FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Environmental Assessment and Restoration, Bureau of Watershed Restoration

NORTHEAST DISTRICT • LOWER ST. JOHNS BASIN

FINAL TMDL Report

Dissolved Oxygen and Nutrient TMDL for Dog Branch (WBID 2578)

Wayne Magley, Ph.D., P.E.

October 2009

Acknowledgments

Editorial assistance provided by: Jan Mandrup-Poulsen and Linda Lord
Geographic information assistance (GIS) provided by: Janis Paulsen

For additional information on the watershed management approach and impaired waters in the Lower St. Johns Basin, contact:
Amy Tracy
Florida Department of Environmental Protection
Bureau of Watershed Restoration
Watershed Planning & Coordination
2600 Blair Stone Road, Mail Station 3565
Tallahassee, FL 32399-2400
amy.tracy@dep.state.fl.us
Phone: (850) 245–8506
Fax: (850) 245–8434

Access to all data used in the development of this report can be obtained by contacting:
Wayne Magley
Florida Department of Environmental Protection
Bureau of Watershed Restoration
Watershed Evaluation & TMDL Section
2600 Blair Stone Road, Mail Station 3555
Tallahassee, FL 32399-2400
Email: wayne.magley@dep.state.fl.us
Phone: (850) 245–8463
Fax: (850) 245–8444

Contents

List of Tables

List of Figures

Websites

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/legal/Rules/shared/62-303/62-303.pdf

STORET Program

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

2008 305(b) Report

http://www.dep.state.fl.us/water/docs/2008_Integrated_Report.pdf

Criteria for Surface Water Quality Classifications

http://www.dep.state.fl.us/water/wqssp/classes.htm

Basin Status Report for the Lower St. Johns Basin

http://www.dep.state.fl.us/water/basin411/sj_lower/status.htm

Water Quality Assessment Report for the Lower St. Johns Basin

http://www.dep.state.fl.us/water/basin411/sj_lower/assessment.htm

U.S. Environmental Protection Agency, National STORET Program

Region 4: Total Maximum Daily Loads in Florida

http://www.epa.gov/region4/water/tmdl/florida/

National STORET Program

http://www.epa.gov/storet/

Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for dissolved oxygen (DO) and nutrients for Dog Branch in the South Mainstem Planning Unit of the Lower St. Johns Basin. The creek was verified as impaired for DO, and was included on the Cycle 1 Verified List of impaired waters for the Lower St. Johns Basin that was adopted by Secretarial Order in May 2004. Since the DO impairment was associated with total phosphorus (TP), Dog Branch was verified as impaired for nutrients in the Cycle 2 assessment and placed on the Lower St. Johns Basin Verified List that was adopted by Secretarial Order in May 2009. This TMDL establishes the allowable loadings to Dog Branch that would restore the waterbody so that it meets its applicable water quality criteria for DO and nutrients.

1.2 Identification of Waterbody

Dog Branch, which is located in the northeastern portion of Putnam County just north of east Palatka (**Figure 1.1**), flows primarily north into the St. Johns River and drains an area of about 3.7 square miles (**Figure 1.2**). The creek is approximately 2.9 miles long and is a second-order stream. County Road (CR) 207 runs through the watershed. The majority of the watershed is agricultural (cropland and pastureland). There are wetlands along the riparian areas of Dog Branch in the northern part of the watershed.

For assessment purposes, the Florida Department of Environmental Protection (Department) has divided the Lower St. Johns Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. This TMDL addresses Dog Branch, WBID 2578, for DO and nutrients.

Dog Branch is part of the South Mainstem Planning Unit. Planning units are groups of smaller watersheds (WBIDs) that are part of a larger basin unit, in this case the Lower St. Johns Basin. The South Mainstem Planning Unit consists of 53 WBIDs. **Figure 1.3** shows the locations of these WBIDs and the Dog Branch watershed in the planning unit.

1.3 Background

This report was developed as part of the Department's 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 52 river basins over a 5-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. They provide important water quality restoration goals that will guide restoration activities.

Figure 1.1. Location of the Dog Branch Watershed (WBID 2578) in the Lower St. Johns Basin and Major Hydrologic Features in the Area

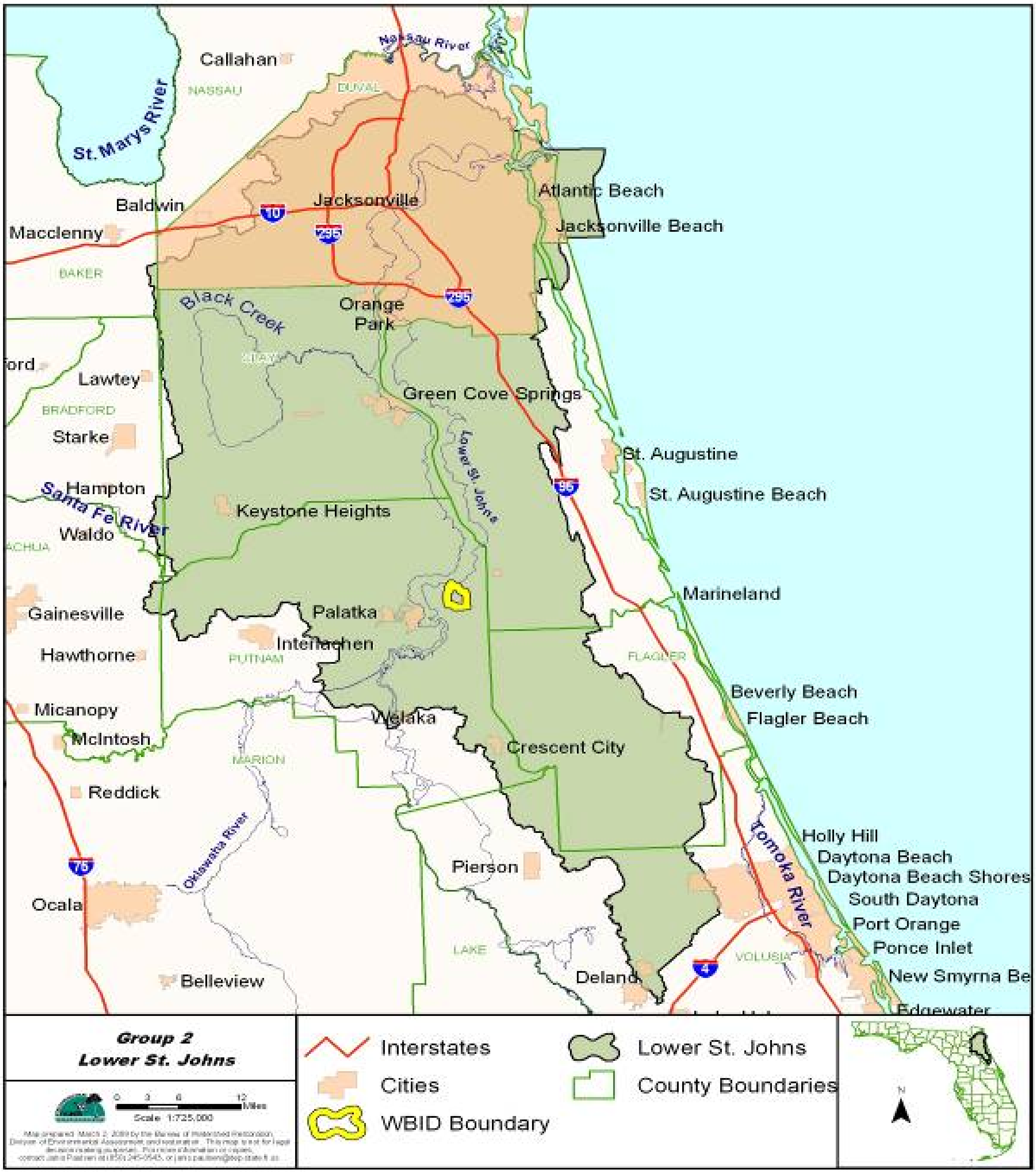


Figure 1.2. Location of the Dog Branch Watershed (WBID 2578) in Putnam County

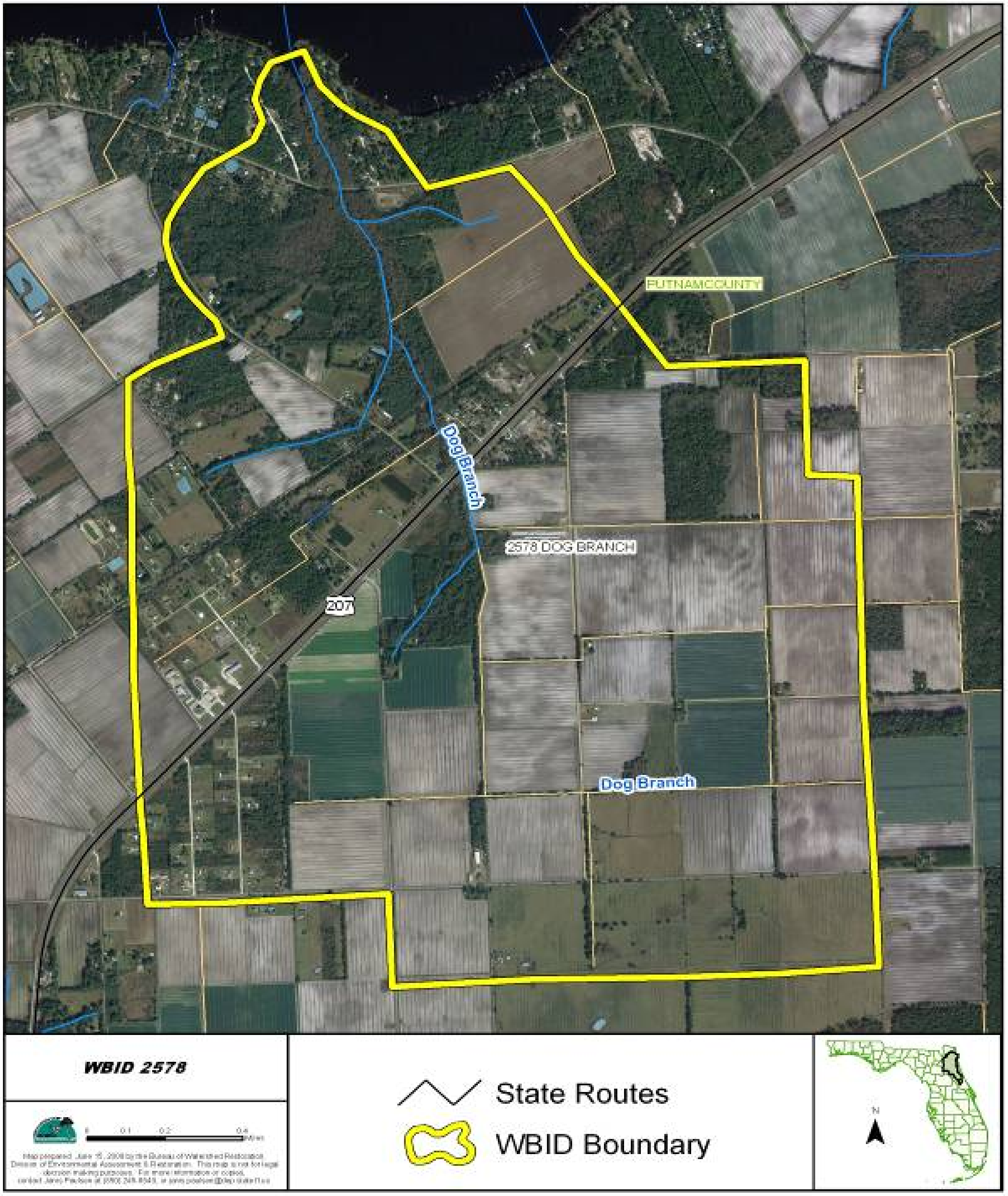
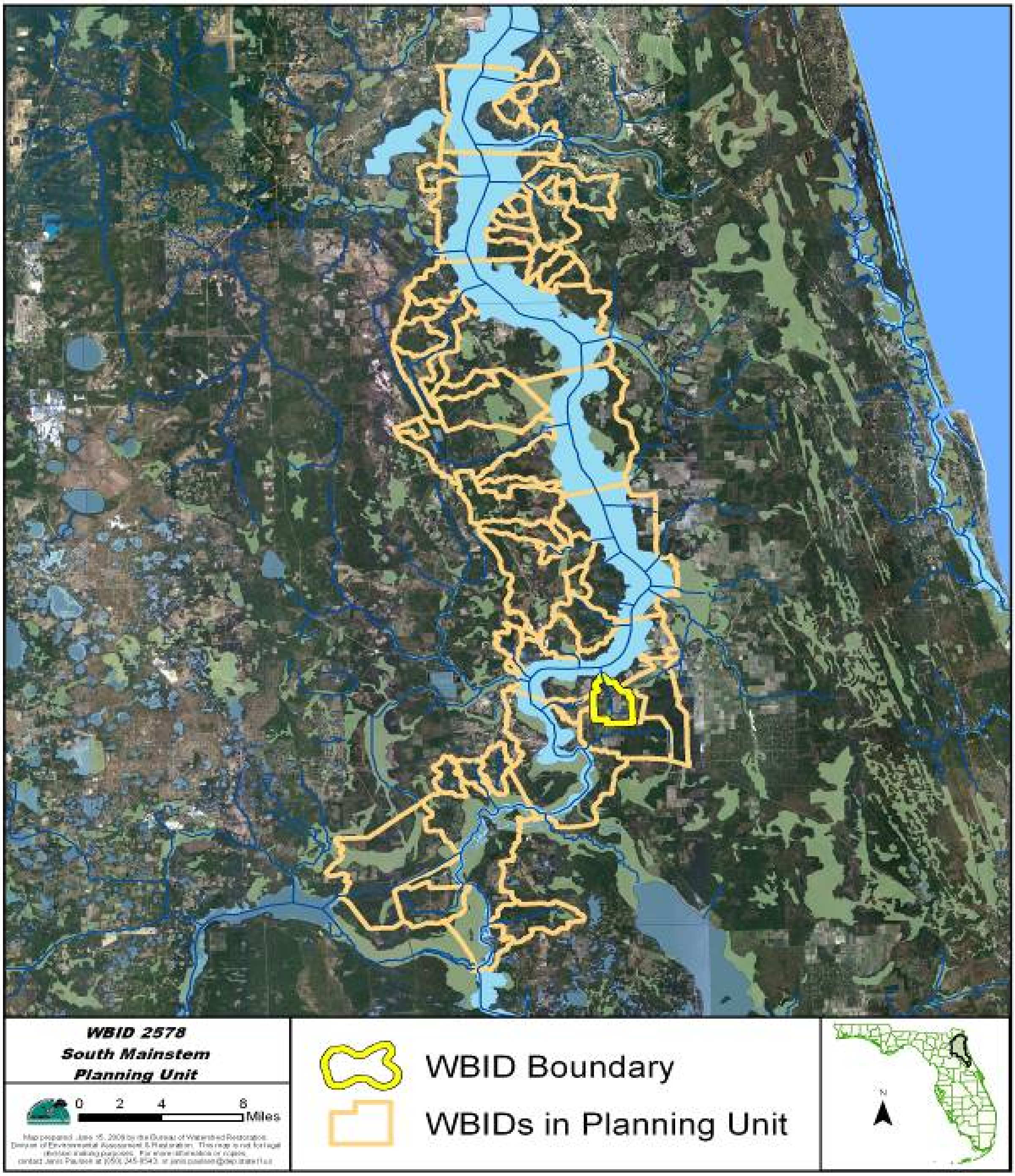


Figure 1.3. WBIDs in the South Mainstem Planning Unit



A nutrient TMDL was adopted in April 2008 for the mainstem of the Lower St. Johns River that required a 30 percent reduction in anthropogenic loadings of nitrogen and phosphorus to the freshwater portion of the Lower St. Johns. A Basin Management Action Plan, or BMAP, was adopted in October 2008 that outlined a number of activities designed to reduce the amount of total nitrogen (TN) and TP to the freshwater portion of the Lower St. Johns River. 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 or continue reductions in the discharge of pollutants and achieve the established TMDLs for impaired waterbodies, including tributaries to the Lower St. Johns such as Dog Branch.

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 U.S. Environmental Protection Agency (EPA) lists of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing the impairment of listed waters on a schedule. The Department has developed such lists, commonly referred to as 303(d) lists, since 1992. The list of impaired waters in each basin, referred to as the Verified List, is also required by the FWRA (Subsection 403.067[4], Florida Statutes [F.S.]); the state's 303(d) list is amended annually to include basin updates.

Florida's 1998 303(d) list included 55 waterbodies in the Lower St. Johns 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 rulemaking process, the Environmental Regulation Commission adopted the new methodology as Rule 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001; the rule was modified in 2006 and 2007.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in the Dog Branch watershed and has verified that this waterbody segment is impaired for DO, based on data in the Department's IWR database. As noted in Chapter 1, the impairment for DO was verified in Cycle 1. **Table 2.1** summarizes the DO data for the verified period, which for Cycle 1, Group 2 waters was January 1, 1996, through June 30, 2003. **Tables 2.2** through **2.4** summarize the Cycle 1 DO data by month, season, and year, respectively. The Cycle 2 verified period, which was January 1, 2001, through June 30, 2008, supported the results of the earlier determination of impairment (Cycle 2 had 67 exceedances out of 118 samples).

There was a 45.2 percent overall exceedance rate for DO in Dog Branch during the verified period (**Table 2.1**). Exceedances occurred in all seasons and in all months except January and March (**Tables 2.2** and **2.3**). During the verified period, samples ranged from 1.0 to 10.5 milligrams per liter (mg/L). As DO solubility in freshwater is influenced by water temperature, ranges in DO saturation (DOSAT) were also evaluated. DOSAT ranged from 11 to 100 percent, averaging 57.1 percent. Fewer than 10 percent of the DOSAT values were less than 30 percent.

When aggregating data by season, the lowest percentage of exceedances occurred in the spring and the highest in summer. Possible relationships between DO and other water quality parameters are further assessed in Chapter 5, using the complete historical dataset.

Table 2.1. Summary of DO Monitoring Data for Dog Branch (WBID 2578) During the Cycle 1 Verified Period (January 1, 1996–June 30, 2003)

- = Empty cell
[1] BOD = Biochemical oxygen demand

Waterbody (WBID)	Parameter	DO
Dog Branch (2578)	Total number of samples	137
Dog Branch (2578)	IWR-required number of exceedances for the Verified List	19
Dog Branch (2578)	Number of observed exceedances	62 (45.2%)
Dog Branch (2578)	Number of observed nonexceedances	75
Dog Branch (2578)	Number of seasons during which samples were collected	4
Dog Branch (2578)	Highest observation (mg/L)	10.5
Dog Branch (2578)	Lowest observation (mg/L)	1.0
Dog Branch (2578)	Median observation (mg/L)	5.1
Dog Branch (2578)	Mean observation (mg/L)	5.2
Dog Branch (2578)	Median value for 49 BOD observations (mg/L)[1]	1.2
Dog Branch (2578)	Median value for 139 TN observations (mg/L)	1.33
Dog Branch (2578)	Median value for 142 TP observations (mg/L)	0.24
Dog Branch (2578)	Possible causative pollutant by IWR	TN & BOD
-	**FINAL ASSESSMENT:**	**Impaired**

Table 2.2. Summary of DO Data by Month for the Cycle 1 Verified Period (January 1, 1996–June 30, 2003)

DO concentrations are mg/L.

Month	N	Minimum	Maximum	Median	Mean	Number of Exceedances	% Exceedances	Mean Precipitation (inches)
January	6	5.23	9.96	6.865	7.11	0	0.00	2.03
February	21	3.2	10.5	6.08	6.49	2	9.52	3.32
March	8	5.17	8.42	6.32	6.53	0	0.00	4.05
April	12	4.65	7.71	5.885	6.06	2	16.67	1.99
May	17	3.46	7.79	5.02	5.20	8	47.06	1.85
June	7	2.39	5.76	3.01	3.53	6	85.71	9.08
July	7	2.4	5.01	4.31	3.98	6	85.71	7.71
August	19	2.13	7.7	4.09	4.39	13	68.42	5.50
September	6	1.55	4.04	3.155	3.12	6	100.00	8.63
October	9	1.99	7.36	3.91	4.11	6	66.67	3.55
November	18	1.97	9.32	4.535	5.06	11	61.11	1.33
December	7	1	7.36	5.5	5.03	2	28.57	3.63

Table 2.3. Summary of DO Data by Season for the Cycle 1 Verified Period (January 1, 1996–June 30, 2003)

DO concentrations are mg/L.

Season	N	Minimum	Maximum	Median	Mean	Number of Exceedances	% Exceedances	Mean Total Precipitation (inches)
Winter	35	3.2	10.5	6.22	6.60	2	5.71	9.40
Spring	36	2.39	7.79	5.04	5.16	16	44.44	12.92
Summer	32	1.55	7.7	3.95	4.07	25	78.13	21.84
Fall	34	1	9.32	4.535	4.80	19	55.88	8.51

Table 2.4. Summary of DO Data by Year for the Cycle 1 Verified Period (January 1, 1996–June 30, 2003)

DO concentrations are mg/L.

Year	N	Minimum	Maximum	Median	Mean	Number of Exceedances	% Exceedances	Total Precipitation (inches)
1996	10	1.55	6.42	4.705	4.34	7	70.00	60.63
1997	20	2.63	7.7	5.89	5.43	7	35.00	57.27
1998	20	2.74	8.46	5.505	5.43	7	35.00	56.72
1999	18	2.35	9.32	5.045	5.40	8	44.44	42.44
2000	19	3.78	8.42	5.13	5.43	9	47.37	39.77
2001	20	1	9.96	4.66	5.06	11	55.00	49.14
2002	20	1.97	8.19	5.02	4.38	9	45.00	54.72
2003	10	2.44	10.5	5.115	6.03	4	40.00	44.47

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)**

Dog Branch (WBID 2578) is a Class III fresh 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 for DO.

3.2 Applicable Water Quality Standards and Numeric Water Quality Target

Numeric criteria for DO are expressed in terms of minimum and daily average concentrations. The water quality criterion for the protection of Class III fresh waterbodies, as established by Rule 62-302, F.A.C., states the following:

Dissolved Oxygen Criteria:

Shall not be less than 5.0. Normal daily and seasonal fluctuations above these levels shall be maintained.

The nutrient criterion in Rule 62-302, F.A.C., is expressed as a narrative:

Nutrients:

In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna [Note: For Class III waters in the Everglades Protection Area, this criterion has been numerically interpreted for phosphorus in Section 62-302.540, F.A.C.].

To assess whether this narrative criterion is being exceeded, the IWR provides thresholds for nutrient impairment in estuaries based on annual average chl*a* levels. The following language is found in Rule 62-303, F.A.C.:

62-303.351 Nutrients in Streams.

A stream or stream segment shall be included on the planning list for nutrients if the following biological imbalances are observed:

(1) Algal mats are present in sufficient quantities to pose a nuisance or hinder reproduction of a threatened or endangered species, or

(2) Annual mean chlorophyll a concentrations are greater than 20 µg/l or if data indicate annual mean chlorophyll a [chla] values have increased by more than 50% over historical values for at least two consecutive years.

62-303.450 Interpretation of Narrative Nutrient Criteria.

(1) A water shall be placed on the verified list for impairment due to nutrients if there are sufficient data from the last five years preceding the planning list assessment, combined with historical data (if needed to establish historical chlorophyll a levels or historical TSIs), to meet the data sufficiency requirements of subsection 62-303.350(2), FA.C. If there are insufficient data, additional data shall be collected as needed to meet the requirements. Once these additional data are collected, the Department shall determine if there is sufficient information to develop a site-specific threshold that better reflects conditions beyond which an imbalance in flora or fauna occurs in the water segment. If there is sufficient information, the Department shall re-evaluate the data using the site-specific thresholds. If there is insufficient information, the Department shall re-evaluate the data using the thresholds provided in Rules 62-303.351-.353, F.A.C., for streams, lakes, and estuaries, respectively. In any case, the Department shall limit its analysis to the use of data collected during the five years preceding the planning list assessment and the additional data collected in the second phase. If alternative thresholds are used for the analysis, the Department shall provide the thresholds for the record and document how the alternative threshold better represents conditions beyond which an imbalance in flora or fauna is expected to occur.

Although the annual average chl*a* concentration did not exceed the IWR stream thresholds, nutrients were considered the cause of impairment, based on the link between DO impairment and TP.

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 pollutants 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 System (NPDES) Program. These nonpoint sources included certain urban stormwater discharges, such as 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" will be used to describe traditional point sources (such as domestic and industrial wastewater discharges) **AND** stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 6.1**). 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 Nutrients in the Dog Branch Watershed

4.2.1 Point Sources

There are no NPDES wastewater facilities located in the watershed. There is a state stormwater permit for the Edgefield Regional Stormwater Treatment Facility pump site (FLR10AC75) that was issued in April 2005 and expires April 12, 2010.

Municipal Separate Storm Sewer System Permittees

There are no Phase I or Phase II municipal separate storm sewer system (MS4) permits in the Dog Branch watershed or Putnam County.

4.2.2 Land Uses and Nonpoint Sources

Nutrient loadings to Dog Branch are generated from nonpoint sources in the watershed. These potential sources include loadings from surface runoff, ground water inflow, and septic tanks.

Land Uses

The spatial distribution and acreage of different land use categories were identified using the SJRWMD's year 2004 land use coverage (scale 1:51,000) contained in the Department's geographic information system (GIS) library. Land use categories in the watershed were aggregated using the Level 2 land use codes and tabulated in **Table 4.1**. **Figure 4.1** shows the acreage of the principal Level 1 land uses in the watershed.

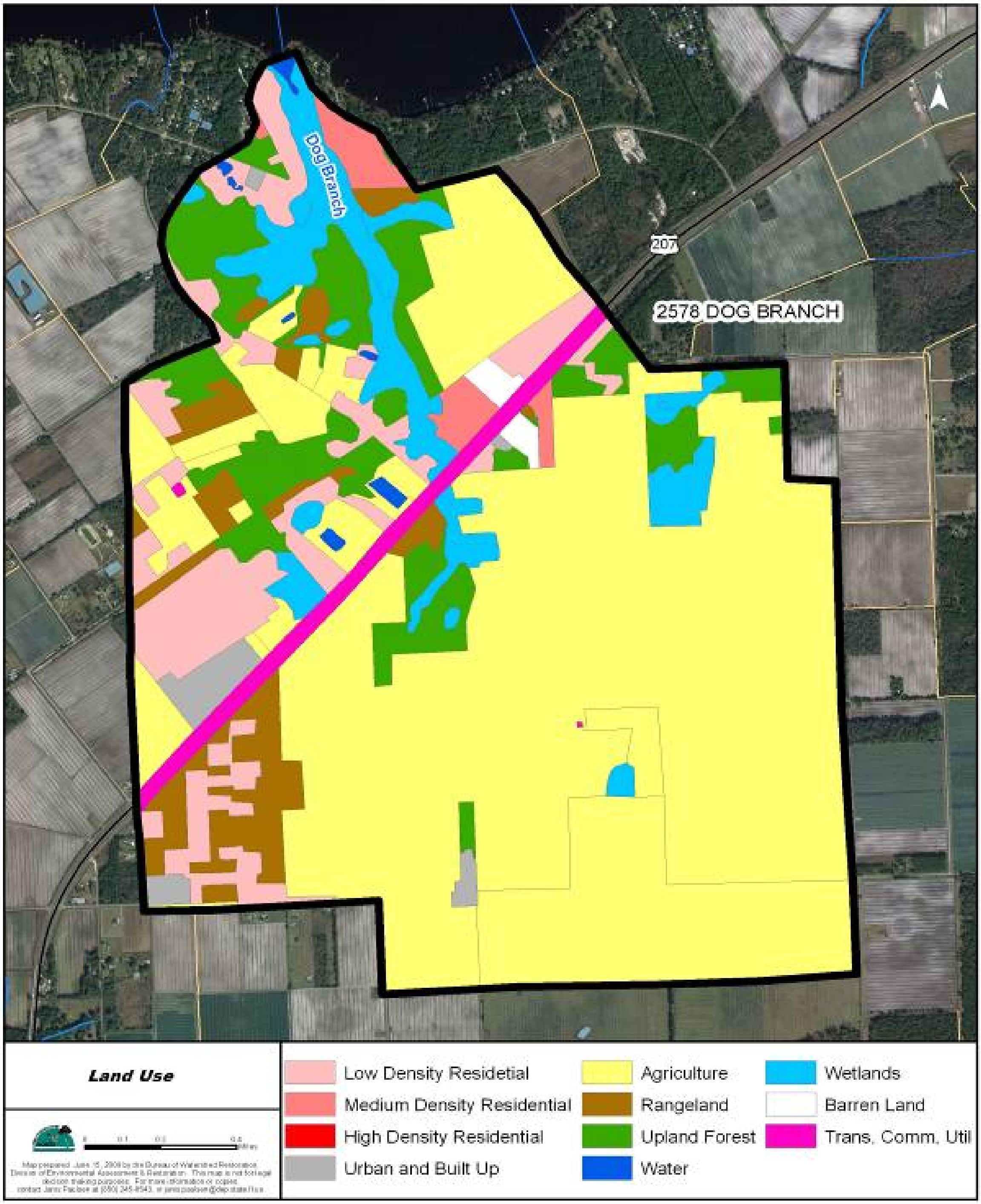
As shown in **Table 4.1**, the total area of the Dog Branch watershed (WBID 2460) is about 7,420 acres. The dominant land use category is wetland, which accounts for about 37.0 percent of the total watershed area. Urban land uses (urban and built-up; low-, medium-, and high-density residential; and transportation, communication, and utilities) occupy 13.2 percent of the total watershed area. Of the 981 acres of urban lands, residential land use occupies about 507 acres, or about 6.9 percent of the total area. Natural land uses, including water/wetlands, upland forest, and barren land, occupy about 4,664 acres, accounting for about 62.8 percent of the total area.

Table 4.1. Classification of Land Use Categories in the Dog Branch Watershed (WBID 2578) in 2004

- = Empty cell

Level 2 Land Use Code	Attribute	Acres	% of Total
1100	Residential, low density – less than 2 dwelling units/acre	226.39	9.52
1200	Residential, medium density – 2-5 dwelling units/acre	41.59	1.75
1400	Commercial and services	1.02	0.04
1500	Industrial	31.08	1.31
1700	Institutional	1.52	0.06
2100	Cropland and pastureland	1,228.15	51.66
2400	Nurseries and vineyards	16.98	0.71
2500	Specialty farms	3.17	0.13
2600	Other open lands	215.56	9.07
3100	Herbaceous upland nonforested	2.74	0.12
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub)	20.35	0.86
3300	Mixed upland nonforested	104.42	4.39
4100	Upland coniferous forests	71.14	2.99
4200	Upland hardwood forests	42.72	1.80
4300	Upland hardwood forests cont.	130.43	5.49
5100	Streams and waterways	2.39	0.10
5200	Lakes	1.22	0.05
5300	Reservoirs – pits, retention ponds, dams	5.1	0.21
6100	Wetland hardwood forests	64.04	2.69
6200	Wetland coniferous forests	11.63	0.49
6300	Wetland forested mixed	84.58	3.56
6400	Vegetated nonforested wetlands	5.06	0.21
7400	Disturbed lands	12.84	0.54
8100	Transportation	52.64	2.21
8200	Communications	0.14	0.01
8300	Utilities	0.66	0.03
-	**SUM:**	**2,377.56**	**100.00**

Figure 4.1. Principal Land Uses in the Dog Branch Watershed (WBID 2578) in 2004



Soil Characteristics

The Soil Survey Geographic (SSURGO) Database in the Department's GIS database from the SJRWMD was accessed to provide coverage of hydrologic soil groups in the Dog Branch watershed (**Figure 4.2**). **Table 4.2** briefly describes the major hydrology soil classes. Soil groups B/D (46.2 percent) and D (39.8 percent) are the most common in the watershed.

Table 4.2. Description of Hydrologic Soil Classes from the SSURGO Database

Hydrology Class	Description
A	High infiltration rates. Soils are deep, well-drained to excessively drained sands and gravels.
A/D	Drained/undrained hydrology class of soils that can be drained and are classified.
B	Moderate infiltration rates. Deep and moderately deep, moderately well- and well-drained soils that have moderately coarse textures.
B/D	Drained/undrained hydrology class of soils that have moderately coarse textures.
C	Slow infiltration rates. Soils with layers impeding downward movement of water, or soils that have moderately fine or fine textures.
C/D	Drained/undrained hydrology class of soils that can be drained and classified.
D	Very slow infiltration rates. Soils are clayey, have a high water table, or are shallow to an impervious layer.

Population

Population and housing unit information from the 2000 census at the block level was obtained from the U.S Census Bureau. GIS was used to estimate the fraction of each block in the Dog Branch watershed and then applied to the block information to estimate the population and number of housing units. Based on **Table 4.3**, the population in the watershed is estimated at 301 people living in 114 households. Based on 2008 Florida Department of Health (FDOH) onsite sewage GIS coverage (http://www.doh.state.fl.us/environment/programs/EhGis/EhGisDownload.htm), about 57 housing units *(N)* were identified as being on septic tanks in the Dog Branch watershed (**Figure 4.3**).

Septic Tanks

Based on the 2000 census estimates and the FDOH onsite sewage coverage, it was assumed that all 114 residences in the Dog Branch watershed are using septic tanks. Using an estimate of 70 gallons/day/person (EPA, 1999), and drainfield TN and TP concentrations of 36 mg/L and 15 mg/L, respectively, potential annual ground water loads of TN and TP were calculated. This is a screening level calculation, and soil types, the age of the system, vegetation, proximity to a receiving water, and other factors will influence the degree of attenuation of this load (**Table 4.4**).

Figure 4.2. Hydrologic Soil Groups Distribution in the Dog Branch Watershed (WBID 2578)

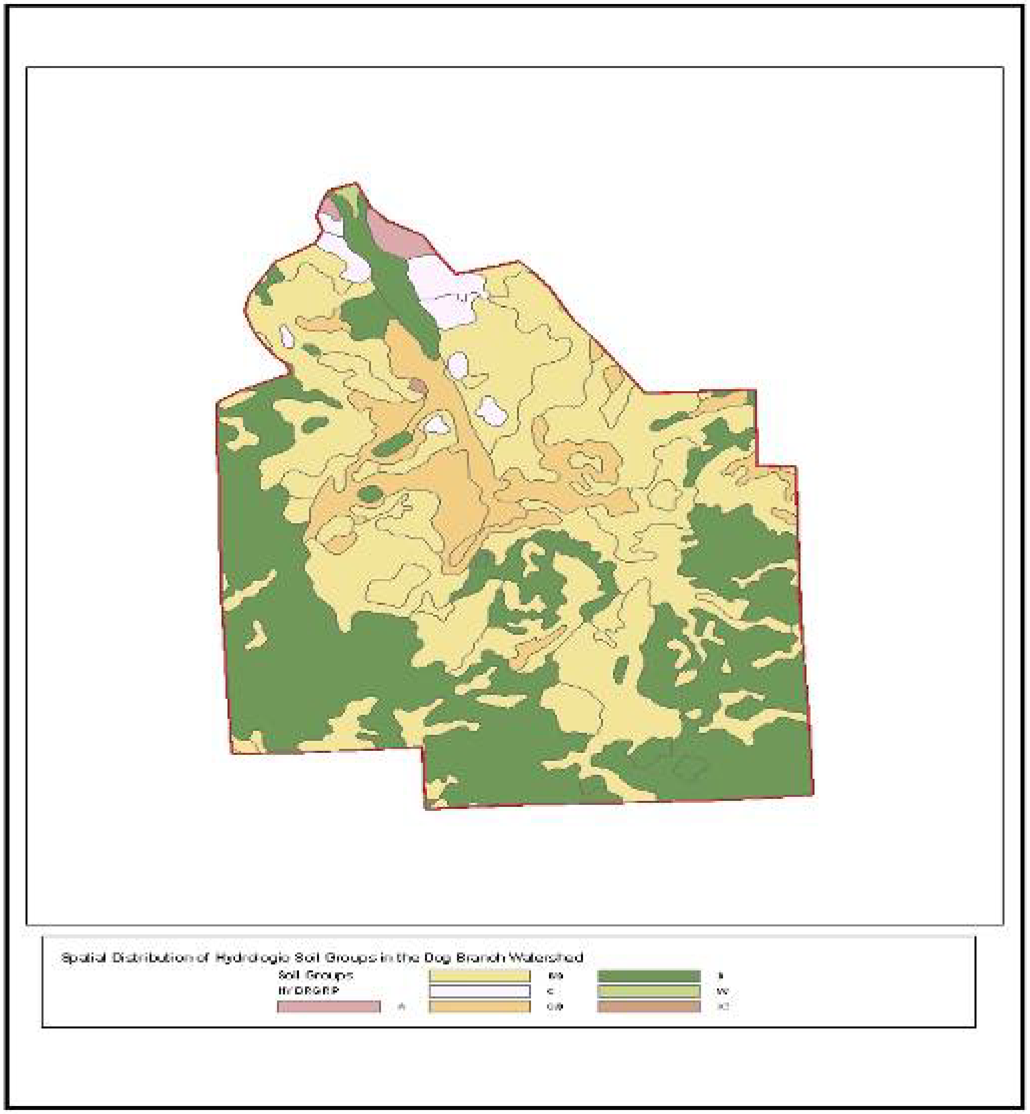


Figure 4.3. Distribution of Onsite Sewage Disposal Systems (Septic Tanks) in the Dog Branch Watershed (WBID 2578)

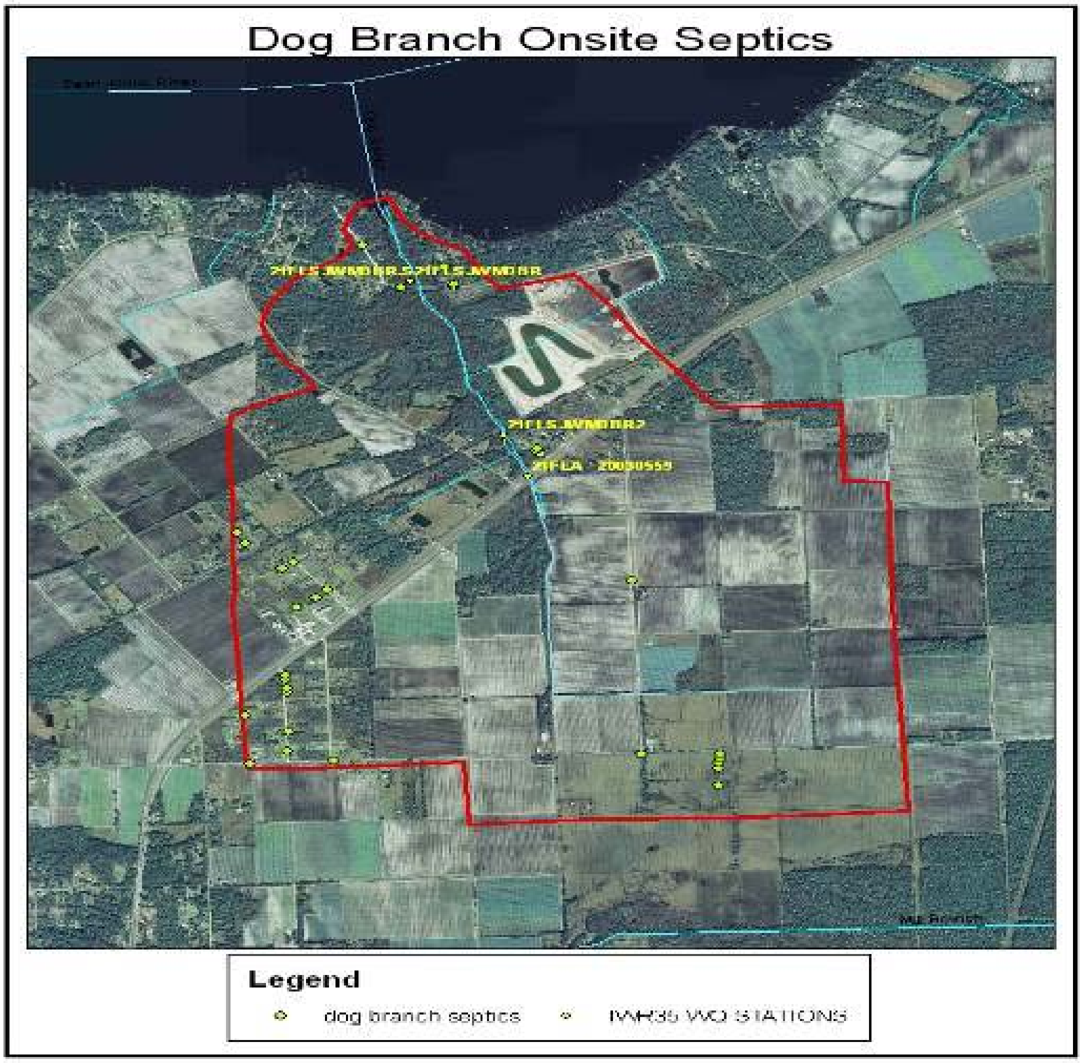


Table 4.3. Estimated Average Household Size in the Dog Branch Watershed (WBID 2578)

Data from U.S. Census Bureau Website, 2000, based on the Putnam County blocks present in the Dog Branch watershed.
- = Empty cell/no data

Tract	Block Group	Population	Housing Units
9510	1	205	80
95109	2	96	34
-	**Total:**	**301**	**114**
		AVERAGE HOUSEHOLD SIZE	**2.64**

Table 4.4. Estimated Nitrogen and Phosphorus Annual Loading from Septic Tanks in the Dog Branch Watershed (WBID 2578)

[1] U.S Census Bureau; see **Table 4.3** for more information on this estimate.
[2] EPA, 1999

Estimated Number of Households on Septic	Estimated Number of People per Household[1]	Gallons/ Person/ Day[2]	TN in Drainfield (mg/L)	TP in Drainfield (mg/L)	Estimated Annual TN Load (lbs/yr)	Estimated Annual TP Load (lbs/yr)
114	2.64	70	36	15	2,310	963

4.2.3 Summary of Nutrient Loadings to Dog Branch from Various Sources

Screening level estimates of annual nitrogen and phosphorus loadings to the watershed were developed based on the 2004 land use and hydrologic soil groups. GIS shapefiles of land use and hydrologic soil groups were used to determine the acreage associated with various Level 2 land uses and soils. Estimates for annual runoff coefficients and event mean concentrations (EMCs) were based on Harper and Baker (2007) and Gao (2006). A screening level estimate of annual runoff was calculated by multiplying the long-term annual average rainfall of 52.44 inches (Jacksonville International Airport [JIA], 1955–2007) by the respective runoff coefficient and area. Estimates of annual nitrogen and phosphorus loading were obtained by multiplying the annual runoff by the corresponding EMC. A more detailed loading analysis could be performed based on the development of site-specific runoff coefficients, EMCs, and knowledge of best management practices (BMPs) that have been implemented in the watershed.

Agriculture

In the Level 3 category, six agricultural land uses were identified in the Dog Branch watershed. Row crops was the largest agricultural category and represented approximately 48.6 percent of the watershed area, or 1,156 acres. Improved pasture was the second largest, representing approximately 2.1 percent of the watershed area, or 51 acres. Aggregating land use to Level 1 for the Dog Branch watershed yields 1,464 acres in agriculture and 128 acres in rangeland. **Table 4.5** summarizes the screening level estimates for nitrogen and phosphorus loads from agricultural sources.

Table 4.5. Estimated Annual Average TN and TP Loads from Agriculture in the Dog Branch Watershed (WBID 2578)

- = Empty cell/no data

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Cropland and pastureland	C/D	92.86	0.226	91.71	696.23	107.55
-	B/D	653.39	0.089	254.12	1,929.20	298.02
-	D	475.01	0.226	469.13	3,561.44	550.17
-	C	6.89	0.166	5.00	37.94	5.86
Cropland and pastureland	D	4.09	0.226	4.04	30.67	4.74
-	B/D	12.88	0.089	5.01	38.03	5.87
Specialty farms	B/D	2.82	0.089	1.10	8.33	1.29
-	D	0.36	0.226	0.36	2.70	0.42
Other open lands	D	156.12	0.226	154.19	1,170.53	180.82
-	B/D	59.44	0.089	23.12	175.50	27.11
Mixed rangeland	B/D	22.57	0.089	8.78	27.47	1.31
-	C/D	8.85	0.226	8.74	27.35	1.31
-	D	73	0.226	72.10	225.60	10.79
-	**SUM:**	**1,568.28**	**-**	**1,097.38**	**7,930.97**	**1,195.27**

Urban Areas

There are 302 acres in the Level 1 category of urban and built-up in the watershed and 53 acres in transportation, communication, and utilities. Low-density residential represents less than 10 percent of the total acreage in the urban and built-up category. **Table 4.6** summarizes the screening level estimates for nitrogen and phosphorus loads from the urban and built-up categories in the watershed.

Forest/Wetland/Water/Open Lands

Table 4.7 summarizes the estimates for nitrogen and phosphorus loadings from land uses in the Level 2 classifications for forest, wetland, and water. Wetlands and upland forests represent 34 and 23 percent, respectively, of the acreage in the watershed.

Table 4.6. Estimated Urban and Built-up Annual Nitrogen and Phosphorus Loading in the Dog Branch Watershed (WBID 2578)

- = Empty cell/no data

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Residential, low density – less than 2 dwelling units/acre	B/D	89.3	0.083	32.39	141.89	16.83
-	D	101.37	0.226	100.12	438.58	52.03
-	C	10.85	0.166	7.87	34.48	4.09
-	A	2.55	0.069	0.77	3.37	0.40
-	C/D	21.59	0.226	21.32	93.41	11.08
-	X?	0.72	0.435	1.37	6.00	0.71
Residential, medium density – 2-5 dwelling units/acre	A	12.55	0.136	7.46	42.01	6.64
-	C	11.86	0.186	9.64	54.30	8.58
-	W	0.13	0.435	0.25	1.39	0.22
-	D	1.62	0.252	1.78	10.05	1.59
-	B/D	12.63	0.108	5.96	33.57	5.30
-	C/D	2.81	0.226	2.78	15.63	2.47
Commercial and services	B/D	1.02	0.35	1.56	7.60	1.11
Industrial	D	25.21	0.375	41.31	201.22	29.45
-	B/D	5.86	0.278	7.12	34.67	5.08
Institutional	B/D	1.52	0.241	1.60	5.23	1.13
Disturbed lands	B/D	9.19	0.089	3.57	15.56	1.95
	C	0	0.166	0.00	0.00	0.00
-	C/D	3.64	0.226	3.59	15.65	1.96
Transportation	B/D	31.82	0.293	40.74	181.81	24.39
-	C/D	7.59	0.375	12.44	55.50	7.45
-	D	13.24	0.375	21.70	96.82	12.99
Communications	B/D	0.14	0.293	0.18	0.80	0.11
Utilities	B/D	0.39	0.278	0.47	2.11	0.28
-	D	0.26	0.375	0.43	1.90	0.26
-	**SUM**	**367.86**	**-**	**326.42**	**1,493.57**	**196.08**

Table 4.7. Estimated Forest/Wetland/Water/Open Lands Annual Nitrogen and Phosphorus Loading in the Dog Branch Watershed (WBID 2578)

- = Empty cell/no data

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Herbaceous upland nonforested	C/D	0.32	0.226	0.32	0.99	0.05
-	B/D	0.35	0.089	0.14	0.43	0.02
-	D	2.07	0.226	2.04	6.40	0.31
Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub)	B/D	11.95	0.089	4.65	14.54	0.70
-	D	2.77	0.226	2.74	8.56	0.41
-	C	5.62	0.166	4.08	12.76	0.61
Upland coniferous forests	B/D	43.03	0.089	16.74	52.37	2.50
-	C/D	19.98	0.226	19.73	61.75	2.95
-	D	5.54	0.226	5.47	17.12	0.82
-	C	2.59	0.166	1.88	5.88	0.28
Upland hardwood forests	D	5.63	0.226	5.56	17.40	0.83
-	B/D	36.08	0.089	14.03	43.91	2.10
-	C	0.92	0.166	0.67	2.09	0.10
-	C/D	0.1	0.226	0.10	0.31	0.01
Upland hardwood forests cont.	B/D	51.32	0.089	19.96	62.46	2.99
-	C	14.38	0.166	10.43	32.64	1.56
-	C/D	40.54	0.226	40.04	125.29	5.99
-	D	23.7	0.226	23.41	73.24	3.50
-	A	0.5	0.021	0.05	0.14	0.01
Streams and waterways	W	2.29	0.435	4.35	14.81	1.30
-	D	0.09	0.435	0.17	0.58	0.05
Lakes	B/D	1.22	0.435	2.32	7.89	0.69
Reservoirs – pits, retention ponds, dams	B/D	1.69	0.435	3.21	10.93	0.96
-	C/D	2.9	0.435	5.51	18.75	1.65
-	X?	0.51	0.435	0.97	3.30	0.29
Wetland hardwood forests	C	0.93	0.435	1.77	7.70	0.29
-	D	43.3	0.435	82.31	358.35	13.44
-	A	1.95	0.435	3.71	16.14	0.61
-	W	1.04	0.435	1.98	8.61	0.32
-	B/D	10.8	0.435	20.53	89.38	3.35
-	C/D	6.02	0.435	11.44	49.82	1.87
Wetland coniferous forests	B/D	7.65	0.435	14.54	63.31	2.37

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (acre-feet)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
-	C/D	2.48	0.435	4.71	20.52	0.77
-	D	1.5	0.435	2.85	12.41	0.47
Wetland forested mixed	B/D	29.11	0.435	55.34	240.91	9.03
-	C/D	39.95	0.435	75.94	330.63	12.40
-	C	6.7	0.435	12.74	55.45	2.08
-	D	8.35	0.435	15.87	69.10	2.59
-	X?	0.46	0.435	0.87	3.81	0.14
Vegetated nonforested wetlands	D	1.9	0.435	3.61	15.72	0.59
-	C/D	1.7	0.435	3.23	14.07	0.53
-	B/D	1.41	0.435	2.68	11.67	0.44
-	W	0.05	0.435	0.10	0.41	0.02
-	**SUM:**	**441.39**	**-**	**502.78**	**1,962.53**	**81.99**

Source Summary

Table 4.8 summarizes the various estimates from various land uses in the watershed. It is important to note that this is not a complete list and represents estimates of potential loadings. In addition, proximity to the waterbody, site-specific soil characteristics, and rainfall frequency and magnitude are just a few of the factors that could influence and determine the actual loadings from these sources that reach Dog Branch. Other factors include the location of the improved pasture and high-density residential areas relative to Dog Branch; whether there is a riparian buffer area between these land uses and the stream; and the types of BMPs, both structural and nonstructural, implemented for specific land uses in the watershed that reduce the actual nutrient loads delivered to Dog Branch. Finally, the age and condition of the septic systems and drainage characteristics in the watershed compared with the county overall could affect assumptions about the assimilation and/or retention of nutrients.

Table 4.8. Summary of Estimated Potential Annual Nitrogen and Phosphorus Loading from Various Sources in the Dog Branch Watershed (WBID 2578)

[1] Potential contribution to ground water

Source	TN (lbs/yr)	TP (lbs/yr)
Septic Tanks[1]	2,310	963
Urban and Built-up	1,493.6	196.1
Agriculture	7,931.0	1,195.3
Forest/Wetland/Water/ Open Lands	1,962.5	82.0

The screening model estimated an annual surface runoff of 1,926 acre-feet or 9.7 inches per year based on the watershed area. Dividing the estimated TN load by the surface runoff volume yielded an average TN concentration of 2.17 mg/L. The average and median TN concentrations from the available data were 1.83 and 1.38 mg/L, respectively. Dividing the estimated TP load by the surface runoff volume yielded an average TP concentration of 0.28 mg/L. The average and median TP concentrations from the available data were 0.394 and 0.254 mg/L, respectively. Flow and nutrient contributions from ground water inputs to Dog Branch were not included in this screening level calculation and would likely influence in-stream concentrations.

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

5.1.1 Data Used in the Determination of the TMDLs

Four sampling stations on Dog Branch have historical DO observations (**Figure 5.1**). **Table 5.1** contains summary information on each of the stations. **Table 5.2** provides a statistical summary of DO observations at each station, and **Appendix B** contains historical DO, corrected chl*a* (CHLAC), TN, TP, and BOD5 available observations from sampling sites in WBID 2578. **Figure 5.2** displays the historical observations of DO over time. DO exceedance rates by station range between 37 and 57 percent. A linear regression of DO versus sampling date in **Figure 5.2** was not significant at an alpha (α) level of 0.05 (R^2 = 0.0043). **Appendix E** contains plots of DO by season, station, and year.

Figures 5.3 through **5.6** present historical CHLAC, TN, TP, and BOD observations, respectively. Linear regressions of each parameter versus sampling date indicate that none of these regressions was significant at an α level of 0.05. **Appendix E** contains additional plots by season, station, and year. **Table 5.3** presents a statistical summary of major water quality parameters from the available data.

Table 5.1. Sampling Station Summary for Dog Branch (WBID 2578)

Station	STORET ID	Station Owner	Years With Data	N
Dog Branch at SR 207	21FLA 20030559	Department	1997–2007	8
Dog Branch 50 Meters Downstream County Rd 207 A	21FLSJWMDBR	SJRWMD	1985–2008	266
Dog Branch 50 M Dwnstrm of 207A Stormflow	21FLSJWMDBR.S	SJRWMD	1992–95	1
Dog Branch 01 Mile N of 207 @ Old Railroad Bridge	21FLSJWMDBR2	SJRWMD	1997–2005	36

Table 5.2. Statistical Summary of Historical DO Data for Dog Branch (WBID 2578)

DO concentrations are mg/L.

Station	N	Minimum	Maximum	Median	Mean	Exceedances	% Exceedances
Dog Branch at SR 207	8	2.6	8.6	6.45	5.78	3	37.50
Dog Branch 50 Meters Downstream County Rd 207 A	266	1	11.68	4.6	4.75	150	56.39
Dog Branch 50 M Dwnstrm of 207A Stormflow	1	5.71	5.71	5.71	5.71	0	0.00
Dog Branch 01 Mile N of 207 @ Old Railroad Bridge	36	2.1	9.32	5.005	5.43	17	47.22

Figure 5.1. Historical Sampling Sites in Dog Branch (WBID 2578)

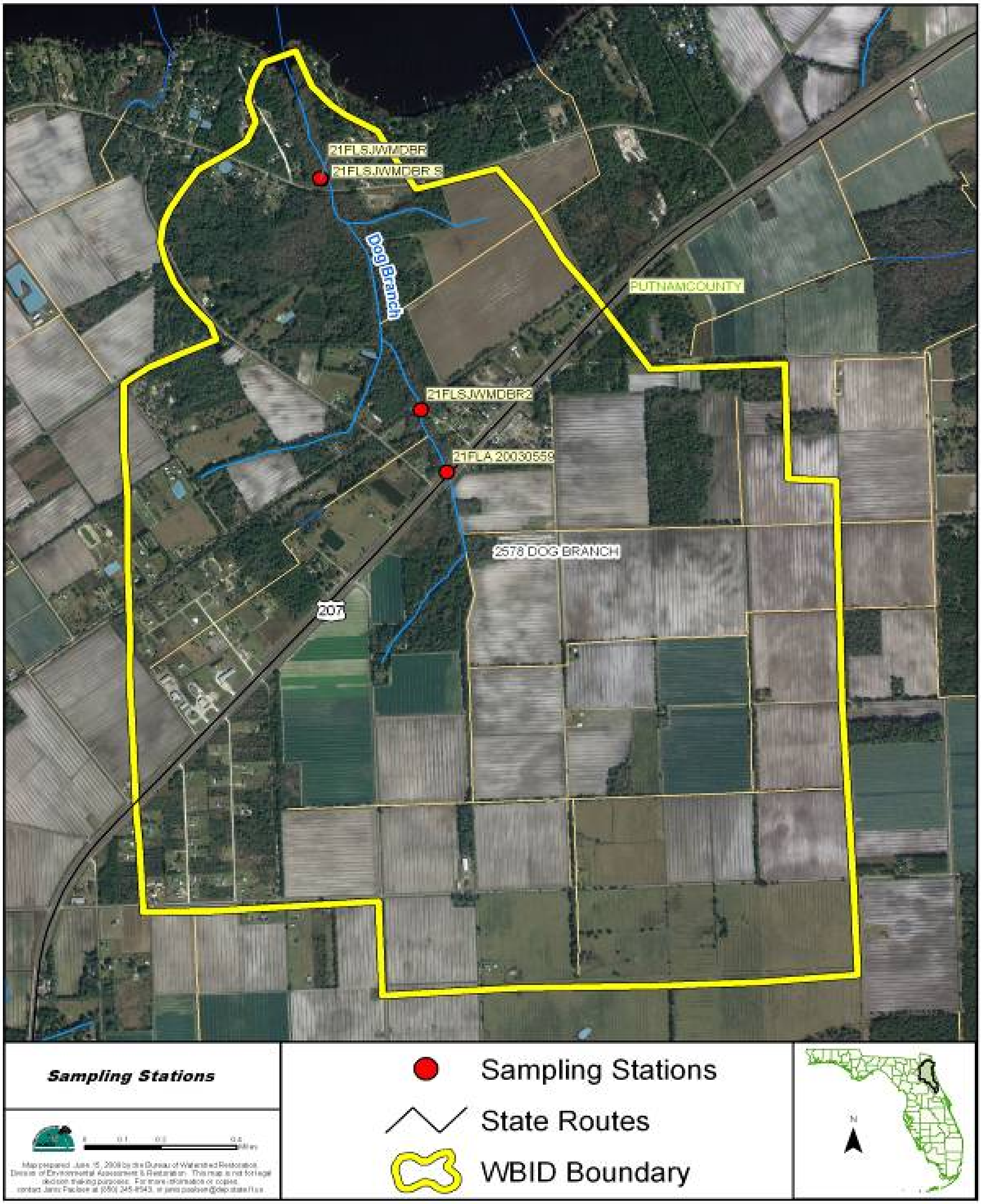


Figure 5.2. Historical DO Observations for Dog Branch (WBID 2578)

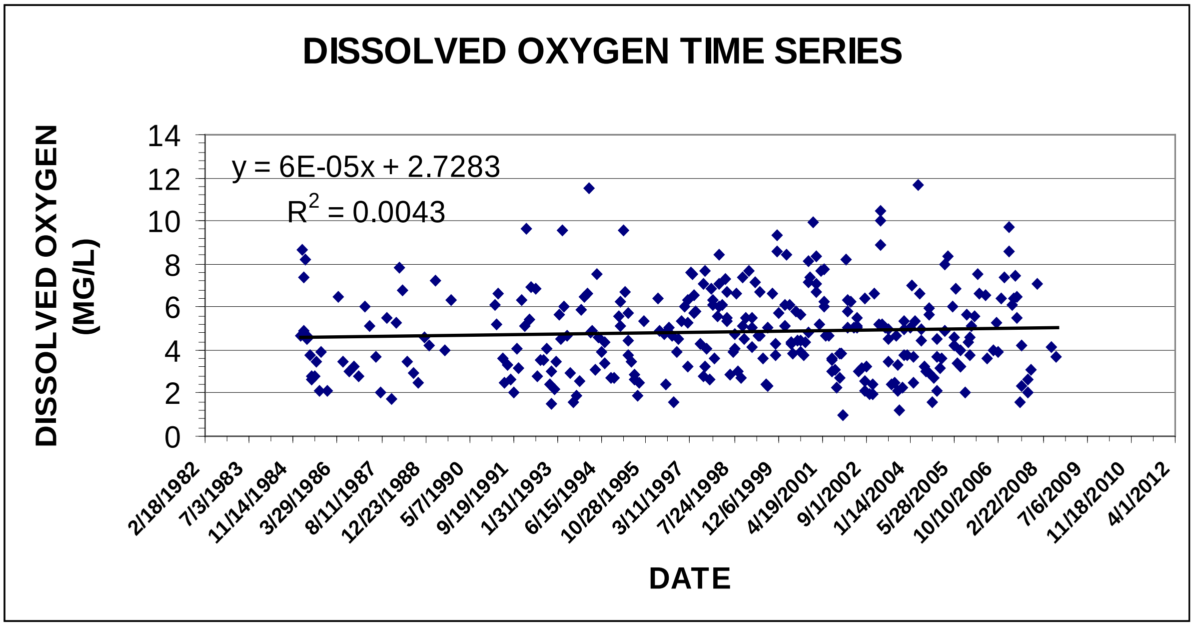


Figure 5.3. Historical CHLAC Observations for Dog Branch (WBID 2578)

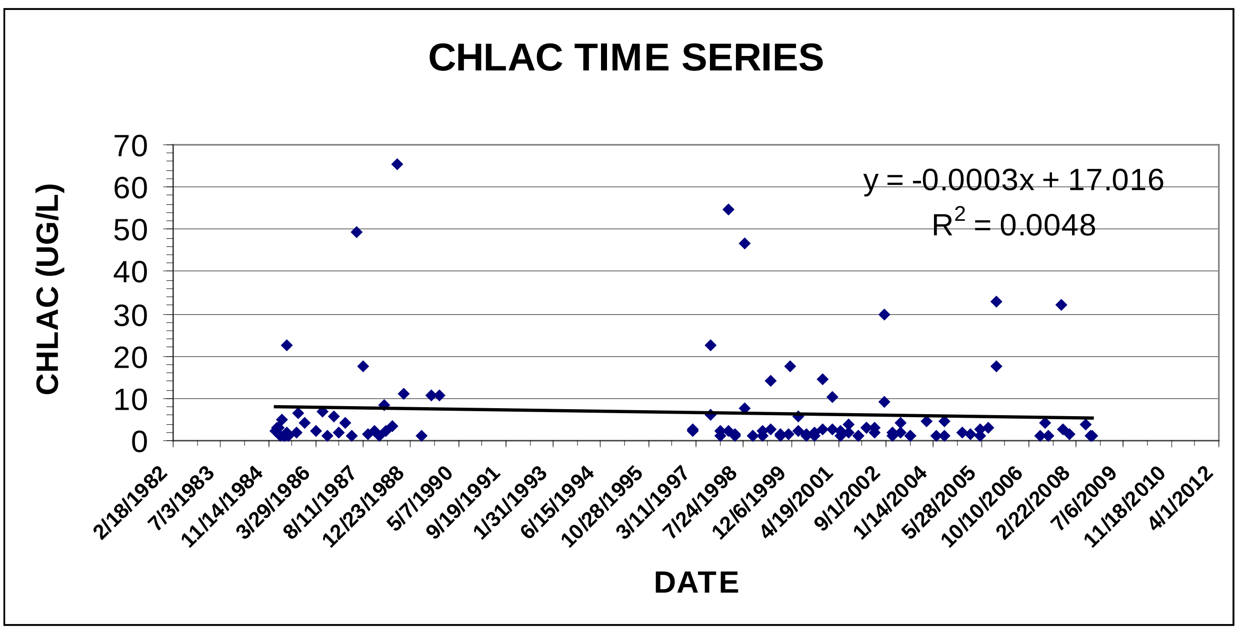


Figure 5.4. Historical TN Observations for Dog Branch (WBID 2578)

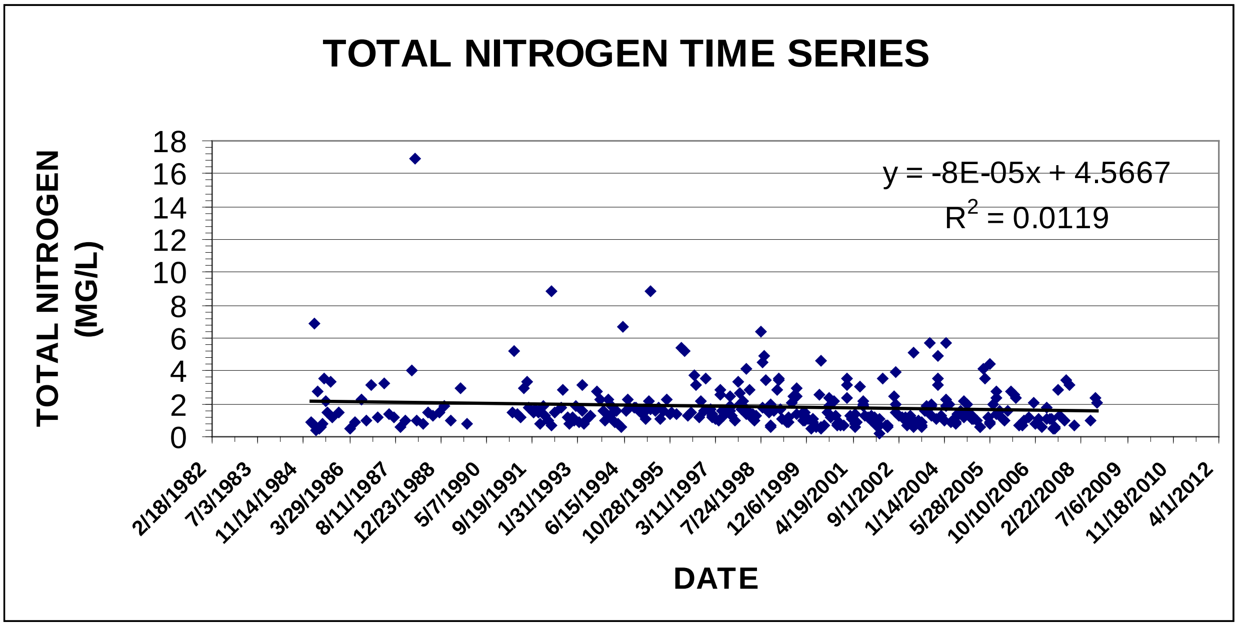


Figure 5.5. Historical TP Observations for Dog Branch (WBID 2578)

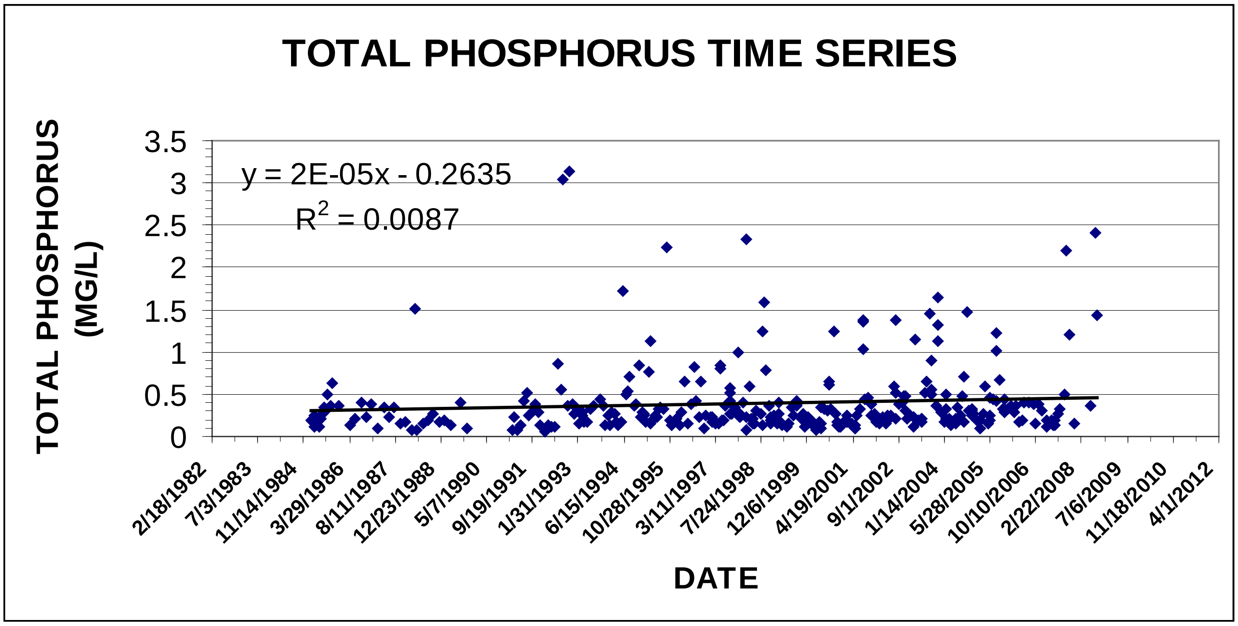


Figure 5.6. Historical BOD5 Observations for Dog Branch (WBID 2578)

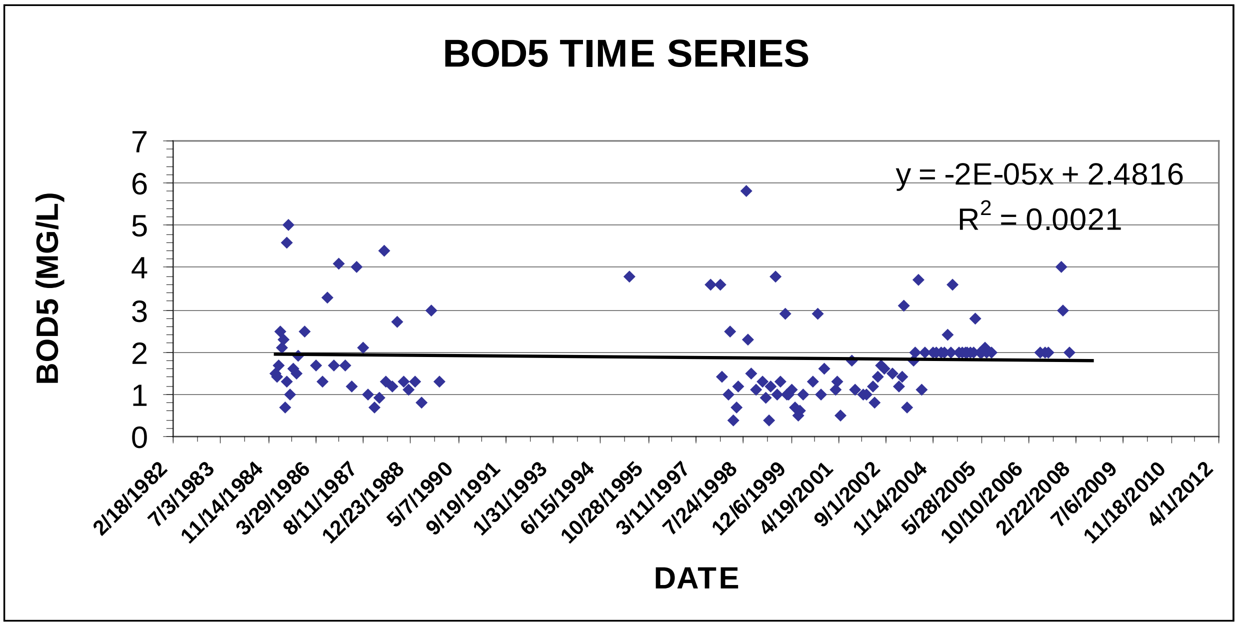


Table 5.3. Summary Statistics for Major Water Quality Parameters Measured in Dog Branch (WBID 2578)

PARM	N	MIN	25%	MEDIAN	MEAN	75%	MAX
BOD (mg/L)	116	0.4	1.1	1.7	1.9	2.1	5.8
CHLAC µg/L)	103	1	1.2	2.4	6.7	5.5	65.2
CHLORIDE (mg/L)	317	1	287	390	431.8	551.1	1200
COLOR (PCU)	222	10	30	50	68.6	80	400
COND (µS/cm)	299	154	1230.8	1731	1830.8	2447.5	3980
DO (mg/L)	311	1.00	3.27	4.65	4.86	6.20	11.68
NH4 (mg/L)	313	0.01	0.07	0.12	0.18	0.19	3.10
NO302 (mg/L)	313	0.01	0.14	0.26	0.59	0.54	11.14
PH (su)	313	4.40	6.59	6.88	6.85	7.11	8.29
SO4 (mg/L)	308	2.00	165.06	249.29	273.84	358.41	656.00
TEMP (C)	320	7.73	17.06	21.52	20.83	25.15	29.92
TKN (mg/L)	322	0.05	0.75	1.14	1.25	1.52	5.76
TN (mg/L)	312	0.23	0.99	1.38	1.83	2.14	16.9
TOC (mg/L)	241	1.50	6.95	13.43	13.40	17.73	49.60
TORTHO (mg/L)	281	0.03	0.09	0.14	0.25	0.27	2.80
TP (mg/L)	320	0.060	0.170	0.250	0.390	0.400	3.130
TSS (mg/L)	315	1	5	7	12.23	10.67	746
TURB (NTU)	320	0.9	4.49	6.8	10.51	10.3	397

Available DO measurements were also summarized by year (**Table 5.4**) and by season (**Table 5.5**). **Tables 5.6a** through **5.6f** provide a statistical summary of DO, TEMP, TN, TP, BOD5, and CHLAC observations at each station in Dog Branch. A nonparametric test (Kruskal-Wallis) was applied to the DO, DOSAT, CHLAC, TN, TP, and BOD5 datasets to determine whether there were significant difference among seasons (**Appendix C**). At an α level of 0.05, differences were significant among seasons for DO, DOSAT, TN, TP, and BOD5. A similar test for differences among months was significant for DO, DOSAT, CHLAC, TN, TP, and BOD5 (**Appendix D**).

Table 5.4. Statistical Summary of Historical DO Data by Year for Dog Branch (WBID 2578)

DO concentrations are mg/L.

Year	N	Minimum	Maximum	Median	Mean	Exceedances	% Exceedances
1985	15	2.1	8.65	3.9	4.43	12	80.00
1986	5	2.8	6.5	3.2	3.80	4	80.00
1987	6	1.7	6	4.4	4.00	3	50.00
1988	7	2.5	7.8	4.6	4.77	4	57.14
1989	4	4	7.2	5.25	5.43	2	50.00
1991	11	2.01	6.59	3.63	4.14	7	63.64
1992	13	1.52	9.66	3.57	4.40	8	61.54
1993	13	1.59	9.56	4.64	4.75	7	53.85
1994	12	2.68	11.5	4.5	4.93	9	75.00
1995	13	1.85	9.56	4.47	4.64	7	53.85
1996	10	1.55	6.42	4.705	4.34	7	70.00
1997	20	2.63	7.7	5.89	5.43	7	35.00
1998	20	2.74	8.46	5.505	5.43	7	35.00
1999	18	2.35	9.32	5.045	5.40	8	44.44
2000	19	3.78	8.42	5.13	5.43	9	47.37
2001	20	1	9.96	4.66	5.06	11	55.00
2002	20	1.97	8.19	5.02	4.38	9	45.00
2003	20	1.23	10.5	4.605	4.71	13	65.00
2004	20	1.57	11.68	4.06	4.49	12	60.00
2005	19	2.01	8.38	4.58	4.78	13	68.42
2006	10	3.59	7.56	5.985	5.69	3	30.00
2007	14	1.6	9.73	5.81	5.23	6	42.86
2008	2	3.72	4.11	3.915	3.92	2	100.00

Table 5.5. Statistical Summary of Historical DO Data by Season for Dog Branch (WBID 2578)

DO concentrations are mg/L.

Season	N	Minimum	Maximum	Median	Mean	Exceedances	% Exceedances
Winter	78	2.45	11.50	6.07	6.37	15	16.67
Spring	83	1.60	11.68	4.77	5.01	44	53.01
Summer	76	1.23	7.70	3.30	3.53	65	85.53
Fall	74	1.00	9.32	4.32	4.45	46	62.16

Table 5.6a. Seasonal Summary Statistics for DO for Dog Branch (WBID 2578)

DO concentrations are mg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	78	2.45	3.52	5.13	6.07	6.37	7.61	11.50
Spring	83	1.60	2.56	3.71	4.77	5.01	6.18	11.68
Summer	76	1.23	1.67	2.54	3.30	3.53	4.21	7.70
Fall	74	1.00	1.97	2.74	4.32	4.45	5.90	9.32

Table 5.6b. Seasonal Summary Statistics for TEMP for Dog Branch (WBID 2578)

TEMP is in °C.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	79	7.73	10.09	13.44	15.01	15.32	17.83	22.30
Spring	87	12.00	16.87	20.63	22.90	22.44	24.63	28.08
Summer	78	22.52	23.46	25.13	25.93	25.93	26.78	29.92
Fall	76	10.78	12.70	17.05	19.39	19.48	22.20	27.52

Table 5.6c. Seasonal Summary Statistics for TN for Dog Branch (WBID 2578)

TN concentrations are mg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	79	0.23	0.56	1.03	1.44	2.09	2.40	16.90
Spring	82	0.39	0.51	0.78	1.02	1.60	1.56	8.88
Summer	77	0.97	1.17	1.48	1.95	2.18	2.44	6.38
Fall	74	0.56	0.65	0.99	1.20	1.44	1.54	4.88

Table 5.6d. Seasonal Summary Statistics for TP for Dog Branch (WBID 2578)

TP concentrations are mg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	81	0.060	0.077	0.146	0.190	0.267	0.260	2.326
Spring	85	0.080	0.104	0.153	0.193	0.270	0.318	1.719
Summer	78	0.131	0.222	0.349	0.463	0.674	0.710	3.040
Fall	76	0.090	0.115	0.204	0.271	0.379	0.374	3.130

Table 5.6e. Seasonal Summary Statistics for BOD5 for Dog Branch (WBID 2578)

BOD5 concentrations are mg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	29	0.5	0.6	1.0	1.5	1.6	2.0	4.4
Spring	34	0.4	0.4	1.0	1.3	1.8	2.1	5.0
Summer	27	1.0	1.0	1.6	2.0	2.3	3.0	5.8
Fall	26	0.7	0.9	1.1	1.5	1.8	2.0	4.1

Table 5.6f. Seasonal Summary Statistics for CHLAC for Dog Branch (WBID 2578)

CHLAC concentrations are µg/L.

Season	N	Minimum	5%	25%	Median	Mean	75%	Maximum
Winter	26	1.0	1.0	1.7	2.5	5.1	4.1	54.6
Spring	30	1.0	1.0	1.0	1.7	4.8	3.3	49.3
Summer	22	1.0	1.0	1.5	5.1	12.4	17.6	65.2
Fall	25	1.0	1.0	1.3	2.1	5.8	7.1	32.9

5.1.2 TMDL Development Process

A Spearman correlation matrix was used to assess potential relationships between DO and other water quality parameters (**Appendix G**). At an alpha (α) level of 0.05, correlations between DO, DOSAT, nitrate nitrite (NO3O2), pH, sulfate (SO_4), total organic carbon (TOC), and water temperature (TEMP) were significant. A simple linear regression of DO versus TEMP explained 32 percent of the variance in DO (**Appendix H**).

In order to determine the influence of nutrients on DO without the confounding effects of water temperature on all these variables, the general linear model (GLM) was used to develop an expression that included TEMP, TN, and TP. Based on 295 cases with DO, TN, TP, and TEMP observations, the following expression was significant at an α level of 0.05 and explained nearly 37 percent of the variance in DO:

DO = 10.244 – 0.226*TEMP – 4.254*TP + 0.091*TN + 0.105*TP*TEMP + 0.539*TN*TP - 0.015*TN*TEMP

Similarly, TEMP was a significant variable with CHLAC. A simple linear regression between CHLAC and TEMP was significant at an α level of 0.05, but explained only 5 percent of the variance in CHLAC (**Appendix H**). Based on 100 cases with CHLAC, TN, TP, and TEMP observations, the GLM yielded the following significant relationship and explained 31 percent of the variance in CHLAC:

CHLAC = -23.177 – 1.327*TN + 1.509*TEMP + + 25.194*TP - 0.144*TEMP*TN – 1.629*TEMP*TP + 5.571*TN*TP

Since DO is influenced by water temperature, the TMDL was developed using the complete record of TN, TP, and TEMP values (**Appendix B**).

Because the adopted nutrient TMDL for the Lower St. Johns River requires a 30 percent reduction in anthropogenic nitrogen and phosphorus loads to the freshwater portion of the river, the GLM model for DO was used to estimate the DO concentration with the historical dataset for TEMP following a 30 percent reduction in TN and TP. **Figure 5.7** presents a cumulative frequency plot of observed and predicted DO from the GLM model with a 30 percent reduction in TN and TP. Reductions in TN and TP increase DO concentrations at the lower end of the distribution, and the overall range is reduced as summarized in **Table 5.7**. The predicted changes to the DO distribution reflect an improved ecological condition. Both the minimum and 25^{th} percentile predicted that DO concentrations increase by 0.50 mg/L and the mean DO is raised above 5.0 mg/L. One percent of the observations from the historical dataset were less than 1.57 mg/L, while the DO GLM predicted that the 1% percentile concentration would be raised to 2.84 mg/L based on a 30 percent reduction in TN and TP concentrations. According to the DO GLM, additional reductions in TN and TP resulted in minimal changes in the DO distribution.

The application of the GLM model with the summer average TEMP of 25.93 °C, the reduction of the summer average TN from 2.18 to 1.53 mg/L, and a reduction in the summer average TP from 0.674 to 0.472 mg/L resulted in a predicted DO concentration of 3.6 mg/L. Similarly, under the historical average TEMP of 20.83 °C, the reduction of the historical average TN from 1.83 to 1.28 mg/L, and a reduction in the historical average TP from 0.394 to 0.276 mg/L resulted in a predicted DO concentration of 4.9 mg/L.

Figure 5.7. Cumulative Frequency Plot of Historical DO Observations Versus GLM Estimates Following a 30 Percent Reduction in TN and TP

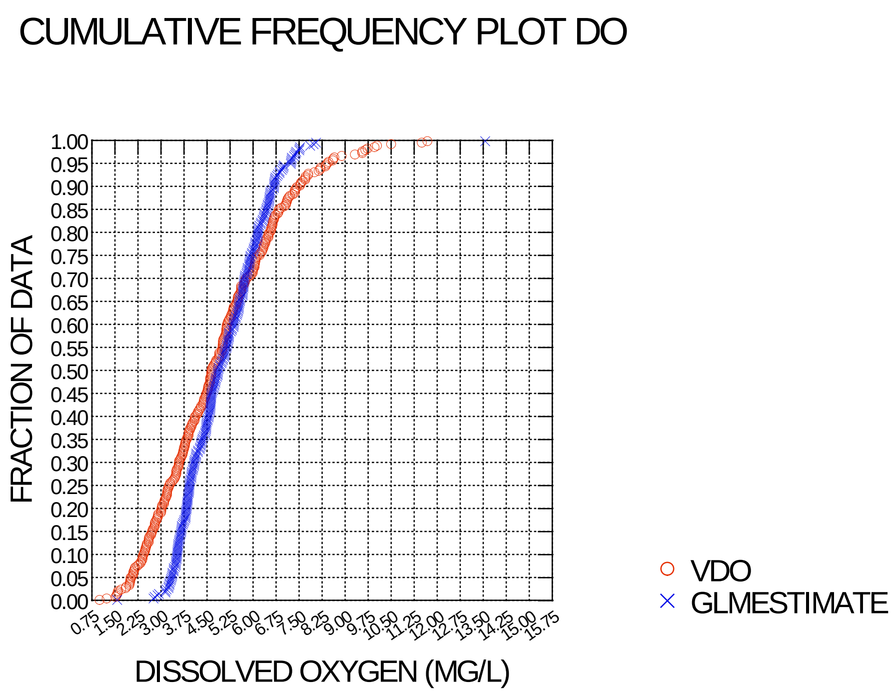


Table 5.7. Summary Statistics for DO and GLM-Estimated DO following a 30 Percent Reduction in TN and TP

- = Empty cell
DO concentrations are mg/L.

-	Minimum	25%	Median	Mean	75%	Maximum
Historical	1.00	3.27	4.65	4.86	6.20	11.68
GLM Estimate	1.57	3.93	4.86	5.03	5.93	13.56

Reductions in CHLAC in response to the TN and TP reductions also influence BOD5 levels in Dog Branch. A simple linear regression between BOD5 and CHLAC explained 14 percent of the variance in BOD5 ($p=0.018$). A GLM that included CHLAC, TN, and TP explained 47 percent of the variance in BOD5. As a result, there will be reductions in BOD5 associated directly and indirectly with reductions in TN and TP.

Although the DO GLM predicted that the minimum DO would be below the Class III freshwater criterion of 5.0 mg/L at times, reductions in BOD will have indirect benefits to DO levels. Since there is an inverse correlation between BOD5 and DO, some additional improvement in DO is expected, along with reductions in sediment oxygen demand associated with the degradation of organic material that settles on the bottom.. These TMDLs are not expected to cause an imbalance in the natural populations of flora and fauna, or cause nuisance conditions that depress DO below natural levels.

Nutrients were also verified impaired based on the linkage of TP to the DO impairment, even though annual chl*a* concentrations were below listing thresholds. The application of the CHLAC GLM model with the summer average TEMP and a 30 percent reduction in summer TN and TP concentrations resulted in a predicted CHLAC concentration of 8.2 μg/L. The summer average CHLAC was 12.4 μg/L. Under the historical average TEMP and a 30 percent reduction in historical TN and TP concentrations, the GLM model predicted a CHLAC concentration of 5.8 μg/L. The historical average CHLAC concentration was 6.7 μg/L. A 30 percent reduction in TN and TP will further reduce existing CHLAC concentrations in Dog Branch.

5.1.3 Critical Conditions/Seasonality

The nonparametric Kruskal-Wallis test demonstrated that there were significant differences among seasons and months for DO, DOSAT, TN, and TP (**Appendices C** and **D**). As seen in **Table 5.6a**, the lowest DO concentrations occurred during the summer season. The highest CHLAC levels were also observed during the summer season (**Table 5.6f**). The TMDL evaluated the DO response to 30 percent reductions in TN and TP over the historical range of TEMP and nutrient concentrations and predicted improvements in the minimum through the median DO concentrations compared with historical DO concentrations. The reductions in TN and TP resulted in reductions in predicted CHLAC under both the historical average and summer average TEMP conditions.

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 (wasteload 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:

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

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

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

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**. The TMDLs for Dog Branch are expressed in terms of a percent reduction in total nitrogen and total phosphorus, to meet both the DO and nutrient criteria (**Table 6.1**).

Table 6.1. TMDL Components for Dog Branch (WBID 2578)

- = Empty cell/no data
NA = Not applicable
[1] As the TMDL represents a percent reduction, it also complies with EPA requirements to express the TMDL on a daily basis.

WBID	Parameter	TMDL (mg/L)	WLA for Wastewater (mg/L)	WLA for NPDES Stormwater (% reduction)[1]	LA (% reduction)[1]	MOS
2578	TN	-	NA	NA	30%	Implicit
2578	TP	-	NA	NA	30%	Implicit

6.2 Load Allocation

TN and TP reductions of 30 percent are required from nonpoint sources. It should be noted that the load allocation includes loading from stormwater discharges that are not part of the NPDES Stormwater Program.

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

There are currently no permitted NPDES discharges in the Dog Branch watershed; however, any future discharge permits issued in the watershed will also be required to meet the state's Class III criterion for DO and contain appropriate discharge limitations on nitrogen and phosphorus that will comply with the TMDLs.

6.3.2 NPDES Stormwater Discharges

There are currently no Phase I or II MS4 permits for Putnam County. It should be noted that any future MS4 permittee is only responsible for reducing the 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.

6.4 Margin of Safety

Consistent with the recommendations of the Allocation Technical Advisory Committee (Department, 2001), an implicit MOS was used in the development of this TMDL by applying the nutrient reductions over the complete historical dataset.

Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

7.1 Basin Management Action Plan

Following the adoption of this TMDL by rule, the Department will determine the best course of action regarding its implementation. Depending on the pollutant(s) causing the waterbody impairment and the significance of the waterbody, the Department will select the best course of action leading to the development of a plan to restore the waterbody. Often this will be accomplished cooperatively with stakeholders by creating a Basin Management Action Plan, referred to as the BMAP. BMAPs are the primary mechanism through which TMDLs are implemented in Florida (see Subsection 403.067[7], F.S.). A single BMAP may provide the conceptual plan for the restoration of one or many impaired waterbodies.

If the Department determines that a BMAP is needed to support the implementation of this TMDL, a BMAP will be developed through a transparent, stakeholder-driven process intended to result in a plan that is cost-effective, technically feasible, and meets the restoration needs of the applicable waterbodies. Once adopted by order of the Department Secretary, BMAPs are enforceable through wastewater and municipal stormwater permits for point sources and through BMP implementation for nonpoint sources. Among other components, BMAPs typically include the following:

- *Water quality goals (based directly on the TMDL);*
- *Refined source identification;*
- *Load reduction requirements for stakeholders (quantitative detailed allocations, if technically feasible);*
- *A description of the load reduction activities to be undertaken, including structural projects, nonstructural BMPs, and public education and outreach;*
- *A description of further research, data collection, or source identification needed in order to achieve the TMDL;*
- *Timetables for implementation;*
- *Implementation funding mechanisms;*
- *An evaluation of future increases in pollutant loading due to population growth;*
- *Implementation milestones, project tracking, water quality monitoring, and adaptive management procedures; and*
- *Stakeholder statements of commitment (typically a local government resolution).*

BMAPs are updated through annual meetings and may be officially revised every five years. Completed BMAPs in the state have improved communication and cooperation among local stakeholders and state agencies; improved internal communication within local governments; applied high-quality science and local information in managing water resources; clarified the obligations of wastewater point source, MS4, and non-MS4 stakeholders in TMDL implementation; enhanced transparency in the Department's decision making; and built strong relationships between the Department and local stakeholders that have benefited other program areas.

7.2 Other TMDL Implementation Tools

However, in some basins, and for some parameters, particularly those with fecal coliform impairments, the development of a BMAP using the process described above will not be the most efficient way to restore a waterbody, such that it meets its designated uses. This is because fecal coliform impairments result from the cumulative effects of a multitude of potential sources, both natural and anthropogenic. Addressing these problems requires good old-fashioned detective work that is best done by those in the area.

A multitude of assessment tools is available to assist local governments and interested stakeholders in this detective work. The tools range from the simple (such as Walk the WBIDs and GIS mapping) to the complex (such as bacteria source tracking). Department staff will provide technical assistance, guidance, and oversight of local efforts to identify and minimize fecal coliform sources of pollution. Based on work in the Lower St Johns River tributaries and the Hillsborough Basin, the Department and local stakeholders have developed a logical process and tools to serve as a foundation for this detective work. In the near future, the Department will be releasing these tools to assist local stakeholders with the development of local implementation plans to address fecal coliform impairments. In such cases, the Department will rely on these local initiatives as a more cost-effective and simplified approach to identify the actions needed to put in place a road map for restoration activities, while still meeting the requirements of Subsection 403.067(7), F.S.

Earlier in the document, reference was made to the BMAP adopted in October 2008 that outlined implementation activities in the freshwater portion of the Lower St. Johns River to achieve the nutrient TMDL. Since Dog Branch represents a contributing watershed to the Lower St. Johns, applicable activities undertaken in the Dog Branch watershed as part of the Lower St. Johns River BMAP should be sufficient to address the DO and nutrient impairment in Dog Branch.

References

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

———. *Rule 62-303, Identification of impaired surface waters.*

Florida Department of Environmental Protection. February 2001. *A report to the Governor and the Legislature on the allocation of Total Maximum Daily Loads in Florida.* Tallahassee, FL: Bureau of Watershed Management.

———. June 2002. *Basin status report: Lower St. Johns.* Tallahassee, FL: Bureau of Watershed Management.

———. 2004. *Water quality assessment report: Lower St. Johns.* Tallahassee, FL: Bureau of Watershed Management.

Florida Department of Health Website. 2008. Available: http://www.doh.state.fl.us/.

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

Gao, X. 2006 *Nutrient and unionized ammonia TMDLs for Lake Jesup, WBIDs 2981 and 2981A*. Tallahassee, FL: Florida Department of Environmental Protection, Bureau of Watershed Management. Available: http://www.dep.state.fl.us/water/tmdl/docs/tmdls/final/gp2/lake-jessup-nutr_ammonia-tmdl.pdf.

Harper, H.H., and D.M. Baker. 2007. *Evaluation of current stormwater design criteria within the state of Florida.* Orlando, FL: Environmental Research & Design, Inc.

Magley, W., and D. Joyner. 2008. *Total Maximum Daily Load for nutrients for the Lower St. Johns River*. Tallahassee, FL: Florida Department of Environmental Protection, Bureau of Watershed Management Available: http://www.dep.state.fl.us/water/tmdl/docs/tmdls/final/gp2/lower-stjohns-nutrients.pdf.

U.S. Census Bureau Website. 2000. Available: http://www.census.gov/.

U.S. Environmental Protection Agency. 1999. *Protocol for developing nutrient TMDLs.* First Edition. EPA 841–B–99–007.

U.S. Environmental Protection Agency, Region 4. 2002. *Estimating water quality loadings from MS4 areas.*

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 Rule 62-40, F.A.C. In 1994, the Department's stormwater treatment requirements were integrated with the stormwater flood control requirements of the water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations.

Rule 62-40, F.A.C., also requires the state's water management districts to establish stormwater Pollutant Load Reduction Goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (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.

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 permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementing the Phase I NPDES Stormwater Program in 1990. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific standard industrial classification (SIC) codes, construction sites disturbing 5 or more acres of land, and the master drainage systems of local governments with a population above 100,000, which are better known as MS4s. However, because the master drainage systems of most local governments in Florida are interconnected, the EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the 15 counties meeting the population criteria. The Department received authorization to implement the NPDES Stormwater Program in 2000.

An important difference between the federal NPDES and the state's stormwater/environmental resource permitting programs is that the NPDES Program covers both new and existing discharges, while the state's programs focus on new discharges only. Additionally, Phase II of the NPDES Program, implemented in 2003, expands the need for these permits to construction sites between 1 and 5 acres, and to local governments with as few as 1,000 people. 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, as are other point sources of pollution such as domestic and industrial wastewater discharges. It should be noted that all MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

Appendix B: Historical DO, CHLAC, BOD5, TN, and TP Observations in Dog Branch (WBID 2578), 1985–2008

- = Empty cell/no data

Station	Sample Date	DO (mg/L)	CHLAC (µg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDBR	2/5/1985	4.65	2.1384	1.5	0.838	0.187
FLSJWMDBR	2/19/1985	8.65	3.2076	1.4	0.797	0.173
FLSJWMDBR	3/5/1985	7.4	3.2076	1.7	0.705	0.115
FLSJWMDBR	3/19/1985	4.9	1	2.5	6.93	0.24
FLSJWMDBR	4/3/1985	8.2	5.0787	2.1	0.393	0.131
FLSJWMDBR	4/16/1985	4.55	1	2.3	2.72	0.171
FLSJWMDBR	5/7/1985	4.6	1	0.7	0.491	0.112
FLSJWMDBR	5/22/1985	3.75	1.8711	1.3	0.617	0.212
FLSJWMDBR	6/5/1985	2.6	22.7205	4.6	0.834	0.269
FLSJWMDBR	6/18/1985	2.8	1.00238	5	3.53	0.347
FLSJWMDBR	7/9/1985	2.8	-	1	2.208	0.3
FLSJWMDBR	8/7/1985	3.5	-	1.6	1.446	0.498
FLSJWMDBR	9/11/1985	2.1	1.8711	1.5	3.325	0.354
FLSJWMDBR	9/30/1985	3.9	6.4152	1.9	1.208	0.627
FLSJWMDBR	12/2/1985	2.1	4.2768	2.5	1.444	0.364
FLSJWMDBR	3/31/1986	6.5	2.4057	1.7	0.53	0.141
FLSJWMDBR	6/2/1986	3.5	6.9498	1.3	0.878	0.216
FLSJWMDBR	8/4/1986	3	1	3.3	2.251	0.4
FLSJWMDBR	10/6/1986	3.2	5.8806	1.7	0.975	0.236
FLSJWMDBR	12/1/1986	2.8	1.8711	4.1	3.19	0.387
FLSJWMDBR	2/5/1987	6	4.2768	1.7	1.199	0.101
FLSJWMDBR	4/6/1987	5.1	1	1.2	3.27	0.345
FLSJWMDBR	6/1/1987	3.7	49.302	4	1.374	0.239
FLSJWMDBR	8/3/1987	2	17.6418	2.1	1.17	0.349
FLSJWMDBR	10/5/1987	5.5	1.6038	1	0.594	0.145
FLSJWMDBR	12/1/1987	1.7	2.1384	0.7	1.012	0.18
FLSJWMDBR	2/1/1988	5.3	1	0.9	4.005	0.077
FLSJWMDBR	3/10/1988	7.8	8.5536	4.4	16.895	1.512
FLSJWMDBR	4/4/1988	6.8	2.1384	1.3	1.017	0.08
FLSJWMDBR	6/6/1988	3.5	3.267	1.2	0.815	0.145
FLSJWMDBR	8/4/1988	2.9	65.2212	2.7	1.476	0.193
FLSJWMDBR	10/3/1988	2.5	10.989	1.3	1.273	0.275
FLSJWMDBR	12/6/1988	4.6	-	1.1	1.503	0.167
FLSJWMDBR	1/23/1989	-	-	-	-	-
FLSJWMDBR	1/30/1989	4.2	-	1.3	1.833	0.196
FLSJWMDBR	4/11/1989	7.2	1	0.8	0.98	0.132
FLSJWMDBR	8/3/1989	4	10.692	3	2.906	0.402
FLSJWMDBR	10/12/1989	6.3	10.692	1.3	0.816	0.09
FLSJWMDBR	2/13/1991	6.09	-	-	1.446	0.068
FLSJWMDBR	3/6/1991	5.22	-	-	5.26	0.221
FLSJWMDBR	4/3/1991	6.59	-	-	1.353	0.086

Station	Sample Date	DO (mg/L)	CHLAC (μg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDBR	5/15/1991	3.63	-	-	1.159	0.127
FLSJWMDBR	6/12/1991	2.48	-	-	2.933	0.421
FLSJWMDBR	7/16/1991	3.29	-	-	3.37	0.51
FLSJWMDBR	8/12/1991	2.6	-	-	1.773	0.247
FLSJWMDBR	9/26/1991	2.01	-	-	1.475	0.303
FLSJWMDBR	10/21/1991	4.1	-	-	1.702	0.383
FLSJWMDBR	11/19/1991	3.16	-	-	1.463	0.294
FLSJWMDBR	12/17/1991	6.35	-	-	0.776	0.129
FLSJWMDBR	1/14/1992	5.14	-	-	1.918	-
FLSJWMDBR	2/11/1992	9.66	-	-	1.232	0.06
FLSJWMDBR	3/10/1992	5.43	-	-	0.97	0.141
FLSJWMDBR	4/7/1992	6.92	-	-	0.658	0.116
FLSJWMDBR.S	4/20/1992	-	-	-	8.88	-
FLSJWMDBR	5/19/1992	6.85	-	-	1.477	0.111
FLSJWMDBR	6/16/1992	2.82	-	-	-	0.865
FLSJWMDBR	7/21/1992	3.57	-	-	1.779	0.551
FLSJWMDBR	4/12/1995	3.8	-	-	-	0.196
FLSJWMDBR	5/16/1995	3.44	-	-	1.564	0.24
FLSJWMDBR	6/6/1995	-	-	-	-	-
FLSJWMDBR	6/13/1995	2.61	-	-	-	0.23
FLSJWMDBR	6/21/1995	2.87	-	-	1.752	0.33
FLSJWMDBR	7/18/1995	1.85	-	-	1.087	0.341
FLSJWMDBR	8/15/1995	2.52	-	-	1.551	0.332
FLSJWMDBR	9/26/1995	5.33	-	-	2.299	2.24
FLSJWMDBR	10/10/1995	-	-	-	-	-
FLSJWMDBR	10/24/1995	-	-	-	1.404	0.187
FLSJWMDBR	11/21/1995	-	-	-	1.45	0.13
FLSJWMDBR	1/9/1996	-	-	-	1.365	0.205
FLSJWMDBR	2/6/1996	-	-	-	-	0.141
FLSJWMDBR	3/4/1996	6.42	-	-	5.41	0.293
FLSJWMDBR	4/2/1996	4.86	-	-	5.19	0.645
FLSJWMDBR	5/14/1996	4.77	-	-	1.274	0.159
FLSJWMDBR	6/11/1996	2.39	-	-	1.475	0.375
FLSJWMDBR	6/19/1996	-	-	-	-	-
FLSJWMDBR	7/16/1996	5.01	-	-	3.75	0.825
FLSJWMDBR	8/13/1996	4.64	-	-	3.194	0.428
FLSJWMDBR	9/10/1996	1.55	-	-	1.17	0.229
FLSJWMDBR	9/26/1996	-	-	-	-	-
FLSJWMDBR	10/9/1996	3.91	-	-	2.125	0.641
FLSJWMDBR	11/5/1996	4.54	-	-	1.533	0.091
FLSJWMDBR	12/3/1996	5.34	-	-	3.53	0.253
FLSJWMDBR	12/19/1996	-	-	-	-	-
FLSJWMDBR	1/14/1997	6.02	-	-	1.626	0.221
FLSJWMDBR	2/6/1997	3.2	2.403	-	1.167	0.173
FLSJWMDBR2	2/6/1997	6.32	2.67	-	1.345	0.225

Station	Sample Date	DO (mg/L)	CHLAC (μg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDBR	2/11/1997	5.28	-	-	1.314	0.206
FLSJWMDBR	3/11/1997	7.61	-	-	1.123	0.153
FLSJWMDBR	3/13/1997	-	-	-	-	-
FLSJWMDBR	4/8/1997	7.53	-	-	1.021	0.155
FLSJWMDBR	4/30/1997	5.7	-	-	2.522	0.812
FLSJWMDBR2	4/30/1997	6.53	-	-	2.897	0.838
FLSJWMDBR	5/14/1997	5.76	-	-	1.57	0.2
FLSJWMDBR	6/6/1997	-	-	-	-	-
FLSJWMDBR	6/10/1997	-	-	-	1.256	0.191
FLSJWMDBR	7/1/1997	4.31	-	-	1.439	0.359
FLSJWMDBR	8/14/1997	2.78	6.141	-	1.789	0.511
FLSJWMDBR2	8/14/1997	7.11	22.428	-	2.433	0.575
FLSJWMDBR	8/19/1997	3.22	-	-	1.605	0.425
FLA20030559	8/20/1997	7.7	-	3.6	-	-
FLA20030559	8/20/1997	-	-	-	1.85	0.26
FLSJWMDBR	9/9/1997	4.04	-	-	1.263	0.272
FLSJWMDBR	9/12/1997	-	-	-	-	-
FLSJWMDBR	9/29/1997	-	-	-	-	-
FLSJWMDBR	10/14/1997	2.63	-	-	1.021	0.339
FLSJWMDBR	11/14/1997	6.83	-	3.6	3.38	1.003
FLSJWMDBR	9/20/2000	3.78	-	2.9	2.159	1.244
FLSJWMDBR	10/16/2000	4.38	-	1	1.266	0.267
FLSJWMDBR	11/6/2000	4.79	14.62359	-	0.762	0.141
FLSJWMDBR	11/20/2000	7.16	-	1.6	0.908	0.107
FLSJWMDBR	12/7/2000	7.36	-	-	0.663	0.111
FLSJWMDBR	1/11/2001	9.96	-	-	0.67	0.166
FLSJWMDBR	2/7/2001	7.07	2.57121	-	3.147	0.176
FLSJWMDBR2	2/7/2001	8.36	10.24835	-	3.582	0.247
FLSJWMDBR	2/8/2001	6.7	-	-	2.371	0.166
FLSJWMDBR	3/15/2001	5.18	-	1.1	1.268	0.144
FLSJWMDBR	4/4/2001	7.71	-	1.3	1.039	0.152
FLSJWMDBR	5/9/2001	6.05	1	-	0.639	0.104
FLSJWMDBR2	5/9/2001	7.79	2.44572	-	1.408	0.137
FLSJWMDBR	5/10/2001	6.22	-	0.5	0.8	0.104
FLSJWMDBR	6/4/2001	4.68	-	-	0.885	0.253
FLSJWMDBR	7/2/2001	4.64	-	-	3.075	0.328
FLSJWMDBR	8/8/2001	3.51	1.87568	-	1.998	1.37
FLSJWMDBR	8/9/2001	3.58	-	-	1.821	1.03
FLSJWMDBR2	8/9/2001	3.01	3.9872	-	2.152	1.35
FLSJWMDBR	9/6/2001	3.11	-	1.8	1.265	0.442
FLSJWMDBR	10/2/2001	2.23	-	1.1	1.174	0.451
FLSJWMDBR	11/7/2001	2.71	1.02528	-	1.254	0.388
FLSJWMDBR2	11/8/2001	3.85	1	-	0.963	0.247
FLSJWMDBR	11/12/2001	3.82	-	-	1.182	0.255
FLSJWMDBR	12/10/2001	1	-	-	1.158	0.265

Station	Sample Date	DO (mg/L)	CHLAC (µg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDBR	1/9/2002	8.19	-	1	0.722	0.17
FLSJWMDBR	2/6/2002	5.03	-	1	1.118	0.149
FLSJWMDBR	2/6/2002	6.35	2.9904	-	0.227	0.204
FLSJWMDBR2	2/6/2002	5.82	2.94501	-	0.735	0.186
FLSJWMDBR	3/4/2002	6.22	-	-	3.561	0.229
FLSJWMDBR	4/10/2002	5.02	-	1.2	0.656	0.154
FLSJWMDBR	5/8/2002	5.46	-	0.8	0.577	0.185
FLSJWMDBR	5/9/2002	5.02	3.09186	-	0.608	0.199
FLSJWMDBR2	5/9/2002	5.15	1.77822	-	0.698	0.243
FLSJWMDBR	6/5/2002	3.01	-	1.4	-	0.245
FLSJWMDBR	7/15/2002	3.13	-	1.7	2.416	0.585
FLSJWMDBR	8/5/2002	2.13	-	1.6	1.995	0.508
FLSJWMDBR2	8/7/2002	2.54	9.28715	-	3.909	1.37
FLSJWMDBR	8/8/2002	6.43	29.9574	-	1.522	0.217
FLSJWMDBR	9/5/2002	3.2	-	-	1.297	0.377
FLSJWMDBR	10/3/2002	1.99	-	-	1.222	0.41
FLSJWMDBR	11/6/2002	1.97	1.07868	-	1.11	0.469
FLSJWMDBR	11/7/2002	1.98	-	1.5	1.041	0.469
FLSJWMDBR2	11/7/2002	2.4	2.03454	-	1.184	0.307
FLSJWMDBR	12/4/2002	6.59	-	-	0.681	0.21
FLSJWMDBR	1/14/2003	5.23	-	1.2	1.281	0.253
FLSJWMDBR	2/5/2003	10.5	4.39749	-	0.952	0.231
FLSJWMDBR2	2/6/2003	8.89	1.73817	-	0.631	0.118
FLSJWMDBR	2/11/2003	10.04	-	1.4	5.083	0.227
FLSJWMDBR	3/5/2003	5.17	-	3.1	-	1.157
FLSJWMDBR	4/7/2003	5.06	-	0.7	0.936	0.197
FLSJWMDBR	5/6/2003	3.46	-	-	0.876	0.217
FLSJWMDBR2	5/7/2003	4.51	1	-	0.609	0.181
FLSJWMDBR	5/8/2003	4.98	1	-	0.645	0.213
FLSJWMDBR	6/12/2003	2.44	-	1.8	1.616	0.522
FLSJWMDBR	7/9/2003	2.49	-	2	1.883	0.652
FLSJWMDBR	8/6/2003	4.7	-	3.7	5.745	1.451
FLSJWMDBR	8/26/2003	3.3	-	-	1.909	0.551
FLSJWMDBR2	8/26/2003	2.1	-	-	1.954	0.906
FLSJWMDBR	9/4/2003	1.23	-	1.1	1.283	0.493
FLSJWMDBR	10/13/2003	2.28	-	2	1.11989	0.35665
FLSJWMDBR	11/5/2003	5.35	-	-	3.55665	1.31648
FLSJWMDBR	11/5/2003	3.78	4.5172	-	3.16484	1.13432
FLSJWMDBR2	11/5/2003	4.99	-	-	4.88389	1.63771
FLSJWMDBR	12/3/2003	3.73	-	-	1.24658	0.28375
FLSJWMDBR	1/8/2004	5.02	-	2	1.02759	0.1689
FLSJWMDBR	2/3/2004	7.02	-	2	5.72861	0.48785
FLSJWMDBR	2/11/2004	2.45	1	-	1.83164	0.20506
FLSJWMDBR2	2/11/2004	3.71	-	-	2.24692	0.3333
FLSJWMDBR	3/2/2004	5.36	-	-	1.96182	0.21183

Station	Sample Date	DO (mg/L)	CHLAC (μg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDBR	4/1/2004	11.68	-	2	0.87346	0.12956
FLSJWMDBR	5/5/2004	6.64	-	2	1.05033	0.16517
FLSJWMDBR	5/12/2004	4.41	1.16412	-	0.78522	0.15774
FLSJWMDBR2	5/12/2004	5	4.50467	-	0.85803	0.21796
FLSJWMDBR	6/10/2004	3.21	-	2.4	1.41616	0.33602
FLSJWMDBR	7/6/2004	3.04	-	2	1.61767	0.23947
FLSJWMDBR	8/4/2004	2.91	-	3.6	-	0.48316
FLSJWMDBR	8/11/2004	5.94	-	-	1.22636	0.17154
FLSJWMDBR2	8/11/2004	5.61	-	-	2.16042	0.71015
FLSJWMDBR	9/14/2004	1.57	-	-	1.98549	1.47298
FLSJWMDBR	10/5/2004	2.72	-	2	1.41008	0.30228
FLSJWMDBR	11/4/2004	2.14	-	2	1.13063	0.32407
FLSJWMDBR	11/16/2004	3.67	2.04522	-	1.3208	0.24444
FLSJWMDBR2	11/16/2004	4.49	-	-	1.09765	0.30658
FLSJWMDBR	12/8/2004	3.17	-	2	1.08749	0.26147
FLSJWMDBR	1/4/2005	3.59	-	2	0.93753	0.19012
FLSJWMDBR	2/1/2005	8	-	2	-	0.09189
FLSJWMDBR	2/10/2005	4.9	1.54593	-	0.54495	0.09344
FLSJWMDBR2	2/10/2005	4.89	-	-	0.56794	0.18299
FLSJWMDBR	3/9/2005	8.38	-	2	4.09191	0.25834
FLSJWMDBR	4/4/2005		-	2.8	3.52411	0.58995
FLSJWMDBR	5/12/2005	5.99	-	2	1.22688	0.15378
FLSJWMDBR	5/18/2005	4.6	1.2282	-	0.8029	0.18362
FLSJWMDBR2	5/18/2005	4.24	2.5365	-	0.89774	0.24158
FLSJWMDBR	6/2/2005	6.83	-	2	4.42543	0.45012
FLSJWMDBR	7/5/2005	3.36	-	2.1	1.95591	0.43109
FLSJWMDBR	8/1/2005	3.26	-	2	1.38524	0.41728
FLSJWMDBR	8/10/2005	3.25	-	-	2.7891	1.22019
FLSJWMDBR2	8/10/2005	4.02	2.9637	-	2.38963	1.01876
FLSJWMDBR	9/15/2005	2.01	-	2	1.58043	0.6659
FLSJWMDBR	10/12/2005	5.61	-	-	1.09555	0.321
FLSJWMDBR	11/2/2005	4.37	-	-	0.96999	0.28951
FLSJWMDBR	11/10/2005	4.58	32.9478	-	-	0.32735
FLSJWMDBR2	11/10/2005	3.75	17.4885	-	-	0.43406
FLSJWMDBR	12/6/2005	5.12	-	-	1.61172	0.32092
FLSJWMDBR	1/5/2006	5.57	-	-	2.79784	0.36495
FLSJWMDBR	2/9/2006	7.56	-	-	2.51621	0.27956
FLSJWMDBR	3/1/2006	6.63	-	-	2.40864	0.35967
FLSJWMDBR	4/3/2006		-	-	0.68774	0.17849
FLSJWMDBR	5/9/2006	6.57	-	-	0.66706	0.19339
FLSJWMDBR	6/8/2006	3.59	-	-	0.98447	0.40863
FLSJWMDBR	8/3/2006	3.99	-	-	1.17465	0.40939
FLSJWMDBR	9/11/2006	5.28	-	-	2.09267	0.3754
FLSJWMDBR	10/9/2006	3.9	-	-	0.79337	0.15496
FLSJWMDBR	11/8/2006	6.4	-	-	1.07496	0.39028

Station	Sample Date	DO (mg/L)	CHLAC (μg/L)	BOD5 (mg/L)	TN (mg/L)	TP (mg/L)
FLSJWMDBR	12/7/2006	7.36	-	-	0.55714	0.30772
FLA20030559	1/31/2007	-	-	-	-	-
FLA20030559	1/31/2007	8.6	1	2	1.74	0.11
FLSJWMDBR	2/1/2007	9.73	-	-	1.07072	0.19122
FLSJWMDBR	3/12/2007	6.13	-	-	1.12698	0.15751
FLA20030559	3/29/2007	-	-	-	-	-
FLA20030559	3/29/2007	6.4	4.1	2	1.04	0.19
FLSJWMDBR	4/10/2007	7.43	-	-	0.525	0.12589
FLA20030559	5/2/2007	6.5	1	2	0.595	0.13
FLA20030559	5/2/2007	-	-	-	-	-
FLSJWMDBR	5/3/2007	5.49	-	-	0.4884	0.18771
FLSJWMDBR	6/7/2007	1.6	-	-	2.82658	0.27163
FLA20030559	6/28/2007	4.2	-	-	-	-
FLSJWMDBR	7/2/2007	2.34	-	-	1.23186	0.33356
FLSJWMDBR	8/28/2007	2.06	-	-	0.96538	0.49999
FLA20030559	9/11/2007	2.6	32	4	3.42	2.2
FLA20030559	10/10/2007	3.1	2.8	3	3.1	1.2
FLA20030559	12/13/2007	7.1	1.7	2	0.73	0.16
FLSJWMDBR	6/5/2008	4.11	3.80475	-	0.9548	0.3653
FLSJWMDBR	7/21/2008	3.72	1	-	2.3585	2.4062
FLSJWMDBR	8/4/2008	-	1	-	2.0556	1.4439

Appendix C: Kruskal–Wallis Analysis of DO, DOSAT, CHLAC, TN, TP, and BOD5 Observations versus Season in Dog Branch (WBID 2578)

Kruskal-Wallis One-Way Analysis of Variance for 311 cases
Dependent variable is VDO
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	74	10274.000
SPRING	83	13804.500
SUMMER	76	7079.500
WINTER	78	17358.000

Kruskal-Wallis Test Statistic = 83.623
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 310 cases
Dependent variable is DOSAT
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	74	9819.000
SPRING	83	14600.000
SUMMER	76	8203.000
WINTER	77	15583.000

Kruskal-Wallis Test Statistic = 51.556
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 103 cases
Dependent variable is VCHLAC
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	25	1343.000
SPRING	30	1263.000
SUMMER	22	1363.500
WINTER	26	1386.500

Kruskal-Wallis Test Statistic = 5.925
Probability is 0.115 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 312 cases
Dependent variable is VTN
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	74	9954.000
SPRING	82	9662.500
SUMMER	77	16303.000
WINTER	79	12908.500

Kruskal-Wallis Test Statistic = 48.780
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 320 cases
Dependent variable is VTP
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	76	12642.000
SPRING	85	10367.000
SUMMER	78	19013.500
WINTER	81	9337.500

Kruskal-Wallis Test Statistic = 97.574
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 116 cases
Dependent variable is VBOD
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	26	1438.500
SPRING	34	1822.500
SUMMER	27	2014.500
WINTER	29	1510.500

Kruskal-Wallis Test Statistic = 8.268
Probability is 0.041 assuming Chi-square distribution with 3 df

Appendix D: Kruskal–Wallis Analysis of DO, DOSAT, CHLAC, TN, TP, and BOD5 Observations versus Month in Dog Branch (WBID 2578)

Kruskal-Wallis One-Way Analysis of Variance for 311 cases
Dependent variable is VDO
Grouping variable is MONTH

Group	Count	Rank Sum
1	16	3413.500
2	38	8476.000
3	24	5468.500
4	26	5906.000
5	33	5838.000
6	24	2060.500
7	19	1574.500
8	39	4264.500
9	18	1240.500
10	22	2529.500
11	32	4646.500
12	20	3098.000

Kruskal-Wallis Test Statistic = 120.620
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 310 cases
Dependent variable is DOSAT
Grouping variable is MONTH

Group	Count	Rank Sum
1	16	2955.000
2	38	7729.000
3	23	4899.000
4	26	5935.000
5	33	6371.000
6	24	2294.000
7	19	1867.000
8	39	4953.000
9	18	1383.000
10	22	2590.000
11	32	4529.000
12	20	2700.000

Kruskal-Wallis Test Statistic = 86.953
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 103 cases
Dependent variable is VCHLAC
Grouping variable is MONTH

Group	Count	Rank Sum
1	1	10.500
2	20	1092.000
3	5	284.000
4	7	200.000
5	17	626.000
6	6	437.000
7	1	10.500
8	18	1134.000
9	3	219.000
10	7	400.500
11	14	747.000
12	4	195.500

Kruskal-Wallis Test Statistic = 20.103
Probability is 0.044 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 312 cases
Dependent variable is VTN
Grouping variable is MONTH

Group	Count	Rank Sum
1	19	3019.000
2	37	5728.000
3	23	4161.500
4	28	3963.500
5	33	2345.000
6	21	3354.000
7	18	3971.000
8	41	8840.000
9	18	3492.000
10	23	2825.000
11	31	4499.000
12	20	2630.000

Kruskal-Wallis Test Statistic = 67.149
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 320 cases
Dependent variable is VTP
Grouping variable is MONTH

Group	Count	Rank Sum
1	18	2228.000
2	39	3831.500
3	24	3278.000
4	28	2943.000
5	33	2695.500
6	24	4728.500
7	19	4401.500
8	41	10114.500
9	18	4497.500
10	23	4159.500
11	33	5650.500
12	20	2832.000

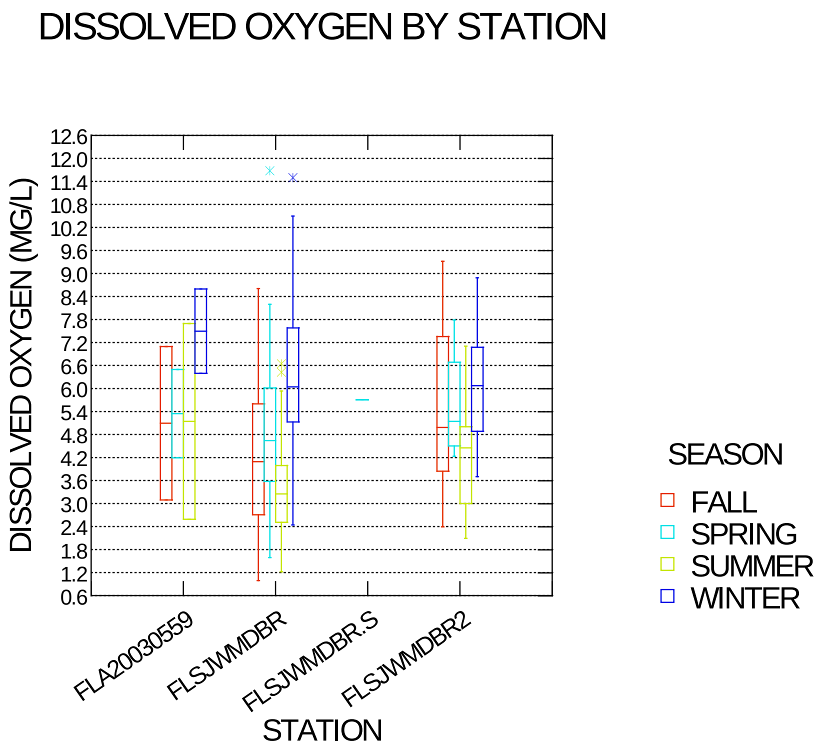
Kruskal-Wallis Test Statistic = 125.833
Probability is 0.000 assuming Chi-square distribution with 11 df

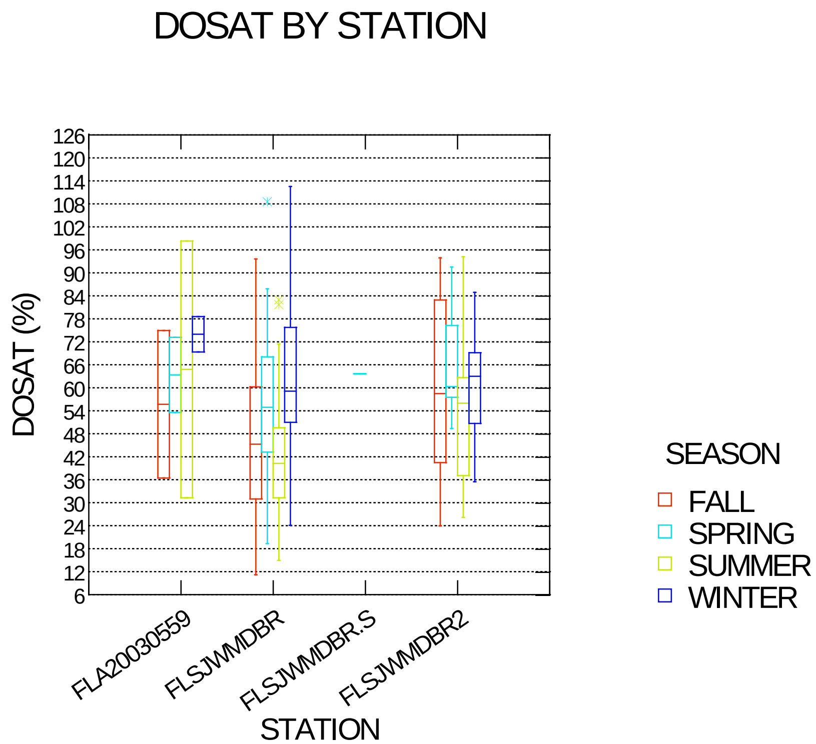
Kruskal-Wallis One-Way Analysis of Variance for 116 cases
Dependent variable is VBOD
Grouping variable is MONTH

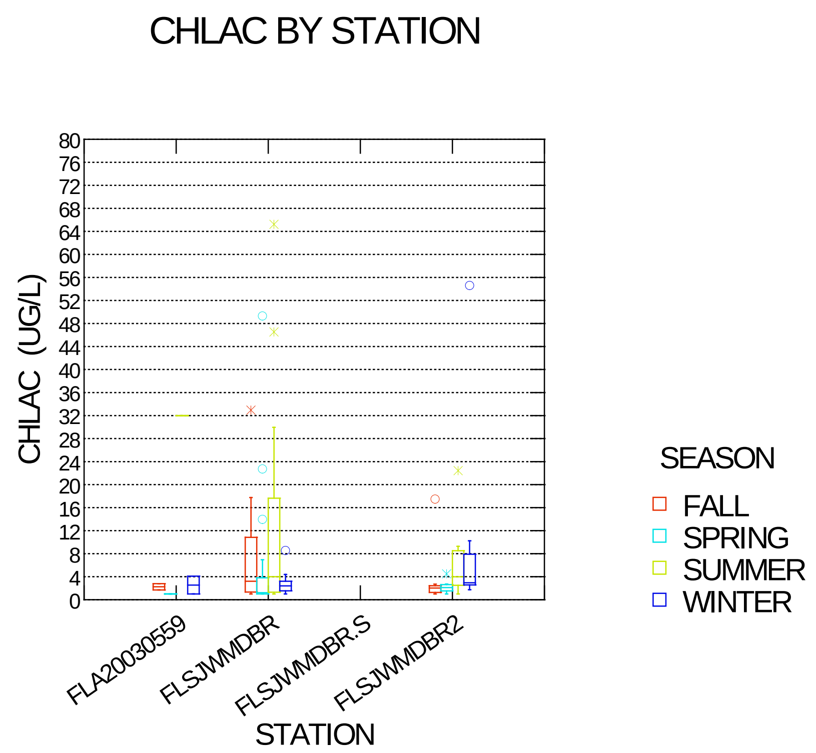
Group	Count	Rank Sum
1	7	330.500
2	11	459.000
3	11	721.000
4	14	652.000
5	9	334.000
6	11	836.500
7	7	380.500
8	12	1050.000
9	8	584.000
10	11	613.000
11	6	328.500
12	9	497.000

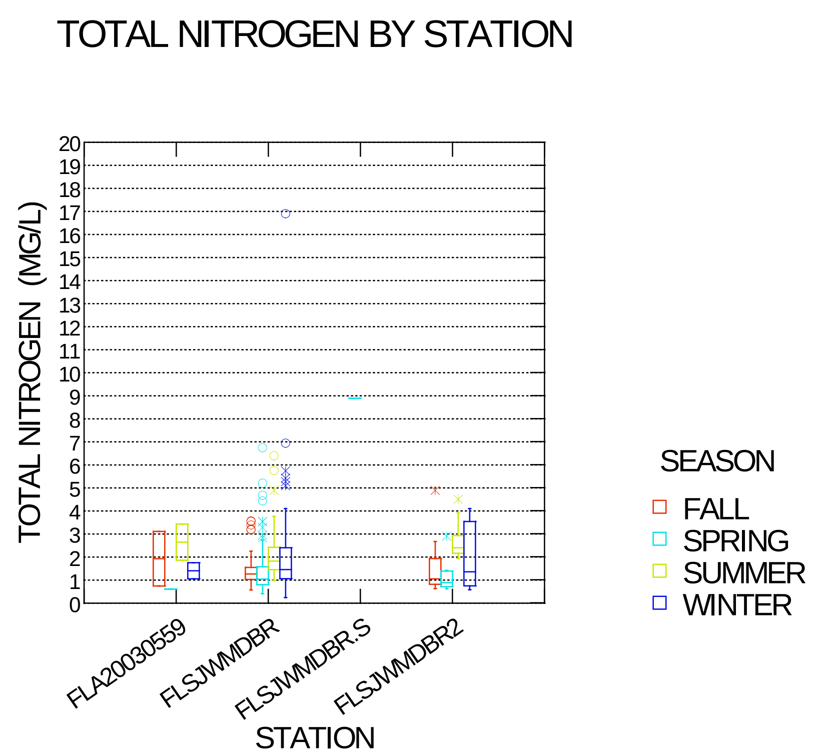
Kruskal-Wallis Test Statistic = 23.336
Probability is 0.016 assuming Chi-square distribution with 11 df

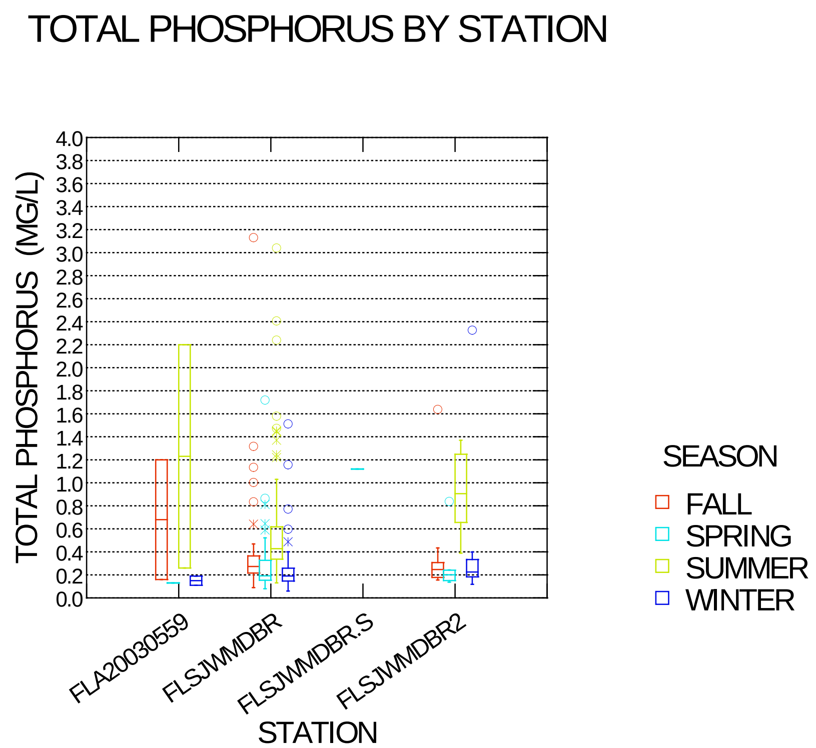
Appendix E: Chart of DO, DOSAT, CHLAC, TN, and TP Observations by Season, Station, and Year in Dog Branch (WBID 2578)

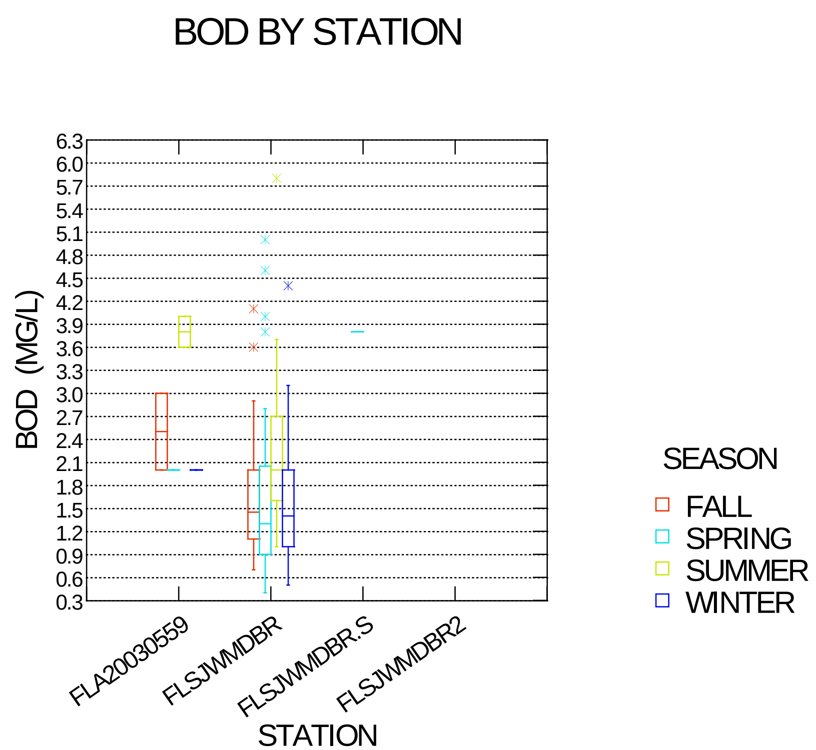


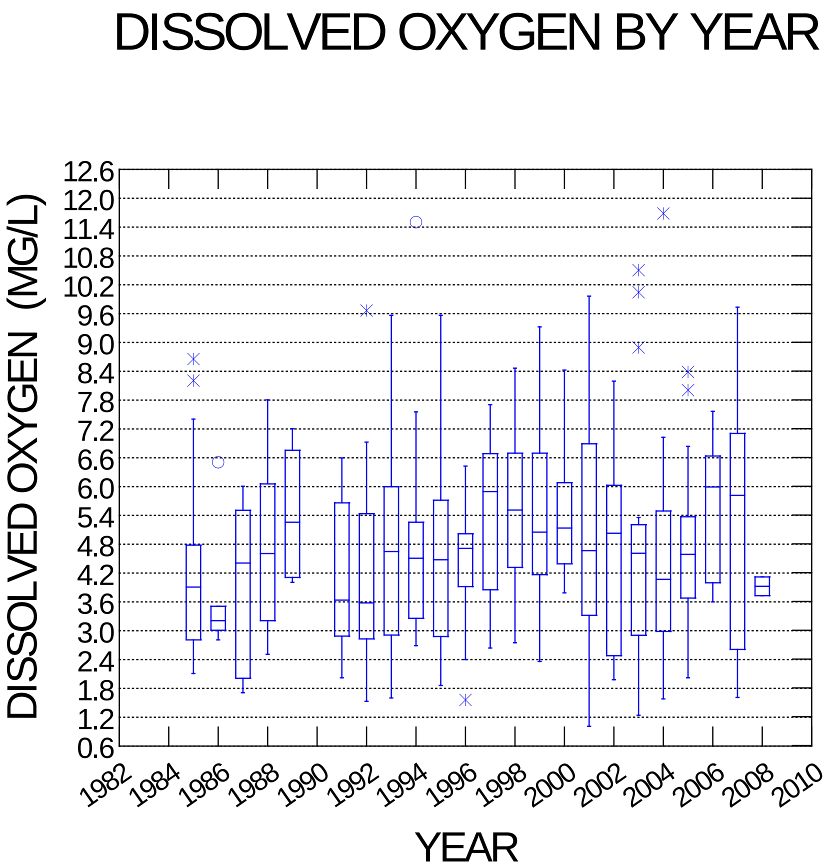

DOSAT BY STATION
126
120
114
108
102
96
90
84
78
72
66
60
54
48
42
36
30
24
18
12
6
DOSAT (%)
FLA20030559
FLSJWMDBR
FLSJWMDBR.S
FLSJWMDBR2
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

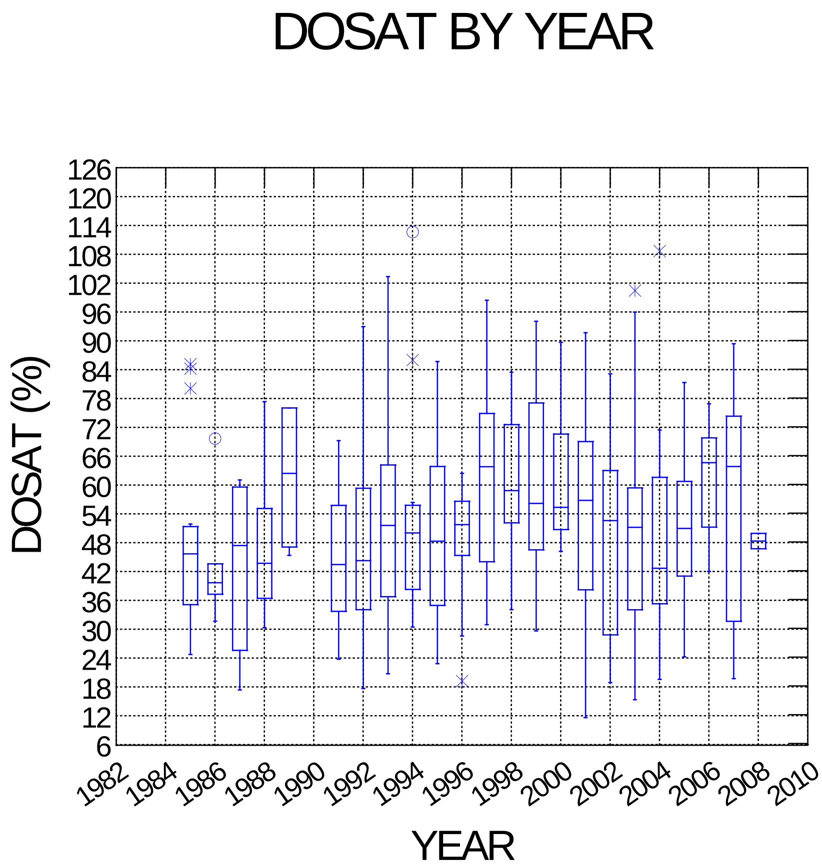

CHLAC BY STATION
CHLAC (UG/L)
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
76
80
FLA20030559
FLSJWMDBR
FLSJWMDBR.S
FLSJWMDBR2
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

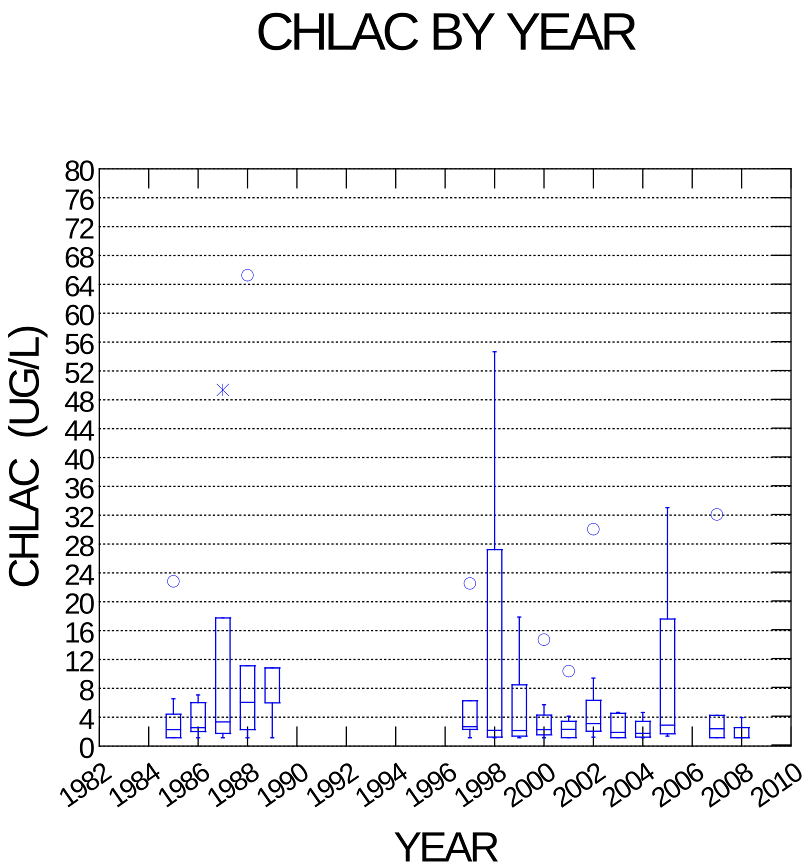

TOTAL NITROGEN BY STATION
TOTAL NITROGEN (MG/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
FLA20030559
FLSJWMDBR
FLSJWMDBR.S
FLSJWMDBR2
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

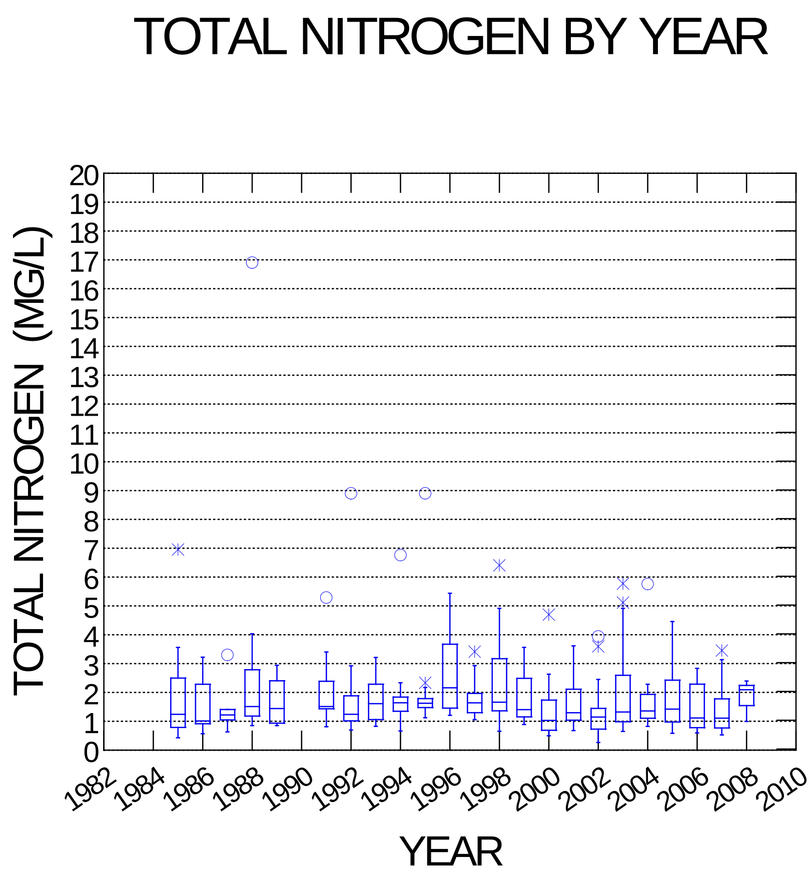

TOTAL PHOSPHORUS BY STATION
TOTAL PHOSPHORUS (MG/L)
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
FLA20030559
FLSJWMDBR
FLSJWMDBR.S
FLSJWMDBR2
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

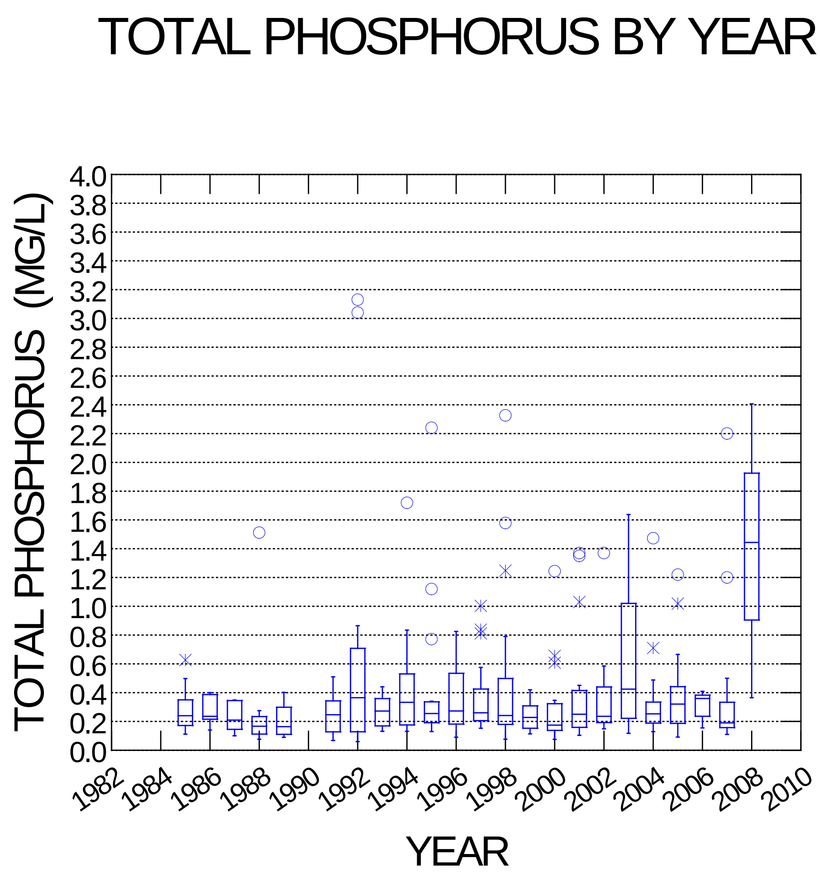

BOD BY STATION
BOD (MG/L)
6.3
6.0
5.7
5.4
5.1
4.8
4.5
4.2
3.9
3.6
3.3
3.0
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
FLA20030559
FLSJWMDBR
FLSJWMDBR.S
FLSJWMDBR2
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

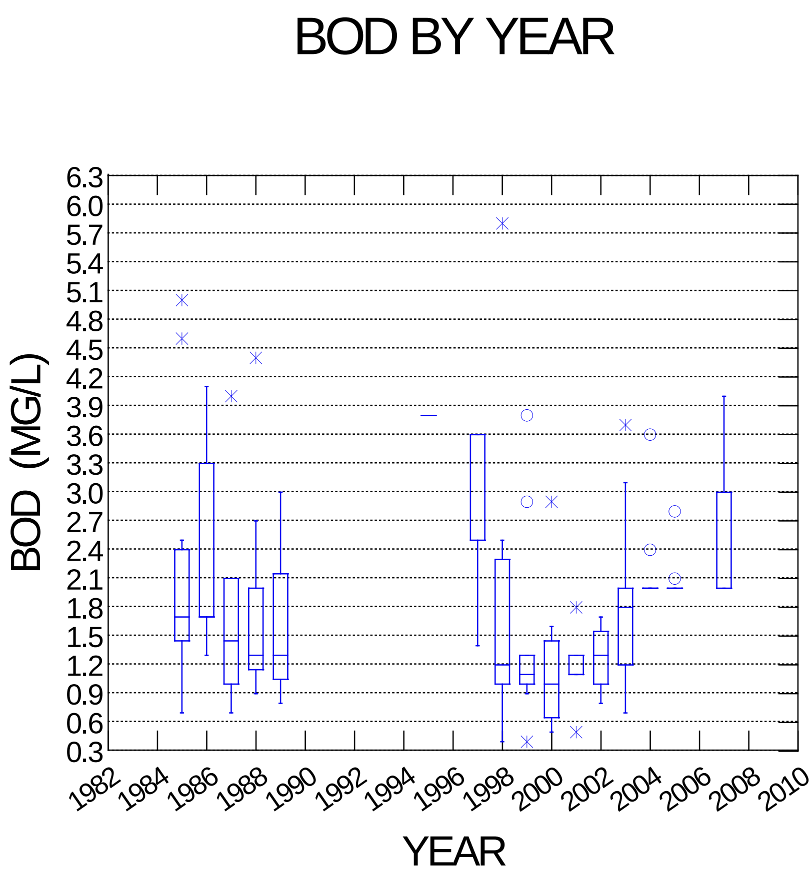

DISSOLVED OXYGEN BY YEAR
DISSOLVED OXYGEN (MG/L)
12.6
12.0
11.4
10.8
10.2
9.6
9.0
8.4
7.8
7.2
6.6
6.0
5.4
4.8
4.2
3.6
3.0
2.4
1.8
1.2
0.6
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

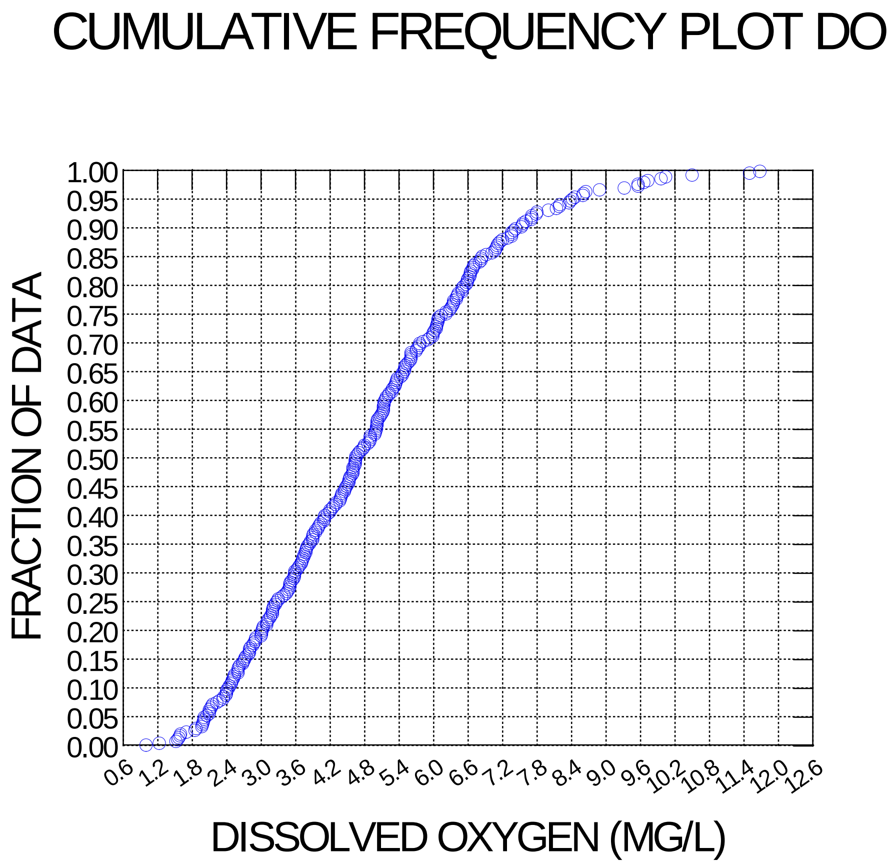

DOSAT BY YEAR
DOSAT (%)
126
120
114
108
102
96
90
84
78
72
66
60
54
48
42
36
30
24
18
12
6
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR


CHLAC BY YEAR
CHLAC (UG/L)
80
76
72
68
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

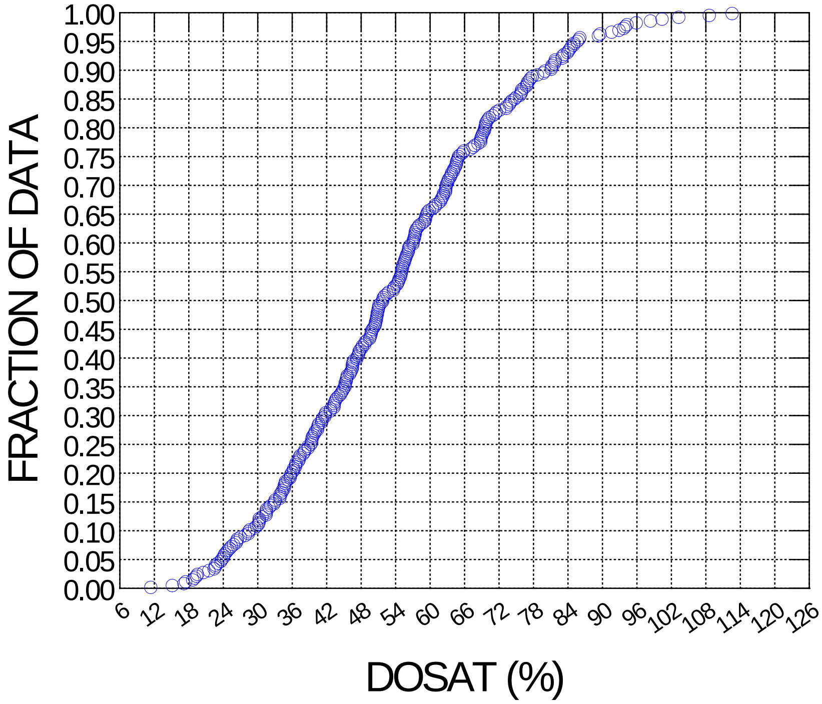

TOTAL NITROGEN BY YEAR
TOTAL NITROGEN (MG/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR


TOTAL PHOSPHORUS BY YEAR
TOTAL PHOSPHORUS (MG/L)
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

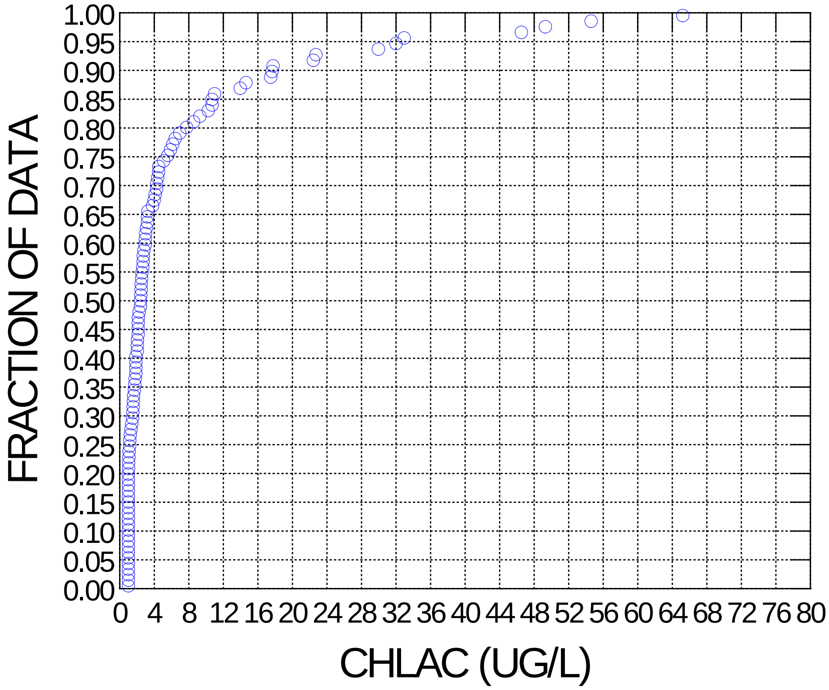

BOD BY YEAR
BOD (MG/L)
6.3
6.0
5.7
5.4
5.1
4.8
4.5
4.2
3.9
3.6
3.3
3.0
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
YEAR

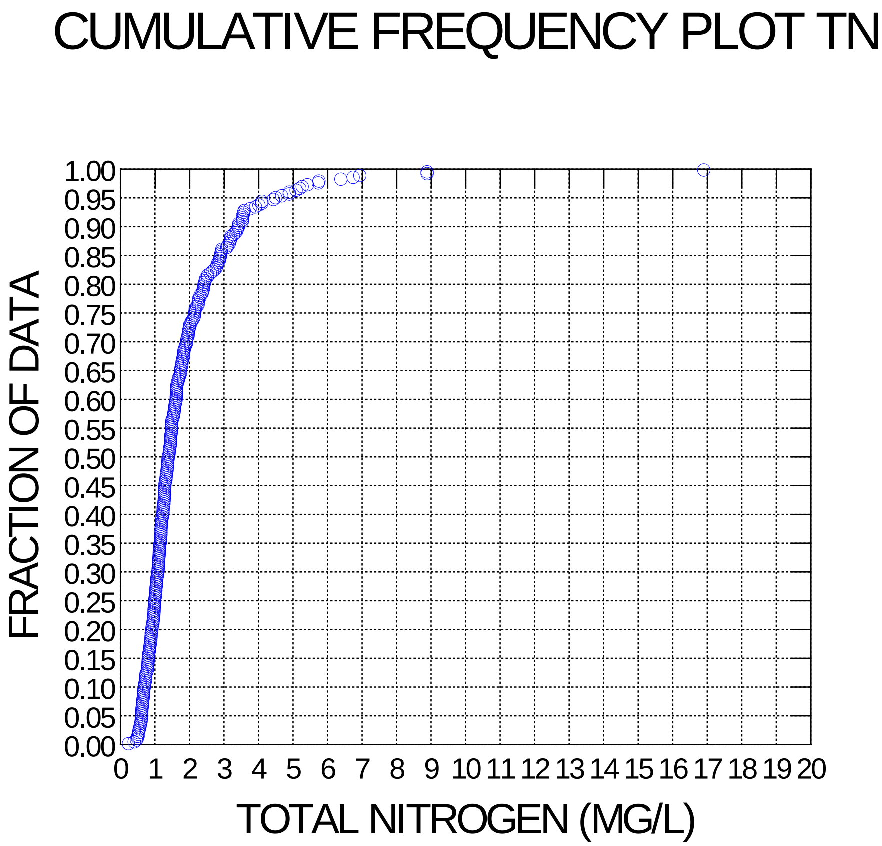

CUMULATIVE FREQUENCY PLOT DO
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.6
1.2
1.8
2.4
3.0
3.6
4.2
4.8
5.4
6.0
6.6
7.2
7.8
8.4
9.0
9.6
10.2
10.8
11.4
12.0
12.6
DISSOLVED OXYGEN (MG/L)

CUMULATIVE FREQUENCY PLOT DOSAT

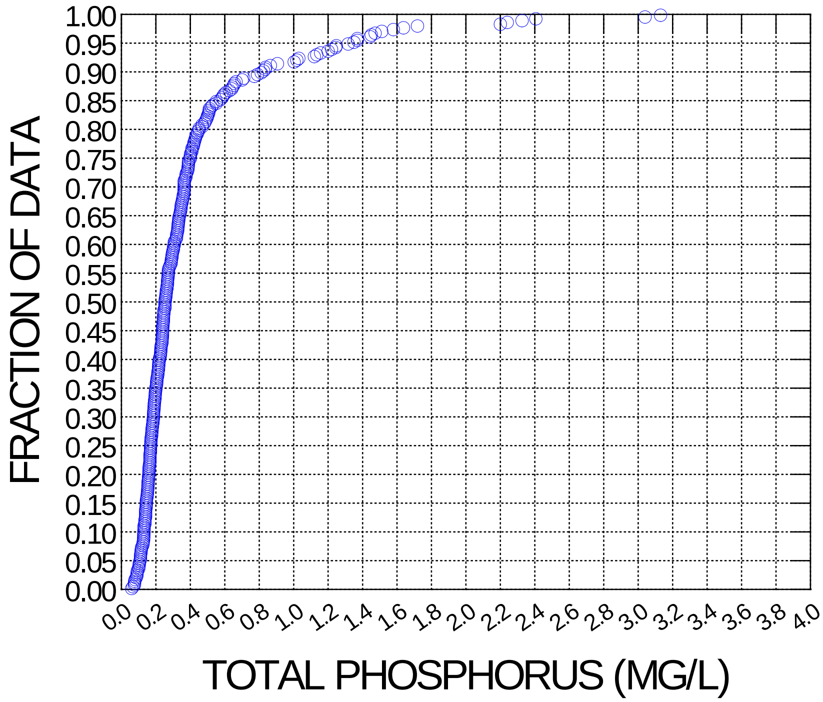


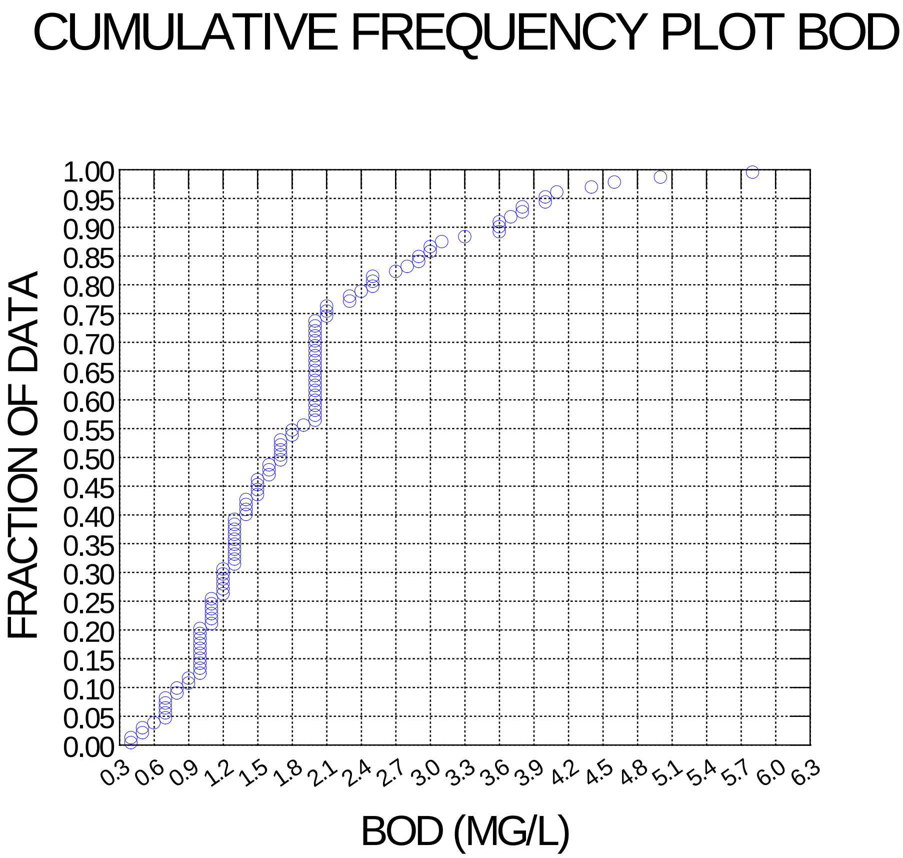
CUMULATIVE FREQUENCY PLOT CHLAC



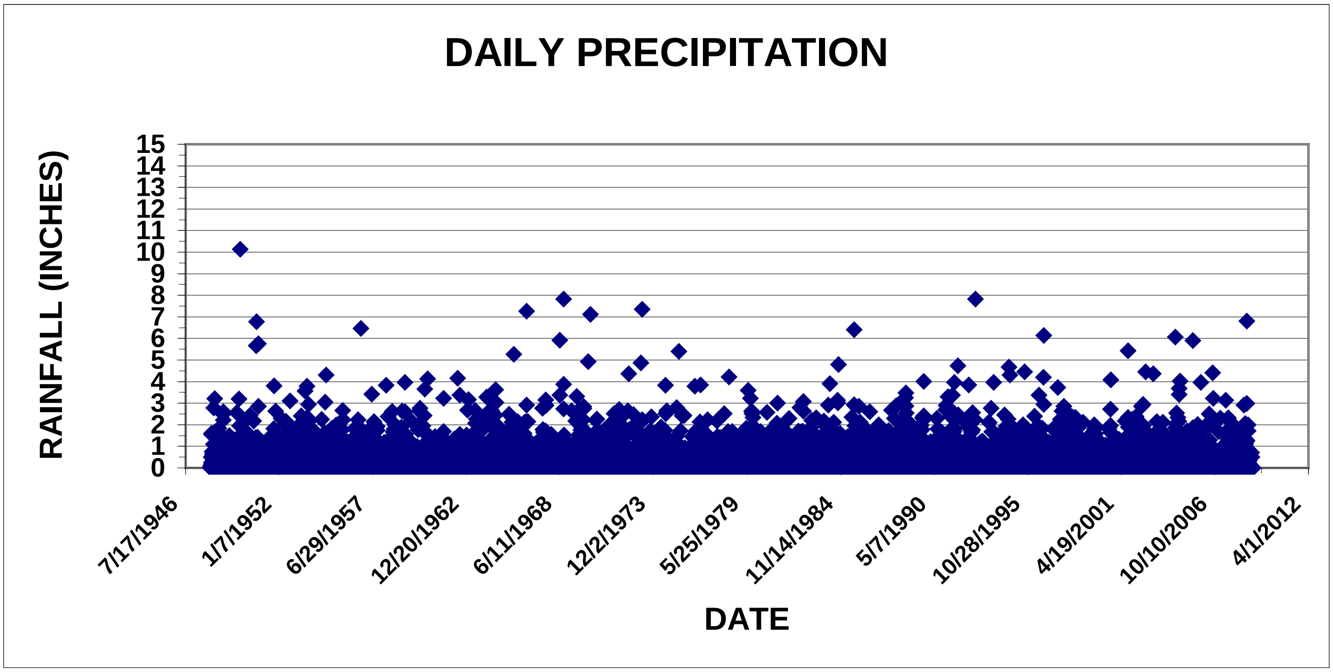

CUMULATIVE FREQUENCY PLOT TN
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
TOTAL NITROGEN (MG/L)

CUMULATIVE FREQUENCY PLOT TP




CUMULATIVE FREQUENCY PLOT BOD
FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3 3.6 3.9 4.2 4.5 4.8 5.1 5.4 5.7 6.0 6.3
BOD (MG/L)

Appendix F: Chart of Rainfall for JIA, 1948–2008



Appendix G: Spearman Correlation Matrix Analysis for Water Quality Parameters in Dog Branch (WBID 2578)

Spearman correlation matrix

- = Empty cell/no data

PARM	PRECIP	PRECIP3D	PRECIP7D	PRECIP14	JULIANDATE	VBOD	VCHLAC
PRECIP	1	-	-	-	-	-	-
PRECIP3DAY	0.556	1	-	-	-	-	-
PRECIP7DAY	0.355	0.7	1	-	-	-	-
PRECIP14DAY	0.252	0.527	0.756	1	-	-	-
JULIANDATE	-0.126	-0.126	-0.11	-0.089	-	-	-
VBOD	0.205	0.406	0.373	0.377	0.11	1	-
VCHLAC	0.005	0.053	0.005	-0.037	-0.089	0.277	1
VCHLOR	-0.111	-0.197	-0.287	-0.387	0.093	-0.397	-0.325
VCOLOR	0.181	0.277	0.408	0.472	-0.134	0.462	0.299
VCOND	-0.038	-0.09	-0.117	-0.264	0.099	-0.383	-0.261
VDO	-0.104	-0.184	-0.199	-0.252	0.045	-0.139	-0.04
DOSAT	-0.09	-0.148	-0.168	-0.21	0.068	-0.142	-0.013
VNH4	0.042	0.164	0.31	0.289	0.072	0.374	-0.084
VNO3O2	0.008	0.13	0.259	0.253	-0.006	0.179	-0.262
VPH	-0.115	-0.14	-0.172	-0.23	0.547	-0.019	0.038
VSO4	-0.093	-0.177	-0.24	-0.319	0.092	-0.418	-0.408
VTEMP	0.123	0.266	0.305	0.351	0	0.27	0.217
VTKN	0.103	0.317	0.488	0.532	-0.114	0.53	0.217
VTN	0.072	0.274	0.466	0.513	-0.102	0.467	0.112
VTOC	0.16	0.26	0.414	0.515	-0.096	0.568	0.178
VTORTH	0.181	0.327	0.383	0.388	-0.013	0.538	0.095
VTP	0.152	0.325	0.399	0.45	0.123	0.538	0.176
VTSS	0.015	0.008	-0.002	-0.009	0.118	0.208	0.243
VTURB	0.083	0.109	0.189	0.271	0.007	0.372	0.189

Spearman correlation matrix (cont.)

PARM	VCHLOR	VCOLOR	VCOND	VDO	DOSAT	VNH4	VNO3O2
VCHLOR	1	-	-	-	-	-	-
VCOLOR	-0.79	1	-	-	-	-	-
VCOND	0.659	-0.55	1	-	-	-	-
VDO	0.253	-0.453	0.174	1	-	-	-
DOSAT	0.265	-0.442	0.183	0.975	1	-	-
VNH4	-0.068	0.087	-0.024	-0.119	-0.148	1	-
VNO3O2	-0.049	-0.053	0.022	0.176	0.145	0.631	1
VPH	0.279	-0.414	0.2	0.329	0.354	-0.099	-0.086
VSO4	0.939	-0.789	0.665	0.304	0.303	0.052	0.134
VTEMP	-0.204	0.373	-0.081	-0.556	-0.382	0.037	-0.126
VTKN	-0.622	0.713	-0.42	-0.278	-0.268	0.429	0.359
VTN	-0.531	0.56	-0.342	-0.161	-0.171	0.558	0.631
VTOC	-0.808	0.891	-0.539	-0.377	-0.355	0.141	0.06
VTORTH	-0.537	0.639	-0.339	-0.53	-0.508	0.366	0.222
VTP	-0.528	0.64	-0.368	-0.5	-0.468	0.427	0.229
VTSS	0.018	0.015	-0.085	0.167	0.215	0.11	0.174
VTURB	-0.254	0.291	-0.247	-0.069	-0.065	0.495	0.429

PARM	VPH	VSO4	VTEMP	VTKN	VTN	VTOC	VTORTH
VPH	1	-	-	-	-	-	-
VSO4	0.22	1	-	-	-	-	-
VTEMP	-0.107	-0.244	1	-	-	-	-
VTKN	-0.381	-0.551	0.311	1	-	-	-
VTN	-0.328	-0.411	0.171	0.921	1	-	-
VTOC	-0.372	-0.784	0.317	0.733	0.623	1	-
VTORTH	-0.337	-0.515	0.437	0.615	0.535	0.627	1
VTP	-0.291	-0.494	0.444	0.681	0.596	0.662	0.904
VTSS	0.098	0.038	0.108	0.162	0.149	-0.005	0.017
VTURB	-0.183	-0.157	0.113	0.528	0.571	0.341	0.359

PARM	VTP	VTSS	VTURB
VTP	1	-	-
VTSS	0.162	1	-
VTURB	0.501	0.434	1

Pairwise frequency table

- = Empty cell/no data

PARM	PRECIP	PRECIP3D	PRECIP7D	PRECIP14	JULIANDATE	VBOD	VCHLAC
PRECIP	339	-	-	-	-	-	-
PRECIP3DAY	339	339	-	-	-	-	-
PRECIP7DAY	339	339	339	-	-	-	-
PRECIP14DAY	339	339	339	339	-	-	-
JULIANDATE	339	339	339	339	339	-	-
VBOD	116	116	116	116	116	116	-
VCHLAC	103	103	103	103	103	40	103
VCHLOR	317	317	317	317	317	114	103
VCOLOR	222	222	222	222	222	103	90
VCOND	299	299	299	299	299	99	90
VDO	311	311	311	311	311	113	102
DOSAT	310	310	310	310	310	112	101
VNH4	313	313	313	313	313	113	100
VNO3O2	313	313	313	313	313	111	101
VPH	313	313	313	313	313	111	102
VSO4	308	308	308	308	308	102	92
VTEMP	320	320	320	320	320	113	102
VTKN	322	322	322	322	322	115	103
VTN	312	312	312	312	312	111	101
VTOC	241	241	241	241	241	77	70
VTORTH	281	281	281	281	281	107	91
VTP	320	320	320	320	320	115	103
VTSS	315	315	315	315	315	115	102
VTURB	320	320	320	320	320	115	102

PARM	VCHLOR	VCOLOR	VCOND	VDO	DOSAT	VNH4	VNO3O2
VCHLOR	317	-	-	-	-	-	-
VCOLOR	218	222	-	-	-	-	-
VCOND	291	216	299	-	-	-	-
VDO	303	217	294	311	-	-	-
DOSAT	302	216	294	310	310	-	-
VNH4	307	217	287	299	298	313	-
VNO3O2	308	217	287	299	298	307	313
VPH	305	217	296	307	307	301	301
VSO4	303	220	294	293	292	298	298
VTEMP	311	219	299	310	310	307	308
VTKN	316	221	295	307	306	312	312
VTN	307	217	286	298	297	306	312
VTOC	237	195	234	231	231	232	234
VTORTH	277	190	258	269	268	274	275
VTP	315	221	294	306	305	310	310
VTSS	308	219	289	301	300	304	304
VTURB	314	222	296	307	306	309	309

Pairwise frequency table (cont.)

PARM	VPH	VSO4	VTEMP	VTKN	VTN	VTOC	VTORTH
VPH	313	-	-	-	-	-	-
VSO4	295	308	-	-	-	-	-
VTEMP	313	302	320	-	-	-	-
VTKN	309	307	316	322	-	-	-
VTN	300	297	307	312	312	-	-
VTOC	234	240	238	241	234	241	-
VTORTH	269	268	276	281	275	204	281
VTP	308	305	314	319	309	241	279
VTSS	303	300	310	313	303	236	274
VTURB	309	305	315	318	308	241	279

PARM	VTP	VTSS	VTURB
VTP	320	-	-
VTSS	312	315	-
VTURB	318	313	320

Appendix H: Linear Regression Analysis of DO and CHLAC Observations versus Nutrients and BOD in Dog Branch (WBID 2578)

Dep Var: VDO N: 113 Multiple R: 0.094 Squared multiple R: 0.009

Adjusted squared multiple R: 0.000 Standard error of estimate: 2.090

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	5.171	0.406	0.000	.	12.736	0.000
VBOD	-0.188	0.189	-0.094	1.000	.994	0.323

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	4.311	1	4.311	0.987	0.323
Residual	484.826	111	4.368		

*** WARNING ***
Case 163 has large leverage (Leverage = 0.135)
Case 274 is an outlier (Studentized Residual = 3.470)

Durbin-Watson D Statistic 1.455
First Order Autocorrelation 0.267

Dep Var: VDO N: 298 Multiple R: 0.020 Squared multiple R: 0.000

Adjusted squared multiple R: 0.000 Standard error of estimate: 1.995

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	4.850	0.181	0.000	.	26.846	0.000
VTN	0.026	0.076	0.020	1.000	0.341	0.733

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.463	1	0.463	0.116	0.733
Residual	1177.779	296	3.979		

*** WARNING ***
Case 28 has large leverage (Leverage = 0.336)
Case 54 has large leverage (Leverage = 0.076)
Case 97 has large leverage (Leverage = 0.076)

Durbin-Watson D Statistic 1.162
First Order Autocorrelation 0.418

Dep Var: VDO N: 306 Multiple R: 0.225 Squared multiple R: 0.050

Adjusted squared multiple R: 0.047 Standard error of estimate: 1.943

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	5.278	0.150	0.000	.	35.130	0.000
VTP	-1.035	0.257	-0.225	1.000	-4.021	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	61.054	1	61.054	16.167	0.000
Residual	1148.075	304	3.777		

*** WARNING ***
Case 58 has large leverage (Leverage = 0.126)
Case 60 has large leverage (Leverage = 0.135)
Case 105 has large leverage (Leverage = 0.063)
Case 153 has large leverage (Leverage = 0.069)
Case 334 has large leverage (Leverage = 0.061)
Case 338 has large leverage (Leverage = 0.074)

Durbin-Watson D Statistic 1.263
First Order Autocorrelation 0.368

Dep Var: VDO N: 295 Multiple R: 0.604 Squared multiple R: 0.365

Adjusted squared multiple R: 0.352 Standard error of estimate: 1.599

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	10.244	0.757	0.000	.	13.528	0.000
VTEMP	-0.226	0.038	-0.550	0.260	-5.975	0.000
VTN	0.091	0.362	0.057	0.043	0.251	0.802
VTP	-4.254	1.505	-0.924	0.021	-2.828	0.005
VTEMP*VTN	-0.015	0.019	-0.209	0.032	-0.794	0.428
VTEMP*VTP	0.105	0.063	0.557	0.020	1.669	0.096
VTN*VTP	0.539	0.158	0.445	0.130	3.413	0.001

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	423.887	6	70.648	27.618	0.000
Residual	736.706	288	2.558		

*** WARNING ***
Case 4 has large leverage (Leverage = 0.201)
Case 58 has large leverage (Leverage = 0.188)
Case 60 has large leverage (Leverage = 0.557)
Case 83 has large leverage (Leverage = 0.256)
Case 97 has large leverage (Leverage = 0.224)
Case 105 has large leverage (Leverage = 0.108)
Case 111 has large leverage (Leverage = 0.104)
Case 153 has large leverage (Leverage = 0.603)
Case 160 has large leverage (Leverage = 0.249)
Case 252 has large leverage (Leverage = 0.107)
Case 260 has large leverage (Leverage = 0.114)
Case 338 has large leverage (Leverage = 0.186)

Durbin-Watson D Statistic 1.541
First Order Autocorrelation 0.227

Dep Var: VDO N: 310 Multiple R: 0.569 Squared multiple R: 0.324

Adjusted squared multiple R: 0.322 Standard error of estimate: 1.643

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	9.756	0.415	0.000	.	23.531	0.000
VTEMP	-0.235	0.019	-0.569	1.000	-12.148	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	398.141	1	398.141	147.562	0.000
Residual	831.021	308	2.698		

Durbin-Watson D Statistic 1.534
First Order Autocorrelation 0.231

Dep Var: VCHLAC N: 102 Multiple R: 0.230 Squared multiple R: 0.053

Adjusted squared multiple R: 0.044 Standard error of estimate: 11.431

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	-5.937	5.469	0.000	.	-1.086	0.280
VTEMP	0.596	0.252	0.230	1.000	2.365	0.020

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	731.148	1	731.148	5.595	0.020
Residual	13067.258	100	130.673		

*** WARNING ***
Case 23 is an outlier (Studentized Residual = 3.788)
Case 31 is an outlier (Studentized Residual = 5.587)
Case 153 is an outlier (Studentized Residual = 5.197)

Durbin-Watson D Statistic 1.985
First Order Autocorrelation 0.005

Dep Var: VCHLAC N: 100 Multiple R: 0.558 Squared multiple R: 0.312

Adjusted squared multiple R: 0.267 Standard error of estimate: 9.803

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	-23.177	8.394	0.000	.	-2.761	0.007
VTN	1.327	3.956	0.135	0.046	0.336	0.738
VTEMP	1.509	0.407	0.600	0.283	3.705	0.000
VTP	25.194	22.451	1.011	0.009	1.122	0.265
VTEMP*VTN	-0.144	0.214	-0.318	0.033	-0.672	0.503
VTEMP*VTP	-1.629	0.665	-1.604	0.017	-2.448	0.016
VTN*VTP	5.571	3.198	0.773	0.038	1.742	0.085

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P

Regression	4044.392	6	674.065	7.015	0.000
Residual	8936.503	93	96.091		

*** WARNING ***
Case 4 has large leverage (Leverage = 0.591)
Case 23 is an outlier (Studentized Residual = 4.508)
Case 31 is an outlier (Studentized Residual = 6.825)
Case 58 has large leverage (Leverage = 0.463)
Case 60 has large leverage (Leverage = 6.803)
Case 83 has large leverage (Leverage = 3.284)
Case 97 has large leverage (Leverage = 2.512)
Case 105 has large leverage (Leverage = 0.323)
Case 111 has large leverage (Leverage = 0.312)
Case 153 has large leverage (Leverage = 0.932)
Case 160 has large leverage (Leverage = 0.861)
Case 161 is an outlier (Studentized Residual = 3.833)
Case 162 has large leverage (Leverage = 0.325)
Case 163 has large leverage (Leverage = 0.856)
Case 197 has large leverage (Leverage = 0.246)
Case 241 has large leverage (Leverage = 0.252)
Case 252 has large leverage (Leverage = 0.316)
Case 260 has large leverage (Leverage = 1.284)
Case 267 has large leverage (Leverage = 0.708)
Case 270 has large leverage (Leverage = 0.274)
Case 334 has large leverage (Leverage = 0.326)
Case 338 has large leverage (Leverage = 0.402)

Durbin-Watson D Statistic 2.096
First Order Autocorrelation -0.049

Dep Var: VCHLAC N: 102 Multiple R: 0.524 Squared multiple R: 0.275

Adjusted squared multiple R: 0.253 Standard error of estimate: 10.103

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	-24.567	6.197	0.000	.	-3.965	0.000
VTEMP	1.391	0.294	0.537	0.573	4.729	0.000
VTP	60.063	11.104	2.339	0.040	5.409	0.000
VTEMP*VTP	-2.439	0.477	-2.330	0.036	-5.110	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	3795.591	3	1265.197	12.395	0.000
Residual	10002.816	98	102.070		

*** WARNING ***
Case 23 is an outlier (Studentized Residual = 4.264)
Case 31 is an outlier (Studentized Residual = 6.422)
Case 58 has large leverage (Leverage = 0.396)
Case 60 has large leverage (Leverage = 0.634)
Case 105 has large leverage (Leverage = 0.209)
Case 153 has large leverage (Leverage = 0.925)
Case 161 is an outlier (Studentized Residual = 3.637)
Case 334 has large leverage (Leverage = 0.191)
Case 338 has large leverage (Leverage = 0.327)

Durbin-Watson D Statistic	1.999
First Order Autocorrelation	-0.002

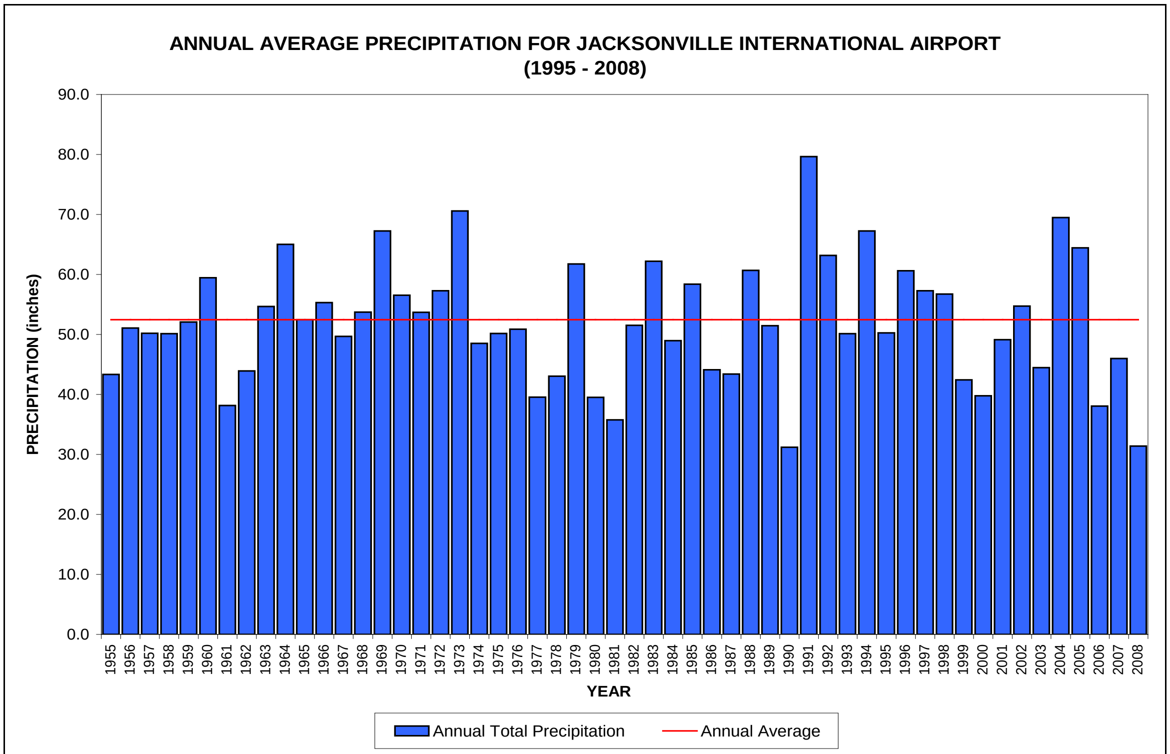
Appendix I: Monthly and Annual Precipitation at JIA, 1955–2008

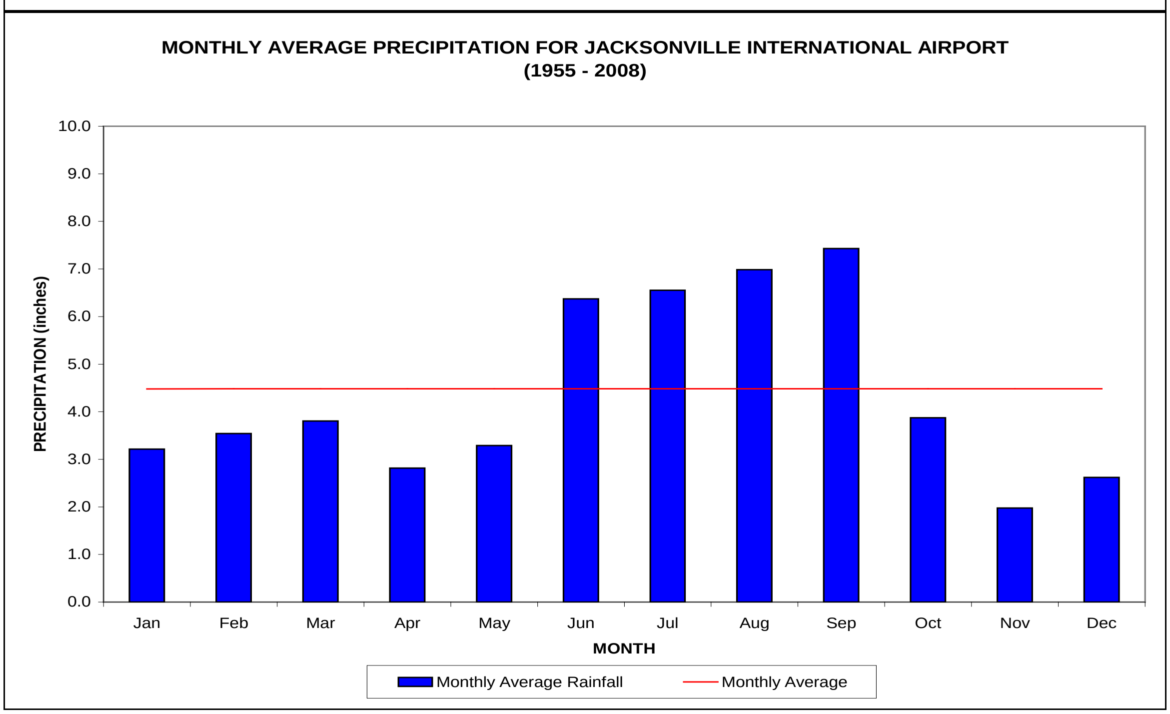
Rainfall is in inches, and represents data from JIA.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1955	3.1	2.46	1.66	1.5	4.51	2.7	5.53	3.85	10.6	5.36	1.9	0.2	**43.33**
1956	2.9	2.94	0.81	2.33	3.98	7.87	8.25	5.24	2.89	13.4	0.4	0	**51.08**
1957	0.3	1.69	3.87	1.61	5.25	7.1	12.3	3.3	8.33	3.5	1.6	1.3	**50.18**
1958	3.4	3.74	3.38	8.24	3.79	3.96	4.37	4.67	4.75	5.07	2	2.8	**50.14**
1959	3	5.22	9.75	2.65	9.2	2.94	4.51	2.86	5.67	3.12	2.2	1	**52.08**
1960	2.1	5.17	6.94	3.54	1.18	4.7	16.2	6.5	8.57	2.95	0.1	1.5	**59.45**
1961	2.9	4.85	1.17	4.16	3.06	5.27	3.48	10.6	1.02	0.27	0.9	0.5	**38.15**
1962	2.2	0.52	3.1	2.36	1.12	8.22	6.31	10.1	4.37	1.13	2.1	2.5	**43.9**
1963	5.4	6.93	2.23	1.75	1.74	12.5	6.47	4.95	4.88	1.53	2.7	3.6	**54.66**
1964	7.3	6.55	1.76	4.65	4.8	4.67	6.12	5.63	10.3	5.09	3.3	4.8	**65.03**
1965	0.7	5.5	3.91	0.95	0.94	9.79	2.71	9.58	11	1.75	1.9	3.8	**52.47**
1966	4.6	5.97	0.71	2.25	10.4	7.74	11.1	3.88	5.94	1.38	0.2	1.1	**55.3**
1967	3.1	4.35	0.81	2	1.18	12.9	5.22	12.3	1.8	1.13	0.2	4.7	**49.68**
1968	0.8	3.05	1.2	0.99	2.17	12.3	6.84	16.2	2.68	5.09	1.3	1.1	**53.72**
1969	0.8	3.39	4.23	0.34	3.78	5.12	5.89	15.1	10.3	9.81	4.6	3.9	**67.26**
1970	4.2	8.85	9.98	1.77	1.84	2.65	7.6	11	3.2	3.95	0	1.6	**56.55**
1971	2	2.55	2.41	4.07	1.9	5.52	5.07	12.8	4.17	6.46	0.8	5.9	**53.69**
1972	5.8	3.48	4.43	2.98	8.26	6.75	3.15	9.76	2.6	4.46	4.2	1.4	**57.29**
1973	4.6	5.07	10.2	11.6	5.33	4.1	5.45	7.49	7.86	4.08	0.4	4.3	**70.57**
1974	0.3	1.28	3.47	1.53	4.14	5.53	9.83	11.2	8.13	0.34	1	1.7	**48.52**
1975	3.5	2.58	2.46	5.78	7	5.21	6.36	6.23	5.24	3.63	0.4	1.8	**50.15**
1976	2.3	1.05	3.41	0.63	10	4.26	5.41	6.37	8.56	1.63	2.4	4.8	**50.87**
1977	3	3.24	1.03	1.76	3.07	2.65	1.97	7.26	7.45	1.68	3.1	3.4	**39.56**
1978	4.6	4.17	2.83	2.24	9.18	2.62	6.67	2.39	4.4	1.26	0.8	1.8	**43.04**
1979	6.3	3.75	1	4.18	7.54	5.91	4.67	4.78	17.8	0.25	3.6	2	**61.76**
1980	2.6	1.06	6.83	3.91	3.02	4.59	5.29	3.97	3.03	2.69	2.3	0.2	**39.53**
1981	0.9	4.53	5.41	0.32	1.48	3.31	2.46	6.47	1.22	1.35	4.9	3.4	**35.77**
1982	3	1.67	4.26	3.6	3.55	8.06	3.81	6.93	9.32	3.37	1.9	2	**51.52**
1983	7.2	4.27	8.46	4.65	1.38	6.86	6.11	4.63	4.61	4.29	3.3	6.4	**62.19**
1984	2.1	4.67	5.77	3.14	1.46	4.76	6.01	3.78	12.3	1.53	3.3	0.1	**48.96**
1985	1.1	1.45	1.26	2.76	2.08	3.71	6.33	8.93	16.8	8.34	2.1	3.6	**58.39**
1986	4.2	4.72	5.44	0.93	2.13	2.53	3.27	9.6	1.99	1.8	2.9	4.7	**44.1**
1987	4.1	6.47	6.27	0.14	0.75	4.18	4.4	4.48	7.13	0.3	5	0.2	**43.39**
1988	6.4	6.08	2.65	3.44	1.35	3.71	4.5	8.48	16.4	2.35	4.3	1.1	**60.68**
1989	1.7	1.77	2.14	2.79	1.55	3.66	8.98	9.16	14.4	1.39	0.5	3.4	**51.45**
1990	1.8	4.07	1.59	1.34	0.18	1.59	6.53	3.81	2.6	4.54	1.2	1.9	**31.2**
1991	10	1.52	7.33	6.31	9.35	11.7	15.9	3.48	6.2	6.36	0.7	0.6	**79.63**
1992	5.8	2.64	4.09	5.33	5.97	7.04	3.32	10.8	7.33	8.34	1.9	0.7	**63.18**
1993	3.9	2.89	5.98	0.85	1.6	2.52	7.54	2.96	7.6	8.84	3.6	1.9	**50.12**
1994	6.6	0.92	2.14	1.51	3.15	14	8.26	3.29	9.79	10.2	3.5	3.9	**67.26**
1995	1.9	2.07	3.67	1.77	1.77	5.35	9.45	9.93	5.41	3.53	3.2	2.2	**50.25**
1996	1.1	1.11	6.83	2.85	0.72	11.4	4.2	7.83	8.49	11.5	1.4	3.2	**60.63**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1997	2.9	1.28	1.84	4.56	3.43	6.33	7.69	8.24	3.97	4.84	2.4	9.8	**57.27**
1998	3.5	11.1	2.64	4.71	0.96	2.95	7.29	10.1	7.65	3.01	2.4	0.4	**56.72**
1999	4.6	1.7	0.4	1.92	1.02	7.75	3.56	3.51	13	3.24	0.8	0.9	**42.44**
2000	2.8	1.17	1.79	2.6	1.15	2.43	5.69	7.38	11.6	0.23	1.6	1.4	**39.77**
2001	0.9	0.68	5.48	0.62	2.56	5.59	8.31	3.58	16	0.81	1.4	3.1	**49.14**
2002	4.5	0.82	4.38	2.41	0.47	6.24	7.8	8.14	9.31	2.58	2.7	5.4	**54.72**
2003	0.1	4.66	10.7	2.63	2.54	6.75	7.33	1.83	3.04	2.98	0.7	1.2	**44.47**
2004	1.6	4.47	1.36	2.02	1.24	17.2	8.6	9.85	16.3	1.32	2.9	2.7	**69.47**
2005	1.9	3.56	3.67	4.53	3.51	14.8	7.37	4.43	5.76	6.49	1.1	7.4	**64.44**
2006	2.30	3.91	0.68	1.22	2.01	7.25	3.97	7.08	4.55	1.81	0.39	2.90	**38.07**
2007	2.29	2.40	2.22	1.02	1.12	6.68	9.48	3.57	5.44	8.85	0.17	2.74	**45.98**
2008	2.63	5.22	3.50	2.34	0.66	8.21	8.73	16.83	5.84	1.62	1.01	0.59	**46.01**
AVG	**3.21**	**3.54**	**3.81**	**2.82**	**3.29**	**6.37**	**6.55**	**6.99**	**7.43**	**3.87**	**1.98**	**2.62**	**52.32**

Appendix J: Annual and Monthly Average Precipitation at JIA





Florida Department of Environmental Protection
Division of Environmental Assessment and Restoration
Bureau of Watershed Restoration
2600 Blair Stone Road, Mail Station 3565
Tallahassee, Florida 32399-2400