells have the potential to affect methyl mercury bioaccumulation downstream. Recovered water may have higher sulfate concentrations than surface water. Increased sulfate may accumulate in lake sediments, reduce to hydrogen sulfide, and result in a sedimentary geochemical environment that can favor mercury methylation. The LOWRP Recommended Plan includes 80 ASR wells so there may be a risk for snail kites, wood storks, the Florida panther, and wading birds. An earlier study at Kissimmee River ASR System (Krabbenhoft and Sunderland 2013) demonstrated that mercury methylation does not occur during storage in the UFA, and extensive monitoring during KRASR cycle testing showed that mercury and methylmercury concentrations were not released in recovered water (USACE, 2013).

C.2.25.4.1 Florida Grasshopper Sparrow

In the Recommended Plan, there is no potential grasshopper sparrow habitat within the Paradise Run footprint (**Figure C.2-60**). For the Kissimmee River–Center wetland site, the entire site is within the area of potential grasshopper sparrow habitat (**Figure C.2-60**). However, based on the existing conditions, most of the site is improved pastures and wetlands (**Table C.2-38**), therefore, it is unlikely that there is actual grasshopper sparrow habitat within this footprint. However, surveys would be conducted during the Preconstruction Engineering and Design (PED) phase of the project to confirm there is no potential

sparrow habitat within the Kissimmee River–Center wetland restoration site. The wetland restoration sites for all alternatives may affect, but are not likely to adversely affect grasshopper sparrows.

Table C.2-38. Existing land use in the Kissimmee River–Center wetland restoration site footprint.

FLUCCS Level 4 Code	FLUCCS Code Description	Area (acres)
2110	Improved Pastures	796
2120	Unimproved Pastures	64
3100	Herbaceous Rangeland	3
4200	Upland Hardwood Forest	4
4270	Live Oak	3
4271	Oak - Cabbage Palm Forest	1
5110	Streams and Waterways	19
5120	Channelized waterways, canals	3
5300	Reservoirs	5
6172	Mixed Wetland Hardwoods - Mixed Shrubs	159
6180	Cabbage Palm Savannah	4
6410	Freshwater Marshes	55
6430	Wet Prairies	41
6440	Emergent Aquatic Vegetation	40
	Total Area	**1,197**

There is minimal potential grasshopper sparrow in the WAF footprint in Alternative 1BWR (**Figure C.2-60**). Alternative 1BWR will not affect grasshopper sparrows because of the minimal potential suitable habitat that occurs the northwest corner of the footprint. Based upon the existing conditions of the wetland restoration sites and lack of suitable sparrow habitat in the WAF, the grasshopper sparrow is not likely to use the current area. Within the proposed footprints of the ASR wells, no potential grasshopper sparrow habitat is present. Construction and use of the ASRs are not expected to affect the grasshopper sparrow. Preconstruction surveys will be conducted prior to building all features to confirm there are no grasshopper sparrows present. If Florida grasshopper sparrows are encountered during the pre-construction surveys, the USACE will work closely with USFWS to identify options to eliminate or minimize any potential effects. The LOWRP Recommended Plan may affect, but is not likely to adversely affect, Florida grasshopper sparrows.

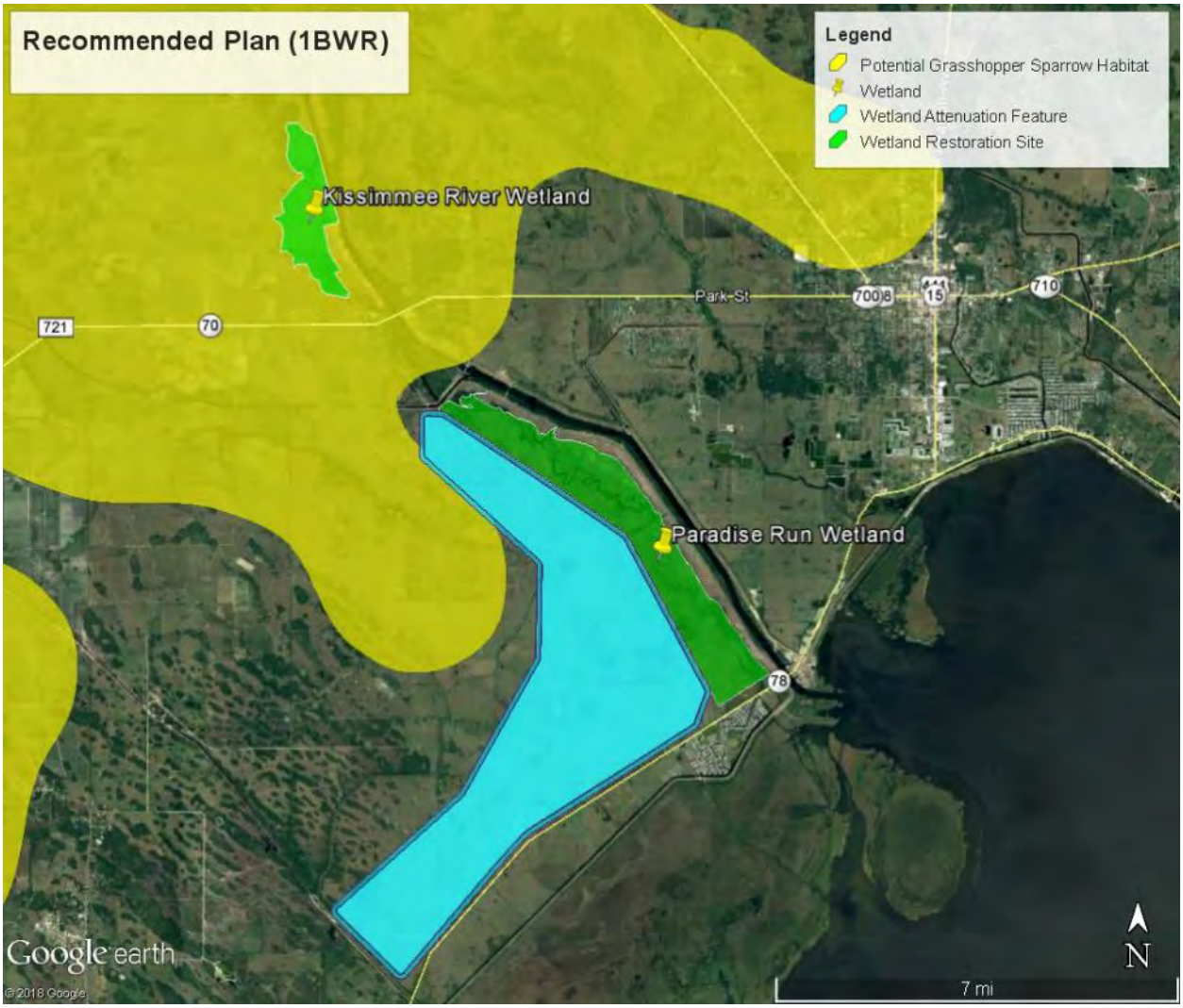

Figure C.2-60. Potential grasshopper sparrow habitat within the Recommended Plan footprint.

C.2.25.4.2 Northern Crested Caracara

There are known and suspected caracara territories within the WAF footprint and there is additional caracara foraging habitat within both wetland sites. **Figure C.2-61** and **Figure C.2-62** show the reported caracara nest locations and other caracara observations in the USFWS's database. Due to the lack of public access, parts of the study area have not been surveyed for caracaras. This is especially true for the interior of the WAF footprint. As a result, there are likely more caracara nests than depicted in **Figure C.2-61**. Given the amount of overall pasture habitat in the study area, the direct effect of habitat loss on caracaras from the Recommended Plan will be proportional to the size of the WAF. ASRs generally have smaller surface footprints, so there may not be any substantial adverse effects of ASR construction and operation on caracaras. A follow-up assessment will be needed once specific ASR sites are selected. For the wetlands, pasture conversion to deep wetlands may displace caracaras, but conversion to short-hydroperiod wetlands may not. Additionally, the anticipated increase in wetland-based prey items associated with restored wetlands is likely to increase foraging opportunities and may benefit the caracara. Caracaras may forage along future storage feature levees and seepage control features. As a result, the Recommended Plan project features would likely need surveys to identify caracara nests and

better define the magnitude of adverse and potentially beneficial effects. A biological opinion exempting incidental take of caracaras will likely be needed for the Recommended Plan. The Recommended Plan proposed removal of upland habitat in the WAF may affect caracaras.

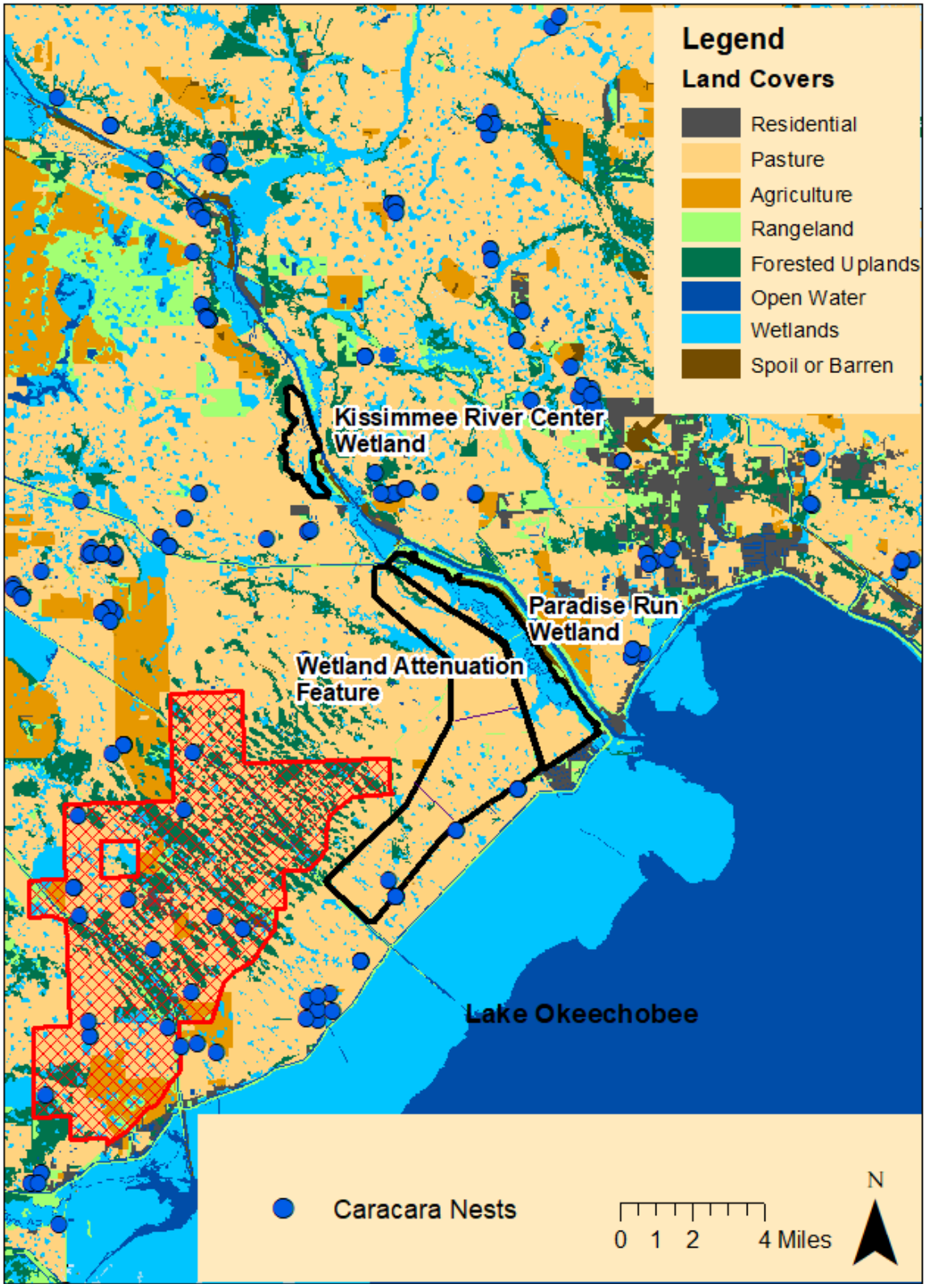

Figure C.2-61. Caracara nest locations in and around the LOWRP from 1994-2018). Source: USFWS 2018.

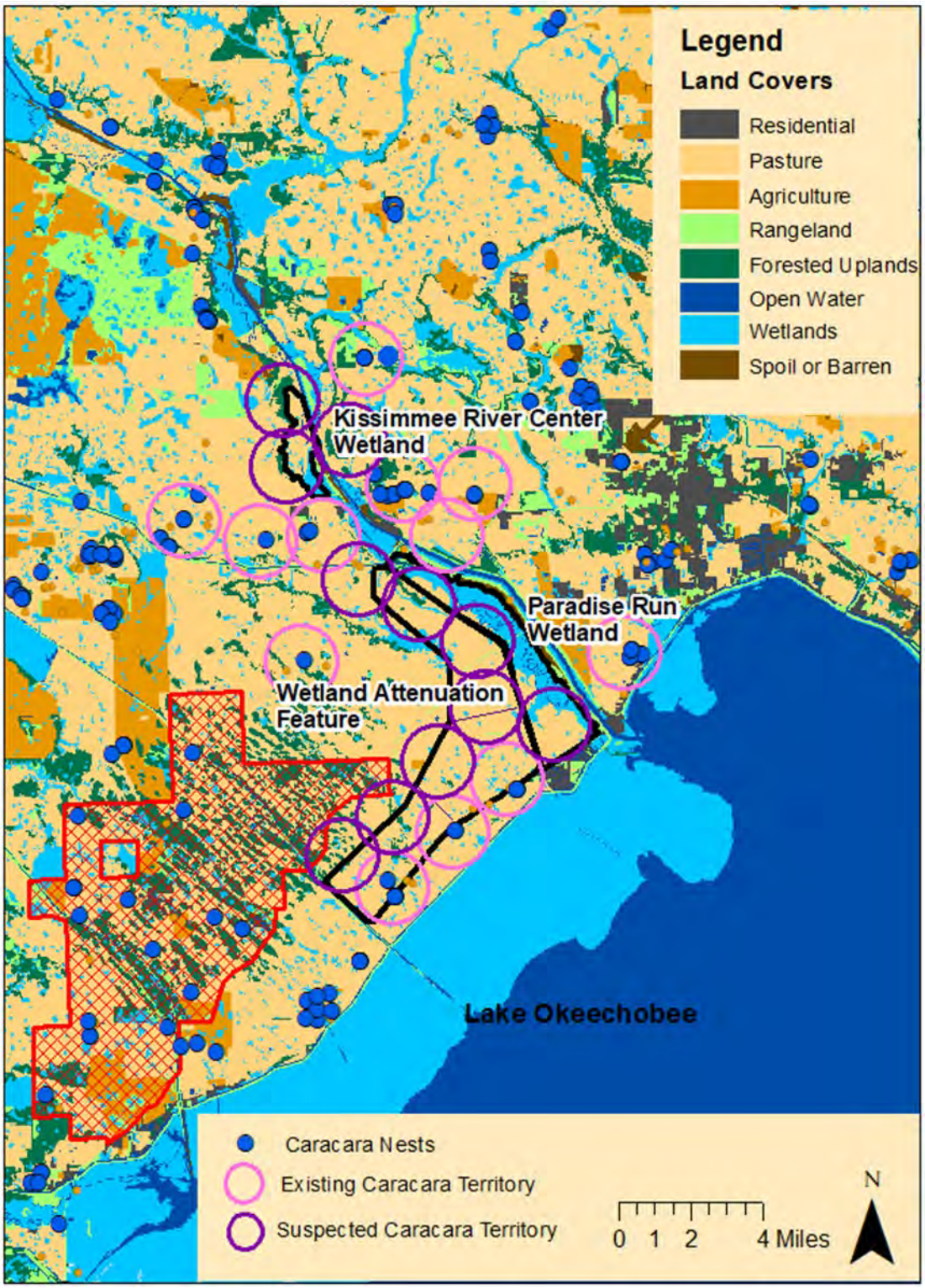

Figure C.2-62. Reported caracara nest locations with accompanying 2,008-acre territories and additional suspected caracara territories in and around the LOWRP. Source: USFWS 2018.

C.2.25.4.3 Florida Bonneted Bat

The Florida bonneted bat consultation area includes Glades, Highlands, and Okeechobee counties, which are within the project area **(Figure C.2-63**). The project area does not include the 2013 bonneted bat focal area as described by FWS (2013). **Figure C.2-64** shows the FBB survey locations and the presence or absence of FBB at those locations surveyed by USFWS. This species forages for insects at night while flying over water; therefore, the Recommended Plan provides benefits of increased wetlands and storage features for foraging. However, the wetland and WAF sites contain uplands that may contain roosting trees, thus the Recommended Plan may be removing roosting habitat **(Table C.2-39**). Acoustic surveys to detect bats should be completed prior to construction so that if bats are encountered, the USACE will coordinate measures with FWS to minimize or avoid potentially adverse effects. Because LOWRP is within the Florida bonneted bat consultation area and contains trees in which bats could potentially roost, the USACE has determined that the Recommended Plan may affect the Florida bonneted bat.

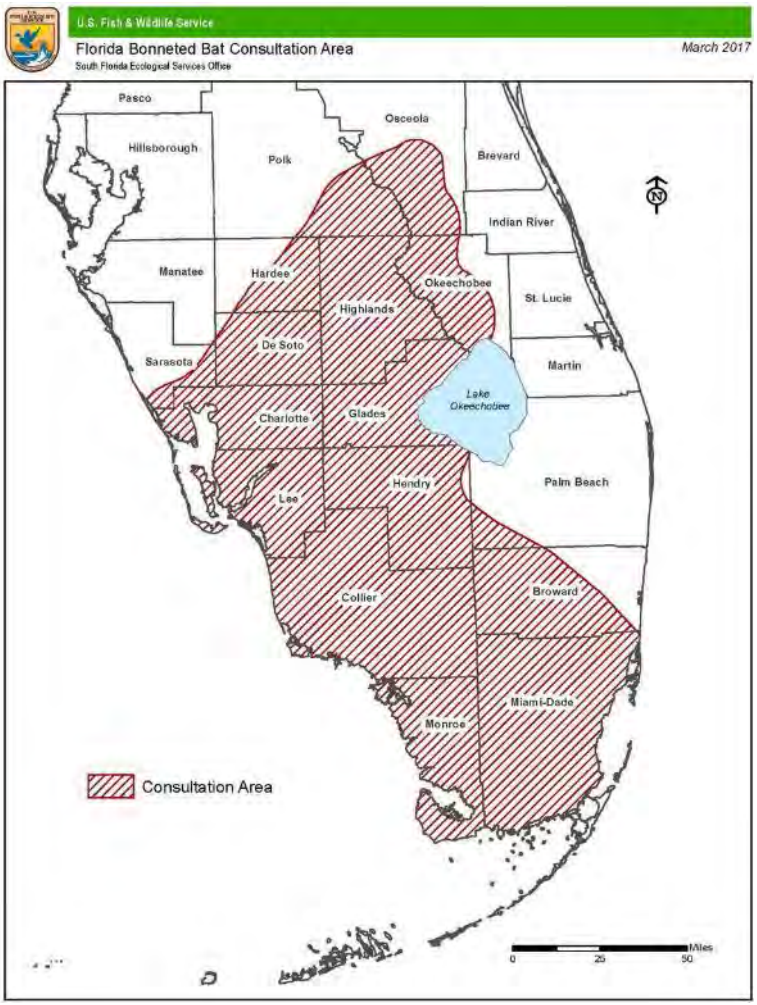

Figure C.2-63. 2017 Florida Bonneted Bat (FBB) Consultation and Focal Area (USFWS 2017).

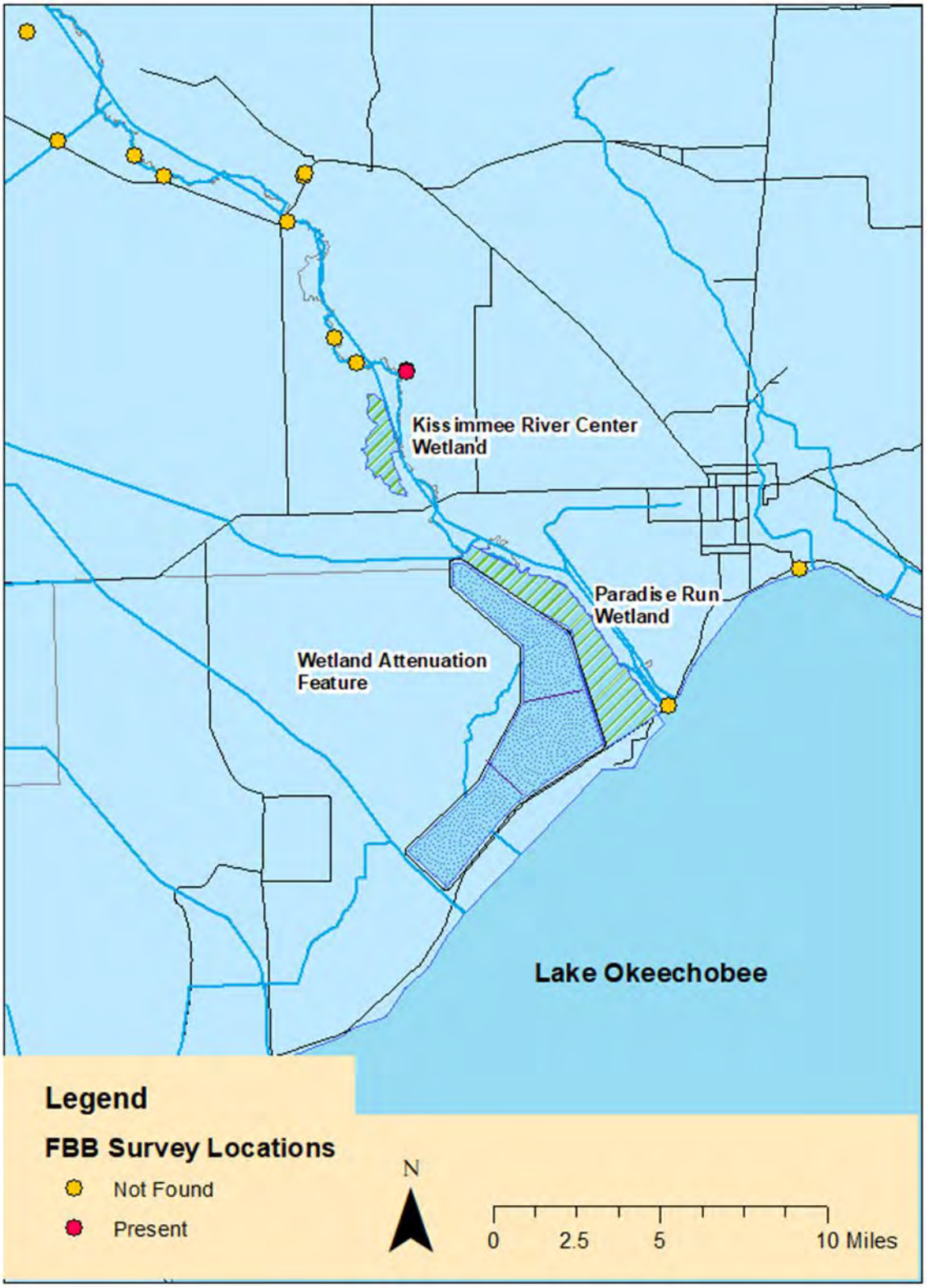

Figure C.2-64. Florida bonneted bat (FBB) survey locations and present (red) or not found (yellow). Source: FWS 2018

Table C.2-39. Acres where potential bonneted bat tree roosts that may be present in the Recommended Plan.

	1BWR
Acres of uplands in WAF footprint	67
Acres of uplands in wetland restoration footprint	114
Total acres of uplands lost	**181**

C.2.25.4.4 Everglades Snail Kite

Snail kites are known to nest and forage in and around Lake Okeechobee during most non-drought years (**Figure C.2-65**). They may also occupy Lake Istokpoga and the Kissimmee River floodplain as hydrologic conditions and availability of apple snails (the kite's main prey item) allow. In recent years, the introduction and expansion of the exotic apple snail (*Pomacea maculata*) population has, in turn, expanded both the areas in which snail kites may forage and nest as well as prolonged the nesting season in some years from the spring into the summer and sometimes fall. We expect that the Recommended Plan will restore or increase the spatial extent of wetlands could benefit the snail kite if apple snails and/or nesting substrate become present in those wetlands. The creation of WAF has the potential to benefit snail kites if the hydrology allows for creation and maintenance of apple snail populations or if nesting substrate is available. However, there is greater uncertainty that the WAF will provide snail kite habitat compared to restored wetlands. The Recommended Plan restores 4,779 acres of wetlands along the Kissimmee River floodplain increasing the spatial extent of suitable foraging opportunities for snail kites (**Table C.2-32**).

Water storage provided by implementation the Recommended Plan is likely to improve overall lake levels and moderate stage fluctuations. This may increase suitable habitat for apple snails, thereby increasing spatial extent of suitable foraging opportunities for snail kites. Minor beneficial effects to vegetation (including vegetation used for snail kite nesting) within Lake Okeechobee's extensive littoral zone are also anticipated as a result of the Recommended Plan. These ecological benefits are a result of the small increase in amount of time within the beneficial stage envelope and less time in the extremely low stages (<10 ft, NGVD) and above the stage envelope compared to the FWO (**Figure C.2-50** to **Figure C.2-52**). Conversely, also as compared with FWO, the LOWRP Recommended Plan reveals the potential for short-term minor adverse effects to the ecological indicators and littoral and nearshore aquatic vegetation due to a slight increase in the amount of time that lake stages in the extremely high stages (>17 ft, NGVD) might occur (**Figure C.2-53**).

The Recommended Plan may potentially increase wetland acreage in the LOW by approximately 17,000 acres, and creating storage with ASR, which will help regulate water levels within the lake and south of the lake. The increase in wetland acreage would significantly increase the spatial extent of suitable foraging habitat and opportunities for snail kites. The change in lake stages does not appear to result in many occurrences of time the lake is above or below the optimal stage envelope for vegetation as compared to the current conditions. The effects of lake stages on snail kites are outlined and discussed in the LORS Biological Opinion, with actions to minimize any potential effects. This project would also follow those guidelines. Rapid recession rates during the dry (breeding) season and associated low water levels can allow nests to become accessible to land-based predators, resulting in decreased nest success

(Beissinger 1986; Sykes 1987b). The potential for this effect is greater for snail kites nesting near land (i.e., in lakes or reservoirs) compared to those nesting in expansive marsh systems such as WCA-3A. While recession rates were not analyzed specific to LOWRP effects on Lake Okeechobee stage, LOWRP provides additional capability to moderate Lake Okeechobee stages particularly in the dry season, which may or may not reduce high recession rates (>0.16 ft. per week, Fletcher et al. 2017). The USACE has determined that the Recommended Plan may affect, but is not likely to adversely affect, Everglade snail kites.

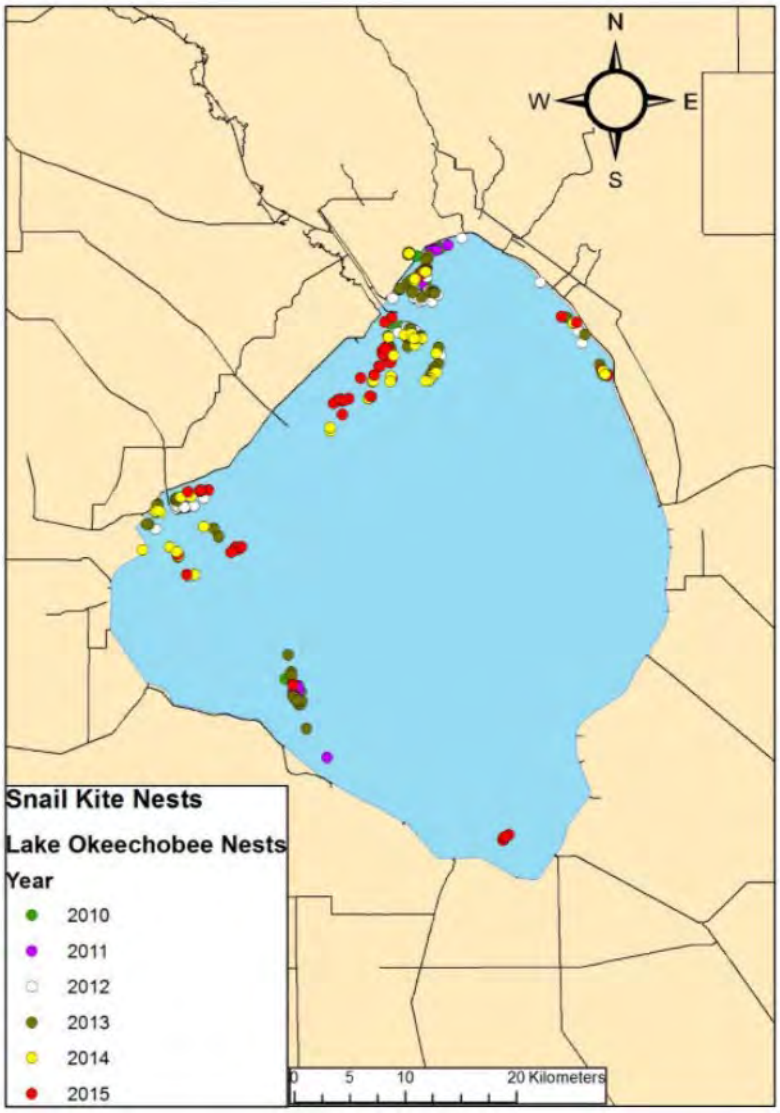

Figure C.2-65. Everglade snail kite nest locations from 2010-2015 (*active nests only). Source: USFWS 2015.

C.2.25.4.5 Everglades Snail Kite Critical Habitat

Based on the description in the Federal Register (1977), snail kite critical habitat in Lake Okeechobee is located in the western parts of Glades and Hendry Counties, extending along the western shore to the

east of the dike system and the undiked high ground at Fisheating Creek, and from the Hurricane Gate at Clewiston northward to the mouth of the Kissimmee River, including all the spike rush (Eleocharis sp.) flats of Moonshine Bay, Monkey Box, and Observation Shoal, but excluding the open water north and west of the northern tip of Observation Shoal north of Monkey Box and east of Fisheating Bay. The project benefits described above for vegetation within the Lake Okeechobee littoral zone are mostly within the designated snail kite critical habitat. Therefore, snail kite critical habitat in Lake Okeechobee should benefit by implementation of the Recommended Plan, particularly by reducing the frequency of extreme low lake stages.

The project benefits described above for vegetation within the Lake Okeechobee littoral zone are mostly within the designated snail kite critical habitat (**Figure C.2-66**). Therefore, snail kite critical habitat in Lake Okeechobee should benefit by implementation of the project, particularly by reducing the frequency of extreme low lake stages. Due to these anticipated beneficial effects on Lake Okeechobee's littoral vegetation, the USACE has determined that implementation of the Recommended Plan may affect, but will not likely adversely affect, Everglade snail kite critical habitat.

C.2.25.4.6 Wood Stork

Implementation of the Recommended Plan is expected to improve conditions for wood storks throughout much of the project area. Rehydration and vegetation shifts within the Lake Okeechobee Watershed (i.e., restored project wetlands) and lake levels (via additional project storage) are likely to increase the spatial extent of suitable foraging opportunities and nesting habitat for wood storks providing a moderate beneficial effect (). Minor beneficial effects to vegetation within Lake Okeechobee's extensive littoral zone are anticipated as a result of the Recommended Plan. These ecological benefits are a result of the small increase in amount of time within the beneficial stage envelope and less time in the extremely low stages (<10 ft, NGVD) and above the stage envelope for the Recommended Plan compared to the FWO (**Figure C.2-2** to **Figure C.2-5**). This increase in time in the beneficial stage envelope improves the foraging habitat in the littoral zone of Lake Okeechobee for wood storks. Conversely, also as compared with FWO, the LOWRP Recommended Plan reveals the potential for short-term minor adverse effects to the ecological indicators and littoral and nearshore aquatic vegetation due to a slight increase in the amount of time that lake stages in the extremely high stages (>17 ft, NGVD) might occur (**Figure C.2-53**) which may affect foraging habitat for wood storks.

The Recommended Plan restores 4,779 acres of wetlands along the Kissimmee River floodplain. The Recommended Plan significantly increases the spatial extent of suitable foraging opportunities and nesting habitat for wood storks (**Table C.2-32**). These benefits should offset the adverse impacts to existing foraging habitat (i.e., wetlands) currently within the WAF footprint.

Figure C.2-66. Snail kite critical habitat located in Lake Okeechobee.

The Recommended Plan is anticipated to improve conditions for wood storks throughout much of the project area, including the littoral community within Lake Okeechobee (**Figure C.2-67**) due to the increased amount of time the water levels would be within the beneficial stage envelope. This would allow for a greater opportunity for wood stork foraging. Rehydration and vegetation shifts within the LOW (i.e., wetland restoration sites) and lake levels (via additional project storage) are likely to increase the spatial

extent of suitable foraging opportunities and nesting habitat for wood storks, which would provide a moderate beneficial effect.

The Recommended Plan proposes to restore 4,779 acres of wetlands along the Kissimmee River floodplain. This significantly increases the spatial extent of suitable foraging opportunities and nesting habitat for wood storks. These benefits should offset the adverse effects to existing foraging habitat (i.e., wetlands) currently within the potential storage footprints. Therefore, the USACE has determined that the Recommended Plan may affect, but is not likely to adversely affect, wood storks.

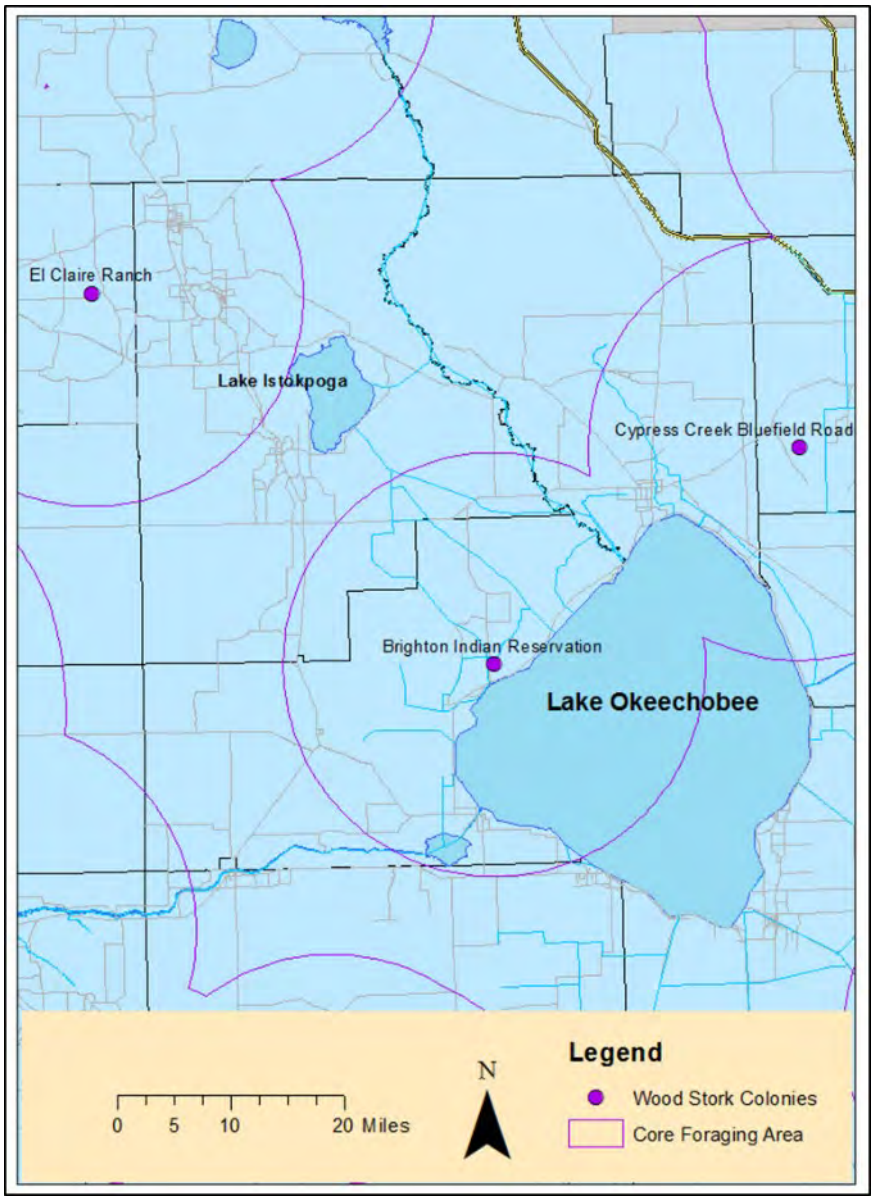

Figure C.2-67. Wood stork colonies active in 2016 near Lake Okeechobee. Source: USFWS 2018.

C.2.25.4.7 Eastern Indigo Snake

The LOWRP Recommended Plan includes a WAF that will convert uplands and wetlands to wetland habitat and wetland restoration sites that will convert some uplands to wetlands. For the Recommended Plan, the majority of the current land uses in the storage features and wetland restoration footprints are improved and unimproved pastures. **Table C.2-40** shows the amount of uplands and pastureland that will be converted to wetlands. Eastern indigo snakes have a high probability of occurrence within the WAF and wetland restoration footprints based on the acreage of the project components and the available potential snake habitat (**Figure C.2-68**). As a result of construction, the species is likely to be displaced or possibly killed. The Recommended Plan would remove approximately 14,493 acres of potential habitat and is likely to have unavoidable adverse effects on Eastern indigo snakes. The USACE will utilize Standard Protection Measures for Eastern Indigo snakes throughout project design and construction in order to minimize any potential adverse effects to the extent practicable. The USACE has determined that the Recommended Plan may affect Eastern indigo snake.

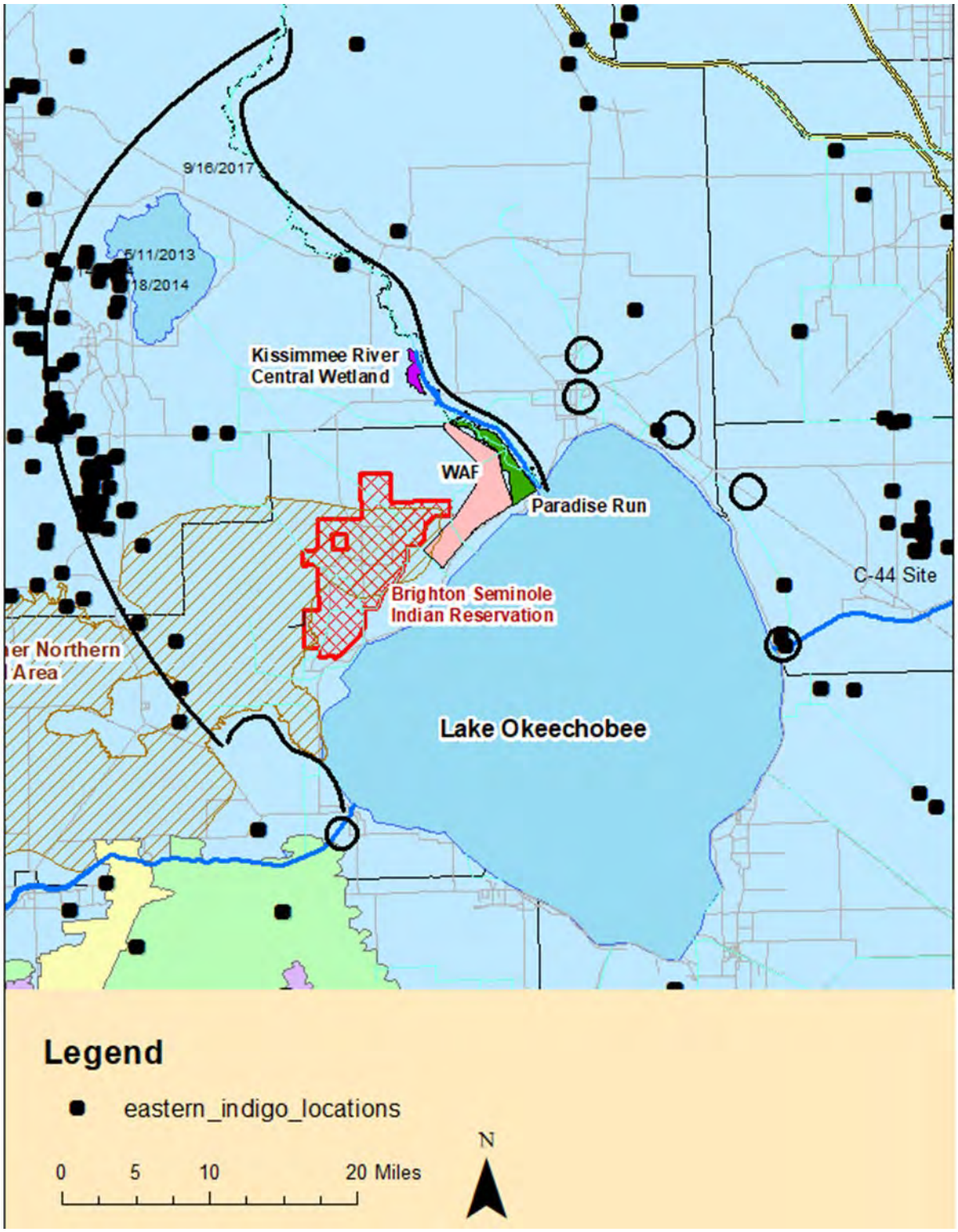

Figure C.2-68. Eastern indigo snake locations in and around the LOWRP action area. Source: FWS 2018

Table C.2-40. Acres of upland and pastureland in the WAF footprint and in the restored wetland sites.

Upland Description	1BWR
Acres of uplands in the WAF footprint	67
Acres of pasture in the WAF footprint	12,552
Acres of pasture in wetland restoration footprint	1,816
Acres of uplands in wetland restoration footprint	114
Total acres of uplands and pasturelands lost	**14,549**

C.2.25.4.8 Florida Manatee

The Florida manatee is a large, plant-eating aquatic mammal that can be found in Lake Okeechobee and its rim canal, the Kissimmee River below S65-E, and the shallow coastal waters, rivers, and springs of Florida. Florida manatees live in freshwater, brackish, and marine habitats, and can move freely between salinity extremes. They move from the inland locations to warmer coastal waters in winter. The Recommended Plan is not likely to adversely impact the overall manatee foraging habitat within Lake Okeechobee, local canals, or the Northern Estuaries; the latter includes designated manatee critical habitat. The LOWRP Recommended Plan shows a slight performance improvement within the Northern Estuaries as indicated by fewer high volume flow months, providing a minor beneficial effect to SAV. Reduction in high flows and accompanying flow velocities would result in lower suspended solid loading and decreased concentration of colored dissolved organic matter, thereby allowing greater light penetration to promote growth of SAV. In addition, reduction in high volume flows from Lake Okeechobee would reduce extreme salinity fluctuations associated with such events. Although some SAV are tolerant of a wide range of salinity levels, a reduction in high volume flows would reduce stress to SAV and promote increases in seagrass shoots and have the potential to increase foraging opportunities for manatees in this region and provide a minor beneficial effect. The Recommended Plan provides significant beneficial effects for the reduction of high flow events which are beneficial for the SAV in the estuaries (refer to **Northern Estuaries** for further information).

Florida manatees also depend upon canals as a source of freshwater and resting sites. It is highly likely that Florida manatees also depend on the deep canals as a cold-weather refuge. The relatively deep waters of the canals respond more slowly to temperature fluctuations at the air/water interface than the shallow bay waters. Thus, the canal waters remain warmer than open bay waters during the passage of winter cold fronts. **Figure C.2-69** illustrates canals that Florida manatees have access to within LOWRP action area. Within Lake Okeechobee, minor beneficial effects to vegetation within Lake Okeechobee's extensive littoral zone are anticipated as a result of the Recommended Plan. These ecological benefits are a result of the small increase in amount of time within the beneficial stage envelope and less time in the extremely low stages (<10 ft. NGVD) and above the stage envelope for any of the alternatives compared to the FWO (**Figure C.2-50** through **Figure C.2-52**). This increase in time in the beneficial stage envelope improves the foraging habitat in Lake Okeechobee for manatees.

In addition to the Endangered Species Act, the manatee is also protected by the Marine Mammal Protection Act, and as such, incidental take of manatees cannot be exempted for federal actions. Therefore, any alternative with ASRs that release to waters inhabited by manatees will need to maintain the thermal profile in the receiving stream if manatees are present. This will preclude entrapment of manatees in temporary warm water ASR plumes (expected to be 75° F) when ambient water temperatures

are below 60° F. This concern could be remediated by having alternative ASR release points to areas not inhabited by manatees and avoid any identified refugium.

The Recommended Plan would improve the overall manatee foraging habitat within Lake Okeechobee, local canals, and the Northern Estuaries; the latter includes designated manatee critical habitat. Within Lake Okeechobee, modeling shows a minor beneficial effect to vegetation within Lake Okeechobee's extensive littoral zone that will improve the foraging habitat in Lake Okeechobee for manatees. The modeling shows performance improvements within the Northern Estuaries as indicated by fewer high-volume flow months, providing a beneficial effect to SAV. Reduction in high flows and accompanying flow velocities would result in lower suspended solid loading and decreased concentration of colored dissolved organic matter, thereby allowing greater light penetration to promote growth of SAV. In addition, reduction in high-volume flows from Lake Okeechobee would reduce extreme salinity fluctuations associated with such events. Although some SAV are tolerant of a wide range of salinity levels, a reduction in high volume flows would reduce stress to SAV and promote increases in seagrass shoots and have the potential to increase foraging opportunities for manatees in this region and provide a minor beneficial effect.

Florida manatees also depend upon canals as transit from one habitat to another, a source of freshwater, and resting sites. Standard manatee protection guidelines will be used during construction along canals/rivers accessible to manatees to avoid effects. It is highly likely that Florida manatees also depend on the deep canals as a cold-weather refuge. The relatively deep waters of the canals respond more slowly to temperature fluctuations at the air/water interface than the shallow bay waters. Thus, the canal waters remain warmer than open bay waters during the passage of winter cold fronts. **Figure C.2-69** illustrates the canals that Florida manatees have access to, some of which are within the LOWRP action area. **Figure C.2-70** shows the manatee mortality data from 1978-2017 for the area in the LOWRP project area.

Figure C.2-69. Canals that Florida manatee have access to within LOWRP action area.

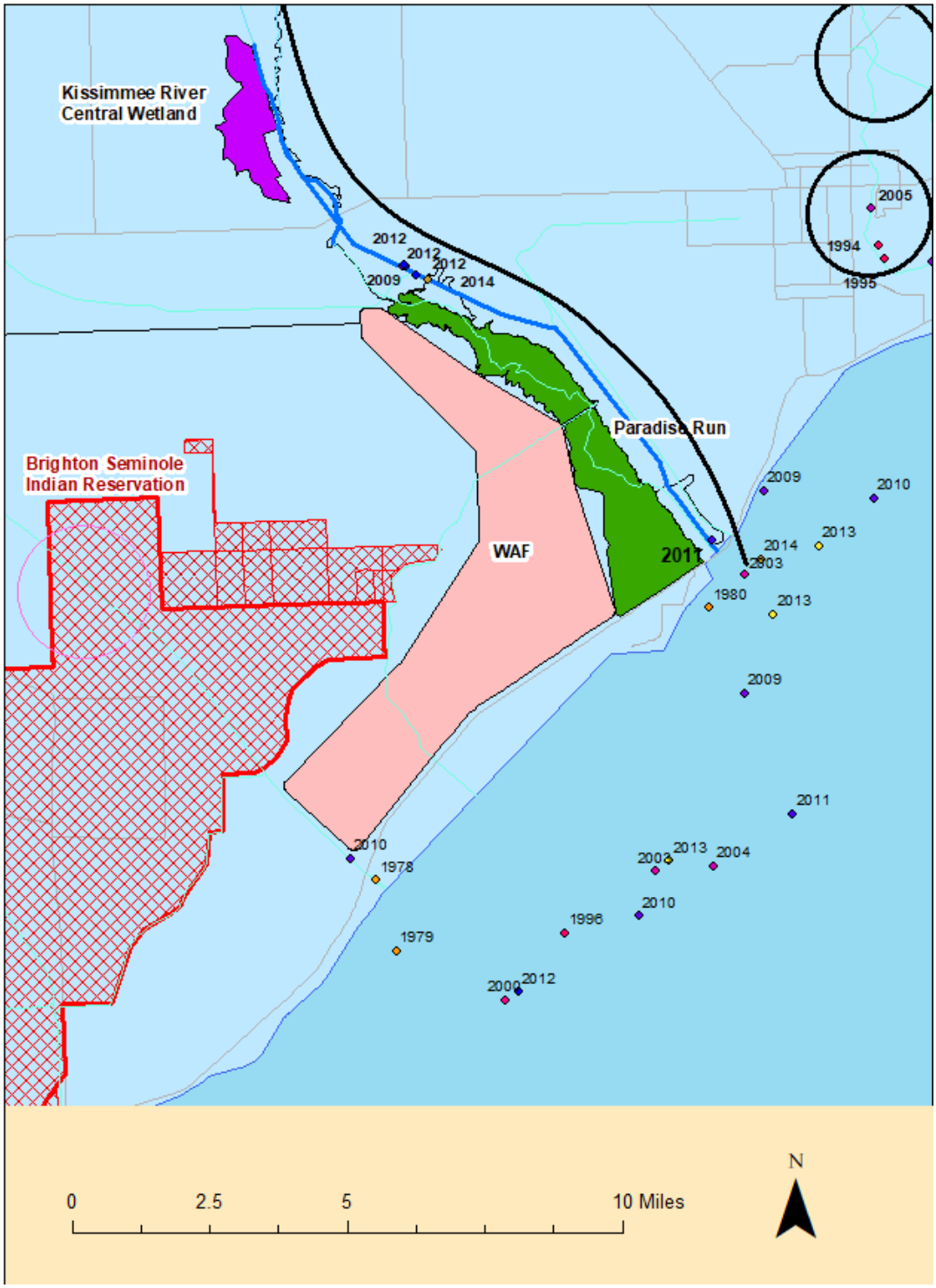

Figure C.2-70. Manatee mortality data from 1978-2017 near the LOWRP project features.

The ASRs are not likely to negatively affect manatee with the release of warmer waters (Ecological Risk Assessment from the Aquifer Storage and Recovery Regional Study Technical Data Report, pages 165-166, May 2015). The typical duration of water releases from ASR wells would likely not be enough water to provide prolonged warm water habitat, as the water is likely to dissipate into the canals without changing

the thermal temperature significantly. ASRs that release to waters inhabited by manatees will need to maintain the thermal profile in the receiving stream if manatees are present. This will preclude entrapment of manatees in temporary warm water ASR plumes (expected to be 75° F) when ambient water temperatures are below 60° F. This concern could be remediated by having alternative ASR release points to areas not inhabited by manatees. In order to avoid potential effects to manatee, the timing of water releases into the canals could be conducted during non-critical times manatee would be present. This concern of change in thermal profile while manatees are in the waters could also be reduced by having alternative ASR release points to areas not inhabited by manatees. With careful planning on timing of releases and placement of ASRs, the USACE has determined that the Recommended Plan may affect, but is not likely to adversely affect Florida manatee.

C.2.25.4.9 Florida Manatee Critical Habitat

Critical habitat for the Florida manatee was designated in 1976 (50 CFR § 17.95[a]). Critical habitat for the West Indian manatee is shown in **Figure C.2-71**.

The Recommended Plan is not likely to adversely affect the overall manatee foraging habitat within the designated manatee critical habitat. The Recommended Plan modeling shows a slight performance improvement within the Northern Estuaries as indicated by fewer high volume flow months, which provides a minor beneficial effect to SAV. Reduction in high flows and accompanying flow velocities would result in lower suspended solid loading and decreased concentration of colored dissolved organic matter, thereby allowing greater light penetration to promote growth of SAV. In addition, reduction in high volume flows from Lake Okeechobee would reduce extreme salinity fluctuations associated with such events. Although some SAV are tolerant of a wide range of salinity levels, a reduction in high volume flows would reduce stress to SAV and promote increases in seagrass shoots and have the potential to increase foraging opportunities for manatees in this region and provide a minor beneficial effect. Therefore, the Recommended Plan may affect, but is not likely to adversely affect, Florida manatee designated critical habitat.

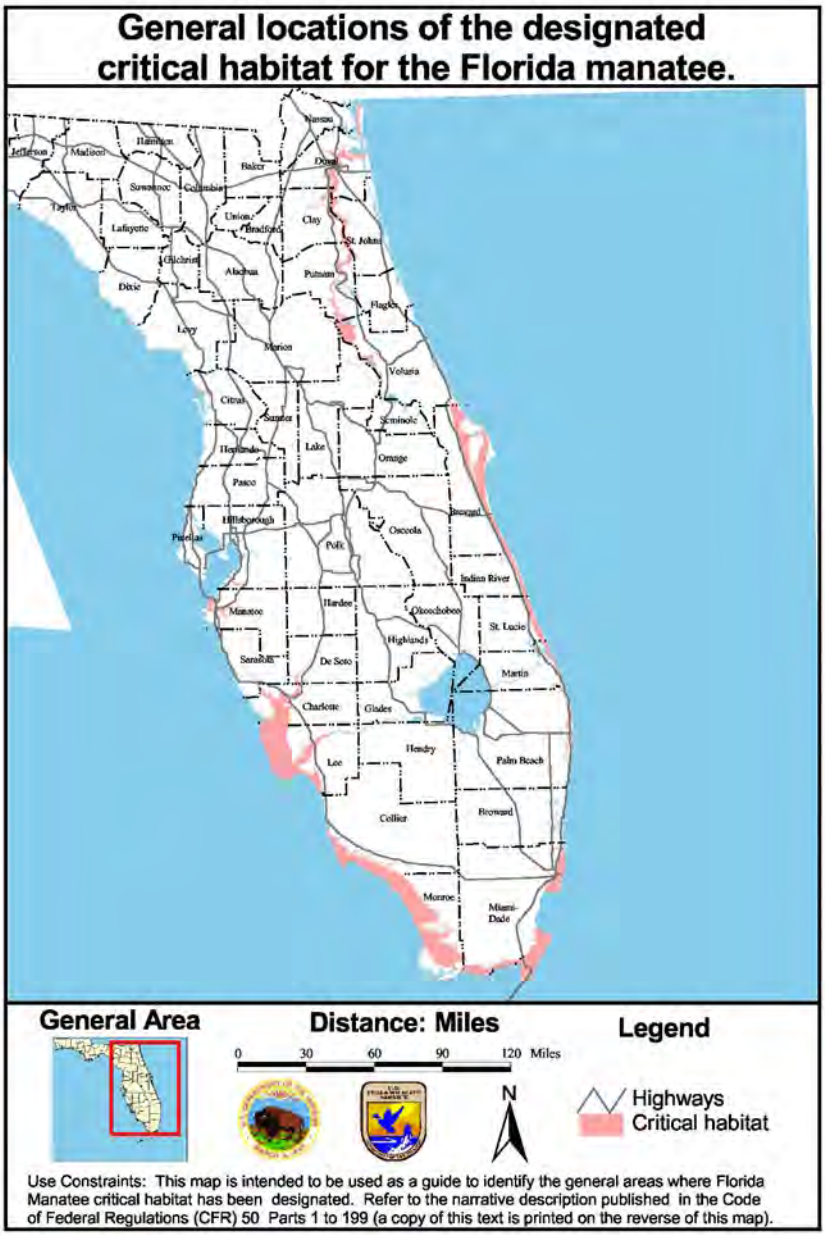

Figure C.2-71. Designated critical habitat for the West Indian Manatee.

C.2.25.4.10 Florida Panther

The LOWRP Recommended Plan has the potential to convert wetland and upland habitat in the Thatcher Dispersal Pathway (as shown in **Figure C.2-72**) to aboveground storage. However, the lower water depth in Alt 1BWR will not be a geographic barrier as panthers could still traverse the WAF. In addition, lands within LOWRP action area become restored to their more historic natural values, the concomitant improved prey base would result in greater use of these areas by the Florida panther. The Thatcher dispersal pathways were not identified as being used by panthers; rather they represented a least-cost pathway for panthers to move north based on the available habitat in 2006. Female panthers have only recently been recorded north of the Caloosahatchee River. It has yet to be determined if the panther population will substantially expand beyond the primary expansion area. **Figure C.2-73** shows the current

Florida panther mortality data and current observation data for the LOWRP action area. In the event it does, the with-project levees, associated seepage canals, and restored wetlands would provide permanent panther prey and dispersal pathways. Because panthers are not using these areas now, it is difficult to say if the Recommended Plan will adversely affect the Florida panther. Based on this information, and the fact that the Florida panther is a wide-ranging species with the majority of sightings west of the action area, the Recommended Plan may affect, but is not likely to adversely affect the Florida panther.

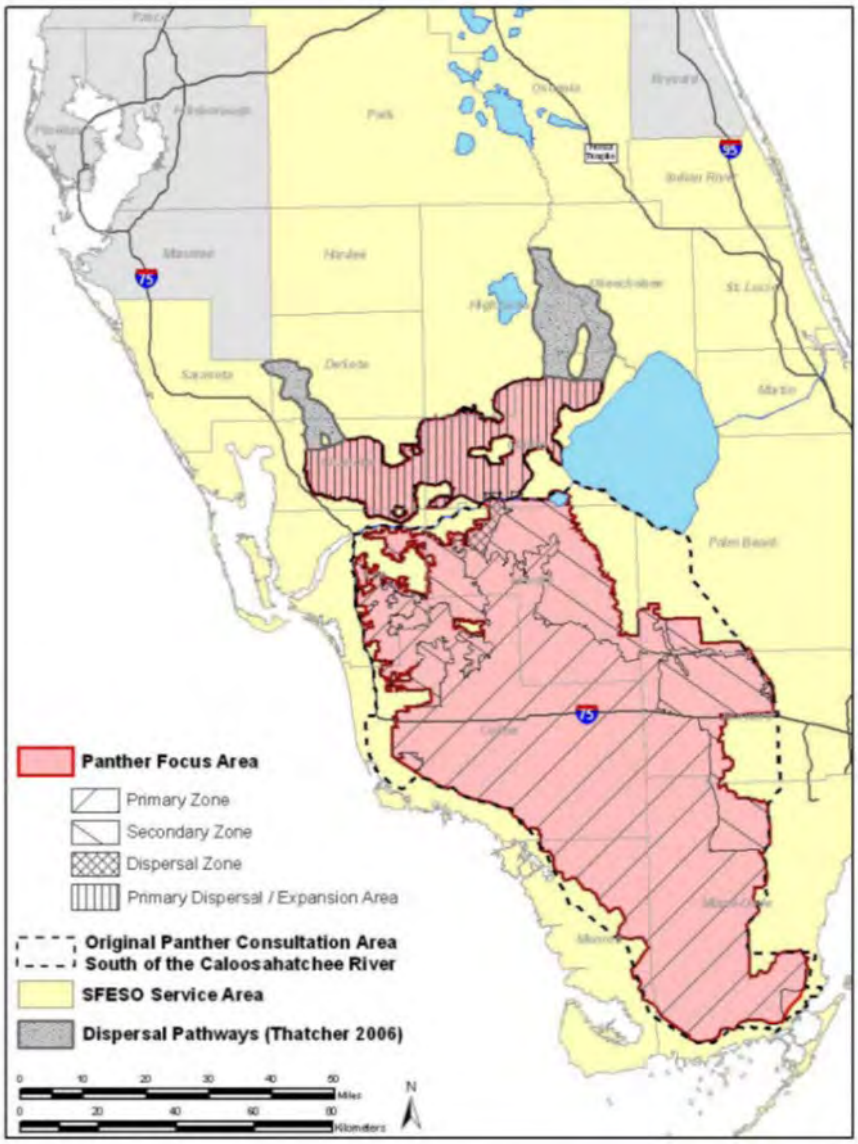

Figure C.2-72. Florida panther zones in South Florida. Source: USFWS 2015.

Figure C.2-73. Florida panther mortality data and current observation data from FWC for LOWRP Action Area; panther observation website accessed August 15, 2018. https://public.myfwc.com/hsc/panthersightings/MapPoints.aspx

C.2.25.4.11 Okeechobee Gourd

The decline of the Okeechobee Gourd is largely attributable to conversion of swamp forests to agriculture and water level management in Lake Okeechobee. For the gourd to maintain viable healthy populations,

fluctuations in lake level are necessary. High lake levels facilitate dispersal and inundate and destroy aggressive weeds in local habitats. As lake levels decrease, the cleared open habitats allow the quickly germinating Okeechobee gourd seeds to sprout and begin climbing before they have to compete with other pioneer species. Water regulation practices can greatly influence the timing and duration of flooding and drying cycles across remnant areas of suitable elevation and soils around Lake Okeechobee. Permanent inundation of suitable soils is detrimental to the plant. Another potential threat to this plant is the proliferation of exotic plant species around the edges of Lake Okeechobee (USFWS 1999). As a result, the Recommended Plan will increase the amount of time that lake stages are within the desired stage envelope and will benefit the gourd. Due to the changes in Lake Okeechobee stages and the increased amount of time that water levels are within the beneficial stage envelopes for the Recommended Plan, the USACE has determined that there may be slight beneficial effects to the Okeechobee gourd.

C.2.25.4.12 Gopher Tortoise

The LOWRP Recommended Plan includes a WAF that will convert uplands to wetland habitat and wetland restoration sites that will convert uplands to wetlands. For the Recommended Plan, the majority of the current land use in the WAF footprint is improved and unimproved pastures. **Table C.2-40** shows the amount of uplands and pastureland that will be converted to aboveground storage or wetlands. Gopher tortoises have a high probability of occurrence within the WAF and wetland restoration footprints and as a result of construction are likely to be displaced. Alternative 1BWR would remove approximately 14,493 acres of potential habitat. Prior to construction, gopher tortoise surveys will be conducted and any tortoises will be relocated to minimize the impact of the project. As needed, the USACE will coordinate with the FWC on appropriate gopher tortoise impact avoidance, minimization, and/or mitigation measures. The Recommended Plan may have unavoidable adverse effects.

C.2.25.4.13 Smalltooth Sawfish

The Recommended Plan has the potential to benefit the smalltooth sawfish by reducing excessive freshwater flows and improving the salinity regime throughout the Caloosahatchee estuary and provide minor beneficial effects. Discharging large volumes of freshwater from Lake Okeechobee to the Caloosahatchee River during the wet season significantly reduces salinities which has a profound adverse effect on estuarine flora and fauna. As a result, the smalltooth sawfish may benefit from the project's ability to reduce excessive freshwater flows by improving the salinity regime throughout the Caloosahatchee estuary.

C.2.25.4.14 Green Sea Turtle

Although green sea turtles are expected to be found foraging in nearshore seagrass habitats within the St. Lucie estuary, the decreased freshwater flows associated with the Recommended Plan may alter seagrass species composition but should have a negligible and less than significant effect on the overall biomass available for sea turtle feeding habits. Additionally, no green sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the USACE has determined green sea turtle may be affected, but is not likely to be adversely affected, by the Recommended Plan.

C.2.25.4.15 Leatherback Sea Turtle

Although leatherback sea turtles are expected to be found foraging in nearshore seagrass habitats within the St. Lucie estuary, the decreased freshwater flows associated with the Recommended Plan may alter seagrass species composition but should have a negligible and less than significant effect on the overall biomass available for sea turtle feeding habits. Additionally, no green sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the USACE has determined green sea turtle may be affected, but is not likely to be adversely affected, by the Recommended Plan.

C.2.25.4.16 Kemp's Ridley Sea Turtle

Although Kemp's ridley sea turtles could be found foraging in nearshore habitats within the St. Lucie and Caloosahatchee estuaries, this species is not expected to be found within the direct area of influence associated with LOWRP. Additionally, no Kemp's ridley sea turtles would attempt to utilize areas for nesting purposes since their main nesting location is on a single stretch of beach on the Gulf Coast of Mexico. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the USACE has determined Kemp's ridley sea turtle may be affected, but would not likely be adversely affected, by the Recommended Plan.

C.2.25.4.17 Loggerhead Sea Turtle

Although loggerhead sea turtles are expected to be found foraging in nearshore habitats within the St. Lucie and Caloosahatchee estuaries, the decreased freshwater flows associated with the Recommended Plan may increase nearshore salinity concentrations but should have a negligible and less than significant effect on crustaceans, mollusks, or other invertebrate food sources utilized by this species. Additionally, no loggerhead sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the USACE has determined loggerhead sea turtle may be affected, but would not likely be adversely affected, by the Recommended Plan.

C.2.25.4.18 Johnson's Seagrass

Johnson's seagrass (*Halophila johnsonii*) was listed as threatened under the Endangered Species Act (ESA) in 1998, and critical habitat was designated in 2000. The species has a very limited distribution along the east coast of Florida from central Biscayne Bay to Sebastian Inlet. The Recommended Plan has the potential to benefit Johnson's seagrass by reducing excessive freshwater flows and improving the salinity regime throughout the St. Lucie estuary and provide minor beneficial effects. Discharging large volumes of freshwater from Lake Okeechobee to the St. Lucie estuary during the wet season significantly reduces salinities which has a profound adverse effect on estuarine flora and fauna. As a result, the Johnson's seagrass may benefit from the project's ability to reduce excessive freshwater flows by improving the salinity regime throughout the St. Lucie estuary. The Recommended Plan has the potential to benefit Johnson's seagrass and its designated critical habitat in the St. Lucie inlet by reducing excessive freshwater

flows and improving the salinity regime throughout the St. Lucie Estuary Negative adverse effects to Johnson's seagrass are not anticipated with the Recommended Plan.

C.2.25.5 State-listed Species

The LOWRP project area contains habitat suitable for the presence, nesting, and/or foraging of 12 state-listed threatened species and 1 species of special concern. Threatened animal species include the American oystercatcher (*Haematopus palliatus*), black skimmer (*Rynchops niger*), least tern (*Sternula antillarum*), Florida burrowing owl (*Athene cunicularia*), Florida sandhill crane (*Grus canadensis pratensis*), little blue heron (*Egretta caerulea*), roseate spoonbill (*Platalea ajaja*), Southeastern American kestrel (*Falco sparverius paulus*), tricolored heron (*Egretta tricolor*), gopher tortoise (*Gopherus polyphemus*), Florida pine snake (*Pituophis melanoleucus mugitus*) and Big Cypress fox squirrel (*Sciurus niger avicennia*). The species of special concern is Sherman's fox squirrel (*Sciurus niger shermani*).

C.2.25.5.1 State-listed Beach-Nesting Birds (American oystercatcher, black skimmer, least tern)

The state listed beach-nesting birds include the American oystercatcher (*Haematopus palliatus*), black skimmer (*Rynchops niger*) and least tern (*Sternula antillarum*). The LOWRP Recommended Plan shows a slight performance improvement within the Northern Estuaries as indicated by fewer high volume flow months, providing a minor beneficial effect to beach-nesting birds. Reduction in high flows and accompanying flow velocities would result in reductions in salinity fluctuations, lower suspended solid loading, and decreased concentration of colored dissolved organic matter and would likely benefit the bivalves, small fish and other prey items within the estuaries.

C.2.25.5.2 Burrowing Owl

The burrowing owl occurs throughout the state although its distribution is considered spotty. The LOWRP Recommended Plan includes a WAF that may provide wetland habitat, and wetland restoration sites that will convert uplands to wetlands. For the Recommended Plan, the majority of the current land use in the WAF footprint and wetland restoration footprints are improved and unimproved pastures. **Table C.2-40** shows the amount of uplands and pastureland that will be converted to wetlands for the Recommended Plan. Florida burrowing owls have a high probability of occurrence within the WAF and wetland restoration footprints and as a result of construction are likely to be displaced. Alt 1BWR would remove approximately 14,493 acres of potential habitat. The USACE will coordinate with the FWC on mitigation measures as well as a secure a permit for relocation. Prior to construction, burrowing owl surveys will be conducted and if burrows are found will be relocated to minimize the impact of the project. The LOWRP Recommended Plan may have an unavoidable adverse effect. As needed, the USACE will coordinate with the FWC on appropriate burrowing owl impact avoidance, minimization, and/or mitigation measures.

C.2.25.5.3 Florida Sandhill Crane

Florida sandhill cranes are non-migratory and inhabit prairies, improved pastures, and freshwater marshes. They occur throughout peninsular Florida north to the Okefenokee Swamp in southern Georgia. Degradation or direct loss of habitat due to wetland drainage or conversion of prairie for development or agricultural use is the primary threat that they face. The LOWRP Recommended Plan includes storage features that may provide wetland habitat, and wetland restoration sites that will convert uplands to wetlands. For the Recommended Plan, the majority of the current land use in the WAF and wetland restoration footprints are improved and unimproved pastures. **Table C.2-40** shows the amount of uplands

and pastureland that will be converted to deep-water habitat or wetlands for the Recommended Plan. Florida sandhill cranes may occur within the WAF and wetland restoration footprints and as a result of construction may be displaced from the WAF and to a lesser extent from wetlands. Alt 1BWR would remove approximately 14,493 acres of potential habitat. The Recommended Plan also restores 4,779 acres of wetlands along the Kissimmee River floodplain (**Table C.2-32**). The Recommended Plan provides a benefit to the Florida sandhill crane. Prior to construction, Florida sandhill crane surveys will be conducted. As needed, the USACE will coordinate with the FWC on appropriate Florida sandhill crane impact avoidance, minimization, and/or mitigation measures.

C.2.25.5.4 State-listed Wading Birds (little blue heron, roseate spoonbill, tricolored heron)

The state-listed wading bird species in the project area include the little blue heron (*Egretta caerulea*), roseate spoonbill (*Platalea ajaja*), and tricolored heron (*Egretta tricolor*). Implementation of the Recommended Plan would be expected to significantly improve conditions for wading birds throughout much of the project area. Rehydration and vegetation shifts within the Lake Okeechobee Watershed and lake levels are likely to increase the spatial extent of suitable foraging opportunities and nesting habitat for wading birds provides a moderate beneficial effect. Minor beneficial effects to vegetation within Lake Okeechobee's extensive littoral zone are anticipated as a result of the Recommended Plan. These ecological benefits are a result of the small increase in amount of time within the beneficial stage envelope and less time in the extremely low stages (<10 ft, NGVD) and above the stage envelope for any of the alternatives compared to the FWO (**Figure C.2-50** to **Figure C.2-52**). This increase in time in the beneficial stage envelope improves the foraging habitat in Lake Okeechobee for wading birds. Conversely, also as compared with FWO, the Recommended Plan reveals the potential for short-term minor adverse effects to the ecological indicators and littoral and nearshore aquatic vegetation due to a slight increase in the amount of time that lake stages in the extremely high stages (>17 ft, NGVD) might occur (**Figure C.2-53**).

The Recommended Plan restores 4,779 acres of wetlands along the Kissimmee River floodplain. The Recommended Plan significantly increases the spatial extent of suitable foraging opportunities and nesting habitat for wading birds (**Table C.2-32**).

C.2.25.5.5 Southeastern American Kestrel

The southeastern American kestrel (*Falco sparverius paulus*) is a non-migratory subspecies of the American kestrel closely tied to sandhills in the southeastern U.S with preferred habitat consisting of open fields, grasslands, savannahs, or other habitats that contain widely scattered trees or similar perches. The LOWRP Recommended Plan includes a WAF that will convert uplands wetland habitat and wetland restoration sites that will convert uplands to wetlands. For the Recommended Plan, the majority of the current land uses in the storage feature footprints are improved and unimproved pastures. **Table C.2-40** shows the amount of uplands and pastureland that will be converted wetlands for the Recommended Plan. Southeastern American kestrels have a high probability of occurrence within all the WAF and wetland restoration footprints and as a result of construction are likely to be displaced and nesting sites lost. Alternative 1BWR would remove approximately 14,493 acres of potential habitat. The Recommended Plan may have an unavoidable adverse effect. Prior to construction, southeastern American kestrel surveys will be conducted. As needed, the USACE will coordinate with the FWC on appropriate southeastern American kestrel impact avoidance, minimization, and/or mitigation measures.

C.2.25.5.6 Florida Pine Snake

The Florida pine snake (*Pituophis melanoleucus mugitus*) is found in the project area. The LOWRP Recommended Plan includes a WAF that will convert uplands to wetland habitat and wetland restoration sites that will convert uplands to wetlands. For the Recommended Plan the majority of the current land use in the WAF footprint is improved and unimproved pastures. **Table C.2-40** shows the amount of uplands and pastureland that will be converted to wetlands for the Recommended Plan. Florida pine snakes have a high probability of occurrence within the WAF and wetland restoration footprints and as a result of construction are likely to be displaced. Alternative 1BWR would remove approximately 14,493 acres of potential habitat. Prior to construction, Florida pine snake surveys will be conducted. As needed, the USACE will coordinate with the FWC on appropriate Florida pine snake impact avoidance, minimization, and/or mitigation measures.

C.2.25.5.7 Big Cypress Fox Squirrel

Big Cypress fox squirrels (*Sciurus niger avicennia*) are large tree squirrels and are a primarily ground-dwelling species that inhabits stands of cypress, slash pine savanna, mangrove swamps, tropical hardwood forests, live oak woods, coastal broadleaf evergreen hammocks, and suburban habitats including golf courses, city parks, and residential areas (Hafner et al. 1998; Humphrey and Jodice 1992; Jansen 2008; Munim et al. 2007; Williams and Humprey 1979). The LOWRP Recommended Plan includes a WAF that will convert uplands to wetland habitat and wetland restoration sites that will convert uplands to wetlands. For the Recommended Plan the majority of the current land use in the WAF and wetland restoration footprints are improved and unimproved pastures. **Table C.2-40** shows the amount of uplands and pastureland that will be converted to wetlands for the Recommended Plan. The Big Cypress fox squirrel may occur within the WAF and wetland restoration footprints and as a result of construction are likely to be displaced. Alternative 1BWR would remove approximately 14,493 acres of potential habitat. Prior to construction, Big Cypress fox squirrel surveys will be conducted. As needed, the USACE will coordinate with the FWC on appropriate Big Cypress fox squirrel impact avoidance, minimization, and/or mitigation measures.

C.2.25.5.8 Sherman's Fox Squirrel

Sherman's fox squirrel is a species of special concern and are large tree squirrels that inhabit mature, open, fire-maintained longleaf pine (*Pinus palustrus*) - turkey oak (*Quercus laevis*) sandhills and flatwooods. The LOWRP Recommended Plan includes a WAF that will convert uplands to wetlands and wetland restoration sites that will convert uplands to wetlands. For the Recommended Plan the majority of the current land use in the storage feature and wetland restoration footprints are improved and unimproved pastures. **Table C.2-40** shows the amount of uplands and pastureland that will be converted to wetlands for each the Recommended Plan. Sherman's fox squirrel may occur within the WAF and wetland restoration footprints and as a result of construction are likely to be displaced. Alternative 1BWR would remove approximately 14,493 acres of potential. Prior to construction, Sherman's fox squirrel surveys will be conducted. As needed, the USACE will coordinate with the FWC on appropriate Sherman's fox squirrel impact avoidance, minimization, and/or mitigation measures.

C.2.25.6 Fish and Wildlife

A comparison of FWO and the LOWRP Recommended Plan and their potential effects on fish and wildlife within the LOWRP action area are summarized below. Effects to state and federally listed species are

described in further detail in **Section C.2.25.4** and in Annex A. Implementation of LOWRP Recommended Plan would benefit most fish and wildlife resources within the LOWRP project area. These benefits are described in greater detail in the sections below.

C.2.25.6.1 Invertebrates

Within the Lake Okeechobee Watershed and restored wetlands, invertebrates would rapidly colonize newly created and restored aquatic habitat with implementation of the LOWRP Recommended Plan providing a moderate beneficial effect, directly benefitting invertebrates within the action area. Increases in stages and hydroperiods within the restored wetlands would promote wetland vegetation transition through contraction of marshes and expansion of wet prairies, and in deeper regions, sloughs. In Alt 1BWR, approximately 13,600 acres of a WAF may provide emergent vegetation that will provide habitat for a diverse population of invertebrates and provide major beneficial effects to the aquatic community on the watershed.

The intakes for the WAF as well as the ASR wells may cause the entrainment and impingement of aquatic invertebrates during operation. See **Section C.2.25.6.2** for the analysis of "with-project" effects on aquatic invertebrates and fish.

Minor beneficial effects to the aquatic invertebrate community within Lake Okeechobee are anticipated under the LOWRP Recommended Plan. The Recommended Plan increases emergent and submerged aquatic vegetation which provides a beneficial effect to invertebrate habitat. Due to the increased potential habitat, the invertebrate diversity and abundance is expected to increase in the pelagic, nearshore and littoral zones.

As compared with FWO, the LOWRP Recommended Plan shows a minor beneficial effect with performance improvement within the Northern Estuaries as indicated by fewer high volume flow months. Reductions in high volume flows and salinity fluctuations would likely benefit oysters and other associated invertebrates (e.g., crabs, shrimp, snails, sea stars) within the Northern Estuaries. Reduction in high flows and accompanying flow velocities would help lessen the current problem of flushing of oyster spat into outer areas of the Northern Estuaries that experience high salinities levels during the dry season resulting in increased predation and disease in the oyster population.

C.2.25.6.2 Fish

C.2.25.6.2.1 Lake Okeechobee Watershed

The construction of a WAF, seepage canals, and perimeter canals may provide some deepwater refugia and/or littoral habitat for use by fish and amphibian species when the WAF is drawn down. The Recommended Plan contains a WAF that will be operated for storage and may provide wetland habitat, therefore, the deeper natural sloughs in the footprint will remain hydrated creating a refugia for fish during drier times providing a major beneficial effect in the watershed.

WAF-assisted ASR wells will recharge from, and recover into, the WAF of Alternative 1BWR. Watershed ASR systems will have site-specific intake and outflow structures. Because watershed ASR systems are associated with canals, it is likely that the ecological impacts from recharge and recovery will not be significant. Pump stations located on or near the Kissimmee River have the potential to impact fish and aquatic invertebrates through entrainment and impingement. The larval and post-larval stages of black crappie (*Pomoxis nigromaculatus*) are especially at risk because after the channelization of the Kissimmee

River, C-38 South of S-65E became a favorite spawning location for this species. The typical spawning period for black crappie at this location occurs from January through May. Adults prefer to nest in colonies in shallow water near aquatic vegetation. A few days after hatching, post-larvae disperse from the nest area and eventually move to deeper water near the middle of the channel. Fry move vertically throughout the water column primarily to forage on other planktonic species and secondarily to avoid predation. They follow the currents downstream into Lake Okeechobee. The black crappie spawning requirements increase the likelihood that in the lower Kissimmee River, which is contiguous with Lake Okeechobee, nest sites will be near intakes (assuming that these structures will also be near or on the stream bank). The larval and post-larval stages are poor swimmers and would be unable to escape intake velocities (0.25 ft./sec) once drawn into the water intake flow-field. This is important to note not only for those fish hatching near the shoreline, but also for those that may be drifting down from upstream spawning locations (including open-water spawners like threadfin or gizzard shad). Shad entrainment and impingement has been a major concern with many water withdrawal systems because shad are the primary forage food for many predators, and locally are nearly the sole food source of adult black crappie (FWC 2017). Many other species of fish spawn during the same period as black crappie (**Table C.2-41**) and they could experience similar effects and have similar risks. For those species that spawn in the summer (shiners) or fall (some sunfishes, *Lepomis* species) the predicted effect may be similar to speckled perch.

Table C.2-41. Spawning months for critical species in the lower Kissimmee River (FWC 2017).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Black crappie	X	X	X	X	X	-	-	-	-	-	-	-
Sunfish species	-		X	X	X	X	X	X	X	-	-	-
Threadfin and Gizzard Shad	X	X	X	X	X	X	X	X	X	-	-	-
Shiners	-	-	X	X	X	X	X	X	-	-	-	-

Figure C.2-74 shows the potential risks to fisheries in the Lake Okeechobee watershed, with the highest risk areas (red) in the lower Kissimmee River, south of S-65E, contiguous with Lake Okeechobee and is a critical spawning area for black crappie and several sunfishes; moderate risk areas (yellow) are further from the critical fish spawning areas and are located along the rim canal and the lowest risk areas (green) are furthest from the critical fish spawning areas and do not have a direct connection to Lake Okeechobee and are located above S-65E.

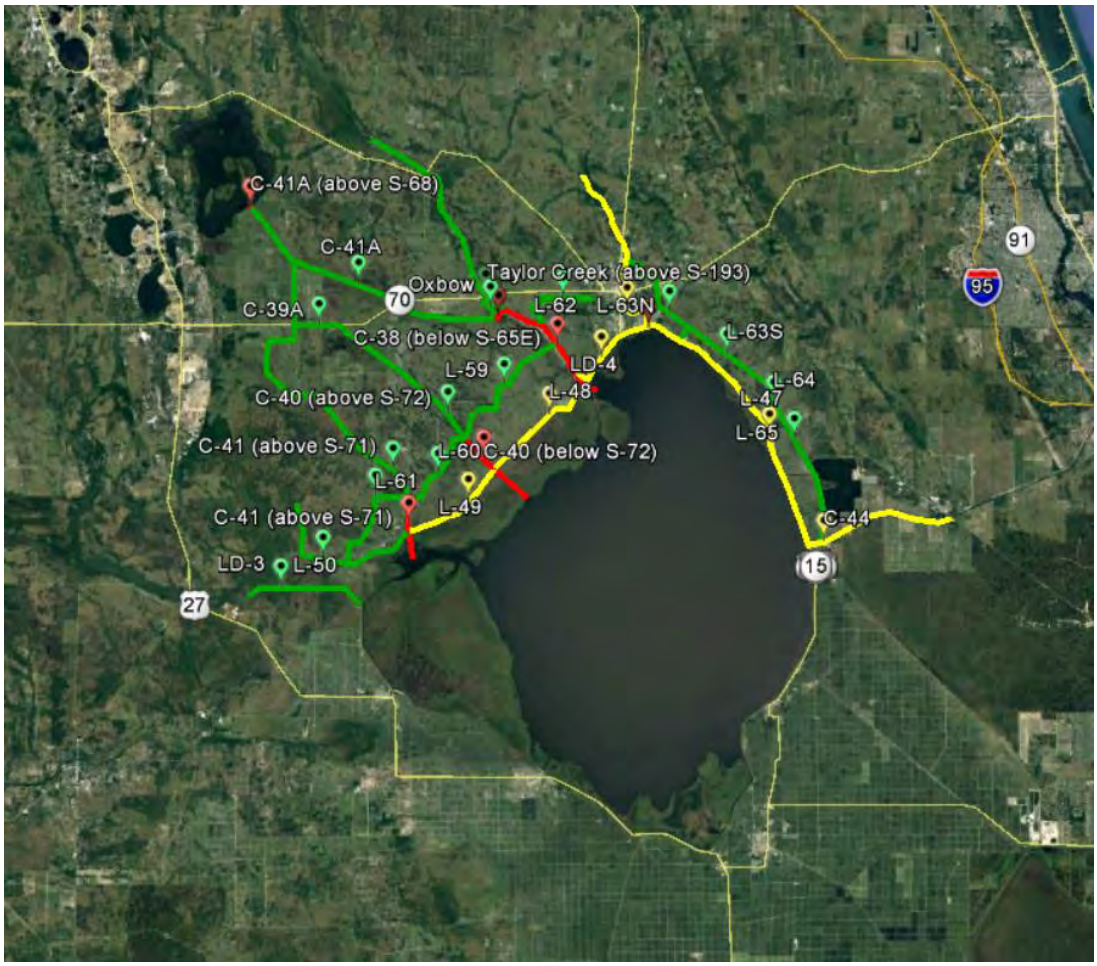

Figure C.2-74. Risk level associated with entrainment and entrapment for different canal segments in the Lake Okeechobee watershed. Red canal segments are the highest risk category, yellow moderate, and green have the lowest risk (FWC 2017).

C.2.25.6.2.1.1 ASR Wells

There are eight tentative locations for ASR fields (**Figure C.2-75**). The number of ASR wells in each location has not been determined. The following is numbered from west to east. (Lake O) indicates a connection in a canal downstream of any structures, which effectively draws water from Lake Okeechobee.

9. ASRs C-41: Intakes on the C-41 canal downstream of S-71 (Lake O), FWC High Risk.
10. ASRs C-40: Intakes on the C-40 canal downstream of S-72 (Lake O), FWC High Risk.
11. ASRs C-38 North Field: Intakes on the C-38 canal downstream of S-65E (Lake O), FWC High Risk-recharge and rec over into/from the WAF – reduces risk to fishery
12. ASRs C-38 South Field: Intakes on the C-38 canal downstream of S-65E (Lake O), FWC High Risk - recharge and rec over into/from the WAF – reduces risk to fishery
13. ASRs L-63N: Intakes on the L-63N canal. There are no structures in L-63N. It connects downstream with C-59. S-191 is on C-59 upstream of Lake O, FWC Low Risk.

14. ASRs Taylor Creek: Intakes on Taylor Creek downstream of S-192 and upstream of S-193, which connects to Lake O, FWC Moderate Risk.
15. ASRs Nubbin Slough: Intakes on Nubbin Slough upstream of the L-63N/L-63S/C-59 confluence. There are no structures in Nubbin Slough, FWC Low Risk.
16. ASRs L-64: Intakes on the L-64 canal. There are no structures in L-64. It connects with L-63S to the north and L-65 to the south. S-153 is on L-65 south of L-64 and connects L-65 with C-44, FWC Low Risk.

Figure C.2-75. Location of tentative ASR fields.

Table C.2-42 shows the risk for the WAF and ASR wells for the LOWRP Recommended Plan. After consultation with FWC on a site visit, it was determined that within the stretch between S-84 and S-65E is a lesser "high risk" of all because the two drops produce turbulence that fish do not like.

Table C.2-42. FWC fisheries risk for the WAF and the eight tentative ASR fields for the LOWRP Recommended Plan (red = highest risk category, yellow = moderate risk, and green= lowest risk).

Alternative	WAF	ASRs C-41	ASRs C-40	ASRs C-38 North Field	ASRs C-38 South Field	ASRs L-63N	ASRs Taylor Creek	ASRs Nubbin Slough	ASRs L-64
1BWR (80 ASRs)	X (red)	X (red)	X (red)	X (red)	X (red)	X (green)	X (yellow)	X (green)	X (green)

The Recommended Plan contains the WAF that has an intake on the C-41A canal downstream of S-84 with uncontrolled access to the C-38 canal downstream of S-65E which is considered by FWC to be high risk for

fisheries (**Figure C.2-76** and **Table C.2-42**) and has 80 ASR wells with intakes listed in **Table C.2-18** in the high-, moderate-, and low-risk areas.

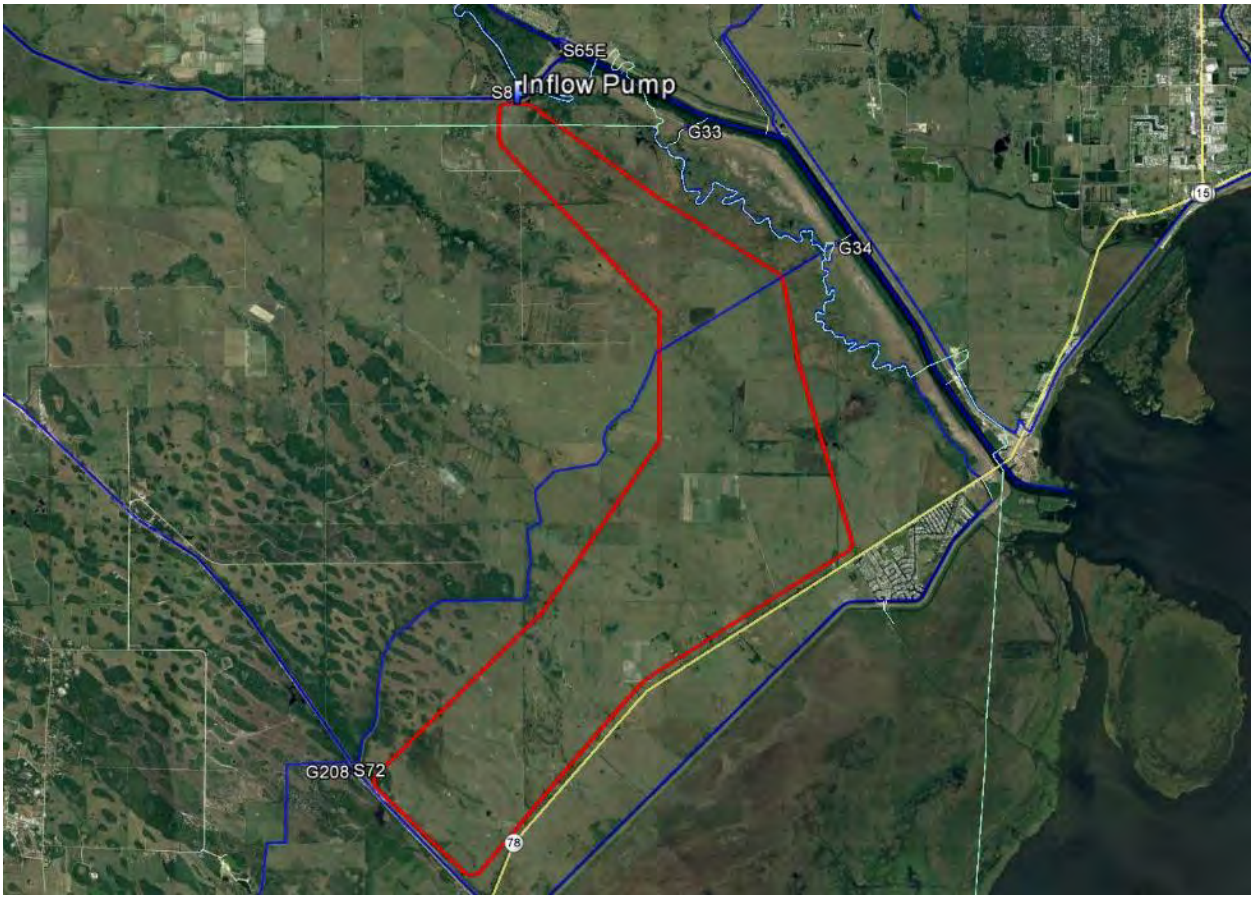

Figure C.2-76. Intake on the storage feature in the Recommended Plan.

The Recommended Plan may have a significant impact on the entrainment and impingement of fish and aquatic invertebrates if they operate at times of the year when these organisms are present in the surface water. The Recommended Plan also has ASR wells that are in areas that have been identified by FWC as high risk for larval fish entrainment and impingement. To minimize the impact, where ASR wells will be co-located with the WAF, the ASR pumps pull water from the storage features and not the canals to minimize the entrainment and impingement of fish and invertebrates. In locations where the ASR wells will pull directly from canals the intake will be designed to limit impingement and entrainment by installing screens with a pore size of 1 mm and an anticipated intake velocity at the screen face of 0.25 ft/sec with underwater setting depth below the zone that fish larvae inhabit and/or installing a wildlife exclusion barrier curtain. The Recommended Plan has the potential to significantly impact the fisheries due to high-risk location of the intake pump for the WAF. As with the ASR locations, the intake pumps will be designed to limit impingement and entrainment by installing screens with a pore size of 1mm and an anticipated intake velocity at the screen face of 0.25 ft/sec with underwater setting depth below the zone that fish larvae inhabit and/or installing a wildlife exclusion barrier curtain. Also, the impact may be limited due to the fact that the stretch between S-84 and S-65E is a lesser "high risk" because the two drops produce

turbulence that fish do not like. The USACE will continue to coordinate with FWC to minimize risks. During PED, the USACE will look to minimize risks by considering installing gravity flow intake systems at C-41A and upstream of S-65E to feed into the northern boundary of the WAF; determine WAF and well intake operations based on results from the potential risk assessment and population studies; consider installing in-bank filtration system adjacent to the Kissimmee River to minimize the risk to fisheries and recreation; consider installing more than one intake system for each storage feature or well to reduce intake velocities and the size of the intake cone; and consider using storage feature water and collocating with facilities with planned storage features.

C.2.25.6.2.2 Lake Okeechobee

The Recommended Plan will help improve conditions for fish in Lake Okeechobee by increasing the amount of time water levels are in the beneficial stage envelope (**Figure C.2-50** and **Figure C.2-51**). The same performance of the Recommended Plan occurs for the extreme low lake stage (**Figure C.2-52**). The increase in time in the beneficial stage envelope will help to increase the emergent and submerged aquatic vegetation habitat that the fish use in the nearshore and littoral zones. An increase in invertebrate and plankton populations and diversity will also benefit fish in the lake as an increased food source. The ecological indicator performance measure combined scores indicate that some ecological benefits are anticipated to occur under the Recommended Plan (**Figure C.2-54**).

C.2.25.6.2.3 Northern Estuaries

The Recommended Plan improves conditions for estuarine and marine resources throughout the Northern Estuaries by restoring more natural timing, volume, and duration of freshwater flows to the Caloosahatchee and St. Lucie estuaries, providing minor beneficial effects for the fish. In the Caloosahatchee Estuary, for high flow events, the LOWRP Recommended Plan performed better than the FWO having 10 fewer months where flows were greater than 2800 cfs. The model output shows that of the number of months flow > 2800 cfs from the C-43 Basin and Lake Okeechobee regulatory flows, 47 of those months are a results of basin runoff. Therefore, flows greater than 2800 cfs from direct Lake Okeechobee flows go from 23 in the FWO to 13 in the Recommended Plan (**Table C.2-35**). For extreme high-flow events (mean monthly flow > 4500 cfs), the Recommended Plan performed better than the FWO with 5 fewer months where the mean monthly flow was greater than 4500 cfs (**Figure C.2-57**). The Recommended Plan provides minor beneficial effects in the reduction of high flows and the duration of high flow events into the Caloosahatchee Estuary which are beneficial to the fish in the estuaries. In the St. Lucie Estuary, the Recommended Plan performed better than the FWO having 9 fewer high flow events where the flow is greater than 2000 cfs from Lake Okeechobee flows (**Figure C.2-58**). The Recommended Plan provides significant beneficial effects for the reduction of high flow events and the duration of the high flow events which are beneficial for the fisheries in the estuaries.

C.2.25.6.3 Amphibians and Reptiles

Amphibians and aquatic reptiles including frogs, turtles, snakes, and alligators will likely inhabit the WAF, providing additional wetland habitat for amphibians and reptiles and provide major beneficial effects. Rehydration within previously dry areas within the watershed would increase spatial extent of suitable habitat for aquatic amphibian species in this area. Increase in forage prey availability (e.g., crayfish and other invertebrates, fish) in areas rehydrated by the LOWRP Recommended Plan will also directly benefit amphibian and reptiles species. There would also be a loss of habitat within the WAF footprint for upland herps (e.g., toads, certain snakes, and box turtle), and through wetland conversion (i.e., for tree frogs or

other aquatic/semi-aquatic herps) with the Recommended Plan removing approximately 14,493 acres of potential habitat.

Submerged aquatic vegetation and algal communities are also common foraging areas for the green sea turtle. Reductions in high flow events within the Northern Estuaries reduce stress on SAV and promote increases in seagrass shoots that have the potential to increase foraging opportunities for green sea turtles in this region.

C.2.25.6.4 Birds

The freshwater wetlands of the Everglades are noted for their abundance and diversity of colonial wading birds. Implementation of the Recommended Plan is anticipated to show a major beneficial effect on nesting and foraging activities of resident bird species. The Recommended Plan will benefit wading birds by increasing foraging and nesting habitat in the wetland sites. Impacts to the grasshopper sparrow, snail kite, and wood stork are further discussed in **subsection C.2.4** and in **Annex A**. Ducks may use the emergent vegetation associated with the WAF. The WAF may create significant foraging habitat for osprey, bald eagle, terns, cormorant, and other aquatic birds that feed on fish. Forested or upland bird species (turkey, bobwhite quail, and songbirds) may lose habitat within the WAF footprint.

As predicted by the Trophic Hypothesis (RECOVER 2004) an increase in density of small fishes would directly benefit higher trophic level predators such as wading birds. Therefore, it is predicted that the Recommended Plan will provide the greatest benefit to small fishes as described in **subsection C.2.25.6.2**, and also perform best overall for wading birds. The Recommended Plan has to potential to have an adverse impact on overwintering, nesting, or foraging songbirds that utilize the uplands in the WAF and wetland restoration site footprints.

C.2.25.6.5 Mammals

As compared with FWO, potential minor beneficial effects to mammals within the LOWRP action area are anticipated with implementation of the LOWRP Recommended Plan. Small mammals including raccoons and river otters would benefit from increased small prey fish biomass in rehydrated areas within the watershed along the Kissimmee River. Effects to state and federally listed species are described in further detail in **subsection C.2.25.4** and in **Annex A**. Mammals in the WAF will likely be limited to river otter.

The LOWRP Recommended Plan, however, could have a significant and adverse effect on mammals dependent upon upland habitat (e.g., deer, armadillos, opossum, skunks, woodrats, and raccoons). Due to the WAF footprint and wetlands being restored, triggering a vegetation transition from upland to wetland habitat. Although, mammals occurring within the action area are adapted to the naturally fluctuating water levels in the Everglades; there is an increased potential for this vegetation transition to negatively affect mammals utilizing upland habitat.

C.2.25.6.6 Airport Wildlife Strike Hazard Assessment

There are three airports within the LOWRP project area (**Figure C.2-77**). Of these, the Okeechobee County Airport (Okeechobee Jet Center; KOBE) is a National Plan of Integrated Airport Systems (NPIAS) airport. The other two airports, River Acres Airport (FAA ID FD70) and River Oak Airport (FAA ID OOFL) are not in the NPIAS system and, therefore, do not require analysis pursuant to the MOA.

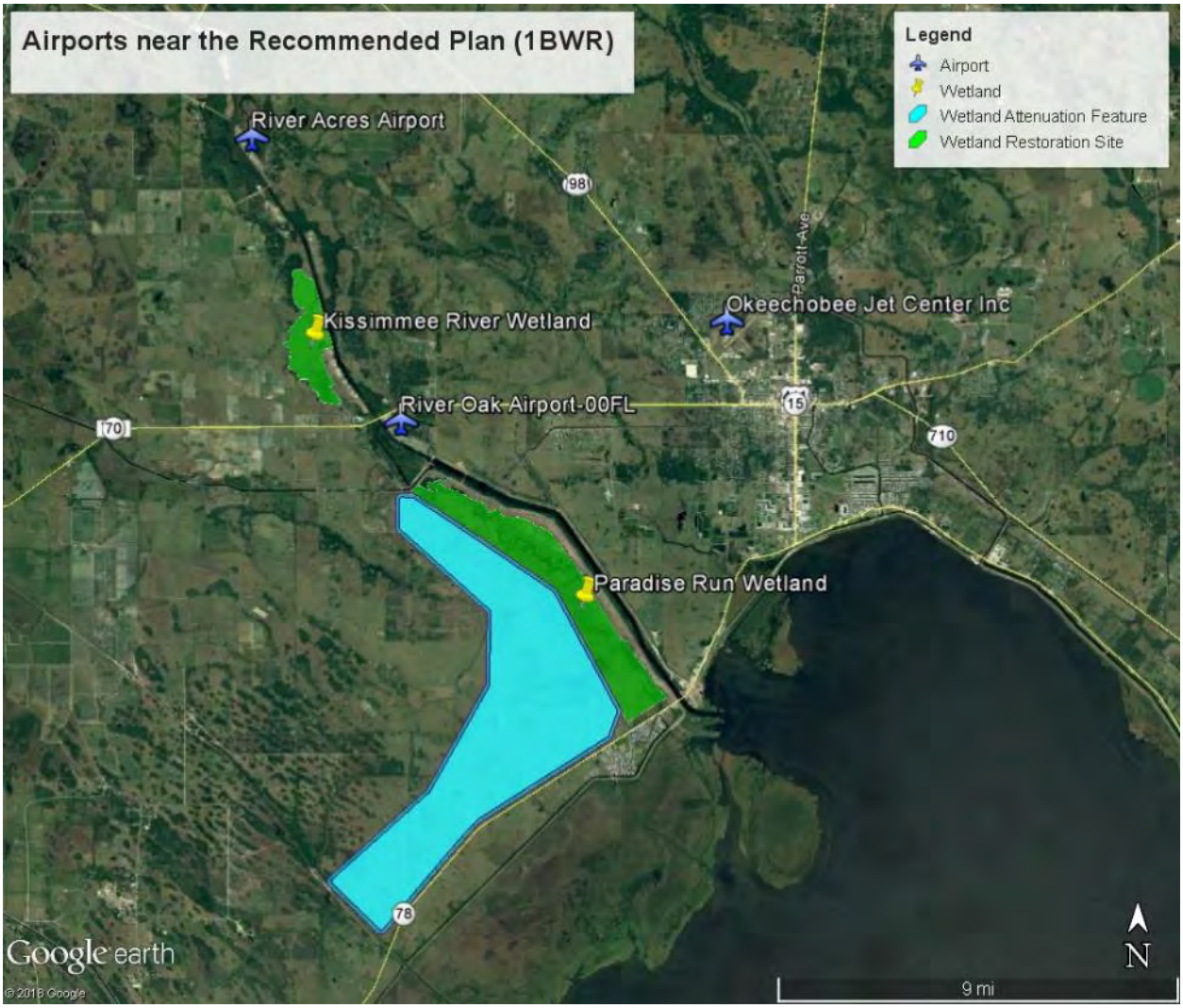

Figure C.2-77. Airport locations within the LOWRP project area.

River Acres Airport and River Oak Airport are both private short grass landing strips within airpark neighborhoods; both are general aviation airports or civilian airports that do not serve scheduled passenger service and usually serve private aircraft and small aircraft charter operations.

The Okeechobee Jet Center is 5.4 miles from the Paradise Run Wetland site, 6.2 miles from the WAF, and 8.1 miles from the Kissimmee River Center Wetland site in the Recommended Plan. ASR well clusters will negligibly change the existing ruderal herbaceous habitat conditions and, therefore, will not increase the risk of strike hazards. In the Recommended Plan, the wetland sites and the WAF are located greater than the 5-mile separation distance from the Okeechobee Jet Center and, thus, no discussion of mitigation recommendations is required. Although analysis of the two non-NPIAS airports is not required per the MOA, the 5,000 ft. separation distance from the Recommended Plan features was evaluated for both. River Acres Airport is 2.6 miles from the Kissimmee River Center wetland, 8.2 miles from the WAF, and 8.1 miles from the Paradise Run Wetland site in the Recommended Plan. River Oak Airport is 1.0 miles from the WAF and the Paradise Run Wetland site, 1.3 miles from the Kissimmee River Center Wetland site in the Recommended Plan.

C.2.25.7 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. § 1801 et seq. Public Law 104-208 reflects the Secretary of Commerce and Fishery Management Council authority and responsibilities for the protection of EFH. Federal agencies that fund, permit, or carry out activities that may adversely impact EFH are required to consult with the NMFS regarding the potential effects of their actions on EFH. In conformance with the 1996 amendment to the Act, the information provided in this Integrated EIS will comprise the required EFH assessment and has been coordinated with NMFS.

Consultation for the LOWRP was initiated on June 28, 2016 through a NEPA scoping letter. The NMFS has indicated that beneficial effects to fish resources and EFH may occur as a result of this project. The NMFS requested an evaluation of potential impacts to living marine resources, including mangroves, seagrasses, live bottom communities, and the marine/estuarine water column that may be impacted by activities or operations of the project action alternatives. The preparation of an EFH assessment will be contained within the project PIR/EIS, and submitted to the NMFS for coordination.

C.2.25.7.1 Essential Fish Habitat in the Project Area

The project area includes two distinct regional estuarine and nearshore coastal systems: the Northern Estuaries including the Caloosahatchee River and the St. Lucie Estuary. Lake Okeechobee flows into the two Northern Estuaries. The St. Lucie Canal feeds into the St. Lucie Estuary, and the Caloosahatchee Canal/River feeds into the Caloosahatchee Estuary to the west.

C.2.25.7.1.1 Caloosahatchee River

The Caloosahatchee River estuary contains EFH for juvenile brown shrimp (*Penaeus aztecus*), juvenile gray snapper (*Lutjanus griseus*), juvenile pink shrimp (*Penaeus duorarum*), adult and juvenile red drum, (*Sciaenops ocellatus*), adult and juvenile Spanish mackerel (*Scomberomorus maculatus*), and juvenile stone crab (*Menippe mercenaria*). Downstream habitats include oyster reefs and seagrass beds (submerged aquatic vegetation).

C.2.25.7.1.2 St. Lucie Estuary

The proposed project is within the jurisdiction of the SAFMC and is located in areas designated as EFH for wormrock, live bottom habitat, for the American oyster (*Crassostrea virginica*); pink shrimp (*Penaeus duorarum*); white shrimp (*Penaeus* sp.) and brown shrimp (*Penaeus aztecus*); Florida red drum (*Sciaenops ocellatus*); grouper (*Epinephelus* spp.); gray snapper (*Lutjanus griseus*); white grunt (*Haemulon plumieri*); red porgy (*Pagrus pagrus*); spiny lobster (*Panulirus argus*); and the snapper-grouper complex. In addition, the nearshore hardbottom habitat outside of the St. Lucie Estuary is designated as EFH-HAPC for the snapper-grouper complex.

C.2.25.7.2 Assessments of Effects on Essential Fish Habitat

Aquatic habitats within the Caloosahatchee Basin have been altered through the channelization of the river. Nevertheless, the basin continues to support fishery resources of some recreational and commercial importance. Seagrass communities within the Caloosahatchee Estuary provide critical refugia for juvenile fishes such as redfish, grouper, snook, and spotted seatrout. The decline in juvenile abundance and distribution of these and other species, along with an overall decrease in species richness may be related to the loss of seagrass habitat and/or a result of alterations in the salinity regime and the timing of the

freshwater flows from the S-79 structure. The model output shows that of the number of months flow > 2800 cfs from the C-43 Basin and Lake Okeechobee regulatory flows, 47 of those months are a results of basin runoff. Therefore, flows greater than 2800 cfs direct from Lake Okeechobee flows go from 23 in the FWO to 13 in in the Recommended Plan (**Table C.2-35**). For extreme high-flow events (mean monthly flow > 4500 cfs), the Recommended Plan perform better than the FWO with 5 fewer months where the mean monthly flow was greater than 4500 cfs (**Figure C.2-57**). Implementation of the LOWRP Recommended Plan would reduce the frequency of high volume freshwater flows during the wet season, ultimately resulting in minor beneficial effects to EFH within the Caloosahatchee Estuary.

Another primary goal of this project is to reduce high freshwater flows to the St. Lucie estuary. Implementation of the project would reduce the frequency of high volume freshwater flows during the wet season, ultimately resulting in minor beneficial effects to EFH within the St. Lucie estuary. For high flow events, the Recommended Plan performed better than the FWO having 9 fewer times where the 14-day moving average flow was greater than 2000 cfs from Lake Okeechobee regulatory flows. For extreme high flow events (mean monthly flow > 3000 cfs), the Recommended Plan performed better than the FWO with 3 fewer times when the mean monthly flow was greater than 3000 cfs (**Figure C.2-59**). Increases in seagrass and oyster reef would provide a large number of benefits to the EFH species. The LOWRP Recommended Plan may increase the acres of SAV, oyster, and healthy benthic habitat.

C.2.25.7.3 Conclusion

The Caloosahatchee and St. Lucie estuaries both receive excessive flows from Lake Okeechobee as well as their local basins during wet years, and suffer from too little flow on excessively dry years. Restoration goals in the Caloosahatchee estuary include; re-establishment of a salinity range favorable to juvenile marine fish, shellfish, oysters and submerged aquatic vegetation (SAV), re-establishment of seasonally appropriate freshwater flows of favorable quality that maintain low salinities in the upper estuary and re-establishment of more stable salinities and ranges in the lower estuary. Restoration goals for the St. Lucie estuary include maintaining a salinity range favorable to fish, benthic invertebrates, oysters, and SAV. This requires a reduction of high volume, long duration flow events from Lake Okeechobee, the C-44, C-23 and C-24 watersheds.

In summary, the LOWRP Recommended Plan may improve conditions for estuarine and marine resources throughout the Northern Estuaries by restoring more natural timing, volume, and duration of freshwater flows to the Caloosahatchee and St. Lucie estuaries and provide minor beneficial effects. It has the potential to provide a more appropriate range of salinity conditions by reducing extreme salinity fluctuations and durations. The improvement of estuarine conditions will ultimately have a significant beneficial effect to EFH resources.

C.2.25.8 Hydrology

Hydrologic modeling simulations of the existing condition baseline (ECB) and the LOWRP future without project condition (FWO) were developed with the RSM-BN sub-regional modeling tool, to provide baseline conditions for plan formulation, the assessment of LOWRP project benefits (comparisons against FWO), and the assessment of LOWRP Recommended Plan performance for the level-of-service for flood protection and water supply (comparisons against ECB). The ECB was developed to represent the system-wide infrastructure and operations that were in place at the time LOWRP plan formulation was initiated, approximately June 2016. The FWO for LOWRP assumes the construction and implementation of currently authorized CERP and non-CERP projects, and other Federal, state or local projects constructed or

approved under existing governmental authorities that occur in the LOWRP study area. Selection of the Recommended Plan is conducted based on comparisons between the LOWRP Recommended Plan and the LOWRP FWO. The reader should refer to **Section 2** of the LOWRP PIR main report and **Appendix C** for additional documentation of the ECB and FWO conditions.

C.2.25.8.1 Lake Okeechobee Watershed

The management measures proposed in LOWRP will improve the system performance, primarily measured in the Lake Okeechobee and Northern Estuaries. **Section 4** covers the modeling results of the Lake Okeechobee and Northern Estuaries compared to the FWO condition. At regional level, the system will experience a moderate improvement to hydrology: 1) wetlands tend to decrease local temperature, atmospheric circulation, duration, and seasonality of flooding; 2) reservoirs will capture high peak flows adding more flexibility into the system and 3) ASR wells will provide additional long-term storage to replenish the system as needed.

C.2.25.8.2 Lake Okeechobee and the Northern Estuaries

For the modeling of the Recommended Plan, operational changes to Lake Okeechobee were limited to changes within the flexibility of the 2008 LORS, with no adjustments to the defined LORS zones. Lake Okeechobee operational assumptions were adjusted for the Recommended Plan modeling. These adjustments included changes to the decision tree outcome maximum allowable flows dependent on Lake Okeechobee inflow forecasts, time of year (wet season or dry season), stage level (regulation zone), and/or stage trends (receding or ascending). The changes are all assumed to occur within the flexibility of LORS 2008 (Regulation Schedule zones unchanged), for the purpose of increasing LOWRP potential benefits. Details pertaining to the proposed LOWRP operations for Lake Okeechobee are separately addressed in the draft Project Operating Manual (refer to **Annex C**).

Compared to the FWO, Lake Okeechobee stages are increased by 0.2-0.6 feet for the upper 50% of the% time exceeded of the stage duration curve, excluding extreme wet hydrologic conditions (**Figure C.2-78**). Peak lake stage is 17.65 ft. in the FWO, and ranges 17.57–18.25 ft. NGVD29 in the alternatives (**Table C.2-43**).

For the Lake Okeechobee mean daily stages greater than 16 ft. NGVD29 (**Figure C.2-79**) and (**Table C.2-44**) are changed compared to the FWO as follows:

- ALTBWR, days in the POR with:
    - LO mean daily stage > 17.25 = 42; increase by <1% from FWO
    - LO mean daily stage > Zone A = 60; increase by <1% from FWO
    - LO mean daily stage > 16 = 1,185; increase by <1% from FWO

For the Caloosahatchee Estuary, compared to the FWO, mean monthly flows above 2800 cfs and 4500 cfs (**Figure C.2-80**) are reduced per alternative by:

- Alt 1BWR – 10 and 5 events (14% and 17%) respectively

Mean monthly flows less than 450 cfs (**Figure C.2-81**) were increased by:

- Alt 1BWR – 1 event (4%)

For the St. Lucie Estuary, compared to the FWO, mean monthly flows between 2000/3000 cfs and mean monthly flows above 3000 cfs (**Figure C.2-82**) are reduced per alternative by:

- Alt 1BWR – 6 and 3 months (19% and 12%) respectively

Mean monthly flows less than 350 cfs (**Figure C.2-83**) did not changed for all with project alternatives.

The hydrologic effects to Lake Okeechobee and Northern Estuaries would be roughly the same for all the future with project alternatives. A summary can be found in **Table C.2-45**.

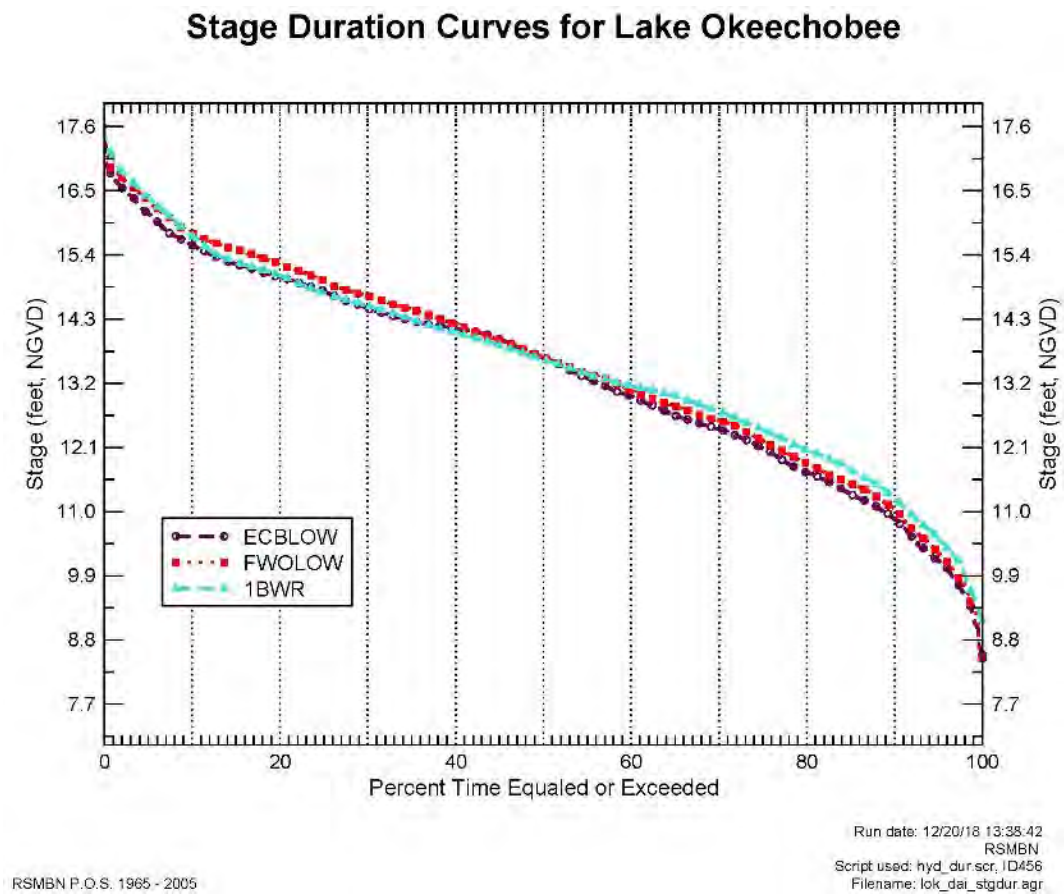

Figure C.2-78. Lake Okeechobee ECB and FWO Stage Duration Curves.

Table C.2-43. Peak Stage in Lake Okeechobee comparisons between the Recommended Plan and baselines.

Area	Criteria	ECB	FWO	Dif. FWO vs ECB	Alt 1BWR	Dif. 1BWR vs FWO
Lake Okeechobee	Peak Stage (in feet NGVD29)	17.58	17.65	<0.1	17.56	0.09

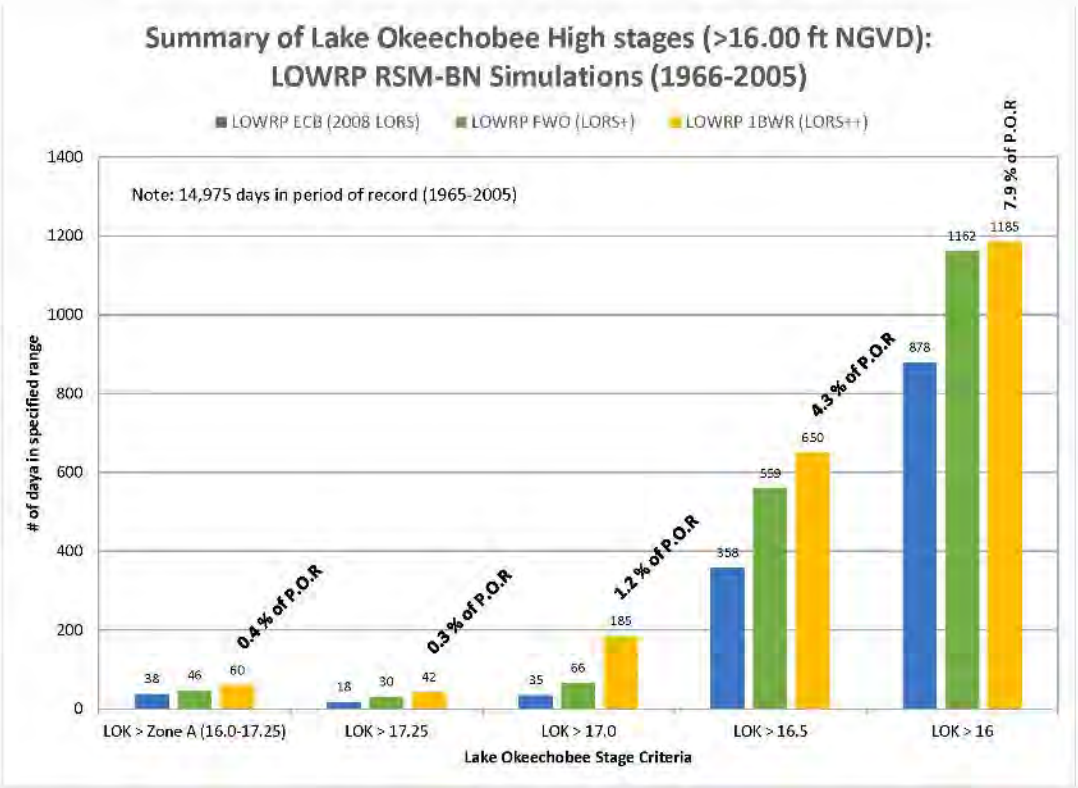

Figure C.2-79. Lake Okeechobee high stages (>16.00 ft. NGVD): LOWRP RSM-BN simulations (1965-2005).

Table C.2-44. Summary and comparison between Lake Okeechobee High Stages (>16.00 ft. NGVD29): LOWRP RSM-BN Simulations (1965-2005) alternatives and baselines.

Criteria	ECB (Days)	FWO (Days)	FWO vs ECB (% in POR)	1BWR (Days)	1BWR vs FWO (% in POR)
LO Mean Daily Stage > 17.25	18	30	0.1	42	0.1
LO Mean Daily Stage > Zone A	38	46	0.1	60	0.1
LO Mean Daily Stage > 16.00	878	1162	2	1,185	0.2

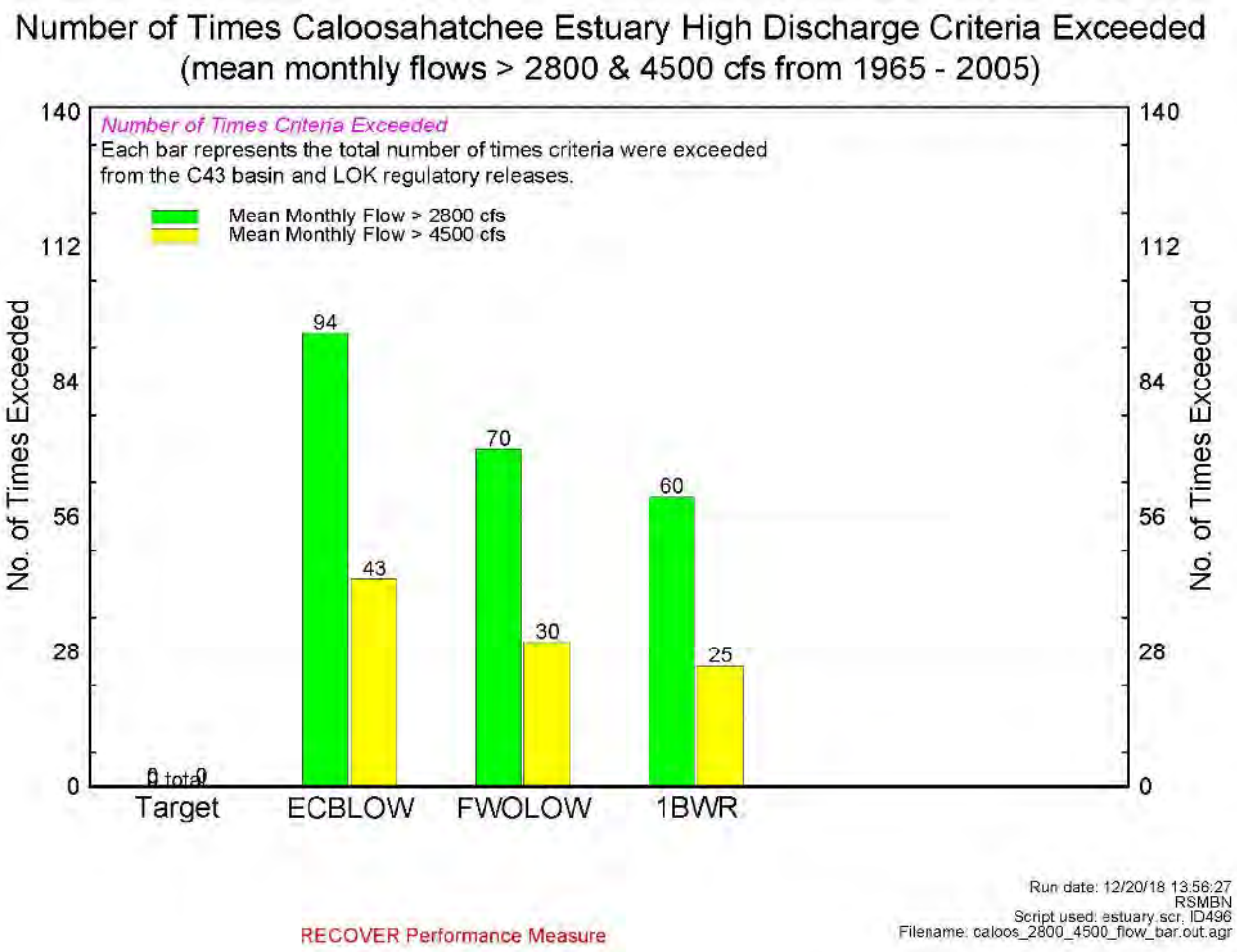

Figure C.2-80. Caloosahatchee high releaseflow criteria exceeded.

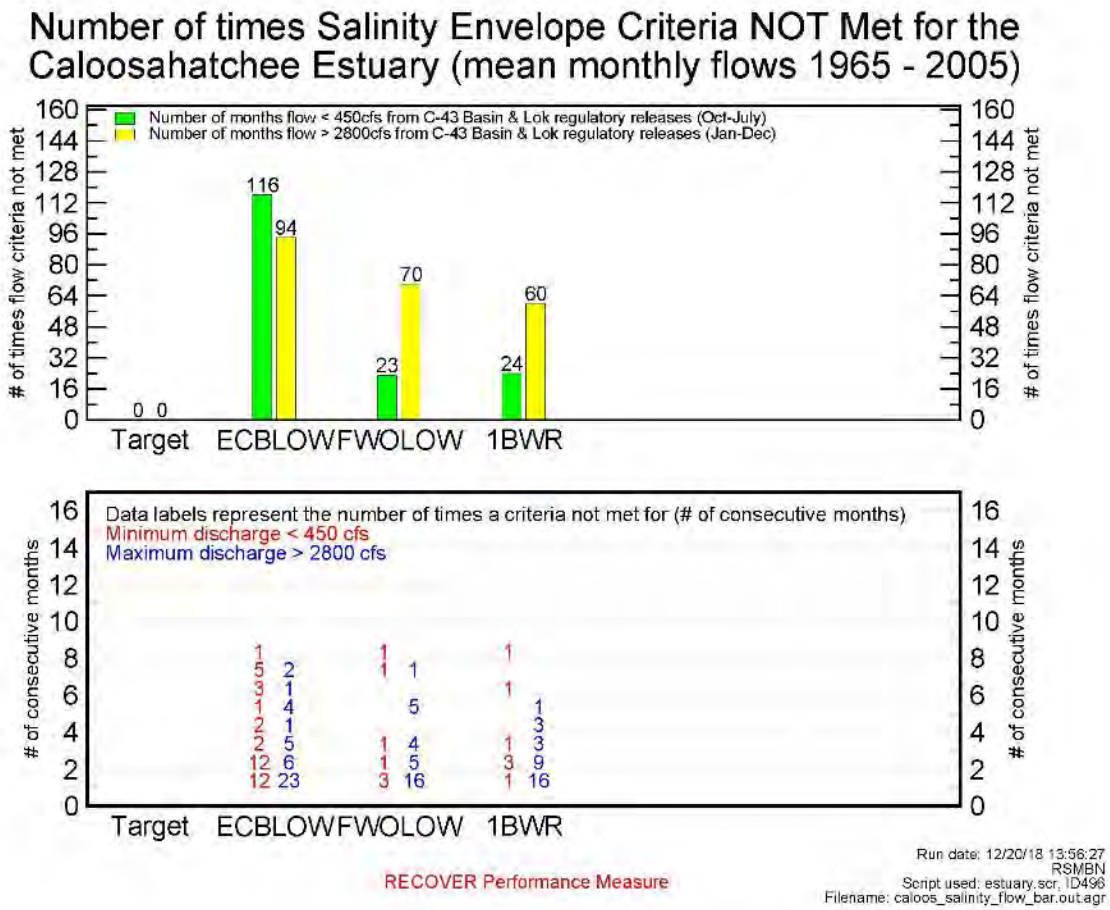

Figure C.2-81. Caloosahatchee salinity envelope criteria not met.

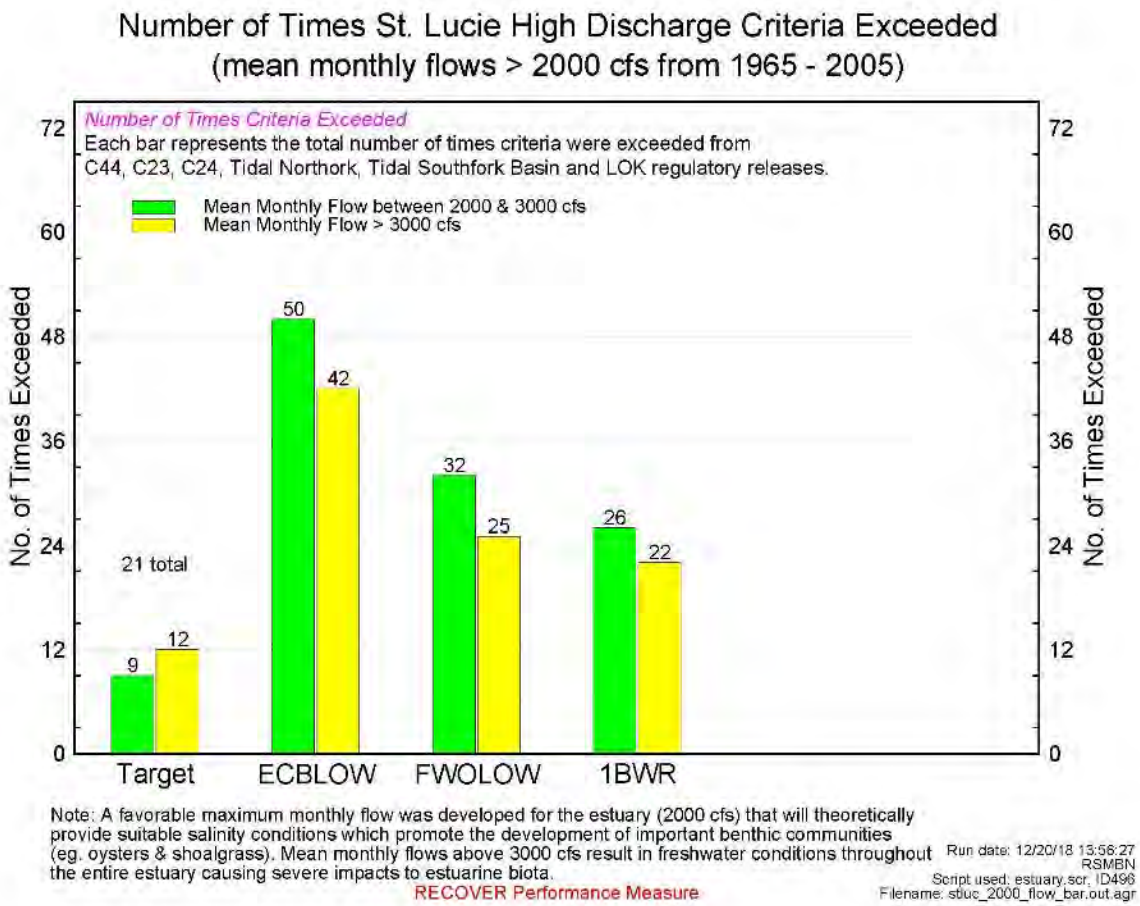

Figure C.2-82. St. Lucie high releaseflow criteria exceeded.

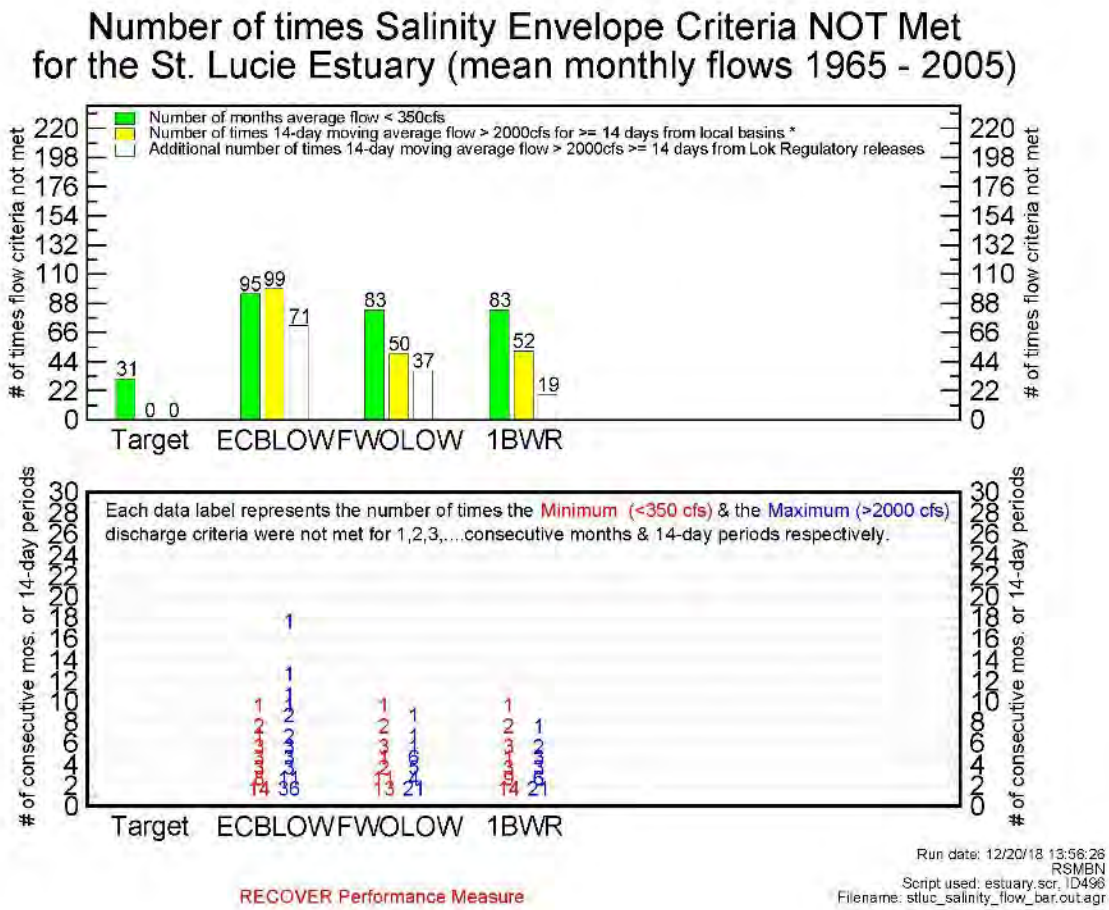

Figure C.2-83. St. Lucie salinity envelope criteria not met.

Table C.2-45. Summary of Caloosahatchee and St. Lucie estuaries flow.

Estuary	Criteria	ECB	FWO	Alt 1BWR
Caloosahatchee	Number of months flow < 450cfs from C-43 Basin & Lake Okeechobee regulatory flows (Oct-July)	116	23	24
	Number of months flow > 2800cfs from C-43 Basin & Lake Okeechobee regulatory flows (Jan-Dec)	94	70	60
St. Lucie	Number of months average flow < 350cfs	95	83	83
	Number of times 14-day moving average flow > 2000cfs for >= 14 days from local basins*	99	50	52
	Additional number of times 14-day moving average flow > 2000cfs >= 14 days from Lake Okeechobee Regulatory flows	71	37	19

C.2.25.8.3 Aquifers

Three aquifers are affected in the FWO condition and implementation of the LOWRP Recommended Plan: the unconfined surficial aquifer system (SAS), the confined UFA and the confined APPZ. In the project area, the UFA occurs at depths of 372–525 ft. below land surface (Sunderland et al., 2011). The APPZ occurs at depths of 1150–1468 ft. below land surface (Sunderland et al., 2011).

Under the FWO condition, SAS groundwater levels are affected primarily by rainfall in the Kissimmee River basin. Regional recharge occurs in the upland areas, and groundwater flows down gradient to release into the Kissimmee River and Lake Okeechobee. The primary use of SAS groundwater is to satisfy agricultural demands, which are expected to increase by 15% by 2035. Under the LOWRP Recommended Plan, SAS groundwater levels are expected to increase as a result of seepage from the shallow or deep storage features and wetland restoration activities.

Under the FWO condition, UFA groundwater levels are affected locally by agricultural pumping stresses. There are few UFA wells in the project area that monitor groundwater levels continuously. OKF-105 (Sunderland et al., 2011) is located near the S-65C structure (now removed), on the Kissimmee River near the border between Highland and Glades counties. Groundwater level variations of up to 6 ft. reflect pumping stresses during the dry season for agricultural demands (**Figure C.2-84**). The UFA in this location is fresh. Chloride concentrations are below the drinking water maximum contaminant level (250 mg/L), ranging 79–153 mg/L (n=3, SFWMD DBHydro, 2018).

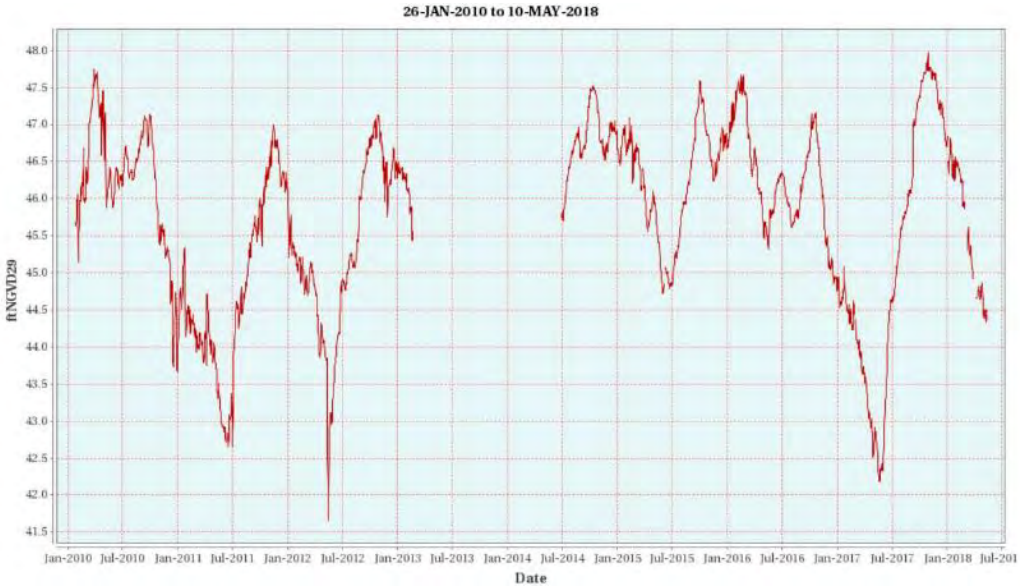

Figure C.2-84. Average daily groundwater level measurements at UFA well OKF-105U (POR January 2010 through May 2018).

Under the FWO condition, APPZ groundwater levels also respond to pumping stresses, most likely from pumping in the UFA. The maximum range in the APPZ groundwater levels is approximately 5 ft., and variations are synchronous with those in the UFA (**Figure C.2-85**). The APPZ in this location is slightly brackish. Chloride concentrations exceed the drinking water maximum contaminant level (250 mg/L), ranging 495–536 mg/L (n=4, SFWMD DBHydro, 2018). Higher chloride concentrations suggest that APPZ groundwater is not suitable for agricultural water supply.

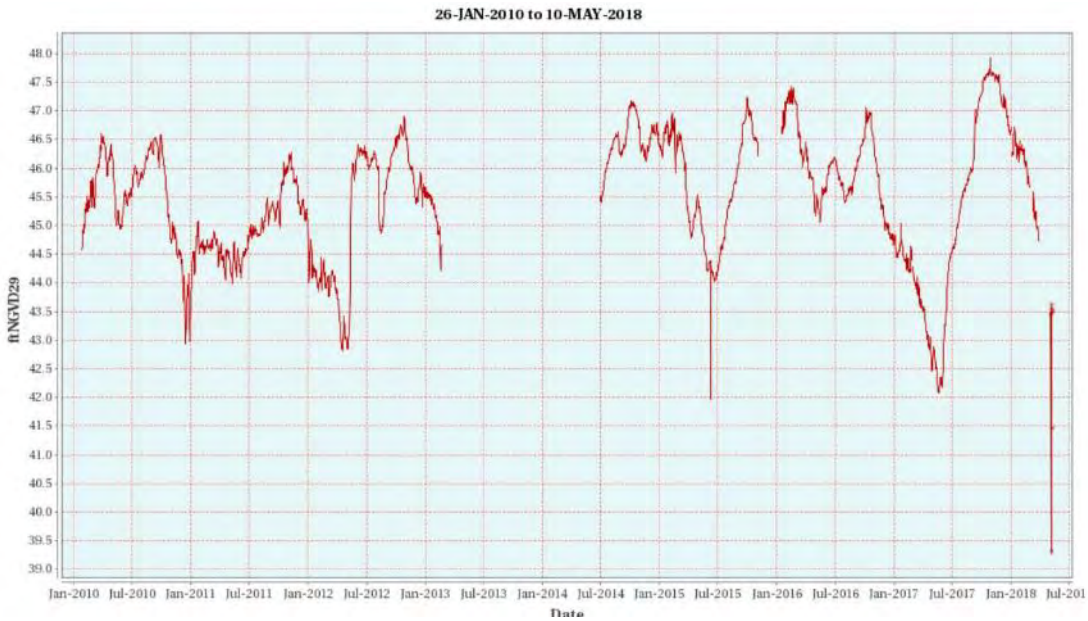

Figure C.2-85. Average daily groundwater level measurements at APPZ well OKF-105M (POR January 2010 through May 2018).

All LOWRP action alternatives include an ASR component, in which surface water will be recharged into, and recovered from, the UFA and the APPZ. Storage-assisted ASR wells are conceptualized to store water in both the UFA and APPZ with co-located well pairs. Because chloride concentrations in the UFA and APPZ generally are low, it is anticipated that recovery efficiencies will exceed 40% by volume. Also, storing surface water in the APPZ will freshen the aquifer, leading to improved recovery efficiencies over time.

C.2.25.9 Regional Water Management (Operations)

The Recommended Plan run was adjusted to achieve project goals of minimizing high flows to the northern Estuaries and improving Lake Okeechobee water levels while reducing water supply cutbacks. This was achieved by adjusting the operating parameters for the proposed management measures in relationship with the Lake regulation schedule. See **Appendix A – Annex A3** for modeling details.

In general, water management operations on Lake Okeechobee may be optimized to account for available storage within LOWRP project features. Changes to the Lake Okeechobee Regulation Schedule (LORS) can only occur after great consideration and required NEPA analysis and the operation of the project features in any of the alternatives will not directly trigger any changes in the LORS. No changes to the operations on the Kissimmee are anticipated at this time due to any of the alternatives.

The LOWRP team identified Alternative 1BWR as the Recommended Plan. The Recommended Plan primary storage component is the wetland attenuation facility. The WAF is primarily used for surface water storage to attenuate peak flows into Lake Okeechobee from the Kissimmee River Basin. Although a WAF allows for aboveground storage like a reservoir, water levels may be suitable for growth of wetland vegetation due to the water depths typically realized through operation of the facility (see **Figure C.2-86**). Storage-assisted ASR wells will rehydrate habitat during dry times to encourage wetland conditions within the WAF footprint without sacrificing desired regional benefits for Lake Okeechobee and the Northern Estuaries. The WAF footprint, including the embankments, seepage canal, and other perimeter features,

is approximately 13,632 acres with a storage capacity of approximately 46,000 ac-ft. A pump station located downstream of the existing S-84 structure on the C-41A canal serves as the water source for the proposed WAF. The pump draws water from the downstream area that is considered to be part of Lake Okeechobee. The engineering design and construction of the WAF will follow state of the practice methods for design and construction of pertinent features of the plan. USACE ER 1110-2-1150, *Engineering and Design for Civil Works Projects*, and ER 1110-2-1156, *Engineering and Design Safety of Dams – Policy and Procedures*, along with various other site/structure specific-regulations, will be adhered to prior to and during the PED phase.

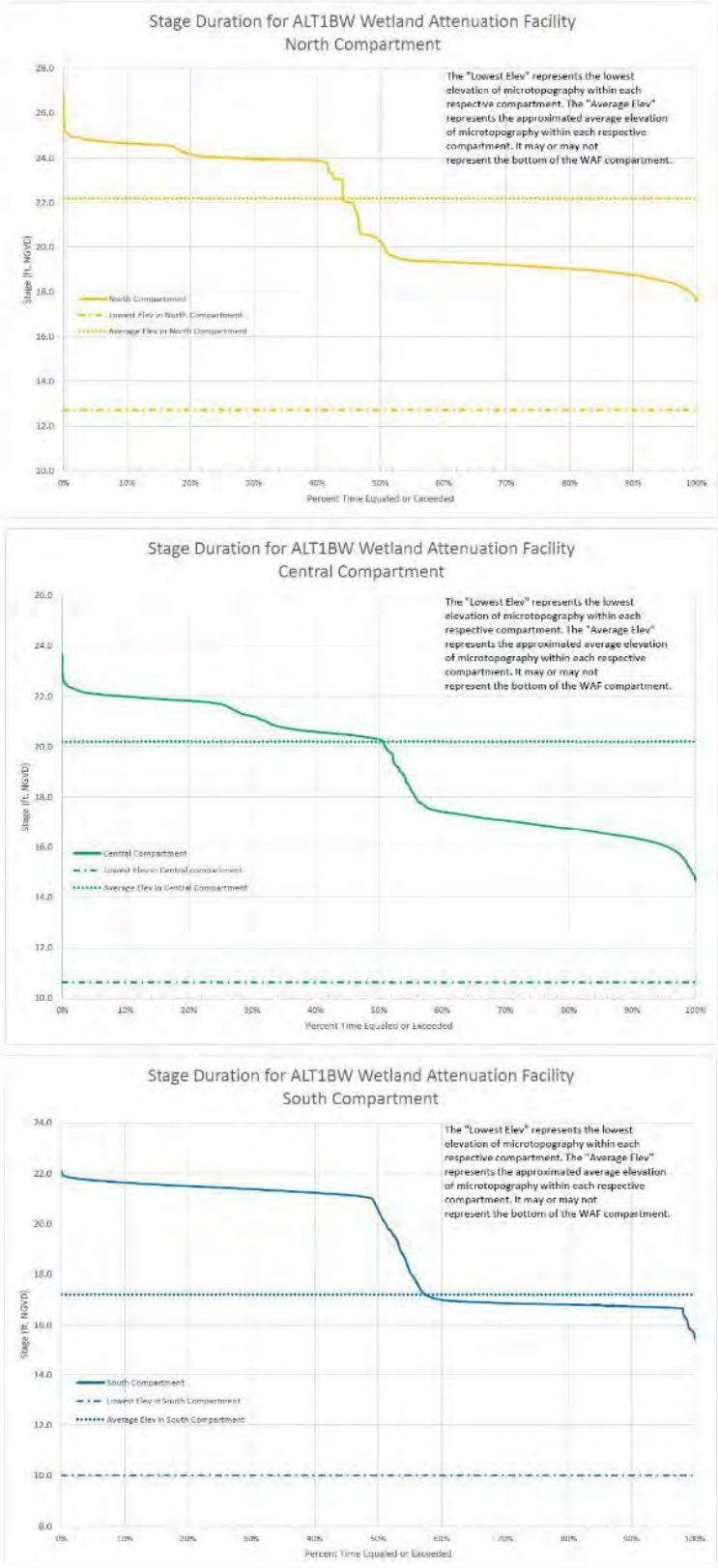

Figure C.2-86. Stage duration curve for ALT1BWR wetland attenuation facility.

C.2.25.10 Groundwater Resources

The LOWRP project area is within the SFWMD Lower Kissimmee River Water Supply Planning Area (SFWMD, 2014a). In conjunction with this planning effort, the Lower Kissimmee River Basin groundwater model was updated (SFWMD, 2014b). The UFA is the main groundwater supply source in the Lower Kissimmee Basin. Objectives of the updated groundwater flow model include evaluation of UFA groundwater withdrawals in the future (2035), which applies to the FWO condition of the LOWRP. A second objective is to evaluate potential impacts to minimum flows and levels in lakes along the Lake Wales Ridge due to UFA groundwater withdrawals within the SFWMD and the SWFWMD boundaries. Modest increases in water demand are projected in the basin with public water supply and domestic self-supply sources increased from 4.9 MGD to 6.0 MGD in 2035 (SFWMD, 2014a). Pumping of the UFA is predicted for agricultural and public water supply in both the SFWMD and SWFWMD areas. However the 2035 simulations suggest that UFA water levels show a rebound or no significant effect beneath minimum flows and levels lakes given projected increases in UFA pumpage and model uncertainty.

Storage-assisted ASR systems located proximal to the shallow impoundment are unlikely to affect existing agricultural users to the north in Highlands County, although this will need further investigation during the UIC permitting process. There are a few existing users of the UFA within the impoundment footprint for the Recommended Plan. **Table C.2-46** describes the groundwater resources for the Recommended Plan.

Table C.2-46. Groundwater resources for the Recommended Plan.

Aquifer	FWO	Alt 1BWR
Surficial Aquifer System (SAS)	Total water demand is expected to increase by 15% by 2035, mostly due to agricultural demands. Surficial aquifer pumping will meet part of those demands. Extensive pumping of the SAS can potentially affect regional water levels in this unconfined aquifer.	On completion of the WAF construction, seepage will occur locally from the impoundment. Eastward flowing seepage from K-05 will hydrate the northern portions of the Paradise Run alluvial plain.
Upper Floridan Aquifer (UFA)	Estimated future demands on UFA groundwater may be limited near the Lake Wales Ridge in order to maintain minimum flows and levels in adjacent lakes. However, sufficient confinement separates Lake Istokpoga and Lake Okeechobee from the UFA, so increased demands are unlikely to affect water levels in these lakes.	Construction of 80 ASR wells (50 open to the UFA) will increase regional storage by 448,000 acre-feet per year. Fully implemented ASR will reduce flows to the estuaries and will augment lake levels during drought. Most ASR systems will be constructed in the watershed, with 25 ASR facilities associated with the K-05 WAF.
Avon Park Permeable Zone (APPZ)	The APPZ is not a water supply source due to greater salinity compared to the UFA, and greater depth. It is unlikely that the APPZ will provide drinking water or agricultural irrigation supplies in the future.	Approximately 30 ASR wells in the APPZ will augment storage in this deeper transmissive aquifer. APPZ wells will be paired with UFA wells.

C.2.25.11 Water Quality

The LOWRP Recommended Plan may provide minor improvements to water quality. The section below outlines the effects of the Recommended Plan on water quality.

C.2.25.11.1 Lake Okeechobee Watershed

In comparison to the FWO, implementation of the Recommended Plan may result in some minor improvement in the water quality of the Lake Okeechobee watershed. The wetland restoration components will provide increased hydroperiods and retention times of watershed runoff, and both the wetland features and WAF will result in direct conversion of pasture and upland to wetland and/or reservoirs in the footprints. This combination of increased wetland quantity and quality may result in minor local improvements to portions of the watershed water quality.

Wetlands assist to improve water quality by removing nutrients such as nitrogen, phosphorus, and pesticides from agricultural and municipal runoff. Wetlands remove nutrients from the surface water and transfer them to the sediment, wetland plants, or the atmosphere. In addition, wetlands act as water storage features further improving water quality. By holding water, a wetland allows sediment and large particles to settle on the wetland bottom and thus act as a sediment trap to prevent translocation of the sediments and nutrients. The root systems of wetland plants then absorb nutrients from the sediment. There may also be differences related to season. During the growing season, in the summer and early fall, emergent and submerged aquatic plants take up large quantities of nutrients from water and sediment. Algae and floating plants absorb nutrients from surface water. These plants essentially convert the wetland into a "nutrient sink," by taking nutrients from the water and sediment and retaining them as plant material. By taking up and holding nutrients during the summer, wetlands decrease the possibility of contamination downstream (Johnston 2009; Reddy et. al 2010; Miller 2014). Based upon the spatial extent of wetlands created within the Recommended Plan, wetlands within Alternative 1BWR would provide a minor improvement in water quality as compared with the FWO.

C.2.25.11.2 Lake Okeechobee

Relative to the FWO option, implementation of the Recommended Plan may result in some improvement in Lake Okeechobee water quality due primarily to reduced flow volume into Lake Okeechobee and thus reducing the nutrient load (**Figure C.2-88**). The major contributor to this reduced volume is the loss to ASR wells, which recover less water than is recharged. However, the expected improvement in Lake Okeechobee water quality will likely be small, since nutrient (phosphorus) loads will only be slightly less compared to FWO project conditions.

To evaluate the Recommended Plan compared to the FWO option, loads were estimated by a phosphorus loading spreadsheet model (PLSM James 2017) for the three sub-watersheds directly affected by this project (Kissimmee River, Taylor Creek/Nubbin Slough and Indian Prairie/Istokpoga). The PLSM used daily flow estimates from the RESOPS model (Modeling Section 2013) and a constant baseline concentration applied to all inflows prior to entering project features. The PLSM demonstrated a slight load reduction compared to the FWO option at varying baseline concentrations (**Figure C.2-89**).

As discussed in the FWO conditions section for Lake Okeechobee, there is an existing total maximum daily load (TMDL) for phosphorus (Florida Department of Environmental Protection (FDEP) 2001). This TMDL requires a reduction in annual phosphorus loading from more than 500 metric tons per year to 140 metric

tons per year. Concentration estimates to reach these loadings range from 25 to 114 μg P l^{-1}, for the Kissimmee and the Taylor Creek/Nubbin Slough subwatersheds. To reflect this variation in ranges and account for the sum of load and flow contributions from the sub-watersheds, results were estimated from the PSLM using a range of concentrations from 40 to 100 μg P l^{-1} (James 2017). This analysis compared the effect of variation of phosphorus concentration on the overall load reduction for the Recommended Plan. This sensitivity analysis indicated that the Recommended Plan may result in reductions of phosphorus loads from 8% to 11%, if baseline concentrations were between 40 to 100 μg P l^{-1} (**Figure C.2-89**).

The annual TMDL phosphorus load release to the lake for the Recommended Plan and at each baseline concentration also is predicted to be a bit lower than the FWO load predictions (**Figure C.2-90**).

The existing condition average annual load from the Kissimmee River, Taylor Creek/Nubbin Slough and Indian Prairie/Istokpoga sub-watersheds using water years 2012 to 2015 was 374 metric tons per year (Sharfstein and Zhang 2017). The future without condition is estimated as 80.2 metric tons/yr (James 2017) to 200.5 metric tons/yr at the highest baseline.

C.2.25.11.2.1.1 Alternative 1BWR vs. FWO

Water quality is expected to improve under the Recommended Plan primarily through reduced releasehigh flow volume due to losses to ASR wells. Model results showed Improvements to phosphorus loading between 8% to 11% over the FWO, depending on baseline concentrations (**Figure C.2-89**), which would equate to loads of 73 to 177 metric tons/yr depending on the baseline (**Figure C.2-42**).

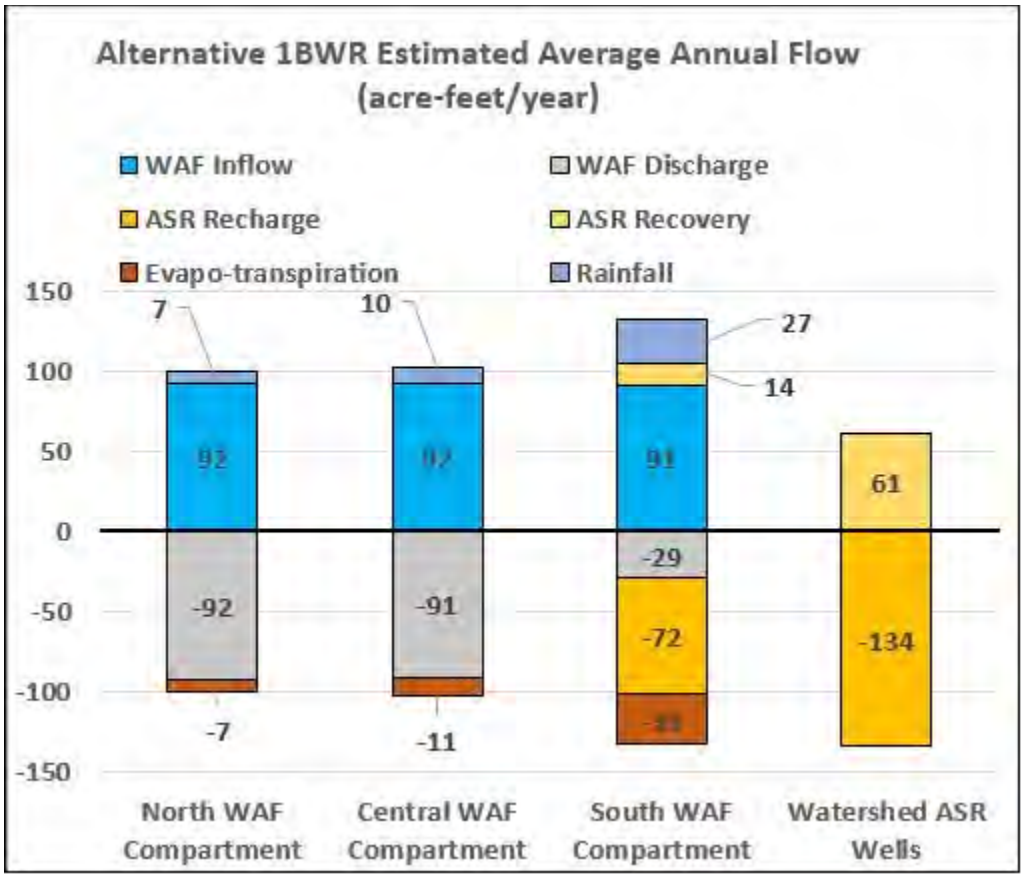

Figure C.2-87. Estimated yearly total flow to Lake Okeechobee from the Taylor-Creek/Nubbin Slough, Indian Prairie/Istokpoga, Kissimmee watersheds and net flow from ASR Wells and storage features included in the Recommended Plan.

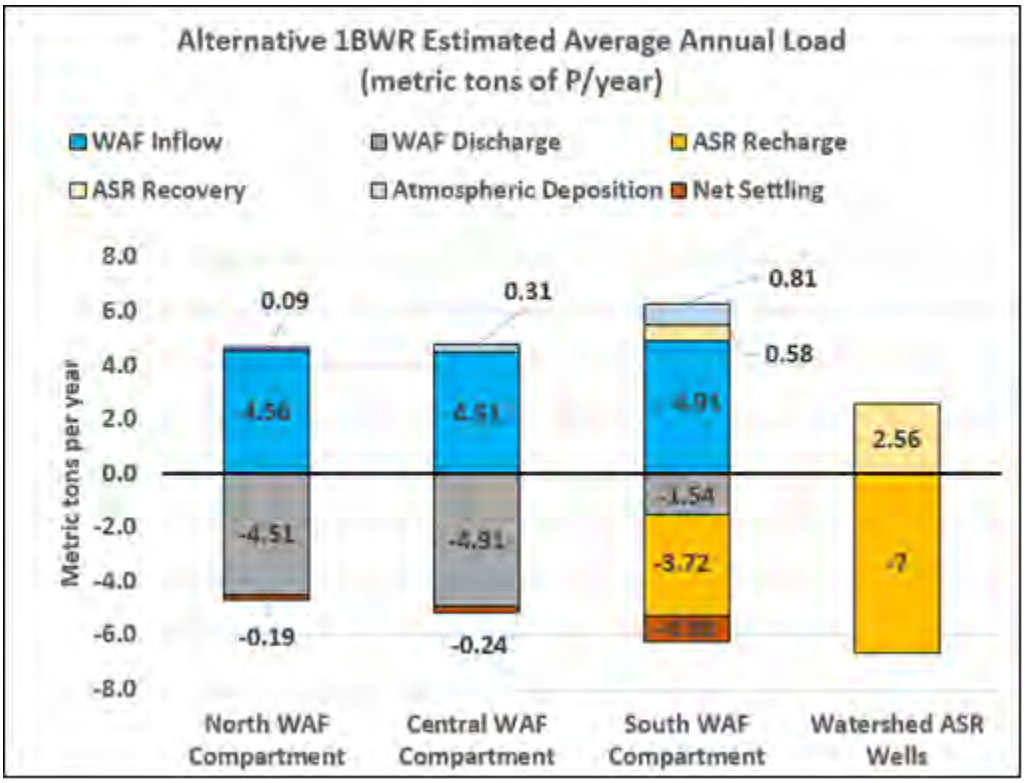

Figure C.2-88. Estimated yearly load to Lake Okeechobee from the Taylor-Creek/Nubbin Slough, Indian Prairie/Istokpoga, Kissimmee watersheds and net loads from ASR Wells and storage features included in the Recommended Plan assuming a base flow concentration of 40 µg l^{-1}.

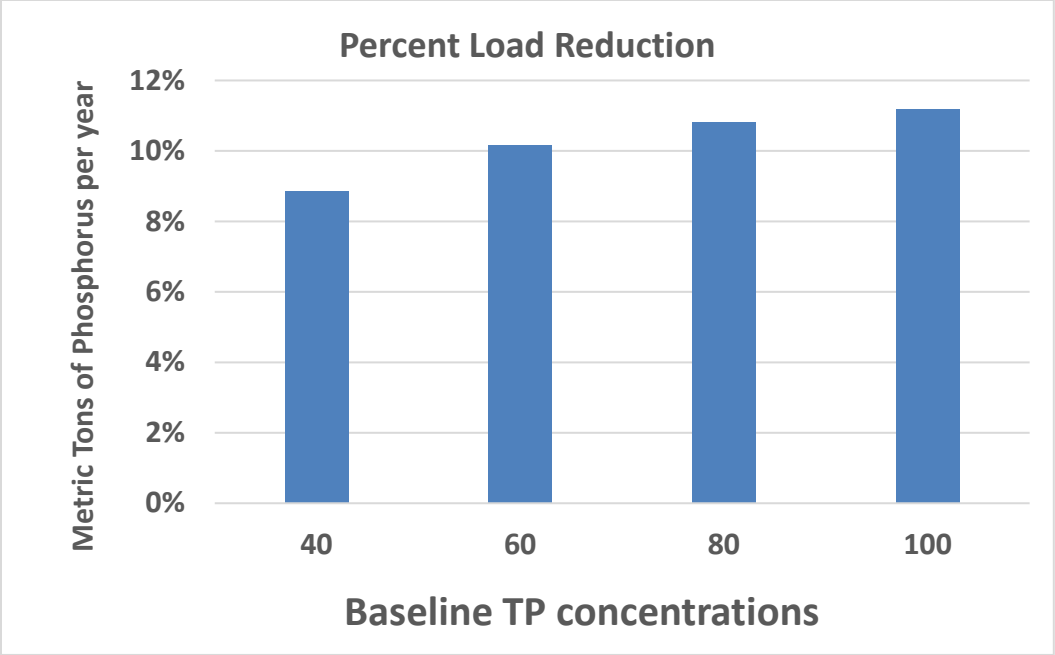

Figure C.2-89. Potential percent reduction of loads from to Lake Okeechobee from the Taylor-Creek/Nubbin Slough, Indian Prairie/Istokpoga, Kissimmee watersheds for different baseline total phosphorus concentrations.

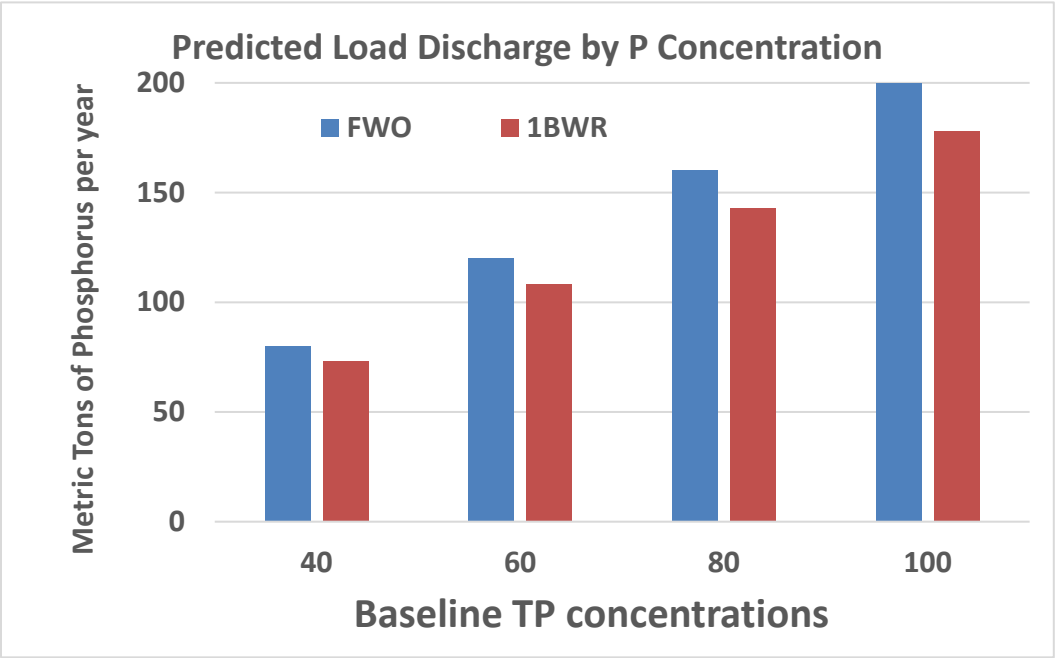

Figure C.2-90. Predicted possible annual total phosphorus metric ton load releaseflows to Lake Okeechobee from the Taylor-Creek/Nubbin Slough, Indian Prairie/Istokpoga, Kissimmee watersheds for different baseline total phosphorus concentrations.

C.2.25.11.3 Northern Estuaries

Caloosahatchee Estuary: Improved salinity conditions may occur within this estuary as a result of a reduction in the number of high flow events and a reduction in the number of extreme low flow events as characterized by flows through the S-79 structure. Salinity and dissolved oxygen conditions should improve during the wet season within the estuary given the reduction in high flow events.

St. Lucie Estuary: Improved salinity conditions may occur within this estuary as a result of a reduction in the number of high flow as characterized by flows through the S-80 structure. Salinity and dissolved oxygen conditions should improve during the wet season within the estuary given the reduction in high flow events.

C.2.25.12 Flood Control

Updated model baselines prescribed for the Assurances analysis, consistent with approach identified in DRAFT Guidance Memoranda #2, were not necessary for the LOWRP because the developed baselines reflected already the requirements for the Initial Operating Regime Baseline (IORBL).Therefore, the FWO project condition is the same as the IORBL.

To address the Savings Clause requirements for CERP, the LOWRP Final PIR includes an analysis of potential effects of the LOWRP Recommended Plan (Alt 1BWR), where applicable, to existing legal sources for water supply and/or the levels of service for flood. Refer to **Section 6** of the PIR main report for summary information and **Annex B** for the complete analysis.. It was determined that the implementation of the Recommended Plan will not degrade the existing level of flood protection offered by various components of the C&SF Project for this area. Further, the LOWRP Recommended Plan will ensure flood protection of the area through engineering design and construction following state of the practice methods for design and construction of pertinent features of the plan. USACE ER 1110-2-1150, “Engineering and Design for Civil Works Projects,” and ER 1110-2-1156, “Engineering and Design Safety of Dams – Policy and Procedures,” along with various other site/structure-specific regulations, will be adhered to prior to and during the PED phase.

C.2.25.13 Water Supply

The water supply performance of the Recommended Plan (Alt 1BWR) was simulated in model runs of RSMBN. Water supply performance is quantified for LOSA and for the Seminole Tribe of Florida Brighton and Big Cypress Reservations. Water supply in the ECB and FWO condition are quantified and displayed for comparison to the Recommended Plan.

C.2.25.13.1 Lake Okeechobee

The Recommended Plan improves water supply for existing legal users in LOSA compared the FWO. For the eight years with the largest water supply cutbacks within the LOSA, the water supply cutback percentage is reduced for seven of the eight years, compared to the FWO (**Figure C.2-91**). Based on the LOWRP modeling assumptions and the resulting moderate stage increase within Lake Okeechobee, the average annual percentage of water supply demand not met is projected to decrease in LOSA including the EAA (**Figure C.2-92**). The Recommended Plan improves or maintains water supply compared to the FWO condition. In the EAA the Recommended Plan (Alt 1BWR) reduces the percentage of unmet demands to 5%, down from 6% in the future without project condition (**Figure C.2-92**).

Following completion of the HHD remediation of Reaches 1, 2, and 3, the degree to which higher maximum lake stages and increased frequency and duration of high lake stages would be accepted, if at all, will be contingent on the conclusions identified in the USACE 2014 Dam Safety Modification Report (DSMR) for the HHD. Any changes to the LORS would be analyzed and coordinated with the public through the NEPA process.

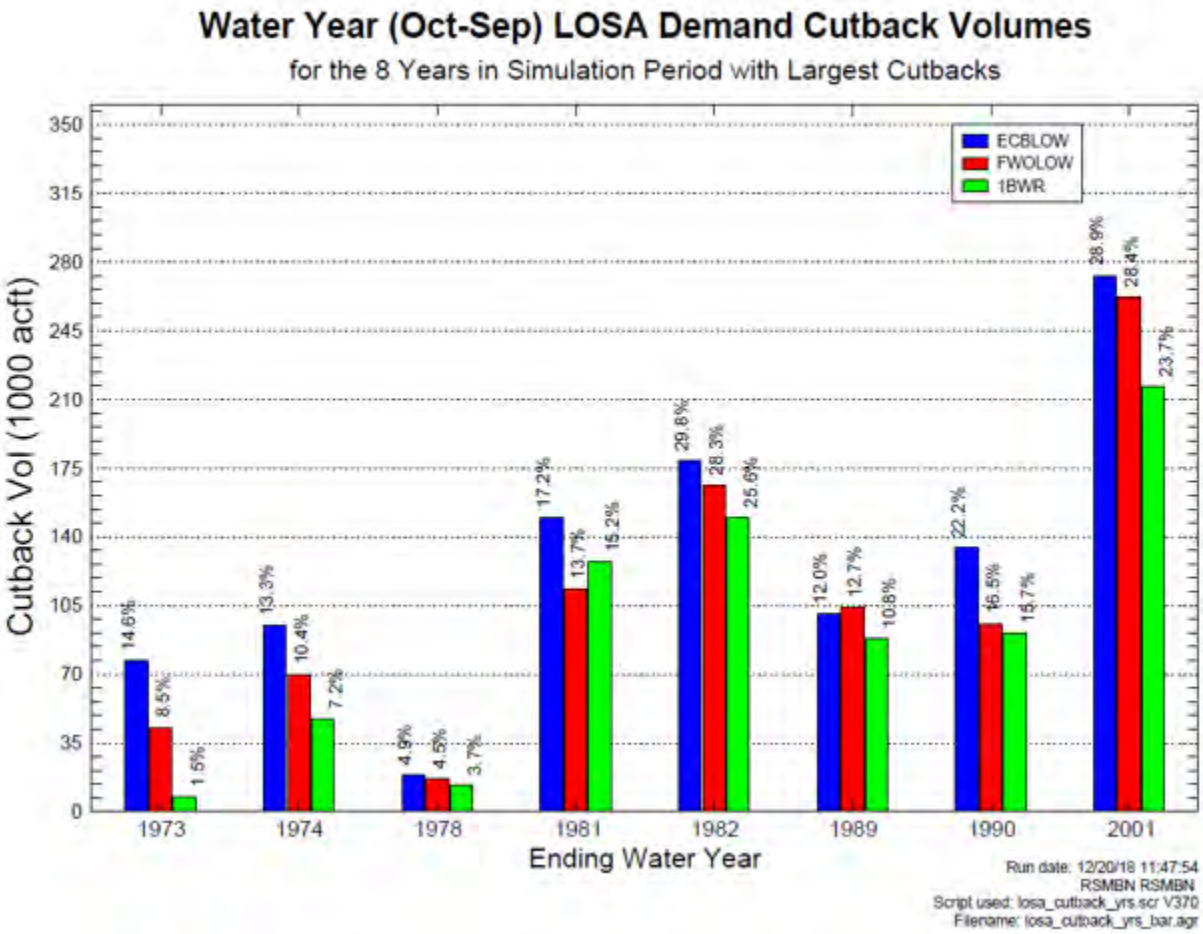

Figure C.2-91. LOSA demand cutback volumes for the 8 years with the largest cutbacks.

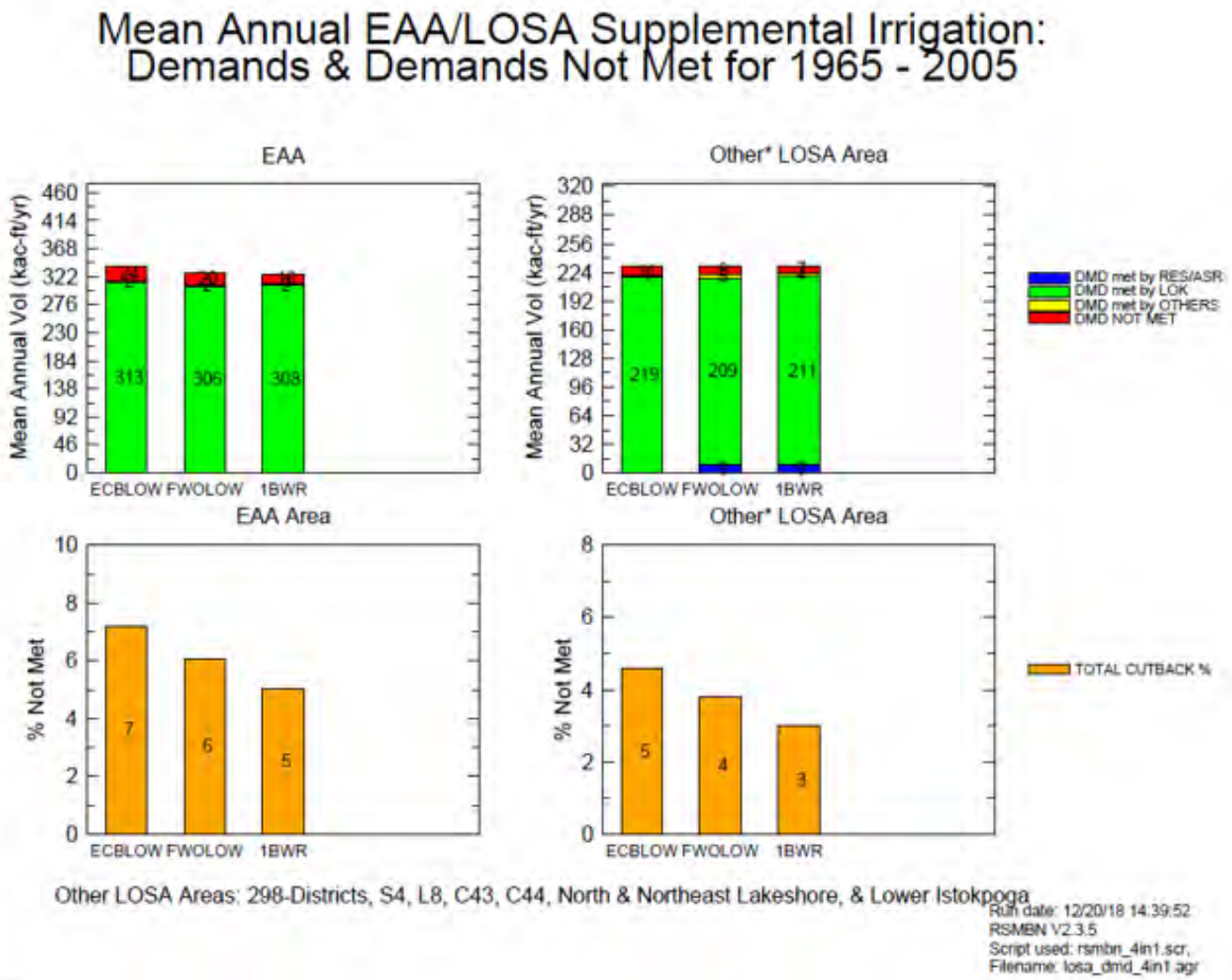

Figure C.2-92. Mean annual EAA/LOSA supplemental irrigation: demands & demands not met for 1965–2005.

As measured by RECOVER Performance Measure WS-1 (**Table C.2-47**), the frequency and severity of water restrictions in LOSA is reduced by the Recommended Plan compared to the FWO condition. The Recommended Plan (Alt 1BWR) reduces the severity score from 12 in the FWO condition to 7.

Table C.2-47. RECOVER Performance Measure WS-1: Frequency and Severity of Water Restrictions for Lake Okeechobee Service Area.

Simulation	POR	*Cutback Total (kaf)	Frequency	Severity Score	Number of WYs with at Least 1 Cutback**
ECB	1965-2005	857	8	13	8
FWO	1965-2005	688	8	12	8
Alt 1BWR	1965-2005	520	6	7	6
*Computed using monthly cutbacks > 18k **Cutback report tabulated by calendar Year					

C.2.25.13.2 Seminole Tribe of Florida

The STOF has surface water entitlement rights pursuant to the 1987 Water Rights Compact and subsequent entitlement provisions executed between the STOF, State of Florida, and SFWMD. Impacts are not expected for the LOWRP action alternatives based on the hydrologic modeling.

Based on the LOWRP Recommended Plan modeling, the percentage of water supply demand not met for the Brighton Reservation is shown to be slightly reduced in the Recommended Plan compared to the FWO (**Figure C.2-93**). The percentage of water supply demand not met for the Recommended Plan (Alt 1BWR) is 2.6% compared to 3.3% in the FWO condition.

The percentage of water supply demand not met for the Big Cypress Reservation is shown to be slightly reduced in the Recommended Plan compared to the FWO (**Figure C.2-94**). The percentage of water supply demand not met for the Recommended Plan (Alt 1BWR) is 3.1% compared to 3.7% in the FWO condition.

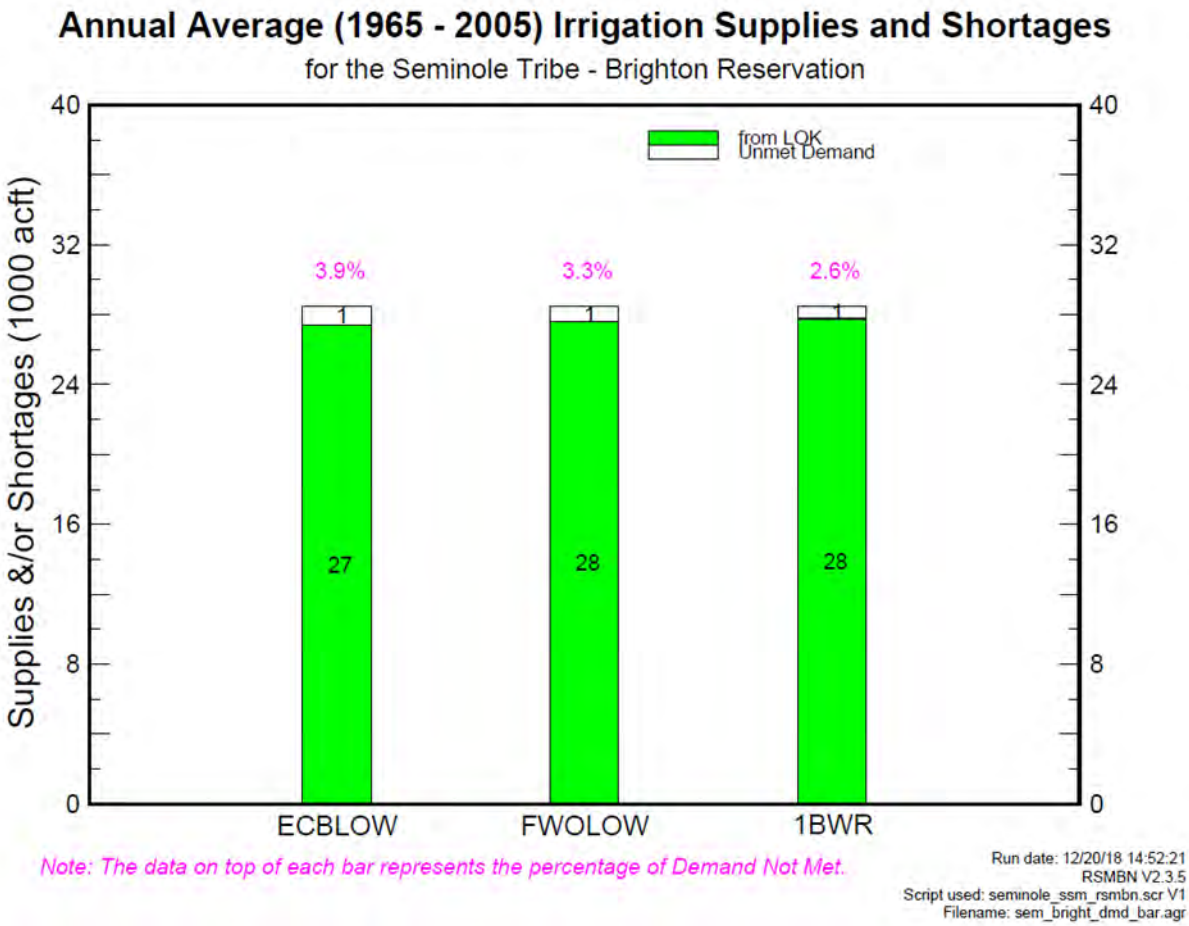

Figure C.2-93. Annual average (1965–2005) irrigation supplies and shortages for the STOF Brighton Reservation.

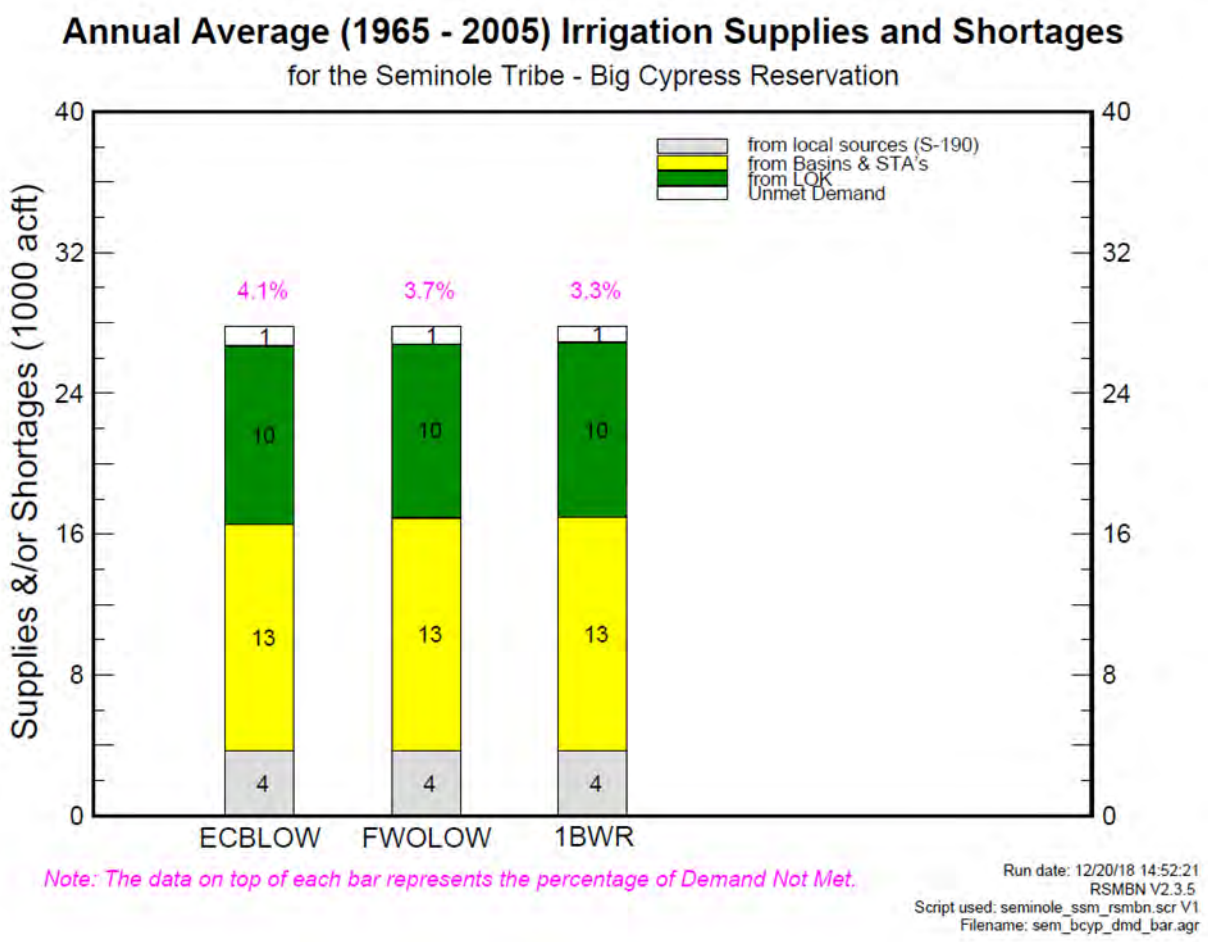

Figure C.2-94. Annual Average (1965–2005) irrigation supplies and shortages for the STOF Big Cypress Reservation.

C.2.25.14 Air Quality

Direct emissions from the proposed construction of the LOWRP project features would be confined to exhaust emissions of labor transport equipment, and construction equipment (dump trucks, excavators, graders, bulldozers, etc.). Clean Air Act pollutants considered in this air quality assessment are SOx; volatile organic compounds (VOCs); nitrogen oxides (NOx), CO, PM10, and PM2.5. Greenhouse gas emissions are also considered. Volatile organic compounds, sulfur oxides, and nitrogen oxides are important since they are precursors to ozone generation. These criteria pollutants are generated by the construction and operational activities associated with the proposed action alternatives.

In Lake Okeechobee and the Northern Estuaries, population growth in the area is expected in the FWO condition relative to existing conditions baseline, representing the potential for an increase in air pollution. However, air quality compliance is expected. The Recommended Plan is expected to have no change relative to FWO conditions in Lake Okeechobee and the Northern Estuaries. Reduction in ranching equipment used on the WAF in FWO condition will be offset by increase in air pollutants from new pump stations and ASR wells. A detailed analysis of air quality impacts has been prepared for the Recommended Plan in **Section 6**.

C.2.25.15 Hazardous, Toxic, and Radioactive Waste

Under the FWO condition, the WAF and the Kissimmee River–Central and Paradise Run wetlands lands will likely continue to be farmed, which will result in the additional application of agricultural pesticides in the cultivated portions of this property and the inadvertent release of petroleum and pesticides in operation and maintenance areas. During the construction of project features, it is possible that undiscovered HTRW contamination will be found. Per EC 1165-2-132, the non-federal sponsor will be required to remediate these sites at their sole expense. There is also the potential for HTRW release associated with the operation of project pump stations; however, with modern facilities and best management practices, this presents a minor risk to the environment.

C.2.25.15.1 Residual Agricultural Chemicals

The USACE HTRW policy (ER 1165-2-132) directs that Construction of Civil Works projects in HTRW-contaminated areas should be avoided where practicable. In September 2011, the ASA (CW) provided an exception to this HTRW policy for CERP Projects (Memorandum for Deputy Commanding General for Civil and Emergency Operations, Subject: Comprehensive Everglades Restoration Plan (CERP) – Residual Agricultural Chemicals, Dated September 14, 2011). If specific criteria are met, this policy memorandum allows residual agrichemicals to remain on project lands and allows the USACE or SFWMD to integrate response actions directly into the construction plan.

This section of the LOWRP PIR will partially fulfill the requirements established in the aforementioned policy for the WAF, Kissimmee River–Central & Paradise Run wetlands, and up to 80 ASR locations of the LOWRP. The Jacksonville District will seek conditional but not final approval of the application of the agricultural chemical policy from HQ USACE. Final approval will be requested prior to design of the K-05 WAF, Kissimmee River–Central & Paradise Run wetlands, and up to 80 ASR locations of the LOWRP when it is expected that supplemental information will be available to completely fulfill the policy requirements.

C.2.25.15.2 Recommendation

The WAF, Kissimmee River–Center and Paradise Run wetlands, and up to 80 ASR locations of the LOWRP project feature require the land conversion from agricultural production to aquatic restoration which inundates the land with water. The avoidance of lands containing residual agricultural chemicals is not practicable.

Environmental Conditions that indicate likely HTRW issues including ag-chemicals have been identified via prior Pre-Acquisition Environmental Due Diligence completed by the non-federal sponsor at relatively localized areas situated within the limited subset of previously acquired properties within the Project footprint. These HTRW issues remain currently unabated. Prior to construction, these HTRW issues will be satisfactorily addressed by the non-federal sponsor. In addition, all additional properties to be acquired will be evaluated via current Pre-Acquisition Environmental Due Diligence requirements to identify any additional Recognized Environmental Conditions and/or HTRW issues. Additionally, due to the time that has elapsed since the acquisition of selected properties within the project footprint, these properties will be evaluated consistent with current requirements to ensure that no HTRW issues remain outstanding. Prior to construction and during operation, the USACE and the non-federal sponsor will comply with applicable requirements.

Specifically, unabated HTRW issues are associated with the former P1 Property (current Tract Nos. MD 100-060, MD 100-057, and MD 100-055) and the former P2 Property (Tract No. 39 105-022). These properties are situated within the revised current configuration of the WAF. A Phase I/II Environmental Assessment of the P1 Property was completed in January 2006, and a Phase I Environmental Assessment of the P2 Property was completed in January 2000.

When the WAF, Kissimmee River–Central & Paradise Run wetlands, and up to 80 ASR locations of the LOWRP lands are set for construction Phase I & if required Phase II assessments will be performed to determine the presence of any potential sources of HTRW in the cultivated areas at selected locations. The results of these audits will be provided to the FDEP and USFWS for their review, comment, and concurrence regarding the need for remedial actions. The project must have concurrence from the USFWS and the FDEP waste cleanup section that the lands are suitable for project use before construction can proceed.

The non-federal sponsor will be 100% responsible for the cost of actions taken due to the presence of residual agricultural chemicals, at no expense to the Federal Government. Any future costs associated with the presence of residual agricultural chemicals at the Federal project site will be 100% non-federal sponsor cost and responsibility. The costs for characterization of the project lands in preparation for conducting a response action for the residual agricultural chemicals and removal of soils that are hazardous waste will be included as 100% non-federal sponsor responsibility. The CESAJ will not conduct actions to address residual agricultural chemicals for the SFWMD during the OMRR&R phase of the project.

C.2.25.16 Noise

For the Recommended Plan, there would be minor, short-term, and less-than- significant increases in noise during construction activities. The LOWRP Recommended Plan includes additional pump stations which would result in long-term, localized increases in noise. Pumps associated with ASR wells would also result in long-term localized increases in noise. ASR pumps are electric, which run much quieter than diesel powered engines. The turbines are submerged to a depth of 30 ft. below the surface, so sound is damped. Compressor for the airburst system (to clean intake screen) runs infrequently for 5 minutes. There will be some noise during the day from the drill rig during well construction (duration approximately 1 month per well). Hospital-grade mufflers will be included in design.

C.2.25.17 Aesthetics

Aesthetic effects refer generally to impacts on the visual qualities of the environment. Restoration of the south Florida ecosystem is expected to result in a healthier environment that would support vigorous plant communities; larger fish and aquatic animal populations; large numbers of wading birds; alligators; and sustainable populations of wide-ranging mammals, in a natural setting, in perpetuity. People value viewing wildlife, wetlands, and open, relatively pristine spaces, as supported by tourism statistics for south Florida. During construction of the Recommended Plan there will be a temporary short-term significant impact to aesthetic values in the construction areas. The Recommended Plan shows a significant increase in aesthetic value over the FWO due to restoration of wetlands in the Lake Okeechobee watershed and provides a minor beneficial effect. The restoration of wetlands provides additional habitat for native plants and animals and opportunities for wildlife viewing. The WAF provides an increase in aesthetics due to the addition of wetland vegetation habitat on the storage footprint. There will be temporary, short-term significant adverse impact to aesthetic values in the construction areas during construction. For the

WAF there will be a long-term, major adverse impact in reservoir areas due to levees in line of sight. An earthen dam will be visible on the rise, but covered in grass to minimize the aesthetics impact. There will be a moderate adverse impact with the addition of a pump stations, ASR wells, and WAF by adding man-made features in the natural landscape. The Recommended Plan will have a minor effect to the night sky resource (nightscape) within and vicinity of this project due to increased light pollution. The light pollution concern includes light pollution at pump stations and ASR wells at night in an otherwise dark landscape. ASR systems and pump stations will be designed to have a minimum number of fully shielded LEDs for exterior lighting. Floodlights used for security during construction will be minimized. The Recommended Plan will have minor effects after minimizing light type, number, direction of orientation, and location compared to residential areas. There are no affects to public parks, conservation areas, or refuges in the project area.

There would be negligible and less than significant effects due to LOWRP in Lake Okeechobee. In the Northern Estuaries, the action alternatives would increase the aesthetic value due to decreased high-flow events and provide minor beneficial effects. Reductions in high volume flows to the estuaries would result in lower suspended solids, increased water clarity, and the correct salinity envelope that maintain healthy SAV beds. These benefits could also and lead to an increase in wildlife viewing opportunities (Orth et al., 2006).

C.2.25.18 Land Use

The LOWRP project area consists of a mixture of private and public land ownership. The public lands belong to the SFWMD and the State of Florida. Publicly owned lands in the WAF and Paradise Run footprints (Alt1BWR) are currently being leased for cattle grazing. The publicly owned lands in the Kissimmee River–Center Wetlands boundary are currently vacant. The parcel map showing land ownership types are shown in **Figure C.2-95**.

C.2.25.18.1 Wetlands and Uplands

The Recommended Plan consists of aboveground storage (WAF) and wetland components. The wetland components are the Kissimmee River–Center and the Paradise Run Wetlands. In the footprint of the Kissimmee River–Center Wetland, approximately 89% of the lands are privately owned and the remaining 11% are publicly owned (**Figure C.2-95**). In the Paradise Run Wetland footprint, approximately 41% of the lands are privately owned and the remaining 59% are publicly owned. In the Recommended Plan, the WAF footprint consists of a combination of public lands (32%) and private lands (68%). Much of the land proposed to be used for the future development of the WAF is currently in agricultural use.

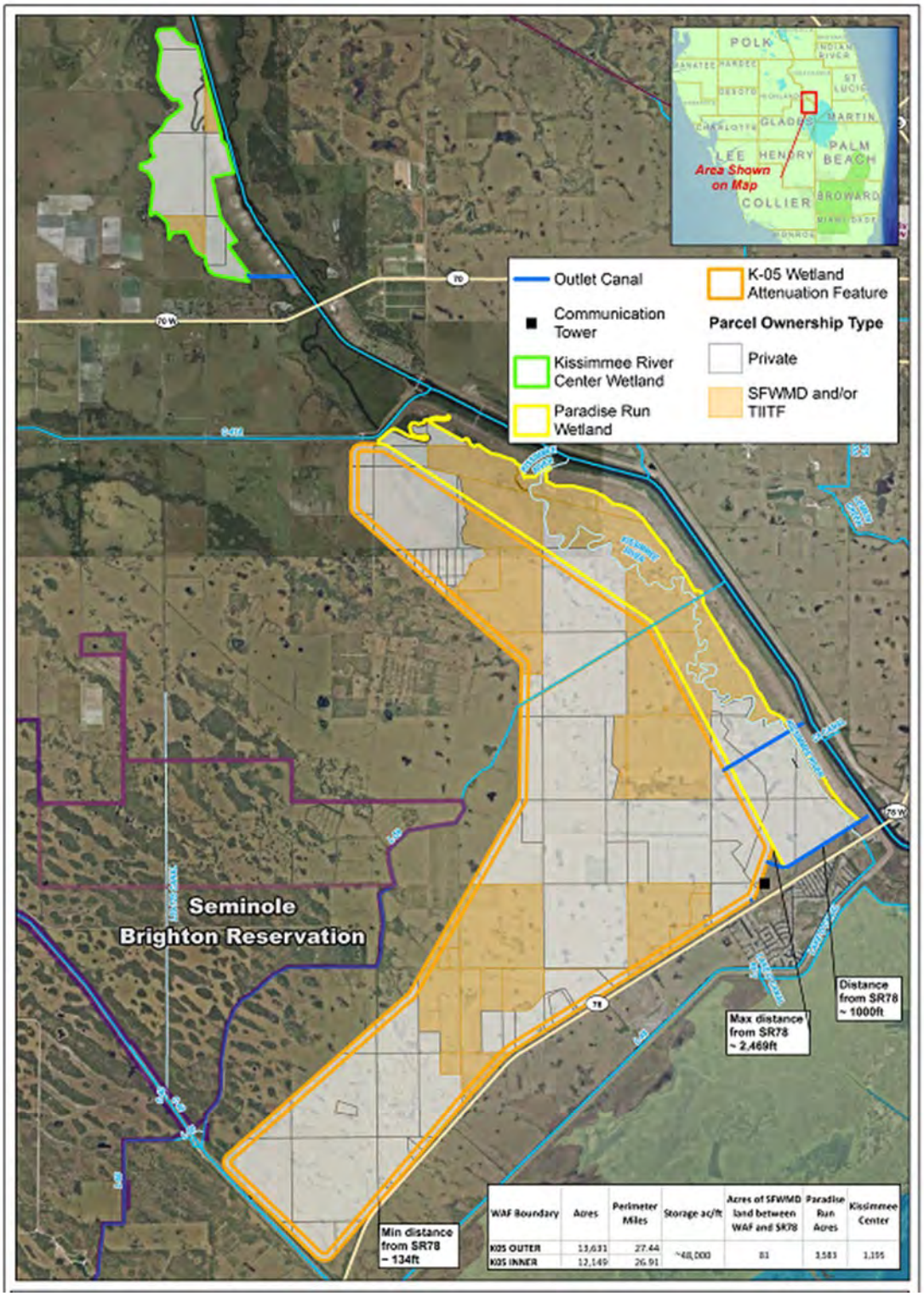

Figure C.2-95. Public and private parcels in the Recommended Plan footprint.

The Kissimmee River–Center wetland and Paradise Run wetland footprints were formerly the floodplain and wet marshes for the meandering Kissimmee River. Currently, approximately 13% of the lands in the Kissimmee River–Center wetland are existing fresh water, marshes, wetlands, or wetland forests. The

remaining 87% of the lands are uplands or pasturelands that will be restored into inland wetlands. The Paradise Run wetland footprint would need much less restoration in comparison to the Kissimmee River–Center wetland footprint. Currently, approximately 61% of the lands in the Paradise Run wetland are fresh water, marshes, wet prairies, or wetlands. The remaining 39% of the lands are uplands or pasturelands that will require restoration to have inland, wetland landscapes features. The land use categories for each component of the alternatives are summarized in **Table C.2-48**.

The WAF footprint in the Recommended Plan is comprised of approximately 13,600 acres of land that are predominantly used for pasture. Although uplands of pasture and rangelands dominant the landscape by 94%, the next significant land use category are freshwater marshes and wetland forests comprising 6% of the landscape. Approximately 976 acres of freshwater marshes and wetland forests will be impacted as a result of this alternative. The WAF footprint is positioned 0.5 miles away from the STOF Brighton Reservation.

Table C.2-48. Current land use (in acres) in the wetland restoration and WAF footprints.

Land Use Category	Kissimmee River Wetland (acres)	Paradise Run Wetland (acres)	WAF (acres)
Improved pastures	796	83	12,432
Unimproved pastures	64	0	120
Citrus Groves	0	0	1
Herbaceous rangeland	3	5	0
Shrub and brushland	0	10	67
Mixed rangeland	0	40	0
Upland hardwood forest	4	35	0
Live Oak	3	0	0
Oak - cabbage palm forest	1	0	0
Cabbage palm	0	5	0
Streams and waterways	19	76	0
Channelized waterways, canals	3	0	1
Reservoirs	5	0	7
Slough waters	0	146	0
Mixed wetland hardwoods	0	32	0
Mixed wetland hardwoods - mixed shrubs	159	182	38
Cabbage palm savannah	4	3	0
Freshwater marshes	55	402	813
Wet prairies	41	830	124
Emergent aquatic vegetation	40	909	1
Spoil areas	0	23	28
TOTAL AREA (acres)	**1,197**	**2,781**	**13,632**

The Recommended Plan shows a significant and major beneficial effect with an increase in wetland habitat compared to the FWO. The Recommended Plan provides an increase of 4,779 acres of wetlands. The storage in the Recommended Plan is a flow-through WAF used for surface water storage to attenuate peak flows and stages in adjacent areas. Although a WAF allows for aboveground storage like a reservoir, water levels may be suitable for growth of wetland vegetation due to the water depths typically realized through operation of the facility. The objective for the LOWRP was to restore a minimum of 3,500 acres of wetlands and the Recommended Plan meets this project objective.

C.2.25.18.2 Agriculture

The LOWRP area consists of a mixture of private and public land ownership. Each component in the Recommended Plan will have an impact on agricultural lands. The Recommended Plan will convert approximately 13,000-acres of agricultural lands to either wetlands or a WAF due to the construction of project features. **Table C.2-49** summarizes the impacts to agricultural lands for each component in the Recommended Plan. Coordination with the USDA and NRCS to meet the requirements of the Farmland Protection Policy Act, is ongoing. It was determined that additional analysis was not needed at this time based on the change in footprints for the Recommended Plan. Additional coordination will occur during PED phase. When detailed design information that locates each of the plan components is completed, it can then be determined how many acres of unique farmland would be affected by the Project. (Refer to **Appendix C, Part 4**).

Table C.2-49. Impacts to agriculture lands (acres) for each project feature or aboveground storage component for the Recommended Plan.

Project Feature	Alternative 1BWR (acres)
Kissimmee River Wetland	861
Paradise Run Wetland	138
WAF (Alt1BWR)	12,620
Total Agriculture Acres Loss	13,621

C.2.25.19 Recreation

There will be no impacts to recreational navigation with this project. The Recommended Plan may provide enhanced fishing opportunities due to better salinity conditions in the Northern Estuaries. Reductions in high flows to the Northern Estuaries would enhance fish populations and subsequently improve related recreational opportunities such as fishing, boating and kayaking.

A Recreation Plan is included in **Appendix F**.

C.2.25.20 Socioeconomics

The counties containing the LOWRP study area are expected to increase in population by 18.2% from 2016 to 2045, with Martin and Highlands counties attracting the greatest number of new residents. Glades and Okeechobee counties are expected to increase by only 2,253 and 5,094, respectively. When aggregated,

the total population is projected to increase by 25,416 people. This rate of growth is consistent with that projected previously in the CERP planning efforts. Population projections are not anticipated to differ between the FWO and alternative conditions.

There will be no impacts to Lake Okeechobee commercial navigation with this project. The hydrologic modeling conducted for all LOWRP alternatives to optimize system-wide performance incorporated the current Regulation Schedule management bands of the 2008 LORS. The hydrologic modeling of the LOWRP alternatives included proposed revisions to the 2008 LORS flow chart guidance of maximum allowable flows, which are dependent on the following criteria:

- Class limits for Lake Okeechobee inflow and climate forecasts, including tributary hydrologic conditions, seasonal climate outlook, and multi-seasonal climate outlook
- Stage level, as delineated by the Regulation Schedule management bands
- Stage trends (whether water levels are receding or ascending)

Most of the 2008 LORS refinements applied in the LOWRP modeling lie within the bounds of the operational limits and flexibility available in the current 2008 LORS, with the exception of the adjustments made to the class limits for the Lake Okeechobee inflow and climate forecasts. Under some hydrologic conditions, the class limit adjustments made to the Lake Okeechobee inflow and climate forecasts reduced the magnitude of allowable flows from the lake, thereby resulting in storage of additional water in the lake in order to optimize system-wide performance and ensure compliance with Savings Clause requirements. However, these class limit changes represent a change in the flow chart guidance that extends beyond the inherent flexibility in the current 2008 LORS. Additional information and documentation of the LOWRP Recommended Plan modeling assumptions for Lake Okeechobee operations are found in the Appendix A. The authorized C&SF project depths for Lake Okeechobee navigation are based on 12.56 ft. NGVD. Effects are provided in the main report in **Section 5.**

C.2.25.21 Environmental Justice

The effects of the Recommended Plan on the EJ communities are described below.

C.2.25.21.1 EJ Aesthetics

Aesthetic effects refer generally to impacts on the visual qualities of the environment. Restoration of the south Florida ecosystem is expected to result in a healthier environment that would support vigorous plant communities; larger fish and aquatic animal populations; large numbers of wading birds; alligators; and sustainable populations of wide-ranging mammals, in a natural setting, in perpetuity. There is concern from the STOF and local communities that the proposed levees will block the current unobstructed view of the landscape. The WAF in the Recommended Plan will have a levee height of 15.5 ft. The geographic area of the LOWRP is that it is relatively flat with no significant change in topography which magnifies the aesthetic impact in the surrounding area. However, the proposed levees will be significantly lower than the existing HHD levees with a levee height of 20–25 ft. and is located in the project area. The levee will be visible on the rise, but covered in grass to minimize the aesthetics impact and could be surrounded by trees to provide screening, a more natural look, and provide habitat for wildlife. Alternative 1BWR features are located 0.5 miles or more from the STOF Brighton Reservation and tribal owned lands.

The Recommended Plan significantly increases the acreage and quality of wetlands in wetland restoration sites which will provide a long-term, significant, beneficial impacts in aesthetic value in the Kissimmee

River–Center and Paradise Run wetland restoration sites. The Recommended Plan will have a temporary, short-term, significant adverse impact to aesthetic values in the construction areas during construction. The Recommended Plan will have a levee height of 15.5 ft. and will have a long-term minor adverse impact in the WAF footprint due to 15.5-ft. levees in the line of sight which is located at least 0.5 mile from tribal lands. The Recommended Plan will also have a minor adverse impact with the addition of a pump station, 80 ASR wells, and a WAF by adding man-made features in the natural landscape. The WAF will contain wetland vegetation, thus providing additional habitat for native plants and animals and opportunities for wildlife viewing.

C.2.25.21.2 EJ Noise

The noise concern includes noise during construction and noise of pump operations in an otherwise quiet landscape with only periodic noise from roads and agricultural/ land management activities. The Recommended Plan will have a minor, short-term, and less than significant increase in noise during construction activities. The Recommended Plan includes one additional pump station, which would result in long-term, localized increases in noise. Pumps associated with ASR wells would also result in long-term, localized increases in noise. ASR pumps are electric, which are much quieter than diesel powered engines. The turbines are submerged to a depth of 30 ft. below the surface, dampening radiated noise. Compressors for the airburst system (to clean intake screen) runs infrequently for 5 minutes. There will be some noise during the day from the drill rig during well construction (duration approximately 1 month per well). Hospital grade mufflers will be included in the design.

C.2.25.21.3 EJ Light Pollution

The light pollution concern includes light pollution at pump stations and ASR wells at night in an otherwise dark landscape. ASR systems and pump stations will be designed to have a minimum number of fully shielded LEDs for exterior lighting. Floodlights used for security during construction will be minimized. The Recommended Plan will have minor effects after minimizing light type, number, direction of orientation, and location compared to residential areas.

C.2.25.21.4 EJ Air Quality

The air quality concern includes pollutants and smog in the air near the local community and the STOF's Brighton Reservation from pump station and ASR use. The ASR system is powered by electricity (no diesel engines), so has no local air quality impacts. The Recommended Plan will have minor, short-term adverse effect in direct emissions from the construction of project features (exhaust emissions of labor transport equipment, and construction equipment (dump trucks, excavators, graders, bulldozers, etc.). The Recommended Plan will have long term, minor, localized adverse effects in air quality from pump stations and ASR wells (1 pump station, 80 ASR wells).

C.2.25.21.5 EJ Wetlands

The wetland concern includes the loss of wetlands in the WAF footprint. While the majority of the WAF is improved and unimproved pastures, there are some wetlands in the footprint that will be removed in the construction of the WAF. **Table C.2-31** shows the acres of wetland in the WAF footprint. While these wetlands will be lost, the Recommended Plan also includes the restoration of the Kissimmee River–Center wetland and the Paradise Run wetland. This wetland alternative restores 4,779 acres of wetlands along the Kissimmee River floodplain. The WAF footprint may provide wetland habitat that can tolerate 0-4 ft.

of water. The Recommended Plan increases the acreage and quality of wetlands in the project area (**Table C.2-32**).

C.2.25.21.6 EJ Cultural and Historic Resources – Kissimmee Circle Earthworks

The Kissimmee Circle Earthworks site (8GL39), which is adjacent to the Recommended Plan, will likely be eligible for listing in the National Register of Historic Places (NRHP). To avoid impacting this site, the WAF boundary was relocated to avoid adverse effect to this site.

C.2.25.21.7 EJ Cultural and Historic Resources – Burial Resources

Potential prehistoric burial resources have been reported within the Recommended Plan footprint. The STOF have expressed concerns that burial resources could be inundated by the construction of the WAF or impacted by wetland restoration. Burial resources are highly likely to be present in mounds and earthwork sites throughout the region. There is also some potential for mortuary ponds (cemeteries) that could be located within one or more ponds within the project boundary. Burials can also be found associated with traditional pre-contact archaeological sites. Burial resource patterns are likely to reflect the demographics of pre-contact Native American demographics and cluster near ceremonial/ ritual areas. Areas with dense pre-contact populations are more likely to contain more burial resources while low density and or nomadic human populations are likely to produce fewer burial resources. There is also a potential for remnant tree islands to be located within the WAF footprint. Similar topographic features are located within the adjacent Brighton Reservation. The Recommended Plan is adjacent to the Kissimmee Circle Earthworks and which has a high potential for the presence of burial resources.

If burials are identified during the project the procedures stipulated within the Burial Resource Agreement (BRA) between the STOF and SAJ will ensure meaningful consultation with respect to burial resources. Although not signatories of the Burial Resources Agreement, the presence of burial resources will also require consultation with the Miccosukee Tribe of Indians of Florida and other appropriate federally recognized Tribes pursuant to Section 106 of the NHPA, the USACE Trust Responsibility, and other federal regulations, executive orders, and departmental policies, including the 2008 CERP Policy on Human Remains. There is a high potential for the presence of burial resources at 8GL77 which is located within the WAF in the Recommended Plan. One previously identified site with reported burial resources 8GL72, was identified within the Paradise Run wetland restoration site. Additional cultural resource investigations will be required during design to identify additional historic properties and burial resources.

C.2.25.21.8 EJ Cultural and Historic Resources – NRHP Eligible Sites

Archaeological sites are present in the Recommended Plan; archaeological survey data is limited in this area. There is one previously identified archaeological site (8GL77) which has been formally evaluated and is eligible for listing in the NRHP. The USACE conducted a Cultural Resource Assessment Survey (CRAS) of portions of SFWMD-owned lands located within the WAF footprint and identified two new archaeological sites that are potentially eligible for listing in the NRHP (8GL494 and 8GL495). The investigation also identified two cultural sites within the Paradise Run wetland restoration area (8GL496 and 8OB365). In the Recommended Plan, additional archaeological investigations will be required during PED to identify archaeological sites within areas that have not been surveyed, and evaluate the NRHP eligibility of all identified archaeological sites which may be impacted by the project.

C.2.25.21.9 EJ Cultural and Historic Resources – Impacts to Traditional Cultural Properties

The concern is there are traditional cultural properties (TCP) that may be eligible for inclusion in the NRHP based on associations with cultural practices, traditions, beliefs, ways of life, arts, crafts, or social institutions of a living community including the STOF and MTIF in the project area. The close proximity of the Recommended Plan to the Brighton Reservation may increase the potential likelihood of the presence of TCPs. National Register Bulletin 38 describes traditional cultural properties as properties that are eligible for inclusion in the NRHP because of their association with cultural practices or beliefs of a living community that is rooted in that community's history, and is important in maintaining the continuing cultural identity of the community (Parker and King 1998). While there is an increased chance of TCPs within the Recommended Plan due to the proximity of Brighton Reservation, the presence of private property around the reservation is likely to limit STOF access to these areas. A TCP must meet specifically defined criteria and any potential TCPs identified within the Recommended Plan will require evaluation and consultation. At this time, there are no known TCPs located within the Recommended Plan. TCPs are frequently identified and evaluated through ethnographic investigations and such a study may be needed during PED.

C.2.25.21.10 EJ Economics – Displacement of Endangered Species

The concern is displacement of species from project footprints to adjacent lands that could increase ESA compliance costs and limit the range of economic activities on lands. Of the number of species identified in the ESA species list (**Annex A**), the best candidate for dispersal is northern crested caracara and the Eastern indigo snake. For the Recommended Plan, species assessments on the project footprint will be required to determine the abundance of threatened and endangered species. Upland species could be planted next to the WAF and the restored wetland sites to replace upland habitat that is affected by project. USFWS can coordinate with the STOF to develop safe harbor agreements that ensures STOF can still pursue economic activities and traditional practices on their land.

C.2.25.21.11 Economics – Water Supply Entitlement

The concern is losing access and volume of water that the STOF has reserved as part of three party water compact. The Seminole Tribe of Florida has surface water entitlement rights pursuant to the 1987 Water Rights Compact and subsequent entitlement provisions executed between the Seminole Tribe of Florida, the State of Florida, and the SFWMD. Impacts are not expected for the LOWRP Recommended Plan based on the hydrologic modeling. Based on LOWRP modeling, the percentage of water supply demand not met for the Brighton Reservation is shown to be slightly reduced in the Recommended Plan compared to the FWO (**Figure C.2-93**). The percentage of water supply demand not met for the Recommended Plan (Alt 1BWR) is 2.6% compared to 3.3% in the FWO condition.

C.2.25.21.12 EJ Economics – Water Supply Entitlement

The concern is for existing users of Lake Okeechobee and other surface and ground water sources to maintain existing permitted withdrawals. The Recommended Plan improves water supply for existing legal users in LOSA compared the future without project (FWO). For the eight years with the largest water supply cutbacks within the LOSA, the water supply cutback percentage is reduced for seven of the eight years, compared to the FWO (**Figure C.2-91**). Based on the LOWRP modeling assumptions and the resulting moderate stage increase within Lake Okeechobee, the average annual percentage of water supply demand not met is projected to decrease in LOSA including the EAA (**Figure C.2-92**). The

Recommended Plan improves or maintain water supply compared to the FWO condition. In the EAA the Recommended Plan (Alt 1BWR) reduces the percentage of unmet demands to 5%, down from 6% in the FWO condition (**Figure C.2-92**).

C.2.25.21.13 EJ Economics – Ranching Impacts

The concern is impacts to ranching due to seepage and potential dam break due to aboveground storage. For the Recommended Plan a seepage canal will be designed to limit seepage outside the WAF and there will be no discernible impact to ranching from seepage. Groundwater effects will be modeled during PED. SAJ performed a Potential Failure Mode Analysis (PFMA) and Qualitative Risk Assessment on the conceptual design of the WAF. The risk assessment judged that the WAF would likely be below the societal tolerable risk guideline (defined in ER 1110-2-1156) assuming further refinement of the design concepts and construction of the WAF is completed in accordance with current dam safety standards. Additional information can be found in the Engineering Appendix. Additional risk assessments will be performed during PED and construction.

C.2.25.21.14 EJ Economics – Restricted Drainage of Brighton Reservation

The concern is that the aboveground storage features will restrict drainage patterns on the Brighton Reservation. Reservoirs could block drainage canals near the perimeter of project and plugged drainage could cause flooding on adjacent STOF lands if not avoided and minimized. The design of WAF will maintain existing drainage patterns outside the WAF. Existing drainage patterns outside of WAF footprints will be maintained as part of savings clause analysis.

C.2.25.21.15 EJ Health – Water Supply Well Contamination

The concern is with ASR water mixing in with water used for water supply bringing up drinking water concerns, especially with sources of drinking water that are in closer to proximity to the ASR wells than the general population. Since there are unknown effects on the environment from the ASR, these uncertainties have the potential to impact drinking water supplies, as well as traditional drinking water practices in the vicinity of the ASR wells. Drinking water supply is obtained from the surficial aquifer (land surface to 170 ft. below land surface) in the project area. The ASR storage zone is 550 ft to 1100 ft below land surface in the project area. The surficial aquifer and ASR storage zone are separated by approximately 330 ft. of Hawthorn Group sands and clays, which form the intermediate confining unit. There is no possibility that the groundwater in the ASR storage zone will contaminate the surficial aquifer during normal ASR operations. FDEP UIC permitting process requires that ASR systems will not impact existing users. All alternatives will not affect drinking water.

C.2.25.21.16 EJ Health – Fish and Wildlife (Food) Contamination

The concern is mercury bioaccumulation in fish and wildlife due to ASR storage. Earlier studies have shown that mercury methylation does not occur during ASR storage in the UFA. Earlier testing shows that mercury concentrations are lower in recovered water than in recharge water. Sulfate in recovered water has a low to moderate risk of enhancing mercury methylation in downstream sediments. ASR system operation can be performed to minimize sulfate in recovered water and mercury and sulfate concentration analysis in test wells will be done during design. The Recommended Plan will not affect fish and wildlife (food) contamination.

C.2.25.21.17 EJ Health – Dam Breach Impacting Property and Life

The concern is the impact to life and property in the event of a dam breach in the aboveground storage features. Deep reservoirs that were determined to be close to or over tolerable risk limits for dam breach consequences were removed from the final array. Formal dam safety risk assessments were not performed at this stage of the planning process. However, a desktop evaluation indicates that the Recommended Plan is well within tolerable risk limit guidelines.

C.2.25.21.18 EJ Cultural Practices – Access to Sacred/Ceremonial Sites

The concern is that access to sacred/ceremonial sites will be impacted by the project. At this time the majority of project lands are under private ownership and access may currently be restricted. An ethnographic study on what and where sacred ceremonial sites are located is currently being conducted in order to identify the sites and the potential impact. D

C.2.25.21.19 EJ Cultural Practices – Hunting and Fishing Impacts

The concern is that traditional hunting and fishing grounds will be impacted by the project. The WAF will limit habitat for upland species. WAFs and restored wetland sites will increase fishing opportunities in the project area. Waterfowl hunting will likely increase in the WAF and wetlands as well. The Recommended Plan has the potential to increase fishing due to increased access to wetland restoration sites and the WAF. The Recommended Plan has the potential to negatively impact fishing due to impingement of larval fish at WAF and ASR wells. However, this impact can be mitigated by location of pump stations, distance from Lake Okeechobee and the Kissimmee River, operations and installment of screens. The Recommended Plan will reduce upland game species on those lands (that are mostly private and probably not open to the public for hunting), but may increase game species on surrounding properties. The Recommended Plan contains approximately 14,493 acres of upland habitat. This represents a potential loss to hunting if there is current access to these properties. However, there is a potential increase to hunting if upland species are relocating to different areas due to habitat loss in WAF and wetland site footprints.

C.2.25.21.20 Summary of EJ Effects and Determination

The LOWRP Recommended Plan would provide benefits to quality of life by improving Lake Okeechobee ecology, improving the estuarine environment and contribute to hydrological improvements in the historic Everglades. These wetland and estuarine habitat improvements would benefits fish and wildlife species abundance for recreation and subsistence fishing/hunting, as well as aesthetic existence value. In addition, the project would have incidental water supply improvements by minimizing the number and severity of Lake Okeechobee Service Area cutbacks.

Several EJ communities were identified in the project area as having a potential to be affected. Low-income communities located west of the Kissimmee River and surrounding Lake Okeechobee have income significantly lower than state/national averages and unemployment rates that are also higher than the state and national averages. Another EJ community that could be affected by the project is the STOF's Brighton Reservation, which represents Tribal National lands that are geographically fixed in position. Based on the above analysis, no disproportionately high and adverse impacts or benefits are imparted upon the STOF and/or lower income communities. Any remaining minimal impacts will be further avoided, minimized, and/or mitigated, as described above.

C.2.25.21.21 Cumulative Effects for EJ

Cumulative environmental justice effects are associated primarily with effects on public health and safety, air quality, traffic and noise, and socioeconomics from implementation of the LOWRP and other past, present and reasonably foreseeable actions. The timeframe will extend beyond the construction period indefinitely because impacts on socioeconomics and county revenues are long term and can continue to occur after construction. The LOWRP is expected to contribute to a net beneficial cumulative impact on the regional ecosystem and public health. While the spatial extent of natural plant communities would not be restored to historic proportions, the quality of vegetative communities would be improved and habitat improvement efforts are anticipated to benefit fish and wildlife resources. Cumulative effects to historic properties and culturally significant sites will potentially be long-term adverse effects if not avoided. Mitigation measures for effects to historic properties could potentially reduce the cumulative effect to minor long-term adverse effects. Mitigation measures for culturally significant sites are unknown. While anthropogenic effects on water quality are unlikely to be eliminated, water quality is expected to slowly improve over existing and recent past conditions. During detailed planning and design, the USACE and SFWMD are committed to ensuring that project feature implementation will not result in violations of water quality standards. While effects on water supplies are unlikely to improve, water supplies available for agricultural and urban users are expected to remain stable until additional storage mechanisms are implemented.

C.2.25.22 Cultural Resources

The project study area consists of the Lake Okeechobee Watershed and includes 5 sub-basins (totaling approximately 920,000 acres) within portions of Glades, Highlands, Okeechobee, St. Lucie, and Martin counties and the STOF's Brighton Reservation. The majority of the LOWRP project features are located within the Indian Prairie sub-basin, although there are proposed ASR wells located around Lake Okeechobee.

The LOWRP study area has been impacted by human agricultural activities for over a hundred years. A review of the FMSF indicate that there are previously recorded cultural resource sites and resource groups within the LOWRP study area that may be eligible for listing in the NRHP; however, the entire study area has not been subject to a systematic archaeological assessment. Three previous cultural resource investigations have been completed within portions of the areas the final array of alternatives.

In 2011, Wampler et al. (2011) completed a cultural resource survey within portions of Alternative 2Cr. This survey identified no new cultural resources within the surveyed portions of the alternative. However, an intensive cultural resource survey that was completed on property located adjacent to the 2Cr reservoir identified ten new archaeological sites, including six that were potentially eligible for listing on the NRHP (Ambrosino 2016). In 2009, Wayne and Dickinson (2009) completed a cultural resource reconnaissance survey of approximately 564 acres located entirely within Alternative 1 Bshlw. The investigation identified one new site. In 2014, Dunn (2014) completed a cultural resource investigation within portions of Alternative 1BW WAF. The investigation failed to identify any new cultural resources; however, one previously identified site 8GL77 was revisited and determined eligible for listing on the NRHP.

Due to the large area considered in the alternative, and the high probability of identifying properties eligible for inclusion in the NRHP within the LOWRP area of potential effects (APE), the USACE will employ a phased process in the identification and evaluation of historic properties and an assessment of effects

through the execution of a programmatic agreement (PA) as provided in 36 CFR § 800.4(b)(2). The PA was executed among the USACE, SHPO, and Advisory Council on Historic Preservation (ACHP) and outlines the process in which the USACE will identify historic properties within the APE, determine effects of the undertaking to historic properties if present, and avoid, minimize, or mitigate adverse effects during the PED phase. Pursuant to Section 106 of the NHPA, consultation on LOWRP and the execution of a PA was undertaken with the STOF's Tribal Historic Preservation Office (THPO), the MTIF NAGPRA Representative, the Florida SHPO, the Seminole Nation of Oklahoma THPO, the ACHP, the Thlopthlocco Tribal Town THPO, and the public.

Engineering Regulation (ER) 1105-2-100 Appendix C, paragraph C-4(d)(6)(a) states that results of cultural resources investigations conducted during the feasibility phase and if needed, the PED phase will "serve as the basis for formulation of plans for management of historic properties prior to or during the construction and operational stages of projects". At which time, as required under ER 1105-2-100 Appendix C, paragraph C-4 (d)(6)(b) the PED phase will be utilized to complete historic property inventories, seek determinations of eligibility for the NRHP, determine effects of the project to historic properties, determine the need to mitigate adverse project effects on National Register and eligible properties, develop plans and cost estimates for such mitigation, and serve as the basis for negotiation of a Memorandum of Agreement with the appropriate parties specifying actions which will be taken by the USACE prior to or during the project construction period to mitigate adverse effects on National Register and eligible properties.

Post project authorization, each suite of features in the Recommended Plan will be subject to separate consultation and consideration of effects during PED as the APE may be subject to change based on final designs or modifications of project features. As outlined in the PA, supplementary cultural resources assessments will be conducted in areas that have not been previously surveyed. During PED and prior to construction, these surveys and a final determination of effects for any historic properties within the APE will be coordinated with the appropriate interested parties. Pursuant to Section 106 of the National Historic Preservation Act (54 U.S.C. 306108), the project design would be modified to avoid impacting significant historic properties and culturally significant sites where possible.

Avoidance of adverse effects to cultural resources is the USACE preference, therefore, throughout the planning process for LOWRP, the project archaeologist, engineers, and plan formulators have worked closely to determine alternatives and features of alternatives that reduce or eliminate impacts to cultural resources. Where avoidance is not possible, other mitigation measures would be considered, which could include, but are not limited to, data recovery excavations. Mitigation measures would be developed in consultation with the SHPO, the ACHP, the appropriate federally recognized tribes, THPOs, and other interested parties as established in implementing regulations for Section 106 of the NHPA (36 CFR 800). This PIR/EIS meets cultural resources requirements as specified under NEPA. The LOWRP will remain in compliance with the NHPA pre and post construction.

C.2.25.22 Area of Potential Effect

The APE for cultural resources differs greatly from the overall LOWRP study area. For this project, the APE for cultural resources covers many of the same features in each alternative. The Paradise Run Wetland Restoration Area, Kissimmee Center Wetland Restoration Area, and nine of the ASR well clusters are nearly identical. The differences between the alternatives is the result of variations between the footprints of the different reservoir and wetland attenuation features and possible ASR well clusters that will be co-located within them. The location of the APE will continue to be refined during PED.

C.2.25.22.1 Evaluation Criteria Specific to Cultural Resources

Impacts to cultural resources vary by individual components within the alternatives. Therefore, impact evaluations were based on a review of the individual components of each Alternative to determine if actions would potentially result in impacts to significant cultural resources (which include sites eligible or potentially eligible for listing in the NRHP) described below. Throughout the development and selection of the components measures to eliminate or lessen adverse cultural resource effects were utilized.

The following significance thresholds have been used in determining whether components proposed for each Alternative would result in a significant impact to cultural resources. The use of the term cultural resources includes historic properties eligible or potentially eligible for listing in the NRHP and culturally significant sites. A cultural resource impact is considered significant if implementation of a component of an Alternative would result in any of the following when compared to FWO:

- Result in a change in the significance or NRHP eligibility of a historical property, including but not limited to any contributing elements.
- Disturb any human remains, including but not limited to those outside of formal cemeteries.*
- Disturb memorials determined to hold public significance regardless of age.
- Result in adverse changes to sites identified through consultation with Native American Tribes as having cultural significance.

* The Jacksonville District has implemented a Burial Resources Agreement (BRA) with the Seminole Tribe of Florida which serves as the basis for consultation regarding the presence of burial resources and sets forth procedures that will ensure the culturally sensitive treatment of burial resources pursuant to the USACE Trust Responsibility. The 2008 CERP Policy on Human Remains also applies to the current study and is only superseded by the BRA for consultation regarding burial resources with the STOF.

C.2.25.22.2 Comparison of Recommended Plan and FWO Conditions

The project schedule (**Section 6.7 and 6.11.2.3**) allows for a phased approach to Section 106 compliance, in that each suite of features will be consulted on as they arise. This will ensure that the most up to date information will be considered in the determination of effect. Also, based on final designs or modifications of the project features, additional work may be required for compliance with the NHPA. *While the USACE is currently in compliance with the procedural requirements of the NHPA through execution of a PA, the USACE recognizes that additional cultural resource surveys, NRHP evaluations, and determination of effects made in consultation with the SHPO, appropriate federally recognized tribes, and other interested parties will be required in PED.*

Based on the stipulations of the PA, consideration of effects and potential mitigation of effects will be finalized during PED; therefore the effects associated with each Alternative have only been preliminarily considered for this feasibility study. A final identification, evaluation of historic properties, and determination of effects, as required under Section 106 of the NHPA, will not be made until the project is authorized and project features are sited during the subsequent PED phase.

For each component discussion below, the environmental effect is determined when compared to the FWO conditions. *This is a preliminary review of potential effects of the undertaking and should not be considered final. For this document, the use of the term "cultural resources" includes significant historic*

*properties that are determined eligible or potentially eligible for NRHP listing and culturally significant sites. See **Section 10** in the Main Document for definitions of terms*.

C.2.25.22.2.1 Lake Okeechobee Watershed

For each project feature in the watershed, the environmental effect is determined when compared to the future without conditions.

C.2.25.22.2.1.1 Kissimmee River–Center (KRC)

The KRC wetland restoration area is located on the west bank of the C-38 canal and is approximately 1,200 acres in size. Plans call for placing a 100 cfs inflow pump in the C-38 canal to divert water into the wetland area. A channel will be dug in the approximate location of the historic Kissimmee River. l. Approximately 21,500 linear feet of silted channel will be excavated at various locations to clear the channel and reopen flow. The water will flow through this channel and reenter the C-38 canal through a culvert that will be placed at the southern end of the old channel. When water is available it will stage up and fill the entire wetland footprint. This flooding is intended to restore the wetlands to natural conditions. No cultural resource surveys have been completed and no known cultural resource sites have been identified within the KRC Wetland restoration area.

Anticipated ground disturbances include the construction of a new weir within the C-38 canal and the construction of a culvert at the southern end of the channel. No containment berm will be constructed around the wetlands to contain the water. The exact placement of the constructed features and associated access and work areas has not been determined. The removal of silt during this project will be confined to the old channel remnants as much as possible to minimize the impact to previously disturbed sediments. Some areas may require new excavations to connect isolated channel segments. Cultural resource surveys will be necessary in areas of proposed construction and adjacent to areas along restored river channels that may potentially be subject to heightened erosion from flooding caused through the restoration.

Additional cultural resource surveys and evaluations will be necessary, specifically during the detailed design phase for construction, when feature designs are finalized and construction staging areas determined.

C.2.25.22.2.1.2 Paradise Run (PR)

The PR wetland restoration area is approximately 4,100 acres located on the west bank of the C-38 canal between the Kissimmee River South and Buckhead Ridge. The wetland restoration requires the installation of a 200 cfs inflow pump, and three culverts for water inflow and release. Approximately 24,500 linear feet of remnant oxbow channel excavations will be excavated in locations where it has silted. The water will flow through the channel and reenter a canal at the southern end. Existing structures G-33 will be abandoned and G-34 will serve as an auxiliary outlet. The water will stage up and fill the entire wetland footprint when water is available. There are no perimeter berms.

Prior to this project, no cultural resource surveys have been conducted in the Paradise Run wetlands although five cultural sites had been previously recorded in this wetlands area (8GL72, 8GL492, 8OB360, 8OB361, and 8OB364). Based on this information, the USACE conducted a reconnaissance survey of within a 900-acre portion of the Paradise Run wetlands (Carlson and Barnett 2018). The survey identified three new cultural sites 8GL496, 8GL499, and 8OB365 within the Paradise Run wetlands and conducted

supplemental investigations at 8GL492. Based on consultation with the FLSHPO sites 8OB360, 8OB361 and 8GL499 are 20th century canals which are not eligible for listing on the NRHP. Sites 8GL72, 8GL492 8GL496, 8OB364, and 8OB365 are all potentially eligible for listing in the NRHP and require additional investigations to determine NRHP eligibility. Site 8GL72 is a prehistoric midden and burial mound site with reported burial resources. The site has reportedly been looted in the past.

Additional cultural resource surveys and evaluations will be necessary, specifically during the detailed design phase for construction, when feature designs are finalized and construction staging areas determined.

C.2.25.22.2.1.3 Wetland Attenuation Feature (WAF)

The WAF is located in the K05B footprint within the Indian Prairie sub-watershed west of the C-38 canal, north of SR 78, east of the STOF Brighton Reservation, and south of the C-41A canal. The K-05 WAF will have a perimeter embankment and internal embankments dividing the WAF into cells. The total area of the WAF is approximately 13,600 acres. A seepage canal will be constructed around the perimeter embankment. Structures will include a 1,600 cfs inflow pump station, two 100 cfs seepage pumps, spillways connecting each cell, and an outflow structure. There will be a building associated with each major structure. Toe roads, crest roads, and other connecting roads will provide vehicular access to each project feature. Toe roads will have small diameter circular HDPE culverts spaced at 500 to 1,500 ft. apart (based on local topography) to drain the area between the embankment and the toe road. Each of the three cells in the WAF has a different design water full elevation. The elevation was determined by taking the average of high and low elevations at the perimeter of each cell and adding four feet for the average water depth. The result was rounded to the nearest foot. The northern cell water elevation is 25.0 feet NAVD88. The center cell water elevation is 23.0 feet NAVD88. The southern cell water elevation is 20.0 feet NAVD 88.

The WAF is primarily used for surface water storage to attenuate peak flows into Lake Okeechobee from the Kissimmee River Basin. The secondary purpose is to encourage habitat utilization by maintaining water levels between 0.5 and 3 ft. during non-flow attenuation periods to encourage the growth of wetland vegetation within the WAF. Storage-assisted ASR wells will rehydrate habitat during dry times to ensure that wetland conditions are maintained within the WAF footprint. A pump station will be located downstream of the existing S-84 structure on the C-41A canal and will serve as the water source for the proposed WAF. The pump draws water from the downstream area that is considered to be part of Lake Okeechobee. The ASR wells that augment storage at the WAF will include the ASR wellhead structure and pumps, well piping, intake and release piping, concrete pad, and ancillary covered operational control panels. ASR wells are planned to be located in pairs, with one pad and control panel serving each pair of wells. ASR wells located in the watershed will include ASR wellhead structures and pumps, well piping, intake and release piping, concrete pad, and a single control building for ASR system operation.

The majority of Alternate 1BWR WAF has not been previously surveyed for cultural resources. In 2014, NRCS completed a reconnaissance survey of a portion of the area containing the WAF. This previous survey identified no new cultural sites; however, it did re-investigate previously identified site 8GL77 (Dunn 2014). This site, called the Mulberry Mound, is a Belle Glades period site with dense midden deposits. The limited investigation expanded the size of the original site and determined it is eligible for listing on the NRHP. The site also yielded a single human tooth and it is likely that Burial Resources are present in this site which would make it a culturally significant resource to the STOF and MTIF. Dunn (2014) defined the site boundaries based on topography rather than through subsurface investigations.

Additional investigations will be required to determine the vertical and horizontal extent of the site and to determine whether Burial Resources are present.

In support of this study, a CRAS of portions of the Alternative 1BWR study area was completed to identify historic and cultural sites within lands owned by the SFWMD. The survey consisted of a Phase I archaeological survey within portions of the proposed WAF footprint and reconnaissance level investigations within the Paradise Run wetland restoration area (Carlson and Barnett 2018). Pursuant to the Burial Resources Agreement, the CRAS methodology/approach was coordinated with the STOF's THPO on October 27, 2016. As a result of this survey two new Belle Glades period cultural resource sites 8GL494 and 8GL495 were identified within the Alternate 1BW WAF. Both sites 8GL494 and 8GL495 are considered potentially eligible for listing on the NRHP and will require Phase II evaluations for a final determination of eligibility for listing in the NRHP.

The results of the CRAS survey demonstrated that that additional surveys will be needed to identify and evaluate cultural resources within the remaining un-surveyed portions of the Recommended Plan. These surveys and evaluations will be necessary, specifically during the detailed design phase for construction, when feature designs are finalized and construction staging areas determined. Due to the lack of information about these known sites, Phase II Investigations are recommended at site 38GL77 to identify the boundaries of the site and to determine whether additional potential Burial Resources are present. Phase II investigations are also recommended for 8GL494 and 8GL495 to determine their eligibility for listing on the NHRP. Mitigation of effects for these sites are unknown at this time and will be determined through consultation with the SHPO, appropriate federally recognized tribes, and if necessary the ACHP, once the Phase II evaluations have been completed.

C.2.25.22.2.1.4 Aquifer Storage and Recovery Wells

A total of 80 ASR wells are proposed in 25 adjacent to the WAF and 55 in various locations throughout the watershed and around Lake Okeechobee. The number of wells in each location has not yet been determined.

Storage-assisted ASR Wells: Storage-assisted ASR wells are co-located within the WAF to increase the total storage capacity, with three well clusters (25 wells) co-located with the WAF. The ASR wells that augment storage at the WAF will include the ASR wellhead structure and pumps, well piping, intake and release piping, concrete pad, and ancillary covered operational control panels. ASR wells are planned to be located in pairs, with one pad and control panel serving each pair of wells. ASR wells located in the watershed will include ASR wellhead structures and pumps, well piping, intake and release piping, concrete pad, and a single control building for ASR system operation.

Watershed ASR wells: The remaining 55 ASR wells are located throughout the watershed.

- One proposed cluster is located adjacent to the C-44 canal in Port Mayaca. This would releaseflow out of the C-44 into Lake Okeechobee or to the St. Lucie River Estuary.
- Three potential cluster areas are located in the S-191 subwatershed. The wells will be adjacent to the L-63N, L-63S, or L-64 canals that can releaseflow to Lake Okeechobee.
- One cluster is located along Taylor Creek, downstream of S-192 and upstream of the S-133 pump station which releases to Lake Okeechobee.

- Two potential clusters are located adjacent to the C-38 canal downstream of S-65E that can release back into the C-38 canal.
- There is a well cluster along C-40 canal downstream of S-72 that can release to Lake Okeechobee.
- There is a well cluster along C-41 canal downstream of S-71 that can release to Lake Okeechobee.
- There is a well cluster along the C-43 canal in Moore Haven that can release to Lake Okeechobee or the Caloosahatchee River.

The footprint of each ASR well is approximately 3 acres in size. Additional cultural resource surveys and evaluations may be will be necessary at the final ASR locations, specifically during the detailed design phase for construction, when feature designs are finalized and construction staging areas determined In most instances the current ASR well locations are tentative and could be moved to avoid and minimize adverse effects to significant cultural resources.

C.2.25.22.2.2 Lake Okeechobee

There are no changes from the future without conditions for this component of LOWRP. Effects: There will be no adverse effect to cultural resources the Recommended Plan.

C.2.25.22.2.3 Northern Estuaries

This component of LOWRP proposes to redirect a percentage of water currently flowing from Lake Okeechobee into the eastern and western Northern Estuaries, south into the Miami Canal and the North New River Canal. Effects: This decrease of freshwater into the estuaries will have no effect to cultural resources for the Recommended Plan.

C.2.25.23 Invasive and Exotic Species

The Recommended Plan has the potential and likelihood for establishment and spread of non-native invasive and native nuisance species. Proposed restoration activities may affect ecosystem drivers that directly or indirectly influence the invasiveness of non-native species. These factors may affect invasive species positively or negatively, depending on the unique characteristics of individual species and the environmental conditions for a given biological invasion (Doren et al. 2009). For example, shortened surface water drawdowns may reduce the recolonization rates of melaleuca in marshes while increasing habitat suitability for Old World climbing fern in other areas. Many of the areas where features are proposed are currently inhabited by non-native invasive and native nuisance species. Construction of the proposed features has the potential to spread the existing non-native invasive and native nuisance species on site as well as introduce new invasive species via contaminated equipment. Disturbed areas resulting from construction are likely to become established with non-native invasive and native nuisance species. New flows created by operations of the proposed features may serve as vectors to spread invasive and native nuisance species into new areas. The large number of existing and potential invasive plant and animal species and the often-incomplete knowledge of invasive mechanisms for each species create moderate to high uncertainty in this evaluation. Long-term monitoring in an adaptive management framework is critical to ensure efficient management of the most threatening non-native invasive species in the restoration footprint.

C.2.25.23.1 Lake Okeechobee Watershed

The Recommended Plan has the potential and likelihood for increasing or decreasing the establishment and spread of non-native and native nuisance species. The establishment of both the WAF could potentially decrease terrestrial invasive species present however, the addition of the WAF will likely increase emergent and/or submersed non-native and potentially native nuisance species such as cattail. In addition, new flows created by the connecting the features could serve as pathways for new plant and animal non-native invasive species introductions.

C.2.25.23.2 Lake Okeechobee

The Recommended Plan has the potential and likelihood for increasing or decreasing the establishment and the spread of non-native and native nuisance species. Decreasing the duration of very low lake stages should reduce the spread of non-native invasive plants species such as torpedograss and melaleuca, and native nuisance species such as saltbush, willow, and wax myrtle. An increased duration of higher lake stages may increase the spread of some littoral zone non-native invasive species such as water lettuce and water hyacinth, and native nuisance species such as cattail and water lily. However, given the tendency the Recommended Plan to reduce lower lake stage frequency (<13.5 ft. NGVD), it is anticipated that there will be beneficial reductions in invasions from species like torpedograss, willow, saltbush, and wax myrtle, which should offset potential minor increases in species like cattail and water lily. Long-term monitoring and employing an adaptive management plan will help enable management of the non-native invasive and native nuisance species in the littoral zone.

C.2.25.23.3 Northern Estuaries

The Recommended Plan will reduce freshwater flows from Lake Okeechobee to the Northern Estuaries, allowing for slightly higher salinity levels to persist in the estuaries. The reduced freshwater outflows are not expected to have an impact on non-native invasive or native nuisance species. Existing invasive species under active management are expected to persist at baseline levels if current funding levels are sustained (e.g., melaleuca, lionfish). Existing species not under active management or which are ineffectively controlled are expected to increase in abundance and spatial extent (tropical American water grass). New invasions of non-native plant and animal species are expected but estimates of species number and severity of impacts are conjectural.

C.2.25.24 Effects of the Recommended Plan on Native Americans

The MTIF and the STOF rely upon the Everglades in its natural state to support their cultural, subsistence, and commercial activities. The STOF's Brighton Reservation lands are situated immediately adjacent to LOWRP project features. Subsistence activities for members of the both the MTIF and the STOF include gathering of materials, hunting, trapping, frogging, and fishing.

C.2.25.24.1 Miccosukee Tribe of Indians of Florida

General background information on the MTIF is provided in Section 2.6 Native Americans. No portion of the proposed action is located within or adjacent to known MTIF -owned lands, reservation lands, or Traditional Cultural Properties. Pursuant to Section 106 of the NHPA (54 U.S.C. §306101 et. seq.) and obligations regarding USACE Trust Responsibilities to federally recognized Native American Tribes, consultation with the MTIF is detailed in **Appendix C**, **Part 5**. Representatives for the MTIF have indicated

that they have significant concerns over the use of ASR wells for water storage for all alternatives under consideration.

The MTIF does not support ASR wells and desires alternatives that maximize the amount of aboveground storage without negatively impacting the STOF. The MTIF are concerned about the disproportionate impacts to both the Indian prairie and the MTIF. The MTIF prefer twice the area of surface water storage within reservoirs which are half the depth of those that were proposed by the USACE. The shallower depths are preferred to remove additional phosphorous from the water. Water quality is one of the highest priorities of MTIF concerns and they desire that water be treated to drinking water standards before injecting the water into the aquifer, and before discharging the water back to the surface. The MTIF prefer shallow storage alternatives that will do more to improve water quality. The MTIF have some concerns about the flushing effect associated with initially rehydrating the wetland restoration areas. The concern is primarily associated with water quality issues; however, the long-term improvements in environmental quality to the wetlands outweighs those concerns. The MTIF would like to see the restoration of as much naturally occurring wetlands as possible.

C.2.25.24.2 Seminole Tribe of Florida

General background information on the STOF is provided in Section 2.6. Portions of the proposed action are located adjacent to known STOF's Brighton Reservation lands. Pursuant to Section 106 of NHPA (54 U.S.C. §306101 et. seq.), obligations regarding USACE Trust Responsibilities to federally recognized Native American Tribes, and in consideration of the Burial Resources Agreement between the USACE and STOF, USACE has consulted with the STOF. The Seminole have provided comments during government-to-government consultation which are applicable to the entire project and comments that are specific to individual project features.

C.2.25.24.2.1 Paradise Run and Kissimmee River–Center Wetland Sites

The STOF leadership supports wetland restorations in in the proposed KRC and PR footprints. There may be potential adverse effects to cultural resources within the wetland restoration areas; however, these impacts will be avoided, minimized, and/or mitigated during the PED phase of this project. Additional cultural resource surveys of the wetland restoration areas will be necessary to identify and avoid impacting historic properties that are of importance to the STOF and MTIF.

C.2.25.24.2.2 ASR Wells

The STOF are concerned that the proximity of ASR wells and well clusters should be located outside the zone of influence of reservation lands so that STOFs groundwater resources on Brighton are not affected. The STOF are concerned about ASR well seal failure, failure in the associated confining layers which may impact STOF access to groundwater. Additionally, the STOF have questioned the impact of ASR well clusters on the quality of the underlying aquifer, and the quality of the water when it is returned to surface water systems. There is a potential to adversely affect cultural resources during ASR well construction; however, these impacts will be avoided, minimized, and mitigated during the PED phase of this project. Additional cultural resource surveys of the ASR well locations will be necessary to identify and avoid impacting historic properties that are of importance to the STOF and MTIF.

C.2.25.24.2.3 WAF

The STOF are concerned with the physical proximity of the WAF to the Brighton Reservation and tribal owned lands. Many of the concerns about potential effects to Native Americans that were provided by the STOF are greatly reduced in the Recommended Plan. Redesigns of this plan moved the WAF feature to a distance that is approximately 0.5 mile from Brighton Reservation and tribal owned lands. The relocation of this major feature and its corresponding reduction in the operationally maintained depth greatly reduced the volume of surface water for storage in the WAF. The increased distance from the Brighton Reservation and water depth reduces the impacts from seepage, flood risk, impact to the cultural landscape, and slightly reduces the probability of displacement of endangered species from the footprint of the WAF. The impacts to cultural resources appear potentially higher within this proposed alternative due to the potential presence of tree islands similar to those located on Brighton Reservation. Site 8GL77 (the Mulberry Mound site), has been determined eligible for listing in the NRHP. Site 8GL77 also has a high potential for containing burial resources. Two other cultural sites identified within the Alt 1BWR footprint (8GL494 and 8GL495) are both potentially eligible for listing in the NRHP and may impacted by this alternative if they are determined NRHP eligible. Alt 1BWR has a slightly elevated potential to contain additional sites in the southern part of the WAF. The close proximity of the Recommended Plan to the Brighton Reservation may increase the potential likelihood of the presence of TCPs. TCPs identified within the Recommended Plan will require evaluation and consultation. At this time, there are no known TCPs located within the Recommended Plan. The Recommended Plan was developed in consultation with the STOF leadership. Additional cultural resource surveys of the WAF will be necessary to identify and avoid impacting historic properties that are of importance to the STOF and MTIF. These impacts will be avoided, minimized, and mitigated during the PED phase of this project.

C.2.26 Cumulative Effects

Cumulative effects are defined in 40 CFR § 1508.7 as those effects that result from:

> *"…the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."*

Cumulative effects for the proposed action were assessed in accordance with guidance provided by the President's Council on Environmental Quality (CEQ). The primary goal of cumulative effects analysis is to determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative effects of other past, present, and future actions. The following summarizes past, present, and projected USACE efforts that cumulatively affect the regional environment of south Florida (**Table C.2-50**). In addition, there are efforts underway by other federal, state, and local agencies, as well as non-governmental organizations, that are too numerous to mention, that are all working towards similar restoration goals. **Table C.2-52** shows the net cumulative effects of the various resources which are directly or indirectly impacted. The LOWRP is expected to contribute to a net beneficial cumulative impact on the regional ecosystem.

C.2.27 Past, Present, and Reasonably Foreseeable Actions Affecting Resources within the Project Area

This section presents the past, present and foreseeable actions within the project area.

Table C.2-50. Past, Present, and Reasonably Foreseeable Actions and Plans Affecting the Action Area.

	Past Actions/Authorized Plans	Current Actions and Operating Plans	Reasonably Foreseeable Future Actions and Plans
Status of Non-CERP Projects	- C&SF Project (1948) - ENP Protection and Expansion Act (1989) - MWD GDM and Final EIS (1992) - C-111 South Dade GRR (1994)	- MWD 8.5 SMA GRR (2000) - MWD Tamiami Trail Modifications Limited Reevaluation Report (2008) - C&SF C-51 West End Flood Control Project - Kissimmee River Restoration - Seepage Barrier near the L-31 N Levee (Miami-Dade Limestone Products Association) - Tamiami Trail Modifications Next Steps (TTMNS) Project - SFWMD Florida Bay Initiatives - C-111 South Dade Project (Contracts 8, 8A, and 9)	- The state of Florida has water quality programs like BMAPs that are intended to improve water quality - MWD Closeout - NRCS wetland reserve projects - State dispersed water projects

	Past Actions/Authorized Plans	Current Actions and Operating Plans	Reasonably Foreseeable Future Actions and Plans
Operations Plan for Lake Okeechobee, WCA 3A, ENP and the SDCS	- Water Supply and Environment (WSE) Lake Okeechobee Regulation Schedule (2000) - IOP 2002 to Present	- Lake Okeechobee Regulation Schedule (2008 LORS) - SFWMD LEC Regional Water Supply Plan - Everglades Restoration Transition Plan (ERTP) October 2012 to present; deviation includes Increment 1 and Increment 1.1 and 1.2 and 2.0 Operational Strategies - Herbert Hoover Dike Dam Safety Modification Study (HHD DSMS) risk reduction measures (2011 through 2025)	- LORS 2008 to be replaced by Lake Okeechobee System Operation Manual (LOSOM) anticipated in 2022 after completion of HHD rehabilitation - SFWMD periodically revises the LEC Regional Water Supply Interim Plan - ERTP to be replaced by COP to be anticipated 2020 to include MWD and C-111 components.

	Past Actions/Authorized Plans	Current Actions and Operating Plans	Reasonably Foreseeable Future Actions and Plans
CERP Projects		*Congressional Authorization Received*: - Broward County Water Preserve Areas Project C-9 Impoundment and SMA - Caloosahatchee River (C-43) West Basin Storage Reservoir - Central Everglades Planning Projects PPA North and PPA New Water - Everglades Agricultural Area Storage Reservoir and Stormwater Treatment Area *Congressional Authorization Received and Construction in Progress:* - Indian River Lagoon-South Project - Picayune Strand Restoration Project - Site 1 Impoundment Project - Biscayne Bay Coastal Wetlands Project - C-111 Spreader Canal Western Project (operated by SFWMD) - Broward County Water Preserve Areas Project C-11 Impoundment - CEPP PPA South, including USDOI removal of portions of the old Tamiami Trail roadway and SFWMD construction of the increased S-333 structure	- Future CERP Projects (Lake Okeechobee Watershed Restoration Project, Western Everglades Restoration Project - CERP LORS (Component F) upon completion of north and south of lake storage features

Prior to drainage and compartmentalization, the Everglades were a shallow wetland conveying water from Lake Okeechobee to the southern coast of Florida. The Everglades Drainage District, encompassing 7,150 square miles, was created in 1907 by Florida Governor Napoleon Bonaparte Broward for the purpose of drainage and reclamation of the Everglades (Light and Dineen 1994). In the early 1900s, the Everglades Drainage District constructed several canals that impacted Lake Okeechobee and the Greater Everglades. By 1917, the West Palm Beach, Hillsboro, North New River, and Miami canals had been constructed (Allison et al., 1948). By 1931, the outlet from Lake Okeechobee to the Caloosahatchee River was improved, and the completion of the St. Lucie Canal east to the Atlantic Ocean provided another way of

controlling lake levels. The Bolles and Cross canals became connectors to the four major canals south of Lake Okeechobee bringing the total miles of canal excavated to 440 (Light and Dineen 1994). The Everglades Drainage District also constructed 47 miles of levees around the southern rim of Lake Okeechobee during this time (Allison et al., 1948). Within a similar time frame (1915-1928) the construction of Tamiami Trail was completed which linked Miami with Naples on the west coast. Hurricanes in 1926 and 1928 shifted attention from Everglades drainage to controlling flooding around Lake Okeechobee. In 1930, the USACE became a major participant with the state (Okeechobee Flood Control District) in controlling flooding around Lake Okeechobee. Florida agreed to share a portion of the costs to increase flows from the lake, improve canal works, and reconstruct and enlarge the levees around it (Light and Dineen 1994). The effect of levees on the agricultural area south of Lake Okeechobee was dramatic and sugarcane production was doubled in 10 years between 1931 and 1941. Drainage of the Everglades and the linkage of the east and west coast, promoted urban growth in south Florida and the population escalated from 22,961 in 1900 to 228,454 by 1930 (Dietrich 1978). During the 1930s and into the 1940s, construction was abandoned and maintenance ceased on Everglades Drainage District works (Light and Dineen 1994).

Although modifications to Lake Okeechobee and the Everglades began in the early 1900s, the greatest influence on the alteration of flow was the Central and Southern (C&SF) Flood Control project, which was originally authorized by Congress in 1948. The C&SF Flood Control project was designed to lower water levels east of the eastern protective levee by 4 to 5 feet (Light and Dineen 1994). Increased flood protection coupled with lowering of the water table east of the levee had a dramatic effect on urbanization and development and acted as a catalyst for a population explosion in south Florida. Between 1952 and 1954 the eastern perimeter levee along the WCAs was constructed from Palm Beach to Dade County in order to stop sheet flow from the Everglades toward the urbanizing eastern coastal areas (Light and Dineen 1994). Between 1954 and 1959 additional levees (L-1–L-7) were constructed to partition the EAA from the remainder of the Everglades, and the old Everglades Drainage District canals (West Palm Beach, Hillsboro, North New River, and Miami) were deepened within the EAA to provide better flood conveyance from the agricultural area into the WCAs (Light and Dineen 1994).

Between 1960 to 1963 substantial portions of the C&SF Flood Control project were completed. Construction of the levees surrounding WCA 3 was completed by 1963 with the L-67A levee dividing WCA 3 into two compartments, WCA 3A and WCA 3B (Light and Dineen 1994). The L-67A levee (completed 1962) and the parallel L-67C levee (completed 1966) were originally constructed for several reasons, including as a step-down system to reduce seepage to the east to allow for urban and agricultural developments in Miami-Dade County, and to increase storage of water in WCA 3A to provide water supply to an expanding urban population to the east. S-151 and S-31 were also constructed during this time period. These two structures improved the release capacity of the Miami Canal to coastal communities (Cooper and Roy, 1991), further exacerbating the unnatural drainage of northern WCA 3A. In an attempt to remedy excessive drainage caused by the Miami Canal, two structures, S-339 and S-340, were built across the Miami Canal in 1980 to block water from flowing directly down the canal, except at times of extreme high water or when increased conveyance capacity is needed to deliver water for the ENP and/or the LEC. Upstream from each structure, water was expected to flow laterally from the canal into the marsh through 100-foot gaps that had been left at 500-foot intervals along the Miami Canal sidecast spoil material. In combination with the northern levees of WCA 3A (L-4 and L-5), the Miami Canal has substantially impacted historical sheetflow and natural wetland hydroperiods. As a result, during wet periods, the natural capability of WCA 3A to store water is lost and the Miami Canal effectively over-drains the area. These hydrologic changes have increased the frequency of severe peat fires and have also resulted in the loss of ridge and slough topography that was once characteristic of the area. Northern

WCA 3A has become largely dominated by sawgrass, cattail and scattered shrubs and lacks the structural diversity of plant communities seen in central and western WCA 3A.

Completion of the L-29 levee in 1962 led to ponding in the southern portions of WCA 3A. Exacerbating this problem were the major canal systems (i.e., Miami Canal, L-67A) which accelerate the flow of water from north to south within WCA 3A, drying the north while further ponding the south (Zaffke 1983), especially along the L-67A and L-29. As a result of this ponding, extended hydroperiods and increased water depths led to changes in vegetation communities in which wet prairies were displaced by aquatic slough communities (Zaffke 1983, Tanner et al. 1987). In addition, many tree islands within southern WCA 3A were lost due to increased water depths (Craighead 1971), with many of the remaining islands showing signs of stress. Wood and Tanner (1990) documented the trend in southern WCA 3A toward deep water lily dominated sloughs due to impoundment within the southern end of WCA 3A.

Four control structures located along the L-29 were constructed between 1960 and 1963 (S-12A, S-12B, S-12C, and S-12 D). These structures were used to regulate release from WCA 3A to the western part of Shark River Slough (Light and Dineen 1994). Construction of the L-67 Extension levee, extending 8 miles south of Tamiami Trail, was completed in 1967 in order to facilitate water delivery from WCA 3A to ENP. Completion of the L-67A and L-67C canal and levee system intercepted water that would otherwise flow to WCA 3B. With its impoundment, WCA 3B became isolated from the rest of the Everglades with inflows and outflows limited to rainfall and levee seepage. Within WCA 3B, the ridge and slough landscape has become severely compromised by the virtual elimination of overland sheetflow and has largely turned into a sawgrass monoculture where relatively few sloughs or tree islands remain. Loss of sheetflow to WCA 3B has also accelerated soil loss reducing elevations of the remaining tree islands in WCA 3B, making them vulnerable to high water stages. With the construction of WCA 3A, WCA 3B and the L-67 Extension Levee, flows to ENP became subject to water supply deficits during the dry season and excesses during the wet season, resulting in a decline in ecological quality.

Among the first congressional actions to offset adverse impacts to ENP by improving the supply and distribution of water, the Flood Control Act of 1968 provided for modifications to the C&SF Project through the implementation of the ENP South Dade Conveyance System (SDCS). Additional congressional actions ensued, including the ENP Protection and Expansion Act of 1989, which expanded ENP to incorporate NESRS and the East Everglades into the Park's boundary for protection and restoration of the natural hydrologic conditions within ENP. This Act also provided authorization for development of the Modified Water Deliveries (MWD) to ENP project. The goal of the MWD Project was to improve water deliveries into ENP and, to the extent practicable, take steps to restore the natural hydrologic conditions within ENP. The Water Resources Development Act (WRDA) of 2000 established CERP to provide for the restoration, protection, and preservation of the water resources of central and southern Florida, including the Everglades and Florida Bay (USACE 1999).

The CERP contains 68 components that include approximately 217,000 acres of new reservoirs and wetlands-based water treatment areas. A number of operational components have also been identified in CERP and will, in most cases, occur in conjunction with related construction features. The operational features in CERP include: a modified Lake Okeechobee regulation schedule; environmental water supply deliveries to the Caloosahatchee and St. Lucie estuaries; modifications to the regulation schedules for WCAs 2A, 2B, 3A, 3B, and the current rainfall delivery formula for ENP to implement rain-driven operations; modified Holey Land Wildlife Management Area Operation Plan; Modified Rotenberger Wildlife Management Area Operations Plan; a modification for coastal well field operations in the Lower

East Coast (LEC); LEC utility water conservation; and operational modifications to the southern portion of L-31 and C-111.

The CERP projects would increase the supply of freshwater for the Everglades and south Florida ecosystem. Large areas within the study area would be used to increase water storage resulting from CERP Projects for the overall gain and long-term benefit of the regional system. These project features would provide important storage functions and are essential to the overall restoration of the freshwater marshes and the estuaries of the greater Everglades ecosystem. Project components in the area, especially storage, seepage control, and redirection of point source canal flows to overland flow will act to restore more natural freshwater flows to the northern and southern estuaries, reduce seepage losses from the Everglades, improve recharge of the Biscayne aquifer, and should result in other beneficial environmental effects.

Construction has begun on the first generation of the CERP project modifications already authorized by Congress. These include the Indian River Lagoon-South Project, the Picayune Strand Restoration Project, and the Site 1 Impoundment Project. The second generation of CERP projects authorized by Congress includes the Biscayne Bay Coastal Wetlands Project, Broward County Water Preserve Areas Project, the Caloosahatchee River (C-43) West Basin Storage Reservoir, the C-111 Spreader Canal Western Project and the Central Everglades Planning Project. Several of these projects are under construction and all of these projects will result in significant environmental benefits to the CERP project area, improving the quantity, quality, timing, and delivery of water to the natural system. Further information on the above-mentioned CERP projects assumed to be in the future without project conditions are provided in **Section 2** and **Appendix C, Part 1** (Existing and Future Without Project Conditions).

Non-CERP projects assumed to be in the future without project condition for LOWRP, which incorporate similar restoration goals of improving flow and water quality to the Everglades, include the Department of Interior (DOI) Tamiami Trail Modifications Next Steps (TTMNS) Project and the Restoration Strategies Regional Water Quality Preliminary Plan (SFWMD 2012). The DOI through the NPS and ENP completed a study to evaluate the feasibility of additional Tamiami Trail bridge length, beyond that to be constructed pursuant to the MWD Project, to restore more natural water flow to ENP and Florida Bay and for the purpose of restoring habitat within the ENP. The TTMNS project was authorized by Congress in the Consolidated Appropriations Act, 2012. The Restoration Strategies Regional Water Quality Preliminary Plan describes resulting projects developed to address water quality concerns associated with existing flows to the Everglades Protection Area to achieve water quality standards established for the Everglades. The SFWMD is implementing a technical plan to complete six projects that will create more than 6,500 acres of new STAs and 110,000 acre-feet of additional water storage through construction of FEBs.

The C&SF Flood Control project has numerous water management structures consisting of culverts, spillways, and pump stations that have specified operating criteria for managing or regulating water levels for congressionally authorized project purposes. Regulation schedules have been, and will continue to be, designed to balance multiple, and often competing, project purposes and objectives. Managing for better performance of one objective often lessens the effectiveness of performance of competing objectives. For example, for Lake Okeechobee, higher regulation schedules tend to benefit water supply, but may increase the risk to public health and safety, and can harm the ecology of the lake. By contrast, lower lake schedules may produce lake levels more desirable for the lake ecology and improved flood protection, but reduce water supply potential.

Since April 2008, Lake Okeechobee has been operated in accordance with the 2008 Lake Okeechobee Regulation Schedule (2008 LORS). Prior to the 2008 LORS, Lake Okeechobee operations were managed under the "Water Supply and Environment (WSE) Regulation Schedule" since July 2000. The 2008 LORS operational study was initiated to address high lake levels, high estuarine flows, estuary ecosystem conditions, and lake ecology conditions that occurred during the 2003 to 2005 time period. The study considered the back-to-back historically significant 2004 and 2005 hurricane seasons' effects on the recognized structural integrity issues of HHD along with effects to other project purposes. The 2008 LORS was identified to be effective at decreasing the risk to public health and safety, reducing the number of high-volume flows to the estuaries, and providing critical flexibility to perform water management operations. When it was approved, LORS 2008 was identified as an interim schedule. The USACE expected to operate under the interim schedule until the earlier of (1) implementation of a new Lake Okeechobee schedule as a component of the system-wide operations to accommodate early CERP projects (Band 1 projects) or (2) completion of the modifications to HHD.

The CERP identifies storage north, south, east, and west of Lake Okeechobee that work together to achieve beneficial ecological effects. These complete storage components are critical to the overall success of the CERP and other CERP components. The combination of these storage features with other CERP components provide synergy in achieving Everglades restoration. The previously authorized projects are components that were identified in the CERP and are being implemented incrementally over time consistent with the Integrated Delivery Schedule, reducing the risks and uncertainties associated with project planning and implementation.

For the LOWRP FWO condition, other CERP and non-CERP projects that improve the condition of Lake Okeechobee that have been authorized, are under construction, or are completed, are assumed to be in place. Perhaps the largest and most important reasonably foreseeable future actions not accounted for in the FWO condition is the ongoing feasibility level study for the SFWMD EAA Storage Reservoir and STA. The EAA Storage Reservoir and STA was completed in March 2018 and congressional authorization was received in October 2018.

The EAA Storage Reservoir and STA proposes to increase the amount of water storage and treatment in the currently authorized CEPP plan. The CEPP provided the first increment of restoration of the central Everglades by reducing some of the high flows to the Northern Estuaries and providing an average of approximately 210,000 ac-ft per year of additional flow into the central portion of the Everglades. The EAA Storage Reservoir and STA is a 240,000 ac-ft reservoir with multi-purpose operational flexibility, 6,500-acre STA, and conveyance improvements would beneficially affect more than 1.5 million acres in the St. Lucie and Caloosahatchee estuaries, WCA 31, WCA 3B, ENP, and Florida Bay.

The EAA Storage Reservoir and STA would increase CEPP flows to the central portion of the Everglades from an average annual of approximately 210,000 ac-ft to 370,000 ac-ft. Similar to the LOWRP objectives, one of the primary purposes of the EAA Storage Reservoir and STA is to further reduce the number, return frequency and severity of high-volume flows from Lake Okeechobee, improving salinity and water quality conditions in the Northern Estuaries. High-flows lasting more than 60 days in the Caloosahatchee Estuary or more than 42 days in the St. Lucie Estuary have been found to be particularly degrading to the oyster populations. The EAA Storage Reservoir and STA would reduce high-flows to the Northern Estuaries, lasting more than 60 days to the Caloosahatchee Estuary by 40% and would provide a 55% reduction in high-flows lasting more than 42 days in the St. Lucie Estuary, in addition to the benefits provided by the previously authorized projects. Salinity conditions in the estuaries would also be improved by reducing

the number of Lake Okeechobee events that exceed the preferred salinity envelope by 45% in the Caloosahatchee Estuary and 39% in the St. Lucie Estuary.

The LOWRP Recommended Plan, EAA Storage Reservoir and STA and other authorized projects complement each other to improve conditions in Lake Okeechobee and Northern Estuaries. To demonstrate this, a LOWRP sensitivity analysis was conducted with and STA to determine additional Lake Okeechobee and northern estuary benefits. The CERP goal is relative to the Pre-CERP Baseline (PCB) conditions. From an effectiveness standpoint, the LOWRP Recommended Plan with the EAA Storage Reservoir and STA, as defined above, is very close to achieving the total CERP goal in reducing the volumes of high-flows to the Northern Estuaries (**Figure C.2-96**). The CERP goal is met for reduction in number of high flows from Lake Okeechobee to the Northern Estuaries flows when the LOWRP Recommended Plan and EAA Storage Reservoir and STA are combined. Additionally, the two projects meet the CERP goal for lake-weighted improvements of Lake Okeechobee. Effectiveness of the LOWRP Recommended Plan with the EAA Storage Reservoir and STA towards the CERP goal is summarized in **Table C.2-51**.

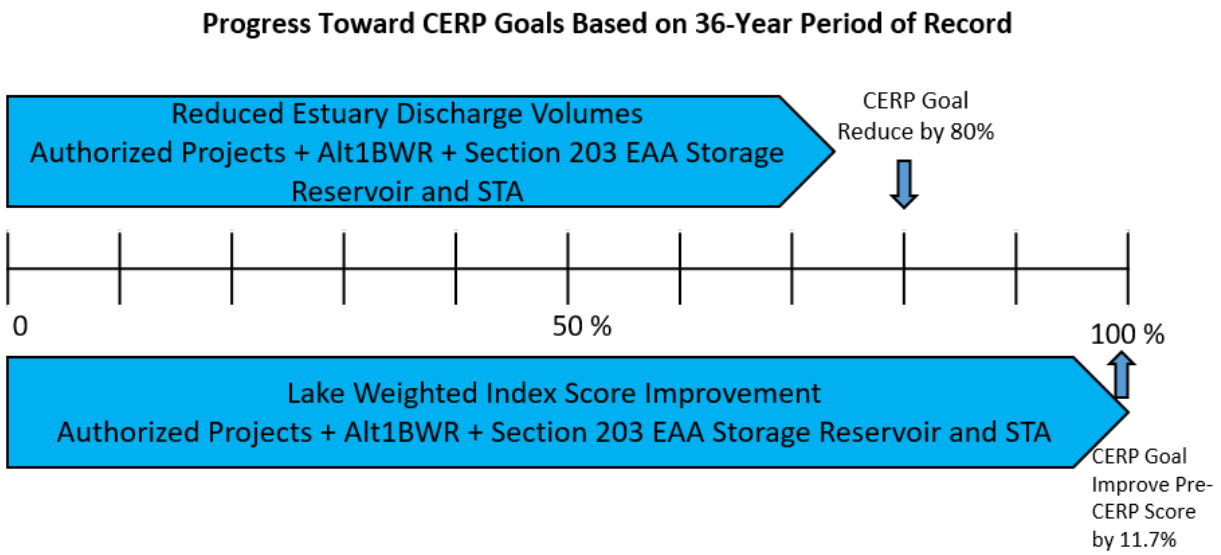

Figure C.2-96. Progress toward meeting CERP goal—authorized CERP projects, LOWRP Recommended Plan and EAA Storage Reservoir and STA.

Table C.2-51. Effectiveness of LOWRP Recommended Plan with the EAA Storage Reservoir and STA.

Metric (36-year POR)*	CERP Goal	LOWRP Recommended Plan (ALT 1BWR)	LOWRP Recommended Plan + EAA STORAGE RESERVOIR AND STA
Reduction in number of high-flow estuary events	81%	67% (83% of CERP goal)	81% (100% of CERP goal)
Reduction in volumes from Lake Okeechobee to the Northern Estuary Flows	80%	57% (71% of CERP goal)	73% (91% of CERP goal)

Metric (36-year POR)*	CERP Goal	LOWRP Recommended Plan (ALT 1BWR)	LOWRP Recommended Plan + EAA STORAGE RESERVOIR AND STA
Lake Okeechobee Index Score (percent improvement)	11.7%	9.2 (79% of CERP goal)	12.6% (100% of CERP goal)

* Based on the 36-year modeled simulation period (1965-2000) available from RECOVER

This combination of the authorized projects, the EAA Storage Reservoir and STA and the LOWRP Recommended Plan would be a significant accomplishment in reducing the volume of flows to the Northern Estuaries. In addition to these improvements, three general conclusions can be drawn from this analysis:

1. The LOWRP Recommended Plan and the EAA Storage Reservoir and STA benefits are complementary. Although parallel planning efforts may illustrate similar trends between the two efforts, the combined effect of the projects is additive, not coincident.
2. The combination of the LOWRP Recommended Plan and the EAA Storage Reservoir and STA project can come close to or fully achieve the CERP Goal in the Northern Estuaries.
3. The CERP goal is met for ecological Lake Okeechobee improvements and in the reduction of number of high-flow estuary events.

Table C.2-52. Summary of Cumulative Effects.

Hydrology	
Past Actions	Flood and water control projects have greatly altered the natural hydrology.
Present Actions	Federal and state agencies are coordinating on and implementing projects to improve hydrology.
Proposed Action	Additional reductions in high flow events from Lake Okeechobee to the Northern Estuaries would be realized by the Recommended Plan compared to the FWO. Improvement in the timing and distributions of flows into Lake Okeechobee. Reductions in high flow events from Lake Okeechobee to the Northern Estuaries. Significant beneficial hydrologic effects are anticipated within the Lake Okeechobee watershed through rehydration of previously drained areas.
Future Actions	Additional CERP projects propose to restore hydrology to more natural conditions (example – Western Everglades Restoration Project (WERP) and Loxahatchee River Watershed Restoration Project (LRWRP)). In addition, future refinements to water control manuals such as the Combined Operational Plan, Kissimmee River Headwaters and future updates to the Lake Okeechobee Regulation Schedule will further improve hydrology within the Northern Estuaries and Greater Everglades.
Cumulative Effect	Although it is unlikely that natural hydrologic conditions would be fully restored to pre-drainage conditions, improved hydrology would occur. CERP is expected to improve the quantity, quality, timing and distribution of freshwater flow.
Threatened and Endangered Species	
Past Actions	Water management practices and urbanization have resulted in the degradation of existing habitat function and direct habitat loss leading to negative population trends of threatened and endangered species.

Present Actions	Ongoing efforts have been made by Federal and state agencies to implement projects to improve hydrology within the project area.
Proposed Action	May affect the Florida grasshopper sparrow, northern crested caracara, Florida bonneted bat, Eastern indigo snake, Florida panther, wood stork, Everglade snail kite, Everglade snail kite critical habitat, Florida manatee, Florida manatee critical habitat, Okeechobee gourd, gopher tortoise, green sea turtle, leatherback sea turtle, loggerhead sea turtle, Kemp's Ridley sea turtle, small tooth sawfish, and small tooth sawfish critical habitat (See Annex A).
Future Actions	Ongoing projects would be implemented to maintain threatened and endangered species within the project area.
Cumulative Effect	Habitat improvement, monitoring and management of threatened and endangered species are anticipated to allow populations to be maintained. Improvement of degraded populations is expected to be facilitated by the restoration and enhancement of suitable habitat through efforts to restore more natural hydrologic conditions within the project area.
Fish and Wildlife Resources	
Past Actions	Water management practices have resulted in aquatic vegetation community changes and a resultant disruption of aquatic productivity and function that has had repercussions through the food web, including effects on wading birds, large predatory fishes, reptiles and mammals.
Present Actions	Ongoing efforts have been made by Federal and state agencies to implement projects to improve hydrology within the project area to restore habitat conditions for fish and wildlife resources.
Proposed Action	Rehydration within previously dry areas of the Lake Okeechobee watershed would increase the spatial extent of suitable habitat for several fish and wildlife resources. Increases in forage prey availability (crayfish, other invertebrates, and fish) would directly benefit amphibian, reptile, small mammal, and wading bird species. Nesting and foraging activities of resident wading bird species are anticipated to be significantly improved. Although upland species occurring within the action area are adapted to the naturally fluctuating water levels, there is an increased potential that species currently utilizing upland habitat may be negatively affected. Beneficial effects to fish and wildlife resources within Lake Okeechobee due to increased time within the preferred stage envelope. Reductions in the number of high flow events to the Northern Estuaries are anticipated to improve suitable habitat for key indicator species such as oysters. ASR wells have the potential to negatively affect fisheries near the intakes.
Future Actions	Some level of improvement to fish and wildlife resources is expected to occur as a result of implementation of projects with the capability of improving the timing, quantity, quality, and distribution of freshwater flow to the study area. Hydrologic restoration planned as part of CERP would further improve fish and wildlife habitat.
Cumulative Effect	Habitat improvement efforts are anticipated to benefit fish and wildlife resources.
Vegetation and Wetlands	
Past Actions	Drainage of Florida's interior wetlands, conversion of wetlands to agriculture, and urban development has reduced the spatial extent and quality of wetland resources.
Present Actions	Efforts are being taken by state and Federal regulatory agencies to reduce wetland losses.

Proposed Action	Significant beneficial effects are anticipated within the Lake Okeechobee watershed that would restore wetland habitat, rebuild the complex mosaic of habitats across the landscape, and restore portions of the Kissimmee River floodplain. Beneficial effects to vegetation within Lake Okeechobee are anticipated. Reductions in the number of high flow events to the Northern Estuaries are anticipated to improve conditions for SAV.
Future Actions	Some level of improvement to vegetative communities is expected to occur as a result of implementation of projects with the capability of improving the timing, quantity, quality, and distribution of freshwater flow to the study area. More natural hydrology as part of the CERP would assist in restoring natural plant communities.
Cumulative Effect	While the spatial extent of natural plant communities would not be restored to historic proportions, the quality of vegetative communities would be improved.
Cultural Resources	
Past Actions	Flood and water control projects, conversion of wetlands into agriculture and urban development have had adverse unmitigated effects to cultural resources either directly or indirectly.
Present Actions	Ongoing efforts have been made by Federal and state agencies to implement projects to improve hydrology within the project area, thereby stabilizing the tree islands which are known to have a high potential for cultural resources.
Proposed Action	While effects of the proposed action have been evaluated, a final determination of effects on cultural resources is not complete. Each suite of features will be subject to separate consultation and consideration of effects during PED as the APE may be subject to change based on final designs or modifications of project features. USACE is consulting with stakeholders, including the State Historic Preservation Office, Advisory Council on Historic Preservation, Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida, Seminole Nation of Oklahoma, and Thlopthlocco Tribal Town. The USACE executed a Programmatic Agreement as provided in 36 CFR § 800.4[b][2].
Future Actions	Continued improvement to hydroperiods and extreme water levels events in Lake Okeechobee could stabilize the environment and prevent impacts to cultural resources within the wetland restoration areas and in Lake Okeechobee. Transferring significant cultural sites within the project area from private ownership into public ownership may assist in protecting sites from impacts from agriculture and looting and other anthropogenic activities.
Cumulative Effect	Cumulative effects to cultural resources are not anticipated based on the placement of features north of Lake Okeechobee and as features are operationally distinct from other CERP features.
Water Quality	
Past Actions	Water quality has been degraded from urban, suburban, commercial, industrial, recreational, and agricultural development in addition to chanelization (such as Kissimmee River) and drainage within the project area and upstream..
Present Actions	Efforts to improve water quality from all nutrient source areas, restoration of channelized areas, and reduction of overdrainage and are ongoing.
Proposed Action	While implementation of the project is not expected to significantly affect the water quality of Lake Okeechobee or the Northern Estuaries, there will be minor improvements to water quality.
Future Actions	Actions by the State of Florida's Restoration Strategies will decrease nutrient concentration and loadings to the project area. The state of Florida has water quality programs like BMAPs that are intended to improve water quality.

Cumulative Effect	While anthropogenic effects on water quality are unlikely to be eliminated, water quality is expected to slowly improve over existing and recent past conditions. During detailed planning and design, the USACE and SFWMD are committed to ensuring that project feature implementation will not result in violations of water quality standards.
Water Supply/Flood Control	
Past Actions	Water supply and flood control for agricultural and urban users has benefited from construction and operation of the C&SF project.
Present Actions	Availability of water from Lake Okeechobee for agricultural users was diminished through implementation of LORS 2008. The SFWMD has implemented Restricted Allocation Area Rules to cap allocations to existing legal users within the Lake Okeechobee Service Area and Indian Prairie Basin.
Proposed Action	Implementation of the project would benefit exiting legal users of water supplies within the Lake Okeechobee Service Area.
Future Actions	Future supplies would not change unless additional CERP storage features are implemented to increase water availability.
Cumulative Effect	While effects on water supplies are unlikely to fully restore the level of service for existing users experienced prior to implementation of LORS 2008, water supply availability will improve as additional storage is constructed.

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