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PART 1

Overview

Summary

This report provides a detailed description of the hydrology of the western portion of Big Cypress National Preserve - an area that includes the Barron River Canal corridor and the Turner River Watershed (Fig 1-1). Part 1 of the report provides a brief introduction to the study. Part 2 provides an in-depth review of the historical and present-day hydrology of the Barron River Canal Corridor. Part 3 provides an in-depth review of historical and present-day hydrology of the Turner River Watershed. Part 4 provides an overview of the major findings of the hydrologic monitoring and mapping work collected over the past two years in the Barron River Canal Corridor and the Turner River Watershed.

Introduction

In Fall 1999, Big Cypress National Preserve entered into cooperative agreement C-10762 with the Big Cypress Basin branch of the South Florida Water Management District in order to establish a hydrologic monitoring program in the western portion of Big Cypress National Preserve. Division of labor for the cooperative agreement was as follows. The Big Cypress Basin agreed to provide "seed money" to fund start-up costs of the project, including funds to pay for installation of groundwater wells,

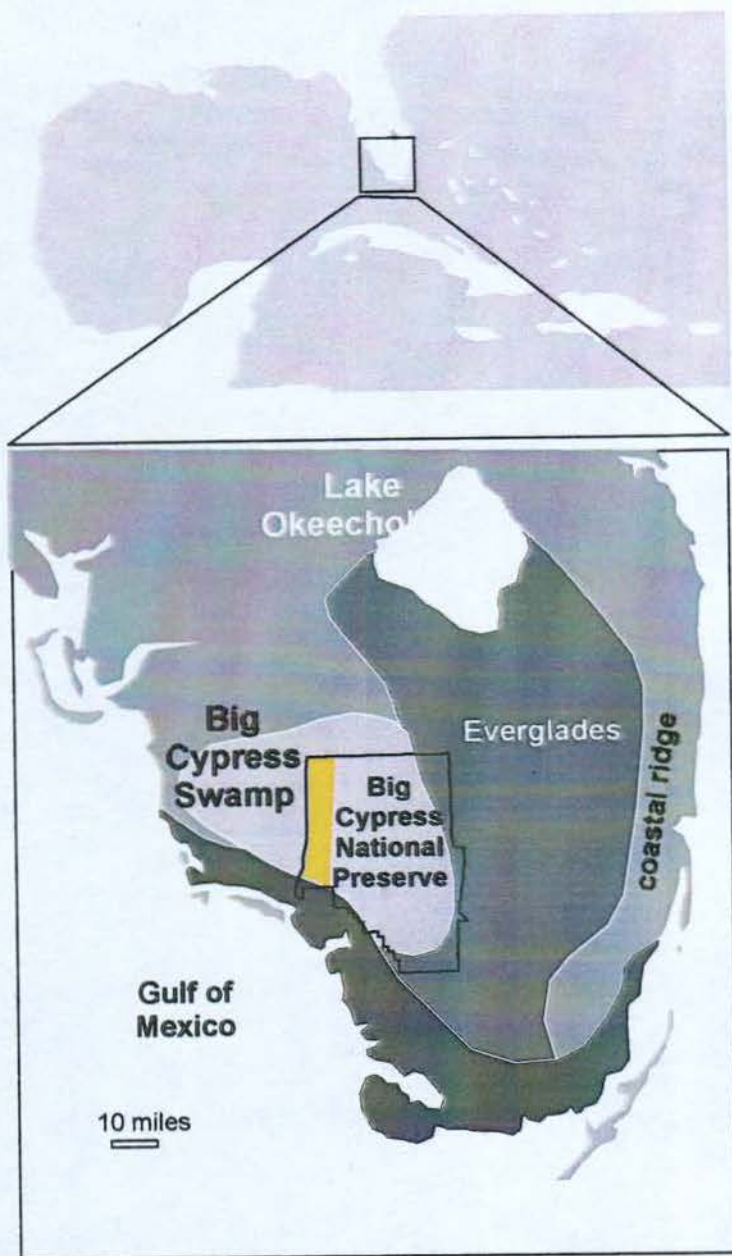
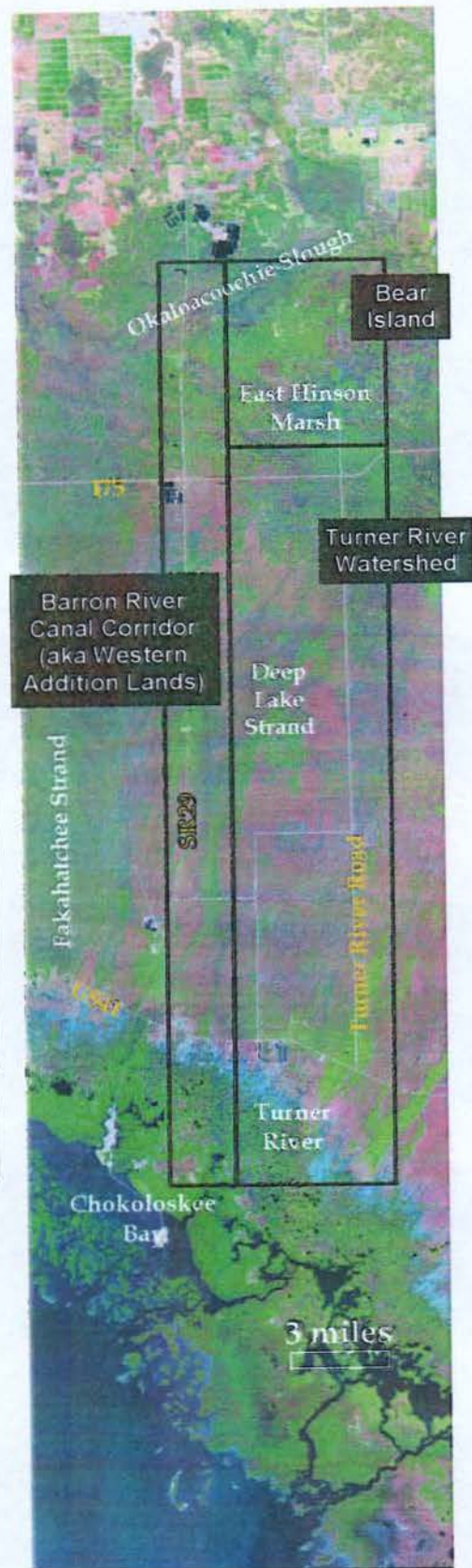


Fig 1-1. Overview of study area



professional surveying services, and surface-water staff gage supplies. Big Cypress National Preserve agreed to implement all aspects of the monitoring program; including site reconnaissance, design of the network, administration of the well drilling and surveying contracts, installation of surface water gages, in-house surveying in areas not covered through the contracted survey crew, monthly monitoring, and generation of two reports.

An approximate time line of the project is as follows. Field reconnaissance and field siting was completed in Winter 2000. Groundwater wells and surface water gages were installed in Spring 2000. Professional survey work was completed in Summer 2000. Monthly monitoring was also initiated in Summer 2000. In-house surveying of areas not covered by the professional surveying crew was completed in Winter 2001. An inventory report which describes critical information for each site was completed and presented to the Big Cypress Basin in Spring 2001. The deadline for the Final Report was extended 6 months to February 2002 in order to incorporate the full duration of the 2001 wet season in the monitoring analysis.

Design of Monitoring Network

The monitoring program consists of a total of 33 stations, from which water levels can be measured relative to NGVD 1929 datum at 63 points (Fig 1-2). Turner River Road contains 13 stations, Birdon Road contains 6 stations, Upper and Lower Wagon Wheel Road contain 6 stations, and State Road 29 contains 8 stations. Most stations are equipped to measure the elevation of surface water stage at two points: (1) on the upstream side of the road and canal and (2) on the downstream side of the road and canal. A schematic drawing of this design standard is shown in Fig 1-3. A paired-well design was chosen because differences in water level are expected to occur across the roadbed and canal channel.

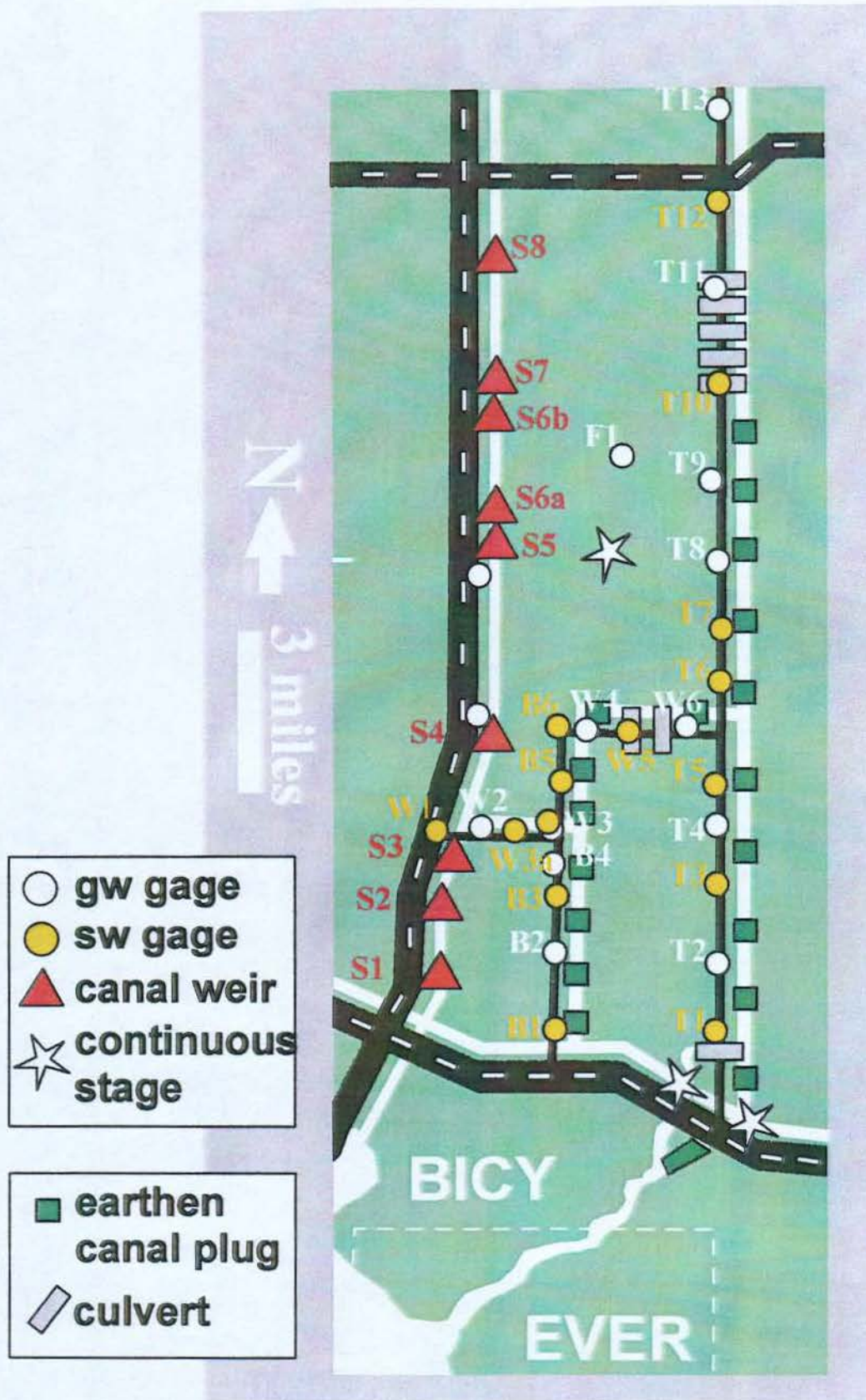


Fig 1-2. Overview of monitoring network

Project Goals

Goals of this monitoring program are as follows:

- (1) **Establish a long-term program for monitoring shallow ground water and surface water levels in the western portion of the preserve.** The majority of the preserve is difficult to access with conventional wheeled vehicles, but instead require use of a helicopter, swamp buggy, all-terrain vehicle, airboat, or foot travel. A network of roads established in the western portion of the preserve prior to its establishment make this area ideal for a road-based monitoring network. Roadways where monitoring stations are located include Turner River Road, Birdon Road, Upper Wagon Wheel Road, Lower Wagon Wheel Road, and State Road 29. Additional work may be completed at a later date to establish stations along Interstate 75, Perochi Grade, and Bear Island Grade.

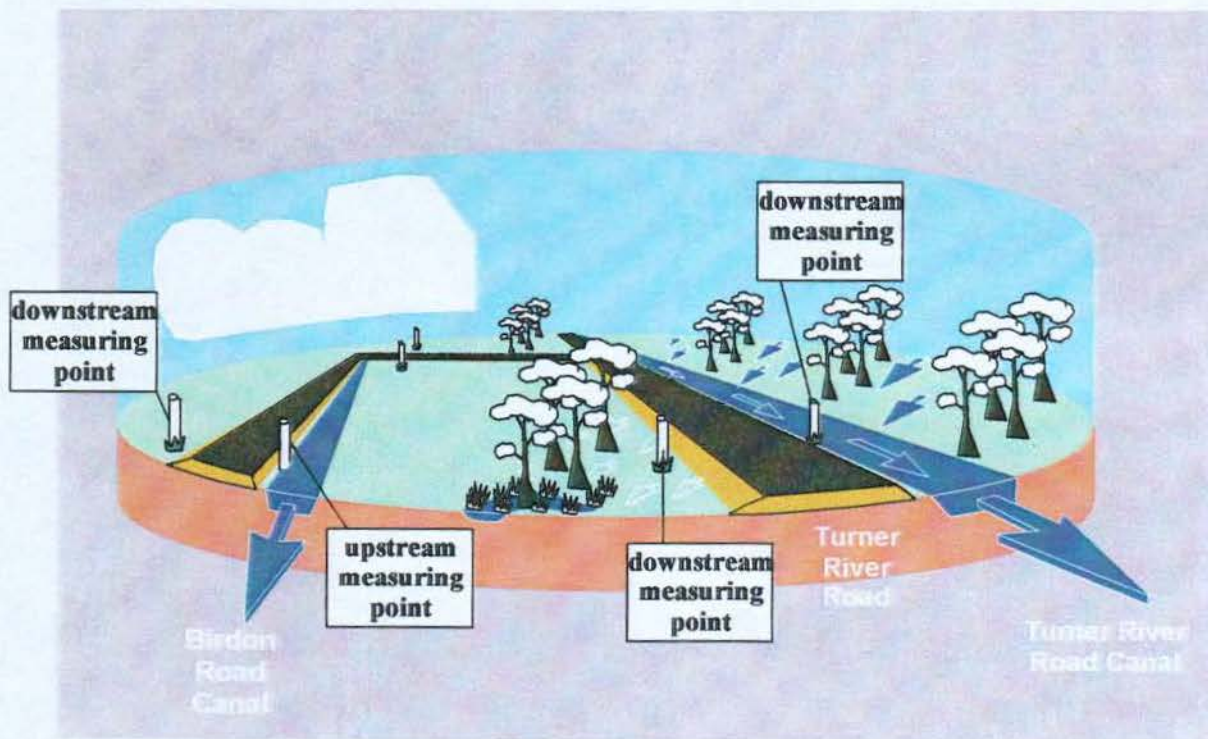


Fig 1-3. Schematic diagram showing the paired well design used at most of the locations.

- (2) **Determine the impact that elevated roadbeds and adjacent canals have on surface water inundation patterns in the western portion of the preserve.**

Previous efforts by National Park Service staff in 1988-89 and 1996 were completed in order to prevent blockage of and over-drainage of natural water flows in the Deep Lake, Airplane Prairie, and Turner River areas of the preserve. However, there has never been a formal post audit to consider the effectiveness of these actions, or whether additional actions should be taken.

- (3) **Improve regional characterization of sheetflow conditions in tandem with a similar monitoring program maintained at Fakahatchee Strand State Preserve.** Two east-west oriented transects of groundwater wells were established across Fakahatchee Strand State Preserve in the late 1980s to provide a long-term water level baseline, and to assess the hydrologic impact caused by drainage canals in the Southern Golden Gate Estates area and along State Road 29. The monitoring program established in western Big Cypress National Preserve provides an opportunity to expand our understanding of the hydrology in this area.

Project Status

Submission of this report is intended to close out the contractual obligations as outlined in cooperative agreement C-10762. However, the author would like to emphasize that work is already underway (1) to expand the existing monitoring network to include additional sites in Bear Island and Fakahatchee Strand (Fig 1), (2) to incorporate data loggers at strategic places in order to better interpret short term response to rain events, and (3) to maintain the monthly sampling regime at the network as part of BCNP's long-term hydrologic monitoring program.

PART 2

Barron River Canal Corridor

SUMMARY

Big Cypress National Preserve expanded its boundaries in 1996, under authorization passed by Congress in 1988, thereby bringing its western boundary in general alignment with State Road 29 and the borrow canal that parallels it - the Barron River Canal. The roadbed and canal act as a major hydrologic disturbance on the natural water regime of wetlands adjacent to the travel corridor and the downstream coastal area. This paper provides an overview of how the hydrology of the Barron River Canal corridor (hereafter called the Western Addition Lands) has been modified in the past, and what steps need to be taken to restore the area hydrologically in the future.

DESCRIPTION OF HYDROLOGIC SYSTEM

The Western Addition Lands form a long, narrow strip of land - 25 miles long by 1 mile wide (2 miles wide at its southern extreme) that contain the following natural systems.

North of I75

The area north of Interstate 75 contains Bear Island - the largest hardwood hammock in the preserve. By definition, hammocks are areas of slightly higher elevation that unlike pinelands are found in places that have escaped the ravages of a regular fire regime. Most hammocks in the preserve are only small features - small dots on the USGS quadrangle maps that are surrounded by a "sea" of longer

Note To Reader

The referenced photos are provided at the end of this chapter as a complement to the discussion provided in the text.

photo
2-1

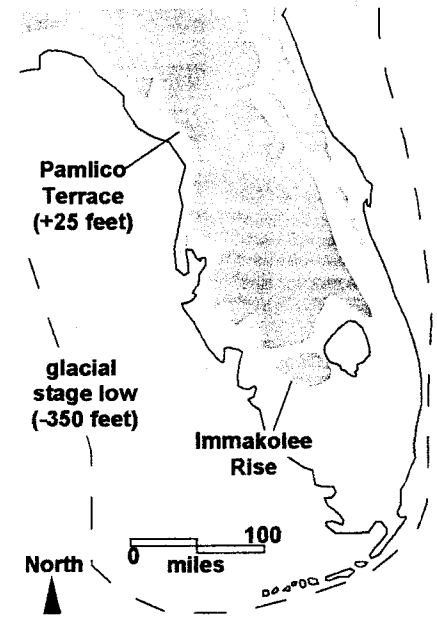
hydroperiod marsh, cypress, or prairie. Bear Island is unique by its size and the sandy consistency of its soils. (The rest of the preserve is predominated by calcium-rich marl and, to a lesser extent, peat soils.)

Bear Island was formed during the last glaciation, starting 100,000 years ago, when sea level stabilized for an extended period at 25 feet above the present level. Wave action along the coast cut into the sandy central ridge of Florida to form the Pamlico Ridge, a land feature whose southern extent reaches south of the present day Caloosahatchee River and is called the Immakolee Rise (Fig 2-1). Bear Island formed as a smaller island or sand bar just south of the rise. During this time, the rest of the present-day preserve was a shallowly submerged marine environment. Today Bear Island is still an island, only it now lies between two freshwater bodies: Okaloacoochee Slough and East Hinson Marsh (Fig 2-2).

The headwaters of the Okaloacoochee Slough form northeast of Immakolee (Fig 2-2). The main course of the slough travels south along the eastern edge of the Immakolee Rise until it runs up against Bear Island where it bends diagonally across the northwest corner of the preserve, flowing from there through the Panther Refuge and then down into Fakahatchee Strand. A few small tendrils of OK Slough also meander directly through Bear Island, thereby connecting it with East Hinson Marsh during high water. Roadbed culverts along Bear Island Grade mark the locations of these marsh tendrils. Other branches of Okaloacoochee Slough feed into the headwaters of Kissimmee Billy Strand and even north into the Caloosahatchee River.

Between I75 and US41

The area between I75 and US41 is dominated by a series of short hydroperiod prairies (Miles City, Rock Island, and Copeland Prairies) that lie between two major flow systems: Fakahatchee Strand to the west and Deep Lake Strand to the east (Fig 2-2). An offshoot of Deep Lake Strand contains Deep Lake, the deepest freshwater feature in the preserve and one of the few major sink holes south of Lake Okeechobee. The lake is circular, with a 300 foot diameter, and tapers conically to a maximum depth of 90 feet.



Adapted from Lodge, 1995

Fig 2-1. Map showing the coastline of Florida at different sea level elevations.

photo
2-2

photo
2-3

South of I75

The area south of US41 is dominated by dense monocultures of cattail along the canals and mangrove forests throughout. Both vegetation types have overtaken the area in recent decades as a result of tidal inflows that flow up from Chokoloskee Bay. Saltwater intrusion into this corridor occurs on a diurnal basis during the winter and spring months, and is especially pronounced if accompanied by storm surges. Saltwater intrusion is excluded during the summer and fall months by the presence of flowing freshwater in the canal.

Entire length

Perhaps the most conspicuous water body in the Western Addition Lands is the one that parallels the road for its entire length – the Barron River Canal. State Road 29 forms the “de facto” border of the preserve and is tightly linked to the patterns of human settlement and economic enterprising that occurred historically along the corridor. What makes State Road 29 vitally important to this discussion is the role it and the Barron River Canal have played as a disturbance to the natural water regime of the corridor.

STATE ROAD 29

State Road 29 is a two-lane highway that extends for 60 miles from Everglades City to LaBelle, and passes through Immakolee at about its midpoint (Fig 2-2). The southern 25 miles of the road runs alongside the preserve to the east and Fakahatchee Strand State Preserve to the west (a narrow strip of private lands lie between the road and Fakahatchee in most places). Several small communities also lie alongside the road. They include Chokoloskee, Plantation Island (via a causeway), Everglades City, Carnestown, Copeland, Jerome, Deep Lake, Miles City, and Sunniland (just north of the preserve).

History of SR29

State Road 29 was originally built back in 1926 at the same time and immediately adjacent to a railroad grade to the west. The railroad grade provided the first transportation artery between two port towns – Everglades and LaBelle – and passed through the rich agricultural lands that lay

photo
2-4



Fig 2-2. Satellite-image map showing major natural landmarks of the Western Addition Lands.

between the two at Immakolee, thereby providing a way for its agricultural goods to get to market. Everglade, renamed to Everglades City in 1961, provided a portage on Florida Bay for delivering goods down to Key West and LaBelle provided a portage on the Caloosahatchee River for delivering goods to Ft. Myers or across Lake Okeechobee to Florida's east coast.

The rail also served as a vital economic lifeline for a budding county and its newly dubbed county seat. Collier County had only recently been established in 1921 and Barron Collier, the county's founder and primary landholder, identified a spot on the coastal fringe of the Big Cypress Swamp across from the island of Chokoloskee as best suited for the seat of his new county. Channels were dredged on either side and the spoil pile in between became known as Everglade.

The rail was just not a line between two markets, it also became a corridor of economic development in and of itself, as did the east-west running Tamiami Trail whose construction Barron Collier picked out of bankruptcy and completed in 1928. The railroad grade and the trail became "gateways" (or inroads) into the interior swamplands of the Big Cypress - opening it up for economic development and human settlement.

Several communities sprang up along the railroad, many of which would fit the label of "company towns" - with the primary company interest in this case falling under the reigns of Barron Collier. Everglade made its mark as the county seat, Copeland and Jerome developed around logging operations underway in the Fakahatchee and Deep Lake Strands, a citrus grove and a hunting resort were established at Deep Lake, Miles City developed around cattle, limestone quarries were dug in several locations (Copeland, Miles City, and Sunniland), a railroad operations facility developed at the rail's junction with the Tamiami Trail called Carnestown, and subsurface extraction of oil and gas occurred around Sunniland - all of which became train stops along the rail (Fig 2-3). The road grade was extended south 2 miles to Chokoloskee in 1955, thereby ending its era as a water-locked island community.

Economic growth at these population centers was relatively short lived. The communities remain, but

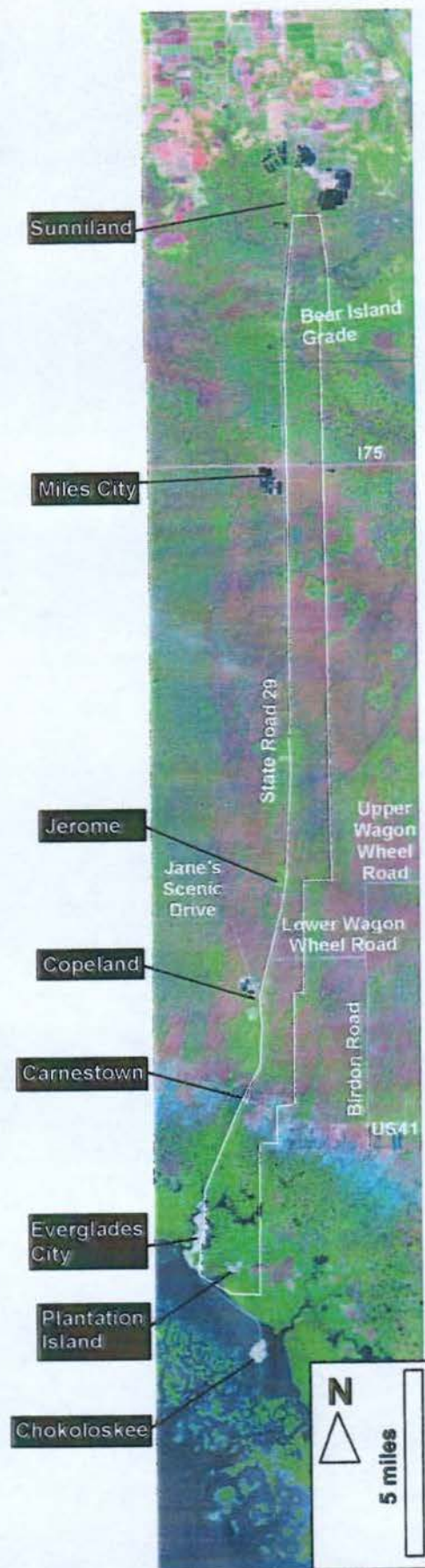


Fig 2-3. Satellite-image map showing major roads and towns along State Road 29

without the internal activity that they were born out of they have generally been reduced in size and in some cases, such as Miles City, have virtually vanished by all other standards other than as a namesake on a map. The populations that remain, even in the largest communities such as Everglades City and Chokoloskee, rely heavily on human services (i.e. shopping, healthcare) provided in Naples, Miami, or Immakolee.

Causes of this decline are varied, but can be explained as a combination of the following: resource depletion, evolution of economic systems at large, a hurricane, and a conservation fervor. Resource depletion can be most directly tied to the cause of decline in Copeland and Jerome. Within two decades of their establishment all the old growth cypress and pine were cut, and so with it went the loggers. Agriculture had a productive, but short lived, occupancy. Its loss can be partially attributed to less-than-ideal soil conditions and an uncooperative water regime (frequent flooding and drought) - but the larger hand in its demise was likely a shift in the economics of agriculture in general with the replacement of railcars with rubber-tired trucks and growing costs of labor after the Second World War.

Hurricane Donna was not so much a cause as it was a catalyst. In 1960 it swept through the underbelly of Southwest Florida and caused much damage in Everglades City, not the least of which was loss of its status as the seat of Collier County. Thereafter the county seat was moved to the much faster growing town of Naples on the west coast - a town that was on higher land and also had sandy beaches on the mainland, a key attraction that Everglades City lacked.

Despite all this, the communities, and the corridor in general, did not just kick up and die. A second wave of economic development, this time fueled under the post World War II auspices of suburban development also swept into the Big Cypress. These efforts started in earnest, but were cut short when it became apparent in the early 1970s that the interior lands of the Big Cypress were poorly suited for widespread development (i.e. experiences at Southern Golden Gate Estates and the Jetport incident) and that their most beneficial use would be to retain them as they were in conservation for

perpetuity, and to restore them from damage already inflicted where possible.

In brief, the rail and road grades connecting Everglades City to Immakolee were born out of a desire to develop the interior swamplands of the Big Cypress. The grades spawned an era of economic development and human settlement along its corridor that stopped growing decades ago or have even vanished. State Road 29 remains today as a gateway to the conservation lands it passes through on either side - Big Cypress National Preserve, Fakahatchee Strand, and the Panther Refuge - and at its southern terminus - Everglades National Park and the Ten Thousand Islands.

Traffic on SR29

Today, traffic flow is low on State Road 29 in comparison to the other two major roadways that intersect with it in the preserve - Interstate 75 and the Tamiami Trail - both of which are east-west bound roadways that connect the east and west coasts of south Florida. I75 is the larger of the two roads. It has double-barreled east- and west-bound traffic lanes that are separated from one another by a grassy median. I75 was built overtop and is an expanded version of what was previously State Road 84 and commonly called "Alligator Alley."

photo
2-5

The original plan for I75 called for only one interior interchange between Naples and Fort Lauderdale - at Snake Road (Exit 13) - to mollify environmental concerns that the expanded traffic flow of the super highway would negatively affect the Big Cypress. However, an exchange was also retained at State Road 29 to placate commercial interest of Immakolee and Everglades City.

State Road 29 was also overhauled a short time later in the 1990s. Travel lanes were widened by consolidating the road and rail grades into a single grade. The new grade was also shifted approximately 20-30 feet away from the adjacent canal bank to make room for a stormwater retention area. This shallow grassy swale catches and retains runoff from the road before entering the canal. Travel speeds on the road have increased as a result of the widening and repaving.

Wildlife undercrossings were added at 4 locations during road construction to decrease roadway mortality but the road does not contain continuous fencing as seen on I75, probably by merit of its lower traffic volumes. The southernmost undercrossing also includes a water conveyance channel under the road. Plans are underway to add two additional wildlife crossings in the Bear Island area (Fig 2-4).

A few hydrologic features were also added during construction. Several roadbed culverts were added at the tailwaters of Deep Lake Strand – all of which are circular concrete culverts measuring 2 foot in diameter. Two adjustable canal weirs were also added: Gate 6A at Deep Lake and Gate 6B just downstream of existing Gate 7 (Fig 2-4).

The original road and rail grades diverge from one another south of Copeland. The rail grade runs in a south-southwest direction to the old train yard at Carnestown. The yard is visible from US41 as a dense thicket of australian pine (*casurina* spp.). The road and canal parallel one another closely between Copeland and Everglades City. The stretch of road between Copeland and Carnestown was not included as part of the road widening project.

Hydrology of SR29

Barron River Canal

State Road 29 was built using the same methodology that other "swampland" roads have been built across south Florida. Blasting and dredging equipment was brought in to dig a long shallow pit. The spoil from the pit was used to build an elevated grade, and the adjacent pit was retained to channel floodwaters alongside the road rather than overtop it. Such canals have typically been dug on the upstream side of the roadbed for this reason.

The Barron River Canal generally lies in a parallel direction to regional surface water flow and, more importantly, is connected directly to tide at its downstream end. This latter condition made it largely unnecessary from a flood-control standpoint to retain gaps in the roadbed for water passage under the road.

photo
2-6



Fig 2-4. Satellite-image map showing major hydrologic control structures along State Road 29.

This contrasts to construction efforts along the Tamiami Trail where the roadbed lies perpendicular to the regional flow regime and it was recognized that periodic breaks in the road grade would be needed to prevent overtopping. Even today, there are only three bridge-sized water conveyances in the section of State Road 29 that lies adjacent to the preserve, all of which are north of I75 proximate to Bear Island. A series of smaller culverts and conveyances are located between Deep Lake and Copeland (Fig 2-4).

Stop Gate Weirs

While the State Road 29 grade has a minimum number of water conveyances, its adjacent canal contains a water control feature that the Tamiami Trail is noticeably lacking: stop gates in its canal. The Barron River Canal contains 10 stop gates (Fig 2-4). Seven of the stop gates are metal stop gates that insert between concrete slots at each bank. A crane is used to remove the metal gates during the wet season and to re-insert them during the dry season. These gates were originally designed so that they could be removed one panel at a time, but have since been welded together to prevent leakage between the panels. Under current conditions, the gates can only be fully inserted or fully removed (Fig 2-4).

photo
2-7

The canal has a much larger capacity to drain both surface and ground waters out of the freshwater system than do natural flow ways. Flow rates in the natural system are limited by a flat topography and slow infiltration into the underlying aquifer (the marl and peat soils form a semi-permeable seal). Conversely, the depth and length of the canal, its direct connection to tide, and the direct connection it has to the underlying aquifer makes the Barron River Canal a more efficient drain than any of the natural flow systems that it intercepts. The canal also receives groundwater seepage from along its banks – a source of water not available to natural flow ways, and one that flows in and down the canal even after water levels have receded below ground.

Ultimately, however, there is more water on the landscape than any one canal can handle by itself. The Barron River Canal is not capable of capturing all the water in the wetlands it intersects. Water continues to persist in adjacent wetlands, but its presence is shallower and briefer

than what would have occurred under the pre-drainage conditions.

The basic purpose of the stop gates is to keep freshwater from freely flowing to tide during the dry season. The gates help maintain aquifer levels, prevent overdrying of adjacent wetlands, reduce wildfire threat, and help reduce inland tidal intrusions from Chokoloskee Bay. The gates are generally removed during the onset of the wet season to allow "flood waters" from Immokalee and adjacent lands to pass to tide and put back soon after the hurricane season comes to a close, usually in October or early November. The stop gates are not water tight seals, however. They experience leakage around their sides (when surface water is still present), through their panels, and at depth along the base of the canal channel.

Three weirs were recently added (in the 1990s) presumably to address these deficiencies at Deep Lake (Gate 6A), just downstream of Gate 7 (Gate 6B), and just north of the preserve at Sunniland. These weirs span the canal channel as a solid concrete structure with windows that are open and closed via "captain's wheels" accessible from the weir's crest. This design is superior to the original gates because they can be manually operated, they prevent leakage at the base, and prevent leakage through the weir.

The keystone feature of the new gates is installation of roadbed culverts in their upstream slackwaters. Gate 6A and the Sunniland gate have slackwater culverts, the result of which is that water from the upstream slackwater pool is diverted across the road as opposed to running around or over the weirs. Gate 6B, on the other hand, does not contain similar culverts. Its slackwaters rise up and flow over its crest during the wet season.

photo
2-8

CONCLUSION

Barron River Canal forms the western border of Big Cypress National Preserve. A series of hydrologic features have been added to the canal over the past three decades for the purpose of providing flood relief for upstream agricultural lands and also for conserving water in downstream natural areas, but to date there has not been a comprehensive assessment of how well the canal performs this dual function. In 2000, a monitoring program was initiated to provide preliminary direction on this issue.

Referenced Photos

Barron River Canal Corridor



Photo 2-7. Photo of Gate 5 at Deep Lake under open (a) and close (b) conditions.



Photo 2-8. Photo of water flowing over the crest of Gate 6B.



Photo 2-9. Aerial view of Jerome, looking southeast.

Referenced Photos

Barron River Canal Corridor



Photo 2-1. Aerial view of Bear Island Grade, looking east.



Photo 2-2. Aerial view of Okaloacoochee Slough, looking north. Sunniland mines are in the background.



Photo 2-3. Aerial view of Deep Lake, looking north



Photo 2-4. Aerial view of the Tamiami Trail, looking south.



Photo 2-5. Aerial view of Interstate 75, looking south.



Photo 2-6. Aerial view of Everglades City, looking south.

PART 3

Turner River Watershed

Summary

The Turner River Watershed has undergone a series of hydrologic changes over the past 50 years. Road and canal-building actions in the 1950s cut off water to both the Turner River and the Turner River Watershed. Restoration actions were initiated in 1980, 1988, and 1996 to return flow to the river channel and its watershed. In 2000, a watershed-wide monitoring program was initiated to assess the degree to which future restoration actions are needed. This chapter describes the historical and present-day hydrology of the Turner River Watershed.

Introduction

Turner River lies in the southwestern portion of Big Cypress National Preserve. Its contributing watershed, headwater pools, and upstream portion of its channel lie within Big Cypress National Preserve (Fig 3-1). Its tailwaters and estuarine terminus lie in Everglades National Park.

Distinct river channels are uncommon in south Florida. A shallow wetland environment predominates the region, and where channels are present they are too short, discontinuous, densely vegetated, shallow, or too remote for navigation with canoe or kayak. Turner River is an

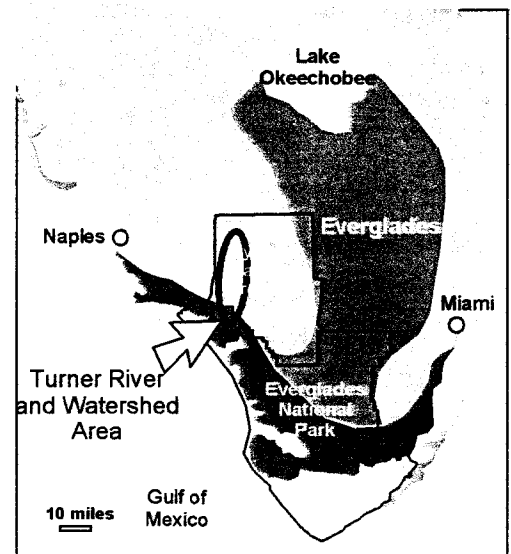


Fig 3-1. Overview of the Turner River Watershed

exception to all of the above. Its channel twists and turns for 9 miles through mixed cypress swamp, open grassland prairie, mangrove tunnels, and estuarine tailwaters before emptying into Chokoloskee Bay.

Turner River is an important resource within Big Cypress National Preserve because it touches upon many of the reasons behind the establishment of the preserve, as listed below and highlighted in Fig 3-2.

1. It is an important cultural and historic landmark.

Calusa and the later Seminole Indians used the river as passage in and out of the interior swamp land from the coast. Shell mounds of Calusa origins are located along the banks of the river. The river is also closely linked to the early European settlement of southwest Florida (Chokoloskee Bay Country), during which the river functioned as a prominent transportation route and its banks were used for settlement and agriculture.

2. It is an important natural feature. Its corridor provides continuity between a range of freshwater and saltwater habitats of the region. Its headwaters form in forested swamp (cypress), its midwaters pass through grassland prairie, and its tailwaters move through mangroves, before finally easing out into Chokoloskee Bay. The channel and corridor provides a unique habitat for a variety of flora and fauna. The channel sustains surface water longer than the surrounding landscape during drydown periods, and so provides natural refuge for wildlife.

3. It is an important coastal discharge feature. The river is part of the upstream watershed that delivers freshwater discharge to the shallow coastal waters of Everglades National Park. This is important because a primary impetus behind Congressional establishment of Big Cypress National Preserve was to protect the quality, volume, and timing of water flowing into the shallow coastal waters of the Ten Thousand Islands which are part of Everglades National Park.

4. It is a popular channel to canoe. Because its channel is long, continuous, deep enough for canoeing, and easily accessible by two roadways, Turner River has become the most popular place to canoe in the preserve. Farther to the east is the New River which, by contrast, also reaches into the freshwater marsh but it is not accessible by roadway

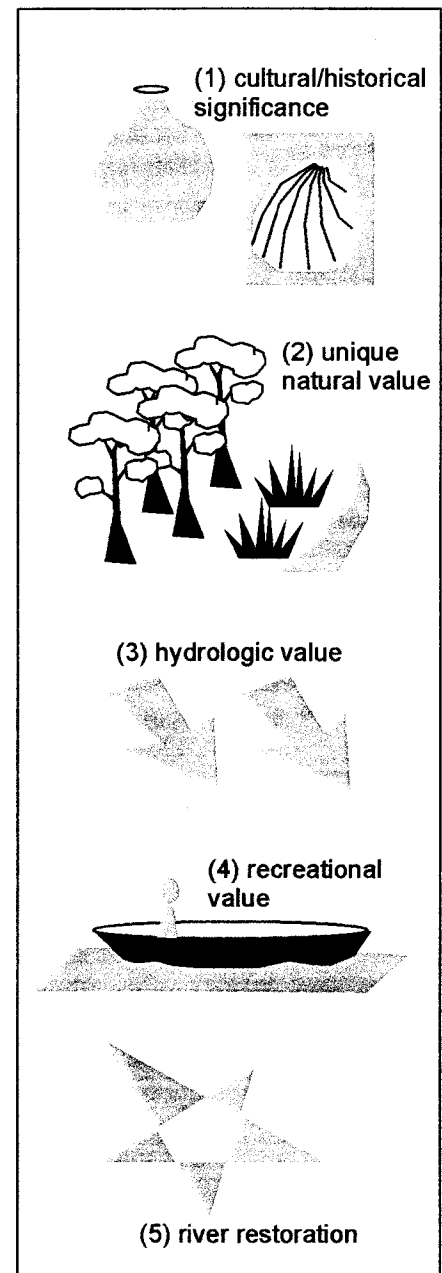


Fig 3-2. Sketch showing the five reasons that Turner River is important.

and even if it were, the channel is blocked by heavy mangrove growth at the tailwaters.

5. It is an important resource because it has been restored. The same roadways that provide access to the river also severed the river from its upstream watershed, causing it to dry up and fill in with vegetation. Restoration actions have been taken over the past 2 decades by the National Park Service to return the river to a natural hydrologic regime and accommodate recreational use. These restoration actions resulted in degradation (infilling) of the canal that recreationalists were previously using to access the tailwaters of the Turner River (and also for fishing) – but these actions were needed to return the water that was escaping down the canal back into the river.

To date, river restoration has reintroduced both “flowing water” and canoeists back into the river. The return of water flow and increased recreational use to the river have created a need to assess the status of the river and watershed-wide restoration actions.

Photographic Tour

In order to provide a background for the rest of the chapter, a photographic tour of the Turner River is provided below. This should be helpful towards better visualizing important aspects and concepts of the river and its restoration as discussed later. The full set of photographs are included at the end of this section, but the location that each photo was shot are referenced to illustrations of the river provided throughout the text.

Boat Launching

Turner River is located near the western edge of Big Cypress National Preserve. The river flows under the Tamiami Trail about a quarter mile downstream of its headwater pools. Motorists will easily miss this roadway view of the river if they are not looking closely because the river is relatively narrow (100 feet) and is forested on both banks with tall cypress trees. The bridge is located about five miles east of the Carnestown intersection of the

photo
3-1

Tamiami Trail and State Road 29 (for traveling to Everglades City) and approximately a quarter mile east of H.P. Williams Wayside.

Canoeists usually enter the river at primitive boat launches on the either the southeast or northwest corners of the bridge. The southeast launch is located directly adjacent to the road whereas the northwest launch is accessible by a short unpaved road. A more formal parking and canoe launch area is being designed in for the northwest corner as part of the Big Cypress National Preserve improvement project. This location was formerly Uncle Turner's Jungle Gardens. This tourist attraction featured a network of trails and canals. Tour rides were provided through the canal network and headwater channel of the river. Among other wildlife, two bears captured in the vicinity of Deep Lake were displayed in cages along the canals. Water was pumped into the canal from south of Tamiami Trail to maintain water levels. The enterprise closed to business in the early 1960s (conversation with Dick Whitlock, 1999). Only the remnant trails and canals are visible today.

photo
3-2

photo
3-3

A quarter mile to the east is H.P. Williams Wayside. This park was established about the same time that Turner River Road and the borrow canal that lies adjacent to it were constructed (the roadbed was constructed from fill taken from the canal). The roadside park is an area where motorists stop for a lunch break, fish, view wildlife, and, until 1996, launch canoes into the borrow canal (called the Turner River Canal). The southernmost 1.5 miles of canal was filled in 1996 in order to return it to natural wetland grade and improve flow to Turner River, thus making the canal no longer accessible for canoeing. A pile of limestone boulders mark the upstream extent of this restoration. This pile is visible from the bridge that spans Turner River Canal at H.P. Williams. Beyond the limestone pile the channel is easily visible as an open swath of grassy wetland that cuts through tall cypress forest on both sides.

photo
3-4

photo
3-5

Turner River Road is frequently used by visiting motorists to view wildlife in and near Turner River Canal. The road becomes dusty during the dry season because its surface is composed of crushed limerock. It experiences relatively little traffic, and much of this traffic is slow with frequent stops (to sight-see). The canopy of cypress forest gives way to open grassland prairie and scattered pines a few

miles north of H.P. Williams. Although not directly related to the Turner River, spoil mounds adjacent to the canal and roadbed were pushed into the canal in 1988-1990. This was done in order to remove dense stands of unnatural and invasive exotic vegetation that blocked motorists' views of the landscape.

The last area to launch a canoe into Turner River is located about three-quarter miles north of H.P. Williams on Turner River Road. A set of culverts marks the launching area. These culverts divert water westward from the canal into the cypress swamp. These culverts were also installed in 1988-89. The river is not visible from the road, but the water moving under the culverts flows towards the headwater pools. During times of high water, canoeists can launch their boats at the culverts, meander through the cypress trunks, navigate through a fringe of tall grass called southern wild rice, and enter into the upstream inlet to the river's headwater pools.

photo
3-6

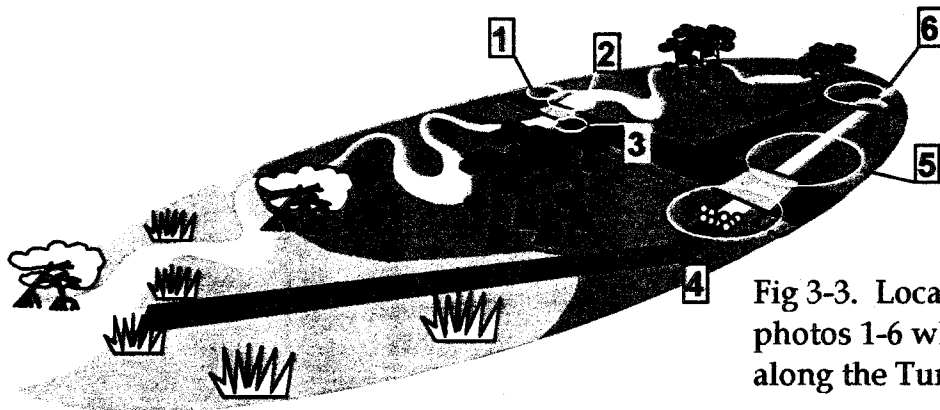


Fig 3-3. Locations that photos 1-6 were shot along the Turner River

Headwater Channel

Turner River contains two headwater pools. These pools are several hundred feet across and only a few feet deep. They completely dry up during extreme drydown periods. Water within the pools is clear, but tends to cloud up when a paddle is struck to its bottom due to a layer of organic sediment that lies over its sandy base. This organic layer is a result of slowly decaying organic material primarily derived from submerged aquatic vegetation. Prior to restoration of flow to the river, the channel had become almost entirely obstructed with submerged and emergent vegetation. It has been suggested that this organic layer has built up relatively recently as a result of reduced flows in the river. Greater flows during high water conditions

photo
3-7

tend to naturally control vegetation overgrowth within the channel, and it is thought that greater flow volume in the river may further eradicate this problem.

The river channel forms just downstream of the second headwater pool. With the exception of its estuarine tailwaters, the river is widest at this point, stretching about a hundred feet from bank to bank. Tall cypress trees line the river on both banks. These banks are not well-defined upland, but are instead shallowly-submerged wetland, and as such provide no dry ground for portage. The Turner River is a river within a flooded wetland.

photo
3-8

The river flows under Tamiami Trail about a quarter mile downstream of its headwater pools. Because the bridge is not arched or ramped above the natural grade of the road, it provides a relatively small opening for canoeists to pass under. Canoeists typically have to lean forward and duck to pass under the bridge.

photo
3-9

Midwater Channel

The channel narrows to just a few tens of feet width as it meanders south of the Tamiami Trail. After a mile of paddling the forested canopy begins to thin. The first mangrove is encountered while still within forested swamp, despite the fact that the river primarily conveys freshwater at this point. Establishment of mangroves communities this far upstream is the result of rooting stock carried on storm-driven tidal surges, a process which may have been assisted by severe drydown conditions that occurred prior to restoration of flow to the river's headwaters.

photo
3-10

The river flows through its first mangrove tunnel before finally leaving the forested swamp and entering into open grassland prairie. Shortly after entering into the prairie habitat, the river converges with the downstream terminus of the Turner River Canal. This area has been given the name Three Corners because three channels converge at it: the headwater channel, the southern terminus of Turner River Canal, and the beginning of Turner River's tailwaters.

photo
3-11

photo
3-12

Immediately downstream of Three Corners the river flows through more open prairie before intersecting with an airboat trail that cuts perpendicularly across the river. To

the east the trail runs to the New River and beyond. To the west it runs to Dona Drive and Halfway Creek. Past the airboat intersection, Turner River vegetation gradually gives way from prairie grasses to mangroves. Canoeists will at first be paddling around the mangroves and then eventually through them. Local citizens and researchers have noted the gradual inland invasion of mangroves in the 20th century, which in turn has caused a loss of the grassland prairie habitat throughout this area. Old photographs of Everglades City show little to no mangrove coverage. This effect may be related to a combination of lower rates of freshwater discharge and the introduction of coastal-discharging canals that enable saltwater surges to migrate farther inland than under "pre-development" conditions.

Mangrove coverage along the river becomes thick for the next few miles, and is characterized by a series of mangrove tunnels periodically interrupted by open pools. Paddling is difficult to impractical inside the tunnels because of the shallow ceiling of prop roots. Navigation in the tunnels requires grabbing onto the prop roots and steering the canoe with one's hands, and in some cases sitting on the floor of the canoe rather than the seat. At the entrance to one of these tunnels a stake marks the boundary between Big Cypress National Preserve and Everglades National Park.

The mangrove pools offer a welcome relief to the confinement of the narrow confines of the tunnels. The pools are surrounded by a seemingly impenetrable wall of mangroves on all sides, with the small inlets and outlets providing the only passage from them. Taller palms and cypress are often visible in the distance overtop the mangrove wall.

photo
3-13

photo
3-14

photo
3-15

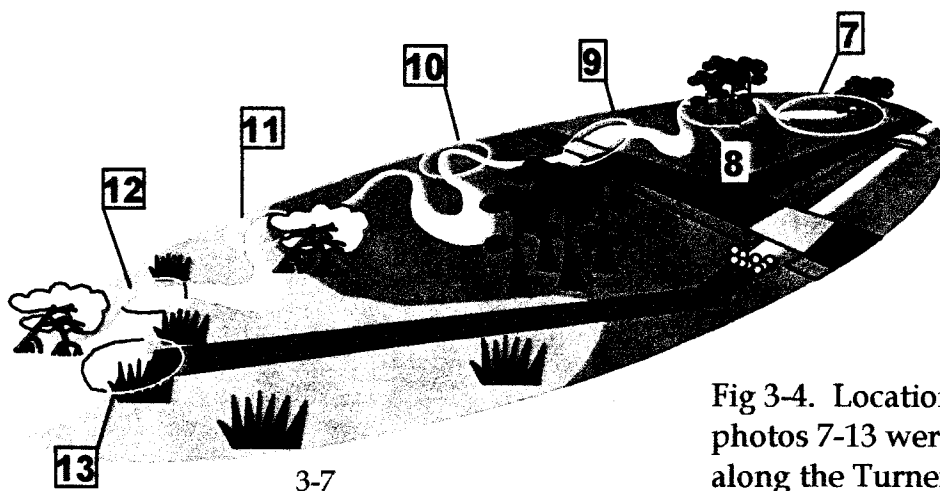


Fig 3-4. Locations that photos 7-13 were shot along the Turner River

Tailwater Channel

The channel gradually begins to widen and deepen as it enters into its estuarine tailwaters. Mangroves continue to predominate, but they become less of a navigational issue since the channel is several hundred feet wide. The channel may have been dredged to open it up to motorboat traffic. Canoeists are best advised to stay close to either bank of the river to avoid motorboat traffic and wake. Most motorboat users slow down in the proximity of canoes to minimize capsizing wakes.

photo
3-16

Just upstream of the mouth of the river, two tidal tributaries break off from the main channel of the river. These channels meander through the mangroves but do not reach inland to freshwater habitat. The river empties into the shallow marine coastal waters of Ten Thousand Islands shortly after its confluence with Chokoloskee Bay.

photo
3-17

At the mouth of the bay and river are a series of interconnected oyster reefs. These shallow reefs are exposed during low tide. Oysters tend to form large colonies at the mouths of rivers and creeks which are oriented perpendicular to river and tidal flow directions. Once oysters grow attached to a surface they are unable to move. They tend to do best in places where tidal currents transport food, remove wastes, and prevent buildup of sedimentation. These oyster reefs can destroy boat bottoms and propellers, and also damage canoes (and bare feet!) because of their hard calcareous shells and very sharp edges.

photo
3-18

Chokoloskee Island becomes visible past the mouth of the river. The boat landing area is recognizable among a cluster of buildings. The bay is shallow throughout but winds have the potential to be stronger in the open water and can make paddling difficult. There can be considerable motor-boat traffic in this area.

photo
3-19

The canoe trip from the river's headwater pools to Chokoloskee Island requires a full day (around 8 hours) under fair-weather conditions. Trip time can increase depending on weather conditions, tides, and one's propensity for getting lost; and can appear to take longer when mosquitoes and other biting bugs are plentiful. Saltwater surges several miles up the channel during high

tide, potentially making it necessary to paddle against a current while traveling downstream. Just the opposite problem may be encountered during low tide if canoeists decide to paddle back upstream to the Tamiami Trail. Under this case, freshwater that was backed up during high tide will be draining down the channel, making northward paddling a tougher proposition than anticipated. It is important to check tide charts before embarking on a trip down the river.

A good trip plan involves leaving word with a responsible party, who may shuttle canoeists from starting and ending points. The shuttle drive from Chokoloskee to Turner River Road is 15 miles and takes about 20 minutes.

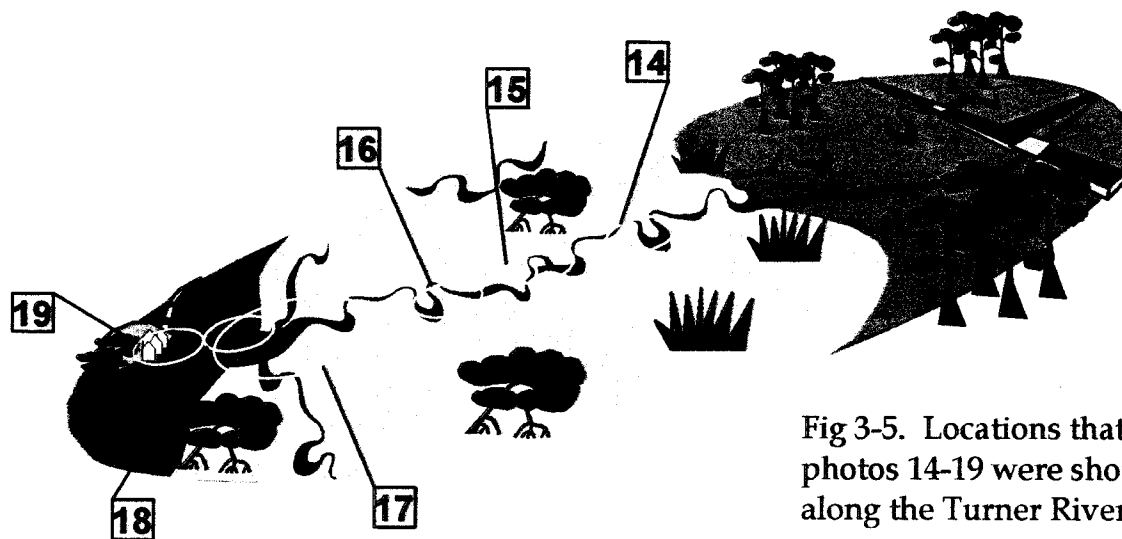


Fig 3-5. Locations that photos 14-19 were shot along the Turner River

Roadbuilding within the Turner River Watershed

Road building has effected the hydrology of the Turner River and its watershed. Prior to roadbuilding, access into the swampland of south Florida was limited to walking and canoe travel. South Florida's non-Indian population was small at this time.

Tamiami Trail

Growing coastal populations and a desire to open up the interiors of Florida to development led to efforts to build a

roadway from coast to coast across south Florida. Roadbuilding was a daunting task because of the extensive and regular flooding of the environment, and difficulties caused by its remoteness.

Construction of the Tamiami Trail began in 1915. Due to funding problems and logistical difficulties of construction in a swamp, the portion of the road that runs through the interior swamplands of southwest Florida was not completed until 1928, two years after completion of State Road 29. Both roads served as transportation arteries for establishing commercial enterprises such as logging, agriculture, and general commerce between coastal population hubs.

Since the road couldn't be routed around the wetlands, the solution was to raise the roadbed above them. The material to raise the roadbed was provided by digging a continuous pit right next to the road. Digging this pit often required blasting to break through the shallow limestone caprock. The material was extracted, crushed, and piled in a mound adjacent to the pit. The road was placed on top of this mound (Fig 3-6). The pit was retained to serve as a drainage canal, commonly called a borrow canal.

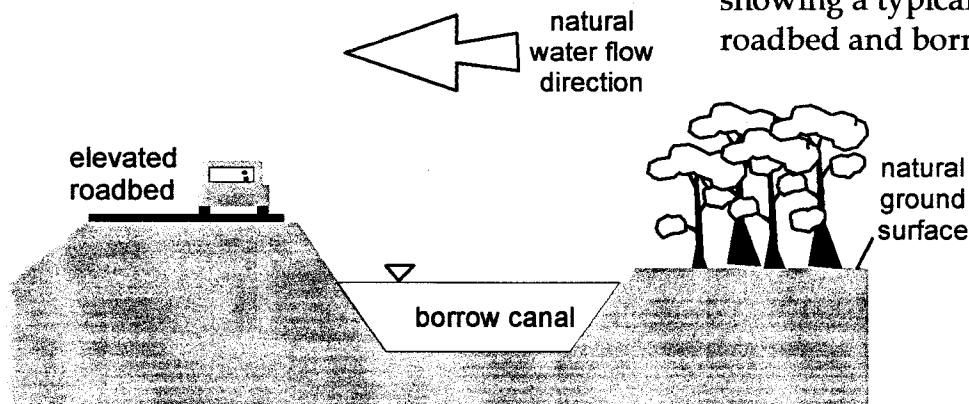


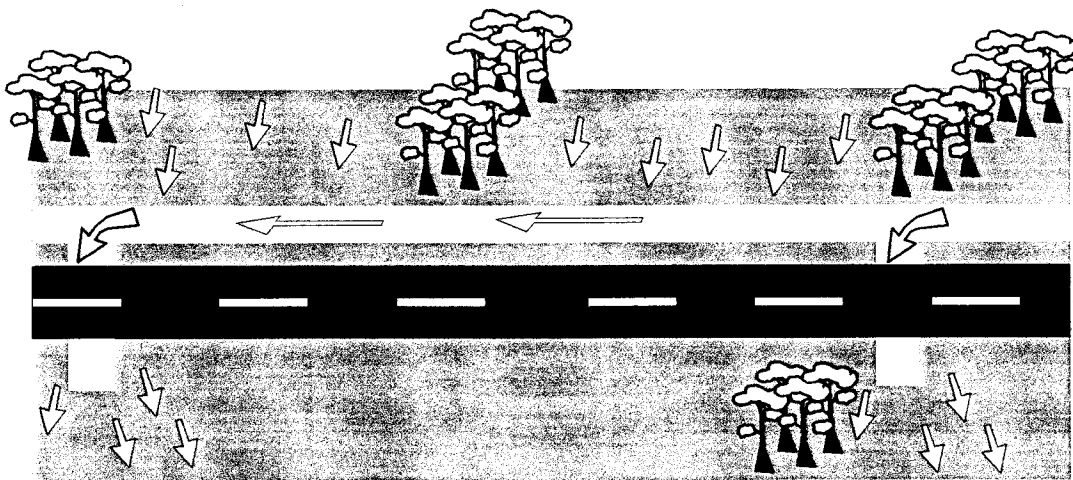
Fig 3-6. Cross-sectional diagram showing a typical swampland roadbed and borrow canal

This simple design was effective from a road construction perspective because it was cheap and kept the road dry. The borrow canal was typically dug upstream of the roadbed for better drainage around the roadway. Upstream placement allowed it to intercept sheetflow and channel it alongside the road.

Bridged gaps were periodically left in the roadbed to allow water to pass under the road, rather than over the top of it.

However, the vast majority of the road did not contain gaps, causing sheetflow to back up behind it or become channelized parallel to the road. Gaps were designed in the roadway to prevent the roadbed from overflowing, and may have been added on a trail and error basis as the road was flooded over. Gaps had to be more frequently placed in the Tamiami Trail (in comparison to State Road 29) because it lay perpendicular to the major direction of flow. Gaps were typically chosen in places that could accommodate the most drainage (Fig 3-7). These places included strands, stream channels such as the Turner River, and also other canals.

Fig 3-7. Plan-view sketch showing how roadbed conveyances allow water to pass under the Tamiami Trail



A large gap was left under the Tamiami Trail for the Turner River because of its drainage capacity. The borrow canal adjacent to the Trail was probably directly connected to the river when it was first built. This would have affected river flow by routing headwater flows directly in the canal, or vice versa. Lack of data prohibits a detailed inquiry, but the historic hydrologic alteration was probably small compared to the Turner River Road alterations which would come later.

Turner River Road

In the late 1950s, three roads were built in the northeast quadrant of the Tamiami Trail and State Road 29 intersection. They were probably constructed in expectation of future residential development. Turner River Road is the longest of these roads. Its southern terminus intersects the Tamiami Trail, from which it extends northward for over twenty miles. Birdon Road

also intersects the Tamiami Trail on its southern end; it parallels Turner River Road for about six miles before turning due east and intersecting Turner River Road. This top portion is commonly called Upper Wagon Wheel Road, with Lower Wagon Wheel referring to the road that connects Birdon Road to State Road 29 a mile and half to the south.

As shown in Fig 3-8, these roads form a continuous loop around the headwaters of the Turner River. The roads were constructed with elevated roadbeds and adjacent borrow canals in a similar fashion as the Trail. However, there were two important differences. First, these elevated roadbeds (especially Turner River Road) were minimally culverted. Almost no roadbed culverts were needed because the adjacent borrow canals were in excellent hydraulic connection with each other and the State Road 29 and Tamiami Trail canals. The north-south orientation of the canals contributed to their drainage efficiency. Second, an extension was added to the downstream end of Turner River Canal. It extended two miles southward from the Tamiami Trail and converged with the natural Turner River channel at the approximate boundary between forested swamp and coastal mangroves.

The absence of roadbed culverts and the southern canal extension to the Turner River Canal significantly increased the drainage capacity of the canal, but those alterations virtually cut off natural flow to the headwaters pools and headwater channel of the Turner River. A sketch of the canal and river is shown in Fig 3-9.

Fig 3-8. Plan-view map of the Turner River Road

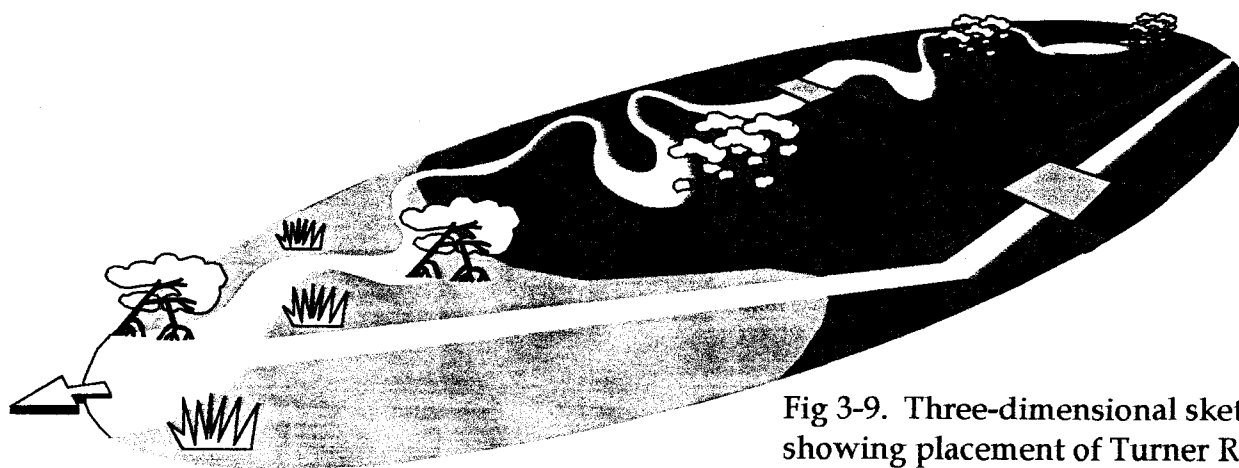
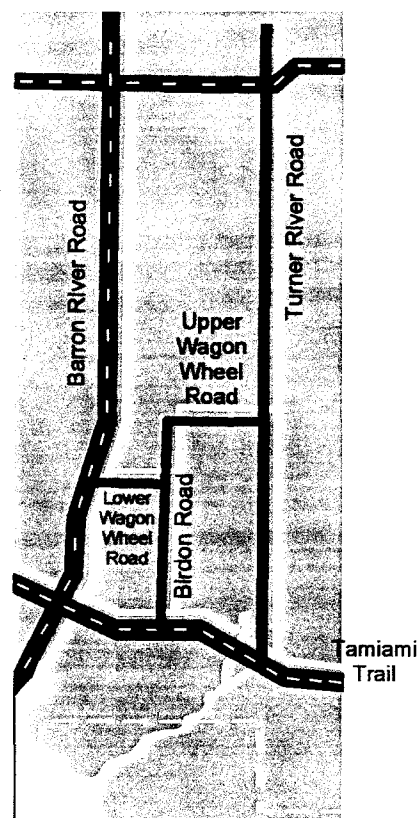
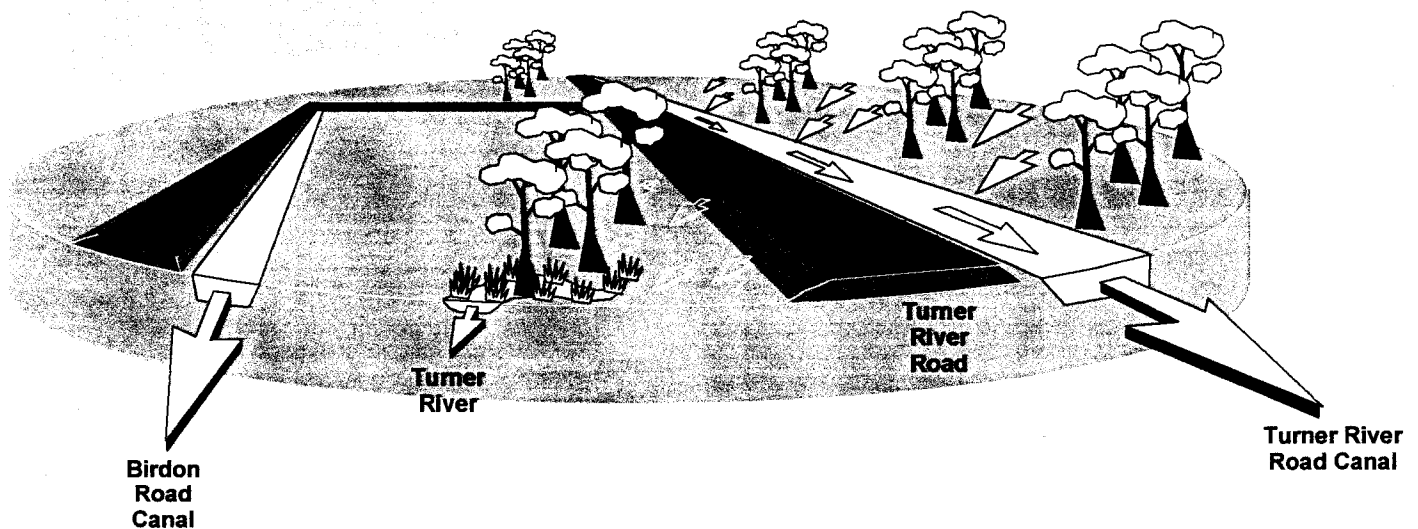


Fig 3-9. Three-dimensional sketch showing placement of Turner River Canal relative to the river channel

There is some evidence that local residents expressed disapproval with the location of Turner River road because they felt it would negatively impact the river. A possible concession to this may have been the addition of roadbed culverts under Turner River Road near the headwater pools of the river. These culverts were not large enough to convey adequate underflow and eventually filled in with sediment and vegetation.

Turner River Road and Turner River Canal had the most direct and profound effect on the river. As shown in Fig 3-10, the elevated roadbed acted as a dam that blocked sheetflow from reaching the river's headwaters, and the canal re-channeled this water away its natural course. A portion of this was routed into the Tamaimi Canal, but the majority was short-circuited around the cypress forest and directly into the river's tailwaters (prairie and mangroves).

Fig 3-10. Three-dimensional sketch showing how Turner River Road and Canal acted to divert water away from the Turner River



Changes to Turner River Watershed, 1950-1988

In many ways, Turner River Canal and its southern extension replaced the original headwater channel of the river. The basic dimensions of the canal – including its greater depth, width, and length – made it a more efficient drain than the river. Greater channel depth and width allowed it to drain and convey more water more efficiently than the river had previously done before the roadways and canals were built. Its geometric straightness also enhanced freshwater drainage as compared to the narrow, tortuous meanders of the natural river channel. And just as freshwater could flow faster downstream, saltwater tidal surges could reach further upstream when freshwater levels dropped in the dry season. Saltwater-tolerant fish and vegetation were commonly observed where the canal crosses under Tamaimi Trail.

Because the Turner River Canal extended 25 miles north of the Turner River headwater pools, the canal was carrying water from a drainage area much larger than the original watershed of the natural river. The primary hydrologic feature affected by the northern reach of the canal was Deep Lake Strand (Fig 3-11). All aspects of the flooding regime in the strand (including depth, duration, and timing of sheetflow) were reduced, which lead to excessive drying of the area and catastrophic wildfires that resulted in a thinning of the peat in many areas (Duever et al, 1980).

Recreational-use shifted from the river to the canal. Prior to 1960, Turner River attracted tourists with "Turner River Jungle Gardens", a guided business which took visitors in small boats along the meandering course of the river and also through a canal circuit connected to the river. After roadway construction, small boating and recreational fishing activities shifted to the Turner River Canal.

The same features that made Turner River Canal a better conduit also allowed it to sustain water longer and deeper than the river. The depth of the canal allowed it to be canoeable well into the dry season. H.P. Williams Wayside picnic area (which is located at the intersection of Tamami Trail and Turner River Road) provided an open

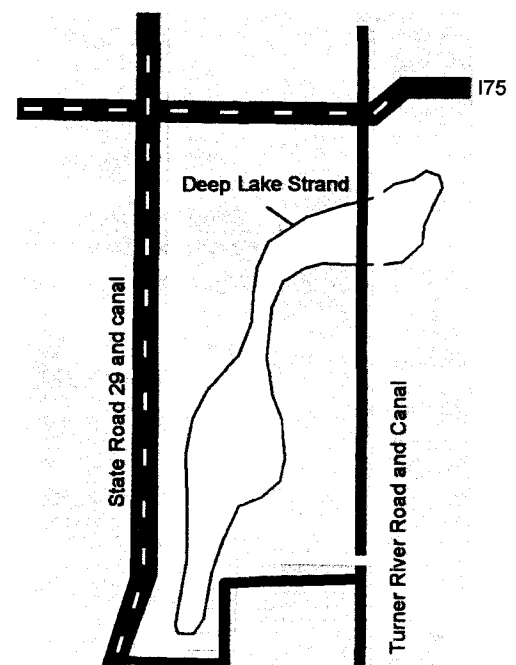


Fig 3-11. Plan-view map of Deep Lake Strand

and safe portage area, which was an improvement over the narrow roadside parking strip next to the river.

With the headwater channel of the Turner River receiving little to no flowing water, it became lost in an overgrowth of vegetation and the canal became the new river. Part of the confusion was caused by the name of the adjacent road being called Turner River, but the larger point of confusion was that the canal was where 99 percent of the visitors fished from and boated into. For all intents and purposes it was the river.

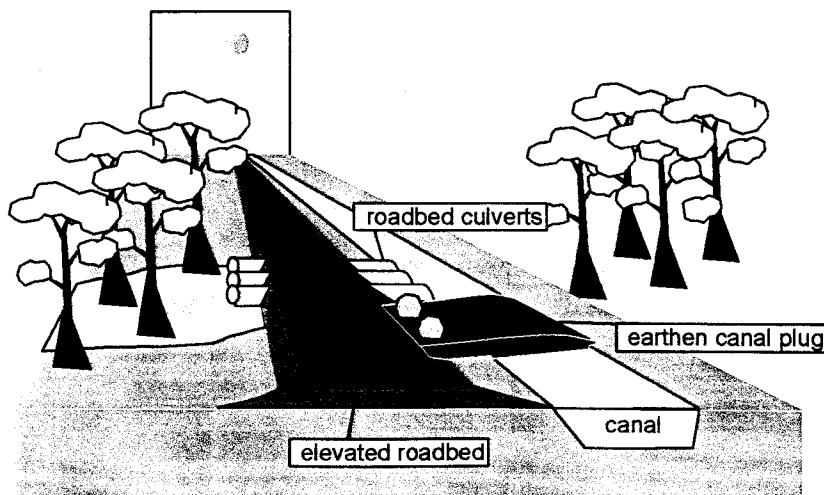
Restoration Efforts, 1980- present

Big Cypress National Preserve was established by an Act of Congress in 1974. This action brought the entire length of the Turner River and its contributing watershed under the single jurisdiction of the National Park Service. Re-establishing flow into the Turner River was seen as a primary management goal.

1980 Plan

Hydrologists from Everglades National Park (Rosendahl and Sikkema) devised the original plan for restoring the river in 1980 as part of initial scoping activities that the Park scientists did for the nascent Preserve. Conceptually, the basic ideas were to plug the canals to prevent water from escaping down them, and to culvert the roadbeds to get water moving back towards the river. As shown in Fig 3-12, culverts and plugs were often added in pairs. This design backs water up and forces it directly through the culverts.

Fig 3-12. Sketch showing a culvert-plug pair. This is a common design for restoring sheetflow under a road bed.



The original restoration plan consisted of 19 plugs and 8 culverts. Figure 3-13 shows the placement of the plugs and culverts, and also highlights the top priority area for restoration. This plan included adding a culvert-plug pair on Turner River road in the proximity of the river's headwater pools, and adding a plug at the at the downstream end of Turner River Canal where it converges with the river. These actions were expected to cause the greatest and most immediate improvement to the river, with the other "upper" watershed actions providing important, but less immediate, effects.

1988 Implementation of Plan

By the late 1980's, increases in staffing allowed the preserve to physically implement the restoration. The restoration was implemented in full over a three year period, with some modifications to the original plan as follows. The "southern terminus" plug was installed a few hundred feet downstream of Tamiami Trail due to logistical difficulties in getting heavy equipment to the confluence of the canal and river. Two additional culverts were added under Upper Wagon Wheel Road to enhance flow to the downstream prairie. A plug was added in the canal adjacent to Lower Wagon Wheel Road to prevent drainage into the State Road 29 canal. A plug was added in the upstream portion of a southwest-running, diagonal canal that intersects the Birdon Road Canal.

The restoration of the river rested on the assumption that hydrologic restoration would be the keystone to flushing out the sedimentation and vegetation that had built up in the channel over the past three decades. When this did not initially occur, the South Florida Water Management District donated an amphibious backhoe (called an Aquamog) and an operator to clear the channel, with hopes that this would open the way for natural flushing. This action only achieved a temporary opening of the channel, as vegetation soon grew back.

The idea that flow volumes were still deficient in the canal was also supported by observations of water bypassing the culverts and flowing around the plugs. This was most frequently observed during times of high water at the plugs located on the downstream end of the Turner River

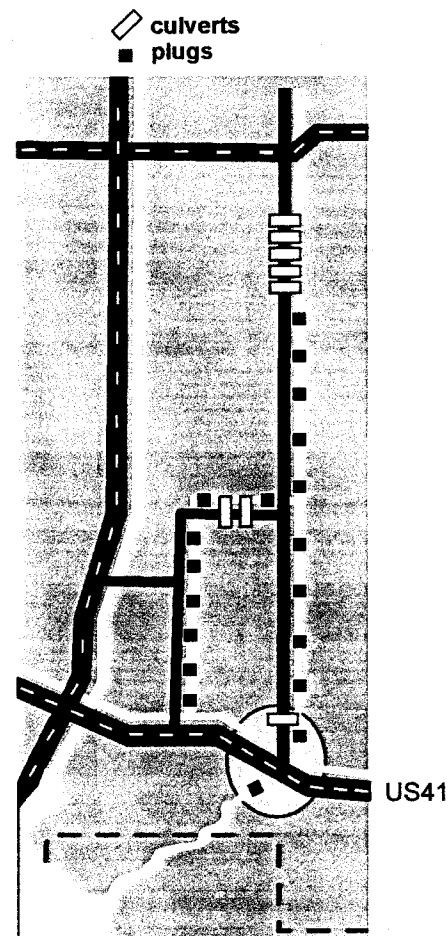


Fig 3-13. Plan-view map of the 1980 Turner River Restoration Plan

Canal. Also, fish kills were occurring as a result of the plugging of the Turner River Canal. Prior to plugging the canal, saltwater surged up the canal as far as the Tamiami Trail. Freshwater fish could escape by swimming further upstream prior to plugging, but once the canal was plugged their freshwater escape route was blocked. Fishkills were also related to the occurrence of stagnant and shallow water conditions in the canals during the dry season, a condition that represses dissolved oxygen levels in the water column.

Despite these actions, Turner River Canal continued to serve as the primary canoe route. In part, this was because the downstream portion of the canal still provided continuous access to the tailwaters of Turner River, a route familiar to boaters from past years. The other option – the headwaters channel of the Turner River – still remained heavily clogged with vegetation and continued to sustain shallower depths and a shorter flowing season than the canal.

1996 Canal Filling Project

In 1996, state wetland mitigation funds were used to fill in the downstream section of Turner River Canal. When the canal was originally dug, the extracted sediment was left in spoil mounds on both sides of the canal. Restoration simply involved use of heavy equipment to push the sediment back into the canal. The filled-in channel is recognizable at the site (H.P. Williams Wayside) by the large limestone boulders just south of Tamiami Trail. An overview sketch of the restoration is shown in Fig 3-14.

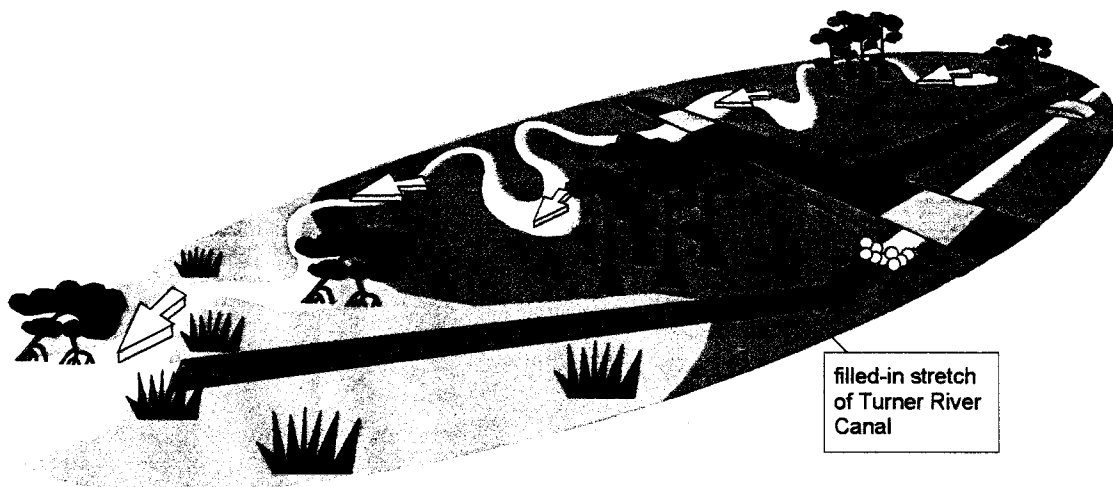
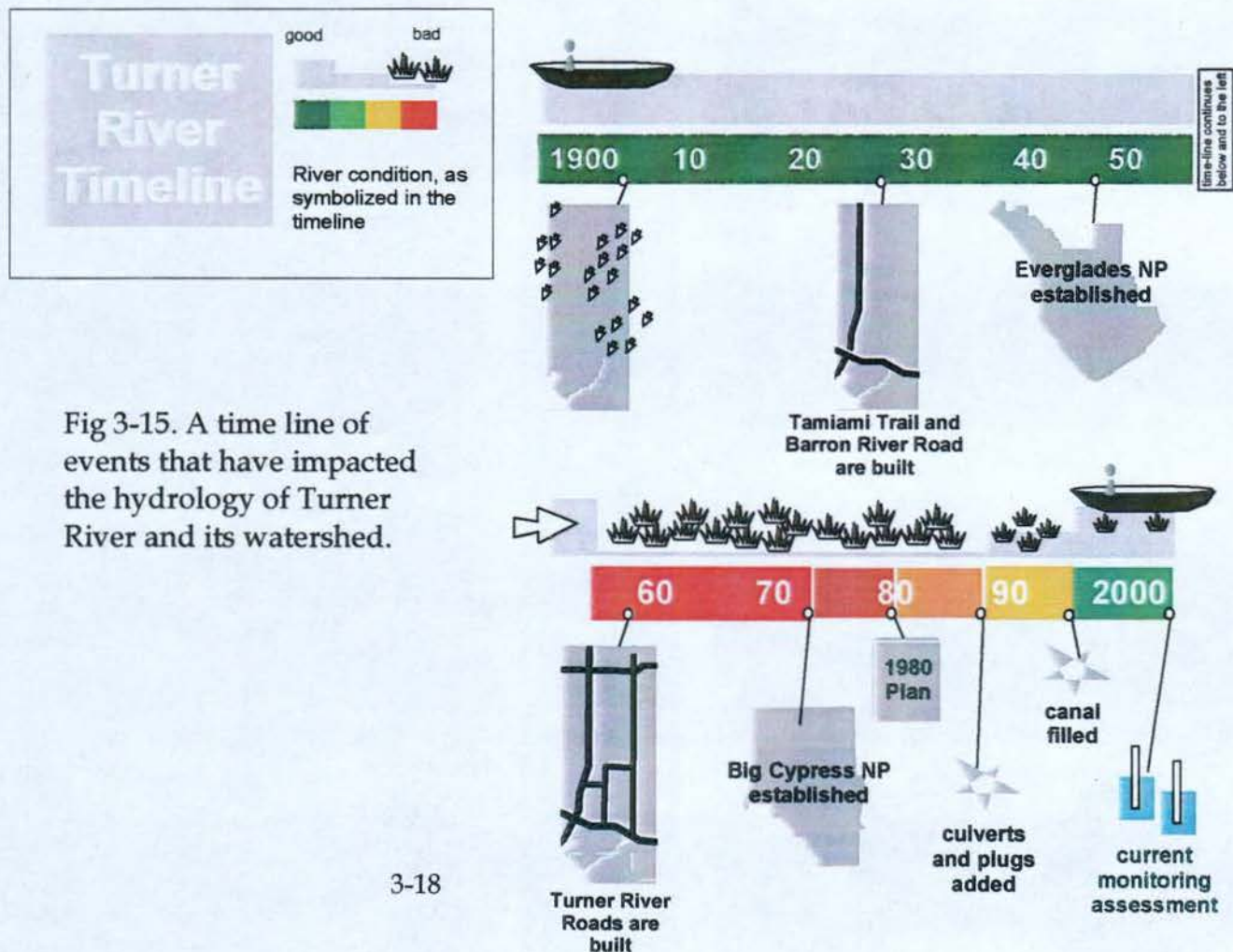


Fig 3-14. Three-dimensional sketch showing the location of the 1996 restoration.

Besides just restoring wetland (by infilling the canal) and eliminating exotic vegetation (that had become established on the canal-side berm), this action further enhanced flow towards the river and also shifted canoeists and kayakers back into the river's headwaters. Turner River Canal no longer provides boat access to the natural channel of the Turner River, to the chagrin of some anglers, but the loss of recreational opportunity in the canal has been replaced by restoration of a unique natural river corridor that teems with scenic, cultural, natural, and hydrologic significance.

Conclusion

The hydrology of the Turner River and its contributing watershed have been significantly impacted by a series of events that have occurred over the past 50 years. The chronology of these events is summarized in the time line contain in Fig 3-15.



In general terms, the river and watershed remained relatively undisturbed prior to 1950. Starting in the mid-1950s a construction of several roads and canals severed flow to the river and its upstream watershed. Restoration actions in 1988 and 1996 re-diverted flows back toward the pre-drainage flowpaths, but there has remained an overall lack of knowledge regarding the extent that these actions succeeded, or whether additional restoration actions were needed.

In 2000, a monitoring program was implemented to assess the status of the watershed and river relative to the major restoration actions that had been taken in 1988 and 1996, and to what extent future restoration work was needed. Results of this monitoring program are discussed in the next chapter.

Referenced Photos

Turner River



photo
3-1

Turner River at US41,
looking west



photo
3-2

Turner River at US41,
aerial



photo
3-3

Remnants of Uncle Georges
Jungle Garden, along banks
of Turner River

Referenced Photos

Turner River



photo
3-4

H.P. Williams Wayside,
looking west



photo
3-5

Filled in canal south
of H.P. Williams Way-
side, looking south



photo
3-6

Turner River's head-
water culverts on
Turner River Road

Referenced Photos

Turner River

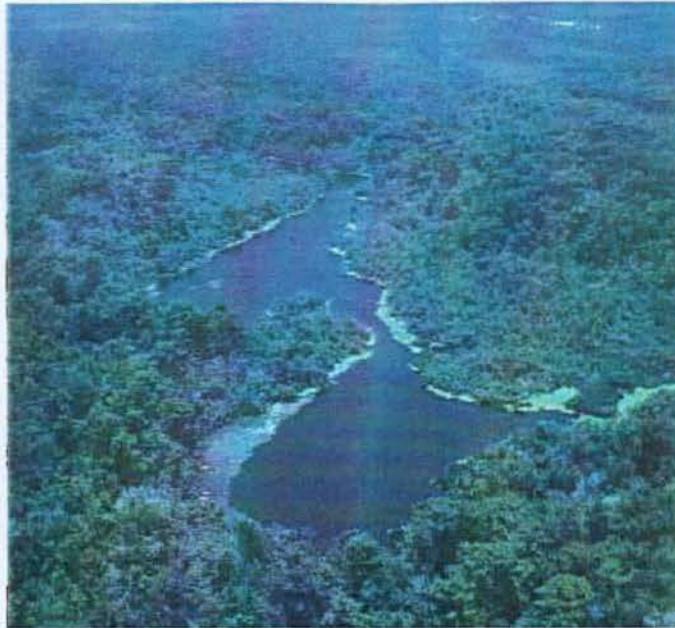


photo
3-7

Headwater pools of
Turner River, aerial

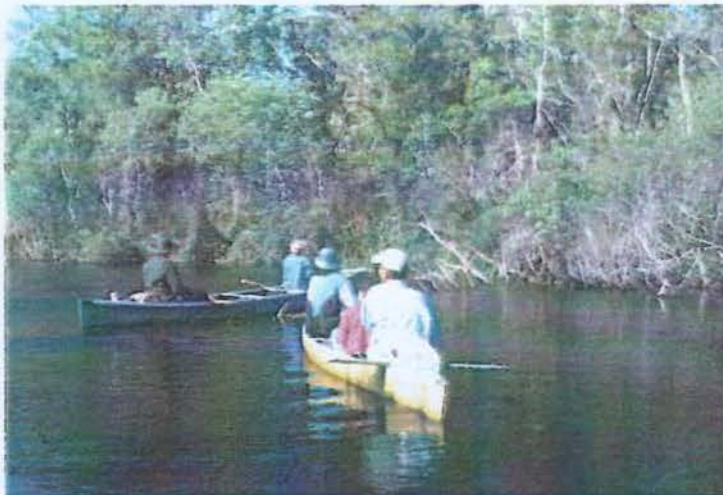


photo
3-8

Turner River, head-
water channel



photo
3-9

Turner River at US41,
looking south



Referenced Photos

Turner River

photo
3-10

Turner River south
of US41



photo
3-11

Prairie reach of
Turner River



photo
3-12

Junction of Turner River
and Canal, aerial

Referenced Photos

Turner River



photo
3-13

Mangrove tunnel along
Turner River



photo
3-14

Boundary between
the park and the
preserve



photo
3-15

Mangrove pool
along the river

Referenced Photos

Turner River



photo
3-16

Estuarine tailwaters
of Turner River, looking
upstream

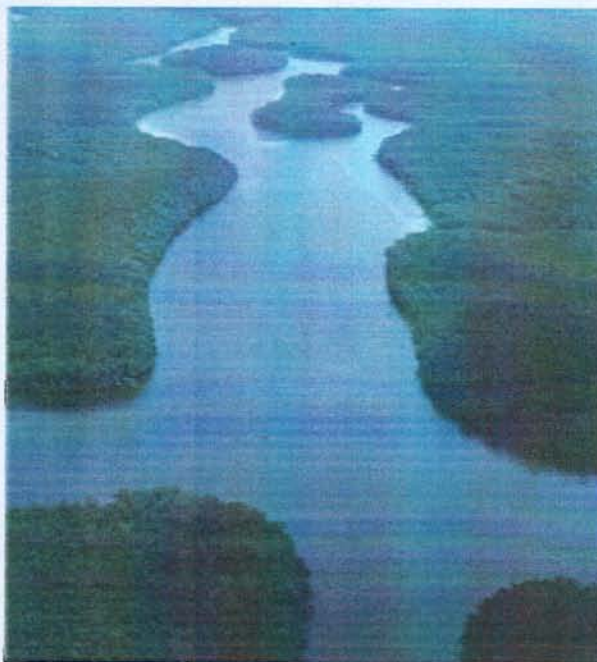


photo
3-17

Estuarine tailwaters
of Turner River, aerial
looking upstream

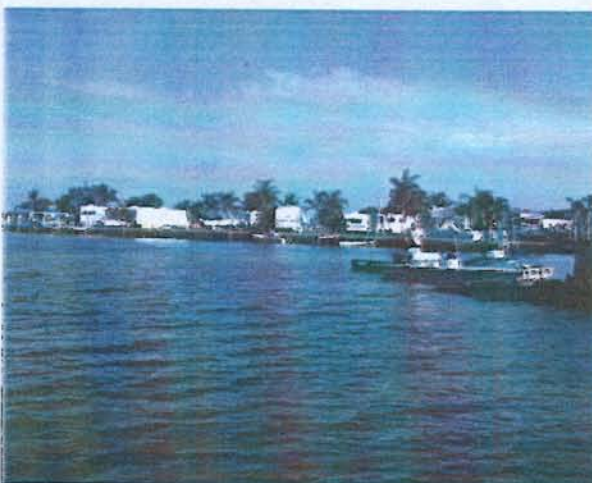


photo
3-18/19

View of Chokoloskee

PART 4

Monitoring Results

This chapter provides an overview of the major findings of the hydrologic monitoring and mapping work completed to assess hydrologic conditions in the Turner River Watershed and the Barron River Canal corridor.

Base Map

The map in Fig 4-1 shows the locations of monitoring stations used in this study and other relevant hydrologic features within the study area on the backdrop of a 60-m pixel resolution satellite-view image. The vast area covered by this study made development of this map a top priority. Fieldwork was conducted to identify and GPS monitoring stations, roadbed culverts, bridges, earthen canal plugs, stop gate weirs, and wildlife crossings. GIS work was completed in order to geo-reference the satellite image relative to the GPS data points.

Data

Water stage was measured at the monitoring stations on a monthly basis from June 2000 to present, as shown in Table 1. Stage is reported in feet above sea level relative to the NGVD 1929 datum. A full set of readings are listed for the wet season (June to November) because water levels were high enough during this time period to measure

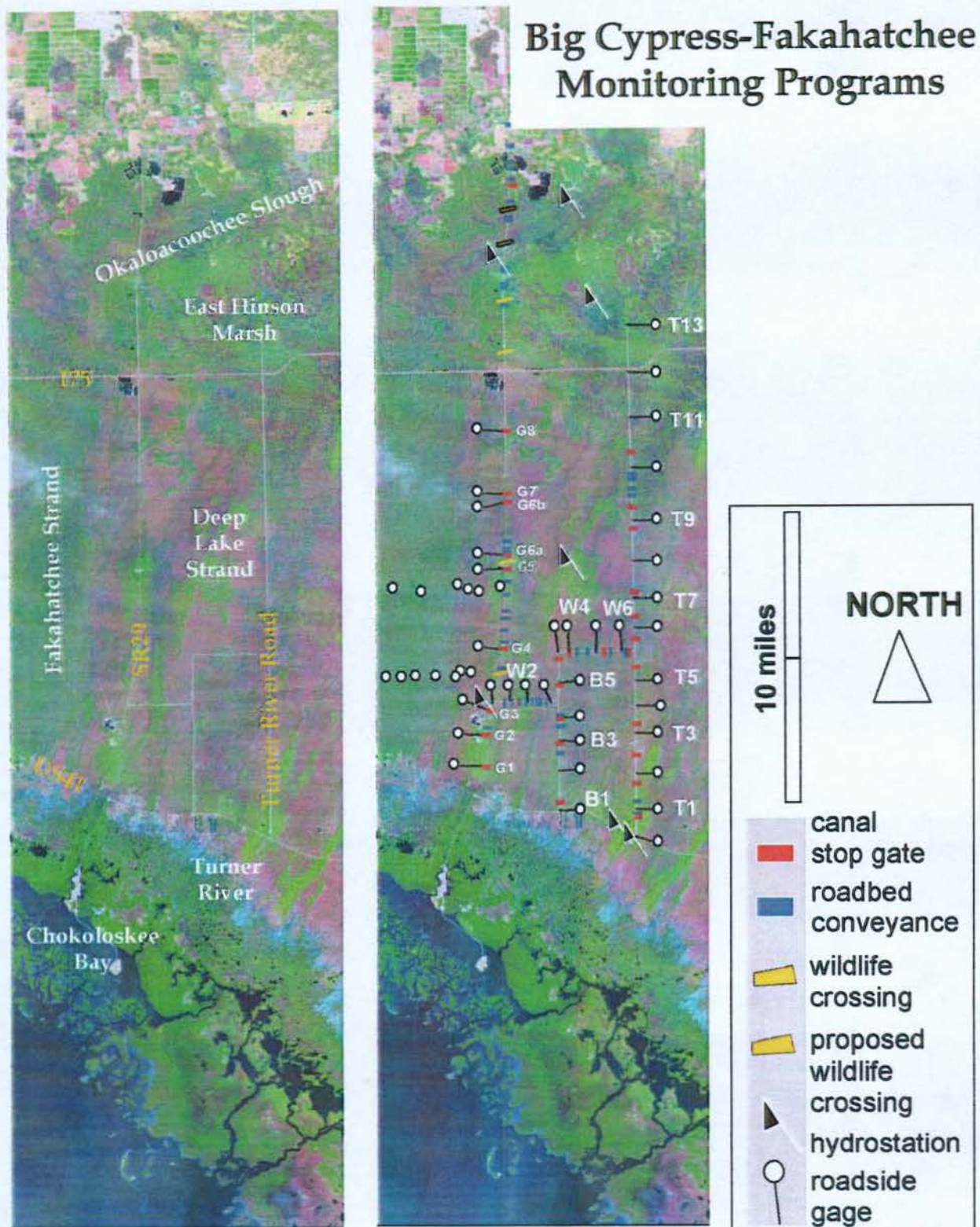


Fig 4-1. Satellite-view map of the monitoring locations and other hydrologic features.

Table 1: Monthly Water Level Measurements in Western Big Cypress, in feet above sea level (NGVD1929)

Site Name	UTM-x	UTM-y	06/14/00	07/17/00	08/22/00	09/20/00	10/18/00	11/16/00	12/19/00	02/08/01	03/13/01	04/18/01	06/28/01	07/09/01	07/24/01	08/30/01	09/28/01	10/30/01	12/04/01	01/05/02
T1e	473767	2864911	1.84	3.17	4.37	5.12	4.33	4.01	3.24	2.5	2.14	nw	2.28	3.23	4.674	4.51	4.734	4.814	3.89	3.96
T1w	473739	2864910	nw	3.91	3.75	4.16	4	3.69	nw	nw	nw	nw	2.28	nw	3.9	3.8	3.96	4	3.64	3.7
T2e	473804	2867281	2.62	4.19	5.85	6.33	6.2	5.73	5.2	3.79	3.5	1.99	2.63	3.81	6.15	6.04	6.14	6.23	5.6	5.67
T2w	473709	2867205	2.6	4.14	5.6	5.52	5.53	5.55	5.14	3.72	3.43	1.93	2.59	4.74	5.55	5.52	5.55	5.59	5.47	5.54
T3e	473751	2869890	3.31	4.74	6.63	7.47	7.33	6.57	5.97	4.63	4.3	3.06	3.05	5.36	7.294	7.074	7.334	7.354	6.514	6.674
T3w	473715	2869888	nw	nw	6.66	6.91	6.92	6.71	6.15	nw	nw	nw	nw	nw	6.91	6.89	6.94	6.97	6.67	6.73
T4e	473817	2871849	3.95	5.53	6.91	8.19	8.2	7.48	6.81	5.47	5.07	3.75	4.32	7.29	8.18	7.85	8.28	8.27	7.39	7.55
T4w	473709	2871785	3.9	5.47	6.84	7.49	7.5	7.39	6.78	5.44	5.04	3.72	4.23	7.11	7.6	7.48	7.54	7.57	7.32	7.39
T5e	473755	2873224	4.21	5.57	6.85	8.51	8.53	7.53	6.86	5.57	5.23	nw	4.69	7.93	8.504	8.134	8.494	8.414	7.414	7.664
T5w	473718	2873216	nw	nw	6.82	8.05	8.07	7.74	7.02	nw	nw	nw	dry	7.7	8.18	8.01	8.16	8.13	7.68	7.86
T6e	473691	2876706	nw	6.77	8.13	9.99	10.07	9.32	8.66	7.1	6.63	nw	9.39	9.58	9.74	9.38	9.62	9.51	9.16	9.18
T6w	473660	2876715	nw	nw	nw	9.54	9.42	9.25	8.65	nw	nw	nw	9.18	9.3	9.45	9.28	9.42	9.36	9.11	9.15
T7e	473658	2878380	reset	reset	8.797	10.847	9.987	9.987	9.297	7.907	7.367	nw	10.417	10.517	10.837	10.44	nm	10.64	9.91	10.03
T7w	473629	2878374	reset	reset	8.912	10.462	10.392	10.152	9.402	nw	nw	nw	10.282	10.342	10.502	10.27	10.44	10.38	10.03	10.2
T8e	473639	2880820	8.22	9.07	10.03	11.8	11.99	11.42	11.1	9.43	8.65	7.23	11.51	11.57	11.76	11.63	11.77	11.71	11.45	11.47
T8w	473464	2880745	7.99	8.82	9.7	11.33	11.38	11.16	10.68	9.26	8.48	7.14	11.28	11.26	11.41	11.26	11.37	11.3	11.13	11.17
T9e	473559	2883383	8.67	10.29	11.13	12.45	12.72	12.07	11.6	10.46	9.45	7.86	12.22	12.23	12.52	12.35	12.57	12.51	12.08	12.12
T9w	473519	2883382	8.72	10.28	11.08	12.21	12.32	12.02	11.6	10.35	9.47	7.9	12.09	12.08	12.31	12.21	12.34	12.28	12.03	12.07
T10e	473505	2886700	9.119	11.289	12.129	13.14	13.52	12.91	12.579	11.989	nm	nm	nm	nm	13.284	nm	nm	0	0.57	0.52
T10w	473474	2886703	nw	nw	12.159	13.099	13.169	12.719	12.519	nw	nw	nw	12.729	12.769	13.239	13.01	13.25	13.22	12.71	12.74
T11e	473445	2889870	9.61	11.93	12.49	13.73	14.08	13.45	13.05	12.14	10.89	9.3	13.05	13.04	13.75	13.33	13.99	13.94	13.19	13.19
T11w	473408	2889873	9.6	12.01	12.5	13.49	13.57	13.25	13.03	12.15	10.89	9.31	13.23	13.16	13.64	13.14	13.67	13.65	13.18	13.23
T12e	473397	2892736	nw	11.9	12.61	14.17	14.66	14.05	13.49	12.37	nw	nw	12.98	12.99	14.12	14.64	14.54	13.87	13.67	13.67
T12w	473366	2892733	nw	12.52	13.01	14.08	14.55	13.99	13.63	12.57	11.98	nw	13.4	13.37	14.27	14.36	14.82	14.62	14.14	14.02
T13e			nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	14.46	14.92	14.77	14.33	14.33
T13w	473314	2895659	12.34	11.5	12.87	14.21	14.96	14.14	13.62	12.74	11.16	9.87	12.75	12.55	11.87	nm	15.24	15.04	14.45	14.02
B1e	468889	2864904	nw	nw	nw	2.905	nw	nw	nw	nw	nw	nw	nw	nw	3.26	nw	nw	2.95	nw	nw
B1w	468862	2864884	nw	nw	1.72	2.9	2.47	1.6	dry	nw	nw	nw	nw	nw	2.95	2.33	2.78	2.76	1.76	1.92
B2e	468920	2867475	1.26	1.75	2.03	4.52	3.6	2.43	1.6	0.99	1.05	0.32	1.15	1.93	4.6	3.53	4.31	4.35	2.36	2.72
B2w	468845	2867496	1.31	1.84	2.18	4.3	3.77	2.55	1.73	1.08	1.15	0.35	1.21	2.1	4.36	3.63	4.06	4.05	2.53	2.91
B3e	468918	2869464	reset	reset	3.865	5.955	5.795	5.465	4.495	3.235	2.935	nw	nw	3.25	6.055	5.79	5.91	5.95	5.47	5.63
B3w	468884	2869459	reset	reset	4.975	5.655	5.545	5.225	4.185	nw	nw	nw	nw	3.53	5.755	5.56	5.67	5.7	5.25	5.42
B4e	468950	2870760	2.63	3.88	4.01	6.55	6.17	5.65	4.76	3.5	3.22	2.16	1.8	3.24	6.7	6.25	6.41	6.45	5.64	5.87
B4w	468865	2870698	2.61	3.82	4.05	6.18	6.03	5.71	4.72	3.46	3.18	2.12	1.8	3.27	6.16	6.01	6.12	6.18	5.72	5.84
B5e	468868	2873081	nw	4.675	4.405	7.455	7.265	6.925	6.135	6.135	4.345	nw	nw	4.55	7.555	7.29	7.43	7.51	6.95	7.14
B5w	468828	2873071	nw	nw	nw	7.435	7.215	7.085	nw	nw	nw	nw	nw	nw	7.365	7.14	7.2	7.36	6.69	6.96
B6	468841	2875083	nw	nw	nw	8.585	8.255	7.815	nw	nw	nw	nw	nw	nw	8.605	8.15	8.37	8.48	7.87	8.02
W1	464613	2871815	not est	1.85	2.6	6.07	5.75	4.84	3.4	2.27	1.8	1.42	1.98	3.33	6.16	5.67	6.1	6.22	5.22	5.25
W2n	465845	2871960	1.88	2.62	3.1	6.8	6.44	6.09	4.54	3.25	2.78	1.84	1.95	skip	6.86	6.27	6.7	6.88	6.16	6.17
W2s	466000	2871804	1.92	2.7	3.16	6.4	6.25	6.1	4.62	3.3	2.81	1.87	1.88	skip	6.39	6.2	6.34	6.38	6.13	6.16
W3n	467197	2871872	dry	dry	dry	7.08	6.82	6.5	5.04	nw	nw	nw	nw	skip	7.05	6.67	6.93	6.99	6.5	6.56
W3s	468441	2871844	2.61	3.79	3.81	6.46	6.38	6.09	5.12	3.85	3.5	3.5	2.09	skip	6.49	6.32	6.49	6.52	6.13	6.23
W4n	469561	2875149	3.99	5.61	5.66	8.92	8.53	8	7.15	5.64	5.2	4.25	4.85	6.73	8.91	8.42	8.66	8.81	7.99	8.13
W4s	469568	2874965	3.92	5.56	5.62	8.19	8.16	8.16	7.03	5.59	5.15	4.19	4.76	6.47	8.28	8.11	8.19	8.24	7.83	7.97
W5n	470992	2875093	reset	reset	6.065	9.135	8.795	8.055	7.335	5.805	5.365	nw	5.365	7.775	9.075	8.67	8.93	9.01	7.97	8.27
W5s	470998	2875056	reset	reset	5.99	8.26	8.23	7.97	7.37	5.81	nw	nw	nw	7.51	8.29	8.24	8.3	8.31	7.91	8.06
W6n	472996	2875154	4.82	6.15	6.88	9.33	9.06	8.52	7.67	6.26	5.83	4.75	6.94	8.9	9.26	8.9	9.21	9.19	8.44	8.58
W6s	472971	2874988	4.73	6.12	6.83	8.71	8.67	8.67	7.61	6.19	5.77	4.68	6.67	8.66	8.72	8.59	8.73	8.81	8.24	8.4
S1n	2867432	464152	1.31	2.51	1.4	2.89	2.66	1.9	1.12	0.62	0.94	0.02	1.15	1.7	nm	nm	2.97	3.01	1.63	1.78
S1s	2867432	464152	1.11	2.51	0.99	2.89	2.49	1.22	0.21	-0.05	0.88	-0.5	0.56	0.97	nm	nm	2.97	3.01	0.69	0.71
S2n	2869746	464159	1.06	1.65	1.86	4.06	3.85	2.77	1.92	1.31	1.18	0.46	1.29	2.06	nm	nm	4.09	4.26	2.84	2.86
S2s	2869746	464159	1.06	1.51	1.41	4.06	3.85	1.92	1.09	0.64	0.89	-0.04	1.13	1.66	nm	nm	4.09	4.26	1.67	1.81
S3n	2871164	464453	1.44	2.05	2.72	5.92	5.67	4.94	3.54	2.43	2.04	1.52	2.18	3.39	nm	nm	5.87	5.94	5.29	5.34
S3@gage	2871164	464453														nm	-5.64	-5.74	-5.08	-5.15
S3s	2871164	464453	1.44	2.05	2.54	5.92	5.67	3.93	3.04	2.31	2.01	1.53	2.06	2.84	nm	nm	5.87	5.94	4.22	4.27
S4n	2875150	465262	2.51	3.81	3.99	7.48	7.16	6.19	4.41	3.8	3.64	2.96	3.86	4.56	nm	nm	7.91	7.68	6.89	6.92
S4s	2875150	465262	1.71	2.51	3.31	7.48	7.16	5.44	4.11	2.82	2.36	1.84	2.91	4.16	nm	nm	7.91	7.68	5.81	5.93
S6n	2880423	465563	6.62	10.01	10.32	9.72	9.61	10.24	9.87	8.22	6.97	6.15	9.99	10.29	10.92	nm	10.43	10.32	10.57	10.61
S6s	2880423	465563	4.82	5.59	6.82	9.72	9.61	7.62	6.42	5.72	5.37	4.9	6.57	8.04	9.8	nm	10.43	10.32	7.96	7.98
S6an	2881373	465511	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	10.55	10.43	10.15	10.37
S6as	2881373	465511	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	10.55	10.43	10.15	10.25
S6bn	2884523	465545	9.25	10.95	11.15	11.31	11.32	11.23	11	10.33	9.32	8.64	11	11.12	11.35	nm	11.7	11.51	11.15	11.22
S6bs	2884523	465545	8.4	9.85	10.3	11.31	11.32	10.2	9.87	9.1	7.95	8.12	10.02	10.29	11.35	nm	11.7	11.51	11.15	11.22
S7n	2884995	465543	9.84</																	

stage from the surface water gages. Only a partial set of readings is listed for the spring months stage measurements can only be measured from the groundwater wells and canal weirs at this time.

Results

Low Water Mark

The low water mark of the period of record occurred during the April 2001 sampling event. Surface water was only present in the canals during this period, therefore stage measurements could not be made from most of the surface water gages in the Turner River Watershed.

Two plan-view maps of the April 2001 low water event are shown in Fig 4-2. The map to the left is a contour map of water stage in feet above sea level (NGVD 1929) drawn at 1-ft intervals. Major roadways and natural flow ways such as Okaloacoochee Slough, East Hinson Marsh, Deep Lake Stand, and Turner River Strand are also shown so that the contours can be geographically referenced. The contour map shows that the highest stage levels are found north of I75 in the vicinity of Okaloacoochee Slough, at approximately 12 ft above sea level. The lowest stage levels are found at the southern part of the study area where the 1-ft contour line extends 1 mile north of US41 at Turner River Road and 3 miles north of US41 at SR29.

The map on the right of Fig 4-2 reports vertical differences in water stage measured on upstream and downstream sides (1) of the roads within the Turner River Watershed and (2) of the stop gate weirs within the Barron River Canal corridor. The height of the blue/orange bar at each site represent the difference in water stage height between upstream and downstream gages. Each marked increment represents a 0.25 ft difference in height. A blue bar means that upstream stage is higher than downstream stage and an orange bar means that upstream stage is lower than downstream stage.

The stop gate weirs in Barron River Canal show the most pronounced difference between upstream and downstream stage for the April 2001 sampling event. This

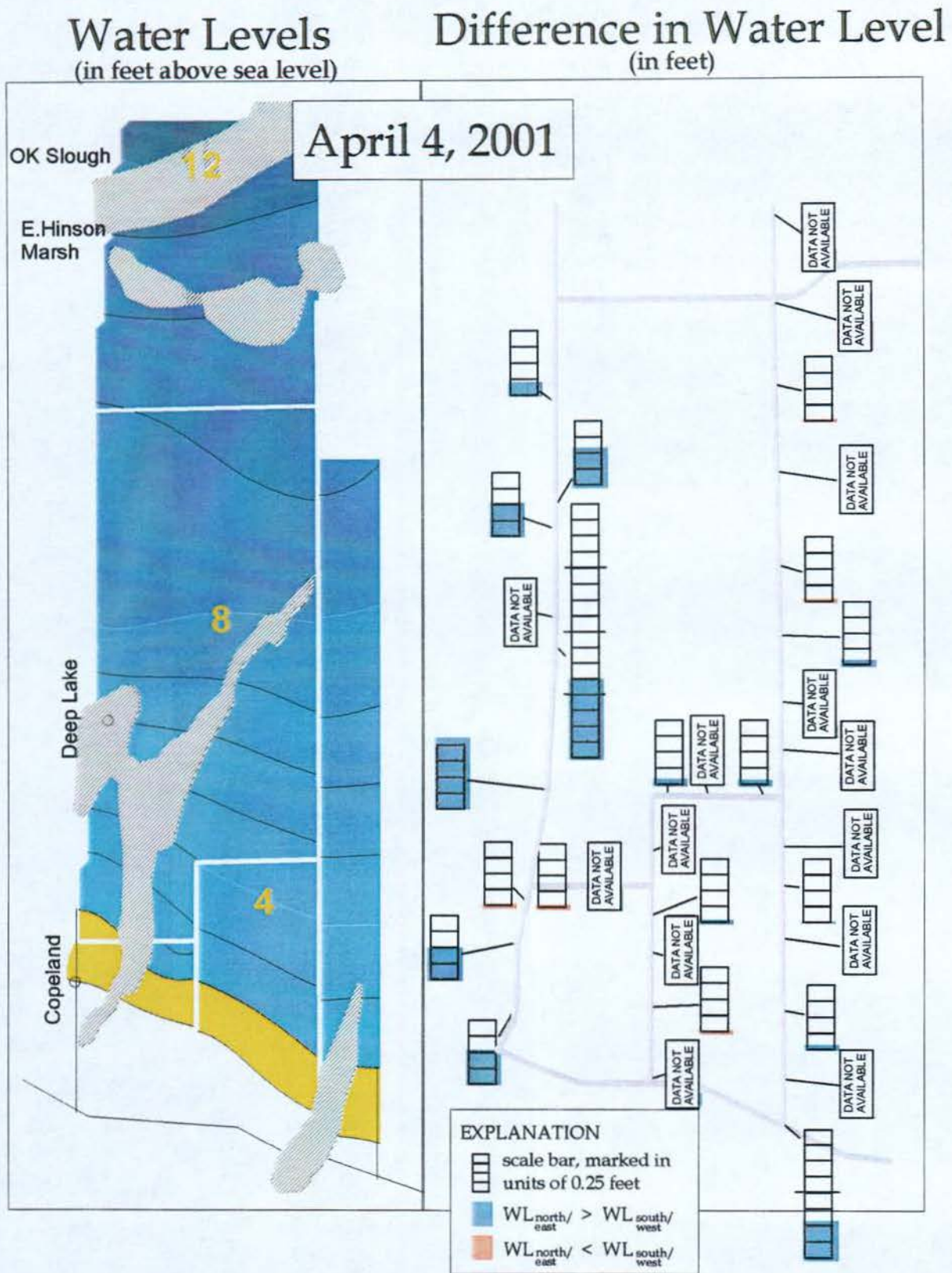


Fig 4-2. Two maps depicting hydrologic conditions during the April 2001 low water mark: a 1-ft interval contour map (left) and a difference in upstream and downstream stage map (right)

difference occurs because the stop gates are in their "closed" setting in order to sustain canal stage as much as possible through the dry season. Stage levels in the canal are generally a half to one foot higher on the upstream side of the stop gate weirs. However, water leaks through or around all the gates with the exception of Gate 6A where upstream culverts divert its slackwater across the road. Slackwater culverts are not present at any of the other stop gates.

The majority of monitoring stations within the Turner River Watershed show no difference between upstream and downstream stage during the April 2001 low water mark. An exception to this rule occurs at the southernmost monitoring station on Turner River Road, at H.P. Williams Wayside, where surface water stage in the Turner River Canal is 0.5 ft higher than in surface water stage in the Turner River.

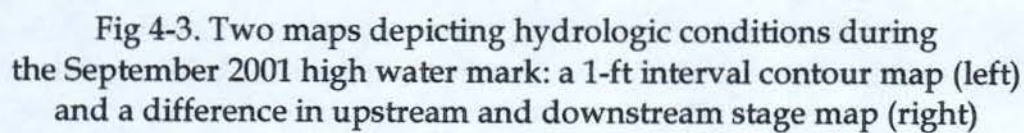
High Water Mark

The high water mark of the period of record occurred during the September 2001 sampling event. Water stage rose above the ground surface throughout most of the study area during this period, thereby allowing stage measurements to be made at the full set of gages.

The map to the left of Fig 4-3 is a contour map of water stage in feet above sea level (NGVD 1929) drawn at 1-ft intervals for the September 2001 sampling event. The highest stage levels are still located in Okaloacoochee Slough, but they are 4 ft higher (at 16 ft above sea level) than measured a half year earlier at the April 2001 low-water mark. The lowest stage levels were measured in the southwest corner of the study area at 2.5 ft above sea level.

The map on the right of Fig 4-4 reports vertical differences in water stage measured on upstream and downstream sides (1) of the roads within the Turner River Watershed and (2) of the stop gate weirs within the Barron River Canal corridor for the September 2001 sampling event. The monitoring stations in Turner River Watershed show the most pronounced difference between upstream and downstream stage. Upstream stage was measured to be

Difference in Water Level (in feet)



between 0.25 and 1.0 feet above downstream stage for most of the stations in the Turner River Watershed. Exceptions to this are seen at the northernmost two stations on Turner River Road where downstream stage is higher than upstream stage and at the southernmost station on Turner River Road (H.P. Williams Wayside) where upstream stage is 1.7 ft higher than downstream stage.

No stage differences are reported along Barron River Canal because the stop gate weirs are removed during the wet season, thereby making upstream and downstream measurements identical.

Discussion

State of Turner River

Fig 4-4 provides a graph of flow measured in the Turner River (at Bridge 83) and Turner River Canal (at Bridge 84) on a bi-weekly basis from 1986 to 2000. This graph provides a looking glass into the effects that restoration actions in 1988 and 1996 have had on the Turner River Watershed.

Prior to 1988 flow to Turner River was cut off by Turner River Road and diverted away to tide by Turner River Canal. The canal also drained water to tide at a much faster rate than did the river did under its pre-drainage condition, as is indicated in Fig 4-4 by the short-interval, high-intensity spikes of flow in the canal. In comparison, the river shows much lower flow rates that occur only sporadically during the wet season, as opposed to a continuous and sustained slow-release of water throughout the entire length of the wet season.

Fig 4-4 shows that the 1988 restoration work of adding 19 canal plugs and 10 roadbed culverts re-diverted a portion of the water from the canal back into Turner River. Fig 4-4 shows that flow conditions in the river are higher and sustained continuously through the wet season after the 1988 restoration work. However, it is not until after the 1996 restoration work (in-filling the southern 1.5 miles of the Turner River Canal) that river flow exceeds canal flow

and that the occurrence of high-intensity pulses of freshwater down the canal are put to an end.

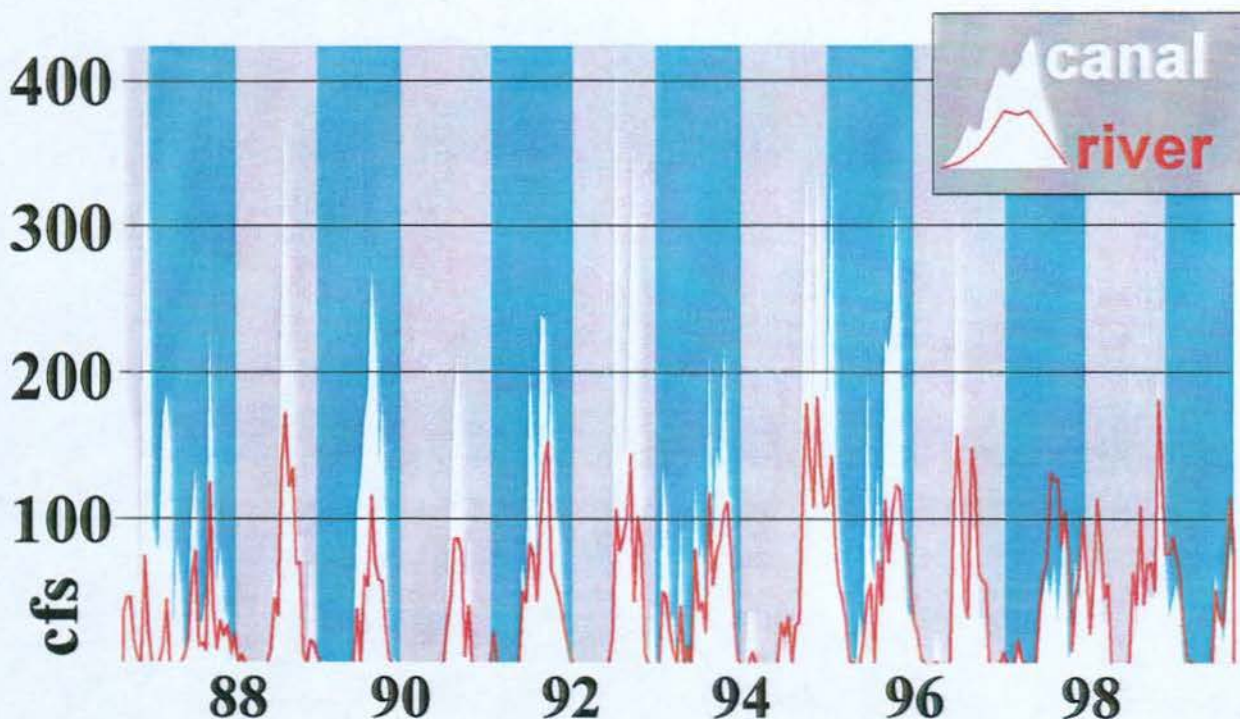


Fig 4-4. Flow rates measured at Turner River (at Bridge 83) and Turner River Canal (at Bridge 84) on a monthly basis from 1986-2000.

State of Turner River Watershed

The restoration actions taken in 1988 and 1996 put more water in the Turner River and reduced the amount of water escaping to tide down the Turner River Canal, but initial analysis of the monitoring program initiated in 2000 indicate that additional restoration work is needed. Roadways and canals in the Turner River Watershed continue to affect the areas hydrologic regime in the following ways.

Impoundment of water behind roadbeds

Roadways in the Turner River Watershed continue to restrict water movement to downstream wetlands and natural flow ways. The highest levels of impoundment were observed along the southernmost 7 mile stretch of Turner River Road (with it being most severe in the vicinity of H.P. Williams Wayside) at along Upper Wagon

Wheel Road. Lower levels of impoundment observed along Birdon Road may be caused by water being restricted from flowing into its upstream watershed by Turner River and Upper Wagon Wheel Roads.

Continuation of flow in canals

Canals preferentially drain water from the Turner River Watershed and Barron River Canal Corridor despite efforts to lessen this effect with installation of earthen canal plugs (TRW) and stop gate weirs (BRCC). Fig 4-5 shows a three-dimensional sketch depicting the manner that water flows around a typical earthen canal plug during the wet season. The rate of this overflow was most pronounced in the Turner River, Birdon Road, and Barron River Canals (although at stop gate weirs) because of their parallel orientation with the natural grade of the land and because most of the plugs are not accompanied by roadbed culverts to release upstream slackwaters across the road.

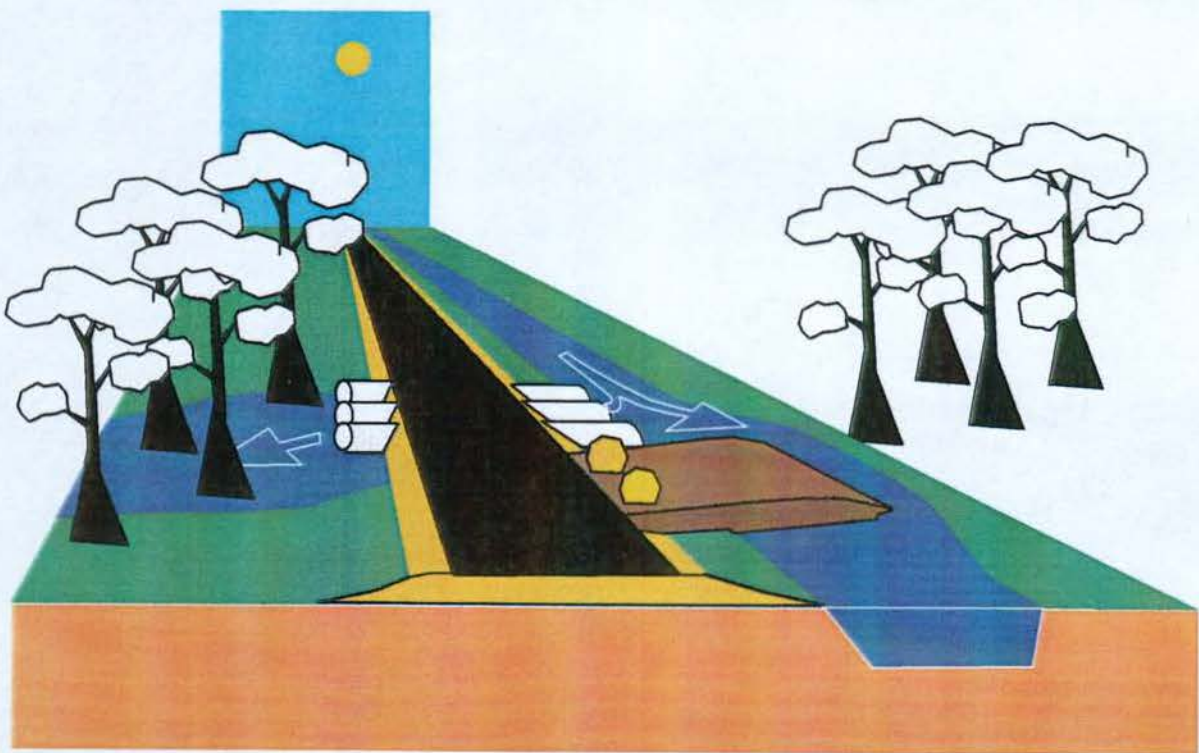


Fig 4-5. A three-dimensional sketch showing how water can flow around an earthen canal plug during high water.

Hydroperiod Reduction

There is an overall reduction in time that surface water inundates the wetland systems within the Turner River Watershed and Barron River Canal corridor. The combination of poorly-culverted roadbeds and canals transport water out of these areas than would occur naturally, thereby causing dry-season water levels to drop at a faster rate and an overall shortening surface-water inundation.

In the case of Barron River Canal and Birdon Road Canal, they spill water directly to tide. Barron River Canal is connected directly to tide at its downstream end. Birdon Road Canal is connected to tide via the Tamiami Trail Canal, which in turn is connected to Halfway Creek Canal (via Bridge 78) and Barron River Canal.

Turner River Canal no longer spills water directly to tide because of the restoration work completed in 1996. As a result, greater amounts of flow are diverted to its other two downstream outlets: (1) Turner River (via the roadbed culverts located 0.8 miles north of US41) and (2) easterly along the Tamiami Trail Canal, where it discharges south of US41 at Bridges 85 and 86. Water also continues to flow under the bridge at H.P. Williams Wayside (Bridge 84), although at a reduced rate. Water does not flow in a westerly direction down the Tamiami Trail Canal because the fill pad at H.P. Williams separates the two canals.

Despite this overall redistribution of flow caused by the 1996 restoration work, the increased flow to the Turner River and easterly down the Tamiami Trail Canal is a reduction to the volume of water that flowed down the unplugged tailwater channel of Turner River Canal. The result has been that surface-water stage rises higher and is sustained longer in the vicinity of H.P. Williams Wayside than occurred prior to 1996, and in all likelihood, prior to 1950.

Fig 3-6 provides a three-dimensional sketch of the increased water pooling condition in the vicinity of H.P. Williams during the wet season, although the full effect of this pooling reaches several miles to the east during the wet season. The wet season stage differences between upstream and downstream sides of US41 for this area are caused by excessive drainage down Turner River Canal, and are not directly caused by lack of conveyance under

US41, as some anecdotal observations may lead some to believe.

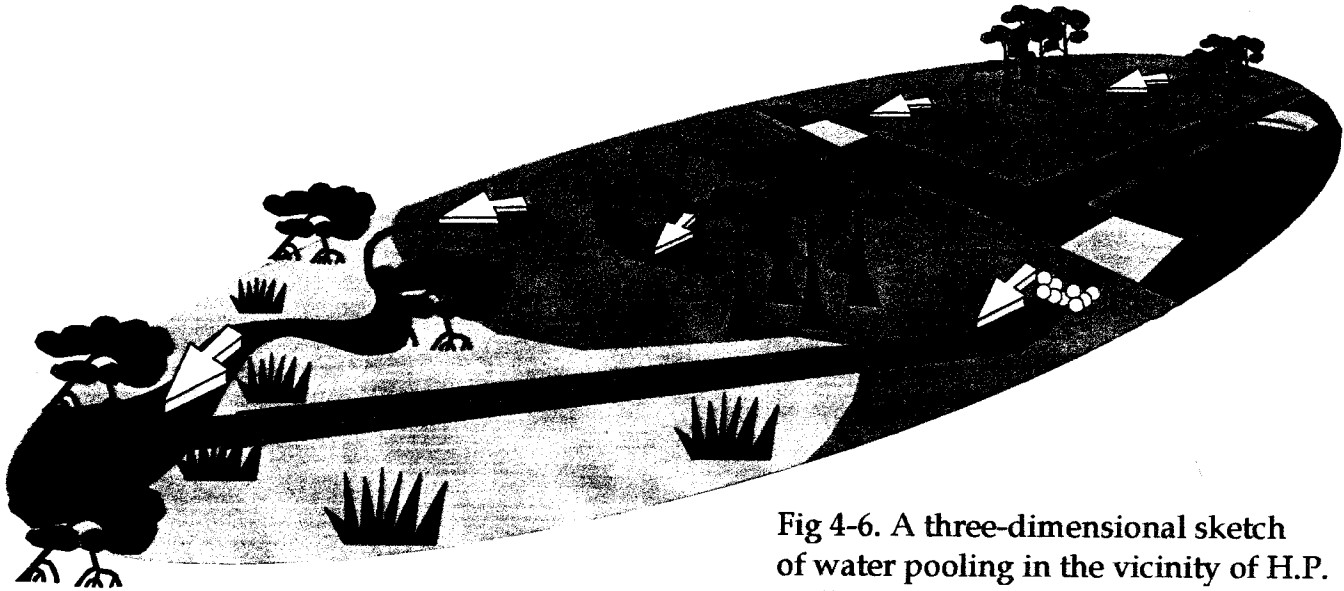


Fig 4-6. A three-dimensional sketch of water pooling in the vicinity of H.P. Williams Wayside.

Management Issues

Turner River Watershed

Roadbeds and canals continue to exert a major influence on the hydrology of the Turner River Watershed, despite restoration actions taken in 1988 and 1996.

Steps need to be taken to divert more water across roadbeds farther upstream in the watershed to prevent downstream accumulation (at Turner River Canal) and loss (at Birdon Road Canal) of water from the watershed. Strategies for doing this include adding new roadbed culverts in the upstream slackwater pools of existing plugs, or adding plug-culvert pairs in new areas. Consideration should also be given to using a portion of the existing roadbed to infill stretches of the canal.

Steps should also be taken to improve the interpretive capacity of the existing monitoring program.

Recommendations include the addition of data loggers at strategic locations to improve interpretation of storm events, expansion of monitoring points into the Bear Island and Fakahatchee Strand, and stream flow monitoring.

Barron River Canal Corridor

The following hydrologic management issues need to be addressed in order to restore natural hydrologic processes and conditions in the Barron River Canal corridor.

Reduce freshwater pulsing down canal

Freshwater pulses down the Barron River Canal and out into Chokoloskee Bay during the wet season. Negative effects include the following. (1) Lands adjacent to the canal are artificially drained, resulting in shorter and shallower surface water inundation of wetland habitats and natural flow ways. (2) The shallow coastal waters of Chokoloskee Bay receive a point-discharge of freshwater pollution during the wet season. (3) Effects of drought are exacerbated during the dry season, including an increase in saltwater intrusion along the coast, a lowering of water levels in the upstream aquifer, and subsequent increase in wildfire threat as a result of a dryer landscape.

There is a need to consider structural and operational changes to promote attenuation of freshwater flows down the State Road 29 corridor. Operational changes should be put in place to accommodate midrange diversions during the wet season, as opposed to the "all or nothing" operation of the stopgates currently in place. Structural changes include upgrading substandard stop gates to water-tight weirs, installation of additional water-tight weirs where needed, and addition of roadbed culverts to release water into the wetlands across the road as opposed to having it pulse down the canal. Locations where structural changes should be considered are described below.

North of I75

Water from Okaloacoochee Slough and East Hinson Marsh are diverted down the Barron River Canal. The following restoration measures should be considered in order to minimize the canal's effect on the hydrology of these

marshes as follows: (1) addition of a weir at Bear Island to sustain near natural stage levels in Okaloacoochee Slough, (2) addition of conveyances under the roadbed north of Bear Island to direct water into Okaloacoochee Slough and Fakahatchee Strand, (3) addition of a weir 2 miles downstream of Bear Island to better direct overflow from Okaloacoochee Slough into East Hinson Marsh.

Between I75 and US41

The Barron River Canal bisects three marl prairies, passes within 1000 feet of Deep Lake, and intercepts the tailwaters of Deep Lake Strand in this stretch. The Miles City and Rock Island Prairie stretch of the canal (north of Deep Lake) contain no roadbed culverts. In the 1990s, a series of culverts was installed south of Deep Lake allow for water diversion across the road, but the new culverts are small (2-ft diameter) and without slackwater-raising weirs. The following restoration measures should be considered in order to minimize the canal's effect on the hydrology of this area: (1) addition of roadbed culverts in the slackwaters of the weirs north of Deep Lake and (2) addition of weirs and weir-culvert pairs south of Deep Lake.

South of I75

This southern stretch of the Barron River Canal contains no stop gates, no roadbed culverts, and is directly connected to tide. Results of this configuration over the past several decades include loss of wet season storage in adjacent freshwater wetlands, increased saltwater intrusion from Chokoloskee Bay, inland migration of mangroves, and creation of an inland water refuge for manatees during the winter season. There are clear hydrologic benefits to adding canal weirs to the canal in this area, but steps also need to be taken to avoid manatee impacts.

Water Quality

The Barron River Canal drains agricultural lands near Immakolee, and also has potential point sources along its length. The C. J. Jones Lumber Company operated a sawmill and creosote treatment plant at Jerome between 1940 and 1956. In the 1990s contaminated soil and groundwater were treated at this site. A number of

photo
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pesticides have also been reported in surface waters of the Barron River Canal (Shahane, 1994). The U.S. Geological Survey completed a synoptic survey of sediment quality in the canal in 2001, and found that no contaminant levels exceeded criteria that would indicate adverse effects on aquatic life (Miller and McPherson, 2001). Miller and McPherson are currently embarking on a study to perform a similar synoptic study on the water quality of the canal.

Monitoring the water quality of the canal is an important component of the overall restoration picture. Physical restoration measures will be difficult to achieve without assurance that the quality of the canal's water is suitable for delivery into natural systems. The USGS study currently underway by Miller and McPherson, combined with their soil quality work, represents a first step to resolving this issue.

In terms of spreading contaminants into the interior wetlands of the preserve, however, the Barron River Canal primarily drains water from the preserve, not into it. Therefore the status of its water quality is not as pressing an issue as it is for the natural areas its waters drain into. Everglades National Park is the primary recipient under current conditions. In the future, restoration actions suggested in this paper would send a greater portion of the canal's water into the Panther Refuge and Fakahatchee Strand.

Boundary Resolution

The southern 25 miles of State Road 29 constitutes the approximate western boundary of the preserve. The legal boundary of the preserve, however, is defined by sectional survey markers and maps, not by the roadway or the canal. In most places the canal falls either entirely or mostly within the preserve, but there are instances where the canal falls within the right-of-way of the road, which is Florida Department of Transportation's jurisdiction.

Effects of the fuzziness of this jurisdictional boundaries have been relatively benign to date, but will likely need to be addressed and resolved among affected parties - including FDOT and the Big Cypress Basin Branch of the South Florida Water Management District - in order to

move forward on implementing any hydrologic restoration actions.