Rainbow River Technical Summary

1991 - 2008

Southwest Florida
Water Management District

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Introduction

The Rainbow River is located in southwest Marion County near the town of Dunnellon, approximately 20 miles southwest of Ocala (Figure 1). The first magnitude spring system that forms the Rainbow River has an average discharge rate of 763 cubic feet per second (cfs), or 493 million gallons per day (mgd) and is one of 33 first magnitude spring systems in the State. The river flows south from the headspring complex approximately 5.7 miles to the tannic Withlacoochee River. The Rainbow River supports numerous listed and unlisted wildlife species through a variety of habitats in and along the river. Accordingly, the unique ecological attributes of Rainbow River/Rainbow Springs were recognized by the state of Florida when the system was designated an aquatic preserve in 1986 and an Outstanding Florida Water (OFW) in 1987. The Florida Park Service opened Rainbow Springs State Park in 1995. The local economy is supported by both recreational and commercial activities associated with the distinctive habitat and wildlife of the Rainbow River. However, land use changes in the watershed and groundwater recharge basin have occurred and threaten the water quality and associated natural systems in the Rainbow River.

In recognition of the need to place additional emphasis on 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 F.S.). In 1989, the Southwest Florida Water Management District (District) adopted the Rainbow River as a SWIM water body and developed the first Rainbow River SWIM Plan. The 1989 SWIM plan identified a variety of projects that included public education, habitat restoration, baseline vegetation and wildlife surveys, and sediment analysis. These projects were diagnostic in nature with a focus on obtaining a basic understanding of the system. As projects were completed and the District staff's understanding of the system increased, SWIM plans were periodically updated. The Rainbow River SWIM plan was updated in 1995 and again in 2004 to evaluate management issues and to determine which areas to focus management strategies in the future. As each SWIM plan was updated, management issues shifted from the area immediately surrounding the river to more regional issues within the 735 square-mile groundwater recharge area.

The purpose of this technical summary is to provide a synopsis of projects that have been completed to date, specifically those completed since the latest Rainbow River SWIM Plan of 2004.

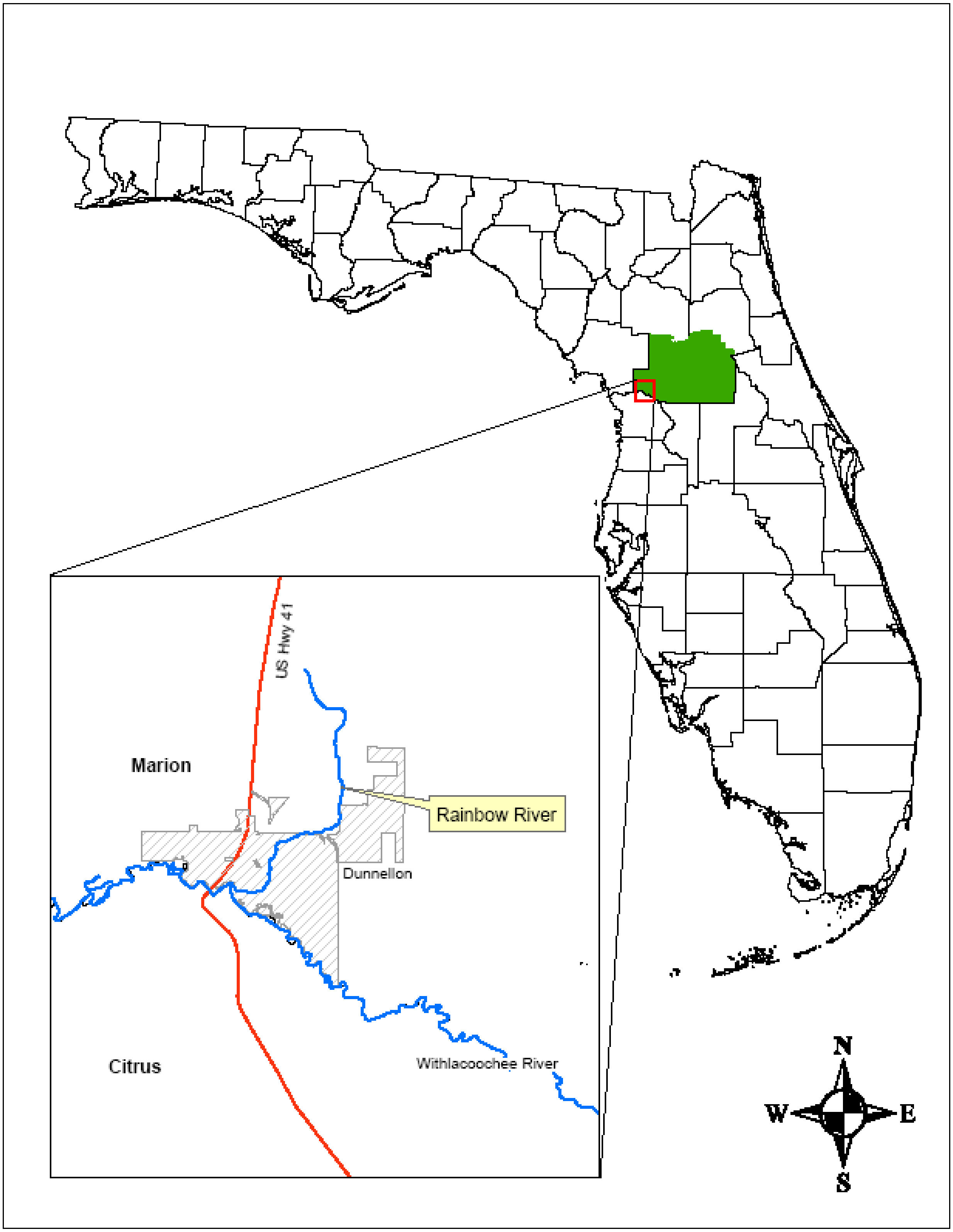

Figure 1. Rainbow River Location Map

Technical Summary

Similar to other spring-fed rivers in the state as well as the District, the natural systems and water quality of the Rainbow River have been impacted by development. Over the last century this system has experienced a variety of land use changes within its watershed. The Rainbow River and its immediate surroundings were mined for phosphate in the early part of the 20th century. From 1934 to 1973 the headspring complex was used as a tourist attraction that included glassbottom boats and mermaid shows. These are just a few of the land use changes that have led to altered surface and groundwater chemistry, reduced wetlands in the watershed, hardened natural shorelines, increased nutrient loading to the system, disturbed natural sediment regimes, the introduction of exotic plant and animal species, and increased disturbances related to recreational activities. Since its inclusion as a SWIM priority water body in 1989, the District, with a variety of state and local government partners, have worked together to identify management issues and develop strategies to protect and improve conditions in this unique first magnitude system. The management issues and strategies identified and implemented to date are summarized in this report.

Management Issues

Water Quality

Current management issues related to water quality on the Rainbow River focus on nutrient loading. The primary nutrients of concern are nitrogen and phosphorus. These nutrients occur naturally in low concentrations and support natural processes associated with aquatic ecosystems. However, excess nutrients from man-made sources fuel the growth of phytoplankton, epiphytic algae and nuisance filamentous algae. Additionally, numerous studies have also suggested that there are toxic effects of nitrogen enrichment on aquatic fauna (Mattson, 2007).

The first SWIM plan for the Rainbow River was developed in 1989 and focused primarily on point source discharges associated with wastewater treatment plants (WWTP) as a source of water quality degradation. These facilities discharged large amounts of nutrients into the Rainbow River. In the late 1980's and early 1990's, many of the WWTP's were either taken off-line or required to significantly improve treatment methods. As a result, concerns about point source discharges subsided and subsequent SWIM plans began focusing on more regional management issues.

By the time the second SWIM plan was developed in 1995, several Rainbow River diagnostic studies had been completed. The Diagnostic Studies of the

Rainbow River report (Water and Air Research, 1991) identified an apparent trend of increasing nitrate concentrations in groundwater discharging from the springs. Because of the concern for increased nitrate loading in the Rainbow River, the 1995 SWIM plan recognized the need to establish a Pollutant Load Reduction Goal (PLRG). A PLRG is an estimated numeric reduction in pollutant loading needed to preserve or restore designated uses of receiving bodies of water and maintain water quality consistent with applicable state standards. Pursuant to State Water Policy, Chapter 62-40, Florida Administrative Code (FAC), a PLRG is to be developed for each SWIM water body and adopted as part of the SWIM Plan. Because the District was in the process of determining the source of increasing nitrates, an interim pollutant load reduction goal of zero was established. This means that the goal was to prevent nutrient levels from increasing beyond the current levels.

The 2004 updated Rainbow River SWIM Plan identified a continuing need for water quality monitoring both within the Rainbow River system and its associated groundwater recharge area. The PLRG was maintained at zero, however nitrate levels have continued to rise as shown in Figure 2. The data shown in Figure 2 was collected by the WQMP from 1994 to 2008 following Florida Department of Environmental Protection (FDEP) sampling protocols.

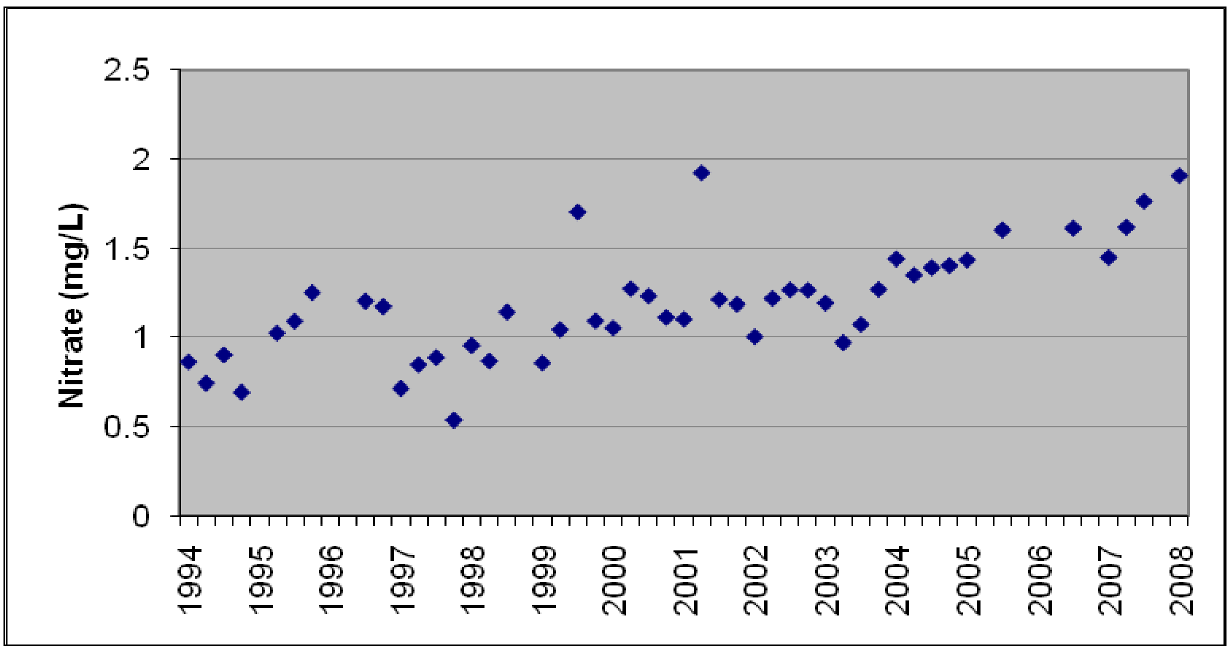

Figure 2. Station RR1 Nitrate Concentrations

Shortly after the 1995 SWIM Plan was adopted, the District's Water Quality Monitoring Program (WQMP) finalized a report investigating the source of nitrates in the Rainbow River groundwater recharge area (Jones, 1996). The report results showed that a 20-fold increase in nitrate concentrations had occurred in the last 40 years. The study noted that the average nitrate concentration in the headspring complex was 0.89 mg/L, while background concentrations are considered to be 0.01 mg/L or lower. It was determined that the source of increased nitrate in the groundwater discharging from the various spring vents was inorganic fertilizer. At the time of the Jones (1996) report, agriculture was the dominant land use in the recharge area, although residential and golf course fertilizers as well as septic systems were identified as future threats due to expected land use changes. By 2001, nitrate concentrations in the headspring area were 1.0 mg/L (Champion, 2001).

The District continues to monitor water quality for this system through various departments within the District, with assistance from FDEP. The Environmental Section is currently managing a surface water quality monitoring project in which nitrate concentrations at the Rainbow River headspring complex are consistently above 1.6 mg/L, and on several occasions approaching 2.0 mg/L. Additional monitoring efforts include the implementation of an Upper Floridan Nutrient Monitoring Network (UFANMN), priority pollutant screening, groundwater monitoring, and isotope sampling. Figure 3 shows the location of the various ongoing District monitoring efforts.

Recent monitoring of nitrogen isotopes has not shown a change in the source of nitrates discharging from the springs. In recent years, the District has also been involved with monitoring for specific pollutants in targeted springs throughout the District. This project has been collecting data since 2002 and involves the monitoring of priority pollutants such as cyanide, mercury, heavy metals, pesticides, and volatile organic compounds. To date, no priority pollutants have been detected from samples collected from the spring vents.

The District also recognizes that phosphorus is a nutrient of concern and it is monitored at the same frequency as nitrates. Phosphorus levels in the Rainbow River remain at or very near background levels averaging 0.03mg/L. Phosphorus contributions to surface water bodies are typically the result of surface runoff.

Groundwater discharge accounts for 97-99% of the river flow with very little surface runoff from the watershed (Water and Air Research, 1991). The Rainbow River watershed is approximately 47,000 acres (73 sq. mi.) while the groundwater recharge area or "springshed" is 470,000 acres (735 sq. mi.) (FGS, 2007; Figure 3). It has been estimated that groundwater may take up to 30 years to reach the spring vents from the recharge areas. Therefore, management strategies applied within the groundwater recharge area may take up to 30 years to realize the "full" benefit in measured water quality at the headspring complex. However, BMPs and other management strategies applied closer to the springs may be realized much sooner.

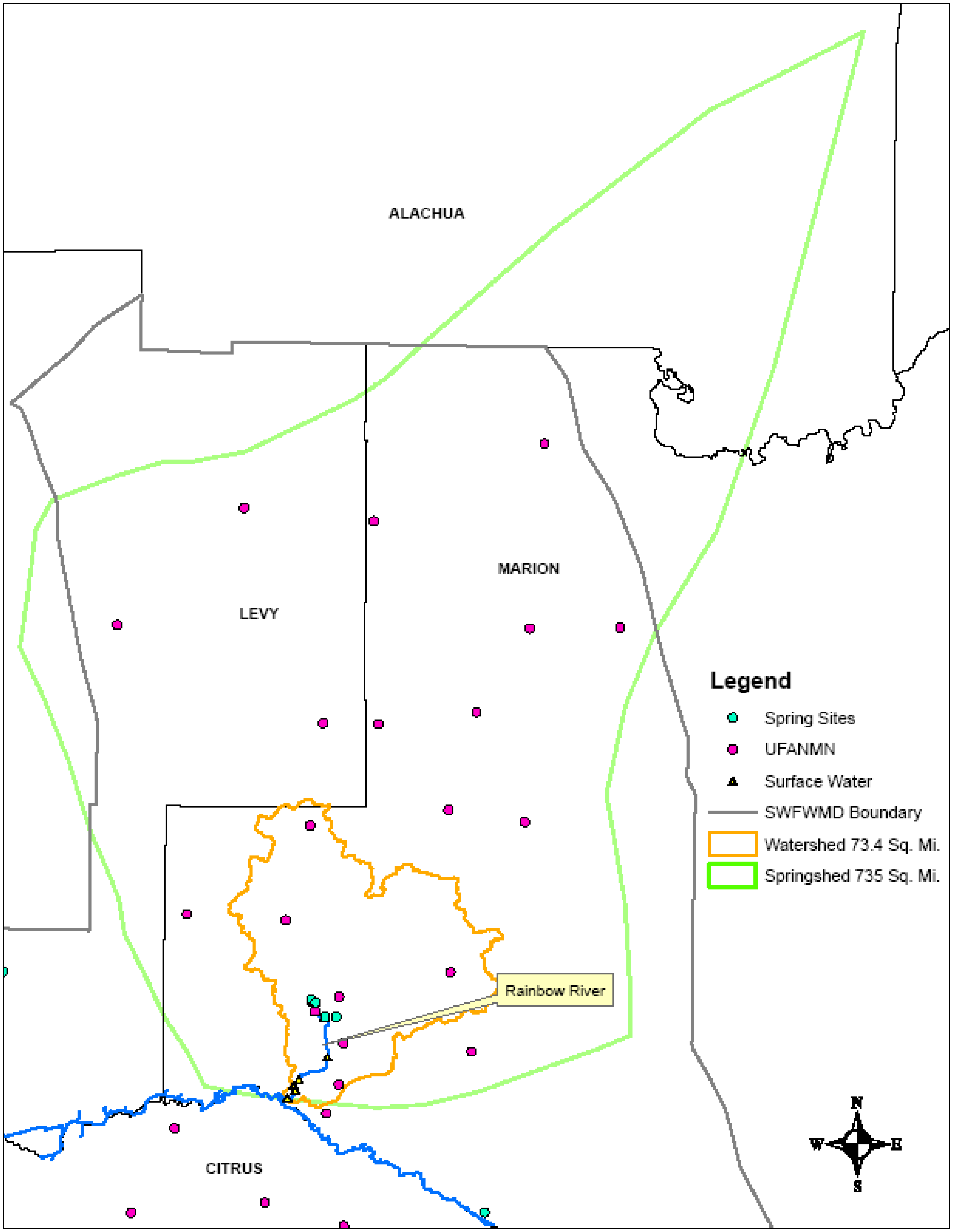

Figure 3. Rainbow River Sample Stations, Watershed, and Springshed

Water Clarity

It has been perceived by many that water clarity along the river has been decreasing over time. As described earlier, current management issues related to water quality on the Rainbow River focus on nutrient loading. Excess nutrients discharging from the spring vents fuel the growth of chlorophyll-producing organisms in receiving rivers and estuaries. The abundance of algal cells in the water column contributes to decreased water clarity or transparency, which impacts rooted aquatic vegetation.

In 2002, the District began a surface water quality monitoring project to examine which water quality parameters, if any, impact water clarity along the Rainbow River. The result of the project was an optical model that explained both spatial and temporal variability in water clarity through chlorophyll concentrations using an exponential decay function (Anastasiou, 2006). Figure 4 shows the relationship between water clarity and chlorophyll concentration for the river reach.

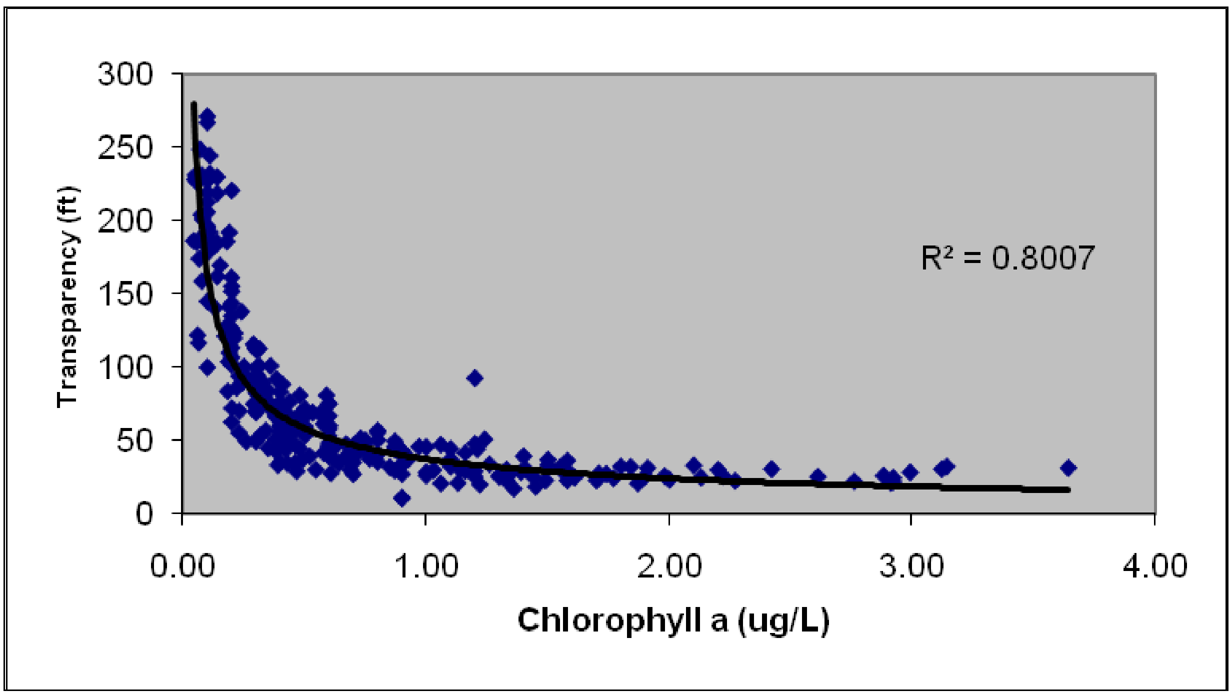

Figure 4. Optical Model – Horizontal Transparency vs. Chlorophyll Concentration

Over 80% of the variability in water clarity can be explained by chlorophyll concentrations. As one travels downstream from the headspring complex, water clarity decreases as chlorophyll concentrations increase (Figure 5). In addition to the optical model development, the project compared limited chlorophyll data from the 1950's to recent data and concluded that past and present water clarity is very similar. The data shown in Figures 4 and 5 was collected by District staff.

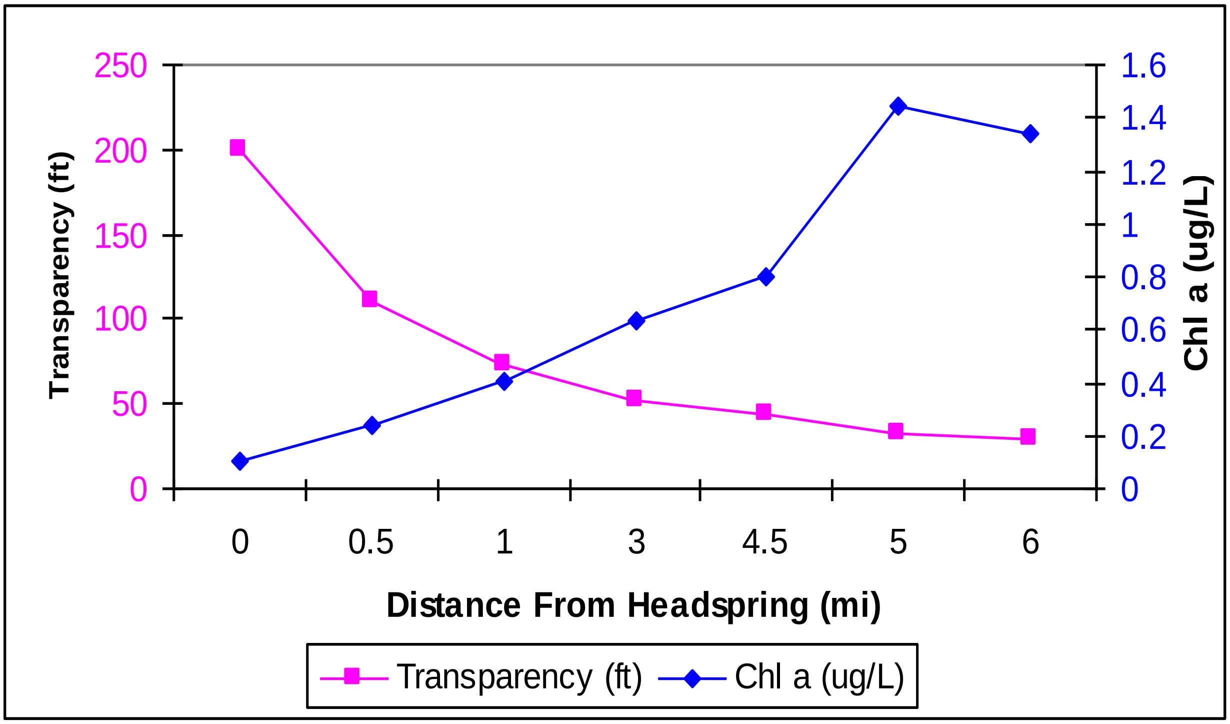

Figure 5. Spatial Distribution of Water Transparency and Chlorophyll Concentration

In conjunction with the study on water clarity, the District completed a project in 2005 to identify the source of chlorophyll in the Rainbow River water column (Cowell, 2005). It was determined that the source of chlorophyll is phytoplankton, whose composition varied seasonally, as opposed to filamentous algae or vascular plants.

In an effort to gain a better understanding of how water clarity is affected by chlorophyll concentrations, the District funded a study to determine the effects of increased nutrients on phytoplankton (Cowell, 2007). Because the Rainbow River has elevated nitrate levels, but low levels of phosphorus, the system is considered phosphorus limited (Frazer, 2001). In the experiment a 25% increase in nitrate concentration had no effect on phytoplankton biovolumes nor did a 4-fold increase in phosphate. However, the addition of trace metals, a micronutrient needed only in very small quantities, caused significant growth in the phytoplankton collected in the Rainbow River. The District will be pursuing further investigation into the effect of trace metals on phytoplankton.

The effect of trace metals on Rainbow River phytoplankton populations is shown in Figure 6. This figure shows the three day growth in biovolume of phytoplankton in four 3 x 2 factorial experiments on water samples from the Rainbow River. Treatments 2, 4, 6 and 8 have trace metal additions; 1, 3, 5, and

7 are ambient levels. Nitrate was added to treatments 5-8 and phosphate to treatments 3, 4, 7 and 8.

The District will continue to monitor water clarity and the potential impacts associated with increasing nutrients on the Rainbow River and implement management strategies to insure that water clarity is preserved.

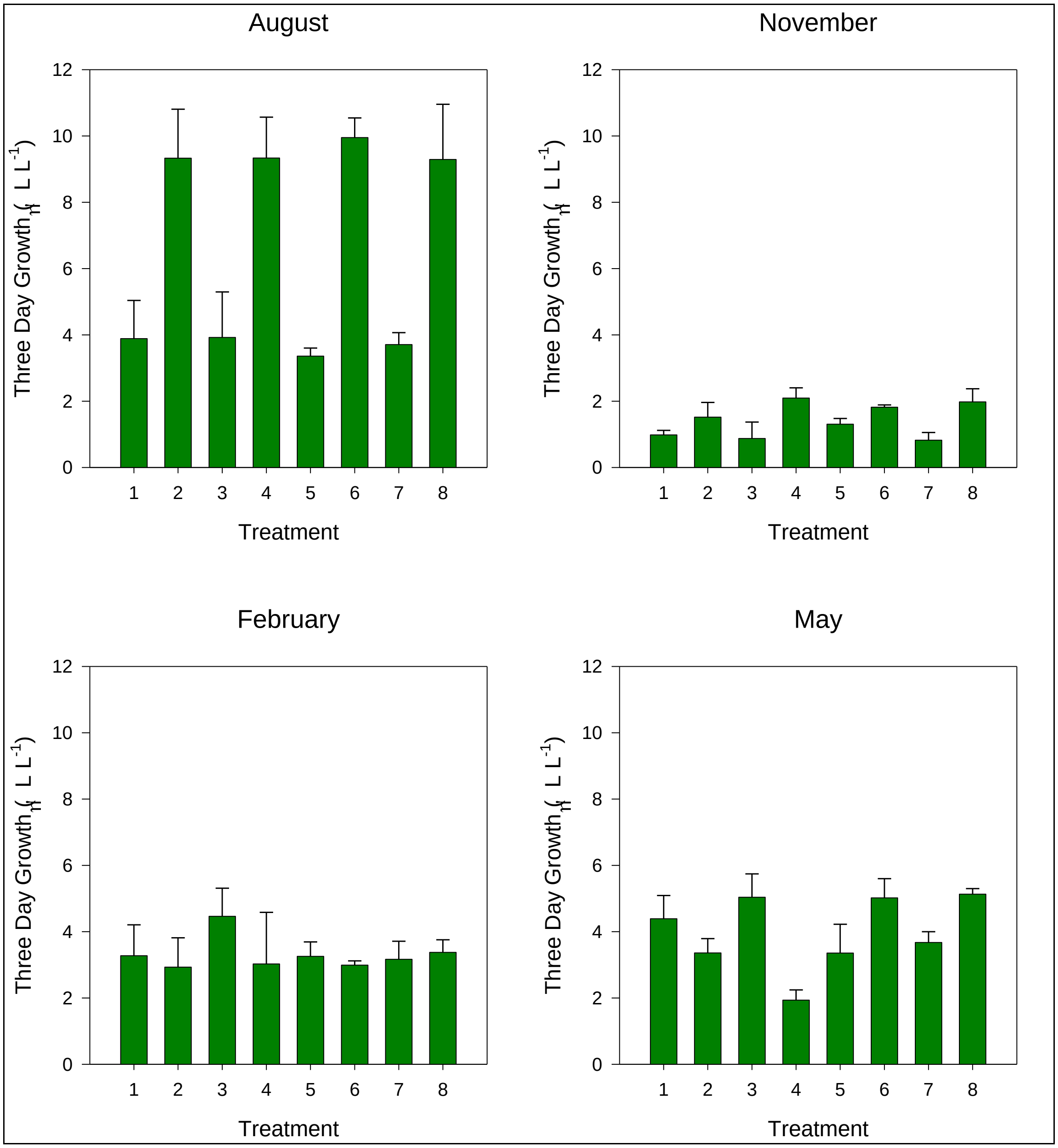

Figure 6. Effects of Increased Nutrients on Rainbow River Phytoplankton

Aquatic Vegetation

Immediately following the designation of the Rainbow River as a SWIM priority water body in 1989, the District recognized the importance of preserving the diverse submerged aquatic vegetation (SAV) found in the system and began documenting and monitoring its condition. The first effort to map submerged aquatic vegetation along the Rainbow River was in 1991 (Water and Air Research, 1991) with subsequent mapping occurring approximately every five years (1991, 1996, 2000, 2005). The 1996 mapping effort identified the four most dominant SAV communities as *Sagittaria kurziana*, *Hydrilla verticillata*, *Vallisneria americana*, and *Najas guadalupensis*. Three of the four plant types are native and desirable with the exception of *Hydrilla verticillata.* Beginning with the 1996 mapping effort, Geographic Information System (GIS) technology was incorporated into the mapping protocol and has proven to be a very useful tool in monitoring and quantifying change in the SAV communities. When comparing the 1996 mapping effort to the 2005 mapping effort, the percent cover of the four most dominant SAV communities change less than 3%. It appears that the SAV community within the Rainbow River is stable and that current management techniques are sufficient in controlling *Hydrilla verticillata* coverage. A comparison between the most recent mapping effort and the two prior efforts are shown in Table 1. The District plans to continue vegetation mapping efforts along the Rainbow River with the next mapping scheduled to occur in 2010.

Table 1. Comparison between 1996, 2000 and 2005 Vegetation Mapping Results

SUBMERGED VEGETATION	1996 Total Percent Cover	2000 Total Percent Cover	2005 Total Percent Cover	96-'00 change	00-'05 change	96-'05 change
Submersed Species	**% Cover**	**% Cover**	**% Cover**	**% Cover**	**% Cover**	**% Cover**
Ceratophyllum demersum	1.9%	1.1%	2.0%	-0.8%	0.9%	0.1%
Chara sp.	1.0%	1.5%	0.7%	0.5%	-0.8%	-0.3%
Hydrilla verticillata	16%	18%	19%	1.3%	1.3%	2.6%
Ludwigia repens	0.04%	0.05%	0.18%	0.0%	0.1%	0.1%
Myriophyllum sp.	0.01%	0.01%	0.01%	0.0%	0.0%	0.0%
Najas quadalupensis	1.8%	0.7%	3.4%	-1.1%	2.7%	1.6%
Nasturitium sp.	0.002%	0%	0.01%	0.0%	0.0%	0.0%
Potamogeton illinoensis	0.40%	0.51%	0.50%	0.1%	0.0%	0.1%
Sagittaria kurziana	36%	35%	35%	-0.8%	0.5%	-0.3%
Utricularia sp.	0.7%	0.1%	0.9%	-0.6%	0.8%	0.2%
Vallisneria americana	4.3%	4.1%	5.9%	-0.2%	1.8%	1.6%
Total bare substrate	8%	11%	5%	3.7%	-6.6%	-2.9%
Total submersed area	100%	100%	100%			

Other recent completed aquatic vegetation projects along the Rainbow River include a study on the effects of recreation on SAV (Mumma, 1996) and a Lyngbya workshop (Hoyer, 1997). The 1996 report investigating the effects of recreation on SAV communities found that biomass of damaged plants was directly related to the number of boats, tubers, and total number of recreational users. The project was funded by the Florida Department of Environmental Protection Division of Recreation and Parks. The 1997 Lyngbya workshop identified a concern that filamentous algae was increasing in coverage in the Rainbow River and that monitoring the spread of Lyngbya was necessary. The workshop also recommended that the effects of increased nutrients on Lyngbya growth be examined. It has been suggested that Lyngbya, a nuisance algae, has been increasing in many of Florida's Gulf Coast spring systems (Stevenson et al., 2007). Past vegetation mapping efforts have not included filamentous algae as a parameter and therefore no quantitative change analysis can be performed. Future vegetation mapping efforts will include filamentous algae as a vegetation type for future long-term monitoring.

Sediment

The sediment that makes up the bottom of the Rainbow River is very important both as a substrate for vegetation and as a sink for nutrients. Therefore, it is important for the District to have a clear understanding of sediment composition in this system. The first sediment study of the Rainbow River was conducted in 1990 (Water and Air Research, 1991). This study focused on detecting specific contaminants, such as heavy metals and organic toxins, associated with the discharge of treated effluent. Sample points were located both upstream and downstream of previous WWTPs discharges. The results of the study indicated that the concentrations of heavy metals were lower at downstream sample sites when compared to upstream (background) sample sites thus indicating that previous discharges by WWTPs did not have a lasting effect on the River. The concentrations of all the organic toxins analyzed were below laboratory detection limits.

The most recent sediment study was completed in 2007 and produced baseline data on the nature and extent of the sediments within the Rainbow River (Ellis et al., 2007). The project involved the collection of 130 sediment cores along the river from the headspring complex to the confluence with the Withlacoochee River shown in Figure 7. Sediment types, sources of sediment, sediment distribution, and sediment biological communities were examined. It was determined that the river is dominated by medium to fine sand conducive to supporting a lush SAV community. However, sediments in the lower portion of the river are nutrient enriched by phosphate contributory soils and the settling of organic debris. This sediment type is more favorable to rapidly growing nuisance/exotic vegetation communities (Ellis et al., 2007). Figure 8 shows the percent coverage of *Hydrilla verticillata.* Note that the percent coverage of

Hydrilla verticillata increases dramatically in the downstream portions of the Rainbow River where nutrient rich sediments dominate the sediment regime.

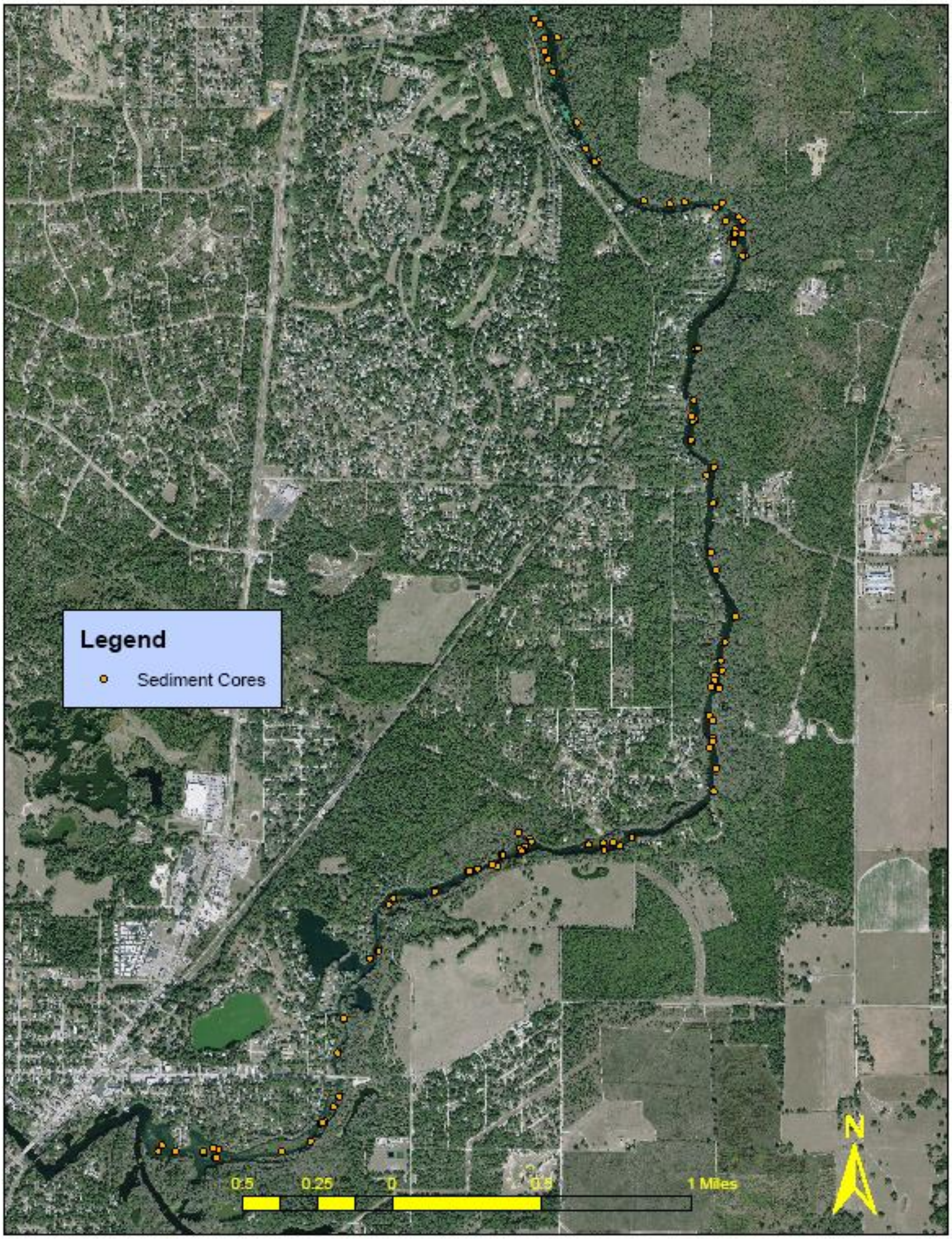

Figure 7. Rainbow River Sediment Core Locations

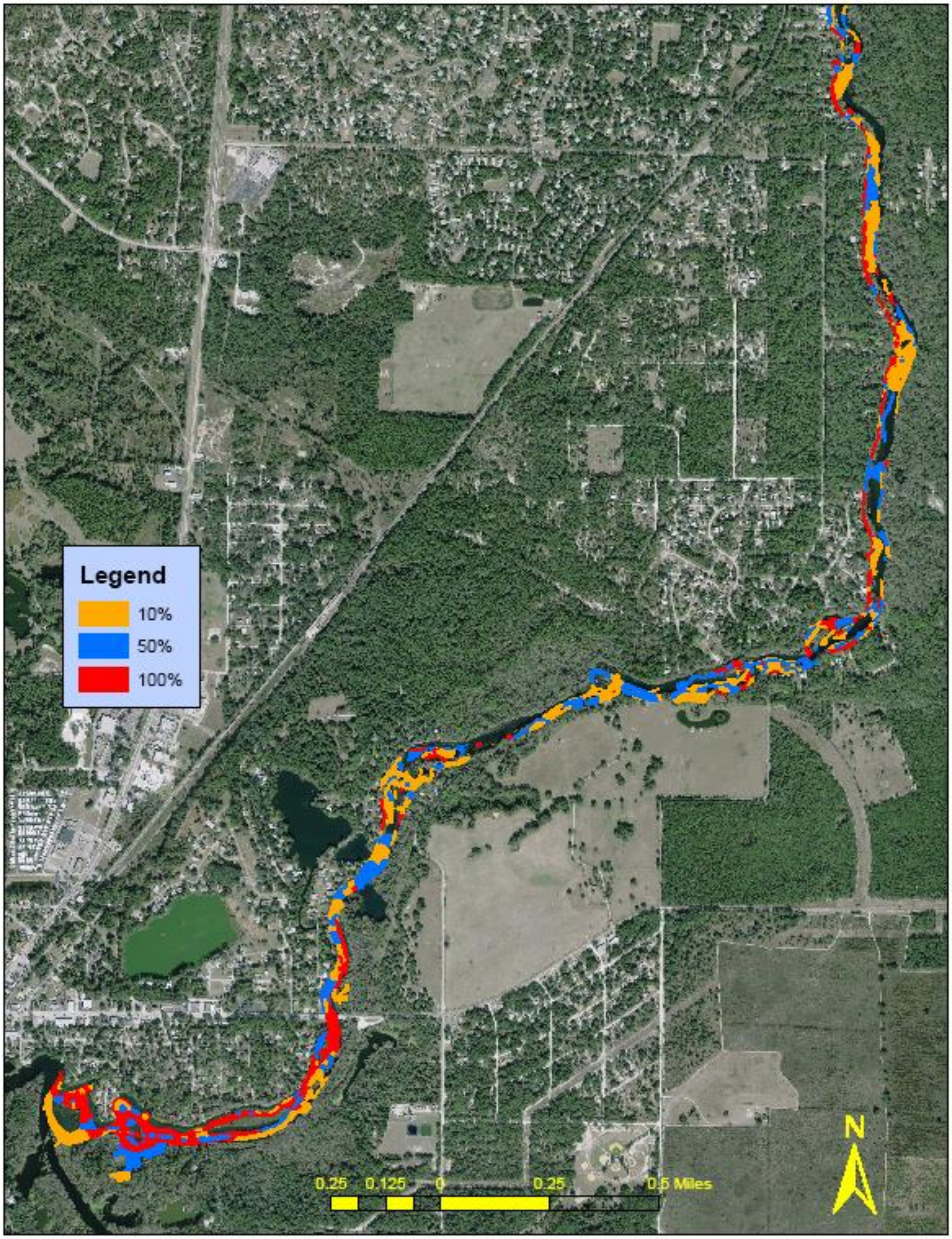

Figure 8. 2005 Hydrilla Coverage – Lower Rainbow River

Management Strategies

The following strategies and projects have been implemented since 1987 to address management issues for the Rainbow River:

Management Actions and Diagnostic Studies of Water Quality and Clarity

- The Rainbow River Management Plan was completed in 1987 for the City of Dunnellon and Marion County. The plan characterized the river as a high-quality, unique ecosystem. The plan identified future land use as the single greatest threat to the health of the system. Specifically noted were untreated stormwater, septic systems and WWTPs as being responsible for degrading water quality. The plan also identified the use of fertilizer, installation of seawalls and conflicting recreational uses as threats to the health of the system.

- Designation of Rainbow River as an OFW and SWIM priority water body in 1987 and 1989, respectively, has improved protection of the river's water quality and natural systems. These designations have enhanced coordination with both state and local government through partnerships and increased public awareness of issues affecting the Rainbow River.

- In 1991, the District initiated a series of diagnostic studies aimed at gaining a better understanding of the system and identifying future management needs. The District mapped existing SAV communities, examined water quality and developed a nutrient budget, and made recommendations that include implementation of BMPs within the groundwater recharge basin, stormwater system upgrades or retrofits, and improved wastewater treatment within the watershed.

- With the acceptance of the 1995 SWIM Plan, the need for additional water quality information was addressed in an effort to establish Pollutant Load Reduction Goals (PLRGs). Specifically, the 1995 SWIM Plan indicated that additional water quality data was needed to substantiate the apparent increase in nitrates and formulate PLRGs. Because the District was in the process of determining the source of increasing nitrates an interim PLRG of zero was established.

- Following recommendations of the 1995 SWIM Plan, a number of water quality reports were completed by the WQMP. In 1996, the District completed a detailed water quality analysis documenting the trend of increased nitrate concentrations discharging from the springs. The report (Jones, 1996) identified inorganic fertilizers associated with intense agricultural use within the groundwater recharge basin as the primary nitrate source. In 2001, the District completed two more reports further documenting the trend of increasing levels of nitrates discharging from the springs over time (Champion, 2001; Champion and Starks, 2001). The findings indicated that the source of nitrates (inorganic fertilizers) had not changed since the 1996 study.

- In 2003 and 2005, the WQMP reported the results of the priority pollutant screening efforts of selected springs in the District. There were no detections of priority pollutants for Rainbow River (Haber, 2003 and Haber, 2005).

- The most recent SWIM Plan was adopted in 2004. Previous and ongoing monitoring efforts have thoroughly documented increasing nutrient concentrations that will continue to increase until significant changes occur in the groundwater recharge area. The District is focused on projects aimed at understanding the effects of increased nutrients on the system as well as projects aimed at reducing nutrient inputs to the aquifer. Several goals identified in the plan have been and will continue to be implemented and will include the development of nutrient reduction goals and the initiation of programs to prevent further nitrate increases. The 2004 SWIM plan resulted in a series of projects that included the development of an optical model that explains how chlorophyll concentrations affect water clarity, what the sources of chlorophyll are, and the effects of increased nutrients on those chlorophyll sources.

- In 2005, the WQMP established a nutrient monitoring network in the District's major springs basins including the Rainbow River recharge area (Haber, 2005). The monitoring network is designed to monitor nutrient concentrations in the Upper Floridan Aquifer and monitor the effectiveness of Best Management Practices (BMPs). Water quality data from the well monitoring network will allow the District to further evaluate nutrient concentrations within the recharge area prior to spring discharge.

- Future management actions for water quality and clarity will involve the continued monitoring of water quality both within the Rainbow River itself as well as the groundwater recharge area. The District will continue to examine the effects of increased nutrients in the river and investigate the effects of trace metals on phytoplankton. In October 2008, the District will begin sampling for trace metals as part of the ongoing surface water quality monitoring effort.

Management Actions for Aquatic Vegetation

- In 1991, the District completed its first project to monitor SAV communities within the Rainbow River. The project collected baseline information on vegetative communities specifically a system-wide plant species composition cover map was created. The project identified both *Hydrilla verticillata* and *Lyngbya* spp. occurring throughout the river with an abundance of Hydrilla in the lower portion near the Withlacoochee.

- In 1996, 2000, and 2005, additional vegetation mapping efforts were completed along the Rainbow River. All three of these mapping efforts incorporated GIS technology, which has proved to be a valuable tool for conducting change analysis. The next scheduled mapping effort will occur in 2010 and will likely include filamentous algae and periphyton load as a category to be mapped and monitored.

Management Actions for Sediment

- Sediments in the Rainbow River were first examined in 1991. The purpose of the project was to determine if the sediments had accumulated significant amounts of undesirable chemical constituents associated with WWTP discharges. It was determined that previous discharges by WWTPs into the Rainbow River did not have a lasting effect on the system.

- A sediment composition study and mapping effort along the length of the river was completed in 2007. The project identified medium to fine sand as the dominant sediment type and found that the lower portions of the river contained sediment regimes conducive to the establishment of nuisance vegetation. Because of the slow nature of sediment formation and transport, future mapping efforts will likely be less frequent and smaller in size. Future efforts will focus on supplementing the existing sediment database and will monitor changes in sediment communities.

Minimum Flows and Levels

- Minimum flows and levels (MFLs) identify the limit at which further withdrawals would be significantly harmful to the water resources or ecosystem of an area. Pursuant to Chapter 373.042 Florida Statutes, the District is required to establish MFLs for aquifers, surface watercourses, and other surface water bodies. Minimum flows are required for rivers, streams, estuaries, and springs while minimum levels are required for lakes, wetlands and aquifers. MFLs are adopted into District rules (Chapter 40D-8, Florida Administrative Code) and used in the District's Water Use Permitting program to ensure that withdrawals do not cause significant harm.

- The District is currently in the process of establishing a minimum flow for the Rainbow River. This process involves data collection, data analysis and reporting, independent peer review and rule adoption. Data collected include flows, bathymetry mapping, vegetation analysis, instream habitat assessments, and fish assessments. The data are used in conjunction with a hydraulic simulation model to predict changes in various habitats under different flow ranges. District staff are currently analyzing all of the collected data with plans for adoption in 2009.

Public Education

- The "Know Where It Flows" watershed education project began in 2005 and focused on the Crystal River/Kings Bay area. Due to the program's success it was expanded into the Rainbow River groundwater recharge area in 2007. The goal of the program is to educate private homeowners, landscape professionals and retail outlets regarding the appropriate use of fertilizers. The program is ongoing and includes training and education workshops, creation and distribution of educational materials and education through media outlets.

- In 2006, the District entered into a cooperative agreement with Marion County to cost-share the public education and outreach portion of the County's Springs Protection Program. The goal of the program is the development and initiation of a comprehensive, long-term education and outreach campaign aimed at promoting and encouraging springs protection through public awareness. The Springs Protection Program is designed to enhance rather than duplicate the District's existing education and outreach efforts. To date, the program has resulted in the distribution of various educational materials throughout the county, the purchase of two billboards with educational messages, shown in Figure 9, and the installation of signage throughout the county notifying the public of springs protection zones.

Figure 9. Marion County Springs Protection Program Billboard

Cooperative Funding Initiative

- The District recognizes the importance of partnerships when trying to manage water resources. One of the programs used to facilitate partnerships with local governments is the District's Cooperative Funding Initiative (CFI). This program is designed to aid local governments in the development and implementation of projects that they could otherwise not afford to fund themselves. The program requires the partnering agency to match at least 50 percent of project costs. The partnering agency is typically the lead on the project as the CFI is a cost reimbursement program that ensures project benefits are realized before District funds are expended.

- In 2004, the District partnered with the City of Dunnellon and Marion County to complete the Dunnellon Watershed Management Plan (Cunningham, 2004). The primary goal of this project was to develop recommendations that enhance stormwater treatment capacity at primary outfalls throughout the City of Dunnellon. The Watershed Management Plan covered a 5 square-mile area and resulted in the identification of 11 specific recommendations involving the implementation of BMPs and associated stormwater retrofits.

- In 2005, the District entered into an agreement with Marion County for the Blue Run (Rainbow River) Watershed Management Plan. The project is ongoing and will cover approximately 68 square miles in Marion County when complete. The Watershed Management Plan includes five elements: (1) Topographic Information, (2) Watershed Evaluation, (3) Watershed Management Plan, (4) Implementation of BMPs, and (5) Maintenance of Watershed Parameters and Models.

- As a result of the Dunnellon Watershed Management Plan, the District partnered with the City of Dunnellon in 2006 to complete the Blue Cove Lake Emergency Overflow Study. The purpose of the project was to examine possible BMPs to reduce flooding and improve stormwater treatment in Blue Cove Lake which discharges directly into the Rainbow River.

- The District partnered with the City of Dunnellon for the Implementation of BMPs – Blue Cove Lake and East Blue Cove Drive Outfalls project. This construction project involved the installation of an outfall structure on the west side of Camp Drive with piping to the Blue Cove Canal. The project was completed in January, 2008. The project will reduce the potential for excessive water flowing overland, erosion of private property, and sediments being deposited into the Blue Cove Canal, which connects directly to the Rainbow River.

- The District partnered with Marion County in 2007 to assist in the implementation of the Marion County Springs Protection Program. The program has several elements in addition to the previously described education and outreach project. With financial and technical assistance from the District, Marion County is currently finalizing a Non-Point Source Pollutant Load Model for the Rainbow River Springshed. This model will enable water resource managers to predict future impacts to the system associated with future land use changes and increased nutrient loads. With this information, water resource managers can focus management strategies on specific land uses as well as prioritizing projects for specific geographic areas identified by the model as potential threats to the spring system.

- The Springs Protection Program is also conducting a research project aimed at gaining a better understanding of nutrient transport and transformation in stormwater management systems in high-recharge and karst environments found in the Rainbow River groundwater recharge area. The goal of the project is to quantify nutrient removal efficiencies of two dry retention ponds in Marion County and retrofit the two ponds with a soil amendment that will improve nutrient removal efficiencies.

- The cooperative agreement with Marion County also includes the implementation of the county's Clean Farms Initiative. This project involves the hiring of a liaison to contact and work with horse farms of all sizes throughout the county in an effort to educate farm owners on nutrient best management practices. All of the above mentioned projects are ongoing and are designed to benefit the Rainbow River by reducing nutrient loads within the groundwater recharge areas.

Conclusions

As a SWIM priority waterbody, the District is responsible to protect and manage the Rainbow River. Currently, the system is not in need of costly restoration and therefore management strategies are focused on preservation. The system however, is not considered to be pristine and continues to be impacted by human activity, particularly from land use changes. Water resource managers are dedicated to monitoring the status of nutrients discharging from the springs and the potential impacts to the system caused by increased nutrients. The District will continue to work with state and local governments to develop and implement projects in the groundwater recharge area that will reduce nutrient loads to the aquifer. The District is also dedicated to working with and educating the public regarding the complex issues that must be managed to protect this unique system.

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