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 LRWRP 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 are developed and agreed to prior to construction. The documents outline the responsibilities of the federal 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 LRWRP study area is approximately 480,000 acres (753 square miles) and is located in northern Palm Beach County and southern Martin County. The study area is bounded on the north by the C-44 Canal, on the south by the C-51 Canal, on the west by the L-10/L-12 Canals and Lake Okeechobee, and on the east by the Loxahatchee River Estuary and Lake Worth Lagoon. The Loxahatchee River discharges into the Atlantic Ocean near the town of Jupiter, Florida. The Northwest Fork of the Loxahatchee River (NWFLR), a federally designated National Wild and Scenic River, is a natural river channel that originates in the Loxahatchee and Hungryland Sloughs. Downstream from these sloughs, the NWFLR receives additional inflow from other major tributaries of the Loxahatchee River that includes Cypress Creek/Ranch Colony Canal, Hobe Grove Ditch, and Kitching Creek. The purpose of LRWRP is to restore and sustain the overall quantity, quality, timing, and distribution of freshwaters to the federally designated “National Wild and Scenic” for current and future generations. This project also seeks to restore, sustain, and reconnect the area’s wetlands and watersheds that form the historic headwaters for the river.

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 “Harmful Non-indigenous Species in the United States” report, 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 February 3, 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); invasive species are second in destructive nature only to human development. In the United States, invasive species directly contributed to the decline of 49% of the T&E species (Wilcove et al. 1998). In addition to environmental impacts, invasive species impact human health, reduce agricultural production and property values, degrade aesthetic quality, decrease recreational opportunities and threaten the integrity of human infrastructure such as waterways/navigation channels, locks, levees, dams and water control structures.

Florida is particularly vulnerable to the introduction, invasion and naturalization of non-native species. This is due to several factors including a subtropical climate, dense human population centers, major ports of entry and the pet, aquarium and ornamental plant industries. Major disturbance to the landscape has also increased Florida's vulnerability to invasive species. Alteration of the landscape for urban development, flood control and agricultural uses has exacerbated non-native plant and animal invasions. 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, Kutner and Adams (2000) estimated that over 32,000 exotic species (25,000 plants and 7,000 animals) have been introduced into Florida. There are approximately 4,000-5,000 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.

Significant scientific evidence and research document invasive non-native plants are degrading and damaging south Florida natural ecosystems (Doren and Ferriter 2001). Many species are causing significant ecological impacts by crowding out and displacing native plants, altering soil types and soil/water chemistry, altering ecosystem functions such as carbon sequestration, nutrient cycling and fire regimes and reducing gene pools and genetic diversity. Non-native invasive animal distribution, extent and impacts are not well understood, however implications of invasive animals are apparent in south Florida. It has been documented there are 14 non-native species that are causing direct impacts to threatened and endangered species and rare habitats. Holm et al. (1977) documented that 19 species within Florida are among the world's worst weeds. 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).

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. 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). The 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

Information regarding both plants and animals is presented below in three categories: widely established within the project area, localized/potential early detection rapid response (EDRR) species, and other species of concern.

F.2.1 Plants

The Guide to the Vascular Plants of Florida (Wunderlin 1998) documented 3,834 plant species in Florida. Of the 3,834 plant species, 1,180 were considered non-native and were naturalized (freely reproducing) populations. The Florida Exotic Pest Plant Council (FLEPPC) identifies 81 of the 1,180 species of non-native plants as Category I and 87 as Category II species in the 2017 Invasive Plant List. Searches through existing data and resources indicate 110 non-native plant species have been documented to occur within the project area (Table F 1: Invasive Plant Species Documented in the Project Area). Other non-native species are probably present; however, documented citations could not be located. Of the 110 species of plants documented to occur within the project area, there are 59 FLEPPC Category I species, 39 FLEPPC Category II species, and 22 Florida Noxious Weed species.

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.

F.2.1.1 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*), cogon grass (*Imperata cylindrical*), torpedo grass (*Panicum repens*), creeping water-primrose (*Ludwigia spp.*), downy rose myrtle (*Rhodomyrtus tomentosa*), shoe button ardisia (*Ardisia crenata*), water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes*).

Summaries on the distribution and impacts of these widely established species are included below. Other non-native plant species with limited or localized distributions or which have a high potential to spread into the project area are also discussed.

F.2.1.2 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, shading out native species. It produces dense litter accumulation, causes beach erosion, and produces an allelopathic agent that inhibits growth of other species. It also interferes with nesting of sea turtles and the American crocodile (Langeland and Burks 1998).

F.2.1.3 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.2.1.4 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 Burks1998). 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, Center, Dray, and Thayer 2008).

F.2.1.5 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 and the first record of it being found in Florida was 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 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. This plant is a threat to many areas within the project site (Ferriter et al. 2005) and disturbed sites.

F.2.1.6 Shoebutton ardesia

Shoebutton ardisia (*Ardisia elliptica*) is an evergreen, glabrous shrub or small tree approximately 17 feet tall. It was imported as an ornamental shrub as early as 1900 (Gordon and Thomas 1997). It invades understories of hammocks, tree islands, disturbed wetlands and cypress and mangrove areas. This species often forms monocultures resulting in local displacement of native plant species. There is a tendency for reinvasion by shoebutton ardisia or other exotic plants following removal of dense thickets of this species. New infestations may go undetected due the physical similarity to the common native marlberry (*Ardisia escallonioides*).

F.2.1.7 Water hyacinth

Water hyacinth (*Eichhornia crassipes*) 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.2.1.8 Water Lettuce

Water lettuce (*Pistia stratiotes*) 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.2.1.9 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. Torpedo grass 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. Torpedo grass 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, lakeshores, canals, and other disturbed sites. Torpedo grass 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 torpedo grass was present in Lake Okeechobee. Approximately 14,000 acres of torpedo grass displaced native plants in Lake Okeechobee’s marsh (Langeland et al. 2008). Torpedo grass 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.2.1.10 Cogongrass

Cogongrass (*Imperata cylindrica*) 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. Cogongrass 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.2.1.11 Cattail

Cattails (*Typha spp.*) are native to Florida and occur in wetlands, lakes, rivers, canals, storm water treatment areas and other disturbed sites. Cattails 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 cattails. 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.2.1.12 Localized or Potential EDRR Species

The Treasure Coast Cooperative Invasive Species Management Area (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 sickle pod *(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).*

F.2.1.13 Other Species of Concern (Containment and Eradication)

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 waterhyacinth *(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*), frogsmouths (*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*). Roundleaf toothcup (*Rotala rotundifolia*) is another species of concern for the project area, it has been located along the southern boundary of J.W.Corbett Wildlife Management Area in Indian Trails Improvement District canal.

F.2.2 Animals

Searches through existing data and resources indicate 65 animal species have been documented to occur within the project area (**Table 1**). 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 65 non-native animal species identified and documented to occur in the LRWRP area will have a significant impact on the ecosystem.

F.2.2.1 Widely Established Species

Species that are well established and are known or presumed to exert significant negative impacts on Florida ecosystems include the island applesnail (*Pomacea* maculata), purple swamphen (*Porphyrio porphyrio)*, feral pig (*Sus scrofa*) Cuban tree frog, Asian swamp eel, and redbay ambrosia beetle (*Xyleborus glabratus)* and associated fungus (*Raffaelea lauricola).*

F.2.2.1.1 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 2011). *Xyleborus glabratus* is the twelfth species of non-native ambrosia beetle known to have become established in the U. S. 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, it impacts other native and non-native members of the Lauraceae (Hanula et al. 2008) including swamp bay (*P. palustris*), an important species of many Everglades plant communities. Since its arrival in 2002, the red bay ambrosia beetle and laurel wilt have spread quickly throughout the southeastern U.S. 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 ENP and WCA 3B. In February 2012, laurel wilt was also confirmed in the LNWR. 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 red bay 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 red bay 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.2.2.1.2 Asian Swamp Eel

The Asian swamp eel (*Monopterus albus*) is a versatile animal, capable of living in extremely shallow water, traveling over land when necessary, and burrowing into mud to survive periods of drought (Shafland et al. 2010). This species is a generalist predator with a voracious appetite for invertebrates, frogs, and fishes (Hill and Watson 2007; Shafland et al. 2010). Wild populations in Florida originated as escapes or releases associated with aquaculture, the pet trade, or live food markets. Regional biologists are concerned that this species may become widely established, since the diverse wetland habitats of the Greater Everglades may be suitable for the species. Additionally, Asian swamp eels have a broad salinity tolerance giving concern that this species could also establish populations in estuaries (Schofield and Nico 2009). There are at least four reproducing populations of Asian swamp eels in Florida: North Miami canals, canal networks near Homestead adjacent to the ENP, eastern ENP, and in water bodies near Tampa (Collins et al. 2002; Nico et al 2011, USGS, personal communication, 2012; Jeff Kline, USNPS, personal communication, 2012). The impact of Asian swamp eels to Everglades fauna is undocumented and management options are currently limited to monitoring and electrofishing in canals. The species' generalist diet and adaptations to low water events suggests that native fishes, aquatic invertebrates, and frogs could be threatened. Nico et al. (2011) also report high parasitism rates in wild caught Asian swamp eels in Florida, raising concern that the species could be a vector for macroparasites to native fishes.

F.2.2.1.3 Cuban Treefrog

The Cuban treefrog is the largest species of treefrog in Florida and range from 1-4 inches in length. The Cuban treefrog has expanded pads on the ends of their 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 combination thereof. It 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 CERP area. 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 CERP projects 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.2.2.1.4 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 with weights 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. This is 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) (Sweeny 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). In favorable habitat, however, 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, Sweeny et al. 2003).

F.2.2.1.5 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, a row of spikes down the center of the 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, and 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, therefore, 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.2.2.1.6 Purple Swamphen

The purple swamphen (*Porphyrio porphyrio*) is a member of the rail family native to Australia, Europe, Africa, and Asia. It is noticeably larger than its Florida native relatives, the American coot (*Fulica americana*), the common moorhen (*Gallinula chloropus*), and the purple gallinule (*Porphyrio martinica).* The swamphen and the gallinule both have purple plumage and red bills, but the face shield above the bill is red and the legs are pink in the swamphen while the face shield is pale blue, the legs are yellow and the bill has a yellow tip in the gallinule. Introduction of the swamphen was likely due to escapes from the Miami zoo and private aviculturists in Broward County. The purple swamphen feeds on shoots and reeds, invertebrates, small mollusks, fish, snakes, and the eggs and young of waterfowl (Pranty et al. 2000). Nests are typically large mounds of vegetation in wetlands. Known to be highly aggressive and territorial, the purple swamphen could negatively affect native water birds through competition for food and space and through direct predation. Rapid response efforts between 2006 and 2009 did not successfully reduce the abundance or distribution of this species. The management goal for the species has shifted from eradication to suppression (Jenny Ketterlin Eckles, FWC, personal communication, 2012). Efforts to remove birds by hunting did not significantly deplete the population. No other control tools are currently developed for this species. In recent years, purple swamphens have been sighted in the WCAs, ENP, Big Cypress National Preserve, Lake Okeechobee, and in all Everglades stormwater treatment areas. The FWC is currently conducting prey and habitat analyses to support a risk assessment, which will guide future management strategies (Jenny Ketterlin Eckles, FWC, personal communication, 2012). There are currently no coordinated monitoring efforts for purple swamphens.

F.2.2.1.7 Island Applesnail

The island applesnail (*Pomacea maculata*) is a large South American freshwater mollusk that is established throughout Florida. It was intentionally introduced through releases from aquaria and as a food crop. Potential impacts to the environment include destruction of native vegetation, competition with native fauna, and disease transmission. There is concern the island applesnail may out-compete the native applesnail, *P. paludosa* which is the primary food source of the endangered Everglade snail kite. In addition a newly described cyanobacterium (*Aetokthonos hydrillicola*) found in the Kissimmee Chain of Lakes is associated with a lethal neurologic disease, avian vacuolar myelinopathy (AVM), which affects avifauna in the southeastern United States (Wilde et al. 2005). Research has confirmed that bioaccumulation of a neurotoxin produced by *A. hydrillicola* in the island applesnail and birds fed with affected snail incur 100 percent development of AVM in laboratory birds (Dodd et al. 2016), suggesting a significant risk to the snail kite and other avifauna.

F.2.2.2 Localized/Early Detection Rapid Response Species

Of the species identified, there are four key carnivorous reptiles that are currently present within or in close proximity to the project area and have potential to cause significant ecological impacts. These include the Argentine black and white tegu, the Burmese python, northern African python, and the Nile monitor. At present time, these occurrences have been isolated but there is concern regarding further spread of these species from the southern portion of the project area. These reptiles are among south Florida’s most threatening invasive animals. The species are considered top predators and increase additional pressures on native wildlife populations, particularly threatened and endangered species (SFER 2013). Other species considered EDRR include Oustalet’s chameleon (*Furcifer oustaleti*), spectacled caiman (*Caiman crocodilus fuscus*), veiled chameleon (*Chamaeleon calyptratus*) and the giant African land snail.

F.2.2.2.1 Northern African Python

Since 2001, over 40 northern African pythons (*Python sebae*) have been found in western Miami-Dade County (Jacob Kline, FWC, personal communication). This giant constrictor’s natural history traits are similar to the Burmese python and is considered a high risk for establishment and expansion throughout south Florida (Reed and Rodda 2009). Rapid response efforts to eradicate this population are now of highest priority. The SFWMD, Miccosukee Tribe of Indians, and Miami-Dade County, the primary landowners within the Bird Drive Basin, are working closely with FWC and other agencies to address this threat.

F.2.2.2.2 Burmese Python

Burmese pythons 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. 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, but has not been distinguished from possible effects of changes in habitats and hydrology on mammal populations that also occurred during this time period (Dorcas et al. 2012).

F.2.2.2.3 Argentine Black and White Tegu

The Argentine black and white tegu 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 its 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 which includes 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.2.2.2.4 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 spp*.), 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 our native wildlife, this species has potential to impact restoration efforts.

F.2.2.2.5 Oustalet's Chameleon

The Oustalet's chameleon (*Furcifer oustaleti*) is a large chameleon native to Madagascar where it utilizes a wide variety of habitats, including human altered environments (D'Cruze et al. 2007). Diet analysis indicates that this species preys on a variety of anole and insect species, particularly moth larvae (Krysko et al. 2012). Florida populations of this species are suspected to have been established through intentional releases by reptile enthusiasts. A population of the Oustalet's chameleon was discovered in rural Miami-Dade County in early 2010. This species does not appear to be spreading without human assistance and the number of chameleons per survey has decreased, indicating eradication may be possible if regular surveys resume. (SFER 2018)

F.2.2.2.6 Veiled Chameleon

The veiled chameleon (*Chamaeleo calyptratus*) naturally occurs in mountain and coastal regions of the Arabian Peninsula, although it is also known to utilize a wide range of habitats. Florida populations of this species are suspected to have been established through intentional releases by reptile enthusiasts. Breeding populations of the veiled chameleon are now documented in the Lee County (northwest estuaries), Miami-Dade County (one population near ENP a second adjacent to BCNP), Broward County, and Palm Beach County near the southern tip of LNWR (FWC 2013). In addition, reports of veiled chameleons are now common from Buckingham, Alva, Cape Coral, Marco Island, and Lutz, Florida. If chameleons continue to demonstrate the ability to spread from suburban and agricultural land and build populations in native Florida habitats, then the argument for an aggressive eradication program will be strong. (SFER 2018)

F.2.2.2.7 Spectacled Caiman

The spectacled caiman (*Caiman crocodilus fuscus*) naturally occurs throughout Central and South America, and can reach sizes of about 2.4 meters. They are easily distinguished from native crocodilians not only by their smaller adult size, but by the characteristic vertical dark bands that can be found on their tails. In Florida, spectacled caiman are commonly encountered in ditches, canals, and disturbed wetlands but are occasionally found in relatively undisturbed marshes. This species was first reported within canals at the Homestead Air Force Base as early as 1960 (Ellis 1980). It feeds primarily on fish, mammals, waterbirds, and snails in its native range (Thorbjarnarson 1993). Breeding populations are documented in localized areas of Miami-Dade and Broward counties. Given its intolerance of cold temperatures, breeding populations will remain limited to southern Florida. (SFER 2018)

F.2.2.2.8 Giant African Land Snail

The Giant African land snail (*Lissachatina fulica*) is a large snail native to Africa, but was discovered in Miami in 2011 (USDA 2013). It is known to eat a variety of vegetation, namely crop plants, horticultural plants and environmentally valuable plants. This species of snail is an intermediate host of the rat lungworm (*Angiostrongylus cantonensis*), which can spread meningitis to humans (Cowie 2013). This lungworm was undetected in Florida prior to the Giant African land snail's introduction. A previous infestation of this snail occurred in Miami in 1966, and the State of Florida spent $1 million and 10 years of effort on eradication (USDA 2013). The Giant African land snail is known to occur in developed areas of Broward and Miami-Dade counties, from Davie south to Homestead. As of July 2017, researchers have identified 31 population cores in Miami-Dade County and a single core in southern Broward County. There are indications that control efforts are having an effect, as fewer large snails are being reported, and local eradications of the snail are being observed in some of the population cores (Roda et al. 2016).

F.3 Introduction to Invasive Species Management

Invasive species management includes prevention, monitoring, education and public awareness, EDRR, control and management as well as adaptive management. In addition to these components, it is important to understand the risks and uncertainties associated with invasive species in order to effectively implement control/management measures and to adaptively manage.

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 Education and Public Awareness

A key to addressing problems caused by invasive species is to increase public awareness of their impacts and providing information about how individuals can help prevent the introduction and spread. However, reaching each person whose activities may affect our natural environment is a daunting task. Collaboration, cooperation and coordination across federal and state agencies, local governments, tribal entities, and the public and private sectors is required to facilitate this effort.

F.3.3 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 et al. 2014). While visual aerial surveys may provide cost-effective information on landscape distributions of targeted plants, it has 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 UAVs 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.3.4 Early Detection and Rapid Response

Once a species becomes widespread, the cost to control it will more than likely require significant and sustained funding. 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, an analysis of the risks associated with the invasion, and 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.3.5 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, and 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 their 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, fungicides etc. Pesticides are applied through ground and aerial applications.

Biological control, also known as bio-control, 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.3.6 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 LRWRP 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 to control and/or new species for which techniques are unknown or haven't been developed. 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.
- Not taking action to manage a species due to inaccurate assessments of the species impact on restoration activities.

The major uncertainty is that in most cases we do not have necessary information for detailed, specific pre-project evaluations of the need for management activities to control invasive species. 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. However, 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).

Several specific uncertainties have been identified in the initial analysis of the selected plan. They are listed here to provide a starting point for developing monitoring, control and BMP strategies for the construction and operations phases of the restoration. Specific uncertainties addressed by the LRWRP Adaptive Management Plan as well as uncertainties addressed in this plan are listed below.

- Will increased flow result in increased nutrient loading thereby increasing spread of invasive and/or nuisance plants (e.g., torpedograss, cattail)?
- Will non-native fish species spread into new areas as a result of hydrologic connection?
- Will there be secured and available funding for management and control of invasive species? Will other priorities outcompete for funds?
- How will the lack of biological information for new introduced species affect invasive species management?
- Will changes in hydrology facilitate the spread of invasive plant species? (AM uncertainty #14)
- How will new invasive faunal species affect the restoration? (AM uncertainty #15)
- How will new invasive plant species affect the restoration? (AM uncertainty #16)
- Is there a potential for the project to transfer/expand invasive plants to other areas? (AM uncertainty #18)

- How will invasive species that are not managed on private property affect the restoration? (AM uncertainty #19)

F.4 Existing Management Programs

Management of invasive species within the project area is conducted by several agencies. The magnitude of the control programs within the project area is dependent upon the level of funding available. Portions of allocated funding for these programs have been and potentially will be redirected to other programs in the future. Management activities vary in effectiveness which also influences species control and spread within the project area.

On the local level, the City of West Palm Beach and Palm Beach County both extensively manage invasive plant and animal species within projects such as Loxahatchee Slough, Grassy Waters Preserve and Cypress Creek Natural Area. Coordination with the City of West Palm Beach and Palm Beach County will be completed to ensure management efforts are implemented in an effective and efficient manner.

F.4.1 South Florida Water Management District

The SFWMD manages invasive exotic aquatic and terrestrial plants in canals and on levees within the project area, 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 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 CEPP study area as funding resources allow.

F.4.2 US Army Corps of Engineers

The USACE also conducts treatments 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 & OMRRR phase for CERP projects. Vegetation treated includes FLEPPC Category I and II species, as well as native nuisance species.

F.4.3 U.S. Department of Agriculture / University of Florida

The SFWMD, USACE, NPS, USFWS, FWC, 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 includes 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.4.4 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.4.5 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 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 USNPS, along with other partner agencies, have utilized digital aerial sketch mapping (DASM) for a region-wide mapping program over 728,000 ha 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 on managed conservation lands in the region. These are Australian pine, Brazilian pepper, melaleuca, and Old World climbing fern. 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.

Since 2010, the SFWMD has been collaborating with UF, FWC, USGS, NPS and FWS on the Everglades Invasive Reptile, Amphibian, and Mammal Monitoring Program (EIRAMMP). The purpose of the project is to develop an early detection, rapid response, removal and monitoring program for invasive reptiles and amphibians within Greater Everglades ecosystems. 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 LNWR, WCA-2, WCA-3, Big Cypress National Preserve (BCNP), Southern Glades Wildlife Management Area, ENP, Corkscrew Swamp Sanctuary, and other areas such as the C-51 canal, US Highway 1, and Card Sound Road. Visual searches and call surveys are conducted to monitor invasive species and their potential prey species. Twenty-one routes have been established, and seven are active. The encounter rates for Burmese pythons ranged from 0.0014 to 0.0035 observations per kilometer. To date, a total of 105 Burmese pythons have been detected during these visual surveys.

F.6 Management Strategy and Plan

Many of the new 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 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 new established species that are localized. The objective for wide spread 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 controlling and containing invasive species that were not previously within the project area. EDRR minimizes the negative impacts the invasive species has 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 needed budget is near impossible. 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 (see ECISMA EDRR Plan at http://www.evergladescisma.org/ECISMA_EDRRPlan_2009-2011.pdf). As discussed above (Section F.3.4 Early Detection and Rapid Response), 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 project elements should greatly increase the probability of detection of new species. In many cases, existing programs could be expanded to include focused monitoring in the project 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 100% accurate in assessing the risk of a species. This plan proposes utilization of the IFAS Assessment of Non-native plants in Florida's Natural Areas, FLEPPCs Invasive Species List, the FWC Non-native Animal Bioprofile protocol, and the ECISMA Rapid Response Plan for assessing the risks of non-indigenous species. These assessments should be conducted with 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 will be utilized to manage invasive species.

Biological control agents will 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 will 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 will 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 it is required to minimize dispersal of floating vegetation. Physical control measures will 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 will 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) will be utilized to uproot, grind and/or clear and grub. It is expected this type of control method will be utilized during levee degrades, canal backfilling and during construction of new project features such as water control structures.

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

F.6.3 Monitoring

Monitoring of invasive species populations will be conducted through DASM, Unmanned Aircraft System (UAS) surveys, electrofishing and 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 construction activities beginning. Although there are no system-wide monitoring programs for invasive species in the Everglades 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 / 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. Site 1 Impoundment is an excellent example. $2.9M is estimated to manage invasive species during construction and until turnover to the local sponsor. The property's prior use included plant nurseries and pasture. Once project lands were acquired by the sponsor, the land sat unused until the Site 1 project was ready to begin construction. By this time, the project lands became highly vegetated, primarily by invasive species. It would have been significantly less expensive to have maintained the lands until the time of construction versus waiting until construction started.

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 operation 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.

Below are examples of cost-saving measures to consider during design and construction.

- Include invasive species management staff from the Corps, SFWMD, and other partner agencies throughout the design and construction phases.
- Work 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.
- Design to promote the establishment of native species.
- Use construction methods that minimize ground disturbance whenever possible.
- Contain mobilized nutrients resulting from soil disturbances.
- Require all construction contractors to follow vehicle and equipment decontamination protocols prior to deployment. Coordinate with invasive species specialists for decontamination protocol specifications.
- Evaluate 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.
- Implement a monitoring and rapid response protocol aimed at detecting and controlling new invasions early.
- Manage and control invasive/nuisance species during the entire construction phase.

- When native planting is specified in the plans, use plant material from regional sources that are weed and pathogen free.

Construction will be the responsibility of either the Corps 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 the Project Implementation Report/Environmental Impact Assessment (Section 5.2.5 Environmental Commitments).

The Corps 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

"Prevention of Invasive and Nuisance Species Transfer" language 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 / 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

Surveillance and management of invasive species may begin as early as 2 years prior to actual construction of the project features. This will be in effort to minimize spread of priority species during the construction phase. Various management measures will be implemented in order to reduce colonization and spread of invasive plant and animal species.

F.6.8.1 Flow-way 1, M1 Pump Station Installation & Connectivity Improvements to GWP Triangle and G-161

Surveys of the pump station installation area should be completed prior to construction to identify invasive and non-native plant and animal species that may be spread by construction activities. These species should be treated prior to construction. Monitoring and treatment of submersed and floating plant species that could impact construction should occur throughout the construction phase. Surveys of the affected area of the GWP footprint should be completed prior to pump station construction to identify invasive and non-native species that may be spread to the footprint from the M-1 basin during construction activities. The discharge site into GWP from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species. Priority plant species in the GWP should be treated during the construction phase. Connectivity improvements may also cause the spread of invasive and non-native species, and these areas should be closely monitored throughout the duration of the project.

F.6.8.2 Flow-way 2

F.6.8.2.1 C-18W Above-Ground Reservoir & Canal Connector Installation

Surveys of the projected reservoir area should be completed prior to construction to identify priority invasive and non-native species that may be spread to C-18 or other discharge canals during construction activities. Such species should be treated prior to the beginning of construction. Coordination with other agencies should be conducted to determine the appropriate measures to be implemented to address the high priority non-native invasive fish and plant species.

F.6.8.2.2 C-18W Inflow Pump Installation

Surveys of the pump installation area should be completed prior to construction to identify priority invasive and non-native plant and animal species that may be spread by construction activities. These species should be treated prior to construction. Monitoring and treatment of submersed and floating plant species that could impact construction should occur throughout the construction phase. Surveys of the affected area of the Hungryland Slough footprint and other nearby discharge areas should be completed prior to pump station construction to identify priority invasive and non-native species that may be spread to the footprint from the C-18W basin during construction activities. The discharge site from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species. Priority plant species in these areas should be treated.

F.6.8.3 Wetland Restoration Sites

F.6.8.3.1 Kitching Creek Hydration – Spreader Canal and Weir/Plug Installation

Surveys of Kitching Creek should be completed prior to construction to identify invasive and non-native species that may be spread by construction activities. Such species should be treated prior to the beginning of construction. Periodic surveys of the areas adjacent to the new weir/plug and spreader canal structures should be conducted throughout the construction phase to identify growth of invasive and non-native species. Water diverted by the weir into the Jenkins Ditch may result in the spread of invasive and non-native species, and should thereby be closely monitored. Priority plant species in these areas should be treated.

F.6.8.3.2 Moonshine Creek (MC) & Gulfstream East (GE) Restoration - Weir Installation, Vegetation clear, Canal Connections & Historic Topography Re-grade

Surveys of MC and GE should be completed prior to construction to identify invasive and non-native species that may be propagated or spread by construction activities. Such species should be treated prior to the beginning of construction. Periodic surveys of the areas adjacent to the Hobe Grove Ditch weir installation should be conducted throughout the construction phase to identify growth of invasive and non-native species. Equipment used for the clearing of vegetation should be thoroughly cleaned and inspected for invasive and non-native plant materials before leaving the project area in order to prevent the spread of invasive plant species. Water flowing into the HSLCD ditch from MC may result in the spread of priority species, and should thereby be closely monitored during this phase. Priority plant species in these areas should be treated. Any land that is graded must be surveyed for invasive and non-native plant species prior to and upon completion of grading.

F.6.8.3.3 Cypress Creek Canal (CCC) Over-drainage Reduction – Weir Replacement, Berm Improvement, Spreader Swale Installation & Southern Fork Re-grade

Surveys of CCC should be completed prior to construction to identify invasive and non-native species that may be propagated or spread by construction activities. Such species should be treated prior to the beginning of construction. Periodic surveys of the areas adjacent to the replacement weir should be conducted throughout the construction phase to identify growth of invasive and non-native species. Material to be used to raise the berm structure should be inspected for signs of invasive and non-native plant species prior to use, and periodically surveyed once material is in place. Any land that is graded must be surveyed for invasive and non-native plant species prior to and upon completion of grading. Water being transported via spreader swale must be surveyed prior to and upon installation; to ensure no non-native or invasive species are propagated throughout the area. The area to which water will be delivered via spreader swale will be hydrologically altered, and must therefore be closely monitored for new invasive and non-native growth.

F.6.8.3.4 Gulfstream West Restoration – Backfill, Canal Relocation, Pump and Flow-through Marsh Installation

Any material to be used as backfill must be thoroughly inspected for signs of invasive and non-native plant species prior to installation. Relocating the southern end of the HSLCD canal may cause a spread of existing invasive and non-native plant and animal species. Surveys of Gulfstream West and HSLCD canal should be conducted both prior to and after relocation is complete. Priority plant species in these areas should be treated. Surveys of the pump installation area should be completed prior to construction to identify priority invasive and non-native plant and animal species that may be spread by construction activities. These species should be treated prior to construction. Monitoring and treatment of submersed and floating plant species that could impact construction should occur throughout the construction phase. Surveys of the affected area of Gulfstream West and other nearby discharge areas should be completed prior to pump station construction to identify priority invasive and non-native species that may be spread to the HSLCD canal from the Gulfstream West basin during construction activities. The discharge site from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species. Priority plant species in these areas should be treated.

F.6.8.3.5 Palmar East Restoration and Connectivity – Plug, Berm and Pump Installation

Surveys of the Palmar East area should be completed prior to construction to identify invasive and non-native species that may be spread by construction activities. Such species should be treated prior to the beginning of construction. Periodic surveys of the areas adjacent to the new plug, berm, and pump structures should be conducted throughout the construction phase to identify growth of invasive and non-native species. Water diverted by the pump into Gulfstream West may result in the spread of invasive and non-native species, and should thereby be closely monitored. Priority plant species in these areas should be treated. The discharge site from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species. Material to be used to build the berm structure should be inspected for signs of invasive and non-native plant species prior to use, and periodically surveyed once material is in place.

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

Surveillance and management of invasive species will occur throughout the OMRR&R phase. This will be in effort to minimize spread of priority species. Various management measures will be implemented in order to reduce colonization and spread of invasive plant and animal species.

F.6.9.1 Flow-way 1, M1 Pump Station & Connectivity Improvements - GWP Triangle, G-161 & G-160

Surveys of the newly installed and improved features should be completed to identify invasive and non-native plant and animal species and these species should be treated/or removal procedures implemented during the OMRR&R Phase. Surveys of the affected area of the GWP footprint should be completed to identify invasive and non-native species that spread to the footprint from the M-1 basin. Regular surveillance should occur at the discharge site into GWP from the outlet structure, appropriate management measures shall be implemented in order to reduce the spread of invasive and non-native species. Priority plant species in the GWP should be treated. Connectivity improvements may also cause the spread of invasive and non-native species, these areas should be surveyed and management measures implemented throughout the duration of the project.

F.6.9.2 Flow-way 2

F.6.9.2.1 C-18W Above-Ground Reservoir & Canal Connector

Surveys of the reservoir, canal connector, C-18W and other discharge canals should be completed to identify priority invasive and non-native species. Treatments and/or appropriate management measures shall be implemented to control priority species. Coordination with other agencies should be conducted to determine the appropriate measures to be implemented to address the high priority non-native invasive fish and plant species.

F.6.9.2.2 C-18W Inflow Pump

Surveys should be completed at the C-18W Inflow Pump, in the Hungryland Slough footprint and nearby discharge areas to identify priority invasive and non-native plant and animal species. Treatments and/or appropriate management measures shall be implemented to control priority species. Regular surveillance should occur at the discharge site from the outlet structure and appropriate treatments shall be conducted to reduce the spread of invasive and non-native species. Priority plant species in these areas should be treated throughout the OMRR&R phase.

F.6.9.3 Wetland Restoration Sites

F.6.9.3.1 Kitching Creek Hydration – Spreader Canal and Weir/Plug

Surveys of Kitching Creek should be to identify invasive and non-native species and these species should be treated throughout the OMRR&R Phase. Periodic surveys of the areas adjacent to the new weir/plug and spreader canal structures should be conducted throughout the OMRR&R phase to identify growth of invasive and non-native species. Water diverted by the weir into the Jenkins Ditch may result in the spread of invasive and non-native species. Surveillance of this area should be conducted on a regular basis and priority plant species in these areas should be treated.

F.6.9.3.2 Moonshine Creek (MC) & Gulfstream East (GE) Restoration - Weir, Canal Connections & Historic Topography Re-grade

Surveys of MC, GE and Hobe Grove Ditch weir should be completed to identify invasive and non-native species and these species should be treated throughout the OMRR&R phase. Water flowing into the HSLCD ditch from MC may result in the spread of priority species, and thereby should receive periodic surveys to identify priority species. Priority plant species in these areas should be treated. Regular periodic inspections shall be conducted in areas where land is graded. Regular treatments shall be conducted to control invasive plants in the graded areas throughout the OMRR&R phase.

F.6.9.3.3 Cypress Creek Canal (CCC) Over-drainage Reduction – Weir, Berm, Spreader Swale & Southern Fork Re-grade

Surveys of the newly installed and improved features should be completed to identify invasive and non-native plant and animal species and these species should be treated/or removal procedures implemented during the OMRR&R Phase. Regular periodic inspections shall be conducted in areas where land is graded and in the spreader swale. Regular treatments shall be conducted to control invasive plants in these areas throughout the OMRR&R phase. The area to which water will be delivered via spreader swale will experience hydrologic alteration, and must therefore be closely monitored for new invasive and non-native growth, management measures shall be implemented as appropriate.

F.6.9.3.4 Gulfstream West Restoration – Backfill, Canal, Pump and Flow-through Marsh

Surveys of the newly installed and improved features should be completed to identify invasive and non-native plant and animal species and these species should be treated/or removal procedures implemented during the OMRR&R Phase. Regular periodic surveys of Gulfstream West and other nearby discharge areas should be completed to identify priority invasive and non-native species and these species should be treated to prevent spread to the HSLCD canal from the Gulfstream West basin. The discharge site from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species. Priority plant species in these areas should be treated.

F.6.9.3.5 Palmar East Restoration and Connectivity – Plug, Berm and Pump

Surveys of the newly installed and improved features should be completed to identify invasive and non-native plant and animal species and these species should be treated/or removal procedures implemented during the OMRR&R Phase. Water diverted by the pump into GW may result in the spread of invasive and non-native species, and should thereby be closely monitored. Priority plant species in these areas should be treated. The discharge site from the outlet structure should be closely monitored to reduce the spread of invasive and non-native species.

F.7 Education / Outreach Opportunities at Recreational Areas

Recreational opportunities will be created by the LRWRP. 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 all management costs are provided in Table F-8 LRWRP Invasive and Nuisance Species Management Costs. Table F-9 LRWRP Invasive and Nuisance Species Monitoring Costs provides a summary of the costs for monitoring. Monitoring costs are provided as a total for 10 years during the OMRR&R phase. Table 10 LRWRP Invasive and Nuisance Species Management Costs –Construction Phase provides a summary of costs during project construction. It was assumed that in the field baselines and potential invasive species treatments and management would need to occur starting about 2 years prior to the actual construction start date. Table 11 LRWRP Invasive and Nuisance Species Management Costs – OMRR&R Phase provides a summary of costs during the OMRR&R phase. OMRR&R costs were estimated for the life of the project, assuming a 50-year life. However, due to size, the OMRR&R table only shows years 1 and the total 50 year cost estimate.

Table F-1. Invasive Plant Species Documented in the Project Area

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
rosarypea	*Abrus precatorius* L.	x	x	x	x	I
earleaf acacia	*Acacia auriculiformis* A. Cunningham ex Benth.	x	x	x	x	I
sisal	*Agave sisalana* Perrine	x	x	x	x	II
mimosa	*Albizia julibrissin* Durazz.	x	x	x	x	I
woman's tongue tree	*Albizia lebbeck* (L.) Benth	x	x	x	x	I
deviltree	*Alstonia macrphylla*	x	x	x	x	II
alligatorweed	*Alternanthera philoxeroides* (Mart.) Griseb.	x	x	x	x	II
coral vine	*Antigonon leptopus* Hook. & Arn.	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	I
Chinese violet, Ganges primrose	*Asystasia gangetica* (L.) T. Anders	x	x	x	x	II
feathered mosquito fern	*Azolla pinnata pinnata*	x	x	x	x	---
mountain ebony	*Bauhinia variegata* L	x	x	x	x	I
Javanese bishopwood	*Bischofia javanica* Blume	x	x	x	x	I
bottlebrush	*Callistemon viminalis* (Gaertn.)G.Don ex Loudon	x	x	x	x	II
river sheoak	*Casuarina cunninghamiana* Miq.	x	x	x	x	II
Australian-pine	*Casuarina equisetifolia* L.	x	x	x	x	I
gray sheoak	*Casuarina glauca* Sieb. ex Spreng	x	x	x	x	I
Madagascar periwinkle	*Catharanthus roseus* (L.) G. Don	x	x	x	x	---
watersprite	*Ceratopteris thalictroides*	x	x	x	x	---
day jessamine	*Cestrum diurnum* L.	x	x	x	x	II
camphortree	*Cinnamomum camphora* (L.) J. Presl	x	x	x	x	I
coconut palm	*Cocos nucifera*	x	x	x	x	II
coco yam, wild taro	*Colocasia esculenta* (L.) Schott	x	x	x	x	I

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
Asian nakedwood	*Colubrina asiatica* (L.) Brongn.	x	x	x	x	I
smooth crotalaria	*Crotalaria pallida* Aiton	x	x	x	x	---
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	---
miniature flatsedge, dwarf papyrus	*Cyperus prolifer* Lam	x	x	x	x	II
crowfootgrass	*Dactyloctenium aegyptium* (L.) Willd	x	x	x	x	II
Indian rosewood	*Dalbergia sissoo* Roxb. ex DC.	x	x	x	x	II
winged yam	*Dioscorea alata* L.	x	x	x	x	I
air-potato	*Dioscorea bulbifera* L.	x	x	x	x	I
Brazilian waterweed	*Egeria densa*	x	x	x	x	---
waterhyacinth	*Eichhornia crassipes* (Mart.) Solms	x	x	x	x	I
centipede tongavine	*Epipremnum pinnatum* (L.) Engl	x	x	x	x	II
Surinam cherry	*Eugenia uniflora* L.	x	x	x	x	I
Eulophia ground orchid	*Eulophia graminea*	x	x	x	x	II
Chinese banyan	*Ficus microcarpa* L. f.	x	x	x	x	I
limpograss	*Hemarthria altissima* (Poir.) Stapf & C.E. Hubbard	x	x	x	x	II
Sea hibiscus	*Hibiscus tiliaceus L.*	x	x	x	x	II
hydrilla	*Hydrilla verticillata* (L. f.) Royle	x	x	x	x	I
miramar weed, green hygro, Indian swampweed	*Hygrophila polysperma* (Roxb.) T. Anders.	x	x	--	x	I
West Indian marsh grass	*Hymenachne amplexicaulis* (Rudge) Nees	x	x	x	x	I
jaraguagrass	*Hyparrhenia rufa* (Nees) Stapf	x	x		x	II
cogongrass	*Imperata cylindrica* (L.) Beauv.	x	x	x	x	I
hairy indigo	*Indigofera hirsuta* L.	x	x	x	x	---
Gold Coast jasmine	*Jasminum dichotomum* Vahl	x	x	x	x	I
Brazilian jasmine	*Jasminum fluminense* Vell.	x	x	x	x	I

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
cathedral bells	*Kalanchoe pinnata (Lam.) Pers.*	x	x	x	x	II
Lantana, shrub verbena	*Lantana camara*	x	x	x	x	I
white leadtree	*Leucaena leucocephala* (Lam.) de Wit	x	x	x	x	II
limnophila, Asian marshweed	*Limnophila sessiliflora* (Vahl) Blume	x	x	x	x	II
primrose-willow	*Ludwigia peruviana* (L.) Hara	x	x	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
sapodilla	*Manilkara zapota* (L.) van Royen	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	II
natalgrass	*Melinis repens* (Willd.) Zizka	x	x	x	x	I
catclaw mimosa	*Mimosa pigra*	x	x	x	x	I
balsamapple	*Momordica charantia* L.	x	x	x	x	II
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	I
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
skunk-vine	*Paederia foetida*	x	x	x	x	I
torpedo grass	*Panicum repens*	x	x	x	x	I
mission grass	*Pennisetum polystachion* (Linnaeus) Schultes		x		x	II
elephant grass, Napier grass	*Pennisetum purpureum* Schumacher	x	x	x	x	I
Senegal date palm	*Phoenix reclinata*	x	x	x	x	II

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
golden bamboo	*Phyllostachys aurea* Carr. ex A.& C. Rivière	x	x		x	II
waterlettuce	*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
ladder brake, Chinese brake fern	*Pteris vittata* L.	x	x	x	x	II
downy rose myrtle	*Rhodomyrtus tomentosa* (Ait.) Hassk.	x	x	x	x	I
largeflower Mexican clover	*Richardia grandiflora*	x	x	x	x	II
castorbean	*Ricinus communis* L.	x	x	x	x	II
roundleaf toothcup	*Rotala rotundifolia* (Buch.-Ham. ex Roxb.) Koehne	x	x	x	x	II
Britton's wild petunia	*Ruellia simplex* C. Wright	x	x	x	x	I
water fern	*Salvinia minima* Baker	x	x	x	x	I
iguanatail, bowstring hemp	*Sansevieria hyacinthoides* (L.) Druce	x	x	x	x	II
beach naupaka	*Scaevola taccada* Vahl	x	x	x	x	I
octopus tree, Queensland umbrella tree	*Schefflera actinophylla* (Endl.) H.A.T. Harms	x	x	x	x	I
Brazilian peppertree	*Schinus terebinthifolius* Raddi	x	x	x	x	I
climbing cassia, Christmas cassia	*Senna pendula var. glabrata*	x	x	x	x	I
red sesbania, purple sesban, rattlebox	*Sesbania punicea* (Cav.) Benth.	x	x	x	x	II
twoleaf nightshade	*Solanum diphyllum* L.	x	x	x	x	II
tropical soda apple	*Solanum viarum* Dunal	x	x	x	x	I
Bay Biscayne creeping-oxeye, wedelia	*Sphagneticola trilobata* (L.C. Rich.) Pruski	x	x	x	x	II
queen palm	*Syagrus romanzoffiana* (Cham.) Glassman	x	x	x	x	II
American evergreen, arrowhead vine	*Syngonium podophyllum* Schott	x	x	x	x	I
Java plum	*Syzygium cumini* (L.) Skeels	x	x	x	x	I

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region	FLEPPC Category
Malabar plum	*Syzygium jambos*	x	x	x	x	II
tropical almond	*Terminalia catappa* L.	x	x	x	x	II
Australian almond	*Terminalia muelleri*	x	x	x	x	II
portia tree, seaside mahoe	*Thespesia populnea* (L.) Soland. ex Correa	x	x	x	x	I
white-flowered spiderwort	*Tradescantia fluminensis* Vell.	x	x	x	x	I
boatlily, oyster plant	*Tradescantia spathacea* Sw.	x	x	x	x	II
Chinese tallowtree	*Triadica sebifera* (L.) Small	x	x		x	I
Jamaica feverplant, puncture vine, burr-nut	*Tribulus cistoides* L.	x	x	x	x	II
Caesarweed	*Urena lobata* L.	x	x	x	x	I
paragrass	*Urochloa mutica* (Forsk.) T.Q. Nguyen	x	x	x	x	I
simpleleaf chastetree	*Vitex trifolia* L.	x	x	x	x	II

Table F-2. Totals of Invasive Plant Species, by Categories, Documented in the Project Area.

Category	TOTALS
Non-native plants	*110*
FLEPPC Category I	*59*
FLEPPC Category II	*39*
Noxious Weeds	*22*
This list was compiled utilizing the 2017 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 Martin, Palm Beach, Hendry and surrounding 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 US Army Corps of Engineers or the National Park Service (based on WEEDDAR (Weed Data and Reports) data).	

Table F-3. Invasive Animal Species –Birds- Documented in the Project Area.

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region
Muscovy Duck	*Cairina moschata*	x	x	x	x
Rock Dove	*Columba livia*	x	x	x	x
Spot-breasted Oriole	*Icterus pectoralis*	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
Purple Swamphen	*Porphyrio porphyrio*	x	x	x	x
Eurasian Collared-Dove	*Streptopelia decaocto*	x	x	x	x
European Starling	*Sturnus vulgaris*	x	x	x	x
White-winged Dove	*Zenaida asiatica*	x	x	x	x
Egyptian Goose	*Alopochen aegyptiaca*	---	x	---	---

Table F-4. Invasive Animal Species –Reptiles and Amphibians- Documented in the Project Area.

Common Name	*Scientific Name*	LO Region	NE Region	EAA Region	GE Region
African Redhead Agama	*Agama agama*	x	x	x	x
Largehead Anole	*Anolis cybotes*	x	x	---	---
Bark Anole	*Anolis distichus*	x	x	x	x
Knight Anole	*Anolis equestris equestris*	x	x	x	x
Cuban Green Anole	*Anolis porcatus*	---	---	---	x
Brown Anole	*Anolis sagrei*	x	x	---	---
Brown Basilisk	*Basiliscus vittatus*	x	x	x	x
Common Boa	*Boa constrictor*	x	x	x	x
Black Spinytail Iguana	*Ctenosaura similis*	x	x	---	x
Greenhouse Frog	*Eleutherodactylus planirostris*	---	x	---	---
Tokay Gecko	*Gekko gecko*	x	x	x	x
Common House Gecko	*Hemidactylus frenatus*	---	---	---	x
Indo-Pacific Gecko	*Hemidactylus garnotii*	---	x	---	x
Tropical House Gecko	*Hemidactylus mabouia*	x	x	x	x
Mediterranean Gecko	*Hemidactylus turcicus*	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
Texas Horned Lizard	*Phrynosoma cornutum*	x	x	x	x
Burmese Python	*Python molurus bivittatus*	x	x	x	x
Brahminy Blind Snake	*Ramphotyphlops braminus*	x	x	---	x
Giant Toad, Cane toad	*Rhinella marina*	x	x	x	x
Red-eared Slider	*Trachemys scripta elegans*	---	---	---	x
Black and white tegu	*Tupinambis merianae Linnaeus, 1758*	---	---	---	x
Nile Monitor	*Varanus niloticus*	x	x	x	x

Table F-5. Invasive Animal Species –Fish- Documented in the Project Area.

Common Name	Scientific Name	LO Region	NE Region	EAA Region	GE Region
Oscar	*Astronotus ocellatus*	x	x	x	x
Bullseye snakehead	*Channa marulius*	x	x	x	x
Clown knifefish	*Chitala ornata*	x	x	x	x
Butterfly peacock bass	*Cichla ocellaris*	---	---	---	x
Black acara	*Cichlasoma bimaculatum*	---	---	---	x
Mayan cichlid	*Cichlasoma urophthalmus*	---	---	---	x
Walking catfish	*Clarias batrachus*	---	---	---	x
African jewelfish	*Hemichromis letourneuxi*	x	x	x	x
Brown hoplo	*Hoplosternum littorale*	---	---	---	x
Suckermouth catfish	*Hypostomus sp.*	---	---	---	x
Silver dollar	*Metynnis hypsauchen*	x	---	---	---
Asian swamp eel	*Monopterus albus*	---	---	---	x
Blue tilapia	*Oreochromis aureus*	---	---	---	x
Nile tilapia	*Oreochromis niloticus*	x	x	x	x
Jaguar Guapote	*Parachromis managuensis*	x	x	x	x
lionfish	*Pterois volitans/miles*	x	x	x	x
Vermiculated sailfin catfish	*Pterygoplichthys disjunctivus*	---	---	---	---
Orinoco sailfin catfish	*Pterygoplichthys multiradiatus*	---	---	---	x
Jack Dempsey	*Rocio octofasciata*	x	x	x	x
Spotted tilapia	*Tilapia mariae*	x	x	x	x
Redhead Cichlid	*Vieja melanura*	x	x	x	x

Table F-6. Invasive Animal Species –Mammals- Documented in the Project Area.

Common Name	Scientific Name	LO Region	NE Region	EAA Region	GE Region
Black rat	*Rattus rattus*	---	---	---	x
Wild hog, feral pig	*Sus scrofa*	x	x	x	x

Table F-7. Invasive Animal Species –Others- Documented in the Project Area.

Common Name	Scientific Name	LO Region	NE Region	EAA Region	GE Region
Asian clam	*Corbicula fluminea*	x	x	x	x
Giant Ramshorn Snail	*Marisa cornuarietis*	x	x	x	x
Asian tiger shrimp	*Penaeus monodon*	x	x	x	x
Green mussel	*Perna viridis*	x	x	x	x
Spiketop applesnail	*Pomacea diffusa Blume, 1957*	x	x	x	x
Island applesnail	*Pomacea insularum (d'Orbigny, 1839)*	x	x	x	x
Giant applesnail	*Pomacea maculata*	x	x	x	x

Table F-8. LRWRP Invasive and Nuisance Species Management Costs.

Category	Cost Estimate
2 Year Pre-Construction	$2,559,070
1 Year Pre-Construction	$1,423,072
Construction Phase	$893,019
Operational Testing & Monitoring Phase	$508,551
1 Year OMRR&R Phase	$536,285
50-Year OMRR&R Phase (Includes Year 1)	$52,279,358
Total Management Cost	**$57,663,070**

Table F-9. LRWRP Invasive and Nuisance Total Monitoring Costs.

Category	Cost Estimate
Total Monitoring Cost	**$1,480,949**

Table F-10. Invasive and Nuisance Species Management Costs – Construction Phase

Flow-Way and Feature/Area	Management Activity	Pre-Construction 2yrs	Pre-Construction 1yr	Construction	OTM
Flow-way 1 - G-160 Structure	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 1 – G-160	Plant Control/Treatment	$0	$616	$616	$616
Flow-way 1 – G-160	Coordination/Inspections/Contract Implementation	$0	$245	$245	$245
Flow-way 1 - G-161 Structure	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 1 - G-161 Structure	Plant Control/Treatment	$0	$616	$616	$616
Flow-way 1 - G-161 Structure	Coordination/Inspections/Contract Implementation	$0	$245	$245	$245
Flow-way 1 - GWP Triangle (350ac)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 1 - GWP Triangle (350ac)	Plant Control/Treatment	$176,400	$66,150	$23,625	$23,625
Flow-way 1 - GWP Triangle (350ac)	Coordination/Inspections/Contract Implementation	$26,612	$10,075	$3,696	$3,696
Flow-way 1 - M-1 Pump Station	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 1 - M-1 Pump Station	Plant Control/Treatment	$0	$616	$616	$616
Flow-way 1 - M-1 Pump Station	Coordination/Inspections/Contract Implementation	$0	$245	$245	$245
Flow-way 2 - CW-18 Reservoir (1920ac)	EDRR/Plant Surveillance	$3,048	$3,048	$2,032	$2,032
Flow-way 2 - CW-18 Reservoir (1920ac)	Plant Control/Treatment	$967,680	$362,880	$362,880	$147,840
Flow-way 2 - CW-18 Reservoir (1920ac)	Coordination/Inspections/Contract Implementation	$145,609	$54,889	$54,737	$22,481
Flow-way 2 - 4 ASR Wells	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016

Flow-Way and Feature/Area	Management Activity	Pre-Construction 2yrs	Pre-Construction 1yr	Construction	OTM
Flow-way 2 - 4 ASR Wells	Plant Control/Treatment	$0	$1,008	$378	$378
Flow-way 2 - 4 ASR Wells	Coordination/Inspections/Contract Implementation	$0	$304	$209	$209
Flow-way 2 - M-O Canal Connector (3,500Lnft)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 2 - M-O Canal Connector (3,500Lnft)	Plant Control/Treatment	$0	$1,512	$1,512	$462
Flow-way 2 - M-O Canal Connector (3,500Lnft)	Coordination/Inspections/Contract Implementation	$152	$379	$379	$222
Flow-way 3 - PalMar East (50ac)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - PalMar East (50ac)	Plant Control/Treatment	$0	$25,200	$9,450	$9,450
Flow-way 3 - PalMar East (50ac)	Coordination/Inspections/Contract Implementation	$152	$3,932	$1,570	$1,570
Flow-way 3 - Thomas Pepper Farm (31,190LNftx35w)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - Thomas Pepper Farm (31,190LNftx35w)	Plant Control/Treatment	$0	$12,600	$4,725	$4,725
Flow-way 3 - Thomas Pepper Farm (31,190LNftx35w)	Coordination/Inspections/Contract Implementation	$152	$2,042	$861	$861
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	Plant Control/Treatment	$0	$15,624	$5,859	$5,859
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	Coordination/Inspections/Contract Implementation	$152	$2,496	$1,031	$1,031
Flow-way 3 - Gulfstream West (700ac)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - Gulfstream West (700ac)	Plant Control/Treatment	$352,800	$132,300	$66,150	$66,150

Flow-Way and Feature/Area	Management Activity	Pre-Construction 2yrs	Pre-Construction 1yr	Construction	OTM
Flow-way 3 - Gulfstream West (700ac)	Coordination/Inspections/Contract Implementation	$53,072	$19,997	$10,075	$10,075
Flow-way 3 - Gulfstream East & Moonshine(1410ac)	EDRR/Plant Surveillance	$3,048	$1,016	$1,016	$1,016
Flow-way 3 - Gulfstream East & Moonshine(1410ac)	Plant Control/Treatment	$710,640	$85,050	$42,525	$42,525
Flow-way 3 - Gulfstream East & Moonshine(1410ac)	Coordination/Inspections/Contract Implementation	$107,053	$12,910	$6,531	$6,531
Flow-way 3 - Kitching Creek (2,500LNftx35w)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - Kitching Creek (2,500LNftx35w)	Plant Control/Treatment	$0	$1,008	$378	$378
Flow-way 3 - Kitching Creek (2,500LNftx35w)	Coordination/Inspections/Contract Implementation	$152	$303	$209	$209
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNft x 35w)	EDRR/Plant Surveillance	$1,016	$1,016	$1,016	$1,016
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNft x 35w)	Plant Control/Treatment	$0	$1,512	$1,512	$462
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNft x 35w)	Coordination/Inspections/Contract Implementation	$152	$379	$379	$222
Flow-way 3 - Shiloh Farm (500ac)	EDRR/Plant Surveillance	$0	$2,032	$2,032	$2,032
Flow-way 3 - Shiloh Farm (500ac)	Plant Control/Treatment	$0	$252,000	$94,500	$47,250
Flow-way 3 - Shiloh Farm (500ac)	Coordination/Inspections/Contract Implementation	$0	$38,105	$14,480	$7,392
Flow-way 3 - Cypress Creek Natural Area (1480a)	EDRR/Plant Surveillance	$0	$4,064	$4,064	$4,064
Flow-way 3 - Cypress Creek Natural Area (1480a)	Plant Control/Treatment	$0	$256,410	$139,860	$69,930

Flow-Way and Feature/Area	Management Activity	Pre-Construction 2yrs	Pre-Construction 1yr	Construction	OTM
Flow-way 3 - Cypress Creek Natural Area (1480a)	Coordination/Inspections/Contract Implementation	$0	$39,071	$21,589	$11,099
Totals	---	**$2,559,070**	**$1,423,072**	**$893,019**	**$508,551**
Construction Phase Total = $5,383,711					

Table F-11. Invasive and Nuisance Species Management Costs – OMRR&R Phase

Feature/Area	Management Activity	YR 1 OMRR&R	50 YR Total
Flow-way 1 - G-160 Structure	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 1 - G-160 Structure	Plant Control/Treatment	$616	$60,050
Flow-way 1 - G-160 Structure	Coordination/Inspections/Contract Implementation	$245	$23,864
Flow-way 1 - G-161 Structure	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 1 - G-161 Structure	Plant Control/Treatment	$616	$60,050
Flow-way 1 - G-161 Structure	Coordination/Inspections/Contract Implementation	$245	$23,864
Flow-way 1 - GWP Triangle (350ac)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 1 - GWP Triangle (350ac)	Plant Control/Treatment	$37,800	$3,684,908
Flow-way 1 - GWP Triangle (350ac)	Coordination/Inspections/Contract Implementation	$5,822	$567,593
Flow-way 1 - M-1 Pump Station	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 1 - M-1 Pump Station	Plant Control/Treatment	$616	$60,050
Flow-way 1 - M-1 Pump Station	Coordination/Inspections/Contract Implementation	$245	$23,864
Flow-way 2 - CW-18 Reservoir (1920ac)	EDRR/Plant Surveillance	$3,048	$297,132
Flow-way 2 - CW-18 Reservoir (1920ac)	Plant Control/Treatment	$73,920	$7,206,043
Flow-way 2 - CW-18 Reservoir (1920ac)	Plant Control/Treatment - Submersed	$57,600	$5,615,098
Flow-way 2 - CW-18 Reservoir (1920ac)	Coordination/Inspections/Contract Implementation	$20,185	$1,967,741
Flow-way 2 - 4 ASR Wells	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 2 - 4 ASR Wells	Plant Control/Treatment	$378	$36,849

Feature/Area	Management Activity	YR 1 OMRR&R	50 YR Total
Flow-way 2 - 4 ASR Wells	Coordination/Inspections/Contract Implementation	$209	$20,384
Flow-way 2 - M-O Canal Connector (3,500LNFTx35w)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 2 - M-O Canal Connector (3,500LNFTx35w)	Plant Control/Treatment	$462	$45,038
Flow-way 2 - M-O Canal Connector (3,500LNFTx35w)	Coordination/Inspections/Contract Implementation	$222	$21,612
Flow-way 3 - PalMar East (50ac)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - PalMar East (50ac)	Plant Control/Treatment	$9,450	$921,227
Flow-way 3 - PalMar East (50ac)	Coordination/Inspections/Contract Implementation	$1,570	$153,041
Flow-way 3 - Thomas Pepper Farm (31,190LNFTx35w)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - Thomas Pepper Farm (31,190LNFTx35w)	Plant Control/Treatment	$4,725	$460,614
Flow-way 3 - Thomas Pepper Farm (31,190LNFTx35w)	Coordination/Inspections/Contract Implementation	$388	$37,813
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	Plant Control/Treatment	$5,859	$571,161
Flow-way 3 - Ranch Colony Canal (19,215LNftx35w)	Coordination/Inspections/Contract Implementation	$1,031	$100,531
Flow-way 3 - Gulfstream West (700ac)	EDRR/Plant Surveillance	$2,032	$198,088
Flow-way 3 - Gulfstream West (700ac)	Plant Control/Treatment	$66,150	$6,448,590
Flow-way 3 - Gulfstream West (700ac)	Coordination/Inspections/Contract Implementation	$10,227	$997,002
Flow-way 3 - Gulfstream East & Moonshine(450ac)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - Gulfstream East & Moonshine(450ac)	Plant Control/Treatment	$18,900	$1,842,454
Flow-way 3 - Gulfstream East & Moonshine(450ac)	Coordination/Inspections/Contract Implementation	$2,987	$291,225
Flow-way 3 - Kitching Creek (2,500LNftx35w)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - Kitching Creek (2,500LNftx35w)	Plant Control/Treatment	$378.00	$36,849
Flow-way 3 - Kitching Creek (2,500LNftx35w)	Coordination/Inspections/Contract Implementation	$209.10	$20,384
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNftx35w)	EDRR/Plant Surveillance	$1,016	$99,044
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNftx35w)	Plant Control/Treatment	$462	$45,038

Feature/Area	Management Activity	YR 1 OMRR&R	50 YR Total
Flow-way 3 - Mack Dairy Spreader Swale (3,500LNftx35w)	Coordination/Inspections/Contract Implementation	$222	$21,612
Flow-way 3 - Shiloh Farm (500ac)	EDRR/Plant Surveillance	$2,032	$198,088
Flow-way 3 - Shiloh Farm (500ac)	Plant Control/Treatment	$94,500	$9,212,271
Flow-way 3 - Shiloh Farm (500ac)	Coordination/Inspections/Contract Implementation	$14,480	$1,411,554
Flow-way 3 - Cypress Creek Natural Area (1480a)	EDRR/Plant Surveillance	$5,080	$495,220
Flow-way 3 - Cypress Creek Natural Area (1480a)	Plant Control/Treatment	$69,930	$6,817,081
Flow-way 3 - Cypress Creek Natural Area (1480a)	Coordination/Inspections/Contract Implementation	$11,252	$1,096,845
Note: Year-1 OMRR&R is $536,285. The 50-yr total is $52,279,358			

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