PROPOSED

TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Dissolved Oxygen and Nutrients

In

Fishing Creek (2324)

Lower St. Johns River Basin, Florida

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LIST OF ABBREVIATIONS

AWT	Advanced Waste Treatment
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Biological Oxygen Demand
CBODu	Ultimate Carbonaceous Biological Oxygen Demand
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
F.A.C.	Florida Administrative Code
GIS	Geographic Information System
HUC	Hydrologic Unit Code
JEA	Jacksonville Electrical Authority
LA	Load Allocation
MGD	Million Gallons per Day
MHP	Mobile Home Park
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer Systems
NLCD	National Land Cover Data
NPDES	National Pollutant Discharge Elimination System
Rf3	Reach File 3
RM	River Mile
SOD	Sediment Oxygen Demand
TBN	Total Bioavailable Nitrogen
TBP	Total Bioavailable Phosphorus
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
USGS	United States Geological Survey
WBID	Water Body Identification
WLA	Waste Load Allocation
WMP	Water Management Plan
WWTP	Wastewater Treatment Plant

SUMMARY SHEET
Total Maximum Daily Load (TMDL)

1. **303(d) Listed Waterbody Information**

State: Florida
HUC: 03080103

1998 303(d) Listing of Impaired Waterbody

WBID	Segment Name and Type	River Basin	County	Constituent(s)
2324	Fishing Creek (freshwater stream)	Lower St. Johns	Duval	Dissolved Oxygen, Nutrients

2. **TMDL Endpoint (i.e., Target):**
The State of Florida water quality criteria for dissolved oxygen (DO) in freshwater streams require in no case shall the concentration be less than 5 mg/L. Therefore, the DO target is a concentration of 5 mg/L. The State of Florida has narrative water quality criteria for nutrients requiring in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. By achieving the DO standard, nutrient loadings will be reduced resulting in a natural balance of flora and fauna in the creek.

3. **TMDL Approach**
The Pollutant Load Screening Model (PLSM) was used to estimate seasonal nutrient (TN and TP) and BOD loadings from nonpoint sources in the watershed. BOD5 loads were converted to ultimate Carbonaceous BOD (CBODu) for input to the Water Quality Analysis Simulation Program (WASP) model for simulation of instream DO concentrations.

4. **TMDL Allocation:**

Parameter	WLA		LA (lb/day)	TMDL (lb/day)	Nonpoint Source Reduction
	Continuous	MS4 (reduction)			
BOD	15.8 lb/day	46%	58.44	74.24	46%
TN	54.29 lb/day (22% reduction)	22%	54.47	108.76	22%

5. **Endangered Species (yes or blank):** Yes

6. **EPA Lead on TMDL (EPA or blank):** EPA

7. **TMDL Considers Point Source, Nonpoint Source, or both:** Both

8. **Major NPDES Discharges to surface waters in the watershed:**

Facility	Effluent Limits	Allocation
Jacksonville Heights WWTP (FL0023671)	**BOD:** 8 mg/L monthly average; **TN and TP:** reporting requirements only; **Ammonia:** 3.2 mg/L max	**BOD:** 15.4 lb/day **TN:** 43.85 lb/day
Royal Court MHP – North (FL0043095)	**BOD:** 20mg/L single sample; **Ammonia:** 2 mg/L monthly average	**BOD:** 0.2 lb/day **TN:** 0.5 lb/day
Royal Court MHP – South (FL0043141)	**BOD:** 20mg/L single sample; **Ammonia:** 2 mg/L monthly average	**BOD:** 0.2 lb/day **TN:** 0.09 lb/day

TOTAL MAXIMUM DAILY LOAD (TMDL)
DISSOLVED OXYGEN AND NUTRIENTS IN FISHING CREEK (WBID 2324)

1. INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not meeting water quality standards. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991). The TMDLs described in this report are being established pursuant to EPA commitments in the 1998 Consent Decree in the Florida TMDL lawsuit (Florida Wildlife Federation, et al. v. Carol Browner, et al., Civil Action No. 4: 98CV356-WS, 1998).

Florida Department of Environmental Protection (FDEP) developed a statewide, watershed-based approach to water resource management. Under the watershed management approach, water resources are managed on the basis of natural boundaries, such as river basins, rather than political boundaries. The state's 52 basins are divided into 5 groups. Water quality is assessed in each group on a rotating five-year cycle. Fishing Creek is in the group 3 basin and was first assessed in 2002 with plans to revisit water management issues in 2007. FDEP established five water management districts (WMD) responsible for managing ground and surface water supplies in the counties encompassing the districts. The streams are located in the Lower St. Johns River basin and are managed through the St. Johns Water Management District (SJRWMD).

For the purpose of planning and management, the WMDs divided the district into planning units defined as either an individual primary tributary basin or a group of adjacent primary tributary basins with similar characteristics. Fishing Creek is within the Ortega River Planning Unit. These planning units contain smaller, hydrological based units called drainage basins, which are further divided into "water segments"; each assigned a unique Waterbody IDentification (WBID) number. A water segment usually contains only one unique waterbody type (stream, lake, cannel, etc.).

2. PROBLEM DEFINITION

Florida's 1998 Section 303(d) list identified Fishing Creek (WBID 2324) as impaired for dissolved oxygen (DO) and nutrients. The stream is located in Duval County within the urban areas of the City of Jacksonville (see Figure 1). Fishing Creek flows into the Ortega River, which then flows north into the St. Johns River. This segment has three NPDES facilities and is highly urbanized, with septic tanks historically causing water quality issues.

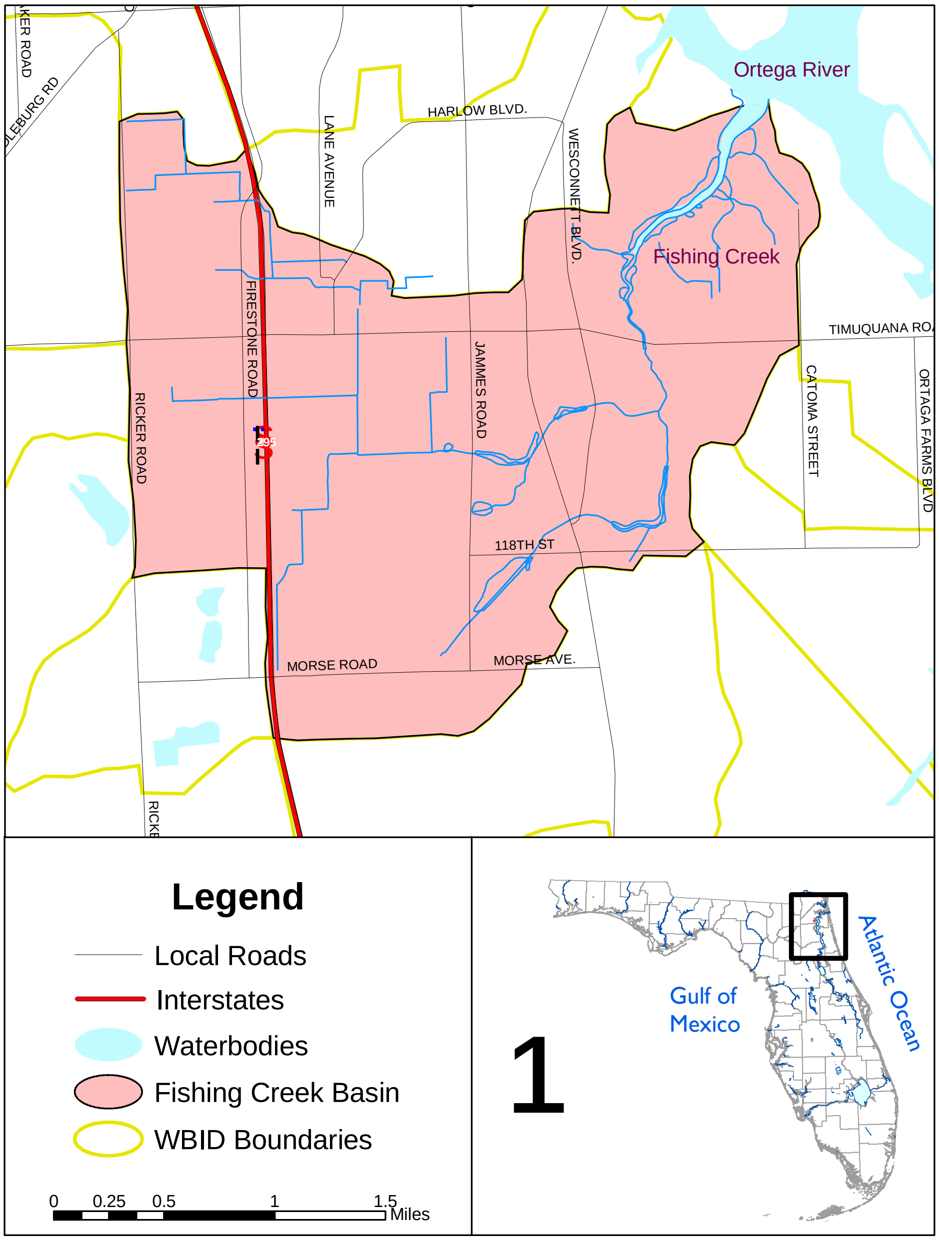

Figure 1. Location of Fishing Creek

3. WATERSHED DESCRIPTION

The St. Johns River is a large river system flowing from south to north just inland from the eastern coast of central and northern Florida and drains a watershed covering approximately 9500 square miles before discharging into the Atlantic Ocean east of the City of Jacksonville. The St. Johns River has been divided into three subwatersheds commonly referred to as the Upper, Middle and Lower St. Johns River. The following description of the watershed is from the Lower St. Johns Basin Status Report (FDEP, 2003). This document should be consulted for additional details.

Fishing Creek (WBID 2324) flows into the Ortega River, a major tributary to the St. Johns River. The WBID is located in south central Duval County and covers an area of about 5.7 square miles (mi^2). This WBID has been assigned a Class 3 Freshwater designation. Land cover within the WBID is shown in Table 1. A large portion of the watershed is dominated by urban land classifications.

Sewage problems from local septic tanks have adversely affected the creek over the years. Septic tanks in a portion of the Fishing Creek watershed identified as chronic sources of water quality impairment were converted to sewer. As part of the American Heritage River study, the City of Jacksonville in cooperation with the US Geological Survey (USGS) initiated a program to perform comparative water quality monitoring before and after the sewers were installed.

Table 1 Land use distribution

Description	Area (acre)	Percentage
Residential	1896	54.7%
Commercial, Industrial, & Public	386	11.1%
Agriculture	30	0.9%
Rangeland	199	5.7%
Forest	199	5.7%
Water	64	1.8%
Wetlands	564	16.3%
Barren & Extractive	0	0%
Transportation & Utilities	127	3.7%
Total	3,465	100%

4. WATER QUALITY STANDARD AND TARGET IDENTIFICATION

The impaired WBID is designated as Class III freshwater. The designated use of Class III waters is recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. Class III waters are further categorized based on fresh or marine waters. The water quality criteria for protection of Class III waters are established by the State of Florida in the Florida Administrative Code (F.A.C.), Section 62-302.530. The individual criteria should be considered in conjunction with other provisions in water quality standards, including Section 62-302.500 F.A.C. [Surface Waters: Minimum Criteria, General Criteria] that apply to all waters unless alternative or more stringent criteria are specified in F.A.C. Section 62-302.530.

Dissolved Oxygen Target

The State of Florida has numeric water quality criteria for DO requiring in no case shall concentrations be less than 5 mg/L. The target for the TMDL is reduction in sources contributing to low DO such that a DO of 5 mg/L is achieved in the stream. Dissolved oxygen is not a pollutant; therefore, the TMDL targets pollutants causing low dissolved oxygen. The causative pollutant for the TMDL is elevated BOD and nutrient loadings.

Nutrient Target

The State of Florida has narrative water quality criteria for nutrients requiring in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. The target for the TMDL is nutrient loadings of total nitrogen (TN) and Biochemical Oxygen Demand (BOD) derived from modeling scenarios. An assumption of this TMDL is achieving the DO standard will result in reduced nutrient loadings providing a natural balance of flora and fauna in the creek.

5. WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

FDEP maintains ambient monitoring stations throughout the basin. Water quality monitoring stations within the impaired WBIDs are listed in Table 2. Data collected during the listing cycle (1996-2002) was used in the analysis. Table 3 provides a statistical summary of water quality data collected in the WBID. The number of observations shown in Table 2 is the total observations of all parameters shown in Table 3. Data used to calculate these statistics is provided in Appendix A. Data are not available to evaluate improvements in water quality resulting from implementations of stormwater Best Management Practices (BMPs). For purposes of this report only, BOD refers to 5-day BOD (or BOD5) and CBOD and ultimate CBOD are equivalent.

Table 2. Monitoring stations

Station ID	Station Name	Sampling Period	Number of Observations
Fishing Creek (WBID 2324)			
21FLJXWQOR4	Fishing Creek at Timuquana Road	3/18/1996 - 11/5/02	54
21FLJXWQOR8	Fishing Creek North Branch at Jammes Creek	3/18/1996 - 11/5/02	54
21FLA 20030617	Fishing Creek at public boat ramp off Seaboard Road	4/18/2002 - 12/16/2002	7
21FLA 20030615	Fishing Creek upstream Timuquana Road	4/18/2002 - 12/16/2002	7
112WRD 02246437	Fishing Creek at 110th Street	2/7/2000 - 9/25/2002	89
112WRD 02246435	Fishing Creek at Wesconnette Blvd	2/7/2000 - 9/25/2002	76

Table 3. Summary of Water Quality Monitoring Data (1996 – 2002)

Parameter	No. of Samples	Minimum	Maximum	Average
BOD (mg/L)	6	1	2	1.333
Chlorophyll-a (µg/L)	Not measured in listing cycle			
DO (mg/L)	135	0.5	18.35	6.430
Ammonia (mg/L)	62	0.00	0.44	0.038
Nitrate-Nitrite (mg/L)	30	0.02	9.83	0.865
Total Kjeldahl Nitrogen (mg/L)	30	0.42	1.60	0.917
Total Organic Carbon (mg/L)	Not measured in listing cycle			
Total Phosphorus (mg/L)	23	0.04	1.8	0.376
Total Nitrogen (mg/L)	30	0.53	10.70	1.782
TN:TP Ratio	30	2.289	18.500	8.797

A comparison of DO samples collected at the monitoring stations with respect to the water quality criteria is shown in Table 4. The distribution of DO measurements over the listing period is shown in Figure 2. There were three BOD measurements colleted in the stream at two different stations (see Appendix A). DO samples collected on the same date and stations as the BOD measurements had concentrations greater than 5 mg/L. BOD data were not available on dates when depressed DO levels were measured; hence a correlation could not be made between elevated BOD levels and depressed DO concentrations. Of the DO measurements recorded in Fishing Creek, about 30 percent of the samples violate the water quality criteria (i.e., measurements less than 5 mg/L).

Table 4. Comparison of DO samples collected in WBID with respect to water quality criteria

Station	No. of Observations	No. Samples Exceeding DO Criteria	Percent Samples Exceeding DO Criteria
21FLJXWQOR4	38	10	26.3%
21FLJXWQOR8	38	0	0.0%
21FLA 20030617	7	2	28.6%
21FLA 20030615	7	5	71.4%
112WRD 02246437	24	13	54.2%
112WRD 02246435	21	12	57.1%
All Location	135	42	31.1%

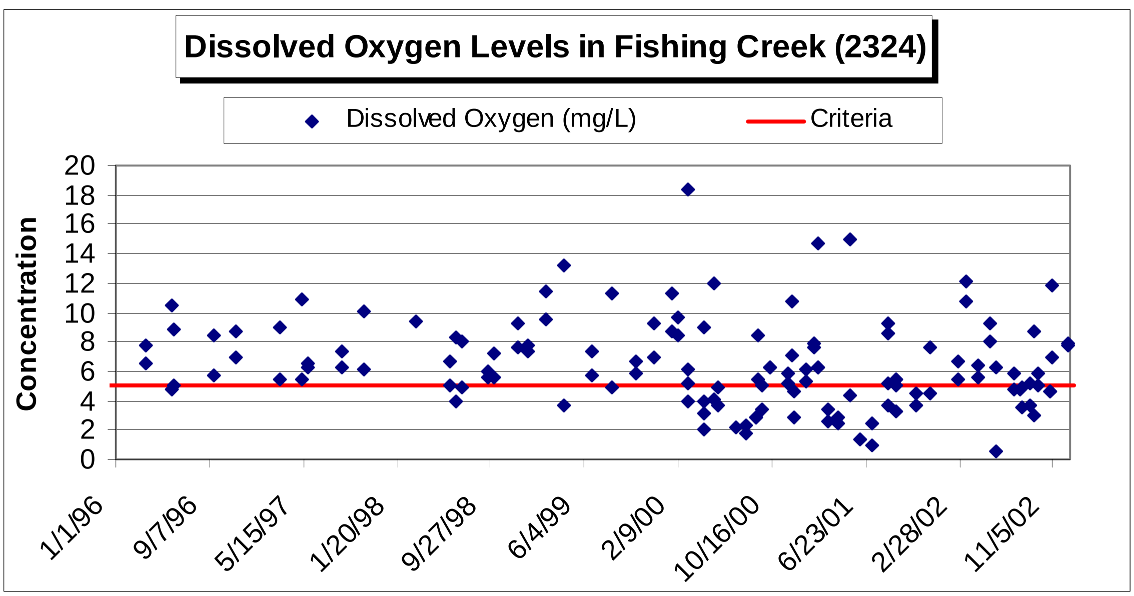

Figure 2. Dissolved Oxygen measurements collected in Fishing Creek

Chlorophyll-a data is often used to assess nutrient impairment in streams and rivers. Limited chlorophyll-a measurements were collected in the WBID and none were collected during the listing cycle. Of the available chlorophyll-a data, none of the values exceed the threshold value of 20 µg/L. Based on the lack of chlorophyll data, the extent of the nutrient impairment could not be determined using chlorophyll (see Appendix A).

6. SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of nutrients in the watershed and the amount of pollutant loading contributed by each. Sources are broadly classified as either point or non-point sources. A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater and treated sanitary wastewater must be authorized by National Pollutant Discharge Elimination System (NPDES) permits.

Non-point sources of pollution are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. Land cover within the WBID can be used as an indication of potential sources. Nonpoint sources addressed in this study primarily include loadings from surface runoff and base flow from the surficial aquifer (including the septic tank). The majority of the pollutants impacting DO levels in the stream are likely generated from urban development.

In DO-impaired waters source assessments often target nutrients and BOD. The limiting nutrient, generally nitrogen or phosphorus, is defined as the nutrient that limits plant growth when it is not available in sufficient quantities. The ratio of nitrogen to phosphorus is used as a first cut to determine the limiting nutrient. An N:P ratio less than 10 implies nitrogen is the limiting nutrient, a ratio greater than 30 implies phosphorus is the limiting nutrient, and a ratio between 10 and 30 implies both nitrogen and phosphorus are co-limiting nutrients. The limiting nutrient in Fishing Creek is nitrogen as the available data indicates the N:P ratio is on average less than 10 (see Table 3). This implies sources of nitrogen are a major contribute to water quality impairment.

6.1 Point Sources

There are three point sources in this WBID; Jacksonville Heights WWTP (FL0023671), Royal Court Mobile Home Park (MHP), Inc-North (FL0043095) and Royal Court MHP, Inc – South (FL0043141). Facility FL0023671 is in the upper portion of the WBID, while the other two are located in the lower portion. Jacksonville Heights WWTP discharges treated effluent into a stormwater canal which then flows into Fishing Creek.

The Royal Court MHP –north WWTF is currently permitted to discharge effluent to a stormwater drain, which flows to the Ortega River. At the time of the fifth year inspection (May 2004), the effluent was flowing through a stormwater drain under Timiquana Road, combining with the discharge from the Royal Court MHP South WWTF, and then flowing west through a stormwater drain and into Fishing Creek. The Royal Court MHP North WWTF is supposed to cease discharge by October 2005 and connect to a regional facility operated by JEA. The Royal Court MHP South WWTP will have to connect to the regional facility within the next four years (personal communication with FDEP). The Duval County Variance Board will determine the exact time frame.

The facilities have permit limits for BOD and ammonia (NH_3-N) and quarterly reporting requirements for phosphorus (P) and nitrogen (N) species. Permit limits for flow, BOD and NH_3-N are shown in Table 5. Time series loadings of select parameters from the facilities Discharge Monitoring Reports (DMR) are provided in Appendix B. Inspections at these facilities have historically reported elevated nutrients (TP and nitrates); permits should be revised to include more stringent nutrient requirements (i.e., effluent limits). Elevated levels of nutrients promote excessive growth of aquatic weeds contributing to the imbalance of flora and fauna.

Table 5. Permit limits for facilities in the Fishing Creek watershed

Facility/NPDES #	Flow (MGD)	BOD		Ammonia	
		Max	Monthly	Max	Monthly
JAX Heights WWTF(FL0023671)	2.5	16 mg/L; 333.6 lb/day	8.0 mg/L; 166.8 lb/day	3.2 mg/L; 66.7 lb/day	2.0 mg/L; 41.7 lb/day
Royal Court MHP - North (FL0043095)	0.015	20.0 mg/L; 2.5 lb/day	Not given	4.0 mg/L; 0.5 lb/day	Not given
Royal Court MHP – South (FL0043141)	0.015	20.0 mg/L; 2.5 lb/day	Not given	4.0 mg/L; 0.5 lb/day	Not given

A statistic summary of DMR data is provided in Table 6. Of the three facilities, Jacksonville Heights (FL0023671) is the most significant contributor, discharging about 1 MGD while the other two combine discharge about 0.02 MGD (based on data from 1995 through March 2005). Based on DMR data, ammonia from this facility is about one percent of the total nitrogen load.

Table 6. Statistical summary of DMR data

Parameter	Count	Minimum	Maximum	Average	Median
Royal Court Mobile Home Park North (FL0043095)					
Flow (MGD)	116	0.003	0.024	0.007	0.007
DO (mg/L)	118	0.1	9.6	6.7	6.8
BOD (mg/L)	98	0.0	23.0	3.3	2.0
BOD (lb/day)	94	0.0	1.3	0.2	0.13
TP (mg/L)	17	0.09	9.91	2.305	1.59
TP (lb/day)	17	0.0	0.9	0.2	0.10
Ammonia (mg/L)	109	0.015	12.4	0.559	0.12
Ammonia (lb/day)	16	0.0	2.2	0.50	0.30
Royal Court Mobile Home Park South (FL0043141)					
Flow (MGD)	116	0.003	0.024	0.007	0.007
DO (mg/L)	118	0.1	9.6	6.7	6.8
BOD (mg/L)	98	0.0	23.0	3.3	2.0
BOD (lb/day)	94	0.0	1.3	0.2	0.13
TP (mg/L)	17	0.09	9.91	2.305	1.59
TP (lb/day)	17	0.0	0.9	0.2	0.1
Ammonia (mg/L)	109	0.015	12.4	0.559	0.12
Ammonia (lb/day)	106	0.0	0.8	0.09	0.02
Jacksonville Heights Wastewater Treatment Facility (FL0023671)					
Flow (MGD)	106	0.864	1.55	1.088	1.0405
DO (mg/L)	123	6.0	8.0	6.5	6.4
BOD (mg/L)	117	0.0	2.4	1.6	2.0
BOD (lb/day)	100	0.0	25.9	15.4	16.16
TP (mg/L)	36	0.02	4.3	1.837	1.92
TP (lb/day)	28	0.2	39.5	14.1	7.22
Ammonia (mg/L)	106	0.0	0.33	0.056	0.05
Ammonia (lb/day)	92	0.0	2.89	0.49	0.38

Parameter	Count	Minimum	Maximum	Average	Median
TN (mg/L)	36	3.71	14.03	8.06	7.05
TN (lb/day)	28	39.3	136.3	69.6	61.46

BOD loads from Jacksonville Heights WWTP display an increasing trend possibly due to rapid population growth in the area (see Figure B- 14). Sampling of plant effluent conducted by FDEP in 1992, 1999, and 2004 indicated "the effluent Algal Growth Potential (AGP) result exceeded the "problem" threshold for fresh receiving waters" (FDEP, 2004c Fifth Year Inspection Reports). "Problem" is defined by Raschke and Shultz (1987) as AGP values above 5 mg dry weight /L. Effluent from this facility is co-limiting (i.e., TN/TP ratio between 10 and 30). These inspections detected nutrient species (nitrate-nitrite, ortho-phosphate, and total phosphorus) in the effluent and at test sites below the discharge at levels higher than 95 percent of Florida streams (FDEP, 1992).

Effluent AGP results from fifth year inspection samples at Royal Court MHP North were below the threshold value. Nutrient data collected for the AGP test suggests that the effluent is nitrogen limiting. This data suggests potential algal growth inhibition, but this could not be determined from the toxicity test (FDEP, 2004b). Long-term DMR data indicate median total phosphorus concentrations at the MHP facilities are above 95% of all streams. Inspection reports from the Royal Court MHP South were not available for review. DMR data for this facility is similar to the data reported from the MHP North facility (see Table 6).

Municipal Separate Storm Sewer Systems (MS4s) may also discharge pollutants to waterbodies in response to storm events. Currently, large and medium MS4s serving populations greater than 100,000 people are required to obtain a NPDES storm water permit. In March 2003, small MS4s serving urbanized areas will be required to obtain a permit under the Phase II storm water regulations. An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of 1,000 people per square mile.

The municipal area of the City of Jacksonville (FLS000012) is covered under the Phase I MS4 permit and includes the Fishing Creek watershed. A requirement of the MS4 permit is the development of a Master Stormwater Management Plan. Implementation of this plan addresses water quality and flooding problems according to a priority list. Water quality in Fishing Creek was considered a priority issue in this plan**.**

In 1997 the city of Jacksonville's Department of Pubic Utilities Water and Sewer Operations merged with the Jacksonville Electric Authority (JEA), which now provides more than 80 percent of water and sewer service to residents of Duval County. JEA monitors water quality in the creek as part of the MS4 requirements for the City**.** JEA anticipates better management of stormwater runoff and capital improvement plans to address flooding issues will result in improved water quality in the Jacksonville area.

The WLA for the MS4 is expressed in terms of percent reduction. Given the available data, it is not possible to estimate loadings in units of pounds per day (lb/day**)** coming exclusively from the MS4 area. Although the aggregate wasteload allocation for storm water discharges is expressed in numeric form, percent reduction, based on the information available today, it is infeasible to calculate numeric WLAs for individual storm water outfalls because discharges from these sources can be highly intermittent, are usually characterized by very high flows occurring over relatively short time intervals, and carry a variety of pollutants whose nature and extent varies according to geography and local land use. Water quality impacts, in turn, also depend on a wide range of factors, including the magnitude and duration of rainfall events, the time period between events, soil conditions, fraction of land that is impervious to rainfall, other land use activities, and the ratio of storm water discharge to receiving water flow.

This TMDL assumes for the reasons stated above that it is infeasible to calculate numeric water quality-based effluent limitations for BOD and nutrients from storm water discharges. Therefore, in the absence of information presented to the permitting authority showing otherwise, the WLA for the City of Jacksonville is expressed in narrative form (e.g., as best management practices), provided that (1) the permitting authority explains in the permit fact sheet the reasons it expects the chosen BMPs to achieve the aggregate wasteload allocation for these stormwater discharges; and (2) the state will perform ambient water quality monitoring for nutrients for the purpose of determining whether the BMPs in fact are achieving such aggregate wasteload allocation.

The percent reduction calculated for nonpoint sources is assigned to the MS4 as violations from both sources typically occur in response to storm events. Permitted MS4s will be responsible for reducing only the loads associated with stormwater outfalls which it owns, manages, or otherwise has responsible control. MS4s are not responsible for reducing other nonpoint source loads within its jurisdiction. All future MS4s permitted in the area are automatically prescribed a WLA equivalent to the percent reduction assigned to the LA.

6.2 Non-point Sources

Land development influences the delivery of water quality constituents to surface waters in two fundamental ways. Through fertilization, lawn maintenance, manure spreading, septic tank operation, vehicular use, etc., nutrients and other pollutants are added to the land surface or to shallow groundwater in excess of natural land cover conditions (i.e., native forest, wetland). Unlike the situation that tends to predominate on developed lands, natural land covers are highly conservative of essential growth nutrients, and thus labile nutrient forms tend to be retained within these terrestrial ecosystems. In addition, the creation of impervious surfaces, drainage development, and the destruction of near stream wetlands increases the amount of rainfall that ultimately ends up as runoff, thus increasing the pollutant exporting capability in developed landscapes. Thus, the process of nonpoint source pollution has both chemical and hydrologic components (Hendrickson, 2002).

The Fishing Creek watershed is predominately urban. Debris carrying nutrients and other pollutants washes off roads and other impervious surfaces and discharges into the stream during storm events. Potential pollutant sources contributing to impairment include: animal waste, fertilizer application to lawns, golf courses, and other grassed areas, and malfunctioning septic tank systems.

Failing septic systems in the Fishing Creek watershed have been identified by JEA as a source of nutrient impairment. JEA funded a project with the US Geological Survey to monitor water quality in the Pernecia/Johnnie Circle community within the Fishing Creek watershed before and after conversion of septic systems to central sewer. Results of this study indicated conversion of septic systems to sewer would reduce nutrient loading to the creek (personal communication, FDEP).

JEA funded a project, known as the Tributary Pollution Assessment Project (TPAP) to develop a standard manual for conducting sanitary surveys. The manual will be used to assess the health of a watershed and potential sources of pollution. This information will be used by JEA to concentrate repair efforts and to identify areas of failing septic tanks. The Fishing Creek watershed is considered a priority watershed in this study.

Stormwater runoff from urban areas can be a significant source of pollutants to a stream. In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as outlined in Chapter 403 Florida Statutes (F.S.), was established as a technology-based program that relies upon the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, F.A.C.

Florida's stormwater program is unique in having a performance standard for older stormwater systems that were built before the implementation of the Stormwater Rule in 1982. This rule states: "the pollutant loading from older stormwater management systems shall be reduced as needed to restore or maintain the beneficial uses of water" (Section 62-4-.432 (5) (c), F.A.C.).

Nonstructural and structural BMPs are an integral part of the State's stormwater programs. Nonstructural BMPs, often referred to as "source controls", are those that can be used to prevent the generation of NPS pollutants or to limit their transport off-site. Typical nonstructural BMPs include public education, land use management, preservation of wetlands and floodplains, and minimizing impervious surfaces. Technology-based structural BMPs are used to mitigate the increased stormwater peak discharge rate, volume, and pollutant loadings that accompany urbanization.

7. ANALYTICAL APPROACH

The SJRWMD Pollutant Load Screening Model (PLSM) was used to calculate the concentration and load of Biochemical Oxygen Demand (BOD) and nutrients (TP and TN) entering Fishing Creek from nonpoint sources (Mundy and Bergman, 1998). The U.S. EPA Water Quality Analysis Simulation Program version 7 (WASP7) was applied as the water quality model (Wool, et. al., 2001) and was used to simulate both point and nonpoint source loadings. The eutrophication component of WASP was used to simulate the complex nutrient transport and cycling in the river, as well as determining the dissolved oxygen sag within river. The purpose of the modeling exercise was to determine what reductions in BOD and nutrients loads to the river would have to occur to protect the water body's designated use and achieve water quality standards for DO and nutrients.

7.1 PLSM Model

PLSM utilizes a computer-driven geographic information system framework to calculate constituent loads as the product of water quality concentration associated with certain land use practices, and runoff water volume associated with those same practices. The computational approach of the PLSM is similar to that of the Surface Water Management Model (SWMM) screening level tool. (Hendrickson, 2002) The model's nonpoint source pollutant concentrations are specific to one of 20 different land use classes. Water quantity is determined through a hybrid of the SCS curve number method, and is the product of rain volumes and a coefficient (referred to as the runoff coefficient, or RC, with values ranging from 0 to 0.9) relating the propensity of various land use and soil hydrologic group combinations to generate runoff. Each landuse category is assumed to transport a characteristic mass load of pollutant from one unit of area form one unit of effective rain. Figure 3 displays the computational framework of PLSM.

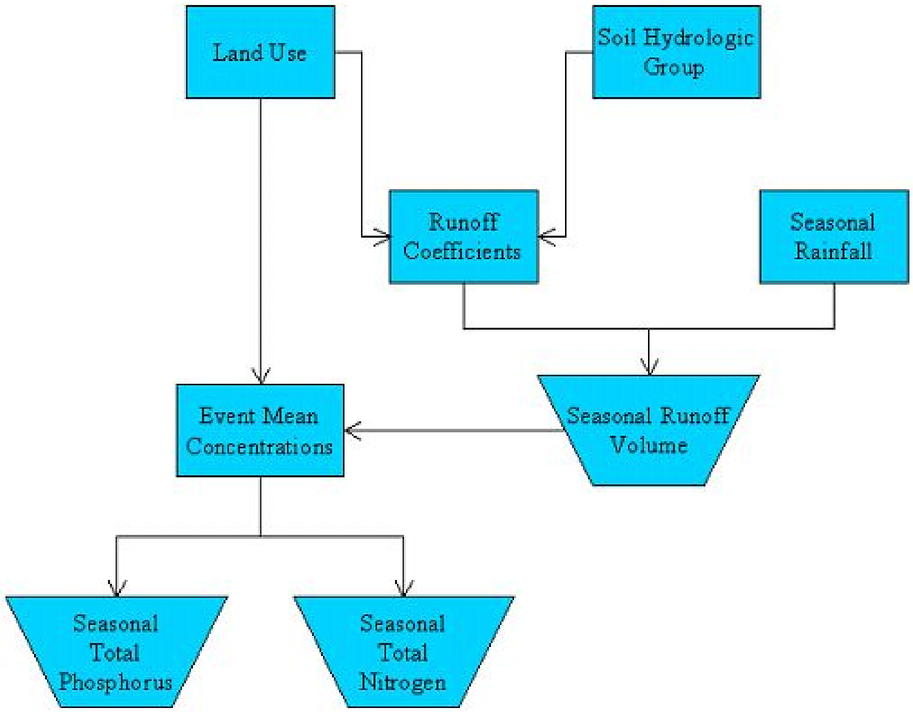

Figure 3. PLSM Conceptual Framework

7.1.1 PLSM Setup

In this application of PLSM, the model was run within Microsoft Excel to calculate seasonal area-weighted runoff coefficients and flow-weighted concentrations for nutrients (nitrogen and phosphorus) and BOD based upon the area within the WBID of unique land use and soil hydrologic group combinations. This was accomplished by following the procedure outlined in Hendrickson and Konwinski (1998). The inputs required to administer PLSM are provided here. PLSM is calibrated by matching simulated pollutant loads and total discharge volumes to observed values.

Land Use
Data from the standard 2000 Florida Land Use, Cover and Forms Classification System (FLUCCS) code was obtained from SJRWMD and the South Florida Water Management District (SFWMD). This data was then aggregated into 20 distinct categories as defined in Table 7.

Table 7. Landuse Categories

Category ID	Category Label	Category Description
1	LDR	Low Density Residential
2	MDR	Medium Density Residential
3	HDR	High Density Residential
4	LC	Commercial, Low

Category ID	Category Label	Category Description
5	HC	Commercial, High
6	I	Industrial
7	M	Mining
8	RO	Range/Open Land
9	AGGEN	General, Agricultural
10	NAGEN	General, Non-Agricultural
91	PAST	Pasture
92	CROPS	Crops
93	CITRUS	Citrus
94	AGMISC	Agricultural, Miscellaneous
95	ANIM	Animal
101	FOR	Forested
102	SILV	Silviculture
103	WATER	Water
104	WETLDS	Wetlands
105	BARREN	Barren

Soils
The Soil Survey Geographic Database (SSURGO), developed by the Natural Resource Conservation Service, was used in PLSM and was obtained from SJRWMD and SFWMD. Soils in PLSM are classified based specifically on their hydrologic group rating of A, B, C and D. Additional soil groups found within the SJRWMD dataset were group U (urban), which allows relatively average drainage, and Group X soils, for which drainage characteristics were unknown. Group U soils were ultimately handled as group C soils. Further, for this process, soils identified in the dataset as B/D and C/D soils were considered as B and C hydrologic group ratings, respectively. Landuse and soils data was then cross-referenced to provide the total area of each specific landuse-soils combination within each TMDL segment. These values were then applied directly to the model.

Rainfall
Rainfall data required to calculate runoff volumes and thus loads in PLSM was obtained from data collected at the Jacksonville International Airport (JAX). Rainfall measurements were available from this station from 1949 to the present.

Long-term rainfall data collected at this station was processed to obtain overall seasonal averages. The seasons used were not the Julian seasons but modified seasons corresponding to hydrologic and meteorological patterns within Florida, and were comprised of a cool, moderately wet winter season from December through March characterized by regular frontal storm events; a hot, dry spring/summer from April through July; and a hot, wet summer/fall from August through November characterized by afternoon convective thunderstorms and tropical systems.

7.1.2 PLSM Calculations

Area-Weighted Runoff Coefficients
PLSM provides runoff coefficients based on the combination of soil type and land use inputs

provided. Runoff coefficients are then multiplied by seasonal rainfall to determine a seasonal runoff volume from each particular combination of landuse and soil type. Runoff coefficients indicate the fraction of loads originating from the catchment that actually reach the stream. A value of 1 means the full load reaches the stream.

Event Mean Concentrations

The event mean concentration (EMC) reflects the average concentration of a parameter that would be found in surface water running off from an area of land with a consistent soil and land use. PLSM generates event mean concentrations for Total Nitrogen (TN), Total Phosphorus (TP), BOD, Total Inorganic Nitrogen (TIN), Phosphate (PO_4), Labile Total Organic Carbon (LTOC), and Refractory Total Organic Carbon (RTOC) based on calibrations as conducted in Hendrickson and Konwinski (1998) and the varying landuse-soils combinations that were provided.

EMCs for Total Nitrogen and Total Phosphorus include both a labile (reactive) and refractory (inert) component. A supplemental study provided by J. Hendrickson, outlines a method by which nutrient loads may be partitioned into labile and refractory components (Hendrickson, 2005). With these, it is possible to identify the total bioavailable nitrogen (TBN) and the total bioavailable phosphorus (TBP) loads which impact the system, and for which a TMDL may be calculated. For this study, the formulas outlined in Hendrickson (2005) were applied to the EMCs for TN and TP to obtain EMCs specific to TBN and TBP for each landuse category. The subsequent EMCs were applied to the seasonal runoff volume to calculate average seasonal TBN and TBP loads for each landuse-soil combination. The sum of all loads within a drainage basin was calculated to develop total seasonal loads for TBN and TBP.

7.2 WASP Model

Fishing Creek was divided into six segments for the WASP model. Segmentation was based on tributaries and monitoring data using the Grid Based Mercury Model (GBMM). The GBMM is a GIS environment extension that aids in defining the segmentation and boundary conditions for the WASP7 model input file. The GBMM extension utilizes the National Hydrography Dataset (NHD) and the National Elevation Dataset (NED) along with various other coverages, including watershed boundary, weather data and soils. GBMM was used to predict inflows to the WASP model where there are no continuous flow gages. GBMM predicts runoff as a function of landuse (pervious/impervious area), slope, soil type, infiltration and evaporation. When the GBMM was executed, two ASCII files were produced for use in building the WASP7 application for Fishing Creek. Those were the segment.txt and the flow.txt files. The segment.txt file contained the following information for each segment:

- Segment Name,
- Segment Number,
- Length (m),
- Width (m),
- Depth Multiplier,
- Velocity Multiplier,
- Slope (m/m), and
- Mannings Roughness.

The flow.txt file contains two important pieces of information, 1) how the segments were connected to one another, and 2) a time series of flow for each individual segment drainage area.

7.2.1 WASP Input

WASP requires BOD to be input as carbonaceous BOD (CBOD). To determine the loading of CBOD to each segment, the load for the entire WBID was area-weighted to the segment drainage area. The units were then converted from (lb/d) to (kg/d) by dividing (lb/d) by 2.2046. The BOD estimates were converted to ultimate CBOD (CBODu) by multiplying the BOD load by an f-ratio of 3.0. This procedure was done for each season.

Total bioavailable nitrogen and phosphorus are portioned into detrital components for input in WASP. Using the Total Nitrogen and Total Bioavailable Nitrogen from the WBID, loads of Ammonia, Nitrate+Nitrite and Detrital Nitrogen were determined. Detrital Nitrogen was calculated using the following equation.

Total Detrital Nitrogen (lb/d) = Total Nitrogen (lb/d) – Total Bioavailable Nitrogen (lb/d)

To determine the Ammonia and Nitrate+Nitrite loads to the WBID, available data from the WBID were first analyzed. For all days where Ammonia and Nitrate+Nitrite were measured, a ratio was determined. That ratio was calculated as the Ammonia divided by the Nitrate+Nitrite. Then all ratios were averaged to determine a representative ratio. For the Fishing Creek WBID, the Ammonia to Nitrate+Nitrite ratio was 0.905. Once this ratio was determined, the Ammonia and Nitrate+Nitrite loads were calculated using the following equations.

Nitrate+Nitrite (lb/d) = Total Bioavailable Nitrogen (lb/d) / (1 + 0.905)

Ammonia (lb/d) = Total Bioavailable Nitrogen (lb/d) – Nitrate+Nitrite (lb/d)

Using the Total Phosphorus and Total Bioavailable Phosphorus from the WBID, loads of Orthophosphate and Detrital Phosphorus were determined. It was assumed that all of the Total Bioavailable Phosphorus was equivalent to Orthophosphate. Detrital Phosphorus was calculated using the following equation.

Total Detrital Phosphorus (lb/d) = TP (lb/d) – Total Bioavailable Phosphorus (lb/d)

The nitrogen and phosphorus loads were then converted from (lb/d) to (kg/d) by dividing (lb/d) by 2.2046. To determine the loading of each water quality constituent to each segment, the load for the entire WBID was area-weighted to the segment drainage area. This procedure was done for each season. A time-series of loadings for each of the water quality parameters that was input into WASP is included in Appendix C.

WASP7 was setup to simulate a modified Streeter-Phelps equation for DO and CBODu and Sediment Oxygen Demand (SOD). SOD is defined as the rate of oxygen consumption exerted by bottom sediments on overlying water. Constants for DO and CBODu were selected based on literature values and experience modeling in Florida and are presented in Table 8. Constants used to simulate DO are related to reaeration and a stoichiometric ratio. The constants for CBODu describe the decay rate and half saturation limit.

Table 8. Constants used in WASP7 model for simulating DO, CBODu, and nutrients

Parameter Simulated	Constant	Value
DO	Minimum Reaeration Rate (per day)	0.5
	Theta—Reaeration Temperature Correction	1.0477
	Oxygen to Carbon Stoichiometric Ratio	2.67
CBOD1 (ultimate)	BOD (1) Decay Rate Constant @ 20^0 C (per day)	0.20
	BOD(1) Decay Rate Temperature Correction Coefficient	1.04
	BOD(1) Half Saturation Oxygen Limit (mg O/L)	0.5
Ammonia	Nitrification Rate Constant @ 20^0 C (per day)	0.15
	Nitrification Temperature Coefficient	1.07
Nitrate	Denitrification Rate Constant @ 20^0 C (per day)	0.05
	Denitrification Temperature Coefficient	1.045
Organic Nitrogen	Dissolved Organic Nitrogen Mineralization Rate Constant @ 20^0 C (per day)	0.1
	Dissolved Organic Nitrogen Mineralization Temperature Coefficient	1.08
Organic Phosphorus	Mineralization Rate Constant for dissolved organic P @ 20^0 C (per day)	0.1
	Dissolved Organic P Mineralization Temperature Coefficient	1.08
Detritus	Detritus Dissolution Rate (1/day)	0.1
	Temperature correction for detritus dissolution	1.08

7.2.2 WASP Calibration

Water quality data available at monitoring stations, 21FLJXWQOR4 (RM 1.36) and 21FLJXWQOR8 (RM 2.08) were used to calibrate the WASP model. During the calibration process it was determined that the dominant parameter was Sediment Oxygen Demand (SOD). Therefore, model calibration involved adjusting SOD until simulated dissolved oxygen values were close to the measured values. SOD data are not available in the WBID, thus model parameters were based on literature values. During initial model set-up, SOD was set using a value of 1.0 $g/m^2/d$. After the iterative calibration process, SOD was set to 3.0 $g/m^2/d$ for all segments.

The model runs were compared to the observed data for the period of 1996-2004. The critical period for the simulations was selected as 1998-1999. This period was identified since the rainfall for these two years was significantly lower than the annual average. Simulated model performance was evaluated at the downstream station Segment 2 (RM 1.36) for dissolved oxygen. A comparison of simulated and observed DO concentrations for the eight year period is shown in Figure 4; the critical period is shown in Figure 5.

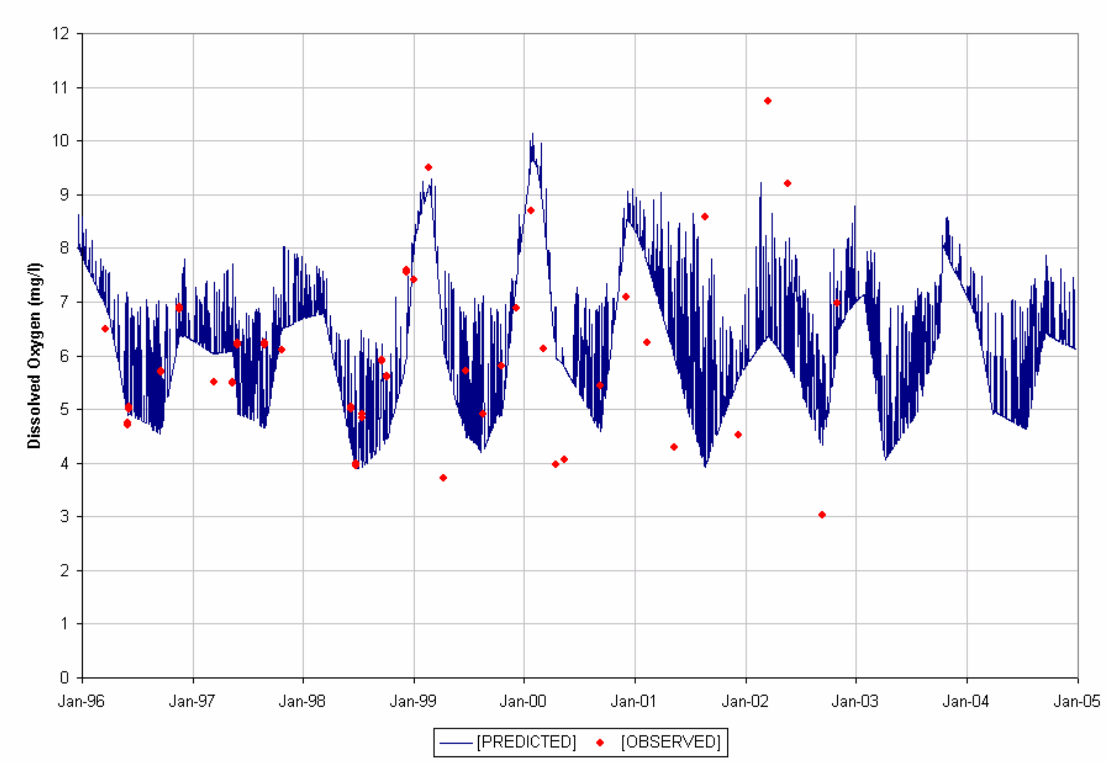

Figure 4. Dissolved Oxygen calibration at Station 21FLJXWQOR4 (RM 1.36)

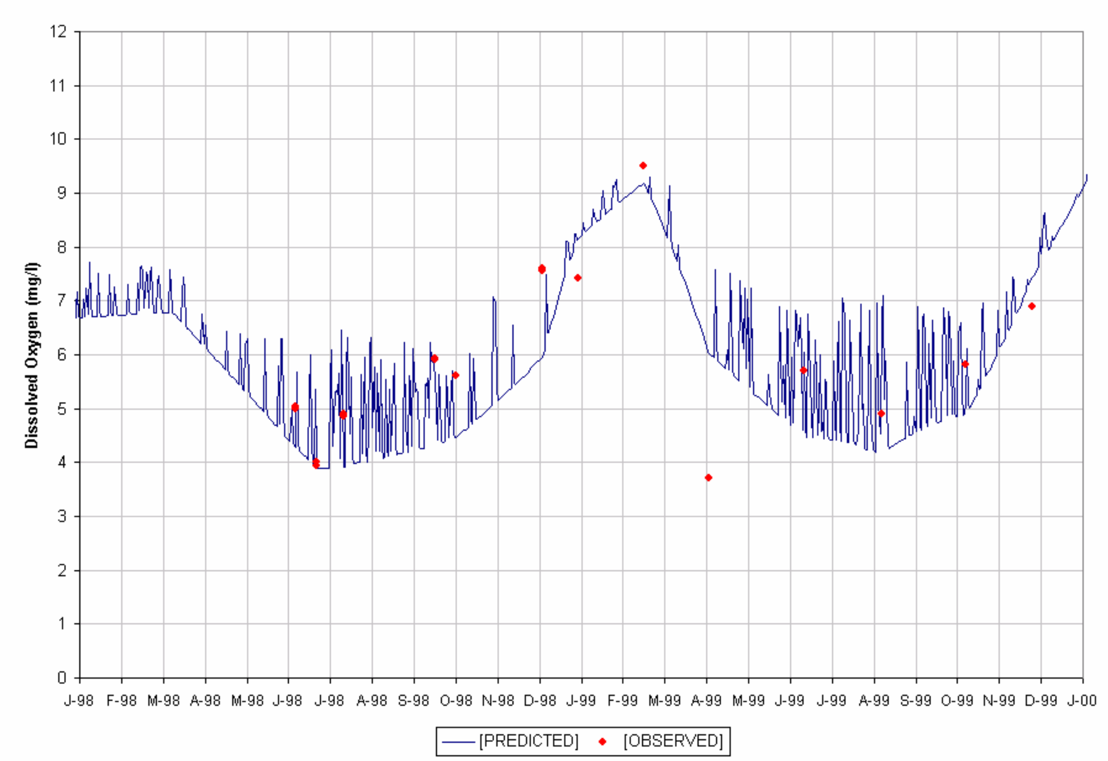

Figure 5. Simulated and observed DO levels during the critical period at segment 2

7.2.3 WASP Results

After the model was calibrated to SOD, allocation scenarios were evaluated at segment 2. Model SOD values were reduced until DO standards were achieved at all times. Acceptable DO levels were achieved with an SOD value of 2.0 g/m^2/day. Simulated DO levels in the creek at the allocated SOD level are shown in Figure 6. Since load allocations cannot be made for SOD, a relationship between CBODu and SOD was needed. Hence, the goal was to determine what reduction in the watershed CBODu load would result in an SOD value of 2.0 g/m^2/day.

WASP7 does not have a sediment diagenesis algorithm to predict SOD based on instream loads of CBOD. The SOD spreadsheet model developed by Quantitative Environmental Analysis (QEA) and modified by Dr. James Martin at Mississippi State University (MSU) was implemented to determine the relative change in SOD by reducing the watershed load of CBODu and nutrients (Martin, 2002). The SOD spreadsheet model was run on segment 2 and was used to determine the watershed load reduction. Results of the SOD spreadsheet model for CBOD reductions of 10, 25, 50, 75 and 90% at model segment 2 are shown in Figure 7. CBODu is converted to BOD by dividing by the F ratio (i.e., 3). Model results indicate a 46 percent reduction in watershed loadings of BOD is needed for Fishing Creek to attain DO standards.

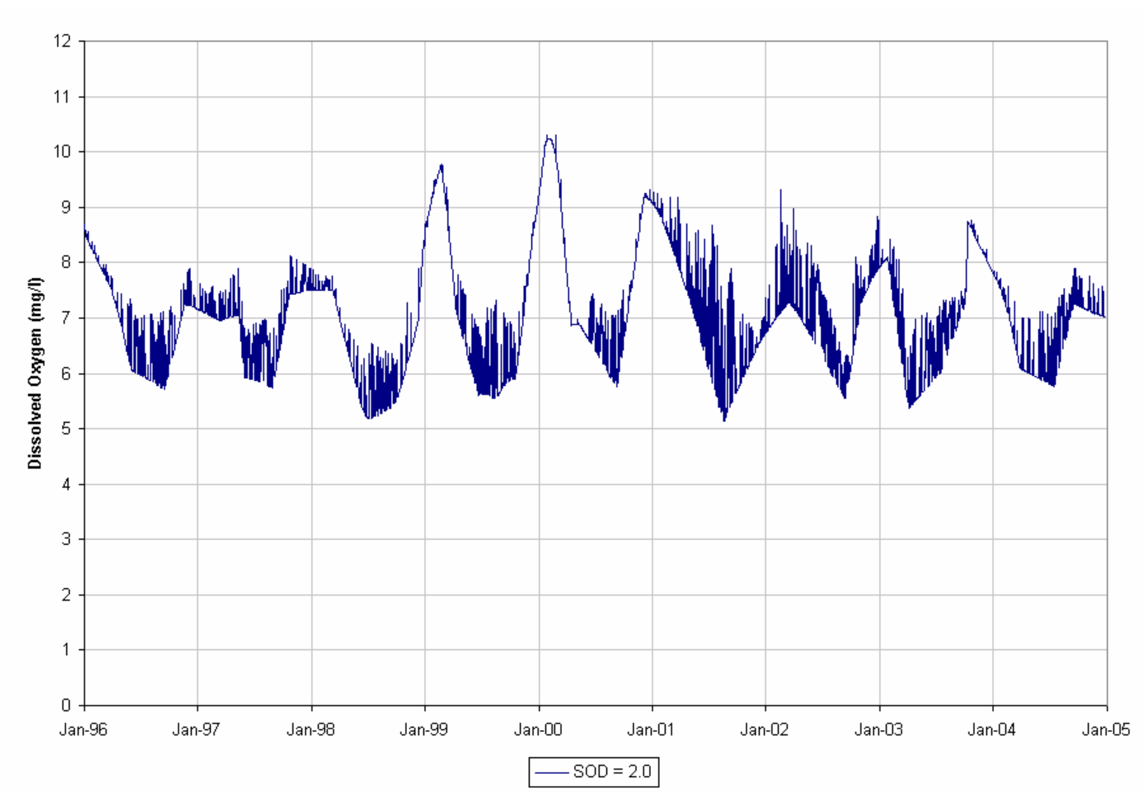

Figure 6. Simulated DO levels for the allocation scenario at Segment 2

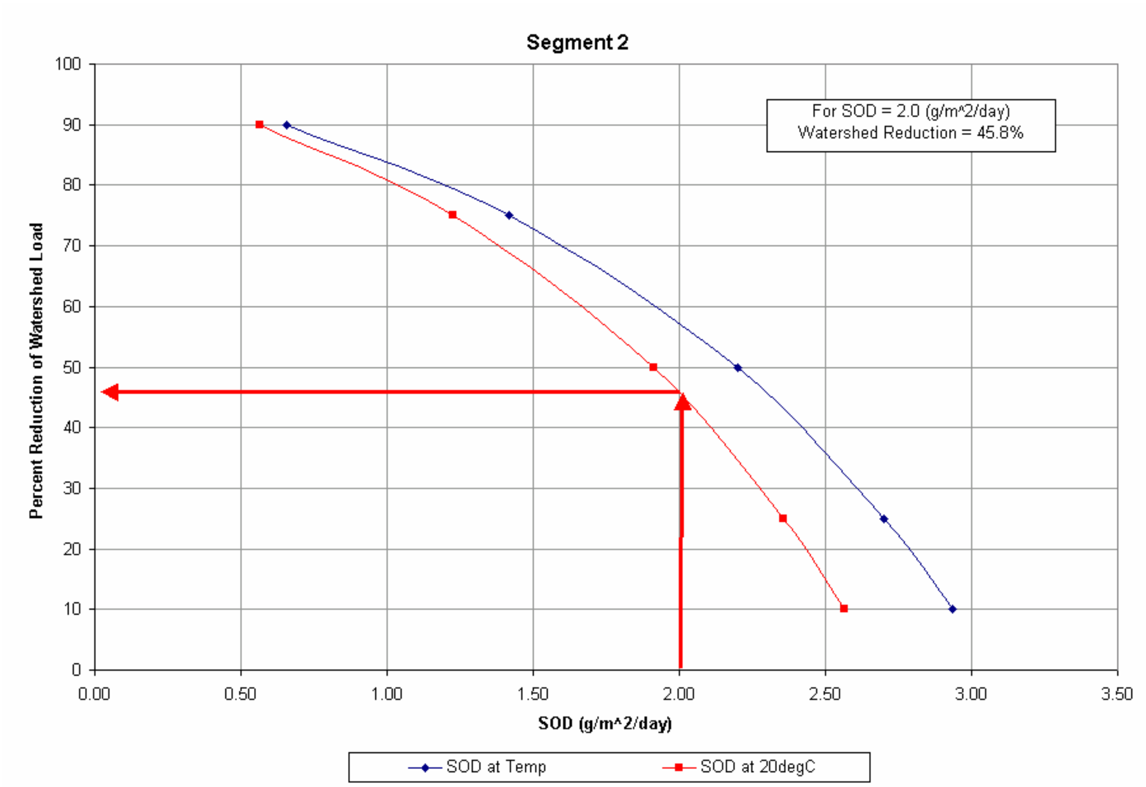

Figure 7. SOD Spreadsheet Model results for Segment 2

8. DETERMINATION OF TMDL

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or <u>other appropriate measure</u>. The TMDL for Fishing Creek is expressed as a daily load based on annual average seasonal loads. The maximum seasonal load is selected as the TMDL, as this represents the maximum load the stream can assimilate and maintain standards. In addition, the percent reduction in BOD from existing conditions necessary to achieve an instream DO concentration of 5 mg/L is provided.

8.1 Critical Conditions

The critical period for the simulations was selected as 1998-1999. Model results were evaluated as seasonal loads. During these two years, rainfall was significantly lower than the annual average and DO levels were lower than other simulated years. By achieving the DO criteria during this period, model results indicate water quality standards are achieved during all other time periods.

8.2 Existing Conditions

Existing conditions are based on modeling simulations of DO at the downstream monitoring station in the WBID over an eight-year time period. Nonpoint source loadings were derived from 2000 landuse data. Point source loads included in the model were retrieved from DMR data and represent actual monthly loadings. Total nitrogen loadings for the Royal Court MHPs are based on ammonia, as this is the only data available to estimate nitrogen loads. The eight-year time period was selected because of monitoring and DMR data available to calibrate the water quality model. Seasonal BOD and nutrient loads representing existing conditions in the WASP model are shown in Table 9.

Table 9. Nutrient and BOD loads for existing conditions

Parameter	Season1 (lb/day)	Season 2 (lb/day)	Season 3 (lb/day)
TN	100.95	110.16	139.44
TP	5.77	7.46	15.81
BOD	83.27	77.13	137.48

8.3 Margin of Safety

There are two methods for incorporating a MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. An implicit MOS was used in the analysis by meeting water quality criteria during the worst-case condition in the simulation time period. Conservative modeling assumptions were used in the analysis in the selection of the F ratio used to convert BOD to CBOD. By using an F ratio on the high end of the range reported in the literature a conservative estimated (i.e., higher) of the CBOD load was used in the model than what would have been calculated using a smaller value.

8.4 Determination of TMDL, LA and WLA

The BOD TMDL is expressed as the load the stream can assimilate and maintain standards. To achieve the BOD load, a 46 percent reduction is required from nonpoint sources and the MS4. The WLA assigned to the continuous facilities is the average existing BOD load reported in each facility's DMR.

The TN TMDL is being proposed to achieve the downstream TMDL for the Lower St. Johns River (FDEP, 2004a). TN is set to achieve an overall 22 percent reduction from all sources in the watershed. The WLA for TN is equivalent to a 22 percent reduction of existing loads. The LA is equal to the load remaining after the TMDL is reduced by the WLA value. TMDL components are summarized in Table 10.

Table 10. Summary of TMDL Components for Fishing Creek (WBID 2324)

Parameter	WLA		LA (lb/day)	TMDL (lb/day)	Nonpoint Source Reduction
	Continuous	MS4 (reduction)			
BOD	15.8 lb/day (see note 1)	46%	58.44	74.24	46%
TN	54.29 lb/day (22% reduction)[2]	22%	54.47	108.76	22%

Notes:
1. WLA value for BOD based on average load reported in DMRs.
2. WLA value for TN based on a 22% reduction of average existing load from facilities.

8.4.1 Waste Load Allocations

There are three NPDES facilities permitted to discharge treated effluent to surface waters in Fishing Creek. Only facilities discharging pollutants directly into streams and MS4 areas are assigned a WLA. The WLAs are expressed separately for continuous discharge facilities and MS4 areas as the former discharges during all weather conditions whereas the later discharges in response to storm events. Any future facility permitted to discharge effluent to surface waters in the watershed that adversely impacts DO or the natural balance of aquatic flora and fauna will be required to meet the requirements of this TMDL and cannot cause or contribute to impairment in the stream.

Individual WLAs for the NPDES facilities in the watershed are shown in Table 11**.** Allocated BOD loads are based on average monthly loads reported in the facilities DMRs. The Lower St. Johns River (LSJR) TMDL (FDEP, 2004a) targeted the Jacksonville Heights WWTP for reductions in TN loadings to the SJR. Reductions in Total Nitrogen are not proposed for the Royal Court MHPs as these are minor facilities and were not considered significant contributors in the LSJR TMDL.

Phosphorus concentrations in the effluent of the WWTPs have historically exceeded 95% of freshwater streams in Florida. Currently the facilities are required to report quarterly monitoring results, but effluent limits are not a requirement. Although chlorophyll data are not available to assess the extent of the nutrient impairment, elevated concentrations of phosphorus and nitrates from these facilities could contribute to the imbalance of flora and fauna in Fishing Creek. Reductions in phosphorus loadings should be achieved through nitrogen reduction strategies.

Table 11. Existing and Allocated WLAs for NPDES facilities in Fishing Creek

Facility	BOD (lb/day)		TN (lb/day)	
	Existing	Allocated	Existing	Allocated

Jacksonville Heights WWTP (FL0023671)	15.4	15.4	69.6	54.29
Royal Court MHP – North (FL0043095)	0.2	0.2	0.5	0.5
Royal Court MHP – South (FL0043141)	0.2	0.2	0.09	0.09

Note: Allocated TN load for the Jacksonville Heights facility represents a 22% reduction from existing loads.

The City of Jacksonville MS4 impacts Fishing Creek. The WLA assigned to the MS4 area is expressed in terms of percent reduction of BOD loads required to attain the target. With the available water quality data it is not possible to calculate the WLA in terms of load or isolate the load discharging exclusively from the MS4 areas.

8.4.2 Load Allocations

The primary mode of transport of BOD to the stream is during a storm event. Nutrient data were collected over an eight-year period. Modification of the land surface from a pervious land cover to an impervious surface results in higher peak flow rates that wash BOD and nutrient-enriched water into the stream. Nonpoint sources load reductions of 46% throughout the watershed should result in attainment of standards.

8.5 Seasonal Variation

Seasonal variation was incorporated in the analysis by simulating loads during the various seasons by using the entire period of record of data collected in the WBID. This incorporates changes in water temperature, rainfall, and rainfall intensity.

9. RECOMMENDATIONS

Controlling sources contributing to reduced DO concentrations should be the focus of implementing this TMDL. FDEP employs the Basin Management Action Plan (B-MAP) as the mechanism for developing strategies to accomplish the necessary load reductions. Components of a B-MAP are:

- Allocations among stakeholders
- Listing of specific activities to achieve reductions
- Project initiation and completion timeliness
- Identification of funding opportunities
- Agreements
- Local ordinances
- Local water quality standards and permits
- Follow-up monitoring

REFERENCES

Adamus, C.L. and M.J. Bergman. 1995. *Estimating nonpoint source pollution loads with a GIS screening model.* Wat. Res. Bull. 31(4): 647-655.

Florida Administrative Code (F.A.C.). Chapter 62-302, Surface Water Quality Standards.

FDEP, 2004a. *Total Maximum Daily Load for Nutrients For the Lower St. Johns River,* Department of Environmental Protection, Bureau of Watershed Management, Watershed Assessment Section, Tallahassee, FL. April 23, 2004.

FDEP, 2004b. *Bioassays of the Royal Court Mobile Home Park North Wastewater Treatment Facility, Duval County, NPDES # FL043095, Sampled February 23, 2004.* Division of Resource Assessment and Management, Bureau of Laboratories, Biology Section, Tallahassee, FL. June 2004.

FDEP, 2004c. *Bioassays of Jacksonville Heights Wastewater Treatment Facility, Duval County, NPDES #FL0023671, Sampled May 10, 12, and 14, 2004.* Division of Resource Assessment and Management, Bureau of Laboratories, Biology Section, Tallahassee, FL. September 2004.

Florida Department of Environmental Protection (FDEP), 2003. *Basin Status Report, Lower St. Johns,* DEP Division of Water Resource Management, Northeast District, Group 2 Basin, March 2003.

FDEP, 1999. *Biological Assessments of Jacksonville Heights WWTP Duval County NPDES #FL0023671 Sampled May 18, 1998.* Florida Department of Environment Regulation, Biology Section, Division of Administrative and Technical Services, Tallahassee, FL. February, 1999.

FDEP, 1992. *Biological Assessments of Jacksonville Heights WWTP Duval County NPDES #FL0023671 Sampled May 1992*. Florida Department of Environment Regulation, Biology Section, Division of Technical Services, September 1992.

Hendrickson, J.C., Trahan, N., Gordon, E., Ouyang, Y. 2005. *Estimating Relevance of Organic Carbon and Nutrient Loads to a Blackwater River Estuary*, St. Johns River Water Management District, Palatka, FL.

Hendrickson, J.C. and J. Konwinski. 1998. *Seasonal Nutrient Import-Export Budgets for the Lower St. Johns River, Florida.* Final report for Contract WM598, Florida Department of Environmental Protection. 109 pp.

Hendrickson, J., E. Lowe, D. Dobberfuhl, P. Sucsy and D. Campbell. 2003. *Characteristics of Accelerated Eutrophication in the Lower St. Johns River Estuary and Recommendation of Targets for the Achievement of Water Quality Goals to Fulfill TMDL and PLRG Objectives.* Water Resources Department Technical Memorandum No., St. Johns River Water Management District, Palatka, FL.

Hendrickson, J., Trahan, N., Stecker, E., Ouyang, Y., *TMDL and PLRG Modeling of the Lower St. Johns River, Technical Report Series Volume 1: Calculation of External Loads*, May 2002

Martin, James A., 2002. *A Review and Evaluation of Sediment Diagenesis Routines for Potential Incorporation into the Water Analysis Simulation Program (WASP)*, Draft Final Report, Mississippi State University, Prepared for Tetra Tech, Inc., Sept. 17, 2002.

Mundy, Christine A and Bergman, M.J., 1998. The Pollution Load Screening Model: A Tool for the 1995 District Water Management Plan and the 1996 Local Government Water Resource Atlases. Technical Memorandum No. 29, St. Johns River Water Management District, Palatka, Florida.

Raschke, R.L., and D.A.Schultz. 1987. The use of the algal growth potential test for data assessment. J. Water Pollution Control Federation. 59(4): 222-227.

Thomann, Robert V. and John A. Mueller, 1987. *Principles of Surface Water Quality Modeling and Control,* HarperCollins Publishers, New York, NY 644p.

USEPA, 1999. *Protocol for Developing Nutrient TMDLs First Edition*. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-841-B-99-007, November 1999

USEPA, 1991. *Guidance for Water Quality–based Decisions: The TMDL Process.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-440/4-91-001, April 1991.

Wool, Tim A., Robert B. Ambrose, James L. Martin, and Edward A. Comer, 2001. 2001, *Water Quality Analysis Simulation Program (WASP) Version 6.0 DRAFT: User's Manual*, U.S. Environmental Protection Agency – Region 4 Atlanta, GA

APPENDIX A WATER QUALITY DATA

Table A- 1. Guide to Water Quality Remark Codes (Rcode column in data tables)

Remark Code	Definition	Use in TMDL
A	Value reported is mean of two or more samples	Data included in analysis as reported
E	Extra sample taken in compositing process	Data included as average
I	The value reported is less than the practical quantification limit and greater than or equal to the method detection limit.	Data included in analysis as reported
J	Estimated. Value shown is not a result of analytical measurement.	Data not included in analysis as reported
K	Off-scale low. Actual value not known, but known to be less than value shown	Data included in analysis as reported
L	Off-scale high. Actual value not known, but known to be greater than value shown	Data included in analysis as reported
Q	Sample held beyond normal holding time	**Data used in analysis – samples held on ice; actual concentration is expected to be at least as high as the value reported.**
T	Value reported is less than the criteria of detection	Data included in analysis if the reported value is below criteria; otherwise, reported value is not used in the analysis
U	Material was analyzed for but not detected. Value stored is the limit of detection.	Data not included in analysis
<	NAWQA – actual value is known to be less than the value shown	Data included in analysis
$	Calculated by retrieval software. Numerical value was neither measured nor reported to the database, but was calculated from other data available during generation of the retrieval report.	Data not included in analysis

Table A- 2. Water quality data collected in Fishing Creek

Parameter	Station	Date	Time	Result	Remark Code
Biochemical Oxygen Demand (mg/L)	21FLJXWQOR4	12/5/95	1150	1	
		6/5/96	925	1	
		5/28/97	1002	1	
		2/23/99	926	2	U
	21FLJXWQOR8	6/5/96	1116	1	
		5/28/97	947	1	
		2/23/99	1018	1	K
Chlorophyll-a (µg/L) - corrected	21FLSJWMLSJ908	5/11/1992	1000	8.55	
		8/4/1992	805	4.34	
		1/20/1993	940	4.54	
Dissolved Oxygen (mg/L)	21FLJXWQOR8	3/19/96	932	7.7	
		5/29/96	1047	10.5	
		6/5/96	947	8.9	
		9/16/96	1138	8.5	
		11/18/96	1029	8.7	
		3/12/97	1008	9	
		5/14/97	1126	10.9	
		5/28/97	1018	6.5	
		8/28/97	944	7.4	
		10/22/97	1132	10.1	
		3/10/98	1429	9.4	
		6/10/98	917	6.7	
		6/25/98	1053	8.24	
		7/15/98	1130	8	
		9/21/98	854	5.6	
		10/7/98	1117	7.2	
		12/10/98	1253	9.24	
		1/5/99	1049	7.79	
		2/23/99	938	11.44	
		4/12/99	1114	13.25	
		6/22/99	948	7.41	
		8/18/99	1138	11.26	
		10/20/99	927	6.65	
		12/8/99	1020	9.2	
		1/25/00	1038	11.34	
		3/6/00	1505	18.35	
		4/17/00	1013	8.93	
		5/17/00	1029	11.94	
		9/11/00	1134	8.46	
		12/7/00	1243	10.78	
		2/15/01	1257	14.68	

Parameter	Station	Date	Time	Result	Remark Code
		5/15/01	1417	14.93	
Dissolved Oxygen (mg/L)	21FLJXWQOR8	8/22/01	1402	9.31	
		12/11/01	1447	7.64	
		3/20/02	1207	12.12	
		5/23/02	1036	8.06	
		9/16/02	1200	8.75	
		11/5/02	1200	11.8	
	21FLJXWQOR4	3/19/96	914	6.5	
		5/29/96	1134	4.74	
		6/5/96	925	5	
		9/16/96	1153	5.72	
		11/18/96	1007	6.9	
		3/12/97	1035	5.51	
		5/14/97	1206	5.5	
		5/28/97	1002	6.24	
		8/28/97	1010	6.24	
		10/22/97	1031	6.1	
		6/10/98	857	5.04	
		6/25/98	1104	4	
		7/15/98	1153	4.85	
		9/21/98	833	5.93	
		10/7/98	1155	5.6	
		12/10/98	1320	7.56	
		1/5/99	1037	7.41	
		2/23/99	926	9.51	
		4/12/99	1128	3.72	
		6/22/99	1010	5.71	
		8/18/99	1125	4.91	
		10/20/99	913	5.81	
		12/8/99	1005	6.89	
		1/25/00	1052	8.69	
		3/6/00	1521	6.12	
		4/17/00	1001	3.96	
		5/17/00	1006	4.06	
		9/11/00	1115	5.43	
		12/7/00	1256	7.08	
		2/15/01	1306	6.25	
		2/15/01	1306	6.25	
		5/15/01	1404	4.29	
		8/22/01	1424	8.57	
		12/11/01	1505	4.52	
		3/20/02	1223	10.74	
		5/23/02	1051	9.19	
		9/16/02	1200	3.02	
		11/5/02	1200	6.98	

Parameter	Station	Date	Time	Result	Remark Code
Dissolved Oxygen (mg/L)	21FLA 20030617	4/18/02	0	6.4	
		6/6/02	1215	6.3	
		7/24/02	1300	5.9	
		8/14/02	1150	3.5	
		9/3/02	1238	5.2	
		10/29/02	1000	4.6	
		12/16/02	1020	7.9	
	21FLA 20030615	4/18/02	0	5.6	
		6/6/02	1200	0.5	
		7/24/02	1245	4.7	
		8/14/02	1130	4.9	
		9/3/02	1226	3.7	
		10/29/02	1025	4.6	
		12/16/02	1000	7.7	
	112WRD 02246437	2/7/00	1155	8.4	
		3/8/00	1015	4	
		4/18/00	845	2.1	
		5/23/00	1030	3.7	
		7/11/00	1045	2.2	
		8/8/00	830	1.8	
		9/5/00	1030	2.8	
		9/18/00	1000	5.1	
		10/10/00	900	6.2	
		11/28/00	1030	5.2	
		12/12/00	1300	2.9	
		1/16/01	930	5.3	
		2/6/01	1045	7.6	
		3/13/01	1015	3.4	
		4/10/01	930	2.4	
		6/6/01	900	1.3	
		7/9/01	930	2.5	
		8/21/01	940	5.2	
		9/10/01	820	5.4	
		9/15/01	1045	5.4	
		11/6/01	1030	4.5	
		2/26/02	945	6.6	
		8/12/02	1000	4.7	
		9/25/02	915	5.8	
		2/7/00	1155	8.4	
	112WRD 02246435	2/7/00	1035	9.7	
		3/8/00	915	5.2	
		4/18/00	745	3.1	
		5/23/00	930	4.9	
		8/8/00	745	2.3	
		9/5/00	910	2.8	
		9/18/00	830	3.4	

Parameter	Station	Date	Time	Result	Remark Code
		10/10/00	830	6.3	
Dissolved Oxygen (mg/L)	112WRD 02246435	11/28/00	945	5.8	
		12/12/00	1120	4.6	
		1/16/01	845	6.1	
		2/6/01	930	7.9	
		3/13/01	945	2.6	
		4/10/01	900	2.9	
		7/9/01	830	1	
		8/21/01	755	3.7	
		9/10/01	800	3.3	
		9/15/01	915	5	
		11/6/01	900	3.7	
		2/26/02	845	5.5	
		9/25/02	815	5	
Ammonia (mg/L)	112WRD 02246435	2/7/00	1035	0.02	
		4/18/00	745	0.07	
		9/5/00	910	0.07	
		9/18/00	830	0.08	
		12/12/00	1120	0.03	
		2/6/01	930	0.01	<
		8/21/01	755	0.08	
		9/15/01	915	0.04	
		11/6/01	900	0.07	
		2/26/02	845	0.02	
		9/25/02	815	0.02	
	112WRD 02246437	2/7/00	1155	0.05	
		4/18/00	845	0.21	
		7/11/00	1045	0.44	
		9/5/00	1030	0.27	
		9/18/00	1000	0.07	
		12/12/00	1300	0.06	
		2/6/01	1045	0.04	
		8/21/01	940	0.09	
		9/15/01	1045	0.05	
		11/6/01	1030	0.05	
		2/26/02	945	0.13	
		8/12/02	1000	0.06	
		9/25/02	915	0.04	
	21FLJXWQOR4	6/5/96	925	0.03	
		5/28/97	1002	0.11	
		2/23/99	926	0.03	
		5/28/97	1018	0.04	
		2/23/99	938	0.08	
Nitrate-Nitrite (mg/L)	112WRD 02246435	2/7/00	1035	0.02	
		4/18/00	745	0.07	
		9/5/00	910	0.06	

Parameter	Station	Date	Time	Result	Remark Code
		9/18/00	830	0.04	
Nitrate-Nitrite (mg/L)	112WRD 02246435	12/12/00	1120	0.02	<
		2/6/01	930	0.02	<
		8/21/01	755	0.07	
		9/15/01	915	0.02	<
		11/6/01	900	0.02	<
		2/26/02	845	0.02	<
		9/25/02	815	0.11	
	112WRD 02246437	2/7/00	1155	0.06	
		4/18/00	845	0.06	
		7/11/00	1045	0.02	<
		9/5/00	1030	0.13	
		9/18/00	1000	0.06	
		12/12/00	1300	0.02	<
		2/6/01	1045	0.10	
		8/21/01	940	0.15	
		9/15/01	1045	0.03	
		11/6/01	1030	0.03	
		2/26/02	945	0.18	
		8/12/02	1000	0.14	
		9/25/02	915	0.13	
	21FLJXWQOR4	6/5/96	925	6.71	
		5/28/97	1002	0.52	
		2/23/99	926	3.37	
	21FLJXWQOR8	6/5/96	947	9.83	
		5/28/97	1018	1.67	
		2/23/99	938	2.26	
Total Kjeldahl Nitrogen (mg/L)	112WRD 02246435	2/7/00	1035	0.72	
		4/18/00	745	0.48	
		9/5/00	910	0.75	
		9/18/00	830	1.60	
		12/12/00	1120	0.63	
		2/6/01	930	0.65	
		8/21/01	755	1.30	
		9/15/01	915	1.20	
		11/6/01	900	0.80	E
		2/26/02	845	0.90	
		9/25/02	815	1.50	
	112WRD 02246437	2/7/00	1155	0.61	
		4/18/00	845	0.56	
		7/11/00	1045	0.51	
		9/5/00	1030	0.92	
		9/18/00	1000	1.60	
		12/12/00	1300	0.56	
		2/6/01	1045	0.47	
		8/21/01	940	1.20	
		9/15/01	1045	1.10	
		11/6/01	1030	0.70	E

Parameter	Station	Date	Time	Result	Remark Code
		2/26/02	945	1.00	
Total Kjeldahl Nitrogen (mg/L)	112WRD 02246437	8/12/02	1000	1.00	
		9/25/02	915	1.60	
	21FLJXWQOR4	6/5/96	925	1.01	
		5/28/97	1002	0.91	
		2/23/99	926	1.23	
	21FLJXWQOR8	6/5/96	947	0.87	
		5/28/97	1018	0.72	
		2/23/99	938	0.42	
Total Phosphorus (mg/L)	112WRD 02246435	2/7/2000	1035	0.04	
		4/18/2000	745	0.07	
		9/5/2000	910	0.11	
		9/18/2000	830	0.19	
		12/12/2000	1120	0.14	
		2/6/2001	930	0.05	
		8/21/2001	755	0.16	
		9/15/2001	915	0.13	
		11/6/2001	900	0.13	E
		2/26/2002	845	0.07	
		9/25/2002	815	0.09	
	112WRD 02246437	2/7/2000	1155	0.05	
		4/18/2000	845	0.14	
		7/11/2000	1045	0.22	
		9/5/2000	1030	0.13	
		9/18/2000	1000	0.19	
		12/12/2000	1300	0.11	
		2/6/2001	1045	0.04	
		8/21/2001	940	0.14	
		9/15/2001	1045	0.15	
		11/6/2001	1030	0.09	E
		2/26/2002	945	0.1	
		8/12/2002	1000	0.13	
		9/25/2002	915	0.1	
	21FLJXWQOR4	6/5/1996	925	1.79	
		5/28/1997	1002	0.206	
		2/23/1999	926	1.14	
	21FLJXWQOR8	6/5/1996	947	1.8	
		5/28/1997	1018	0.48	
		2/23/1999	938	1.17	
Total Nitrogen (mg/L)	112WRD 02246435	2/7/00	1035	0.74	
		4/18/00	745	0.55	
		9/5/00	910	0.81	
		9/18/00	830	1.64	
		12/12/00	1120	0.65	
		2/6/01	930	0.67	
		8/21/01	755	1.37	
		9/15/01	915	1.22	

Parameter	Station	Date	Time	Result	Remark Code
		11/6/01	900	0.82	
Total Nitrogen (mg/L)	112WRD 02246435	2/26/02	845	0.92	
		9/25/02	815	1.61	
	112WRD 02246437	2/7/00	1155	0.67	
		4/18/00	845	0.62	
		7/11/00	1045	0.53	
		9/5/00	1030	1.05	
		9/18/00	1000	1.66	
		12/12/00	1300	0.58	
		2/6/01	1045	0.57	
		8/21/01	940	1.35	
		9/15/01	1045	1.13	
		11/6/01	1030	0.73	
		2/26/02	945	1.18	
		8/12/02	1000	1.14	
		9/25/02	915	1.73	
	21FLJXWQOR4	6/5/96	925	7.72	
		5/28/97	1002	1.43	
		2/23/99	926	4.60	
	21FLJXWQOR8	6/5/96	947	10.70	
		5/28/97	1018	2.39	
		2/23/99	938	2.68	

APPENDIX B Discharge Monitoring Report Data

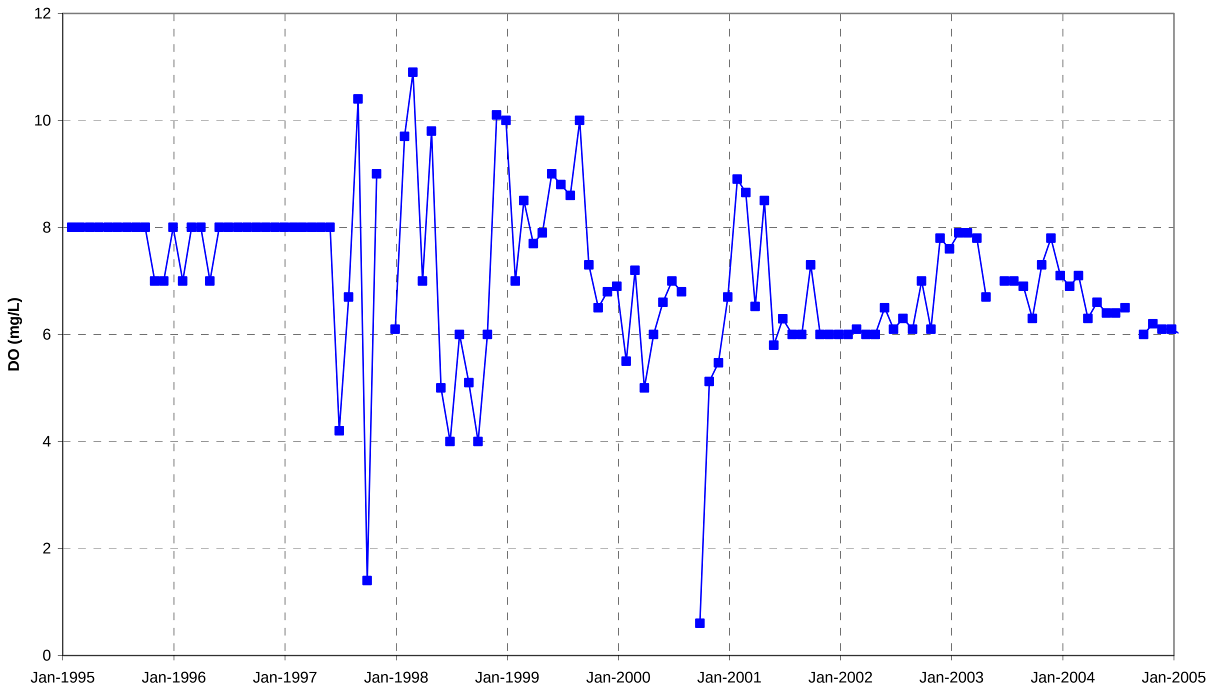

Figure B- 1. Effluent DO levels reported from Royal Court Mobile Home Park South (FL0043141)

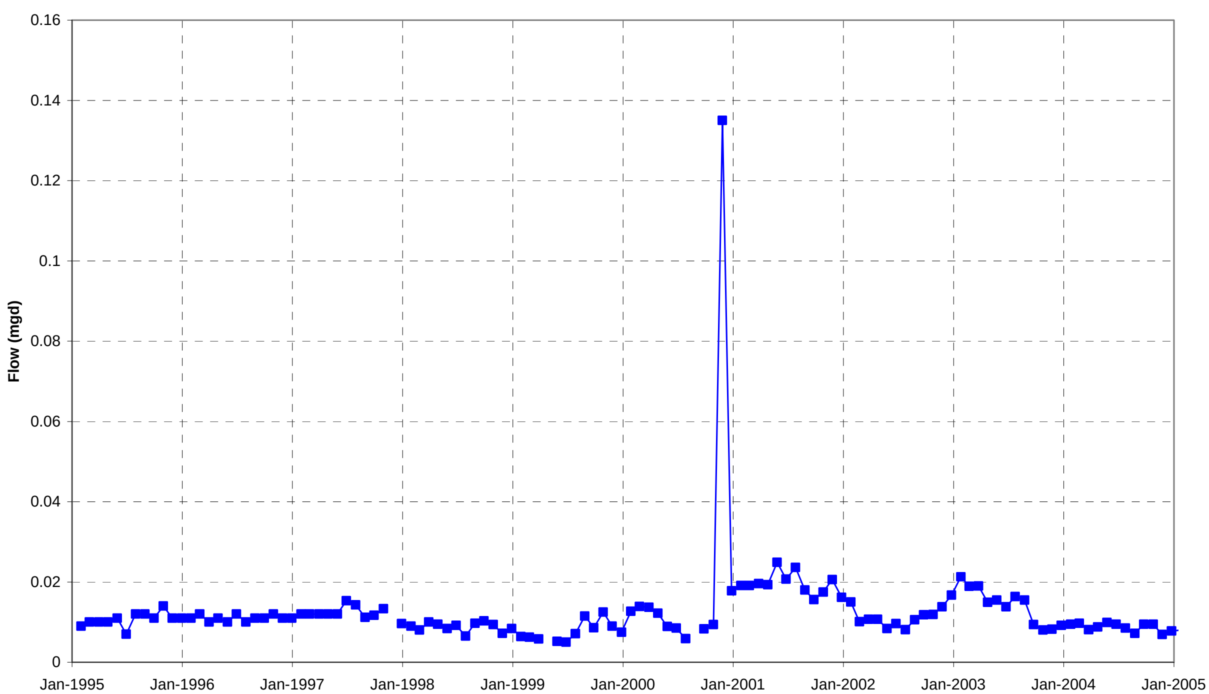

Figure B- 2. Discharge from Royal Court Mobile Home Park South (FL0043141)

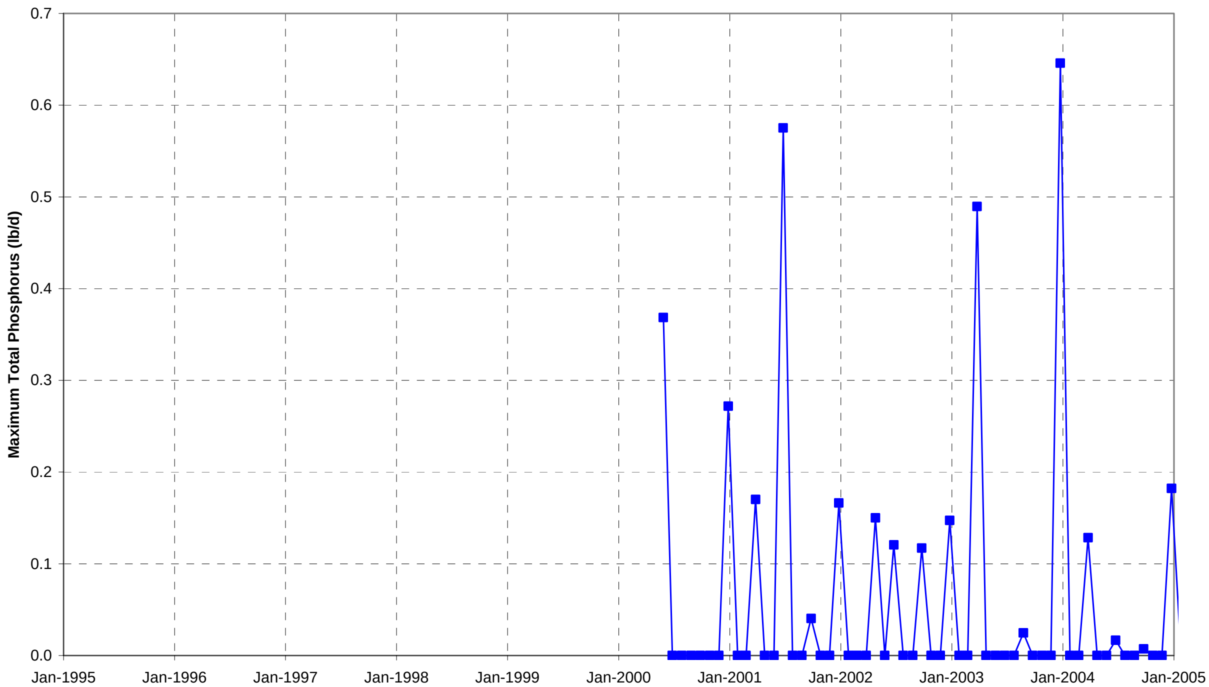

Figure B- 3. Maximum Total Phosphorus load reported from NPDES facility FL0043141

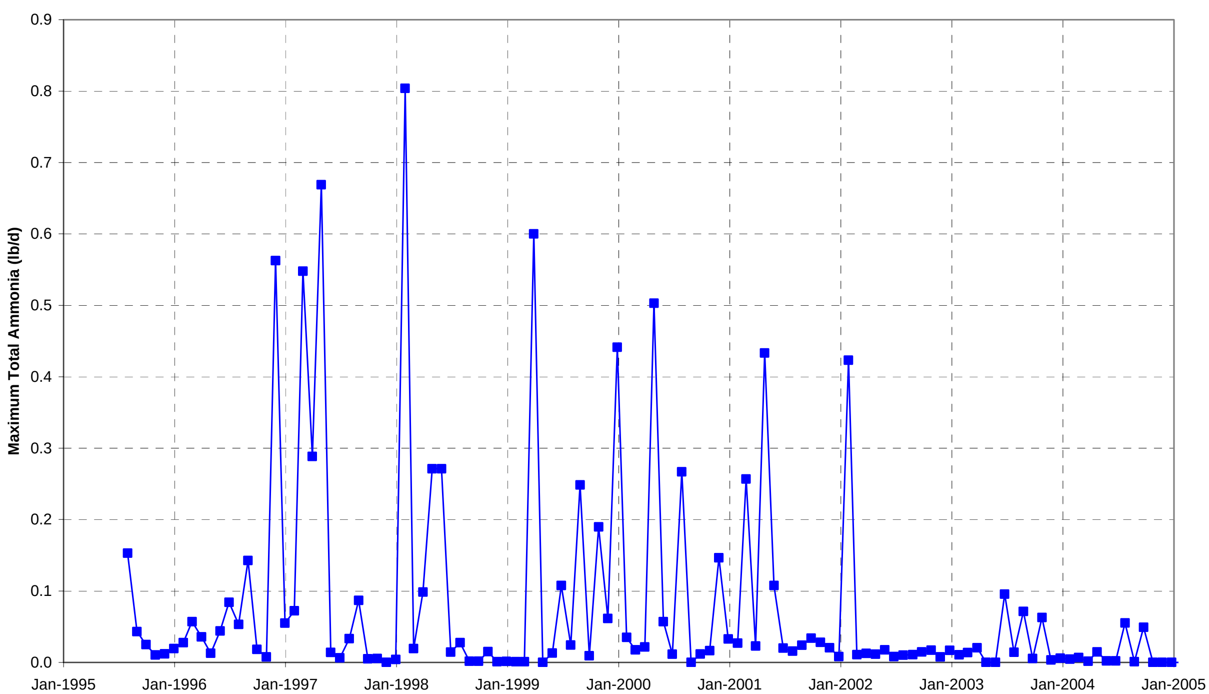

Figure B- 4. Maximum total ammonia load in effluent from facility FL0043141

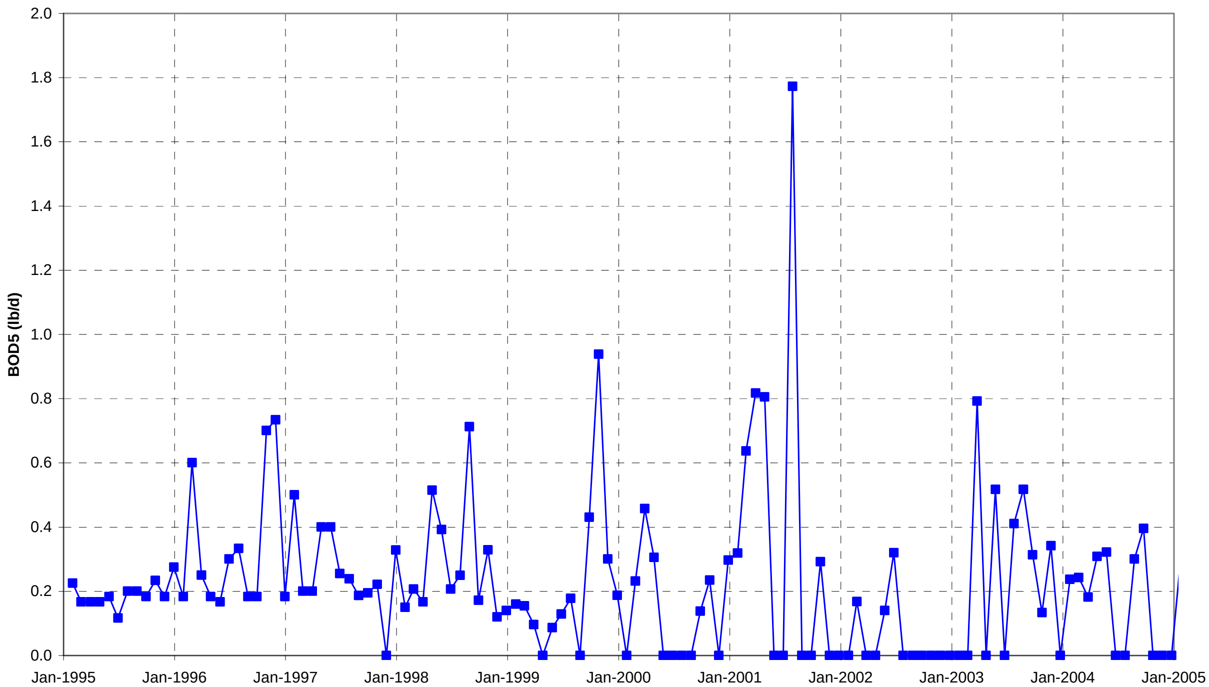

Figure B- 5. Total BOD load in effluent reported by NPDES facility FL0043141

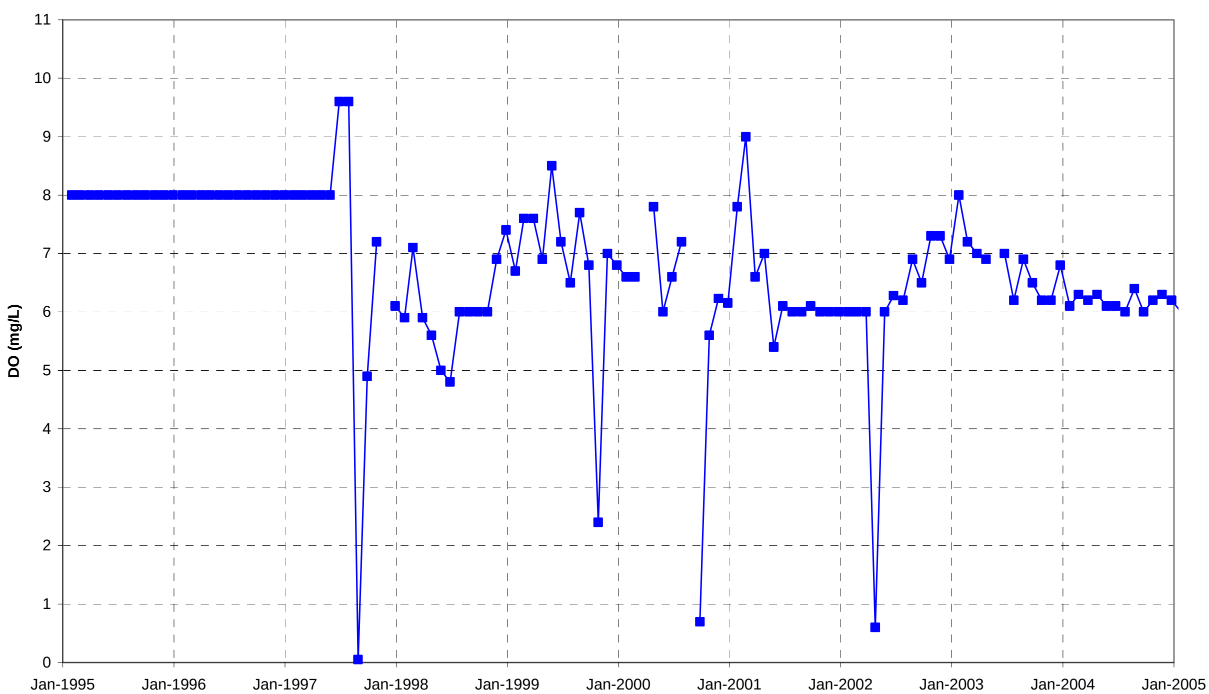

Figure B- 6. Effluent DO levels reported by Royal Court Mobile Home Park South (FL0043095)

Figure B- 7. Discharge reported by Royal Court Mobile Home Park South (FL0043095)

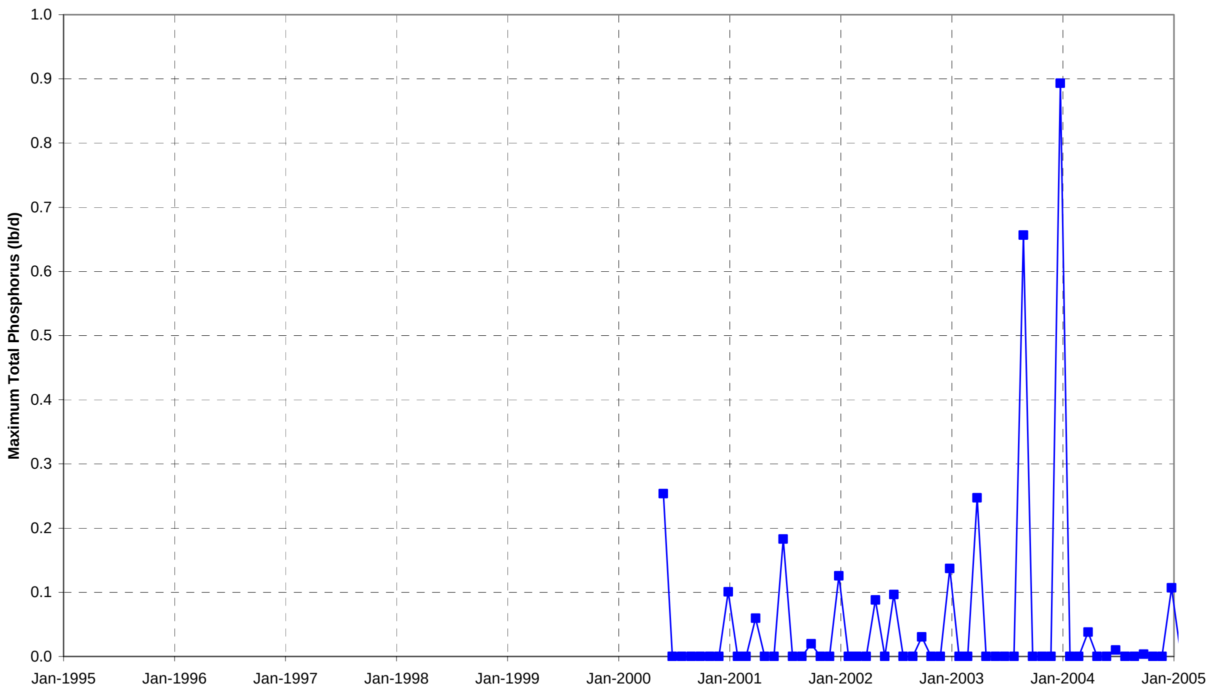

Figure B- 8. Maximum Total Phosphorus load reported by NPDES facility FL0043095

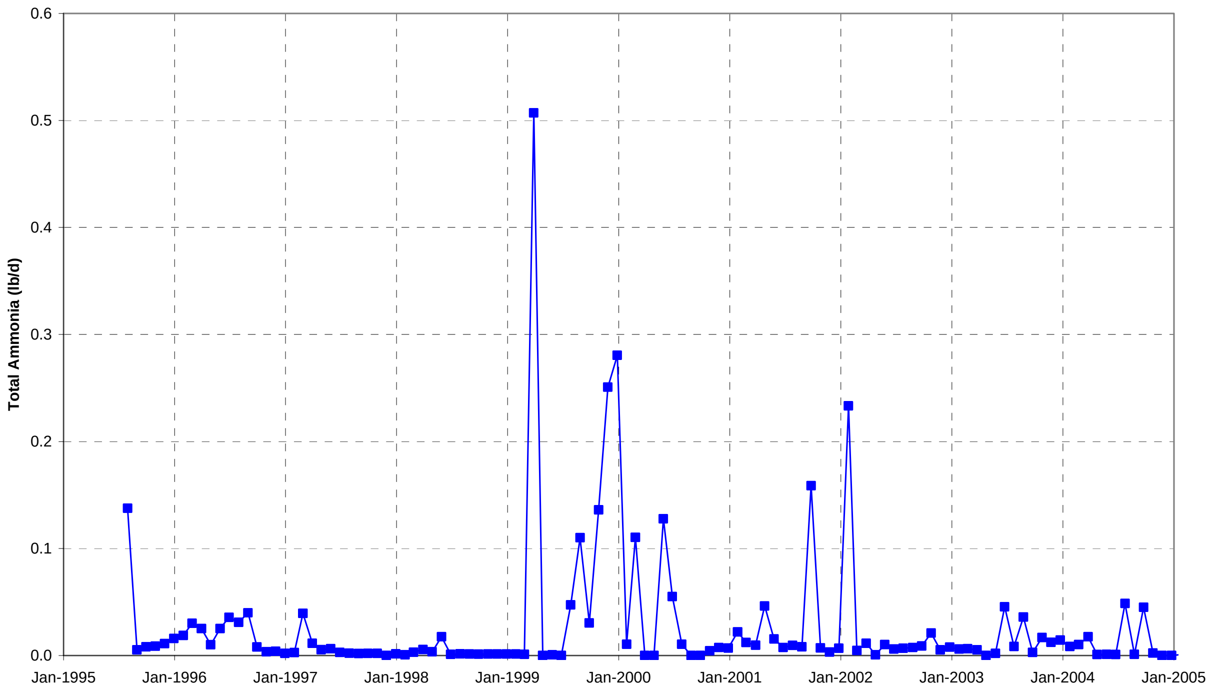

Figure B- 9. Total Ammonia load reported by NPDES facility FL0043095

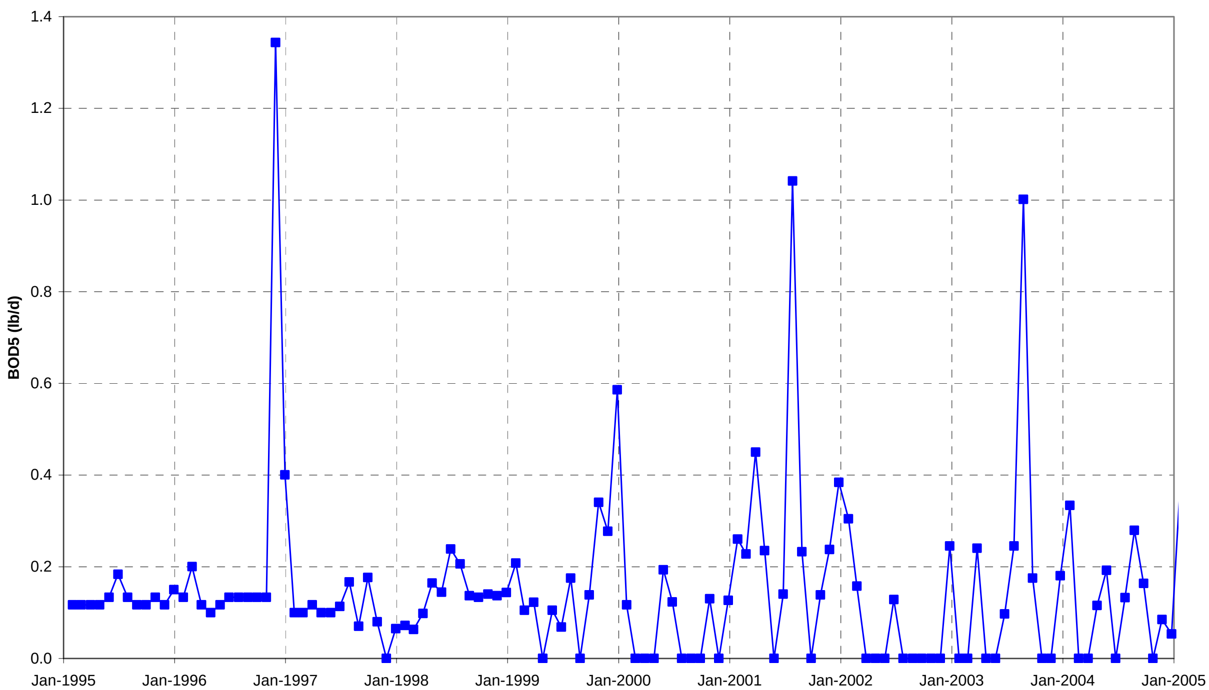

Figure B- 10. Total BOD load reported by NPDES facility FL0043095

Figure B- 11. Effluent DO levels reported by Jacksonville Heights WWTF (FL0023671)

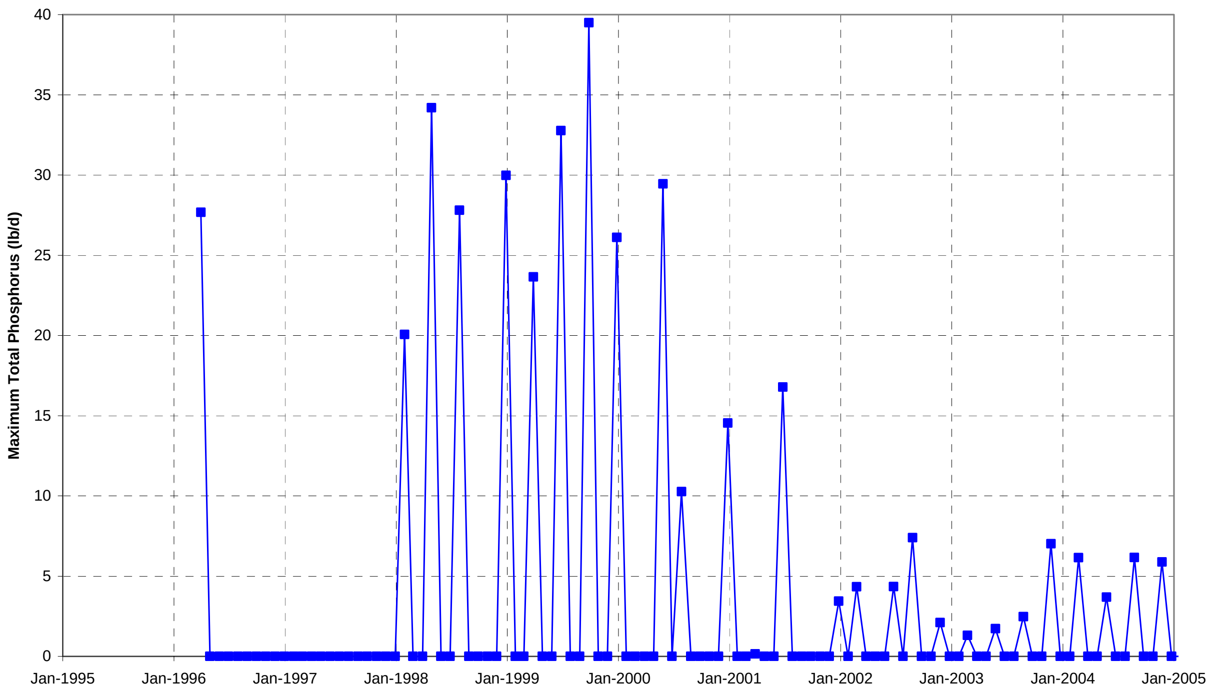

Figure B- 12. Maximum Total Phosphorus load reported by FL0023671

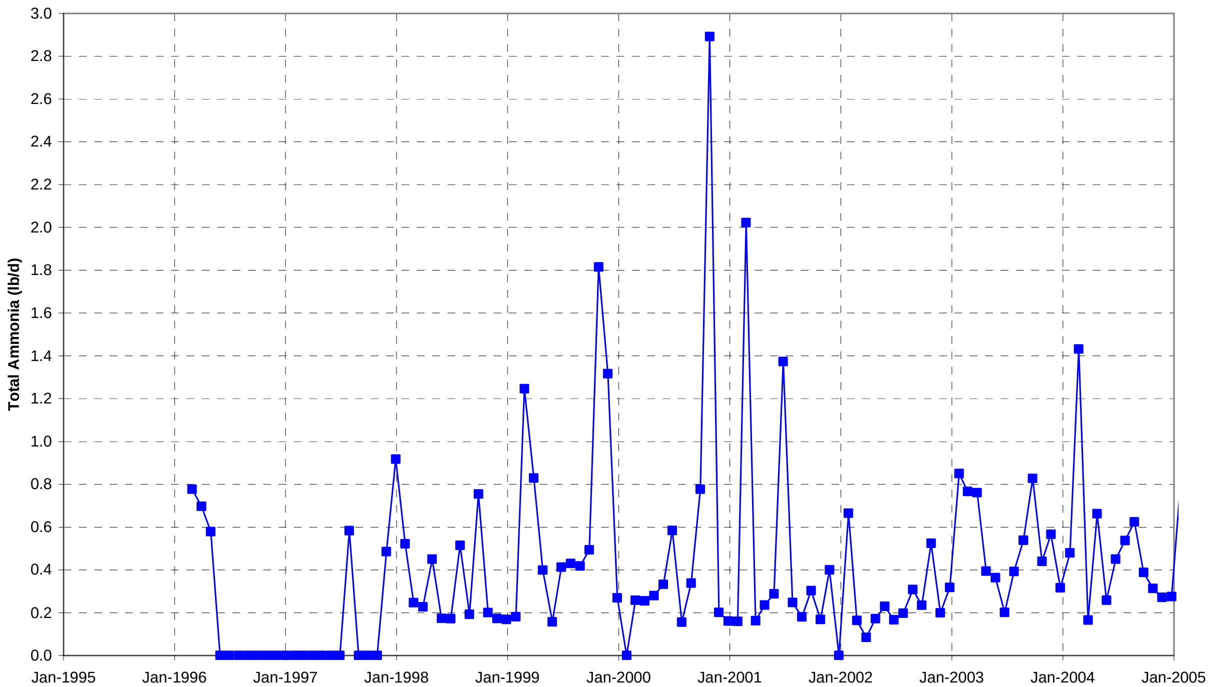

Figure B- 13. Total Ammonia load reported by FL0023671

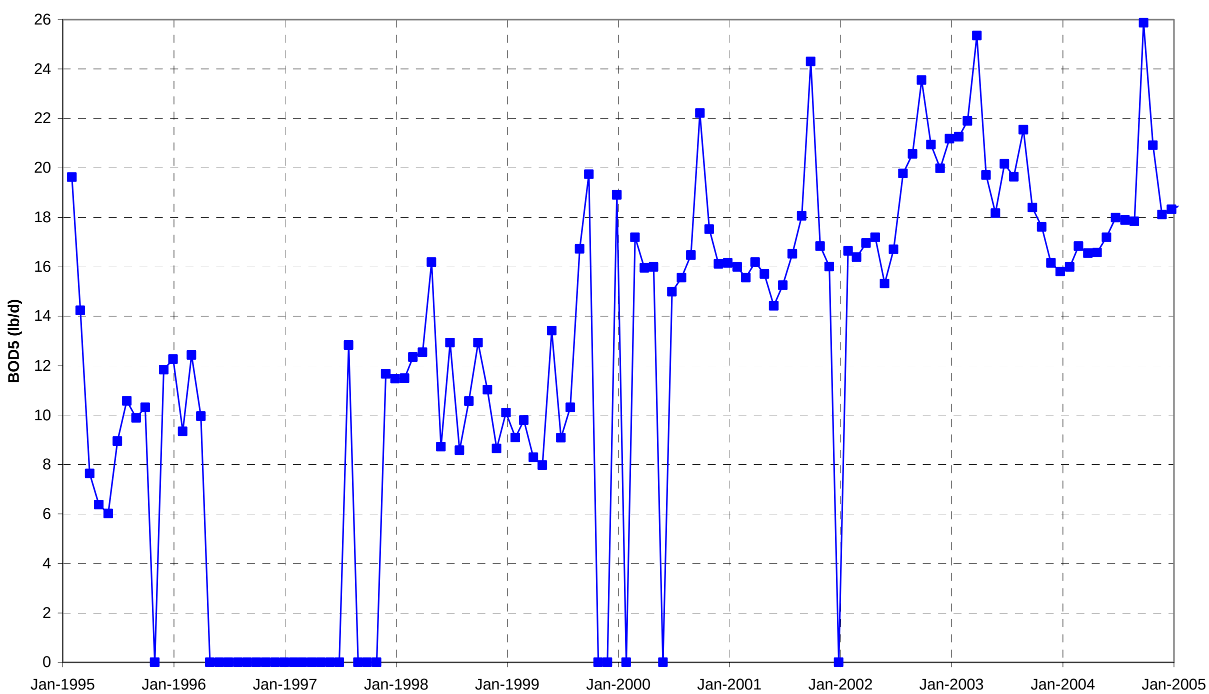

Figure B- 14. Total BOD load reported by FL0023671

Table B- 1. Total Nitrogen load from Jacksonville Heights WWTP

Date	Season	TN Load (lb/day)
3/1/1996	1	108.92
1/1/1998	1	84.21
3/1/1999	1	89.92
12/1/1999	1	42.32
12/1/2000	1	45.32
3/1/2001	1	47.60
12/1/2001	1	48.35
2/1/2002	1	39.34
2/1/2003	1	69.75
2/1/2004	1	57.93
2/1/2005	1	62.27
4/1/1998	2	126.22
7/1/1998	2	102.52
6/1/1999	2	91.20
5/1/2000	2	45.24
7/1/2000	2	42.08
6/1/2001	2	53.16
6/1/2002	2	49.79
5/1/2003	2	85.06
5/1/2004	2	61.29
12/1/1998	3	86.98
9/1/1999	3	136.64
8/1/2002	3	65.90
11/1/2002	3	61.63
8/1/2003	3	59.26
11/1/2003	3	53.48
8/1/2004	3	59.59
Average Seasonal Loads (lb/day)		
Season 1 (Dec – Mar)	63.27	
Season 2 (Apr – July)	72.95	
Season 3 (Aug – Nov)	74.39	

APPENDIX C: WASP Model Loadings

Table C- 1. WASP Segmentation

Segment	Area (sq. meters)	Area-Weighted Factor
1	1009,800	0.0682
2	2875,500	0.1943
3	883,800	0.0597
4	1467,900	0.0992
5	248,400	0.0168
6	327,600	0.0221
Totals	6813,000	0.4603

Table C- 2. WASP Seasonal Input Loads (kg/day)

Segment	Season 1 (Dec – Mar)	Season 2 (Apr – July)	Season 3 (Aug – Nov)
CBODu Loadings			
1	13.639	12.348	23.791
2	38.840	35.162	67.748
3	11.938	10.807	20.823
4	19.827	17.949	34.584
5	3.355	3.037	5.852
6	4.425	4.006	7.718
Totals	92.024	83.309	160.516
Ammonia Loadings			
1	0.888	0.966	1.647
2	2.528	2.752	4.689
3	0.777	0.846	1.441
4	1.290	1.404	2.394
5	0.218	0.238	0.405
6	0.288	0.313	0.534
Totals	5.989	6.519	11.11
Nitrate Loadings			
1	0.981	1.067	1.819
2	2.792	3.039	5.179
3	0.858	0.934	1.592
4	1.425	1.551	2.644
5	0.241	0.263	0.447
6	0.318	0.346	0.590
Totals	6.615	7.200	12.271
Detrital Nitrogen Loadings			
1	0.561	0.378	0.796
2	1.598	1.077	2.265
3	0.491	0.331	0.696
4	0.816	0.550	1.156
5	0.138	0.093	0.196

6	0.182	0.122	0.258
Totals	3.786	2.551	5.367
Orthophosphate Loadings			
1	0.366	0.486	1.022
2	1.041	1.383	2.910
3	0.320	0.425	0.894
4	0.532	0.706	1.486
5	0.090	0.119	0.251
6	0.119	0.158	0.332
Totals	2.468	3.277	6.895
Detrital Phosphorus Loadings			
1	0.022	0.015	0.041
2	0.063	0.044	0.117
3	0.020	0.014	0.036
4	0.032	0.023	0.059
5	0.005	0.004	0.010
6	0.007	0.005	0.013
Totals	0.149	0.105	0.276

Table C- 3. Existing Loads from Jacksonville Heights WWTP input in WASP

Month	BOD5 (lb/d)	BOD5 (kg/d)	NH3 (lb/d)	NH3 (kg/d)
December-97	11.47	5.205	0.92	0.416
January-98	11.49	5.213	0.52	0.237
February-98	12.34	5.599	0.25	0.112
March-98	12.54	5.688	0.23	0.103
April-98	16.19	7.345	0.45	0.204
May-98	8.72	3.956	0.17	0.079
June-98	12.93	5.865	0.17	0.078
July-98	8.58	3.891	0.51	0.233
August-98	10.57	4.793	0.19	0.087
September-98	12.93	5.864	0.75	0.342
October-98	11.03	5.001	0.20	0.091
November-98	8.65	3.922	0.17	0.078
December-98	10.10	4.583	0.17	0.076
January-99	9.09	4.122	0.18	0.082
February-99	9.80	4.443	1.25	0.565
March-99	8.30	3.763	0.83	0.376
April-99	7.98	3.619	0.40	0.181
May-99	13.42	6.088	0.16	0.072
June-99	9.08	4.118	0.41	0.187
July-99	10.31	4.679	0.43	0.195
August-99	16.72	7.586	0.42	0.190
September-99	19.75	8.956	0.49	0.224
October-99	14.50*	6.577*	1.82	0.824
November-99	14.50*	6.577*	1.32	0.597
December-99	18.91	8.577	0.27	0.123

Note: BOD values were not recorded for these months; therefore, the value assigned in the model is the average of all monthly data reported from 1995 through 2004.

Table C- 4. Existing Seasonal Loads from Jacksonville Heights WWTP during Critical Period

Month	BOD5 (lb/d)	BOD5 (kg/d)	NH3 (lb/d)	NH3 (kg/d)
Dec-97 – Mar 98	11.960	5.426	0.480	0.217
Apr-98 – July 98	11.605	5.264	0.325	0.149
Aug-98 – Nov-98	10.795	4.895	0.328	0.150
Dec-98 – Mar-99	9.323	4.228	0.608	0.275
Apr-99 – July 99	10.198	4.626	0.350	0.159
Aug-99 – Nov-99	18.235	8.271	1.013	0.459

Table C- 5. Existing Loads from Royal Court MHPs during Critical Period

Month	Flow (MGD)	BOD5 (mg/L)	BOD5 (kg/d)	NH3 (mg/L)	NH3 (kg/d)
Dec-97 – Mar 98	0.015	20.0	1.135	4.0	0.227
Apr-98 – July 98	0.015	20.0	1.135	4.0	0.227
Aug-98 – Nov-98	0.015	20.0	1.135	4.0	0.227
Dec-98 – Mar-99	0.015	20.0	1.135	4.0	0.227
Apr-99 – July 99	0.015	20.0	1.135	4.0	0.227
Aug-99 – Nov-99	0.015	20.0	1.135	4.0	0.227