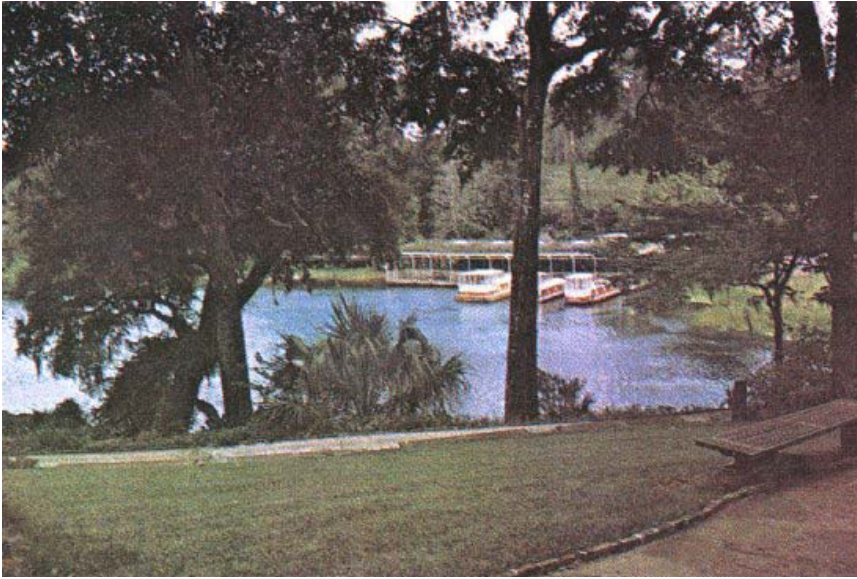


# **RAINBOW RIVER**

## **Surface Water Improvement and Management (SWIM) Plan**



**APRIL 2004**

**Surface Water Improvement and Management Program  
Southwest Florida Water Management District  
7601 U.S. Highway 301 North  
Tampa, Florida 33637  
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## Executive Summary

The Rainbow River is an important natural resource to the people of the state of Florida. From an ecological perspective, the river has an abundance of diverse plant communities providing excellent habitat for many different types of fish and wildlife. It is this natural beauty that also makes the river an important recreational resource. About 220,000 people visit the river annually to dive, swim, boat, and fish. Of the 33 first magnitude springs in the State of Florida, Rainbow Springs, forming the headwaters of the Rainbow River, is the fourth largest in terms of discharge. The Rainbow River discharges an average of 22 cubic meters per second ( $m^3/s$ ), or 493 million gallons of water per day (mgd) into the Withlacoochee River, just upstream of Lake Rousseau. Because of the Rainbow River's exceptional scenic beauty and its ecological significance, the river has been designated by the State, to be an Outstanding Florida Water (OFW), an Aquatic Preserve, and a SWIM priority water body. Also, in 1972, Rainbow Springs was designated a National Natural Landmark by the National Park Service.

Overall, the Rainbow River is an ecologically healthy system. However, the river should not be thought of as being pristine. Past human activities over the last hundred fifty years have significantly altered the character of the river, especially in the lower reaches. In the later half of the 19<sup>th</sup> century and into the first half of the 20<sup>th</sup> century, the major land uses along the Rainbow River and surrounding areas were agriculture and mining. In 1909, the Florida Power Corporation completed construction of the Inglis Dam, now the Inglis Lock, across the Withlacoochee River forming Lake Rousseau and raising water levels in the lower reaches of the Rainbow River. Land use immediately surrounding the Rainbow River has slowly transitioned from mining and agriculture to mostly residential. Although most of the 190 square kilometer (73.4 square mile) watershed is still largely rural, parts of the watershed are rapidly losing their rural character. Within a ten-mile radius of Dunnellon, the population has increased 37.5% over the past ten years and all indications are that this trend will continue. In western Marion County, residential and commercial growth has occurred at a rapid rate, and with it, potential sources and increased loads of nitrates and other contaminants. Additionally, demands on the aquifer from increased residential and commercial pumping could impact both flow and water quality. In order to ensure that the Rainbow River remains an ecologically healthy system, specific issues will continue to be identified, their potential impacts understood, and methods to offset these impacts implemented. Specific issues concerning impacts to water quality, water clarity, and native plant and animal communities are the focus of this SWIM Plan.

The water quality of the river is good, based on the State of Florida's Water Quality Index. However, nitrate concentrations in the groundwater discharging from the springs have steadily increased over the last hundred years. Average nitrate concentrations in the headspring area are about 1.0 mg/L. Nitrate

concentrations measured in the 1950's have been as low as 0.08 mg/L. It is generally accepted that background nitrate concentrations in the Floridan aquifer are at or below 0.01 mg/L. Increases in nutrients, like nitrate, may cause harmful algal blooms and enhance the growth of nuisance species, such as *Lyngbya* and *Hydrilla*. Although both *Lyngbya* and *Hydrilla* occur throughout the river, they are concentrated in the lower reaches. In 2000, *Hydrilla* was found in approximately 37% of the river. Chlorophyll concentration is also highest in the lower river.

Increases in chlorophyll can cause a significant decrease in water clarity. In the Rainbow River, the water clarity decreases rapidly, from approximately 50 meters at the headspring to 20 meters about two kilometers downstream. Water clarity continues to decline throughout the rest of the river run, but at a much slower rate. Just upstream of the confluence of the Rainbow River and the Withlacoochee River, nine kilometers from the headsprings, water clarity is about 8 meters. It is not known whether this pattern of declining water clarity, from the headsprings to the mouth, is a natural phenomenon, a result of anthropogenic impacts, or a combination of both. Furthermore, there is little historical information available to relate present water clarity conditions with past conditions. Understanding the factors affecting water clarity is an important issue in the Rainbow River and will continue to be addressed.

By virtue of its exceptional water clarity and good water quality, the Rainbow River is home to diverse plant and animal communities. The submerged aquatic vegetation (SAV), along with the emergent macrophytes, provide critical habitat for fish and wildlife, help maintain water clarity, and stabilize sediment. The SAV communities are dominated by *Sagittaria kurziana* (strap-leaf *Sagittaria*) and, to a lesser extent, *Vallisneria americana* (eelgrass). These native grasses form extensive beds throughout the upper and middle reaches of the river. In the lower reaches of the river, however, *Sagittaria* and *Vallisneria* are almost completely absent and the river becomes dominated by the nuisance vegetation *Hydrilla verticillata* and *Lyngbya* sp. In 1996, *Sagittaria* and *Vallisneria* were found to occur in 57% and 17% of the river, respectively. While in 2000, the occurrence of these species declined to 53% and 12% of the river, respectively. Most of this decline occurred in the lower reaches of the river. It should be noted that previous efforts in both Rainbow River and Kings Bay to re-establish native SAV in areas where they had been lost, resulted in little or no long-term success. Therefore, it is very important that adequate measures are taken to protect the existing native SAV beds and to prevent further increases in nuisance species. Vegetation loss can also cause an increase in suspended sediment that could lead to a further decline in water clarity. Issues regarding changes in vegetation coverage, especially with respect to SAV, and ways in which to maintain and/or improve vegetation coverage, are the subjects of both ongoing and future work.

The following SWIM Plan goals and strategies have been established in order to address the issues of water quality, water clarity, and native plant and animal communities.

**GOAL:** Continue to monitor water quality status and trends throughout the watershed and identify water quality parameters of special concern.

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*Strategies:*

- Develop and implement a long-term water quality monitoring strategy for the Rainbow River and its watershed.
  - Continue collecting and analyzing water quality data, in the river, the springs, and the groundwater basin.
  - Conduct diagnostic studies, as necessary, to further understand the role of water quality on the entire Rainbow River system.
- 

**GOAL:** Develop and implement nitrate reduction goals for the river and help initiate programs aimed at preventing further nitrate increases.

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*Strategies:*

- Establish a numerical target for nitrate reduction in the river.
  - Update and refine the nutrient loading model for the watershed.
  - Work with other government agencies and stakeholders to implement measures to achieve nitrate reduction goals.
- 

**GOAL:** Maintain water clarity at current levels throughout the river and identify areas along the river where improvements in water clarity can be made.

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*Strategies:*

- Establish baseline conditions for water clarity and gain a better understanding of the dynamics between biological and physical factors, and water clarity.
  - Collect routine water clarity data to detect any spatial and/or temporal changes in water clarity.
  - Set quantitative goals for water clarity along the Rainbow River.
- 

**GOAL:** Develop and implement projects to protect and manage aquatic and emergent vegetation in the river.

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*Strategies:*

- Continue mapping aquatic and emergent vegetation in the river to quantify changes in distribution and abundance both spatially and temporally.
  - Work with other government agencies and stakeholders to develop ways to maintain and protect existing SAV coverage and prevent future impacts to these communities.
  - Better understand the interaction between vegetation and abiotic factors such as sediment, water quality, and water clarity.
- 

**GOAL:** Conduct other projects and studies, as needed, in order to refine and achieve the goals set forth in this SWIM Plan.

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## **Introduction**

### **The SWIM Act**

In recognition of the need to place additional emphasis on the restoration, protection and management of the surface water resources of the State, the Florida Legislature, through the Surface Water Improvement and Management (SWIM) Act of 1987, directed the State's water management districts to "design and implement plans and programs for the improvement and management of surface water" (Section 373.451, Florida Statutes). The SWIM legislation requires the water management districts to protect the ecological, aesthetic, recreational, and economic value of the State's surface water bodies, keeping in mind that water quality degradation is frequently caused by point and non-point source pollution, and that degraded water quality can cause both direct and indirect losses of habitats.

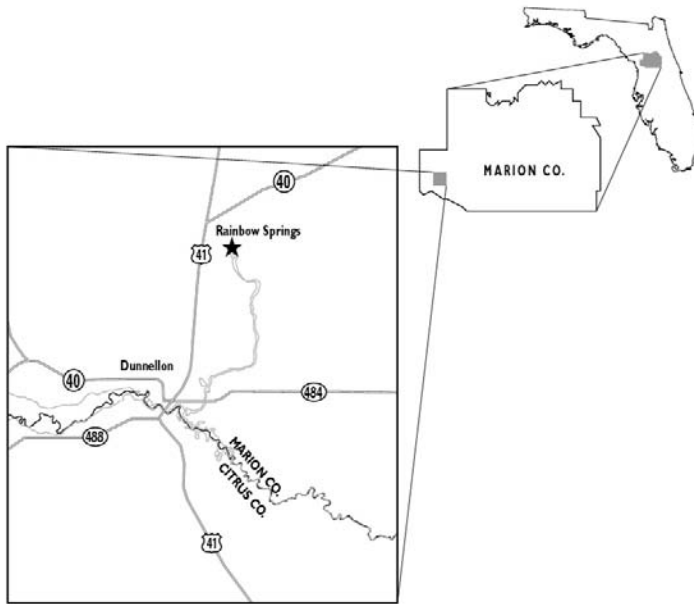
Under the act, water management districts identify water bodies for inclusion into the program based on their regional significance and their need for protection and/or restoration. This process is carried out in cooperation with the Florida Department of Environmental Protection (FDEP), the Florida Fish and Wildlife Conservation Commission (FFWCC), the Department of Agriculture and Consumer Services (DACS), the Department of Community Affairs (DCA), and local governments. The Rainbow River was adopted as a SWIM water body by the Southwest Florida Water Management District in 1989.

In accordance with the SWIM Act, once a water body is selected, a SWIM Plan must be adopted by the water management district's governing board and approved by the FDEP. Before the SWIM Plan can be adopted, it must undergo a review process involving the required state agencies. The purpose of this updated Rainbow River SWIM Plan is to set forth a course of action by identifying the quantity, scope, and required effort of projects appropriate for the system, while considering the levels and trends of SWIM funding.

The Rainbow River SWIM Plan was originally prepared and approved in 1989, and was updated in 1995. The focus of the previous plan was to conduct diagnostic studies to document baseline conditions as a means to assess future impacts or improvements to the river's water quality and natural systems.

### **Geographic Setting**

The Rainbow River is located in western Marion County, 120 kilometers (75 miles) north of Tampa and 32 kilometers (20 miles) southeast of Ocala, near the town of Dunnellon (Figure 1). The river starts at Rainbow Springs and empties into the Withlacoochee River 9.2 kilometers (5.7 miles) to the south of the headsprings. The Withlacoochee River flows westward into Lake Rousseau, past



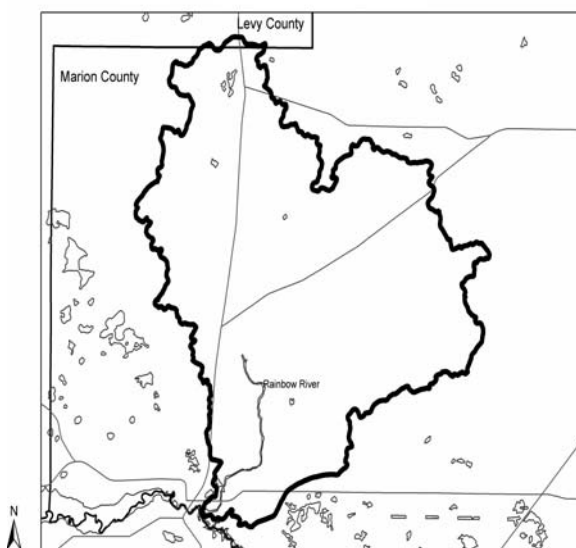
**Figure 1. Map showing the location of the Rainbow River and Rainbow Springs.**

the Inglis Dam, and eventually into the Gulf of Mexico. The Rainbow River discharges an average of 22 cubic meters per second (m<sup>3</sup>/s), or 493 million gallons of water per day (mgd) into the Withlacoochee River (Rosenau et al. 1977). Because of the Rainbow River's exceptional scenic beauty and its ecological significance, the river has been designated by the State, to be an Outstanding Florida Water (OFW), an Aquatic Preserve, and a SWIM priority water body. Rainbow

Springs was designated a National Natural Landmark by the National Park Service in 1972 (Appendix C). In contrast to the tea colored tannic water of the Withlacoochee, the water in Rainbow River is very clear.

### The Rainbow River Watershed

This SWIM Plan adopts the Rainbow River watershed as defined by the FDEP Watershed Management Approach (Figure 2). The Watershed Management Approach uses a statewide comprehensive plan to managing water resources on the basis of surface hydrologic features. The Rainbow River watershed boundary



**Figure 2. FDEP defined watershed and SWIM Plan management boundary.**

has an area of 190 square kilometers (73.4 square miles) and lies within the USGS defined Withlacoochee Hydrologic Unit (Seaber, et al. 1987; Foose 2000). It should be noted, however, that almost all of the river discharge is derived from groundwater (WAR, 1991) and that the immediate groundwater recharge area is significantly larger than the FDEP defined watershed. The immediate recharge area is approximately 910 square kilometers, or 350 square miles (Jones, et al. 1996), with the total Rainbow Springs groundwater basin having an area of approximately 1,670

square kilometers, or 645 square miles (Faulkner 1973). Managing such a large area is beyond the scope of this SWIM Plan. However, because spring discharge originates from within the Rainbow Springs groundwater basin, (Jones, et al. 1996), some issues may require the implementation of projects outside the FDEP defined watershed. For example, sources of nitrate reaching the springs could come from anywhere within the immediate recharge area (Jones, et al. 1996). Therefore, certain projects addressing nitrates in groundwater may extend beyond the FDEP watershed boundary.

### **Land Use in the Watershed: Past, Present, and Future**

Overall, the Rainbow River is an ecologically healthy system. However, the river should not be thought of as being pristine. Past human activities over the last hundred fifty years have significantly altered the character of the river, especially in the lower reaches. By the 1880's, much of the land surrounding the river had been logged and converted to citrus (Dinkins 1997). In 1890, hard rock phosphate was discovered near Dunnellon and triggered a mining boom rivaling



**Figure 3. Example of phosphate mining operations along the Withlacoochee and lower Rainbow Rivers. Dunnellon Phosphate Co. Section One Plant, 1906. (Source: Florida State Library)**

that of California's gold rush and Pennsylvania's oil boom (Dinkins 1997). Dozens of mines operated along the banks of the Withlacoochee River and the lower reaches of the Rainbow River. Most of these mines were dug by hand, some of which are over 12 meters (40 feet) deep (Figure 3). For example, Blue Cove, on the west bank of the Rainbow River, is an old mine quarry that is directly connected to the Rainbow River. In addition to the old mine pits, other artifacts of the area's mining days can still be seen. The pilings that supported cable-driven mine cars (Figure 3) are still standing in many of the now submerged mine pits. Also, the remains of what appears to be a

floating barge steam shovel, used in areas where water seepage was a problem, is clearly visible on the bottom of the Rainbow River, just upstream of the river's mouth. World War I and the discovery of pebble rock phosphate in Hillsborough and Polk Counties officially ended the Dunnellon mining boom, although some phosphate mining continued until 1966 (Dinkins 1997).

In 1909, the Inglis Dam, located about 6.5 kilometers (4 miles) upstream of the town of Inglis, was constructed across the Withlacoochee River, forming Lake Rousseau, a 1,685 hectare (4,163 acre) impoundment of the Withlacoochee River (Downing, et al. 1989). A power facility operated at the dam until 1965. The

Inglis Lock, located next to the dam, was completed in 1969 by the United States Army Corps of Engineers as part of the Cross Florida Barge Canal project. Although it is unlikely the dam changed water levels in the upper reaches of the Rainbow River, the water levels in the lower reaches of the river could have been significantly elevated (Downing, et al. 1989). Unfortunately, there is no documentation of water levels prior to the installation of the dam. However, results from a modeled drawdown simulation for Lake Rousseau indicated that drawing the Lake level down from the present elevation of about 8 meters (27 feet) to 5.5 meters (18 feet) would lower the water elevation at the mouth of the Rainbow River by as much as 2.5 meters (8 feet). The simulation also predicted that lower water elevations would extend as far as 3 kilometers (2 miles) upstream of the river's mouth (Downing, et al. 1989). How much impact, if any, water level changes, caused by the dam, may have had on water quality, water clarity, and the plant and animal communities in the Rainbow River, is not known and needs further investigation.

Since the 1940's, land use in the Rainbow River watershed has transitioned from mining and agriculture to residential. Although much of the 190 square kilometer (73.4 square mile) watershed is still largely rural, parts of the watershed are rapidly losing their rural character (Jones, et al. 1996). Land uses within parts of the Rainbow River watershed have changed significantly since 1944 (Figures 4 and 5). Residential and commercial development increased from 64 acres in 1944 to 7,151 acres in 1999, and an additional 10,349 acres have been platted for development. Agricultural lands have increased from 7,454 acres in 1944 to 18,418 acres in 1999, while forested lands decreased from 36,969 to 9,620 acres during the same time period (USGS photography; SWFWMD GIS database).

As residential and commercial development throughout the Rainbow River watershed continues to increase, the health of the river, and its many springs, could be compromised. For example, nitrates in Rainbow Springs have increased from concentrations less than 0.1mg/L in the 1950's to around 1.0mg/L today representing more than a ten-fold increase (Jones, et al. 1996; SWFWMD unpublished data). Because the Rainbow River is almost entirely spring fed (WAR 1991; Jones, et al. 1995), land use activities in both the watershed and the groundwater recharge basin directly impact the quantity and quality of groundwater entering the river (Florida Springs Task Force 2000). This, in turn, can have direct effects on the water quality, water clarity, and overall health of the river system.

# Rainbow River Watershed Land Use

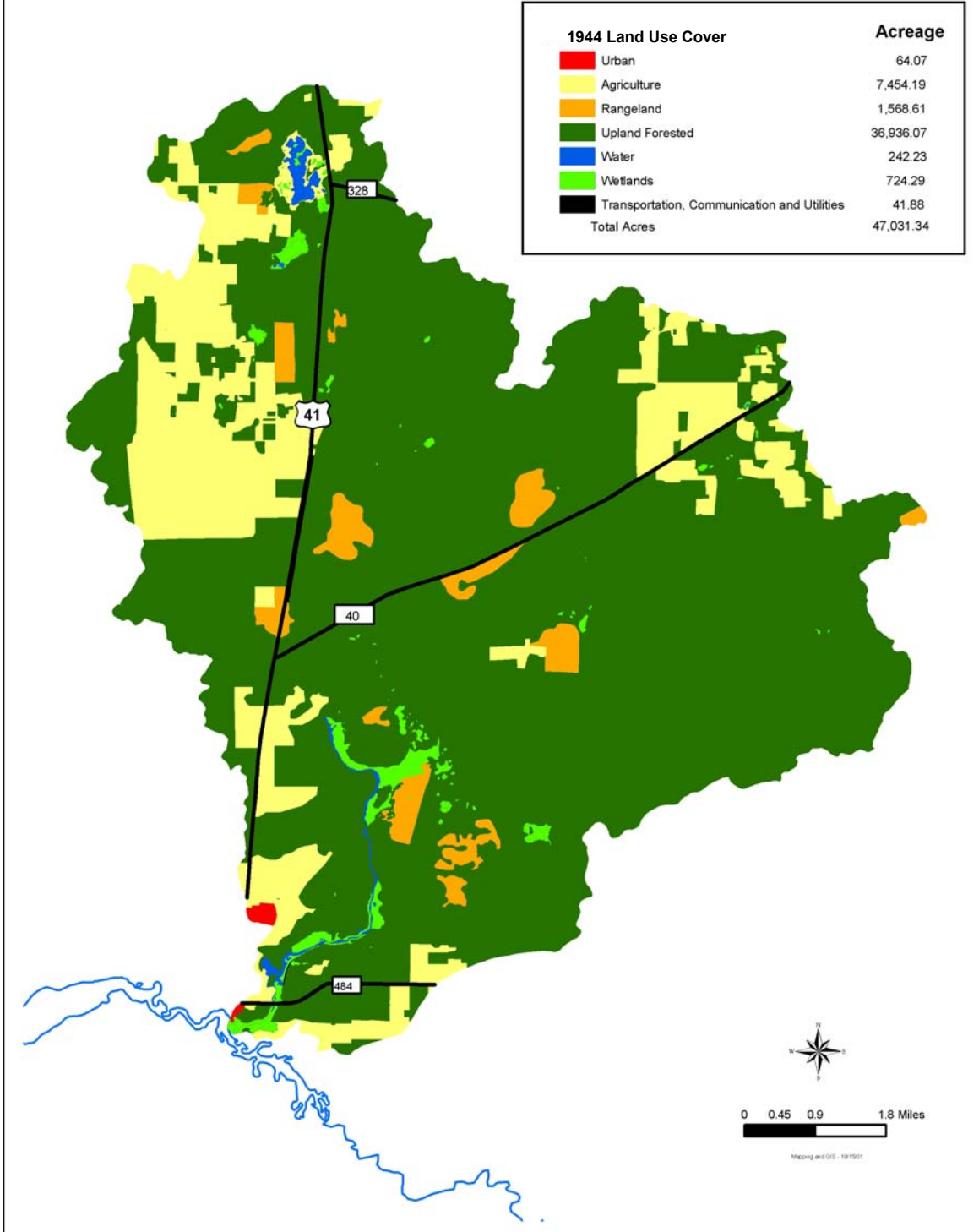


Figure 4. Land use in the Rainbow River Watershed in 1944. (Source: SWFWMD)

# Rainbow River Watershed Land Use

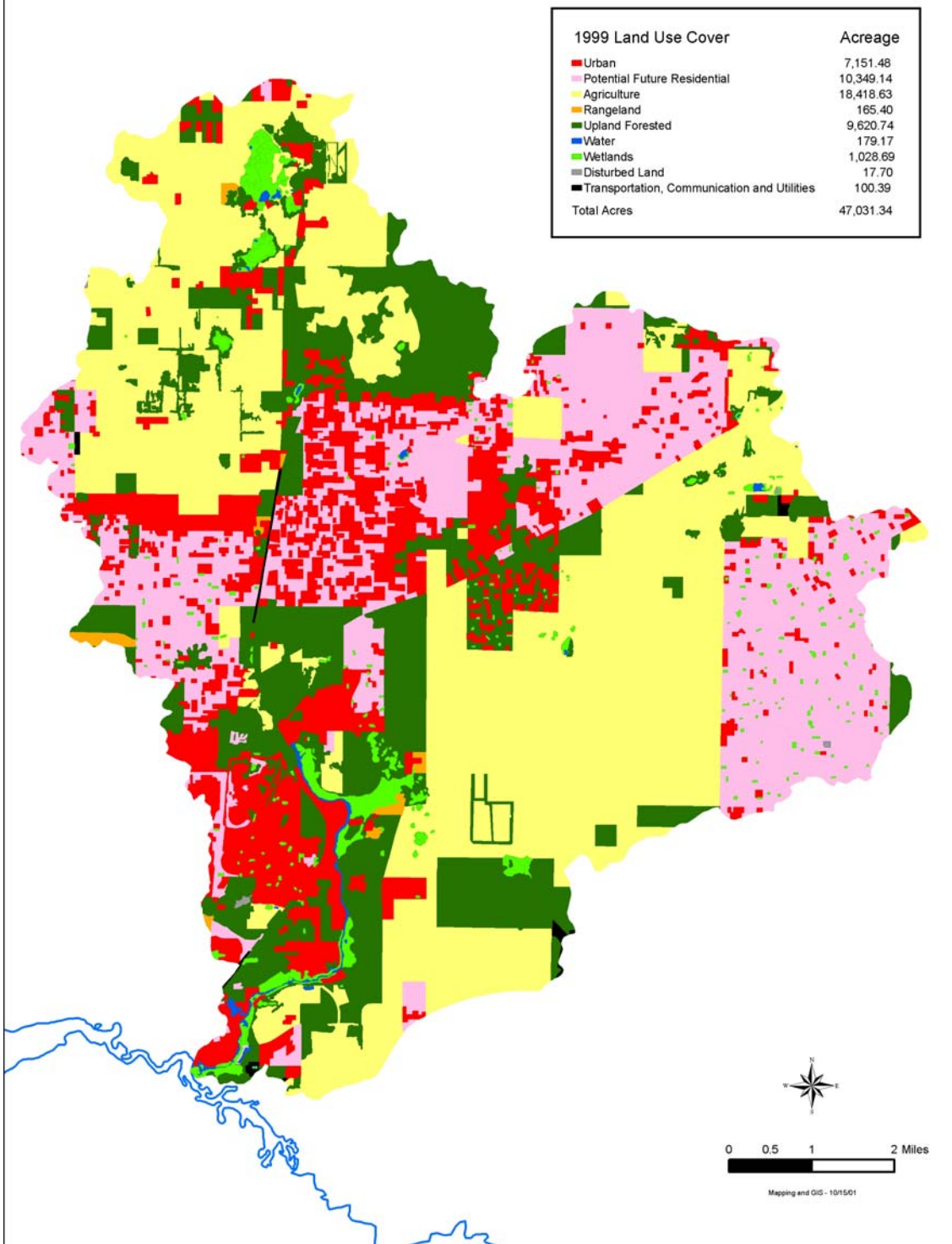


Figure 5. Land use in the Rainbow River Watershed in 1999. (Source: SWFWMD)

The primary management issues regarding the Rainbow River are water quality, water clarity, and native plant and animal communities. Accordingly, the goals of the SWIM plan focus on identifying and implementing management strategies to address these primary concerns. Results of diagnostic studies and pilot restoration activities, completed as part of the 1989 and 1995 SWIM Plans, respectively, have been used to develop management strategies outlined in this updated plan. The following management issues are the basis for this revision to the 1995 Rainbow River SWIM Plan.

## Management Issues

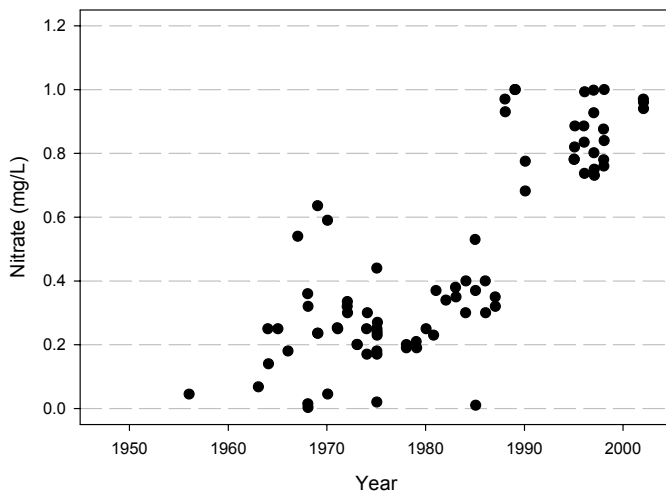
### Water Quality

Using the FDEP water quality index (WQI), the water quality of the Rainbow River is considered good (Hand, et al 2000). The WQI is a single numeric value condensed from several individual water quality parameters (Table 1) (Hand, et al. 1988). Seasonal medians are calculated using data from the EPA STORET chemical database. Prior to 2000, the WQI was calculated by using a statewide percentile distribution of typical water quality values (Friedemann and Hand 1989) that were irrespective of the stream type. Because of the unique nature of the chemical and biological characteristics of spring-fed systems, as opposed to, for example, black water streams, the WQI was modified to address these differences (Table 1) (Hand, et al. 2000). Using this modified WQI, a River with a WQI less than 45 is considered to have good water quality (Hand, et al. 2000). The WQI for Rainbow River is 14.83.

Water Quality Parameter	Streams	Springs
Turbidity	X	X
Total Suspended Solids (TSS)	X	X
Dissolved Oxygen (DO)	X	
Biochemical Oxygen Demand (BOD)	X	X
Chemical Oxygen Demand (COD)	X	X
Total Organic Carbon (TOC)	X	X
Total Nitrogen	X	
Nitrate (NO <sub>3</sub> )		X
Total Phosphorus (TP)	X	X
Total Coliform	X	X
Fecal Coliform	X	X

**Table 1. Modified Water Quality Index parameter list. (Source: Hand, et al. 2000)**

Although water quality in the river is good, nitrates in Rainbow Springs have steadily increased over the past fifty years (Figure 6). Nitrate concentrations in the headsprings are about 1.0 mg/L (Jones, et al. 1996; SWFWMD 2002, unpublished data) while nitrate concentrations in the 1940's and 1950's have been less than 0.1 mg/L (Odom 1957; Jones et al. 1996). Background nitrate concentrations in the Floridan aquifer are typically less than 0.1mg/L (Jones, et al. 1996). Although current nitrate concentrations in Rainbow Springs are considered low when compared to other River systems statewide, this change represents more than an order of magnitude increase over the past half century. Furthermore, when one considers the total discharge of Rainbow Springs



**Figure 6. Nitrate concentrations in the Rainbow River 1956 – 2002.** (Source: USGS, SWFWMD)

(460 mgd), 1.0 mg/L nitrate results in a total nitrate load of approximately 700 tons annually. This means that the annual nitrate loading into Rainbow Springs today is 700 times greater than it was when nitrates were at background concentrations. Nitrogen isotope analyses, at Rainbow Springs, indicate that inorganic fertilizer is the principle source of nitrate discharging from the Springs (Jones et al. 1996). The St. John's River Water Management District has found similar nitrogen isotope results in Wekiwa Springs, located in Orange County, Florida (Toth and Fortich 2002).

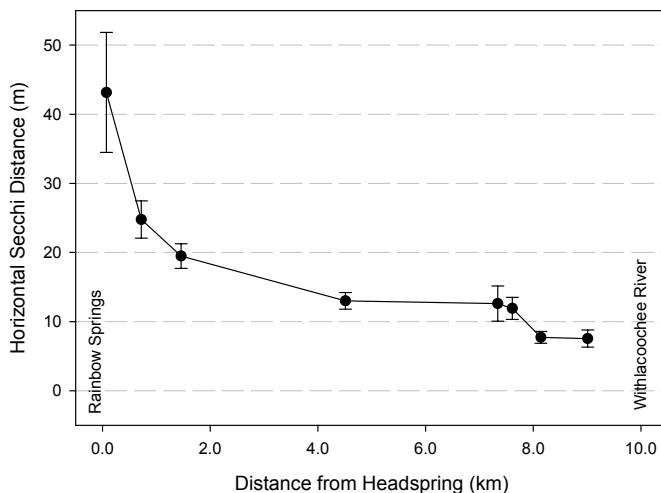
It is uncertain if this increase in nitrate has impacted the river system and what impacts, if any, further increases in nitrates may have on the river's water quality, water clarity, and biological communities. In many estuarine systems and lakes, increases in nitrate have been shown to stimulate the growth of phytoplankton and algae. Laboratory experiments have shown that increases in nitrates can lead to a significant increase in *Lyngbya* biomass (Romie 1990; Cowell and Dawes 2002). *Lyngbya* sp. are found throughout the river, although concentrated in the lower reaches. Increases in phytoplankton and algae can also decrease water clarity because of the resultant increase in suspended material in the water column (Whitford, 1956; Hoyer, et al. 1997). It should be cautioned, however, that there is no direct evidence of a link between nitrates and the growth of phytoplankton or *Lyngbya* sp. in spring-fed systems. In fact, preliminary reconnaissance data collected by the SWFWMD from several first magnitude springs in north-central Florida suggest that elevated levels of nitrates may have little or no effect on the ecology of spring-fed streams (SWFWMD, unpublished data) and that the impacts may not be evident until the nitrates reach the estuary

(Frazer, et al. 2001). Although nitrates may not have a direct ecological impact to the immediate spring run, it may have a major impact in the Gulf coastal waters. For this reason, as well as for known impacts to human health, increasing nitrate concentrations are a priority issue and will continue to be addressed.

Many springs throughout north-central Florida have experienced increases in nitrates over the past hundred years (Jones, et al. 1996; Jones, et al. 1997; Toth 1999; Florida Springs Task Force 2000; Toth and Fortich 2002). However, a few have remained relatively stable. The FDEP has designated Silver Glenn Spring as an example of one such spring. Silver Glen Spring has maintained good water quality and a relatively constant discharge since the 1930's. The main reason for this is because nearly all of its watershed area is located within the Ocala National Forest and is protected from development and water extraction (Florida Springs Task Force 2000). It should be noted, however, that although Silver Glen is a reference spring with respect to nitrate concentrations, the spring, and its associated run, are heavily impacted by recreational uses and therefore should not be considered pristine. Although the ecological impacts of this usage have not been well documented, there are large amounts of *Lynbya* sp. throughout the relatively short spring run. That *Lynbya* sp. is so prevalent in a system with background levels of nitrate is surprising and warrants further investigation.

## Water Clarity

Few places in the world can match the exceptional water clarity of the springs of Florida. In the Rainbow River, water clarity, measured using a horizontal secchi disk (Davies-Colley 1988), has been as high as 70 meters at the headspring (SWFWMD 2002, unpublished data). From the headspring, water clarity decreases rapidly within the first 2.0 river kilometers (1.2 miles) from about 45 meters to 20 meters (Figure 7). Water clarity continues to decline further downstream, only at a much slower rate. At about 9.0 river kilometers (5.6 miles) downstream of the headsprings, water clarity is about 8.0 meters (Figure 7). This represents almost a ten-fold decrease in water clarity from the headspring to just upstream of the river's mouth. It is not well understood whether this observed decline in water clarity is a natural phenomenon, a result of anthropogenic impacts,



**Figure 7. Water clarity in the Rainbow River.** Data are from June – November 2002. Error bars are  $\pm$  the standard deviation of the mean. (Source: SWFWMD unpublished data)

It is not well understood whether this observed decline in water clarity is a natural phenomenon, a result of anthropogenic impacts,

or a combination of both. Furthermore, there is little historical information available to relate present water clarity conditions with past conditions. Because water clarity is such an important issue in this system, understanding the factors that control water clarity are priority issues and will continue to be addressed.

### **Aquatic Vegetation**

The Rainbow River supports a wide variety of native emergent and submerged aquatic plants (WAR, 1991; FDEP 2000). These plants provide habitat (FGFWFC 1992), help maintain water clarity (LeConte, 1861), aid in sediment stabilization, and provide an aesthetically pleasing environment for people who visit and live on the river. The dominant SAV species is the native *Sagittaria kurziana* that forms tall, underwater meadows. Based on results from a 2000 vegetative mapping effort (FDEP, 2000), *Sagittaria* is present in 53 percent of the river, and may cover up to 74 acres of the total 140 acres of submersed area. *Vallisneria americana* (eelgrass) is the second most common native plant, found in 12 percent of the river (FDEP 2000).

Although submerged aquatic and emergent vegetation communities appear healthy in the upper reaches of the river, there are concerns that the future of these communities may be at risk. While native grasses, especially *Sagittaria*, form extensive meadows in the upper and middle reaches of the river, they are nearly absent from the lower region. Also, a comparison between the 1996 and 2000 vegetative mapping results indicates that the presence of *Sagittaria* and *Vallisneria* decreased by 6 and 7 acres, respectively (FDEP 2000). Other native species, such as *Najas guadalupensis* and *Chara* sp. also decreased during this time period. Additionally, bare substrate increased by about 5 acres from 1996 to 2000, primarily in recreational areas such as the State Park swimming area (FDEP 2000). Recreational activities can have a negative impact on aquatic and wetland vegetation (Dutoit 1979; Mumma, et al. 1996). During the summer, it is not uncommon to have more than 500 recreational users on the river (Pridgen, et al. 1992).

In the lower portion of the river, where native grasses are scarce, *Hydrilla verticillata* and *Lyngbya* sp. dominate. *Hydrilla* is an exotic invasive aquatic plant found in the Rainbow River. Well established on the Rainbow River since the 1970s, *Hydrilla* can grow up to an inch per day, and thus has the ability to out-compete native submerged aquatic plant communities. Results of the 1996 and 2000 vegetative mapping efforts indicate that while the overall acreage of *Hydrilla* has not increased, its distribution has expanded approximately 500 feet further upstream. *Lyngbya* sp. are blue-green alga and may factor into the difficulties in reestablishing native plant communities, and may contribute to the loss of submerged plants by forming dense mats that can shade, smother, and uproot native vegetation. *Lyngbya* may be expanding in the Rainbow River, though limited data from previous mapping efforts have only established baseline conditions and do not offer evidence of changing abundance.

## **Sediment Accumulation**

An analysis of stream sediments was conducted in 1991 to determine the effects of historic effluent discharges on riverine sediments downstream of the point of discharge of the City of Dunnellon's wastewater plant into Rainbow River (WAR 1991). Sediments in Rainbow River downstream of the site of historic discharge did not show any contamination (WAR 1991). There are concerns, however, that sediment quality and/or sediment accumulation in the lower river may be having a negative impact on the vegetative communities there. Sediment samples collected upstream of the state road 484 bridge consisted of 94% sand, and 6% percent silt and clay. Four downstream sample locations ranged from 36 to 70 percent sand, and 30 to 64 percent silt and clay. These preliminary data indicate that there may be a shift in sediment quality from mostly sand to a mixture of sand, silt, and clay (WAR 1991). Additional diagnostic work to further evaluate the sediment conditions within the Rainbow River and the effects these sediments may be having on the vegetative communities may be required.

## **Management Strategies**

### **Management Actions for Water Quality and Clarity**

The main source of nitrate-nitrogen in Rainbow Springs, and the Rainbow River, is from inorganic fertilizers (Jones et al. 1996). There is evidence to suggest that agriculture may be a major contributor (Jones, et al. 1996), although specific load allocations associated with the different land-use practices within the recharge area are not well understood and bear further investigation. Given the large increase in nitrate concentration over the past century, steps will be taken to prevent further increases in nitrates entering the river. Management strategies will be carried out via multiple partner groups and educational programs aimed at reducing the input of inorganic fertilizers to the immediate recharge area. In addition, as residential and commercial development continue to increase, assessing and managing impacts from stormwater runoff and waste disposal practices, such as waste water treatment plants, sprayfields, and septic tanks, will become more critical.

Water clarity in the river rapidly decreases within the upper 2.0 kilometers of the river. From there, water clarity continues to decline but at a much slower rate. In an effort to better quantify the spatial and temporal variations in water clarity, as well as water quality, the District initiated a study in June 2002 to identify the major factors contributing to the observed differences in water clarity. Fixed sampling stations are located from the headsprings to just upstream of the confluence with the Withlacoochee River. Samples are collected monthly and analyzed for nutrients, chlorophyll, suspended solids, turbidity and color.

Horizontal secchi disk measurements are taken at every station as a measure of water clarity (Davies-Colley 1988). All field measurements and water sampling protocols adhere to FDEP standard operating procedures. Results from this study will provide insight to the causes of the decline in water clarity from the headsprings to the mouth, and whether this pattern is a natural phenomenon, a result of anthropogenic impacts, or a combination of both. Other relevant data sources including the FDEP biological and water quality monitoring program will be included as part of this plan. Additional actions may be recommended based on these results.

### **Management Actions for Aquatic Vegetation**

Mapping efforts will be repeated regularly in order to detect any changes in coverage of SAV, with the next mapping project scheduled for 2004. Specifically, increases in the distribution and abundance of *Hydrilla* and *Lyngbya* sp. will be a focus of this work. Any decreases in desirable native plants such as *Sagittaria* and *Vallisneria* will also be closely monitored. Part of this mapping effort will be to better understand the underlying causes of any observed change in SAV abundance and distribution.

New methods for re-vegetation with *Sagittaria*, and other native species, will continue to be investigated. However, the difficulty in re-establishing submerged plant communities (Sleszynski 2001) makes the protection of existing native vegetation a priority. Typically, areas of recreational activities, such as swimming areas and boat docks are devoid of native vegetation (WAR 1991). Rather, these areas are either bare bottom or dominated by *Hydrilla*, a phenomenon observed in other river and lake systems as well (Wagner 1990; WAR 1991; Pridgen, et al. 1993; Mumma, et al. 1996). Efforts should therefore be made to minimize, where practical, the amount of disturbance to native communities as it may result in the loss of desirable species and the gain of *Hydrilla*. These efforts may include shallow water signs, restricted use of certain areas of the river, and public education. In addition to protecting native species, new methods to control the growth and spread of *Hydrilla* and *Lyngbya* should be investigated.

### **Management Actions for Sediments**

Fine unconsolidated (flocculent) sediments have been reported in some sections of the river. There are concerns that these flocculent sediments may have a negative impact on the vegetation, water quality, and water clarity, especially in the lower river. The first strategy in addressing these concerns is to better understand the distribution, thickness, quality, and origins of the river sediments. Following this initial survey, a more detailed evaluation of the impacts, if any, of these sediments on the vegetation, water quality, and water clarity may be necessary.

## **Public Education**

Education is an important component of natural resource management. Through education, the public can gain a better appreciation of Florida's springs and bring about more effective stakeholder cooperation. Homeowners, lawn care companies, farmers, and ranchers need to understand the direct impacts fertilizer use is having on the groundwater feeding the springs. Residents and visitors who utilize the Rainbow River need to be aware of potential impacts their recreational activities have on vegetation, water quality, and water clarity. Though not directly involved in implementing public education efforts, the SWIM Program can provide scientific information that will aid in the development of education materials and programs. Rainbow Springs and the other first magnitude springs of Florida are unique to the world. Education materials should be available to public visitors and residents to educate them about the importance of this unique national resource. The District's SWIM Program will continue to provide information to local agencies that will assist them in developing public education materials.

## **Pollutant Load Reduction Goal**

Pursuant to State Water Policy, Chapter 62-40, Florida Administrative Code (FAC), a pollutant load reduction goal (PLRG) is to be developed for each SWIM waterbody and adopted as part of the SWIM Plan. By definition a "PLRG means estimated numeric reductions in pollutant loading needed to preserve or restore designated uses of receiving bodies of water and maintain water quality consistent with applicable state water quality standards" (Chapter 63-40-210(18)), Florida Administrative Code). Chapter 62-40.432(5)(c) and (d) further discuss the intent of PLRG's, which is to reduce pollutants from older stormwater management systems and to restore or maintain the beneficial uses of waters.

The PLRG for the Rainbow River is to prevent nutrient levels from increasing beyond current levels. Additionally, the SWIM Program will work with other agencies and stakeholders, such as the FDACS Office of Agricultural Water Policy, to promote best management practices and programs designed not only to keep nitrate levels from increasing, but also to reduce current levels to the greatest extent practicable. Projects to address elevated nitrates in groundwater are a goal of both this SWIM Plan and the Florida Springs Initiative (Florida Springs Task Force 2001).

The SWIM Program will work with the FDEP Watershed Monitoring and Data Management Section through the FDEP Watershed Management Approach in developing numerical targets for nutrients and water clarity. The primary objective of the Watershed Management Approach is to stimulate the

involvement of government and local stakeholders in developing and implementing watershed management plans. It promotes the management of entire natural systems by establishing a framework for increasing cooperation among programs and providing consistent environmental management, while maintaining the flexibility to address local and regional issues, and implement Total Maximum Daily Loads (TMDL).

In order to set numerical targets for water quality and water clarity, data collection efforts in the river, the springs, and the recharge basin will continue. Currently, several agencies are involved in monitoring surface and groundwater within the Rainbow River recharge area. For example, the Water Quality Monitoring Program (WQMP) of the SWFWMD collects water quality samples from the springs, the USGS collects and calculates discharge data for the river, and the SWIM Program monitors water quality and water clarity in the river.

## **Linkage to Other Water Resource Management Activities**

The District's SWIM Program coordinates internally with other District programs and externally through partnerships with local governments and other state and federal agencies to meet the SWIM Plan goals and objectives.

### **Internal Linkages**

The District has many tools available to implement the legislative intent of the SWIM program, including but not limited to, integrated planning and coordination, regulatory authority, land acquisition programs and the SWIM Program itself. Each of these areas provides opportunities to assist in the management of the Rainbow River, one of the prominent natural systems within the District.

### Southwest Florida Water Management District's Water Management Plan

As required in Chapter 373 of the Florida Statutes, the District prepared its Water Management Plan (DWMP). Within this plan, the District delineated its mission into four areas of responsibility; water supply, flood protection, water quality and natural systems. The DWMP recognizes that the integration of these areas is essential to effective planning and management of the resource. The District Water Management Plan lists policies that relate to the restoration, protection and management of Rainbow River, as well as other SWIM water bodies.

### Comprehensive Watershed Management

The District recognized a need to take a more aggressive and unified approach to water management and, therefore, created an initiative to prioritize resource management needs in each of 11 watersheds identified throughout the District. It

is intended to combine water quantity (i.e., flood) management with water quality and natural systems objectives, as well as water supply when applicable. Ultimately regulation, land acquisition, facilities and land use controls would be combined into a comprehensive surface water management strategy including appropriate policies, on a watershed specific basis. This effort is the District's embodiment of the EPA's Watershed Planning Approach and the FDEP's Watershed Management Approach.

Local governments, as the parties responsible for land planning/development and service provision, will be key players in this integrated management approach. Similarly, the State's Ecosystem Management initiative will provide an impetus to collective efforts as it implements an environmental strategy that encourages innovation, pollution prevention, incentive-based regulatory alternatives, public education and individual stewardship.

### Regulation

*Wetlands Protection Through Regulatory Programs* - One way that the District achieves wetlands protection is through regulatory programs. Wetlands protection is addressed under Chapters 40D-2, 40D-3, 40D-4, 40D-40 and 40D-400, F.A.C. The District's surface water permitting rules (40D-4 and 40, F.A.C.) require that any impact to wetlands not specifically exempted must either be avoided or compensated. Compensation for impacts must replace lost functions. Compensation may include preservation of associated upland areas, wetland creation, protection of exempt wetlands, and restoration for previously impacted wetlands. The intent is to ensure that the habitat necessary for the survival of fish and wildlife is maintained.

*Minimum Flows and Levels* - Another management tool available for water and related natural resource protection is through the District's minimum flows and levels program (MFL). Maintaining minimum flows and levels is a significant statutory charge for Florida's water management districts. District programs for minimum flows and levels originate in Chapter 373.042, F.S., as well as from the District's desire to treat the environment as a rightful "user" of water. If water resources and associated natural systems are to be protected and maintained, the identification and establishment of water levels and flows is essential. Such activities will also serve to balance water withdrawals for human needs with protection of surface water levels for navigation, recreation and related functions.

Once established, MFLs are implemented through a variety of means. Most prevalent is the application of these flows and levels to the District's water use permitting program. As directed by Chapter 373.042, F.S., the District may restrict withdrawals of water which would cause flows and levels to drop below their established minimums and which would be significantly harmful to the water resources or ecology of an area. The District's water use permitting rules, which

include criteria to prevent adverse impacts from occurring as a result of withdrawals, effectively establish MFLs for specific sources throughout the District.

### Mitigation Banking

Mitigation banking allows developers to compensate for wetland losses in one place by preserving, restoring or creating wetlands in another to achieve a no-net loss of wetland function. Mitigation banking in some instances remains a controversial issue.

### Land Acquisition

Land acquisition at the District is currently guided and funded by two major statewide initiatives: The Water Management Lands Trust Fund (also known as the Save our Rivers Program or SOR), and Preservation 2000 (P2000). The Florida Forever Act, passed by the Florida Legislature in 1999, makes funds available to the water management districts for both land acquisition and restoration, including funding for SWIM projects.

The District's land acquisition programs target the protection of natural resources at the regional level. Lands of importance to water resources and water management are acquired along with lands of unique environmental values endangered by development activities. The District owns more than 200,000 acres, the majority of which were purchased through the SOR and P2000 programs. Many recent purchases have been a joint acquisition between the District and a local government or with other state agencies. Leveraging District land acquisition funds with those of local governments and other agencies has resulted in significant acquisitions that might otherwise not be made. These programs will be coordinated with SWIM Plans by focusing on critical habitats, such as wetlands and their interconnected upland communities that are part of the Rainbow River ecosystem that should be acquired for preservation or for restoration. Purchase of critical habitats or conservation easements in the Rainbow River watershed will be vital for reduction of nutrient loading and maintenance of water quality.

### Basin Board Activities

The District's eight Basin Boards have specific functions and duties that are consistent with Chapter 373, F.S., and the programs of the Governing Board. Their purpose is to identify and evaluate key water resource management issues in order to develop and fund management strategies to address them. The Basin boards are facilitators in the resolution of non-regulatory water management issues for a number of other governments. It is at the Basin level that intergovernmental water resource programs are implemented, monitored and evaluated for improvement. The Basins are a sounding board for the District, a

means of obtaining feedback from local governments and citizens. Basin boards also serve as funding partners with local governments and others in addressing mutually beneficial water resource solutions.

The District, through the eight basin boards, has an established Cooperative Funding Program, which provides financial assistance on a cost-share basis primarily to local governments for regional water resource projects. Projects can also be funded through "Basin initiatives" where a Basin decides to provide the impetus for a water management solution, with or without a local partner. The Basins use their respective Comprehensive Watershed Management (CWM) plans to reflect their issues, priorities, and strategies. The plans are prepared in close coordination with local governments demonstrating another opportunity for integration with local governments and ensuring the most efficient and cost-effective approach to addressing the mutual water resource management goals and objectives.

## **External Linkages**

### FDEP

The Florida Department of Environmental Protection is required by the Florida Environmental Protection Act of 1993 to develop and implement measures to "protect the functions of entire ecological systems through enhanced coordination or public land acquisition, regulatory and planning programs."

The FDEP in 2000 adopted a Watershed Management Approach, whereby water resource management and the development of TMDL's for individual impaired water bodies are the prime components of a comprehensive plan that allows for planning, evaluation, and implementation of water resource protection activities at the basin level. The specifics of this new approach are detailed in the FDEP's Florida Water Plan, published in December 2001.

The District has been an active participant in this evolving process, both in terms of statewide program development, and support for the Hillsborough River Basin Pilot Project. The Pilot is one of six throughout the State intended to illustrate how this concept can provide for a comprehensive, holistic linking of environmental protection at many governmental (and private) levels. A strong correlation is apparent between District's Comprehensive Watershed Management Initiative (CWM) and Surface Water Improvement and Management (SWIM) program and FDEP's Rainbow River Aquatic Preserve and Watershed Management Approach goals to preserve and restore the Rainbow River ecosystem.

### Local Government Coordination and Partnering

Relationships and partnerships that have been developed over the past decade of management activities in Rainbow River is central to the future of managing the system. Local governments are key to the implementation of any management activity that is proposed for the system.

The District has prepared county level Integrated Plans for the local governments within its jurisdiction as part of the District's Water Management Plan. The purpose of these Integrated Plans are to identify and evaluate key water resource management issues within the local government's jurisdiction and to develop common District and local government strategies to address these issues. The Integrated Plans are also intended to serve as a tool to foster the integration of land use planning and growth management activities of local governments with the water use planning and management activities of the District. This effort will strengthen the local government's comprehensive plan by linking local water resources planning to the best available data and other resources of the District. The development of the Integrated Plans is a cooperative effort of the District, local governments and citizens. This endeavor is best viewed as a process, however, since it is intended to promote continuing relations and mutual planning in the best interest of the resource. It is hoped the action strategies identified will be added to the local government plan where local and District energies, and funding, can be directed toward them.

Local governments and other state and regional agencies offer not only a funding partner but a wide range of services – from land acquisition and technical assistance to providing equipment and personnel – all of which when combined with District and State resources can make for a substantial effort.

### **Multiple Partner Groups**

#### Withlacoochee Regional Planning Council

The Withlacoochee Regional Planning Council (Council) is one of eleven regional planning councils within the state that were formed to provide planning and technical assistance to their member local governments. The Council, comprised of Citrus, Hernando, Levy, Marion and Sumter counties, employs professional staff to perform state mandated duties and assist local governments with various issues in such areas as growth management, economic development, natural resources protection and strategic regional planning. Council staff are involved in a number of natural resource protection initiatives within the Withlacoochee region, including the Rainbow River, Lake Panasoffkee and Crystal River/Kings Bay SWIM projects, the Withlacoochee and Springs Coast Comprehensive Watershed Management (CWM) teams, Silver Springs Forever, Nutrient Remediation Workgroup, and the Rainbow Springs Coordination Council.

### Nutrient Remediation Workgroup

The Nutrient Remediation Workgroup is an organization composed of citizens, industry and government representatives and is administered by the Withlacoochee Regional Planning Council. The primary goal of the Workgroup is to address impacts to central Florida's springs and drinking water sources caused by increasing nitrate levels in ground and surface waters. To achieve this goal, the Workgroup engages public education and the exchange of information on research, education, remediation and prevention measures with other organizations addressing similar problems throughout the State of Florida.

### Rainbow Springs Coordination Council

No single government agency has the authority or resources required to provide adequate protection for a spring. Participation by spring stakeholders is imperative for effective protection. The Rainbow Springs Coordination Council formed in 2001 provides a forum for a collaborative process for identification and resolution of problems within the Rainbow Springs recharge basin. The group consists of federal, state and local government agencies having information or responsibilities concerning the function of the spring recharge basin. Other important stakeholders include agricultural and commercial interests, environmental organizations, and citizens. The mission of this group is to preserve and protect the unique biological communities and scenic beauty of the Rainbow River.

### Florida Springs Task Force

The Department of Environmental Protection initiated the multi-agency Florida Springs Task Force to provide recommended strategies for the protection and restoration of Florida's springs. The Task Force originally consisted of sixteen members representing one federal and three state agencies, four water management districts, a state university, a regional planning council, the business community, and private citizens. The task force developed the Florida's Springs Strategies for Protection and Restoration published in November 2000. This plan provides guidelines for protecting Florida's springs.

## **Priority Projects**

The priority projects for Rainbow River focus on preservation and restoration of water quality, water clarity, and aquatic vegetation. Specifically, monitoring and diagnostic efforts are proposed to better understand factors effecting water quality and water clarity, and determining trends in vegetation coverage. A diagnostic study is proposed to further evaluate sediments to develop appropriate management strategies. Additional diagnostic studies will investigate the role that water level changes may have on water quality, water clarity, and aquatic vegetation. The following project summaries briefly describe the projects and provide an estimated budget:

**Project Title:** Factors affecting water clarity and water quality in the Rainbow River

**Summary:** This project was initiated in June 2002 in an effort to better quantify the spatial and temporal distribution of water clarity and water quality from the headsprings to the mouth of the Rainbow River. This study will provide an understanding of the major biotic and abiotic factors controlling water clarity and water quality in the river. Results will be used to establish strategies to manage the water clarity of the river.

**Annual Budget Estimates:**

	<i>FY2003</i>	<i>FY2004</i>	<i>FY2005</i>
<b>Salaries:</b>	\$2,000	\$2,000	
<b>Contracts:</b>			
<b>Expenses:</b>	\$8,500	\$8,500	
<b>Equipment:</b>			
<b>Total:</b>	\$10,500	\$10,500	TBD

**Agency or Local Government Coordination and Partnering:**

District staff is conducting this project.

**Project Title:** Re-establishment and protection of emergent and submerged aquatic vegetation

**Summary:** An important link in the management of Rainbow River is to re-establish emergent and submerged aquatic vegetation in areas that have been impacted from recreational uses or exotic invasive species. This includes developing a successful method of re-vegetation off submerged species.

**Annual Budget Estimates:**

	<i>FY2003</i>	<i>FY2004</i>	<i>FY2005</i>
<b>Salaries:</b>		\$2,000	\$2,000
<b>Contracts:</b>			\$56,000
<b>Expenses:</b>			
<b>Equipment:</b>			
<b>Total:</b>			\$58,000

**Agency or Local Government Coordination and Partnering:**

The District will continue to work with the Florida Department of Environmental Protection's Aquatic Preserve Program, and Bureau of Invasive Plant Management.

**Project Title:** Spatial and temporal changes in vegetation distribution: mapping and evaluation

**Summary:** Vegetation mapping efforts will be repeated regularly to evaluate changes in the aquatic plant communities of Rainbow River. These data will be used for comparison to historical data to determine trends in vegetation coverage, and to evaluate success of management efforts. Diagnostic work will focus on understanding the causes of the changes in vegetation.

**Annual Budget Estimates:**

	<i>FY2003</i>	<i>FY2004</i>	<i>FY2005</i>
<b>Salaries:</b>	\$100	\$2,000	\$2,000
<b>Contracts:</b>		\$100,000	
<b>Expenses:</b>			
<b>Equipment:</b>			
<b>Total:</b>	\$100	\$102,000	\$2,000

**Agency or Local Government Coordination and Partnering:**

The District will continue to work with the Florida Department of Environmental Protection's Aquatic Preserve Program, as necessary.

**Project Title:** Understanding the role of sediment on vegetation, water quality, and water clarity: evaluation and management

**Summary:** Fine, unconsolidated sediments have been reported in some sections of the river. Flocculent sediment has the potential to negatively impact native vegetation and water clarity of the river. Additional work is needed to evaluate sediments within the Rainbow River.

**Annual Budget Estimates:**

	<i>FY2003</i>	<i>FY2004</i>	<i>FY2005</i>
<b>Salaries:</b>	\$2,000	\$2,000	\$2,000
<b>Contracts:</b>		\$100,000	
<b>Expenses:</b>			
<b>Equipment:</b>			
<b>Total:</b>	\$2,000	\$102,000	\$2,000

**Agency or Local Government Coordination and Partnering:**

The District will continue to work with the Florida Department of Environmental Protection's Aquatic Preserve Program, as needed.

**Project Title: Nitrate management in the Rainbow River watershed and the immediate groundwater recharge area**

**Summary:** The main source of nitrate in the Rainbow River springs is inorganic fertilizer. Contributors to nitrate loading include agriculture, residential, golf courses, stormwater, and others. As the surrounding watershed continues to develop, it is likely that further increases in nitrogen loading will occur. The District's SWIM Program will continue to work with appropriate entities to assist in developing and implementing management strategies to minimize further nitrate contributions from the surrounding watershed.

**Annual Budget Estimates:**

	<i>FY2003</i>	<i>FY2004</i>	<i>FY2005</i>
<b>Salaries:</b>		\$2,000	\$2,000
<b>Contracts:</b>			
<b>Expenses:</b>			
<b>Equipment:</b>			
<b>Total:</b>		\$2,000	\$2,000

**Agency or Local Government Coordination and Partnering:**

The District will continue to work with the Florida Department of Environmental Protection Aquatic Preserve Program, the Florida Department of Agriculture and Consumer Services Office of Agricultural Water Policy, Marion County, Nutrient Remediation Workgroup, Rainbow River Coordination Council, United States Geological Survey and other agencies.

**Project Title: Nutrient budget refinement and re-assessment**

**Summary:** Additional studies may be recommended as a result of the water quality and water clarity monitoring project. For instance, if the study suggests the Rainbow River may have been changed from nitrogen limited to phosphorus limited, then additional work may be needed to understand the source of phosphorus and potential implications.

**Annual Budget Estimates:**

	<i>FY2003</i>	<i>FY2004</i>	<i>FY2005</i>
<b>Salaries:</b>		\$2,000	\$2,000
<b>Contracts:</b>			\$50,000
<b>Expenses:</b>			
<b>Equipment:</b>			
<b>Total:</b>		\$2,000	\$52,000

**Agency or Local Government Coordination and Partnering:**

The District will continue to work with the Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, United States Geological Survey and other agencies.

**Project Title:** Historical water level changes and its affects on the lower Rainbow River with special emphasis on vegetation, water clarity, and water quality

**Summary:** Water levels in the lower reaches of the Rainbow River have been effected by the Lake Rousseau impoundment constructed in 1909. This study is to determine if the water level changes may have effected water quality, water clarity, and/or vegetation within the river.

**Annual Budget Estimates:**

	<i>FY2003</i>	<i>FY2004</i>	<i>FY2005</i>
<b>Salaries:</b>		\$2,000	\$2,000
<b>Contracts:</b>			\$50,000
<b>Expenses:</b>			
<b>Equipment:</b>			
<b>Total:</b>		\$2,000	\$52,000

**Agency or Local Government Coordination and Partnering:**

The District will continue to work with the Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, United States Geological Survey, United States Army Corps of Engineers, and other agencies.

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## **Appendix A: Physical Characteristics**

(Adapted from Jones *et al.* 1996)

### **Geology**

A prerequisite to comprehending the groundwater hydrology of the study area is an understanding of the dominant role karst processes play in moving groundwater through the Floridan aquifer. The region of Marion county has been extensively modified by karst processes. These areas are characterized by numerous sinkholes, lack of surface drainage, and undulating topography. In karst areas, the dissolution of limestone by groundwater has created and enlarged cavities within the limestone which eventually collapse and form sinkholes. Sinkholes capture surface water drainage and funnel it underground which further promotes dissolution of the limestone. This leads to progressive integration of voids beneath the surface, and allows larger and larger amounts of water to be funneled into the underground drainage system. Dissolution is most active at the water table or in the zone of water table fluctuation where carbonic acid, contained in atmospheric precipitation and generated by reaction with soil carbon dioxide, reacts with limestone and dolostone (Carroll 1970). The thickness of the active karst flow system is related to the cyclic rise and fall of sea level over the past several million years. During periods when sea level was lower than present, there was corresponding drops in the potentiometric surface of the Floridan aquifer.

According to Faulkner (1970) most of the flow to Rainbow Springs is probably concentrated in the Ocala Limestone in the upper 100 feet of the Floridan aquifer. This portion of the flow system is characterized by rapid flow and short residence times which result in low total dissolved solids concentrations.

### **Topography and Drainage**

The Rainbow Springs study area contains two small centers of population: Morriston and Dunnellon. The study area also abuts the City of Ocala which is a rapidly urbanizing area. Western Marion County lies in an area of gently rolling hills and karst plains. Land surface elevations range from 50 feet above NGVD near Dunnellon, to greater than 200 feet in the Fairfield Hills area northwest of Ocala (SWFWMD, 1987). White (1970) separated Marion County into eleven physiographic provinces, eight of which lie within the study area. These provinces include the Fairfield and Martel Hills, the Brooksville and Cotton Plant Ridges, the Western Valley, the Sumter Upland, the Tsala Apopka Plain, and the Dunnellon Gap.

West of Ocala the topography is dominated by gently rolling hills, ranging in elevation from 100 to 215 feet above NGVD. These highland divisions include the Fairfield and Martel Hills, and the Brooksville and Cotton Plant Ridges.

Surrounding the highlands are comparatively low, broad, nearly flat to gently rolling terrains, which include the Western Valley and Sumter Uplands (SWFWMD, 1987). West of Dunnellon and the Brooksville Ridge, the Coastal Lowlands slope gently to the west toward the Coastal Swamps of Levy County.

Levy County lies in an area of flat coastal swamps, karst plains, and gently rolling highlands. Land surface elevations range from sea level along the coast to some in excess of 125 feet NGVD in the Brooksville Ridge area. White (1970) separated Levy County into four physiographic provinces, two of which lie within the study area. These provinces include the Gulf Coastal Lowlands and the Brooksville Ridge.

The only major surface drainage features in the study area are the Withlacoochee and Rainbow Rivers. About 25 percent of the rainfall in Marion County contributes to surface drainage which supplies the rivers, lakes, and ponds in the county (Rohrer, 1984). The remainder, excluding evapotranspiration, drains internally into the Floridan aquifer or becomes temporarily perched over thin, discontinuous clay layers. Much of the water percolated into the Floridan aquifer in western Marion County reappears as surface flow at Rainbow Springs.

The Withlacoochee River flows along the southwestern boundary of Marion County having traveled from its headwaters in the Green Swamp southeast of the county. East of Inglis, the Withlacoochee River has been dammed, and Lake Rousseau, a relatively small lake, occupies much of the reach of the river between Citrus and Levy Counties. Prior to entering the lake, the Withlacoochee River receives discharge from Rainbow Springs by way of the Rainbow River in Dunnellon.

## **Climate**

(Adapted from Wolfe et al., 1990)

The climate of the Marion County area is humid and subtropical. The overriding climatological factor affecting the area is the Gulf of Mexico. Winter cold fronts and high summer temperatures are moderated by the Gulf waters. The average mean daily temperature is approximately 70°F (21°C). Mean summer temperatures are in the low 80's and mean winter temperatures are in the upper 50's. Winter temperatures are quite variable due to the passage of frontal systems. This area is primarily influenced by tropical air masses in the spring and summer and by cold continental air masses during the fall and winter.

Rainfall in the area is the result of three types of systems: frontal, convective, and tropical cyclonic. Although most of the rainfall is associated with summer convective storms, the area has two distinct peak rainfall periods: June through

September and February through April. The average rainfall totals vary from 54 to 58 inches (137 to 147 cm) per year with the highest monthly rainfall in August.

Periodic changes in climate and weather have been tied to the phenomenon known as El Niño. Rainbow River last experienced high flows caused by heavy rains from this phenomenon in 1997. This has been followed in 2000 with the worst recorded drought in the history of Florida.

### Surficial Aquifer

The surficial aquifer consists of Miocene to Holocene age siliciclastic deposits that, where present, are contiguous with the land surface. The clastics are usually sand, silty sand, and kaolinitic clay. The lower limit of the surficial aquifer coincides with the top of the low permeability beds of the Hawthorn Group or its residuum. Since a large portion of Marion and Levy Counties does not have an extensive confining layer, most of the study area does not have a surficial aquifer.

### Floridan Aquifer

The Floridan aquifer is the principle source of water for the springs and domestic, agricultural, and industrial supplies in the study area (Figure A.1). The freshwater-bearing part of the Floridan is known as the upper Floridan

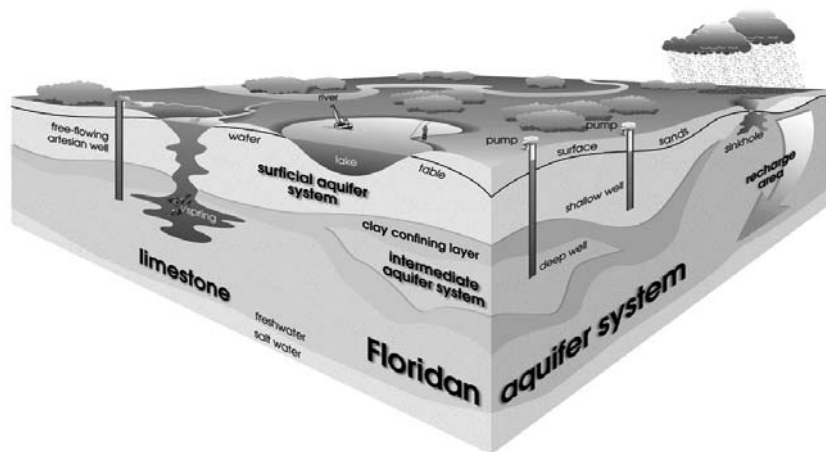


Figure A.1. USGS Floridan aquifer system model. (Source: USGS)

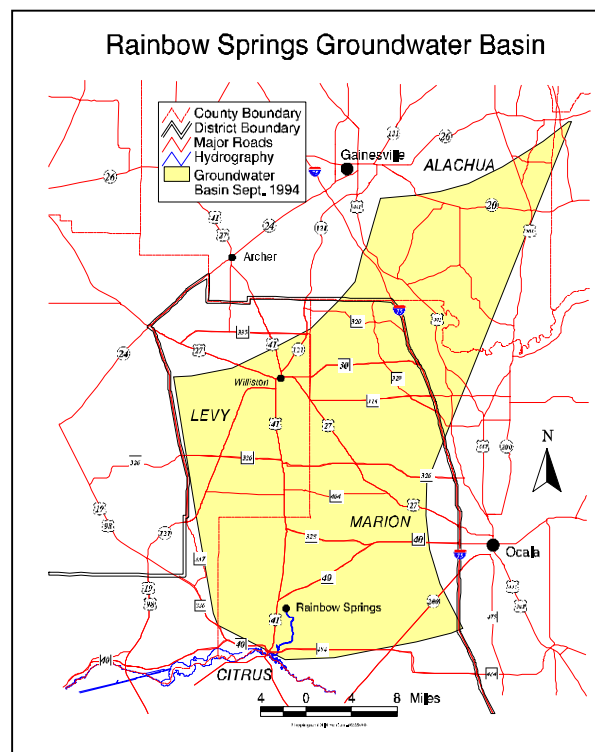
aquifer. The upper Floridan aquifer is composed of the Ocala Limestone and Avon Park Formation, in descending stratigraphic order. The lower Floridan aquifer contains poor-quality water and is not used in the study area. The top of the upper Floridan aquifer is usually defined as the uppermost vertically persistent permeable limestone or dolostone. Where the confining beds that separate the surficial and upper Floridan aquifers are present, the top of the upper Floridan coincides with the base of the confining beds. The middle to lower portions of the Avon Park Formation contains gypsiferous dolomite and dolomitic limestone. The permeability of this portion of the aquifer is generally low and is considered to be the middle confining unit of the Floridan aquifer. The middle confining unit occurs at an elevation of 500 to 800 feet below sea level in the study area (Miller, 1986).

In general, the upper Floridan aquifer is unconfined in the study area. However, thin and discontinuous clay layers in the Brooksville Ridge and Fairfield Hills areas may be sufficiently thick to cause local, semi-confining conditions to exist (Figure A.1). As a result, a limited surficial aquifer may occur in these areas, but there are probably enough breaches in the clay layer to allow percolation of water from the sand into the underlying limestone. In areas where saturated sand lies directly above limestone, water in the sand is hydraulically connected to the upper Floridan aquifer. Since the lower Floridan aquifer is not relevant to this report, the upper Floridan aquifer will be referred to simply as the Floridan aquifer.

## Recharge

The Floridan aquifer in the Rainbow Springs groundwater basin (Figure A.2) is recharged from local rainfall. Recharge is high (>10 inches per year) over most of the study area because the area is an internally drained karst terrain (Faulkner, 1970). The greatest amount of recharge occurs on the flanks of the Ocala Platform where the Ocala Limestone is at or near land surface. Where the low-permeability Hawthorn sediments cover the limestone, significant recharge is concentrated at sinkholes. Faulkner (1970) and Anderson and Laughlin (1982) designated areas of poor recharge northwest and southeast of Dunnellon. Direct recharge of the aquifer occurs in these areas because the Avon Park Formation is at or near land surface on the crest of the Ocala. However, the comparatively low permeability of the upper part of the Avon Park, resulting from dolomitization and the presence of sand and clay fill in solution cavities, has caused local potentiometric highs, water levels near land surface, and rejection of recharge during wet periods.

Faulkner (1970) used the size of the dry-season Rainbow Springs Groundwater Basin (645 square miles), and a discharge for the springs of 468 mgd to calculate an average recharge value for the basin of 15.2 inches per year. Ryder (1985),



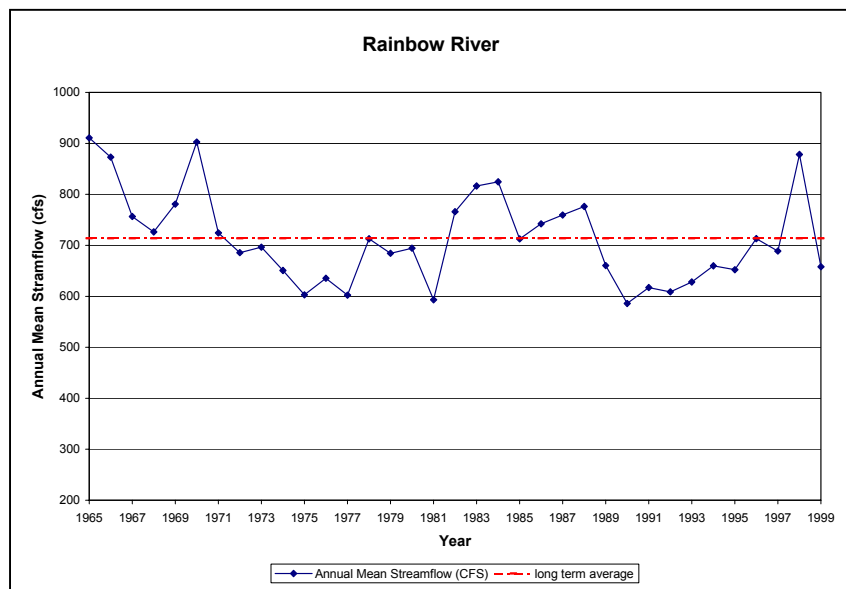
**Figure A.2. Rainbow Springs groundwater basin. (Source: Faulkner 1973; Jones, et al. 1996)**

modeling the Floridan aquifer flow system in west central Florida, used high recharge values (>10 inches per year) for much of the study area. Stewart (1980) delineated high recharge areas over Marion and northeastern Levy Counties and low to moderate recharge (2 to 10 inches per year) in the Rainbow and Withlacoochee River vicinities and the area west of the Brooksville Ridge. Recharge is low to moderate along the Rainbow and Withlacoochee Rivers because the potentiometric surface of the Floridan aquifer is close to land surface.

The quantity of runoff to the River from the watershed (4,660 acres) is small in comparison to that provided by the recharge area of the springs. The recharge area includes southern Alachua County, eastern Levy County and western Marion County comprising a drainage area of approximately 700 square miles (Figure A.2) Of the almost 500 mgd discharged by the Rainbow River about 5 mgd is contributed by recharge from the topographic watershed itself.

The discharge from Rainbow Springs, USGS Station Number 02313100, is estimated based on known water levels in USGS Well Number 290514082270701. Data from this site have been collected continuously since 1930 and intermittently since 1989 (Figure A.3). The average daily flow during this period of record was 727 cfs (equivalent to 470 mgd). The minimum and maximum flows

were 538 and 1,060 cfs, respectively. The 7Q10 flow (i.e., the 7-day average flow level that is exceeded 90% of the time) was 588 cfs and is the value used to calculate the water and nutrient budget for the river. This value was used to allow a stronger expression of watershed sources compared to spring flow (WAR 1991).



**Figure A.3. Annual mean streamflow (CFS) at USGS Station 02313100. (Source: USGS)**

## Rainbow Springs

The 5.7 mile long Rainbow River is a spring-fed river of exceptional ecological and scenic beauty located tributary to the Withlacoochee River just upstream of Lake Rousseau in Marion County, Florida. Although a small stream reach, the Rainbow River discharges on average (from 1965 to 1999) 462 million gallons of water per day (mgd) (714 cfs) to the Withlacoochee River (USGS stream flow data, Figure 7). In contrast to the tea colored tannic waters of the Withlacoochee, the waters of the predominantly spring fed Rainbow River are clear. Coker (1954) has remarked that Crater Lake in Oregon with a secchi

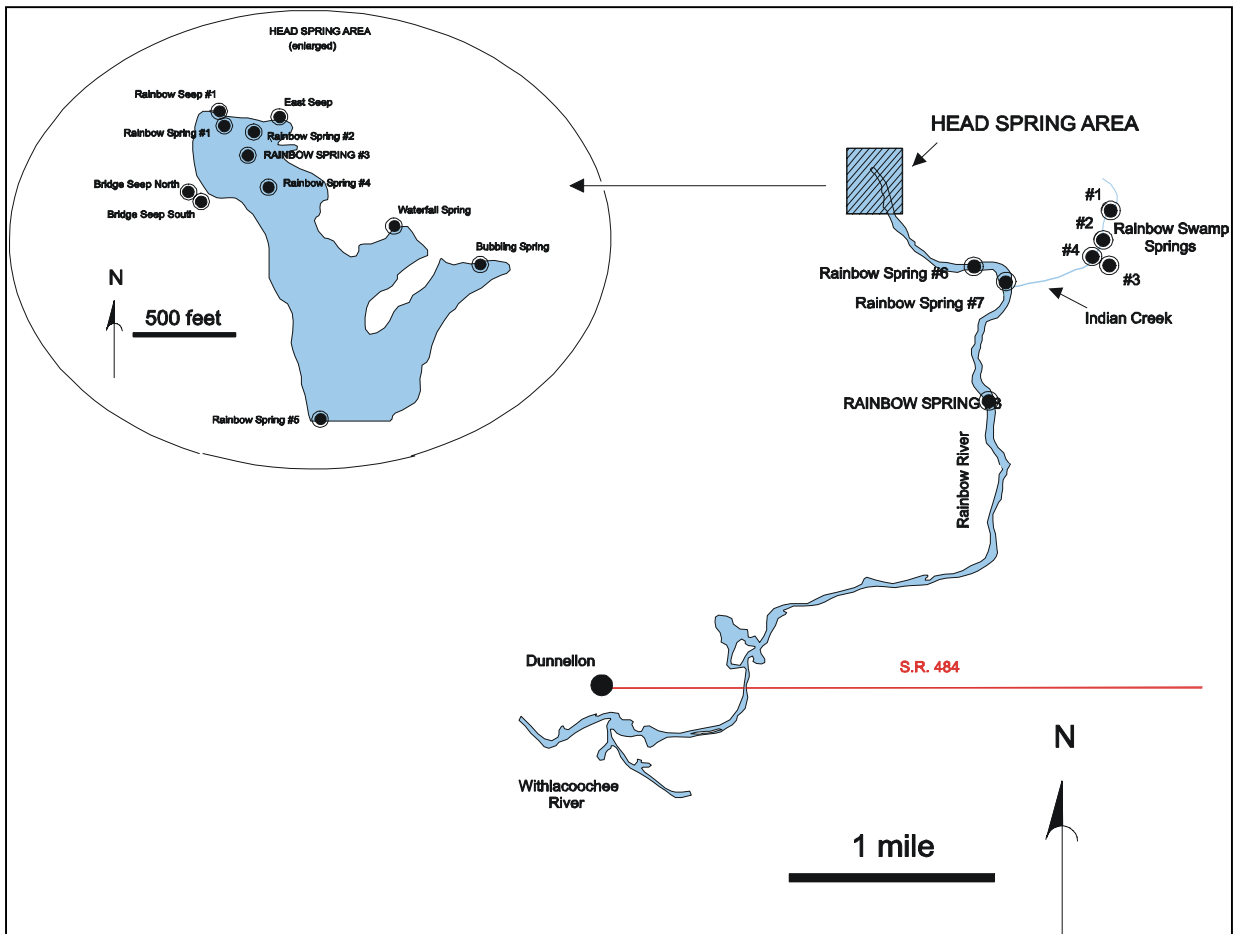


Figure A.4. Location of spring vents in the Rainbow Springs Complex. (Source: Jones, et al. 1996)

transparency of over 40 meters (130 feet) can have few if any freshwater rivals with respect to water clarity, but noted that the waters of deep springs of Florida can be even clearer. The waters of Rainbow River have their source from these springs and appear blue due to the high transmittance of light waves.

Rainbow River (also known as Blue Run and Wekiva Creek) is a first magnitude spring run having an average discharge of at least 100 cfs with four main boils in its 250 feet diameter headspring area. Florida has thirty-three first magnitude springs; Rainbow River is ranked fourth in the state in terms of volume of discharge. A number of vents are located on several small tributaries near the headsprings as well as four or five major vents within the first downstream mile of the main channel (Figure A.4). A small tributary draining a forested area to the east enters Rainbow River approximately 700 feet downstream of the headsprings area. Numerous small, shallow sand boils are the primary generators of its flow. Further downstream (approx. 300 feet) another tributary enters; this system receives the bulk of its flow from four shallow limestone formations including Bubbling Spring. Indian Creek joins the Rainbow from the northeast approximately one mile downstream of the headsprings. A circular depression approximately 70 feet in diameter can be found in Indian Creek about 2000 feet upstream from its confluence with the Rainbow. Two smaller channels extending into the associated wetland and marsh area feed this depression. The water in the pool area is clear, and it is speculated that artesian flow is the main source. Several other small vents discharge into the bed of the river throughout most of its length.

Blue Cove, an old phosphate mine pit, connects to the Rainbow River approximately 4 miles downstream of the headspring. The berm of this pit was removed in the mid-1900s in an effort to increase the water quality within the pit. A plume of turbid water has reportedly been traced from the bridge at SR 484 to the outflow canal of Blue Cove.

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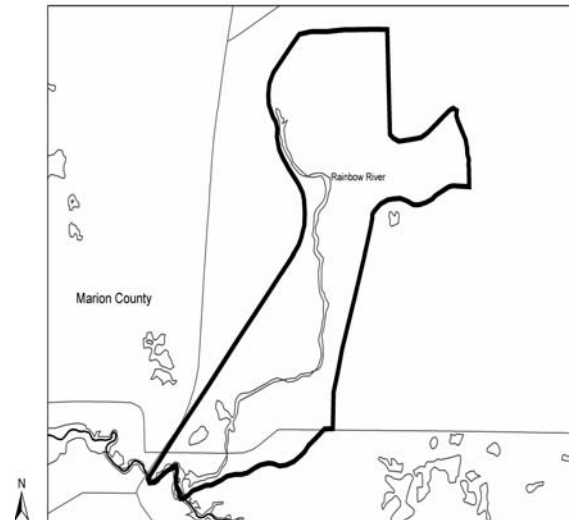
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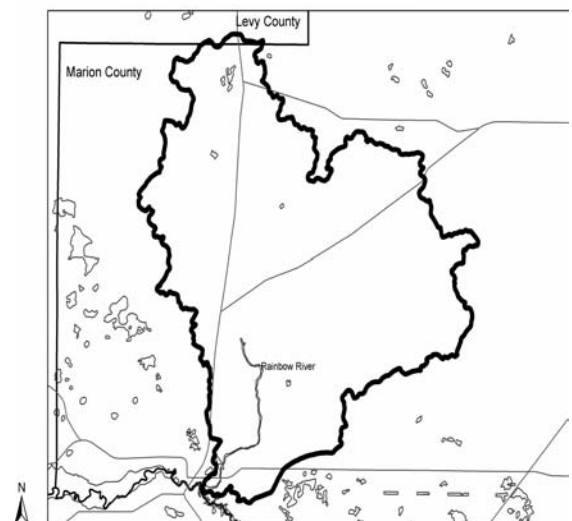
## Appendix B: The Rainbow River Watershed

### Definition of the Management Boundary

The initial focus of the SWIM management effort was within Rainbow River and the immediate watershed (Figure B.1) as defined by Henigar and Ray (1991). The location of this boundary was arbitrarily set and was based on the surface topography and the existence of two railroad grades on the east and west side of the river (Henigar and Ray 1991). This boundary was chosen because typically, the geographic area for management is limited to the watershed directly discharging to the system. However, since Rainbow River is a spring-fed system driven almost entirely by groundwater (Jones et al. 1996), impacts to the groundwater recharge basin have a direct impact on the surface waters within Rainbow River. The immediate groundwater recharge area is approximately 910 square kilometers, or 350 square miles (Jones, et al. 1996), with the total Rainbow Springs groundwater basin having an area of approximately 1,670 square kilometers, or 645 square miles (Faulkner 1973). Managing such a large area is beyond the scope of this SWIM Plan. Presently, there is uncertainty as to the extent and specific boundaries of both the groundwater basin and the immediate recharge area. Furthermore, there is inherent seasonal and inter-annual variation in the location of these groundwater features (Faulkner 1973; Jones et al. 1996). Therefore, for management purposes, this SWIM Plan adopts the Rainbow River watershed as defined by the FDEP Watershed Management Approach (Figure B.2). The Watershed Management Approach uses a statewide comprehensive plan to managing water resources on the basis of surface hydrologic features. The Rainbow River watershed boundary has an area of 190 square kilometers (73.4 square miles) and lies within the USGS defined Withlacoochee Hydrologic Unit (Seaber, et al. 1987; Foose



**Figure B.1. The management boundary as defined by the 1995 SWIM Plan. (Source: Henigar and Ray 1988)**



**Figure B.2. The current SWIM Plan management boundary as defined by the FDEP Watershed Management Approach. (Source: Foose 2000)**

2000). It is understood that the immediate groundwater recharge area is significantly larger than the FDEP defined watershed and that some issues may require the implementation of projects outside the watershed defined here. For example, sources of nitrate reaching the springs could come from anywhere within the immediate recharge area (Jones, et al. 1996). Therefore, certain projects addressing nitrates in groundwater may extend beyond the FDEP watershed boundary.

## Historical Uses

There is archaeological evidence at various sites along the river that prehistoric cultures used the area as early as 7000 – 3000 BC (Dinkins 1997). The discovery of widespread lithic scatter within the area indicates that portions of the area were probably used, at least on a seasonal basis for subsistence hunting and fishing and possibly for habitation.

Settlement by non-Indian settlers was negligible prior to 1830 (Dinkins 1997). After the Spanish cession and the Armed Occupation Act of 1842 – 1843, settlers began to stream into central Florida (Dinkins 1997). Farming was the main occupation with cotton, citrus, grain and peanuts the major crops. Timber and the subsequent distillation of turpentine were significant industries. As a result of the severe winter of 1894 and 1895, all of the commercial citrus groves in the region were destroyed. Many farmers sold their land to phosphate companies that proliferated following the discovery of high-grade phosphate in 1890. Parts of the watershed were extensively mined during what is known as the Dunnellon phosphate boom of the 1890's (Dinkins 1997). Most of these mines were dug by hand, some of which are over 12 meters (40 feet) deep (Figure B.3). For example, Blue Cove, on the west bank of the Rainbow River, is an old mine quarry that is directly connected to the Rainbow River. In addition to the old mine pits, other artifacts of the area's mining days can still be seen. The pilings that supported cable-driven mine cars are still standing in many of the now submerged mine pits and in the lower Rainbow River. Also, the remains of what appears to be a floating barge steam shovel, used in areas where water seepage was a problem, is clearly visible on the bottom of the Rainbow River, just upstream of the river's mouth. World War I and the discovery of pebble rock phosphate in Hillsborough



**Figure B.3. Many mines such as this one were dug by hand using. Dunnellon Phosphate Company, Mine Number 2. (Source: Bowe 1965)**

and Polk Counties officially ended the Dunnellon mining boom, although some phosphate mining continued until 1966 (Dinkins 1997).

The Rainbow Springs complex has been a popular recreation area since the 1890's. A tourist attraction featuring glass bottom boat rides was built in 1934.

Over the years, the park expanded to include a rodeo, bird aviary, and a unique leaf shaped monorail that gave visitors a unique view of the forest canopy (Figure B.4).

The park ceased operations in 1973. Between 1973 and 1990, the headwaters area remained closed to the public. In 1990 the state of Florida purchased 595 acres around the headsprings and



**Figure B.4. Map depicting the former tourist attraction at Rainbow Springs. (Source: Rainbow Springs State Park)**

re-opened the grounds as a state park. In 1992 the state purchased the 310-acre privately owned campground to the south of the headsprings complex and incorporated it as part of Rainbow Springs State Park. Several other parcels have since been purchased by the state and made part of the state park.

## **Present Uses**

The river continues to be a major recreational attraction and provides opportunities for canoeing, boating, tubing, swimming, snorkeling, SCUBA, fishing, and sightseeing. The river can be accessed via KP Hole county park, Rainbow Springs State Park at the headsprings, Rainbow River State Park Campground, the State Road 484 Bridge, the City of Dunnellon Beach, and at the Dunnellon City Park on the Withlacoochee River just downstream from the mouth of the Rainbow River. Both KP Hole and the Dunnellon City Park have boat ramps. Tube rentals are available during the summer at KP Hole. The State park has a swimming area, and canoe and kayak rentals. Rainbow River Campground is owned by the State and is operated under a concession arrangement by Marion County that acquired a 10-year lease beginning in 1992. The campground offers opportunities for swimming, fishing and boating and

provides a canoe launch and rental. There is no boat ramp at the SR 484 Bridge but there is access for tube and canoe pick-up there.

## Population

The population of Marion County has increased from 26,941 in 1910 to 258,916 in 2000, a 861 percent increase (U.S. Bureau of Census 2000). Figure B.5 shows population growth since 1960. The percent increase from 2000 to 1960 is 402 percent. The population in Marion County has increased by 33 percent since 1990 when there was a population of 194,833.

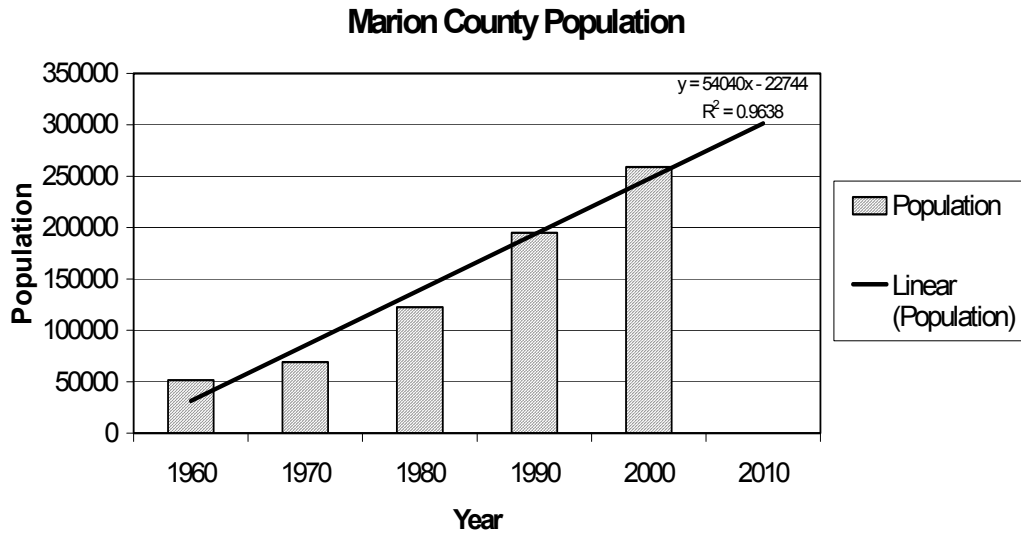


Figure B.5. Marion County population 1960 to 2000. Trendline projects population for 2020 to be 300,000. (Source: U.S. Bureau of Census)

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## Appendix C: Origin of Nitrate Discharging from Rainbow Springs

Although water quality in the river is good, nitrates in Rainbow Springs have steadily increased over the past fifty years. Nitrate concentrations in the headsprings are about 1.0 mg/L (Jones, et al. 1996; SWFWMD 2002, unpublished data) while nitrate concentrations in the 1940's and 1950's have been less than 0.1 mg/L (Odom 1957; Jones et al. 1996). Background nitrate concentrations in the Floridan aquifer are typically less than 0.1mg/L (Jones, et al. 1996). Although current nitrate concentrations in Rainbow Springs are considered low when compared to other River systems statewide, this change represents more than an order of magnitude increase over the past half century. Furthermore, when one considers the total discharge of Rainbow Springs (460 mgd), 1.0 mg/L nitrate results in a total nitrate load of approximately 700 tons annually. This means that the annual nitrate loading into Rainbow Springs today is 700 times greater than it was when nitrates were at background concentrations. Nitrogen isotope analyses, at Rainbow Springs, indicate that inorganic fertilizer is the principle source of nitrate discharging from the Springs (Jones et al. 1996). The St. John's River Water Management District has found similar nitrogen isotope results in Wekiwa Springs, located in Orange County, Florida (Toth and Fortich 2002).

Nutrient inputs to the river originate from the following sources: spring flow, land use activities, atmospheric fallout, and naturally occurring nutrients on the land surface and/or within the soils and sediments. Water and Air Research (WAR 1991) concluded that the sheer volume of water contributed by the springs made them the most significant source of nitrogen and phosphorus to the spring run, 85 percent of the annual nitrogen load and 83 percent of the total phosphorus load, respectively. Using worst case assumptions, (failure of all septic systems within 500 feet of the river), it was estimated that the septic systems along the river contributed, at most, 7 percent of the total nitrogen load and 8 percent of the total phosphorus load.

Nitrogen isotopes were measured in five springs in the Rainbow Complex and 19 wells in the recharge area (Jones, et al. 1996). The mean  $\delta^{15}\text{N}$  value for the springs was +1.9ppt with a range of +0.7ppt to +2.6ppt. For well water, the mean  $\delta^{15}\text{N}$  was +2.4ppt with a range of -0.5ppt to +7.7ppt. Ratios of  $\delta^{15}\text{N}$  from +2.0 and below are primarily from inorganic fertilizer (Tihansky and Sacks 1997). Therefore, the principle source of nitrate entering Rainbow Springs is inorganic nitrogen (Jones, et al. 1996). This inorganic nitrogen is primarily from fertilizer used in agricultural applications, although it is also used in residential and golf course turf fertilization as well. Nitrogen inputs from septic tank effluent and sewage effluent disposal do not appear to be significantly contributing to the nitrates entering the springs (Jones, et al. 1996). However, as residential and commercial development continues to increase, contributions of nitrogen from

residential and golf course fertilization, septic tank effluent, and sewage disposal will also increase.

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## Appendix D: Vegetation and Sediments in the Rainbow River

Several projects have been designed and implemented to better understand the vegetative communities in the Rainbow River. These efforts include an ongoing mapping project to identify changes in plant distribution and abundance, continued control of invasive species such as *Hydrilla verticillata* and *Lyngbya* sp., re-vegetation projects with native *Sagittaria kurziana*, and studies to identify controls on the growth of the blue-green alga *Lyngbya* sp. (Cowel 1990; Cowel and Dawes 2002).

### Vegetation Mapping

Vegetation mapping in 1996 and 2000 was completed in coordination with the Florida Department of Environmental Protection Rainbow Springs Aquatic Preserve. Vegetation polygons were delineated along the river using aerial photography and ground truthing. The percent cover class for each submerged aquatic species within a given polygon was estimated (Table 1). Results of the 1996 mapping effort indicated that *Sagittaria kurziana* (strap-leaf sagittaria), *Hydrilla verticillata*, and *Vallisneria americana* (eelgrass) were the most extensive submersed species on the Rainbow River, occurring in 57% (79.6 acres), 37% (51.9 acres), and 17% (23.8) of the river respectively (PBS&J 2000). *Ceratophyllum demersum* (coontail), *Najas guadalupensis* (southern naiad), and *Chara* sp. each occurred in about 8% to 13% (11 acres to 19 acres) of the river (PBS&J 2000). *Potamogeton illinoensis* (Illinois pondweed), *Ludwigia repens* (red ludwigia), *Myriophyllum* sp., *Utricularia* sp., and *Nasturtium* sp. were found only in the headsprings complex and occurred in less than 4% (less than 6 acres) of the entire river. *Sagittaria kurziana* was predominant in the upper two thirds of the river and decreased to negligible amounts downstream where *Hydrilla verticillata* was the dominant species. Bare sand and rock could be found in 8% (10.7 acres) of the river. Emergent vegetation totaled 51.4 acres, 26.8 acres of which was primarily woody, and 24.6 acres of which was herbaceous (PBS&J 2000).

Results of the 2000 mapping effort showed a decrease in occurrence for most of the aquatic and emergent species (Table D.1). Specifically, *Sagittaria kurziana* and *Vallisneria Americana* decreased 4% (5.75 acres) and 5% (7.2 acres) respectively. Most of the decrease in occurrence of these two species was concentrated downstream of Blue Cove and just north of Sateke Village (Figure D.1). Conversely, there was a slight increase in the occurrence of *Sagittaria kurziana* in the vicinity of the “narrows” just above Blue Cove (PBS&J 2000). The only coverage class that increased in occurrence was bare substrate which increased by about 4% (Table D.1).

The greatest decrease in aerial coverage was for *Ceratophyllum demersum* (coontail) followed by *Najas guadalupensis* (southern naiad) (Table D.1). *Chara*

sp. showed a 4% decrease in occurrence. While these species are not dominant in the Rainbow River in terms of percent cover, this decline in occurrence is significant and will continue to be monitored.

Although the overall occurrence of *Hydrilla* did not change significantly, the 2000 results showed that the species expanded in certain locations, for example, along the western bank upstream from Devils Elbow, and near Rio Vista (Figure D.2). In 2000, the presence and dominance of *Hydrilla*, across the entire width of the river, extended approximately 500 feet upstream (FDEP 2000). Further impacts of *Hydrilla* on the Rainbow River are discussed below. Coverage along the upper sections is variable, typically increasing in density in areas where it had been less well established in 1996, such as above Blue Cove. In 2000, bare substrate was present near the confluence with the Withlacoochee River, where *Hydrilla* had previously dominated (Figure D.2). Also, in the main channel, approximately 350 meters upstream of the Rainbow River's mouth, bare substrate had replaced *Hydrilla* (Figure D.2). This shift from *Hydrilla* to bare substrate may be caused by changes in sediment accumulation rates. A build up of silt can cause sub-optimal conditions for the growth of submerged aquatic vegetation. Herbicide treatments are routinely made in this area of the river to control for *Hydrilla*, which may add to the organic sediment layer. It should be noted, however, that the abundance and distribution of *Hydrilla* varies greatly from year to year (FDEP, unpublished data) and any conclusions drawn solely from the 1996 and 2000 mapping efforts should be made with caution.

Increases in bare substrate in the headsprings complex coincides with a change in the boundary of the swimming area regulated by the Rainbow Springs State Park. Bare patches throughout the remainder of the river, previously documented as rock and/or sand, have changed only slightly in size and shape. Areas of bare substrate correlate well with areas of heavy recreational use, specifically, designated swimming areas. By concentrating these recreational activities, the impact these activities have on vegetation is limited to only a few locations along the river.

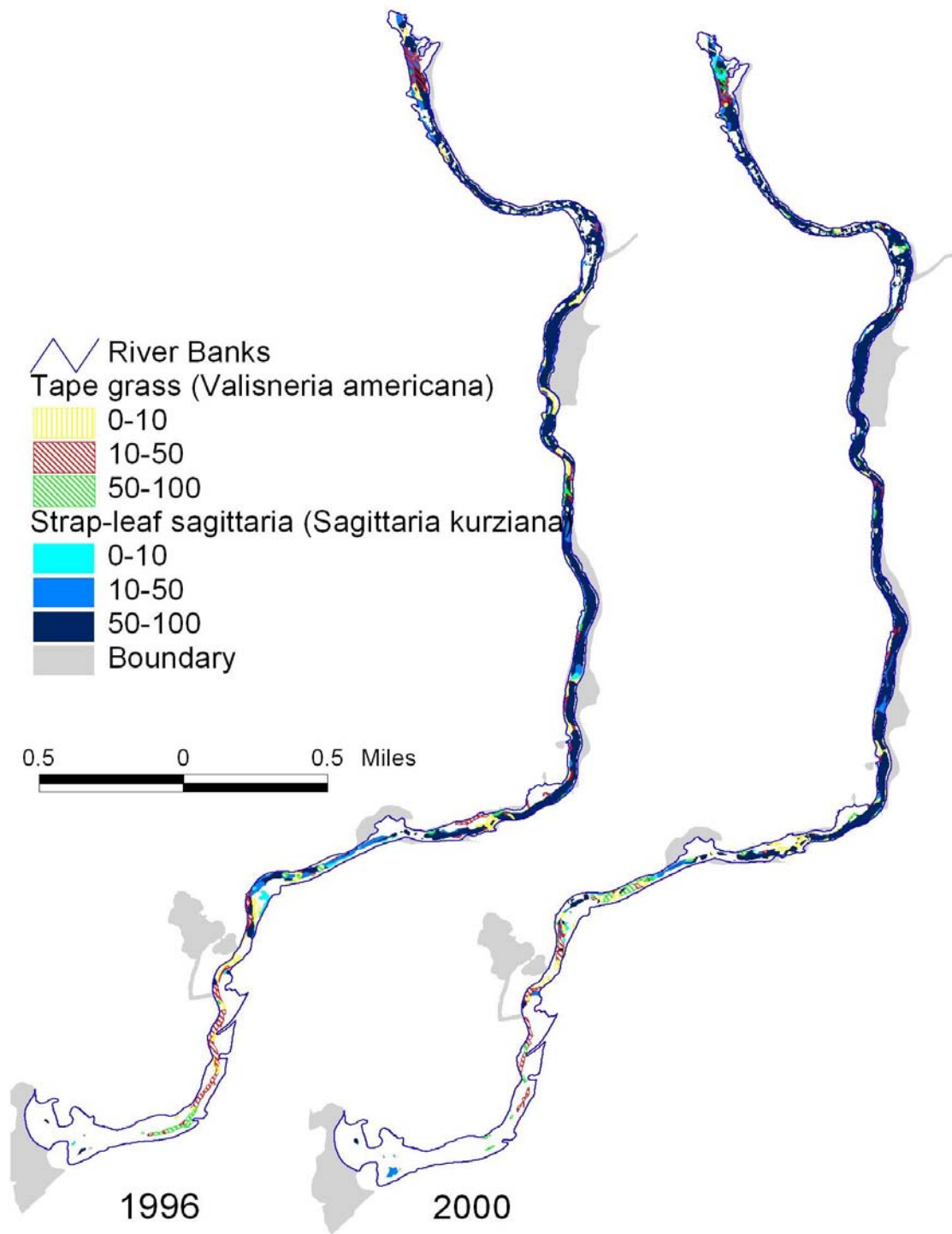
Epiphyte coverage, benthic algal mat thickness and percent coverage of substrate were also measured in 2000 (Table 3; FDEP 2000). Since there are no earlier data available to compare with the 2000 data, they will serve as baseline information for future mapping projects.

	1 to 10 Percent Cover					10 to 50 Percent Cover					50 to 100 Percent Cover					1 to 100 Percent Cover				
	1996		2000		Change	1996		2000		Change	1996		2000		Change	1996		2000		Change
<b>Submersed Species</b>	<b>Acres</b>	<b>%</b>	<b>Acres</b>	<b>%</b>	<b>Acres</b>	<b>Acres</b>	<b>%</b>	<b>Acres</b>	<b>%</b>	<b>Acres</b>	<b>Acres</b>	<b>%</b>	<b>Acres</b>	<b>%</b>	<b>Acres</b>	<b>Acres</b>	<b>%</b>	<b>Acres</b>	<b>%</b>	<b>Acres</b>
<i>Sagittaria kurziana</i>	5.70	4.1	4.16	3.0	<b>-1.54</b>	12.28	8.7	7.79	5.6	<b>-4.49</b>	61.57	43.9	61.85	44.1	<b>0.28</b>	79.55	<b>56.7</b>	73.80	<b>52.7</b>	<b>-5.75</b>
<i>Vallisneria americana</i>	9.74	6.9	5.55	4.0	<b>-4.19</b>	11.01	7.8	6.29	4.5	<b>-4.72</b>	3.02	2.1	4.74	3.4	<b>1.72</b>	23.77	<b>16.9</b>	16.58	<b>11.8</b>	<b>-7.19</b>
<i>Hydrilla verticillata</i>	17.18	12.2	13.18	9.4	<b>-4.00</b>	9.33	6.6	11.59	8.3	<b>2.26</b>	25.42	18.1	27.20	19.4	<b>1.78</b>	51.93	<b>37</b>	51.97	<b>37.1</b>	<b>0.04</b>
<i>Najas guadalupensis</i>	9.29	6.6	1.93	1.4	<b>-7.36</b>	1.93	1.4	0.78	0.6	<b>-1.15</b>	1.93	1.4	0.80	0.6	<b>-1.13</b>	13.15	<b>9.37</b>	3.51	<b>2.5</b>	<b>-9.64</b>
<i>Potamogeton illinoensis</i>	0.00	0.0	0.07	0.0	<b>0.07</b>	0.93	0.7	0.34	0.2	<b>-0.59</b>	0.37	0.3	0.81	0.6	<b>0.44</b>	1.30	<b>0.93</b>	1.22	<b>0.9</b>	<b>-0.08</b>
<i>Ceratophyllum demersum</i>	13.84	9.9	3.52	2.5	<b>-10.32</b>	4.04	2.9	2.62	1.9	<b>-1.42</b>	0.97	0.7	0.80	0.6	<b>-0.17</b>	18.85	<b>13.4</b>	6.94	<b>5.0</b>	<b>-11.91</b>
<i>Ludwigia repens</i>	0.52	0.4	0.11	0.1	<b>-0.41</b>	0.11	0.1	0.21	0.1	<b>0.10</b>	0.00	0.0	0.00	0.0	<b>0.00</b>	0.63	<b>0.45</b>	0.32	<b>0.2</b>	<b>-0.31</b>
<i>Myriophyllum</i> sp.	0.18	0.1	0.06	0.0	<b>-0.12</b>	0.00	0.0	0.06	0.0	<b>0.06</b>	0.00	0.0	0.00	0.0	<b>0.00</b>	0.18	<b>0.13</b>	0.12	<b>0.1</b>	<b>-0.06</b>
<i>Chara</i> sp.	7.55	5.4	1.29	0.9	<b>-6.26</b>	3.30	2.3	2.15	1.5	<b>-1.15</b>	0.00	0.0	1.78	1.3	<b>1.78</b>	10.85	<b>7.73</b>	5.22	<b>3.7</b>	<b>-5.63</b>
<i>Utricularia</i> sp.	0.52	0.4	0.31	0.2	<b>-0.21</b>	2.02	1.4	0.42	0.3	<b>-1.60</b>	0.49	0.3	0.00	0.0	<b>-0.49</b>	3.03	<b>2.15</b>	0.73	<b>0.5</b>	<b>-2.30</b>
<i>Nasturtium</i> sp.	0.05	0.0	0.00	0.0	<b>-0.05</b>	0.00	0.0	0.00	0.0	<b>0.00</b>	0.00	0.0	0.00	0.0	<b>0.00</b>	0.05	<b>0.04</b>	0.00	<b>0.0</b>	<b>-0.05</b>
Total bare substrate																10.68	<b>7.61</b>	15.85	<b>11.3</b>	<b>5.17</b>
																Total submersed area		140.39	140.13	

	1996		2000		Change
<b>Emergent Vegetation</b>	<b>Acres</b>	<b>%</b>	<b>Acres</b>	<b>%</b>	<b>Acres</b>
Herbaceous	24.64	47.9	25.09	49.0	<b>0.45</b>
Woody	26.78	52.1	26.08	51.0	<b>-0.70</b>
Total emergent vegetation	51.42	100.0	51.17	100.0	<b>-0.25</b>

Table D.1. Submerged aquatic species and emergent vegetation cover for 1996 and in 2000 (FDEP 2000). Vegetation polygons were delineated based on aerial photography. Species were identified and percent cover estimated for each polygon. Submerged vegetation coverage classes were used to categorize each polygon. These classes are 1-10, 10-50, and 50-100 percent cover. Emergent vegetation was classified as either herbaceous or woody. (Source: PBS&J 2000)



**Figure D.1. *Sagittaria kurziana* and *Vallisneria americana* coverage in Rainbow River for 1996 and 2000. (Source: PBS&J 2000)**

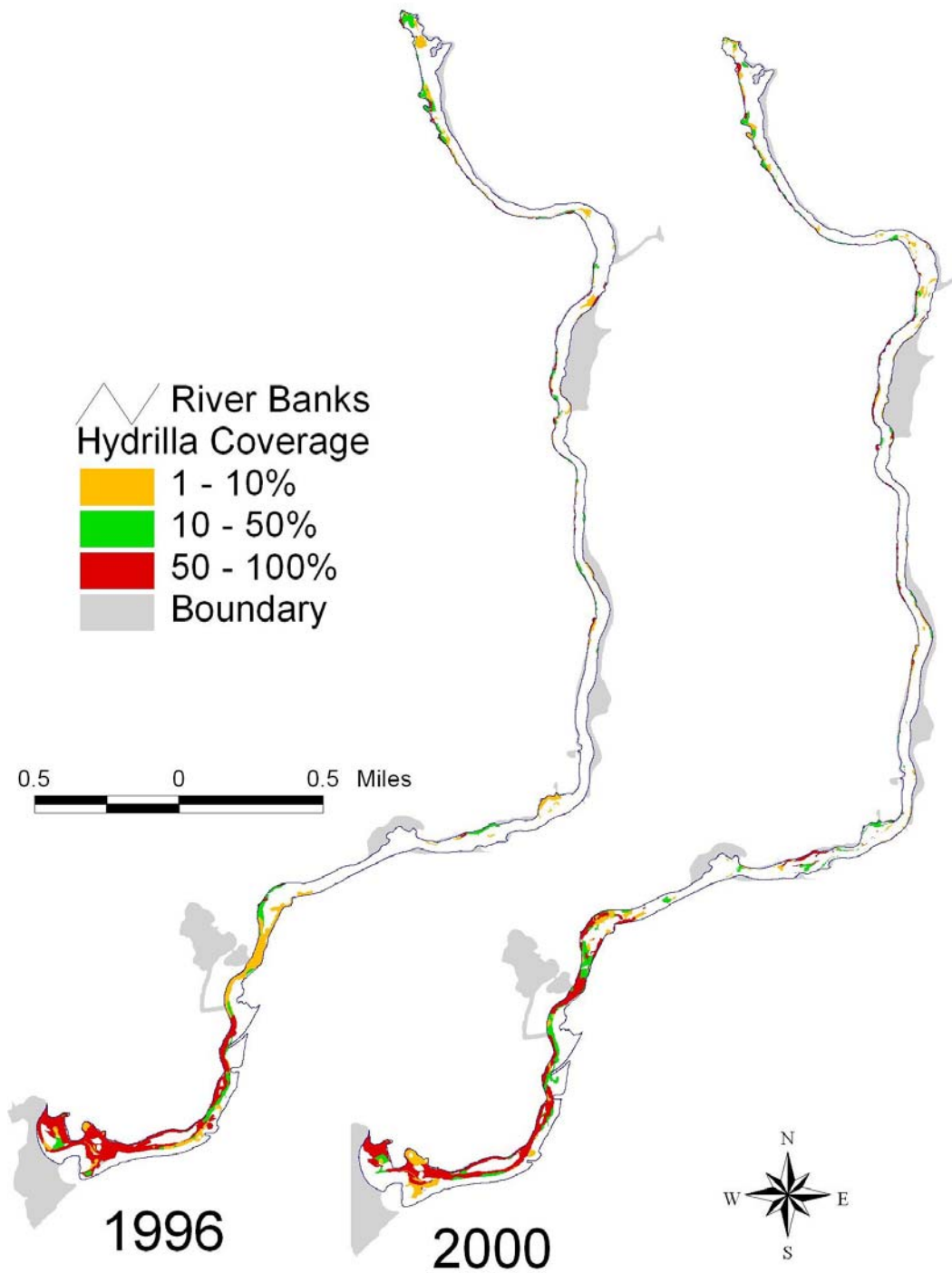


Figure D.2. *Hydrilla* coverage in Rainbow River for 1996 and 2000 (Source: PBS&J 2000).

## Hydrilla and the Rainbow River

*Hydrilla verticillata*, a submersed aquatic plant native to Africa and Southeast Asia, was brought into the United States by aquarium plant horticulturists in the early 1950's. By the early 1990's occupied 140,000 acres of public lakes and rivers in Florida (FDEP Bureau of Aquatic Plant Management). *Hydrilla* can clog drainage and residential canals, preclude boating access for fishing and other water-related recreation, impede navigation, and crowd out desirable native vegetation. *Hydrilla* was first noted in Rainbow River in the 1970's and is now present in approximately 52 acres. *Hydrilla* has the ability to grow up to an inch per day and this high growth rate allows *Hydrilla* to out-compete native submerged aquatic species (Figure D.3). *Hydrilla* is spread primarily by asexual reproduction that is accelerated through fragmentation from boating activities. The reproductive structures of *Hydrilla* are turions, small prickly structures that grow along the stem, and tubers, which are underground structures that can lie dormant for several years. *Hydrilla* is extremely difficult to control because of its rapid growth rate and reproductive strategy.



**Figure D.3. *Hydrilla* growing in the Rainbow River. Photograph taken downstream of KP Hole in the lower portion of the river.**

In Rainbow River, the 450 mgd spring discharge and fast flowing water further complicate *Hydrilla* management techniques. Normal treatment strategies are not adequate for this system and only slow the pace of *Hydrilla*'s spread at best. Currently the District treats areas below the SR 484 Bridge with Aquathol Super K, a granular aquatic herbicide, when the plant impedes navigation. The area upriver of the SR 484 Bridge is treated only when requested by FDEP Aquatic Preserve staff. Single herbicide applications to treat the small, scattered *Hydrilla* infestations present on the upper sections of the river have provided inconsistent results due to the lack of sufficient herbicide concentration and contact time. Treating larger sections of the river or utilizing a continuous herbicide drip application to treat the entire river would result in more consistent *Hydrilla* control. However, these application methods also have the potential to increase impacts on some of the non-target, native plant species. FDEP and District aquatic plant control staff have considered the feasibility of conducting more aggressive *Hydrilla* control operations on the upper section of the Rainbow River. Given the small amount of hydrilla and abundant native species populations present on the upper river, large-scale treatments are not considered feasible at this time.

Unfortunately, this does not deal with the immediacy of the *Hydrilla* problem on Rainbow River. Only four techniques are available for control of undesirable

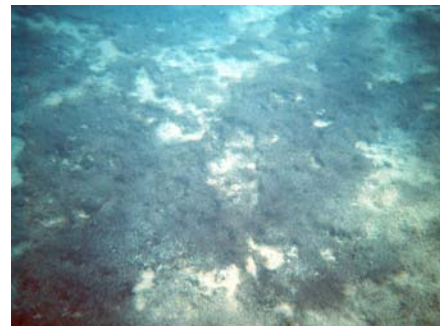
aquatic plants. These are: 1) herbicide treatment, 2) biocontrol using insects which attack only the target plant, 3) bio-control using triploid grass carp, and 4) physical removal or harvesting. Note however, the use of grass carp in an open system would not be recommended since they could move downstream into other systems. In addition, grass carp do not target specific species of vegetation and would be detrimental to native vegetation.

*Hydrilla* is present from the headsprings to the confluence with the Withlacoochee River; however, it dominates in the last mile south of County Road Bridge 484. Upstream of this area, *Hydrilla* tends to be found near the shoreline especially along seawalls and around boat docks (WAR 1991). This indicates that *Hydrilla* tends to be present in higher quantities in disturbed areas, at least upstream of SR484, thus the importance of protecting native vegetation and minimizing disturbances.

### **Lyngbya species**

Species of *Lyngbya* are filamentous alga that develop as thick mats on river bottoms and over submerged aquatic vegetation (Figure D.4). *Lyngbya* sp. is a ubiquitous cyanobacteria (blue-green algae) and, along with *Hydrilla*, is a major threat to native submerged aquatic vegetation throughout the river.

These mats may detach from the bottom or vegetation to which they are attached and enter the water column. Once floating, these mats are carried downriver impeding navigation, impairing the recreational use of the water body, and often accumulating around emergent and submerged vegetation. The accumulation of *Lyngbya* on and around emergent and submerged vegetation can uproot, weigh down, or smother the vegetation. Upon decomposition the algal cells release a compound (geosmin) that has a strong musty odor that further impairs the aesthetic value of the water body (Romie 1990).



**Figure D.4. *Lyngbya* sp. growing in the Rainbow River. Photograph taken downstream of KP Hole in the lower portion of the river.**

*Lyngbya* sp. have been identified in the Northeast United States as early as the 1870's and are now distributed throughout the Southeast. In Rainbow River, *Lyngbya* has been common in the headspring area since the early 1990s. Currently, there is insufficient evidence to determine whether *Lyngbya* is native to the Rainbow River. It is also uncertain as to whether *Lyngbya* has been expanding in the Rainbow River over the past 10 years. The 1996 and 2000 mapping project included a specific category for *Lyngbya* and other algae. This baseline information can be compared to data from future mapping efforts to identify changes in distribution and abundance of *Lyngbya* in the Rainbow River.

Benthic algal mats were found in 19 of 20 transects in the Rainbow River during the 2000 vegetative mapping project (Table D.2). Thickness of the algal mats ranged from 0.17 cm to 10.14 cm, and averaged 4.17 to 100.00 percent of the ground cover. Epiphytic algae coverage averaged 5.00 to 29.29 percent of leaf cover in the upper half of leaf blades of the submerged aquatic vegetation (SAV). Epiphytic algae on the lower half of the blades of the SAV ranged from 28.47 to 78.33 average percent leaf cover. The highest percent epiphytic coverage was found at transects 1, and 12 through 19.

Transect Number	<u>Benthic Algal Mat Distribution</u>			<u>Epiphytic Algal Coverage on SAV Leaf Area</u>			
	Average Thickness (cm)	Average % Ground Coverage	Percentage of algae versus silt	Upper Half of SAV Profile		Lower Half of SAV Profile	
				Average Filament Length (cm)	Average % Leaf Coverage	Average Filament Length (cm)	Average % Leaf Coverage
1	1.14	14.29	43.00	0.86	17.14	1.29	61.43
2	6.83	97.5	100.00	1.00	8.33	2.17	35.83
3	0.83	25.00	16.67	1.17	11.67	2.17	49.17
4	0.17	4.17	16.67	0.50	14.17	1.50	48.33
5	0.00	0.00	0.00	0.50	5.00	1.00	30.83
6	0.33	16.67	11.17	0.42	9.17	1.00	28.47
7	2.14	64.29	57.29	1.14	10.00	1.71	32.14
8	10.14	100.00	95.29	2.29	15.71	2.86	46.43
9	6.67	50.00	50.00	1.33	12.50	2.00	55.00
10	8.29	85.71	52.57	1.86	15.71	2.71	44.29
11	9.71	70.12	64.43	0.31	2.62	1.79	43.21
12	2.83	50.00	44.50	0.67	20.83	1.50	55.00
13	9.83	83.33	83.33	3.00	18.33	2.83	66.67
14	6.83	75.83	89.00	3.17	23.33	2.50	78.33
15	8.00	75.00	81.00	3.00	20.71	4.00	55.00
16	4.14	67.14	85.71	5.29	29.29	3.86	49.29
17	4.57	85.71	85.71	4.14	22.14	3.43	47.86
18	8.43	85.71	81.00	2.14	13.57	3.00	47.86
19	4.29	66.43	66.71	3.14	27.86	2.71	58.57
20	1.00	14.29	14.29	4.71	14.29	3.71	37.86

**Table D.2. Data for benthic and epiphytic filamentous algae coverage from 20 transects on the Rainbow River (FDEP 2000).**

Several field and laboratory studies have been and are being conducted to determine the factors that affect the growth of *Lyngbya*. In field investigations, (Cowell 1990) specific conductivity and the abundance of *Hydrilla* accounted for almost 62 percent of the variability in *Lyngbya* biomass; no nutrient/*Lyngbya sp.* relationships were revealed by multiple regression analysis. In contrast to the field investigations, which did not establish a nutrient/*Lyngbya* relationship, follow up laboratory studies by Cowell (1990) suggested that *Lyngbya* growth can increase with increasing nitrate and calcium concentrations. Cowell and Dawes, at the University of South Florida, completed a *Lyngbya* bioassessment study in

2002. When relatively pure *Lyngbya* cultures were used, increases in nitrate concentrations resulted in increases in biomass. However, work with intact algal mats did not produce any significant relationships between nutrients and *Lyngbya* biomass. Additionally, preliminary reconnaissance data from the SWFWMD indicate that *Lyngbya* sp. are prevalent in spring runs irrespective of water column nitrate concentrations (SWFWMD, unpublished data).

Water movement is a major physical factor affecting the distribution of *Lyngbya* sp. in the Rainbow River. Floating mats may be transported downriver and then sink to the bottom forming new monospecific stands of *Lyngbya* sp. This mechanism can increase its distribution. This could explain why in a system like Silver Glen, where nitrate concentrations are very low (<0.05 mg/L), *Lyngbya* sp. are so prevalent.

*Lyngbya* sp. may be a stress tolerant organism (Larry Dyck, Clemson University, personal communication). In severely stressed systems, *Lyngbya* have even been able to expand. Both natural and anthropogenic forces can stress aquatic systems. For example, drought, severe pollutant loading, and increases in recreational pressures and disturbances can all be stressors to aquatic systems.

Cowell (1990) made several recommendations regarding the management and restoration of *Lyngbya* sp. infested areas. These included the removal of bottom mats of *Lyngbya* sp., the prevention of movement of floating *Lyngbya* sp. mats, hydraulic dredging of sediments, and planting of native macrophytes. Other recommendations include the establishment of long-term quantitative monitoring, laboratory and in-situ bioassays, and the continuation of mechanical harvesting and herbicide. It should be noted, however, to date, there have been no documented restoration projects that have successfully removed *Lyngbya* sp. from spring-fed systems.

## Re-vegetation

Several projects to re-establish native emergent and submerged aquatic vegetation (SAV) species have been completed since the 1995 SWIM Plan update. Emergent vegetation was planted at the Rainbow River Campground to minimize shoreline erosion and prevent stormwater runoff (Figure D.5). Species such as *Paspalidium geminatum*



**Figure D.5. SWIM staff conducting a re-vegetation experiment in the Rainbow River.**

(Egyptian paspalidium), and *Scirpus* sp. (Bulrush) were planted in several areas where vegetation had been impacted from floating vegetation mats, recreation, or other

forms of defoliation.

Re-vegetation experiments using the SAV species *Sagittaria kurziana* have been conducted by the Rainbow Springs Aquatic Preserve. Initial survival was high when efforts were made to prevent fouling and uprooting of the transplanted *Sagittaria* (Sleszynski 2001). However, unlike the more successful emergent re-vegetation efforts, survivorship of SAV decreased over time. It is unlikely that the transplanted beds became established in the river. Therefore, since SAV re-vegetation, to date, has not been successful, protection of native aquatic vegetation is of the utmost importance. As the levels of recreation increase on the Rainbow River, efforts need to be made to minimize the disturbance to the native plant communities. These efforts may include educational projects, buoys to restrict traffic in sensitive areas, and structures to control the use of the resources (i.e. mooring buoys, shallow water signs).

### **Sediment Chemistry and Accumulation**

The City of Dunnellon historically discharged treated effluent from its wastewater treatment plant into the Rainbow River. To determine if sediments had been contaminated and posed an ecological threat to the health of the Rainbow River, sediment samples were collected and analyzed upstream and downstream of the discharge point. Two sites were sampled upstream of the former discharge point (one in the headsprings area and one downstream of Sat eke Village) to establish background levels of selected constituents. Four sites were located downstream of the discharge point at varying distances to just upstream of the confluence with the Withlacoochee River. Sites are described in detail in WAR (1991).

Sediments were essentially free of contaminants based on a comparison with upstream “background” sites. There was a general trend of decreasing arsenic, chromium, lead and nickel from upstream to downstream. All organic parameters analyzed for were below detection limits. Results indicate that sediments in Rainbow River downstream of the site of historic discharge are not measurably contaminated and as such pose no significant ecological problems.

Sediment appears to have accumulated in the lower portions and other low energy areas of the river. Although natural deposition of sediment in these areas is expected due to decreased flow velocities, sediments may negatively impact water clarity and the native plant communities. Re-suspension of fine sediments may contribute to decreased water clarity in certain areas of the river. WAR (1991) performed grain size analysis of sediment samples and found that upstream of the historic WWTP outfall, sediments were primarily fine sand while stations below the outfall site were mainly fine sand and silt. This study included sediment analyses of samples collected at six locations in the river, focusing on the lower mile of the river, with only two stations in the remaining 4.7 miles. This

study does not provide information on sediments in other potentially impacted areas of the river, such as Blue Cove, or other upstream, low energy areas. Additional diagnostic work is needed to better understand potential issues associated with sediment, especially as it relates to the long-term health of the river.

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## **Appendix E: Classifications and Designations**

### **STATE:**

**Class III Waters:** All Florida waters are classified according to their designated uses under the Florida Administrative Code 62-302.400 (Classification of Surface Waters, Usage, Reclassification, Classified Waters). Rainbow River is classified as a Class III water: Recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife.

**Outstanding Florida Waters (OFW):** An Outstanding Florida Water is water designated worthy of special protection because of its natural attributes. This special designation is applied to certain waters with the intent of maintaining existing good water quality under the Florida Administrative Code 62-302.700 (Special protection, Outstanding Florida Waters, Outstanding National Resource Waters). Rainbow River was designated an OFW in 1988.

**Aquatic Preserve:** To protect these distinctive natural features for the enjoyment of future generations, the Florida Legislature created aquatic preserves under the Florida Aquatic Preserve Act of 1975 (section 258.35, Florida Statutes). Aquatic preserves are submerged lands of exceptional beauty, which are to be maintained in their natural or existing conditions. Rainbow River was designated an Aquatic Preserve in 1986.

**Surface Water Improvement and Management (SWIM) Program Priority Waterbody:** Please see Introduction: SWIM Act, page 1 of document for detailed description.

### **FEDERAL:**

**National Natural Landmark (NNL):** A National Natural Landmark is a nationally significant natural area that has been designated by the Secretary of the Interior of the United States. To be nationally significant, a site must be one of the best examples of a type of biotic community or geologic feature in its physiographic province. This designation was established by the Secretary of the Interior in 1962, under authority of the Historic Sites Act of 1935 (16 U.S.C. 461-467), and administered by the National Park Service. (The revised National Natural Landmark Program Regulations, 36 CFR, Part 62, were published in the Federal Register May 12, 1999). To date, 587 sites have been designated and NNL's. Rainbow River was designated a NNL in 1972.

## **Appendix F: Regulatory Jurisdictions**

### **FEDERAL**

Federal jurisdiction in Rainbow River involves the regulatory responsibilities of the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the U.S. Coast Guard, and the U.S. Fish and Wildlife Service their main regulatory functions include overseeing dredge and fill activities, maintaining navigability of the waters of the U.S., overseeing cleanups following pollution spills, protecting endangered species, and protecting overall environmental quality. These agencies, in conjunction with the U.S. Geological Survey, also contribute to the collection of technical data concerning the Rainbow River and its watershed.

#### **U.S. Army Corps of Engineers (ACOE)**

“Projects constructed by the U.S. Army Corps of Engineers for local flood protection are subject to regulations prescribed to cover operation and maintenance. These regulations are contained in Sections 208.10 and 208.11, Title 33 of the Code of Federal Regulations” (US Corps of Engineers 1987).

The U.S. Army Corps of Engineers received jurisdiction over Inland Waters of the United States, for navigation purposes, in Section 9 and 10 of the Rivers and Harbors Act of 1899. A revision of the Rivers and Harbors Act in 1968 extended Corps jurisdiction allowing them to consider the fish and wildlife, conservation, pollution, aesthetics, ecology and other relevant factors of a project. The Corps regulatory program was further expanded in 1972 with the passage of the Federal Water Pollution Control Act Amendments, also known as the Clean Water Act (CWA). The discharge of dredge and fill into United States waters is regulated by the Corps under Section 404 of this act. The Corps jurisdiction was extended to wetlands due to a Supreme Court order in 1975 and Amendments to the CWA in 1977 (Barile et al. 1987). The Corps also contributes 50% of the funds reimbursed to SWFWMD by FDEP for exotic aquatic plant control on Rainbow River.

#### **U.S. Environmental Protection Agency (EPA)**

The Environmental Protection Agency (Southeast Regional Office, Region IV, Atlanta, Georgia) has jurisdiction over surface waters in the state. Enforcement authority was given under the Clean Water Act of 1972 and broadened under its revision in 1977. Key activities include the issuance of National Pollution Discharge Elimination System (NPDES) permits and restoration of surface and groundwater. The agency also reviews Corps of Engineers permit activities, sets minimum quality standards, and sets guidelines for state environmental

programs. The EPA also funds sewerage facilities' studies through the SWFRPC and the TBRPC, and system improvements through the Florida Department of Environmental Protection. Authority regarding the discharge of oil or hazardous substances into surface water is divided between the EPA and the US Coast Guard (Barile *et al.* 1987).

### **U.S. Coast Guard**

In inland waters the Coast Guard Auxiliary performs boating safety inspections and search and rescue missions. The Auxiliary is a volunteer group reimbursed expenses when assigned missions by the U.S. Coast Guard (Barile *et al.* 1987).

### **U.S. Fish and Wildlife (FWS)**

The US Fish and Wildlife Service is responsible for oversight of the federal program for fish and wildlife as authorized in the Coastal Resources Barrier Act, National Environmental Protection Act, Migratory Bird Act, Endangered Species Act, and Fish and Wildlife Coordination Act. "Under provisions of the Fish and Wildlife Coordination Act, the Fish and Wildlife Service must be consulted before the Corps of Engineers can submit a plan for Congressional approval. The Fish and Wildlife Service comments on the impacts of proposed projects on endangered species, migratory birds and other fish and wildlife and their habitats" (Barile *et al.* 1987). The Fish and Wildlife Service is directed to prepare environmental impacts assessments or statements for proposed Corps projects under provisions of the National Environmental Protection Act, and the Fish and Wildlife Service is authorized under the Endangered Species Act to issue "Jeopardy Opinion" against any proposed project which will negatively affect an endangered species (Barile *et al.* 1987).

## **STATE AGENCIES**

Many state agencies are involved in environmental regulation and resource management in the Rainbow River watershed. The Florida Department of Environmental Protection is the lead agency in the protection and management of Rainbow River. Other relevant entities include the Florida Department of Agriculture and Consumer Services, the Florida Department of Community Affairs, the Florida Fish and Wildlife Conservation Commission, the Florida Department of Health, and the Florida Department of Transportation.

### **Department of Agriculture and Consumer Services (DACS)**

The Department, through its Division of Agriculture and Environmental Services (AES) regulates the registration and use of pesticides, including the purchase of restricted pesticides, maintains registration and quality control of fertilizers, regulates pest control operations, mosquito control, and evaluates and manages environmental impacts associated with agrochemicals.

Through the Division of Forestry, the DACS is responsible for developing Best Management Practices (BMP's) to control forestry-related non-point source pollution. The Division of Forestry is also responsible for statewide implementation of BMP's, and for monitoring public and private forestry operations to determine BMP compliance and effectiveness. The Division of Forestry manages Florida's 34 State Forests and several other parcels of public land.

The Division of Plant Industry is responsible for, among other duties, regulation of the movement of noxious weeds, and, with input from the Endangered Plant Advisory Council, protecting endangered, threatened or commercially exploited plant species.

The Office of Water Policy Coordination is responsible for participating in water policy issues to ensure the availability of an adequate supply and quality of water for the production of food and fiber. The office cooperates with agencies and agricultural producers to make available streamlined agricultural regulatory processes and voluntary, incentive-based, acceptable alternative and agricultural BMP's consistent with the sustainability of agriculture and resource conservation. The office provides assistance to Soil and Water Conservation Districts, including the Tampa and the Manatee River Districts, in carrying out conservation activities at the local and watershed level, and providing improved local delivery of resource management services to agricultural producers. The office facilitates the participation of Soil and Water Conservation Districts in water-related issues at the County or watershed level.

### **Department of Community Affairs (DCA)**

This Department is responsible for reviewing local comprehensive plans and has jurisdiction over developments of regional impact (DRIs). DRI investigations are concerned with proposed developments that have the potential to affect the health, safety, or welfare of citizens of more than one county.

### **Florida Department of Environmental Protection (FDEP)**

This agency has three management jurisdictions along the Rainbow River:

#### ***Office of Coastal and Aquatic Managed Areas***

The entire length of the Rainbow River was designated an Aquatic Preserve in 1986 (FS 258.39(32)). This management area represents all sovereign submerged state-owned lands along the river's length. The managerial intent of the designation is for these areas to be set aside and maintained in their natural or existing condition. Management efforts by this office focus on resource

management and study of the ecological communities, and community environmental education.

### ***Division of Recreation and Parks***

Approximately 1000 acres of upland property adjacent to the river were purchased by the state in 1990, and are now managed as Rainbow Springs State Park. The park is divided into three management units. The headsprings are mainly managed for the swimming area, canoe dock, ornamental gardens and picnicking pavilions. A second area one mile downstream has 105 camping sites and is currently being managed by Marion County. The third area, further downstream, is a mixture of undeveloped sandhill and floodplain forest community.

### ***Division of Water Resource Management***

The Southwest District Office in Tampa has responsibility for proprietary and regulatory permitting issues in the Rainbow River area.

### **Department of Health (DOH)**

The Department of Health responsibilities include the public health functions of water supplies (primarily small to medium supplies), onsite sewage disposal, septic tank cleaning and waste disposal (in conjunction with FDEP), and solid waste control (secondary role) (Barile *et al.* 1987).

The primary statutes providing DOH authority are to be found in Chapter 154, 381 and 386 of the Florida Statutes and the 10D Series of the Florida Administrative Code, known as the "Sanitary Code". Each county has a DOH Office responsible for jurisdiction within the county (Barile *et al.* 1987).

### **Florida Fish and Wildlife Conservation Commission (FFWCC)**

Florida voters elected in 1998 to replace The Florida Game and Fresh Water Fish Commission (GFC) and the Marine Fisheries Commission (MFC) with the Florida Fish and Wildlife Conservation Commission (FFWCC) - effective July 1, 1999. The result is that Florida has placed responsibility for conserving the state's freshwater aquatic life, marine life and wild animal life all under a single agency.

The new FFWCC basically encompasses all the programs of the old GFC and MFC, plus some employees and programs from the Florida Department of Environmental Protection. FDEP's Bureau of Coastal and Aquatic Managed Areas and some other elements stayed with FDEP's Division of Marine Resources. The Florida Marine Research Institute (FMRI), the Office of Fisheries Management and Assistance Services (OFMAS) and the Bureau of Protected Species Management were transferred to the new agency. OFMAS, with some MFC staff, will be the new agency's Division of Marine Fisheries.

All employees from FDEP's Division of Law Enforcement, except for the Park Patrol, the Bureau of Emergency Response, the Office of Environmental and Resource Crimes Investigations and some field investigators now are part of the FFWCC.

Former Marine Patrol officers will continue to concentrate on enforcing saltwater laws, and former wildlife officers will continue to focus on freshwater and wildlife laws. However, when there is a need to reallocate law enforcement officers to deal with an emergency, the agency can do so. The Marine Patrol serves as an enforcement agency for the Florida Endangered and Threatened Species Act and the Oil Spill Prevention and Pollution Control Act. The Florida Marine Patrol also enforces state motorboat laws and the saltwater fisheries regulations of the Commission.

The FDEP Bureau of Protected Species Management, with responsibility for managing imperiled marine life, is now part of the FFWCC's Office of Environmental. The old GFC's Endangered Species Section is part of the new agency's Division of Wildlife.

Meanwhile, the Bureau of Marine Resource Regulation and Development which has jurisdiction over processing plants and shellfish management, is now part of the Florida Department of Agriculture and Consumer Services.

The Commission's efforts within the SWIM plan area primarily involve freshwater sport and commercial fishing, fisheries and habitat management, fish stocking, fisheries research, wildlife monitoring, enforcement of fisheries/wildlife regulations, listed species protection, wildlife research, development review, and regional planning. The Commission is directed by law to review SWIM plans to determine if the plan has adverse effects on wild animal life and fresh water aquatic life and their habitats

## **SUB-STATE AGENCIES**

Two sub-state agencies exist that would be involved in the implementation of the SWIM plan. These are the Southwest Florida Water Management District and the Withlacoochee Regional Planning Council.

### **Southwest Florida Water Management District (SWFWMD)**

The Southwest Florida Water Management District is responsible for performing duties assigned under Ch. 373, F.S., as well as duties delegated through FDEP for Ch. 253 and 403, F.S., and for local plan review (Ch. 163, F.S.). It performs those duties for the entire Rainbow River watershed.

### **Withlacoochee Regional Planning Council**

The Withlacoochee Regional Planning Council is the Regional Planning Agency designated in Section 186.505 of the Florida Statutes. It performs the responsibilities described in that section and the Regional Planning Agency roles assigned in Section 380.05 F.S. (Resource Planning Committees, DRI reviews and Ch. 163, Local Plan Reviews).

## **LOCAL GOVERNMENTS**

There are primarily two local governments within the Rainbow River watershed, the City of Dunnellon and Marion County which play a role in management of Rainbow River through daily management of their communities, the planning, zoning and other land use decisions, and the implementation and enforcement of local codes.

### **Marion County**

The following ordinances have been adopted by Marion County for the protection/ preservation of Rainbow River:

(1) Ordinance No. 73-4 - An emergency ordinance prohibiting dredging, filling, earth moving, and land clearing ... for a distance of 500 feet from the water's edge upon either side of Rainbow River or Blue Run in Marion County, Florida, between Rainbow Springs and the northern city limits of the City of Dunnellon. (Adopted June 14, 1973).

(2) Ordinance No. 73-9 - An ordinance regulating development in the unincorporated area of Marion County along and 500 ft upland of the Rainbow River. Establishes the need for a permit and the conditions of a permit for land clearing between the ordinary high water line and the 25 year flood plain; and for construction, land clearing, and septic tank placement between the 25 year floor plain elevation and the 100 year flood plain elevation. (Adopted November 13, 1973).

(3) Ordinance No. 85-17 - Section III: Prohibits food and non-alcoholic beverages in disposable containers on Rainbow River. Section IV: Makes possession of alcoholic beverages on Rainbow River unlawful. Section V: Established a twenty (20) miles per hour speed limit between October 16 of each year and April 14 of

the following year. Section VI: Establishes a no wake-idle zone on Rainbow River from April 15 to October 15 of each calendar year. Section VII: Establishes a five miles per hour speed limit and a no wake-idle speed only zone for motor boats upon the headwaters of the Rainbow River and KP Hole at all times during the year. Section VIII: Prohibits the operation of motors on motorboats and other craft in designated environmentally sensitive areas. Ordinance adopted October 22, 1985.

(4) Ordinance No. 86-10 - Prohibits SCUBA diving in the headwaters of Rainbow River.

(5) Resolution No. 85-R-279 - A resolution creating a Rainbow River Advisory Committee to make recommendations to the Marion Board of County Commissioners on safety and environmental issues relevant to the Rainbow River.

(6) Ordinance No. 88-4 - An ordinance amending the zoning code of Marion County affecting waterfront properties along designated water bodies (including Rainbow River). The ordinance established the waterfront side of the lot as the front yard. This in effect causes accessory structures with the exception of swimming pools, septic drain-fields and wells to be placed in either the side or back yards.

(7) Ordinance No. 88-7 - Because of recent sightings of manatee in the Rainbow River, this ordinance establishes a no wake-idle speed only limit on the Rainbow River for the entire year.

### **City of Dunnellon**

(1) Ordinance 85-8 - Similar in part to County Ordinance 85-17. Makes possession and consumption of alcohol illegal. This Ordinance also prohibits food and non-alcoholic beverages in disposable containers on Rainbow River.

(2) Ordinance 85-9 - Similar in part to County Ordinance 85-17, and establishes seasonal speed limits identical to those for the unincorporated County.

## Appendix G: Permitted Point Sources

PERMIT NUMBER	REVISION NUMBER	PROJECT SIZE	PROJECT NAME
016653	002	2.14	DEP-RAINBOW SPRINGS STATE PARK
011973	000	0.15	RAINBOW SPRINGS BEACH-RESTROOM FACILITY
016741	000	0.01	RILEY DOCK PERMIT
011285	001	3.57	MARION CO.-RAINBOW RIVER K.P. HOLE PARK
017405	000	16.78	BOUNDARY, THE
004702	001	70.9	RAINBOW SPRINGS WWTP EXPANSION
016894	001	5.62	DUNNELLON H/S-REMOCOMPONENT II-ADD III
004702	000	10.4	RAINBOW SPRINGS SEWAGE TREATMENT
016894	000	5.66	DUNNELLON HIGH SCHOOL-WING ADDITION
004702	000	10.4	RAINBOW SPRINGS SEWAGE TREATMENT
006735	001	92	RIO VISTA SUBDIVISION
006187	000	4.2	MARION CO.- CHATMIRE SUBDIVISION
010216	003	9.32	DUNNELLON BUSINESS CENTER
000318	000	42	BLUE COVE SUBDIVISION, UNIT II
013913	000	0.53	DUNNELLON MULTISPECIALTY DIAGNOSTIC CTR.
013170	000	2.44	DUNNELLON, CITY OF-ST. LAWRENCE DRIVE
001066	001	5.06	RAINBOW GARDEN APARTMENTS-ROADWAY
005871	001	1.1	LOVE COMMERCIAL SITE-PHASE II
011193	001	0.47	BALL OFFICE/DILLON LOCK N' STORE
010908	000	0.37	RAINBOW RIVER ANIMAL HOSPITAL
012064	000	0.34	MILLS, MCHENRY-SITE PLAN
010428	000	1.43	SHAH, DR.-MEDICAL OFFICE
006834	000	0.3	WINKLER, PAT & LARRY-OFFICE SITE
009905	000	3.1	DUNNELLON, CITY OF-SAN JOSE BLVD. IMPR.
006834	001	0.14	WINKLER OFFICE BUILDING
008509	000	0.93	BLUFFS ON THE RAINBOW
006969	004	4	RAINBOW RIVER CLUB-PHASE II
013197	000	2.02	DUNNELLON, CITY OF-CITY BEACH
019209	000	0.43	C.J.'S TRANSMISSION
006969	003	1.31	RAINBOW RIVERS CLUB-PHASE I

Table G.1. Permitted point sources for the City of Dunnellon.