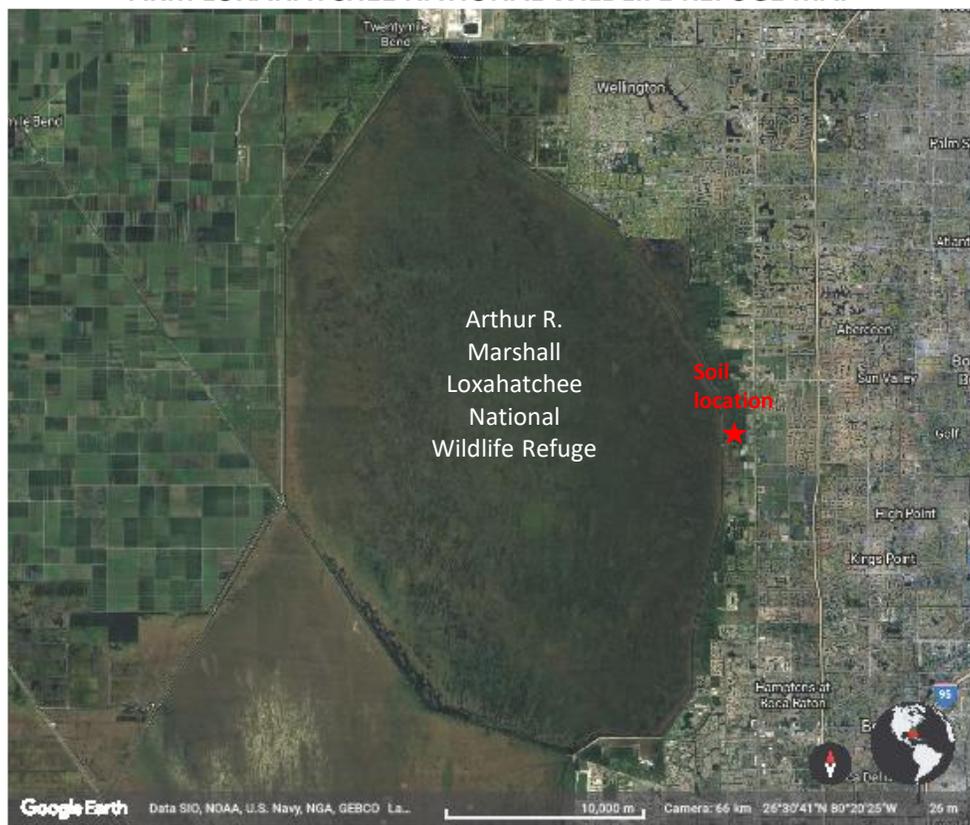


# Arthur R. Marshall Loxahatchee National Wildlife Refuge

Latitude 26°29'57.4" N, Longitude 80°13'19.6" W  
Main Entrance, Lee Road, Boynton Beach, Florida  
Palm Beach County, Hydrologic Unit 03090202  
[https://www.fws.gov/refuge/arm\\_loxahatchee/](https://www.fws.gov/refuge/arm_loxahatchee/)

## ARM LOXAHATCHEE NATIONAL WILDLIFE REFUGE MAP



Wetland Field Project  
Wetland and Riparian Ecology FW479  
Denise Valentin  
August 25, 2021

The Arthur R. Marshall Loxahatchee National Wildlife Refuge (“the Refuge”) is the northern Everglades. It is also known as Water Management Area 1 with the South Florida Water Management District (“SFWMD”). The Refuge contains 145,188 acres of numerous wetlands – sloughs, cypress swamp, wet prairies, sawgrass ridges, and tree islands. The Refuge was established in 1951 with a 50-year license agreement between the U.S. Fish and Wildlife Service (“USFWS”) and the State of Florida under the Migratory Bird Conservation Act of 1929. The agreement was renewed for another 20 years in 2018.

## HISTORY OF THE EVERGLADES

The Everglades originally contained many different ecosystems (as shown below). The top three ecosystems were wetland marshes, sloughs, and wet prairies. (Lemaire and Sisto 2012). Originally, water flowed from the Kissimmee River, into Lake Okeechobee, and then flowed slowly down to the Florida Bay. The Everglade system was home to many plants and animals because of the numerous ecosystems found there.

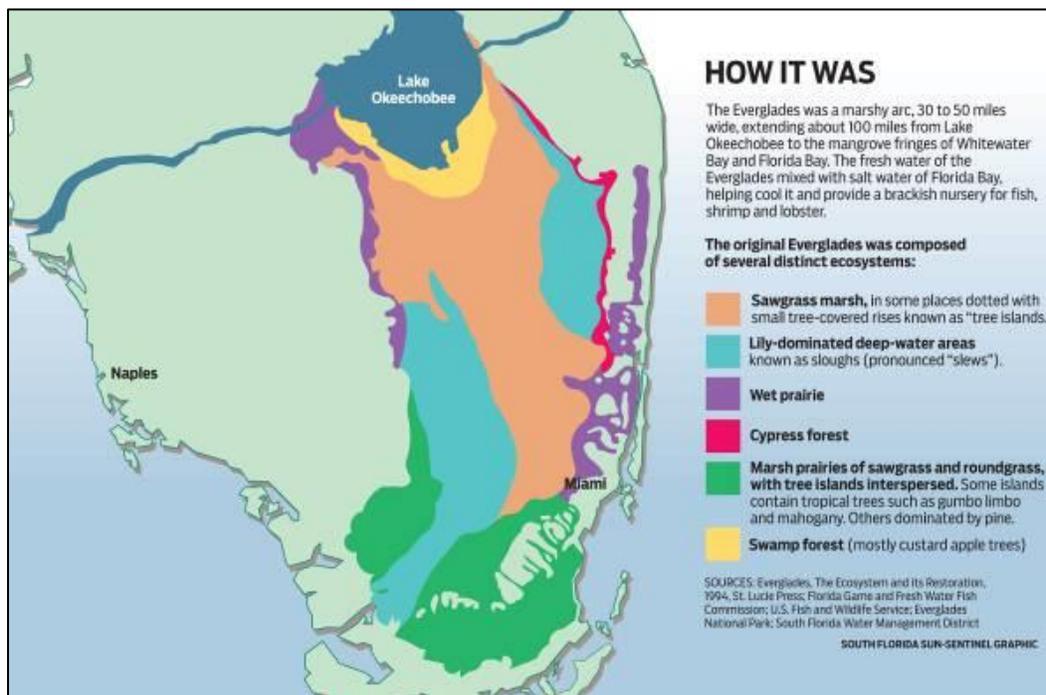


Fig 1. How it Was – The Everglades System  
Source: Lemaire and Sisto (2012)

In the late 1800’s, filling and draining of areas of the Everglades began as it was decided that land for agriculture and development was needed. The Caloosahatchee River on the west coast was channeled and connected to Lake Okeechobee in 1883. In 1902, the U.S. Army Corp of Engineers (“USACE”) built the 109-mile channel of the Kissimmee River. Between 1905 and 1912, the North New River, South New River, Hillsboro, and Miami canals were built.

Then work began on draining the marshes below Lake Okeechobee. The highly rich muck soil that had been found in this area attracted farmers, and the land was changed for agricultural needs. Drainage canals continued to be built between 1913 and 1927, further destroying the water flow to and around the Everglades. The St. Lucie River on the east was then channeled and connected to Lake Okeechobee from 1916-1925. More water was now being sent to the west and east coasts, and less to the Everglades.

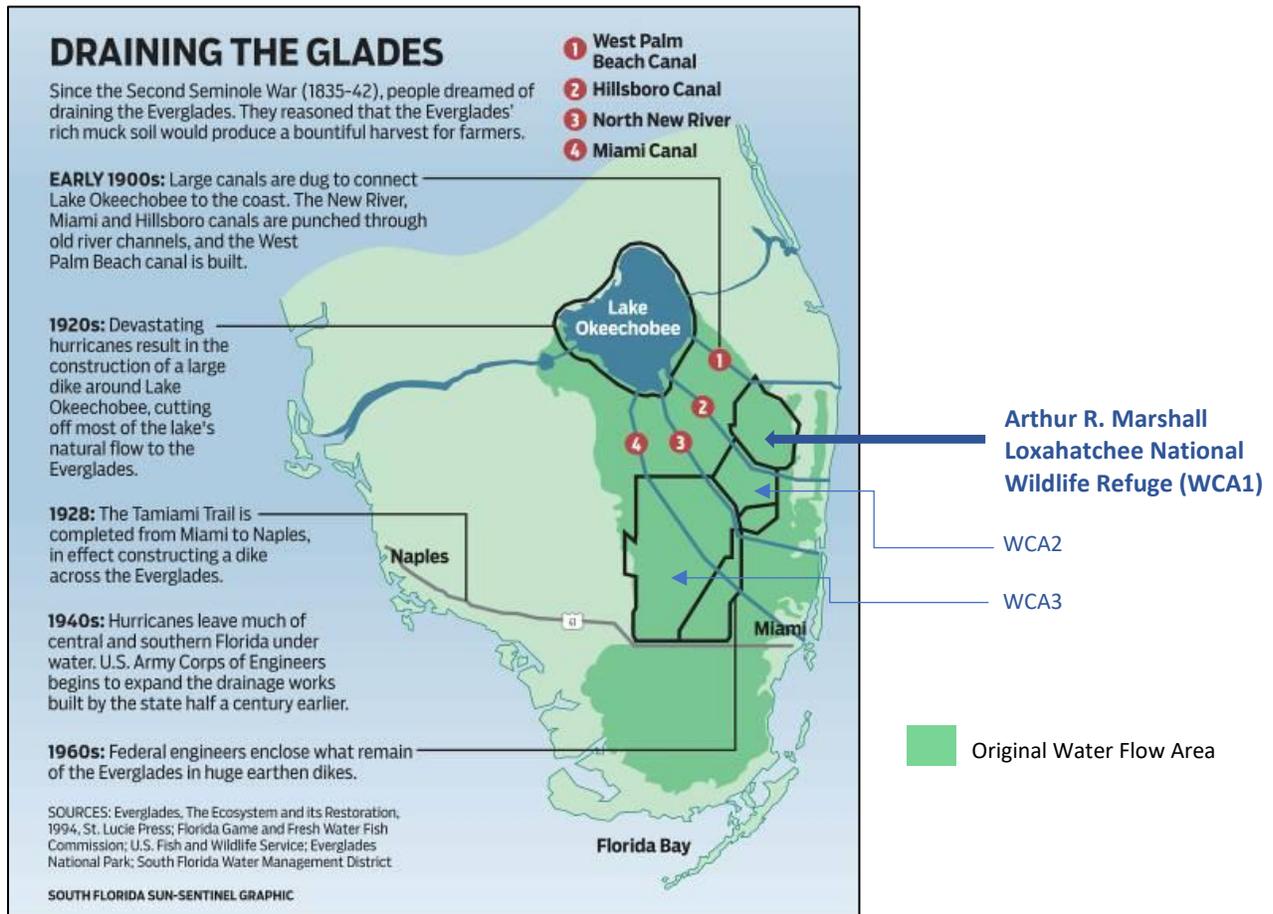


Fig 2. Draining the Glades  
 Source: Lemaire and Sisto (2012)

Between 1932 and 1938, the Lake Okeechobee Herbert Hoover Dike was built, further reducing water flow from the lake southward. In 1948, the Central and Southern Florida Flood Control Project (“C&SF”) was approved by Congress to help with flooding. More of the Everglades were drained and filled and then converted to lands for farming and development. The C&SF project included the creation of 128 miles of canals, 300 miles of levees, six pumping stations, and three water conservation areas (SFWMD 2009). Fortunately, the Everglades National Park was created in 1947 to save the remainder of the Everglades.

U.S. Sugar Corporation set up shop in the early 1960’s and became one of the biggest industries on the old Everglades land. Since sugar cane must be dry in the wet season, water was diverted from the central Everglades so sugar and other agricultural crops could be grown in the organic

Everglades soil south of Lake Okeechobee. At this point, 50% of the Everglades wetlands are now agricultural areas (a lot of which turned to housing developments later). Now the hydrology of the entire Everglades system from the Kissimmee River down to the mangroves in Florida Bay is negatively changed forever. (Lemaire and Sisto 2012).

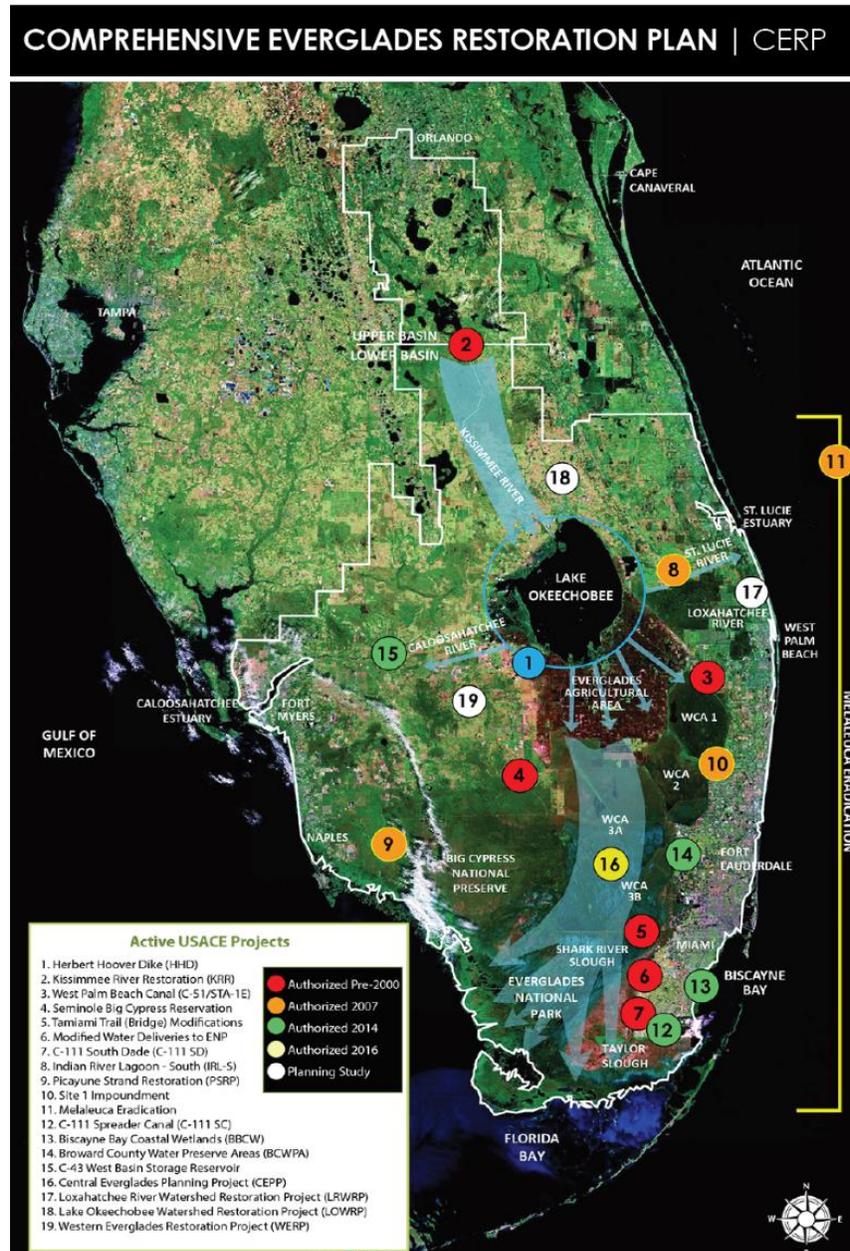


Fig 3. CERP - Active USACE Projects  
Source: USACE.org

This project includes partnerships between the Federal Government, SFWMD, the Florida Department of Environmental Protection (“FDEP”), local governments, and Indian Tribes. The Comprehensive Everglades Restoration Program (“CERP”) includes many different parts, some of which are completed. The Kissimmee River Restoration project that restored water flow to 22 miles of the river was completed in 2020. Creations of the Indian River Lagoon reservoir and

the Stormwater Creation Areas were completed in 2020 and 2017, respectively. Additional storage areas for water were created in the Everglades National Park, and an impoundment to collect surface water runoff from Lake Okeechobee and Arthur R. Marshall Loxahatchee National Wildlife Refuge were completed in 2016.

CERP still have some projects under way. Picayune Strand Restoration for over 55,000 acres (to be completed FY2023), Biscayne Bay Coastal Wetlands restoration to redistribute surface waters (to be completed FY2022), work to prevent seepage at the Broward County Water Preserves Areas (to be completed beyond FY2023), and the creation of 170,000-acre Caloosahatchee River west basin storage (to be completed FY2022).

## HYDROLOGY AND THE HYDROPERIOD

The most important thing to know about the hydrology of the Everglades system is that it gets most of its water from rain. According to Lenaire and Sisto (2012), 81% of water in the Everglades is from precipitation. The other modes are water releases from Lake Okeechobee overflow 8%, freshwater runoff 10%, and groundwater 1%.

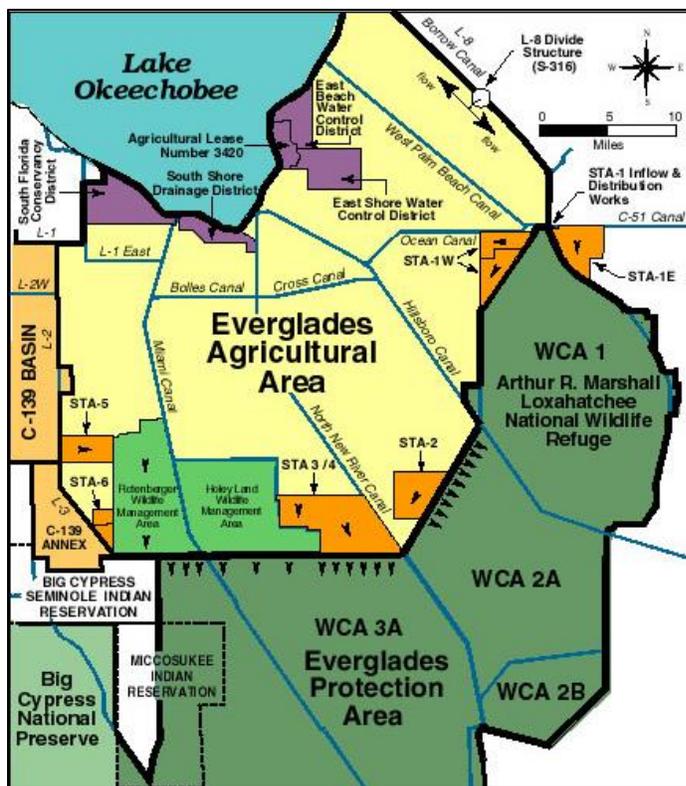


Fig. 4 Compartmentalization of the Everglades  
 Source: Walker, W. and Kadlec R. (2008)

Because canals have broken up the land, the original sheet flow of the Everglades has for the most part vanished. Above average precipitation seasons can cause areas to be under water, damaging plants and animal habitats. Above average dry seasons can lower water levels damaging soils and plants, which makes food scarce for animals.

Water depths have changed throughout the Everglades system. Areas that were deep are now dry. Areas that were shallow are now deep. This has affected the quantity of fish concentrations throughout the system. Because of water releases through both the Caloosahatchee River and the St. Lucie River, much less water is reaching the Florida Bay.

Due to the levees and canals, water levels in the Everglades were lowered in many areas, causing peat soil loss, higher salinity in wetlands, and saltwater intrusion near the coasts. The SFWMD started performing irregular, timed pulses of water that flooded wildlife habitats and scattered fish concentrations. (Harvey et al. 2019).

Another reason for lower water levels in the Everglades is that SFWMD diverted water directly down in canals to recharge the Biscayne Aquifer (which provides water for all of Southeast Florida), so this water does not flow through the system.

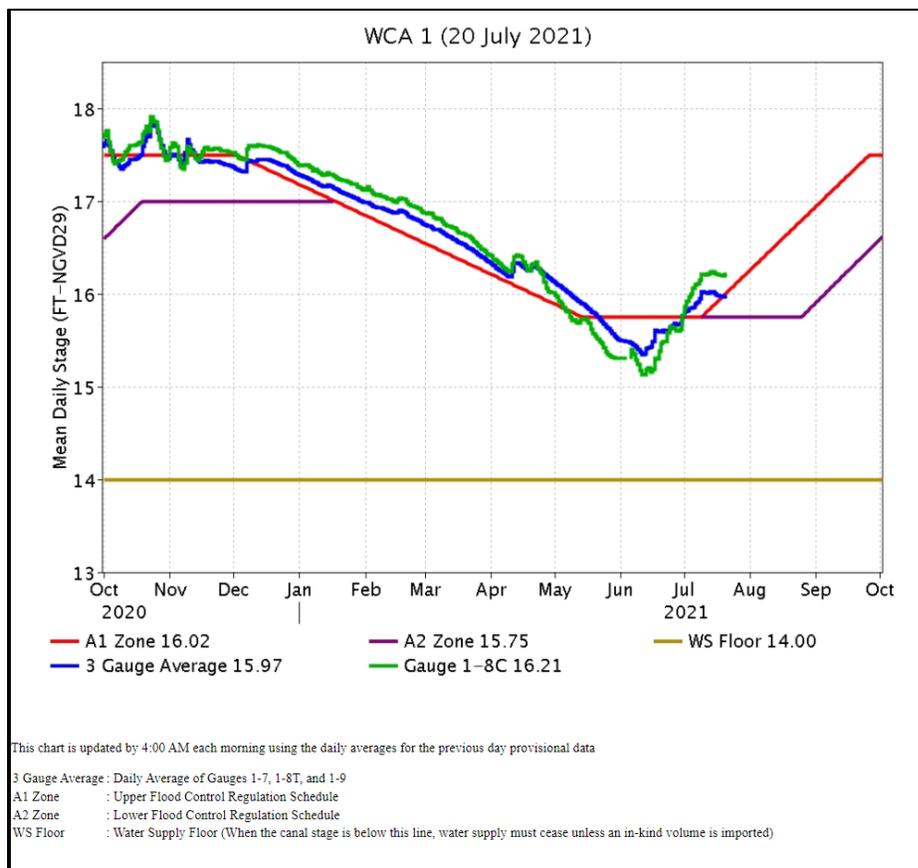


Fig. 5 – Hydrograph WCA1 (ARM Loxahatchee NWR) – Central Portion  
 Source: SFWMD.gov

Fig 5. shows the hydrograph for the central portion of the Refuge. The A1 and A2 zones show the flood control regulation schedules. For the most part, the water level amounts are near those schedules, but as you get to May and June, the amounts recorded are below average. Also, starting at mid-July, the water levels are not rising as forecasted.

## SOILS

Wetland soils are hydric soils due to a loss of oxygen from water. There are two types of soils found in wetlands: organic and mineral. The soil we found in Impoundment B in the Refuge was organic. After reviewing the Web Soil Survey, we found our soil was Okeelanta muck. Okeelanta muck ranges from moderately alkaline to strongly acidic. These soils are found in freshwater marshes and depressional areas of Southern Flatwoods and Southern Florida Lowlands. They have rapid permeability and are poorly drained. (National Cooperative Soil Survey 2014).



Photo 1 – Soil Sample Landscape in Impoundment B at ARM Loxahatchee NWR



Photos 2 and 3 – Soil Samples taken at Impoundment B at ARM Loxahatchee NWR  
Source: Denise Valentin

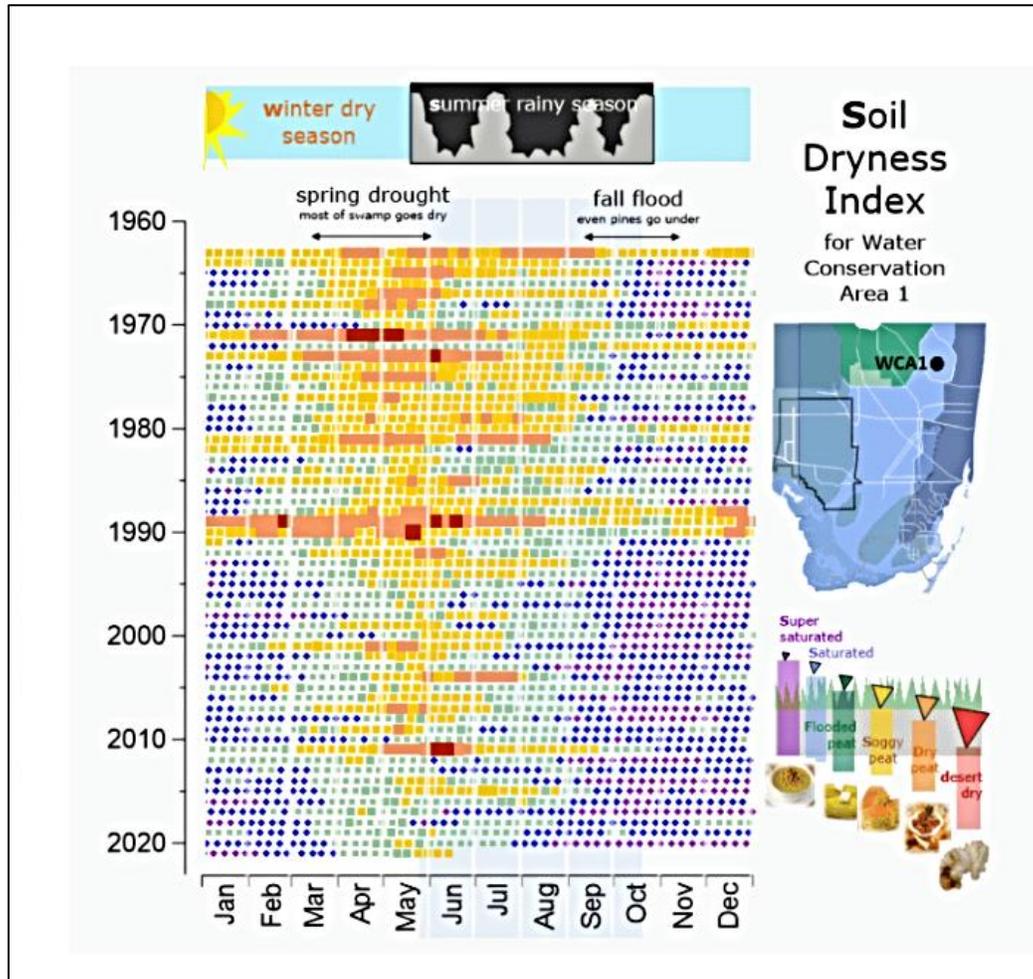
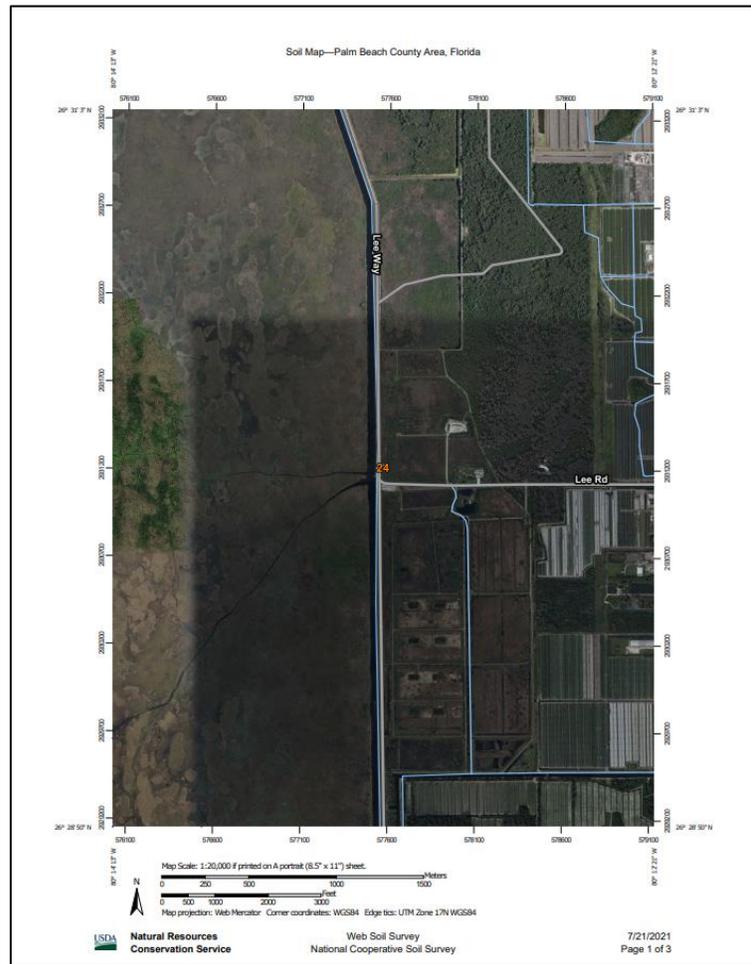


Fig 6. Soil Dryness Index for WCA 1 – ARM Loxahatchee NWR  
 Source: GoHydrology.org

Fig. 6 shows that back in 1960 the soils were mostly soggy or dry peat, with a few desert dry months. In the 1970's and 1980's, the soil starts getting a little more flooded. As we get to 1989, the peat becomes dry again for half of the year and soggy for the other half. The 1990's shows an increase in soil saturation and less dry peat. 2000-2020 shows very little dry peat and more supersaturated soils.

### WEB SOIL SURVEY



#### MAP LEGEND

**Area of Interest (AOI)**

- Area of Interest (AOI)
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

**Special Point Features**

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot

#### MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service  
 Web Soil Survey URL:  
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Palm Beach County Area, Florida  
 Survey Area Data: Version 17, Jun 9, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 7, 2020—Mar 26, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

#### Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
24	Okeelanta muck, drained, frequently ponded, 0 to 1 percent slopes	0.1	100.0%
<b>Totals for Area of Interest</b>		<b>0.1</b>	<b>100.0%</b>

Fig 7. Web Soil Survey for ARM Loxahatchee NWR  
 Source: National Cooperative Soil Survey

## PLANTS AND ANIMALS

The Refuge is home to many native and migratory animals, and unfortunately, a few non-native animals. It is also home to hundreds of native plants living in different habitats. Like animals, non-natives plants are scattered within. A large portion of the Refuge is closed to public use, but scientists have been tracking both flora and fauna within the Refuge for many years.

According to The Floristic Inventory of South Florida, there are 259 plants reported in the Refuge. Of all 259 plants, 195 plants are native. Among this list are 64 species that have been introduced and out of those, 25 are invasive. Note, however, that many of these “introduced” plants have now been considered non-native but naturalized.

Scientists have documented over 23 mammal species, 15 amphibian species, 250 bird species, 10 turtle species, 8 lizard species, 24 snake species, and of course, American Alligators in the Refuge. There are over 46 species of temperate freshwater fish that have been seen in the Refuge waterways. Many insects make the northern Everglades their home also. 40 species of butterflies, 23 species of dragonflies, and 7 species of damselflies have been documented in the Refuge.

The Refuge, as part of the Everglades system, contains numerous ecosystems and habitats found in both the Refuge and Everglades National Park. Below are pictures of the plants and animals for the main habitats found in the Refuge: freshwater cypress swamp, freshwater marsh habitats (marshes, sloughs, wet prairies), sawgrass ridge, and tree islands.

### Some native plants seen in the Refuge:

### All Photographs (Denise Valentin)

Alligator lily  
*Hymenocallis palmeri*  
Habitat: Marshes



American White Water Lily  
*Nymphaea odorata*  
Habitat: Marshes



Giant Leather Fern  
*Acrostichum danaeifolium*  
Habitat: Cypress Swamps



Bulltongue arrowhead  
*Sagittaria lancifolia*  
Habitat: Marshes



Cardinal air plant (epiphyte)  
*Tillandsia fasciculata*  
Habitat: Cypress Swamp



Duck weed  
*Lemna minor*  
Habitat: Marshes



Pickerelweed  
*Pontederia cordata*  
Habitat: Marshes



Pond cypress tree  
*Taxodium ascendens*  
Habitat: Cypress Swamp



Sawgrass  
*Cladium jamaicense*  
Habitat: Sawgrass ridge



**Some native animals seen in the Refuge:**

**All Photographs (Denise Valentin)**

American alligator  
*Alligator mississippiensis*  
Habitat: All



Anhinga  
*Anhinga anhinga*  
Habitat: Marshes & Swamps



Florida banded water snake  
*Nerodia fasciata pictiventris*  
Habitat: All



Florida Mottled duck  
*Anas fulvigula*  
Habitat: Marshes



Florida softshell turtle  
*Apalone ferox*  
Habitat: Marshes



Great Blue Heron  
*Ardea Herodias*  
Habitat: Marshes & Swamps



Great egret  
*Casmerodius albus*  
Habitat: Marshes & Swamps



Florida Red-bellied Cooter  
*Pseudemys nelson*  
Habitat: Marshes



Pig Frog  
*Rana grylio*  
Habitat: Marshes



**Endangered / threatened animals found in the Refuge:**

American alligator  
*Alligator mississippiensis*  
Threatened (due to appearance)  
Habitat: All



Credit: Denise Valentin (juvenile alligator)

Everglades snail kite  
*Rostrhamus sociabilis plumbeus*  
Endangered  
Habitat: Marshes & Tree Islands



Credit: Allen Hoffacker/Audubon

Eastern indigo snake  
*Drymarchon couperi*  
Threatened  
Habitat: All



Credit: Bill Frank/UFL

Wood stork  
*Mycteria americana*  
Threatened  
Habitat: Marshes



Credit: Denise Valentin (juveniles storks)

## Four highly non-native, invasive plants found in the Refuge

### FISC Category 1

All Photographs by UF/IFAS

Australian pine

*Casuarina sp.*

Habitat: Tree Islands



Brazilian pepper

*Schinus terebinthifolius*

Habitat: Tree Islands



Melaleuca tree

*Melaleuca quinquenervia*

Habitat: Tree Islands



Old world climbing fern

*Lygodium microphyllum*

Habitat: Tree Islands



## Invasive Plant Species Removal Programs

Currently, the Refuge has been fighting a battle with the four top invasives shown above, and also aquatic floating plants including water lettuce and water hyacinth. The Refuge has over 96,000 acres of land where these invasives can still be found (as of 2008). The Refuge uses prescribed fire, herbicides, mechanical control (heavy equipment), hand-pulling (seedlings and vines), and recently added biological controls. Over 200,000 acres have been treated by both ground and aerial methods to date.

The newest plan for the Refuge is using biological controls. The Bud Gall Midge and Melaleuca Psyllid have been released on the Refuge for the Melaleuca trees. The Brown and White Lygodium Moths have been released. Since fire kills the insects, they must be applied after prescribed burns. They have been shown to help, but unfortunately, these invasives still continue to flourish and it appears a never-ending battle will be going on for many years to come.

**Non-native invasive animals found in the Refuge:**

Argentine tegu  
*Salvator merianea*



Photo: FFWCC/Bugwood.org

Burmese Python  
*Python molurus ssp. bivittatus*



Photo: Lori Oberhofer, NPS/Bugwood.org

Giant African Snail  
*Achatina fulica*



Photo: Yuri Yashin/Bugwood.org

Cuban Tree Frog  
*Osteopilus spectentrionalis*



Photo: EvergladesCISMA.org

Green Iguana  
*Iguana iguana*



Photo: Carolyn Parrish FFWCC/Bugwood.org

Nile Monitor  
*Varanus niloticus*



Photo: UF/FLREC

**Invasive Animal Species Removal Programs**

Currently, there is a Python Elimination Program through the South Florida Water Management District (SFWMD) throughout South Florida. As of June 21, 2021, the number of pythons eliminated throughout South Florida is 4,490. The tracker was started in March 2017.

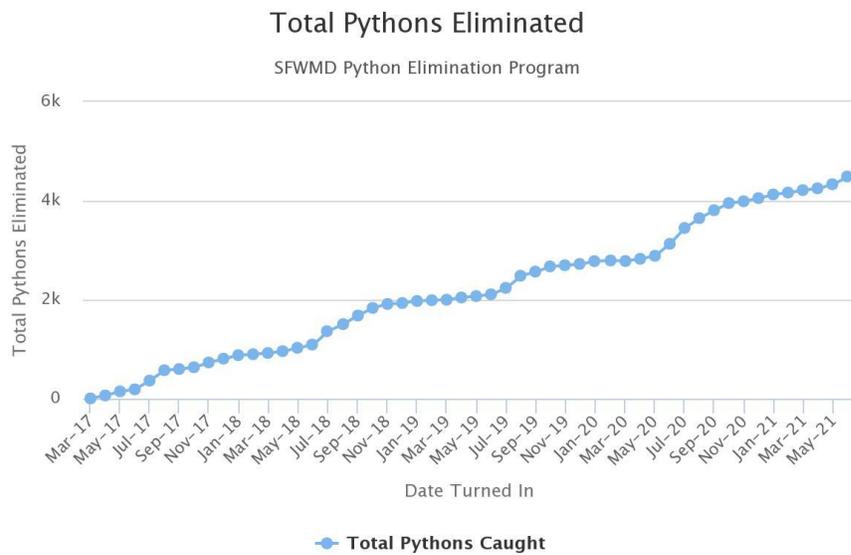


Fig 8. – Total pythons eliminated under SFWMD Python Elimination Program  
Credit: SFWMD.gov

Other programs are offered through the Everglades Cooperative Invasive Species Management Area (Everglades CISMA). They work together with university and scientists from numerous agencies to assess invasive species. Everglades CISMA cooperates with federal, state, and local governments, nonprofit organizations, and Indian tribes.

## RESTORATION AND MANAGEMENT

Canals, levees and pump stations now control the water level at the Refuge. The outer perimeter of the Refuge itself is a canal. According to Harvey et al. (2019), canals and levees affect the connectivity at the landscape scale. They decompartmentalize the Northern Everglades (aka the Refuge) and affect the flow of nutrients and pollutants. Canals also pull water from the surrounding wetlands causing reduced water levels throughout the Refuge.

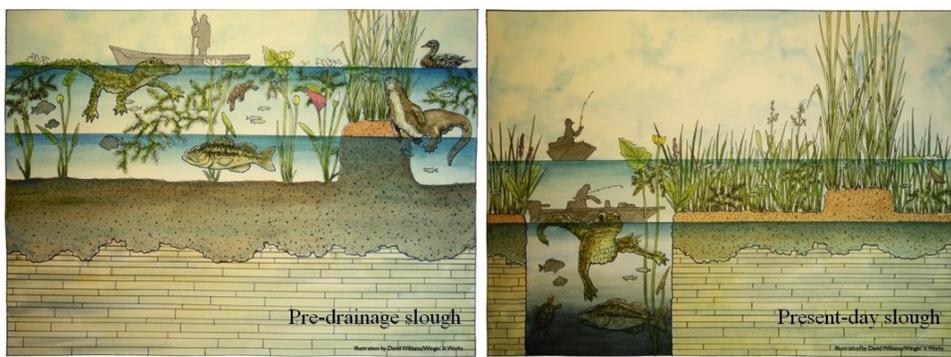


Fig. 9 – Canals draw water from the surrounding wetlands  
 Credit: Christopher McVoy, SFWMD

As such, the waterflow at the Refuge has been changed. Since the hydrology has been highly altered, this has caused physical conditions at the Refuge to be highly altered also. Currently, water levels are now monitored and controlled to bring back the proper waterflow. The impacts to the ecosystem has degraded wildlife habitat and reduced the richness of wildlife species.

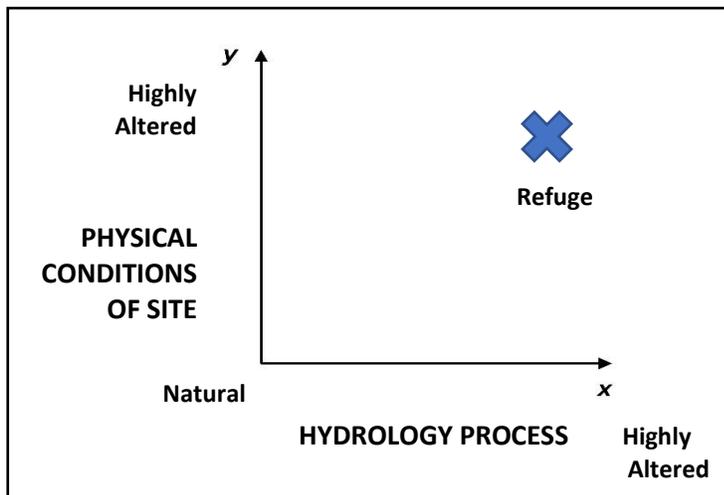


Fig. 9 – Conceptual model for the hydrology process and physical conditions of the Refuge  
 Credit: Denise Valentin



Regarding restoration of the waterflow to the Refuge, there is no plan under CERP to remove canals from Lake Okeechobee to allow the historic flows to the Refuge. As such, water inflows and water levels will continue to be controlled by SFWMD and USACE. There are also no plans to remove the levees at the southern end going into WCA 2 as this would cause all water to flow south, thus drying out the Refuge. The Refuge is part of the Everglades Watershed that will never fully be returned to its historical waterflows.

### ***Goals of the Refuge***

The federally-listed threatened and endangered species that live in the Refuge can only survive if their habitat is healthy and if food is readily available. The Refuge monitors their habitats to ensure their breeding numbers are strong. The Refuge believes that wildlife conservation is the number one priority in managing the Refuge. There are four goals of the Refuge (taken directly from the Comprehensive Conservation Plan ("CCP")):

1. "Restore and conserve the natural diversity, abundance, and ecological function of refuge flora and fauna.
2. Conserve natural and cultural resources through partnerships, protection, and land acquisition from willing sellers.
3. Develop and implement appropriate and compatible wildlife-dependent recreation and environmental education and interpretation programs that lead to enjoyable experiences and greater understanding of the Everglades and south Florida ecosystems. Continue a partnership with the South Florida Water Management District, including renewal of the license agreement for Water Conservation Area 1.
4. Continue the development of an effective and productive staff to achieve the vision, goals, and objectives of this plan." (CCP, pg. 58).

### ***Management Plan***

Unfortunately, the last management plan written for the Refuge was in 2000 (included in the CCP) and it outdated. Some of the items found in that management plan included the following:

1. Regulating amount and timing of water released into or transferred out of the Refuge
2. Expand testing and monitoring of the water for pesticides, fertilizers, and other contaminants in the water and underlying soils
3. Expand invasive plant treatment for melaleuca trees and Old World climbing fern
4. Prescribed burns to remove treated and dead exotics, and to reduce future exotic and invasive plant growth
5. Enhancing wildlife habitat in the public area compartments (impoundments and cypress swamp) and the Strazzulla Marsh
6. Inventory and map wildlife and habitats and monitor these inventories
7. Maintain or enhance threatened and endangered species habitats
8. Protect Refuge resources

The Refuge is still continuing to battle the invasive plants. Reports from SFWMD show that infestations in WCA-2 and WCA-3 decreased, while infestations increased in WCA-1 (the Refuge). Many goals to reduce the spread of invasives have not been met. Funding is part of the reason why as the treatment is very costly (in the millions), and the Refuge is over 144,000 acres. The Refuge has a budget that is given to them from the U.S. Fish & Wildlife. There is not enough funds to bring in many troops to fight the invasive species so it will remain an issue indefinitely.



**Measure:** Percentage of infestation at sustain maintenance control will meet or exceed the following schedule:

Species	Year 2007	Year 2012	Year 2017
Melaleuca	20%	75%	<del>100%</del>
Old World climbing fern	10%	50%	<del>100%</del>
Brazilian pepper	20%	50%	100%
Australian pine	100%	100%	100%

**NOT MET AS OF 2020 EITHER**

Fig. 11 – A.R.M. Loxahatchee NWR: *Status of Priority Invasive Plants* Presentation 2015  
 Credit: SFWMD.gov

## Recommendations

1. Update the Conservation Plan and the Management Plan contained therein.
2. Continued monitoring of changes to the different zones of the Refuge must be done frequently so as to make necessary changes needed in the waterflow. Only the correct change in waterflow is going to bring the Northern Everglades (the Refuge) back to its former glory. Due to this water flow change, plant succession has occurred throughout the Refuge, and this has changed both the organism species and their habitats.
3. Research water flows and drawdowns and their effect on plants, organisms and soil should continue in the Loxahatchee Impoundment Landscape Assessment (“LILA”). These four impoundments have recirculated water whose levels can be manipulated to simulate the physical features of the Everglades. Many studies have been performed in LILA in the past.

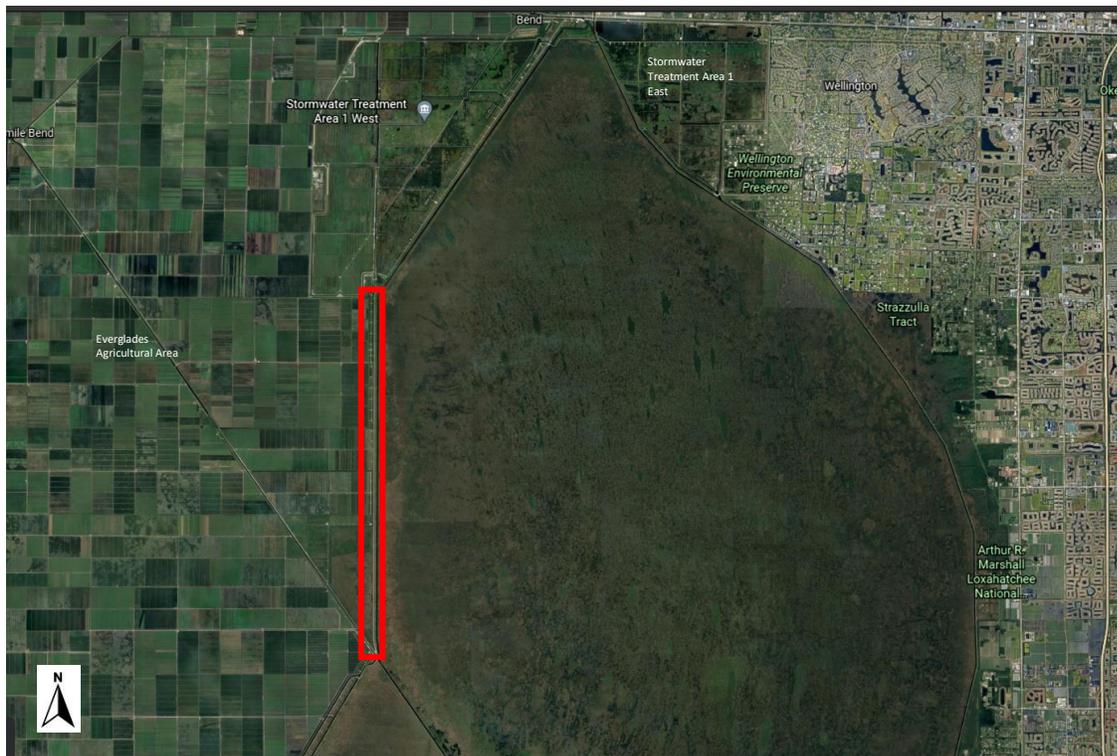


Fig. 12 – A.R.M. Loxahatchee National Wildlife Refuge and surrounding agricultural area and developments.  
Credit: Google Earth

4. Since the canals negatively affect the waterflow and the water levels of the surrounding wetlands, a section of Canal 7 below the STA-1W should be filled. Studies would then be immediately performed on the changes in water quality, levels of contaminants, soil characteristics, and plant, animal, and aquatic organism populations.

Closing this portion of the canal will also close a portion of the agricultural land that borders the Refuge on the west side. The intent of this recommendation, is to allow the flow of water to slowly meander through the Refuge and allow better filtering of the water. It will also allow succession of the correct plant communities while flooding out nonnative species.

Water will still flow to WCA 2 through spillways at the southern portion of the Refuge. The Levee beside the closure area will still remain to protect the outer areas from flooding. Access to this area will still be available by motor vehicle and air boat.

5. Continued work on chemical and mechanical removal of the invasives found in the Refuge (*Melaleuca* trees and *Lygodium* vine).
6. Continued research and testing of scientific techniques to eradicate the invasive plants without harming nearby wetlands and tree islands.

7. Increase relationships with neighboring communities and businesses, and work together to find ways to lower both water usage and chemical use (pesticides, herbicides, other chemicals).
8. Continued work with the Everglades Agricultural Area farmers, especially the sugar growers, to find ways to lower their fertilizer and pesticide use.
9. Continued environmental education to improve awareness of what services the Refuge provides as a water conservation area, and the importance of the Everglades ecosystem as a whole. An increase in knowledge develops into interest and concern, and that gives people the desire to contact leaders in government to show their support of restoration.

In conclusion, more time, funding and staff are needed in order to restore the Refuge's hydrology and plant communities (and fauna). This critical water treatment area was chosen by the U.S. Fish and Wildlife Service to make a national wildlife refuge. The main goal of the Refuge is to restore and conserve biodiversity and the ecological function therein. Along with the changes from the CERP projects, the entire Everglades ecosystem may have the chance to become a portion of its former self, with the Refuge being the starting point of the change.

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