ANNEX F
Invasive and Nuisance Species Management Plan

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F INVASIVE AND NUISANCE SPECIES MANAGEMENT PLAN

In accordance with the Comprehensive Everglades Restoration Plan (CERP) Guidance Memorandum 062.00 (CGM62), Invasive Species, the Lake Okeechobee Watershed Restoration Project (LOWRP) will incorporate invasive and nuisance species assessments and management of those species into pertinent planning documents and phases of the project. The Invasive and Nuisance Species Management Plan (INSMP) is a living document and will be updated throughout the Design; Construction; and Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) phases.

The Project Partnership Agreement (PPA) and the Construction Phasing, Transfer, and Warranty (CPTW) Plan will be developed and agreed upon prior to construction. These documents outline the responsibilities of the Federal Government and non-Federal sponsor during the construction phase, the operational testing and monitoring period, and the OMRR&R phase, and will include the cost estimates associated with this INSMP. This INSMP must be included with the CPTW Plan.

F.1 Introduction

The project area covers a portion of the Lake Okeechobee Watershed in Florida. It includes 5 sub-basins (totaling approximately 920,000 acres) within the Lake Okeechobee Watershed and includes portions of Glades, Highlands, Okeechobee, St. Lucie, and Martin Counties, along with the Seminole Tribe of Florida (STOF) Brighton Reservation. The majority of the LOWRP features are located in the Indian Prairie sub-basin, although there are aquifer storage and recovery (ASR) wells proposed throughout the project area. The study area includes the project area, along with Lake Okeechobee and the Caloosahatchee and St. Lucie Estuaries.

Nationally, more than 50,000 species of introduced plants, animals, and microbes cause more than $120 billion in economic damages and control costs each year (Pimentel et al. 2005). Not all introduced species become invasive species. According to the U.S. Congress Office of Technology Assessment's Harmful Non-Indigenous Species in the United States Report (1993), approximately 10 to 15% of introduced species will become established and 10% of the established species may become invasive.

Executive Order (E.O.) 13112, entitled *Invasive Species*, signed 03 February 1999, 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 means "with respect to a particular ecosystem, any species, including its seeds, eggs, spores or other biological material capable of propagating that species, that 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. The terms 'alien' and 'exotic' also refer to non-native species. 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.

Invasive non-native species decrease biodiversity, displace native plant and animal communities, reduce wildlife habitat and forage opportunities, alter the rates of soil erosion and accretion, alter fire regimes, upset predator/prey relationships, alter hydrology, degrade environmental quality, and spread diseases to native plants, animals and other organisms. Furthermore, invasive species are the second largest threat to biodiversity following only habitat destruction (Wilcove et al. 1998). In the United States, invasive species directly contributed to the decline of 49% of threatened and endangered species (Wilcove et al. 1998). In addition to environmental impacts, invasive species can 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 its 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. Florida is listed as one of the states with the largest number of invasive species. This list also includes Hawaii, California, and Louisiana. 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 (Cuda 2009a). Stein et al. (2000) estimated that over 32,000 exotic species (25,000 plants and 7,000 animals) have been introduced into Florida. There are approximately 4,000-5,000 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 2008) 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 2019 Invasive Plant List (FLEPPC 2011). Invasive exotics are termed Category I invasives when they are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives (FLEPPC 2011). Category II invasive exotics have increased in abundance or frequency but have not yet altered Florida plant communities to the extent shown by Category I species (FLEPPC 2011). These species may become Category I if ecological damage is demonstrated (FLEPPC 2011). Searches through existing data and resources indicate 74 non-native plant species have been documented to occur within the project area (**Table F-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 (FLEPPC 2011).

Table F-1. Summary of invasive plant species documented in the project area[1].

Category	Total Number of Species
Total Non-native Plants	74
Total FLEPPC Category I	44
Total FLEPPC Category II	12
Total Noxious Weeds	15

[1]This list was compiled from the 2019 Florida Exotic Pest Plant Council (FLEPPC) Category I and II species lists. It was cross-checked with species occurrences reported in EDDMapS (Early Detection and Distribution Mapping System) for Broward, Charlotte, Collier, DeSoto, Glades, Hendry, Highlands, Lee, Miami-Dade, Martin, Monroe, Okeechobee, Palm Beach, and St. Lucie counties. Any of the FLEPPC species that had not been recorded in these counties were removed from the list. The list also includes any species that are being actively managed in these areas by the U.S. Army Corps of Engineers or the National Park Service (based on WEEDDAR (Weed Data and Reports) data).

Significant scientific evidence and research documents 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. It has also been documented that 19 species within Florida are among the world's worst weeds (Holm et al. 1977). It is estimated that federal, state, and county agencies in Florida spend between $94 million and $127 million each year in an effort to manage invasive non-native plants (GAO 2000).

Non-native invasive animal distribution, extent, and impacts are not well understood; however, implications of invasive animals are apparent in south Florida. Searches through existing data and resources indicate 51 non-native animal species have been documented to occur within the project area (See **Appendix C**). 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.

Invasive species are a major threat to the success of CERP. The intent of CERP is to restore, preserve and protect the south Florida ecosystem while providing for other water-related needs of the region (USACE and SFWMD 2010). CERP focuses on hydrologic restoration to improve degraded natural habitat in the south Florida ecosystem. Hydrologic restoration alone cannot ensure habitat restoration (USACE and SFWMD 2010). In order to restore the Everglades and ensure south Florida's natural ecosystems are preserved and remain intact, invasive species must be comprehensively addressed (Doren and Ferriter 2001). Lack of management will allow invasive non-native species to flourish and to continue to out-compete native species.

F.2 Status of Priority Species and Their Impacts

F.2.1 Plants

Searches through existing data and resources indicate 74 non-native plant species have been documented to occur within the project area. The species list is presented in **Table F-2.** 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.

Some plant species can exhibit traits similar to invasive species and become problematic in their native ecosystem under certain conditions. 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 1950s. Areas where water control structures, conveyance features, and levees exist provide a suitable habitat for invasion and expansion of cattail.

Table F-2. Invasive plant species documented in the project area.

Invasive Plant Species		Region Documented In				FLEPPC Category
Common Name	Scientific Name	LO	NE	EAA	GE	
Rosary pea	*Abrus precatorius* L.	x	x	x	x	I
Mimosa	*Albizia julibrissin* Durazz.	x	x	x	x	I
Woman's tongue	*Albizia lebbeck* (L.) Benth	x	x	x	x	I
Alligator weed	*Alternanthera philoxeroides* (Mart.) Griseb.	x	x	x	x	II
Coral ardisia	*Ardisia crenata* Sims	x	x	x	x	I
Shoebutton ardisia	*Ardisia elliptica* Thunb	x	x	x	x	I
Sprenger's asparagus fern	*Asparagus aethiopicus* L.	x	x	x	x	
River she-oak	*Casuarina cunninghamiana* Miq.	x	x	x	x	
Australian pine	*Casuarina equisetifolia* L.	x	x	x	x	I
Watersprite	*Ceratopteris thalictroides*	x				
Camphor tree	*Cinnamomum camphora* (L.) J. Presl	x	x	x	x	I
Coco yam, Wild taro	*Colocasia esculenta* (L.) Schott	x	x	x	x	I
Showy rattlebox	*Crotalaria spectabilis* Roth	x	x	x	x	
Carrotwood	*Cupaniopsis anacardioides* (A. Rich.) Radlk.	x	x	x	x	I
Cuban bulrush	*Cyperus blepharoleptos*	x	x	x	x	
Umbrella plant	*Cyperus involucratus* Rottb	x	x	x	x	II
Miniature flatsedge, dwarf papyrus	*Cyperus prolifer* Lam	x	x	x	x	II
Indian rosewood	*Dalbergia sissoo* Roxb. ex DC.	x	x	x	x	
Air potato	*Dioscorea bulbifera* L.	x	x	x	x	I
Brazilian waterweed	*Egeria densa*	x	x	x	x	
Water hyacinth	*Eichhornia crassipes* (Mart.) Solms	x	x	x	x	I
Surinam cherry	*Eugenia uniflora* L.	x	x	x	x	I
Chinese crown orchid	*Eulophia graminea*	x	x	x	x	II
Chinese banyan	*Ficus microcarpa* L. f.	x	x	x	x	I

Invasive Plant Species		Region Documented In				FLEPPC Category
Common Name	Scientific Name	LO	NE	EAA	GE	
Limpograss	*Hemarthria altissima* (Poir.) Stapf & C.E. Hubbard	x	x	x	x	II
Hydrilla	*Hydrilla verticillata* (L. f.) Royle	x	x	x	x	I
Miramar weed	*Hygrophila polysperma* (Roxb.) T. Anders.	x	x		x	I
West Indian marsh grass	*Hymenachne amplexicaulis* (Rudge) Nees	x	x	x	x	I
Cogongrass	*Imperata cylindrica* (L.) Beauv.	x	x	x	x	I
Swamp morning glory	*Ipomoea aquatica* Forssk.	x	x	x	x	I
Dotted duckmeat, Spotted duckweed	*Landoltia punctata*	x	x		x	II
Lantana, Shrub verbena	*Lantana camara*	x	x	x	x	I
Limnophila	*Limnophila sessiliflora* (Vahl) Blume	x	x	x	x	II
Primrose willow	*Ludwigia peruviana* (L.) Hara	x	x	x	x	I
Tropical American watergrass	*Luziola subintegra*		x		x	I
Japanese climbing fern	*Lygodium japonicum* (Thunb. ex Murr.) Sw.	x	x	x	x	I
Old World climbing fern	*Lygodium microphyllum* (Cav.) R. Br.	x	x	x	x	I
Guineagrass	*Megathyrsus maximus* (Jacq.) R. Webster	x	x	x	x	
Melaleuca	*Melaleuca quinquenervia* (Cav.) Blake	x	x	x	x	I
Chinaberry	*Melia azedarach* L.	x	x	x	x	
Natalgrass	*Melinis repens* (Willd.) Zizka	x	x	x	x	I
Parrot feather	*Myriophyllum aquaticum*	x	x	x	x	
Asian swordfern	*Nephrolepis brownii* (Desv.) Hovenkamp & Miyam.	x	x	x	x	I
Narrow swordfern	*Nephrolepis cordifolia* (L.) C. Presl	x	x	x	x	
Burmareed	*Neyraudia reynaudiana* (Kunth) Keng ex A.S. Hitchc.	x	x	x	x	I
Cape Blue waterlily	*Nymphaea capensis var. zanzibariensis*	x	x	x	x	
Crested floating heart	*Nymphoides cristata* (Roxb.) O. Ktze.	x	x	x	x	I
Torpedograss	*Panicum repens*				x	I

Invasive Plant Species		Region Documented In				FLEPPC Category
Common Name	Scientific Name	LO	NE	EAA	GE	
Elephant grass, Napier grass	*Pennisetum purpureum* Schumacher	x	x	x	x	I
Water lettuce	*Pistia stratiotes*	x	x	x	x	I
Strawberry guava	*Psidium cattleianum* Sabine	x	x	x	x	I
Guava	*Psidium guajava* L.	x	x	x	x	I
Downy rose myrtle	*Rhodomyrtus tomentosa* (Ait.) Hassk.	x	x	x	x	I
Castorbean	*Ricinus communis* L.	x	x	x	x	
Wild sugarcane	*Saccharum spontaneum*	x			x	
Water fern	*Salvinia minima* Baker	x	x	x	x	I
Giant salvinia	*Salvinia molesta*				x	
Iguanatail	*Sansevieria hyacinthoides* (L.) Druce	x	x	x	x	II
Brazilian peppertree	*Schinus terebinthifolius* Raddi	x	x	x	x	I
Lakeshore nutrush	*Scleria lacustris* C. Wright	x	x	x	x	I
Climbing cassia	*Senna pendula var. glabrata*	x	x	x	x	I
Twoleaf nightshade	*Solanum diphyllum* L.	x	x	x	x	II
Jamaican nightshade	*Solanum jamaicense*	x	x			
Wetland nightshade	*Solanum tampicense* Dunal	x	x	x	x	I
Turkeyberry	*Solanum torvum Sw.*	x	x	x	x	
Tropical soda apple	*Solanum viarum* Dunal	x	x	x	x	I
Bay Biscayne creeping oxeye	*Sphagneticola trilobata* (L.C. Rich.) Pruski	x	x	x	x	
Java plum	*Syzygium cumini* (L.) Skeels	x	x	x	x	I
Chinese tallowtree	*Triadica sebifera* (L.) Small	x	x		x	I
Caesarweed	*Urena lobata* L.	x	x	x	x	I
Paragrass	*Urochloa mutica* (Forsk.) T.Q. Nguyen	x	x	x	x	I
Washington fan palm	*Washingtonia robusta*		x		x	II
Arrowleaf elephant's ear	*Xanthosoma sagittifolium*	x	x	x	x	II

F.2.2 Widely Established Species

Plants that are widely established within the project area that are managed for long term suppression include Australian pine (*Casuarina equisetifolia*), Old World climbing fern (*Lygodium microphyllum*), melaleuca (*Melaleuca quinquenervia*), Brazilian pepper (*Schinus terebinthifolius*), cogongrass (*Imperata cylindrica*), torpedograss (*Panicum repens*), creeping water-primrose (*Ludwigia* spp.), downy rose myrtle (*Rhodomyrtus tomentosa*), water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*) and hydrilla (*Hydrilla verticillata*) (SFER 2019).

F.2.2.1 Australian Pine

Australian pine is an evergreen tree that can grow to 150 feet tall. It has inconspicuous flowers and produces tiny fruit, a 1-seeded winged nutlet that is formed in a woody cone-like cluster. Australian pine is a prolific seed producer and seeds are dispersed by birds, wind, and water flow. It is native to Australia, the south Pacific Islands, and southeast Asia. Australian pine was introduced in the late 1800s and was planted extensively in south Florida as windbreaks and shade trees. It inhabits sandy shores and pinelands and is salt tolerant. It also invades disturbed sites such as filled wetlands, roadsides, cleared undeveloped land, canal banks, and levees. Australian pine grows rapidly, shades out native species, produces dense litter accumulation, causes beach erosion, and produces an allelopathic agent that inhibits growth of other species. In addition, it interferes with nesting of sea turtles and the American crocodile (Langeland and Burks 1998).

F.2.2.2 Brazilian Pepper

Brazilian pepper is an evergreen shrub or tree that can grow up to 40 feet tall. It forms dense thickets and is a prolific seed producer. It produces a small bright red fruit in the form of a spherical drupe. Brazilian pepper is native to Brazil, Argentina, and Paraguay and was imported in the 1840s as an ornamental plant (Langeland and Burks 1998). Brazilian pepper inhabits natural areas such as pinelands, hardwood hammocks, and mangrove forests. It is an aggressive pioneer species that quickly colonizes and thrives in disturbed areas (Francis n.d.) such as fallow farmland, fence lines, right-of-ways, roadsides, canal banks, and levees. Seeds are spread primarily by birds and mammals through consumption and deposition of the fruit. Seeds are also spread by flowing water (Langeland and Burks 1998). Brazilian pepper seedlings will not tolerate inundation and are quickly killed; however, large plants can withstand 6 months of flooding (Francis n.d.) with several feet of inundation. Brazilian pepper forms dense monocultures and completely shades out, crowds, and displaces native vegetation. It also produces allelopathic agents that possibly suppress the growth of other plants. Brazilian pepper is a member of the family Anacardiaceae which includes plants such as poison ivy, poison oak, and poison sumac. The leaves, flowers, and fruits of Brazilian pepper produce a chemical that can irritate and form a rash on human skin and cause respiratory problems (Langland and Burks 1998).

F.2.2.3 Melaleuca

Melaleuca is an evergreen tree that can grow up to 100 feet tall. It has white flowers that form spikes often referred to as a “bottle brush.” The fruit is a round woody capsule in clusters along the stem; each capsule can contain 200-330 tiny seeds. It is native to Australia and was introduced to Florida in 1906 as an ornamental plant and in the 1930s it was scattered over the Everglades in order to create forests (Langeland and Burks 1998). Melaleuca inhabits natural areas such as pine flatwoods, hardwood bottomlands, cypress forests, freshwater marshes, sawgrass prairies, and mangrove forests. It also infests disturbed sites such as improved pasture, natural rangeland, idle farmland, canal and levee banks, and urban areas. It prefers sites that are seasonally wet. Melaleuca also flourishes in areas with standing water and persists in well-drained upland sites (Langeland and Burks 1998). Melaleuca displaces native plant species, reduces quality of wildlife habitat, alters fire regimes, and potentially alters wetland hydrology (Mazotti et al. 2008).

F.2.2.4 Old World Climbing Fern

Old World climbing fern (*Lygodium microphyllum*) is a plant that has long fronds that can grow up to 90 feet. The fronds grow along the ground, over shrubs, or climb by twisting and winding around trees, vines, and other structures. The rhizomes and rachis are wiry and they are brown to black in color. The leafy branches that form along the rachis are 2 to 5 inches in length and have many pairs of leaflets. It produces spores that are dispersed by the wind. In south Florida, the plant produces spores throughout the year. Each fertile leaflet of Old World climbing fern can produce up to 28,600 spores. Old World climbing fern is native to Africa, Asia, and Australia. It was first recorded in Florida in 1958. It was collected from a Delray Beach plant nursery where it was being cultivated (Langeland and Hutchinson 2005). Old World climbing fern has been documented to occur in hardwood hammocks, mesic flatwoods, forested swamps, wet flatwoods, hydric hammocks, floodplain forests, and strand swamps. It can completely overgrow the vegetation in these areas, which allows the plant to compete with canopy trees and understory vegetation for light. The growth in the tree canopy provides an avenue for fire to spread into the canopy, which damages or even kills the trees. Over time, rhizomes accumulate in mats 3 feet or more thick on top of the soil (Langeland et al. 2008) which can prevent new growth of native plants.

F.2.2.5 Torpedograss

Torpedograss (*Panicum repens*) is a perennial grass that can grow up to 3 feet tall. It has extended rhizomes that can be rooted or floating. It has a panicle-type inflorescence that is 3-9 inches long. It flowers nearly year round. Torpedograss reproduces primarily through rhizome extension and fragmentation. It is native to Africa and Asia and was introduced into the Gulf Coast of the United States before 1876. Torpedograss seed was introduced as a forage crop in the south and was planted in almost every southern Florida County by 1950. It is drought tolerant and grows in upland areas but thrives in areas with moist to wet sandy or organic soil. It inhabits scrub, coastal flatwoods, upper tidal marshes, mesic flatwoods, herbaceous wetlands, wet prairies, swales, lake shores, canals, and other disturbed sites. Torpedograss can quickly form a monoculture and displace native vegetation. In 1992, it was present in approximately 70% of the public waters in Florida. The largest population of torpedograss was present in Lake Okeechobee. Approximately 14,000 acres of torpedograss displaced native plants in the Lake's marsh (Langeland et al. 2008). Torpedograss is present in agricultural and water conveyance canals throughout the project area and has potential to spread into areas with the removal of levees and backfilling canals.

F.2.2.6 Cogongrass

Cogongrass is a perennial grass that grows in compact bunches and produces extensive rhizomes. The leaf blades are erect and narrow with a whitish midvein off center and leaves can be one to four feet in length. The inflorescence is narrow, white, and plume-like. Cogongrass flowers in the spring, fall, and sometimes year round. It produces seeds that are spread by wind, animals, and equipment. Congongrass is native to southeast Asia and was introduced into Florida in the 1930s and 1940s for forage and soil stabilization in Gainesville, Brooksville, and Withlacoochee. More than 1,000 acres of cogongrass was established in central and northwest Florida by 1949. Cogongrass inhabits dry to moist sites and has been documented to occur in xeric hammocks, mesic flatwoods, herbaceous marshes, and floodplain forests (Langeland et al. 2008). It has extensively invaded disturbed areas such as fallow pastures (FDEP n.d.) and is commonly found along transportation and utility corridors (Langeland et al. 2008). Cogongrass forms dense stands which results in almost complete displacement of native plants. Dense stands of cogongrass also create a severe fire hazard, especially when mixed with other volatile fuels (FDEP n.d.).

F.2.2.7 Water Lettuce

Water lettuce is a floating aquatic plant native to South America. The plant reproduces extremely quickly except in the coolest months. It reproduces both vegetatively and from seed, which are found to be up to 80% viable (Dray and Center 1989). Water lettuce was reported as early as 1765 by William Bartram as forming dense mats on the St. Johns River. It forms large floating mats that block navigation, impact water control structures, degrade water quality, and dramatically alter native plant and animal communities.

F.2.2.8 Water Hyacinth

Water hyacinth is a floating aquatic plant native to tropical South America that was introduced in Florida in 1884. The plant reproduces extremely quickly; it grows at explosive rates that exceed any other tested vascular plant (Wolverton and McDonald 1979). Vegetative reproduction occurs rapidly except in the coolest months. It forms large floating mats that block navigation, impact water control structures, degrade water quality, and dramatically alter native plant and animal communities (Gowanlock 1944; Penfound and Earle 1948). New plants are produced vegetatively and from seed, which germinate abundantly on exposed moist soils (Perez 2011). Water hyacinth has low nutrient needs and wide tolerance for water conditions that enables it to persistence and spread.

F.2.2.9 Hydrilla

Hydrilla (*Hydrilla verticillata*) is a rooted submerged plant that often forms dense mats throughout the water column, creating a monoculture which displaces native plant communities. It is designated as a Federal Noxious Weed and a Florida Prohibited Aquatic Plant. It is native to the Old World and Indo-Pacific and was likely first introduced to Florida in the 1950s as a consequence of aquarium dumping. Hydrilla also supports the growth of a cyanobacterial epiphyte (*Aetokthonos hydrillicola*) which produces an avian toxin affecting herbivorous waterbirds and their avian predators, like coots (*Fulica americana*) and bald eagles (*Haliaeetus leucocephalus*) (Wilde 2005, 2014; Martin 2015). It is found in all types of Florida waterbodies, and it has been present in Lake Okeechobee for over 20 years.

F.2.2.10 Downy Rose Myrtle

Downy rose myrtle (*Rhodomyrtus tomentosa*) is an ornamental shrub native to Asia, but was introduced to Florida in the late 1800s, and is now a registered Federal noxious weed. This fast-growing shrub spreads into Central and South Florida pine flatwoods and drained cypress strands, even in the absence of disturbance, and can form dense thickets that crowd out native vegetation. It is very fire tolerant and can change the fire regime of the ecosystem in which it resides. It is exceedingly important to detect and eliminate downy rose myrtle before it dominates any one area because of its high cost per hectare to treat advanced invasions.

F.2.2.11 Creeping Water Primrose

A complex of invasive aquatic *Ludwigia* species (*Ludwigia* spp.) native to South and Central America has become widely established in Florida. Involved species include *L. grandiflora*, *L. hexapetala*, *L. uruguayensis,* and *L. peploides*. Young plants of the creeping water primrose grow horizontally across the surface of the water, spreading into other plant communities. When mature, some grow upright to form dense stands up to six feet tall, and the dense rhizome mats fill the water column. Allelopathic effects further contribute to the plant's invasiveness (Dandelot et al. 2008). They are currently found from Kissimmee to Lake Okeechobee and are reported from many other Florida waterbodies.

F.2.2.12 Cattail

Cattail (*Typha* spp.) are native to Florida and occur in wetlands, lakes, rivers, canals, stormwater treatment areas, and other disturbed sites. Cattail grow up to 12 feet tall and have strap-like leaf blades. The inflorescence is spike-like with very tiny flowers. This plant is a primary native nuisance species within the project area. Many areas within the project area have been invaded by cattail. This is attributed to water with increased phosphorus being delivered to these areas which began in the late 1950s (Holmes et al. 2002). Areas where water control structures, conveyance features, and levees exist provide a suitable habitat for invasion and expansion of cattail.

F.2.3 Localized/Potential Early Detection and Rapid Response Species

Four Cooperative Invasive Species Management Areas (CISMA) cover potions of the project area. These include Heartland, Southwest, Treasure Coast, and Lake Okeechobee CISMAs.

The Heartland CISMA includes Polk, Hardee, Desoto, Highlands, and Okeechobee counties. The CISMA's Early Detection and Rapid Response (EDRR) list includes the following species: sisal (*Agave sisalana*), coral ardisia (*Ardisia crenata*), crested Philippine violet (*Barleria cristata*), basket plant (*Callisia fragrans*), day jessamine (*Cestrum diurum*), carrotwood (*Cupaniopsis anacardioides*), Japanese dodder (*Cuscuta japonica), f*oxtail flatsedge (*Cyperus alopecuroides), c*erulean flaxsedge (*Dianella ensifolia*), aroma (*Dichrostachys cinera* subsp. *Africana*), lesser roundweed (*Hyptis brevipes),* cowitch (*Mucuna pruriens*), red-root floater (*Phyllanthus fluitans*), Praxlies (*Praxelis clematidea),* kudzu (*Pueraria montana var. lobata*), downy rose myrtle (*Rhodomyrtus tomentosa*), Britton's wild petunia (*Ruellia simplex),* tropical nutrush (*Scleria microcarpa*), java plum (*Syzygium cumini*), sea hibiscus (*Talipariti tiliaceum*), portia tree (*Thespesia populnea*), boatlily (*Tradescantia spathacea), and p*aragrass (*Urochloa mutica).*

The Southwest CISMA includes Charlotte, Glades, Lee, Hendry, and Collier counties. The following species are considered to be EDRR species: sisal (*Agave sisalana*), nightflowering jessamine (*Cestrum nocturnum*), grand eucalyptus (*Eucalyptus grandis*), Torell's eucalyptus (*Eucalyptus torelliana*), swamp morning glory (*Ipomoea aquatica*) and giant salvinia (*Salvinia molesta*).

The Treasure Coast CISMA, which includes Indian River, St. Lucie, Martin, and portions of Palm Beach County, has identified 24 species of plants as EDRR species: Antilles calophyllum (*Calophyllum antillanum),* mission grass (*Cenchrus polystachios*), Torell's eucalyptus *(Corymbia torelliana),* day jessamine (*Cestrum diurnum),* camphortree (*Cinnamomum camphora),* deeprooted sedge *(Cyperus entrerianus),* aroma *(Dichrostachys cinerea subsp. Africana)*, grand eucalyptus (*Eucalyptus grandis),* Gold Coast jasmine (*Jasminum dichotomum),* glossy privet (*Ligustrum lucidum),* Japanese climbing fern *(Lygodium japonicum),* monkey's apple (*Mimusops coriacea),* strawberry tree *(Muntingia calabura),* Eurasian water-milfoil *(Myriophyllum spicatum),* burmareed (*Neyraudia reynaudiana),* elliptic yellowwood *(Ochrosia elliptica),* skunk-vine (*Paederia foetida),* arrow bamboo *(Pseudosasa japonica),* Russian thistle (*Salsola kali),* cortadera blanca *(Scleria gaertneri),* Wright's nutrush (*Scleria lacustris*), tropical nut-rush (*Scleria microcarpa*), Chinese tallowtree *(Triadica sebifera),* and Oriental tremis (*Trema orientalis).*

The Lake Okeechobee Aquatic Plant Management CISMA has identified the following EDRR species for Lake Okeechobee: earleaf acacia (*Acacia auriculiformis*), bishopwood (*Bischovia javanica*), carrotwood (*Cupaniopsis anacardioides*), tropical American watergrass (*Luziola subintegra*), and paragrass (*Urochloa mutica)*.

F.2.3.1 Other Species of Concern

Other species that are present within, or are likely to invade, the LOWRP footprint and cause environmental harm include Napier grass (*Pennisetum purpureum*), climbing cassia (*Senna pendula var. glabrata*), Wright's nutrush, castor bean (*Ricinus communis*), crested floating heart (*Nymphoides cristata*), and West Indian marsh grass (*Hymenachne amplexicaulis)*.

The Treasure Coast CISMA also identifies 17 plants as "to be watched" species: nightflowering jessamine (*Cestrum nocturnum*), water-trumpet (*Cryptocoryne walker*), spurgecreeper (*Dalechampia scandens*), cerulean flaxlily (*Dianella ensifolia*), anchored water hyacinth *(Eichhornia azurea),* water-spinach (*Ipomoea aquatic),* Indian marshweed (*Limnophila indica*), black mangrove (*Lumnitzera racemosa),* Tropical American watergrass *(Luziola subintegra*), monarch fern (*Microsorum scolopendria*), mile-a-minute (*Mikania micrantha*), frogsmouth (*Philydrum lanuginosum*), red-root floater (*Phyllanthus fluitans*), multiflora rose (*Rosa multiflora*), giant salvinia (*Salvinia molesta*), Egger's nut-rush (*Scleria eggersiana*), and beach vitex (*Vitex rotundifolia*).

F.2.4 Animals

Searches through existing data and resources indicate 51 animal species have been documented to occur within the project area (**Table F-3**). 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*), Mexican bromeliad weevil (*Metamasius callizona*), Cuban tree frog (*Osteopilus septentrionalis*), redbay ambrosia beetle (*Xyleborus glabratus),* and associated fungus (*Raffaelea lauricola*)*.* Two additional key carnivorous reptiles have potential to cause significant ecological impacts in the project area: the Argentine black and white tegu (***Salvator merianae***) and the northern African python (***Python sebae***).

Table F-3. Invasive animal species documented in the project area.

Invasive Animal Species		Region Documented In			
Common Name	**Scientific Name**	**LO**	**NE**	**EAA**	**GE**
BIRDS					
Common myna	*Acridotheres tristis*	x	x	x	x
Egyptian geese	*Alopochen aegyptiacus*	x	x	x	x
Muscovy duck	*Cairina moschata*	x	x	x	x
House finch	*Carpodacus mexicanus*	x	x	x	x
Rock dove	*Columba livia*	x	x	x	x
Budgerigar	*Melopsittacus undulatus*	x	x		x
Monk parakeet	*Myiopsitta monachus*	x	x	x	x
House sparrow	*Passer domesticus*	x	x	x	x
Common pheasant	*Phasianus colchicus*	x	x	x	x
Purple swamphen	*Porphyrio porphyrio*	x	x	x	x
Eurasian collared dove	*Streptopelia decaocto*	x	x	x	x
African collared dove	*Streptopelia roseogrisea*	x	x	x	x
European starling	*Sturnus vulgaris*	x	x	x	x
White-winged dove	*Zenaida asiatica*	x	x	x	x
REPTILES & AMPHIBIANS					
African redhead agama	*Agama agama*	x	x	x	x
Largehead anole	*Anolis cybotes*	x	x		
Knight anole	*Anolis equestris equestris*	x	x	x	x
Brown anole	*Anolis sagrei*	x	x		
Greenhouse frog	*Eleutherodactylus planirostris*		x		
Green anaconda	*Eunectes murinus*				x
African spurred tortoise	*Geochelone sulcata*	x	x	x	x
Tropical house gecko	*Hemidactylus mabouia*	x	x	x	x
Green iguana	*Iguana iguana*	x	x	x	x
Northern curlytail lizard	*Leiocephalus carinatus armouri*	x	x	x	x
Cuban treefrog	*Osteopilus septentrionalis*	x	x	x	x
Ball python	*Python regius*	x	x	x	x
Burmese python	*Python molurus bivittatus*	x	x	x	x
Brahminy blind snake	*Ramphotyphlops braminus*	x	x		x
Giant toad	*Rhinella marina*	x	x	x	x
Black and white tegu	*Salvator merianae*				x
Red-eared slider	*Trachemys scripta elegans*				x
FISH					
Oscar	*Astronotus ocellatus*				x
Black acara	*Cichlasoma bimaculatum*				x
Mayan cichlid	*Cichlasoma urophthalmus*				x
Walking catfish	*Clarias batrachus*				x
Grass carp	*Ctenopharyngodon idella*	x	x	x	x
Common carp	*Cyprinus carpio*				x
African jewelfish	*Hemichromis letourneuxi*	x	x	x	x

Invasive Animal Species		Region Documented In			
Common Name	**Scientific Name**	**LO**	**NE**	**EAA**	**GE**
Brown hoplo	*Hoplosternum littorale*				x
Blue tilapia	*Oreochromis aureus*				x
Nile tilapia	*Oreochromis niloticus*	x			x
Vermiculated sailfin catfish	*Pterygoplichthys disjunctivus*				x
Orinoco sailfin catfish	*Pterygoplichthys multiradiatus*				x
Amazon sailfin catfish	*Pterygoplichthys paradalis*				x
Spotted tilapia	*Tilapia mariae*				x
MAMMALS					
Wild hog, feral pig	*Sus scrofa*	x	x	x	x
OTHER					
Asian clam	*Corbicula fluminea*	x	x	x	x
Freshwater jellyfish	*Craspedacusta sowerbyi*	x	x	x	x
Island apple snail	*Pomacea insularum (d'Orbigny, 1839)*	x	x	x	x
Giant apple snail	*Pomacea maculata*	x	x	x	x
Fungus (causes laurel wilt)	*Raffaelea lauricola*				x

F.2.4.1 Widely Established Species

F.2.4.2 Redbay Ambrosia Beetle (Laurel Wilt)

Laurel wilt is a lethal disease of redbay (*Persea borbonia*) and other members of the Laurel family (*Lauraceae*). The disease is caused by a fungus (*Raffaelea lauricola*) that is introduced into trees by the wood-boring redbay ambrosia beetle (*Xyleborus glabratus*) (FDACS 2011b). *X. glabratus* is the twelfth species of non-native ambrosia beetle known to have become established in the United States since 1990. All are suspected to have been introduced in solid wood packing materials, such as crates and pallets (Haack 2003). Most native ambrosia beetles attack stressed, dead, or dying woody plants, but *X. glabratus* attacks healthy Florida trees. Once infected, susceptible trees rapidly succumb to the pathogen and die. Besides redbay, the disease impacts other native and non-native members of the Lauraceae (Hanula et al. 2008) family including swamp bay (*P. palustris*), an important species of many Everglades plant communities.

Since its arrival in 2002, the redbay ambrosia beetle and laurel wilt have spread quickly throughout the southeastern United States. In March 2010, the beetle was found in Miami-Dade County. Laurel wilt disease was subsequently confirmed on nearby swamp bay trees in February 2011. Aerial reconnaissance identified symptomatic swamp bay trees scattered throughout the Bird Drive Basin, northward into the Pennsuco Wetland area, and westward into Everglades National Park (ENP) and Water Conservation Area 3B. In February 2012, laurel wilt was also confirmed in the Loxahatchee National Wildlife Refuge.

There is currently no feasible method for controlling this pest or associated disease in natural areas. A systemic fungicide (propiconazole) can protect individual trees for up to one year, but widespread utilization in natural areas is impractical (Mayfield et al. 2009). State and federal agencies are monitoring the spread of laurel wilt disease and the redbay ambrosia beetle through the Cooperative Agricultural Pest Survey (CAPS) program. There is little to no research underway to assess the ecological impacts of laurel wilt disease. Interagency coordination is limited to the exchange of reporting information and some coordinated research. The redbay ambrosia beetle is considered a plant pest, so screening for additional introductions is carried out, but is inadequate. Critical research areas include: (1) evaluating *Persea* resistance, (2) *Persea* seed/genetic conservation efforts, (3) potential chemical or biological control tools, (4) impacts on native plant communities, and (5) impacts on the Palamedes swallowtail butterfly (*Papilio palamedes*) and other host-specific herbivores.

F.2.4.3 Cuban Treefrog

The Cuban treefrog (*Osteopilus septentrionalis*) is the largest species of treefrog in Florida and ranges from 1-4 inches in length. The Cuban treefrog has expanded pads on the ends of its toes which are exceptionally larger than toepads of Florida's native treefrogs. Cuban treefrogs have large eyes and usually have rough, somewhat warty skin. Sometimes Cuban treefrogs have a pattern of large wavy marks or blotches on their back and have stripes or bands on their legs. The color of the treefrogs varies from creamy white to light brown but Cuban treefrogs can be green, beige, yellow, dark brown, or a combination thereof.

The Cuban treefrog is native to Cuba, the Cayman Islands, and the Bahamas. It was first reported in Florida in the 1920s in the Florida Keys and was likely transported in cargo or ornamental plant shipments. Cuban treefrogs inhabit natural areas such as pine forests, hardwood hammocks, and swamps. They also inhabit disturbed sites such as urban and suburban developments, agricultural areas such as orange groves, and plant nurseries (Johnson 2007). Cuban treefrogs inhabit areas throughout most of the LOWRP footprint. These treefrogs are introduced to new areas as stowaways on cars, trucks, boat trailers and through shipment of ornamental plants and trees.

Cuban treefrogs consume a variety of invertebrates and native treefrog species (Maskell et al. 2003). Native green and squirrel treefrogs (*Hyla cinerea* and *H. squirella)* are less likely to be found when Cuban treefrogs are present (Waddle et al. 2010), and when Cuban treefrogs are removed from an area, the abundance of native treefrogs increases (Rice et al. 2011). In addition, tadpoles of Cuban treefrogs are fierce competitors and can inhibit the growth and development of two species of native treefrogs (Johnson 2007). Effects of LOWRP on the distribution and abundance of Cuban treefrogs should be assessed given the Cuban treefrog's wide distribution and habitat tolerances, mounting evidence of direct impacts to native anuran species, and the lack of regional monitoring and control programs.

F.2.4.4 Burmese Python

Burmese pythons *(Python molurus bivittatus*) are large (up to 5.5 meters) constrictors that are native to Southeast Asia (Dorcas et al. 2012) and are top predators (SFER 2013). For 20 years prior to being considered established, python sightings occurred intermittently in south Florida. In 2000, the Burmese python was considered established in south Florida and since that time, the population has increased significantly in abundance and geographic range (Dorcas et al. 2012). The Burmese python is found throughout the southern Everglades, particularly in ENP and adjacent lands including the East Coast Buffer lands and the northern ENP boundary along Tamiami Trail. Sightings have also been documented in the Key Largo region (SFER 2013).

Pythons consume a wide variety of mammals and birds. More than 100 species have been identified as a food source and these include the endangered Key Largo woodrat (*Neotoma floridana smalli*) and the wood stork *(Mycteria americana).* In addition, American alligators (*Alligator mississippiensis*) are infrequently preyed upon by the python. Little is known about the impacts of predation by pythons on native species; however a recent study by Dorcas et al. (2012) indicates there has been a dramatic decline in mammal populations that coincides with the increase of pythons in ENP. The increase in the population size of pythons has been linked to a regional decline in small and medium mammals (Dorcas et al. 2012) but has not been distinguished from possible effects of changes in habitats and hydrology on mammal populations that also occurred during this time period.

F.2.4.5 Feral Hog

Feral hogs (*Sus scrofa*), also known as wild pigs, have existed on the Florida landscape since their introduction four centuries ago. They are reported in all 67 Florida counties within a wide variety of habitats, but prefer oak-cabbage palm hammocks, freshwater marshes and sloughs, and pine flatwoods. Although they do not favor marshes with deep water, during the dry season they make extensive use of partially dried out wetlands. Feral hog populations are particularly high in the counties immediately north and west of Lake Okeechobee, and in the Big Cypress and East Coast Regions.

Hogs commonly grow 5-6 feet long and weigh over 150 pounds. With a keen sense of smell and a powerful snout, they can detect and root up buried food. The diet of feral hogs includes vegetation, earthworms, insects, reptiles, frogs, bird eggs, rodents, small mammals, and carrion (Laycock 1966; Baber and Coblentz 1987). This invasive mammal is also known to prey on sea turtles, gopher tortoises, and other at-risk wildlife (Singer 2005). No animal native to North America creates the kind of disturbance when feeding that hogs do (Baber and Coblentz 1986).

Rooting by feral hogs can convert native grassland and other low vegetation to what looks like plowed fields. Hog rooting may facilitate establishment of invasive plant species because invasive exotics typically favor disturbed areas and colonize more quickly than many native plants (Belden and Pelton 1975; Duever et al. 1986). Feral hogs are unusually prolific for large mammals because they reach sexual maturity at an early age (6-10 months) (Barrett 1978), can farrow more than once a year (Springer 1977; Taylor et al. 1998), have large litters (4-8) (Sweeney et al. 2003), and often experience low natural mortality rates (Bieber and Ruf 2005). Recreational hunting is often a major source of mortality (Barrett and Pine 1980). However, in favorable habitat, hog populations are typically not greatly reduced by hunting (Bieber and Ruf 2005). There is no regional, coordinated monitoring program for the ubiquitous feral hog. Monitoring is limited to efforts associated with trapping programs and game management. Numerical monitoring of hogs present challenges because they are wary and adaptable animals that change their activity patterns and feeding areas in response to changing needs and threats from humans (Hughs 1985; Sweeney et al. 2003).

F.2.4.6 Island Apple Snail

The island apple snail (*Pomacea maculata*) is a freshwater mollusk. This large snail can grow up to 10 centimeters in length. It is native to South America (SFER 2013). Mating and egg-laying begins in March and can continue through October. It is thought the island apple snail was introduced in Florida in the early 1980s through the tropical pet industry (Fasulo 2004). This species has been globally introduced through releases associated with aquariums and intentional releases as a food crop. The island apple snail is considered as one of the 100 World’s Worst Invasive Alien Species. Potential impacts to Florida flora and fauna include destruction of native aquatic vegetation by consumption and competition with native aquatic fauna. The island apple snail has a voracious appetite for vegetation and in other countries has converted lush ecosystems into barren areas. It is likely the island apple snail will continue to spread and possibly outcompete the native apple snail (*P. paludosa*). The native apple snail is the primary food source for the Everglade snail kite (*Rostrhamus sociabilis*) which is an endangered species (SFER 2013). The Everglade snail kite is also known to feed on the island apple snail, which has been found in several canals within the LOWRP area. It is thriving in Lake Okeechobee, the Kissimmee Chain of Lakes, and the Kissimmee River.

F.2.4.7 Mexican Bromeliad Weevil

The Mexican bromeliad weevil (*Metamasius callizona*) was originally introduced to Florida through a shipment of bromeliads imported from Mexico. It was first detected in 1969 and is now found in many parts of South and Central Florida (Frank and Cave 2005). Larvae of the weevil destroy bromeliads by mining into their stems. The damaging insect is documented to attach 12 native bromeliad species, 10 of which are state-listed as threatened or endangered, and one of which occurs naturally only in Florida. Among the contributions of bromeliads to wildlife is that they catch rainwater, making it available to a variety of animals during periods of drought. The Mexican bromeliad weevil now infests bromeliads in the Sebastian, St. Lucie, Loxahatchee, Caloosahatchee, Peace, Myakka, and Manatee river systems as well as non-riverine sites.

F.2.5 Localized/Early Detection Rapid Response Species

F.2.5.1 Argentine Black and White Tegu

The Argentine black and white tegu (*Salvator merianae*) is a large South American lizard that can reach 1.5 meters in length in the wild. Tegus seem to prefer savannas and other grassy open areas in their native range (SFER 2013). In Florida, tegus seem to prefer disturbed upland areas adjacent to wetlands or permanent bodies of water. These types of habitats are frequently found adjacent to canals and rock pits and occur throughout the South Florida landscape. Tegus are generalist predators with a diet that includes a variety of fruits, vertebrates, invertebrates, and eggs. Because the tegu is a predator of eggs, it threatens native ground nesting birds and reptiles, including threatened and endangered species such as the American crocodile (*Crocodylus acutus*) and Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*). Endangered snail species such as *Liguus fasciatus* are also potential prey.

There are two known established populations in Florida; one in Hillsborough and Polk counties and one in southern Miami-Dade County. The population in Miami-Dade County seems to be increasing and expanding its range both to the west towards ENP and east toward Turkey Point. Both areas are home to endangered wildlife that may be threatened by tegus. Continued monitoring and removal efforts are needed to prevent the expansion into natural areas and control the population. Recently, there has been an increase in sightings near ENP which suggests the population is expanding. Systematic surveys of the species are needed to validate the population is expanding near ENP (SFER 2011) and to provide early detection of possible range expansion to new areas.

F.2.5.2 Nile Monitor

The Nile monitor (*Varanus niloticus*) is a large, carnivorous lizard from sub-Saharan Africa that is capable of reaching 2.4 meters (FWC bioprofile). It is a generalist feeder and an egg specialist in its native range (SFER 2013) that will feed on a wide variety of invertebrates and vertebrates it acquires by either predation or scavenging (FWC bioprofile). As such, the Nile monitor could impact a variety of native and threatened species in Florida through both competition and predation. The Nile monitor may pose a serious threat to a number of wading birds, marsh birds, gopher tortoises (*Gopherus polyphemus*), burrowing owls (*Athene cunicularia*), Florida gopher frogs (*Lithobates capito*), sea turtles, and other ground nesting species. They may negatively impact populations of American alligators and American crocodiles via egg predation and competition (FWC bioprofile). The Nile monitor has been well established in the Cape Coral area since the 1990s. There is also a small breeding population near Homestead Air Force base in Miami-Dade County (SFER 2011). More recently, a breeding population of Nile monitors has been discovered in Palm Beach County and numerous reports of the species throughout Broward County also suggest a breeding population. Because of their threat to native wildlife, this species has the potential to impact restoration efforts.

F.2.5.3 Green Iguana

The green iguana (*Iguana iguana*) is a large lizard native to Central and South America, extending to the eastern Caribbean (FWC 2018). Green iguanas can be found on the ground, in shrubs, or in trees in a variety of habitats, from agricultural and natural areas to suburban developments. They are excellent swimmers and are often found near canals and waterways. Male green iguanas can reach lengths of 1.5 meters and can feed on a variety of vegetation, fruits, bird eggs, and dead animals. This species is characterized by its green coloration, row of spikes down the center of its neck, back and upper section of the tail, which is banded with dark rings. Mature male iguanas display heavy jowls and a large throat fan, used both for sexual selection and self-defense.

Green iguanas were first reported in Florida in the 1960s in Hialeah, Coral Gables, and Key Biscayne along Miami-Dade's southeastern coast (FWC 2018). Breeding populations now extend along the Atlantic coast in Collier and Lee counties, as well as in Hendry County at Lake Okeechobee. Reports have been made as far north as Alachua, Highlands, Hillsborough, Indian River, and St. Lucie counties (FWC 2018). Those reported in more northern counties are likely individual pet releases, however, as green iguanas are not cold resistant and will be unlikely to establish breeding populations in these locations. In cleared habitats such as canal banks and vacant lots, green iguanas reside in burrows, culverts, drainage pipes, and rock or debris piles. South Florida's extensive man-made canals serve as ideal dispersal corridors to further allow iguanas to colonize new areas (FWC 2018). Green iguanas cause damage to residential and commercial landscape foliage, and are often considered a nuisance by landowners. Some iguanas may even cause damage to infrastructure by digging burrows that erode and collapse sidewalks, foundations, seawalls, berms, levees, and canal banks (FWC 2018). It is vital that this species be actively managed throughout South Florida to prevent further damage to infrastructure and native vegetation.

F.2.6 Other Species of Concern

Other species that are present within, or are likely to invade, the LOWRP footprint and cause environmental harm include the purple swamphen (*Porphyrio porphyrio*), brown hoplo (*Hoplosternum thoracatum*), bullseye snakehead (*Channa marulius*), sailfin catfish (*Pterygoplichthys disjunctivus*), and Gambian pouch rat (*Cricetomys gambianus*).

F.3 Introduction to Management

F.3.1 Prevention

Prevention is the first line of defense and the most efficient and cost-effective approach to reduce the threat of invasive non-native species. Successful prevention will reduce the rate of introduction and establishment and thereby reduce the impacts of invasive species. One essential element to prevention is identifying the high risk pathways that facilitate introductions and implementing actions to impede those introductions. Other critical elements include using effective management tools to reduce unintentional introductions and using risk assessment for both intentional and accidental introductions of non-native species. Baseline data and monitoring systems are required in order to evaluate the success of preventative measures.

F.3.2 Monitoring

Natural resource managers need spatial data on invasive species populations to develop management strategies for established populations, direct rapid response efforts for new introductions, and evaluate the success of control efforts (Myers et al. 2000; Dewey and Andersen 2004; Barnett et al. 2007). Several approaches may be taken to document the spatial distribution and population trends of invasive species. Each method has strengths and weaknesses and should be utilized according to specific management objectives.

Monitoring is the collection and analysis of population measurements in order to determine changes in population status and progress towards meeting a management objective (Elzinga et al. 1998). This type of monitoring is usually intended to detect relatively small changes in populations over time and often utilize small scale plots and/or transects. Invasive species surveys and inventories may be preferred when the objective is to detect populations and describe their spatial distributions over large landscapes, especially when early detection of new populations is desired (see EDRR discussion below).

Optimally, invasive plant mapping methods have high positional accuracy, high species detection accuracy (particularly for low-density infestations), rapid turnaround time, relatively low cost, and the ability to quantify the degree of infestation (USDA 2012). Ground-based surveys can provide high positional accuracy and species detection, but can be time consuming and logistically unrealistic for large landscapes (Rew et al. 2005). Stratified subsampling approaches to ground surveys can mitigate some of these limitations but probabilistic mapping may be ineffective for early detection needs of land managers (Barnett et al. 2007) and may not provide sufficient fine-scale information over large areas.

Developments in remote sensing technology have greatly improved opportunities for rapidly obtaining spatially precise data on invasive plant populations, particularly for large areas (Lass et al. 2005). However, the ability to detect target species using remote sensing is still limited to conditions where the species has a unique spectral signature or is a dominant canopy species and is often ineffective at detecting target species at low densities (Shafii et al. 2003). This inability to detect target species at low densities is a significant limitation for land managers focused on containment of expanding populations and detection of new invasions. Visual surveys from aircraft have been effectively used to map invasive plant distributions in the Everglades since 2008 (Rodgers and Pernas, in press). While visual aerial surveys may provide cost-effective information on landscape distributions of targeted plants, they have limited value for long-term change detection or fine scale assessments of abundance. This method may also lack sufficient detection precision for small plant species or species that occupy understories. Use of unmanned aerial vehicles may also provide relatively inexpensive invasive plant monitoring data and video documentation provides a permanent record of conditions. However, detection accuracy may be less than that of visual surveys, especially at low densities or new species introductions.

F.3.3 Early Detection and Rapid Response

Once a species becomes widespread, the cost to control it will more than likely require significant and sustained funding. Early detection and rapid response (EDRR) may be a cost-effective strategy to locate, contain, and eradicate invasive species early in the invasion process in order to minimize ecological and economic impacts of non-indigenous species (Rejmanek and Pitcairn 2002).

The three components of EDRR are Early Detection, Rapid Assessment, and Rapid Response. Early detection is defined as a comprehensive and integrated system of active or passive surveys to locate, identify, and report new invasive species as quickly as possible in order to implement procedures when it is feasible and less costly. Rapid Assessment includes the actions necessary to determine the appropriate response. This assessment identifies the current and potential range of the infestation, analyzes the risks associated with the invasion, and evaluates the timing and overall strategy for the appropriate actions. Rapid response is defined as a systematic approach to control, contain, or eradicate these species while the infestation is still contained in a particular area. Based on the results of the rapid assessment, a rapid response may be implemented to address new introductions or isolated infestations of a previously established species invading a new site (i.e., containment strategy).

Another critical element to rapid response is having the infrastructure in place to quickly implement management actions while new invasions can still be eradicated or contained. Effectively implementing EDRR will require coordination and collaboration among federal, tribal, state, local governments, nongovernment organizations (NGOs) and the private sector (National Invasive Species Council 2008).

F.3.4 Control and Management

Integrated Pest Management (IPM) is an effective approach to manage invasive species. IPM is the coordinated use of the most appropriate strategy to prevent or reduce unacceptable levels of invasive species and their damage by utilizing the most economical means, with the least possible hazard to people, property, and the environment. Physical, mechanical, chemical, and biological control methods are utilized in IPM.

Physical control, sometimes referred to as cultural control, is the physical manipulation of an invasive species or its habitat. A number of techniques are used for physical control. These include manual removal; installing barriers; and environmental alterations such as water level manipulation, prescribed fire, and light attenuation.

Mechanical control refers to the use of machinery designed to cut, shear, shred, uproot, grind, transport, and remove invasive species. Equipment used to complete mechanical control may include, but is not limited to, heavy equipment such as an excavator or front-end loader (with a root rake, grinding heads, or other attachments), cutter boats, dredges, and mechanical harvesters (Haller 2009).

Chemical control is the use of a specially formulated pesticide to control an invasive species. The United States Environmental Protection Agency defines a pesticide as “a substance or mixture of substances intended for the prevention, destruction, repulsion, or mitigation of any pest.” The term pesticide encompasses a broad range of substances including herbicides, insecticides, and fungicides. Pesticides are applied through ground and aerial applications.

Biological control, also known as biocontrol, is the planned use of one organism to suppress the growth of another. Biological control is primarily the search for and purposeful introduction of species-specific organisms that selectively attack a single target species. Organisms such as insects, animals, or pathogens that cause plant diseases are used as biological controls (Cuda 2009).

Objectives of management can include complete eradication within a given area, population suppression, limiting spread, and reducing effects of invasive species. Once an invasive species becomes widely established, complete eradication is usually not feasible. The most effective action for managing widely spread invasive species is often preventing the spread and reducing the impacts by implementing control measures. This concept is known as maintenance control. Maintenance control is defined as controlling an invasive species in order to maintain the population at the lowest feasible level.

F.3.5 Risk and Uncertainties Related to Invasive Species

As with most land management activities, there are a number of risks and uncertainties associated with invasive species management. The use of an adaptive management approach will help develop and prioritize invasive species control strategies. As restoration proceeds, invasive species may establish and/or spread as a direct result or independently of restoration activities. In the context of LOWRP and the long-term management of the natural resources within the study area, risks include but are not limited to:

- Introduction of new invasive species which are difficult or impossible to control;
- Restoration activities which unintentionally facilitate the spread of invasive species via contaminated earth moving equipment;
- Undetected spread of invasive species into new areas, making containment of populations more costly and less likely to succeed;
- Uncontrolled invasive species which create disturbances or alter ecosystems such that desired restoration outcomes are not achieved;
- Failure to secure necessary funding to control invasive species;
- Undesirable impacts on non-target species and ecosystem functions resulting from invasive species control efforts; and
- Not taking action to manage a species due to inaccurate assessments of the species' impact on restoration activities.

In most cases, the necessary information for detailed, specific pre-project evaluations of the need for management activities to control invasive species is not available. With the exception of a few well-established and well-studied species (e.g., melaleuca), there is an information deficit on the status, potential impact, and effective control techniques for priority species. This is particularly true for non-indigenous animals. Current knowledge on invasion mechanisms suggests that some restoration activities may facilitate the spread of certain priority species. For example, partial removal of canals and levees could encourage spread of or provide sites for colonization by numerous invasive species, including Brazilian pepper, Old World climbing fern, Nile monitors, pythons, and Cuban treefrogs. There remains considerable uncertainty regarding the degree to which different species will respond, if at all, to restoration activities and how these responses will impact achievement of restoration goals. Given the high degree of uncertainty, the most effective and lowest cost management option is early detection and rapid removal of invasive species during and post project. Central to this strategy is the implementation of a rigorous monitoring program (discussed below).

F.4 Existing Management Programs

F.4.1 South Florida Water Management District

The South Florida Water Management District (SFWMD) manages invasive exotic aquatic and terrestrial plants in canals and on levees of the Central and Southern Florida Project, Water Conservation Areas 2 and 3, stormwater treatment areas (STAs), interim project lands, and on public conservation lands. Most of the vegetation management is outsourced through the Vegetation Management Division and includes herbicide application contractors, mechanical removal contractors, and the use of biological controls such as plant-specific insects and herbivorous fish. The Melaleuca Control Program is a major focus for the SFWMD, but other priority plant species are controlled within the LOWRP study area as funding resources allow.

F.4.2 Lake Okeechobee

The U.S. Army Corps of Engineers (USACE), Florida Fish and Wildlife Conservation Commission (FWC), and SFWMD manage various species of invasive plants on Lake Okeechobee. Vegetation managed includes floating vegetation on Lake Okeechobee, the Okeechobee Waterway, and associated tributaries, as well as torpedograss, tropical American watergrass, and cattail.

F.4.3 U.S. Army Corps of Engineers

The USACE also conducts treatment of priority species on the Herbert Hoover Dike. In addition to the operations and maintenance program on Lake Okeechobee, the USACE conducts treatments of vegetation during the construction and Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRRR) phase for CERP projects. Vegetation treated includes FLEPPC Category I and II species, as well as native nuisance species.

F.4.4 U.S. Department of Agriculture / University of Florida

The SFWMD, FWC, USACE, National Park Service (NPS), U.S. Fish and Wildlife Service (USFWS), and other agencies provide financial support to the U.S. Department of Agriculture – Agricultural Research Service (USDA-ARS) and the University of Florida (UF) for the development of invasive plant biological controls. Efforts to identify safe and effective biological controls have led to important advancements in the integrative management of several invaders, including melaleuca, Old World climbing fern, water hyacinth, and alligator weed.

The CERP Melaleuca Eradication and Other Exotic Plants – Implement Biological Controls Project is dedicated to the implementation of biological control agents once overseas surveys and quarantine testing has developed agents deemed safe for release in Florida. The project included the construction of a mass rearing annex to the existing USDA-ARS biological control facility in Davie, Florida, in support of implementing the mass rearing, field release, establishment, and field monitoring of approved biological control agents for melaleuca and other invasive nonindigenous species.

F.4.5 Florida Fish and Wildlife Conservation Commission

The FWC’s Invasive Plant Management Section is the designated lead entity in Florida responsible for coordinating and funding the statewide control of invasive aquatic and upland plants in public waterways and on public conservation land. In addition to funding the SFWMD melaleuca control program, FWC annually awards funding for individual invasive plant management projects in the Everglades region. Allocation of control funding is determined by an interagency regional working group.

F.4.6 Invasive Animals

Efforts to develop control tools and management strategies for several priority species are underway for a few priority animal species. These include the Burmese python and other giant constrictors, the Nile monitor, and the Argentine black and white tegu. Control tools are very limited for free-ranging reptiles, and the application of developed methods is often impracticable in sensitive environments where impacts to non-target species are unacceptable. Available tools for removing large constrictor snakes and lizards currently include trapping, detection dogs, and visual searching. Potential tools include the use of toxicants, introduced predators, and pheromone attractants, but these have not been fully explored to date.

Regional invasive biologists have developed a conceptual response framework for established priority invasive animals in south Florida. Objectives within this framework are classified into three main categories—containment (slow the spread), eradicating incipient populations (remove outliers), and suppression (reduce impact in established areas). The resources to implement this strategic framework remain insufficient, but close collaboration between agencies has allowed for some coordinated efforts. Currently, FWC, NPS, UF, and SFWMD are conducting trapping and visual searching for Burmese pythons, northern African pythons, Argentine black and white tegus, spectacled caimans, and Nile monitors.

F.5 Existing Monitoring Programs

Since 2008, the SFWMD and NPS, along with other partner agencies, have used digital aerial sketch mapping (DASM) for a region-wide mapping program on over 728,000 hectares in the Everglades. DASM is a method for mapping plant infestations "on-the-fly" using GPS-linked computers and trained biologists. Visual surveys allow an observer to learn to recognize targeted species, sometimes at low densities, under a range of environmental and phenological conditions. Visual aerial surveys also may provide data more rapidly than other methods, which is important when rapid responses to newly established threats are expected. The primary objective of the DASM inventory program is to determine the distributions of four priority invasive plant species (Australian pine, Brazilian pepper, melaleuca, and Old World climbing fern) on managed conservation lands in the region. A secondary objective of the program is to detect new plant species invasions in remote areas to facilitate rapid response efforts. This data is currently collected on a two-year cycle.

In 2010, the UF, FWC, and SFWMD began collaboration on the Everglades Invasive Reptile, Amphibian, and Mammal Monitoring Program (EIRAMMP). The purpose of the project is to develop a monitoring program for priority invasive reptiles and amphibians and evaluate their impacts to south Florida. Specifically, the program seeks to (1) determine the status and spread of existing populations and the occurrence of new populations of invasive reptiles and amphibians, (2) provide additional EDRR capability for removal of invasive reptiles and amphibians, and (3) evaluate the status and trends of populations in native reptiles, amphibians, and mammals. The monitoring program involves visual searches for targeted invasive species on fixed routes along levees and roads within Arthur R. Marshall Loxahatchee National Wildlife Refuge, Water Conservation Areas 2 and 3, Big Cypress National Preserve, and ENP. In addition to trapping, visual searches and call surveys are conducted to monitor invasive reptile and amphibian species. Thirteen routes have been established.

F.6 Management Strategy and Plan

Many of the features of the water management system, as well as construction and operations and maintenance activities, have the potential to spread and promote establishment 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).

Many of the areas where LOWRP 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. Monitoring is a critical component of the management strategy. Information on distribution and restoration responses of invasive species should be used to inform decisions on control strategies. Invasive species surveillance, monitoring, and control should be carried out within the construction footprints, as well as impacted areas. Species of non-native vegetation to be treated include, but are not limited to, species listed in the current version of the FLEPPC invasive plant lists and the Florida Department of Environmental Protection prohibited plant list. The priorities for managing vegetation include FLEPPC Category I and II species, new invasive plant introductions, native nuisance species, and plants that impact project operations. Management of animal species will include surveillance, control, and monitoring.

The strategy for managing invasive species will be to utilize an IPM approach. Objectives of management will include complete eradication, population suppression, limiting spread, and reducing effects of invasive species. Eradication will be the objective for newly established species that are localized. The objective for widespread invasive species will be to implement control measures to suppress and prevent the spread of identified priority invasive species.

F.6.1 Surveillance – Early Detection and Rapid Response

EDRR should be implemented during every phase, for the life of a project. EDRR is an effective management measure to control and contain invasive species that were not previously within the project area. EDRR minimizes the negative impacts that invasive species have on the ecosystem and economy, and reduces future treatment and management costs. It is very difficult to predict when and where an invasive species may appear. As such, estimating a budget is challenging. However, to assist managers, a priority list of species to immediately respond to under EDRR management strategy has been developed.

A framework for establishing an EDRR program in the Everglades was recently drafted by an interagency team of invasive species experts and land managers. As discussed above, EDRR includes three strategy elements: 1) early detection, 2) rapid assessment, and 3) rapid response.

1.) Early Detection: This plan proposes implementation of routine surveillance in the project area in order to minimize the time between initial introduction and detection of a new species. Strategic surveillance by trained biologists in proximity to the LOWRP project features should greatly increase the probability of detection of new species. In many cases, existing programs could be expanded to include focused monitoring in the LOWRP footprint. For example, the EIRAMMP is well suited for enhanced surveillance for numerous invasive animal species (see **Section F.4** Existing Management Programs).

2.) Rapid Assessment: Following the detection of new invasions (or expansion of formerly contained invasions), it is important to gather and process available information to determine the potential risk and control options in the face of high uncertainty. Critical questions must be answered in a relatively short period of time. Example questions include:

- What is the spatial extent and abundance of the invasive non-native species?

- What is the likelihood that the species will impact native species, ecosystem function, operations infrastructure, or human health?
- What are the management options for containment or eradication?

Numerous tools are available to assist natural resource managers with the assessment phase of EDRR, though none of them is likely to be completely accurate in assessing the risk of a species. This plan proposes utilization of the University of Florida's Institute of Food and Agricultural Sciences (IFAS) Assessment of Non-native Plants in Florida's Natural Areas, the Florida Exotic Pest Plant Council's Invasive Species List, the FWC's Non-native Animal Bioprofile protocol, and the ECISMA's Rapid Response Plan for assessing the risks of non-indigenous species in the LOWRP footprint. These assessments should be conducted with LOWRP biologists, subject matter experts, and stakeholders.

3.) Rapid Response: This is the "risk management" component of EDRR. Once a species is determined to have a high probability of ecological impact and control options are available, rapid response strategies aimed at containment, and ultimately eradication, can be formulated and implemented. To be effective, rapid response programs must have built in procedural, financial, and logistical capacity to respond quickly to newly established threats. Since it is not possible to accurately predict the number and severity of new invasions during the project, this plan proposes contingency funding for rapid response activities in the event new, high-priority species establish in the project area. During the pre-construction phase, protocols for implementing rapid response should be developed.

F.6.2 Control

A combination of biological, physical, mechanical, and chemical control methods may be used to manage invasive species.

Biological control agents may be used to decrease the targeted invasive species' competitive advantages over native species and to weaken the invading population by increasing leaf mortality, decreasing plant size, reducing flower and seed production, and/or limiting population expansion. Biological control agents may be acquired through the Melaleuca Eradication and Other Exotic Plants – Implement Biological Controls project which is a component of CERP. One element of this CERP component includes the implementation of biological control agents which involves mass rearing, field release, establishment and monitoring of approved biological controls in south Florida and the Everglades. The four main invasive plant species targeted for control through this component include melaleuca, Australian pine, Brazilian pepper, and Old World climbing fern.

It is anticipated that physical control methods will be limited. Prescribed burns may be conducted in order to promote native plant growth and should be planned, if possible, to target invasive species when they are most susceptible to fire. Hand pulling of melaleuca and other non-native plant species will occur when it is feasible. Weed/debris barriers will be placed at water control structures when required to minimize dispersal of floating vegetation. Physical control measures may be utilized for invasive animal control. Examples of these measures include trapping of feral hogs, controlled harvest/overfishing (nets, fishing tournaments specific to invasive fish species), and compliance with FWC Fishing Regulation release/movement of fish (no return to water/used as bait).

Mechanical control may be implemented to remove non-native plant species when the construction of project features requires such removal. Heavy equipment such as bulldozers, front-end loaders and excavators (with or without grinding heads) may be utilized to uproot, grind and/or clear and grub. It is expected this type of control method may be utilized during levee degrades, canal backfilling, and during construction of new project features such as water control structures.

Chemical control may be utilized to treat aquatic and terrestrial invasive plants. Methods for treatment may include hack-n-squirt, basal bark, cut-stump, foliar, and/or aerial application. EPA-approved herbicides will be utilized to control invasive plants when required. Chemical control may be used to treat invasive plants in canals, along levees, in wetland/natural areas, as well as the Wetland Attenuation Feature (WAF).

F.6.3 Monitoring

Monitoring of invasive species populations may be conducted through DASM, Unmanned Aircraft System surveys, electrofishing, and/or EIRAMMP. Invasive species will also be identified through monitoring for the Adaptive Management Plan. This information will be provided to invasive species managers to ensure appropriate management measures are implemented.

F.6.4 Pre-construction Phase

Baseline conditions need to be established prior to the construction phase. Existing monitoring programs should be used as much as possible to establish baseline conditions prior to the start of construction activities. Although there are no system-wide monitoring programs for invasive species in the region, several individual agencies collect data. Data mining will be the primary resource to obtain baseline data via collaboration with the individual agencies. In areas with data gaps, surveys will need to be accomplished by the most cost-effective method (e.g., ground survey, Unmanned Aircraft Systems survey, DASM).

Existing monitoring and management programs should continue to be implemented. The existing programs help maintain invasive and nuisance species at a controlled level.

A significant length of time lapses from the time a project is planned to when it receives congressional authorization and appropriations, and ultimately goes to construction. As property (lands and structures) sit with no activity, vegetation and wildlife changes can occur. Unmanaged areas become inhabited by many species of flora and fauna, native and non-native. Older growth vegetation is more difficult and more costly to treat and remove versus lands that are managed along the way. As these lands become established with invasive species, there is an increased risk of spreading the invasive species to neighboring lands. Therefore, it is beneficial, ecologically and economically, to manage the lands early on. Managing invasive vegetation throughout the interim phase reduces construction costs since mowing is much less costly than clearing/grubbing and treating, and rapid response of new infestations helps reduce spread into environmentally sensitive areas.

F.6.5 Design and Construction Phases

The best method of controlling invasive and nuisance species is to prevent non-native species from being introduced and established to begin with. Incorporation of invasive species prevention and control into project designs, alternatives analysis, and operational plans has the potential to save significant resources during the long-term. The plans and specifications phase should simply design “with the end in mind.” When the end goal is ecosystem restoration, the designers should periodically obtain input from invasive species experts to identify design features and operational strategies that could potentially favor the establishment and spread of invasive species. An example of design influences on invasive species is levee removal without backfill of canals. Without canal backfilling, deep water refuges for non-native fishes and invertebrates (from both seasonal cold temperatures and seasonal drying) are maintained, and barriers to dispersal from canal waters to marsh habitats are removed. Design alternatives should be explored that would allow seasonal cooling of water in the canals. Cooler water temperatures will reduce the refuge capacity for cold temperature sensitive non-native fishes. In some cases, such as the coastal canals, aquatic barrier technologies could be used to mitigate the spread of non-native aquatic species.

Cost-saving measures to consider during design and construction include:

- Seeking input from invasive species management staff from the USACE, SFWMD, and other partner agencies throughout the design and construction phases.
- Working with subject matter experts to identify design features that may create habitat or entry points for invaders. Evaluate design alternatives to mitigate potential design vulnerabilities.
- Designing to promote the establishment of native species.
- Using construction methods that minimize ground disturbance whenever possible.
- Containing mobilized nutrients resulting from soil disturbances.
- Requiring all construction contractors to follow vehicle and equipment decontamination protocols prior to deployment. Coordinate with invasive species specialists for decontamination protocol specifications.
- Evaluating cost/benefit ratios for treating invasive/nuisance species prior to construction activities. In some cases, pre-construction removal of a species may significantly reduce its spread.
- Implementing a monitoring and rapid response protocol aimed at detecting and controlling new invasions early.
- Managing and controlling invasive/nuisance species during the entire construction phase.
- Using plant material from regional sources that are weed and pathogen free when native planting is specified in the plans.

Construction will be the responsibility of either the USACE or the SFWMD. This will be determined at a future time. Regardless of which agency will be responsible, both agencies commit to requiring the construction contractor to implement preventive measures and best management practices that will minimize the potential introduction and spread of invasive and nuisance species due to construction equipment (including personal protective equipment) and activities. This commitment is also included in **Section 5.2.5** (Environmental Commitments).

The USACE currently includes the following language in all of their specifications (Specification # 01 57 20 Environmental Protection, "Prevention of Invasive and Nuisance Species Transfer"):

> *The Contractor shall thoroughly clean equipment prior to and following work on the project site to ensure that items/materials including, but not limited to, soil, vegetative debris, eggs, mollusk larvae, seeds, and vegetative propagules are not transported from a previous work location to this project site, nor transported from this project site to another location. Prevention protocols require cleaning all equipment surfaces, including but not limited to, undercarriages, tires, and sheet metal. All equipment, including but not limited to, heavy equipment, vehicles, trailers, ATV's, and chippers must be cleaned. Smaller equipment, including, but not limited to, chainsaws, loppers, shovels, and backpack sprayers, must be cleaned and inspected to ensure they are free of eggs, vegetative debris, vegetative propagules, etc. The Contractor may utilize any method*

accepted by the Government; common accepted methods include pressure washing and steam cleaning/washing equipment. Prevention protocols should also address clothing and personal protective equipment.

Prior to the commencement of work, the Contractor shall complete and provide an invasive and nuisance species transfer prevention plan to the Corps for approval. This plan shall be part of the Environmental Protection Plan as defined in subparagraph "Environmental Protection Plan" of paragraph SUBMITTALS (Part 1.5) above. The invasive and nuisance species transfer prevention plan shall identify specific transfer prevention procedures and designated cleaning sites/locations. Prevention protocols may vary depending upon the nature of the project site. It will be the responsibility of the Contractor to ensure all equipment coming onto and leaving the project site is inspected and not harboring materials that would spread, or potentially spread, invasive and nuisance species onto or off the project site. The Contractor shall provide a report verifying equipment brought on site was cleaned and shall provide a report verifying equipment was cleaned prior to removal from the project site.

F.6.6 Operational Testing and Monitoring Period

The operational testing and monitoring period is the timeframe from the end of construction until the project is transferred and accepted by the local sponsor. EDRR is very critical and the most cost-effective management measure during this period. Disturbed areas, such as areas impacted from construction activities, are prone to the establishment of invasive and nuisance species. Early detection of invasive and nuisance species and immediate treatment/control measures prevent these species from establishing and becoming long-term problems, ecologically and economically.

F.6.7 OMRR&R Phase

The "Prevention of Invasive and Nuisance Species Transfer" language above applies not only to the construction phase, but also to the OMRR&R phase. The preventive measure applies to contractors and government employees. Maintenance equipment and rental equipment are often used at multiple locations. As equipment is moved from one location to another, this potential spread vector can easily be reduced or prevented simply by ensuring the equipment is clean prior to arrival on site and prior to leaving the site.

In addition, numerous operational aspects of the restoration can influence mechanisms of invasion. For example, many non-indigenous species become more invasive in environments with elevated nutrient availability. With large pulses of only slightly elevated phosphorus levels, some invasive plant species could establish and spread.

F.6.8 Specific Control by Project Feature – Construction Phase

F.6.8.1 Wetland Attenuation Feature

The wetland attenuation feature (WAF) is located within the Indian Prairie sub-watershed west of the C-38 canal, north of SR 78, east of the Seminole Tribe of Florida Brighton Reservation, and south of the C-41A canal. The WAF is used for surface storage to attenuate Kissimmee River basin flows when the Lake Okeechobee stage is above the ecologically-preferred stage envelope and to provide a water source for co-located ASR wells. Although a WAF provides aboveground storage like a typical reservoir, water levels may at times be suitable for growth of wetland vegetation due to the water depths typically realized through the designed operation of the facility. Thus, the peak flows from the Kissimmee Basin are the aquatic conditions that a WAF is directly designed to 'attenuate.' The WAF footprint, including the embankments, seepage canal, and other perimeter features, is approximately 13,600 acres, with a storage capacity of approximately 46,000 acre-feet (ac-ft). The WAF includes a pump station located downstream of the existing S-84 structure on the C-41A canal. The pump draws water downstream of S-65E that is considered water of Lake Okeechobee.

Wetlands, Embankments, Seepage Canals, and Pump Station. Surveys of the WAF should be completed prior to construction to identify priority species that may be spread by construction activities as well as species that should be treated prior to the beginning of construction. Periodic surveys of the new structures should be conducted throughout the construction phase to identify growth of priority species. Water diverted may result in the spread of priority species and should therefore be closely monitored. Priority plant species in these areas should be treated. Priority species located within the excavation area for the seepage canals shall be treated and surveillance conducted throughout the construction period. It is recommended that adjacent areas within 0.5 mile of the spoil mound be systematically surveyed and treated to eliminate close proximity seed sources, thereby preventing spread of priority plant species, such as Brazilian pepper and cogongrass.

F.6.8.2 Aquifer Storage and Recovery Wells

Eighty ASR wells with 5 million gallons per day (MGD) capacity per well are proposed in clusters in various locations throughout the Lake Okeechobee watershed and co-located with the WAF. The well clusters will include a combination of wells that will utilize either the Upper Floridian Aquifer (UFA) or the Avon Park Permeable Zone (APPZ) for storage and recovery. Underlying geology and presence of existing users within the vicinity limit the siting of ASR wells. Proposed ASR cluster locations are based upon the findings of the 2015 Comprehensive Everglades Restoration Plan (CERP) ASR Regional Study; however, these locations are conceptual and may be adjusted based on the results of exploratory testing. Final siting will be determined during preconstruction engineering and design (PED), although initial siting of WAF co-located ASR wells will likely be on the southwest portion of the WAF due to greater water availability.

- **ASR wells co-located with the WAF:** These wells can withdraw water from the WAF when it is full, thus providing additional storage capacity in the WAF.
    - There are three well clusters (25 wells each) co-located with the WAF.
    - ASR wells will recharge using water from the WAF and release into the WAF prior to release into the Kissimmee River.
    - The combination of ASR wells and the WAF provides dynamic aboveground and belowground storage.
    - It is anticipated that the ASR wells will support maintenance of wetland habitat in the WAF during dry periods such that the risk of dryout is minimized.
- **Watershed ASR wells:** The remaining 55 ASR wells are located throughout the watershed in several clusters.
    - One proposed cluster is located adjacent to the C-44 canal in Port Mayaca. This will 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. Some of the wells will be adjacent to the L-63N canal and the rest will be adjacent to the L-63S canal. These will allow flow into the lake at the S-191 structure.
- Two potential clusters are located adjacent to the C-38 canal downstream of S-65E that release back into the C-38 canal.
- One cluster is located along Taylor Creek, downstream of S-192 and upstream of the S-133 pump station which releases fresh water to Lake Okeechobee.
- 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.

Construction Footprint of ASR Wells. The construction footprint of each ASR should be surveyed prior to construction. Species that can be spread by construction activities (e.g., cogongrass) should be treated prior to beginning construction. Surveys should be conducted throughout the construction period and priority/EDRR species should be treated.

F.6.8.3 Wetland Restoration Sites

The purpose of wetland restoration component of the LOWRP is to increase the spatial extent and functionality of aquatic and wildlife habitat within the Lake Okeechobee Watershed by restoring the hydrology of selected isolated and riverine wetlands. The Recommended Plan will restore approximately 4,800 acres of wetlands in the Paradise Run and Kissimmee River-Center locations.

The Paradise Run site, approximately 3,600 acres, contains remnant Kissimmee River channel and floodplain. The site is located downstream of S-65E on the west bank of the C-38 canal, between the C-41A canal and the Buckhead Ridge community. A pump station on the C-41A canal downstream of S-84 will serve as the water source to bring water into the historic river channel running through the overdrained Paradise Run site. Approximately 24,500 linear feet of channel excavation will be performed to restore flow to a portion of the river and rehydrate the floodplain wetlands. The L-59 canal will be plugged to allow overland flow over the former canal. The flow will release back into the C-38 canal by way of the WAF outlet canal and a system of culverts through the Herbert Hoover Dike (HHD) on the southeast corner of the site.

The Kissimmee River–Center site, approximately 1,200 acres, is located on the west bank of the C-38 canal, about halfway between S-65D and S-65E. A pump station will be placed in the C-38 canal at the north end of the site to divert water to the west into a created river channel that mimics the historic Kissimmee River. Approximately 21,500 feet of channel excavation will be performed to create riverine habitat and to rehydrate floodplain wetlands.

Spoil Mound Degradation, Channel Excavation, Pump Station, and Weir Installation. Surveys of the Kissimmee River-Center and Paradise Run wetland areas should be completed prior to construction to identify priority species that may be spread by construction activities as well as species that should be treated prior to construction. Such species should be treated prior to the beginning of construction.

Periodic surveys of the degraded areas, spoil mounds, and the areas adjacent to the new weir structures should be conducted throughout the construction phase to identify growth of priority species. Water diverted west by the weir into the historic Kissimmee River may result in the spread of priority species and should thereby be closely monitored. Priority plant species in these areas should be treated. Material removed during channel excavation should be closely monitored to decrease the spread of submerged vegetation. It is recommended that adjacent areas within 0.5 mile of the spoil mound be systematically surveyed and treated to eliminate close proximity seed sources, thereby preventing spread of priority plant species, such as Brazilian pepper and cogongrass.

F.6.9 Specific Control by Project Feature – OMRR&R Phase

F.6.9.1 Wetland Attenuation Feature

Vegetation within the WAF will likely be difficult to manage due to high nutrient loading from surface water inflows. Similar conditions are experienced in the stormwater treatment areas (STAs), and maintenance control of many invasive plant species have proven difficult and not cost-effective. Vegetation management within the WAF should focus on maintaining WAF functionality. Vegetation should be controlled to ensure adequate surface water conveyance and minimal impact to infrastructure (e.g., levee instability, floating tussocks). However, any invasive species capable of establishing in the WAF and spreading to natural areas should be a priority for control. Chemical treatments of floating and submerged vegetation should be performed upstream and downstream of water control structures. Occasional mechanical removal of tussocks or uprooted submerged species may be required in order to maintain operations and the function of the WAF. Vegetation should be maintained throughout the OMRR&R phase, with an emphasis on minimizing the spread of invasive plants capable of spreading to natural areas (e.g., cogongrass). Non-native invasive animal species that have potential to damage infrastructure or hinder recovery efforts should be removed from the project.

F.6.9.2 Aquifer Storage and Recovery Wells

The construction footprint of each ASR should be surveyed throughout the OMRR&R phase. Non-native species of vegetation should be treated within the footprint. Non-native invasive animal species that have potential to damage infrastructure should be removed to prevent damage.

F.6.9.3 Wetland Restoration Sites

Surveys of the Kissimmee River-Center and Paradise Run wetland areas should be completed throughout the OMRR&R phase. Invasive non-native vegetation should be treated. Periodic surveys of the degraded areas, spoil mounds, and the areas adjacent to the new weir structures should be conducted throughout the OMRR&R phase to identify growth of invasive native and non-native plant species. Vegetation should be maintained throughout the OMRR&R phase. Non-native invasive animal species that have potential to damage infrastructure or hinder recovery efforts should be removed from the project.

F.7 Education/Outreach

F.7.1 Education / Outreach Opportunities at Recreational Areas

Recreational opportunities will be created by the LOWRP. Recreation areas such as boat ramps, hiking trails, and hunting areas can serve as vectors and pathways for aquatic and terrestrial invasive species. For example, invasive species can be transferred from one area to another by hikers and by boats/trailers. Many recreational users are unaware of their role in the spread of unwanted species. Hence, educating the public on preventing the spread of invasive species can be a cost-effective component of the overall management strategy. The recreation access points can be used to display educational information on invasive species identification, prevention/control measures, and awareness of the invasive species programs in the area, and how individuals can contribute to invasive species prevention. Educational kiosks are recommended and should include information on:

- Specific priority invasive species in the area
- Impacts and costs of invasive species on conservation, human health, and recreation
- Preventative measures, such as removing vegetation from boats/trailers before leaving the boat ramp or removing vegetation from shoes and clothing before leaving the area.
- Ways to report invasive species observations
- Programs that citizens can get involved with and learn more about invasive species
- Laws against the release of non-native wildlife

F.8 Costs

A summary of invasive and nuisance species management costs is presented in **Table F-4**Error! Reference source not found.. Detailed costs for the construction phase and OMRR&R phase can be found in **Table F-5** and **Table F-6**, respectively. It was assumed that in the field baselines and potential invasive species treatments and management would need to occur starting about two years prior to the actual construction start date. Costs were estimated for the life of the project, assuming a 50-year life. However, due to size, the OMRR&R table only shows Year 1 and Year 50.

Table F-4. Invasive and nuisance species management costs.

Invasive and Nuisance Species Management	
1 Year Pre-Construction	$5,018,790
Construction Phase	$1,400,874
Operational Testing & Monitoring Phase	$402,029
1 Year OMRR&R Phase	$818,164
50-Year OMRR&R Phase (Includes Year 1)	$36,232,635
Total Management Cost	**$43,872,492**
Invasive and Nuisance Species Management Monitoring	
1 Year Pre-Construction	$25,000
Construction Phase	$25,000
1 Year OMRR&R Phase	$25,000
10-Year OMRR&R Phase (Includes Year 1)	$250,000
Total Monitoring Cost	**$325,000**

Table F-5. Invasive and nuisance species management costs – construction phase.

Project Feature	Management Activity	Pre-Construction 1 year	Construction	Operational Testing & Monitoring Phase
Wetland Restoration Kissimmee River-Center *1,200 acres* *Construction period – 3 years*	EDRR surveillance - plants	$13,632	$20,448	$13,632
	Plant control/treatment (1,200 acres @ 25% infestation)	$255,000	$56,250	$14,625
	EDRR surveillance and removal - animals		$4,666	$4,666
	Coordination/inspections/contract implementation	$53,726	$15,340	$5,651
Wetland Restoration Paradise Run *3,600 acres* *Construction period - 3 years*	EDRR surveillance - plants	$20,448	$20,448	$6,816
	Plant control/treatment (3,600 acres @ 25% infestation)	$867,000	$191,250	$49,725
	EDRR surveillance and removal - animals		$4,666	$4,666
	Coordination/inspections/contract implementation	$177,490	$43,273	$12,241
K-05 Wetland Attenuation Feature *13,600 acres* *Construction period - 3 years*	EDRR surveillance - plants	$61,344	$61,344	$20,448
	Plant control/treatment (13,600 acres @ 30% infestation)	$2,550,000	$562,500	$146,250
	EDRR surveillance and removal - animals	$27,996	$41,994	$9,332
	Coordination/inspections/contract implementation	$522,269	$124,769	$33,340
Aquifer Storage and Recovery Wells *80 wells*	EDRR surveillance - plants	$13,632	$20,448	$13,632
	Plant control/treatment (5 acres @ 80 sites)	$85,000	$75,000	$25,000
	EDRR surveillance and removal - animals	$23,330	$69,990	$23,330
	Coordination/inspections/contract implementation	$30,491	$41,360	$15,491
	Subtotal Cost	**$4,562,537**	**$1,167,395**	**$335,024**
Other Costs	Oversight of management activities; revise/update INSMP; development of EDRR framework; budget, contract, administrative support; assessment of species	$456,253	$233,479	$67,004
	Total Cost	**$5,018,790**	**$1,400,874**	**$402,029**

Table F-6. Invasive and nuisance species management costs – OMRR&R phase.

Project	Management Activity	Year 1 OMRR&R	50-Year OMRR&R
K-05 Wetland Attenuation Feature *13,600 acres*	EDRR surveillance - plants	$40,896	$1,196,437
	Plant control/treatment - floating/emergent	$234,000	$15,084,385
	Plant control/treatment - submerged	$17,000	$1,095,874
	EDRR surveillance and removal - animals	$58,325	$3,759,815
	Coordination/inspections/contract implementation	$70,044	$4,515,272
Wetland Restoration • *Kissimmee River-Center - 1,200 acres* • *Paradise Run -3,600 acres*	EDRR surveillance - plants	$10,906	$703,010
	Plant control/treatment	$47,712	$3,075,667
	EDRR surveillance and removal - animals	$9,332	$601,570
	Electrofishing	$24,000	$1,547,116
	Coordination/inspections/contract implementation	$18,390	$1,185,473
Aquifer Storage and Recovery Wells *80 wells*	EDRR surveillance - plants	$13,632	$878,762
	Plant control/treatment	$31,200	$2,011,251
	Coordination/inspections/contract implementation	$8,966	$578,003
	Subtotal Cost	**$584,403**	**$36,232,635**
Other Costs	Oversight of management activities; revise/update INSMP; development and implementation of EDRR framework; budget, contract, administrative support; assessment of species; coordination with other agencies/EDRR response	$233,761	$12,681,422
	Total Cost	**$818,164**	**$49,147,819**

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