FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Water Resource Management, Bureau of Watershed Management

CENTRAL DISTRICT • MIDDLE ST.JOHNS RIVER BASIN

TMDL Report
Nutrient and Dissolved Oxygen TMDL for the Little Wekiva Canal (WBID 3004)

Nathan Bailey, PhD

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Florida Department of Environmental Protection, Bureau of Watershed Management

TMDL Program

http://www.dep.state.fl.us/water/tmdl/index.htm

Identification of Impaired Surface Waters Rule

http://www.dep.state.fl.us/water/tmdl/docs/AmendedIWR.pdf

STORET Program

http://www.dep.state.fl.us/water/storet/index.htm

2000 305(b) Report

http://www.dep.state.fl.us/water/305b/index.htm

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Basin Status Report for the Middle St. Johns River Basin

http://www.dep.state.fl.us/water/tmdl/stat_rep.htm

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Allocation Technical Advisory Committee (ATAC) Report

http://www.dep.state.fl.us/water/tmdl/docs/Allocation.pdf

U.S. Environmental Protection Agency, National STORET Program

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Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for total nitrogen (TN) and Biochemical Oxygen Demand (BOD) that cause nutrient and low DO impairments in the Little Wekiva Canal, a canal located in the southwest section of the Middle St. Johns River Basin. The Little Wekiva Canal, was verified as impaired for DO based on the results of sampling and analysis carried out between 1996 and 2002. These results revealed that 31% of the DO values measured during the planning period and 35% of the DO values measured during the verified period were below the Class III DO criterion of 5 mg/L. The Little Wekiva Canal was also verified as impaired for Nutrients based on the results of Chlorophyll a (*Chl a*) sampling and analysis carried out between 1996 and 2002. During this period there were 84 surface water samples analyzed for Total Nitrogen and Total Phosphorus with median values of 1.16 mg/L and 0.08 mg/L, respectively. The Little Wekiva Canal was subsequently included on the Verified List of Impaired Waters (impaired for nutrients(*Chl a*) and dissolved oxygen) that was adopted by Secretarial Order in May 2004. The TMDL for the Little Wekiva Canal establishes the allowable loadings that would restore the waterbody, so that it meets its applicable water quality criteria for DO and nutrients (*Chl a*).

1.2 Identification of Waterbody

The Little Wekiva Canal (WBID 3004) sub-basin is located in central Florida, encompassing a small portion of the northwest corner of the city of Orlando (**Figure 1.1)** in North Central Orange County as well as Western Seminole County. It is in the southeastern part of the area designated by the Florida Legislature as the 'Wekiva Study Area' and in the southwest section of the Middle St Johns River Basin. The Little Wekiva Canal is one of a total of 426 WBIDs in the Middle St. Johns River Basin; however this TMDL only addresses WBID 3004.

The Little Wekiva Canal and River flows north and originates as a north flowing channel outlet from the 0.25 square mile Lake Lawne (WBID 3004C) in the south-central section of WBID 3004. Lake Lawne is fed from the southwest by an east flowing creek and on the east by a west-flowing canal. The canal is 1.9 miles long between Lake Lawne and Lake Wekiva (also known as Lake Orlando), 3.7 miles between Lake Wekiva and Lake Lotus, and 0.33 miles between Lake Lotus and Bear Lake and the outlet of WBID 3004. The Little Wekiva Canal flows from WBID 3004 into North Altamonte Springs and the Little Wekiva River. In total, including the segment in WBID 3004, the Little Wekiva Canal/River is approximately 15 miles long. The Little Wekiva Canal (WBID 3004) has a drainage area of 13,657 acres.

It should be noted that the Little Wekiva Canal (WBID 3004) has within its boundaries several lakes, two of which are impaired for Nutrients (see **Table 1.1** and **Figure 1.2**). Eighty five percent (85%) of the 21.4-square-mile (mi^2) drainage area of the Little Wekiva Canal is located in Orange County, and the remaining 15% (the northeast corner) is in Seminole County **(Figure 1.2).**

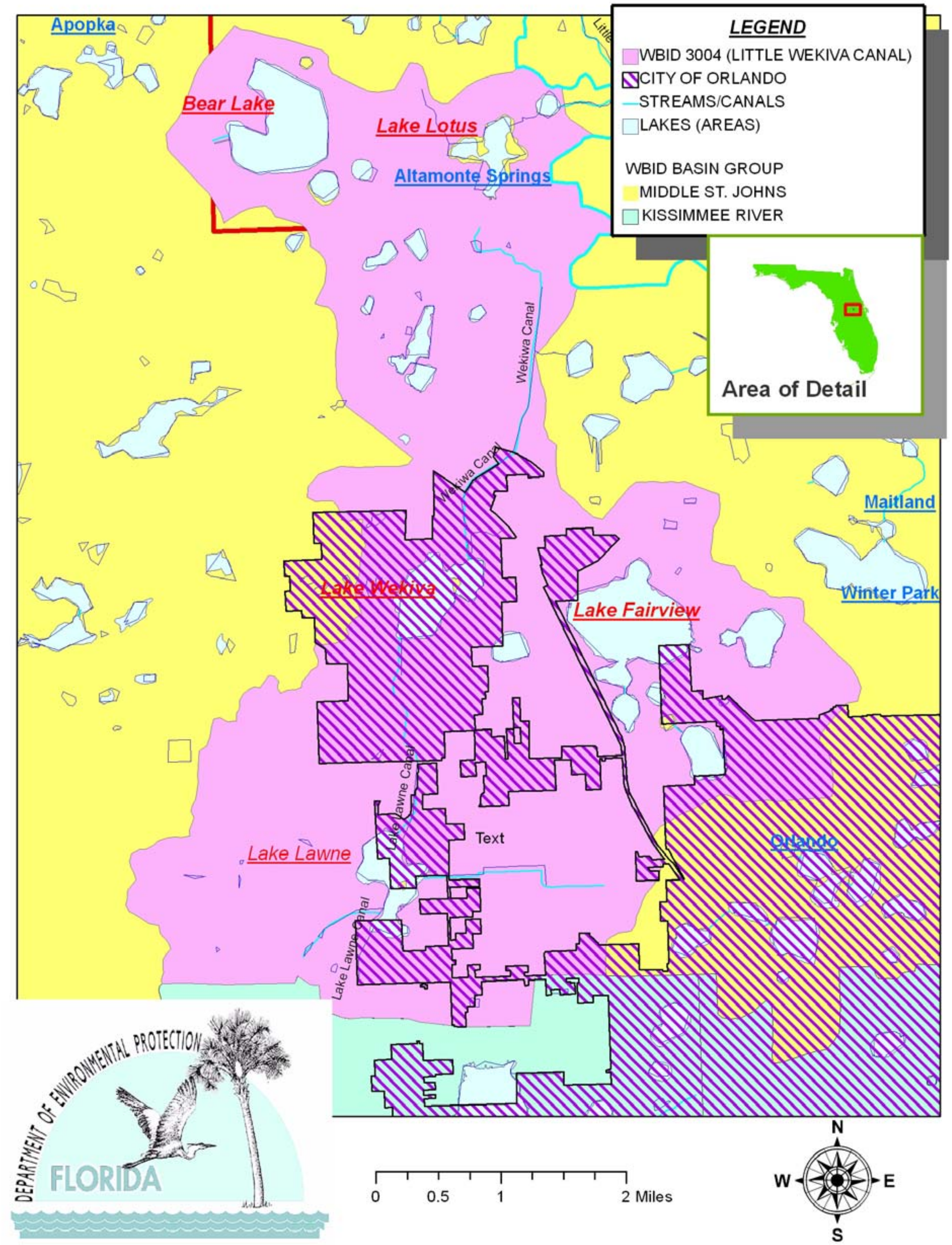

Figure 1.1 Little Wekiva Canal (WBID 3004) with Cities in Region

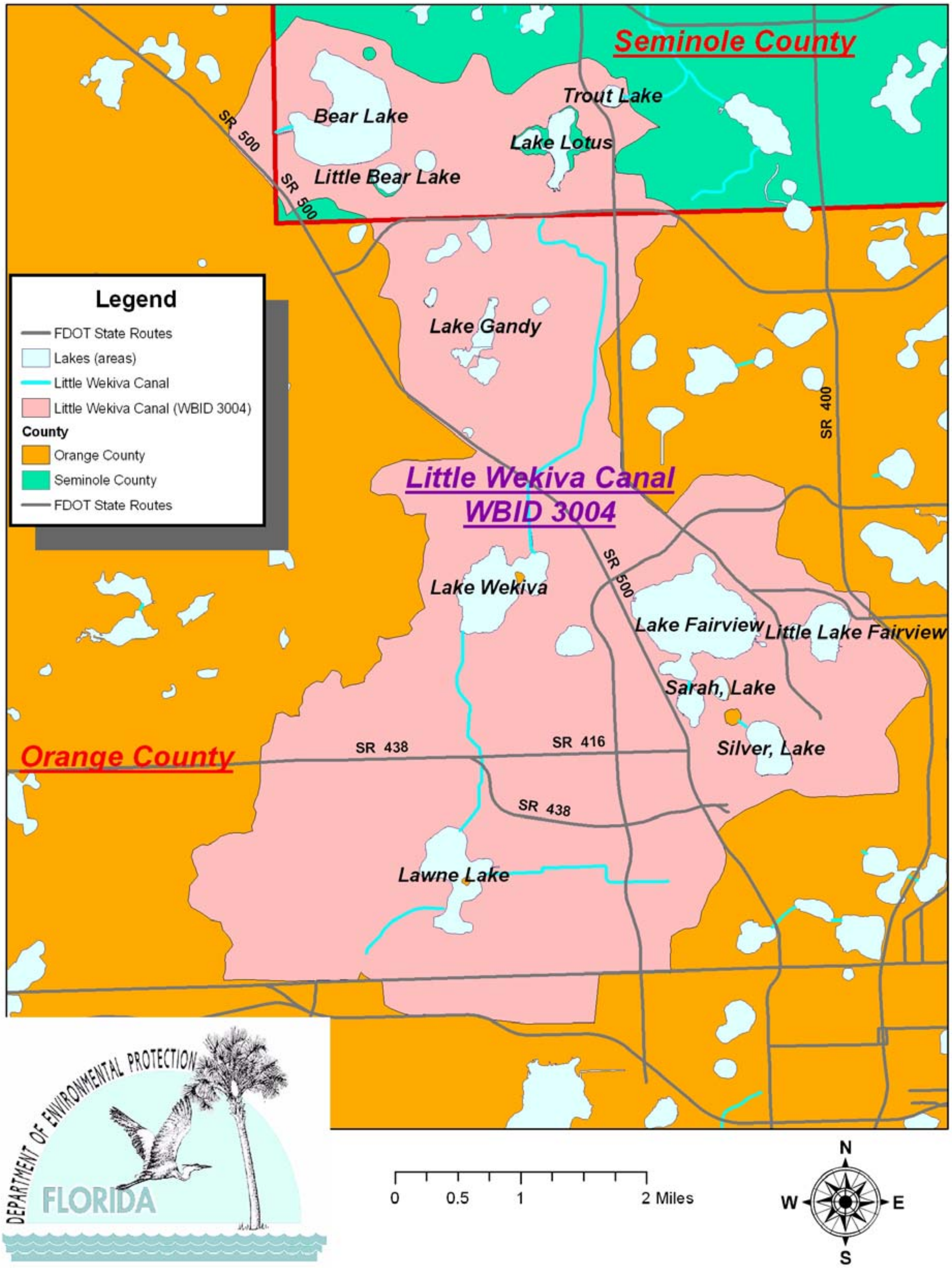

Figure 1.2 Little Wekiva Canal (WBID 3004) in Seminole and Orange County.

The major population areas in the Little Wekiva Canal (WBID 3004) basin include the Rosemont and Lockhart sections of Orlando (around Lake Wekiva), the Pine Hills section of Orlando (around Lake Lawne), and parts of Fairvilla in the Southeast portion of the WBID. Besides containing portions of Orlando, WBID 3004 also includes the southwest corner of the outside the limits of Orlando and Altamonte Springs.

Table 1.1 Verified Impaired Segments in the Little Wekiva Canal

WBID Number and Name	Area (Acres)	Impairments
3004 Little Wekiva Canal**	**13,657.2**	**Nutrients, D.O., Fecal Coliform, & BOD**
3004A Bear Lake	**309.6**	
3004B Lake Fairview	**30.3**	
3004C Lake Lawne	**156.7**	**Nutrients**
3004D Silver Lake	**70.8**	**Nutrients**
3004E Lake Daniel	**8.5**	
3004F Lake Sarah	**12.6**	
3004G Bay Lake	**36.5**	**Nutrients**
3004H Little Lake Fairview	**85.0**	
3004I Lake Rose	**6.2**	
3004J Lake Gandy	**28.1**	
3004K Lake Wekiva/Orlando	**195.3**	
3004L Trout Lake	**16.6**	
3004M Lake Lotus	**115.9**	
3004N Lake Fairview	**364.3**	
3004O Asher Lake	**5.2**	
3004P Cub Lake	**14.9**	
3004Q Little Bear Lake	**27.3**	
TOTAL Area:	**15,141.0**	

**Note: The area (13,657.2 acres) provided for WBID 3004 above excludes the area of the Lake WBIDs provided in Table 1.1. The total drainage area (15,141 acres) of WBID 3004 actually includes the areas of the lake WBIDs listed.

1.3 Background

This report was developed as part of the Florida Department of Environmental Protection's (Department) watershed management approach for restoring and protecting state waters and addressing TMDL Program requirements. The watershed approach, which is implemented using a cyclical management process that rotates through the state's fifty-two river basins over a five-year cycle, provides a framework for implementing the TMDL Program–related requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (FWRA, Chapter 99-223, Laws of Florida).

A TMDL represents the maximum amount of a given pollutant that a waterbody can assimilate and still meet water quality standards, including its applicable water quality criteria and its designated uses. TMDLs are developed for waterbodies that are verified as not meeting their water quality standards. TMDLs provide important water quality restoration goals that will guide restoration activities.

This TMDL Report will be followed by the development and implementation of a Basin Management Action Plan, or BMAP, to decrease the nutrient concentrations, which should increase the amount of Dissolved Oxygen, decrease the amount of Chlorophyll a (*Chl a)*, and reduce any other causative pollutants responsible for these impairments of Little Wekiva Canal (WBID 3004). These activities will depend heavily on the active participation of the St. Johns River Water Management District (SJRWMD), local governments, businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake and continue reductions in the discharge of pollutants and achieve the established TMDLs for this waterbody.

1.3.1 Development of TMDL

This TMDL was developed in cooperation with SJRWMD, Orange County Public Works Department, Seminole County Public Works, and the City of Orlando. There was also active coordination with a variety of local stakeholders throughout the TMDL development process. This included meetings and teleconference discussions between the Orange County Storm Water Management Division and FDEP's Watershed Planning and Coordination Section. There were also regular meetings between DEP officers, Seminole County officials, environmental advocacy groups, consultants, and other stakeholders who volunteered to participate or whose participation was requested.

Chapter 2: DESCRIPTION OF WATER QUALITY PROBLEM

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the Federal Clean Water Act requires states to submit to the EPA a list of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant source in each of these impaired waters on a schedule. The Department has developed these lists, commonly referred to as 303(d) lists, since 1992. The list of impaired waters in each basin is also required by the FWRA [Subsection 403.067(4), Florida Statutes (F.S.)], and the list is amended annually to include updates for each basin statewide.

Florida's 1998 303(d) list included 24 waterbodies in the Middle St. Johns River Basin. However, the FWRA (Section 403.067, F.S.) stated that all previous Florida 303(d) lists were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. After a long rule-making process, the Environmental Regulation Commission adopted the new methodology as Chapter 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001, as modified in 2006 and 2007. The list of waters for which impairments have been verified using the methodology in the IWR is referred to as the Verified List.

2.2 Information on Verified Impairment

The Department has used the IWR to assess water quality impairments in the Little Wekiva Canal (WBID 3004) and has verified the impairments for low DO, with BOD as the causative pollutant and an impairment for high nutrient concentrations (**Tables 2.1** and **2.2**). The Little Wekiva Canal stream was verified as impaired for DO because, based on the analysis results, there is at least 90% confidence that the exceedance rate is greater than or equal to 10 percent. The data are based on samples collected between the years 1996 and 2001. The annual *Chl a* concentrations (in ug/L) for the years 1991 through 1994 were 20.5, 20.7, 13.6, and 23.2, respectively. The annual *Chl a* concentrations (in ug/L) from 1996 through 2000 were 25.1, 13.0, 20.0, 26.6, and10.0 ug/l, respectively. Thus, during the planning period 6 *Chl a* annual means exceeded the Class III *Chl a* assessment threshold for streams of 20 ug/l (1991, 1992, 1994, 1996, 1998, 1999) and during the verified period three *Chl a* annual means exceeded 20 ug/l (1996, 1998, 1999). The BOD criteria for Class III fresh water is that BOD shall not be increased so as to cause DO to be depressed below the applicable DO criterion, and in no case, shall it be great enough to cause nuisance conditions. The existence of elevated BOD (median values > 2.0 mg/L) led to the conclusion that BOD levels were affecting the DO concentrations.

Table 2.1   Verified Impairments in the Little Wekiva Canal

WBID	Waterbody Segment Name	Parameters Identified Using the Impaired Waters Rule (IWR)	Concentrations Causing Impairment	Priority for TMDL Develop ment	Projected Year for TMDL
3004	Little Wekiva Canal	Dissolved Oxygen and BOD	< 5.0 mg/L	Low	2008
3004	Little Wekiva Canal	Fecal Coliform Bacteria	> 400 per 100 ml	Low	2008
3004	Little Wekiva Canal	Nutrients (*Chl a*)	TN = 1.16 mg/L TP = 0.08 mg/L	Low	2008

Note: The parameters listed in Table 2.1 provide a complete picture of the impairment in the Little Wekiva Canal, but this TMDL only addresses the DO, BOD, and Nutrient impairment.

Table 2.2   Summary of Dissolved Oxygen, BOD, and Chlorophyll A Data from Verified Period Sampling (1996 – 2001) of Little Wekiva Canal, WBID 3004

Parameter of Concern	Number of Samples	IWR Required Exceedances (for impairment)	Actual Number of Exceedances	Summary of Analysis Concentrations, mg/L			
				Minimum	Maximum	Mean	Median
Dissolved Oxygen (Run 18)	65	11	23	0.5	12.09	5.92	6.16
BOD	62			0.2	9.61	2.4	2.1
Total Phosphorus	85			0.0024	0.14	0.054	0.057
Total Nitrogen	84			0.54	11.4	1.26	1.14

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criteria Applicable to the TMDL

Florida's surface waters are protected for five designated use classifications, as follows:

Class I	**Potable water supplies**
Class II	**Shellfish propagation or harvesting**
Class III	**Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife**
Class IV	**Agricultural water supplies**
Class V	**Navigation, utility, and industrial use (there are no state waters currently in this class)**

3.1.1 Applicable Water Quality Standards and Numeric Water Quality Target

3.1.1.1 Interpretation of Narrative BOD and Nutrient Criterion

The Little Wekiva Canal (WBID 3004) is considered a Class III waterbody, with a designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criterion applicable to the impairment addressed by this TMDL is that dissolved oxygen shall not be less than 5.0 mg/L, with normal daily and seasonal fluctuations above these levels maintained. The BOD (Biochemical Oxygen Demand) shall not be increased to exceed values that would cause the dissolved oxygen to be depressed below the established DO limit, and in no case shall it be great enough to produce nuisance conditions. The nutrient criteria is narrative and states that the discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter [Section 62.302 F.A.C.] It also states that no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora and fauna [Section 62.302530 F.A.C.].

3.1.1.2 Relationship between DO, Nutrients, and BOD

After verification of the low dissolved oxygen in the Little Wekiva Canal, the Department identified the causative pollutants by investigating those parameters typically responsible for depressed DO. These include nutrients (nitrogen and phosphorus) and biochemical oxygen demand (BOD). To identify causative pollutants, the Department uses screening level concentrations set at the 70th percentile of all STORET data across the state from 1970 to 1987. The screening levels for streams are 2.0 mg/L for BOD5, 1.6 mg/L for Total Nitrogen (TN), and 0.22 mg/L for Total Phosphorus (TP). Although there is an expectation that one should find a relationship between the causative pollutants and DO data, it is often difficult to establish such a relationship without extensive data collection.

There is a known inverse relationship between average BOD and DO (with an elevated average BOD one would expect to see depressed DO concentrations in a stream). However, there are many other factors responsible for temporal and spatial variation in DO and BOD concentrations, including atmospheric interchange, plant respiration, sediment oxygen demand (SOD), and plant photosynthesis. This is likely the reason why there was generally no statistically significant relationship between DO and BOD when looking at a sample by sample analysis of the Little Wekiva Canal sample data **(Figure 3.1)**. Even a sudden drop in BOD is not always matched by a corresponding increase in DO (Gray, 2004). The limited amount of samples collected (and lack of continuous sampling throughout the day) in the Little Wekiva Canal also made it more difficult to observe a correlation.

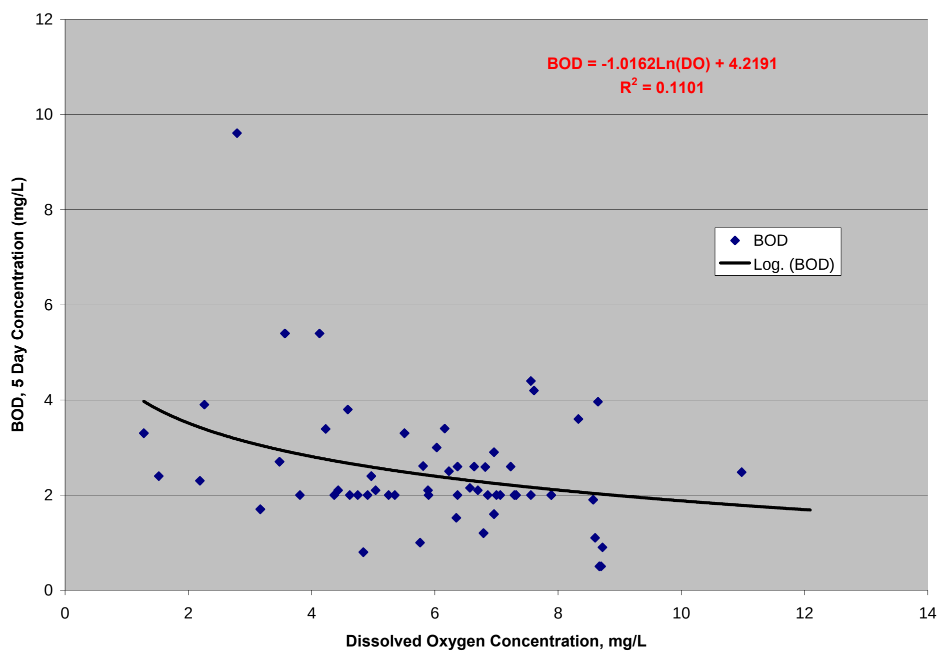

Figure 3.1 Relationship between DO and BOD in the Little Wekiva Canal on a Sample-by-Sample basis

Even though no specific relationship between BOD and DO was observed (for the reasons outlined above), it is well established that high BOD is associated with depressed dissolved oxygen. Thus, the fact that the median BOD concentration of the Little Wekiva Canal exceeded the screening level of 2 mg/L **(Table 2.2)** is utilized as evidence that BOD was a factor in the low DO levels.

It is also very noteworthy that when observing the data on a station-by-station monthly-average basis (between 1996 and 2000), a statistical analysis of the three major sampling stations provides mixed results relative to BOD concentrations **(Tables 3.1, 3.2, and 3.3)**. Whereas the BOD medians of the upstream stations of 21FLORANLWA (LWA) and 21FLORANLWB (LWB) are well above the screening level of 2.0, the BOD median of the station 21FLORANLWD (LWD) is well below the screening level. But, at the same time, it is at Station WLD where the R^2 is highest. Note the R^2 relationship **(Figure 3.2)** when plotting monthly average DO vs. BOD (for years 1996 through 2000). Thus, for the WBID 3004, the best correlation between DO and BOD is seen at the station where there is a smaller range of fluctuation in BOD values and the lowest median BOD value. This is most likely because fluctuations in BOD and higher BOD values may be indicative of a more complex system, including time lags, of those factors that influence BOD and DO.

Table 3.1   Station 21FLORANLWA WBID 3004 Little Wekiva Canal

Table 3.1 Station 21FLORANLWA WBID 3004 LITTLE WEKIVA CANAL						
Month	**D.O.**	***Chl* a**	**TN**	**TKN**	**TP**	**BOD**
January	10.98	21.00	1.25	1.17	0.02	2.48
February	6.57	9.30	1.22	1.16	0.04	2.88
March	5.57	19.85	1.17	1.10	0.01	2.60
April	2.19	5.20	1.25	1.18	0.12	2.30
May	4.27	21.80	5.59	5.54	0.07	5.04
June	4.78	4.70	1.09	0.95	0.05	2.95
July	3.81	34.10	N/A	N/A	N/A	2.00
August	1.28	19.20	1.77	1.73	0.09	3.30
September	6.00	29.37	1.10	1.28	0.06	2.54
October	7.56	57.30	1.62	1.60	0.02	4.40
November	3.48	19.20	1.56	1.50	0.08	2.70
December	4.26	5.83	1.59	1.43	0.06	2.33
Average	**5.06**	**20.57**	**1.74**	**1.69**	**0.06**	**2.96**
Geometric Mean	**4.44**	**15.87**	**1.53**	**1.47**	**0.05**	**2.86**
Median	**4.52**	**19.53**	**1.25**	**1.28**	**0.06**	**2.65**
Standard Deviation	**2.57**	**14.92**	**1.30**	**1.30**	**0.03**	**0.90**

Table 3.2 Station 21FLORANLWB WBID 3004 Little Wekiva Canal

Month	D.O.	Chl a	TN	TKN	TP	BOD
January	8.65	63.00	1.40	1.31	0.02	3.96
February	6.91	20.80	1.20	1.11	0.06	3.15
March	5.80	14.05	0.72	0.70	0.04	2.30
April	6.37	9.70	1.00	0.95	0.08	2.00
May	6.23	35.17	1.24	1.22	0.07	3.72
June	6.70	16.70	0.94	0.90	0.09	2.10
July	4.75	41.30	N/A	N/A	N /A	2.00
August	4.43	16.00	0.98	0.91	0.03	2.10
September	6.02	31.87	1.03	0.99	0.03	2.43
October	6.16	36.60	1.14	1.10	0.06	3.40
November	6.64	32.40	1.17	1.07	0.04	2.60
December	6.24	9.60	0.99	0.83	0.05	2.31
Average	6.24	27.27	1.07	1.01	0.05	2.67
Geometric Mean	6.16	23.26	1.06	0.99	0.04	2.60
Median	6.23	26.33	1.03	0.99	0.05	2.37
Standard Deviation	1.06	15.80	0.18	0.18	0.02	0.70

Table 3.3 Station 21FLORANLWD WBID 3004 Little Wekiva Canal

Month	D.O.	Chl a	TN	TKN	TP	BOD
January	N/A	N/A	0.99	0.66	0.13	N/A
February	7.78	8.10	1.20	0.75	0.06	1.48
March	7.34	5.60	0.82	0.52	0.05	1.25
April	4.62	1.00	0.91	0.54	0.05	2.00
May	3.99	19.86	1.27	1.03	0.07	2.60
June	6.46	2.85	0.92	0.60	0.03	1.67
July	5.35	35.60	1.16	1.10	0.02	2.00
August	6.77	5.17	1.06	0.73	0.05	1.38
September	7.38	50.00	0.94	0.93	0.01	1.45
October	7.06	44.90	1.14	1.00	0.07	1.52
November	7.51	10.00	1.12	0.77	0.05	1.73
December	5.75	1.80	1.21	0.54	0.07	2.00
Average	6.36	16.81	1.06	0.76	0.06	1.73
Geometric Mean	6.24	8.60	1.05	0.74	0.05	1.70
Median	6.77	8.10	1.09	0.74	0.05	1.67
Standard Deviation	1.27	18.18	0.14	0.21	0.03	0.39

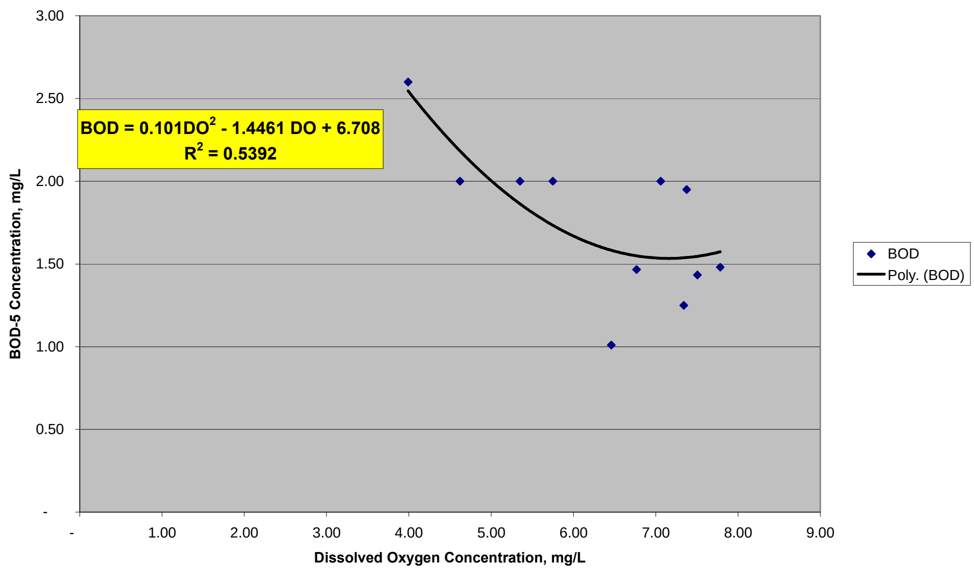

Figure 3.2 Comparison of Monthly Averages of BOD vs. DO from samples taken at Station LWD from 1996 through 2000

When observing the *Chl* a monthly averages over the same period, one again observes that stations 21FLORANLWA and 21FLORANLWB (henceforth referred to as LWA and LWB) have substantially higher levels than were found in station 21FLORANLWD (henceforth referred to as LWD). When observing the individual stations, one sees that the TN of LWA is higher than LWB and LWD (whose averages are approximately the same). When graphing and looking at the relationships between nutrients and *Chl* a or DO, the picture also varies between sample stations.

For the three major sample stations in the Little Wekiva Canal (LWA, LWB, and LWD), the relationships between DO and potential causative pollutants TN, TP and BOD and between *Chl* a and nutrients TP and TN were determined. **Table 3.4** lists the linear regression equations relating the 4-year monthly averages (**Tables 3.1 through 3.3**) of the given parameters and their respective coefficient of determinations (R^2). The R^2, which illustrates the goodness of fit of the data to the regression equation, varies between parameters and stations.

Table 3.4 WBID 3004 Sample Stations 4 – year Monthly Averages: Relationships Between Nutrients and BOD, DO or *Chl a*

	Station LWA		Station LWB		Station LWD	
	Equation	R^2	Equation	R^2	Equation	R^2
DO vs. TP	TP = -.0094DO+.1045	0.638	TP=.0003DO+.0472	0.0002	TP=-.003DO+.066	0.029
DO vs BOD	BOD = .00077DO + 3.04	5.38 E -6	BOD=.421DO + .091	0.28	BOD = $0.101DO^2$ - 1.4461 DO + 6.708	0.5392
Chl a vs. TN	TN = .0094*Chl a*+1.56	0.012	TN=.009Chla+.837	0.637	TN=.0011Chla+1.047	0.02
Chla vs. TP	TP= -.00103Chla +.08	0.241	TP= -.0006Chla+.0654	0.205	TP= -.0003Chla+.0554	0.113

Tables 3.1 through 3.3 show TP annual average concentrations to be fairly constant throughout the length covered by these stations, but **Table 3.4** shows a strong correlation between TP and DO only at Station LWA. This could be due to the fact that Lake Lawne, which is immediately upstream of LWA, is a system that is phosphorus limited. There is no significant coefficient of determination for TP vs. either DO or *Chl a* at the other two stations (LWB and LWD). The only station where there is any possible significant correlation between TN and *Chl a* is Station LWB where the R^2 is 0.638. It is interesting that the R^2 appears to increase between BOD and DO as the station annual BOD average decreases. Thus, for Station LWB the R^2 for BOD vs. DO is 0.28 and for LWD the R^2 for these parameters is 0.539. There is a definite relationship when plotting the three stations in terms of their annual averages of DO vs. BOD **(Figure 3.4)**, which supports a higher correlation between high BOD and low DO upstream than downstream.

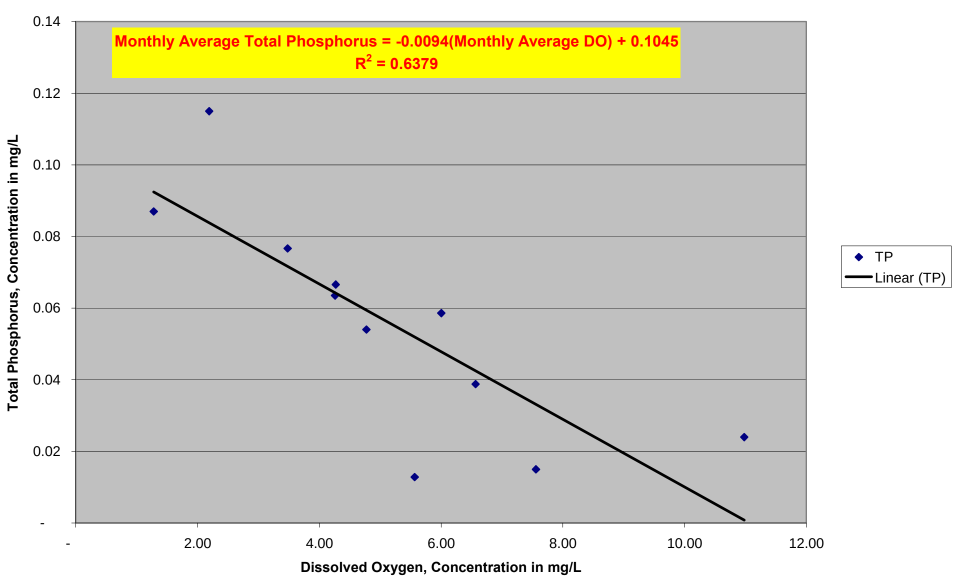

Figure 3.3   Total Phosphorus vs. DO at Station WLA –WBID 3004

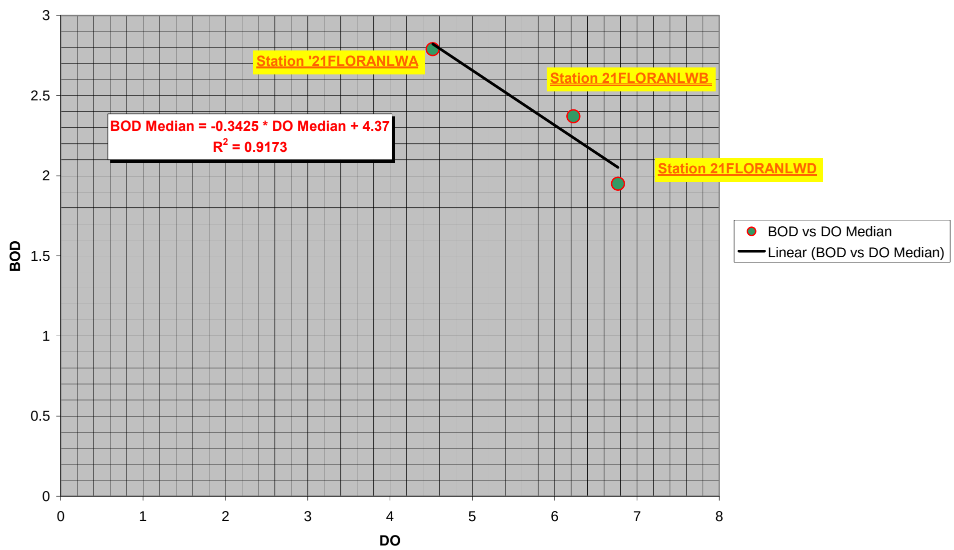

Figure 3.4   Annual Median DO and BOD at three Stations

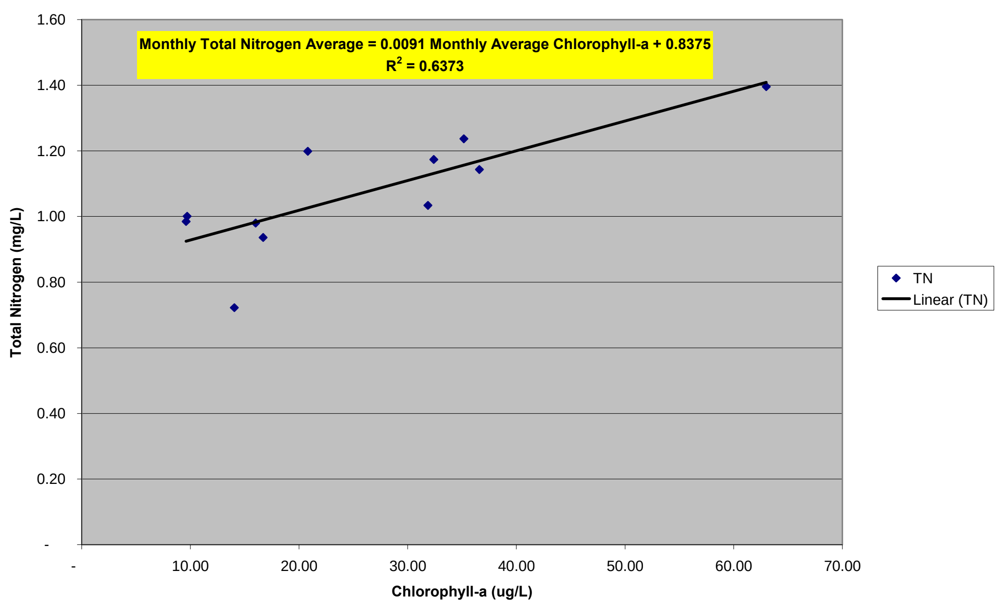

Figure 3.5. Total Nitrogen vs Chl a at Station LWB

The only observed relationship between DO and TP is an inverse relationship seen at Station LWA **(Figure 3.3 and Table 3.4)**. At Station LWB there is a positive relationship observed between *Chl* a and TN **(Table 3.4, Figure 3.5)**. Although correlation between monthly average DO and TP (Station LWA) and *Chl* a and Total Nitrogen (Station LWB) is much stronger than between DO and BOD at these stations, one cannot discount the impact of BOD at these stations because both BOD and DO are dependent on other variables to differing degrees.

The equations relating TP and BOD to DO as well as *Chl* a and TN at stations within WBID 3004 are summarized below.

The regression equation relating TN to *Chl* a as shown in **Figure 3.5** is provided below

TN = .0091 Chl-a + .8375 R^2 = .6373 (Equation 3.1)

Where TN = Total Nitrogen Concentration (mg/L), and

Chl-a = *Chl* a Concentration (ug/L)

Solving the above equation at the Class III freshwater assessment threshold (*Chl* a of 20 µg/L) gives a resulting TN concentration = 1.02 mg/L. It should be noted that this target TN annual average value is below the Department's screening level for TN (1.6 mg/L). However, based on data collected in Little Wekiva Canal, a TN concentration of 1.6 mg/L would result in DO levels in Little Wekiva Canal significantly below the DO criterion. A target of 1.02 is only slightly below the 1.06 mg/l annual average TN presently observed at downstream Station LWD. Thus, the Department set the target TN load at 1.02 mg/L.

At Station LWA, where the highest TP concentrations are found, TP is related to DO (**Figure 3.3**) by equation;

TP = -0.0094 DO + .1045 R^2 = .6379 (Equation 3.2)

Where TP = Total Phosphorus Concentration (mg/L), and

DO = Dissolved Oxygen Concentration (mg/L)

Solving the above equation at the Class III freshwater criterion (a DO of 5 mg/L) gives a resulting TP concentration = 0.05 mg/L. Although the strong correlation between TP and DO is a reflection of TP being the limiting nutrient for algae in receiving waters directly downstream of Lake Lawne which is only .01 mg/L lower than present average TP concentration at Stations LWA and LWB (0.06 mg/L) and equal to the present average TP concentration at station LWD. It is also far below the threshold screening level concentration of .22 mg/L. Thus, because the TP concentration is already approximately the same as the calculated target and all are also far below the TP screening level, neither a TP target nor TMDL will be pursued for the Little Wekiva Canal.

At Station LWD where the lowest BOD, TP, and TN concentrations are found, BOD is related to DO (see **Figure 3.2**) by the polynomial regression equation;

BOD = 0.101 $(DO)^2$ – 1.4461 DO + 6.708 R^2 = 0.539 (Equation 3.3)

Where BOD = Biochemical Oxygen Demand – 5 Day (mg/L), and

DO = Dissolved Oxygen Concentration (mg/L)

Solving the above equation at the Class III freshwater criterion (a DO of 5 mg/L) gives a resulting BOD concentration = 2.0025 mg/L or 2.0 mg/L which is identical to the BOD 70 percentile screening value previously mentioned. Again, it should not be unreasonable to require a reduction to 2.0mg/L because BOD levels within this WBID are near this concentration. Thus, the Department sets the target BOD load at 2.0 mg/L.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of low dissolved oxygen in the watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either "point sources" or "nonpoint sources." Historically, the term point sources has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. In contrast, the term "nonpoint sources" was used to describe intermittent, rainfall driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture, and mining; discharges from failing septic systems; and atmospheric deposition.

However, the 1987 amendments to the Clean Water Act redefined certain nonpoint sources of pollution as point sources subject to regulation under the EPA's National Pollutant Discharge Elimination Program (NPDES). These nonpoint sources included certain urban stormwater discharges, including those from local government master drainage systems, construction sites over five acres, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs).

To be consistent with Clean Water Act definitions, the term "point source" is used to describe traditional point sources (such as domestic and industrial wastewater discharges) and stormwater systems requiring an NPDES storm water permit when allocating pollutant load reductions required by a TMDL. However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES stormwater discharges and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2 Potential Sources of BOD and Low DO in Little Wekiva Canal (WBID 3004) Watershed

4.2.1 Point Sources

4.2.1.1 Estimating Point Source Loads

There are no permitted wastewater facilities located in Little Wekiva Canal (WBID 3004), but to the northeast of WBID 3004, in WBID 2987 (Little Wekiva River) there is the Altamonte Springs Regional Water Reclamation Facility which is a domestic wastewater treatment facility **(Table 4.1).** Because this facility does not discharge into WBID 3004, no pollutant loading is calculated for this facility in this report.

Table 4.1 Point Sources in Little Wekiva Canal (WBID 3004)

Facility Name	Type	Permit
Altamonte Springs Regional Water Reclamation Facility 950 Keller Road, Altamonte Springs, 32714	Municipal WWTF	WAFR - FL0033251 Domestic Wastewater Program

4.2.1.2 Municipal Separate Storm Sewer System Permittees

Within WBID 3004 Orange County has a Phase I MS4 permit (FLS000011). The Florida Department of Transportation (FDOT) District 5 and City of Maitland are co-permittees for this permit. In addition, City of Orlando holds a separate Phase I permit (FLS000014).

4.2.2 Land Uses and Nonpoint Sources

Because land uses in Little Wekiva Canal are essentially urban in nature, most of the nonpoint source runoff is consistent with an urban environment. With the only agriculture existing in the form of 82 acres devoted to tree crops (0.6% of the sub-basin), 15 acres devoted to nurseries and vineyards (0.11% of the sub-basin), and 0.09% of the sub-basin devoted to cropland/pastureland. Thus the total contribution from agriculture is 109 acres (0.8% of the basin). Thus, there are relatively little nonpoint sources of BOD or TN from production agriculture (horticulture, food crops or livestock) in the basin. The main nonpoint sources include runoff and erosion from developed areas, small-scale construction, residential and commercial fertilizer use, pets, and residential septic failure or poor design.

4.2.2.1 Land Uses

Land use categories in the Little Wekiva Canal watershed were aggregated using the simplified Level 1 codes (**Table 4.2**). By far the largest Level 1 land use is “Urban and Built-up” (80%). When looking at Level 2, a more detailed categorization of Land Use (**Table 4.3**), urban and built-up land uses are comprised of (in order of highest to lowest) Medium Density Residential (36.1%), High Density Residential (10.7%), Industrial (9.3%), Commercial (9%), Recreational (4.5%), Institutional (3.1%), and Low density Residential (2.8%). If the Level 1 Category of Transportation, Communication, and Utilities (4.1 %) is added to the “Urban and Built-up,” human land uses constitute more than 80% of the WBID.

Table 4.2 Level 1 Land Uses in the Little Wekiva Canal (WBID 3004)

Land use Code and Description	*Acres*	*% Total*
1000: Urban and Built up	10,908.3	79.87%
6000: Wetland	1,018.4	7.46%
4000: Upland Forests	632.8	4.63%
8000: Transportation, Communication, & Utilities	555.5	4.07%
5000: Water	274.9	2.01%
2000: Agriculture	109.8	0.80%

3000: Rangeland	100.4	0.74%
7000: Barren Land	57.0	0.42%
Total	**13,657.2**	**100.00%**

Primarily non-human land use includes wetland (7.5%), upland forest (4.6%), rangeland (0.74%), barren land (0.42%) and agriculture (tree crops at 0.6%, nurseries and vineyards at 0.11%, and cropland/pastureland at 0.09%). Based on an analysis of Land Use percentages for the sub-basin and the corresponding Event Mean Concentrations **(Table 4.4a and 4.4b)**, the three largest land use contributors BOD, TP, and TN from storm runoff are medium density residential, high density residential, and commercial. The EMCs and DCIAs shown in table 4.4a and 4.4b were provided by the CDM based on their previous study in Little Wekiva River basin (CDM, 2005).

Table 4.3   Classification of Level 2 Land Use Categories in Little Wekiva Canal (WBID 3004) Watershed

Landuse Code and Description	Acres	% Total
1200: Residential, Medium Density	4,929.6	36.10%
1300: Residential, High Density	1,456.0	10.66%
1500: Industrial	1,271.5	9.31%
1400: Commercial	1,227.3	8.99%
1800: Recreation	612.9	4.49%
1900: Openland	605.8	4.44%
4300: Upland Mixed Forest	525.8	3.85%
8100: Transportation	441.6	3.23%
1100: Residential, Low Density	424.2	3.11%
6300: Wetland Forest Mixed	408.0	2.99%
1700: Institutional	381.0	2.79%
6400: Vegetated Nonforested Wetlands	377.0	2.76%
6200: Wetland Coniferous Forests	177.4	1.30%
5300: Reservoirs	161.0	1.18%
5200: Lakes	111.9	0.82%
2200: Treecrops	82.4	0.60%
8300: Utilities	76.5	0.56%
4100: Upland Coniferous	74.7	0.55%
7400: Disturbed land	57.0	0.42%
6100: Wetland hardwood forests	55.9	0.41%
8200: Communication	37.5	0.27%
3200: Shrub and Brushland	35.9	0.26%
3300: Mixed Rangeland	32.4	0.24%
4200: Upland Hardwood	32.3	0.24%
3100: Herbaceous	32.2	0.24%
2400: Nurseries and Vineyards	15.3	0.11%
2100: Cropland and Pastureland	12.1	0.09%
5100: Streams and Waterways	2.0	0.01%
Total	**13,657.2**	**100.00%**

Table 4.4a Land Use Categories for Modeling and Corresponding Relative DCIA Contributions, EMC, and Pollutant Contributions

WMM LANDUSE BREAKDOWN	3004-Little Wekiva Canal Area		DCIA - Directly Connected Imperv. Area for each Land Use	Weighted Average DCIA for WBID	Percentage of Toal WBID DCIA by Landuse (%Area x DCIA)
	Acres	%			
A. Forest/Rural Open	1702.9	12.47%	1.00%	0.125%	0.28%
B. Urban Open	57.0	0.42%	17.00%	0.071%	0.16%
C. Agriculture/Pasture	109.8	0.80%	1.00%	0.008%	0.02%
D. Low Density/Residential	424.2	3.11%	30.00%	0.932%	2.06%
E. Medium Density/Residential	4929.6	36.10%	37.00%	13.355%	29.48%
F. High Density/Residential	1456.0	10.66%	71.00%	7.570%	16.71%
G. Commercial	1608.2	11.78%	85.00%	10.009%	22.10%
H. Industrial	1004.4	7.35%	71.00%	5.222%	11.53%
I. Highways	441.6	3.23%	100.00%	3.234%	7.14%
J. Water	274.9	2.01%	28.00%	0.564%	1.24%
K. Wetland	1018.4	7.46%	28.00%	2.088%	4.61%
L. Institutional	381	2.79%	65.00%	1.813%	4.00%
M. Golf Courses	249	1.82%	17.00%	0.310%	0.68%
TOTAL	13,657.2	100%		45%	100%

Table 4.4 b Land Use Categories and Corresponding EMC Contributions

SWMM LANDUSE BREAKDOWN	Event Mean Concentrations								
	TOTAL N			TOTAL P			DISSOLVED P		
	EMC	EMC WEIGHTED BY Landuse % Total WBID DCIA	% TOTAL LOAD BASED ON WEIGHTED EMC	EMC	EMC WEIGHTED BY Landuse % Total WBID DCIA	% TOTAL LOAD BASED ON WEIGHTED EMC	EMC	EMC WEIGHTED BY Landuse % Total WBID DCIA	% TOTAL LOAD BASED ON WEIGHTED EMC
A. Forest/Rural Open	1.41	1.56E-03	0.08%	0.053	4.00E-05	0.01%	0.004	4.34E-07	0.00%
B. Urban Open	1.41	8.90E-04	0.04%	0.053	2.28E-05	0.01%	0.004	2.47E-07	0.00%
C. Agriculture/Pasture	2.32	4.91E-04	0.02%	0.34	8.06E-05	0.02%	0.23	5.02E-05	0.02%
D. Low Density/Residential	1.97	4.04E-02	1.95%	0.3	5.86E-03	1.59%	0.18	2.86E-03	1.30%
E. Medium Density/Residential	2.13	7.13E-01	34.48%	0.4	1.38E-01	37.35%	0.24	8.96E-02	40.86%
F. High Density/Residential	2.3	4.96E-01	23.95%	0.49	1.17E-01	31.79%	0.26	8.27E-02	37.68%
G. Commercial	1.75	3.30E-01	15.97%	0.29	4.63E-02	12.54%	0.14	1.76E-02	8.00%
H. Industrial	2.03	1.80E-01	8.71%	0.31	2.70E-02	7.31%	0.17	1.24E-02	5.67%
I. Highways	2.01	1.09E-01	5.27%	0.34	1.79E-02	4.86%	0.19	9.23E-03	4.21%
J. Water	0.79	1.32E-03	0.06%	0.11	7.03E-05	0.02%	0.02	3.81E-06	0.00%
K. Wetland	1.5	3.59E-02	1.74%	0.19	3.30E-03	0.89%	0.09	8.04E-04	0.37%
L. Institutional	2.29	1.41E-01	6.81%	0.15	1.02E-02	2.77%	0.08	2.21E-03	1.01%
M. Golf Courses	2.32	1.89E-02	0.91%	0.34	3.11E-03	0.84%	0.23	1.94E-03	0.88%
TOTAL		2.07E+00			3.69E-01			2.19E-01	

4.2.3 Modeling Nonpoint Source Loading

4.2.3.1 Estimating Flow

The determination of nonpoint source loading requires an estimation of stream flow rate as well as the concentration of pollutant. There has been nearly continuous USGS flow monitoring near the Little Wekiva Canal (WBID 3004) at USGS Site # 02234990 on State Rd 434 (Wekiva Springs Road near intersection with Kensington Park) between 2/1972 and the present. Site 02234990 is approximately 3.75 canal miles north of WBID 3004. There was a 3-year interruption in monitoring between 10/1/79 and 9/30/82 (**See Figure 4.1**). There was also continuous flow monitoring between 6/9/95 and 3/11/02 at USGS site # 02234998 on Springs Landing (**see Figure 4.2**), 5.0 miles north of WBID 3004. Finally, between 1972 and 1974 there were flow gage heights translated into flow measurements at USGS Station 02234815 at the Lake Wekiva outlet (see **Figure 4.3**).

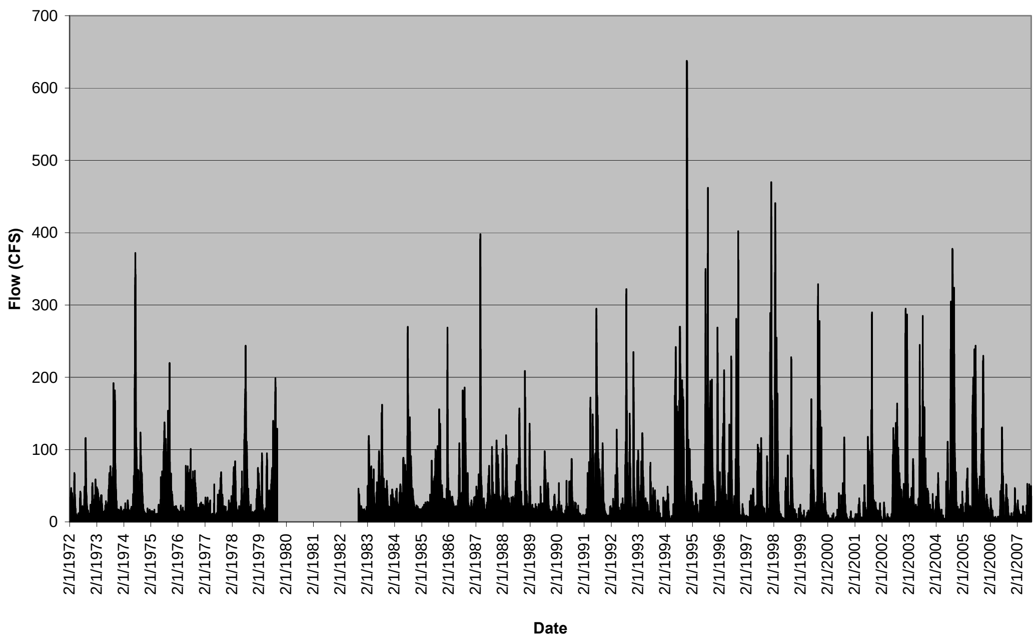

Figure 4.1 Flow at USGS Station 02234990

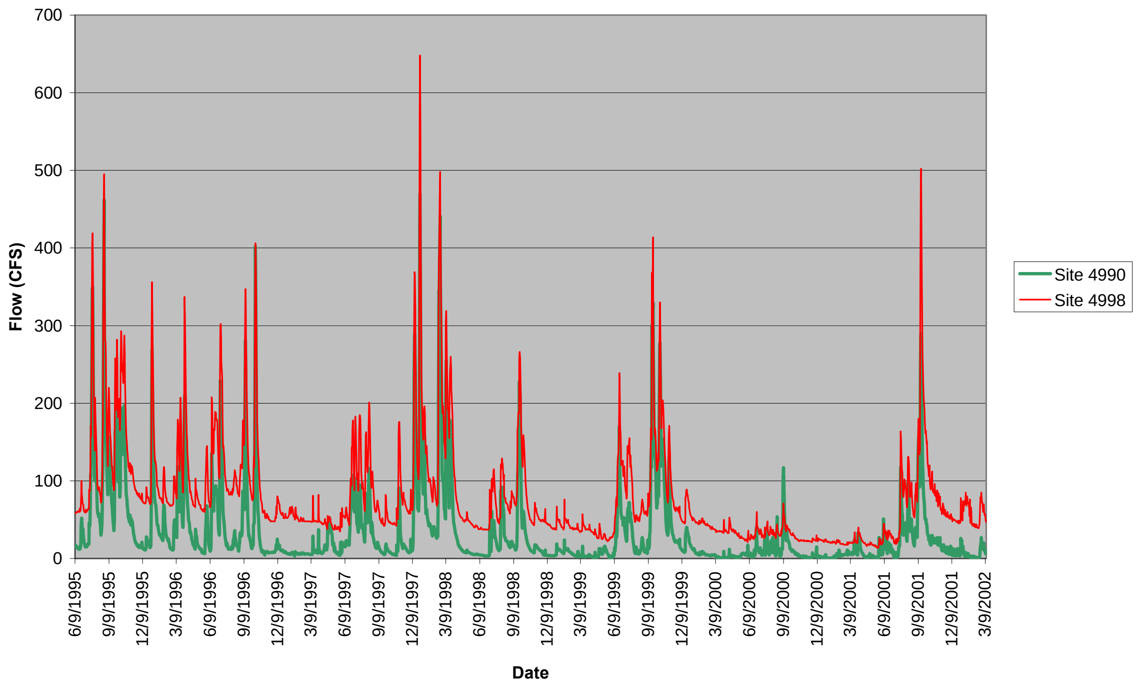

Figure 4.2 Flow at USGS Stations 02234998 and 02234990

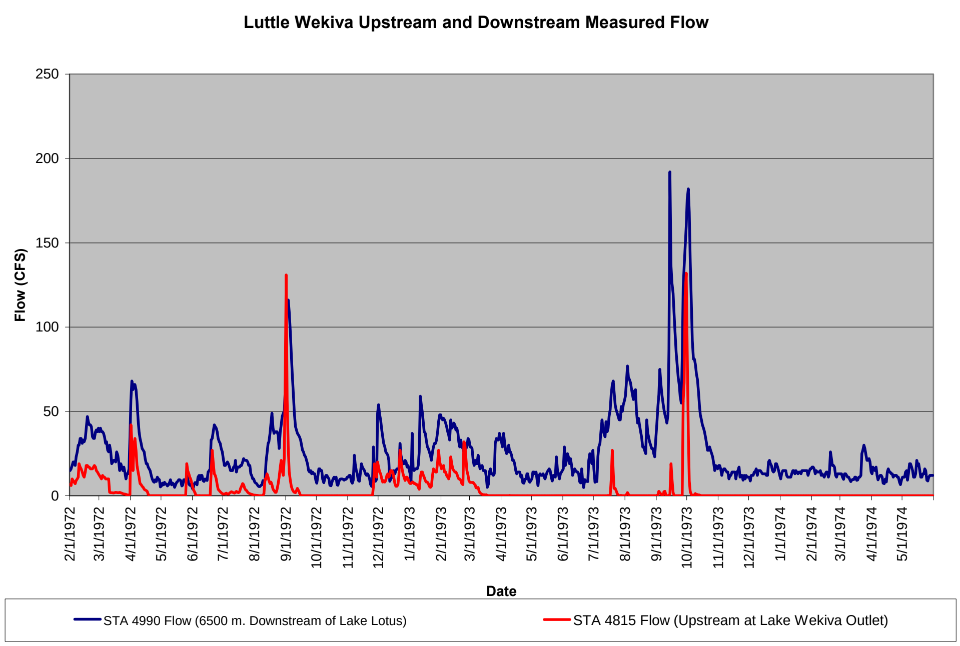

Figure 4.3 Flow at USGS Stations 02234815 and 02234990

On 2/22/07 and 6/21/07, the USGS gauged flows at the Little Wekiva near Altamonte Springs Station (STA 2234990) were recorded as 5.8 cfs and 4.6 cfs, respectively. On the same dates, the Department Watershed Assessment Section crew, utilizing a Marsh-McBirney flow meter and wading rod, recorded flows at the same site of 6.4 and 4.2 cfs, respectively. The differences are reasonable and can be attributed, at least in part, to the fact that the USGS value is a mean daily flow, and Department's measurements represent a measurement taken across a stream during ½ hour monitoring event during those days. Both measurements were taken during a "longer than normal" dry season. There were near-drought conditions during May and June 2007, explaining the lower flow values in late June, which is typically the beginning of the wet season.

The base flow can, in many cases, be correlated to the area of contributing watershed. The Little Wekiva Canal basin is complicated by the existence of areas of springs, ground water recharge, and connecting conduits providing flow and overflow from nearby lakes and springs. Thus on 2/22/07 and 6/21/07 a Department's Watershed Assessment crew measured flow along the length of the Little Wekiva Canal to observe the change in flow along the length of the canal. The goal was to develop a relationship between the point of continuous USGS flow measured at STA 2234990 and the various stations along the length of the Little Wekiva Canal, including the basin outlet at station 9. The measured flows and DO at the stations are shown in **Table 4.5** and locations displayed on **Figures 4.4, 4.5, 4.6, and 4.7**.

Table 4.5 D.O. and Flow data from 2/22/07 and 6/20/07

Site No.	Site Description	D.O., mg/L		2/22/07 FDEP		6/20/07 FDEP		USGS	USGS
		2/22/2007	6/20/2007	Ft3/sec	Gal/min	Ft3/sec	Gal/min	2/22/07 cfs	6/20/07 cfs
1	Lake Lawne Inlet 1		0.32						
2	Lake lawne Inlet 2	2	2.6	0.08	35.	0.1	50		
3	Lake Lawne Inlet East Side - Apartment Complex	8.3	0.4						
4	Outlet, Lake Lawne	13.7	6.21	0.98	438.7	1.2	543		
5	Lake Wekiva Upstream	9.1	5.6	1.1	512.8	2.0	916		
6	Riverside Pk Road	7.8	8.3	2.9	1345				
7	Lake wekiva on upstream side / dam structure	6.5	4						
8	South of Lake Lotus	8.9		3.2	1416				
9	North of Lake Lotus	5.4	1.6	6.0	2701	2.6	1151		
10	After Confluence from Lotus & Spring	7.7	2.7	5.3	2386.	2.9	1292		
11	Bridge near hotel		3.9			3.5	1574		
12	Montgomery Road & Pump Station	7.9	6.5			3.9	1750		
13	Rte 434 * USGS 4990	8.1	11.1	6.4	2862	4.2	1873	5.8	4.6
14	Springs Landing Blvd	5.2	4.6						

Figure 4.4   Upstream Flow Monitoring

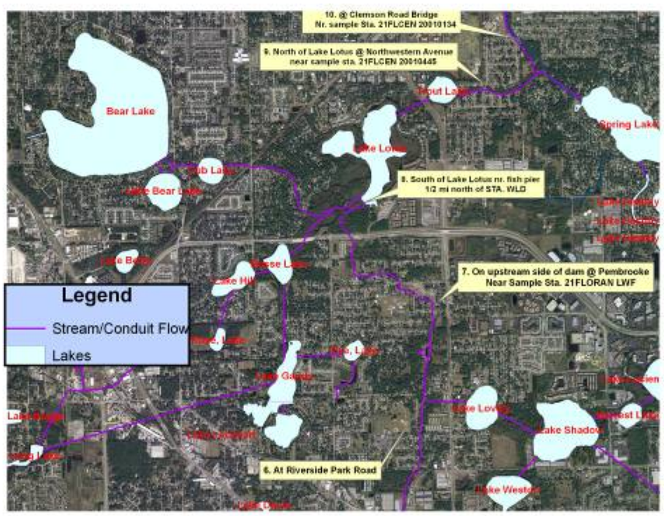

Figure 4.5   Downstream Monitoring

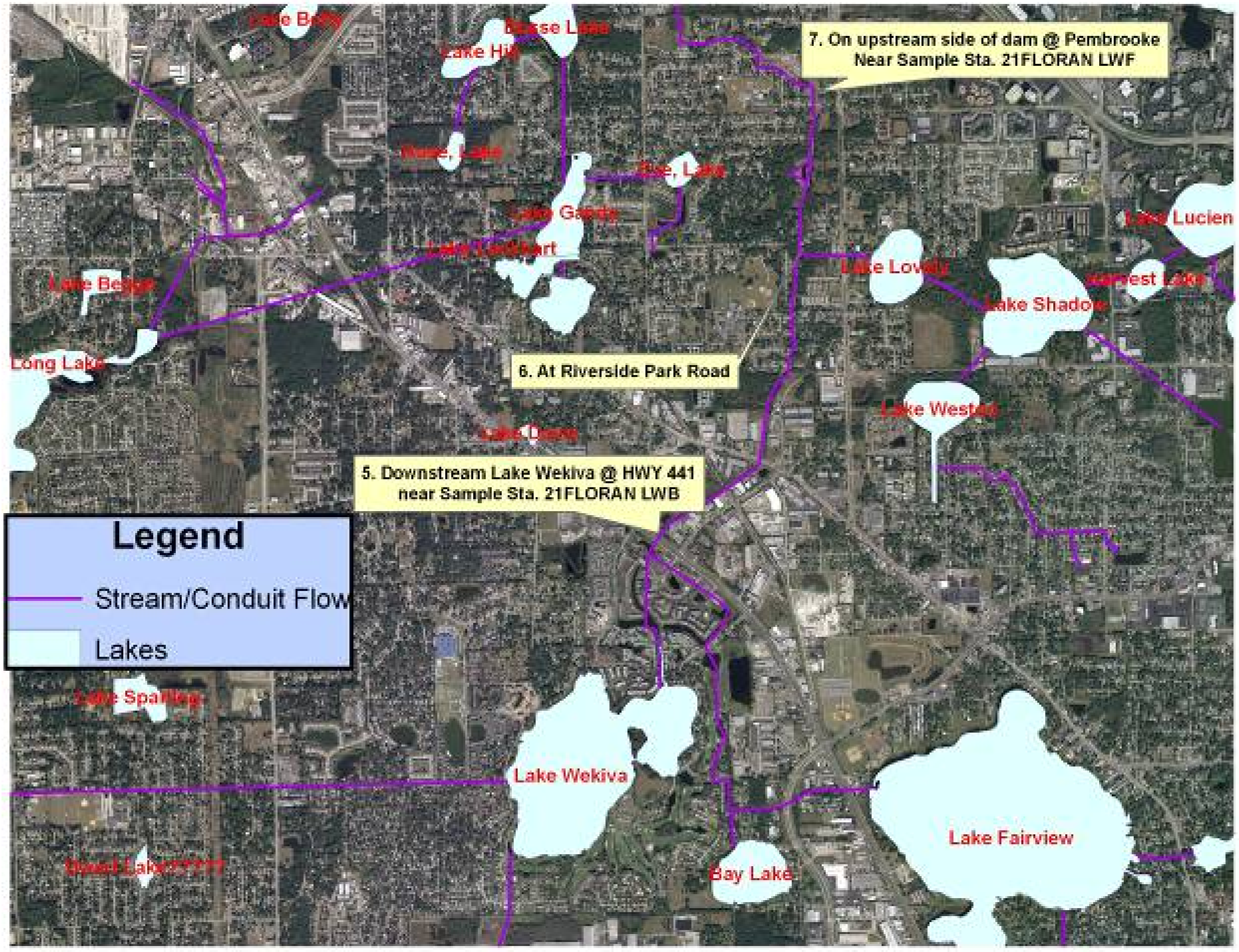

Figure 4.6 Central WBID 3004 Flow Monitoring

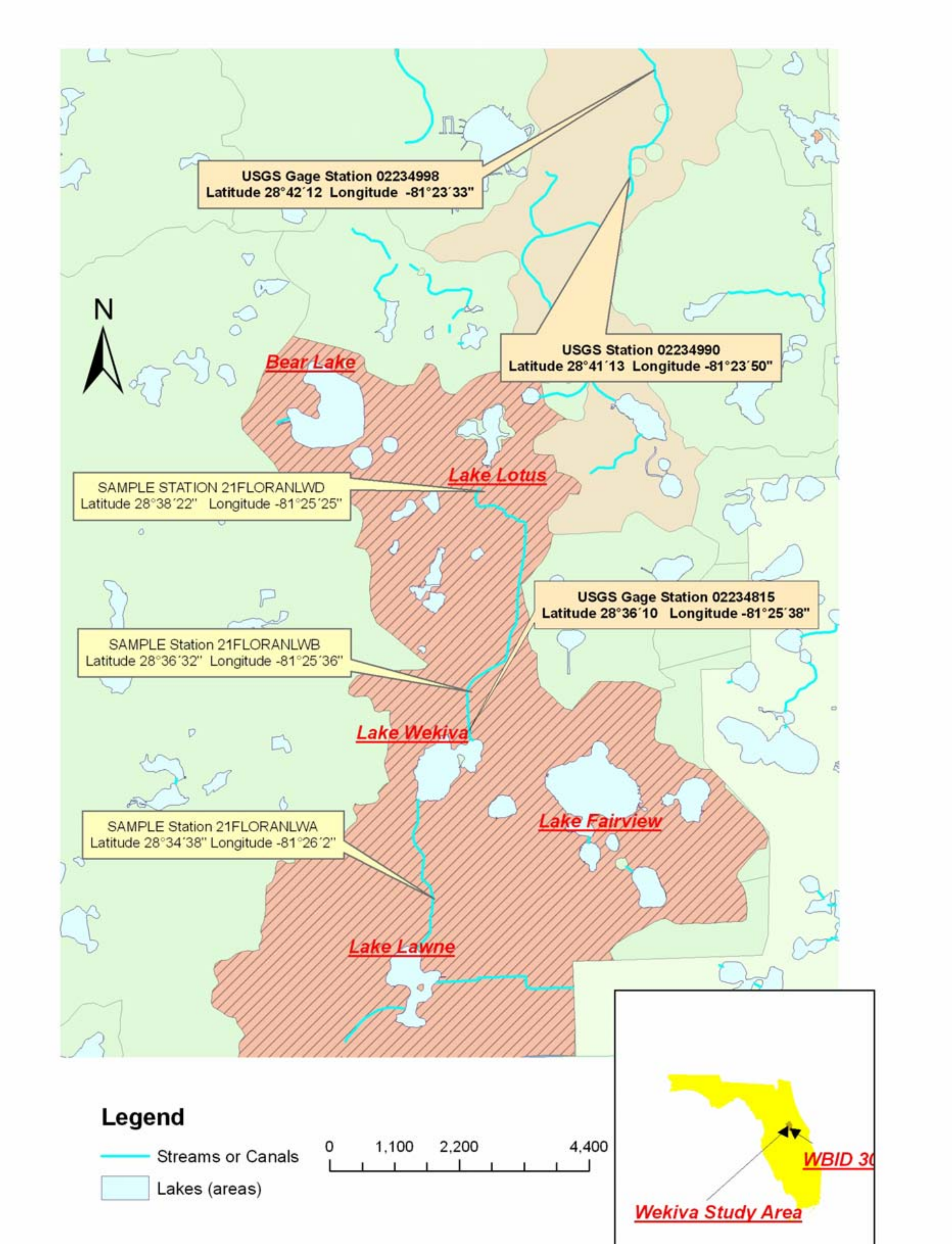

Figure 4.7 USGS Flow Monitoring Locations and Major Sampling locations.

BASE Flow Determination

The goal is to determine the base flow for STA 2234990 entering the USGS flow data for this station into the SWAT baseflow program. Because of the proximity of the STA 2234990 to the other monitored stations, the goal is to determine the relationship between these stations and the STA 2234990 utilizing results from field flow surveys on 2/22/07 and 6/20/07. **Figure 4.8** shows the change in flow as we move downstream on the Little Wekiva Canal. **Table 4.9** shows the station flow expressed as a percentage of the flow at station 13, which is the same as USGS Station 2234990. The slope of the flow line in **Figure 4.8** becomes more negative between 8 and 14 mile markers, or following stations 9, 10, and 11. These flows were obtained during the dry season and the percentages assumed to be representative of the relationships between base flows at those points along the Little Wekiva Canal. Thus, using the average base flow at USGS Station 2234990 over the past ten years to develop monthly average base flows at that point, and the average relationships between 2234990 and the points along the canal average monthly average base flows were calculated at several points along the Little Wekiva Canal for use in the SWMM computer program. Thus, at station 9, which is at the outlet of WBID 3004, the base flow is assumed to range from 61% (wet portion of 2007 dry season) to 94% (driest part of the season), for an average 78% of the flow (on the date of monitoring) at 2234990. The higher percentage at the beginning of the dry season reflected influence of groundwater recharge at points downstream of Station 9 and contribution from connected to nearby lakes upstream of STA 9.

The amount and location of recharge in the Little Wekiva Canal requires further study, but based on the measurements taken an observed reduction in base flow occurs between stations 8 and 10. This reduction during the dry season was between 0 and 11% of the flow measured at the preceding station. This is in the region where groundwater recharge is indicated to exist in the Little Wekiva Canal.

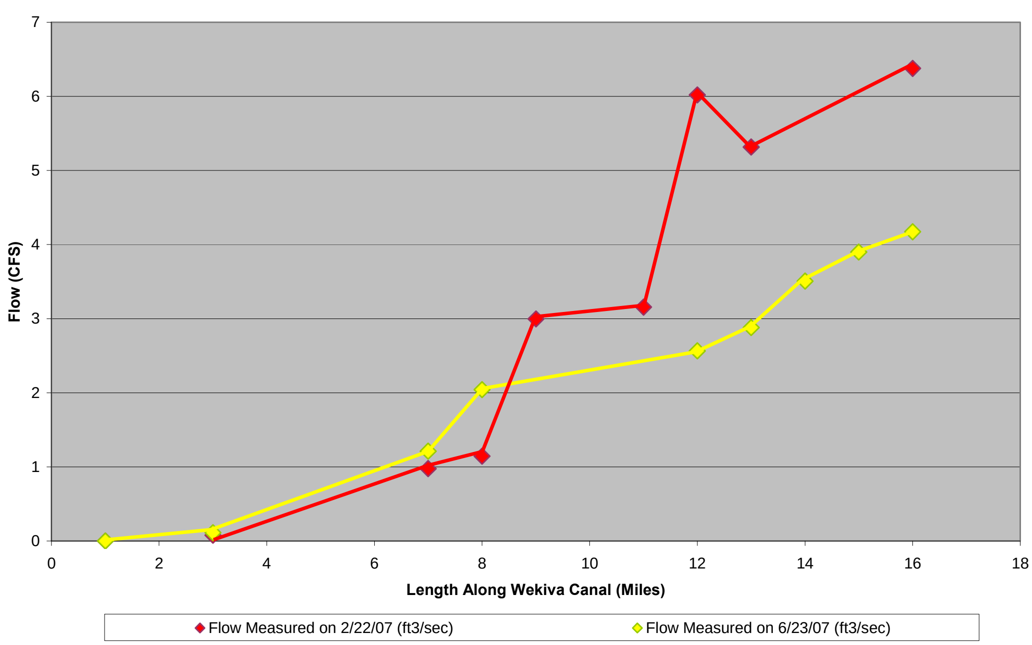

Figure 4.8 Little Wekiva Canal Flow on 2/22/07 & 6/20/07

4.2.3.1.1 Estimating Base Flow

Base flow was estimated for the stations within the Little Wekiva Canal by first predicting base flow for USGS STA 2234990 with the use of the computer program 'Baseflow for SWAT.' (We need to provide some background information about this program,' From the base flow of STA 2234990, the relationships of flow along the length of the Wekiva Canal as measured by the Department, to the continuous USGS gage-based measurements, was utilized to develop continuous estimates for base flow along the length of the Little Wekiva Canal **(Figure 4.9 and 4.10).** The monthly average baseflow values were derived for several points along the Little wekiva Canal, utilizing ten years of USGS data for station 2234990 (1997 through 2007).

Table 4.6   Monthly Base Flows (in CFS) at Monitored Sites on Wekiva.

Month	**Site Numbers**									
	2	**4**	**5**	**6**	**8**	**9**	**10**	**11**	**12**	**13**
January	0.24	2.46	1.37	1.65	0.30	3.47	(0.21)	0.96	1.14	0.80
February	0.19	1.93	1.07	1.29	0.24	2.708	(0.17)	0.75	0.89	0.63
March	0.23	2.41	1.34	1.62	0.30	3.39	(0.21)	0.94	1.12	0.78
April	0.10	1.07	0.60	0.72	0.13	1.51	(0.09)	0.42	0.50	0.35
May	0.08	0.83	0.46	0.56	0.10	1.17	(0.07)	0.32	0.39	0.27
June	0.20	2.10	1.17	1.41	0.26	2.95	(0.18)	0.82	0.98	0.68
July	0.46	4.72	2.62	3.17	0.58	6.64	(0.41)	1.84	2.19	1.53
August	0.46	4.80	2.67	3.22	0.59	6.75	(0.42)	1.87	2.23	1.56
September	0.46	4.77	2.65	3.20	0.59	6.71	(0.41)	1.86	2.21	1.55
October	0.38	3.89	2.16	2.61	0.48	5.48	(0.34)	1.52	1.81	1.26
November	0.24	2.53	1.40	1.70	0.31	3.56	(0.22)	0.98	1.17	0.82
December	0.23	2.36	1.31	1.59	0.29	3.32	(0.21)	0.92	1.10	0.77

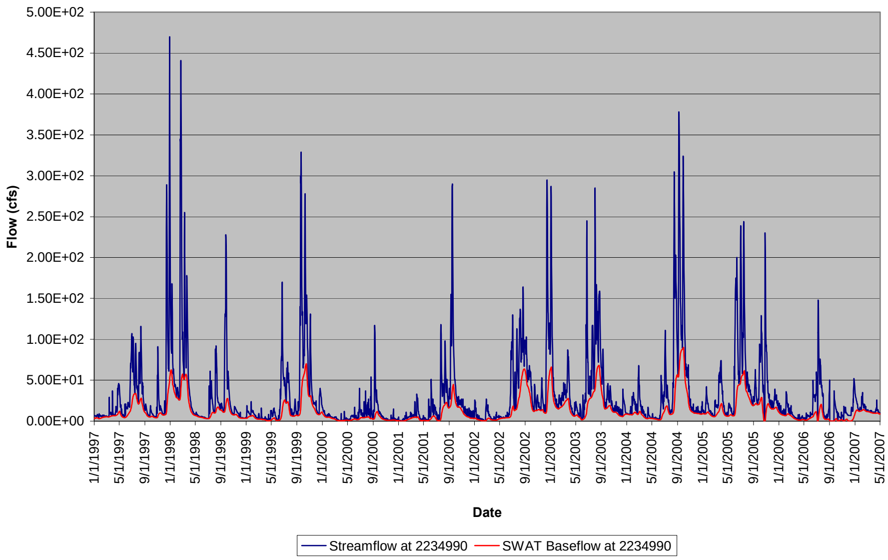

Figure 4.9   Little Wekiva Canal Flow & Baseflow, 1997 - 2007

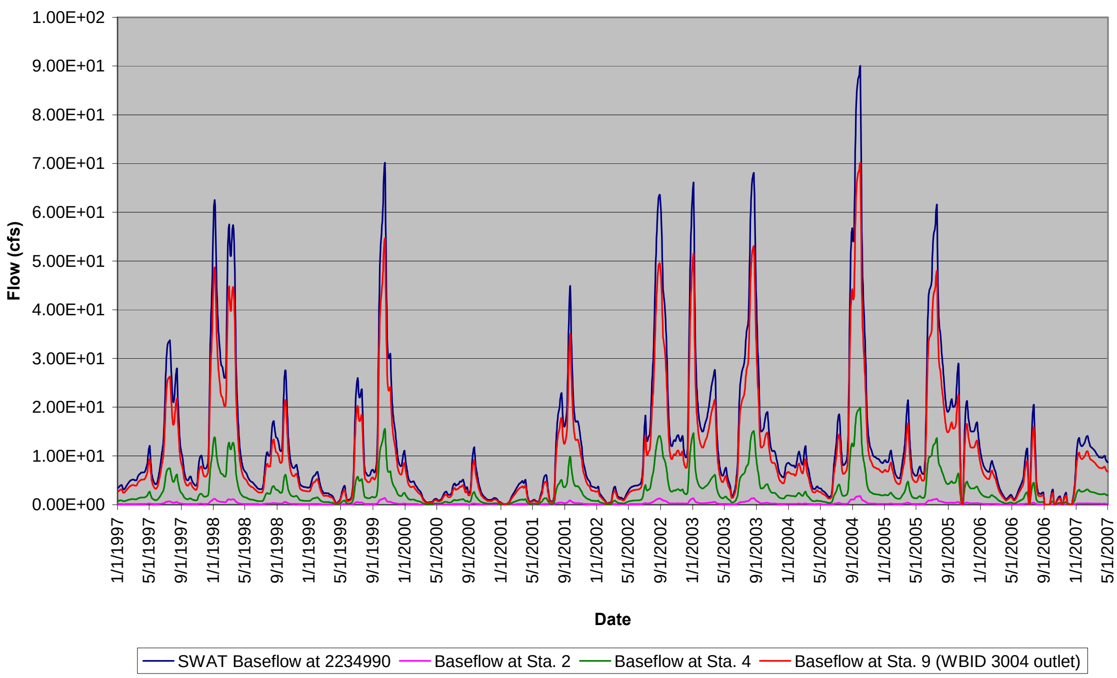

Figure 4.10   Base flow data obtained generated for Little Wekiva Canal Sample Stations utilizing established flow relationship with USGS STA 2234990.

4.2.3.2 SWMM Model

The Storm Water Management Model (Rossman 2004), Version 5.0 was used to simulate the Little Wekiva Canal's water quantity and quality. SWMM can simulate individual storm events with a time step of a few seconds or minutes, or a continuous simulation over an extended period of time (Rossman 2004). SWMM includes the hydrologic processes of rainfall, surface and subsurface runoff, flow routing through a drainage network, storage and treatment. SWMM is composed of three groups of elements: hydrologic, hydraulic, and quality. The hydrologic elements include rain gages, subcatchments, aquifers, and snow packs. The hydraulic elements include vehicles to move and store water and are grouped into links or nodes. Links (which handles flow mechanisms) include conduits (streams and pipes), pumps,orifices, weirs, and outlets. Nodes (which are turning points, storage points, receiving or discharge points) include junctions, outfalls, dividers, and storage units. The SWMM computer model requires the subcatchment properties of percent imperviousness, infiltration rate, depression storage, and surface roughness (Rossman 2004). It also requires other inputs such as stream or conduit geometry (shape, width, depth, side slopes), landuses, base flow, base flow concentrations, and Event Mean Concentrations (EMCs) by landuse. These basic components were used to represent the Little Wekiva Canal, and are shown **(Figure 4.11**) as they appear in the Windows-based SWMM (Rossman 2004), with a backdrop transferred from GIS Arcmap.

The sub-basin the Little Wekiva sub-basin and surrounding area was divided into 57 subcatchments because:

- A greater number of subcatchments provide greater opportunities to utilize internal mechanisms to create storage and delay flow within the modeled basin. This more accurately simulates long-term storm effects and gives width to the flow hydrograph.
- Instead of lumping and averaging all properties within larger subcatchments, for each smaller subcatchment you can specify such parameters as area, infiltration rate, percent impervious area, slope, point of entry into conduit (stream), ground water characteristics, and landuses.

Given that the SWMM model lumps the properties of each subcatchment, the best way to model an individual subcatchment with different characteristics is to create a new subcatchment. Of course, there is a balance between making subcatchment divisions and the time required to define each subcatchment. The benefits are also proportional to the degree of detail that you can describe for the different parameters related to each subcatchment. Other data inputs include stream widths and depths (from information obtained during stream flow measurements), surface slopes, areas, soils, landuse (information obtained from GIS shape files and maps), and rainfall data. **Table 4.4a** displays the imperviousness factors associated with each land use.

Data Required for Estimating BOD and TN Loadings. To estimate TN and BOD loadings from the Little Wekiva Canal watershed using SWMM, the following data were collected:

A. ***Rain precipitation data*** were obtained from the weather stations located in Orange County, Orlando WSO Airport, (086638).

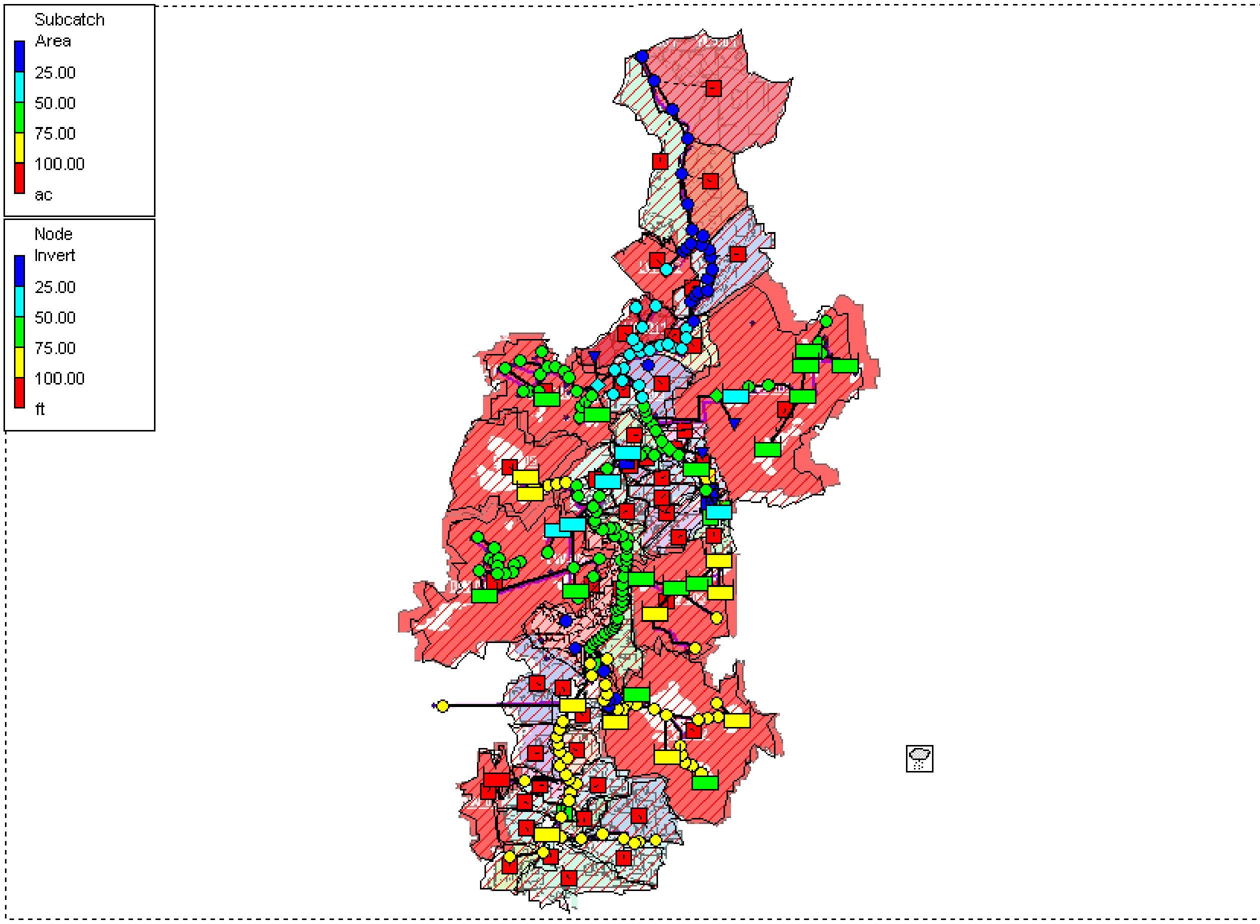

Figure 4.11   Basic Components of SWMM applied to Little Wekiva Canal

B. Areas of different land use categories in the Little Wekiva Canal (WBID 3004) were obtained by aggregating GIS land use coverage based on the simplified Level 1 codes, as well as Level 2 codes. These were applied to the sub-basin as a whole and to the divisions. These areas are listed in **Table 4.2 and Table 4.3** (for the entire watershed) and **Table 10** (examples for the watershed divisions subcatchments? required for the SWMM model). These tables show percent distributions of each land use category in the watershed.

C. Percent impervious area of each land use category is a very important parameter in estimating surface runoff using the SWMM model. Nonpoint pollution monitoring studies throughout the United States over the past fifteen years have shown that annual per-acre discharges of urban stormwater pollution are positively related to the amount of imperviousness in land use (User's Manual: Watershed Management Model, 1998). Ideally, the *impervious area* is the area that does not retain water and therefore, 100 percent of the precipitation falling on the impervious area should become surface runoff. In practice, however, the runoff coefficient for impervious area typically ranges between

95 and 100 percent. Impervious runoff coefficients lower than this range were observed in the literature, but usually the number should not be lower than 80 percent. For pervious area, the runoff coefficient usually ranges between 10 and 20 percent. However, values lower than this range were also observed (User's Manual, 1998). In this study, the imperviousness was obtained by integrating information from **Tables 4.4 and 4.5, and 4.8** to develop a weighted average impervious figure, based on the relative landuses for the given WBID division.

It should be noted that the impervious area percentages do not necessarily represent the directly connected impervious area (DCIA). Using a single-family residence as an example, rain falls on rooftops, sidewalks, and driveways. The sum of these areas may represent 30 percent of the total area of the residential lot. However, much of the rain that falls on the roof drains to the grass and infiltrates to the ground or runs off the property, and thus does not run directly to the street. For the SWMM model DCIA was used to characterize Imperviousness according landuse (see **Table 4.8** for references).

To simulate infiltration, the SWMM model provides the user with the option of utilizing either the Horton Equation or the Green-Ampt Equation. The Green-Ampt equation was selected because the parameters required were more accessible. The parameters required by the Green-Ampt equation are the soil saturated hydraulic conductivity, the initial deficit (difference between initial moisture and soil porosity), and the soil suction head (average values of soil capillary suction along wetting front). The GIS Soils Shape file (SSURGO Soils SJRWMD) was used to determine the percentage of the sub-basin soils in each of the area divisions. The required soil properties were calculated utilizing information from the NRCS Soils Manuals for Orange and Seminole Counties, as well as the GIS data files. The saturated hydraulic conductivity or permeability values were typically given in the form of a range, with final values estimated based on information about soil hydrologic group and drainage class. Based on the percentage of each soil in the sub-basin's section, weighted averages of these soil properties were calculated and these values were input to their respective subcatchment data file **(Table 4.8)**. The 10 year stream flow obtained through use of the SWMM program is shown in **Figure 4.12.**

Table 4.7   Illustrating DCIA Calculations for Little Wekiva Canal Drainage Area Sections (Used in the SWMM computer model)

Land Uses	% Directly Connected Impervious Areas (DCIA) For Given Land Uses Source: CDM	Weighted DCIA Components of Below Land Sections producing total DCIA Weighted = DCIA for land use x % of that land use in given land section						
		SWMM Model Subcatchments for Little Wekiva, Areas, & % landuses						
		41	42	43	44	45	46	47
		280.4 ac.	132.3 ac.	243.7 ac.	704.5 ac.	1025 ac.	788.4 ac.	1,999 ac.
Forest/Rural Open	1.0%	0.3%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%
Urban Open	17.0%	0.0%	0.1%	0.0%	2.3%	0.1%	0.0%	0.2%
Agriculture/Pasture	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Low Density Residential	30.0%	0.0%	0.0%	0.7%	2.3%	0.0%	9.2%	2.2%
Medium Density Residential	37.0%	18.9%	24.9%	13.4%	13.5%	5.1%	17.1%	19.3%
High Density Residential	71.0%	1.8%	17.3%	31.0%	2.9%	0.0%	0.0%	0.0%
Commercial	85.0%	8.4%	4.1%	0.0%	7.9%	0.0%	0.0%	0.0%
Industrial	71.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.7%	0.0%
Highways	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Water/Wetland	28.0%	2.0%	0.8%	2.8%	4.7%	23.3%	6.1%	8.4%
Total Weighted Average DCIA for Subcatchment		31.4%	47.2%	48.0%	34.5%	28.6%	33.1%	30.2%

Sample Calculation: Based on Land Use for Section 47, the DCIA for section 20 is calculated below.	
DCIA = (.1% x 1.0%) + (0.2% x 17%) + (2.2% x 30%) + (19.3% x 37%) + (8.4% x 28.0%)	
DCIA =	28.7%

Table 4.8   Saturated Hydraulic Conductivities and Suction Heads used for Green-Ampt Infiltration Equation in SWMM

Division	HYDCON	SUCT	Division	HYDCON	SUCT	Division	HYDCON	SUCT
1	6.64	2.64	9	0.63	4.41	17	3.87	3.36
2	0.71	4.28	10	3.19	2.74	18	7.79	2.31
3	3.42	2.79	11	1.45	3.94	19	6.43	2.35
4	3.07	3.09	12	4.58	2.77	20	5.31	2.45
5	4.79	2.61	13	1.20	3.99	21	3.84	2.78
6	10.39	1.89	14	1.83	3.95	22	5.29	2.73
7	14.29	1.77	15	4.59	2.52	23	5.16	2.64
8	6.65	2.44	16	7.32	2.30			

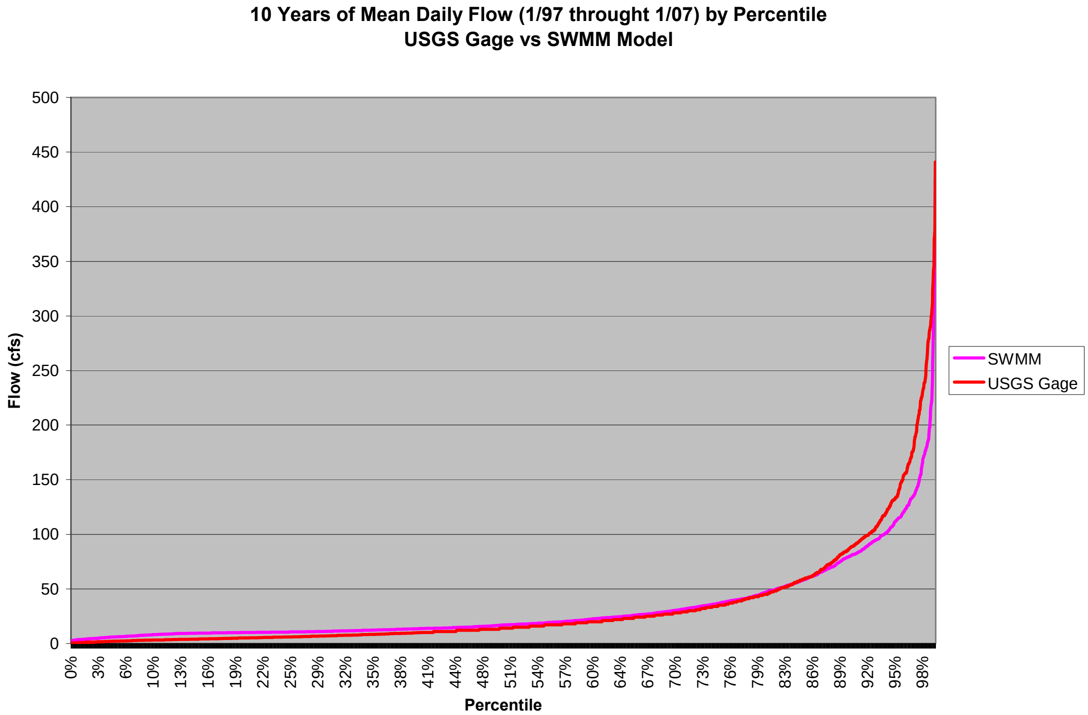

Figure 4.12 Little Wekiva Canal Flow & SWMM Model flow

Table 4.9 Error associated with Extended Period Flow Prediction using SWMM computer program.

Total 10 yr Measured Flow (Million Gallons) at STA 2234990 (based on average daily CFS)	Total 10 yr SWMM Simulated Flow in Million Gallons	ERROR AS PERCENTAGE OF TOTAL USGS GAGE FLOW	ERROR AS PERCENTAGE OF MEDIAN USGS FLOW
76,645	79,718	4%	16%

The Event Mean Concentrations used in the model (**Table 4.4b**, ERD Report, 2003) were input into the "Landuse" section. The base flow concentrations for BOD and TN were determined by averaging the respective concentrations from the samples collected during the three "lowest flow" conditions **(Table 4.10).** .The values also were in the range of literature **(Table 4.11).**

Table 4.10 Dry Season, Low Flow Concentrations.

Sample Date	Sample Station	DO mg/L	BOD mg/L	TKN mg/L	NO2 mg/L	NO3 mg/L	TN (Calc) mg/L
3/8/2000	21FLORANLWA	4.59	3.8	1.5	0.02	0.16	1.68
4/28/2005	21FLORANLWA			1.15	0.004	0.046	1.2
1/19/2006	21FLORANLWA	6.2		0.99		0.154	1.15
4/20/2006	21FLORANLWA	2	4	1.41		0.114	1.54

1/18/2007	21FLORANLWA	5.8					
3/8/2000	21FLORANLWB	7.23	2.6	0.59	0.005	0.02	0.615
4/28/2005	21FLORANLWB			0.99	0.002	0.078	1.07
1/19/2006	21FLORANLWB	6.8		0.65		0.285	0.94
4/20/2006	21FLORANLWB	7.3	3	0.9		0.008	0.91
1/18/2007	21FLORANLWB	4.9					
3/16/2000	21FLORANLWD	6.03		0.67	0.009	0.68	1.359
2/21/2001	21FLORANLWD	12.09	2 - U	0.32	0.006	0.63	0.96
4/28/2005	21FLORANLWD			0.58	0.004	0.326	0.91
1/19/2006	21FLORANLWD	10		0.52	0.02	0.554	1.08
4/7/2006	21FLORANLWD	4.52	1 - U	0.43	0.004	0.447	0.9
4/20/2006	21FLORANLWD	4	1 - U	0.49	0.004	0.216	0.75
1/18/2007	21FLORANLWD	6					
21FLORANLWA AVERAGE		4.648	3.900	1.263	0.012	0.119	1.393
21FLORANLWB AVERAGE		6.558	2.800	0.783	0.004	0.098	0.884
21FLORANLWD AVERAGE		7.107	0.667	0.502	0.008	0.476	0.993
Overall Average (3 Station)		6.104	2.456	0.849	0.008	0.231	1.090

Model output was transferred to an Excel spreadsheet and summarized in **Tables 4.15 and 4.16**. The results of the "water quantity" section of the model showed a good mass balance (a 5% difference in total flow between SWMM simulated stream flow and stream flow from the gage-based flow), **Table 4.13**. The cumulative flow matched well through the first months of simulation and began to deviate during the later months **(Figure 4.13)**. The flow hydrograph comparison **(Figure 4.14)** illustrates that there are multiple storm events where SWMM simulated higher flow than the gage, and there are a few gage-based storm flows that are much higher than the simulated SWMM simulation. The SWMM model was calibrated by changing the percent impervious areas input (there is a range of values available concerning impervious areas to be used for various land uses); the initial selected values that were on the high end of that range were replaced with lower ones to bring the peak flows from the SWMM simulation down. This is one of two parameters suggested by model developers for calibration to reduce peaks and volume of flow. Another parameter suggested for calibration is the width of overland flow path (reducing the width should increase the time span of the storm hydrograph). A factor that limits the impact of these calibration tools is the time step utilized in this application. Calibration has a greater impact where the time of concentration is larger than the modeled time step. For this modeling effort, the time step was fixed by the fact that daily rainfall data are used rather than a smaller time interval.

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Table 4.11 Ranges of Base Flow Concentrations, Literature Summary / Hugh Duncan

Range of Baseflow Concentrations (mg/L) (from Chapt. 3 Chart, "Urban Wastewater Pollutant Concentrations", Hugh Duncan)												
	BOD				Total Phosphorus				Total Nitrogen			
	Sample Size	Min	Mean	Max	Sample Size	Min	Mean	Max	Sample Size	Min	Mean	Max
Urban	15	2	5	12	17	0.04	0.14	0.59	13	0.90	2.10	4.50
Rural	8	1	2.1	4	15	0.03	0.06	0.12	13	0.45	0.95	2.10

Figure 4.13   Modeling Cumulative Flow from Little Wekiva Canal, 1997 through 2007

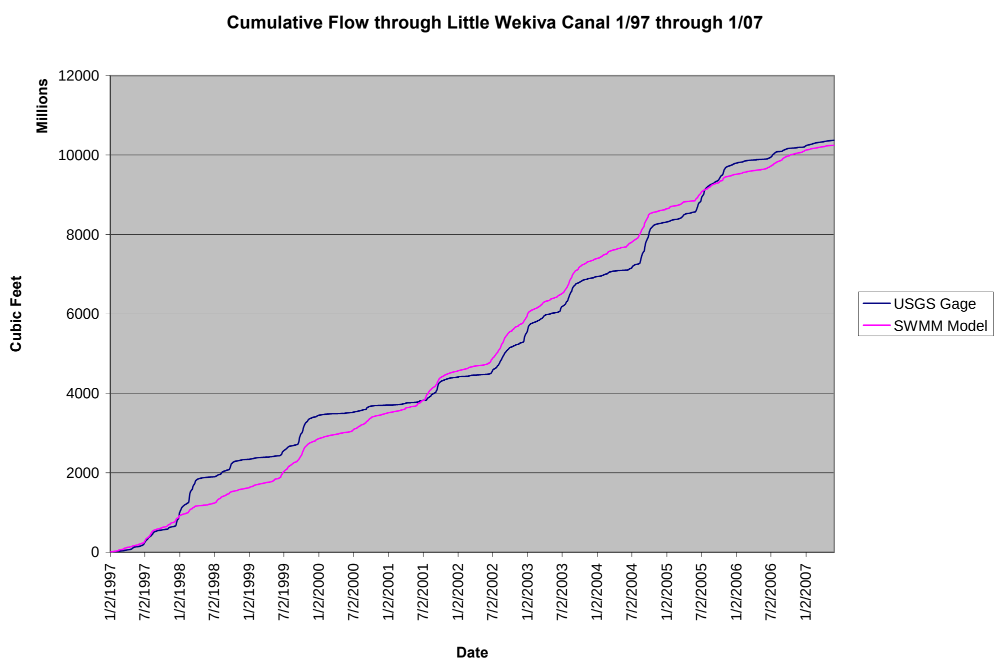

Table 4.12 SWMM Output Comparison Table

SWMM Simulation, utilizing Weather Data from Orlando WSO Airport Weather Station Flow in the last Section of the Little Wekiva Canal											
Date	A SWMM Simulated Flow (CFS)	B BOD Concentration (mg/L)	C Total Nitrogen (mg/L)	D Total Phosphorus (mg/L)	E Flow Based on 2234990 Gage	F BOD Load (LBS/DAY) A x B x 5.395	G TN load (LBS/DAY) A x C x 5.395	H TP load (LBS/DAY) A x D x 5.395	I BOD load limit A x 2.0 mg/L x 5.395	J TP load limit A x .05 mg/L x 5.396	K TN load limit A x 1.02 mg/L x 5.396
1/2/97	10.09	0.88	0.91	0.05	6.80	47.90	49.54	2.72	108.87	2.72	55.52
1/3/97	10.08	0.78	0.89	0.05	6.60	42.42	48.40	2.72	108.76	2.72	55.47
1/4/97	9.18	0.86	0.89	0.05	6.50	42.59	44.08	2.48	99.05	2.48	50.52
1/5/97	10.08	0.81	0.93	0.05	6.40	44.05	50.57	2.72	108.76	2.72	55.47
1/6/97	9.5	0.93	0.92	0.05	6.10	47.66	47.15	2.56	102.51	2.56	52.28
1/7/97	9.38	0.94	0.92	0.05	6.20	47.57	46.56	2.53	101.21	2.53	51.62
1/8/97	7.91	0.91	0.92	0.05	5.50	38.83	39.26	2.13	85.35	2.13	43.53
1/9/97	23.68	3.73	1.32	0.2	5.70	476.52	168.63	25.55	255.51	6.39	130.31
1/10/97	9.28	1.47	1.09	0.1	6.30	73.60	54.57	5.01	100.13	2.50	51.07
1/11/97	9.28	0.84	0.83	0.05	6.60	42.06	41.55	2.50	100.13	2.50	51.07
1/12/97	9.95	0.84	0.83	0.05	6.50	45.09	44.55	2.68	107.36	2.68	54.75
1/13/97	9.25	0.84	0.84	0.05	5.30	41.92	41.92	2.50	99.81	2.50	50.90
1/14/97	11.8	0.69	0.69	0.04	6.00	43.93	43.93	2.55	127.32	3.18	64.93
1/15/97	15.44	2.95	1.22	0.16	7.40	245.73	101.62	13.33	166.60	4.17	84.96
1/16/97	9.53	1.13	0.96	0.08	8.10	58.10	49.36	4.11	102.83	2.57	52.44
1/17/97	9.63	0.8	0.81	0.05	8.20	41.56	42.08	2.60	103.91	2.60	52.99
1/18/97	9.69	0.79	0.82	0.05	7.50	41.30	42.87	2.61	104.56	2.61	53.32
1/19/97	9.5	0.8	0.81	0.05	6.80	41.00	41.51	2.56	102.51	2.56	52.28
1/20/97	9.5	0.8	0.82	0.05	5.80	41.00	42.03	2.56	102.51	2.56	52.28
1/21/97	9.5	0.8	0.83	0.05	5.70	41.00	42.54	2.56	102.51	2.56	52.28
1/22/97	9.49	0.8	0.83	0.05	4.40	40.96	42.49	2.56	102.40	2.56	52.22
1/23/97	9.5	0.8	0.83	0.05	3.10	41.00	42.54	2.56	102.51	2.56	52.28
1/24/97	9.5	0.8	0.84	0.05	4.70	41.00	43.05	2.56	102.51	2.56	52.28
1/25/97	13.14	2.57	1.16	0.14	9.00	182.19	82.23	9.92	141.78	3.55	72.31
1/26/97	9.21	0.81	0.82	0.05	7.70	40.25	40.74	2.48	99.38	2.48	50.68

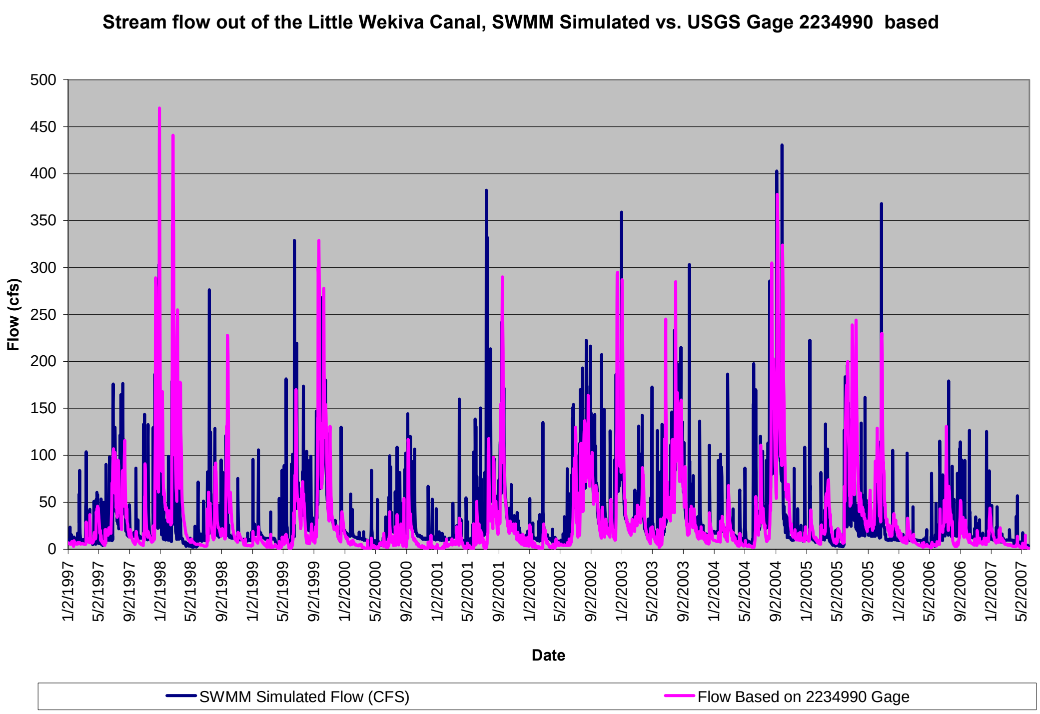

Figure 4.14   Stream Flow From Little Wekiva Canal (WBID 3004), Comparison between SWMM Simulation and Calculated flow based on STA 2234990 USGS Gage.

Table 4.13 Simulation Summary of Wekiva Canal

LITTLE WEKIVA CANAL FLOW BETWEEN 1/2/1997 AND 12/31/2006					
METHOD OF DETERMINATION	TOTAL 10-YR VOLUME (MILLION GALLONS)	FLOW (CUBIC FEET PER SECOND)			
		Average	Median	Maximum	Minimum
SWMM SIMULATION	79,718	33.8	16.2	494.8	2.7
USGS GAGE BASED CALCULATION	76,645	32.5	14.0	470.0	0.1

LITTLE WEKIVA CANAL LOADS, 1/2/1997 THROUGH 12/31/2006			
SIMULATION SCENARIO	Load	Reduction Relative to	
BOD	(LBS/YR)	Pounds	Percent
SWMM SIMULATION OF EXISTING CONDITIONS	86,051	N/A	N/A
SWMM SIMULATION OF BOD LOAD AT 2.0 mg/L (SCREEN LEVEL)	133,066	(47,015)	-54.6%
SWMM SIMULATION OF NATURAL CONDITIONS	20,041	66,010	76.7%
AVERAGE OF SCREENING LEVEL & BACKGROUND	76,554	9,497	11.0%
TOTAL NITROGEN			
SWMM SIMULATION OF EXISTING CONDITIONS	77,725	N/A	N/A
SWMM SIMULATION OF TN LOAD AT 1.02 MG/L	67,864	9,862	12.7%
SWMM SIMULATION OF NATURAL CONDITIONS	17,389	60,337	77.6%
AVERAGE OF 1.02 MG/L LOAD AND NATURAL CONDITIONS	42,626	35,099	45.2%

Table 4.14a SWMM Simulation Summary of downstream Sample site WLD.

LITTLE WEKIVA CANAL POLLUTANT CONCENTRATION (mg/L) AT STA LWD (DATA vs. SWMM).			
BOD	Average	Maximum	Minimum
SWMM SIMULATION OF EXISTING CONDITIONS, 97 - '05	1.17	5.72	-
FIELD SAMPLE ANALYSIS (62 GRAB SAMPLES, '97 - '05)	1.73	2.60	1.25
SWMM SIMULATION OF NATURAL CONDITIONS, '97 - '05	0.35	0.62	0.06
TOTAL NITROGEN			
SWMM SIMULATION OF EXISTING CONDITIONS, '97 - '05	1.45	1.96	0.34
FIELD SAMPLE ANALYSIS (30 GRAB SAMPLES, '97 - '05)	1.06	1.27	0.82
SWMM SIMULATION OF NATURAL CONDITIONS, '97 - '05	0.66	1.04	0.12

Table 4.14b SWMM Simulation Summary of Upstream Sample site WLA.

AT THE UPSTREAM STATION LWA (DATA vs. SWMM).			
BOD	Average	Maximum	Minimum
SWMM SIMULATION OF EXISTING CONDITIONS, 97 - '05	2.66	5.29	0.39
FIELD SAMPLE ANALYSIS (62 GRAB SAMPLES, '97 - '01)	2.96	9.61	1.00
TOTAL NITROGEN			
SWMM SIMULATION OF EXISTING CONDITIONS, '97 - '05	1.56	1.96	0.57
FIELD SAMPLE ANALYSIS (30 GRAB SAMPLES, '97 - '05)	1.74	2.75	0.42

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Overall Approach

The overall approach is to model the existing BOD, TP, and TN loads utilizing the SWMM computer model, and then reduce loads of BOD, TP, and TN loads until the target DO would be expected to be met based on the target BOD and target TN. For BOD, TP and TN the load will be set through consideration of the observed relationships with dissolved oxygen (BOD and TP) and *Chl* a (for TN) as well as the simulated natural pre-developed conditions.

5.2 Relationship between Measured Flow and Nutrients, BOD, and DO

Attempts were also made to relate DO to stream flow. As has been found in other studies, low DO concentrations were consistent with low flow conditions. Using all of the individual data, there was no correlation between DO and flow rate of the Little Wekiva Canal **(Figure 5.1). However, there were some relationships between** quarterly flow and DO values. For 2002 (2002 was chosen because that is the year when there is the most complete set of data for DO and flow) the DO was at its lowest average and median values during the third quarter, or the rainy season, when the flow is at its highest average and median values **(Figure 5.2)**. Unfortunately, there were not enough BOD data to evaluate quarterly averages during 2002. There were adequate TN data to evaluate quarterly averages, and the TN median and average quarterly concentrations were highest during the third quarter as well

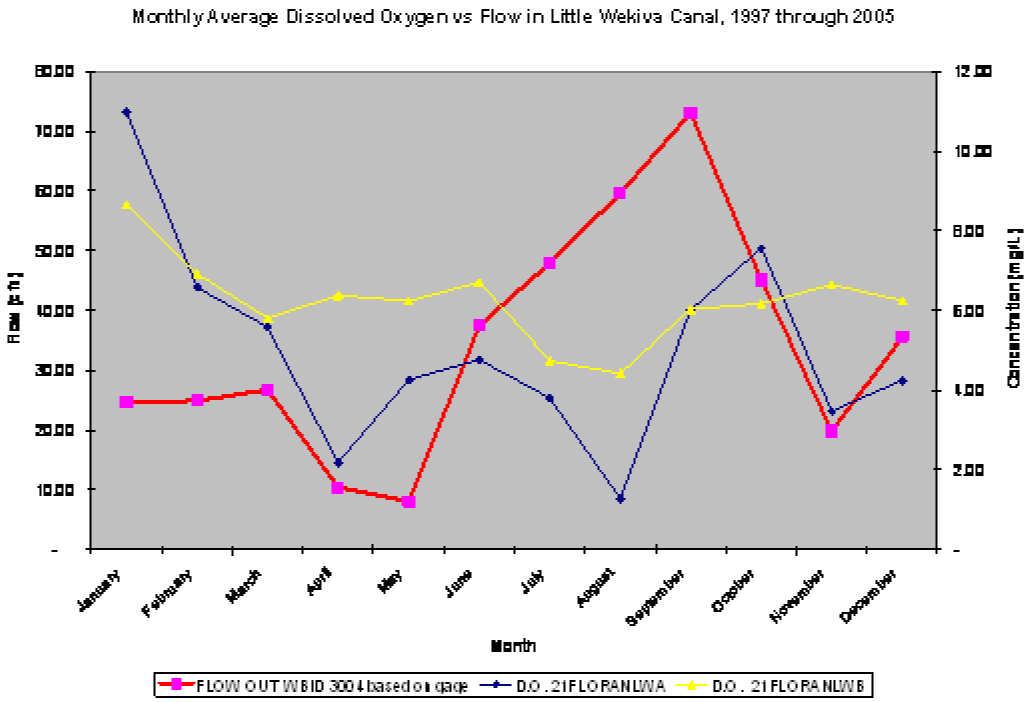

Figure 5.1 Relationship between DO and Flow Rate

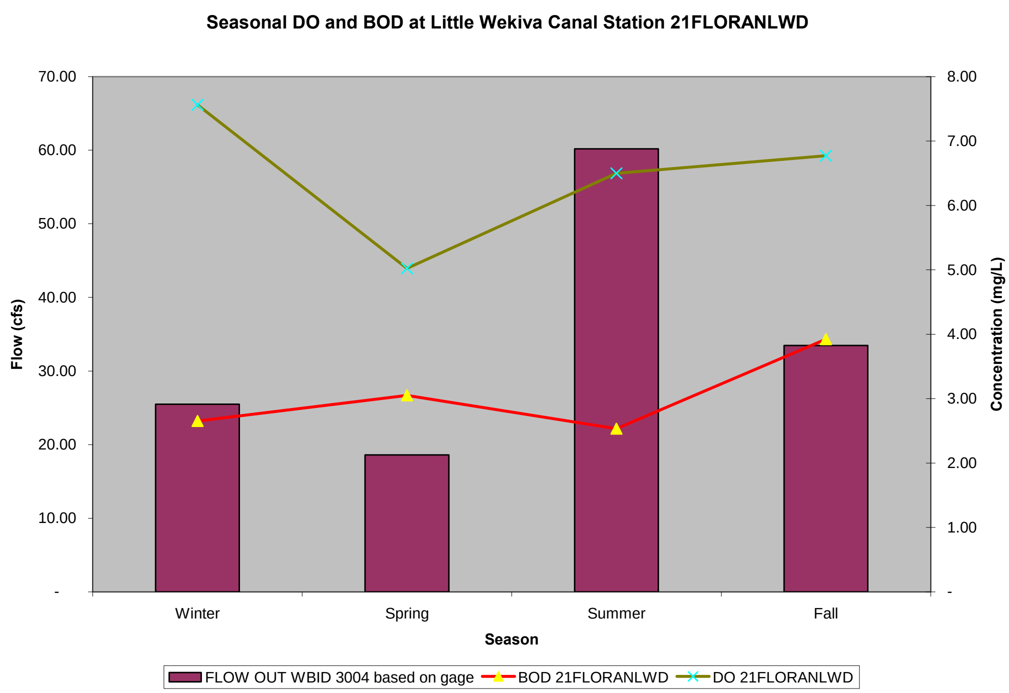

Figure 5.2 Relationship between Quarterly Median DO and Flow Rate

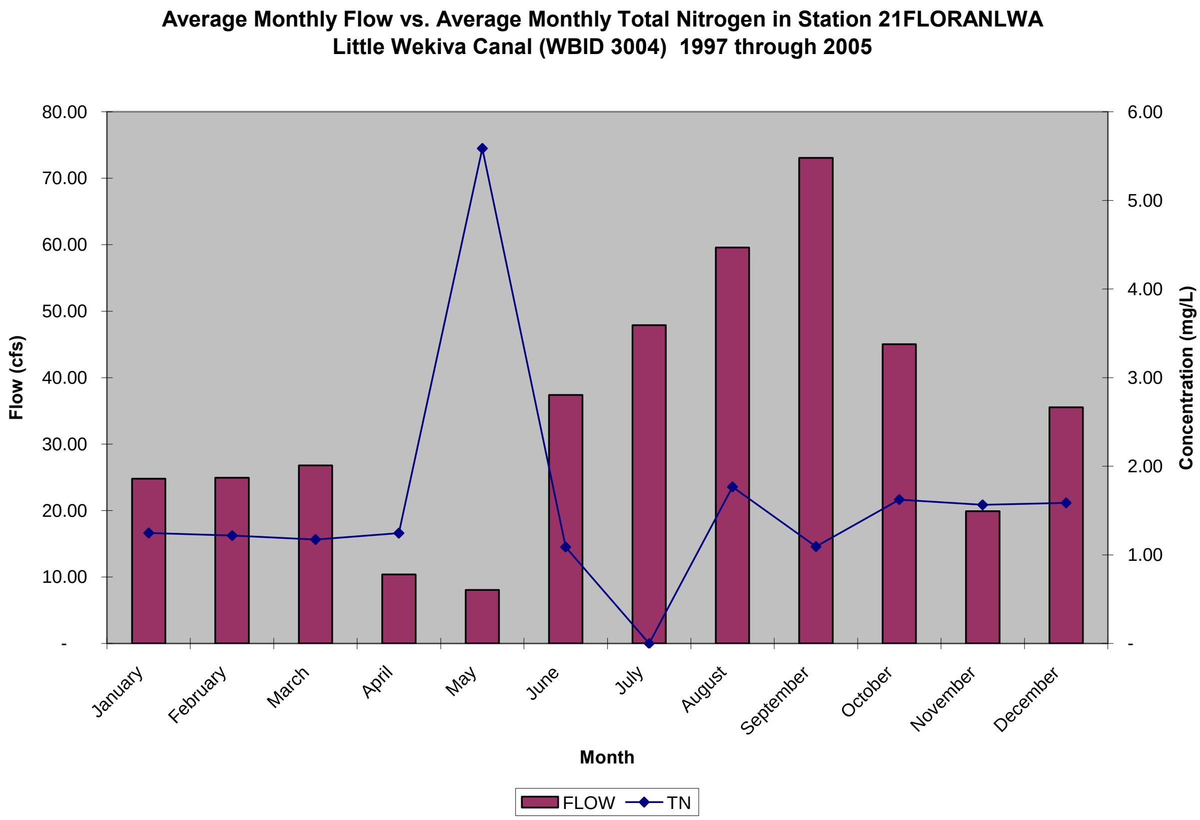

Figure 5.3   Relationship between Quarterly Average TN and Flow Rate

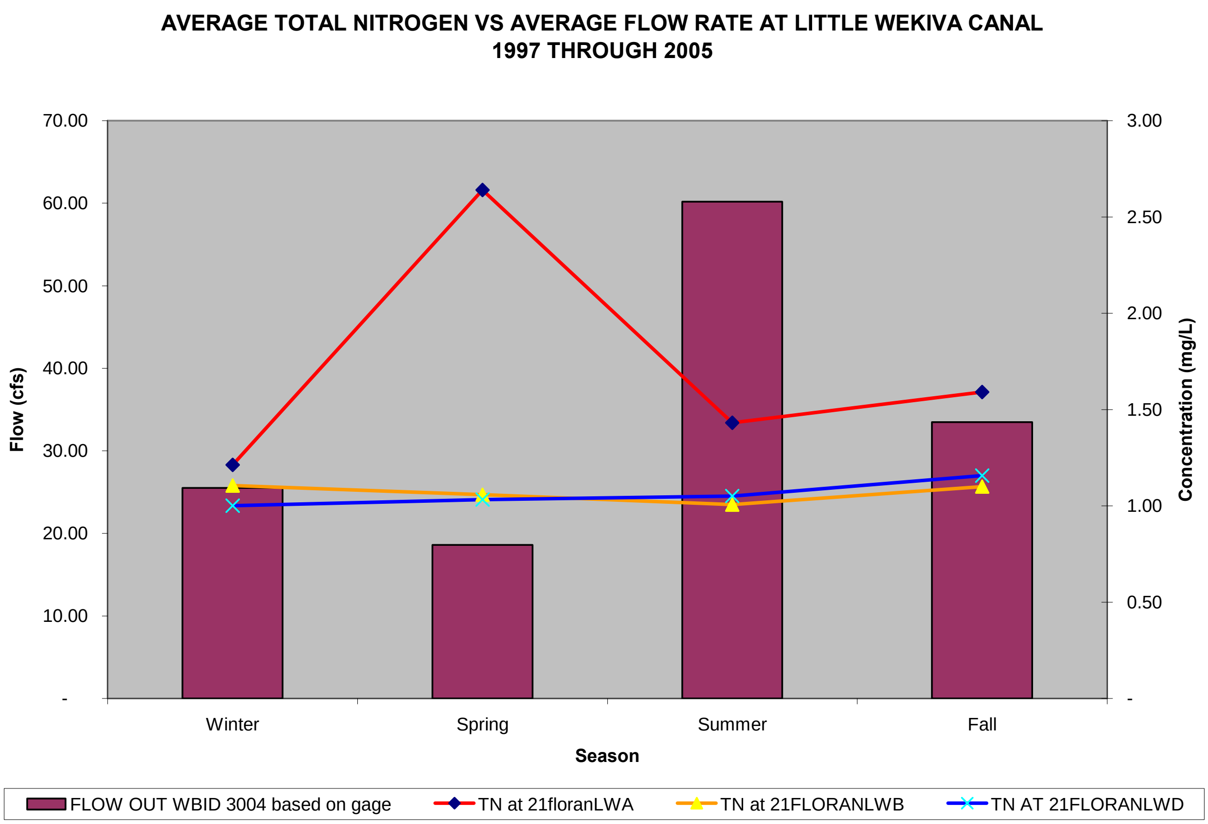

Figure 5.4 Relationship between Quarterly Average TN and Flow Rate

5.4 Critical Conditions:

The Little Wekiva Canal TMDL was determined through the simulation of flow and pollutant loads during the entire year, rather than focusing on a critical "low flow" season or condition. Depressed dissolved oxygen levels have been observed in all flow conditions, with higher averages observed during high flow periods, and thus has not been solely related to seasonal or flow condition. There may be other as yet undetermined critical conditions related to low dissolved oxygen or elevated BOD, but based on current knowledge it was determined best to simulate the annual flows and concentrations and relate them to the target maximum loads.

The assimilative capacity for BOD must be sufficient to achieve the loads consistent with the screening level of 2.0 mg/L. However, it should be noted that the natural background BOD levels in some regions of Florida have been shown to be approximately 2.0 mg/L (Reference??). At one location on the Wekiva Canal WBID, the BOD during low flow seasons has been observed to average below method detection limits. In recognition of these two factors, the approach taken here will be to simulate and determine the natural background BOD load for the Little Wekiva Canal, and set the BOD target to be midway between the load consistent with a 2.0 mg/L and the load associated with undeveloped land uses.

Based on the results of the SWMM model simulation for the years 2002 through 2004 (**Table 4.13**), the average BOD load in the Little Wekiva Canal was 86,051 lbs BOD/year. The SWMM simulation results also indicate that the BOD load at the screening level of 2.0 mg/L would have been 133,066 lbs/year (55% beow than simulated existing) and the BOD load associated with natural undeveloped conditions is 20,041 lbs/year (76.7% below the simulated existing load). The assimilative capacity for BOD is thus 76,554 lbs/year (the average of these two loads).

Similarly, the assimilative capacity for Total Nitrogen is the average of the load associated with the critical concentration related to *Chl* a (1.02 mg/L based on regression relationship) and the load associated with undeveloped landuse conditions. The SWMM model simulation results (**Table 4.13**) for the years 1997 through 2005 estimated the average Total Nitrogen (TN) load was 77.725 lbs/yr. At a load consistent with the concentration of 1.02 mg/L the total load would have been 67,864 pounds per year. Based on the SWMM model results, the Total Nitrogen load associated with natural undeveloped conditions is 17,389 lbs/year. The assimilative capacity is thus 42,626 lbs/year (the average of these two loads**).**

In modeling the natural undeveloped conditions, the base flow concentrations were left the same as the present conditions. In simulating natural conditions, all landuses for the sub basin were changed to upland forest, except the channelized wetland, which was converted to wetland. The TN and BOD reduced loads were thus associated with the reduced event mean concentrations associated with the undeveloped land uses.

Chapter 6: DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (Waste Load Allocations, or WLAs), nonpoint source loads (Load Allocations, or LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\textbf{TMDL} = \sum \textbf{WLAs} + \sum \textbf{LAs} + \textbf{MOS}$$

As discussed earlier, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

$$\textbf{TMDL} \cong \sum \textbf{WLAs}_{\textbf{wastewater}} + \sum \textbf{WLAs}_{\textbf{NPDES Stormwater}} + \sum \textbf{LAs} + \textbf{MOS}$$

It should be noted that the various components of the revised TMDL equation may not sum up to the value of the TMDL because a) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is also accounted for within the LA, and b) TMDL components can be expressed in different terms (for example, the WLA for stormwater is typically expressed as a percent reduction, and the WLA for wastewater is typically expressed as mass per day).

WLAs for stormwater discharges are typically expressed as “percent reduction” because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish loads from MS4s from other nonpoint sources (given the nature of stormwater transport). The permitting of stormwater discharges also differs from the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored, and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the “maximum extent practical” through the implementation of BMPs.

This approach is consistent with federal regulations (40 CFR § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or **other appropriate measure**. TMDLs for Little Wekiva Canal (WBID 3004) are expressed in terms of pounds per year and percent reduction, and represent the amount of BOD and TN loading that will bring the current DO levels to the standard of 5 mg/L **(Table 6.1).**

Table 6.1   TMDL Components and Current Loadings for Little Wekiva Canal (WBID 3004)

Parameter	WLA		LA (lbs/year)	MOS	Percent Reduction
	Wastewater (lbs/year)	NPDES Stormwater (Percent Reduction)			
BOD	N/A	11.0%	76,554	Implicit	11.0%
TN	N/A	45.2%	42,624	Implicit	45.2%

6.2 Wasteload Allocation (WLA)

6.2.1 NPDES Wastewater Discharges

There are currently no wastewater facilities in the Little Wekiva Canal watershed.

6.2.2 NPDES Stormwater Discharges

The WLAs for stormwater discharges with an MS4 permit (Orange and Seminole County and the City of Winter Park) are a 11% reduction in BOD load and 45.2% reduction in TN load. It should be noted that any MS4 permittee will only be responsible for reducing the anthropogenic loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

6.3 Load Allocation (LA)

The Load Allocation is the nonpoint source component of the load, which, combined with WLA stormwater discharges, is responsible for 100% of the current load as well as the percentage load reduction. The total maximum daily load is 76,554 lbs/yr BOD and 42,626 lbs/yr of Total Nitrogen, all of which is allocated to the categories of LA and WLA stormwater. Based on the SWMM model simulation, this represents a BOD and TN load reduction of 11% and 45.2%, respectively.

6.4 Margin of Safety (MOS)

Consistent with the recommendations of the Allocation Technical Advisory Committee (Florida Department of Environmental Protection, February 1, 2001), an implicit margin of safety (MOS) was used in the development of this TMDL. An implicit MOS was provided by the conservative decisions associated with a number of modeling assumptions, the development of site-specific alternative water quality targets, and the development of the assimilative capacity. This includes the establishment of the TMDL at a load that is expected to maintain the annual average BOD concentration below the screening threshold of 2 mg/L and TN below the critical concentration of 1.02 mg/L. (**Table 4.13 and 4.14**). In establishing these loads, error margins were included by setting the assimilative capacities midway between simulated natural background conditions and the screening load (BOD) or critical load (Total Nitrogen).

Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

7.1 Basin Management Action Plan

Following the adoption of this TMDL by rule, the next step in the TMDL process is to develop an implementation plan for the TMDL, which will be a component of the Basin Management Action Plan (BMAP) for the Middle St. Johns River basin. This document will be developed over the next year in cooperation with local stakeholders and will attempt to reach consensus on more detailed allocations and on how load reductions will be accomplished. The BMAP will include the following:

- Appropriate allocations among the affected parties,
- A description of the load reduction activities to be undertaken,
- Timetables for project implementation and completion,
- Funding mechanisms that may be utilized,
- Any applicable signed agreement,
- Local ordinances defining actions to be taken or prohibited,
- Local water quality standards, permits, or load limitation agreements, and
- Monitoring and follow-up measures.

References

Florida Administrative Code. *Chapter 62-302, Surface water quality standards.*

Florida Administrative Code. *Chapter 62-303, Identification of impaired surface waters*.

Florida Watershed Restoration Act. *Chapter 99-223, Laws of Florida.*

Florida Department of Environmental Protection. February 1, 2001. *A report to the governor and the legislature on the allocation of total maximum daily loads in Florida.* Tallahassee, Florida: Bureau of Watershed Management, Division of Water Resource Management. Available: http://www.dep.state.fl.us/water/tmdl/docs/Allocation.pdf.

Rossman, L. A. 2004. Storm Water Management Model, User's Manual, Version 5.0. Water Suppply and Water Resources Division, National Risk Management Research Laboratory, Cincinnati, OH 45268.

User's Manual: Watershed management model, Version 4.1 1998. Rouge River national wet weather demonstration project. Wayne County, Michigan. PRO-NPS-TM27.02.

Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

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 authorized in Chapter 403, F.S., was established as a technology-based program that relies on 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.

The rule requires the state's water management districts (WMDs) to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a SWIM plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka. No PLRG has been developed for Newnans Lake at the time this study was conducted.

In 1987, the U.S. Congress established Section 402(p) as part of the federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES stormwater permitting program to designate certain stormwater discharges as "point sources" of pollution. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific Standard Industrial Classification (SIC) codes, construction sites disturbing five or more acres of land, and master drainage systems of local governments with a population above 100,000, which are better known as municipal separate storm sewer systems (MS4s). However, because the master drainage systems of most local governments in Florida are interconnected, the EPA has implemented Phase 1 of the MS4 permitting program on a countywide basis, which brings in all cities (incorporated areas), Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the fifteen counties meeting the population criteria.

An important difference between the federal and state stormwater permitting programs is that the federal program covers both new and existing discharges, while the state program focuses on new discharges. Additionally, Phase 2 of the NPDES Program will expand the need for these permits to construction sites between one and five acres, and to local governments with as few as 10,000 people. These revised rules require that these additional activities obtain permits by 2003. While these urban stormwater discharges are now technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility similar to other point sources of pollution, such as domestic and industrial wastewater discharges. The Department recently accepted delegation from the EPA for the stormwater part of the NPDES Program. It should be noted that most MS4 permits issued in Florida include a re-opener clause that allows permit revisions to implement TMDLs once they are formally adopted by rule.

Appendix B: SWMM Model Output Used to Calculate Pollutant Loads

Table B.1Little Wekiva Canal Natural Background Condition Daily Simulation Summary

BACKGROUND

SWMM Simulation, utilizing Weather Data from Orlando WSO Airport Weather Station

Outflow from Little Wekiva Canal (WBID 3004)

Date	A SWMM Simulated Flow (CFS)	B BOD Concentration (mg/L)	C Total Nitrogen (mg/L)	D Total Phosphorus (mg/L)	E Flow Based on 2234990 Gage	F BOD Load (LBS/DAY) A x B x 5.395	G TN load (LBS/DAY) A x C x 5.395	H TP load (LBS/DAY) A x D x 5.395	I BOD load limit A x 2.0 mg/L x 5.395	J BOD load limit A x .05 mg/L x 5.396	J TN load limit A x 1.02 mg/L x 5.396
1/2/1997	10.09	0.54	0.84	0.05	6.80	17.92	45.73	2.72	108.87	2.72	55.52
1/3/1997	10.08	0.51	0.81	0.05	6.60	17.99	44.05	2.72	108.76	2.72	55.47
1/4/1997	9.18	0.51	0.82	0.05	6.50	20.75	40.61	2.48	99.05	2.48	50.52
1/5/1997	10.08	0.54	0.85	0.05	6.40	23.83	46.22	2.72	108.76	2.72	55.47
1/6/1997	9.5	0.52	0.85	0.05	6.10	24.04	43.56	2.56	102.51	2.56	52.28
1/7/1997	9.38	0.53	0.85	0.05	6.20	25.25	43.01	2.53	101.21	2.53	51.62
1/8/1997	7.91	0.52	0.84	0.05	5.50	25.36	35.85	2.13	85.35	2.13	43.53
1/9/1997	10.41	0.49	0.8	0.05	5.70	49.12	44.93	2.81	112.32	2.81	57.29
1/10/1997	9.88	0.51	0.83	0.05	6.30	28.75	44.24	2.67	106.61	2.67	54.37
1/11/1997	9.76	0.51	0.83	0.05	6.60	27.93	43.70	2.63	105.31	2.63	53.71
1/12/1997	10	0.51	0.83	0.05	6.50	28.23	44.78	2.70	107.90	2.70	55.03
1/13/1997	10.06	0.5	0.82	0.05	5.30	27.97	44.50	2.71	108.55	2.71	55.36
1/14/1997	10.09	0.5	0.81	0.05	6.00	31.80	44.09	2.72	108.87	2.72	55.52
1/15/1997	9.66	0.49	0.79	0.05	7.40	37.38	41.17	2.61	104.23	2.61	53.16
1/16/1997	10.1	0.49	0.8	0.05	8.10	25.67	43.59	2.72	108.98	2.72	55.58
1/17/1997	8.39	0.5	0.8	0.05	8.20	26.57	36.21	2.26	90.53	2.26	46.17
1/18/1997	9.64	0.49	0.79	0.05	7.50	26.36	41.09	2.60	104.02	2.60	53.05
1/19/1997	9.25	0.5	0.81	0.05	6.80	27.16	40.42	2.50	99.81	2.50	50.90
1/20/1997	9.79	0.5	0.8	0.05	5.80	27.33	42.25	2.64	105.63	2.64	53.87
1/21/1997	9.95	0.49	0.79	0.05	5.70	26.88	42.41	2.68	107.36	2.68	54.75
1/22/1997	9.62	0.48	0.78	0.05	4.40	26.41	40.48	2.59	103.80	2.59	52.94
1/23/1997	9.28	0.48	0.78	0.05	3.10	26.44	39.05	2.50	100.13	2.50	51.07
1/24/1997	9.09	0.48	0.78	0.05	4.70	26.47	38.25	2.45	98.08	2.45	50.02
1/25/1997	10.01	0.47	0.77	0.05	9.00	32.68	41.58	2.70	108.01	2.70	55.08
1/26/1997	9.95	0.47	0.77	0.05	7.70	25.20	41.33	2.68	107.36	2.68	54.75
1/27/1997	9.96	0.48	0.77	0.05	6.60	30.14	41.38	2.69	107.47	2.69	54.81
1/28/1997	9.94	0.48	0.78	0.05	6.50	25.69	41.83	2.68	107.25	2.68	54.70
1/29/1997	9.95	0.48	0.78	0.05	6.20	25.87	41.87	2.68	107.36	2.68	54.75
1/30/1997	9.96	0.47	0.77	0.05	6.00	28.22	41.38	2.69	107.47	2.69	54.81
1/31/1997	9.75	0.47	0.77	0.05	7.10	24.87	40.50	2.63	105.20	2.63	53.65
2/1/1997	9.24	0.45	0.76	0.05	5.80	24.01	37.89	2.49	99.70	2.49	50.85
2/2/1997	9.22	0.44	0.74	0.05	6.30	23.50	36.81	2.49	99.48	2.49	50.74
2/3/1997	9.2	0.44	0.75	0.05	5.60	22.91	37.23	2.48	99.27	2.48	50.63
2/4/1997	9.18	0.44	0.75	0.05	5.50	22.46	37.14	2.48	99.05	2.48	50.52
2/5/1997	9.17	0.44	0.75	0.05	5.50	22.10	37.10	2.47	98.94	2.47	50.46
2/6/1997	9.15	0.44	0.76	0.05	5.50	21.82	37.52	2.47	98.73	2.47	50.35
2/7/1997	9.27	0.44	0.75	0.05	5.50	31.26	37.51	2.50	100.02	2.50	51.01
2/8/1997	9.33	0.43	0.74	0.05	6.10	34.03	37.25	2.52	100.67	2.52	51.34
2/9/1997	9.1	0.45	0.76	0.05	7.00	23.31	37.31	2.45	98.19	2.45	50.08
2/10/1997	9.01	0.45	0.77	0.05	7.30	23.94	37.43	2.43	97.22	2.43	49.58
2/11/1997	8.65	0.45	0.77	0.05	6.40	24.13	35.93	2.33	93.33	2.33	47.60
2/12/1997	6.9	0.47	0.78	0.05	5.90	24.52	29.04	1.86	74.45	1.86	37.97
2/13/1997	9.44	0.45	0.77	0.05	5.90	23.02	39.22	2.55	101.86	2.55	51.95
2/14/1997	9.31	0.41	0.69	0.04	5.90	76.89	34.66	2.01	100.45	2.51	51.23
2/15/1997	9.36	0.43	0.73	0.05	6.60	64.58	36.86	2.52	100.99	2.52	51.51
2/16/1997	10.33	0.39	0.66	0.04	7.30	166.09	36.78	2.23	111.46	2.79	56.84
2/17/1997	9.06	0.44	0.75	0.05	6.70	67.63	36.66	2.44	97.76	2.44	49.86
2/18/1997	9.08	0.45	0.77	0.05	5.90	53.05	37.72	2.45	97.97	2.45	49.97
2/19/1997	9	0.46	0.78	0.05	6.10	37.15	37.87	2.43	97.11	2.43	49.53
2/20/1997	7.65	0.47	0.79	0.05	5.80	30.58	32.60	2.06	82.54	2.06	42.10
2/21/1997	8.71	0.46	0.78	0.05	5.50	29.48	36.65	2.35	93.98	2.35	47.93
2/22/1997	9.06	0.46	0.79	0.05	5.80	24.40	38.61	2.44	97.76	2.44	49.86
2/23/1997	9.01	0.46	0.78	0.05	6.10	22.58	37.91	2.43	97.22	2.43	49.58
2/24/1997	9.01	0.47	0.79	0.05	6.00	23.07	38.40	2.43	97.22	2.43	49.58
2/25/1997	7.99	0.49	0.81	0.05	6.00	24.06	34.92	2.16	86.21	2.16	43.97
2/26/1997	8.97	0.46	0.79	0.05	6.10	22.58	38.23	2.42	96.79	2.42	49.36
2/27/1997	6.51	0.47	0.8	0.05	6.10	23.38	28.10	1.76	70.24	1.76	35.82
2/28/1997	6.76	0.47	0.8	0.05	6.30	24.22	29.18	1.82	72.94	1.82	37.20
3/1/1997	8.88	0.5	0.82	0.05	5.90	26.11	39.28	2.40	95.82	2.40	48.87
3/2/1997	8.94	0.5	0.83	0.05	5.70	26.25	40.03	2.41	96.46	2.41	49.20
3/3/1997	8.99	0.5	0.82	0.05	5.60	26.38	39.77	2.43	97.00	2.43	49.47
3/4/1997	9.05	0.5	0.82	0.05	5.40	26.54	40.04	2.44	97.65	2.44	49.80
3/5/1997	9.09	0.5	0.82	0.05	5.50	26.73	40.21	2.45	98.08	2.45	50.02
3/6/1997	9.13	0.5	0.82	0.05	5.50	26.92	40.39	2.46	98.51	2.46	50.24
3/7/1997	9.17	0.5	0.82	0.05	5.60	27.08	40.57	2.47	98.94	2.47	50.46
3/8/1997	8.82	0.49	0.82	0.05	5.30	26.70	39.02	2.38	95.17	2.38	48.54
3/9/1997	9.93	0.5	0.82	0.05	5.00	27.41	43.93	2.68	107.14	2.68	54.64
3/10/1997	9.79	0.48	0.81	0.05	5.10	26.47	42.78	2.64	105.63	2.64	53.87

Table B.2 Little Wekiva Canal Natural Daily BOD Simulation Summary

Date	STREAM FLOW		BOD				
	SWMM Simulated Flow (CFS)	Area:Ratio Relationship Utilizing 2234990 Gage	Existing Conditions		Natural Background		Load at FLDEP Screening Level (BOD=2.0 mg/L)
			SWMM Simulated Concentration (mg/L)	SWMM Based Load (LBS/DAY)	SWMM Simulated Concentration (mg/L)	SWMM Based Load (LBS/DAY)	SWMM Simulated Screening Level Load (LBS/DAY)
1/2/1997	10.09	6.80	1.4	46.45	0.54	17.92	66.36
1/3/1997	10.08	6.60	1.35	47.63	0.51	17.99	70.57
1/4/1997	9.18	6.50	1.17	47.59	0.51	20.75	81.36
1/5/1997	10.08	6.40	1.07	47.22	0.54	23.83	88.26
1/6/1997	9.5	6.10	1.02	47.16	0.52	24.04	92.47
1/7/1997	9.38	6.20	0.99	47.16	0.53	25.25	95.28
1/8/1997	7.91	5.50	0.97	47.31	0.52	25.36	97.54
1/9/1997	10.41	5.70	4.38	439.05	0.49	49.12	200.48
1/10/1997	9.88	6.30	0.8	45.10	0.51	28.75	112.76
1/11/1997	9.76	6.60	0.83	45.45	0.51	27.93	109.52
1/12/1997	10	6.50	0.83	45.94	0.51	28.23	110.71
1/13/1997	10.06	5.30	0.83	46.44	0.50	27.97	111.89
1/14/1997	10.09	6.00	0.72	45.80	0.50	31.80	127.21
1/15/1997	9.66	7.40	3.14	239.54	0.49	37.38	152.57
1/16/1997	10.1	8.10	0.84	44.00	0.49	25.67	104.77
1/17/1997	8.39	8.20	0.84	44.64	0.50	26.57	106.28
1/18/1997	9.64	7.50	0.83	44.64	0.49	26.36	107.58
1/19/1997	9.25	6.80	0.83	45.09	0.50	27.16	108.66
1/20/1997	9.79	5.80	0.83	45.36	0.50	27.33	109.30
1/21/1997	9.95	5.70	0.83	45.54	0.49	26.88	109.73
1/22/1997	9.62	4.40	0.83	45.67	0.48	26.41	110.06
1/23/1997	9.28	3.10	0.83	45.72	0.48	26.44	110.17
1/24/1997	9.09	4.70	0.83	45.76	0.48	26.47	110.27
1/25/1997	10.01	9.00	2.67	185.68	0.47	32.68	139.08
1/26/1997	9.95	7.70	0.84	45.05	0.47	25.20	107.25
1/27/1997	9.96	6.60	0.81	50.87	0.48	30.14	125.60
1/28/1997	9.94	6.50	0.83	44.42	0.48	25.69	107.04
1/29/1997	9.95	6.20	0.83	44.73	0.48	25.87	107.79
1/30/1997	9.96	6.00	0.74	44.43	0.47	28.22	120.09
1/31/1997	9.75	7.10	0.81	42.87	0.47	24.87	105.85
2/1/1997	9.24	5.80	0.68	36.28	0.45	24.01	106.71
2/2/1997	9.22	6.30	0.69	36.85	0.44	23.50	106.82
2/3/1997	9.2	5.60	0.71	36.96	0.44	22.91	104.12
2/4/1997	9.18	5.50	0.72	36.75	0.44	22.46	102.07
2/5/1997	9.17	5.50	0.73	36.67	0.44	22.10	100.45
2/6/1997	9.15	5.50	0.74	36.69	0.44	21.82	99.16
2/7/1997	9.27	5.50	2.76	196.10	0.44	31.26	142.10
2/8/1997	9.33	6.10	3.32	262.76	0.43	34.03	158.29
2/9/1997	9.1	7.00	0.69	35.74	0.45	23.31	103.58
2/10/1997	9.01	7.30	0.68	36.17	0.45	23.94	106.39
2/11/1997	8.65	6.40	0.69	37.00	0.45	24.13	107.25
2/12/1997	6.9	5.90	0.7	36.52	0.47	24.52	104.34
2/13/1997	9.44	5.90	0.72	36.82	0.45	23.02	102.29
2/14/1997	9.31	5.90	4.61	864.51	0.41	76.89	375.06
2/15/1997	9.36	6.60	2.2	330.43	0.43	64.58	300.39
2/16/1997	10.33	7.30	3	1277.64	0.39	166.09	851.76

Table B.3Little Wekiva Canal Daily Total Nitrogen Simulation Summary

Date	STREAM FLOW		TOTAL NITROGEN				
	SWMM Simulated Flow (CFS)	Area:Ratio Relationship Utilizing 2234990 Gage	Existing Conditions		Natural Background		Critical TN Concentration Based on Regression Equation (TN=1.02 mg/L)
			SWMM Simulated Concentration (mg/L)	SWMM Based Load (LBS/DAY)	SWMM Simulated Concentration (mg/L)	SWMM Based Load (LBS/DAY)	SWMM Simulated Load (LBS/DAY) at Critical Total Nitrogen Concentration
1/2/1997	10.09	6.80	0.99	32.85	0.84	45.73	33.84
1/3/1997	10.08	6.60	0.97	34.22	0.81	44.05	35.99
1/4/1997	9.18	6.50	0.84	34.17	0.82	40.61	41.49
1/5/1997	10.08	6.40	0.75	33.10	0.85	46.22	45.01
1/6/1997	9.5	6.10	0.71	32.83	0.85	43.56	47.16
1/7/1997	9.38	6.20	0.69	32.87	0.85	43.01	48.59
1/8/1997	7.91	5.50	0.67	32.68	0.84	35.85	49.75
1/9/1997	10.41	5.70	1.4	140.33	0.80	44.93	102.24
1/10/1997	9.88	6.30	0.53	29.88	0.83	44.24	57.51
1/11/1997	9.76	6.60	0.55	30.12	0.83	43.70	55.85
1/12/1997	10	6.50	0.56	31.00	0.83	44.78	56.46
1/13/1997	10.06	5.30	0.57	31.89	0.82	44.50	57.07
1/14/1997	10.09	6.00	0.48	30.53	0.81	44.09	64.88
1/15/1997	9.66	7.40	1.1	83.91	0.79	41.17	77.81
1/16/1997	10.1	8.10	0.54	28.29	0.80	43.59	53.43
1/17/1997	8.39	8.20	0.55	29.23	0.80	36.21	54.20
1/18/1997	9.64	7.50	0.56	30.12	0.79	41.09	54.86
1/19/1997	9.25	6.80	0.56	30.42	0.81	40.42	55.41
1/20/1997	9.79	5.80	0.57	31.15	0.80	42.25	55.74
1/21/1997	9.95	5.70	0.57	31.27	0.79	42.41	55.96
1/22/1997	9.62	4.40	0.58	31.92	0.78	40.48	56.13
1/23/1997	9.28	3.10	0.58	31.95	0.78	39.05	56.18
1/24/1997	9.09	4.70	0.58	31.98	0.78	38.25	56.24
1/25/1997	10.01	9.00	1	69.54	0.77	41.58	70.93
1/26/1997	9.95	7.70	0.58	31.10	0.77	41.33	54.70
1/27/1997	9.96	6.60	0.5	31.40	0.77	41.38	64.05
1/28/1997	9.94	6.50	0.58	31.04	0.78	41.83	54.59
1/29/1997	9.95	6.20	0.58	31.26	0.78	41.87	54.97
1/30/1997	9.96	6.00	0.51	30.62	0.77	41.38	61.25
1/31/1997	9.75	7.10	0.58	30.70	0.77	40.50	53.98
2/1/1997	9.24	5.80	0.53	28.28	0.76	37.89	54.42
2/2/1997	9.22	6.30	0.54	28.84	0.74	36.81	54.48
2/3/1997	9.2	5.60	0.55	28.63	0.75	37.23	53.10
2/4/1997	9.18	5.50	0.56	28.58	0.75	37.14	52.06
2/5/1997	9.17	5.50	0.57	28.63	0.75	37.10	51.23
2/6/1997	9.15	5.50	0.58	28.76	0.76	37.52	50.57
2/7/1997	9.27	5.50	1.04	73.89	0.75	37.51	72.47
2/8/1997	9.33	6.10	1.14	90.22	0.74	37.25	80.73
2/9/1997	9.1	7.00	0.54	27.97	0.76	37.31	52.83
2/10/1997	9.01	7.30	0.55	29.26	0.77	37.43	54.26
2/11/1997	8.65	6.40	0.56	30.03	0.77	35.93	54.70
2/12/1997	6.9	5.90	0.58	30.26	0.78	29.04	53.21
2/13/1997	9.44	5.90	0.59	30.18	0.77	39.22	52.17
2/14/1997	9.31	5.90	1.38	258.79	0.69	34.66	191.28
2/15/1997	9.36	6.60	0.77	115.65	0.73	36.86	153.20
2/16/1997	10.33	7.30	0.95	404.59	0.66	36.78	434.40
2/17/1997	9.06	6.70	0.31	47.65	0.75	36.66	156.78
2/18/1997	9.08	5.90	0.35	41.26	0.77	37.72	120.24

Table B.4 Little Wekiva Canal Daily Total Phosphorus Simulation Summary

Date	STREAM FLOW		TOTAL PHOSPHORUS				
	SWMM Simulated Flow (CFS)	Area:Ratio Relationship Utilizing 2234990 Gage	Existing Conditions: SWMM Simulated Concentration (mg/L)	Existing Conditions: SWMM Based Load (LBS/DAY)	Natural Background: SWMM Simulated Concentration (mg/L)	Natural Background: SWMM Based Load (LBS/DAY)	Critical TP Concentration Based on Regression Equation (TN=0.05 mg/L): SWMM Simulated Load (LBS/DAY) at Critical Total Phosphorus Concentration
1/2/1997	10.09	6.80	0.06	1.99	0.05	2.72	1.66
1/3/1997	10.08	6.60	0.05	1.76	0.05	2.72	1.76
1/4/1997	9.18	6.50	0.05	2.03	0.05	2.48	2.03
1/5/1997	10.08	6.40	0.04	1.77	0.05	2.72	2.21
1/6/1997	9.5	6.10	0.04	1.85	0.05	2.56	2.31
1/7/1997	9.38	6.20	0.04	1.91	0.05	2.53	2.38
1/8/1997	7.91	5.50	0.04	1.95	0.05	2.13	2.44
1/9/1997	10.41	5.70	0.22	22.05	0.05	2.81	5.01
1/10/1997	9.88	6.30	0.03	1.69	0.05	2.67	2.82
1/11/1997	9.76	6.60	0.03	1.64	0.05	2.63	2.74
1/12/1997	10	6.50	0.03	1.66	0.05	2.70	2.77
1/13/1997	10.06	5.30	0.03	1.68	0.05	2.71	2.80
1/14/1997	10.09	6.00	0.03	1.91	0.05	2.72	3.18
1/15/1997	9.66	7.40	0.15	11.44	0.05	2.61	3.81
1/16/1997	10.1	8.10	0.03	1.57	0.05	2.72	2.62
1/17/1997	8.39	8.20	0.03	1.59	0.05	2.26	2.66
1/18/1997	9.64	7.50	0.03	1.61	0.05	2.60	2.69
1/19/1997	9.25	6.80	0.03	1.63	0.05	2.50	2.72
1/20/1997	9.79	5.80	0.03	1.64	0.05	2.64	2.73
1/21/1997	9.95	5.70	0.03	1.65	0.05	2.68	2.74
1/22/1997	9.62	4.40	0.03	1.65	0.05	2.59	2.75
1/23/1997	9.28	3.10	0.03	1.65	0.05	2.50	2.75
1/24/1997	9.09	4.70	0.03	1.65	0.05	2.45	2.76
1/25/1997	10.01	9.00	0.13	9.04	0.05	2.70	3.48
1/26/1997	9.95	7.70	0.03	1.61	0.05	2.68	2.68
1/27/1997	9.96	6.60	0.03	1.88	0.05	2.69	3.14
1/28/1997	9.94	6.50	0.03	1.61	0.05	2.68	2.68
1/29/1997	9.95	6.20	0.03	1.62	0.05	2.68	2.70
1/30/1997	9.96	6.00	0.03	1.80	0.05	2.69	3.00
1/31/1997	9.75	7.10	0.03	1.59	0.05	2.63	2.65
2/1/1997	9.24	5.80	0.03	1.60	0.05	2.49	2.67
2/2/1997	9.22	6.30	0.03	1.60	0.05	2.49	2.67
2/3/1997	9.2	5.60	0.03	1.56	0.05	2.48	2.60
2/4/1997	9.18	5.50	0.03	1.53	0.05	2.48	2.55
2/5/1997	9.17	5.50	0.03	1.51	0.05	2.47	2.51
2/6/1997	9.15	5.50	0.03	1.49	0.05	2.47	2.48
2/7/1997	9.27	5.50	0.14	9.95	0.05	2.50	3.55
2/8/1997	9.33	6.10	0.16	12.66	0.05	2.52	3.96
2/9/1997	9.1	7.00	0.03	1.55	0.05	2.45	2.59
2/10/1997	9.01	7.30	0.03	1.60	0.05	2.43	2.66
2/11/1997	8.65	6.40	0.03	1.61	0.05	2.33	2.68
2/12/1997	6.9	5.90	0.03	1.57	0.05	1.86	2.61
2/13/1997	9.44	5.90	0.03	1.53	0.05	2.55	2.56
2/14/1997	9.31	5.90	0.23	43.13	0.04	2.01	9.38
2/15/1997	9.36	6.60	0.11	16.52	0.05	2.52	7.51
2/16/1997	10.33	7.30	0.15	63.88	0.04	2.23	21.30
2/17/1997	9.06	6.70	0.01	1.54	0.05	2.44	7.69
2/18/1997	9.08	5.90	0.02	2.36	0.05	2.45	5.90

Appendix C: General SWMM Little Wekiva Canal Simulation Model Component Summary

Raingages	1
Subcatchments	57
Aquifers	4
Snowpacks	0
RDII Hydrographs	0
Infiltration	GREEN_AMPT

Junction Nodes	200
Outfall Nodes	3
Flow Divider Nodes	3
Storage Unit Nodes	32

Conduit Links	226
Pump Links	0
Orifice Links	0
Weir Links	0
Outlet Links	0

Flow Units	CFS

Florida Department of Environmental Protection
Division of Water Resource Management
Bureau of Watershed Management
2600 Blair Stone Road, Mail Station 3565
Tallahassee, Florida 32399-2400
(850) 245-8561
www2.dep.state.fl.us/water/