Appendices for Proposed Minimum Flows for the Pithlachascotee River - Revised Draft Report for Peer Review

August 29, 2016

Southwest Florida
Water Management District

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Appendix 6A - Email and attachment from Carolyn Voyles to Mike Heyl, dated November 18, 2014. Subject: DEP comment on the draft Pithlachascotee River MFL report. Florida Department of Environmental Protection. Tallahassee, Florida.

Appendix 6B - Memorandum to file by Doug Leeper, dated August 12, 2016. Subject: staff response to comments submitted by the Florida Department of Environmental Protection on November 14, 2014 concerning the District's draft report on proposed minimum flows and levels for the Pithlachascotee River. Southwest Florida Water Management District. Brooksville, Florida.

Appendix 6C - Letter from Tom Champeau to Doug Leeper, dated December 1, 2014. Regarding: proposed minimum flows and levels for the Pithlachascotee River – peer review draft. Florida Fish and Wildlife Conservation Commission. Tallahassee, Florida.

Appendix 6D - Memorandum to file by Doug Leeper, dated May 29, 2015. Subject: staff response to comments submitted by the Florida Fish and Wildlife Conservation Commission on December 1, 2014 concerning the District's draft report on proposed minimum flows and levels for the Pithlachascotee River. Southwest Florida Water Management District. Brooksville, Florida.

Appendix 6E - Letter and attachment from R. Warren Hogg to Doug Leeper, dated April 6, 2015. Regarding: proposed minimum flows for the Pithlachascotee River – technical comments on District reports used to establish proposed minimum flows. Tampa Bay Water. Clearwater, Florida.

Appendix 6F - Memorandum to file by Doug Leeper and Ron Basso, dated June 29, 2015. Subject: District staff response to evaluation comments submitted by Tampa Bay Water staff on April 6, 2015 concerning "Recommended Minimum Flows for the Pithlachascotee River", Draft July 8, 2014 and "Appendices – Recommended Minimum Flows for the Pithlachascotee

River” Draft August 26, 2015. Southwest Florida Water Management District. Brooksville, Florida.

APPENDIX 2A

Characterization of rainfall records for Pasco County and the Pithlachascotee River Watershed during the period of streamflow record at the Pithlachascotee River near New Port Richey gage.

Analysis of the Pasco County rainfall estimates and rainfall stations within the Pithlachascotee River watershed

Two sources of rainfall data for the Pithlachascotee River basin were available for examination as part of the minimum flows study.

#1 *Pasco County Rainfall Estimates* - This is a record of estimated monthly rainfall totals combined from several data sources by the Southwest Florida Water Management District. For the period 1915 through the 1970, most rainfall data were from observer sites and data recorder sites operated and/or maintained by the National Oceanic and Atmospheric Administration (NOAA). After 1970, the District began collecting its own rainfall data from within the 16-county region. This data set was augmented with the District's near-real time SCADA (Supervisory Control and Data Acquisition) system beginning in 1989. The number of recording sites varied greatly during the 1915 through 2000 period. After QA/QC screening, selected data were then used to estimate rainfall from geographical information system (GIS) constructed Thiessen polygons. Since 1999, rainfall data has been acquired from NexRad weather radar. The NexRad estimates are calibrated against to the SCADA rainfall data to generate daily rainfall for a 2 km^2 grid resolution for the county. These combined data sources were used to create a record of monthly rainfall totals that begin in 1915 and extend to present.

Because the Pithlachascotee River watershed lies principally in Pasco County, monthly rainfall totals for Pasco County were retrieved from the District data base. To compare seasonal and inter-annual rainfall patterns to streamflow in the river, rainfall data that were assessed for the minimum flows project were limited to the period that the Pithlachascotee River near New Port Richey streamflow gage has been operation (April 1, 1963 to present). To correspond to the most recent period when streamflow data for were available (September 2013), the analyses of both the rainfall and streamflow records utilized water years that ran from October 1st through September 30th, with the final water year ending September 30, 2013. The year in which the water year ends is used to denote the water year (the final water year was 2013).

#2 Pithlachascotee *River Watershed Values* – An alternate source of rainfall data for the minimum flows analysis was obtained from various daily rainfall recording stations in or very close to the Pithlachascotee River watershed (**Figure 2A-1**). Based on availability of historical data, the District selected six stations to be representative of the Pithlachascotee River watershed: 20186, 20187, 20188, 20189, 20384, and 2044. These stations are all located below Crews Lake, where most of the streamflow in the river is generated. There were no historical daily rainfall data of significant length available for the watershed above Crews Lake.

The period of coverage for the watershed stations was from June 1, 1973 through September 30, 2013. However, none of the stations covered this entire period. To increase the period of daily rainfall record for analysis, daily rainfall data were averaged from different stations to create a continuous periods of average daily values for the watershed from June 1, 1973 through September 30, 2013 (Table 2A-1).

Table 2A-1. Stations used for computation of average daily rainfall values during different periods in the Pithlachascotee River Watershed	
Period	**Stations used in daily average**
Jun 1, 1973 – Dec 31, 1975	20189
Jan 1, 1976 – Dec 31, 1982	20189 20187 20188
Jan 1, 1983 – Dec 31, 1984	20189 20384
Jan 1, 1985 – Oct 31, 1986	20186 20189 20384
Nov 1, 1986 – Nov 30, 1991	20186 20189 20384 20442
Dec 1, 1991 – April 30, 1997	20189 20384 20442
May 1, 1997 – Sep. 30, 2013	20384 20442

Figure 2A-1. Location of daily rainfall sites in or near the Pithlachascotee River watershed selected for analysis with the Pithlachascotee River watershed below Crews Lake shaded in green.

Comparison of yearly and seasonal rainfall totals from the two data sources

The average daily rainfall values from the Pithlachascotee watershed stations were summed to create total yearly rainfall values using the October to September water year designation previously described. Additionally, two seasonal rainfall indices were created by summing daily values for June through September (Wet Season) and October through May (Dry Season). Monthly rainfall values from the Pasco County rainfall estimates were similarly summed to produce yearly and seasonal rainfall totals.

A comparison of data from the two data sources is limited to the 40 –year period when the watershed values are available from October 1973 through September 2013. Summary statistics for yearly and seasonal rainfall totals during this period for the county rainfall estimates and the watershed rainfall values are listed in Table 2A-2.

Table 2A-2. Summary statistics for yearly, dry season, and wet season rainfall totals for the Pasco County rainfall estimates and the average values for stations within the Pithlachascotee River watershed for water years 1974 - 2013.

Yearly Rainfall	**Mean**	**St .Dev.**	**Minimum**	**Maximum**
Pasco County	52.6	9.0	37.7	74.7
Pithlachascotee Watershed	55.1	12.4	31.0	85.9
Dry Season (Oct. - May)				
Pasco County	22.2	7.8	9.9	45.9
Pithlachascotee Watershed	22.4	8.69	8.8	54.6
Wet Season (Jun. - Sep.)				
Pasco County	30.5	6.0	21.0	46.2
Pithlachascotee Watershed	32.1	9.5	19.1	61.2

Mean values for dry season rainfall for the two data sources were very similar (22.2 and 22.4 inches). However, the mean yearly rainfall total was slightly greater for the watershed stations (55.1 inches) compared to 52.6 inches for county estimates. A statistical comparison of yearly rainfall totals using the Wilcoxon Sign rank test found the watershed values to be significantly greater ($p < 0.024$) than the county estimates. The mean wet season total for the watershed stations was 32.1 inches compared to a mean of 30.5 for the Pasco County estimates. The Wilcoxon sign rank test also found the wet season rainfall totals at the watershed stations were significantly greater ($p <0 .016$) than the county rainfall estimates. There was no significant difference in the dry season rainfall totals.

A plot of yearly rainfall totals for the watershed stations vs. the Pasco County estimates with a 1 to 1 agreement line shows that there was not a clear tendency for either data source to have greater values for years with near average (≈ 55 inches) or below average rainfall. However, in wet years there was a tendency for the rainfall totals to be greater for the watershed station values.

A plot of cumulative distributions of yearly rainfall values for the county estimates and watershed station values shows the watershed stations to have higher rainfall totals in the upper 20 percent of the yearly values. However, using the Kolmogorov-Smirnov test, the overall distributions of these yearly rainfall totals were not found to be significantly different ($P < 0.704$).

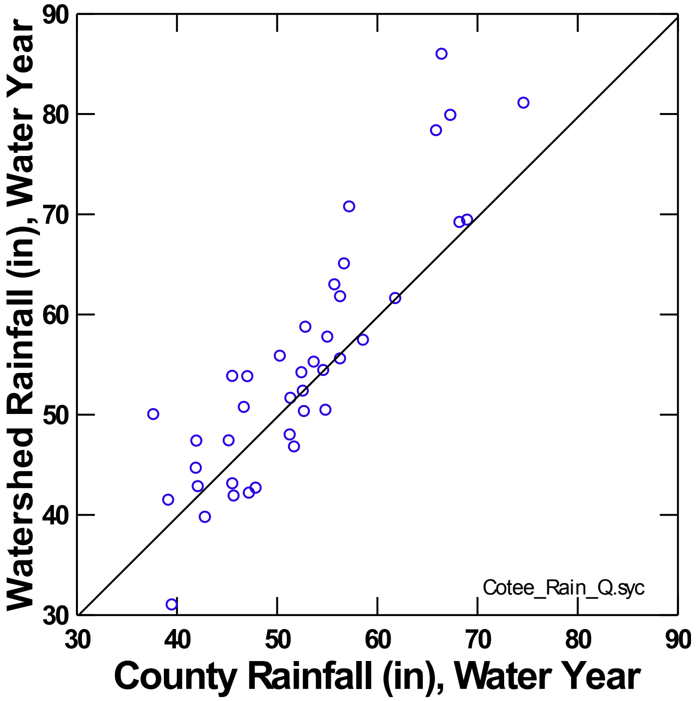

Figure 2A-2. Yearly rainfall totals for the Pithlachascotee River watershed stations vs. the Pasco County rainfall estimates for the years 1974 – 2013 with a 1 to 1 agreement line.

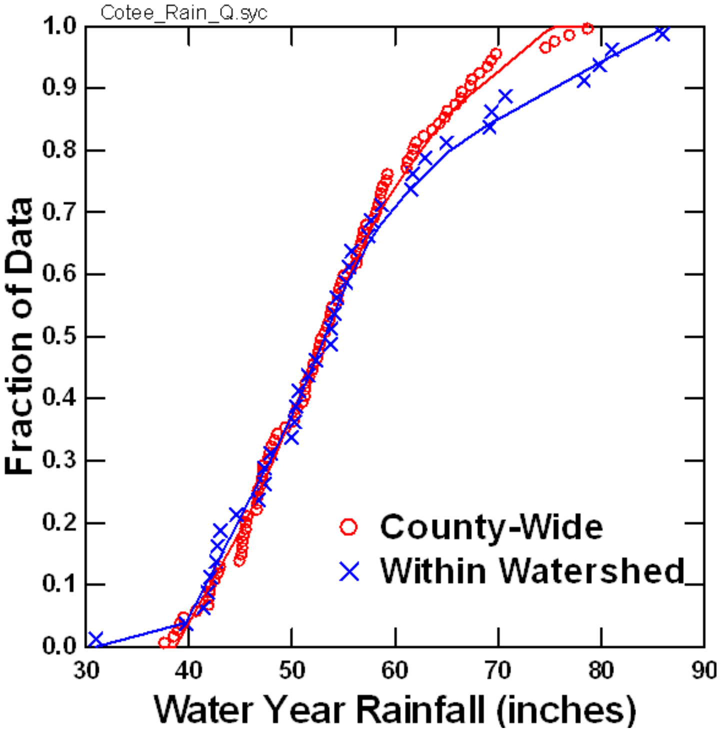

Figure 2A-3. Cumulative distribution functions of yearly rainfall totals for the Pithlachascotee River watershed stations and the Pasco County rainfall estimates for the years 1974 – 2013.

Given the differences in these two data sets, it was concluded that data from both sources would be assessed in the minimum flows study to characterize inter-annual rainfall patterns and trends. The watershed stations are informative because they occur below Crews Lake, where most of the streamflow in the river is generated. However, these data are limited to water years since 1974. The County data are informative because they cover the entire period of data collection at the Pithlachascotee River near New Port Richey streamflow gage, which began in 1963.

Differences in Rainfall Before and After Relocation of New Port Richey Flow Gage

As described in Chapter 2 of the minimum flows report, the Pithlachascotee River near New Port Richey gage was moved 1.1 miles upstream on May 21, 1981. To evaluate to the extent changes in rainfall may have affected flow after relocation of the gage, rainfall data were summarized for the periods of flow record before and after the gage was moved. The analysis was limited to the county rainfall estimates as these values covered the entire period of streamflow record. In order to use complete water years for comparison, water year 1981, during which the gage was moved, was omitted from the analysis. Also, the partial water year in 1963 (April 1 to September 30, 1963) when the flow record began was omitted from the analysis. Thus, the period before relocation of the gage included 17 water years from 1964 to 1980 and the period after relocation of the gage included 32 water years from 1982 to 2013.

Summary statistics for yearly and seasonal rainfall totals for the periods before and after relocation of the gage are listed in Table 2A-3. The mean yearly rainfall for before gage relocation (55.3 inches) was three inches greater than the mean value for after relocation. However, the non-parametric Kruskal-Wallis text found but there was no significant difference in yearly rainfall totals between the two periods ($p < 0.147$). Similarly, mean values for both dry season and wet season rainfall totals were slightly greater for the before relocation period (1.8 inches difference in dry season, 1.1 inches in the wet), but there were no statistically significant differences in values between the two periods (Kruskal-Wallis test, $p < 0.334$ for dry season, $p < 0.475$ for wet season).

Table 2A-3. Summary statistics for yearly, dry season, and wet season rainfall totals for the Pasco County rainfall estimates for water years before (1964-1980) and after (1982-2013) movement of the Pithlachascotee River near New Port Richey streamflow gage

Yearly Rainfall	N	**Mean**	**St .Dev.**	**Minimum**	**Maximum**
Pre (1964 - 1980)	17	55.3	8.0	42.0	68.3
Post (1982 - 2013)	32	52.3	8.9	37.7	74.7
Dry Season (Oct. - May)					
Pre (1964 - 1980)	17	23.8	6.8	10.5	35.7
Post (1982 - 2013)	32	22	8.2	9.9	46.0
Wet Season (Jun. - Sep.)					
Pre (1964 - 1980)	17	31.4	6.5	21.0	42.2
Post (1982 - 2013)	32	30.3	5.7	21.8	46.2

Rainfall Trend Analysis

The non-parametric Mann-Kendall test was used to examine trends in yearly and seasonal rainfall totals for the Pasco County rainfall estimates and the watershed rainfall totals. Results of these tests for the county data are summarized in Table 2A-4. Trends were examined for the period of flow record before and after relocation of the long-term streamflow gage and for the entire period of streamflow record. Plots of these yearly and seasonal totals vs. water year generated by Minitab® software are shown in Figure 2A-4 through 2A-6, with lines shown corresponding to the Theil Seil-Kendall slope generated by the Mann-Kendall test and for a slope resulting from an ordinary least squares regression fitted to the data. However, both slope lines were generated automatically for each graphic and the presence of a slope line does not mean it was statistically significant. That information for the Mann-Kendall test is presented in Table 2A-4. No statistical results were generated corresponding to the plotted linear regression.

Table 2A-4. Results of Mann-Kendall tests of trends in yearly and wet and dry season rainfall totals for the Pasco County rainfall estimates for the entire period of streamflow record at the Pithlachascotee River near New Port Richey gage and the periods before and after relocation of the gage.

			Yearly totals		Dry Season		Wet Season	
Water Years	Period	Number of years	Tau	P value	Tau	P value	Tau	P value
1964 - 2013	Entire period	50	-0.179	0.068	-0.151	0.124	-0.046	0.654
1964 - 1980	Before gage relocation	17	-0.177	0.343	0.118	0.536	-0.265	0.149
1982 - 2013	After gage relocation	32	-0.129	0.307	-0.226	0.072	0.115	0.364

There were no significant trends in yearly or seasonal rainfall for the entire period of streamflow record at the p< .05 confidence level, but there was some indication (p< 0.068) of a declining trend in yearly rainfall totals over this period (Figure 2A-4A). Although the Tau values were negative, there were no significant declining trends in yearly rainfall totals within the periods either before or after relocation of the streamflow gage. There only indication (p<.072) of a significant trend for dry season rainfall was during the period after relocation of the streamflow gage (Figure 2A-5C). There were no indications of any significant trends for wet season rainfall during any of the periods examined.

Trends were also examined for yearly and seasonal rainfall totals for the watershed station values. The results of those tests are listed in Table 2A-5, while plots of the data are shown in Figure 2A-7 and 2A-8. With data beginning in 1974, the watershed stations do not cover the entire length of flow record at the long-term streamflow gage. However, trends were examined for the entire period of rainfall record (1974 forward) and for the period after relocation of the long-term streamflow gage.

Table 2A-5. Results of Mann-Kendall tests of trends in yearly and wet and dry season rainfall totals for the watershed based rainfall values for the period since those records began and for the period after relocation of the Pithlachascotee River near New Port Richey gage.

			Yearly totals		Dry Season		Wet Season	
Water Years	Period	Number of years	Tau	P value	Tau	P value	Tau	P value
1974 - 2013	Entire rainfall record	40	-0.123	0.268	-0.239	0.033	0.013	0.916
1982 - 2013	After gage relocation	32	-0.080	0.540	-0.247	0.053	0.045	0.733

There were no significant trends in yearly rainfall totals for entire period of rainfall record or for the period after relocation of the streamflow gage. Similarly, there were no significant trends in wet season rainfall in either period. However, there significant or near significant trends in dry season rainfall for the entire period of rainfall record ($p < 0.033$) and the period after relocation of the streamflow gage ($p < 0.053$).

In comparing the results of the County and watershed rainfall values, the only consistent trend is a near significant decline in dry season rainfall after relocation of the long-term streamflow gage. As describe in Chapter 2 of the minimum flows report, this has likely contributed to declining low flows in the Pithlachascotee River in recent decades.

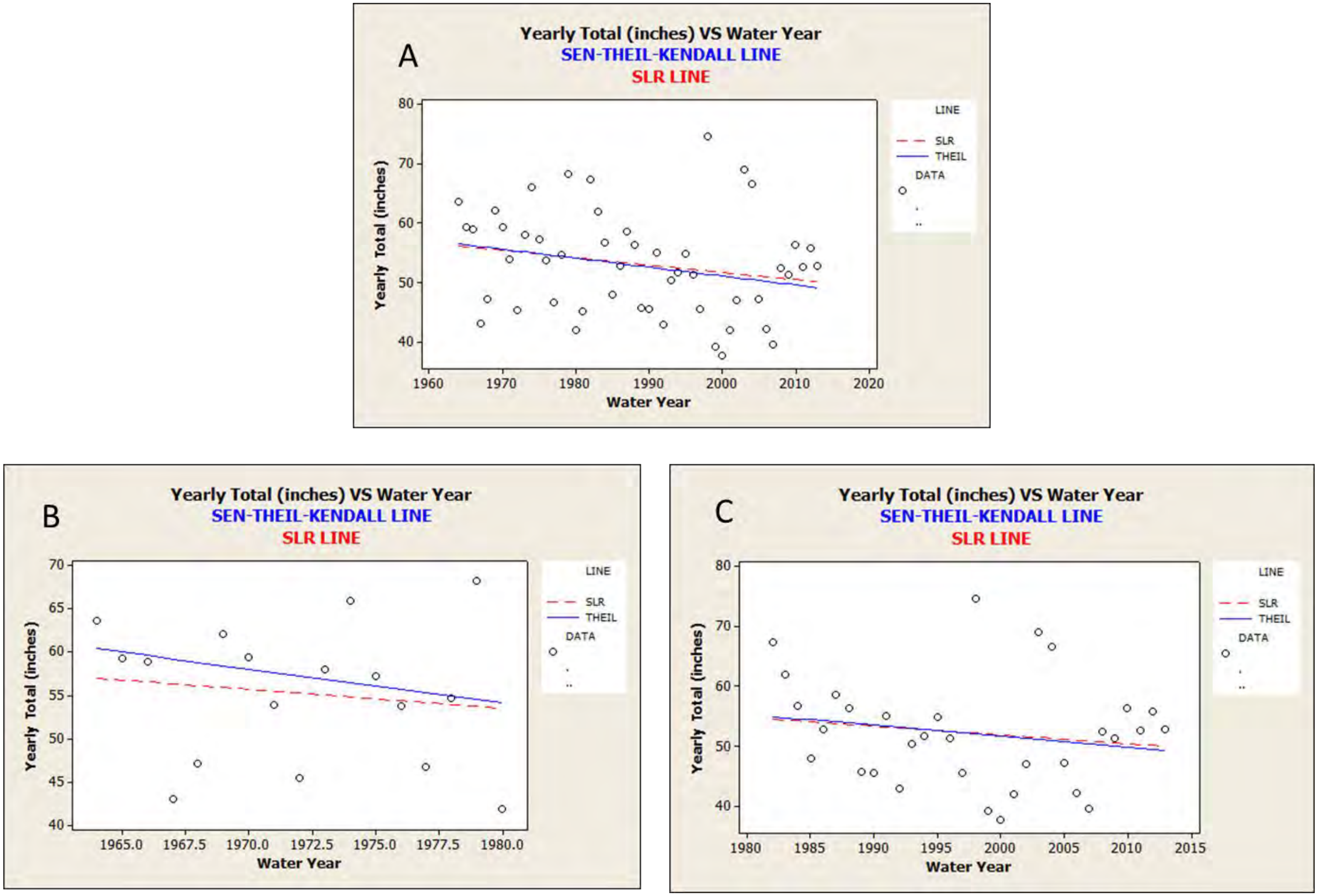

Figure 2A-4. Yearly rainfall totals vs. water year for the Pasco County rainfall estimates for the periods covering the combined period of record at the Pithlachascotee River near New Port Richey gage (A) and the periods before (A) and after (B) relocation of the gage. Slopes are shown for a Sen-Theil line generated by the Mann-Kendall test and by a linear regression (SLR) fitted to the data.

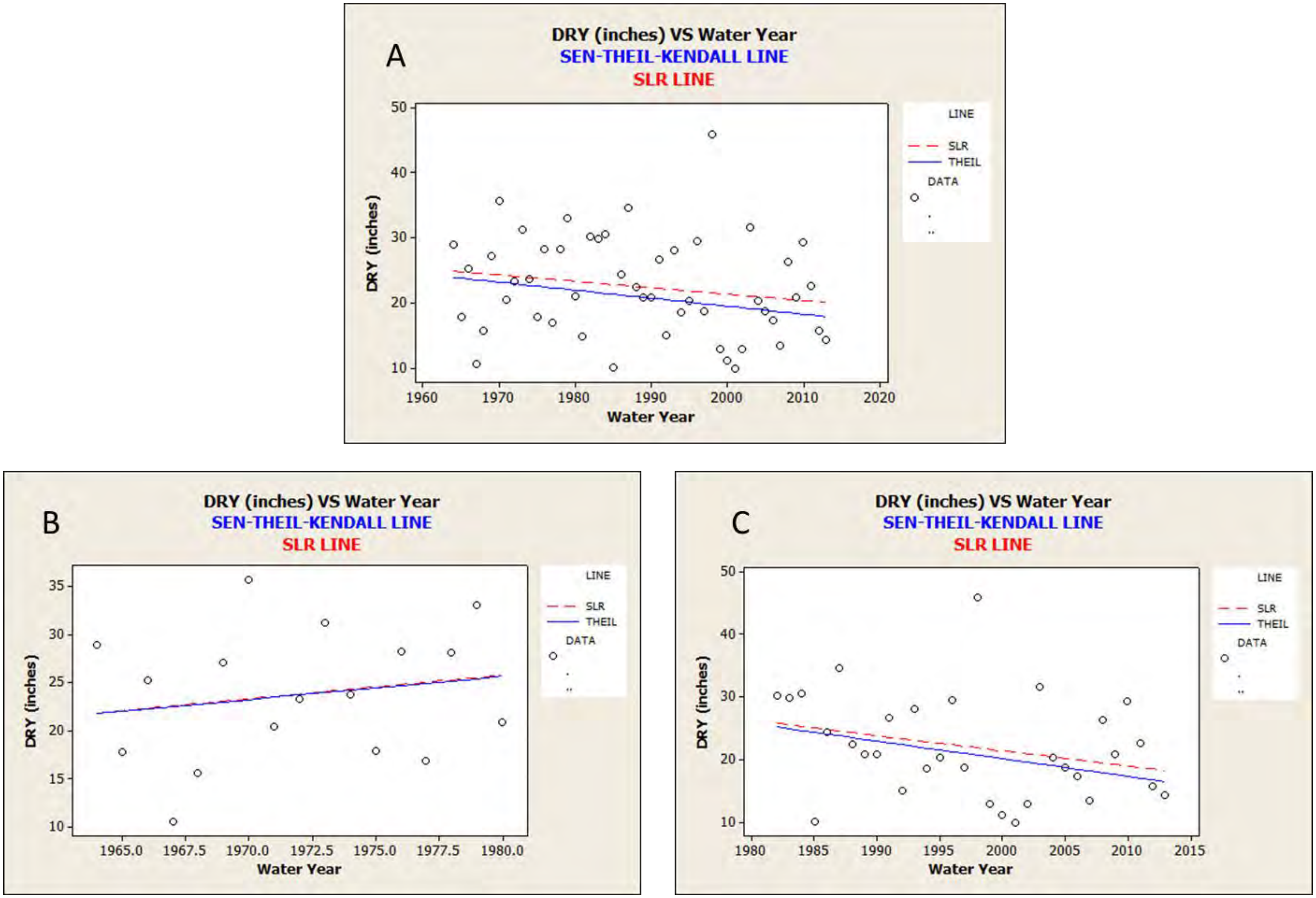

Figure 2A-5. Dry season (October – May) rainfall totals vs. water year for the Pasco County rainfall estimates for the periods covering the combined period of record at the Pithlachascotee River near New Port Richey gage (A) and the periods before (A) and after (B) relocation of the gage. Slopes are shown for a Sen-Theil line generated by the Mann-Kendall test and by a linear regression (SLR) fitted to the data.

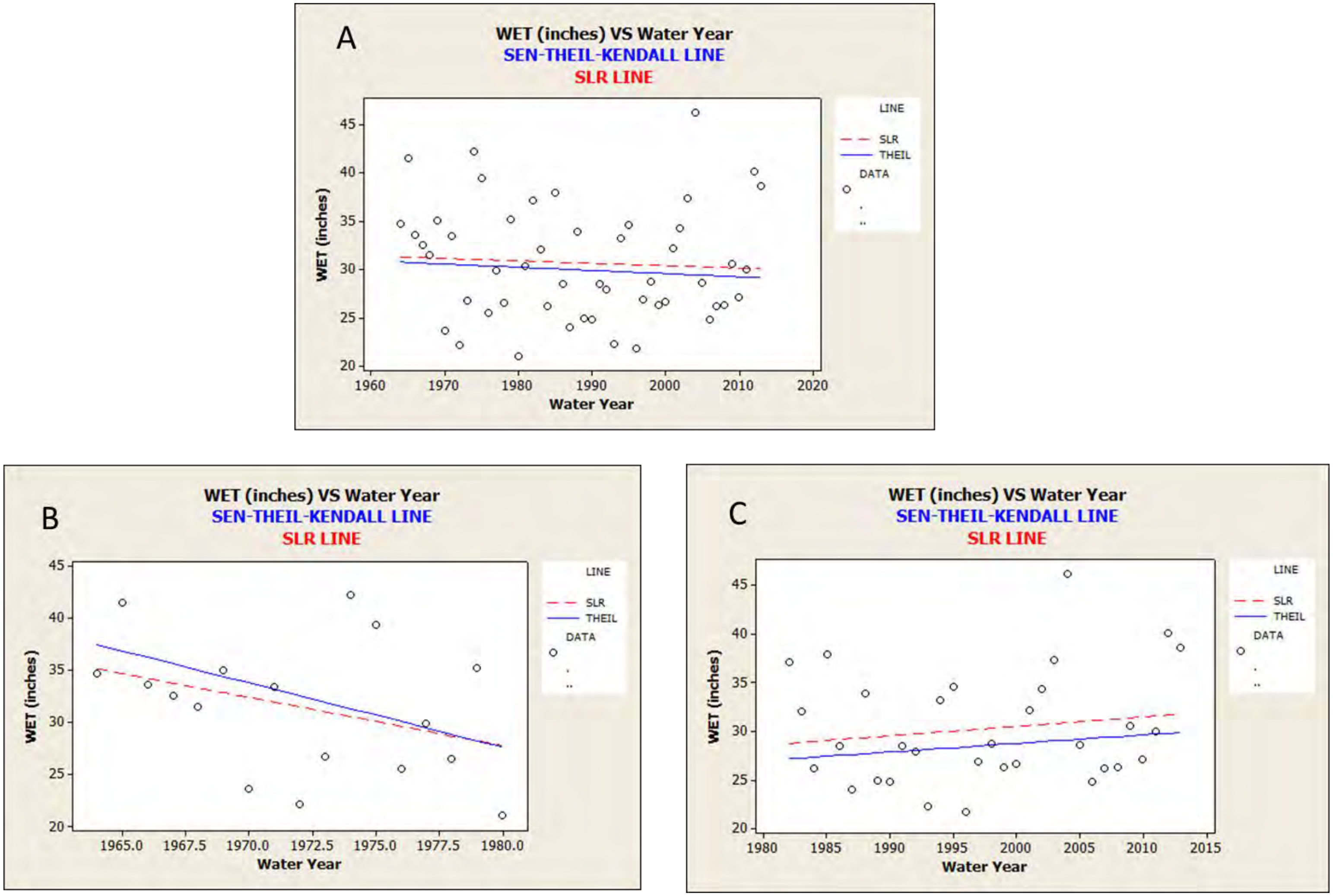

Figure 2A-6. **Wet season (June - September) rainfall totals vs. water year for the Pasco County rainfall estimates for the periods covering the combined period of record at the Pithlachascotee River near New Port Richey gage (A) and the periods before (A) and after (B) relocation of the gage. Slopes are shown for a Sen-Theil line generated by the Mann-Kendall test and by a linear regression (SLR) fitted to the data.**

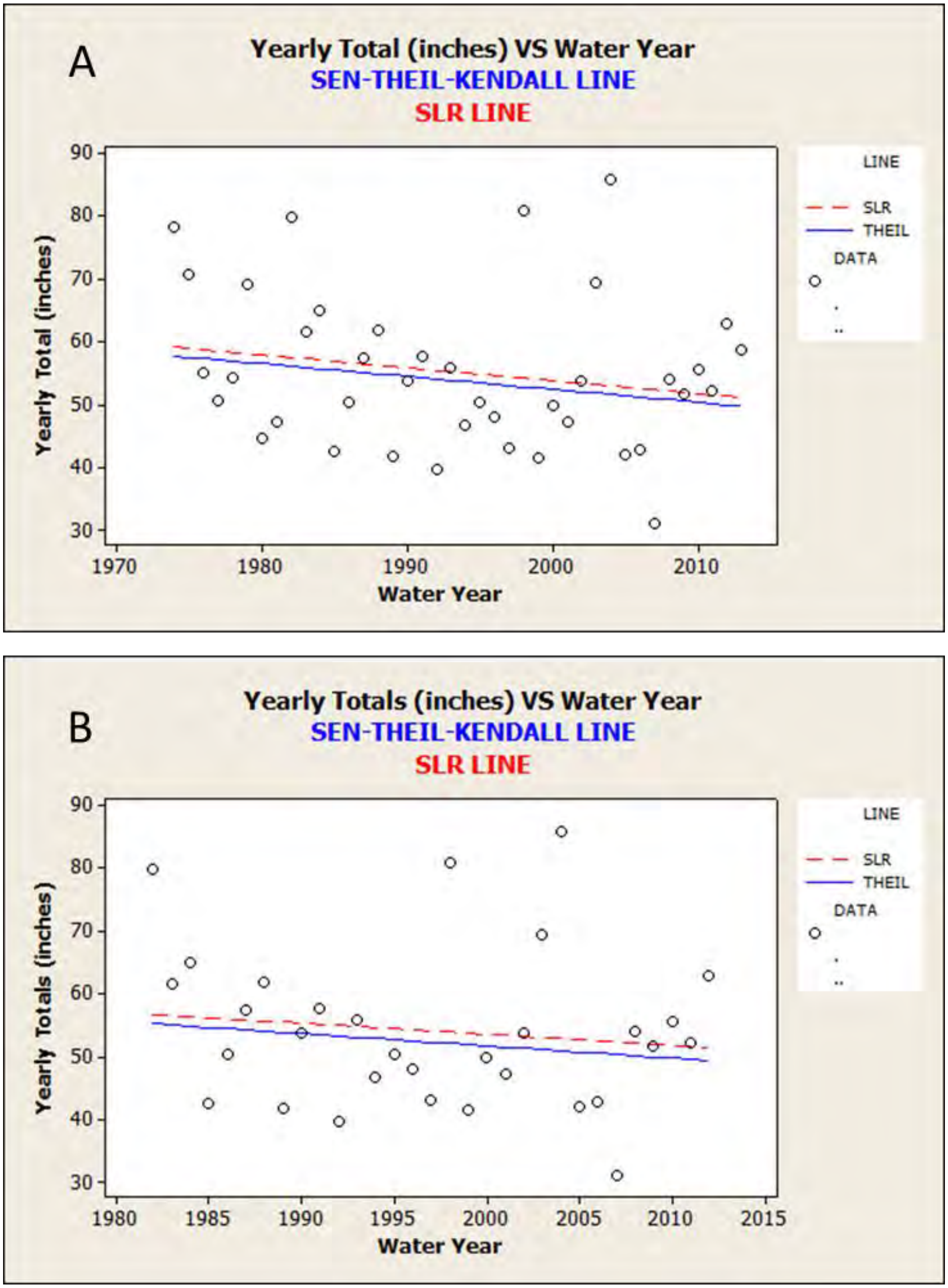

Figure 2A-7. Yearly rainfall totals vs. water year for the watershed station based values for the periods covering the combined period of record at the Pithlachascotee River near New Port Richey gage (A) and the period after (B) relocation of the gage. Slopes are shown for a Sen-Theil line generated by the Mann-Kendall test and by a linear regression (SLR) fitted to the data.

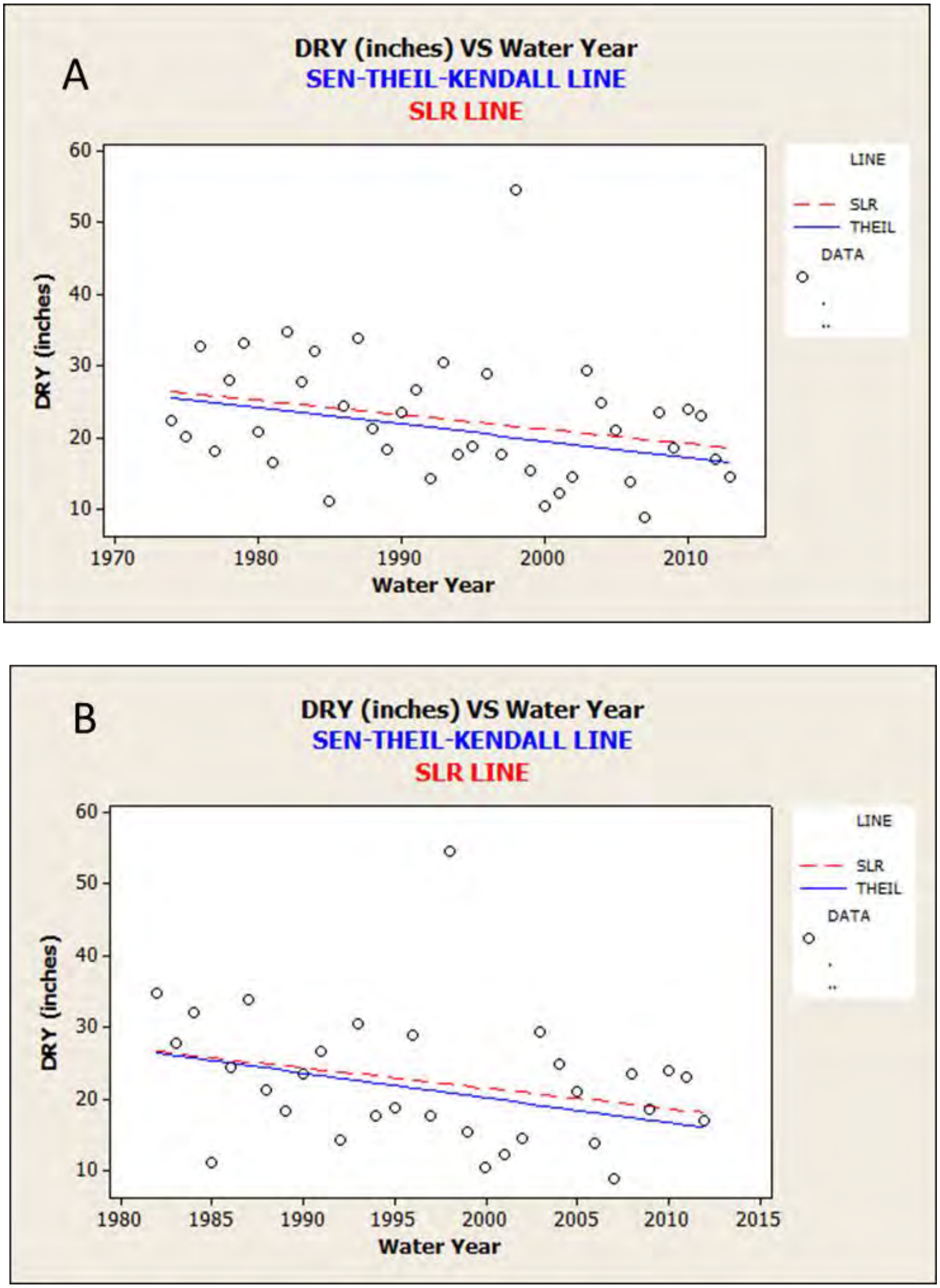

Figure 2A-8. Dry season (October – May) rainfall totals vs. water year for the watershed station based values for the periods covering the combined period of record at the Pithlachascotee River near New Port Richey gage (A) and the period after (B) relocation of the gage. Slopes are shown for a Sen-Theil line generated by the Mann-Kendall test and by a linear regression (SLR) fitted to the data.

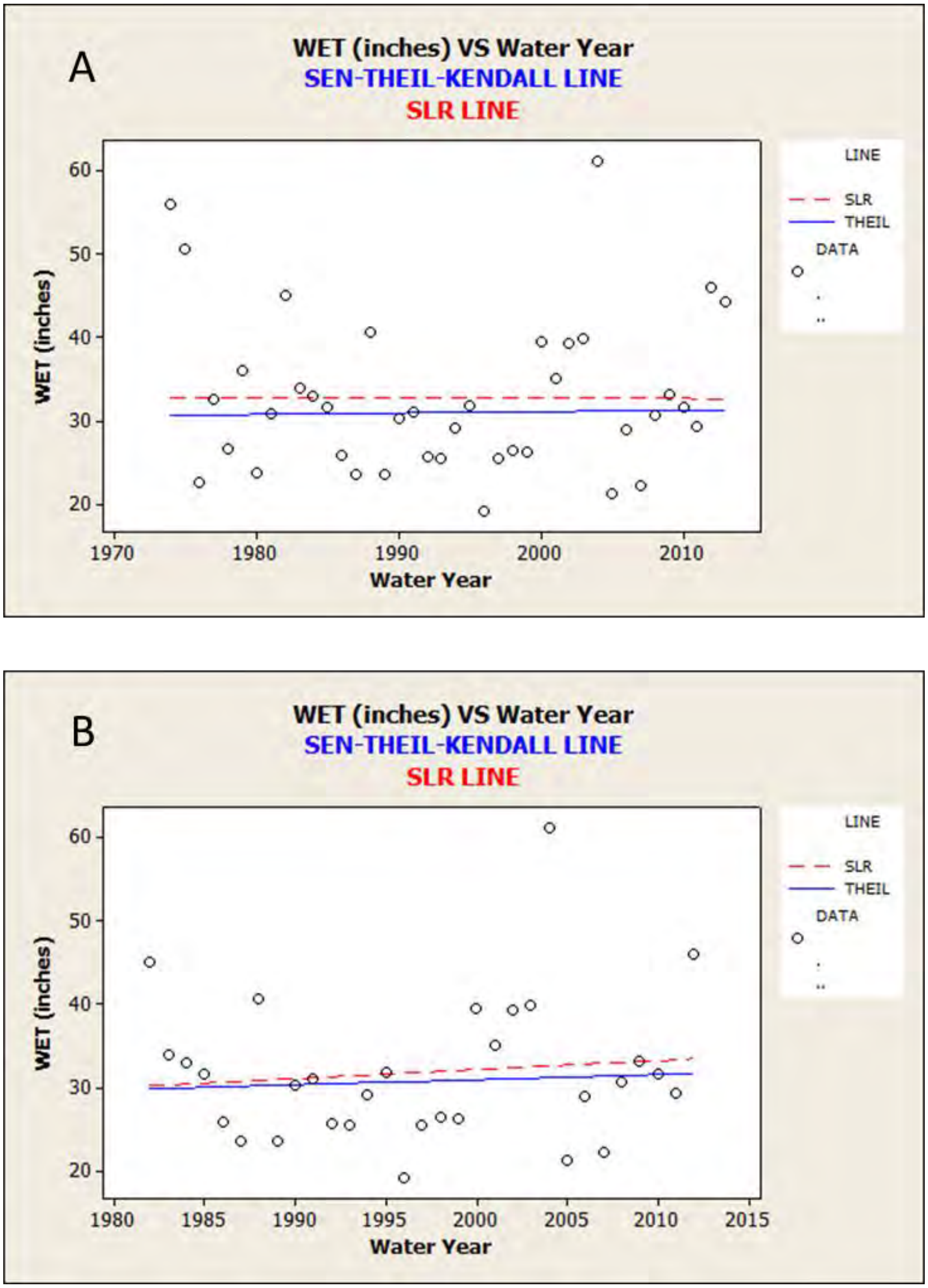

Figure 2A-9. Wet season (June – September) rainfall totals vs. water year for the watershed station based values for the periods covering the combined period of record at the Pithlachascotee River near New Port Richey gage (A) and the period after (B) relocation of the gage. Slopes are shown for a Sen-Theil line generated by the Mann-Kendall test and by a linear regression (SLR) fitted to the data.

APPENDIX 2B

Basso, R. 2014. Technical memorandum, dated February 10, 2014. Subject: predicted groundwater withdrawal impacts to the Pithlachascotee River based on numerical modeling results. Southwest Florida Water Management District, Brooksville, Florida.

Technical Memorandum

February 10, 2014

TO: Sid Flannery, Chief Environmental Scientist, Natural Systems & Restoration Section
Gary Williams, Ph. D., Senior Environmental Scientist, Natural Systems & Restoration Section
Tammy Hinkle, Environmental Scientist, Natural Systems & Restoration Section
Veronica Craw, Manager, Natural Systems & Restoration Section

THROUGH: Jerry Mallams, P.G., Manager, Resource Evaluation Section

FROM: Ron Basso, P.G., Senior Hydrogeologist, Resource Evaluation Section

Subject: Predicted groundwater withdrawal impacts to the Pithlachascotee River based on numerical model results

1.0 Introduction

The Pithlachascotee River is located in southwest Pasco County and contains a drainage basin area of 182 square miles upstream of the New Port Richey gage (Figure 1). Mean annual discharge for the Pithlachascotee River near New Port Richey gage averaged 25.5 cubic feet per second (cfs) or 16.7 million gallons per day (mgd) from April 1963 through November 2010.

Prior to establishment of a Minimum Flow (MF), an evaluation of hydrologic changes in the vicinity of the river is necessary to determine if the water body has been significantly impacted by existing groundwater withdrawals. The establishment of the MF for the Pithlachascotee River is not part of this report. This memorandum describes the hydrogeologic setting near the river and provides the results of several numerical model simulations of predicted stream flow change due to existing groundwater withdrawals.

2.0 Hydrogeologic Framework

The hydrogeology of the area includes a surficial sand aquifer; a discontinuous, intermediate clay confining unit and the thick carbonate Upper Floridan aquifer (UFA). In general, the surficial aquifer is in good hydraulic connection with the underlying UFA because the clay confining unit is generally thin, discontinuous, and breeched by numerous karst features. The surficial sand aquifer is generally a few tens of feet thick and overlies the limestone of the UFA that averages nearly 1,000 feet thick in the area (Miller, 1986). In between these two aquifers is the Hawthorn Group clay that varies between a few feet to as much as 25 feet thick. Because the clay unit is breached by buried karst features and has previously been exposed to erosional processes, preferential pathways locally connect the overlying surficial aquifer to the UFA resulting in moderate-to-high leakage to the UFA (SWFWMD, 1996). Thus the UFA is defined as a leaky artesian aquifer system.

The UFA is the principal aquifer in the watershed area and is the major source of water for municipal water use. Tampa Bay Water, a regional utility service for portions of Hillsborough, Pasco, and Pinellas Counties, has seven major wellfields within or adjacent to the Pithlachascotee River watershed (Figure 1). In the mid-to late 1990s, these wellfields withdrew an average annual total of about 120 mgd of groundwater from the UFA. Since 2008, reductions in groundwater withdrawals as part of the partnership plan reduced TBW withdrawals from these seven wellfields to approximately 60 mgd from 2008 through 2010.

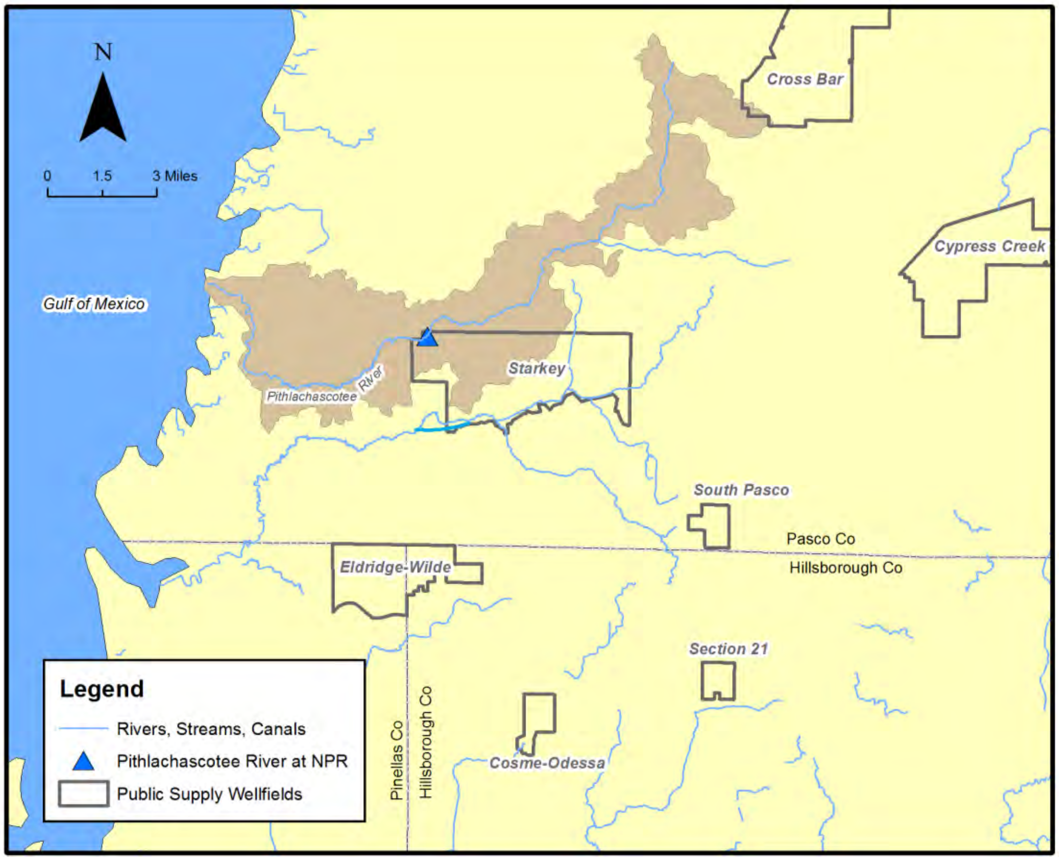

Figure 1. Location of Pithlachascotee River and drainage basin.

3.0 Numerical Model Results

A number of regional groundwater flow models have included the Pithlachascotee River area. Ryder (1982) simulated the entire extent of the Southwest Florida Water Management District. In 1993, the District completed the Northern Tampa Bay groundwater flow model that covered a 2,000 square mile area of Hillsborough, Pinellas, Pasco, and Hernando Counties (SWFWMD, 1993). In 2002, the USGS simulated the entire Florida peninsula in their Mega Model of regional groundwater flow (Sepulveda, 2002). The most recent and advanced simulation of southwest Pasco County and the surrounding area is the Integrated Northern Tampa Bay (INTB) model (Geurink and Basso, 2013). The construction and calibration of this model was part of a cooperative effort between the SWFWMD and Tampa Bay Water, a regional water utility that operates 11 major wellfields in the area. The INTB Model covers a 4,000 square-mile area of the Northern Tampa Bay region (Figure 2).

An integrated model represents the most advanced simulation tool available to the scientific community in water resources investigations. It combines the traditional ground-water flow model with a surface water model and contains an interprocessor code that links both systems. One of the many advantages of an integrated model is that it simulates the entire hydrologic system. It represents the "state-of-art" tool in assessing changes due to rainfall, drainage alterations, and withdrawals.

The model code used to run the INTB simulation is called the Integrated Hydrologic Model (IHM) which combines the HSPF surface water code and the MODFLOW ground-water code using interprocessor software. During the INTB development phase, several new enhancements were made to move the code toward a more physically-based simulation. The most important of these enhancements was the partitioning of the surface into seven major land use segments: urban, irrigated land, grass/pasture, forested, open water, wetlands, and mining/other. For each land segment, parameters were applied in the HSPF model consistent with the land cover, depth-to-water table, and slope. Recharge and evapotranspiration (ET) potential were then passed to each underlying MODFLOW grid cell based on an area weighted-average of land segment processes above it. Other new software improvements included a new ET algorithm/hierarchy plus allowing the model code to transiently vary specific yield and vadose zone storages. The model underwent peer review by a team of outside consultants in early 2013 (West and others,

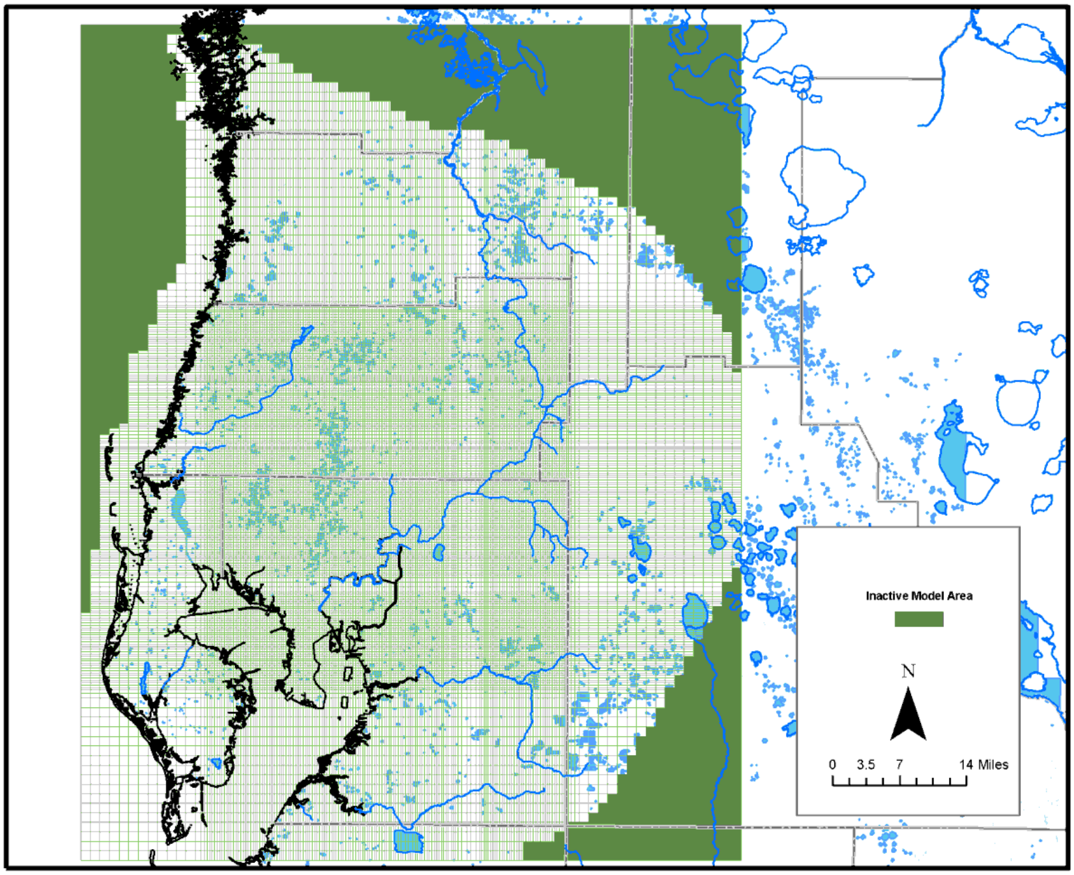

Figure 2. Groundwater grid used in the INTB model.

2013). Their findings found that the INTB model was "…extremely well conceived, that the model made good use of the tremendous amount of available data, and that the final model was well calibrated."

The INTB model contains 172 subbasin delineations in HSPF (Figure 3). There is also an extensive data input time series of 15-minute rainfall from 300 stations for the period 1989-1998, a well pumping database that is independent of integration time step (1-7 days), a methodology to incorporate irrigation flux into the model simulation, construction of an approximate 150,000 river cell package that allows simulation of hydrography from major rivers to small isolated wetlands, and GIS-based definition of land cover/topography. An empirical estimation of ET was also developed to constrain model derived ET based on land use and depth-to-water table relationships.

The MODFLOW gridded domain of the INTB contains 207 rows by 183 columns of variable spacing ranging from 0.25 to one mile. The groundwater portion is comprised of three layers: a surficial aquifer (layer 1), an intermediate confining unit or aquifer (layer 2), and the Upper Floridan aquifer (layer 3). The model simulates leakage between layers in a quasi-3D manner through a leakance coefficient term.

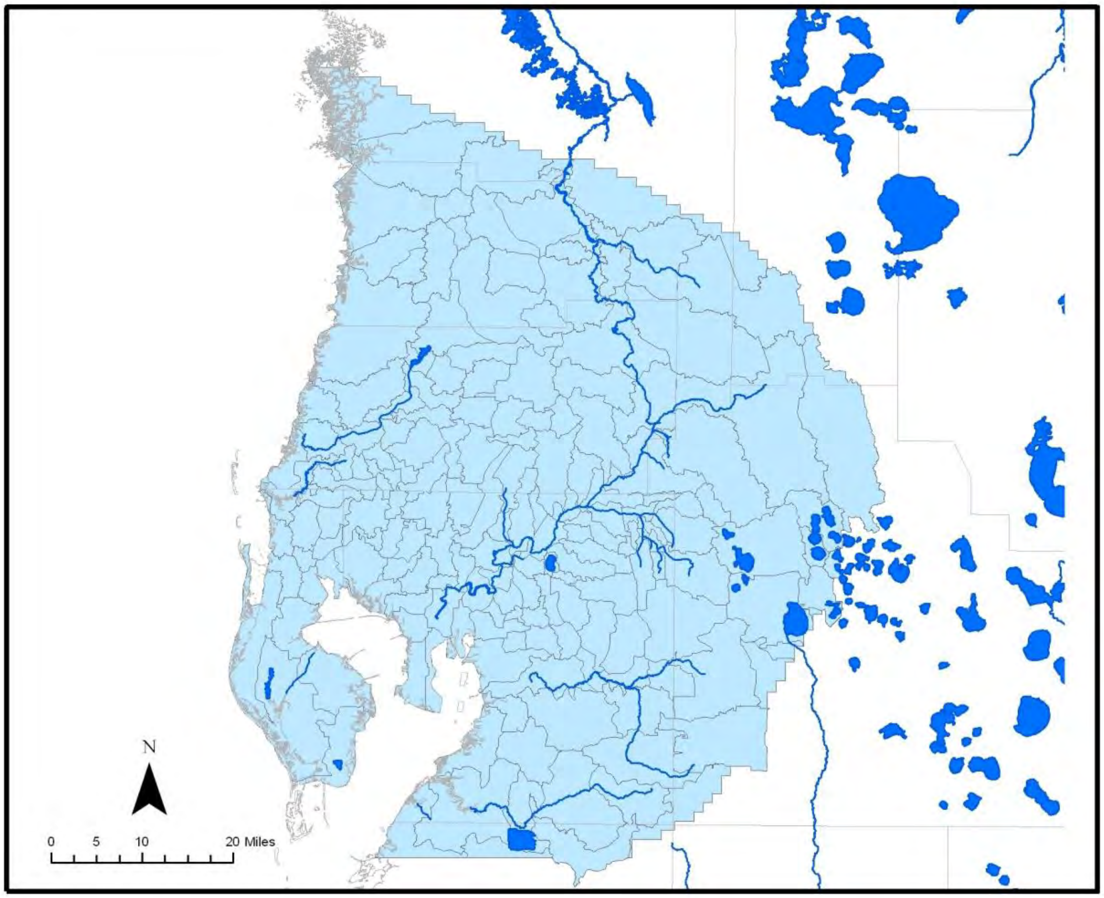

Figure 3. HSPF subbasins in the INTB model.

The INTB model is a regional simulation and has been calibrated to meet global metrics. The model is calibrated using a daily integration step for a transient 10-year period from 1989-1998. A model verification period from 1999 through 2006 has recently been added. Model-wide mean error for all wells in both the surficial (SAS) and Upper Floridan aquifers is less than 0.2 feet. Mean absolute error was less than two feet for both the SAS and UFA. Total stream flow and spring flow mean error averaged for the model domain is each less than 10 percent for both the calibration and verification periods. Further information regarding the construction and calibration of the INTB model is found in Geurink and Basso (2013).

3.1 INTB Model Scenarios

Seven different groundwater withdrawal scenarios were run with the INTB model using the pumping period from 1989-2000. Each scenario consisted of turning off pumping in a certain wellfield or region and then comparing heads and flows with the base model run. The difference between the zero pumping run and the base run is the predicted impact due to that feature. The first scenario consisted of simulating the impacts from all groundwater withdrawn within the Central West-Central Florida Groundwater Basin (CWCFGWB). The area of withdrawals totaled 239.4 mgd (average 1989-2000 conditions) and is shown in Figure 4. The simulated monthly average stream flow hydrograph of the Pithlachascotee River at the New Port Richey gage showing both current conditions and zero withdrawals within the CWCFGWB is illustrated in Figure 5. The predicted mean and median stream flow decline over the 12-year period for the Pithlachascotee River is 8.3 cfs and 4.5 cfs, respectively due to 239.4 mgd of groundwater extraction in the CWCFGWB. Figures 6 and 7 depict the predicted mean drawdown in the surficial and Upper Floridan aquifers over the 12-year simulation period due to pumping in the CWCFGWB.

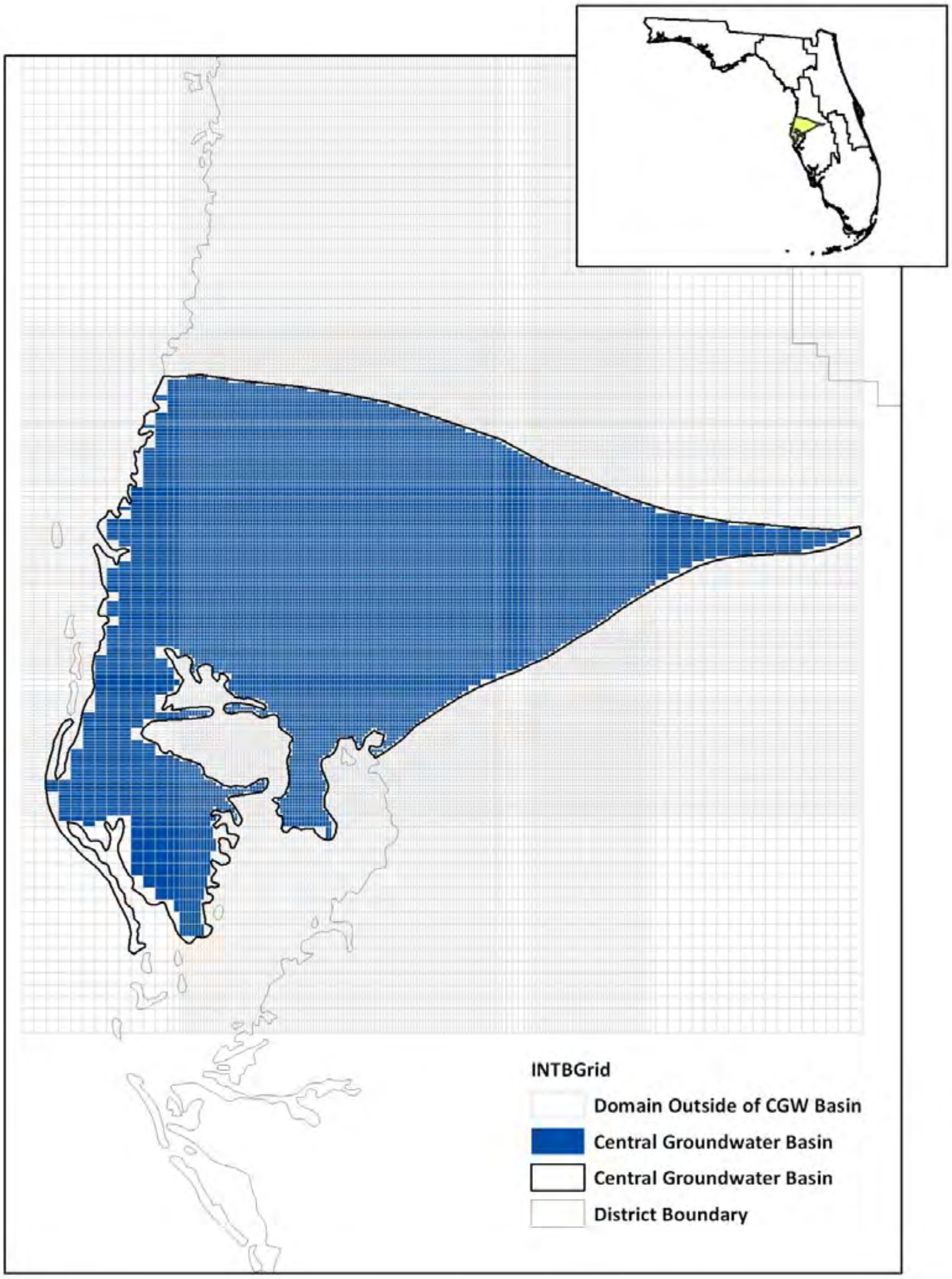

Figure 4. INTB scenario 1 where impacts to the hydrologic system were simulated due to groundwater withdrawals of 239.4 mgd (1989-2000 average) in the shaded area.

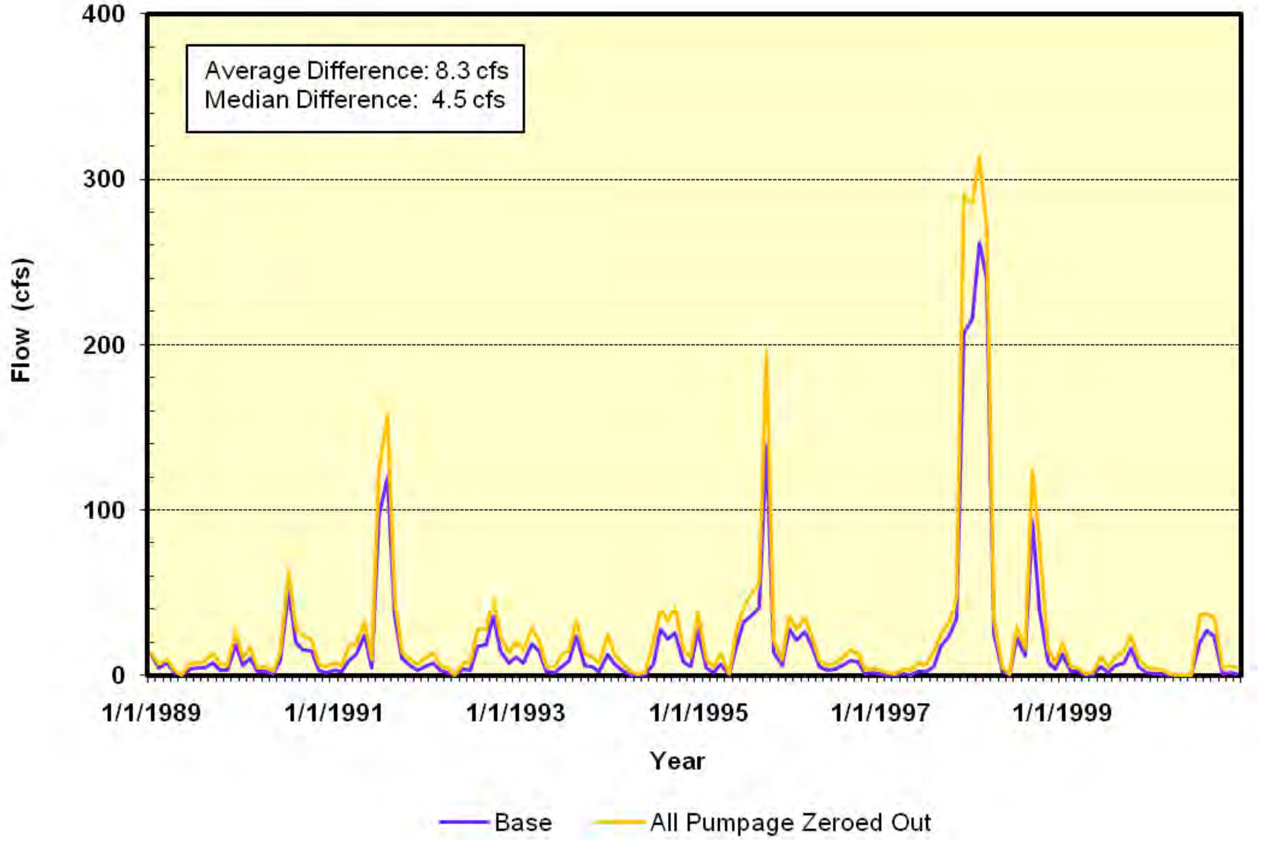

Figure 5. Simulated monthly stream flow to the Pithlachascotee River near New Port Richey due to 239.4 mgd of groundwater withdrawn and zero pumping within the Central West-Central Florida Groundwater Basin.

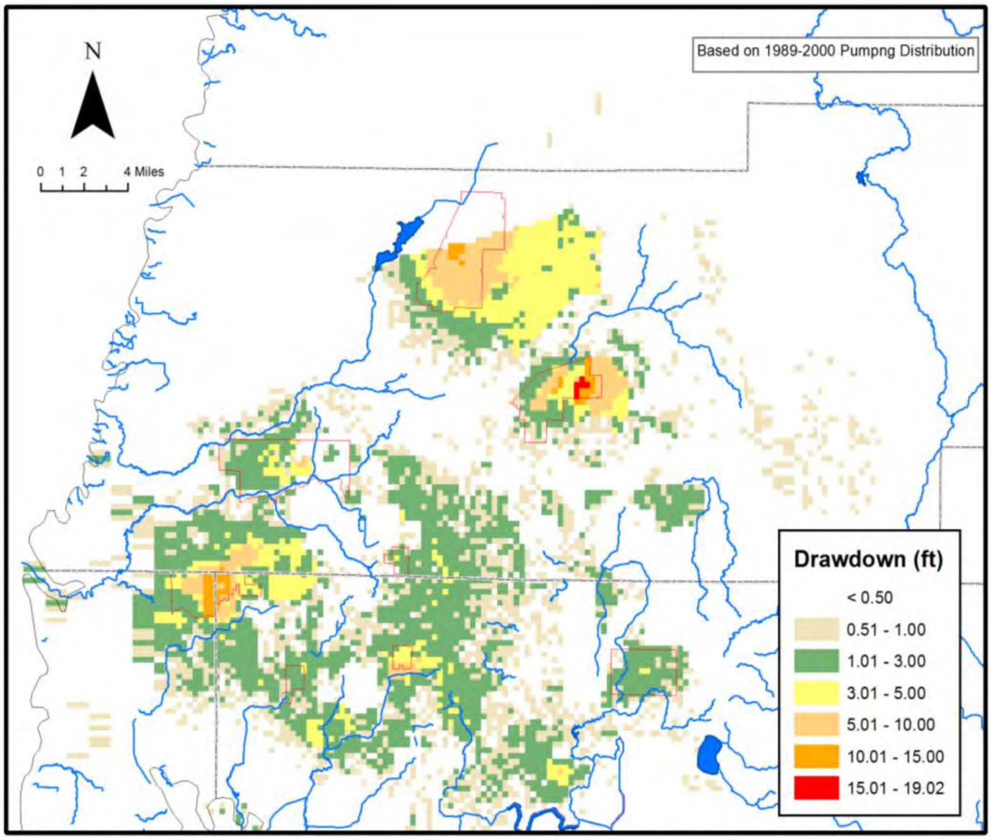

Figure 6. Predicted mean drawdown in the Surficial Aquifer due to 239.4 mgd of groundwater withdrawals within the Central West-Central Florida Groundwater Basin from 1989-2000.

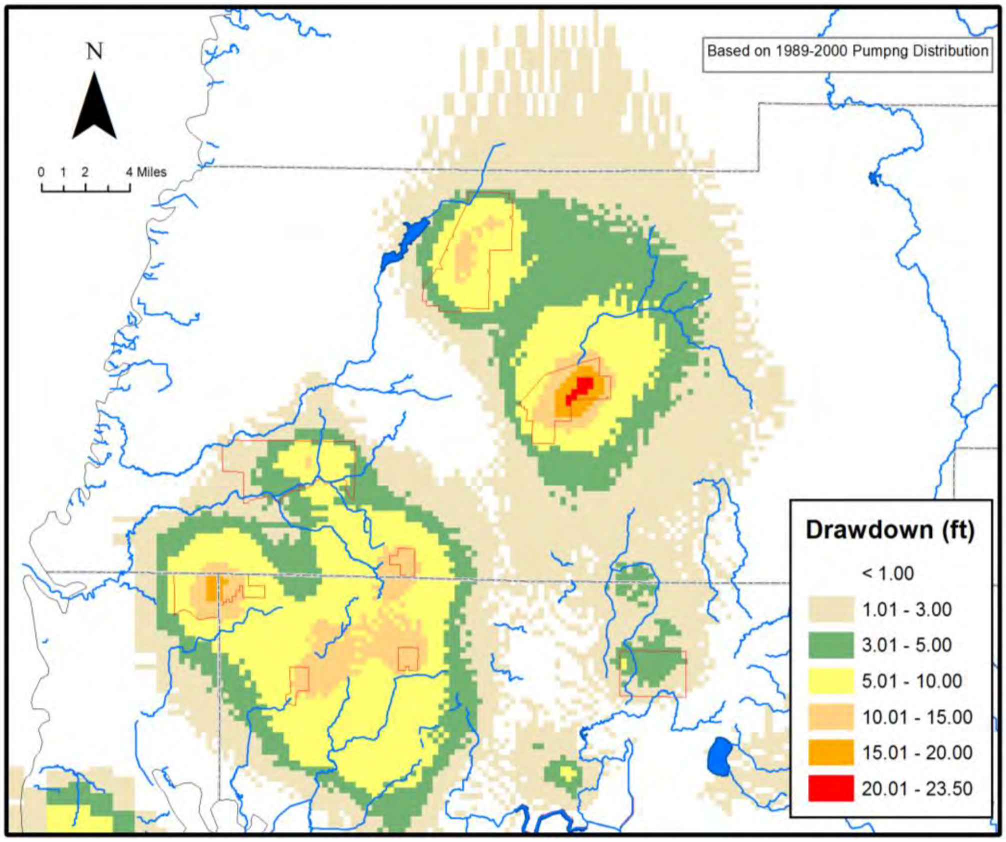

Figure 7. Predicted mean drawdown in the Upper Floridan Aquifer due to 239.4 mgd of groundwater withdrawals within the Central West-Central Florida Groundwater Basin from 1989-2000.

To estimate the historic impact on stream flow, seven major wellfields within or near the Pithlachascotee Basin were modeled either individually (Eldridge-Wilde, Cosme-Odessa, Section 21, and South Pasco) or as groups (Cypress Creek-Cross Bar and Starkey-North Pasco). Table 1 summarizes the mean and median flow declines as predicted by the INTB model for each scenario. Appendix A depicts the predicted drawdown in the surficial and Upper Floridan aquifers for each of the six scenarios.

4.0 Estimation of groundwater impacts to Pithlachascotee River Flow from 1955 to 2007

The earliest groundwater withdrawals for public supply began as early as the 1930s at Cosme-Odessa wellfield. However, stream flow measurements did not originate from the New Port Richey gage on the Pithlachascotee River until 1963. After Cosme-Odessa, the Eldridge–Wilde wellfield began pumping in 1956. Thereafter, Section 21, South Pasco, and the Starkey wellfield initiated withdrawals in 1963, 1973, and 1976, respectively. In 1976 and 1980, Cypress Creek and Cross Bar wellfields began operations, respectively. All of these wellfields extracted a combined average of about 120 mgd during the 1990s. Figure 8 displays the groundwater withdrawal history of these wellfields that are within or near the Pithlachascotee River Basin. Since 2008, reductions in groundwater withdrawals as part of the partnership plan reduced TBW central system wellfield withdrawals from approximately 150 mgd to 90 mgd. Groundwater withdrawals from the seven major wellfields within or near the Pithlachascotee Basin averaged about 60 mgd from 2008 through 2010.

To estimate the approximate impact to the Pithlachascotee River through time due to groundwater extraction, a ratio of stream flow decline of the Pithlachascotee River at the New Port Richey gage per one mgd groundwater withdrawal quantity was calculated for each of the wellfields based on the scenario runs (Table 1). Due to their distance from the Pithlachascotee River watershed, both the

Table 1. Description and results of changes to Pithlachascotee River stream flow from seven different INTB model scenarios (1989-2000 simulation period).

Model Scenario No.	Groundwater Extraction (mgd)*	Description	Mean Stream Flow Reduction (cfs) Pithlachascotee River near New Port Richey	Median Stream Flow Reduction (cfs) Pithlachascotee River near New Port Richey
1	239.4	Central West-central Florida Groundwater Basin	8.3	4.5
2	14.4	Starkey, North Pasco Wellfields	4.4	3.2
3	57.5	Cypress Creek and Cross Bar Wellfields	2.5	0.4
4	27.6	Eldridge-Wilde Wellfield	0.2	0.2
5	15.5	South Pasco Wellfield	0.2	0.1
6	10.8	Section 21 Wellfield	0	0
7	10.7	Cosme-Odessa Wellfield	0	0

* = 1989-2000 Average Quantities

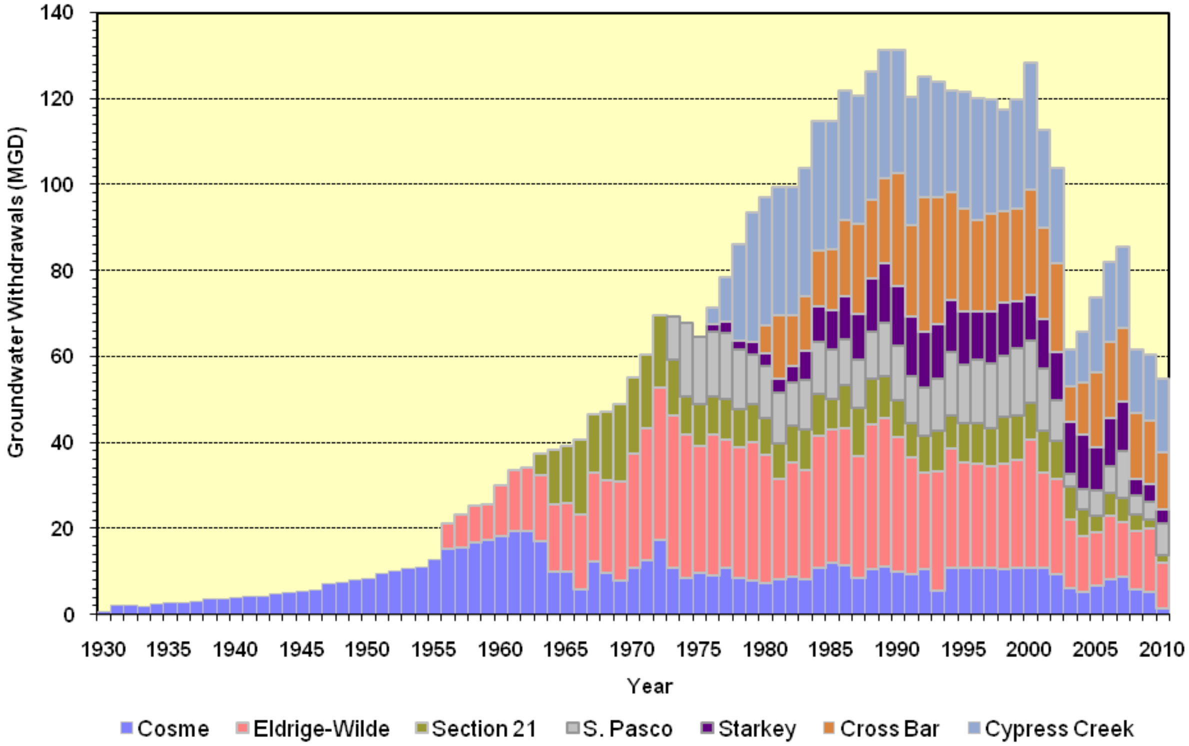

Figure 8. Groundwater withdrawal history from seven wellfields within or near the Pithlachascotee River Basin.

Cosme-Odessa and Section 21 wellfields have a negligible impact on Pithlachascotee River flow. In addition to these wellfields, one cfs of impact to Pithlachascotee River flow is predicted from the model from all other users. Description and results of changes to Pithlachascotee River stream flow from seven different INTB model scenarios (1989-2000) are found in Table 1. The seven TBW wellfields account for 88 percent of total predicted mean flow decline at the New Port Richey gage due to groundwater withdrawals.

The projected decline in Pithlachascotee River stream flow through time was developed by multiplying the mean and median flow declines per mgd of pumping listed in Table 1 by the actual wellfield extraction through time. The flow decline was estimated each year beginning in 1955 and ending in 2007 based on each year's distribution of average annual wellfield withdrawals.

The total projected stream flow decline from other users was simply incrementally apportioned through time from 1955 to the full impact in 1993 since water use history of these withdrawals is poorly understood. After 1993, other user's impact was held steady. The chronological history of projected impacts to Pithlachascotee River stream flow is shown in Figure 9 and summarized in Table 2.

5.0 Estimation of groundwater impacts to Pithlachascotee River Flow from 2008 to 2010

Due to implementation of the partnership plan, TBW's groundwater withdrawals declined significantly from 2008 through 2010. Groundwater withdrawals during 2008 through 2010 from the TBW central system wellfields averaged 85.8 mgd. Groundwater withdrawals from the seven wellfields previously modeled averaged 59.3 mgd from 2008 through 2010. The INTB model was run again to simulate the impacts from all groundwater withdrawn within the Central West-Central Florida Groundwater Basin (CWCFGWB). Except this time, the model was run from 1996 through 2006 and TBW wellfield pumpage was adjusted to match their recovery

quantities of 90 mgd from their central system wellfields. The TBW wellfield distribution run for this 11-year period was based
on calendar year 2008 adjusted slightly upward to account for a total of 90 mgd.

The area of withdrawals totaled 184.3 mgd (average 1996-2006 conditions). The results of this simulation was again compared to the zero withdrawal simulation within the basin. Based on the INTB model results, current mean and median withdrawal impacts to Pithlachascotee River stream flow at the New Port Richey gage from all users are 5.2 and 2.2 cfs, respectively, based on current conditions. TBW wellfield mean and median withdrawal impacts to Pithlachascotee River stream flow at the New Port Richey gage represent 4.0 and 1.6 cfs, respectively, of the total impact. As a note of caution, varying the distribution of individual wellfield pumping will result in differing groundwater withdrawal impacts to the Pithlachascotee River. In this case, we assumed a distribution that closely matched 2008. Actual wellfield pumping may vary significantly from this distribution in the future.

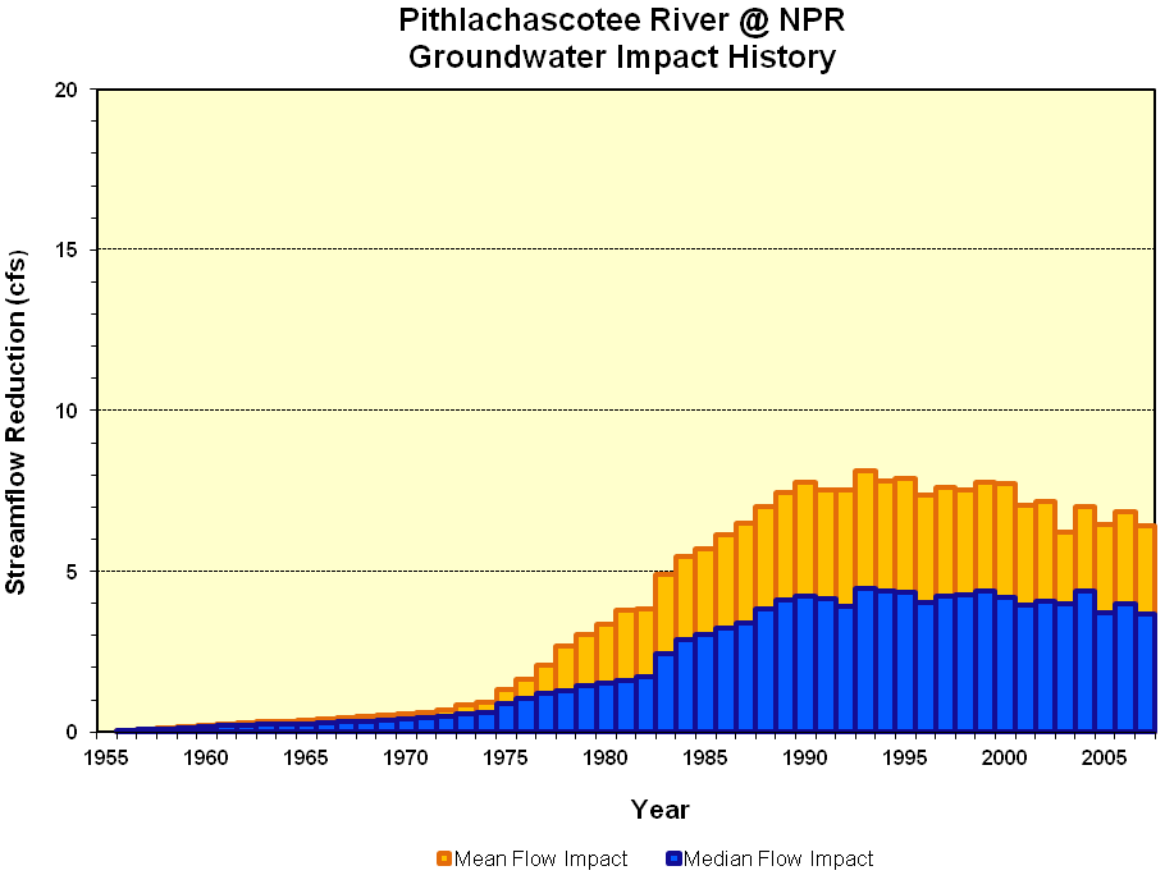

Figure 9. Projected mean and median annual stream flow impact to the Pithlachascotee River at New Port Richey gage due to groundwater withdrawals in the region (1955-2007).

Table 2. Projected mean and median annual stream flow impact to the Pithlachascotee River at New Port Richey gage due to groundwater withdrawals (1955-2007).

Year	Wellfield Total (mgd)	TBW Mean Pith River Impact at NPR (cfs)	TBW Median Pith River Impact at NPR (cfs)	Other User Mean Pith River Impact at NPR (cfs)	Other User Median Pith River Impact at NPR (cfs)	Total Mean Pith River Impact at NPR (cfs)	Total Median Pith River Impact at NPR (cfs)
1955	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1956	6.0	0.0	0.0	0.0	0.0	0.1	0.1
1957	7.5	0.1	0.1	0.1	0.0	0.1	0.1
1958	7.8	0.1	0.1	0.1	0.0	0.1	0.1
1959	7.7	0.1	0.1	0.1	0.1	0.2	0.1
1960	11.0	0.1	0.1	0.1	0.1	0.2	0.2
1961	14.0	0.1	0.1	0.2	0.1	0.3	0.2
1962	14.0	0.1	0.1	0.2	0.1	0.3	0.2
1963	15.5	0.1	0.1	0.2	0.1	0.3	0.2
1964	16.0	0.1	0.1	0.2	0.1	0.3	0.3
1965	16.1	0.1	0.1	0.3	0.2	0.4	0.3
1966	17.4	0.1	0.1	0.3	0.2	0.4	0.3
1967	20.6	0.1	0.1	0.3	0.2	0.4	0.3
1968	21.6	0.2	0.2	0.3	0.2	0.5	0.4
1969	23.1	0.2	0.2	0.4	0.2	0.5	0.4
1970	26.6	0.2	0.2	0.4	0.2	0.6	0.4
1971	30.5	0.2	0.2	0.4	0.2	0.6	0.5
1972	34.8	0.3	0.3	0.4	0.3	0.7	0.5
1973	45.6	0.4	0.3	0.5	0.3	0.8	0.6
1974	50.3	0.5	0.3	0.5	0.3	0.9	0.6
1975	46.5	0.8	0.6	0.5	0.3	1.3	0.9
1976	52.6	1.1	0.7	0.5	0.3	1.6	1.1
1977	57.4	1.6	0.9	0.6	0.3	2.1	1.2
1978	68.8	2.1	1.0	0.6	0.3	2.7	1.3
1979	75.0	2.5	1.1	0.6	0.4	3.1	1.4
1980	78.8	2.8	1.1	0.6	0.4	3.4	1.5
1981	81.3	3.2	1.2	0.7	0.4	3.8	1.6
1982	80.9	3.2	1.3	0.7	0.4	3.9	1.7
1983	84.1	4.2	2.0	0.7	0.4	4.9	2.5
1984	94.1	4.8	2.4	0.7	0.4	5.5	2.9

1985	94.7	5.0	2.6	0.8	0.5	5.7	3.0
1986	98.1	5.4	2.8	0.8	0.5	6.2	3.2
Year	**Wellfield Total (mgd)**	**TBW Mean Pith River Impact at NPR (cfs)**	**TBW Median Pith River Impact at NPR (cfs)**	**Other User Mean Pith River Impact at NPR (cfs)**	**Other User Median Pith River Impact at NPR (cfs)**	**Total Mean Pith River Impact at NPR (cfs)**	**Total Median Pith River Impact at NPR (cfs)**
1987	99.2	5.7	2.9	0.8	0.5	6.5	3.4
1988	104.8	6.2	3.4	0.8	0.5	7.0	3.9
1989	109.5	6.6	3.6	0.9	0.5	7.5	4.1
1990	112.3	6.9	3.7	0.9	0.5	7.8	4.2
1991	103.5	6.7	3.6	0.9	0.5	7.6	4.2
1992	106.5	6.6	3.4	0.9	0.6	7.6	3.9
1993	109.8	7.2	3.9	1.0	0.6	8.2	4.5
1994	107.1	6.9	3.8	1.0	0.6	7.8	4.4
1995	104.2	6.9	3.8	1.0	0.6	7.9	4.4
1996	101.1	6.4	3.4	1.0	0.6	7.4	4.0
1997	101.3	6.6	3.6	1.0	0.6	7.6	4.2
1998	97.3	6.6	3.7	1.0	0.6	7.6	4.3
1999	101.8	6.8	3.8	1.0	0.6	7.8	4.4
2000	111.6	6.8	3.6	1.0	0.6	7.8	4.2
2001	93.1	6.1	3.3	1.0	0.6	7.1	3.9
2002	86.4	6.2	3.5	1.0	0.6	7.2	4.1
2003	50.2	5.2	3.4	1.0	0.6	6.2	4.0
2004	57.2	6.0	3.8	1.0	0.6	7.0	4.4
2005	65.5	5.5	3.1	1.0	0.6	6.5	3.7
2006	71.1	5.9	3.4	1.0	0.6	6.9	4.0
2007	71.4	5.5	3.1	1.0	0.6	6.5	3.7

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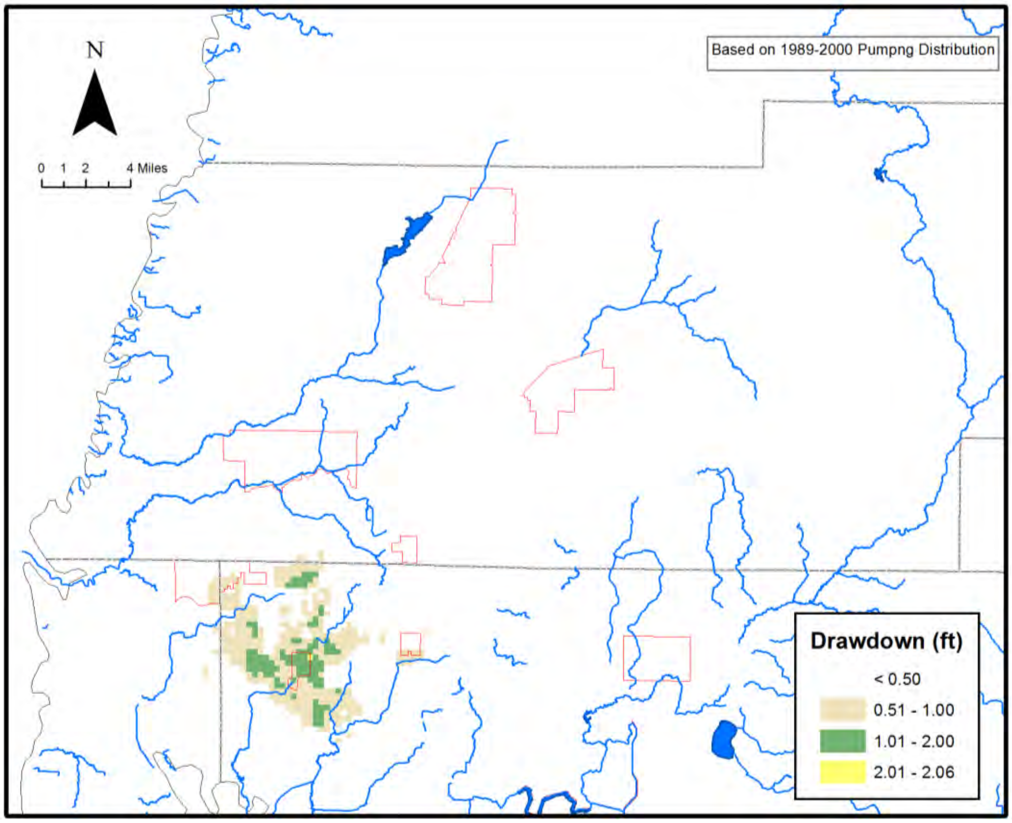
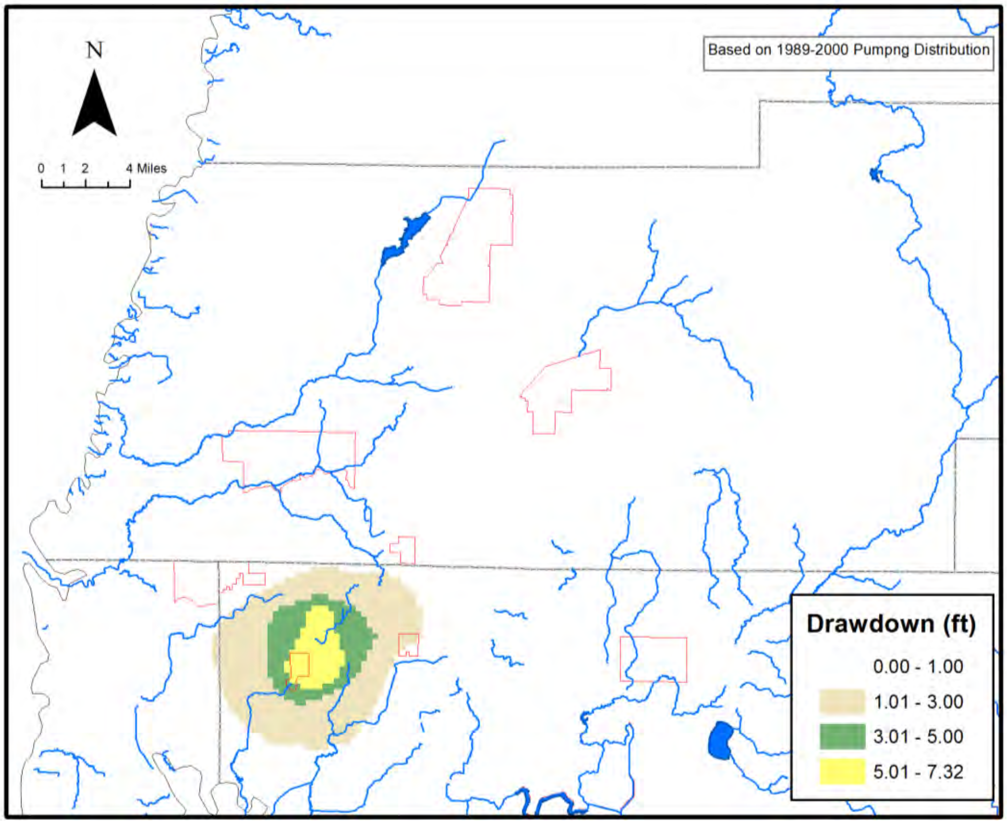
Appendix A

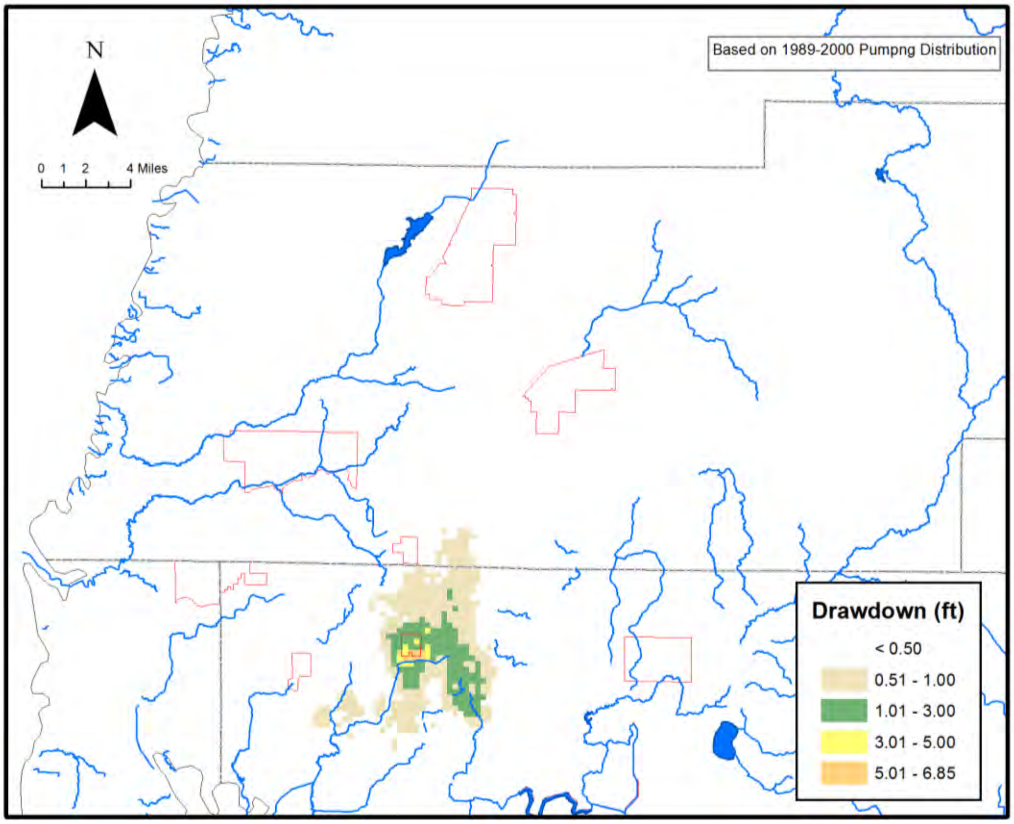
(Surficial and Upper Floridan Aquifer Average Drawdown by Wellfield for the period 1989-2000)



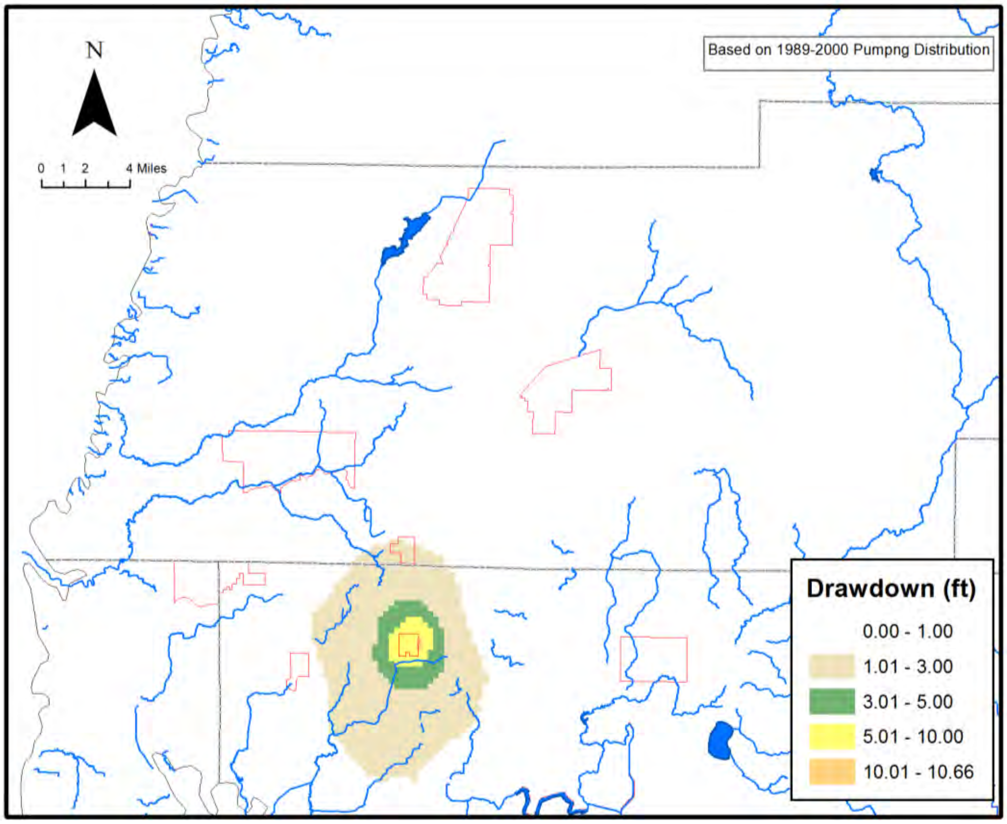
Predicted mean drawdown in the surficial aquifer due to Cosme-Odessa wellfield withdrawals from 1989-2000.



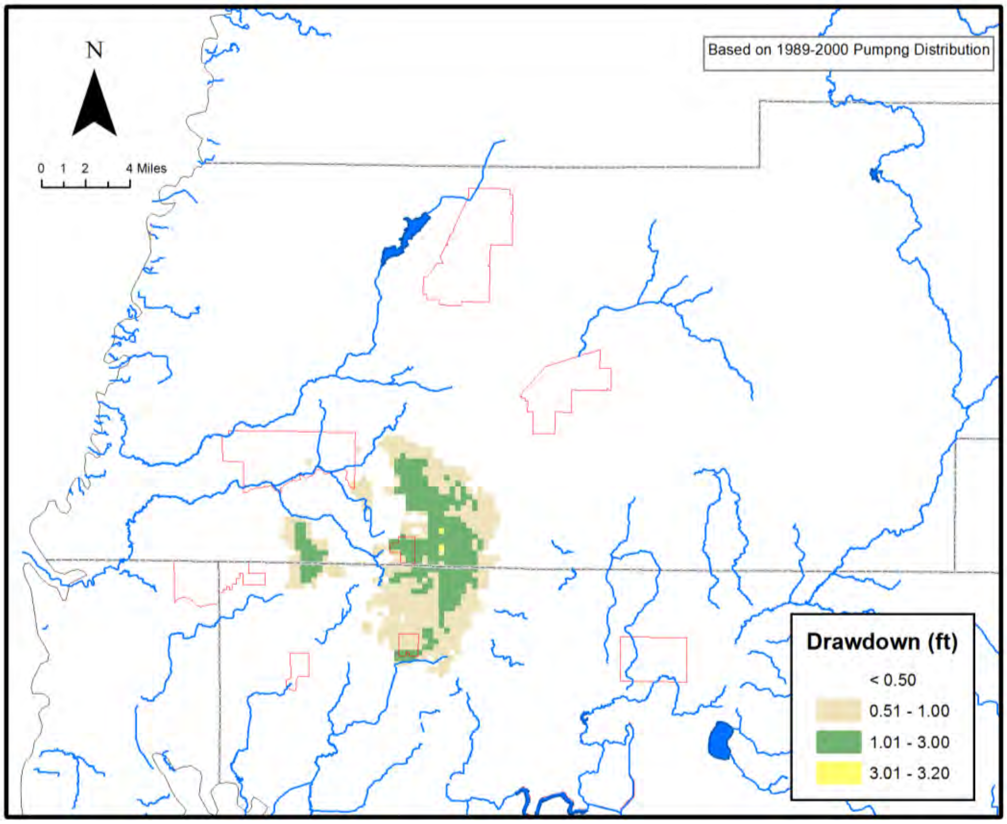
Predicted mean drawdown in the Upper Floridan aquifer due to Cosme-Odessa wellfield withdrawals from 1989-2000.



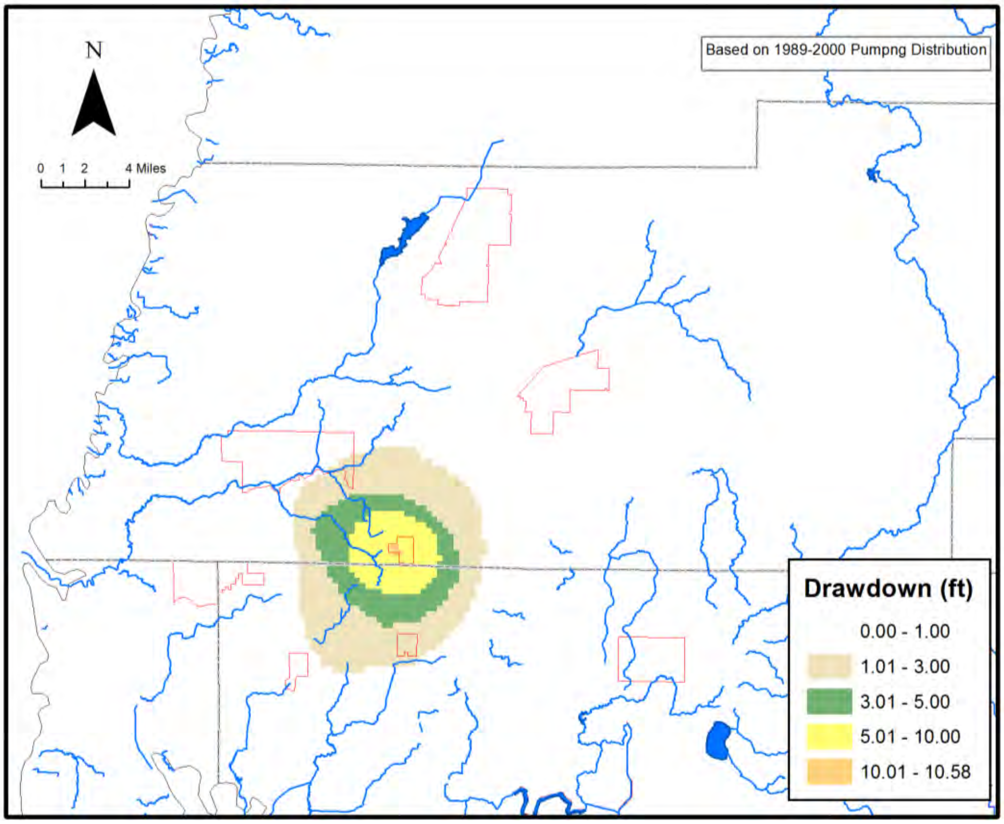
Predicted mean drawdown in the surficial aquifer due to Section 21 wellfield withdrawals from 1989-2000.



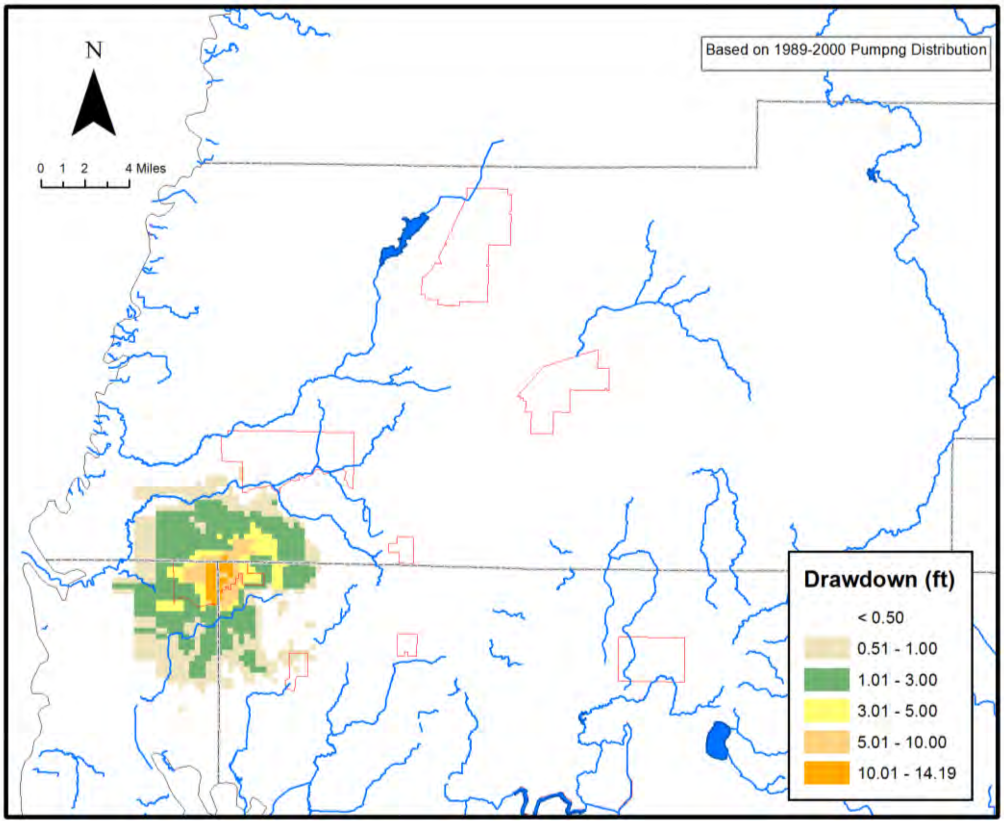
Predicted mean drawdown in the Upper Floridan aquifer due to Section 21 wellfield withdrawals from 1989-2000.



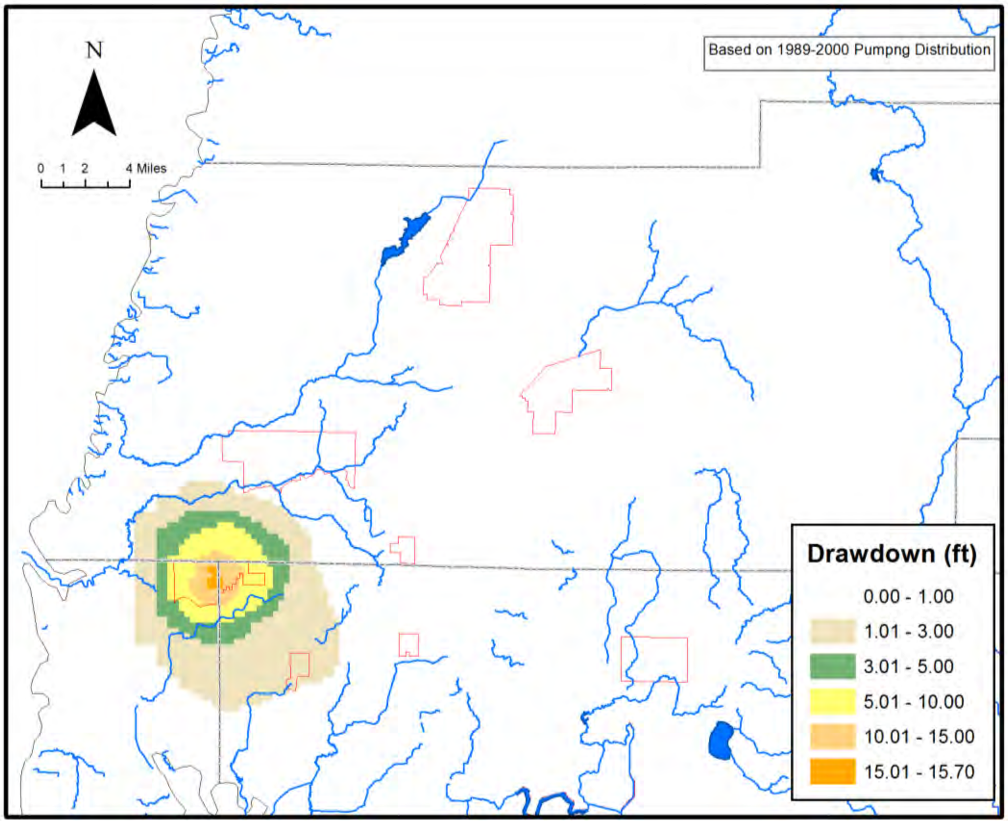
Predicted mean drawdown in the surficial aquifer due to South Pasco wellfield withdrawals from 1989-2000.



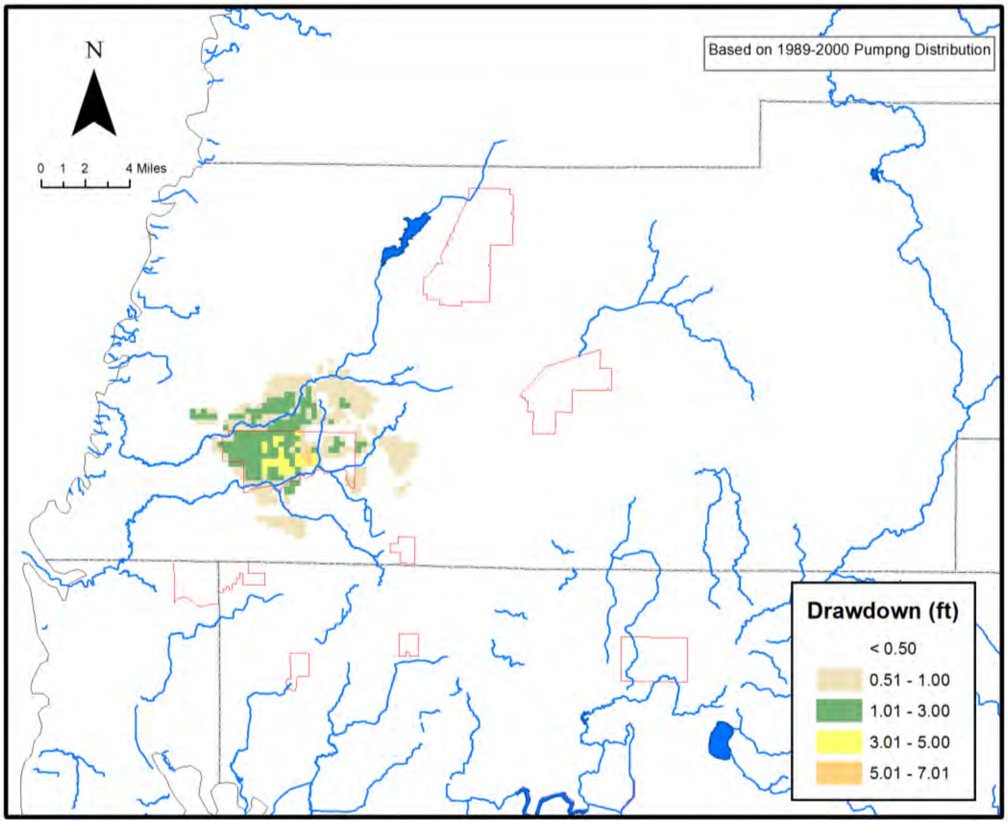
Predicted mean drawdown in the Upper Floridan aquifer due to South Pasco wellfield withdrawals from 1989-2000.



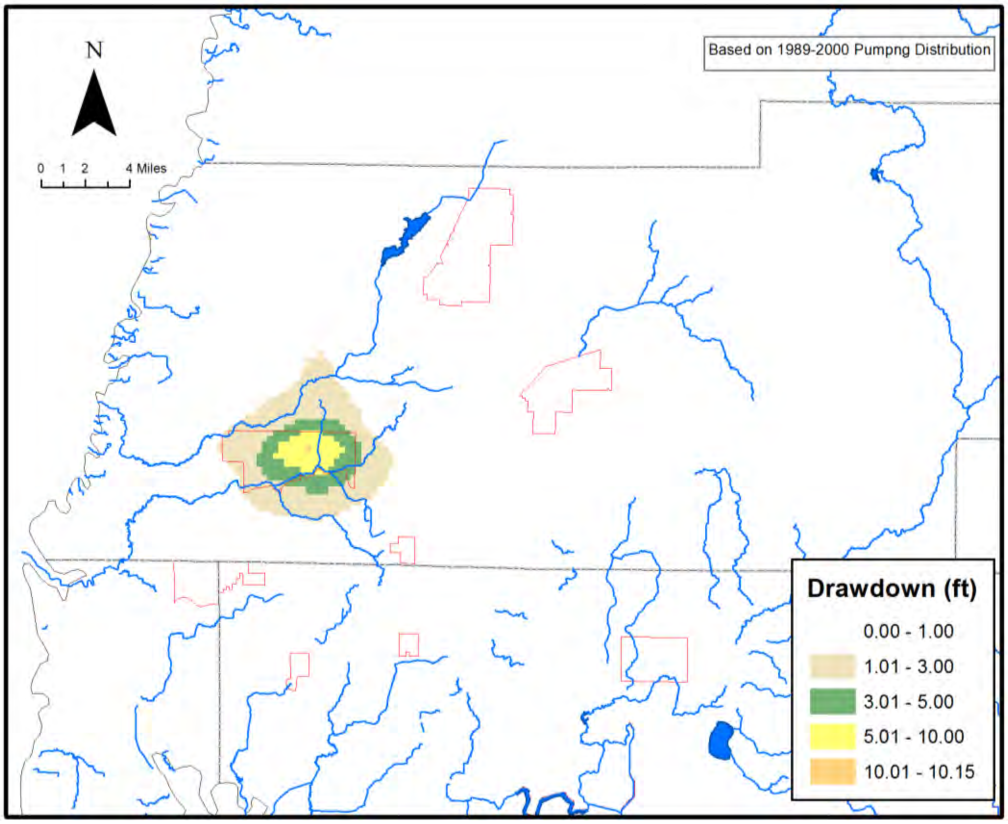
Predicted mean drawdown in the surficial aquifer due to Eldridge-Wilde wellfield withdrawals from 1989-2000.



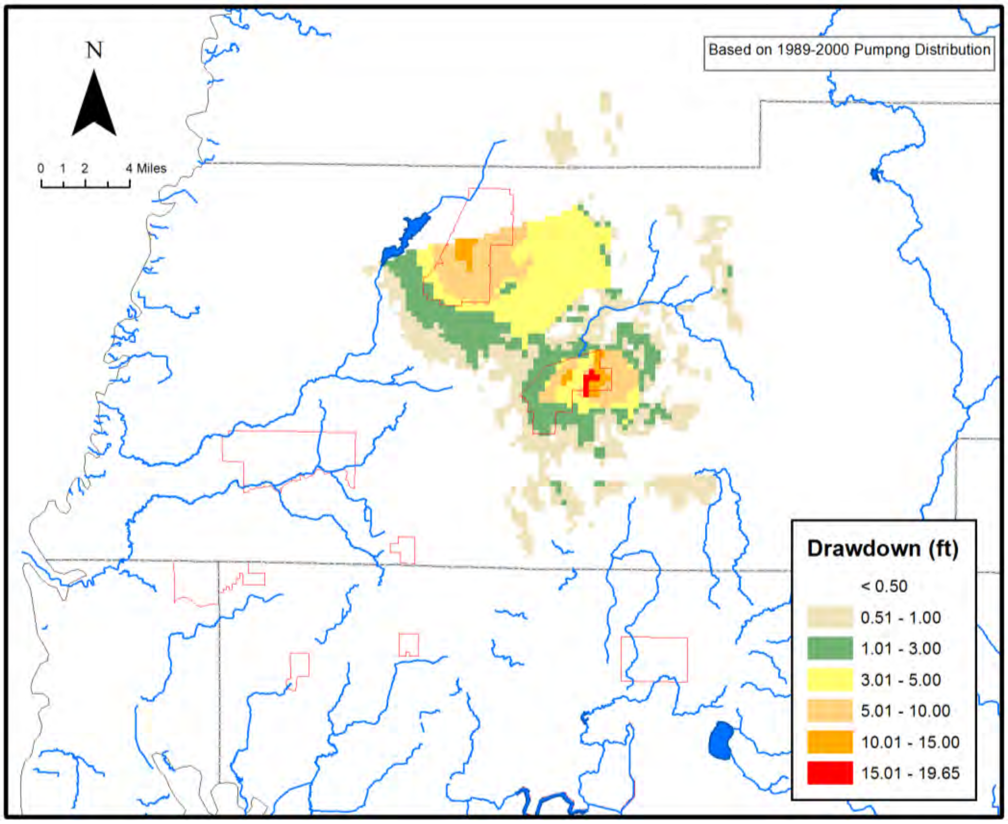
Predicted mean drawdown in the Upper Floridan aquifer due to Eldridge-Wilde wellfield withdrawals from 1989-2000.



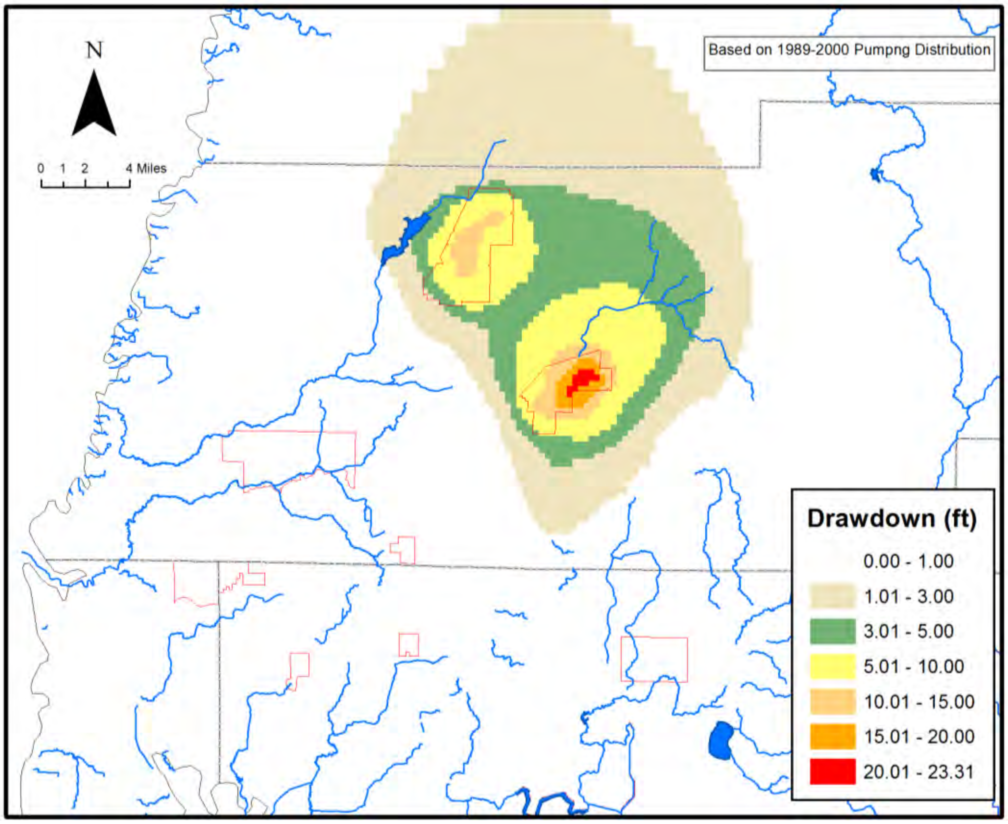
Predicted mean drawdown in the surficial aquifer due to Starkey-North Pasco wellfield withdrawals from 1989-2000.



Predicted mean drawdown in the Upper Floridan aquifer due to Starkey-North Pasco wellfield withdrawals from 1989-2000.



Predicted mean drawdown in the surficial aquifer due to Cypress Creek and Cross Bar wellfield withdrawals from 1989-2000.



Predicted mean drawdown in the Upper Floridan aquifer due to Cypress Creek and Cross Bar wellfield withdrawals from 1989-2000.

APPENDIX 3A

Wang, P. 2008. Shoreline mapping and bathymetric survey for the Pithlachascotee (Cotee) River system. University of South Florida, Tampa, Florida. Prepared for the Southwest Florida Water Management District, Brooksville, Florida.

Shoreline Mapping and Bathymetric Survey for the
Pithlachascotee (Cotee) River System

Final Report

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July 30, 2008

INTRODUCTION

The Pithlachascotee (Cotee) River system survey project included: 1) the Pithlachascotee (Cotee) River and all the side creeks, 2) the Millers Bayou, and 3) the river mouth area. The project included two tasks: 1) mapping of the shoreline and 2) surveying of the bathymetry.

The shoreline configuration was mapped in the field using a RTK (Real-Time Kinematics) global positioning system (GPS). The shoreline position was obtained by navigating the survey vessel along the shoreline. The bathymetry was measured using a synchronized precision echo sounder with the GPS. Sections across the water body and centerlines were surveyed.

STUDY AREA

The project area along the Pithlachascotee (Cotee) River system is shown in Figure 1. The survey extended from its entrance to Gulf of Mexico to approximately 300 river meters upstream of Rowan Road, which is roughly 1800 meters downstream of the Little Road intersection and the furthest upstream location we could reach due to many blockages by falling trees. All the navigable branches and side creeks were included in the survey. Miller Bayou and the associated canals are also surveyed. The bathymetry measurement included cross-section surveys spaced at 500 ft (150 m) or less and at least one centerline survey. At narrow sections of the river, zigzag survey lines were sometimes added to ensure adequate coverage and are considered part of the river centerline. The shoreline of the main river and all the branches were mapped in the field by navigating the survey vessel along the shoreline. To cover the entire stretch of the river, the GPS base station (control point) was established at two different locations.

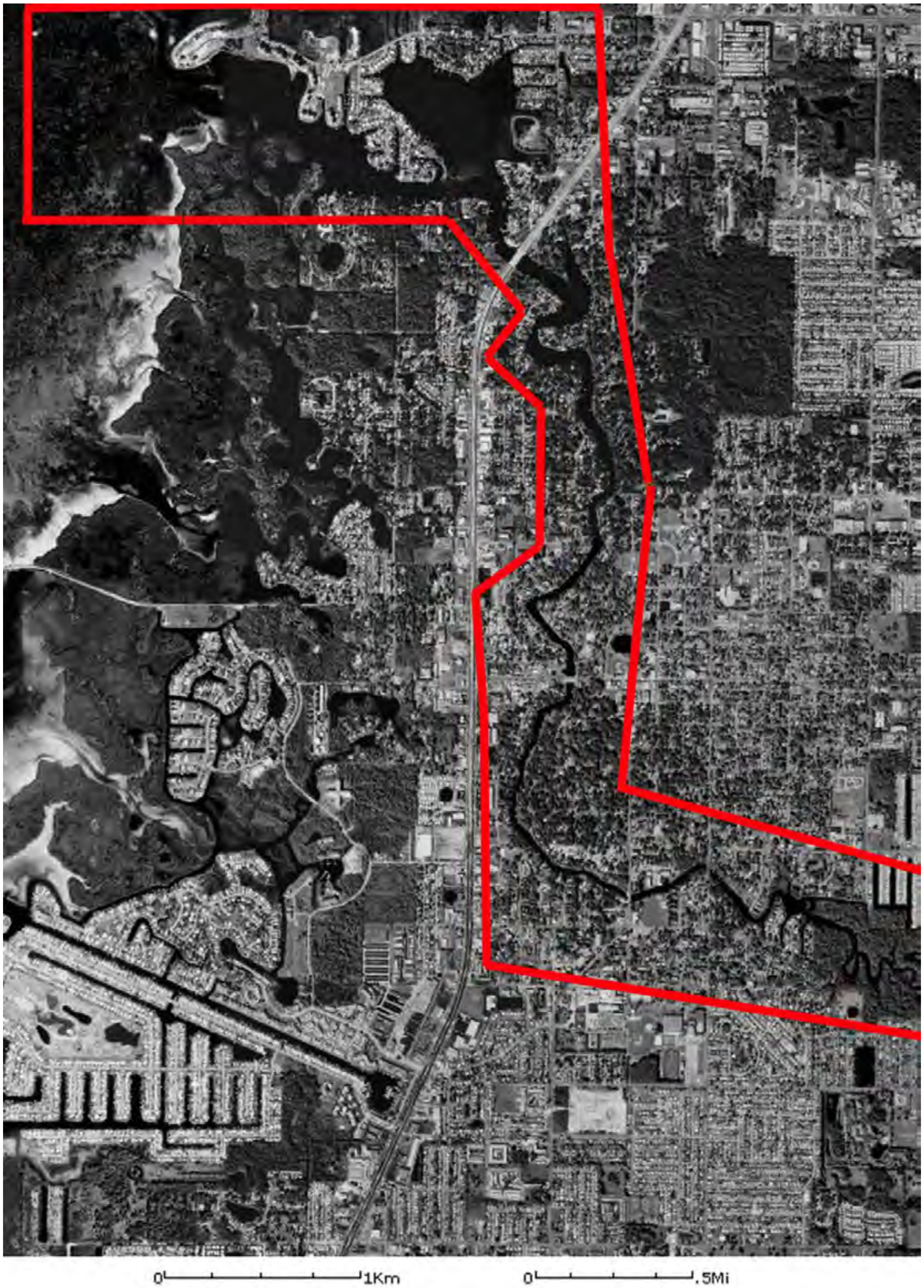

Figure 1. Study area at the Pithlachascotee (Cotee) River and Millers Bayou system. The project area is within the red lines.

FIELD METHODOLOGY

A 24-ft pontoon boat and a 15-ft aluminum boat were used for the shoreline and bathymetry survey (Figure 2). Both boats require only 1 ft (0.3 m) or less draft, but needs calm water to operate. The smaller boat was used to survey the shoreline and most of the narrow tidal creeks and the upper stretch of the river. These boats are ideal for this project.

Figure 2. The survey vessels, upper: the pontoon boat; lower: the 15-ft aluminum boat.

Shoreline Mapping

The shoreline was mapped with the RTK GPS mounted on board the survey vessels. The shoreline positions were obtained by navigating the survey vessel as close to the vegetated shoreline as possible. In the present study, the shoreline is defined as the clear boundary between vegetated land and water. Same definition would apply to digitize shoreline from aerial photos or maps. Given the relatively low tidal range, typically less than 3 ft (1 m), the shoreline (as defined here) position is not significantly influenced by tidal water-level variations in most areas. The shoreline survey was mostly conducted during high tide. Most of the vegetated boundary remains clear regardless of tidal stage.

The shoreline survey was conducted using the 15-ft boat. The shoreline mapped here is typically 3 to 6 ft from the actual vegetation line along the riverbank. Given the typical width of several hundred feet, this limitation should not have any significant influence on the mapping of the river configuration. However, this limitation may induce considerable uncertainty in the shoreline position at some of the narrow creeks, simply because 3- to 6-ft length equals a considerable portion of the creek width.

The upper stream of Pithlachascotee (Cotee) River is very narrow and covered, from bank to bank at most places, by heavy vegetation. The quality of the GPS receiving is influenced by the vegetation coverage. Along a large portion of the river upstream of the Colony Cove mobile home park, the RTK GPS encountered constant difficulties of acquiring “fixed” position (the “fixed” reading from RTK GPS provides accurate position). A WAAS-enabled sub-meter accuracy DGPS was used to supplement the RTK GPS at places with dense vegetation.

The positions of the actual shoreline, used in the generation of a final map, were corrected during the data processing phase by manually moving the survey points about 4.5 feet (1.5 m) landward, as discussed and agreed with the SWFWMD researchers. The moved shoreline, or edited shoreline, position is double-checked with rectified LABIN aerial photos. At places where the surveyed shoreline was obviously far from the actual shoreline due to protruding docks, very shallow water, rock outcrops, or protruding vegetation, the LABIN photo was used to position the moved shoreline. No elevation values were assigned to this “edited” shoreline position. Water depth was measured during the mapping of the shoreline. These water depths were used in the mapping of the bathymetric contours.

The software HYPACK version 6.2 was used to manage the sampling of the RTK GPS system and the Odom survey grade echo sounder. Dynamic sampling regulated largely by the quality of the RTK GPS position reading was conducted using this newest version of HYPACK. The close spacing reduced the uncertainty of interpolation between points. Given the complicated shoreline configuration, closely spaced sampling is important for accurate mapping.

Additional uncertainties in the shoreline mapping were caused by obstacle intrusions, both natural and artificial. Along some parts of the populated shoreline, the protruding boat docks caused some uncertainties for shoreline mapping (Figure 3). The survey vessel had to be navigated around the docks. The relative errors caused by the boat docks are not high because they tend to concentrate in areas with relatively wide water body.

The shoreline mapping is also influenced by various protruding natural objects, particularly overturned tree trunks. These tree trunks might become dangerous navigational hazard because many of them extending underwater. The survey vessel had to be navigated around them. Another shoreline-mapping obstacle is the low overhanging trees (Figure 4). It was not possible for the survey vessel to be navigated under the trees. Therefore, the vessel had to deviate from the shoreline to avoid the trees.

Some of the obvious shoreline intrusions, e.g., those that created a sharp concave shape along an otherwise straight stretch of shoreline, were corrected in the lab during the processing of the shoreline data. Also, field notes were taken at some of the substantial intrusions. These were also corrected based on the field notes, and rectified 2006 DOQQ aerial photos.

Figure 3. Protruding boat docks caused some problem in shoreline mapping.

Figure 4. Protruding palm trees caused some problem in the shoreline mapping.

These obstacles, both artificial and natural, did not have significant influence on the shoreline mapping along most of the river. Their impacts were mostly scarce and local. Limited by the scope and budget of the present project, most of their locations were not marked in the shoreline mapping. These artificial and natural protruding obstacles had minimal impact on the bathymetry survey. The survey lines were selected such that the obstacles were avoided. However, along the very narrow upper stream of Pithlachascotee (Cotee) River, as discussed above, the dense vegetation had considerable influence on the survey.

Bathymetry Survey

The bathymetry was measured with a narrow-beam (2.8 degrees) echo sounder. The narrow beam sensor was designed to obtain accurate depth measurement over steep slope, which is ideal for the present project. The sensor was mounted at 18 cm below the water surface on the pontoon boat (Figure 5) and 12 cm below on the aluminum Jon boat. The sensor has a minimum range of approximately 20 cm. Therefore, the minimum measurable water depth for the present system is roughly 30 cm.

Under most circumstances, the cross-section survey lines are roughly perpendicular to the shoreline (Figure 6). The cross-section survey lines were space at 500 ft (150 m) or less to ensure adequate spatial coverage. Additional survey lines were added at areas with complicated bathymetry. A considerable portion of the upstream reach of the Pithlachascotee (Cotee) River and some of the creeks and are too narrow, e.g., less than 60 ft (18 m) wide. A large portion of the creek could not be covered by the survey vessel simply because the river is too narrow for the vessel to go across. In this case, in addition to cross sections, a survey line following a zigzag pattern over mostly the center of the creek was added. A centerline was surveyed over the entire project area.

The echo sounder is synchronized and co-located with the GPS system. The GPS yields horizontal position, in terms of latitude and longitude, and the echo sounder provides water depth measured at the same time as the geographic position. The survey was administrated using the most recent HYPACK survey software version 6.2.

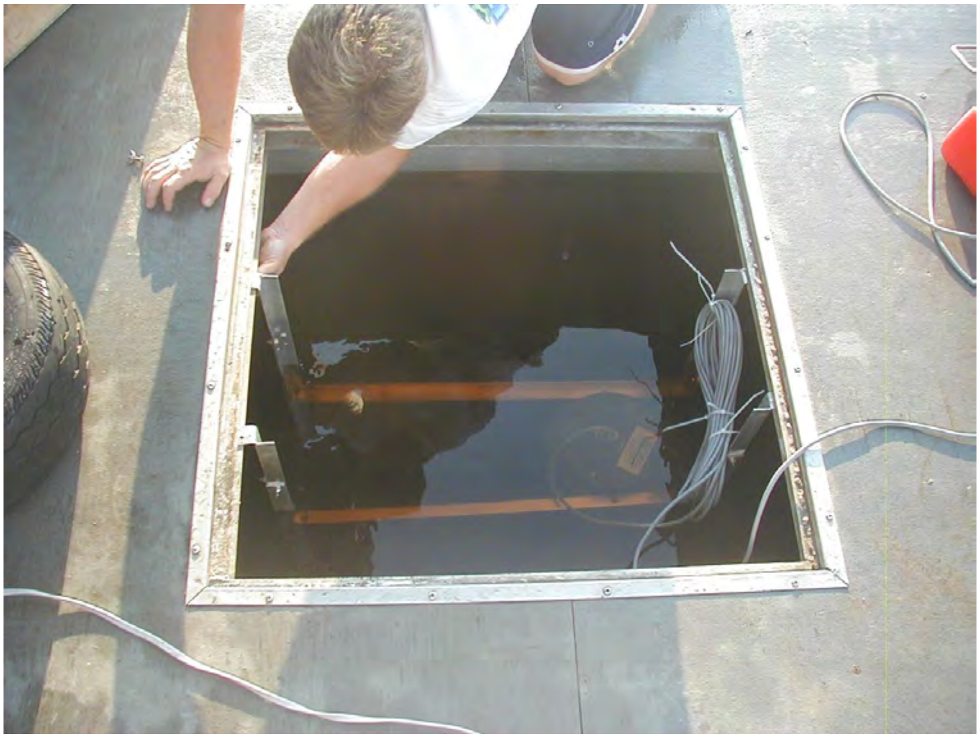

Figure 5. The survey echo sounder was mounted at 18 cm below water surface.

Figure 6. Surveying cross sections.

Several sources may induce errors in the survey. The soundings sometimes collected abnormal readings in shallower water, mostly when water depth became shallower than 0.3 m in combination with relatively rough conditions. This is particularly notable in areas of dense river bottom vegetation. Occasionally, the echo sounder will return a reading of zero under these circumstances. These erroneous readings were removed during the data processing. The reason for zero soundings recorded in Hypack is attributed to the echo sounder processing algorithms.

Occasionally, the echo sounder returned a reading that was apparently twice the water depth (Figure 7). This seems to be caused by multiple reflections of the sound signal, i.e., the signal was reflected back and forth twice between the bottom and the sensor. Very rarely the signal was reflected back and forth for more than two times. These points were corrected by simply dividing the recorded depth by the number of multiple reflections. The data processing part of the Hypack software provides a routine to correct these apparent multi-reflections. The program will check the general trend of water depth and compare with adjacent depth. If a point was approximately twice of those adjacent measurement, it would be corrected by dividing by two. Figure 7 illustrates the multiple reflections and the corrected water depth (solid square). The reason for the multiple reflections is not clear. Bottom conditions, e.g., hard sand and oyster-reef bottom versus soft mud bottom, may have some influences. The HYPACK software also allows a certain degree of data smoothing during the initial data quality check and processing.

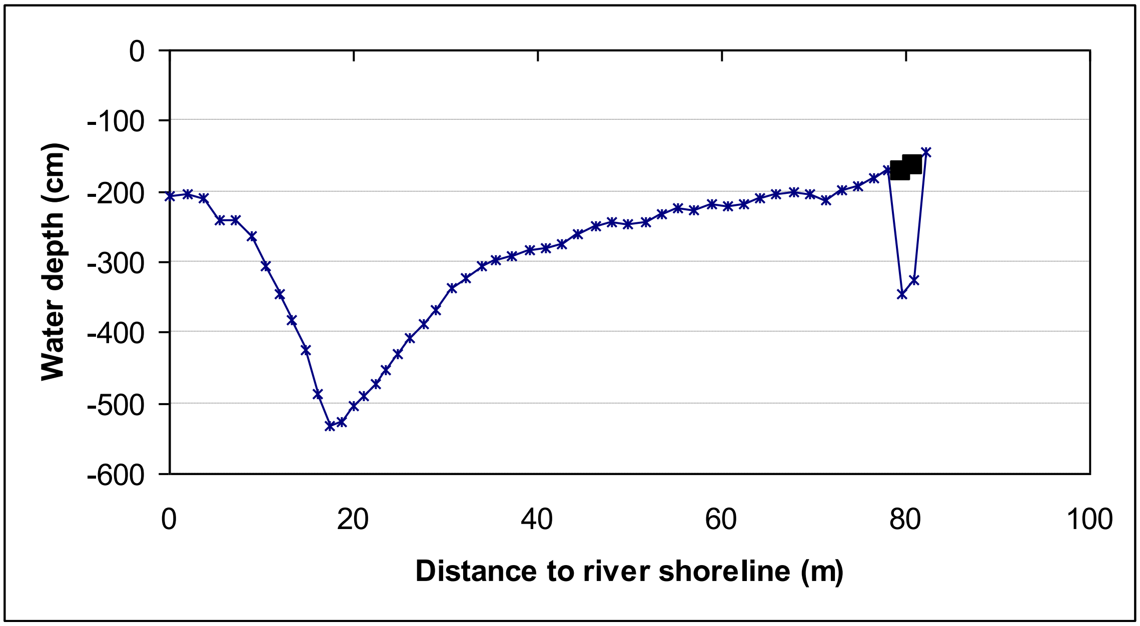

Figure 7. Multiple reflections in the echo sounder record. The solid squares are corrected water depth. An example of a cross section at Peace River (from an earlier SWFWMD project).

Because the echo sounder is mounted on a floating platform, wave motions can cause errors in the measurement. Various software packages are available to remove uncertainties caused by wave motion. Typically, a certain filter is applied to remove regulated wave motions. For the present project, influences of wave motions were minimal due to the relatively restricted water bodies.

The field operation over relatively open water, e.g., at the Cotee River entrance, was conducted during calm conditions to minimize influences of waves. No field operation was conducted when the waves were higher than 1 ft. The waves in the project area were largely local-wind generated, with short wavelength and wave period. Most of the time, the wavelength is shorter than the length of the survey vessel. Motions caused by these short waves are not apparent in the record and are not possible to remove. Given that all the field operations were conducted with waves far less than 1 ft, it was decided that wave-motion filtering was not necessary and was not likely to improve the data accuracy.

Wave motions seemed to have some influence on the performance of the echo sounder. Under relatively rough conditions, more zero readings and more multiple reflections were observed. The reason for the reduced sensor performance under rough conditions is not clear. The wave motion may also induce pitch and roll of the survey vessel. The influences of the pitch and roll are not apparent in the data record. It was difficult to detect because of the short wave period and wavelength, which tend to induce rather irregular motion. No procedure was adopted to remove the potential influence of pitch and roll. Their influences are believed to be negligible for this project, due to narrow water body of the Cotee River.

Another uncertainty associated with the floating platform survey was caused by the tidal water-level variations. A large portion of the study area is influenced by tides, both astronomical and meteorological. To improve the sensor performance, especially in shallow areas, the field operations were mostly conducted during high tides. It is necessary to remove the influence of tidal water-level variations. The elevation of the water surface was measured by the RTK GPS. The trend of tidal water level change was clearly reflected in the GPS elevation measurements. The elevation of the bed level is obtained by subtracting the depth reading obtained from the echo sounder from the water surface elevation obtained from the RTK GPS. This is an improvement from the previous method of using tidal gages that are distributed typically several miles apart. The vertical datum NAVD88 was used in the survey.

Data Format and Organization

The horizontal latitude and longitude positions were recorded by the GPS in reference to NAD83. The latitude and longitude positions were converted to Florida State Plane coordinates (NAD 83) and UTM 17, in meters, using the CORPSCON (Version 5) software developed by the U.S. Army Corps of Engineers. The digital files are submitted in the formats of Excel spreadsheet and ASCII Text. The data are submitted in four sets includes:

Set I: Surveyed data, which include

a) Surveyed shoreline positions in Florida State Plane and UTM 17 coordinates in meters and elevations in centimeters (NGVD88 – cm);

b) Surveyed centerline positions in Florida State Plane and UTM 17 coordinates in meters and elevations in centimeters (NAVD88 – cm);

c) Surveyed cross-sections in State Plane and UTM17 Northing in meters, State Plane and UTM17 Easting in meters, and elevation in centimeters (NAVD88-cm);

Set II: Edited data, which include

a) Edited shoreline positions in UTM17 coordinates in meters with no elevation information;

b) Edited centerline positions in UTM17 coordinates in meters and elevations in centimeters (NAVD88 – cm), largely the same as the surveyed data;

c) Edited cross-sections in UTM17 Northing in meters, UTM17 Easting in meters, and elevation in centimeters (NGVD88-cm), largely the same as the surveyed data;

Set III: GIS maps including the bathymetry contour and shoreline maps of the entire project area, in UTM17 coordinate system.

Set IV: JPG format of the GIS maps including the bathymetry contour and shoreline maps of the entire project area.

The GIS maps are preliminary in the sense that detailed work to improve the map presentation was not conducted. However, the data processing was completed. The details of the contour maps can also be improved by improving the data interpolation schemes in areas with complicated sinuosity. However, the overall bathymetric characteristics are clearly reflected in the present maps. It is beyond the scope of this project to produce detailed local bathymetry maps although the coverage of the field data is adequate to do so. It is worth emphasizing that the bathymetry here is interpreted by the USF researchers and may be different from other interpretations, although the differences are expected to be minor.

Deliverables

The final deliverables include a final report, consisting of two parts. Part I (this volume) documents the field operation procedures, data processing schemes, estimates of uncertainties, and data organization. Part II (accompanying volume) includes the GIS maps (in UTM17 Coordinates in meters, bathymetry in centimeters). All the processed data are delivered on one CD with each set as one folder.

APPENDIX 3B

Water & Air, Research, Inc. 2010. Spatial distribution of benthic macroinvertebrates in the Pithlachascotee River during low-flow conditions with emphasis on relationships with salinity, Purchase Order # 08POSOW1805. Gainesville, Florida. Prepared for the Southwest Florida Water Management District, Brooksville, Florida.

Spatial Distribution of Benthic Macroinvertebrates in the Pithlachascotee River During Low-Flow Conditions with Emphasis on Relationships with Salinity

Purchase Order # 08POSOW1805

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Sediment volatile solids were analyzed by Advanced Environmental Laboratories in Gainesville, Florida. Sediment grain size analysis was performed by MACTEC in Jacksonville, Florida.

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Laura Line	Invertebrate Taxonomist
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Julian DeLaFuente	Field Sample Collection
CAD/GIS staff	Mapping and Figures
Document Production Staff	Report Preparation

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1.0 Introduction

The Southwest Florida Water Management District (SWFWMD) is responsible for protection and management of water resources in southwest Florida. Establishment of minimum flows and levels (MFLs) for freshwater streams and estuarine waters is one of SWFWMD's charges. To that end, the project objectives are to quantify the relationship of physical characteristics, particularly salinity, and the spatial distribution of benthic macroinvertebrates in the Pithlachascotee River.

1.1 Minimum Flows and Levels

Florida Statute 372.042 defines MFLs as "the limit at which further withdrawals would be significantly harmful to the water resources or the ecology of the area." MFLs are not static and vary seasonally and spatially. The MFL process establishes relationships between key ecological components, such as salinity and flow, to the structure of biological communities, such as benthic macroinvertebrates.

1.2 Benthic Macroinvertebrates

Benthic macroinvertebrates are small, typically sedentary, bottom-dwelling organisms that live on or in sediments of waterbodies or wetlands. Examples include shrimp, snails, worms, aquatic insects, and clams, among others. Benthic macroinvertebrates are ecologically important organisms in food webs and are integral in establishing trophic structure of an aquatic ecosystem. They also mix the sediments allowing exchange of oxygen, nutrients and pollutants between the water column and the bottom. Because of their inability to escape exposure to changing conditions (relative to more motile aquatic fauna), benthic macroinvertebrates are often used to assess the condition of an aquatic system since they integrate numerous environmental factors over time spans exceeding those of typical water quality monitoring programs.

1.3 Relationship between Flow and Benthos

Flow regimes are an important characteristic of a river influencing a wide array of biological communities, including benthic macroinvertebrates. Flow is a measure of both volume and velocity and is typically measured in cubic feet per second (cfs) of water. Additionally, flows affect salinity, dissolved oxygen, sediments, and nutrients.

Salinity of tidal rivers shift based on flow conditions and tidal state. Salinity affects the biological communities of the rivers, including the benthic community. A species distribution and abundance, as well as the community structure, are affected by salinity. Under low flow conditions, estuarine species habitat will increase upstream. Conversely, under high flow conditions, some freshwater species may occupy sediment areas farther downstream.

Changes in freshwater inflow can affect the benthic community structure, alter the availability of sediment types, and change water chemistry. The dynamic shifts that occur between freshwater and estuarine benthic species in a tidal river are driven by the osmotic tolerances of the individual species. In general, estuarine species are better adapted to these changes than are freshwater species. Also, sediment type significantly affects the type of benthic community present. An altered salinity regime along a reach of river can exclude those benthic organisms that normally inhabit a given sediment or substrate type. River inflows alter residence times and stratification, ultimately influencing availability of dissolved oxygen along the river course. Water quality constituents, such as nutrients and metals, become more concentrated at lower flows. Increased residence times under low flow conditions allow phytoplankton to take up more nutrients, whereas under high flow conditions downstream, nutrient loading is increased. Sediment loading increases during periods of higher flow and can bury and suffocate benthic communities.

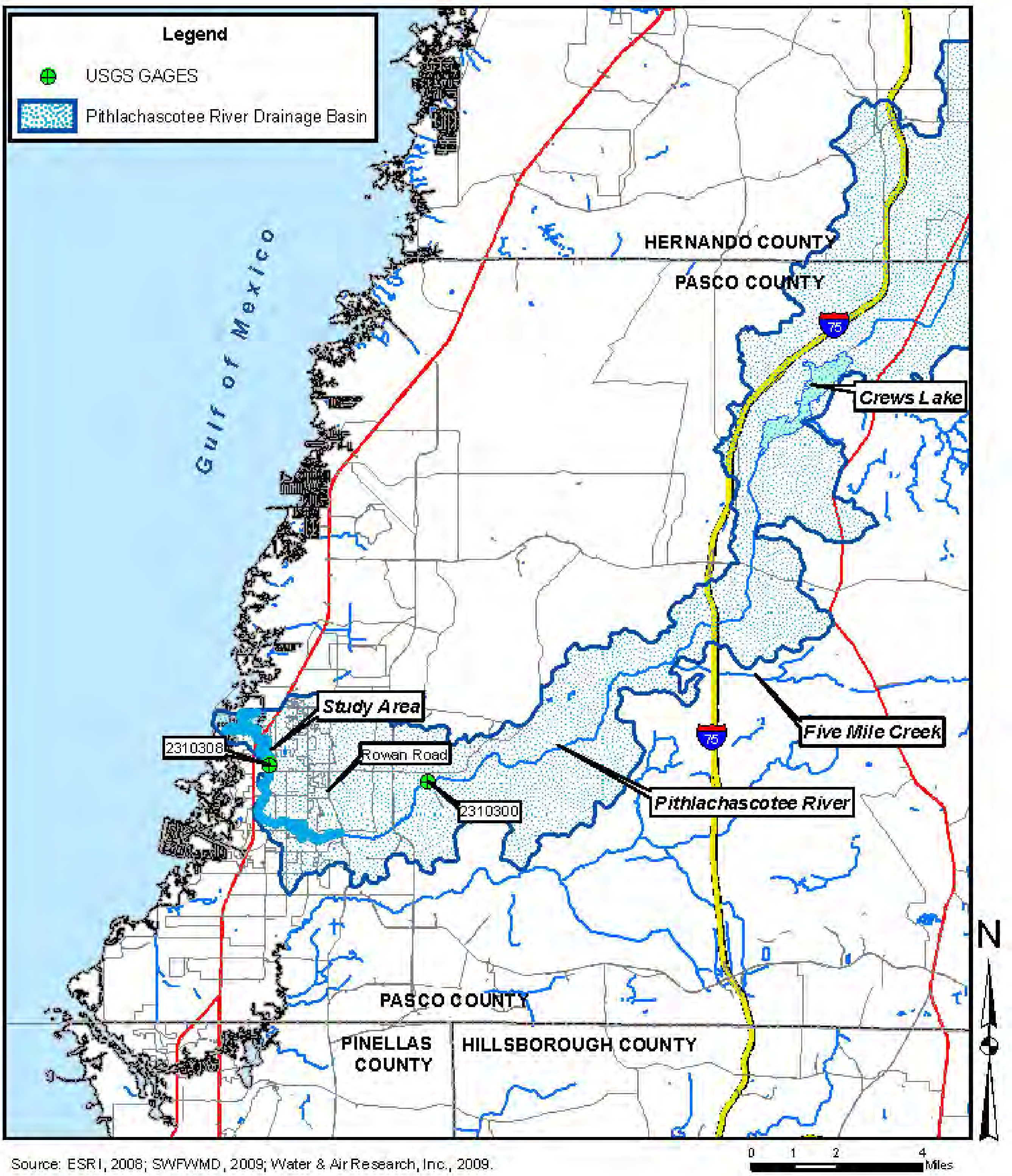
The type of substrate available in a stream for colonization by benthic organisms is determined by native soil material and geology, current velocity, and organic inputs. Substrate composition is also affected by grain size and the interstitial space between the grains. In general, increased substrate stability and presence of organic detritus as a food resource lead to an increase in invertebrate abundance and diversity.

1.4 Quantitative Response of Benthos to Changes in Freshwater Inflow

Benthic macroinvertebrates integrate responses to direct and indirect changes in freshwater inflows in tidal rivers. Although a high degree of natural variation exists, predictable responses can be discerned in species distribution, abundance, and composition. Species distributions are controlled by the degree to which the invertebrate fauna can physiologically adapt to changing water chemistry, particularly salinity. Species abundances are affected by altered flow due to: increased stress placed on individual species at the extremes of optimal salinity ranges; differential affects on early life stages of the organism, and affects on the availability of prey organisms. Community structure depends upon the integration of species presence and abundance on the entire benthic community. Measurements of the benthic community response to altered freshwater flows include the univariate metrics, species richness, abundance, and diversity among others. Multivariate ordinations and multivariate procedures can be used to assess responses at the community level.

1.5 Study Area

The Pithlachascotee watershed begins in south-central Hernando County, and the headwaters of the river is Crews Lake in northern Pasco County. The drainage basin extends approximately 195 square miles (Figure 1-1; USGS 2009a, Station 02310308 at Main Street, New Port Richey, Florida). The Pithlachascotee is a blackwater river that flows approximately 25 miles (40 km) southwest through Pasco County and empties into the Gulf of Mexico through Millers Bayou at Port Richey (SWFWMD 2001). Tributaries of the Pithlachascotee River include Five-mile Creek which is approximately 20 miles (32 km) upstream of the mouth of the river. The river is highly urbanized in its lower reaches and is tidally influenced. Submerged aquatic vegetation is present in shallow areas at the river mouth approximately to river kilometer (RK) 0.3. Stream-side hardened river banks occur from the mouth of the river to approximately RK 7.5. The study area includes those portions of the Pithlachascotee River from approximately RK 11.0 at Rowan Road downstream to the mouth.



Source: ESRI, 2008; SWFWMD, 2009; Water & Air Research, Inc., 2009.

Figure 1-1. The Pithlachascotee River and Drainage Basin.

The source of freshwater to the Pithlachascotee River is largely from rainfall and surface water runoff, rather than artesian flow from the Floridan Aquifer. Flow from Crews Lake to the river is not directly monitored. Discharge from the lake to the river occurs when lake levels exceed 54.1 feet NGVD at a high spot in the riverine wetlands south of the lake (Ardaman & Associates, Inc. 2007). At RK 16.9 (USGS Station 02310300), the river has no flow at times during the dry season for the period of record March 1963 to present (USGS 2009b). Peak flow at this monitoring station occurred in September 1988 of 1480 cfs, and average annual flow has varied from 0.4 cfs (2007) to 67.2 cfs (1967) for the period of record.

Historical data show brackish water rarely penetrating above RK 12 (personal communication with Sid Flannery, SWFWMD, 2009). Coble (1973) showed the upstream extent of the transitional zone (mixing of salt and freshwater) to be at 9.6 RK. SWFWMD and USF (1997) described the extent of saltwater influence extending to between approximately RK 9.0 and RK 11.0. Salinity characteristics were investigated by the SWFWMD at six locations and analyses between flow and salinity were reported in Dames & Moore and Environmental Research and Design (1991). The most upstream site at mile 6.11 (RK 9.8) had limited saltwater influence with maximum salinity of 2 parts per thousand (ppt) at insignificant river flow. Salinity was below 0.5 ppt for river flows over 5 cfs. This study concluded that the upstream extent of salt water influence was between Rowan and Little Roads (upstream of RK 11.0).

Previous studies and reports on the Pithlachascotee River watershed from Crews Lake downstream include river water quality assessment and management (Coble 1973; Dames & Moore and Environmental Research and Design 1991; SWFWMD and USF 1997; FDEP 2009), floodplain analyses and flood profiles (Coble 1973; Turner, et al. 1979; Ghioto & Associates 1996 and 1997; Kane 2005), syntheses of the area (Cherry et al. 1970; Wolfe 1990; Estevez et al. 1991; SWFWMD 2001), and Crews Lake water quality and management (Mote Marine Laboratory 1992; SWFWMD 2006; Ardaman & Associates 2007).

2.0 Methods

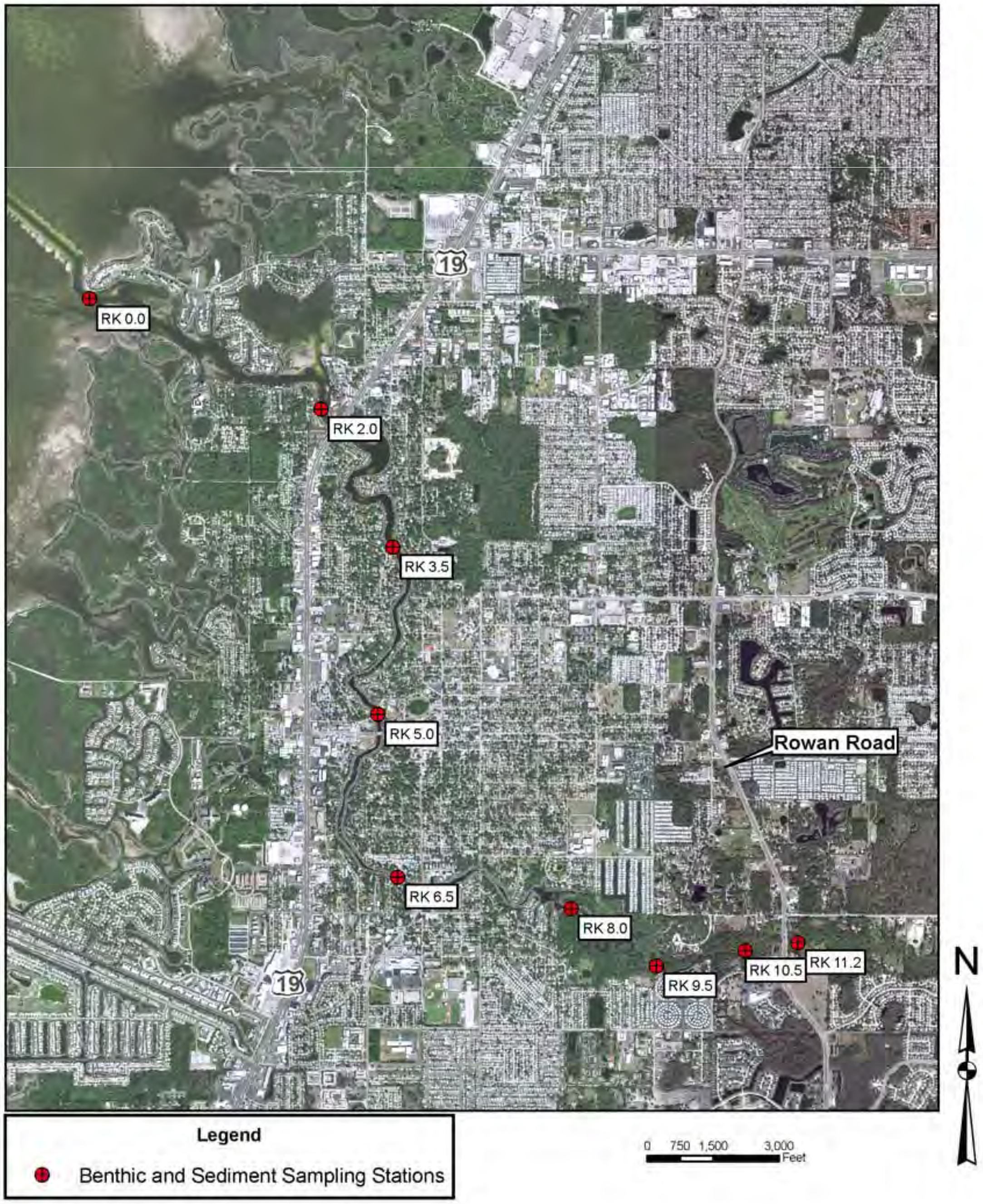
2.1 Field Methods

Water & Air staff conducted benthic infauna sampling, sediment sampling, water column physical-chemical measurements, and oyster bed mapping during a period of dry, low flow conditions on May 13-14, 2009 in the saline/brackish areas of the lower river, downstream of river kilometer RK 12.0.

Oyster beds and resources were mapped at low tide from the river mouth to their upstream extent. Locations of emergent oyster beds were recorded using a GPS. Data collected included oyster bar orientation, presence of live oysters, and presence of emergent vegetation. In addition, the location and presence of encrusting oyster clumps was noted on both man-made and natural substrates along the river course.

Benthic infauna sampling transects were established at the following locations: RK 0, 2, 3.5, 5, 6.5, 8, 9.5, 10.5, and 11.2 (Figure 2-1). Benthic infauna samples were collected using a stainless steel petite Ponar dredge with sample surface area of 0.0232 square meters. Three sample grabs were collected at varying depths across the river channel at each transect location. Each benthic sample was placed in a plastic bag with magnesium sulfate solution added to relax the organisms. Bags were placed on ice until further processing and preservation was completed within 12 hours of sample collection. Samples were sieved using a 500-µm mesh screen to remove fine sediments. Sieved samples were placed in plastic wide-mouth containers of appropriate size and fixed in 10% buffered formalin with

Rose Bengal stain added to the solution to facilitate sorting efficiency in the laboratory. Water temperature, dissolved oxygen, salinity/conductivity, and pH were measured at the water surface, just above the bottom and at one-meter intervals between surface and bottom. Three sediment samples were collected and composited at each transect for grain size analysis (gravimetric method) and organic fraction (loss on ignition) analyses.



Source: NRCS, 2008; Water & Air Research, Inc., 2009.

Figure 2-1. Location of Benthic Infauna and Sediment Sampling Stations in the Pithlachascotee River.

2.2 Laboratory Methods

Benthic infauna samples were processed and analyzed in Water & Air's biological laboratory using methods and quality assurance checks consistent with Water & Air's Quality Manual. Macroinvertebrates were identified and enumerated to the Lowest Practical Identification Level, usually to species or genus level. Analysis of sediment grain size distribution was performed by MACTEC, Jacksonville, Florida using methods ASTM D 422 and ASTM D 1140. Analysis of organic content of sediments as percent volatile solids by wet weight was performed by Advanced Environmental Laboratories, Gainesville, Florida.

2.3 Data Analysis

The biological, chemical, and physical data were entered into a database and reviewed for accuracy. Both pooled and unpooled data were statistically analyzed using a variety of univariate, regression, and multivariate techniques available through Primer and MINITAB statistical software programs as described below. Particular emphasis was given to analysis of relationships between univariate biological metrics and chemical parameters that are known to influence macroinvertebrate spatial distribution and are known to be affected by water flow (e.g., salinity).

2.3.1 Historical and Primary Data

Historical salinity and flow data provided by Sid Flannery, SWFWMD, were reviewed. Data included in the review were measured at longitudinal river locations in close proximity to the benthic infauna sampling location chosen for the current study. Trend analysis of historical flow data was performed using fitted time series values in a linear trend model. Historical (1985-1987) longitudinal mean salinity values were compared with current data.

Other studies relating benthic macroinvertebrate communities to salinity conditions in southwest Florida rivers in the context of minimum flows and levels assessments have utilized salinity and/or flow data for antecedent periods (often 30 days) prior to sampling as a factor explaining distribution and occurrence of benthic fauna (Grabe and Janicki 2007; Janicki 2007; Mote Marine Laboratory 2003). While the merits of this approach are recognized, this approach was not feasible for the current study. Antecedent water quality data were not available for the study area. Flow data were available (for USGS flow station 02310300 at river kilometer 16.9), but zero flow was recorded for this station from March 9, 2009, through the sampling dates of May 13-14, 2009, and no flows were recorded over 1 cfs after February 9, 2009.

Assuming this station represents most or all of the freshwater input to the sampling reach, the lack of flow precludes including antecedent data in the analyses. The lack of flow for an extended period prior to sampling provides some assurance that the physico-chemical data recorded at the time of sampling represented the conditions present during development of the benthic communities sampled in the study reach, and provides some justification for the use of these data in the analyses.

The primary data collected and analyzed from the Pithlachascotee River include: river location (as RK from the river mouth), water quality data from sample locations (conductivity/salinity, temperature, dissolved oxygen, and pH), sediment characteristics, benthic macroinvertebrate data, and oyster resource location. The benthic macroinvertebrate data were used to calculate community metrics of species richness diversity and total abundance.

2.3.2 Univariate Analyses

Conventional statistical analyses were performed using MINITAB® version 15.1.1.0 (Minitab 2000). Results were considered significant if $P \leq 0.05$. All analyses were performed on raw, untransformed data unless otherwise noted. Trend and regression analyses were performed using a linear model. Regression analyses were performed on the same data as the trend analyses in order to determine if the trends observed were significant. These data were regressed versus a column of sequential numbers representing sampling dates in order (as advised by MINITAB® help section staff), resulting in a regression equation that was the same as that produced by the trend analysis. Significance levels for Spearman's rank correlation coefficients were determined using Table A-11 from Snedecor and Cochran (1967). Mann-Whitney tests were performed to compare medians, and one-way Analysis of Variance (ANOVA) was used to compare means for salinity data from various sources.

The fifty dominant taxa for this study were determined using a procedure developed by Janicki Environmental Inc. (2007) and Grabe and Janicki (2008).

The Dominance Index (DI) was calculated for all taxa as the geometric mean of the frequency of occurrence (P_o) and the relative abundance (P_a) where:

P_o = Number of Samples with Taxon/Total Number of Samples Collected X100

P_a = Total Number of Taxon Individuals in all Samples/Total Number of Individuals of all Species in all Samples X100

The geometric mean of these terms equals the square root of their product:

$DI = (P_o * P_a)^{-0.5}$

P_o was calculated from the unpooled data (replicates separate). P_a was calculated from the pooled data (replicates combined).

The center of abundance river kilometer for the 50 most dominant taxa was determined using a weighted averaging method. The number of individuals for the taxon for each site where the taxon occurred was multiplied by the river kilometer. This was repeated for each site where the taxon was identified, and then the sum of these products was divided by the sum of all the individuals for that species. Salinity data were also treated in this manner, and these data are presented in a table that also gives mean salinity and densities (number of individuals per square meter) for the sites where the 50 most dominant taxa occurred.

Other univariate metrics calculated included number of taxa (species richness) and abundance (raw counts of individuals). Three diversity indices were calculated including Shannon-Wiener H', Margalef's d, and Simpson's d. Pielou's evenness was also calculated. The diversity indices use various mathematical formulations of the number of taxa and number of individuals to calculate a value representing the diversity of a given sample. Higher values indicate a sample with higher diversity. The Shannon-Wiener index incorporates a measure of the evenness of distribution of individuals that can be represented by the value for Pielou's evenness for a given sample. Further details about these measures can be found in Washington (1984). Three Shannon-Wiener index permutations are given in the metrics tables (base e, 2, and 10) for comparison purposes. The base 2 value was used in data analyses herein.

Forward stepwise multiple linear regression (with $P=0.5$) was performed to identify relationships between taxa richness, Shannon-Wiener diversity (base 2), and abundance and the physicochemical variable measured at the time of collection of macroinvertebrate samples. This analysis was intended to generate equations significantly relating these community metrics to the abiotic variables (Janicki 2008).

Fully nested ANOVA was used to identify significant differences among macroinvertebrate metrics for each river kilometer group. Where significant differences were found, one-way

ANOVA was used with the Tukey method to determine which site metrics were significantly different. Fully nested ANOVA could not be used to find significant differences for the means of river kilometer groups for the physicochemical data because the number of records between sites was uneven. One-way ANOVA was used instead to determine if there were any significant differences among the means for those data. Conductivity was excluded from this analysis, since it is correlated to the salinity data, and dissolved oxygen percent saturation was excluded from this analysis, since it is correlated to the dissolved oxygen (mg/L) data.

All univariate outputs from the statistical software are given in Appendix A.

2.3.3 Multivariate Analyses

Multivariate ordinations and procedures were performed using Primer version 6.1.8 (Clarke and Gorley 2001 and 2006; Clarke and Warwick 2001). Bray-Curtis similarity matrices were used to construct cluster diagrams and non-metric multidimensional scaling (MDS) ordination plots for the unpooled and pooled macroinvertebrate data.

A Principal Components Analysis (PCA) ordination for the mean values of the physicochemical data (excluding the non-independent variables conductivity and dissolved oxygen percent saturation) was performed as an independent method to determine site groups. PCA was performed on the normalized environmental data.

A Bray-Curtis similarity matrix for the unpooled macroinvertebrate data was used for the Primer ANOSIM procedure to test for significant differences among replicates for each river kilometer group and among salinity groups determined using PCA. Fourth root transformed unpooled macroinvertebrate density (individuals per square meter) data were used for these tests. 9999 permutations were performed.

Where significant differences were found by the ANOSIM procedure, the Primer SIMPER method was used to identify taxa contributing most to the differences between the groups.

Organism abundance, a calculated dominance index, and SIMPER output of average contribution to dissimilarity were used to identify eleven dominant taxa having the greatest contribution toward differences in benthic invertebrate community structure along the salinity gradient. This selection method is further described in Section 3.3.5.

The Primer BEST procedure was run to determine which variables best explained the multivariate relationship between the biotic and abiotic matrices.

Primer Statistical Outputs are given in Appendix B, except for the SIMPER results, which are presented in Appendix C.

3.0 Results

3.1 Abiotic Physicochemical Factors

Trends in historical flow and salinity are discussed in this section. Primary physicochemical water and sediment data are described, and some interrelationships between these factors are discussed.

3.1.1 Historical Trends in Flow and Salinity

Trend analysis of historical flow data from 1963 to 2009 shows a gradual but significant decrease in flow over time (p=0.011; Figure 3.1.1-1). USGS notes that for the flow station 02310300, “PERIOD OF RECORD. -- March 1963 to current year. March 1963 to May 1981, at [a] site 1.1 mi [1.77 kilometers] downstream [data were] not equivalent due to differences in base flow characteristics of the different drainage areas" (USGS 2009). This refers to relocation of site 02310300 to the current location from a previous location 1.77 kilometers downstream. While there may have been a slight difference in flow for these two locations, this difference is not thought to be great enough to negate the results of the trend analysis given herein.

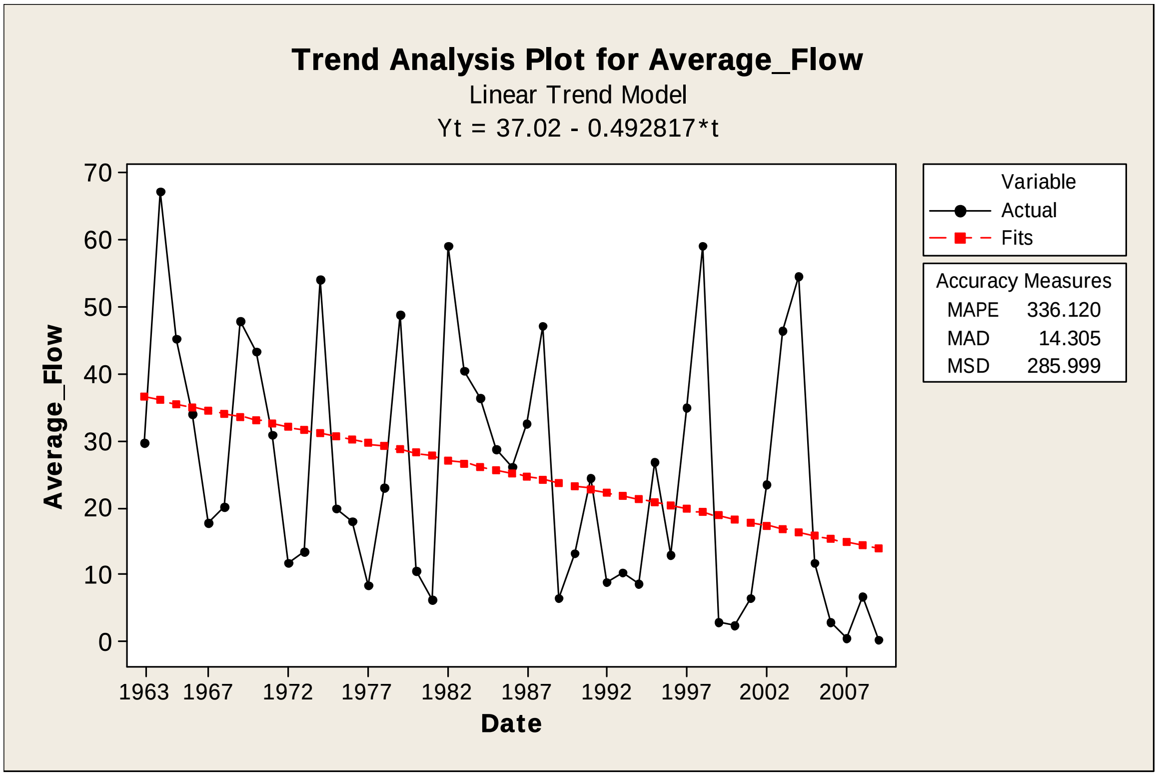


Figure 3.1.1-1. Trend Analysis for Pithlachascotee River flow data from the USGS station 02310300 at RK 16.9. The y-intercept is 37.02, and the value representing decrease over time is -0.493 multiplied by a time factor. These values indicate that river flow at this station is decreasing over time. Regression analysis indicated that the decreasing trend was significant (P=0.011). Mean Absolute Percentage Error (MAPE) is a measure of the accuracy of fitted time series values given as a percentage. Mean Absolute Deviation (MAD) is another measure of the fitted time series values given in the same units of the data. Mean Squared Deviation (MSD) is another commonly used measure of accuracy of fitted time series values.

Gage height daily minima and maxima for the 30-day period prior to the May 2009 sampling event illustrate tidal influence at the mouth of the river (Figure 3.1.1-2). To illustrate temporal changes in salinity, 1985-1987 data are plotted with the May 2009 data, showing an apparent increase in salinity over a 20-year period (Figure 3.1.1-3). The single sampling event performed by Water & Air in May 2009 occurred after a sustained period of low flow and was meant to capture near maximum salinity conditions in the river. Figure 3.1.1-3 illustrates the anticipated high salinity conditions during May 2009 relative to historical 1985-1987 mean salinity concentrations recorded at or near the May 2009 sampling locations.

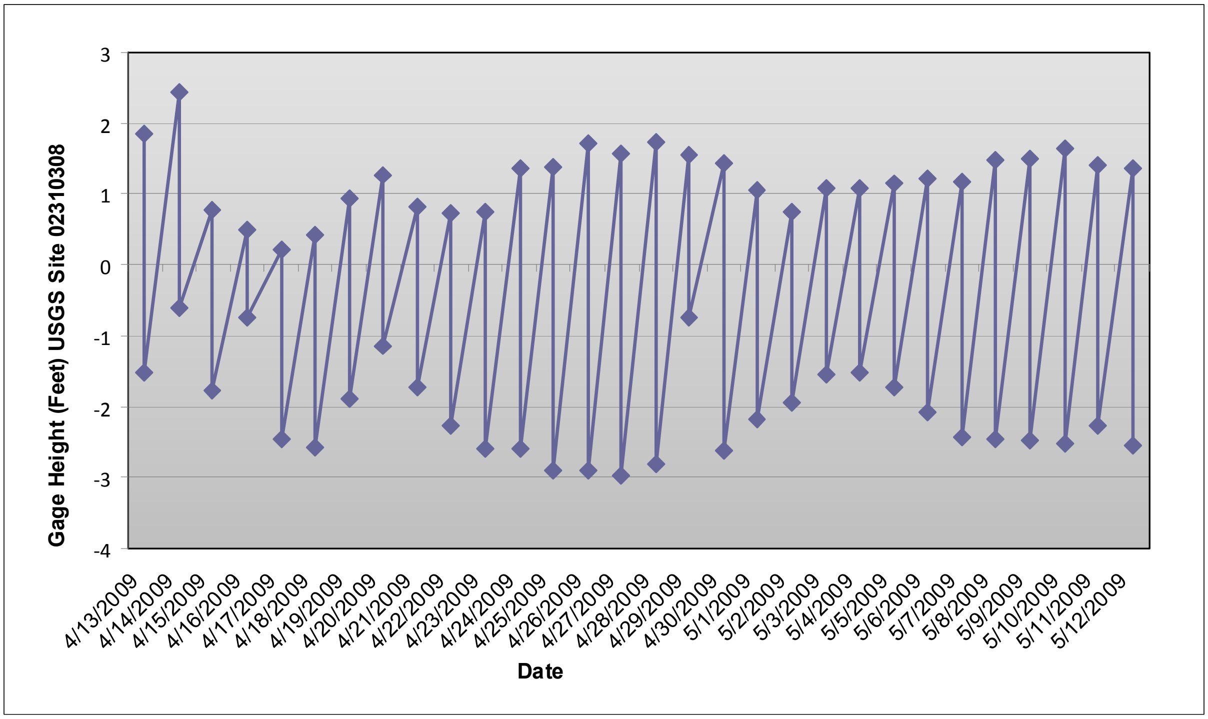


Figure 3.1.1-2. Gage height daily minim and maxima recorded for USGS flow station 02310308 near the mouth of the Pithlachascotee River.

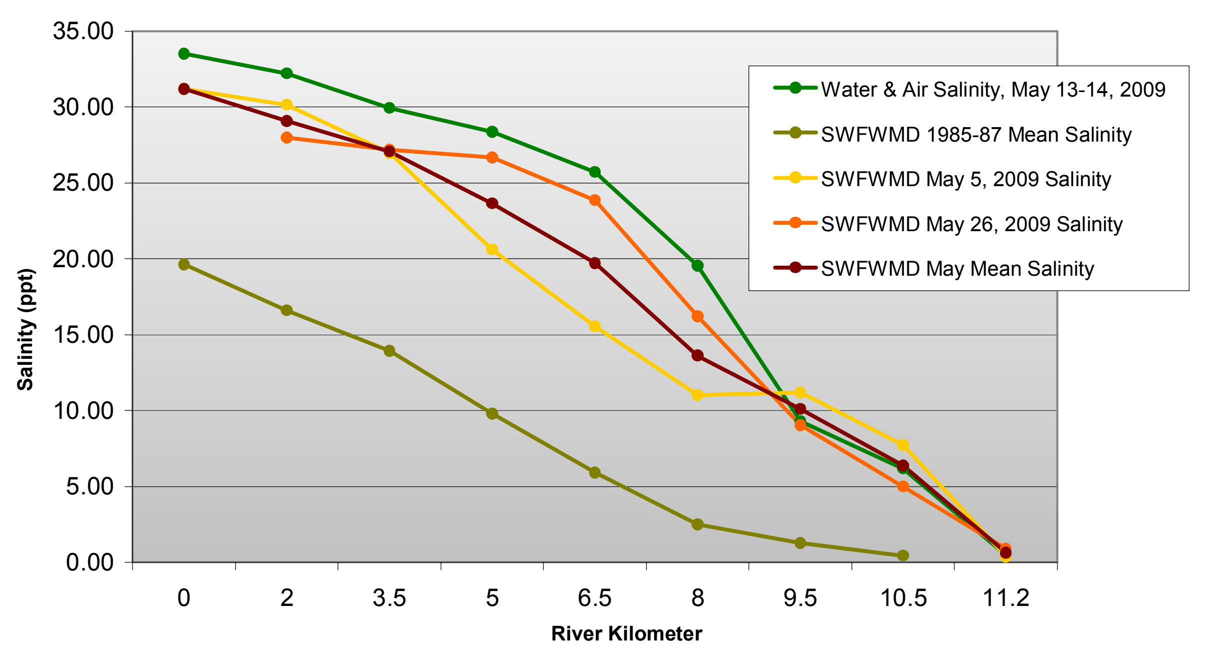


Figure 3.1.1-3. Historical Salinity Concentrations in the Pithlachascotee River.

Although a rigorous analysis of historical conditions in the Pithlachascotee River is not within the scope of this study, the historical flow data reviewed suggest an overall decline in flow during the periods reviewed. This finding has direct relevance within the context of the MFL framework.

Comparison of May 2009 salinity concentrations with historical mean concentrations shows the May 2009 sampling event captured near maximum salinity conditions on the river.

3.1.2 Sediments

Based on PCA analysis of grain size data collected from five Tampa Bay rivers including the Manatee and Braden Rivers, Janicki Environmental (2007) classified sediments of 18% or less silt and clay are classified as sand, and those with > 18% silt and clay are classified as mud. This convention is followed herein. Percent silt + clay in Pithlachascotee River sand sediments ranged from 6.4% to 17.4%, with the exception of one duplicate sample at RK 5 that was 19.8% silt + clay and tentatively classified as mud (Table 3.1.2-1). Sediment grain size was generally similar at all sites. Sediments at RK 0, RK 2, and RK 3.5 had a slightly higher fine gravel and coarse sand content. Organic content of sediments ranged from 1.3% to 9.7% dry weight Table 3.1.2-1). Descriptive summary statistics for sediment characteristics are given in Appendix D; Table D-1.

			Grain Size									
			Gravel	Gravel	Sand	Sand	Sand	Fines	Fines	SUM		
Sample Date	Sample No.	%>3"	% Coarse Gravel	% Fine	% Coarse Gravel	% Medium	% Fine	% Silt	% Clay	% Silt+Clay	Classification	Percent Organics
05/13/09	RK 0	0.0	1.5	17.2	6.2	2.9	65.1	2.1	5.0	7.1	Sand	1.3
05/13/09	RK 2	0.0	0.0	6.6	1.6	2.8	77.9	4.5	6.6	11.1	Sand	1.3
05/13/09	RK 3.5	0.0	0.0	1.2	1.1	1.9	78.4	8.7	8.7	17.4	Sand	3.1
05/13/09	RK 5-A	0.0	0.0	0.0	0.0	4.2	79.3	8.2	8.3	16.5	Sand	5.5
05/13/09	RK 5-B	0.0	0.0	0.0	0.0	5.2	75.0	10.5	9.3	19.8	Mud	7.4
05/13/09	RK 6.5	0.0	0.0	0.3	1.3	1.0	83.2	6.8	7.4	14.2	Sand	3.3
05/13/09	RK 8	0.0	0.0	0.0	0.0	1.7	82.1	8.4	7.8	16.2	Sand	8.6
05/14/09	RK 9.5	0.0	0.0	0.0	0.0	1.6	85.0	8.1	5.3	13.4	Sand	6.4
05/14/09	RK 10.5	0.0	0.0	0.0	0.0	0.6	91.7	3.1	4.6	7.7	Sand	3.7
05/14/09	RK 11.2	0.0	0.0	0.0	0.0	0.3	93.3	2.6	3.8	6.4	Sand	9.7

Table 3.1.2-1. Pithlachascotee River Benthic Infauna Survey-Characteristics of Composite Sediment Samples.

3.1.3 Water

Salinity and dissolved oxygen at the water surface and bottom were similar at all sites, suggesting that waters were relatively well mixed (Table 3.1.3-1, Figures 3.1.3-1 and 3.1.3-2). Mean water column salinity ranged from 0.48 ppt at RK 11.2 to 33.46 ppt at the river mouth (Table 3.1.3-2, Figure 3.1.3-3). Descriptive summary statistics for water column physical and chemical data are given in Appendix D; Table D-2.

Station	Date	Time	Depth of Collection (meters)	Temperature (C)	pH	Conductivity (umhos/cm)	Salinity (ppt)	DO (% Saturation)	DO (mg/L)	Total Site Depth (meters)	Tidal Stage
RK 0.0	5/13/09	9:06	0.5	26.47	7.89	50820	33.42	53.0	3.49	1.5	Outgoing (low)
	5/13/09	9:09	1.2	26.48	7.89	50901	33.49	51.5	3.39		
RK 2.0	5/13/09	10:50	0.5	27.35	7.76	49039	32.12	53.7	3.51	1.7	Incoming (low)
	5/13/09	10:52	1.0	27.23	7.76	49161	32.18	49.8	3.28		
	5/13/09	10:54	1.5	27.23	7.75	49144	32.20	47.7	3.07		
RK 3.5	5/13/09	11:58	0.5	28.20	7.69	44210	28.85	58.8	3.83	1.7	Incoming
	5/13/09	11:59	1.0	27.86	7.67	45936	29.87	57.5	3.76		
	5/13/09	12:00	1.5	27.86	7.66	46043	29.93	56.8	3.71		
RK 5.0	5/13/09	13:22	0.5	28.81	7.52	39109	24.91	57.5	3.83	2.8	Incoming
	5/13/09	13:23	1.0	28.61	7.52	41100	26.39	54.0	3.59		
	5/13/09	13:24	2.0	28.26	7.54	43311	28.04	50.8	3.33		
	5/13/09	13:25	2.5	28.15	7.54	43960	28.36	48.3	3.19		
RK 6.5	5/13/09	14:39	0.5	29.22	7.53	35788	22.60	60.5	4.04	2.7	Incoming (high)
	5/13/09	14:40	1.0	28.74	7.51	38337	24.46	52.0	3.46		
	5/13/09	14:41	2.0	28.49	7.50	40211	25.71	48.8	3.25		
	5/13/09	14:42	2.5	28.49	7.50	40205	25.71	48.7	3.25		
RK 8.0	5/13/09	15:35	0.5	29.37	7.52	28008	17.01	67.2	4.60	1.8	Incoming (high)
	5/13/09	15:36	1.0	29.17	7.46	30088	18.61	56.7	3.88		
	5/13/09	15:37	1.6	28.97	7.43	31458	19.55	51.6	3.52		
RK 9.5	5/14/09	9:45	0.5	26.47	7.25	14148	8.18	40.3	3.03	1.6	Outgoing
	5/14/09	9:46	1.0	26.59	7.24	14699	8.56	31.6	2.39		
	5/14/09	9:47	1.5	26.94	7.31	16047	9.30	28.9	2.16		
RK 10.5	5/14/09	10:25	0.5	24.83	7.43	4254	2.32	31.2	2.54	2.6	Outgoing
	5/14/09	10:36	1.0	24.90	7.39	5133	2.84	28.8	2.33		
	5/14/09	10:37	2.0	25.88	7.29	10136	5.72	19.8	1.55		
	5/14/09	10:38	2.5	26.05	7.27	10875	6.18	17.3	1.35		
RK 11.2	5/14/09	11:33	0.5	24.03	7.46	929.3	0.48	31.9	2.65	1.2	Outgoing
	5/14/09	11:34	1.0	23.99	7.45	926.3	0.48	29.9	2.47		

Table 3.1.3-1. Pithlachascotee River Physicochemical Data

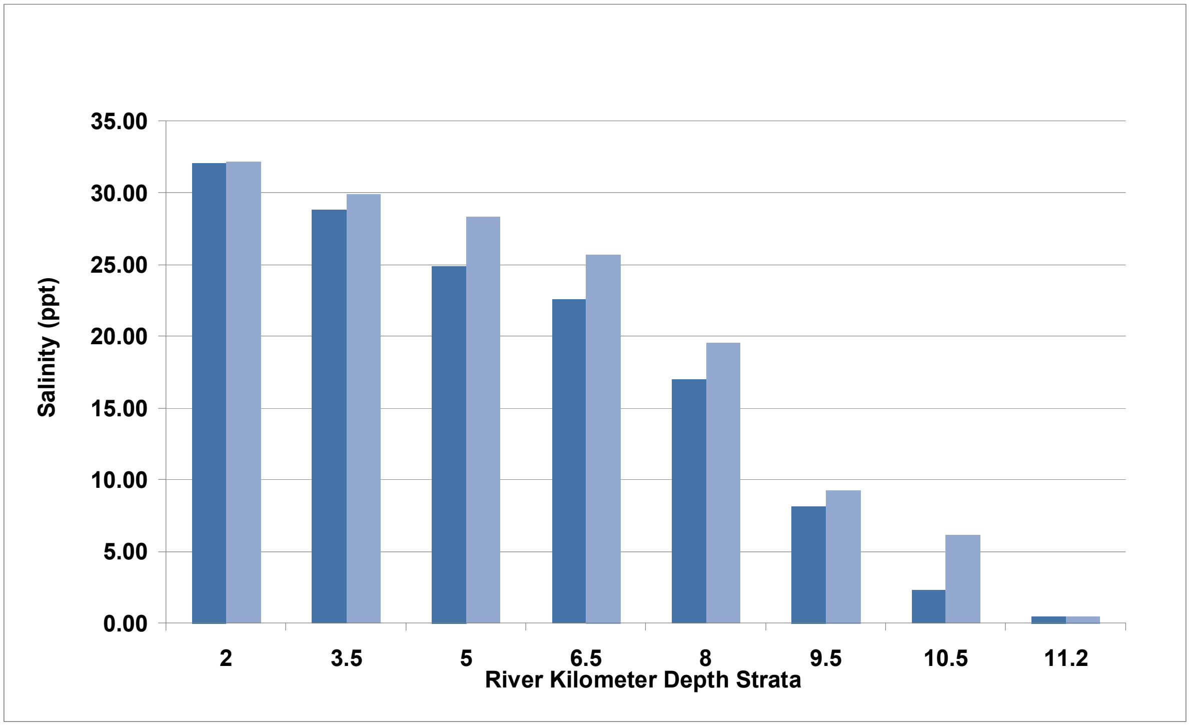


Figure 3.1.3-1. Salinity for River Kilometer Top and Bottom Strata for the Pithlachascotee River May 2009.

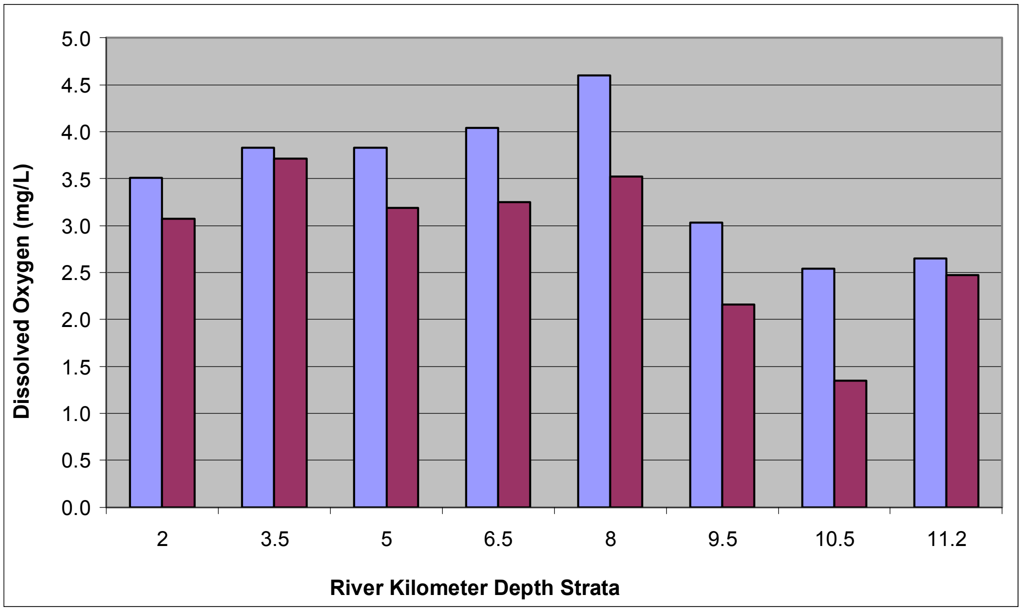


Figure 3.1.3-2. Dissolved Oxygen for River Kilometer Top and Bottom Strata for the Pithlachascotee River May 2009.

Station	Temperature (C)	pH	Conductivity (umhos/cm)	Salinity (ppt)	DO (% Saturation)	DO (mg/L)	Total Site Depth (meters)	Tidal Stage
RK 0.0	26.48	7.89	50860.50	33.46	52.25	3.44	1.5	Outgoing (low)
RK 2.0	27.27	7.76	49114.67	32.17	50.40	3.29	1.7	Incoming (low)
RK 3.5	27.97	7.67	45396.33	29.55	57.70	3.77	1.7	Incoming
RK 5.0	28.46	7.53	41870.00	26.93	52.65	3.49	2.8	Incoming
RK 6.5	28.74	7.51	38635.25	24.62	52.50	3.50	2.7	Incoming (high)
RK 8.0	29.17	7.47	29851.33	18.39	58.50	4.00	1.8	Incoming (high)
RK 9.5	26.67	7.27	14964.67	8.68	33.60	2.53	1.6	Outgoing
RK 10.5	25.42	7.35	7599.50	4.27	24.28	1.94	2.6	Outgoing
RK 11.2	24.01	7.46	927.80	0.48	30.90	2.56	1.2	Outgoing

Table 3.1.3-2. Pithlachascotee River Mean Values of Water Column Physicochemical Data Profiles.

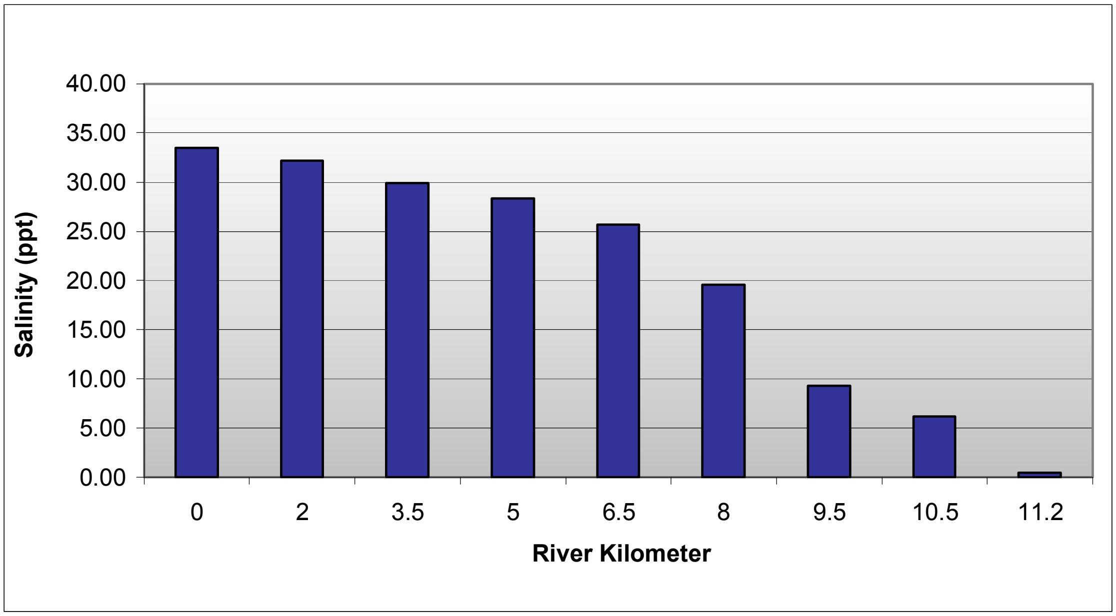


Figure 3.1.3-3. Mean Water Column Salinity Concentrations in the Pithlachascotee River, May 13-14, 2009.

Janicki (2007) divided river segments into the following salinity zones based on PCA analysis of benthic community structure occurring along a wide range of salinities within multiple river systems along Florida's west coast: Oligohaline (0-7 ppt), Mesohaline (7-18 ppt), Polyhaline (18-29 ppt), and euhaline (>29 ppt). This classification is used as a frame of reference for the current study of the Pithlachascotee River: Oligohaline (RK 10.5 and RK 11.2); Mesohaline (RK 9.5); Polyhaline (RK 5, RK 6.5, and RK 8); and Euhaline (RK 0, RK 2, and RK 3.5).

Mean water column dissolved oxygen ranged from 1.94 to 4.00 mg/L at approximately 25 - 60% saturation. pH was slightly above 7 throughout the study area.

One-way ANOVA was employed to determine significant differences among river kilometer groups for the physicochemical data. No significant differences were found for the site depth data. Mean temperature for site RK 8 was higher than that for all stations except RK 6.5 (P=0.0001). Site RK 6.5 temperature was higher than that for all stations except RK 8, RK 5, and RK 3.5. Site RK 5 temperature was higher than that for all stations except RK 8, RK 6.5, RK 5, and RK 3.5. Site RK 3.5 temperature was higher than that for stations RK 0, RK 9.5, RK 10.5, and RK 11.2. Site RK 2 temperature was higher than that for stations RK 10.5 and RK 11.2. Site RK 0 temperatures was higher than that for stations RK 10.5 and RK 11.2, and RK 10.5 temperature was higher than that for RK 11.2 (Appendix A).

Mean pH for RK 0 was higher than that for all the other sites. pH for RK 2 was higher than that for all the other sites except RK 0 and RK 3.5. pH for RK 3.5 was higher than that for all the other sites except RK 0 and RK 2. Mean pH for sites RK 5, RK 6.5, RK 8, and RK 11.2 was higher than pH for sites RK 10 and RK 9.5. Mean salinity for RK 0 was significantly higher than that for sites RK 9.5, RK 10.5, and RK 11.2 (but RK 0 salinity was not significantly different from salinity for sites RK 2, RK 3.5, RK 5, RK 6.5, and RK 8). Site RK 9.5 salinity was higher than that for sites RK 10.5 and RK 11.2. Site RK 10.5 salinity was significantly higher than that for site RK 11.2. Site RK 8 mean dissolved oxygen (DO) was higher than DO for sites RK 9.5, RK 10.5, and RK 11.2. Site RK 3.5 dissolved oxygen was higher than DO for sites RK 10.5 and RK 11.2. Site RK 0 dissolved oxygen was higher than DO for site RK 10.5 (Appendix A).

3.2 Oyster Distribution

Oyster bars were defined as intertidal mounds of living oysters and dead shell. Five (5) oyster bars were observed in the river channel occurring within 2.5 km of the river mouth (Figure 3.2-1). Oyster bar #1 was located at RK 0.6 closest to the mouth of the river, and oyster bar # 5 was located farthest upstream at RK 2.4 (Table 3.2-1).

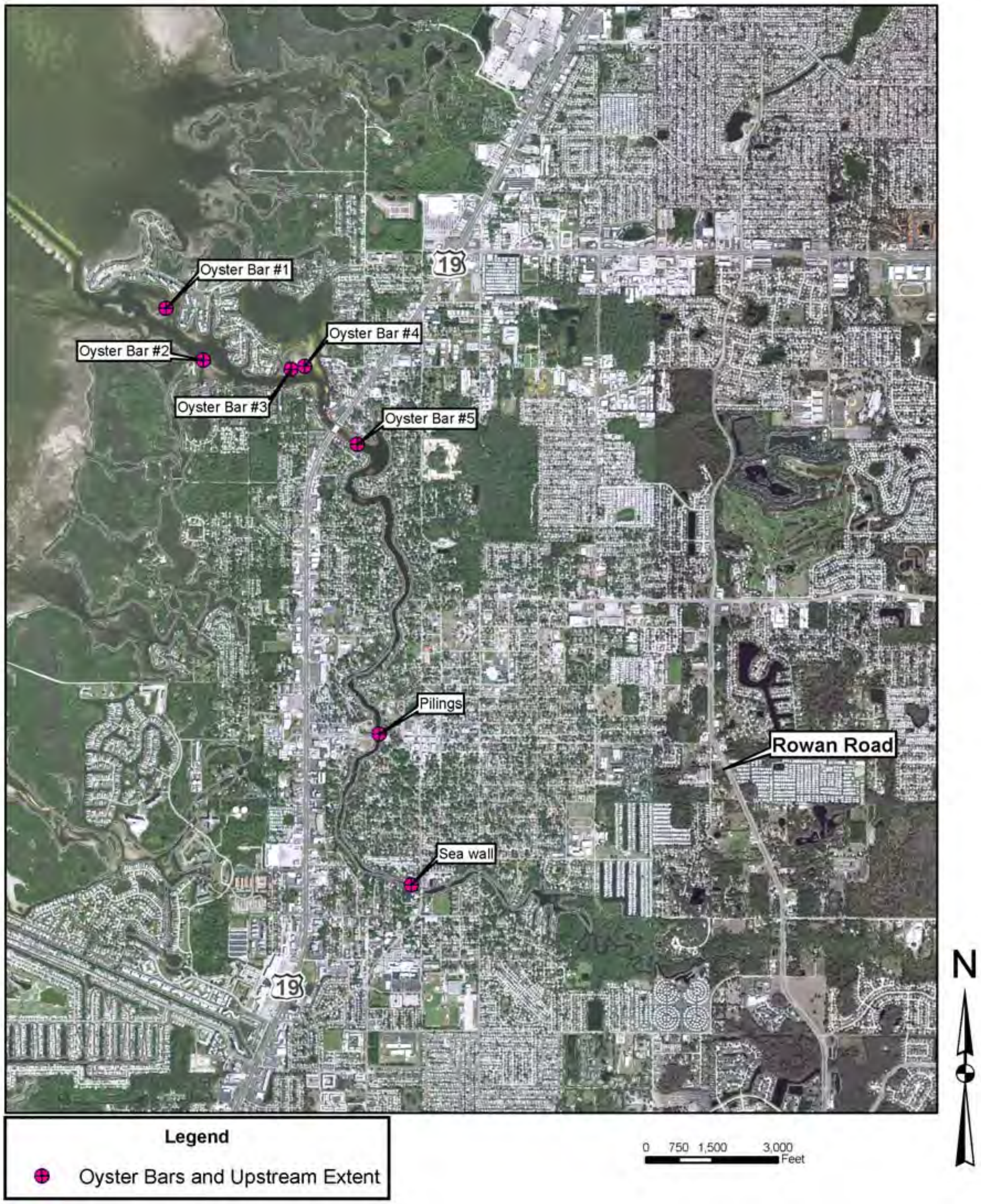


Figure 3.2-1. Oyster Bars and Upstream Oyster Extent in the Pithlachascotee River.

ID	Date	Time	Latitude	Longitude	River Kilometer	Emergent Vegetation Present	Orientation	*Tidal Stage (Feet Above Mean Lower Low Water)
1	5/13/2009	9:56	28.27681	-82.73782	0.6	*Spartina sp.*	North-South	1.39
2	5/13/2009	10:10	28.27357	-82.73516	1.6	n/a	North-South	1.39
3	5/13/2009	10:23	28.27303	-82.72896	1.7	*Spartina sp.* *Rhizophora mangle Laguncularia racemosa Avicennia germinans*	East-West	1.41
4	5/13/2009	10:30	28.27322	-82.72798	1.0	n/a	East-West	1.43
5	5/13/2009	11:33	28.26834	-82.72424	2.4	n/a	North-South	1.78

* Source of tidal stage data:
http://tbone.biol.sc.edu/tide/tideshow.cgi?site=Hwy.+19+bridge%2C+Pithlachascotee+River%2C+Florida&units=f

Table 3.2-1. Locations of Oyster Beds Observed in the Lower Pithlachascotee River.

Above RK 2.5 optimal oyster substrate consists of concrete bridge and dock pilings in the main river channel (pictured below). Colonization of these structures is made possible by the longevity of the structures as well as the presence of adequate river flow (Figure 3.2-2).

Figure 3.2-2. Oyster Colonization of Artificial Substrates at Mid-Channel.

Along the edge of the river channel, suboptimal oyster substrate exists in the form of rocks and concrete seawalls (Figure 3.2-3).

Figure 3.2-3. Oyster Colonization of Rocks Along River Shoreline.

Based on live oyster sightings in both optimal (main channel) and suboptimal (river margins) habitats, the upstream extent of oyster is approximately RK 6.6. Clumps of oysters were observed growing on concrete pilings of the Main Street Bridge at RK 5.1. However, no oysters were observed growing on the concrete pilings of the Grand Boulevard Bridge at RK 6.7. Live submerged oysters were viewed, in approximately 1 foot of water, at the base of a concrete seawall at RK 6.6. No live oysters were found further upstream of this point. However, some dead shells were found on a concrete seawall close to RK 6.8.

3.3 Macroinvertebrate Community Analyses

Characteristic benthic macroinvertebrate taxa and benthic community metrics of the Pithlachascotee River are discussed in relation to longitudinal distribution, the salinity gradient, and other physical-chemical parameters.

3.3.1 Dominant Pithlachascotee River Macroinvertebrate Taxa

Characteristic macroinvertebrates of the river were tabulated based on their dominance index score. The 50 macroinvertebrate taxa with the highest dominance scores are listed in a table also giving values for mean density, river kilometer center of abundance, mean salinity of capture, and the abundance-weighted salinity (Table 3.3.1-1). These 50 taxa made up 89.3 percent of the total number of organisms collected during this study.

Taxa	Mean Density (m^2)	Dominance Index	Center of Abundance (RK)	Mean Salinity of Capture (ppt)	Abundance-weighted Salinity (ppt)
Grandidierella bonnieroides	2634	26.79	7.30	22.57	20.67
Apocorophium louisianum	2224	26.44	8.11	17.82	18.27
Fabricinuda trilobata	2027	17.24	1.39	31.87	32.59
Hobsonia florida	618	14.39	8.27	21.60	16.54
Mediomastus ambiseta	554	12.28	3.35	29.94	30.33
Edotia triloba	393	9.51	7.79	24.18	19.42
Americorophium sp. A Lecroy	565	9.10	10.10	5.32	7.14
Ampelisca sp.	396	8.64	3.56	24.48	29.68
Polypedilum halterale group Epler	399	8.18	10.54	5.32	5.69
Axiothella sp.	449	8.11	1.88	31.87	32.27
Uromunna reynoldsi	278	7.63	10.03	8.88	7.67
Laeonereis culveri	520	7.38	7.25	18.19	22.60
Pyrgophorus platyrachis	631	7.27	6.50	25.71	25.71
Capitella capitata	246	7.18	2.27	28.21	34.55
Streblospio sp.	208	6.92	6.37	25.89	24.27
Prionospio heterobranchia	212	5.58	1.20	31.87	32.64
Xenanthura brevitelson	241	5.50	3.61	30.16	29.87
Halmyrapseudes cf. bahamensis Heard	348	5.40	2.37	31.07	31.64
Gammarus cf. tigrinus LeCroy	310	5.09	11.13	3.33	1.07
Syllis sp.	177	4.31	0.36	32.85	33.26
Tubificoid Naididae imm. w/o hair setae (L	85	4.21	8.66	14.93	13.73
Ampelisca holmesi	417	4.18	3.46	31.71	29.97
Mooreonuphis pallidula	166	4.17	1.81	32.85	32.32
Hydrobiidae (LPIL)	118	4.16	7.49	24.13	19.60
Leptochelia sp.	104	3.90	5.65	22.57	26.12
Cyclaspis varians	86	3.56	3.11	29.05	30.61
Angulus versicolor	97	3.50	1.52	31.87	32.38
Turbellaria (LPIL)	70	3.21	9.42	20.58	10.57
Nemertea (LPIL)	53	3.15	2.68	29.94	53.00
Monticellina dorsobranchialis	94	2.81	1.97	32.85	32.22
Cirrophorus sp.	105	2.57	0.00	33.49	33.49
Procladius (Holotanypus) sp.	99	2.49	10.18	7.74	7.19
Melinna sp.	56	2.42	2.26	30.16	31.85
Cerapus benthophilus	53	2.35	6.14	27.04	26.35
Parandalia tricuspis	38	2.19	5.38	27.15	26.96
Oxyurostylis smithi	54	2.13	1.85	31.87	32.22
Scolelepis texana	41	2.09	1.54	32.85	32.50
Duridrilus tardus	48	2.00	0.40	32.85	33.23
Merisca sp.	61	1.95	2.00	32.20	32.20
Aoridae (LPIL)	57	1.90	2.17	31.07	31.95
Caecidotea sp.	57	1.90	10.58	3.33	5.55
Tubificoides sp.	37	1.75	6.96	25.88	21.75
Polypedilum scalaenum group Epler	48	1.74	8.40	14.43	16.82
Aulodrilus pigueti	35	1.72	10.63	3.33	5.14
Potamethus spathiferus	45	1.68	2.00	32.20	32.20
Tanytarsus sp. G Epler	45	1.68	10.21	7.74	7.07
Apocorophium lacustre	62	1.62	8.81	17.51	13.09
Gammarus sp.	42	1.62	10.35	7.74	6.66
Procladius sp.	41	1.62	9.58	7.74	9.06
Ablabesmyia rhamphe group Epler	38	1.55	10.50	6.18	6.18

Table 3.3.1-1. 50 Dominant benthic taxa, mean abundance, mean center of abundance (as river kilometer; RK), and mean salinity of capture in the Pithlachascotee River, May 2009.

The amphipods *Grandidierella bonnieroides* and *Apocorophium louisianum* and the polychaete, *Fabricinuda trilobata*, were ranked highest in dominance with index scores of 26.79, 26.44, and 17.24, respectively. These three species made up 39 percent of the total number of organisms collected during this study.

3.3.2 Longitudinal Patterns in Macroinvertebrate Community Metrics

The macroinvertebrate metrics number of taxa, density, and the Margalef's and Shannon-Wiener diversity indices were used to explore the longitudinal distribution of macroinvertebrate community characteristics (Tables 3.3.2-1 and 3.3.2-2). Both number of taxa and the diversity indices showed a bowl-shaped longitudinal distribution (Figures 3.3.2-1 and 3.3.2-2). Number of taxa decreased to a nadir (the artenminimum) at station RK 9.5, while the diversity indices were lowest value at RK 8.

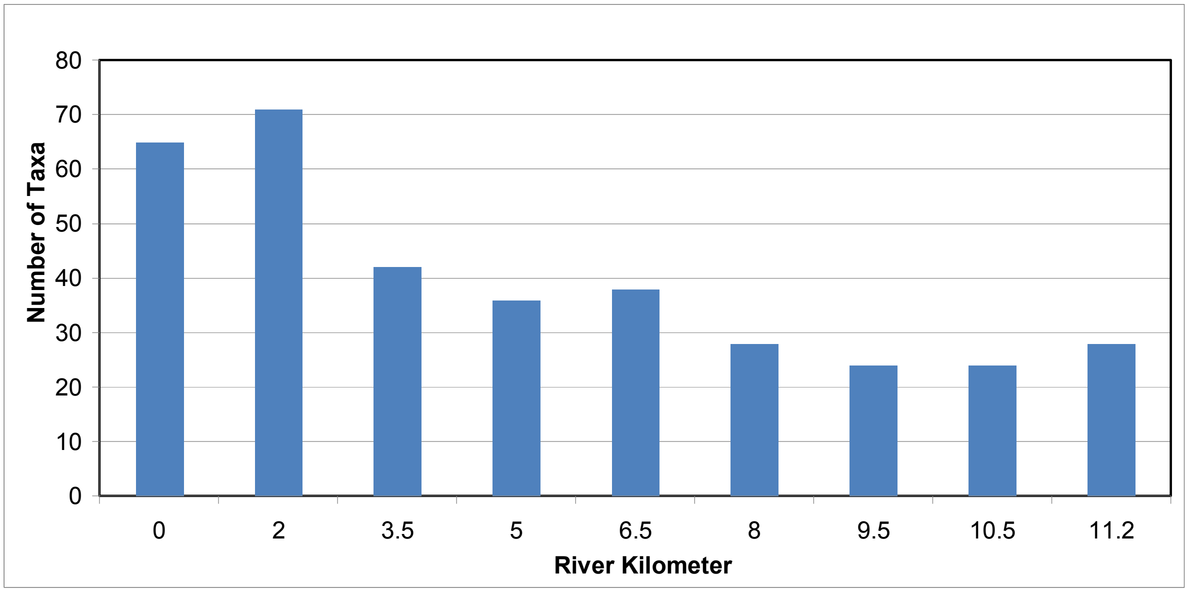


Figure 3.3.2-1. Number of taxa for pooled Pithlachascotee River macroinvertebrate data.

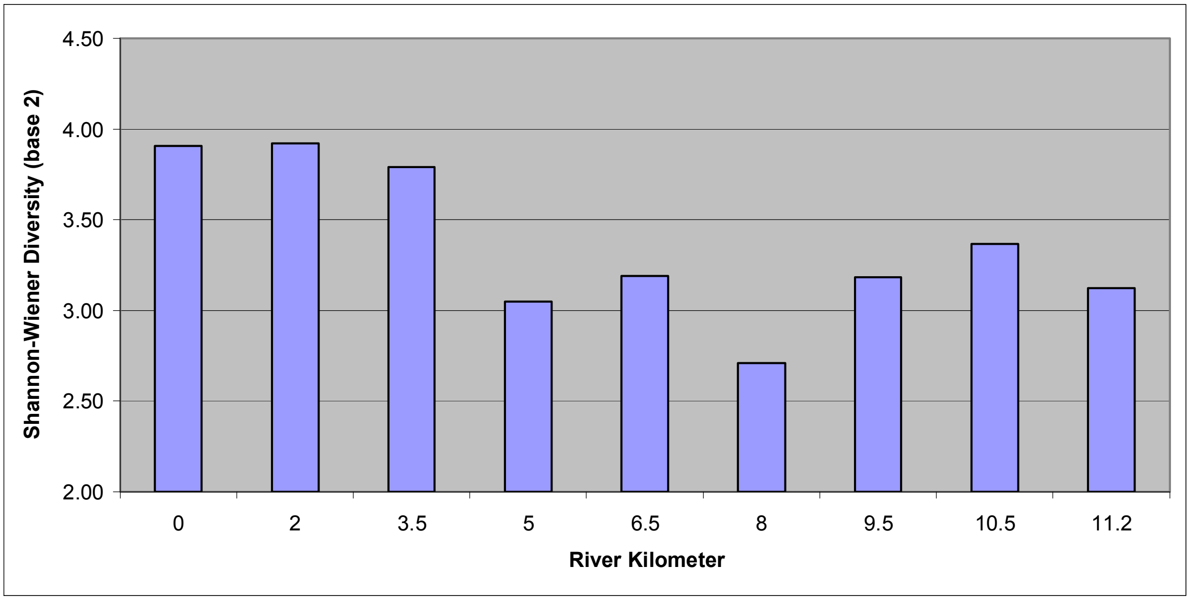


Figure 3.3.2-2. Shannon-Wiener Diversity (base 2) for pooled Pithlachascotee River macroinvertebrate data.

Unpooled Petite Ponar Metrics								
Site/Metrics	Taxa	Individuals	Margalef's d	Pielou's Evenness	Shannon Diversity			Simpson's d (1-λ)
	S	N	d	J'	H'(loge)	H'(log2)	H'(log10)	1-Lambda'
RK-0-A	30	147	5.811	0.790	2.688	3.878	1.168	0.877
RK-0-B	30	795	4.342	0.586	1.992	2.874	0.865	0.722
RK-0-C	28	109	5.755	0.872	2.906	4.193	1.262	0.936
RK-2-A	37	1014	5.201	0.646	2.332	3.365	1.013	0.843
RK-2-B	42	846	6.083	0.535	1.999	2.884	0.868	0.662
RK-2-C	47	512	7.374	0.791	3.045	4.393	1.322	0.913
RK-3.5-A	19	425	2.974	0.525	1.547	2.232	0.672	0.607
RK-3.5-B	23	386	3.694	0.702	2.202	3.176	0.956	0.841
RK-3.5-C	21	288	3.532	0.728	2.217	3.199	0.963	0.833
RK-5-A	15	123	2.909	0.618	1.675	2.416	0.727	0.684
RK-5-B	19	234	3.300	0.635	1.868	2.696	0.811	0.764
RK-5-C	19	225	3.323	0.660	1.943	2.802	0.844	0.750
RK-6.5-A	15	330	2.414	0.637	1.725	2.489	0.749	0.715
RK-6.5-B	24	284	4.072	0.560	1.779	2.567	0.773	0.719
RK-6.5-C	16	816	2.237	0.632	1.752	2.528	0.761	0.727
RK-8-A	22	1365	2.909	0.533	1.648	2.378	0.716	0.685
RK-8-B	15	644	2.165	0.698	1.890	2.727	0.821	0.800
RK-8-C	5	276	0.712	0.729	1.174	1.693	0.510	0.649
RK-9.5-A	13	284	2.124	0.625	1.603	2.313	0.696	0.651
RK-9.5-B	12	444	1.805	0.663	1.647	2.376	0.715	0.671
RK-9.5-C	12	248	1.995	0.702	1.745	2.517	0.758	0.760
RK-10.5-A	10	140	1.821	0.845	1.946	2.808	0.845	0.840
RK-10.5-B	16	330	2.587	0.748	2.074	2.992	0.901	0.831
RK-10.5-C	16	452	2.454	0.806	2.235	3.225	0.971	0.863
RK-11.2-A	18	176	3.288	0.555	1.604	2.314	0.697	0.596
RK-11.2-B	12	102	2.378	0.698	1.734	2.502	0.753	0.733
RK-11.2-C	17	78	3.672	0.889	2.519	3.634	1.094	0.904

Table 3.3.2-1. Pithlachascotee River Macroinvertebrate Data, May 2009.

Pooled Petite Ponar Metrics								
Site/Metrics	Taxa	Individuals	Margalef's d	Pielou's Evenness	Shannon Diversity			Simpson's d (1-λ)
	S	N	d	J'	H'(loge)	H'(log2)	H'(log10)	1-Lambda'
RK-0	65	1051	9.199	0.649	2.709	3.908	1.176	0.833
RK-2	71	2372	9.007	0.637	2.717	3.919	1.180	0.840
RK-3.5	42	1099	5.855	0.703	2.627	3.790	1.141	0.880
RK-5	36	582	5.498	0.590	2.113	3.049	0.918	0.772
RK-6.5	38	1430	5.093	0.608	2.212	3.191	0.961	0.823
RK-8	28	2285	3.491	0.564	1.879	2.710	0.816	0.760
RK-9.5	24	976	3.341	0.694	2.207	3.184	0.958	0.822
RK-10.5	24	922	3.369	0.735	2.335	3.368	1.014	0.865
RK-11.2	28	356	4.596	0.650	2.165	3.124	0.940	0.743

Table 3.3.2-2. Pithlachascotee River Macroinvertebrate Data, May 2009.

Macroinvertebrate density did not show any regular longitudinal relationship. Density was highest at stations RK 2 (34,080 individuals per square meter) and RK 8 (32,830 individuals per square meter) and lowest at RK 5 (8,362 individuals per square meter) and RK 11.2 (5,115 individuals per square meter; Figure 3.3.2-3). Descriptive summary statistics for unpooled and pooled macroinvertebrate metrics are given in Appendix D; Tables D-3 and D-4, respectively.

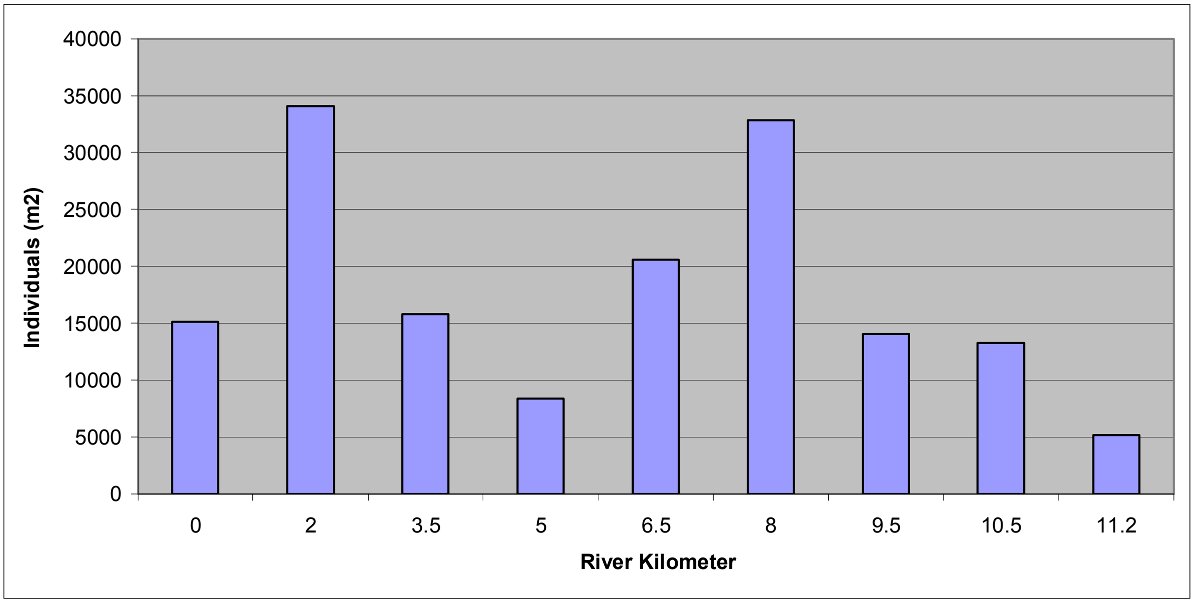


Figure 3.3.2-3. Number of Individuals per square meter for pooled Pithlachascotee River macroinvertebrate data.

3.3.3 Association of Macroinvertebrate Metrics with Physiochemical Parameters

Forward stepwise linear regression was used to seek relationships between univariate metrics and the physical-chemical variables collected at the time of sampling. Number of taxa, Shannon-Wiener diversity, and density were the metrics selected for this exercise. A significant relationship (whereby the variables included in the model met the condition of $P \leq 0.05$) was found between number of taxa and river kilometer. For Shannon-Wiener diversity and density, significant relationships were not found (Table 3.3.3-1.). In the future, a more robust sampling design with more stations and/or replicates per station may result in a better outcome for this procedure (e.g., Grabe and Janicki 2008).

The Spearman's rank correlation method was used to reveal correlations among and between physicochemical parameters and select macroinvertebrate metrics (Table 3.3.3-2). No significant correlations were found with temperature or total site depth. Dissolved oxygen percent saturation was significantly correlated to dissolved oxygen (mg/L). pH was found to be significantly correlated with conductivity, salinity, number of taxa, and Margalef's d index. pH was inversely correlated with river kilometer. Conductivity was significantly correlated with number of taxa and pH, and highly correlated with salinity. Conductivity had a highly significant inverse correlation with river kilometer. Salinity was significantly correlated with pH and number of taxa. Salinity was highly correlated with conductivity, and had a highly significant inverse correlation with river kilometer. River kilometer had significant inverse correlations with pH and number of taxa. River kilometer had highly significant inverse correlations with conductivity and salinity.

There were no significant correlations for number of individuals, Pielou's evenness, Shannon-Wiener diversity, or the Simpson's d index. Number of taxa was significantly correlated with pH, conductivity, salinity, and Margalef's d index. Number of taxa had a significant inverse correlation with river kilometer. Margalef's d index was significantly correlated with pH and number of taxa.

The high degree of correlation between conductivity and salinity and the correlation between dissolved oxygen percent saturation and dissolved oxygen (mg/L) can be explained by the fact that the instrument used to record these parameters used the same data to calculate their values. In other words, conductivity data are used to calculate salinity, and dissolved oxygen data are used in the calculation of dissolved oxygen percent saturation. This justifies the exclusion of conductivity and dissolved oxygen percent saturation from many of the analyses performed due to the redundancy of these variables with salinity and dissolved oxygen (mg/L), respectively.

The influence of salinity (or, alternatively, conductivity as a surrogate for salinity) on macroinvertebrate community composition can be seen in its correlation with number of taxa. There is a well-known relationship between estuarine salinity and numbers of species. Taxa richness is highest in full strength seawater. Marine species decline in richness as salinity decreases, with some tolerant estuarine opportunistic species appearing. Between 5 and 10 ppt, taxa richness reaches a nadir, with most species captured being estuarine specialists with some freshwater taxa also present. Below 5 ppt, taxa richness increases as freshwater taxa begin to predominate (Remane 1934; Remane and Schlieper 1971; Attrill 2002).

The correlation of pH with conductivity and salinity and its inverse correlation with river kilometer can be explained by the buffering capacity of seawater. Full strength seawater has a large capacity for buffering acids due to its calcium-magnesium hardness content (Mitchell and Rakestraw 1933). Thus, at the mouth of the river where salinity is high, the acid content of the inflowing freshwater is neutralized. At further upstream stations, the seawater buffering capacity is reduced due to dilution, and the natural acidity due to humic and tannic acids picked up from vegetation and carried by the freshwater runoff of a blackwater river is less neutralized, resulting in lower pH. At the upstream sites sampled (RK 9 through RK 11.2), salinity is negligible, and pH reaches its lowest values. Although these pH correlations are significant, due to the small range of difference in pH along the river kilometer/conductivity/salinity gradient, it is doubted that pH is a key direct factor influencing the macroinvertebrate community composition. It is suggested that significant correlations of pH with number of taxa and Margalef's d index are coincidental to pH correlation with conductivity, salinity, and river kilometer.

The fully nested ANOVA revealed that mean number of taxa (P=0.001), abundance (P=0.022), Margalef's d (P=0.001), and Shannon-Wiener diversity (P=0.037), were significantly different among some subset of river kilometer groups. One-way ANOVA showed that mean number of taxa was significantly higher for station RK 0 than for stations RK 8, RK 9.5, and RK 10.5. Number of taxa was significantly higher for station RK 2 than all the stations except RK 0 and RK 3.5. Mean abundance was significantly higher for RK 2 than for RK 5 and RK 11.2, and the RK 8 mean abundance was higher than that for RK 11.2. Mean RK 0 Margalef's d was significantly higher than that for stations RK 8, RK 9.5, and RK 10.5. Mean RK-2 Margalef's d was significantly higher than that for stations RK 6.5, RK 8, RK 9.5, and RK 10.5. Mean base 2 Shannon-Wiener for RK 0 was significantly higher than that for stations RK 8 and RK 9.5. Mean base 2 Shannon-Wiener for RK 2 was significantly higher than that for station RK 8 (Appendix A).

3.3.4 Multivariate Community Analyses

Relationships among the macroinvertebrate communities for unpooled (replicates separate) and pooled (replicates combined) data were explored using cluster diagrams and MDS. Both of these methods employ Bray-Curtis similarity matrices (Appendix E). The Primer ANOSIM procedure was used to determine if a priori groups were significantly different from each other. To determine the taxa most responsible for dissimilarity among the groups, the Primer SIMPER procedure was applied. The Primer BEST procedure was used to determine which abiotic variables best matched or explained the multivariate distribution of the macroinvertebrate communities.

The cluster diagram with the replicates (river kilometer groups) separate (unpooled) shows that most of the replicates for a given site transect were very similar to each other, and thus clustered together, though there was some inter-digitation of replicates for stations RK 6.5 and RK 9.5 with adjacent station replicates (Figure 3.3.4-1). The generally close relationship among these replicates supports the idea that samples taken at the same longitudinal position in the river will share similar macroinvertebrate communities, and justifies pooling the transect replicates. The MDS ordination diagram (drawn from the same Bray-Curtis similarity matrix used to create the cluster diagram) shows that the replicates group together, and also shows a curvilinear trend from the downstream RK 0 group (in the left bottom corner) to the upstream RK 11.2 group (in the right bottom corner) along the longitudinal salinity gradient (Figure 3.3.4-2). The stress value associated with this MDS of 0.077 “corresponds to a good ordination with no real prospect of a misleading interpretation” (Clarke and Warwick 2001).

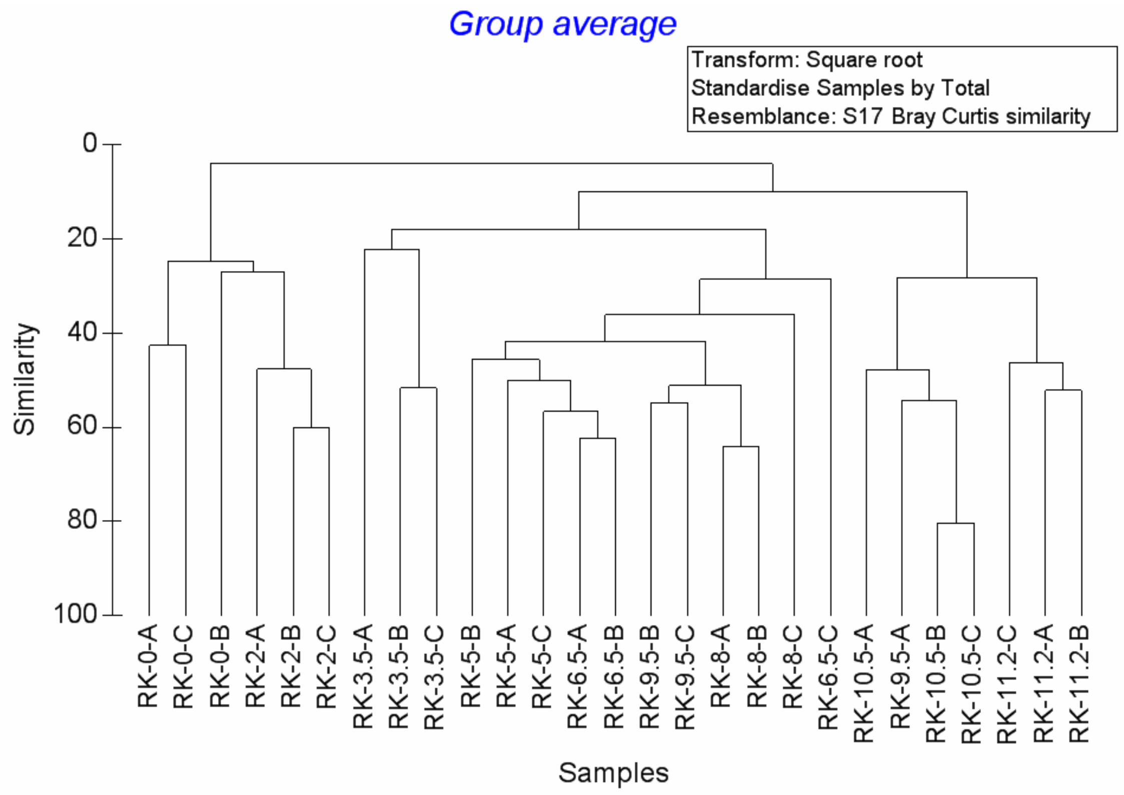


Figure 3.3.4-1. Agglomerative hierarchical cluster diagram for unpooled Pithlachascotee River macroinvertebrate data. Data were square root transformed prior to being standardized and converted to a Bray-Curtis similarity matrix. The cluster diagram was constructed using the group averaging method.

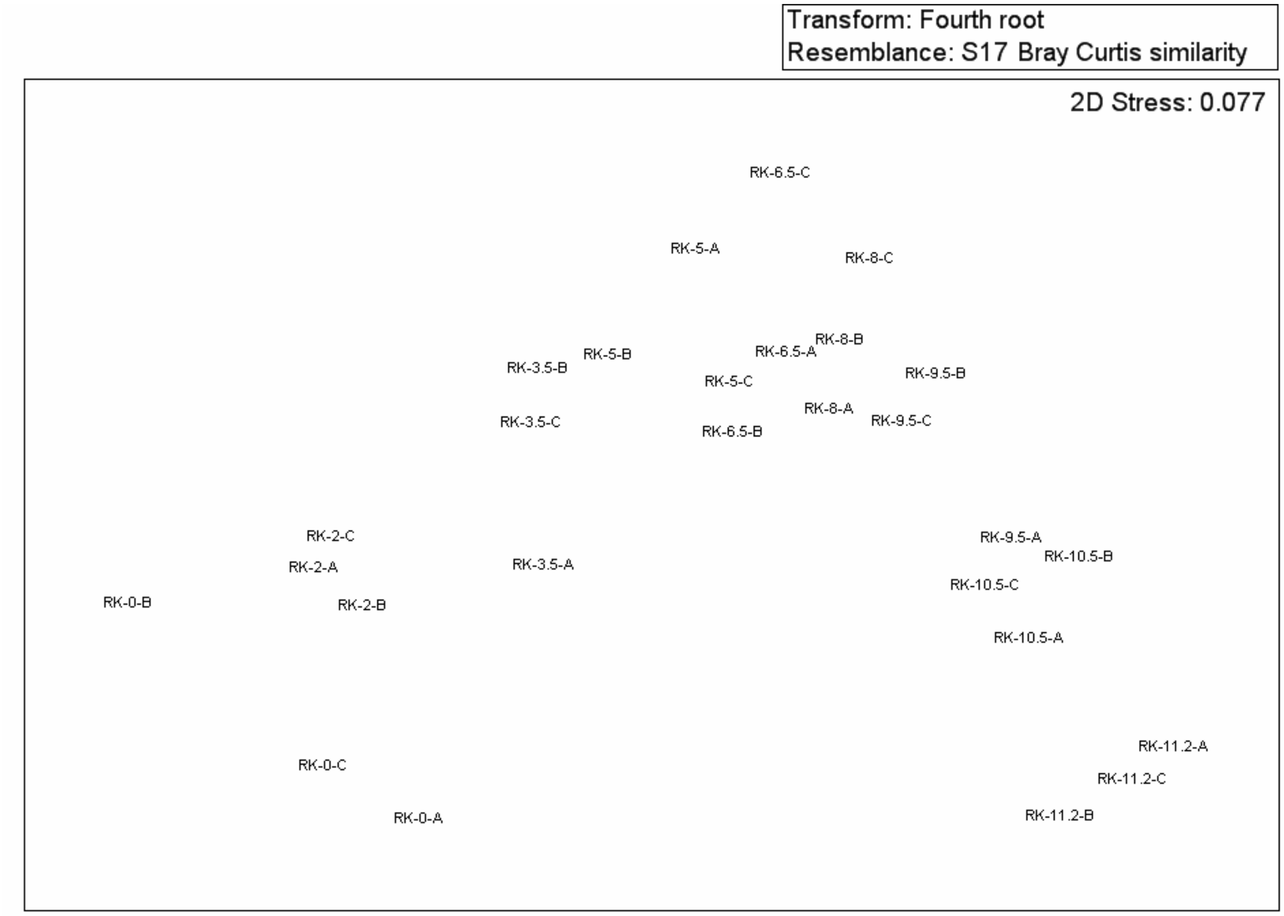


Figure 3.3.4-2. Non-metric multidimensional scaling ordination for unpooled Pithlachascotee River macroinvertebrate data. Data were fourth root transformed and converted to a Bray-Curtis similarity matrix. The Primer 6 Kruskal fit option 1 was selected, and 100 restarts were performed. The stress level of 0.077 "corresponds to a good ordination with no real prospect of a misleading interpretation" (Clarke and Warwick 2001).

The cluster diagram with the replicates combined (pooled) shows two main groups – RK 0, RK 2, and RK 3.5 in one group, and the rest of the stations in another group (Figure 3.3.4-3). The MDS diagram for the pooled data shows a curvilinear relationship similar to that of the unpooled data (but inverted) in order of their longitudinal river locations. The closeness of RK 5 and RK 6.5 indicates that the macroinvertebrate communities of these stations were very similar to each other (Figure 3.3.4-4). The stress value of 0.033 associated with this ordination suggests that it "gives an excellent representation with no prospect of misinterpretation" (Clarke and Warwick 2001).

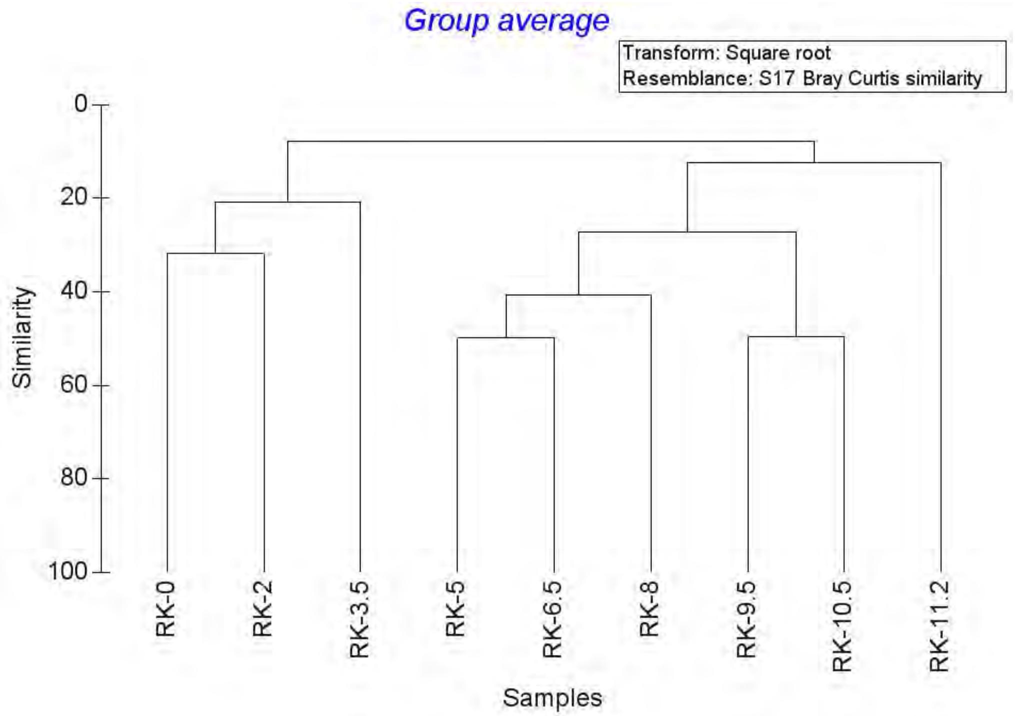


Figure 3.3.4-3. Agglomerative hierarchical cluster diagram for pooled Pithlachascotee River macroinvertebrate data. Data were square root transformed prior to being standardized and converted to a Bray-Curtis similarity matrix. The cluster diagram was constructed using the group averaging method.

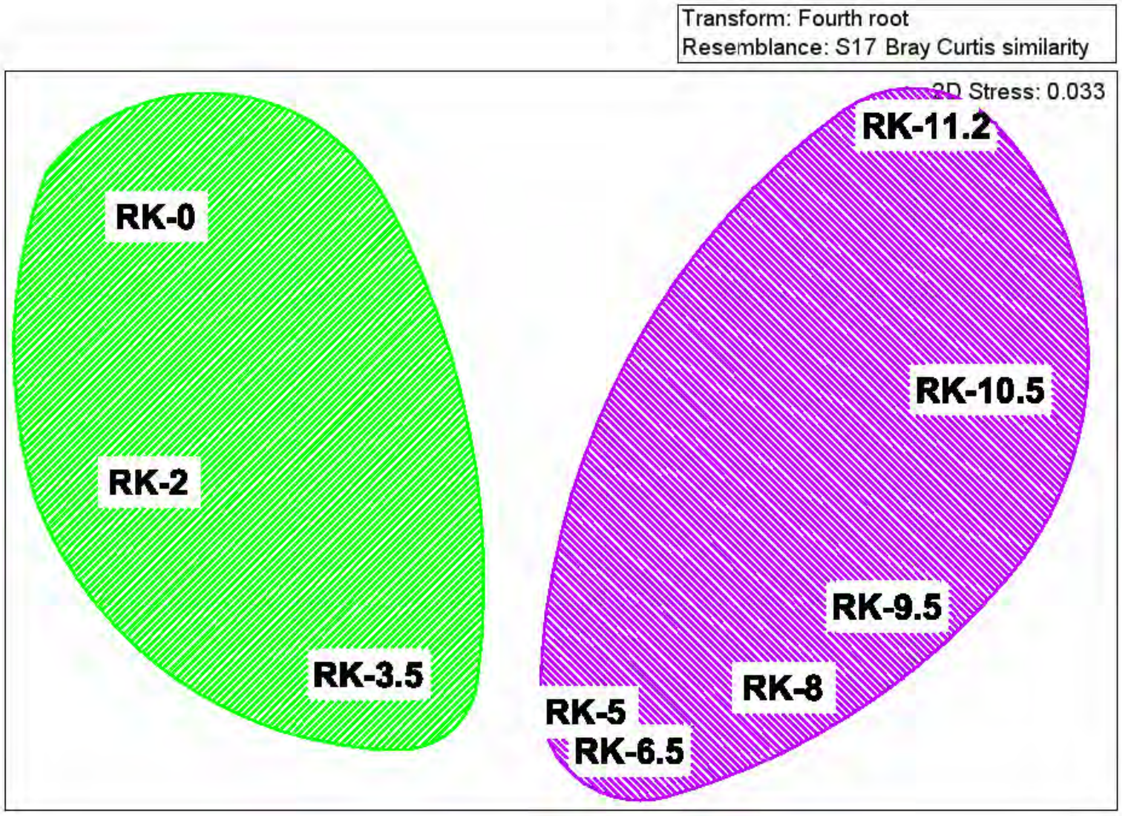


Figure 3.3.4-4. Non-metric multidimensional scaling ordination for pooled Pithlachascotee River macroinvertebrate data. Data were fourth root transformed prior to being standardized and converted to a Bray-Curtis similarity matrix. The Primer 6 Kruskal fit option 1 was selected, and 100 restarts were performed. The stress level of 0.033 "gives an excellent representation with no prospect of misinterpretation" (Clarke and Warwick 2001).

A PCA ordination for the mean values of the physicochemical data (excluding the non-independent correlated variables conductivity and dissolved oxygen percent saturation) was performed as an independent method to determine site groups. The PCA ordination diagram shows the sites in relation to gradients for the included parameters (Figure 3.3.4-5). There is a distinct separation between a group composed of RK 9.5, RK 10.5, and RK 11.2 on the left side of the diagram, and all the other sites on the right side. The pointers representing the physicochemical parameters indicate that salinity and dissolved oxygen (and to a lesser extent temperature and pH) increase to the right side of the diagram and decrease to the left. Site depth is shown to increase to the top of the diagram and decrease towards the bottom. There is some separation of two groups of sites along the right side of this gradient, with a group composed of RK 0, RK 2, and RK 3.5 towards the bottom and another group including RK 5, RK 6.5, and RK 8 at the top. The PCA diagram showed that the sites RK 5 and RK 6.5 (which exhibited very similar macroinvertebrate communities with the highest Bray-Curtis similarity of all pairs of stations; Appendix E, Table E-2) also were very similar in water quality characteristics as measured at the time of sampling.

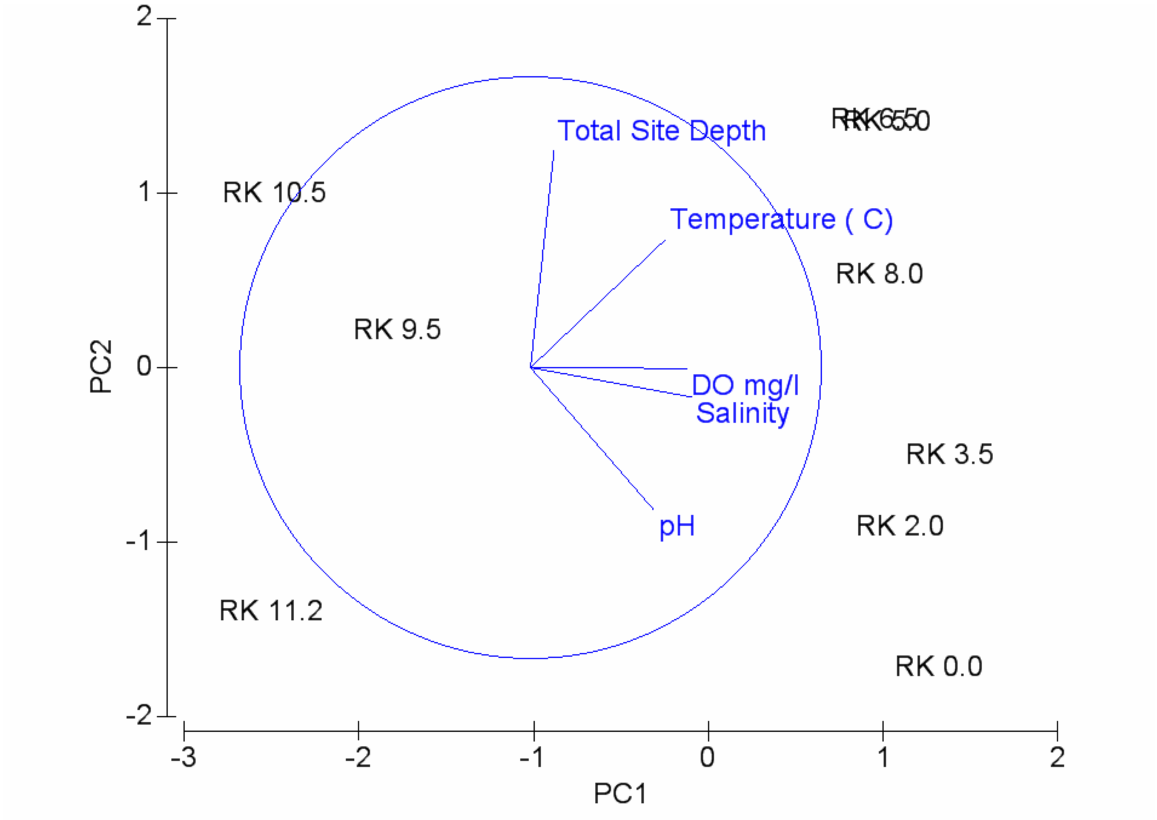


Figure 3.3.4-5. Principal Components Analysis ordination for the mean values of the physiochemical data excluding conductivity and dissolved oxygen percent saturation. PCA was performed on the normalized environmental data.

The Primer ANOSIM procedure was performed on river kilometer groups and on two arrangements of salinity groups identified by the PCA on the environmental data. The ANOSIM test was conducted on river kilometer groups as the factor. The test was performed on a Bray-Curtis similarity matrix constructed from standardized, fourth root transformed unpooled abundance data. All of the adjacent groups had R-values below the global R-statistic of 0.852 (significance level of 0.0001), except for the pairs of RK 2 and RK 3.5 (R=0.889) and RK 10.5 and RK 11.2 (R=0.963). PCA ordination results suggest the latter result (RK 10.5 versus RK 11.2) may be due to the difference in site depth between these two stations. None of the pairwise comparisons were significant at $P<0.05$ ($P=0.10$), although more emphasis is placed on the global R-statistic than the pairwise significance level for this procedure. The high P-value was likely due to the low number of replicates per site (3); according to Clarke and Gorley (2006), “The significance level is very dependent on the number of replicates in the comparison.” The cluster diagrams based on the Bray-Curtis similarity matrix also illustrate these differences (Figures 3.3.4-1 and 3.3.4-3).

Given the ANOSIM results described above, it is appropriate to explore in more detail a comparison of taxa contributing to the observed differences in benthic community structure. Mean densities of dominant taxa (> 5 percent) are summarized by river kilometer in Table 3.3.4-1. The polychaetes, *Fabricinuda trilobata*, *Axiothella* sp., *Capitella capitata*, *Prionospio heterobranchiata*, and *Syllis* sp. and the tanaid, *Halmyrapseudes cf. bahamensis*, were notably more abundant at RK 2 than at RK 3.5. The amphipods, *Grandidierella bonnieroides*, *Ampelisca holmesi, Ampelisca* sp., the isopod, *Xenanthura brevitelson*, and the polychaete, *Streblospio* sp., were more abundant at RK 3.5. SIMPER results showed that many of the polychaete taxa in relatively high abundance at RK 2 contributed the most toward dissimilarity between these benthic communities at these sites (Table 3.3.4-2). The average dissimilarity between these groups was 76.25 percent.

Taxa Contributing Greater than 5 Percent of Abundance in at Least One Sample. Highest Abundance (raw count) is Indicated with Bold Font.

Taxa	**RK-0**	**RK-2**	**RK-3.5**	**RK-5**	**RK-6.5**	**RK-8**	**RK-9.5**	**RK-10.5**	**RK-11.2**	**Total**
Grandidierella bonnieroides	0	0	76	251	379	**604**	340	0	0	1650
Apocorophium louisianum	0	0	0	53	173	**891**	122	154	0	1393
Fabricinuda trilobata	398	**862**	10	0	0	0	0	0	0	1270
Pyrgophorus platyrachis	0	0	0	1	**394**	0	0	0	0	395
Hobsonia florida	0	5	14	4	31	**195**	68	70	0	387
Americorophium sp. A Lecroy	0	0	0	0	0	0	160	**166**	28	354
Mediomastus ambiseta	4	**128**	116	95	4	0	0	0	0	347
Laeonereis culveri	0	0	0	0	**168**	154	4	0	0	326
Axiothella sp.	19	**260**	2	0	0	0	0	0	0	281
Ampelisca holmesi	3	0	**258**	0	0	0	0	0	0	261
Polypedilum halterale group Epler	0	0	0	0	0	0	8	**216**	26	250
Ampelisca sp.	0	28	**198**	17	1	0	0	4	0	248
Edotia triloba	0	4	2	10	29	**165**	36	0	0	246
Halmyrapseudes cf. bahamensis Heard	0	**164**	54	0	0	0	0	0	0	218
Gammarus cf. tigrinus LeCroy	0	0	0	0	0	0	0	20	**174**	194
Uromunna reynoldsi	0	0	0	0	0	6	72	**88**	8	174
Capitella capitata	12	**130**	6	1	2	3	0	0	0	154
Xenanthura brevitelson	0	12	**116**	23	0	0	0	0	0	151
Prionospio heterobranchia	59	**66**	8	0	0	0	0	0	0	133
Streblospio sp.	0	0	18	31	25	**56**	0	0	0	130
Syllis sp.	**91**	20	0	0	0	0	0	0	0	111
Paradialychone sp.	**72**	0	0	0	0	0	0	0	0	72
Cirrophorus sp.	**66**	0	0	0	0	0	0	0	0	66
Turbellaria (LPIL)	0	0	0	1	3	16	4	0	**20**	44

Table 3.3.4-1. Pithlachascotee River Macroinvertebrate Data. Number per Square Meter Conversion Factor = Multiply Count by 14.3678.

Twenty-five Taxa Identified by the Primer SIMPER Procedure as Contributing Most to the Dissimilarity Between the RK-2 and RK-3.5 River Kilometer Groups

	Group RK-2	Group RK-3.5				
Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Fabricinuda trilobata	10.25	2.45	2.95	3.02	3.87	3.87
Axiothella sp.	6.71	1.02	2.19	1.86	2.87	6.74
Mooreonuphis pallidula	5.6	0	2.1	3.72	2.76	9.49
Monticellina dorsobranchialis	5.32	0	2	18.32	2.63	12.12
Potamethus spathiferus	4.21	0	1.58	4.36	2.08	14.2
Merisca sp.	4.09	0	1.56	2.41	2.04	16.24
Syllis sp.	4	0	1.51	5.71	1.99	18.23
Ampelisca sp.	4.43	5.38	1.48	5.9	1.94	20.16
Prionospio heterobranchia	5.27	1.44	1.47	1.68	1.93	22.1
Halmyrapseudes cf. bahamensis Hea	4.24	3.66	1.47	1.3	1.93	24.02
Scolelepis texana	3.87	0	1.47	4.09	1.92	25.95
Grandidierella bonnieroides	0	3.89	1.44	1.23	1.89	27.83
Xenanthura brevitelson	2.64	4.71	1.44	1.72	1.88	29.71
Piromis roberti	3.79	0	1.42	7.9	1.87	31.58
Capitella capitata	5.95	2.22	1.41	1.56	1.84	33.42
Streblospio sp.	0	3.68	1.39	3.76	1.82	35.25
Ampelisca holmesi	0	3.42	1.33	0.67	1.74	36.99
Melinna sp.	4.48	1.02	1.29	2.17	1.69	38.68
Nemertea sp. J	3.37	0	1.26	9.28	1.66	40.34
Angulus versicolor	4.71	1.34	1.26	1.66	1.65	41.99
Scoloplos rubra	3.24	0	1.22	17.3	1.6	43.59
Oxyurostylis smithi	3.3	1.02	1.12	1.37	1.46	45.05
Aricidea taylori	2.91	0	1.07	1.21	1.4	46.45
Aoridae (LPIL)	3.17	1.21	1.03	1.18	1.35	47.8
Onuphidae (LPIL)	2.67	0	1	1.21	1.31	49.1

Table 3.3.4-2. Pithlachascotee River Macroinvertebrate Data.

Apocorophium louisianum, *Hobsonia florida*, *Americorophium* sp. *A*, *Polypedilum halterale* group, *Uromunna reynoldsi*, and *Ablabesmyia rhamphe* group Epler were notably more abundant at RK 10.5 than at RK 11.2. *Gammarus* cf. *tigrinus* and unidentified turbellarians were more abundant at RK 11.2. SIMPER results indicated that these taxa were among the greatest contributors to dissimilarity in benthic community structure between these two sites (Table 3.3.4-3). The average dissimilarity between these groups was 71.2 percent (Appendix C).

Twenty-five Taxa Identified by the Primer SIMPER Procedure as Contributing Most to the Dissimilarity Between the RK-10.5 and RK-11.2.5 River Kilometer Groups						
	Group RK-10.5	**Group RK-11.2**				
Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Apocorophium louisianum	6.35	0	4.99	5.6	7.01	7.01
Hobsonia florida	5.61	0	4.55	7.64	6.4	13.41
Gammarus cf. tigrinus LeCroy	1.81	6.72	3.76	1.88	5.28	18.69
Ablabesmyia rhamphe group Epler	4.26	0	3.45	7.22	4.85	23.54
Turbellaria (LPIL)	0	3.87	3.21	2.91	4.51	28.05
Procladius (Holotanypus) sp.	3.62	0	2.65	1.32	3.72	31.78
Caecidotea sp.	2.03	2.03	2.33	1.4	3.27	35.04
Polypedilum halterale group Epler	7.18	4.16	2.27	2.22	3.19	38.23
Gammarus sp.	3.05	0	2.23	1.31	3.13	41.36
Americorophium sp. A LeCroy	6.91	4.21	2.14	2.57	3.01	44.37
Tanytarsus sp. G Epler	2.92	0	2.13	1.29	2.99	47.36
Cernotina sp.	1.02	3.37	1.97	1.4	2.77	50.13
Ceratopogonidae (LPIL)	2.54	0	1.87	1.31	2.63	52.76
Aulodrilus pigueti	2.96	2.03	1.84	1.46	2.59	55.35
Cryptotendipes sp.	0	2.35	1.82	1.28	2.55	57.9
Stenochironomus sp.	0	2.35	1.82	1.28	2.55	60.45
Amnicola dalli	2.45	0	1.79	1.29	2.52	62.96
Dicrotendipes sp.	0	2.22	1.72	1.28	2.42	65.38
Uromunna reynoldsi	5.32	3.24	1.63	1.37	2.29	67.67
Tubificoid Naididae imm. w/o hair setae (LPIL)	1.21	2.22	1.57	1.09	2.21	69.88
Coelotanypus tricolor	0	2.03	1.57	1.3	2.21	72.09
Dicrotendipes neomodestus	0	1.65	1.31	0.66	1.84	73.93
Tanytarsus sp. T Epler	1.02	1.34	1.3	0.9	1.83	75.76
Tubificoid Naididae imm. w/ hair setae (LPIL)	1.02	0	0.99	0.66	1.4	77.16
Procladius sp.	1.02	0	0.99	0.66	1.4	78.55

Table 3.3.4-3. Pithlachascotee River Macroinvertebrate Data.

ANOSIM was also run on these same data with salinity groups derived from PCA of the mean values for the measured physico-chemical data (excluding the non-independent variables conductivity and dissolved oxygen percent saturation). A test run on three groups separated on the PCA by salinity and total site depth did not reveal any significant differences among the multivariate distribution of macroinvertebrate communities. The ANOSIM procedure was then run on two groups separated along an upstream/downstream gradient of salinity alone (see discussion of the PCA results above). The upstream group included sample replicates from the RK 9.5, RK 10.5, and RK 11.2 stations. The downstream group included sample replicates from all the other stations. These groups correspond to salinities of less than or equal to 8.68 ppt (the oligohaline upstream group) and greater than 18 ppt (poly- to euhaline downstream group). The test exceeded the global R-value of 0.486 (P=0.0002; Appendix B). Interestingly, there is a zone of rapid change in salinity along the longitudinal river axis between RK 8 and RK 9.5 that roughly represents the mesohaline zone described by Janicki (2007; Figure 3.1.3-3). Although the sampling design was insufficient to characterize benthic assemblages within the relatively “short” (1.5 km) mesohaline zone, this portion of the river is now recognized as an important zone of transition during low flow conditions.

Taxa tending to be more abundant in the upstream oligohaline group (RK 9.5, RK 10.5, RK 11.2) included *Americorophium* sp. A LeCroy, *Polypedilum halterale* group Epler, *Gammarus* cf. *tigrinus* LeCroy, and *Uromunna reynoldsi.* All other dominant taxa were more abundant downstream (Table 3.3.4-1).

Potential biological indicators of the upper longitudinal limit of mesohaline zone, where salinity approaches 8 ppt, include: *Americorophium* sp. A, *Uromunna reynoldsi*, and *Polypedilum halterale* group. Potential biological indicators of the lower longitudinal limit of the mesohaline, with salinities approaching 18 ppt, include: *Apocorophium louisianum*, *Edotia triloba*, and *Laeonereis culveri*. Collectively these are the most important taxa representing the dissimilarity in benthic community structure at RK 8 and RK 9.5 (based on a review of Table 3.3.4-1).

The Primer SIMPER procedure was performed on the Bray-Curtis similarity matrix constructed from fourth root transformed unpooled abundance data to identify the taxa most contributing to the difference between the upstream (oligohaline to freshwater) and downstream (polyhaline to euhaline) salinity groups. The average dissimilarity between these groups was 81.18 percent. The twenty-five taxa contributing most to the dissimilarity between upstream and downstream groups are given in Table 3.3.4-4. These taxa account for 46.24 percent of the dissimilarity between the upstream and downstream salinity groups.

Twenty-five Taxa Identified by the Primer SIMPER Procedure as Contributing Most to the Dissimilarity Between the Upstream and Downstream Salinity Groups						
	Group Downstream	**Group Upstream**				
	Average	**Average**	**Average**	**Dissimilarity**	**Percent**	**Cumulative**
Species	**Abundance**	**Abundance**	**Dissimilarity**	**Standard Dev.**	**Contribution**	**% Contribution**
Grandidierella bonnieroides	4.94	2.02	2.95	1.15	3.64	3.64
Americorophium sp. A LeCroy	0	4.72	2.69	1.47	3.31	6.95
Polypedilum halterale group Epler	0	4.58	2.61	1.86	3.22	10.17
Uromunna reynoldsi	0.22	4.59	2.51	2.35	3.09	13.26
Apocorophium louisianum	3.45	4.26	2.28	1.33	2.8	16.06
Mediomastus ambiseta	3.63	0	1.99	1.28	2.45	18.52
Hobsonia florida	2.66	3.59	1.78	1.32	2.19	20.71
Gammarus cf. tigrinus LeCroy	0	2.84	1.72	0.83	2.12	22.82
Streblospio sp.	2.7	0	1.66	1.14	2.05	24.87
Edotia triloba	2.33	1.13	1.48	0.99	1.82	26.69
Tubificoid Naididae imm. w/o hair setae (LPIL)	0.8	2.55	1.33	1.21	1.64	28.33
Fabricinuda trilobata	2.92	0	1.28	0.71	1.58	31.5
Ampelisca sp.	2.26	0.4	1.23	0.81	1.52	33.02
Laeonereis culveri	1.57	0.4	1.14	0.56	1.41	34.43
Capitella capitata	2.31	0	1.14	1.05	1.41	35.83
Turbellaria (LPIL)	0.61	1.69	1.08	0.9	1.32	37.16
Hydrobiidae (LPIL)	1.32	0.53	1	0.67	1.23	38.39
Leptochelia sp.	1.42	0.4	0.95	0.74	1.18	39.57
Procladius (Holotanypus) sp.	0	1.81	0.95	0.68	1.18	40.74
Xenanthura brevitelson	1.73	0	0.94	0.64	1.16	41.91
Aulodrilus pigueti	0	1.66	0.91	0.85	1.13	43.03
Axiothella sp.	1.95	0	0.87	0.73	1.08	44.11
Nemertea (LPIL)	1.69	0	0.87	0.98	1.08	45.19
Prionospio heterobranchia	1.86	0	0.86	0.76	1.05	46.24
Caecidotea sp.	0	1.35	0.85	0.62	1.05	47.29

Table 3.3.4-4. Pithlachascotee River Macroinvertebrate Data.

The Primer BEST procedure was run with the Bray-Curtis similarity matrix of the pooled data (data square root transformed) and select abiotic parameters (river kilometer, temperature, pH, salinity, DO mg/L, total site depth, and percent silt & clay) square root transformed and normalized. The procedure found that the variables best explaining the multivariate relationship between the biotic and abiotic matrices were river kilometer, pH, and salinity ($\rho=0.932$; $P\leq0.001$). When pH was excluded from the procedure, the variables best explaining the multivariate relationship between the biotic and abiotic matrices were river kilometer and salinity ($\rho=0.917$; $P\leq0.001$). Excluding river kilometer, the variables best explaining the multivariate relationship between the biotic and abiotic matrices were pH and salinity ($\rho=0.880$; $P\leq0.001$). Excluding salinity, the variables best explaining the multivariate relationship between the biotic and abiotic matrices were river kilometer, temperature, and ($\rho=0.899$; $P\leq0.001$). Excluding river kilometer and pH, the variables best explaining the multivariate relationship between the biotic and abiotic matrices were salinity and percent silt and clay ($\rho=0.701$; $P\leq0.008$). Interestingly, the one variable solution with salinity was next ranked in this iteration ($\rho=0.670$). This result emphasizes the importance of salinity in shaping the benthic macroinvertebrate assemblages along the river's longitudinal axis. Applying the principle of parsimony, the solution with river kilometer and salinity is regarded as the optimum solution. This solution had the highest ρ value with the fewest variables included (Appendix B).

3.3.5 River Longitudinal Distribution of Eleven Important Taxa and Relationships with Salinity Concentration

A rank analysis was performed to determine which of the dominant taxa had the greatest contribution to differences in benthic macroinvertebrate community structure along the river longitudinal and salinity gradients. Taxa were ranked by descending dominance index value (Table 3.3.1-1), total abundance (Table 3.3.4-1), and average contribution to dissimilarity (Table 3.3.4-4). Based on these three rankings, an average ranking was calculated to identify the following eleven important taxa:

Amphipoda	*Grandidierella bonnieroides*
Amphipoda	*Apocorophium louisianum*
Polychaeta	*Fabricinuda trilobata*
Polychaeta	*Hobsonia florida*
Amphipoda	*Americorophium* sp. A Lecroy
Polychaeta	*Mediomastus ambiseta*
Amphipoda	*Ampelisca* sp.
Isopoda	*Uromunna reynoldsi*
Isopoda	*Edotia triloba*
Polychaeta	*Laeonereis culveri*
Insecta	*Polypedilum halterale* group Epler

Total abundance (raw count) of the eleven select taxa (as well as other dominant taxa) by river kilometer is presented in Table 3.3.4-1. Abundance-weighted salinity for each taxon and center of abundance for each taxon is presented in Table 3.3.1-1. Figure 3.3.5-1 depicts salinity ranges and abundance-weighted salinity (referenced below as "optimal" salinity) for each of the eleven taxa. Additional figures showing total abundance (raw count) of these taxa by river kilometer and salinity concentrations are given in Appendix F. Collectively, these taxa occurred across the salinity gradient, with three taxa dominating the euhaline zone with rather narrow distributions (*Fabricinuda trilobata, Mediomastus ambiseta,* and *Laeonereis culveri)*, five taxa spanning the polyhaline zone with wide ranges of salinity tolerance (*Grandidierella bonnieroides, Apocorophium louisianum, Hobsonia florida*, *Edotia triloba,* and *Laeonereis culveri)*, and three other taxa that typify the oligohaline to freshwater zone. Of these dominant taxa from the oligohaline to freshwater zone, two *(Americorophium* sp. A and *Polypedilum halterale)* had narrow longitudinal distributions, while the third taxon *(Uromunna reynoldsi)* had a wider distribution.

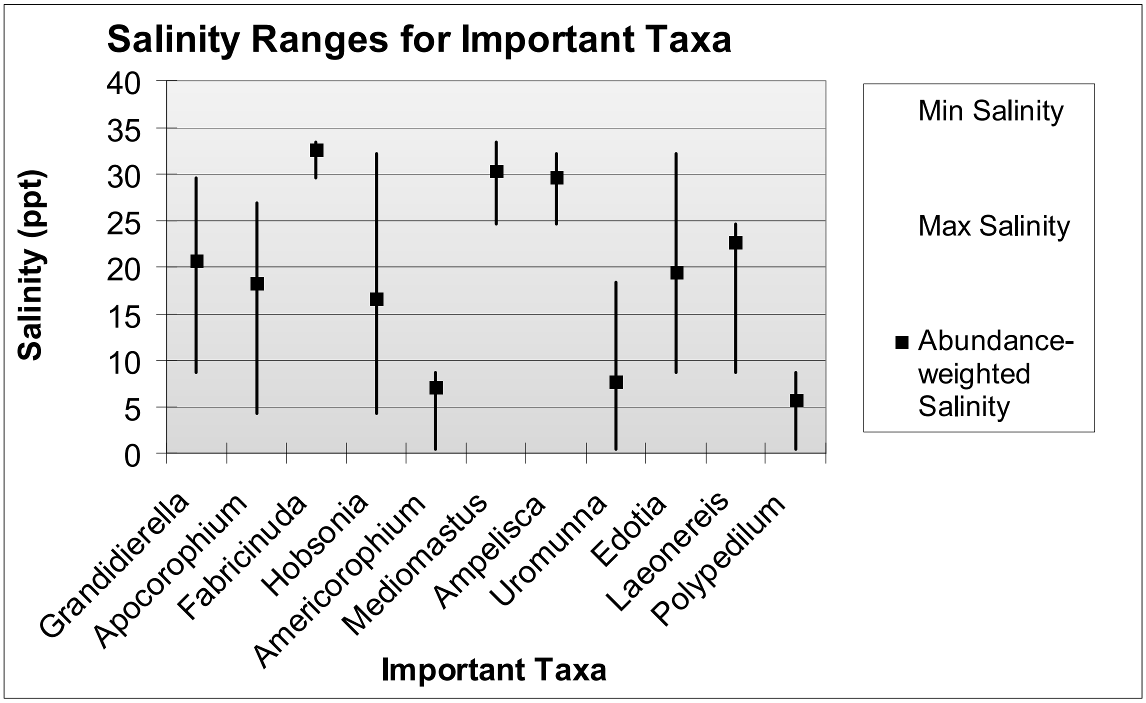


Figure 3.3.5-1. Optimal Salinity and Salinity Ranges for Eleven Important Taxa

Pithlachascotee River sampling in May 2009 occurred after a sustained period of low flow and was meant to capture near maximum salinity conditions in the river. In comparing results for these species to studies in which sampling occurred throughout the year (e.g., Janicki 2007), higher optimal salinities at capture might be expected in the Pithlachascotee River where high salinity conditions were prevalent at the time of the single sampling event.

Grandidierella bonnieroides was observed from RK 3.5 to RK 9.5 with a center of abundance at RK 7.3. Salinities for this species ranged from around 8 to 30 ppt with an abundance-weighted salinity of 20.67 ppt.

Apocorophium louisianum was collected from RK 5 to RK 10.5 with a center of abundance at RK 8.1. *A. louisianum* was associated with salinities ranging from 4 to 27 ppt (optimal salinity was 18.3 ppt).

Fabricinuda trilobata had a relatively narrow longitudinal range in the euhaline zone (29 to 34 ppt, optimal was 32) near the river mouth (RK 0 to RK 2, center at RK 1.4).

Hobsonia florida had a wide range of salinity tolerance (4 to 32 ppt, optimal salinity 16.5 ppt), occurring from RK 2 to RK 10.5 (center at RK 8.3).

Americorophium sp. A was observed in the oligohaline portion of the river (RK 9.5 to RK 11.2, center at RK 10.1). It was associated with salinities from near 0 to 9 ppt (optimal was 7.1 ppt).

Mediomastus ambiseta was found in the lower river (RK 0 to RK 6.5, center at RK 3.4) where salinity concentrations ranged from 25 to 33 ppt (optimal was 30 ppt).

Ampelisca sp. occurred primarily along the lower river from RK 2 to RK 10.5 with center at RK 3.6. Optimal salinity for this taxon was approximately 30 ppt.

Uromunna reynoldsi occurred in the upper river (RK 8 to RK 11.2; center at RK 10) where salinities ranged from 0 to 18 ppt (optimal was 8 ppt).

Edotia triloba was observed from RK 2 to RK 9.5 (center at RK 8) in a wide range of salinity concentrations (8 to 32 ppt; optimal was19 ppt).

Laeonereis culveri exhibited tolerance to a moderately wide range in salinity (8 to 25 ppt, optimal was 22.6 ppt) and was observed from RK 6.5 to RK 9.5 (center at RK 7).

Polypedilum halterale group tolerates low salinity concentrations in the oligohaline zone (0 to 8 ppt, abundance-weighted salinity was 6 ppt) where fresh and salt water meet at the upper end of the study area (RK 9.5 to RK 11.2; center at RK 10.5).

4.0 Conclusions

In order to establish minimum flow for tidal rivers, it is necessary to establish quantitative relationships between flow or factors influenced by flow (salinity) and important biological communities, including benthic infauna. One objective of this work is to document quantitative relationships that explain the spatial distribution of the benthic invertebrate assemblages.

Mean water column salinity ranged from 0.48 ppt at RK 11.2 to 33.46 ppt at the river mouth. During low flow conditions, there is a zone of rapid change in salinity along the longitudinal river axis between RK 8 and RK 9.5 that roughly represents the mesohaline zone (salinity of 8 to 18 ppt).

Live oysters were observed from the river mouth upstream approximately to RK 6.6 where mean water column salinity was approximately 25 ppt at the time of sample collection.

The dominant species contributing most towards explaining longitudinal variability in benthic infauna distribution were the amphipods *Grandidierella bonnieroides* and *Apocorophium louisianum* and the polychaete, *Fabricinuda trilobata.* These three species represented 39 percent of the total number of organisms collected.

Number of taxa declined longitudinally from the river mouth traveling upstream.

Forward stepwise regression revealed a significant relationship between number of taxa and river kilometer. Rank correlation indicated a significant decline in number of taxa with decreasing salinity. Number of taxa declined from 71 taxa at RK 2 to 24 taxa observed between RK 9.5 and RK 10.5. The decline in benthic community number of benthic invertebrate species with decreasing salinity is a commonly observed spatial pattern in estuaries that may, in part, be attributed to relatively wide fluctuations in environmental conditions along the river longitudinal axis.

Diversity index values (Shannon’s and Margalef’s) generally declined longitudinally with increasing river kilometer and decreasing salinity, but the Spearman rank correlation technique did not indicate statistically significant relationships of these metrics to physicochemical variables.

A forward stepwise linear regression model indicated number of taxa was significantly related to river kilometer. No significant relationships were found between other biotic metrics (Shannon-Wiener diversity and density) and abiotic factors. Lack of significant relationships with salinity may be attributed to relatively small sample size. A more robust sampling design (e.g., collection of a larger number of samples) might change this outcome. Total macroinvertebrate density (number per square meter) did not show any regular longitudinal relationship.

Benthic community structure varied longitudinally along the river axis. ANOSIM benthic infauna assemblages at RK 0 through RK 8 significantly differed from assemblages at RK 9.5 through RK 11.2, and this difference was strongly driven by the salinity gradient. During low flow conditions, there is a zone of rapid change in salinity along the longitudinal river axis between RK 8 and RK 9.5 that roughly represents the mesohaline zone (8-18 ppt). Although the sampling design was insufficient to adequately characterize benthic assemblages within the relatively short (1.5 km) mesohaline zone, this portion of the river is now recognized as an important zone of transition during low flow conditions.

Benthic community structure was very similar at RK 5 and RK 6.5, and physicochemical conditions were also very similar at those sites during the May 2009 sampling event.

The following eleven dominant taxa were identified as having the greatest influence on dissimilarity in benthic community structure along the river's longitudinal axis:

Amphipoda	*Grandidierella bonnieroides*
Amphipoda	*Apocorophium louisianum*
Polychaeta	*Fabricinuda trilobata*
Polychaeta	*Hobsonia florida*
Amphipoda	*Americorophium* sp. A Lecroy
Polychaeta	*Mediomastus ambiseta*
Amphipoda	*Ampelisca* sp.
Isopoda	*Uromunna reynoldsi*
Isopoda	*Edotia triloba*
Polychaeta	*Laeonereis culveri*
Insecta	*Polypedilum halterale* group Epler

Potential biological indicators of the upper longitudinal limit of mesohaline zone, where salinity approaches 8 ppt, include: *Americorophium* sp. A, *Uromunna reynoldsi*, and *Polypedilum halterale* group. Potential biological indicators of the lower longitudinal limit of the mesohaline, with salinities approaching 18 ppt. include: *Apocorophium louisianum*, *Edotia triloba*, and *Laeonereis culveri*. Collectively, these are the most important taxa representing the dissimilarity in benthic community structure at RK 8 and RK 9.5, and the transition in species assemblages associated with the mesohaline zone.

Pithlachascotee River sampling in May 2009 occurred after a sustained period of low flow and was intended to capture near maximum salinity conditions in the river. In comparing current results for these species to studies in which sampling occurred throughout the year (e.g., Janicki 2007), higher optimal salinities at capture might be expected in the Pithlachascotee River due to the high salinity conditions at the time of the single sampling event.

Sustained decline in river flow and elevated salinity concentrations might lead to an increase in number of taxa, an increase in number of salt-tolerant taxa, and perhaps a decrease in chironomids (e.g., *Polypedilum halterale* group), *Gammarus cf. tigrinus*, and other taxa characteristic of the oligohaline and freshwater zones of the river.

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Appendix A

Univariate Statistical Outputs

Appendix A: Conventional Statistical Analysis Documentation

Cotee River Data Analysis Documentation

Salinity Data

Descriptive Statistics

```
Variable                   N  N*   Mean  SE Mean  StDev  Minimum    Q1  Median
Water&AirSalinity          9   0  20.58     4.11  12.33     0.48  7.74   25.71
SWFWMD_Mean_1985-87_Sali   8   1   8.77     2.60   7.37     0.46  1.58    7.86
SWFWMD_May_5_09_Salinity   9   0  17.20     3.57  10.72     0.37  9.38   15.56
SWFWMD_May_26_09_Salinit   8   1  17.10     3.85  10.90     0.89  6.01   20.04
SWFWMD_Mean_May_5&26_09_   9   0  17.93     3.60  10.79     0.63  8.24   19.71

Variable                      Q3  Maximum
Water&AirSalinity          31.07    33.49
SWFWMD_Mean_1985-87_Sali  15.94    19.63
SWFWMD_May_5_09_Salinity  28.55    31.18
SWFWMD_May_26_09_Salinit  27.04    27.97
SWFWMD_Mean_May_5&26_09_  28.06    31.18
```

*N indicates missing data values.

Mann-Whitney Tests

Mann-Whitney Test and CI: Water&AirSalinity, SWFWMD_Mean_1985-87_Salinity

```
                              N  Median
Water&AirSalinity             9   25.71
SWFWMD_Mean_1985-87_Salinity  8    7.86


Point estimate for ETA1-ETA2 is 13.48
95.1 Percent CI for ETA1-ETA2 is (-0.08,24.45)
W = 101.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0606
```

Mann-Whitney Test and CI: Water&AirSalinity, SWFWMD_May_5_09_Salinity

```
                          N  Median
Water&AirSalinity         9   25.71
SWFWMD_May_5_09_Salinity  9   15.56


Point estimate for ETA1-ETA2 is 2.96
95.8 Percent CI for ETA1-ETA2 is (-9.37,17.93)
W = 92.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.5962
```

Mann-Whitney Test and CI: Water&AirSalinity, SWFWMD_May_26_09_Salinity

```
                           N  Median
Water&AirSalinity          9   25.71
```

```
SWFWMD_May_26_09_Salinity  8   20.04


Point estimate for ETA1-ETA2 is 3.79
95.1 Percent CI for ETA1-ETA2 is (-8.42,17.29)
W = 91.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.3606
```

Mann-Whitney Test and CI: Water&AirSalinity, SWFWMD_Mean_May_5&26_09_Salinit

```
                                 N  Median
Water&AirSalinity                9   25.71
SWFWMD_Mean_May_5&26_09_Salinit  9   19.71


Point estimate for ETA1-ETA2 is 2.87
95.8 Percent CI for ETA1-ETA2 is (-9.62,16.32)
W = 91.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.6588
```

Mann-Whitney Test and CI: SWFWMD_Mean_1985-87_Salinity, SWFWMD_May_5_09_Salinit

```
                              N  Median
SWFWMD_Mean_1985-87_Salinity  8    7.86
SWFWMD_May_5_09_Salinity      9   15.56


Point estimate for ETA1-ETA2 is -9.16
95.1 Percent CI for ETA1-ETA2 is (-19.35,2.13)
W = 56.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.1358
```

Mann-Whitney Test and CI: SWFWMD_Mean_1985, SWFWMD_May_26_09

```
                              N  Median
SWFWMD_Mean_1985-87_Salinity  8    7.86
SWFWMD_May_26_09_Salinity     8   20.04


Point estimate for ETA1-ETA2 is -8.46
95.9 Percent CI for ETA1-ETA2 is (-21.36,3.42)
W = 54.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.1563
```

Mann-Whitney Test and CI: SWFWMD_Mean_1985, SWFWMD_Mean_May_

```
                                 N  Median
SWFWMD_Mean_1985-87_Salinity     8    7.86
SWFWMD_Mean_May_5&26_09_Salinit  9   19.71


Point estimate for ETA1-ETA2 is -9.67
95.1 Percent CI for ETA1-ETA2 is (-21.13,0.63)
W = 53.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0750
```

Mann-Whitney Test and CI: SWFWMD_May_5_09_Salinity, SWFWMD_May_26_09_Salinity

```
                           N  Median
SWFWMD_May_5_09_Salinity   9   15.56
SWFWMD_May_26_09_Salinity  8   20.04


Point estimate for ETA1-ETA2 is 1.14
95.1 Percent CI for ETA1-ETA2 is (-12.83,10.75)
W = 82.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.9616
```

Mann-Whitney Test and CI: SWFWMD_May_5_09_, SWFWMD_Mean_May_

```
                                 N  Median
SWFWMD_May_5_09_Salinity         9   15.56
SWFWMD_Mean_May_5&26_09_Salinit  9   19.71


Point estimate for ETA1-ETA2 is -0.10
95.8 Percent CI for ETA1-ETA2 is (-13.25,10.50)
W = 84.5
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.9648
```

Mann-Whitney Test and CI: SWFWMD_May_26_09, SWFWMD_Mean_May_

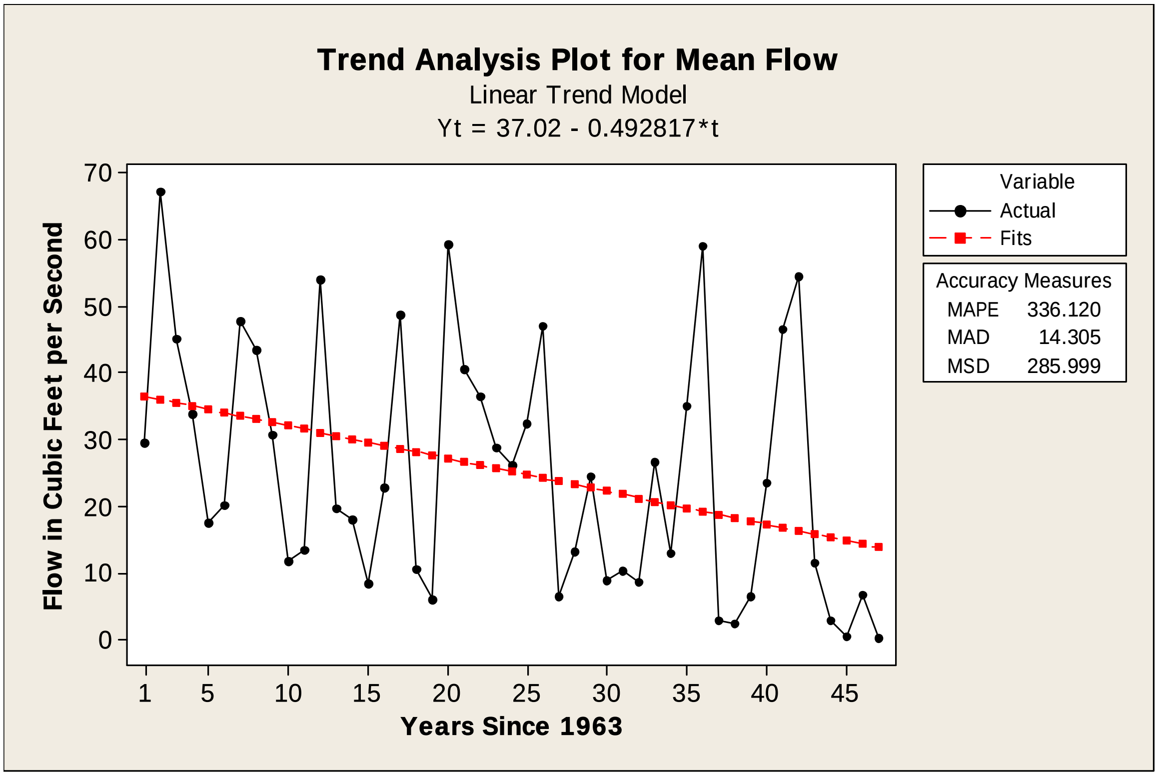
```
                                 N  Median
SWFWMD_May_26_09_Salinity        8   20.04
SWFWMD_Mean_May_5&26_09_Salinit  9   19.71


Point estimate for ETA1-ETA2 is -1.08
95.1 Percent CI for ETA1-ETA2 is (-12.85,13.05)
W = 70.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.8852
```

One-way ANOVA

```
Source  DF    SS   MS     F      P
Factor   4   654  163  1.45  0.236
Error   38  4278  113
Total   42  4932

S = 10.61   R-Sq = 13.25%   R-Sq(adj) = 4.12%



Level                       N   Mean  StDev
Water&AirSalinity           9  20.58  12.33
SWFWMD_Mean_1985-87_Sali    8   8.77   7.37
SWFWMD_May_5_09_Salinity    9  17.20  10.72
SWFWMD_May_26_09_Salinit    8  17.10  10.90
SWFWMD_Mean_May_5&26_09_    9  17.93  10.79

                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level                       --------+---------+---------+---------+-
Water&AirSalinity                            (---------*----------)
SWFWMD_Mean_1985-87_Sali    (----------*---------)
SWFWMD_May_5_09_Salinity                (----------*---------)
SWFWMD_May_26_09_Salinit                (---------*----------)
SWFWMD_Mean_May_5&26_09_                 (----------*---------)
                            --------+---------+---------+---------+-
                                  7.0      14.0      21.0      28.0

Pooled StDev = 10.61
```

Flow Data

Trend and Regression Analysis



Regression Analysis: Average Flow versus Date

```
The regression equation is
Average_Flow = 1004 - 0.493 Date


Predictor      Coef  SE Coef      T      P
Constant     1003.9    369.1   2.72  0.009
Date        -0.4928   0.1859  -2.65  0.011


S = 17.2832   R-Sq = 13.5%   R-Sq(adj) = 11.6%

Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   2100.3  2100.3  7.03  0.011
Residual Error  45  13441.9   298.7
Total           46  15542.3

Unusual Observations

Obs  Date  Average_Flow    Fit  SE Fit  Residual  St Resid
 36  1998         59.04  19.28    3.37     39.76     2.35R
 42  2004         54.55  16.33    4.19     38.23     2.28R

R denotes an observation with a large standardized residual.
```

Macroinvertebrate Numbers of Taxa, Diversity, and Number of Individuals per Square Meter Related to Physico-chemical Variables

Physico-Chemical/Water Quality Data

Descriptive Statistics

```
Variable                  N  N*    Mean  SE Mean   StDev  Minimum      Q1
Depth of Collection (m)  28   0   1.189    0.127   0.671    0.500   0.500
Temperature ( C)         28   0  27.309    0.296   1.564   23.990  26.470
pH                       28   0  7.5261   0.0339  0.1795   7.2400  7.4300
Conductivity             28   0   31213     3242   17155      926   14286
Salinity                 28   0   19.91     2.16   11.44     0.48    8.28
DO%                      28   0   45.88     2.48   13.14    17.30   31.68
DO mg/l                  28   0   3.159    0.141   0.745    1.350   2.567
Total Site Depth          9  18   1.956    0.195   0.585    1.200   1.550

Variable                 Median      Q3  Maximum
Depth of Collection (m)   1.000   1.575    2.500
Temperature ( C)         27.605  28.580   29.370
pH                       7.5150  7.6675   7.8900
Conductivity              38723   45505    50901
Salinity                  24.69   29.62    33.49
DO%                       50.30   56.03    67.20
DO mg/l                   3.305   3.680    4.600
Total Site Depth          1.700   2.650    2.800
```

Unpooled Macroinvertebrate Metrics

Descriptive Statistics

```
Variable                   N  N*    Mean  SE Mean   StDev  Minimum      Q1
N_Taxa                    27   0   20.48     1.89    9.80     5.00   15.00
N_Individuals             27   0   410.1     60.8   315.8     78.0   176.0
Margalefs d               27   0   3.368    0.297   1.545    0.712   2.237
Pielous Evenness          27   0  0.6818   0.0200  0.1037   0.5254  0.6183
Shannon Diversity(loge)   27   0  1.9811   0.0829  0.4305   1.1738  1.6745
Shannon Diversity(log2)   27   0   2.858    0.120   0.621    1.693   2.416
Shannon Diversity(log10)  27   0  0.8604   0.0360  0.1870   0.5098  0.7272
Simpsons d (1-λ)          27   0  0.7621   0.0185  0.0964   0.5964  0.6844

Variable                  Median      Q3  Maximum
N_Taxa                     18.00   24.00    47.00
N_Individuals              288.0   512.0   1365.0
Margalefs d                2.974   4.072    7.374
Pielous Evenness          0.6628  0.7480   0.8890
Shannon Diversity(loge)   1.8899  2.2171   3.0448
Shannon Diversity(log2)    2.727   3.199    4.393
Shannon Diversity(log10)  0.8208  0.9629   1.3224
Simpsons d (1-λ)          0.7496  0.8410   0.9365
```

Pooled Macroinvertebrate Metrics

Descriptive Statistics

```
Variable                   N  N*    Mean  SE Mean   StDev  Minimum      Q1
N_Taxa                     9   0   39.56     5.78   17.35    24.00   26.00
N_Individuals              9   0    1230      231     694      356     752
Margalefs d                9   0   5.494    0.748   2.245    3.341   3.430
Pielous Evenness           9   0  0.6477   0.0186  0.0557   0.5638  0.5989
Shannon Diversity(loge)    9   0  2.3292   0.0978  0.2933   1.8786  2.1392
Shannon Diversity(log2)    9   0   3.360    0.141   0.423    2.710   3.086
Shannon Diversity(log10)   9   0  1.0116   0.0425  0.1274   0.8159  0.9291
Simpsons d (1-λ)           9   0  0.8153   0.0158  0.0474   0.7428  0.7657

Variable                   Median      Q3  Maximum
N_Taxa                      36.00   53.50    71.00
N_Individuals                1051    1858     2372
Margalefs d                 5.093   7.431    9.199
Pielous Evenness           0.6489  0.6986   0.7346
Shannon Diversity(loge)    2.2119  2.6678   2.7167
Shannon Diversity(log2)     3.191   3.849    3.919
Shannon Diversity(log10)   0.9606  1.1586   1.1799
Simpsons d (1-λ)           0.8228  0.8525   0.8803
```

Forward Stepwise Multiple Regression

Stepwise Regression: Taxa versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.25


Response is Taxa on 8 predictors, with N = 9


Step            1
Constant   -568.0

pH             81
T-Value      6.13
P-Value     0.000

S            7.35
R-Sq        84.29
R-Sq(adj)   82.04
```

Stepwise Regression: Taxa versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.25


Response is Taxa on 8 predictors, with N = 9


Step              1
Constant     -568.0

pH               81
T-Value        6.13
P-Value       0.000

S              7.35
R-Sq          84.29
R-Sq(adj)     82.04
PRESS       671.712
R-Sq(pred)    72.11
```

Stepwise Regression: Taxa versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.05


Response is Taxa on 8 predictors, with N = 9


Step              1
Constant     -568.0

pH               81
T-Value        6.13
P-Value       0.000

S              7.35
```

```
R-Sq          84.29
R-Sq(adj)     82.04
PRESS       671.712
R-Sq(pred)    72.11
```

Stepwise Regression: Taxa versus RK, Temperature (C), ...

```
  Alpha-to-Enter: 0.05  Alpha-to-Remove: 0.05


Response is Taxa on 8 predictors, with N = 9


Step              1
Constant     -568.0

pH               81
T-Value        6.13
P-Value       0.000

S              7.35
R-Sq          84.29
R-Sq(adj)     82.04
PRESS       671.712
R-Sq(pred)    72.11


MTB > Stepwise 'Taxa' 'RK' 'Temperature ( C)' 'pH' 'Conductivity'  &
CONT>     'Salinity' 'DO%' 'DO mg/l' 'Total Site Depth';
SUBC>   AEnter 0.05;
SUBC>   ARemove 0.05;
SUBC>   Best 0;
SUBC>   Steps 8;
SUBC>   Constant;
SUBC>   Press.
```

Stepwise Regression: Taxa versus RK, Temperature (C), ...

```
  Alpha-to-Enter: 0.05  Alpha-to-Remove: 0.05


Response is Taxa on 8 predictors, with N = 9


Step              1
Constant     -568.0

pH               81
T-Value        6.13
P-Value       0.000

S              7.35
R-Sq          84.29
R-Sq(adj)     82.04
PRESS       671.712
R-Sq(pred)    72.11
```

Regression Analysis: Taxa versus RK, Temperature (C), ...

```
The regression equation is
Taxa = - 2281 - 4.60 RK + 56.2 Temperature ( C) + 147 pH - 0.0434 Conductivity
       + 66.0 Salinity - 18.6 DO% + 203 DO mg/l - 19.9 Total Site Depth


                                SE
Predictor              Coef  Coef  T  P
Constant           -2280.95     *  *  *
RK                 -4.59667     *  *  *
Temperature ( C)    56.2280     *  *  *
pH                  147.248     *  *  *
Conductivity     -0.0434161     *  *  *
Salinity            65.9506     *  *  *
DO%                -18.5638     *  *  *
DO mg/l             202.645     *  *  *
Total Site Depth   -19.8831     *  *  *


S = *


Analysis of Variance

Source          DF        SS       MS  F  P
Regression       8  2408.222  301.028  *  *
Residual Error   0         *        *
Total            8  2408.222


Source            DF    Seq SS
RK                 1  1955.345
Temperature ( C)   1   152.858
pH                 1    21.112
Conductivity       1    22.845
Salinity           1   112.291
DO%                1     0.000
DO mg/l            1    10.203
Total Site Depth   1   133.569


MTB > Stepwise 'Taxa' 'RK' 'Temperature ( C)' 'pH' 'Conductivity'  &
CONT>     'Salinity' 'DO%' 'DO mg/l' 'Total Site Depth';
SUBC>   Forward;
SUBC>   AEnter 0.05;
SUBC>   Best 0;
SUBC>   Steps 8;
SUBC>   Constant;
SUBC>   Press.
```

Stepwise Regression: Taxa versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.05


Response is Taxa on 8 predictors, with N = 9


Step              1
Constant     -568.0

pH               81
T-Value        6.13
P-Value       0.000

S              7.35
R-Sq          84.29
R-Sq(adj)     82.04
PRESS       671.712
R-Sq(pred)    72.11

More? (Yes, No, Subcommand, or Help)

SUBC> yes

No variables entered or removed

More? (Yes, No, Subcommand, or Help)

SUBC> no
MTB > Stepwise 'H(log2)' 'RK' 'Temperature ( C)' 'pH' 'Conductivity'  &
CONT>     'Salinity' 'DO%' 'DO mg/l' 'Total Site Depth';
SUBC>   Forward;
SUBC>   AEnter 0.05;
SUBC>   Best 0;
SUBC>   Steps 8;
SUBC>   Constant;
SUBC>   Press.
```

Stepwise Regression: H(log2) versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.05


Response is H(log2) on 8 predictors, with N = 9


Step              1
Constant     -8.468

pH             1.57
T-Value        2.85
P-Value       0.025

S             0.308
R-Sq          53.71
R-Sq(adj)     47.09
PRESS       1.01452
R-Sq(pred)    29.17

More? (Yes, No, Subcommand, or Help)
```

```
SUBC> yes

No variables entered or removed

More? (Yes, No, Subcommand, or Help)

SUBC> no
MTB > Regress 'H(log2)' 8 'RK' 'Temperature ( C)' 'pH' 'Conductivity'  &
CONT>     'Salinity' 'DO%' 'DO mg/l' 'Total Site Depth';
SUBC>   Constant;
SUBC>   Brief 2.
```

Regression Analysis: H(log2) versus RK, Temperature (C), ...

```
The regression equation is
H(log2) = 30.2 + 0.509 RK - 1.46 Temperature ( C) + 0.791 pH
          + 0.00121 Conductivity - 1.70 Salinity + 0.631 DO% - 9.08 DO mg/l
          - 0.232 Total Site Depth


                               SE
Predictor              Coef  Coef  T  P
Constant            30.2319     *  *  *
RK                 0.508964     *  *  *
Temperature ( C)   -1.45706     *  *  *
pH                 0.791383     *  *  *
Conductivity     0.00120802     *  *  *
Salinity           -1.69803     *  *  *
DO%                0.630525     *  *  *
DO mg/l            -9.07628     *  *  *
Total Site Depth  -0.231888     *  *  *


S = *


Analysis of Variance

Source          DF        SS        MS  F  P
Regression       8  1.432357  0.179045  *  *
Residual Error   0         *         *
Total            8  1.432357


Source            DF    Seq SS
RK                 1  0.734099
Temperature ( C)   1  0.391042
pH                 1  0.029316
Conductivity       1  0.028310
Salinity           1  0.010424
DO%                1  0.009931
DO mg/l            1  0.211068
Total Site Depth   1  0.018167

MTB > Save  "V:\7180-SWFWMD Tampa\DLE\08-7180-02-Cotee and Homosassa
River\WorkFile\Cotee River\MINITAB\Cotee R Data for Linear Regression.MTW";
SUBC>    Replace.
Saving file as: 'V:\7180-SWFWMD Tampa\DLE\08-7180-02-Cotee and Homosassa
River\WorkFile\Cotee River\MINITAB\Cotee R Data for Linear Regression.MTW'
Existing file replaced.
MTB > Stepwise 'N_Ind_m2' 'RK' 'Temperature ( C)' 'pH' 'Conductivity'  &
CONT>     'Salinity' 'DO%' 'DO mg/l' 'Total Site Depth';
SUBC>   Forward;
```

```
SUBC>   AEnter 0.05;
SUBC>   Best 0;
SUBC>   Steps 8;
SUBC>   Constant;
SUBC>   Press.
```

Stepwise Regression: N_Ind_m2 versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.05


Response is N_Ind_m2 on 8 predictors, with N = 9


No variables entered or removed

More? (Yes, No, Subcommand, or Help)

SUBC> yes

No variables entered or removed

More? (Yes, No, Subcommand, or Help)

SUBC> no
MTB > Stepwise 'N_Ind_m2' 'RK' 'Temperature ( C)' 'pH' 'Conductivity'  &
CONT>     'Salinity' 'DO%' 'DO mg/l' 'Total Site Depth';
SUBC>   Forward;
SUBC>   AEnter 0.05;
SUBC>   Best 0;
SUBC>   Steps 8;
SUBC>   Constant;
SUBC>   Press.
```

Stepwise Regression: N_Ind_m2 versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.25


Response is N_Ind_m2 on 8 predictors, with N = 9


Step                      1
Constant            -214178

Temperature ( C)       9849
T-Value                1.76
P-Value               0.122

S                     26630
R-Sq                  30.59
R-Sq(adj)             20.67
PRESS            7417976907
R-Sq(pred)             0.00

Best alternatives:

Variable                DO%
T-Value                1.55
P-Value               0.166
```

Regression Analysis: N_Ind_m2 versus RK, Temperature (C), ...

```
The regression equation is
N_Ind_m2 = - 9966420 - 20853 RK + 242850 Temperature ( C) + 661989 pH
           - 156 Conductivity + 221103 Salinity - 41575 DO% + 342338 DO mg/l
           - 86786 Total Site Depth


                              SE
Predictor             Coef  Coef  T  P
Constant          -9966420     *  *  *
RK                -20853.3     *  *  *
Temperature ( C)    242850     *  *  *
pH                  661989     *  *  *
Conductivity      -155.582     *  *  *
Salinity            221103     *  *  *
DO%               -41575.2     *  *  *
DO mg/l             342338     *  *  *
Total Site Depth  -86786.0     *  *  *


S = *


Analysis of Variance

Source          DF          SS         MS  F  P
Regression       8  7151378532  893922317  *  *
Residual Error   0           *          *
Total            8  7151378532


Source            DF      Seq SS
RK                 1   770684731
Temperature ( C)   1  1519142094
pH                 1   350733606
Conductivity       1   304936783
Salinity           1  1492184628
DO%                1    76911491
DO mg/l            1    92100402
Total Site Depth   1  2544684796
```

Stepwise Regression: Taxa versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.25


Response is Taxa on 8 predictors, with N = 9


Step               1
Constant      -568.0

pH                81
T-Value         6.13
P-Value        0.000

S               7.35
R-Sq           84.29
R-Sq(adj)      82.04
```

```
PRESS          671.712
R-Sq(pred)       72.11

Best alternatives:

Variable            RK
T-Value          -5.50
P-Value          0.001
```

Stepwise Regression: H(log2) versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.25


Response is H(log2) on 8 predictors, with N = 9


Step                 1
Constant        -8.468

pH                1.57
T-Value           2.85
P-Value          0.025

S                0.308
R-Sq             53.71
R-Sq(adj)        47.09
PRESS          1.01452
R-Sq(pred)       29.17

Best alternatives:

Variable            RK
T-Value          -2.71
P-Value          0.030


Step                 2
Constant        -12.54

pH                2.26
T-Value           4.46
P-Value          0.004

DO mg/l          -0.36
T-Value          -2.44
P-Value          0.050

S                0.235
R-Sq             76.79
R-Sq(adj)        69.06
PRESS         0.720441
R-Sq(pred)       49.70

Best alternatives:

Variable           DO%
T-Value          -1.97
P-Value          0.097


Step                 3
```

```
Constant       -8.381

pH               1.80
T-Value          3.39
P-Value         0.019

DO mg/l         -1.61
T-Value         -2.06
P-Value         0.094

DO%             0.071
T-Value          1.62
P-Value         0.166

S               0.209
R-Sq            84.78
R-Sq(adj)       75.66
PRESS        0.473920
R-Sq(pred)      66.91

Best alternatives:

Variable           RK
T-Value         -1.48
P-Value         0.198


Step                            4
Constant                   -1.038

pH                           0.98
T-Value                      1.91
P-Value                     0.128

DO mg/l                     -2.86
T-Value                     -3.71
P-Value                     0.021

DO%                         0.145
T-Value                      3.27
P-Value                     0.031

Total Site Depth            -0.32
T-Value                     -2.38
P-Value                     0.076

S                           0.150
R-Sq                        93.69
R-Sq(adj)                   87.38
PRESS                    0.458134
R-Sq(pred)                  68.02

Best alternatives:

Variable          Temperature ( C)
T-Value                     -1.49
P-Value                     0.211


Step                        5
Constant               -10.55

pH                       2.28
```

```
T-Value                   2.65
P-Value                  0.077

DO mg/l                   -5.1
T-Value                  -3.55
P-Value                  0.038

DO%                      0.280
T-Value                   3.25
P-Value                  0.047

Total Site Depth         -0.46
T-Value                  -3.36
P-Value                  0.044

RK                       0.139
T-Value                   1.73
P-Value                  0.182

S                        0.123
R-Sq                     96.84
R-Sq(adj)                91.57
PRESS                 0.366901
R-Sq(pred)               74.38

Best alternatives:

Variable          Conductivity
T-Value                  -1.55
P-Value                  0.220


Step                         6
Constant                 6.224

pH                         0.8
T-Value                   0.71
P-Value                  0.552

DO mg/l                   -6.2
T-Value                  -4.64
P-Value                  0.043

DO%                      0.381
T-Value                   4.13
P-Value                  0.054

Total Site Depth         -0.41
T-Value                  -3.54
P-Value                  0.072

RK                       0.139
T-Value                   2.15
P-Value                  0.164

Temperature ( C)         -0.25
T-Value                  -1.64
P-Value                  0.243

S                       0.0983
R-Sq                     98.65
R-Sq(adj)                94.61
PRESS                 0.554800
```

```
R-Sq(pred)               61.27

Best alternatives:

Variable          Conductivity
T-Value                  -0.33
P-Value                  0.776
```

Stepwise Regression: Taxa versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.25


Response is Taxa on 8 predictors, with N = 9


Step                1
Constant       -568.0

pH                 81
T-Value          6.13
P-Value         0.000

S                7.35
R-Sq            84.29
R-Sq(adj)       82.04
PRESS         671.712
R-Sq(pred)      72.11

Best alternatives:

Variable           RK
T-Value         -5.50
P-Value         0.001
```

Stepwise Regression: H(log2) versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.25


Response is H(log2) on 8 predictors, with N = 9


Step                1
Constant       -8.468

pH               1.57
T-Value          2.85
P-Value         0.025

S               0.308
R-Sq            53.71
R-Sq(adj)       47.09
PRESS         1.01452
R-Sq(pred)      29.17

Best alternatives:
```

```
Variable            RK
T-Value          -2.71
P-Value          0.030


Step                 2
Constant        -12.54

pH                2.26
T-Value           4.46
P-Value          0.004

DO mg/l          -0.36
T-Value          -2.44
P-Value          0.050

S                0.235
R-Sq             76.79
R-Sq(adj)        69.06
PRESS         0.720441
R-Sq(pred)       49.70

Best alternatives:

Variable           DO%
T-Value          -1.97
P-Value          0.097


Step                 3
Constant        -8.381

pH                1.80
T-Value           3.39
P-Value          0.019

DO mg/l          -1.61
T-Value          -2.06
P-Value          0.094

DO%              0.071
T-Value           1.62
P-Value          0.166

S                0.209
R-Sq             84.78
R-Sq(adj)        75.66
PRESS         0.473920
R-Sq(pred)       66.91

Best alternatives:

Variable            RK
T-Value          -1.48
P-Value          0.198


Step                             4
Constant                    -1.038

pH                            0.98
T-Value                       1.91
P-Value                      0.128
```

```
DO mg/l                      -2.86
T-Value                      -3.71
P-Value                      0.021

DO%                          0.145
T-Value                       3.27
P-Value                      0.031

Total Site Depth             -0.32
T-Value                      -2.38
P-Value                      0.076

S                            0.150
R-Sq                         93.69
R-Sq(adj)                    87.38
PRESS                     0.458134
R-Sq(pred)                   68.02

Best alternatives:

Variable          Temperature ( C)
T-Value                      -1.49
P-Value                      0.211


Step                         5
Constant                -10.55

pH                        2.28
T-Value                   2.65
P-Value                  0.077

DO mg/l                   -5.1
T-Value                  -3.55
P-Value                  0.038

DO%                      0.280
T-Value                   3.25
P-Value                  0.047

Total Site Depth         -0.46
T-Value                  -3.36
P-Value                  0.044

RK                       0.139
T-Value                   1.73
P-Value                  0.182

S                        0.123
R-Sq                     96.84
R-Sq(adj)                91.57
PRESS                 0.366901
R-Sq(pred)               74.38

Best alternatives:

Variable          Conductivity
T-Value                  -1.55
P-Value                  0.220


Step                         6
```

```
Constant                 6.224

pH                         0.8
T-Value                   0.71
P-Value                  0.552

DO mg/l                   -6.2
T-Value                  -4.64
P-Value                  0.043

DO%                      0.381
T-Value                   4.13
P-Value                  0.054

Total Site Depth         -0.41
T-Value                  -3.54
P-Value                  0.072

RK                       0.139
T-Value                   2.15
P-Value                  0.164

Temperature ( C)         -0.25
T-Value                  -1.64
P-Value                  0.243

S                       0.0983
R-Sq                     98.65
R-Sq(adj)                94.61
PRESS                 0.554800
R-Sq(pred)               61.27

Best alternatives:

Variable          Conductivity
T-Value                  -0.33
P-Value                  0.776
```

Stepwise Regression: Taxa versus RK, Salinity, DO mg/l, Total Site Depth

```
Forward selection.  Alpha-to-Enter: 0.25


Response is Taxa on 4 predictors, with N = 9


Step                1
Constant        64.50

RK              -4.00
T-Value         -5.50
P-Value         0.001

S                8.04
R-Sq            81.19
R-Sq(adj)       78.51
Mallows Cp        1.6
PRESS         768.156
R-Sq(pred)      68.10

Best alternatives:
```

```
Variable     Salinity
T-Value          3.49
P-Value         0.010


Step                2
Constant        90.13

RK              -4.71
T-Value         -5.35
P-Value         0.002

DO mg/l          -6.7
T-Value         -1.31
P-Value         0.238

S                7.66
R-Sq            85.38
R-Sq(adj)       80.50
Mallows Cp        2.1
PRESS         730.173
R-Sq(pred)      69.68

Best alternatives:

Variable     Salinity
T-Value         -1.31
P-Value         0.239
```

Stepwise Regression: Taxa versus RK

```
Forward selection.  Alpha-to-Enter: 0.25


Response is Taxa on 1 predictors, with N = 9


Step              1
Constant      64.50

RK            -4.00
T-Value       -5.50
P-Value       0.001

S              8.04
R-Sq          81.19
R-Sq(adj)     78.51
Mallows Cp      2.0
PRESS       768.156
R-Sq(pred)    68.10
```

Regression Analysis: Taxa versus RK

```
The regression equation is
Taxa = 64.5 - 4.00 RK


Predictor     Coef  SE Coef      T      P
Constant    64.503    5.271  12.24  0.000
RK         -3.9952   0.7267  -5.50  0.001
```

```
S = 8.04343   R-Sq = 81.2%   R-Sq(adj) = 78.5%


Analysis of Variance

Source          DF      SS      MS      F      P
Regression       1  1955.3  1955.3  30.22  0.001
Residual Error   7   452.9    64.7
Total            8  2408.2


Unusual Observations

Obs   RK   Taxa    Fit  SE Fit  Residual  St Resid
  2  2.0  71.00  56.51    4.09     14.49      2.09R

R denotes an observation with a large standardized residual.
```

Stepwise Regression: H(log2) versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.25


Response is H(log2) on 8 predictors, with N = 9


Step                1
Constant       -8.468

pH               1.57
T-Value          2.85
P-Value         0.025

S               0.308
R-Sq            53.71
R-Sq(adj)       47.09
PRESS         1.01452
R-Sq(pred)      29.17

Best alternatives:

Variable           RK
T-Value         -2.71
P-Value         0.030


Step                2
Constant       -12.54

pH               2.26
T-Value          4.46
P-Value         0.004

DO mg/l         -0.36
T-Value         -2.44
P-Value         0.050

S               0.235
R-Sq            76.79
R-Sq(adj)       69.06
```

```
PRESS        0.720441
R-Sq(pred)      49.70

Best alternatives:

Variable          DO%
T-Value         -1.97
P-Value         0.097


Step                3
Constant       -8.381

pH               1.80
T-Value          3.39
P-Value         0.019

DO mg/l         -1.61
T-Value         -2.06
P-Value         0.094

DO%             0.071
T-Value          1.62
P-Value         0.166

S               0.209
R-Sq            84.78
R-Sq(adj)       75.66
PRESS        0.473920
R-Sq(pred)      66.91

Best alternatives:

Variable           RK
T-Value         -1.48
P-Value         0.198


Step                             4
Constant                    -1.038

pH                            0.98
T-Value                       1.91
P-Value                      0.128

DO mg/l                      -2.86
T-Value                      -3.71
P-Value                      0.021

DO%                          0.145
T-Value                       3.27
P-Value                      0.031

Total Site Depth             -0.32
T-Value                      -2.38
P-Value                      0.076

S                            0.150
R-Sq                         93.69
R-Sq(adj)                    87.38
PRESS                     0.458134
R-Sq(pred)                   68.02
```

```
Best alternatives:

Variable          Temperature ( C)
T-Value                      -1.49
P-Value                      0.211


Step                             5
Constant                    -10.55

pH                            2.28
T-Value                       2.65
P-Value                      0.077

DO mg/l                       -5.1
T-Value                      -3.55
P-Value                      0.038

DO%                          0.280
T-Value                       3.25
P-Value                      0.047

Total Site Depth             -0.46
T-Value                      -3.36
P-Value                      0.044

RK                           0.139
T-Value                       1.73
P-Value                      0.182

S                            0.123
R-Sq                         96.84
R-Sq(adj)                    91.57
PRESS                     0.366901
R-Sq(pred)                   74.38

Best alternatives:

Variable          Conductivity
T-Value                      -1.55
P-Value                      0.220


Step                             6
Constant                     6.224

pH                             0.8
T-Value                       0.71
P-Value                      0.552

DO mg/l                       -6.2
T-Value                      -4.64
P-Value                      0.043

DO%                          0.381
T-Value                       4.13
P-Value                      0.054

Total Site Depth             -0.41
T-Value                      -3.54
P-Value                      0.072

RK                           0.139
```

```
T-Value                  2.15
P-Value                 0.164

Temperature ( C)        -0.25
T-Value                 -1.64
P-Value                 0.243

S                      0.0983
R-Sq                    98.65
R-Sq(adj)               94.61
PRESS                0.554800
R-Sq(pred)              61.27

Best alternatives:

Variable          Conductivity
T-Value                  -0.33
P-Value                  0.776
```

Regression Analysis: H(log2) versus DO mg/l

```
The regression equation is
H(log2) = 3.34 + 0.007 DO mg/l


Predictor    Coef  SE Coef     T      P
Constant   3.3392   0.7667  4.36  0.003
DO mg/l    0.0067   0.2373  0.03  0.978


S = 0.452326   R-Sq = 0.0%   R-Sq(adj) = 0.0%


Analysis of Variance

Source          DF      SS      MS     F      P
Regression       1  0.0002  0.0002  0.00  0.978
Residual Error   7  1.4322  0.2046
Total            8  1.4324
```

Stepwise Regression: H(log2) versus DO mg/l

```
Forward selection.  Alpha-to-Enter: 0.25


Response is H(log2) on 1 predictors, with N = 9


No variables entered or removed
```

Stepwise Regression: N_Ind_m2 versus RK, Temperature (C), ...

```
Forward selection.  Alpha-to-Enter: 0.25


Response is N_Ind_m2 on 8 predictors, with N = 9


Step                       1
```

```
Constant              -214178

Temperature ( C)         9849
T-Value                  1.76
P-Value                 0.122

S                       26630
R-Sq                    30.59
R-Sq(adj)               20.67
PRESS              7417976907
R-Sq(pred)               0.00

Best alternatives:

Variable                  DO%
T-Value                  1.55
P-Value                 0.166
```

Macroinvertebrate Metrics and Physicochemical Data Significant Differences

Nested ANOVA

Nested ANOVA: Taxa versus Site

```
Analysis of Variance for Taxa

Source  DF      SS      MS      F      P
Site     8  4.1563  0.5195  5.675  0.001
Error   18  1.6480  0.0916
Total   26  5.8042


Variance Components

                    % of
Source  Var Comp.  Total  StDev
Site        0.143  60.91  0.378
Error       0.092  39.09  0.303
Total       0.234         0.484


Expected Mean Squares

1  Site     1.00(2) +  3.00(1)
2  Error    1.00(2)
```

Nested ANOVA: Abundance versus Site

```
Analysis of Variance for Abundance

Source  DF       SS      MS      F      P
Site     8   8.4153  1.0519  3.112  0.022
Error   18   6.0851  0.3381
Total   26  14.5004


Variance Components

                    % of
Source  Var Comp.  Total  StDev
Site        0.238  41.31  0.488
Error       0.338  58.69  0.581
Total       0.576         0.759


Expected Mean Squares

1  Site     1.00(2) +  3.00(1)
2  Error    1.00(2)
```

Nested ANOVA: Margalefs d versus Site

```
Analysis of Variance for Margalefs d
```

```
Source  DF      SS      MS      F      P
Site     8  4.4036  0.5505  5.986  0.001
Error   18  1.6551  0.0920
Total   26  6.0588


Variance Components

                    % of
Source  Var Comp.  Total  StDev
Site        0.153  62.44  0.391
Error       0.092  37.56  0.303
Total       0.245         0.495


Expected Mean Squares

1  Site     1.00(2) +  3.00(1)
2  Error    1.00(2)
```

Nested ANOVA: Pielous Evenness versus Site

```
Analysis of Variance for Pielous Evenness

Source  DF      SS      MS      F      P
Site     8  0.1731  0.0216  0.923  0.521
Error   18  0.4221  0.0234
Total   26  0.5952


Variance Components

Source  Var Comp.   % of Total  StDev
Site      -0.001*         0.00  0.000
Error       0.023       100.00  0.153
Total       0.023               0.153

* Value is negative, and is estimated by zero.


Expected Mean Squares

1  Site     1.00(2) +  3.00(1)
2  Error    1.00(2)
```

Nested ANOVA: Shannon Diversity versus Site

```
Analysis of Variance for Shannon Diversity

Source  DF      SS      MS      F      P
Site     8  0.6267  0.0783  2.727  0.037
Error   18  0.5171  0.0287
Total   26  1.1438


Variance Components

                    % of
Source  Var Comp.  Total  StDev
```

```
Site        0.017  36.53  0.129
Error       0.029  63.47  0.169
Total       0.045         0.213


Expected Mean Squares

1  Site     1.00(2) +  3.00(1)
2  Error    1.00(2)
```

Nested ANOVA: Simpsons d versus Site

```
Analysis of Variance for Simpsons d

Source  DF      SS      MS      F      P
Site     8  0.1280  0.0160  0.985  0.479
Error   18  0.2924  0.0162
Total   26  0.4204


Variance Components

Source  Var Comp.   % of Total  StDev
Site       -0.000*        0.00  0.000
Error       0.016       100.00  0.127
Total       0.016               0.127

* Value is negative, and is estimated by zero.


Expected Mean Squares

1  Site     1.00(2) +  3.00(1)
2  Error    1.00(2)
```

One-way ANOVA: Taxa versus Site

```
Source  DF      SS      MS     F      P
Site     8  4.1563  0.5195  5.67  0.001
Error   18  1.6480  0.0916
Total   26  5.8042

S = 0.3026   R-Sq = 71.61%   R-Sq(adj) = 58.99%


                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level    N    Mean   StDev  --------+---------+---------+---------+-
RK-0     3  3.3782  0.0398                    (-------*------)
RK-10.5  3  2.6159  0.2714     (------*-------)
RK-11.2  3  2.7362  0.2195       (-------*------)
RK-2     3  3.7329  0.1197                           (-------*------)
RK-3.5   3  3.0415  0.0956             (-------*-------)
RK-5     3  2.8656  0.1365          (------*-------)
RK-6.5   3  2.8862  0.2548          (-------*------)
RK-8     3  2.4695  0.7691  (------*-------)
RK-9.5   3  2.5116  0.0462   (------*-------)
                            --------+---------+---------+---------+-
                                  2.50      3.00      3.50      4.00
```

```
Pooled StDev = 0.3026


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Site

Individual confidence level = 99.75%


Site = RK-0 subtracted from:

Site       Lower   Center    Upper  --------+---------+---------+---------+-
RK-10.5  -1.6288  -0.7623   0.1042      (-------*------)
RK-11.2  -1.5085  -0.6420   0.2244       (-------*------)
RK-2     -0.5118   0.3547   1.2212                (------*------)
RK-3.5   -1.2032  -0.3367   0.5298          (------*------)
RK-5     -1.3790  -0.5126   0.3539         (------*------)
RK-6.5   -1.3584  -0.4920   0.3745         (------*------)
RK-8     -1.7752  -0.9087  -0.0422     (------*-------)
RK-9.5   -1.7331  -0.8666  -0.0001      (------*------)
                                    --------+---------+---------+---------+-
                                         -1.2       0.0       1.2       2.4


Site = RK-10.5 subtracted from:

Site       Lower   Center   Upper  --------+---------+---------+---------+-
RK-11.2  -0.7462   0.1202  0.9867              (------*------)
RK-2      0.2505   1.1170  1.9835                      (------*-------)
RK-3.5   -0.4409   0.4256  1.2920                (-------*------)
RK-5     -0.6168   0.2497  1.1162               (------*------)
RK-6.5   -0.5962   0.2703  1.1368               (------*------)
RK-8     -1.0129  -0.1464  0.7201            (------*------)
RK-9.5   -0.9708  -0.1043  0.7621            (------*------)
                                   --------+---------+---------+---------+-
                                        -1.2       0.0       1.2       2.4


Site = RK-11.2 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-2     0.1303   0.9967  1.8632                     (------*-------)
RK-3.5  -0.5612   0.3053  1.1718               (-------*------)
RK-5    -0.7370   0.1295  0.9960              (------*------)
RK-6.5  -0.7164   0.1501  1.0165              (------*------)
RK-8    -1.1331  -0.2667  0.5998           (------*------)
RK-9.5  -1.0911  -0.2246  0.6419           (------*------)
                                  --------+---------+---------+---------+-
                                       -1.2       0.0       1.2       2.4


Site = RK-2 subtracted from:

Site      Lower   Center    Upper  --------+---------+---------+---------+-
RK-3.5  -1.5579  -0.6914   0.1751       (------*------)
RK-5    -1.7337  -0.8673  -0.0008      (------*------)
RK-6.5  -1.7132  -0.8467   0.0198      (------*------)
RK-8    -2.1299  -1.2634  -0.3969  (------*-------)
RK-9.5  -2.0878  -1.2213  -0.3548   (------*------)
                                   --------+---------+---------+---------+-
                                        -1.2       0.0       1.2       2.4
```

```
Site = RK-3.5 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-5    -1.0423  -0.1758  0.6906           (-------*------)
RK-6.5  -1.0217  -0.1553  0.7112           (-------*------)
RK-8    -1.4385  -0.5720  0.2945        (------*------)
RK-9.5  -1.3964  -0.5299  0.3366        (-------*------)
                                  --------+---------+---------+---------+-
                                       -1.2       0.0       1.2       2.4


Site = RK-5 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-6.5  -0.8459   0.0206  0.8871             (------*------)
RK-8    -1.2626  -0.3961  0.4703         (-------*------)
RK-9.5  -1.2205  -0.3541  0.5124          (------*------)
                                  --------+---------+---------+---------+-
                                       -1.2       0.0       1.2       2.4


Site = RK-6.5 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-8    -1.2832  -0.4167  0.4498         (-------*------)
RK-9.5  -1.2411  -0.3746  0.4918          (------*------)
                                  --------+---------+---------+---------+-
                                       -1.2       0.0       1.2       2.4


Site = RK-8 subtracted from:

Site      Lower  Center   Upper  --------+---------+---------+---------+-
RK-9.5  -0.8244  0.0421  0.9086             (------*-------)
                                 --------+---------+---------+---------+-
                                      -1.2       0.0       1.2       2.4
```

One-way ANOVA: Abundance versus Site

```
Source  DF      SS     MS     F      P
Site     8   8.415  1.052  3.11  0.022
Error   18   6.085  0.338
Total   26  14.500

S = 0.5814   R-Sq = 58.03%   R-Sq(adj) = 39.38%


                            Individual 95% CIs For Mean Based on Pooled StDev
Level    N    Mean   StDev    +---------+---------+---------+---------
RK-0     3  5.4534  1.0713           (-------*------)
RK-10.5  3  5.6181  0.6066             (------*------)
RK-11.2  3  4.7174  0.4147    (------*------)
RK-2     3  6.6335  0.3540                       (------*------)
RK-3.5   3  5.8903  0.2027                (------*------)
RK-5     3  5.2279  0.3605         (------*------)
RK-6.5   3  6.0508  0.5710                 (-------*------)
RK-8     3  6.4357  0.7997                     (------*------)
RK-9.5   3  5.7527  0.3047              (-------*------)
                              +---------+---------+---------+---------
                            4.0       5.0       6.0       7.0

Pooled StDev = 0.5814


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Site

Individual confidence level = 99.75%


Site = RK-0 subtracted from:

Site       Lower   Center   Upper  --------+---------+---------+---------+-
RK-10.5  -1.5003   0.1648  1.8298              (--------*-------)
RK-11.2  -2.4010  -0.7360  0.9290          (-------*--------)
RK-2     -0.4849   1.1801  2.8451                    (-------*-------)
RK-3.5   -1.2281   0.4369  2.1019                (-------*--------)
RK-5     -1.8905  -0.2255  1.4395             (-------*-------)
RK-6.5   -1.0676   0.5975  2.2625                 (-------*-------)
RK-8     -0.6827   0.9823  2.6473                   (-------*-------)
RK-9.5   -1.3657   0.2994  1.9644               (-------*--------)
                                   --------+---------+---------+---------+-
                                        -2.0       0.0       2.0       4.0


Site = RK-10.5 subtracted from:

Site       Lower   Center   Upper  --------+---------+---------+---------+-
RK-11.2  -2.5658  -0.9008  0.7643         (-------*--------)
RK-2     -0.6497   1.0154  2.6804                   (-------*-------)
RK-3.5   -1.3929   0.2722  1.9372               (-------*--------)
RK-5     -2.0553  -0.3903  1.2747            (-------*-------)
RK-6.5   -1.2323   0.4327  2.0977                (-------*-------)
RK-8     -0.8475   0.8175  2.4826                  (-------*-------)
RK-9.5   -1.5304   0.1346  1.7996             (--------*-------)
                                   --------+---------+---------+---------+-
                                        -2.0       0.0       2.0       4.0


Site = RK-11.2 subtracted from:
```

```
Site      Lower  Center   Upper  --------+---------+---------+---------+-
RK-2     0.2511  1.9161  3.5811                     (--------*-------)
RK-3.5  -0.4921  1.1729  2.8379                  (-------*-------)
RK-5    -1.1545  0.5105  2.1755              (--------*-------)
RK-6.5  -0.3316  1.3334  2.9985                  (--------*-------)
RK-8     0.0533  1.7183  3.3833                    (--------*-------)
RK-9.5  -0.6297  1.0354  2.7004                 (-------*--------)
                                 --------+---------+---------+---------+-
                                      -2.0       0.0       2.0       4.0


Site = RK-2 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-3.5  -2.4082  -0.7432  0.9218        (-------*--------)
RK-5    -3.0707  -1.4056  0.2594     (-------*-------)
RK-6.5  -2.2477  -0.5827  1.0823         (-------*-------)
RK-8    -1.8629  -0.1978  1.4672           (-------*-------)
RK-9.5  -2.5458  -0.8808  0.7843       (--------*-------)
                                  --------+---------+---------+---------+-
                                       -2.0       0.0       2.0       4.0


Site = RK-3.5 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-5    -2.3274  -0.6624  1.0026        (--------*-------)
RK-6.5  -1.5045   0.1605  1.8256            (--------*-------)
RK-8    -1.1196   0.5454  2.2104              (--------*-------)
RK-9.5  -1.8026  -0.1376  1.5275           (-------*--------)
                                  --------+---------+---------+---------+-
                                       -2.0       0.0       2.0       4.0


Site = RK-5 subtracted from:

Site      Lower  Center   Upper  --------+---------+---------+---------+-
RK-6.5  -0.8421  0.8230  2.4880                (-------*-------)
RK-8    -0.4572  1.2078  2.8728                  (-------*-------)
RK-9.5  -1.1401  0.5249  2.1899              (--------*-------)
                                 --------+---------+---------+---------+-
                                      -2.0       0.0       2.0       4.0


Site = RK-6.5 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-8    -1.2802   0.3848  2.0499              (-------*-------)
RK-9.5  -1.9631  -0.2981  1.3669          (--------*-------)
                                  --------+---------+---------+---------+-
                                       -2.0       0.0       2.0       4.0


Site = RK-8 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-9.5  -2.3479  -0.6829  0.9821        (--------*-------)
                                  --------+---------+---------+---------+-
                                       -2.0       0.0       2.0       4.0
```

One-way ANOVA: Margalefs d versus Site

```
Source  DF      SS      MS     F      P
Site     8  4.4036  0.5505  5.99  0.001
Error   18  1.6551  0.0920
Total   26  6.0588

S = 0.3032   R-Sq = 72.68%   R-Sq(adj) = 60.54%


                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level    N    Mean   StDev  --------+---------+---------+---------+-
RK-0     3  1.6594  0.1655                      (-----*-----)
RK-10.5  3  0.8158  0.1892       (------*-----)
RK-11.2  3  1.1192  0.2258             (-----*-----)
RK-2     3  1.8174  0.1748                        (-----*-----)
RK-3.5   3  1.2195  0.1144              (-----*-----)
RK-5     3  1.1542  0.0748             (-----*-----)
RK-6.5   3  1.0302  0.3259           (-----*-----)
RK-8     3  0.5000  0.7424  (-----*-----)
RK-9.5   3  0.6781  0.0823     (-----*-----)
                            --------+---------+---------+---------+-
                                  0.60      1.20      1.80      2.40

Pooled StDev = 0.3032


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Site

Individual confidence level = 99.75%


Site = RK-0 subtracted from:

Site       Lower   Center    Upper  --------+---------+---------+---------+-
RK-10.5  -1.7120  -0.8436   0.0247      (------*------)
RK-11.2  -1.4086  -0.5403   0.3281        (------*-------)
RK-2     -0.7104   0.1580   1.0263              (------*-------)
RK-3.5   -1.3083  -0.4400   0.4284         (------*-------)
RK-5     -1.3736  -0.5052   0.3631         (------*------)
RK-6.5   -1.4976  -0.6292   0.2391        (------*------)
RK-8     -2.0278  -1.1595  -0.2911   (------*-------)
RK-9.5   -1.8497  -0.9813  -0.1129     (------*------)
                                    --------+---------+---------+---------+-
                                         -1.2       0.0       1.2       2.4


Site = RK-10.5 subtracted from:

Site       Lower   Center   Upper  --------+---------+---------+---------+-
RK-11.2  -0.5650   0.3034  1.1717               (-------*------)
RK-2      0.1332   1.0016  1.8700                     (------*-------)
RK-3.5   -0.4647   0.4037  1.2720                (------*-------)
RK-5     -0.5299   0.3384  1.2068                (------*------)
RK-6.5   -0.6539   0.2144  1.0828               (------*------)
RK-8     -1.1842  -0.3158  0.5525          (------*-------)
RK-9.5   -1.0060  -0.1377  0.7307            (------*------)
                                   --------+---------+---------+---------+-
                                        -1.2       0.0       1.2       2.4
```

```
Site = RK-11.2 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-2    -0.1701   0.6982  1.5666                   (------*------)
RK-3.5  -0.7681   0.1003  0.9687              (------*------)
RK-5    -0.8333   0.0350  0.9034             (------*-------)
RK-6.5  -0.9573  -0.0890  0.7794            (------*------)
RK-8    -1.4876  -0.6192  0.2492        (------*------)
RK-9.5  -1.3094  -0.4410  0.4273         (------*-------)
                                  --------+---------+---------+---------+-
                                       -1.2       0.0       1.2       2.4


Site = RK-2 subtracted from:

Site      Lower   Center    Upper  --------+---------+---------+---------+-
RK-3.5  -1.4663  -0.5979   0.2704        (------*------)
RK-5    -1.5315  -0.6632   0.2052       (------*-------)
RK-6.5  -1.6556  -0.7872   0.0812      (------*-------)
RK-8    -2.1858  -1.3174  -0.4491  (------*------)
RK-9.5  -2.0076  -1.1393  -0.2709   (-------*------)
                                   --------+---------+---------+---------+-
                                        -1.2       0.0       1.2       2.4


Site = RK-3.5 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-5    -0.9336  -0.0652  0.8031            (------*-------)
RK-6.5  -1.0576  -0.1893  0.6791           (------*-------)
RK-8    -1.5879  -0.7195  0.1489       (------*------)
RK-9.5  -1.4097  -0.5413  0.3270        (------*-------)
                                  --------+---------+---------+---------+-
                                       -1.2       0.0       1.2       2.4


Site = RK-5 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-6.5  -0.9924  -0.1240  0.7444            (------*------)
RK-8    -1.5226  -0.6542  0.2141       (-------*------)
RK-9.5  -1.3444  -0.4761  0.3923         (------*------)
                                  --------+---------+---------+---------+-
                                       -1.2       0.0       1.2       2.4


Site = RK-6.5 subtracted from:

Site      Lower   Center   Upper  --------+---------+---------+---------+-
RK-8    -1.3986  -0.5302  0.3381        (-------*------)
RK-9.5  -1.2204  -0.3521  0.5163          (------*------)
                                  --------+---------+---------+---------+-
                                       -1.2       0.0       1.2       2.4


Site = RK-8 subtracted from:

Site      Lower  Center   Upper  --------+---------+---------+---------+-
RK-9.5  -0.6902  0.1782  1.0465              (------*-------)
                                 --------+---------+---------+---------+-
                                      -1.2       0.0       1.2       2.4
```

One-way ANOVA: Shannon Diversity versus Site

```
Source  DF      SS      MS     F      P
Site     8  0.6267  0.0783  2.73  0.037
Error   18  0.5171  0.0287
Total   26  1.1438

S = 0.1695   R-Sq = 54.79%   R-Sq(adj) = 34.70%


                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level    N    Mean   StDev  ------+---------+---------+---------+---
RK-0     3  1.2814  0.1995                      (-------*-------)
RK-10.5  3  1.0998  0.0692               (-------*-------)
RK-11.2  3  1.0155  0.2412           (--------*-------)
RK-2     3  1.2508  0.2129                     (-------*-------)
RK-3.5   3  1.0404  0.2057            (--------*-------)
RK-5     3  0.9681  0.0770         (--------*-------)
RK-6.5   3  0.9273  0.0155        (-------*-------)
RK-8     3  0.7987  0.2452   (-------*-------)
RK-9.5   3  0.8756  0.0432      (-------*-------)
                            ------+---------+---------+---------+---
                                0.75      1.00      1.25      1.50

Pooled StDev = 0.1695


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Site

Individual confidence level = 99.75%


Site = RK-0 subtracted from:

Site       Lower   Center   Upper  ---------+---------+---------+---------+
RK-10.5  -0.6670  -0.1816  0.3037         (--------*---------)
RK-11.2  -0.7513  -0.2659  0.2194       (---------*--------)
RK-2     -0.5160  -0.0306  0.4548            (--------*---------)
RK-3.5   -0.7264  -0.2410  0.2444       (---------*---------)
RK-5     -0.7988  -0.3134  0.1720      (---------*--------)
RK-6.5   -0.8395  -0.3541  0.1312     (---------*---------)
RK-8     -0.9681  -0.4828  0.0026   (--------*---------)
RK-9.5   -0.8912  -0.4058  0.0796    (---------*---------)
                                   ---------+---------+---------+---------+
                                         -0.50      0.00      0.50      1.00


Site = RK-10.5 subtracted from:

Site       Lower   Center   Upper  ---------+---------+---------+---------+
RK-11.2  -0.5696  -0.0843  0.4011           (--------*---------)
RK-2     -0.3343   0.1510  0.6364               (---------*---------)
RK-3.5   -0.5447  -0.0594  0.4260           (---------*---------)
RK-5     -0.6171  -0.1317  0.3536          (--------*---------)
RK-6.5   -0.6579  -0.1725  0.3129         (---------*--------)
RK-8     -0.7865  -0.3011  0.1843      (---------*---------)
RK-9.5   -0.7095  -0.2242  0.2612        (---------*--------)
                                   ---------+---------+---------+---------+
                                         -0.50      0.00      0.50      1.00
```

```
Site = RK-11.2 subtracted from:

Site      Lower   Center   Upper  ---------+---------+---------+---------+
RK-2    -0.2501   0.2353  0.7207                (---------*--------)
RK-3.5  -0.4605   0.0249  0.5103            (--------*---------)
RK-5    -0.5328  -0.0475  0.4379          (---------*---------)
RK-6.5  -0.5736  -0.0882  0.3972          (--------*---------)
RK-8    -0.7022  -0.2168  0.2685       (---------*--------)
RK-9.5  -0.6253  -0.1399  0.3455        (---------*---------)
                                  ---------+---------+---------+---------+
                                        -0.50      0.00      0.50      1.00


Site = RK-2 subtracted from:

Site      Lower   Center   Upper  ---------+---------+---------+---------+
RK-3.5  -0.6958  -0.2104  0.2750       (---------*--------)
RK-5    -0.7681  -0.2828  0.2026      (--------*---------)
RK-6.5  -0.8089  -0.3235  0.1618     (---------*--------)
RK-8    -0.9375  -0.4522  0.0332  (---------*---------)
RK-9.5  -0.8606  -0.3752  0.1102    (--------*---------)
                                  ---------+---------+---------+---------+
                                        -0.50      0.00      0.50      1.00


Site = RK-3.5 subtracted from:

Site      Lower   Center   Upper  ---------+---------+---------+---------+
RK-5    -0.5577  -0.0724  0.4130          (---------*--------)
RK-6.5  -0.5985  -0.1131  0.3723         (---------*--------)
RK-8    -0.7271  -0.2417  0.2436      (---------*---------)
RK-9.5  -0.6502  -0.1648  0.3206        (---------*--------)
                                  ---------+---------+---------+---------+
                                        -0.50      0.00      0.50      1.00


Site = RK-5 subtracted from:

Site      Lower   Center   Upper  ---------+---------+---------+---------+
RK-6.5  -0.5261  -0.0407  0.4446          (---------*---------)
RK-8    -0.6548  -0.1694  0.3160        (---------*--------)
RK-9.5  -0.5778  -0.0924  0.3929         (---------*---------)
                                  ---------+---------+---------+---------+
                                        -0.50      0.00      0.50      1.00


Site = RK-6.5 subtracted from:

Site      Lower   Center   Upper  ---------+---------+---------+---------+
RK-8    -0.6140  -0.1286  0.3567         (--------*---------)
RK-9.5  -0.5370  -0.0517  0.4337          (---------*---------)
                                  ---------+---------+---------+---------+
                                        -0.50      0.00      0.50      1.00


Site = RK-8 subtracted from:

Site      Lower  Center   Upper  ---------+---------+---------+---------+
RK-9.5  -0.4084  0.0770  0.5623             (---------*--------)
                                 ---------+---------+---------+---------+
                                       -0.50      0.00      0.50      1.00
```

Nested ANOVA: Depth of Collection versus Station

```
Analysis of Variance for Depth of Collection

Source   DF      SS      MS
Station   8  1.0922  0.1365
Error    19  7.9318  0.4175
Total    27  9.0240


Variance Components

Source   Var Comp.   % of Total  StDev
Station     -0.091*        0.00  0.000
Error        0.417       100.00  0.646
Total        0.417               0.646

* Value is negative, and is estimated by zero.


Expected Mean Squares

1  Station    1.00(2) +  3.09(1)
2  Error      1.00(2)
```

Nested ANOVA: Temperature versus Station

```
Analysis of Variance for Temperature

Source   DF      SS      MS
Station   8  0.0894  0.0112
Error    19  0.0030  0.0002
Total    27  0.0924


Variance Components

                    % of
Source   Var Comp.  Total  StDev
Station      0.004  95.70  0.060
Error        0.000   4.30  0.013
Total        0.004         0.061


Expected Mean Squares

1  Station    1.00(2) +  3.09(1)
2  Error      1.00(2)
```

Nested ANOVA: pH versus Station

```
Analysis of Variance for pH

Source   DF      SS      MS
Station   8  0.0148  0.0018
Error    19  0.0005  0.0000
Total    27  0.0152


Variance Components
```

```
                    % of
Source   Var Comp.  Total  StDev
Station      0.001  95.82  0.024
Error        0.000   4.18  0.005
Total        0.001         0.025


Expected Mean Squares

1  Station    1.00(2) +  3.09(1)
2  Error      1.00(2)
```

Nested ANOVA: Salinity versus Station

```
Analysis of Variance for Salinity

Source   DF       SS      MS
Station   8  38.3751  4.7969
Error    19   0.7702  0.0405
Total    27  39.1453


Variance Components

                    % of
Source   Var Comp.  Total  StDev
Station      1.540  97.43  1.241
Error        0.041   2.57  0.201
Total        1.580         1.257


Expected Mean Squares

1  Station    1.00(2) +  3.09(1)
2  Error      1.00(2)
```

Nested ANOVA: DO_mg/l versus Station

```
Analysis of Variance for DO_mg/l

Source   DF      SS      MS
Station   8  1.6538  0.2067
Error    19  0.4442  0.0234
Total    27  2.0980


Variance Components

                    % of
Source   Var Comp.  Total  StDev
Station      0.059  71.74  0.244
Error        0.023  28.26  0.153
Total        0.083         0.288


Expected Mean Squares

1  Station    1.00(2) +  3.09(1)
2  Error      1.00(2)
```

One-way ANOVA: Depth of Collection versus Station

```
Source   DF     SS     MS     F      P
Station   8  1.092  0.137  0.33  0.945
Error    19  7.932  0.417
Total    27  9.024

S = 0.6461   R-Sq = 12.10%   R-Sq(adj) = 0.00%


                             Individual 95% CIs For Mean Based on
                             Pooled StDev
Level    N     Mean   StDev  --+---------+---------+---------+-------
RK 0.0   2  -0.2554  0.6190     (---------------*---------------)
RK 10.5  4   0.2291  0.7281                  (----------*----------)
RK 11.2  2  -0.3466  0.4901   (---------------*---------------)
RK 2.0   3  -0.0959  0.5555          (------------*------------)
RK 3.5   3  -0.0959  0.5555          (------------*------------)
RK 5.0   4   0.2291  0.7281                  (----------*----------)
RK 6.5   4   0.2291  0.7281                  (----------*----------)
RK 8.0   3  -0.0744  0.5851           (------------*------------)
RK 9.5   3  -0.0959  0.5555          (------------*------------)
                             --+---------+---------+---------+-------
                             -1.20     -0.60      0.00      0.60

Pooled StDev = 0.6461


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Station

Individual confidence level = 99.75%


Station = RK 0.0 subtracted from:

Station    Lower   Center   Upper  -------+---------+---------+---------+--
RK 10.5  -1.4622   0.4845  2.4311         (------------*------------)
RK 11.2  -2.3390  -0.0912  2.1566   (--------------*--------------)
RK 2.0   -1.8924   0.1595  2.2115      (-------------*-------------)
RK 3.5   -1.8924   0.1595  2.2115      (-------------*-------------)
RK 5.0   -1.4622   0.4845  2.4311         (------------*------------)
RK 6.5   -1.4622   0.4845  2.4311         (------------*------------)
RK 8.0   -1.8709   0.1810  2.2330       (------------*-------------)
RK 9.5   -1.8924   0.1595  2.2115      (-------------*-------------)
                                   -------+---------+---------+---------+--
                                       -1.5       0.0       1.5       3.0


Station = RK 10.5 subtracted from:

Station    Lower   Center   Upper  -------+---------+---------+---------+--
RK 11.2  -2.5223  -0.5756  1.3710  (------------*------------)
RK 2.0   -2.0418  -0.3250  1.3918     (-----------*----------)
RK 3.5   -2.0418  -0.3250  1.3918     (-----------*----------)
RK 5.0   -1.5894   0.0000  1.5894        (----------*----------)
RK 6.5   -1.5894   0.0000  1.5894        (----------*----------)
RK 8.0   -2.0202  -0.3035  1.4133      (----------*----------)
RK 9.5   -2.0418  -0.3250  1.3918     (-----------*----------)
                                   -------+---------+---------+---------+--
                                       -1.5       0.0       1.5       3.0
```

```
Station = RK 11.2 subtracted from:

Station    Lower  Center   Upper  -------+---------+---------+---------+--
RK 2.0   -1.8013  0.2507  2.3026       (-------------*------------)
RK 3.5   -1.8013  0.2507  2.3026       (-------------*------------)
RK 5.0   -1.3710  0.5756  2.5223          (------------*------------)
RK 6.5   -1.3710  0.5756  2.5223          (------------*------------)
RK 8.0   -1.7798  0.2722  2.3242       (-------------*------------)
RK 9.5   -1.8013  0.2507  2.3026       (-------------*------------)
                                  -------+---------+---------+---------+--
                                      -1.5       0.0       1.5       3.0


Station = RK 2.0 subtracted from:

Station    Lower  Center   Upper  -------+---------+---------+---------+--
RK 3.5   -1.8353  0.0000  1.8353       (-----------*-----------)
RK 5.0   -1.3918  0.3250  2.0418          (----------*-----------)
RK 6.5   -1.3918  0.3250  2.0418          (----------*-----------)
RK 8.0   -1.8138  0.0215  1.8568       (-----------*-----------)
RK 9.5   -1.8353  0.0000  1.8353       (-----------*-----------)
                                  -------+---------+---------+---------+--
                                      -1.5       0.0       1.5       3.0


Station = RK 3.5 subtracted from:

Station    Lower  Center   Upper  -------+---------+---------+---------+--
RK 5.0   -1.3918  0.3250  2.0418          (----------*-----------)
RK 6.5   -1.3918  0.3250  2.0418          (----------*-----------)
RK 8.0   -1.8138  0.0215  1.8568       (-----------*-----------)
RK 9.5   -1.8353  0.0000  1.8353       (-----------*-----------)
                                  -------+---------+---------+---------+--
                                      -1.5       0.0       1.5       3.0


Station = RK 5.0 subtracted from:

Station    Lower   Center   Upper  -------+---------+---------+---------+--
RK 6.5   -1.5894   0.0000  1.5894        (----------*----------)
RK 8.0   -2.0202  -0.3035  1.4133      (----------*----------)
RK 9.5   -2.0418  -0.3250  1.3918     (-----------*----------)
                                   -------+---------+---------+---------+--
                                       -1.5       0.0       1.5       3.0


Station = RK 6.5 subtracted from:

Station    Lower   Center   Upper  -------+---------+---------+---------+--
RK 8.0   -2.0202  -0.3035  1.4133      (----------*----------)
RK 9.5   -2.0418  -0.3250  1.3918     (-----------*----------)
                                   -------+---------+---------+---------+--
                                       -1.5       0.0       1.5       3.0


Station = RK 8.0 subtracted from:

Station    Lower   Center   Upper  -------+---------+---------+---------+--
RK 9.5   -1.8568  -0.0215  1.8138       (-----------*-----------)
                                   -------+---------+---------+---------+--
                                       -1.5       0.0       1.5       3.0
```

One-way ANOVA: Temperature versus Station

```
Source   DF        SS        MS      F      P
Station   8  0.089389  0.011174  69.70  0.0001
Error    19  0.003046  0.000160
Total    27  0.092435

S = 0.01266   R-Sq = 96.70%   R-Sq(adj) = 95.32%


                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level    N    Mean   StDev  ---+---------+---------+---------+------
RK 0.0   2  3.2762  0.0003                  (--*--)
RK 10.5  4  3.2351  0.0252            (-*-)
RK 11.2  2  3.1785  0.0012  (--*--)
RK 2.0   3  3.3058  0.0025                       (--*--)
RK 3.5   3  3.3312  0.0070                            (-*--)
RK 5.0   4  3.3484  0.0107                               (-*-)
RK 6.5   4  3.3581  0.0119                                (--*-)
RK 8.0   3  3.3731  0.0069                                   (-*--)
RK 9.5   3  3.2834  0.0091                    (-*--)
                            ---+---------+---------+---------+------
                             3.180     3.240     3.300     3.360

Pooled StDev = 0.0127


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Station

Individual confidence level = 99.75%


Station = RK 0.0 subtracted from:

Station     Lower    Center     Upper
RK 10.5  -0.07925  -0.04110  -0.00295
RK 11.2  -0.14178  -0.09773  -0.05368
RK 2.0   -0.01063   0.02958   0.06979
RK 3.5    0.01482   0.05503   0.09524
RK 5.0    0.03402   0.07217   0.11031
RK 6.5    0.04371   0.08186   0.12001
RK 8.0    0.05671   0.09692   0.13713
RK 9.5   -0.03302   0.00719   0.04740

Station     +---------+---------+---------+---------
RK 10.5                  (---*--)
RK 11.2             (---*---)
RK 2.0                         (--*---)
RK 3.5                           (---*--)
RK 5.0                             (--*--)
RK 6.5                              (--*--)
RK 8.0                               (--*--)
RK 9.5                       (---*--)
            +---------+---------+---------+---------
         -0.24     -0.12      0.00      0.12


Station = RK 10.5 subtracted from:

Station     Lower    Center     Upper
RK 11.2  -0.09478  -0.05663  -0.01849
```

```
RK 2.0    0.03704   0.07068   0.10433
RK 3.5    0.06249   0.09613   0.12978
RK 5.0    0.08212   0.11327   0.14441
RK 6.5    0.09181   0.12296   0.15411
RK 8.0    0.10438   0.13802   0.17167
RK 9.5    0.01464   0.04828   0.08193

Station     +---------+---------+---------+---------
RK 11.2                 (--*--)
RK 2.0                             (--*--)
RK 3.5                               (--*--)
RK 5.0                                 (-*--)
RK 6.5                                  (-*--)
RK 8.0                                   (--*-)
RK 9.5                           (--*--)
            +---------+---------+---------+---------
         -0.24     -0.12      0.00      0.12


Station = RK 11.2 subtracted from:

Station    Lower   Center    Upper
RK 2.0   0.08710  0.12731  0.16753
RK 3.5   0.11255  0.15277  0.19298
RK 5.0   0.13175  0.16990  0.20805
RK 6.5   0.14145  0.17959  0.21774
RK 8.0   0.15444  0.19466  0.23487
RK 9.5   0.06471  0.10492  0.14513

Station     +---------+---------+---------+---------
RK 2.0                                 (---*--)
RK 3.5                                   (---*--)
RK 5.0                                     (--*--)
RK 6.5                                      (--*--)
RK 8.0                                       (--*---)
RK 9.5                               (---*--)
            +---------+---------+---------+---------
         -0.24     -0.12      0.00      0.12


Station = RK 2.0 subtracted from:

Station     Lower    Center    Upper
RK 3.5   -0.01052   0.02545  0.06142
RK 5.0    0.00894   0.04258  0.07623
RK 6.5    0.01863   0.05228  0.08592
RK 8.0    0.03137   0.06734  0.10331
RK 9.5   -0.05836  -0.02240  0.01357

Station     +---------+---------+---------+---------
RK 3.5                         (--*--)
RK 5.0                           (--*-)
RK 6.5                            (-*--)
RK 8.0                             (--*--)
RK 9.5                     (--*--)
            +---------+---------+---------+---------
         -0.24     -0.12      0.00      0.12


Station = RK 3.5 subtracted from:

Station     Lower    Center     Upper
RK 5.0   -0.01651   0.01713   0.05078
```

```
RK 6.5   -0.00682   0.02683   0.06047
RK 8.0    0.00592   0.04189   0.07786
RK 9.5   -0.08381  -0.04785  -0.01188

Station     +---------+---------+---------+---------
RK 5.0                         (-*--)
RK 6.5                         (--*--)
RK 8.0                          (--*--)
RK 9.5                   (--*--)
            +---------+---------+---------+---------
         -0.24     -0.12      0.00      0.12


Station = RK 5.0 subtracted from:

Station     Lower    Center     Upper
RK 6.5   -0.02145   0.00969   0.04084
RK 8.0   -0.00889   0.02476   0.05840
RK 9.5   -0.09862  -0.06498  -0.03134

Station     +---------+---------+---------+---------
RK 6.5                        (--*-)
RK 8.0                         (--*--)
RK 9.5                  (--*-)
            +---------+---------+---------+---------
         -0.24     -0.12      0.00      0.12


Station = RK 6.5 subtracted from:

Station     Lower    Center     Upper
RK 8.0   -0.01858   0.01506   0.04871
RK 9.5   -0.10832  -0.07468  -0.04103

Station     +---------+---------+---------+---------
RK 8.0                        (--*--)
RK 9.5                 (--*--)
            +---------+---------+---------+---------
         -0.24     -0.12      0.00      0.12


Station = RK 8.0 subtracted from:

Station     Lower    Center     Upper
RK 9.5   -0.12570  -0.08974  -0.05377

Station     +---------+---------+---------+---------
RK 9.5                (--*--)
            +---------+---------+---------+---------
         -0.24     -0.12      0.00      0.12
```

One-way ANOVA: pH versus Station

```
Source   DF         SS         MS      F       P
Station   8  0.0147576  0.0018447  71.76  0.0001
Error    19  0.0004884  0.0000257
Total    27  0.0152460

S = 0.005070   R-Sq = 96.80%   R-Sq(adj) = 95.45%


                              Individual 95% CIs For Mean Based on Pooled StDev
Level    N     Mean    StDev  ---------+---------+---------+---------+
RK 0.0   2  2.06560  0.00000                                  (--*--)
RK 10.5  4  1.99398  0.01051      (--*-)
RK 11.2  2  2.00888  0.00095            (--*--)
RK 2.0   3  2.04855  0.00074                            (-*--)
RK 3.5   3  2.03775  0.00199                        (-*--)
RK 5.0   4  2.01889  0.00153                (--*-)
RK 6.5   4  2.01623  0.00188               (-*--)
RK 8.0   3  2.01088  0.00613             (-*--)
RK 9.5   3  1.98329  0.00520  (-*--)
                              ---------+---------+---------+---------+
                                     2.000     2.025     2.050     2.075

Pooled StDev = 0.00507


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Station

Individual confidence level = 99.75%


Station = RK 0.0 subtracted from:

Station     Lower    Center     Upper
RK 10.5  -0.08689  -0.07162  -0.05634
RK 11.2  -0.07435  -0.05671  -0.03907
RK 2.0   -0.03315  -0.01704  -0.00094
RK 3.5   -0.04395  -0.02785  -0.01174
RK 5.0   -0.06198  -0.04670  -0.03143
RK 6.5   -0.06464  -0.04936  -0.03409
RK 8.0   -0.07082  -0.05471  -0.03861
RK 9.5   -0.09841  -0.08231  -0.06621

Station     +---------+---------+---------+---------
RK 10.5        (--*--)
RK 11.2          (---*--)
RK 2.0                   (---*--)
RK 3.5                 (--*---)
RK 5.0              (--*--)
RK 6.5             (--*--)
RK 8.0            (--*--)
RK 9.5      (---*--)
            +---------+---------+---------+---------
         -0.100    -0.050     0.000     0.050


Station = RK 10.5 subtracted from:

Station     Lower    Center    Upper
RK 11.2  -0.00037   0.01491  0.03018
RK 2.0    0.04110   0.05457  0.06805
```

```
RK 3.5    0.03030   0.04377  0.05724
RK 5.0    0.01244   0.02492  0.03739
RK 6.5    0.00978   0.02226  0.03473
RK 8.0    0.00343   0.01690  0.03038
RK 9.5   -0.02416  -0.01069  0.00278

Station     +---------+---------+---------+---------
RK 11.2                         (--*--)
RK 2.0                                  (--*--)
RK 3.5                                (--*-)
RK 5.0                            (--*-)
RK 6.5                            (-*--)
RK 8.0                           (-*--)
RK 9.5                     (--*--)
            +---------+---------+---------+---------
         -0.100    -0.050     0.000     0.050


Station = RK 11.2 subtracted from:

Station     Lower    Center     Upper
RK 2.0    0.02357   0.03967   0.05577
RK 3.5    0.01276   0.02887   0.04497
RK 5.0   -0.00527   0.01001   0.02528
RK 6.5   -0.00793   0.00735   0.02262
RK 8.0   -0.01410   0.00200   0.01810
RK 9.5   -0.04170  -0.02560  -0.00949

Station     +---------+---------+---------+---------
RK 2.0                               (--*--)
RK 3.5                             (--*--)
RK 5.0                         (--*--)
RK 6.5                        (--*---)
RK 8.0                       (--*---)
RK 9.5                  (--*--)
            +---------+---------+---------+---------
         -0.100    -0.050     0.000     0.050


Station = RK 2.0 subtracted from:

Station     Lower    Center     Upper
RK 3.5   -0.02520  -0.01080   0.00360
RK 5.0   -0.04313  -0.02966  -0.01619
RK 6.5   -0.04579  -0.03232  -0.01885
RK 8.0   -0.05207  -0.03767  -0.02327
RK 9.5   -0.07967  -0.06526  -0.05086

Station     +---------+---------+---------+---------
RK 3.5                     (--*--)
RK 5.0                 (--*--)
RK 6.5                 (--*-)
RK 8.0                (-*--)
RK 9.5          (--*--)
            +---------+---------+---------+---------
         -0.100    -0.050     0.000     0.050


Station = RK 3.5 subtracted from:

Station     Lower    Center     Upper
RK 5.0   -0.03233  -0.01886  -0.00538
RK 6.5   -0.03499  -0.02152  -0.00804
```

```
RK 8.0   -0.04127  -0.02687  -0.01247
RK 9.5   -0.06886  -0.05446  -0.04006

Station     +---------+---------+---------+---------
RK 5.0                    (-*--)
RK 6.5                   (--*-)
RK 8.0                  (--*--)
RK 9.5            (--*--)
            +---------+---------+---------+---------
         -0.100    -0.050     0.000     0.050


Station = RK 5.0 subtracted from:

Station     Lower    Center     Upper
RK 6.5   -0.01513  -0.00266   0.00981
RK 8.0   -0.02148  -0.00801   0.00546
RK 9.5   -0.04908  -0.03561  -0.02213

Station     +---------+---------+---------+---------
RK 6.5                       (-*--)
RK 8.0                      (-*--)
RK 9.5                  (--*--)
            +---------+---------+---------+---------
         -0.100    -0.050     0.000     0.050


Station = RK 6.5 subtracted from:

Station     Lower    Center     Upper
RK 8.0   -0.01882  -0.00535   0.00812
RK 9.5   -0.04642  -0.03295  -0.01947

Station     +---------+---------+---------+---------
RK 8.0                      (--*--)
RK 9.5                 (-*--)
            +---------+---------+---------+---------
         -0.100    -0.050     0.000     0.050


Station = RK 8.0 subtracted from:

Station     Lower    Center     Upper
RK 9.5   -0.04200  -0.02759  -0.01319

Station     +---------+---------+---------+---------
RK 9.5                  (-*--)
            +---------+---------+---------+---------
         -0.100    -0.050     0.000     0.050
```

One-way ANOVA: Salinity versus Station

```
Source   DF       SS      MS       F       P
Station   8  38.3751  4.7969  118.34  0.0001
Error    19   0.7702  0.0405
Total    27  39.1453

S = 0.2013   R-Sq = 98.03%   R-Sq(adj) = 97.20%


                             Individual 95% CIs For Mean Based on
                             Pooled StDev
Level    N     Mean   StDev  -------+---------+---------+---------+--
RK 0.0   2   3.5102  0.0015                              (-*-)
RK 10.5  4   1.3627  0.4929                 (*)
RK 11.2  2  -0.7340  0.0000  (-*-)
RK 2.0   3   3.4709  0.0013                               (*-)
RK 3.5   3   3.3859  0.0207                              (-*)
RK 5.0   4   3.2917  0.0600                              (*)
RK 6.5   4   3.2022  0.0609                             (*-)
RK 8.0   3   2.9102  0.0706                           (*-)
RK 9.5   3   2.1596  0.0651                      (*-)
                             -------+---------+---------+---------+--
                                  0.0       1.5       3.0       4.5

Pooled StDev = 0.2013


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Station

Individual confidence level = 99.75%


Station = RK 0.0 subtracted from:

Station    Lower   Center    Upper     +---------+---------+---------+---------
RK 10.5  -2.7541  -2.1475  -1.5409              (-*--)
RK 11.2  -4.9446  -4.2442  -3.5437     (--*--)
RK 2.0   -0.6787  -0.0393   0.6001                      (--*-)
RK 3.5   -0.7637  -0.1243   0.5151                      (--*-)
RK 5.0   -0.8251  -0.2185   0.3881                      (-*--)
RK 6.5   -0.9146  -0.3080   0.2986                     (--*-)
RK 8.0   -1.2394  -0.6000   0.0394                    (--*-)
RK 9.5   -1.9900  -1.3506  -0.7112                 (--*-)
                                       +---------+---------+---------+---------
                                    -5.0      -2.5       0.0       2.5


Station = RK 10.5 subtracted from:

Station    Lower   Center    Upper     +---------+---------+---------+---------
RK 11.2  -2.7032  -2.0966  -1.4900              (--*-)
RK 2.0    1.5733   2.1083   2.6432                               (-*--)
RK 3.5    1.4883   2.0233   2.5582                               (-*-)
RK 5.0    1.4338   1.9291   2.4243                               (-*-)
RK 6.5    1.3442   1.8395   2.3348                              (-*-)
RK 8.0    1.0125   1.5475   2.0825                             (-*-)
RK 9.5    0.2620   0.7969   1.3319                          (-*-)
                                       +---------+---------+---------+---------
                                    -5.0      -2.5       0.0       2.5
```

```
Station = RK 11.2 subtracted from:

Station   Lower  Center   Upper     +---------+---------+---------+---------
RK 2.0   3.5655  4.2049  4.8443                                       (--*-)
RK 3.5   3.4805  4.1199  4.7593                                       (-*--)
RK 5.0   3.4191  4.0257  4.6323                                       (-*--)
RK 6.5   3.3296  3.9362  4.5427                                      (--*-)
RK 8.0   3.0047  3.6441  4.2835                                     (--*-)
RK 9.5   2.2542  2.8936  3.5330                                  (--*-)
                                    +---------+---------+---------+---------
                                 -5.0      -2.5       0.0       2.5


Station = RK 2.0 subtracted from:

Station    Lower   Center    Upper     +---------+---------+---------+---------
RK 3.5   -0.6569  -0.0850   0.4869                      (--*-)
RK 5.0   -0.7142  -0.1792   0.3557                      (-*-)
RK 6.5   -0.8037  -0.2687   0.2662                      (-*-)
RK 8.0   -1.1327  -0.5608   0.0111                    (--*-)
RK 9.5   -1.8832  -1.3113  -0.7394                 (--*-)
                                       +---------+---------+---------+---------
                                    -5.0      -2.5       0.0       2.5


Station = RK 3.5 subtracted from:

Station    Lower   Center    Upper     +---------+---------+---------+---------
RK 5.0   -0.6292  -0.0942   0.4407                      (--*-)
RK 6.5   -0.7187  -0.1838   0.3512                      (-*-)
RK 8.0   -1.0477  -0.4758   0.0961                     (-*-)
RK 9.5   -1.7982  -1.2263  -0.6544                  (-*-)
                                       +---------+---------+---------+---------
                                    -5.0      -2.5       0.0       2.5


Station = RK 5.0 subtracted from:

Station    Lower   Center    Upper     +---------+---------+---------+---------
RK 6.5   -0.5848  -0.0895   0.4057                       (-*-)
RK 8.0   -0.9165  -0.3816   0.1534                     (-*--)
RK 9.5   -1.6671  -1.1321  -0.5972                  (-*--)
                                       +---------+---------+---------+---------
                                    -5.0      -2.5       0.0       2.5


Station = RK 6.5 subtracted from:

Station    Lower   Center    Upper     +---------+---------+---------+---------
RK 8.0   -0.8270  -0.2920   0.2429                      (-*-)
RK 9.5   -1.5775  -1.0426  -0.5076                   (-*-)
                                       +---------+---------+---------+---------
                                    -5.0      -2.5       0.0       2.5


Station = RK 8.0 subtracted from:

Station    Lower   Center    Upper     +---------+---------+---------+---------
RK 9.5   -1.3225  -0.7506  -0.1787                    (-*-)
                                       +---------+---------+---------+---------
                                    -5.0      -2.5       0.0       2.5
```

One-way ANOVA: DO_mg/l versus Station

```
Source   DF      SS      MS     F      P
Station   8  1.6538  0.2067  8.84  0.0001
Error    19  0.4442  0.0234
Total    27  2.0980

S = 0.1529   R-Sq = 78.83%   R-Sq(adj) = 69.91%


                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level    N    Mean   StDev  ----+---------+---------+---------+-----
RK 0.0   2  1.2354  0.0206                    (------*-------)
RK 10.5  4  0.6291  0.3074  (----*----)
RK 11.2  2  0.9394  0.0497          (------*-------)
RK 2.0   3  1.1884  0.0670                   (------*-----)
RK 3.5   3  1.3261  0.0160                        (-----*-----)
RK 5.0   4  1.2460  0.0810                      (-----*----)
RK 6.5   4  1.2487  0.1027                      (-----*----)
RK 8.0   3  1.3801  0.1354                          (-----*-----)
RK 9.5   3  0.9167  0.1737          (------*-----)
                            ----+---------+---------+---------+-----
                              0.60      0.90      1.20      1.50

Pooled StDev = 0.1529


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Station

Individual confidence level = 99.75%


Station = RK 0.0 subtracted from:

Station    Lower   Center    Upper  ---------+---------+---------+---------+
RK 10.5  -1.0670  -0.6063  -0.1456   (-------*-------)
RK 11.2  -0.8279  -0.2960   0.2360       (--------*--------)
RK 2.0   -0.5326  -0.0470   0.4386            (-------*-------)
RK 3.5   -0.3949   0.0907   0.5763              (--------*-------)
RK 5.0   -0.4500   0.0106   0.4713             (-------*-------)
RK 6.5   -0.4473   0.0133   0.4740              (------*-------)
RK 8.0   -0.3409   0.1448   0.6304               (-------*--------)
RK 9.5   -0.8043  -0.3187   0.1669        (-------*-------)
                                    ---------+---------+---------+---------+
                                          -0.60      0.00      0.60      1.20


Station = RK 10.5 subtracted from:

Station    Lower  Center   Upper  ---------+---------+---------+---------+
RK 11.2  -0.1504  0.3103  0.7710                  (-------*-------)
RK 2.0    0.1530  0.5593  0.9656                        (-----*------)
RK 3.5    0.2907  0.6970  1.1033                          (------*-----)
RK 5.0    0.2408  0.6169  0.9931                         (-----*------)
RK 6.5    0.2435  0.6196  0.9958                         (-----*------)
RK 8.0    0.3447  0.7510  1.1573                           (------*-----)
RK 9.5   -0.1187  0.2876  0.6938                   (------*------)
                                  ---------+---------+---------+---------+
                                        -0.60      0.00      0.60      1.20
```

```
Station = RK 11.2 subtracted from:

Station    Lower   Center   Upper  ---------+---------+---------+---------+
RK 2.0   -0.2366   0.2490  0.7346                 (-------*-------)
RK 3.5   -0.0989   0.3867  0.8723                   (-------*--------)
RK 5.0   -0.1541   0.3066  0.7673                  (-------*-------)
RK 6.5   -0.1514   0.3093  0.7700                  (-------*-------)
RK 8.0   -0.0449   0.4407  0.9263                    (-------*-------)
RK 9.5   -0.5083  -0.0227  0.4629             (-------*-------)
                                   ---------+---------+---------+---------+
                                         -0.60      0.00      0.60      1.20


Station = RK 2.0 subtracted from:

Station    Lower   Center   Upper  ---------+---------+---------+---------+
RK 3.5   -0.2966   0.1377  0.5721                (------*-------)
RK 5.0   -0.3487   0.0576  0.4639               (------*------)
RK 6.5   -0.3460   0.0603  0.4666               (------*------)
RK 8.0   -0.2426   0.1917  0.6261                 (------*------)
RK 9.5   -0.7061  -0.2717  0.1626         (------*-------)
                                   ---------+---------+---------+---------+
                                         -0.60      0.00      0.60      1.20


Station = RK 3.5 subtracted from:

Station    Lower   Center   Upper  ---------+---------+---------+---------+
RK 5.0   -0.4864  -0.0801  0.3262             (------*-----)
RK 6.5   -0.4837  -0.0774  0.3289             (------*-----)
RK 8.0   -0.3803   0.0540  0.4883               (------*------)
RK 9.5   -0.8438  -0.4095  0.0249       (------*------)
                                   ---------+---------+---------+---------+
                                         -0.60      0.00      0.60      1.20


Station = RK 5.0 subtracted from:

Station    Lower   Center   Upper  ---------+---------+---------+---------+
RK 6.5   -0.3734   0.0027  0.3789               (-----*-----)
RK 8.0   -0.2722   0.1341  0.5404                (------*------)
RK 9.5   -0.7356  -0.3293  0.0769         (------*-----)
                                   ---------+---------+---------+---------+
                                         -0.60      0.00      0.60      1.20


Station = RK 6.5 subtracted from:

Station    Lower   Center   Upper  ---------+---------+---------+---------+
RK 8.0   -0.2749   0.1314  0.5377                (------*------)
RK 9.5   -0.7383  -0.3321  0.0742         (-----*------)
                                   ---------+---------+---------+---------+
                                         -0.60      0.00      0.60      1.20


Station = RK 8.0 subtracted from:

Station    Lower   Center    Upper  ---------+---------+---------+---------+
RK 9.5   -0.8978  -0.4635  -0.0291      (------*-------)
                                    ---------+---------+---------+---------+
                                          -0.60      0.00      0.60      1.20
```

Sediment Analysis

Descriptive Statistics: Sediment Analysis

```
Variable             N  N*      Mean   SE Mean     StDev   Minimum        Q1
%>3"                10   0  0.000000  0.000000  0.000000  0.000000  0.000000
% Coarse Gravel     10   0     0.150     0.150     0.474     0.000     0.000
% Fine              10   0      2.53      1.75      5.55      0.00      0.00
% Coarse Gravel_1   10   0     1.020     0.610     1.929     0.000     0.000
% Medium            10   0     2.220     0.496     1.569     0.300     0.900
% Fine_1            10   0     81.10      2.57      8.14     65.10     77.18
% Silt              10   0     6.300     0.941     2.976     2.100     2.975
% Clay              10   0     6.680     0.603     1.906     3.800     4.900
% Silt plus Clay    10   0     12.98      1.49      4.71      6.40      7.55

Variable              Median        Q3   Maximum
%>3"                0.000000  0.000000  0.000000
% Coarse Gravel        0.000     0.000     1.500
% Fine                  0.00      2.55     17.20
% Coarse Gravel_1      0.000     1.375     6.200
% Medium               1.800     3.225     5.200
% Fine_1               80.70     86.67     93.30
% Silt                 7.450     8.475    10.500
% Clay                 7.000     8.400     9.300
% Silt plus Clay       13.80     16.73     19.80
```

Water Quality Mean Values

Spearman’s Rank Correlations

```
                  Temperature ( C)         pH__Ranks  Conductivity__Ra
pH__Ranks                    0.217
                             0.576

Conductivity__Ra             0.317             0.933
                             0.406             0.000

Salinity__Ranks              0.317             0.933             1.000
                             0.406             0.000                 *

DO%__Ranks                   0.867             0.450             0.483
                             0.002             0.224             0.187

DO mg/l__Ranks               0.833             0.467             0.433
                             0.005             0.205             0.244

Total Site Depth             0.644            -0.025             0.042
                             0.061             0.949             0.915

River Kilometer_            -0.317            -0.933            -1.000
                             0.406             0.000                 *


                   Salinity__Ranks        DO%__Ranks    DO mg/l__Ranks
DO%__Ranks                   0.483
                             0.187

DO mg/l__Ranks               0.433             0.967
                             0.244             0.000

Total Site Depth             0.042             0.368             0.318
                             0.915             0.330             0.404

River Kilometer_            -1.000            -0.483            -0.433
                                 *             0.187             0.244


                  Total Site Depth
River Kilometer_            -0.042
                             0.915


Cell Contents: Pearson correlation
               P-Value
```

Pooled Macroinvertebrate Metrics

Spearman's Rank Correlations

Correlations: N Taxa_Ranks, N Individual, Margalefs d_, Pielous Even, ...

```
                   N Taxa_Ranks  N Individuals_Ra  Margalefs d_Rank
N Individuals_Ra          0.538
                          0.135

Margalefs d_Rank          0.958             0.317
                          0.000             0.406

Pielous Evenness         -0.277            -0.367            -0.217
                          0.470             0.332             0.576

Shannon Diversit          0.639             0.367             0.600
                          0.064             0.332             0.088

Simpsons d_Ranks          0.378             0.333             0.350
                          0.316             0.381             0.356


               Pielous Evenness  Shannon Diversit
Shannon Diversit          0.450
                          0.224

Simpsons d_Ranks          0.567             0.817
                          0.112             0.007


Cell Contents: Pearson correlation
               P-Value
```

Pooled Macroinvertebrate Metrics versus Water Quality Mean Values

Spearman’s Rank Correlations

```
                   Temperature ( C)         pH__Ranks  Conductivity__Ra
pH__Ranks                     0.217
                              0.576

Conductivity__Ra              0.317             0.933
                              0.406             0.000

Salinity__Ranks               0.317             0.933             1.000
                              0.406             0.000                 *

DO%__Ranks                    0.867             0.450             0.483
                              0.002             0.224             0.187

DO mg/l__Ranks                0.833             0.467             0.433
                              0.005             0.205             0.244

Total Site Depth              0.644            -0.025             0.042
                              0.061             0.949             0.915

River Kilometer_             -0.317            -0.933            -1.000
                              0.406             0.000                 *

N Taxa_Ranks                  0.218             0.958             0.891
                              0.572             0.000             0.001

N Individuals_Ra              0.600             0.433             0.533
                              0.088             0.244             0.139

Margalefs d_Rank              0.083             0.983             0.883
                              0.831             0.000             0.002

Pielous Evenness             -0.717            -0.300            -0.267
                              0.030             0.433             0.488

Shannon Diversit             -0.333             0.567             0.600
                              0.381             0.112             0.088

Simpsons d_Ranks             -0.100             0.367             0.467
                              0.798             0.332             0.205


                    Salinity__Ranks        DO%__Ranks    DO mg/l__Ranks
DO%__Ranks                    0.483
                              0.187

DO mg/l__Ranks                0.433             0.967
                              0.244             0.000

Total Site Depth              0.042             0.368             0.318
                              0.915             0.330             0.404

River Kilometer_             -1.000            -0.483            -0.433
                                  *             0.187             0.244

N Taxa_Ranks                  0.891             0.378             0.429
                              0.001             0.316             0.250
```

```
N Individuals_Ra             0.533             0.483             0.517
                             0.139             0.187             0.154

Margalefs d_Rank             0.883             0.333             0.367
                             0.002             0.381             0.332

Pielous Evenness            -0.267            -0.617            -0.617
                             0.488             0.077             0.077

Shannon Diversit             0.600            -0.267            -0.233
                             0.088             0.488             0.546

Simpsons d_Ranks             0.467            -0.067            -0.083
                             0.205             0.865             0.831


                  Total Site Depth  River Kilometer_      N Taxa_Ranks
River Kilometer_            -0.042
                             0.915

N Taxa_Ranks                -0.076            -0.891
                             0.846             0.001

N Individuals_Ra             0.142            -0.533             0.538
                             0.715             0.139             0.135

Margalefs d_Rank            -0.109            -0.883             0.958
                             0.781             0.002             0.000

Pielous Evenness            -0.385             0.267            -0.277
                             0.306             0.488             0.470

Shannon Diversit            -0.268            -0.600             0.639
                             0.486             0.088             0.064

Simpsons d_Ranks             0.117            -0.467             0.378
                             0.764             0.205             0.316


                  N Individuals_Ra  Margalefs d_Rank  Pielous Evenness
Margalefs d_Rank             0.317
                             0.406

Pielous Evenness            -0.367            -0.217
                             0.332             0.576

Shannon Diversit             0.367             0.600             0.450
                             0.332             0.088             0.224

Simpsons d_Ranks             0.333             0.350             0.567
                             0.381             0.356             0.112


                  Shannon Diversit
Simpsons d_Ranks             0.817
                             0.007


Cell Contents: Pearson correlation
               P-Value
```

Appendix B

PRIMER Statistical Outputs

Appendix B: PRIMER 6 Documentation – Part 1

ANOSIM

Analysis of Similarities

One-Way Analysis

```
Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Factor Values
Factor: River Kilometer Groups
RK-0
RK-2
RK-3.5
RK-5
RK-6.5
RK-8
RK-9.5
RK-10.5
RK-11.2

Factor Groups
Sample    River Kilometer Groups
RK 0_A    RK-0
RK 0_B    RK-0
RK 0_C    RK-0
RK 2_A    RK-2
RK 2_B    RK-2
RK 2_C    RK-2
RK 3.5_A  RK-3.5
RK 3.5_B  RK-3.5
RK 3.5_C  RK-3.5
RK 5_A    RK-5
RK 5_B    RK-5
RK 5_C    RK-5
RK 6.5_A  RK-6.5
RK 6.5_B  RK-6.5
RK 6.5_C  RK-6.5
RK 8_A    RK-8
RK 8_B    RK-8
RK 8_C    RK-8
RK 9.5_A  RK-9.5
RK 9.5_A  RK-9.5
RK 9.5_A  RK-9.5
RK 10.5_A RK-10.5
RK 10.5_B RK-10.5
RK 10.5_C RK-10.5
RK 11.2_A RK-11.2
RK 11.2_B RK-11.2
RK 11.2_C RK-11.2

Global Test
```

```
Sample statistic (Global R): 0.864
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

Pairwise Tests
                          R Significance     Possible       Actual
                  Number >=
Groups            Statistic      Level % Permutations Permutations
Observed
RK-0, RK-2             0.63           10           10           10
1
RK-0, RK-3.5          0.926           10           10           10
1
RK-0, RK-5                1           10           10           10
1
RK-0, RK-6.5              1           10           10           10
1
RK-0, RK-8                1           10           10           10
1
RK-0, RK-9.5              1           10           10           10
1
RK-0, RK-10.5             1           10           10           10
1
RK-0, RK-11.2             1           10           10           10
1
RK-2, RK-3.5          0.889           10           10           10
1
RK-2, RK-5                1           10           10           10
1
RK-2, RK-6.5              1           10           10           10
1
RK-2, RK-8                1           10           10           10
1
RK-2, RK-9.5              1           10           10           10
1
RK-2, RK-10.5             1           10           10           10
1
RK-2, RK-11.2             1           10           10           10
1
RK-3.5, RK-5          0.593           10           10           10
1
RK-3.5, RK-6.5        0.852           10           10           10
1
RK-3.5, RK-8              1           10           10           10
1
RK-3.5, RK-9.5            1           10           10           10
1
RK-3.5, RK-10.5           1           10           10           10
1
RK-3.5, RK-11.2           1           10           10           10
1
RK-5, RK-6.5          0.037           50           10           10
5
RK-5, RK-8            0.815           10           10           10
1
```

```
RK-5, RK-9.5          0.852           10           10            10
1
RK-5, RK-10.5             1           10           10            10
1
RK-5, RK-11.2             1           10           10            10
1
RK-6.5, RK-8          0.296           20           10            10
2
RK-6.5, RK-9.5        0.556           10           10            10
1
RK-6.5, RK-10.5           1           10           10            10
1
RK-6.5, RK-11.2           1           10           10            10
1
RK-8, RK-9.5          0.185           30           10            10
3
RK-8, RK-10.5             1           10           10            10
1
RK-8, RK-11.2             1           10           10            10
1
RK-9.5, RK-10.5       0.519           10           10            10
1
RK-9.5, RK-11.2           1           10           10            10
1
RK-10.5, RK-11.2      0.963           10           10            10
1

Outputs
Plot: Graph1
Worksheet: Resem2
```

PCA
Principal Component Analysis

```
Data worksheet
Name: Data1
Data type: Environmental
Sample selection: All
Variable selection: All

Eigenvalues
PC Eigenvalues %Variation Cum.%Variation
 1        2.92       58.5           58.5
 2        1.41       28.2           86.7
 3        0.57       11.4           98.1
 4      8.6E-2        1.7           99.8
 5     8.72E-3        0.2          100.0

Eigenvectors
(Coefficients in the linear combinations of variables making up PC's)
Variable           PC1    PC2    PC3    PC4    PC5
Temperature ( C) 0.464  0.441  0.375  0.369  0.559
pH               0.424 -0.489 -0.475 -0.271  0.531
Salinity         0.555 -0.101 -0.310  0.547 -0.534
```

```
DO mg/l           0.538 -0.003  0.456 -0.621 -0.341
Total Site Depth  0.081  0.746 -0.574 -0.324 -0.056

Principal Component Scores
Sample   SCORE1  SCORE2  SCORE3   SCORE4   SCORE5
RK 0.0     1.32   -1.72  -0.684  -2.08E-2  3.42E-2
RK 2.0      1.1  -0.915  -0.454     0.311  5.44E-2
RK 3.5     1.39  -0.505   0.293   2.26E-2  -6.6E-2
RK 5.0     1.02     1.4  -0.458    -0.139   -0.141
RK 6.5    0.952    1.41  -0.183     -0.11 -1.54E-3
RK 8.0    0.985   0.529    1.39    -0.195    0.136
RK 9.5    -1.78   0.204   0.754     0.577 -6.37E-2
RK 10.5   -2.48   0.994   -0.98  -1.34E-2    0.118
RK 11.2    -2.5    -1.4   0.326    -0.433 -7.04E-2

Outputs
Plot: Graph1
```

ANOSIM

Analysis of Similarities on Salinity Groups from PCA

One-Way Analysis

```
Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Factor Values
Factor: Salinity Group
Downstream
Upstream

Factor Groups
Sample    Salinity Group
RK 0_A    Downstream
RK 0_B    Downstream
RK 0_C    Downstream
RK 2_A    Downstream
RK 2_B    Downstream
RK 2_C    Downstream
RK 3.5_A  Downstream
RK 3.5_B  Downstream
RK 3.5_C  Downstream
RK 5_A    Downstream
RK 5_B    Downstream
RK 5_C    Downstream
RK 6.5_A  Downstream
RK 6.5_B  Downstream
RK 6.5_C  Downstream
RK 8_A    Downstream
RK 8_B    Downstream
RK 8_C    Downstream
RK 9.5_A  Upstream
RK 9.5_A  Upstream
```

```
RK 9.5_A  Upstream
RK 10.5_A Upstream
RK 10.5_B Upstream
RK 10.5_C Upstream
RK 11.2_A Upstream
RK 11.2_B Upstream
RK 11.2_C Upstream

Global Test
Sample statistic (Global R): 0.486
Significance level of sample statistic: 0.02%
Number of permutations: 9999 (Random sample from 4686825)
Number of permuted statistics greater than or equal to Global R: 1

Outputs
Plot: Graph2
```

ANOSIM

Analysis of Similarities on Four Salinity Groups

One-Way Analysis

```
Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Factor Values
Factor: Salinity Classes from PCA
Euhaline
Polyhaline
Oligohaline
Freshwater

Factor Groups
Sample    Salinity Classes from PCA
RK-0-A    Euhaline
RK-0-B    Euhaline
RK-0-C    Euhaline
RK-2-A    Euhaline
RK-2-B    Euhaline
RK-2-C    Euhaline
RK-3.5-A  Euhaline
RK-3.5-B  Euhaline
RK-3.5-C  Euhaline
RK-5-A    Polyhaline
RK-5-B    Polyhaline
RK-5-C    Polyhaline
RK-6.5-A  Polyhaline
RK-6.5-B  Polyhaline
RK-6.5-C  Polyhaline
RK-8-A    Polyhaline
RK-8-B    Polyhaline
RK-8-C    Polyhaline
RK-9.5-A  Oligohaline
RK-9.5-B  Oligohaline
```

```
RK-9.5-C  Oligohaline
RK-10.5-A Oligohaline
RK-10.5-B Oligohaline
RK-10.5-C Oligohaline
RK-11.2-A Freshwater
RK-11.2-B Freshwater
RK-11.2-C Freshwater

Global Test
Sample statistic (Global R): 0.785
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0

Pairwise Tests
                                 R Significance     Possible
Actual                   Number >=
Groups                   Statistic      Level % Permutations
                         Permutations            Observed
Euhaline, Polyhaline         0.814         0.01        24310
9999                             0
Euhaline, Oligohaline        0.962         0.02         5005
5005                             1
Euhaline, Freshwater             1          0.5          220
220                              1
Polyhaline, Oligohaline      0.648         0.02         5005
5005                             1
Polyhaline, Freshwater           1          0.5          220
220                              1
Oligohaline, Freshwater      0.778          1.2           84
84                               1

Outputs
Plot: Graph1
Worksheet: Resem2
```

BEST

Biota and/or Environment matching

```
Data worksheet
Name: Cotee WQ square root transformed  normalized
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 10
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 RK
  2 Temperature ( C)
  3 pH
  4 Salinity
  5 DO mg/l
  6 Total Site Depth
  7 % Silt+Clay

Number of variables: 1
No.Vars    Corr. Selections
      1    0.841 1
      1    0.683 3
      1    0.670 4
      1    0.371 2
      1    0.336 7
      1    0.271 5
      1   -0.003 6

Number of variables: 2
No.Vars    Corr. Selections
      2    0.917 1,4
      2    0.880 3,4
      2    0.836 2,3
      2    0.821 3,7
      2    0.818 1,2
      2    0.817 1,7
      2    0.791 1,3
      2    0.720 1,5
      2    0.701 4,7
      2    0.648 3,5
      2    0.605 2,4
      2    0.551 1,6
      2    0.514 4,5
```

```
      2    0.507 3,6
      2    0.448 2,5
      2    0.430 4,6
      2    0.417 5,7
      2    0.382 2,7
      2    0.207 2,6
      2    0.167 6,7
      2    0.110 5,6
```

Number of variables: 3

```
No.Vars    Corr. Selections
      3    0.932 1,3,4
      3    0.899 1-3
      3    0.885 1,3,7
      3    0.871 3,4,7
      3    0.859 1,4,7
      3    0.850 1,2,4
      3    0.832 2-4
      3    0.776 1,4,5
      3    0.770 1,3,5
      3    0.753 1,2,7
      3    0.752 3-5
      3    0.750 2,3,7
      3    0.748 1,4,6
      3    0.737 3,4,6
      3    0.727 1,5,7
      3    0.712 1,2,5
      3    0.703 3,5,7
      3    0.694 1,3,6
      3    0.680 2,3,6
      3    0.657 3,6,7
      3    0.654 2,3,5
      3    0.653 2,4,7
      3    0.639 1,6,7
      3    0.633 1,2,6
      3    0.601 4,5,7
      3    0.591 1,5,6
      3    0.569 4,6,7
      3    0.527 2,4,5
      3    0.507 3,5,6
      3    0.497 2,5,7
      3    0.448 2,4,6
      3    0.443 4-6
      3    0.282 2,6,7
      3    0.272 5-7
      3    0.266 2,5,6
```

Number of variables: 4

```
No.Vars    Corr. Selections
      4    0.920 1,3,4,7
      4    0.900 1-4
      4    0.864 1-3,7
      4    0.846 1,3-5
      4    0.819 1,3,4,6
      4    0.810 1,3,6,7
      4    0.805 1-3,6
      4    0.802 1,3,5,7
```

```
      4    0.801 2-4,7
      4    0.800 1,2,4,7
      4    0.792 1-3,5
      4    0.783 3,4,6,7
      4    0.774 1,4,6,7
      4    0.773 1,4,5,7
      4    0.765 3-5,7
      4    0.754 1,2,4,6
      4    0.746 2-4,6
      4    0.726 1,2,4,5
      4    0.719 1,3,5,6
      4    0.717 2-5
      4    0.688 2,3,5,7
      4    0.687 2,3,6,7
      4    0.685 1,4-6
      4    0.673 1,2,5,7
      4    0.665 3-6
      4    0.649 1,2,6,7
      4    0.643 1,5-7
      4    0.623 1,2,5,6
      4    0.611 3,5-7
      4    0.592 2,4,5,7
      4    0.581 2,3,5,6
      4    0.534 2,4,6,7
      4    0.508 4-7
      4    0.451 2,4-6
      4    0.382 2,5-7
```

Number of variables: 5

```
No.Vars    Corr. Selections
      5    0.873 1-4,7
      5    0.856 1,3-5,7
      5    0.843 1,3,4,6,7
      5    0.829 1-5
      5    0.829 1-4,6
      5    0.800 1,3-6
      5    0.794 1-3,6,7
      5    0.787 1-3,5,7
      5    0.778 1,3,5-7
      5    0.757 2-4,6,7
      5    0.752 1-3,5,6
      5    0.730 1,2,4,6,7
      5    0.711 3-7
      5    0.708 1,2,4,5,7
      5    0.705 1,4-7
      5    0.701 2-5,7
      5    0.665 1,2,4-6
      5    0.645 2-6
      5    0.610 2,3,5-7
      5    0.601 1,2,5-7
      5    0.523 2,4-7
```

Number of variables: 6

```
No.Vars    Corr. Selections
      6    0.819 1-4,6,7
      6    0.814 1,3-7
      6    0.808 1-5,7
```

```
      6    0.792 1-6
      6    0.734 1-3,5-7
      6    0.672 2-7
      6    0.659 1,2,4-7
```

Number of variables: 7

```
No.Vars    Corr. Selections
      7    0.774 All
```

Best results

```
No.Vars    Corr. Selections
      3    0.932 1,3,4
      4    0.920 1,3,4,7
      2    0.917 1,4
      4    0.900 1-4
      3    0.899 1-3
      3    0.885 1,3,7
      2    0.880 3,4
      5    0.873 1-4,7
      3    0.871 3,4,7
      4    0.864 1-3,7
```

BEST (Re-run with permutations test)

Biota and/or Environment matching

```
Data worksheet
Name: Cotee WQ square root transformed  normalized
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 10
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 RK
  2 Temperature ( C)
  3 pH
  4 Salinity
  5 DO mg/l
  6 Total Site Depth
  7 % Silt+Clay

Number of variables: 1
No.Vars    Corr. Selections
      1    0.841 1
      1    0.683 3
      1    0.670 4
      1    0.371 2
      1    0.336 7
      1    0.271 5
      1   -0.003 6

Number of variables: 2
No.Vars    Corr. Selections
      2    0.917 1,4
      2    0.880 3,4
      2    0.836 2,3
      2    0.821 3,7
      2    0.818 1,2
      2    0.817 1,7
      2    0.791 1,3
      2    0.720 1,5
      2    0.701 4,7
      2    0.648 3,5
      2    0.605 2,4
      2    0.551 1,6
      2    0.514 4,5
```

```
      2    0.507 3,6
      2    0.448 2,5
      2    0.430 4,6
      2    0.417 5,7
      2    0.382 2,7
      2    0.207 2,6
      2    0.167 6,7
      2    0.110 5,6
```

Number of variables: 3

```
No.Vars    Corr. Selections
      3    0.932 1,3,4
      3    0.899 1-3
      3    0.885 1,3,7
      3    0.871 3,4,7
      3    0.859 1,4,7
      3    0.850 1,2,4
      3    0.832 2-4
      3    0.776 1,4,5
      3    0.770 1,3,5
      3    0.753 1,2,7
      3    0.752 3-5
      3    0.750 2,3,7
      3    0.748 1,4,6
      3    0.737 3,4,6
      3    0.727 1,5,7
      3    0.712 1,2,5
      3    0.703 3,5,7
      3    0.694 1,3,6
      3    0.680 2,3,6
      3    0.657 3,6,7
      3    0.654 2,3,5
      3    0.653 2,4,7
      3    0.639 1,6,7
      3    0.633 1,2,6
      3    0.601 4,5,7
      3    0.591 1,5,6
      3    0.569 4,6,7
      3    0.527 2,4,5
      3    0.507 3,5,6
      3    0.497 2,5,7
      3    0.448 2,4,6
      3    0.443 4-6
      3    0.282 2,6,7
      3    0.272 5-7
      3    0.266 2,5,6
```

Number of variables: 4

```
No.Vars    Corr. Selections
      4    0.920 1,3,4,7
      4    0.900 1-4
      4    0.864 1-3,7
      4    0.846 1,3-5
      4    0.819 1,3,4,6
      4    0.810 1,3,6,7
      4    0.805 1-3,6
      4    0.802 1,3,5,7
```

```
      4    0.801 2-4,7
      4    0.800 1,2,4,7
      4    0.792 1-3,5
      4    0.783 3,4,6,7
      4    0.774 1,4,6,7
      4    0.773 1,4,5,7
      4    0.765 3-5,7
      4    0.754 1,2,4,6
      4    0.746 2-4,6
      4    0.726 1,2,4,5
      4    0.719 1,3,5,6
      4    0.717 2-5
      4    0.688 2,3,5,7
      4    0.687 2,3,6,7
      4    0.685 1,4-6
      4    0.673 1,2,5,7
      4    0.665 3-6
      4    0.649 1,2,6,7
      4    0.643 1,5-7
      4    0.623 1,2,5,6
      4    0.611 3,5-7
      4    0.592 2,4,5,7
      4    0.581 2,3,5,6
      4    0.534 2,4,6,7
      4    0.508 4-7
      4    0.451 2,4-6
      4    0.382 2,5-7

Number of variables: 5
No.Vars    Corr. Selections
      5    0.873 1-4,7
      5    0.856 1,3-5,7
      5    0.843 1,3,4,6,7
      5    0.829 1-5
      5    0.829 1-4,6
      5    0.800 1,3-6
      5    0.794 1-3,6,7
      5    0.787 1-3,5,7
      5    0.778 1,3,5-7
      5    0.757 2-4,6,7
      5    0.752 1-3,5,6
      5    0.730 1,2,4,6,7
      5    0.711 3-7
      5    0.708 1,2,4,5,7
      5    0.705 1,4-7
      5    0.701 2-5,7
      5    0.665 1,2,4-6
      5    0.645 2-6
      5    0.610 2,3,5-7
      5    0.601 1,2,5-7
      5    0.523 2,4-7

Number of variables: 6
No.Vars    Corr. Selections
      6    0.819 1-4,6,7
      6    0.814 1,3-7
      6    0.808 1-5,7
```

```
      6    0.792 1-6
      6    0.734 1-3,5-7
      6    0.672 2-7
      6    0.659 1,2,4-7
```

Number of variables: 7

```
No.Vars    Corr. Selections
      7    0.774 All
```

Global Test

```
Sample statistic (Rho): 0.932
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample)
Number of permuted statistics greater than or equal to Rho: 0
```

Best results

```
No.Vars    Corr. Selections
      3    0.932 1,3,4
      4    0.920 1,3,4,7
      2    0.917 1,4
      4    0.900 1-4
      3    0.899 1-3
      3    0.885 1,3,7
      2    0.880 3,4
      5    0.873 1-4,7
      3    0.871 3,4,7
      4    0.864 1-3,7
```

Outputs

```
Plot: Graph5
```

PCA Run with BEST Procedure on Select Environmental Variables

PCA
Principal Component Analysis

```
Data worksheet
Name: Cotee WQ square root transformed  normalized
Data type: Environmental
Sample selection: All
Variable selection: All

Eigenvalues
PC Eigenvalues  %Variation  Cum.%Variation
 1         3.8        54.3            54.3
 2        2.18        31.1            85.4
 3        0.76        10.9            96.2
 4       0.155         2.2            98.5
 5     8.04E-2         1.1            99.6

Eigenvectors
(Coefficients in the linear combinations of variables making up PC's)
Variable             PC1    PC2    PC3    PC4    PC5
RK                 0.348  0.459 -0.254  0.338  0.179
Temperature ( C)  -0.429  0.349 -0.078  0.054 -0.600
pH                -0.344 -0.479  0.133  0.285  0.479
Salinity          -0.497 -0.066  0.185 -0.366 -0.108
DO mg/l           -0.464  0.015 -0.398  0.620  0.007
Total Site Depth  -0.108  0.459  0.795  0.298  0.162
% Silt+Clay       -0.321  0.472 -0.294 -0.440  0.583

Principal Component Scores
Sample   SCORE1    SCORE2  SCORE3   SCORE4   SCORE5
RK 0.0    -1.37     -2.92   0.538 -2.21E-2   -0.242
RK 2.0    -1.12     -1.18   0.162   -0.172  4.07E-2
RK 3.5    -1.64  -3.43E-2  -0.683   -0.229     0.42
RK 5.0    -1.39      1.46   0.618 -1.45E-2    0.351
RK 6.5    -1.01      1.29   0.588    0.406   -0.185
RK 8.0    -1.04      1.14   -1.13    0.386   -0.353
RK 9.5     1.57     0.827  -0.662   -0.795   -0.249
RK 10.5    2.75     0.605    1.44 -2.15E-2 -2.98E-2
RK 11.2    3.24     -1.18  -0.879    0.463    0.249

Outputs
Plot: Graph4
```

MDS Run with BEST Procedure on Select Environmental Variables

MDS
Non-metric Multi-Dimensional Scaling

```
Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Parameters
Kruskal stress formula: 1
Minimum stress: 0.001

Best 3-d configuration (Stress: 0.009)
Sample       1     2     3    %
RK-0    -1.19 -0.77  0.28  3.2
RK-2    -1.07 -0.25 -0.31 21.1
RK-3.5  -0.72  0.44 -0.19 11.6
RK-5    -0.02  0.59  0.06  6.3
RK-6.5  -0.01  0.60  0.07  4.6
RK-8     0.43  0.24  0.57  3.5
RK-9.5   0.69  0.39 -0.14 24.6
RK-10.5  0.88 -0.33 -0.42 18.1
RK-11.2  1.01 -0.91  0.08  7.0

Best 2-d configuration (Stress: 0.029)
Sample       1     2    %
RK-0     1.21  0.84  1.8
RK-2     1.28  0.05 25.3
RK-3.5   0.68 -0.48  4.7
RK-5     0.15 -0.45 15.0
RK-6.5  -0.12 -0.50  4.0
RK-8    -0.51 -0.49  1.7
RK-9.5  -0.75 -0.18 25.9
RK-10.5 -1.01  0.21 20.1
RK-11.2 -0.93  0.99  1.6

STRESS VALUES
Repeat    3D       2D
     1  0.02 **  0.029
     2 0.013 **  0.029
     3 0.024 **   0.03
     4 0.013 **  0.029
     5 0.031      0.03 **
     6 0.026 **  0.057
     7 0.031      0.03
     8 0.009 **  0.029
     9  0.02 **  0.029
    10 0.013     0.029
    11 0.009     0.226
    12 0.013 **   0.03 **
    13 0.014 **  0.029
    14 0.143      0.03
    15 0.013 **   0.03
    16 0.014 **   0.03
```

```
17 0.018    0.029
18 0.018     0.03 **
19 0.033 ** 0.032 **
20 0.046    0.029 **
21 0.013    0.057
22 0.013    0.029
23 0.013     0.03
24  0.02    0.029
25 0.018 **  0.03
26 0.017    0.029
27 0.009     0.03
28 0.018     0.03
29 0.021 ** 0.029
30 0.018    0.029
31 0.024    0.029
32 0.164     0.03 **
33 0.019    0.029
34 0.014 ** 0.029
35  0.02     0.03
36 0.017 ** 0.029
37 0.044     0.03
38 0.021 ** 0.029
39 0.019    0.242
40 0.024     0.03
41 0.013 **  0.03
42 0.178    0.029
43 0.021 **  0.03
44 0.026 ** 0.029 **
45  0.02    0.029
46 0.024    0.205
47 0.031    0.032 **
48 0.013 **  0.03
49 0.022 ** 0.029
50 0.014    0.029
51 0.012 ** 0.029
52 0.016 ** 0.029
53 0.031    0.079
54 0.019     0.03
55 0.178    0.029
56 0.032     0.03
57 0.013    0.029
58 0.024     0.03 **
59 0.013    0.029
60 0.018 ** 0.029
61 0.025 ** 0.029
62 0.019 ** 0.029
63 0.044    0.057
64 0.014 ** 0.029
65 0.019    0.029
66 0.031     0.03
67 0.013 ** 0.058
68 0.031     0.03
69 0.031     0.03 **
70 0.017 ** 0.029
71 0.019    0.077
72  0.02     0.03
73 0.043    0.058
```

```
    74  0.03      0.03 **
    75 0.122     0.205
    76 0.022 **  0.029
    77 0.014 **  0.029
    78 0.132     0.032 **
    79 0.031      0.03
    80 0.014 **  0.029
    81  0.02     0.029
    82 0.014      0.03
    83 0.017 **  0.029
    84 0.031      0.03
    85 0.013     0.029
    86 0.014     0.029
    87 0.122      0.03
    88 0.017     0.029
    89 0.019 **   0.03
    90 0.021 **   0.03
    91 0.031      0.03 **
    92 0.015 **  0.029
    93 0.018 **  0.057
    94 0.122     0.226
    95 0.009     0.029
    96 0.044     0.057
    97 0.029     0.029
    98 0.019     0.029
    99 0.045 **  0.029
   100 0.014 **   0.03

** = Maximum number of iterations used

3-d : Minimum stress: 0.009 occurred 4 times
2-d : Minimum stress: 0.029 occurred 48 times
```

Outputs

Plot: Graph1
Plot: Graph2

BEST (Re-run with permutations test and forced exclusion of pH)

Biota and/or Environment matching

```
Data worksheet
Name: Data2
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 10
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 RK
  2 Temperature ( C)
  3 pH
  4 Salinity
  5 DO mg/l
  6 Total Site Depth
  7 % Silt+Clay

Global Test
Sample statistic (Rho): 0.917
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample)
Number of permuted statistics greater than or equal to Rho: 0

Best results
No.Vars    Corr. Selections
      2    0.917 1,4
      3    0.859 1,4,7
      3    0.850 1,2,4
      1    0.841 1
      2    0.818 1,2
      2    0.817 1,7
      4    0.800 1,2,4,7
      3    0.776 1,4,5
      4    0.774 1,4,6,7
      4    0.773 1,4,5,7

Outputs
Plot: Graph1
```

BEST (Re-run with permutations test and forced exclusion of pH and RK)

Biota and/or Environment matching

```
Data worksheet
Name: Data2
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 RK
  2 Temperature ( C)
  3 pH
  4 Salinity
  5 DO mg/l
  6 Total Site Depth
  7 % Silt+Clay

Number of variables: 1
No.Vars    Corr. Selections
      1    0.670 4
      1    0.371 2
      1    0.336 7
      1    0.271 5
      1   -0.003 6

Number of variables: 2
No.Vars    Corr. Selections
      2    0.701 4,7
      2    0.605 2,4
      2    0.514 4,5
      2    0.448 2,5
      2    0.430 4,6
      2    0.417 5,7
      2    0.382 2,7
      2    0.207 2,6
      2    0.167 6,7
      2    0.110 5,6

Number of variables: 3
No.Vars    Corr. Selections
      3    0.653 2,4,7
```

```
      3    0.601 4,5,7
      3    0.569 4,6,7
      3    0.527 2,4,5
      3    0.497 2,5,7
      3    0.448 2,4,6
      3    0.443 4-6
      3    0.282 2,6,7
      3    0.272 5-7
      3    0.266 2,5,6
```

Number of variables: 4

```
No.Vars    Corr. Selections
      4    0.592 2,4,5,7
      4    0.534 2,4,6,7
      4    0.508 4-7
      4    0.451 2,4-6
      4    0.382 2,5-7
```

Number of variables: 5

```
No.Vars    Corr. Selections
      5    0.523 2,4-7
```

Global Test

```
Sample statistic (Rho): 0.701
Significance level of sample statistic: 0.8%
Number of permutations: 999 (Random sample)
Number of permuted statistics greater than or equal to Rho: 7
```

Best results

```
No.Vars    Corr. Selections
      2    0.701 4,7
      1    0.670 4
      3    0.653 2,4,7
      2    0.605 2,4
      3    0.601 4,5,7
      4    0.592 2,4,5,7
      3    0.569 4,6,7
      4    0.534 2,4,6,7
      3    0.527 2,4,5
      5    0.523 2,4-7
```

Outputs

```
Plot: Graph1
```

BEST (Re-run with permutations test and forced exclusion of RK)
Biota and/or Environment matching

```
Data worksheet
Name: Data2
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 RK
  2 Temperature ( C)
  3 pH
  4 Salinity
  5 DO mg/l
  6 Total Site Depth
  7 % Silt+Clay

Number of variables: 1
No.Vars    Corr. Selections
      1    0.683 3
      1    0.670 4
      1    0.371 2
      1    0.336 7
      1    0.271 5
      1   -0.003 6

Number of variables: 2
No.Vars    Corr. Selections
      2    0.880 3,4
      2    0.836 2,3
      2    0.821 3,7
      2    0.701 4,7
      2    0.648 3,5
      2    0.605 2,4
      2    0.514 4,5
      2    0.507 3,6
      2    0.448 2,5
      2    0.430 4,6
      2    0.417 5,7
      2    0.382 2,7
      2    0.207 2,6
      2    0.167 6,7
```

```
      2    0.110 5,6

Number of variables: 3
No.Vars    Corr. Selections
      3    0.871 3,4,7
      3    0.832 2-4
      3    0.752 3-5
      3    0.750 2,3,7
      3    0.737 3,4,6
      3    0.703 3,5,7
      3    0.680 2,3,6
      3    0.657 3,6,7
      3    0.654 2,3,5
      3    0.653 2,4,7
      3    0.601 4,5,7
      3    0.569 4,6,7
      3    0.527 2,4,5
      3    0.507 3,5,6
      3    0.497 2,5,7
      3    0.448 2,4,6
      3    0.443 4-6
      3    0.282 2,6,7
      3    0.272 5-7
      3    0.266 2,5,6

Number of variables: 4
No.Vars    Corr. Selections
      4    0.801 2-4,7
      4    0.783 3,4,6,7
      4    0.765 3-5,7
      4    0.746 2-4,6
      4    0.717 2-5
      4    0.688 2,3,5,7
      4    0.687 2,3,6,7
      4    0.665 3-6
      4    0.611 3,5-7
      4    0.592 2,4,5,7
      4    0.581 2,3,5,6
      4    0.534 2,4,6,7
      4    0.508 4-7
      4    0.451 2,4-6
      4    0.382 2,5-7

Number of variables: 5
No.Vars    Corr. Selections
      5    0.757 2-4,6,7
      5    0.711 3-7
      5    0.701 2-5,7
      5    0.645 2-6
      5    0.610 2,3,5-7
      5    0.523 2,4-7

Global Test
Sample statistic (Rho): 0.88
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample)
Number of permuted statistics greater than or equal to Rho: 0
```

Best results

```
No.Vars    Corr. Selections
      2    0.880 3,4
      3    0.871 3,4,7
      2    0.836 2,3
      3    0.832 2-4
      2    0.821 3,7
      4    0.801 2-4,7
      4    0.783 3,4,6,7
      4    0.765 3-5,7
      5    0.757 2-4,6,7
      3    0.752 3-5
```

Outputs

```
Plot: Graph1
```

BEST (Re-run with permutations test and forced exclusion of salinity)

Biota and/or Environment matching

```
Data worksheet
Name: Data2
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 RK
  2 Temperature ( C)
  3 pH
  4 Salinity
  5 DO mg/l
  6 Total Site Depth
  7 % Silt+Clay

Number of variables: 1
No.Vars    Corr. Selections
      1    0.841 1
      1    0.683 3
      1    0.371 2
      1    0.336 7
      1    0.271 5
      1   -0.003 6

Number of variables: 2
No.Vars    Corr. Selections
      2    0.836 2,3
      2    0.821 3,7
      2    0.818 1,2
      2    0.817 1,7
      2    0.791 1,3
      2    0.720 1,5
      2    0.648 3,5
      2    0.551 1,6
      2    0.507 3,6
      2    0.448 2,5
      2    0.417 5,7
      2    0.382 2,7
      2    0.207 2,6
      2    0.167 6,7
```

```
      2    0.110 5,6
```

Number of variables: 3

```
No.Vars    Corr. Selections
      3    0.899 1-3
      3    0.885 1,3,7
      3    0.770 1,3,5
      3    0.753 1,2,7
      3    0.750 2,3,7
      3    0.727 1,5,7
      3    0.712 1,2,5
      3    0.703 3,5,7
      3    0.694 1,3,6
      3    0.680 2,3,6
      3    0.657 3,6,7
      3    0.654 2,3,5
      3    0.639 1,6,7
      3    0.633 1,2,6
      3    0.591 1,5,6
      3    0.507 3,5,6
      3    0.497 2,5,7
      3    0.282 2,6,7
      3    0.272 5-7
      3    0.266 2,5,6
```

Number of variables: 4

```
No.Vars    Corr. Selections
      4    0.864 1-3,7
      4    0.810 1,3,6,7
      4    0.805 1-3,6
      4    0.802 1,3,5,7
      4    0.792 1-3,5
      4    0.719 1,3,5,6
      4    0.688 2,3,5,7
      4    0.687 2,3,6,7
      4    0.673 1,2,5,7
      4    0.649 1,2,6,7
      4    0.643 1,5-7
      4    0.623 1,2,5,6
      4    0.611 3,5-7
      4    0.581 2,3,5,6
      4    0.382 2,5-7
```

Number of variables: 5

```
No.Vars    Corr. Selections
      5    0.794 1-3,6,7
      5    0.787 1-3,5,7
      5    0.778 1,3,5-7
      5    0.752 1-3,5,6
      5    0.610 2,3,5-7
      5    0.601 1,2,5-7
```

Global Test

```
Sample statistic (Rho): 0.899
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample)
Number of permuted statistics greater than or equal to Rho: 0
```

Best results

```
No.Vars    Corr. Selections
      3    0.899 1-3
      3    0.885 1,3,7
      4    0.864 1-3,7
      1    0.841 1
      2    0.836 2,3
      2    0.821 3,7
      2    0.818 1,2
      2    0.817 1,7
      4    0.810 1,3,6,7
      4    0.805 1-3,6
```

Outputs

```
Plot: Graph1
```

BEST

Biota and/or Environment matching

```
Data worksheet
Name: Data2
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Parameters
Rank correlation method: Spearman
Method: BIOENV
Maximum number of variables: 5
Resemblance:
Analyse between: Samples
Resemblance measure: D1 Euclidean distance

Variables
  1 RK
  2 Temperature ( C)
  3 pH
  4 Salinity
  5 DO mg/l
  6 Total Site Depth
  7 % Silt+Clay

Number of variables: 1
No.Vars    Corr. Selections
      1    0.683 3
      1    0.371 2
      1    0.336 7
      1    0.271 5
      1   -0.003 6

Number of variables: 2
No.Vars    Corr. Selections
      2    0.836 2,3
      2    0.821 3,7
      2    0.648 3,5
      2    0.507 3,6
      2    0.448 2,5
      2    0.417 5,7
      2    0.382 2,7
      2    0.207 2,6
      2    0.167 6,7
      2    0.110 5,6

Number of variables: 3
No.Vars    Corr. Selections
      3    0.750 2,3,7
      3    0.703 3,5,7
```

```
      3    0.680 2,3,6
      3    0.657 3,6,7
      3    0.654 2,3,5
      3    0.507 3,5,6
      3    0.497 2,5,7
      3    0.282 2,6,7
      3    0.272 5-7
      3    0.266 2,5,6
```

Number of variables: 4

```
No.Vars    Corr. Selections
      4    0.688 2,3,5,7
      4    0.687 2,3,6,7
      4    0.611 3,5-7
      4    0.581 2,3,5,6
      4    0.382 2,5-7
```

Number of variables: 5

```
No.Vars    Corr. Selections
      5    0.610 2,3,5-7
```

Global Test

```
Sample statistic (Rho): 0.836
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample)
Number of permuted statistics greater than or equal to Rho: 0
```

Best results

```
No.Vars    Corr. Selections
      2    0.836 2,3
      2    0.821 3,7
      3    0.750 2,3,7
      3    0.703 3,5,7
      4    0.688 2,3,5,7
      4    0.687 2,3,6,7
      1    0.683 3
      3    0.680 2,3,6
      3    0.657 3,6,7
      3    0.654 2,3,5
```

Outputs

```
Plot: Graph1
```

Appendix C

Results of SIMPER Statistical Procedure

Appendix C: PRIMER 6 Documentation – Part 2

SIMPER
Similarity Percentages - species contributions
Upstream versus Downstream Groups
One-Way Analysis

Data worksheet
Name: Data1
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

Sample	Salinity Groups
RK 0_A	Downstream
RK 0_B	Downstream
RK 0_C	Downstream
RK 2_A	Downstream
RK 2_B	Downstream
RK 2_C	Downstream
RK 3.5_A	Downstream
RK 3.5_B	Downstream
RK 3.5_C	Downstream
RK 5_A	Downstream
RK 5_B	Downstream
RK 5_C	Downstream
RK 6.5_A	Downstream
RK 6.5_B	Downstream
RK 6.5_C	Downstream
RK 8_A	Downstream
RK 8_B	Downstream
RK 8_C	Downstream
RK 9.5_A	Upstream
RK 9.5_A	Upstream
RK 9.5_A	Upstream
RK 10.5_A	Upstream
RK 10.5_B	Upstream
RK 10.5_C	Upstream
RK 11.2_A	Upstream
RK 11.2_B	Upstream
RK 11.2_C	Upstream

Group Downstream
Average similarity: 28.33

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Grandidierella bonnieroides	4.94	3.01	0.7	10.64	44.86
Mediomastus ambiseta	3.63	1.8	0.89	6.34	51.21
Streblospio sp.	2.7	1.48	0.71	5.24	56.44
Apocorophium louisianum	3.45	1.43	0.54	5.06	61.5
Hobsonia florida	2.66	1.17	0.61	4.14	65.64
Edotia triloba	2.33	0.82	0.52	2.91	68.55
Capitella capitata	2.31	0.78	0.63	2.74	71.28
Ampelisca sp.	2.26	0.58	0.43	2.06	73.34
Nemertea (LPIL)	1.69	0.58	0.54	2.05	75.4
Fabricinuda trilobata	2.92	0.46	0.36	1.64	77.04
Cyclaspis varians	1.62	0.4	0.39	1.41	78.45
Leptochelia sp.	1.42	0.39	0.32	1.39	79.84
Prionospio heterobranchia	1.86	0.36	0.39	1.29	81.13

Xenanthura brevitelson	1.73	0.36	0.31	1.26	82.38
Axiothella sp.	1.95	0.35	0.39	1.25	83.64
Hydrobiidae (LPIL)	1.32	0.34	0.31	1.2	84.84
Parandalia tricuspis	1.19	0.3	0.32	1.06	85.9
Angulus versicolor	1.48	0.28	0.32	0.98	86.87
Laeonereis culveri	1.57	0.25	0.19	0.9	87.77
Cerapus benthophilus	1.08	0.25	0.26	0.9	88.67
Americamysis sp.	0.84	0.2	0.26	0.7	89.37
Mooreonuphis pallidula	1.36	0.17	0.26	0.6	89.96
Pyrgophorus platyrachis	1.27	0.16	0.2	0.56	90.53

Group Upstream
Average similarity: 41.41

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Uromunna reynoldsi	4.59	5.03	5.07	12.16	42.44
Polypedilum halterale group Epler	4.58	4.43	1.62	10.7	53.14
Americorophium sp. A LeCroy	4.72	3.89	1.08	9.4	62.54
Apocorophium louisianum	4.26	3.12	0.82	7.53	70.08
Hobsonia florida	3.59	2.67	0.81	6.44	76.51
Tubificoid Naididae imm. w/o hair setae (LPIL)	2.55	1.93	0.82	4.65	81.16
Gammarus cf. tigrinus LeCroy	2.84	1.47	0.44	3.54	84.7
Turbellaria (LPIL)	1.69	0.84	0.44	2.02	86.72
Cernotina sp.	1.46	0.72	0.44	1.75	88.47
Aulodrilus pigueti	1.66	0.7	0.44	1.69	90.16

Groups Downstream & Upstream
Average dissimilarity = 81.18

	Group Downstream	Group Upstream				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Grandidierella bonnieroides	4.94	2.02	2.95	1.15	3.64	3.64
Americorophium sp. A LeCroy	0	4.72	2.69	1.47	3.31	6.95
Polypedilum halterale group Epler	0	4.58	2.61	1.86	3.22	10.17
Uromunna reynoldsi	0.22	4.59	2.51	2.35	3.09	13.26
Apocorophium louisianum	3.45	4.26	2.28	1.33	2.8	16.06
Mediomastus ambiseta	3.63	0	1.99	1.28	2.45	18.52
Hobsonia florida	2.66	3.59	1.78	1.32	2.19	20.71
Gammarus cf. tigrinus LeCroy	0	2.84	1.72	0.83	2.12	22.82
Streblospio sp.	2.7	0	1.66	1.14	2.05	24.87
Edotia triloba	2.33	1.13	1.48	0.99	1.82	26.69
Tubificoid Naididae imm. w/o hair setae (LPIL)	0.8	2.55	1.33	1.21	1.64	28.33
Fabricinuda trilobata	2.92	0	1.28	0.71	1.58	31.5
Ampelisca sp.	2.26	0.4	1.23	0.81	1.52	33.02
Laeonereis culveri	1.57	0.4	1.14	0.56	1.41	34.43
Capitella capitata	2.31	0	1.14	1.05	1.41	35.83
Turbellaria (LPIL)	0.61	1.69	1.08	0.9	1.32	37.16
Hydrobiidae (LPIL)	1.32	0.53	1	0.67	1.23	38.39
Leptochelia sp.	1.42	0.4	0.95	0.74	1.18	39.57
Procladius (Holotanypus) sp.	0	1.81	0.95	0.68	1.18	40.74
Xenanthura brevitelson	1.73	0	0.94	0.64	1.16	41.91
Aulodrilus pigueti	0	1.66	0.91	0.85	1.13	43.03
Axiothella sp.	1.95	0	0.87	0.73	1.08	44.11
Nemertea (LPIL)	1.69	0	0.87	0.98	1.08	45.19
Prionospio heterobranchia	1.86	0	0.86	0.76	1.05	46.24
Caecidotea sp.	0	1.35	0.85	0.62	1.05	47.29
Cernotina sp.	0	1.46	0.85	0.84	1.04	48.33
Procladius sp.	0	1.4	0.82	0.67	1	49.34
Cyclaspis varians	1.62	0	0.81	0.76	1	50.34
Ablabesmyia rhamphe group Epler	0	1.42	0.79	0.68	0.97	51.31
Pyrgophorus platyrachis	1.27	0	0.79	0.46	0.97	52.28
Tanytarsus sp. G Epler	0	1.45	0.77	0.68	0.95	53.23
Gammarus sp.	0	1.42	0.75	0.68	0.93	54.16
Angulus versicolor	1.48	0	0.7	0.68	0.87	55.02

Cerapus benthophilus	1.08	0	0.67	0.61	0.83	55.85
Parandalia tricuspis	1.19	0	0.67	0.67	0.83	56.68
Halmyrapseudes cf. bahamensis Heard	1.32	0	0.62	0.5	0.76	57.44
Mooreonuphis pallidula	1.36	0	0.6	0.6	0.74	58.18
Syllis sp.	1.25	0	0.54	0.55	0.66	58.84
Americamysis sp.	0.84	0	0.53	0.6	0.65	59.49
Bivalvia (LPIL)	0.65	0.34	0.52	0.62	0.64	60.13
Tagelus plebeius	0.77	0	0.51	0.53	0.62	60.75
Melinna sp.	1.09	0	0.5	0.61	0.61	61.37
Polypedilum scalaenum group Epler	0.52	0.48	0.49	0.49	0.61	61.98
Apocorophium lacustre	0.25	0.67	0.49	0.42	0.6	62.57
Cirrophorus sp.	0.88	0	0.47	0.43	0.58	63.15
Tanytarsus sp.	0	0.8	0.46	0.52	0.57	63.72
Melita nitida complex LeCroy	0.65	0	0.46	0.42	0.56	64.28
Ampelisca holmesi	0.76	0	0.45	0.3	0.56	64.84
Scolelepis texana	1	0	0.45	0.6	0.55	65.39
Cryptotendipes sp.	0	0.78	0.45	0.51	0.55	65.94
Stenochironomus sp.	0	0.78	0.45	0.51	0.55	66.49
Duridrilus tardus	0.9	0	0.44	0.49	0.54	67.04
Ceratopogonidae (LPIL)	0	0.85	0.44	0.52	0.54	67.57
Abra aequalis	0	0.8	0.43	0.52	0.53	68.11
Tanytarsus sp. T Epler	0	0.78	0.43	0.51	0.53	68.63
Dicrotendipes sp.	0	0.74	0.43	0.51	0.52	69.16
Monticellina dorsobranchialis	1.03	0	0.42	0.53	0.52	69.68
Amnicola dalli	0	0.82	0.42	0.51	0.52	70.19
Platyhelminthes (LPIL)	0.39	0.4	0.42	0.49	0.51	70.71
Oxyurostylis smithi	0.92	0	0.41	0.53	0.51	71.22
Tubificoides sp.	0.81	0	0.39	0.47	0.48	71.7
Coelotanypus tricolor	0	0.68	0.39	0.52	0.48	72.18
Caryocorbula sp.	0.67	0	0.38	0.44	0.47	72.65
Leitoscoloplos fragilis	0.63	0	0.37	0.42	0.46	73.11
Scoletoma sp. A (strom)	0.67	0	0.35	0.44	0.43	73.55
Mytilopsis leucophaeata	0.27	0.4	0.35	0.42	0.43	73.97
Pionosyllis sp.	0.77	0	0.34	0.52	0.42	74.4
Dicrotendipes neomodestus	0	0.55	0.32	0.34	0.4	74.8
Amphipoda (LPIL)	0.2	0.4	0.32	0.42	0.39	75.19
Acteocina canaliculata	0.59	0	0.32	0.44	0.39	75.58
Aoridae (LPIL)	0.73	0	0.31	0.44	0.38	75.96
Polymesoda caroliniana	0.25	0.4	0.31	0.42	0.38	76.34
Crepidula plana	0.56	0	0.3	0.44	0.37	76.71
Sphaerosyllis sp.	0.67	0	0.29	0.53	0.36	77.07
Apocorophium sp.	0.17	0.34	0.29	0.41	0.36	77.43
Anomalocardia auberiana	0.54	0	0.28	0.43	0.34	77.77
Potamethus spathiferus	0.7	0	0.27	0.43	0.33	78.1
Merisca sp.	0.68	0	0.26	0.41	0.32	78.42
Collembola (LPIL)	0.14	0.34	0.26	0.42	0.31	78.74
Amygdalum papyrium	0.48	0	0.25	0.43	0.31	79.05
Eteone heteropoda	0.58	0	0.25	0.44	0.31	79.36
Onuphidae (LPIL)	0.59	0	0.25	0.43	0.3	79.67
Olivella sp.	0.43	0	0.24	0.35	0.3	79.97
Piromis roberti	0.63	0	0.24	0.44	0.3	80.26
Cyrnellus fraternus	0	0.4	0.24	0.34	0.29	80.55
Leitoscoloplos sp.	0.41	0	0.23	0.35	0.29	80.84
Cyathura polita	0.42	0	0.23	0.35	0.28	81.12
Chironomus sp.	0	0.4	0.23	0.34	0.28	81.41
cf. Semelidae (LPIL)	0.56	0	0.23	0.44	0.28	81.69
Dicrotendipes lobus	0.38	0	0.23	0.34	0.28	81.98
Tribelos fuscicorne	0	0.4	0.23	0.34	0.28	82.25
Glossiphoniidae (LPIL)	0	0.34	0.22	0.34	0.27	82.52
Neurocordulia alabamensis	0	0.34	0.22	0.34	0.27	82.79
Tubificoid Naididae imm. w/ hair setae (LPIL)	0	0.34	0.22	0.34	0.27	83.06
Nemertea sp. J	0.56	0	0.21	0.44	0.26	83.32
Oecetis sp. E Floyd	0	0.4	0.21	0.34	0.26	83.58
Scoloplos rubra	0.54	0	0.21	0.44	0.25	83.84

Leptochelia rapax	0.41	0	0.2	0.33	0.25	84.09
Americorophium sp.	0.33	0	0.2	0.24	0.25	84.33
Sphaeromatidae (LPIL)	0	0.34	0.2	0.34	0.24	84.58
Cricotopus sp.	0	0.34	0.2	0.34	0.24	84.82
Orthocladiinae (LPIL)	0	0.34	0.2	0.34	0.24	85.07
Onobops jacksoni	0.34	0	0.2	0.24	0.24	85.31
Melitidae (LPIL)	0.39	0	0.19	0.35	0.24	85.55
cf. Potamethus sp.	0.34	0	0.19	0.35	0.24	85.79
Sphaeroma terebrans	0	0.34	0.19	0.34	0.23	86.02
Dubiraphia vittata	0	0.34	0.19	0.34	0.23	86.26
Polypedilum beckae	0	0.34	0.19	0.34	0.23	86.49
Tanytarsus sp. H Epler	0.33	0	0.19	0.24	0.23	86.72
Paradialychone sp.	0.41	0	0.19	0.24	0.23	86.95
Monocorophium acherusicum	0.33	0	0.18	0.24	0.23	87.18
Aricidea taylori	0.48	0	0.18	0.34	0.22	87.4
Pagastiella sp.	0	0.34	0.18	0.34	0.22	87.63
Actiniaria (LPIL)	0.43	0	0.18	0.35	0.22	87.84
Corophiidae (LPIL)	0.29	0	0.18	0.24	0.22	88.06
Rictaxis punctostriatus	0.34	0	0.17	0.34	0.21	88.27
Amakusanthura magnifica	0.28	0	0.17	0.24	0.21	88.48
Bulla striata	0.33	0	0.17	0.35	0.21	88.68
Caulleriella sp.	0.39	0	0.17	0.34	0.21	88.89
Polyplacophora sp. A (Strom)	0.36	0	0.16	0.24	0.2	89.09
Phascolion sp.	0.28	0	0.16	0.24	0.2	89.29
Dipolydora sp.	0.41	0	0.15	0.34	0.19	89.48
Pseudonototanais sp. B Heard	0.25	0	0.15	0.24	0.18	89.66
Langerhansia sp.	0.39	0	0.15	0.35	0.18	89.84
Spiochaetopterus costarum	0.39	0	0.15	0.35	0.18	90.02

SIMPER
Similarity Percentages - species contributions
River Kilometer Groups
One-Way Analysis

Data worksheet
Name: Data1
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 90.00%

Factor Groups

Sample	River Kilometer
RK 0_A	RK-0
RK 0_B	RK-0
RK 0_C	RK-0
RK 2_A	RK-2
RK 2_B	RK-2
RK 2_C	RK-2
RK 3.5_A	RK-3.5
RK 3.5_B	RK-3.5
RK 3.5_C	RK-3.5
RK 5_A	RK-5
RK 5_B	RK-5
RK 5_C	RK-5
RK 6.5_A	RK-6.5
RK 6.5_B	RK-6.5
RK 6.5_C	RK-6.5
RK 8_A	RK-8
RK 8_B	RK-8

RK 8_C	RK-8
RK 9.5_A	RK-9.5
RK 9.5_B	RK-9.5
RK 9.5_C	RK-9.5
RK 10.5_A	RK-10.5
RK 10.5_B	RK-10.5
RK 10.5_C	RK-10.5
RK 11.2_A	RK-11.2
RK 11.2_B	RK-11.2
RK 11.2_C	RK-11.2

Group RK-0
Average similarity: 29.82

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Cirrophorus sp.	5.26	4.15	7.13	13.92	13.92
Scoletoma sp. A (strom)	4	3.57	10.54	11.96	25.88
Axiothella sp.	3.99	3.32	10.52	11.12	37
Nemertea (LPIL)	3.63	3.02	7.4	10.14	47.14
Prionospio heterobranchia	4.45	2.89	9.87	9.69	56.83
Duridrilus tardus	3.16	1.53	0.58	5.12	61.95
Mooreonuphis pallidula	2.56	1.32	0.58	4.42	66.37
Capitella capitata	2.67	1.32	0.58	4.42	70.79
Olivella sp.	2.56	1.32	0.58	4.42	75.22
Angulus versicolor	2.83	1.16	0.58	3.89	79.11
Fabricinuda trilobata	4.83	0.89	0.58	2.98	82.09
Scolelepis texana	2.13	0.88	0.58	2.95	85.04
Pionosyllis sp.	2.19	0.75	0.58	2.51	87.55
Syllis sp.	3.48	0.75	0.58	2.51	90.06

Group RK-2
Average similarity: 55.50

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Fabricinuda trilobata	10.25	5.14	6.35	9.27	9.27
Mediomastus ambiseta	6.24	3	4.52	5.4	14.67
Monticellina dorsobranchialis	5.32	2.84	30.24	5.12	19.78
Axiothella sp.	6.71	2.83	9.11	5.1	24.88
Capitella capitata	5.95	2.69	15.11	4.84	29.73
Prionospio heterobranchia	5.27	2.51	6.39	4.52	34.25
Mooreonuphis pallidula	5.6	2.51	3.37	4.52	38.77
Angulus versicolor	4.71	2.49	38.13	4.48	43.25
Cyclaspis varians	4.29	2.33	22.55	4.2	47.45
Ampelisca sp.	4.43	2.33	32.58	4.2	51.65
Melinna sp.	4.48	2.28	6.46	4.11	55.76
Syllis sp.	4	2.05	29.63	3.7	59.45
Potamethus spathiferus	4.21	1.96	5.35	3.53	62.98
Piromis roberti	3.79	1.9	6.99	3.43	66.41
Scolelepis texana	3.87	1.83	10.33	3.3	69.72
Nemertea sp. J	3.37	1.73	29.63	3.11	72.83
Scoloplos rubra	3.24	1.73	29.63	3.11	75.94
Merisca sp.	4.09	1.73	29.63	3.11	79.05
Oxyurostylis smithi	3.3	0.89	0.58	1.6	80.65
Nemertea (LPIL)	2.77	0.75	0.58	1.35	82
Xenanthura brevitelson	2.64	0.68	0.58	1.22	83.22
Halmyrapseudes cf. bahamensis Heard	4.24	0.68	0.58	1.22	84.44
Aoridae (LPIL)	3.17	0.67	0.58	1.2	85.64
Eteone heteropoda	2.45	0.6	0.58	1.08	86.71
Pionosyllis sp.	2.45	0.6	0.58	1.08	87.79
cf. Semelidae (LPIL)	2.22	0.6	0.58	1.08	88.87
Sphaerosyllis sp.	2.03	0.57	0.58	1.02	89.89
Duridrilus tardus	2.22	0.57	0.58	1.02	90.91

Group RK-3.5

Average similarity: 34.99

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Mediomastus ambiseta	6.07	5.85	2.98	16.73	16.73
Hobsonia florida	3.75	4.07	21.35	11.63	28.36
Streblospio sp.	3.68	3.42	21.35	9.78	38.15
Ampelisca sp.	5.38	2.83	0.58	8.09	46.23
Xenanthura brevitelson	4.71	2.44	0.58	6.98	53.22
Grandidierella bonnieroides	3.89	1.55	0.58	4.42	57.64
Cyclaspis varians	3.09	1.55	0.58	4.42	62.05
Halmyrapseudes cf. bahamensis Heard	3.66	1.55	0.58	4.42	66.47
Hydrobiidae (LPIL)	2.54	1.42	0.58	4.07	70.54
Nemertea (LPIL)	2.03	1.2	0.58	3.42	73.97
Capitella capitata	2.22	1.2	0.58	3.42	77.39
Crepidula plana	2.03	1.2	0.58	3.42	80.81
Platyhelminthes (LPIL)	2.35	1.13	0.58	3.24	84.05
Fabricinuda trilobata	2.45	1.13	0.58	3.24	87.29
Leptochelia sp.	2.53	1.13	0.58	3.24	90.52

Group RK-5
Average similarity: 46.67

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Grandidierella bonnieroides	7.72	11.19	17.75	23.97	23.97
Mediomastus ambiseta	5.52	6.76	10.67	14.47	38.44
Apocorophium louisianum	5.07	6.71	35.04	14.37	52.81
Streblospio sp.	4.55	6.45	6.33	13.81	66.62
Tagelus plebeius	3.42	4.76	8.21	10.2	76.83
Leptochelia sp.	2.97	1.77	0.58	3.78	80.61
Ampelisca sp.	2.87	1.74	0.58	3.73	84.34
Xenanthura brevitelson	3.04	1.74	0.58	3.73	88.07
Cerapus benthophilus	2.4	1.53	0.58	3.28	91.34

Group RK-6.5
Average similarity: 41.94

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Grandidierella bonnieroides	8.57	10.19	12.78	24.29	24.29
Apocorophium louisianum	6.58	6.69	2.56	15.94	40.23
Pyrgophorus platyrachis	6.78	5.5	9.52	13.11	53.34
Edotia triloba	4.27	4.42	6.95	10.54	63.88
Streblospio sp.	4.13	4.28	4.06	10.21	74.09
Cerapus benthophilus	4.09	4.24	39.14	10.11	84.2
Hobsonia florida	3.15	1.55	0.58	3.7	87.9
Parandalia tricuspis	2.4	1.44	0.58	3.44	91.34

Group RK-8
Average similarity: 43.25

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Grandidierella bonnieroides	9.46	11.86	3.86	27.43	27.43
Apocorophium louisianum	9.03	7.78	3.89	17.98	45.41
Laeonereis culveri	6.34	6.95	3	16.06	61.47
Hobsonia florida	6.55	6.45	4.14	14.92	76.39
Edotia triloba	5.15	2.55	0.58	5.9	82.29
Hydrobiidae (LPIL)	3.67	2.05	0.58	4.74	87.03
Streblospio sp.	3.86	1.72	0.58	3.99	91.02

Group RK-9.5
Average similarity: 43.81

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Apocorophium louisianum	6.45	10.23	11.01	23.36	23.36
Uromunna reynoldsi	5.21	7.11	27.22	16.23	39.59

Hobsonia florida	5.16	6.77	5.66	15.45	55.04
Tubificoid Naididae imm. w/o hair setae (LPIL)	4.23	6.34	13.87	14.47	69.51
Grandidierella bonnieroides	6.05	4.41	0.58	10.06	79.57
Procladius sp.	3.18	2.53	0.58	5.77	85.34
Edotia triloba	3.4	2.37	0.58	5.41	90.74

Group RK-10.5
Average similarity: 55.59

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Americorophium sp. A LeCroy	6.91	9.48	15.42	17.06	17.06
Polypedilum halterale group Epler	7.18	9.12	11.19	16.41	33.47
Hobsonia florida	5.61	8.02	9.73	14.43	47.9
Apocorophium louisianum	6.35	7.42	4.3	13.35	61.24
Ablabesmyia rhamphe group Epler	4.26	5.97	7.18	10.74	71.99
Uromunna reynoldsi	5.32	5.68	4.07	10.22	82.21
Procladius (Holotanypus) sp.	3.62	2.08	0.58	3.74	85.95
Aulodrilus pigueti	2.96	1.81	0.58	3.25	89.21
Gammarus sp.	3.05	1.68	0.58	3.03	92.23

Group RK-11.2
Average similarity: 50.30

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Gammarus cf. tigrinus LeCroy	6.72	9.95	4.98	19.78	19.78
Polypedilum halterale group Epler	4.16	6.13	3.46	12.2	31.97
Americorophium sp. A LeCroy	4.21	6.09	4.12	12.11	44.08
Turbellaria (LPIL)	3.87	5.7	5.47	11.33	55.42
Uromunna reynoldsi	3.24	5.34	11.05	10.61	66.03
Cernotina sp.	3.37	5.34	11.05	10.61	76.64
Caecidotea sp.	2.03	1.92	0.58	3.82	80.46
Aulodrilus pigueti	2.03	1.82	0.58	3.61	84.06
Tubificoid Naididae imm. w/o hair setae (LPIL)	2.22	1.6	0.58	3.19	87.25
Coelotanypus tricolor	2.03	1.6	0.58	3.19	90.44

Groups RK-0 & RK-2
Average dissimilarity = 74.04

	Group RK-0	Group RK-2				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Fabricinuda trilobata	4.83	10.25	2.3	1.5	3.1	3.1
Cirrophorus sp.	5.26	0	1.85	4.22	2.5	5.61
Melinna sp.	0	4.48	1.57	7.11	2.12	7.73
Ampelisca sp.	0	4.43	1.55	11.29	2.09	9.82
Monticellina dorsobranchialis	0.85	5.32	1.55	3.72	2.09	11.91
Halmyrapseudes cf. bahamensis Heard	0	4.24	1.51	1.04	2.03	13.94
Cyclaspis varians	0	4.29	1.5	12.8	2.03	15.97
Mediomastus ambiseta	1.98	6.24	1.5	2.1	2.03	18
Potamethus spathiferus	0	4.21	1.47	4.21	1.99	19.99
Merisca sp.	0	4.09	1.45	2.39	1.96	21.95
Scoletoma sp. A (strom)	4	0	1.4	13.08	1.9	23.85
Piromis roberti	0	3.79	1.32	7.04	1.79	25.64
Nemertea sp. J	0	3.37	1.18	7.94	1.59	27.22
Scoloplos rubra	0	3.24	1.13	11.69	1.53	28.76
Capitella capitata	2.67	5.95	1.12	1.3	1.52	30.27
Aoridae (LPIL)	0	3.17	1.09	1.25	1.47	31.74
Syllis sp.	3.48	4	1.08	2.32	1.45	33.2
Mooreonuphis pallidula	2.56	5.6	1.06	1.44	1.43	34.62
Oxyurostylis smithi	1.21	3.3	1.01	1.31	1.36	35.99
Aricidea taylori	0	2.91	0.99	1.2	1.34	37.33
Axiothella sp.	3.99	6.71	0.98	1.06	1.33	38.66
Olivella sp.	2.56	0	0.94	1.33	1.26	39.92
Xenanthura brevitelson	0	2.64	0.92	1.3	1.25	41.17
Eteone heteropoda	0	2.45	0.88	1.26	1.19	42.36

Duridrilus tardus	3.16	2.22	0.85	1.37	1.15	43.52
Dipolydora sp.	0	2.45	0.85	1.25	1.15	44.67
Onuphidae (LPIL)	0.85	2.67	0.83	1.24	1.12	45.79
Langerhansia sp.	0	2.35	0.81	1.3	1.09	46.88
Spiochaetopterus costarum	0	2.35	0.81	1.3	1.09	47.98
Paradialychone sp.	2.49	0	0.8	0.67	1.08	49.05
Melitidae (LPIL)	2.33	0	0.79	1.26	1.07	50.12
Dipolydora socialis	0	2.17	0.77	0.66	1.04	51.17
Angulus versicolor	2.83	4.71	0.73	1.19	0.99	52.15
Podarkeopsis levifuscina	0	2.03	0.7	1.32	0.95	53.1
Ceratonereis sp.	0	2.03	0.7	1.32	0.95	54.05
Lysilla sp.	0	2.03	0.7	1.32	0.95	55
Tubificoides sp.	0	2.03	0.7	1.32	0.95	55.94
Polyplacophora sp. A (Strom)	2.17	0	0.7	0.67	0.94	56.88
cf. Semelidae (LPIL)	1.12	2.22	0.69	1.11	0.93	57.82
Prionospio heterobranchia	4.45	5.27	0.68	1.66	0.92	58.74
Pionosyllis sp.	2.19	2.45	0.68	1.2	0.92	59.66
Bulla striata	1.98	0	0.68	1.32	0.92	60.57
Scolelepis texana	2.13	3.87	0.67	1.28	0.9	61.47
Actiniaria (LPIL)	1.12	1.44	0.63	0.89	0.85	62.32
Phascolion sp.	1.65	0	0.61	0.67	0.83	63.15
Grubeosyllis clavata	1.89	0	0.61	0.67	0.82	63.97
Acteocina canaliculata	0	1.65	0.6	0.66	0.81	64.78
Caulleriella sp.	1.34	1.02	0.57	0.93	0.77	65.55
Nemertea (LPIL)	3.63	2.77	0.56	0.97	0.75	66.3
Sphaerosyllis sp.	1.98	2.03	0.54	1.05	0.73	67.03
Sphaerosyllis bilobata	1.44	0	0.53	0.67	0.72	67.75
Magelona pettiboneae	1.39	0	0.52	0.67	0.7	68.45
Odontosyllis sp.	0	1.44	0.51	0.66	0.69	69.14
Lucinidae (LPIL)	1.34	0	0.48	0.67	0.65	69.79
Fabriciinae (LPIL)	0.85	1.02	0.46	0.9	0.63	70.41
Capitella jonesi	1.28	0	0.46	0.67	0.62	71.03
Hobsonia florida	0	1.28	0.45	0.66	0.61	71.65
Aricidea philbinae	0.85	1.02	0.45	0.9	0.61	72.26
Listriella sp.	0	1.21	0.44	0.66	0.59	72.85
Chaetognatha (LPIL)	1.21	0	0.43	0.67	0.59	73.44
Lysianopsis alba	0	1.21	0.43	0.66	0.58	74.02
Gyptis brevipalpa	1.34	0	0.43	0.67	0.58	74.6
Paracaprella tenuis	1.34	0	0.43	0.67	0.58	75.17
Kalliapseudes sp.	1.34	0	0.43	0.67	0.58	75.75
Crepidula plana	1.34	0	0.43	0.67	0.58	76.33
Crassinella lunulata	1.34	0	0.43	0.67	0.58	76.91
Leitoscoloplos fragilis	1.12	0	0.42	0.67	0.56	77.48
Ampelisca holmesi	1.12	0	0.4	0.67	0.55	78.02
Phyllodoce arenae	0	1.21	0.4	0.66	0.55	78.57
Paracaprella sp.	0	1.21	0.4	0.66	0.55	79.12
Edotia triloba	0	1.21	0.4	0.66	0.55	79.66
Grubeosyllis sp.	0	1.02	0.37	0.66	0.5	80.16
Sphaerosyllis brevifrons	0	1.02	0.37	0.66	0.5	80.66
Parandalia tricuspis	0	1.02	0.37	0.66	0.5	81.15
Leptochelia rapax	0	1.02	0.37	0.66	0.5	81.65
Eulimastoma sp.	0	1.02	0.37	0.66	0.5	82.15
Lyonsia floridana	0	1.02	0.37	0.66	0.5	82.64
Ophiuroidea (LPIL)	0	1.02	0.37	0.66	0.5	83.14
Janua sp.	1.02	0	0.37	0.67	0.49	83.63
Americhelidium sp. A Lecroy	1.02	0	0.37	0.67	0.49	84.13
Nemertea sp. k (strom)	0	1.02	0.36	0.66	0.49	84.61
Lumbrineris sp.	0	1.02	0.36	0.66	0.49	85.1
Demonax microphthalmus	0	1.02	0.36	0.66	0.49	85.59
Naineris sp.	0	1.02	0.36	0.66	0.49	86.08
Rictaxis punctostriatus	0	1.02	0.36	0.66	0.49	86.56
Mooreonuphis sp.	1.12	0	0.36	0.67	0.49	87.05
Exogone sp.	1.12	0	0.36	0.67	0.49	87.54
Opisthosyllis longidentata	1.12	0	0.36	0.67	0.49	88.02

Microspio pigmentata	1.12	0	0.36	0.67	0.49	88.51
Tanaidomorpha (LPIL)	1.12	0	0.36	0.67	0.49	89
Polyplacophora sp. B (Strom)	1.12	0	0.36	0.67	0.49	89.48
Phoronida (LPIL)	1.12	0	0.36	0.67	0.49	89.97
Dorvillea rudolphi	0	1.02	0.34	0.66	0.46	90.43

Groups RK-0 & RK-3.5
Average dissimilarity = 87.76

Species	Group RK-0 Av.Abund	Group RK-3.5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Cirrophorus sp.	5.26	0	2.69	3.97	3.06	3.06
Ampelisca sp.	0	5.38	2.68	1.32	3.05	6.11
Xenanthura brevitelson	0	4.71	2.34	1.32	2.66	8.78
Mediomastus ambiseta	1.98	6.07	2.13	1.87	2.42	11.2
Scoletoma sp. A (strom)	4	0	2.03	10.08	2.31	13.51
Fabricinuda trilobata	4.83	2.45	2.03	1.18	2.31	15.83
Ampelisca holmesi	1.12	3.42	1.99	0.87	2.26	18.09
Grandidierella bonnieroides	0	3.89	1.92	1.22	2.19	20.28
Hobsonia florida	0	3.75	1.9	10.25	2.17	22.45
Streblospio sp.	0	3.68	1.87	3.54	2.13	24.58
Halmyrapseudes cf. bahamensis Heard	0	3.66	1.81	1.25	2.06	26.64
Prionospio heterobranchia	4.45	1.44	1.72	1.88	1.95	28.6
Duridrilus tardus	3.16	0	1.71	1.32	1.94	30.54
Syllis sp.	3.48	0	1.64	1.07	1.87	32.41
Cyclaspis varians	0	3.09	1.54	1.3	1.75	34.16
Axiothella sp.	3.99	1.02	1.52	1.84	1.73	35.89
Mooreonuphis pallidula	2.56	0	1.38	1.33	1.57	37.46
Olivella sp.	2.56	0	1.38	1.33	1.57	39.03
Angulus versicolor	2.83	1.34	1.3	1.22	1.49	40.52
Leptochelia sp.	0	2.53	1.29	1.22	1.47	41.99
Leitoscoloplos sp.	0	2.45	1.21	1.28	1.38	43.37
Platyhelminthes (LPIL)	0	2.35	1.18	1.3	1.35	44.72
Hydrobiidae (LPIL)	0.85	2.54	1.16	1.35	1.32	46.04
Scolelepis texana	2.13	0	1.14	1.27	1.3	47.34
Melitidae (LPIL)	2.33	0	1.13	1.28	1.29	48.63
Anomalocardia auberiana	0	2.22	1.12	1.31	1.28	49.91
Paradialychone sp.	2.49	0	1.11	0.67	1.26	51.17
Pionosyllis sp.	2.19	0	1.07	1.3	1.21	52.38
Americorophium sp.	0	1.96	1.04	0.66	1.18	53.56
Crepidula plana	1.34	2.03	1.03	1.31	1.18	54.74
cf. Potamethus sp.	0	2.03	1.01	1.32	1.15	55.89
Bulla striata	1.98	0	0.97	1.33	1.11	57
Monocorophium acherusicum	0	2	0.97	0.66	1.11	58.1
Polyplacophora sp. A (Strom)	2.17	0	0.97	0.67	1.1	59.21
Capitella capitata	2.67	2.22	0.96	1.15	1.09	60.3
Sphaerosyllis sp.	1.98	0	0.95	1.33	1.08	61.38
Corophiidae (LPIL)	0	1.73	0.92	0.66	1.04	62.42
Phascolion sp.	1.65	0	0.91	0.67	1.04	63.46
Amakusanthura magnifica	0	1.65	0.87	0.66	0.99	64.45
Grubeosyllis clavata	1.89	0	0.84	0.67	0.96	65.41
Sphaerosyllis bilobata	1.44	0	0.79	0.67	0.9	66.31
Oxyurostylis smithi	1.21	1.02	0.79	0.88	0.9	67.21
Nemertea (LPIL)	3.63	2.03	0.78	1.03	0.89	68.1
Pseudonototanais sp. B Heard	0	1.52	0.77	0.66	0.88	68.98
Magelona pettiboneae	1.39	0	0.77	0.67	0.87	69.86
Lucinidae (LPIL)	1.34	0	0.7	0.67	0.8	70.66
Tellina versicolor	0	1.34	0.68	0.66	0.78	71.43
Capitella jonesi	1.28	0	0.67	0.67	0.77	72.2
Chaetognatha (LPIL)	1.21	0	0.63	0.67	0.72	72.92
Leitoscoloplos fragilis	1.12	0	0.62	0.67	0.71	73.63
Gyptis brevipalpa	1.34	0	0.6	0.67	0.68	74.31
Caulleriella sp.	1.34	0	0.6	0.67	0.68	74.98
Paracaprella tenuis	1.34	0	0.6	0.67	0.68	75.66

Kalliapseudes sp.	1.34	0	0.6	0.67	0.68	76.34
Crassinella lunulata	1.34	0	0.6	0.67	0.68	77.02
Parandalia tricuspis	0	1.21	0.59	0.66	0.67	77.69
Aoridae (LPIL)	0	1.21	0.59	0.66	0.67	78.35
Melinna sp.	0	1.02	0.54	0.66	0.61	78.96
Edotia triloba	0	1.02	0.54	0.66	0.61	79.57
Rictaxis punctostriatus	0	1.02	0.54	0.66	0.61	80.18
Janua sp.	1.02	0	0.53	0.67	0.61	80.79
Americhelidium sp. A Lecroy	1.02	0	0.53	0.67	0.61	81.4
Cymadusa compta	0	1.02	0.52	0.66	0.59	81.99
Americamysis sp.	0	1.02	0.52	0.66	0.59	82.58
Acteocina canaliculata	0	1.02	0.52	0.66	0.59	83.17
Amygdalum papyrium	0	1.02	0.52	0.66	0.59	83.76
Actiniaria (LPIL)	1.12	0	0.5	0.67	0.57	84.33
Mooreonuphis sp.	1.12	0	0.5	0.67	0.57	84.9
Exogone sp.	1.12	0	0.5	0.67	0.57	85.47
Opisthosyllis longidentata	1.12	0	0.5	0.67	0.57	86.04
Microspio pigmentata	1.12	0	0.5	0.67	0.57	86.61
Tanaidomorpha (LPIL)	1.12	0	0.5	0.67	0.57	87.18
Polyplacophora sp. B (Strom)	1.12	0	0.5	0.67	0.57	87.75
cf. Semelidae (LPIL)	1.12	0	0.5	0.67	0.57	88.32
Phoronida (LPIL)	1.12	0	0.5	0.67	0.57	88.89
Eteone foliosa	0	1.02	0.49	0.66	0.56	89.45
Eteone heteropoda	0	1.02	0.49	0.66	0.56	90.01

Groups RK-2 & RK-3.5
Average dissimilarity = 76.25

	Group RK-2	Group RK-3.5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Fabricinuda trilobata	10.25	2.45	2.95	3.02	3.87	3.87
Axiothella sp.	6.71	1.02	2.19	1.86	2.87	6.74
Mooreonuphis pallidula	5.6	0	2.1	3.72	2.76	9.49
Monticellina dorsobranchialis	5.32	0	2	18.32	2.63	12.12
Potamethus spathiferus	4.21	0	1.58	4.36	2.08	14.2
Merisca sp.	4.09	0	1.56	2.41	2.04	16.24
Syllis sp.	4	0	1.51	5.71	1.99	18.23
Ampelisca sp.	4.43	5.38	1.48	5.9	1.94	20.16
Prionospio heterobranchia	5.27	1.44	1.47	1.68	1.93	22.1
Halmyrapseudes cf. bahamensis Heard	4.24	3.66	1.47	1.3	1.93	24.02
Scolelepis texana	3.87	0	1.47	4.09	1.92	25.95
Grandidierella bonnieroides	0	3.89	1.44	1.23	1.89	27.83
Xenanthura brevitelson	2.64	4.71	1.44	1.72	1.88	29.71
Piromis roberti	3.79	0	1.42	7.9	1.87	31.58
Capitella capitata	5.95	2.22	1.41	1.56	1.84	33.42
Streblospio sp.	0	3.68	1.39	3.76	1.82	35.25
Ampelisca holmesi	0	3.42	1.33	0.67	1.74	36.99
Melinna sp.	4.48	1.02	1.29	2.17	1.69	38.68
Nemertea sp. J	3.37	0	1.26	9.28	1.66	40.34
Angulus versicolor	4.71	1.34	1.26	1.66	1.65	41.99
Scoloplos rubra	3.24	0	1.22	17.3	1.6	43.59
Oxyurostylis smithi	3.3	1.02	1.12	1.37	1.46	45.05
Aricidea taylori	2.91	0	1.07	1.21	1.4	46.45
Aoridae (LPIL)	3.17	1.21	1.03	1.18	1.35	47.8
Onuphidae (LPIL)	2.67	0	1	1.21	1.31	49.1
Hydrobiidae (LPIL)	0	2.54	0.97	1.33	1.28	50.38
Hobsonia florida	1.28	3.75	0.96	1.44	1.26	51.64
Leptochelia sp.	0	2.53	0.96	1.24	1.26	52.9
Pionosyllis sp.	2.45	0	0.95	1.27	1.24	54.15
Dipolydora sp.	2.45	0	0.91	1.26	1.2	55.34
Leitoscoloplos sp.	0	2.45	0.91	1.29	1.19	56.54
Platyhelminthes (LPIL)	0	2.35	0.88	1.31	1.16	57.69
Langerhansia sp.	2.35	0	0.87	1.31	1.14	58.83
Spiochaetopterus costarum	2.35	0	0.87	1.31	1.14	59.97

cf. Semelidae (LPIL)	2.22	0	0.86	1.31	1.13	61.1
Duridrilus tardus	2.22	0	0.84	1.3	1.1	62.19
Dipolydora socialis	2.17	0	0.83	0.67	1.09	63.28
Eteone heteropoda	2.45	1.02	0.81	1.14	1.07	64.35
Nemertea (LPIL)	2.77	2.03	0.79	1.4	1.03	65.38
Crepidula plana	0	2.03	0.78	1.33	1.02	66.4
Acteocina canaliculata	1.65	1.02	0.76	0.94	1	67.4
Americorophium sp.	0	1.96	0.76	0.67	1	68.4
Sphaerosyllis sp.	2.03	0	0.76	1.33	1	69.4
cf. Potamethus sp.	0	2.03	0.75	1.33	0.99	70.39
Podarkeopsis levifuscina	2.03	0	0.75	1.33	0.99	71.38
Ceratonereis sp.	2.03	0	0.75	1.33	0.99	72.36
Lysilla sp.	2.03	0	0.75	1.33	0.99	73.35
Tubificoides sp.	2.03	0	0.75	1.33	0.99	74.34
Monocorophium acherusicum	0	2	0.73	0.67	0.96	75.29
Anomalocardia auberiana	1.02	2.22	0.71	1.12	0.94	76.23
Corophiidae (LPIL)	0	1.73	0.67	0.67	0.88	77.11
Cyclaspis varians	4.29	3.09	0.66	0.87	0.87	77.98
Amakusanthura magnifica	0	1.65	0.64	0.67	0.84	78.82
Parandalia tricuspis	1.02	1.21	0.58	0.9	0.76	79.58
Edotia triloba	1.21	1.02	0.58	0.9	0.76	80.34
Pseudonototanais sp. B Heard	0	1.52	0.57	0.67	0.75	81.09
Actiniaria (LPIL)	1.44	0	0.55	0.67	0.72	81.81
Odontosyllis sp.	1.44	0	0.55	0.67	0.72	82.53
Rictaxis punctostriatus	1.02	1.02	0.52	0.84	0.68	83.21
Tellina versicolor	0	1.34	0.51	0.67	0.66	83.87
Amygdalum papyrium	1.02	1.02	0.5	0.84	0.66	84.54
Mediomastus ambiseta	6.24	6.07	0.49	1.05	0.64	85.17
Listriella sp.	1.21	0	0.47	0.67	0.62	85.79
Lysianopsis alba	1.21	0	0.46	0.67	0.61	86.4
Phyllodoce arenae	1.21	0	0.43	0.67	0.57	86.96
Paracaprella sp.	1.21	0	0.43	0.67	0.57	87.53
Grubeosyllis sp.	1.02	0	0.4	0.67	0.52	88.05
Sphaerosyllis brevifrons	1.02	0	0.4	0.67	0.52	88.57
Fabriciinae (LPIL)	1.02	0	0.4	0.67	0.52	89.09
Leptochelia rapax	1.02	0	0.4	0.67	0.52	89.61
Eulimastoma sp.	1.02	0	0.4	0.67	0.52	90.13

Groups RK-0 & RK-5
Average dissimilarity = 95.21

Species	Group RK-0 Av.Abund	Group RK-5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Grandidierella bonnieroides	0	7.72	4.43	9.02	4.65	4.65
Cirrophorus sp.	5.26	0	3.04	3.79	3.2	7.85
Apocorophium louisianum	0	5.07	2.9	6.15	3.04	10.89
Streblospio sp.	0	4.55	2.62	5.83	2.75	13.64
Fabricinuda trilobata	4.83	0	2.53	1.01	2.65	16.29
Prionospio heterobranchia	4.45	0	2.46	3.24	2.59	18.88
Scoletoma sp. A (strom)	4	0	2.3	8.31	2.41	21.29
Axiothella sp.	3.99	0	2.27	10.41	2.39	23.68
Mediomastus ambiseta	1.98	5.52	2.06	1.61	2.16	25.84
Tagelus plebeius	0	3.42	1.96	6.64	2.06	27.9
Duridrilus tardus	3.16	0	1.94	1.31	2.04	29.94
Syllis sp.	3.48	0	1.84	1.08	1.93	31.88
Angulus versicolor	2.83	0	1.73	1.27	1.82	33.69
Leptochelia sp.	0	2.97	1.71	1.25	1.8	35.49
Xenanthura brevitelson	0	3.04	1.67	1.27	1.76	37.25
Nemertea (LPIL)	3.63	0.85	1.6	1.96	1.68	38.93
Ampelisca sp.	0	2.87	1.58	1.29	1.66	40.59
Mooreonuphis pallidula	2.56	0	1.57	1.32	1.65	42.24
Olivella sp.	2.56	0	1.57	1.32	1.65	43.89
Melita nitida complex LeCroy	0	2.44	1.46	1.12	1.53	45.42
Capitella capitata	2.67	0.85	1.44	1.3	1.52	46.94

Edotia triloba	0	2.33	1.34	1.24	1.41	48.35
Cerapus benthophilus	0	2.4	1.32	1.31	1.39	49.74
Scolelepis texana	2.13	0	1.3	1.27	1.37	51.1
Melitidae (LPIL)	2.33	0	1.27	1.28	1.34	52.44
Paradialychone sp.	2.49	0	1.23	0.67	1.29	53.73
Pionosyllis sp.	2.19	0	1.2	1.31	1.26	54.99
Bulla striata	1.98	0	1.09	1.33	1.15	56.14
Polyplacophora sp. A (Strom)	2.17	0	1.08	0.67	1.13	57.27
Sphaerosyllis sp.	1.98	0	1.07	1.32	1.12	58.39
Phascolion sp.	1.65	0	1.04	0.66	1.09	59.49
Americamysis sp.	0	1.71	1	1.31	1.05	60.54
Grubeosyllis clavata	1.89	0	0.94	0.67	0.98	61.53
Sphaerosyllis bilobata	1.44	0	0.91	0.66	0.95	62.48
Magelona pettiboneae	1.39	0	0.88	0.66	0.92	63.4
Leitoscoloplos fragilis	1.12	0.85	0.84	0.89	0.88	64.28
Lucinidae (LPIL)	1.34	0	0.8	0.66	0.84	65.12
Parandalia tricuspis	0	1.39	0.77	0.66	0.81	65.92
Capitella jonesi	1.28	0	0.76	0.66	0.8	66.73
Cyclaspis varians	0	1.34	0.74	0.66	0.78	67.5
Oxyurostylis smithi	1.21	0	0.72	0.66	0.76	68.26
Chaetognatha (LPIL)	1.21	0	0.72	0.66	0.76	69.02
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	1.28	0.7	0.66	0.74	69.75
Ampelisca holmesi	1.12	0	0.67	0.66	0.71	70.46
Hobsonia florida	0	1.21	0.66	0.66	0.7	71.15
Gyptis brevipalpa	1.34	0	0.66	0.67	0.7	71.85
Caulleriella sp.	1.34	0	0.66	0.67	0.7	72.55
Paracaprella tenuis	1.34	0	0.66	0.67	0.7	73.24
Kalliapseudes sp.	1.34	0	0.66	0.67	0.7	73.94
Crepidula plana	1.34	0	0.66	0.67	0.7	74.63
Crassinella lunulata	1.34	0	0.66	0.67	0.7	75.33
Bivalvia (LPIL)	0.85	0.85	0.66	0.83	0.69	76.02
Hydrobiidae (LPIL)	0.85	0.85	0.65	0.83	0.69	76.7
Janua sp.	1.02	0	0.61	0.66	0.64	77.34
Americhelidium sp. A Lecroy	1.02	0	0.61	0.66	0.64	77.98
cf. Sipuncula (LPIL)	0	1.02	0.56	0.66	0.59	78.57
Melinna sp.	0	1.02	0.56	0.66	0.59	79.16
Actiniaria (LPIL)	1.12	0	0.56	0.67	0.58	79.74
Mooreonuphis sp.	1.12	0	0.56	0.67	0.58	80.33
Exogone sp.	1.12	0	0.56	0.67	0.58	80.91
Opisthosyllis longidentata	1.12	0	0.56	0.67	0.58	81.49
Microspio pigmentata	1.12	0	0.56	0.67	0.58	82.08
Tanaidomorpha (LPIL)	1.12	0	0.56	0.67	0.58	82.66
Polyplacophora sp. B (Strom)	1.12	0	0.56	0.67	0.58	83.25
cf. Semelidae (LPIL)	1.12	0	0.56	0.67	0.58	83.83
Phoronida (LPIL)	1.12	0	0.56	0.67	0.58	84.41
Phyllodocidae (LPIL)	0.85	0	0.54	0.66	0.57	84.98
Sphaerosyllis taylori	0.85	0	0.54	0.66	0.57	85.55
Monticellina dorsobranchialis	0.85	0	0.54	0.66	0.57	86.11
Terebellidae (LPIL)	0.85	0	0.54	0.66	0.57	86.68
Aricidea sp.	0.85	0	0.54	0.66	0.57	87.24
Crepidula maculosa	0.85	0	0.54	0.66	0.57	87.81
Transennella cubaniana	0.85	0	0.54	0.66	0.57	88.37
Leitoscoloplos foliosus	0	0.85	0.53	0.66	0.56	88.93
Rhithropanopeus harrisii	0	0.85	0.53	0.66	0.56	89.49
Acteocina canaliculata	0	0.85	0.53	0.66	0.56	90.05

Groups RK-2 & RK-5
Average dissimilarity = 87.63

	Group RK-2	Group RK-5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Fabricinuda trilobata	10.25	0	4.24	5.38	4.84	4.84
Grandidierella bonnieroides	0	7.72	3.18	20.95	3.63	8.47
Axiothella sp.	6.71	0	2.8	2.5	3.19	11.66

Mooreonuphis pallidula	5.6	0	2.3	3.69	2.62	14.29
Monticellina dorsobranchialis	5.32	0	2.19	16.02	2.5	16.79
Prionospio heterobranchia	5.27	0	2.18	4.36	2.49	19.27
Capitella capitata	5.95	0.85	2.13	2.22	2.43	21.7
Apocorophium louisianum	0	5.07	2.08	7.17	2.38	24.08
Angulus versicolor	4.71	0	1.94	8.92	2.22	26.3
Streblospio sp.	0	4.55	1.88	7.99	2.14	28.44
Halmyrapseudes cf. bahamensis Heard	4.24	0	1.77	1.03	2.02	30.46
Potamethus spathiferus	4.21	0	1.73	4.31	1.98	32.44
Merisca sp.	4.09	0	1.7	2.39	1.94	34.38
Syllis sp.	4	0	1.66	5.51	1.89	36.28
Scolelepis texana	3.87	0	1.6	4.01	1.83	38.11
Piromis roberti	3.79	0	1.56	7.76	1.77	39.88
Melinna sp.	4.48	1.02	1.43	2.07	1.64	41.52
Tagelus plebeius	0	3.42	1.41	9.23	1.61	43.12
Nemertea sp. J	3.37	0	1.38	9.12	1.58	44.7
Oxyurostylis smithi	3.3	0	1.35	1.32	1.54	46.24
Scoloplos rubra	3.24	0	1.33	15.5	1.52	47.76
Aoridae (LPIL)	3.17	0	1.27	1.25	1.45	49.21
Cyclaspis varians	4.29	1.34	1.23	1.45	1.4	50.62
Leptochelia sp.	0	2.97	1.23	1.26	1.4	52.02
Aricidea taylori	2.91	0	1.16	1.21	1.33	53.35
Onuphidae (LPIL)	2.67	0	1.09	1.2	1.24	54.59
Eteone heteropoda	2.45	0	1.04	1.27	1.19	55.78
Pionosyllis sp.	2.45	0	1.04	1.27	1.19	56.96
Melita nitida complex LeCroy	0	2.44	1.03	1.15	1.18	58.14
Nemertea (LPIL)	2.77	0.85	1.03	1.37	1.17	59.31
Dipolydora sp.	2.45	0	1	1.25	1.14	60.45
Cerapus benthophilus	0	2.4	0.96	1.32	1.1	61.55
Langerhansia sp.	2.35	0	0.95	1.31	1.08	62.63
Spiochaetopterus costarum	2.35	0	0.95	1.31	1.08	63.71
cf. Semelidae (LPIL)	2.22	0	0.94	1.31	1.07	64.79
Xenanthura brevitelson	2.64	3.04	0.94	1.11	1.07	65.86
Duridrilus tardus	2.22	0	0.91	1.3	1.04	66.9
Dipolydora socialis	2.17	0	0.91	0.67	1.04	67.94
Edotia triloba	1.21	2.33	0.9	1.23	1.02	68.96
Sphaerosyllis sp.	2.03	0	0.83	1.33	0.95	69.91
Podarkeopsis levifuscina	2.03	0	0.82	1.33	0.94	70.85
Ceratonereis sp.	2.03	0	0.82	1.33	0.94	71.78
Lysilla sp.	2.03	0	0.82	1.33	0.94	72.72
Tubificoides sp.	2.03	0	0.82	1.33	0.94	73.66
Acteocina canaliculata	1.65	0.85	0.82	0.95	0.94	74.6
Ampelisca sp.	4.43	2.87	0.78	0.9	0.89	75.49
Americamysis sp.	0	1.71	0.72	1.33	0.82	76.3
Parandalia tricuspis	1.02	1.39	0.71	0.94	0.81	77.12
Hobsonia florida	1.28	1.21	0.69	0.86	0.79	77.9
Mediomastus ambiseta	6.24	5.52	0.66	1.23	0.75	78.65
Actiniaria (LPIL)	1.44	0	0.6	0.67	0.69	79.34
Odontosyllis sp.	1.44	0	0.6	0.67	0.69	80.03
Amygdalum papyrium	1.02	0.85	0.52	0.9	0.6	80.62
Listriella sp.	1.21	0	0.52	0.67	0.59	81.21
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	1.28	0.51	0.67	0.58	81.8
Lysianopsis alba	1.21	0	0.51	0.67	0.58	82.37
Phyllodoce arenae	1.21	0	0.47	0.67	0.54	82.91
Paracaprella sp.	1.21	0	0.47	0.67	0.54	83.45
Grubeosyllis sp.	1.02	0	0.43	0.67	0.5	83.94
Sphaerosyllis brevifrons	1.02	0	0.43	0.67	0.5	84.44
Fabriciinae (LPIL)	1.02	0	0.43	0.67	0.5	84.94
Leptochelia rapax	1.02	0	0.43	0.67	0.5	85.43
Eulimastoma sp.	1.02	0	0.43	0.67	0.5	85.93
Lyonsia floridana	1.02	0	0.43	0.67	0.5	86.42
Ophiuroidea (LPIL)	1.02	0	0.43	0.67	0.5	86.92
Nemertea sp. k (strom)	1.02	0	0.42	0.67	0.48	87.4
Lumbrineris sp.	1.02	0	0.42	0.67	0.48	87.89

Caulleriella sp.	1.02	0	0.42	0.67	0.48	88.37
Demonax microphthalmus	1.02	0	0.42	0.67	0.48	88.86
Naineris sp.	1.02	0	0.42	0.67	0.48	89.34
Rictaxis punctostriatus	1.02	0	0.42	0.67	0.48	89.83
cf. Sipuncula (LPIL)	0	1.02	0.41	0.67	0.47	90.29

Groups RK-3.5 & RK-5
Average dissimilarity = 69.35

	Group RK-3.5	Group RK-5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Apocorophium louisianum	0	5.07	3.25	7.84	4.69	4.69
Ampelisca sp.	5.38	2.87	2.85	1.63	4.12	8.81
Grandidierella bonnieroides	3.89	7.72	2.55	1.17	3.68	12.49
Xenanthura brevitelson	4.71	3.04	2.39	1.42	3.45	15.94
Ampelisca holmesi	3.42	0	2.32	0.66	3.35	19.29
Halmyrapseudes cf. bahamensis Heard	3.66	0	2.29	1.26	3.3	22.59
Tagelus plebeius	0	3.42	2.2	8.47	3.18	25.77
Cyclaspis varians	3.09	1.34	1.7	1.16	2.45	28.22
Hobsonia florida	3.75	1.21	1.68	1.38	2.42	30.64
Melita nitida complex LeCroy	0	2.44	1.64	1.13	2.37	33.01
Fabricinuda trilobata	2.45	0	1.59	1.24	2.3	35.31
Leitoscoloplos sp.	2.45	0	1.54	1.29	2.21	37.52
Leptochelia sp.	2.53	2.97	1.53	1.26	2.2	39.72
Platyhelminthes (LPIL)	2.35	0	1.5	1.31	2.17	41.89
Hydrobiidae (LPIL)	2.54	0.85	1.49	1.31	2.15	44.05
Cerapus benthophilus	0	2.4	1.48	1.32	2.13	46.18
Anomalocardia auberiana	2.22	0	1.42	1.32	2.05	48.24
Crepidula plana	2.03	0	1.35	1.32	1.94	50.18
Edotia triloba	1.02	2.33	1.34	1.26	1.93	52.11
Americorophium sp.	1.96	0	1.33	0.66	1.92	54.03
Capitella capitata	2.22	0.85	1.28	1.22	1.85	55.89
cf. Potamethus sp.	2.03	0	1.28	1.32	1.84	57.73
Monocorophium acherusicum	2	0	1.22	0.66	1.76	59.49
Corophiidae (LPIL)	1.73	0	1.18	0.66	1.7	61.18
Nemertea (LPIL)	2.03	0.85	1.15	1.18	1.66	62.85
Parandalia tricuspis	1.21	1.39	1.12	0.88	1.62	64.47
Amakusanthura magnifica	1.65	0	1.12	0.66	1.62	66.08
Mediomastus ambiseta	6.07	5.52	1.06	1.36	1.53	67.61
Americamysis sp.	1.02	1.71	1.03	1.23	1.49	69.1
Pseudonototanais sp. B Heard	1.52	0	0.99	0.66	1.42	70.52
Prionospio heterobranchia	1.44	0	0.93	0.66	1.34	71.87
Angulus versicolor	1.34	0	0.91	0.66	1.31	73.18
Melinna sp.	1.02	1.02	0.88	0.84	1.27	74.44
Tellina versicolor	1.34	0	0.87	0.66	1.25	75.69
Acteocina canaliculata	1.02	0.85	0.86	0.91	1.24	76.93
Amygdalum papyrium	1.02	0.85	0.83	0.89	1.2	78.13
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	1.28	0.78	0.67	1.13	79.26
Aoridae (LPIL)	1.21	0	0.74	0.66	1.06	80.32
Streblospio sp.	3.68	4.55	0.74	1.59	1.06	81.39
Rictaxis punctostriatus	1.02	0	0.69	0.66	0.99	82.38
Cymadusa compta	1.02	0	0.66	0.66	0.95	83.33
cf. Sipuncula (LPIL)	0	1.02	0.63	0.67	0.91	84.24
Eteone foliosa	1.02	0	0.62	0.66	0.89	85.13
Eteone heteropoda	1.02	0	0.62	0.66	0.89	86.02
Axiothella sp.	1.02	0	0.62	0.66	0.89	86.91
Apocorophium sp.	1.02	0	0.62	0.66	0.89	87.81
Oxyurostylis smithi	1.02	0	0.62	0.66	0.89	88.7
Ensis minor	1.02	0	0.62	0.66	0.89	89.59
Leitoscoloplos foliosus	0	0.85	0.6	0.67	0.87	90.46

Groups RK-0 & RK-6.5
Average dissimilarity = 96.38

	Group RK-0	Group RK-6.5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Grandidierella bonnieroides	0	8.57	4.54	7.14	4.71	4.71
Pyrgophorus platyrachis	0	6.78	3.54	2.1	3.68	8.38
Apocorophium louisianum	0	6.58	3.5	3.33	3.63	12.02
Cirrophorus sp.	5.26	0	2.8	3.88	2.9	14.92
Fabricinuda trilobata	4.83	0	2.34	1.01	2.43	17.35
Prionospio heterobranchia	4.45	0	2.27	3.17	2.36	19.71
Edotia triloba	0	4.27	2.25	4.52	2.33	22.04
Streblospio sp.	0	4.13	2.2	3.64	2.28	24.32
Cerapus benthophilus	0	4.09	2.15	4.59	2.23	26.55
Scoletoma sp. A (strom)	4	0	2.12	9.13	2.19	28.75
Axiothella sp.	3.99	0	2.09	11.1	2.17	30.92
Duridrilus tardus	3.16	0	1.78	1.31	1.85	32.77
Hobsonia florida	0	3.15	1.72	1.18	1.78	34.55
Syllis sp.	3.48	0	1.7	1.07	1.77	36.32
Angulus versicolor	2.83	0	1.58	1.27	1.64	37.96
Laeonereis culveri	0	3.07	1.56	0.66	1.62	39.58
Nemertea (LPIL)	3.63	0.85	1.47	1.98	1.53	41.11
Mooreonuphis pallidula	2.56	0	1.44	1.33	1.49	42.6
Olivella sp.	2.56	0	1.44	1.33	1.49	44.1
Parandalia tricuspis	0	2.4	1.29	1.32	1.34	45.43
Capitella capitata	2.67	1.02	1.29	1.23	1.33	46.77
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	2.33	1.27	1.16	1.32	48.09
Caryocorbula sp.	0	2.33	1.25	1.32	1.3	49.39
Scolelepis texana	2.13	0	1.19	1.27	1.24	50.63
Melitidae (LPIL)	2.33	0	1.17	1.28	1.22	51.85
Leitoscoloplos fragilis	1.12	1.81	1.15	0.97	1.19	53.04
Paradialychone sp.	2.49	0	1.15	0.67	1.19	54.23
Pionosyllis sp.	2.19	0	1.11	1.3	1.15	55.38
Onobops jacksoni	0	2.06	1.05	0.66	1.09	56.47
Bulla striata	1.98	0	1.01	1.33	1.05	57.52
Polyplacophora sp. A (Strom)	2.17	0	1	0.67	1.04	58.56
Tanytarsus sp. H Epler	0	1.96	1	0.66	1.04	59.59
Sphaerosyllis sp.	1.98	0	0.99	1.32	1.02	60.61
Phascolion sp.	1.65	0	0.95	0.67	0.99	61.6
Leptochelia sp.	0	1.81	0.92	0.66	0.95	62.55
Grubeosyllis clavata	1.89	0	0.87	0.67	0.9	63.46
Melita nitida complex LeCroy	0	1.48	0.84	0.66	0.87	64.33
Sphaerosyllis bilobata	1.44	0	0.83	0.67	0.86	65.19
Magelona pettiboneae	1.39	0	0.8	0.67	0.83	66.02
Mediomastus ambiseta	1.98	1.98	0.79	1.02	0.82	66.84
Apocorophium lacustre	0	1.48	0.76	0.66	0.79	67.62
Lucinidae (LPIL)	1.34	0	0.73	0.67	0.76	68.39
Leptochelia rapax	0	1.44	0.73	0.66	0.76	69.14
Dicrotendipes lobus	0	1.44	0.73	0.66	0.76	69.9
Capitella jonesi	1.28	0	0.7	0.67	0.73	70.63
Bivalvia (LPIL)	0.85	1.02	0.69	0.9	0.71	71.34
Oxyurostylis smithi	1.21	0	0.66	0.67	0.69	72.03
Chaetognatha (LPIL)	1.21	0	0.66	0.67	0.69	72.71
Ampithoidae (LPIL)	0	1.12	0.64	0.66	0.66	73.37
Cymadusa sp.	0	1.12	0.64	0.66	0.66	74.03
Tellinidae (LPIL)	0	1.12	0.64	0.66	0.66	74.69
Sipuncula (LPIL)	0	1.21	0.62	0.66	0.64	75.33
Gyptis brevipalpa	1.34	0	0.62	0.67	0.64	75.97
Caulleriella sp.	1.34	0	0.62	0.67	0.64	76.61
Paracaprella tenuis	1.34	0	0.62	0.67	0.64	77.25
Kalliapseudes sp.	1.34	0	0.62	0.67	0.64	77.89
Crepidula plana	1.34	0	0.62	0.67	0.64	78.53
Crassinella lunulata	1.34	0	0.62	0.67	0.64	79.17
Ampelisca holmesi	1.12	0	0.62	0.67	0.64	79.81
Polydora cornuta	0	1.21	0.61	0.66	0.64	80.45
Almyracuma bacescui	0	1.21	0.61	0.66	0.64	81.08
Tagelus plebeius	0	1.21	0.61	0.66	0.64	81.72

Turbellaria (LPIL)	0	1.12	0.58	0.66	0.6	82.32
Janua sp.	1.02	0	0.56	0.67	0.58	82.89
Americhelidium sp. A Lecroy	1.02	0	0.56	0.67	0.58	83.47
Cyclaspis varians	0	1.02	0.52	0.66	0.54	84.01
Actiniaria (LPIL)	1.12	0	0.52	0.67	0.54	84.55
Mooreonuphis sp.	1.12	0	0.52	0.67	0.54	85.09
Exogone sp.	1.12	0	0.52	0.67	0.54	85.62
Opisthosyllis longidentata	1.12	0	0.52	0.67	0.54	86.16
Microspio pigmentata	1.12	0	0.52	0.67	0.54	86.7
Tanaidomorpha (LPIL)	1.12	0	0.52	0.67	0.54	87.23
Polyplacophora sp. B (Strom)	1.12	0	0.52	0.67	0.54	87.77
cf. Semelidae (LPIL)	1.12	0	0.52	0.67	0.54	88.31
Phoronida (LPIL)	1.12	0	0.52	0.67	0.54	88.85
Phyllodocidae (LPIL)	0.85	0	0.49	0.67	0.51	89.36
Sphaerosyllis taylori	0.85	0	0.49	0.67	0.51	89.87
Monticellina dorsobranchialis	0.85	0	0.49	0.67	0.51	90.38

Groups RK-2 & RK-6.5
Average dissimilarity = 93.46

	Group RK-2	Group RK-6.5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Fabricinuda trilobata	10.25	0	4	5.46	4.28	4.28
Grandidierella bonnieroides	0	8.57	3.33	10.85	3.57	7.84
Axiothella sp.	6.71	0	2.63	2.51	2.82	10.66
Pyrgophorus platyrachis	0	6.78	2.61	2.1	2.79	13.46
Apocorophium louisianum	0	6.58	2.57	3.59	2.75	16.2
Mooreonuphis pallidula	5.6	0	2.16	3.7	2.32	18.52
Monticellina dorsobranchialis	5.32	0	2.06	16.58	2.21	20.73
Prionospio heterobranchia	5.27	0	2.05	4.4	2.19	22.92
Capitella capitata	5.95	1.02	1.94	2.04	2.08	25
Angulus versicolor	4.71	0	1.83	9.15	1.96	26.96
Melinna sp.	4.48	0	1.73	7.83	1.86	28.81
Halmyrapseudes cf. bahamensis Heard	4.24	0	1.67	1.04	1.78	30.6
Potamethus spathiferus	4.21	0	1.63	4.33	1.75	32.34
Mediomastus ambiseta	6.24	1.98	1.63	2.29	1.74	34.09
Streblospio sp.	0	4.13	1.61	4.07	1.73	35.81
Merisca sp.	4.09	0	1.6	2.4	1.72	37.53
Cerapus benthophilus	0	4.09	1.58	4.9	1.69	39.22
Syllis sp.	4	0	1.56	5.61	1.67	40.89
Scolelepis texana	3.87	0	1.51	4.05	1.62	42.51
Piromis roberti	3.79	0	1.47	7.77	1.57	44.08
Ampelisca sp.	4.43	0.85	1.39	2.63	1.49	45.56
Nemertea sp. J	3.37	0	1.3	9.09	1.39	46.96
Cyclaspis varians	4.29	1.02	1.28	2.09	1.37	48.33
Oxyurostylis smithi	3.3	0	1.27	1.32	1.36	49.69
Scoloplos rubra	3.24	0	1.25	15.88	1.34	51.03
Edotia triloba	1.21	4.27	1.23	1.6	1.31	52.34
Aoridae (LPIL)	3.17	0	1.2	1.25	1.28	53.63
Laeonereis culveri	0	3.07	1.16	0.67	1.24	54.87
Aricidea taylori	2.91	0	1.1	1.2	1.17	56.05
Hobsonia florida	1.28	3.15	1.09	1.17	1.17	57.22
Onuphidae (LPIL)	2.67	0	1.03	1.21	1.1	58.31
Xenanthura brevitelson	2.64	0	1.02	1.3	1.1	59.41
Eteone heteropoda	2.45	0	0.98	1.27	1.05	60.45
Pionosyllis sp.	2.45	0	0.98	1.27	1.05	61.5
Nemertea (LPIL)	2.77	0.85	0.97	1.37	1.03	62.54
Dipolydora sp.	2.45	0	0.94	1.26	1.01	63.54
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	2.33	0.93	1.18	0.99	64.54
Caryocorbula sp.	0	2.33	0.92	1.33	0.98	65.52
Langerhansia sp.	2.35	0	0.89	1.31	0.96	66.47
Spiochaetopterus costarum	2.35	0	0.89	1.31	0.96	67.43
cf. Semelidae (LPIL)	2.22	0	0.89	1.31	0.95	68.38
Duridrilus tardus	2.22	0	0.86	1.3	0.92	69.3

Dipolydora socialis	2.17	0	0.86	0.67	0.92	70.21
Parandalia tricuspis	1.02	2.4	0.8	1.21	0.86	71.07
Sphaerosyllis sp.	2.03	0	0.78	1.33	0.84	71.91
Onobops jacksoni	0	2.06	0.78	0.67	0.83	72.74
Podarkeopsis levifuscina	2.03	0	0.77	1.33	0.83	73.57
Ceratonereis sp.	2.03	0	0.77	1.33	0.83	74.4
Lysilla sp.	2.03	0	0.77	1.33	0.83	75.23
Tubificoides sp.	2.03	0	0.77	1.33	0.83	76.05
Tanytarsus sp. H Epler	0	1.96	0.74	0.67	0.79	76.85
Leptochelia rapax	1.02	1.44	0.69	0.95	0.73	77.58
Leitoscoloplos fragilis	0	1.81	0.68	0.67	0.73	78.31
Leptochelia sp.	0	1.81	0.68	0.67	0.73	79.04
Acteocina canaliculata	1.65	0	0.66	0.67	0.71	79.75
Melita nitida complex LeCroy	0	1.48	0.6	0.67	0.65	80.4
Actiniaria (LPIL)	1.44	0	0.57	0.67	0.61	81
Odontosyllis sp.	1.44	0	0.57	0.67	0.61	81.61
Apocorophium lacustre	0	1.48	0.56	0.67	0.6	82.21
Dicrotendipes lobus	0	1.44	0.54	0.67	0.58	82.79
Listriella sp.	1.21	0	0.49	0.67	0.52	83.31
Lysianopsis alba	1.21	0	0.48	0.67	0.51	83.82
Ampithoidae (LPIL)	0	1.12	0.46	0.67	0.49	84.31
Cymadusa sp.	0	1.12	0.46	0.67	0.49	84.8
Tellinidae (LPIL)	0	1.12	0.46	0.67	0.49	85.29
Sipuncula (LPIL)	0	1.21	0.46	0.67	0.49	85.78
Polydora cornuta	0	1.21	0.46	0.67	0.49	86.27
Almyracuma bacescui	0	1.21	0.46	0.67	0.49	86.76
Tagelus plebeius	0	1.21	0.46	0.67	0.49	87.25
Phyllodoce arenae	1.21	0	0.45	0.67	0.48	87.72
Paracaprella sp.	1.21	0	0.45	0.67	0.48	88.2
Turbellaria (LPIL)	0	1.12	0.43	0.67	0.46	88.65
Grubeosyllis sp.	1.02	0	0.41	0.67	0.44	89.09
Sphaerosyllis brevifrons	1.02	0	0.41	0.67	0.44	89.53
Fabriciinae (LPIL)	1.02	0	0.41	0.67	0.44	89.97
Eulimastoma sp.	1.02	0	0.41	0.67	0.44	90.4

Groups RK-3.5 & RK-6.5
Average dissimilarity = 79.94

	Group RK-3.5	Group RK-6.5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Pyrgophorus platyrachis	0	6.78	3.94	2.15	4.93	4.93
Apocorophium louisianum	0	6.58	3.9	3.46	4.88	9.81
Ampelisca sp.	5.38	0.85	2.95	1.47	3.69	13.5
Grandidierella bonnieroides	3.89	8.57	2.83	1.38	3.55	17.04
Xenanthura brevitelson	4.71	0	2.7	1.33	3.38	20.43
Mediomastus ambiseta	6.07	1.98	2.4	2.07	3	23.43
Cerapus benthophilus	0	4.09	2.39	5.11	2.99	26.42
Ampelisca holmesi	3.42	0	2.11	0.67	2.64	29.06
Halmyrapseudes cf. bahamensis Heard	3.66	0	2.09	1.26	2.62	31.68
Edotia triloba	1.02	4.27	1.88	1.9	2.35	34.03
Laeonereis culveri	0	3.07	1.73	0.67	2.17	36.19
Cyclaspis varians	3.09	1.02	1.6	1.33	2.01	38.2
Leptochelia sp.	2.53	1.81	1.56	1.28	1.95	40.16
Hydrobiidae (LPIL)	2.54	0	1.53	1.33	1.92	42.08
Fabricinuda trilobata	2.45	0	1.45	1.24	1.82	43.89
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	2.33	1.42	1.16	1.78	45.67
Leitoscoloplos sp.	2.45	0	1.4	1.29	1.76	47.43
Caryocorbula sp.	0	2.33	1.4	1.33	1.75	49.18
Platyhelminthes (LPIL)	2.35	0	1.37	1.31	1.72	50.9
Anomalocardia auberiana	2.22	0	1.3	1.32	1.63	52.52
Parandalia tricuspis	1.21	2.4	1.23	1.11	1.54	54.06
Crepidula plana	2.03	0	1.23	1.33	1.53	55.59
Americorophium sp.	1.96	0	1.21	0.67	1.51	57.11
Hobsonia florida	3.75	3.15	1.17	1.3	1.46	58.57

cf. Potamethus sp.	2.03	0	1.17	1.33	1.46	60.03
Onobops jacksoni	0	2.06	1.16	0.67	1.45	61.49
Capitella capitata	2.22	1.02	1.13	1.11	1.42	62.9
Monocorophium acherusicum	2	0	1.12	0.67	1.4	64.3
Tanytarsus sp. H Epler	0	1.96	1.11	0.67	1.38	65.68
Corophiidae (LPIL)	1.73	0	1.07	0.67	1.34	67.02
Nemertea (LPIL)	2.03	0.85	1.05	1.19	1.31	68.33
Amakusanthura magnifica	1.65	0	1.02	0.67	1.27	69.6
Leitoscoloplos fragilis	0	1.81	1.02	0.67	1.27	70.88
Melita nitida complex LeCroy	0	1.48	0.94	0.67	1.17	72.05
Pseudonototanais sp. B Heard	1.52	0	0.9	0.67	1.12	73.17
Prionospio heterobranchia	1.44	0	0.85	0.67	1.06	74.24
Apocorophium lacustre	0	1.48	0.84	0.67	1.05	75.29
Angulus versicolor	1.34	0	0.82	0.67	1.03	76.32
Leptochelia rapax	0	1.44	0.81	0.67	1.01	77.33
Dicrotendipes lobus	0	1.44	0.81	0.67	1.01	78.34
Tellina versicolor	1.34	0	0.79	0.67	0.99	79.33
Americamysis sp.	1.02	0.85	0.76	0.89	0.95	80.28
Ampithoidae (LPIL)	0	1.12	0.71	0.67	0.89	81.18
Cymadusa sp.	0	1.12	0.71	0.67	0.89	82.07
Tellinidae (LPIL)	0	1.12	0.71	0.67	0.89	82.96
Sipuncula (LPIL)	0	1.21	0.69	0.67	0.86	83.82
Polydora cornuta	0	1.21	0.68	0.67	0.85	84.67
Almyracuma bacescui	0	1.21	0.68	0.67	0.85	85.52
Tagelus plebeius	0	1.21	0.68	0.67	0.85	86.37
Aoridae (LPIL)	1.21	0	0.67	0.67	0.84	87.21
Turbellaria (LPIL)	0	1.12	0.64	0.67	0.8	88.01
Melinna sp.	1.02	0	0.62	0.67	0.78	88.8
Rictaxis punctostriatus	1.02	0	0.62	0.67	0.78	89.58
Streblospio sp.	3.68	4.13	0.61	1.15	0.76	90.34

Groups RK-5 & RK-6.5
Average dissimilarity = 56.53

	Group RK-5	Group RK-6.5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Pyrgophorus platyrachis	0.85	6.78	3.91	1.78	6.91	6.91
Mediomastus ambiseta	5.52	1.98	2.34	1.76	4.13	11.05
Laeonereis culveri	0	3.07	1.99	0.66	3.51	14.56
Xenanthura brevitelson	3.04	0	1.97	1.28	3.48	18.04
Hobsonia florida	1.21	3.15	1.95	1.1	3.45	21.49
Leptochelia sp.	2.97	1.81	1.93	1.22	3.42	24.91
Ampelisca sp.	2.87	0.85	1.71	1.37	3.02	27.93
Tagelus plebeius	3.42	1.21	1.66	1.5	2.94	30.87
Melita nitida complex LeCroy	2.44	1.48	1.63	1.16	2.88	33.75
Caryocorbula sp.	0	2.33	1.62	1.32	2.87	36.62
Tubificoid Naididae imm. w/o hair setae (LPIL)	1.28	2.33	1.53	1.15	2.71	39.33
Edotia triloba	2.33	4.27	1.52	1.37	2.68	42.01
Parandalia tricuspis	1.39	2.4	1.51	1.19	2.67	44.68
Apocorophium louisianum	5.07	6.58	1.4	1.49	2.48	47.16
Leitoscoloplos fragilis	0.85	1.81	1.37	0.92	2.42	49.58
Onobops jacksoni	0	2.06	1.33	0.66	2.36	51.93
Cerapus benthophilus	2.4	4.09	1.31	0.95	2.32	54.25
Tanytarsus sp. H Epler	0	1.96	1.27	0.66	2.25	56.5
Dicrotendipes lobus	0.85	1.44	1.13	0.93	2	58.49
Cyclaspis varians	1.34	1.02	1.11	0.91	1.96	60.46
Americamysis sp.	1.71	0.85	0.99	1.04	1.75	62.21
Apocorophium lacustre	0	1.48	0.97	0.66	1.71	63.91
Turbellaria (LPIL)	0.85	1.12	0.93	0.91	1.65	65.56
Leptochelia rapax	0	1.44	0.93	0.66	1.64	67.2
Bivalvia (LPIL)	0.85	1.02	0.86	0.89	1.53	68.73
Capitella capitata	0.85	1.02	0.86	0.89	1.52	70.25
Ampithoidae (LPIL)	0	1.12	0.83	0.66	1.48	71.73
Cymadusa sp.	0	1.12	0.83	0.66	1.48	73.2

Tellinidae (LPIL)	0	1.12	0.83	0.66	1.48	74.68
Sipuncula (LPIL)	0	1.21	0.79	0.66	1.4	76.07
Polydora cornuta	0	1.21	0.78	0.66	1.38	77.45
Almyracuma bacescui	0	1.21	0.78	0.66	1.38	78.83
Nemertea (LPIL)	0.85	0.85	0.76	0.84	1.34	80.17
cf. Sipuncula (LPIL)	1.02	0	0.66	0.66	1.17	81.34
Melinna sp.	1.02	0	0.66	0.66	1.17	82.51
Leitoscoloplos foliosus	0.85	0	0.64	0.66	1.13	83.64
Rhithropanopeus harrisii	0.85	0	0.64	0.66	1.13	84.76
Acteocina canaliculata	0.85	0	0.64	0.66	1.13	85.89
Ischadium recurvum	0.85	0	0.64	0.66	1.13	87.02
Crassostrea virginica	0.85	0	0.64	0.66	1.13	88.15
Grandidierella bonnieroides	7.72	8.57	0.6	1.38	1.07	89.21
Prionospio sp.	0	0.85	0.56	0.66	0.99	90.2

Groups RK-0 & RK-8
Average dissimilarity = 98.30

Species	Group RK-0 Av.Abund	Group RK-8 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Grandidierella bonnieroides	0	9.46	5.24	5.91	5.33	5.33
Apocorophium louisianum	0	9.03	4.68	3.6	4.76	10.09
Laeonereis culveri	0	6.34	3.69	2.11	3.76	13.85
Hobsonia florida	0	6.55	3.46	4.46	3.52	17.37
Cirrophorus sp.	5.26	0	2.99	2.9	3.04	20.41
Edotia triloba	0	5.15	2.5	1.3	2.55	22.96
Fabricinuda trilobata	4.83	0	2.48	0.98	2.52	25.48
Prionospio heterobranchia	4.45	0	2.42	2.71	2.46	27.94
Scoletoma sp. A (strom)	4	0	2.26	4.07	2.3	30.24
Axiothella sp.	3.99	0	2.23	4.34	2.27	32.51
Nemertea (LPIL)	3.63	0	2.04	3.89	2.07	34.58
Hydrobiidae (LPIL)	0.85	3.67	2.03	1.17	2.07	36.65
Duridrilus tardus	3.16	0	1.91	1.23	1.95	38.6
Streblospio sp.	0	3.86	1.89	1.25	1.93	40.53
Syllis sp.	3.48	0	1.81	1.04	1.84	42.36
Angulus versicolor	2.83	0	1.7	1.2	1.73	44.09
Mooreonuphis pallidula	2.56	0	1.54	1.25	1.57	45.67
Olivella sp.	2.56	0	1.54	1.25	1.57	47.24
Polypedilum scalaenum group Epler	0	3.11	1.51	1.3	1.54	48.78
Capitella capitata	2.67	1.12	1.41	1.07	1.44	50.21
Tubificoides sp.	0	2.83	1.4	1.18	1.43	51.64
Scolelepis texana	2.13	0	1.28	1.2	1.3	52.94
Melitidae (LPIL)	2.33	0	1.25	1.23	1.27	54.21
Cyathura polita	0	2.54	1.23	1.32	1.25	55.46
Paradialychone sp.	2.49	0	1.21	0.65	1.23	56.69
Pionosyllis sp.	2.19	0	1.18	1.24	1.2	57.89
Mediomastus ambiseta	1.98	0	1.08	1.26	1.09	58.98
Bulla striata	1.98	0	1.08	1.26	1.09	60.08
Polyplacophora sp. A (Strom)	2.17	0	1.06	0.65	1.07	61.15
Sphaerosyllis sp.	1.98	0	1.05	1.26	1.06	62.22
Phascolion sp.	1.65	0	1.03	0.64	1.04	63.26
Grubeosyllis clavata	1.89	0	0.92	0.65	0.93	64.19
Sphaerosyllis bilobata	1.44	0	0.89	0.64	0.91	65.1
Magelona pettiboneae	1.39	0	0.86	0.64	0.88	65.98
Bivalvia (LPIL)	0.85	1.21	0.83	0.92	0.84	66.82
Lucinidae (LPIL)	1.34	0	0.79	0.65	0.8	67.62
Americamysis sp.	0	1.44	0.76	0.66	0.77	68.39
Turbellaria (LPIL)	0	1.71	0.76	0.66	0.77	69.16
Caryocorbula sp.	0	1.71	0.76	0.66	0.77	69.93
Capitella jonesi	1.28	0	0.75	0.65	0.76	70.7
Mytilopsis leucophaeata	0	1.62	0.72	0.66	0.73	71.43
Oxyurostylis smithi	1.21	0	0.71	0.65	0.72	72.15
Chaetognatha (LPIL)	1.21	0	0.71	0.65	0.72	72.87
Leitoscoloplos fragilis	1.12	0	0.7	0.64	0.71	73.58

Polymesoda caroliniana	0	1.52	0.67	0.66	0.69	74.27
Ampelisca holmesi	1.12	0	0.66	0.65	0.67	74.94
Gyptis brevipalpa	1.34	0	0.65	0.65	0.66	75.6
Caulleriella sp.	1.34	0	0.65	0.65	0.66	76.26
Paracaprella tenuis	1.34	0	0.65	0.65	0.66	76.92
Kalliapseudes sp.	1.34	0	0.65	0.65	0.66	77.58
Crepidula plana	1.34	0	0.65	0.65	0.66	78.24
Crassinella lunulata	1.34	0	0.65	0.65	0.66	78.9
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	1.21	0.64	0.66	0.65	79.55
Hourstonius laguna	0	1.21	0.64	0.66	0.65	80.2
Amphipoda (LPIL)	0	1.21	0.64	0.66	0.65	80.85
Leptochelia sp.	0	1.21	0.64	0.66	0.65	81.49
Janua sp.	1.02	0	0.6	0.65	0.61	82.1
Americhelidium sp. A Lecroy	1.02	0	0.6	0.65	0.61	82.71
Boccardiella sp.	0	1.34	0.59	0.66	0.6	83.31
Gammarus mucronatus group LeCroy	0	1.34	0.59	0.66	0.6	83.92
Uromunna reynoldsi	0	1.34	0.59	0.66	0.6	84.52
Cyrenoida floridana	0	1.34	0.59	0.66	0.6	85.12
Actiniaria (LPIL)	1.12	0	0.55	0.65	0.55	85.68
Mooreonuphis sp.	1.12	0	0.55	0.65	0.55	86.23
Exogone sp.	1.12	0	0.55	0.65	0.55	86.79
Opisthosyllis longidentata	1.12	0	0.55	0.65	0.55	87.34
Microspio pigmentata	1.12	0	0.55	0.65	0.55	87.9
Tanaidomorpha (LPIL)	1.12	0	0.55	0.65	0.55	88.45
Polyplacophora sp. B (Strom)	1.12	0	0.55	0.65	0.55	89
cf. Semelidae (LPIL)	1.12	0	0.55	0.65	0.55	89.56
Phoronida (LPIL)	1.12	0	0.55	0.65	0.55	90.11

Groups RK-2 & RK-8
Average dissimilarity = 96.44

Species	Group RK-2 Av.Abund	Group RK-8 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Fabricinuda trilobata	10.25	0	4.16	4.17	4.31	4.31
Grandidierella bonnieroides	0	9.46	3.77	12.11	3.91	8.22
Apocorophium louisianum	0	9.03	3.44	3.22	3.56	11.78
Axiothella sp.	6.71	0	2.74	2.32	2.84	14.63
Laeonereis culveri	0	6.34	2.62	2.53	2.71	17.34
Mediomastus ambiseta	6.24	0	2.51	4.23	2.6	19.94
Mooreonuphis pallidula	5.6	0	2.25	3.22	2.33	22.27
Monticellina dorsobranchialis	5.32	0	2.15	6.22	2.22	24.5
Prionospio heterobranchia	5.27	0	2.13	3.63	2.21	26.71
Capitella capitata	5.95	1.12	2.04	1.73	2.11	28.82
Hobsonia florida	1.28	6.55	2.03	2.08	2.1	30.92
Angulus versicolor	4.71	0	1.91	5.35	1.98	32.9
Melinna sp.	4.48	0	1.8	5.09	1.87	34.77
Ampelisca sp.	4.43	0	1.78	6.15	1.85	36.62
Edotia triloba	1.21	5.15	1.78	1.47	1.85	38.46
Halmyrapseudes cf. bahamensis Heard	4.24	0	1.74	1.01	1.8	40.26
Cyclaspis varians	4.29	0	1.73	6.25	1.8	42.06
Potamethus spathiferus	4.21	0	1.7	3.61	1.76	43.82
Merisca sp.	4.09	0	1.67	2.23	1.73	45.55
Syllis sp.	4	0	1.62	4.23	1.68	47.23
Scolelepis texana	3.87	0	1.57	3.41	1.63	48.86
Hydrobiidae (LPIL)	0	3.67	1.55	1.15	1.61	50.48
Piromis roberti	3.79	0	1.52	5.09	1.58	52.06
Streblospio sp.	0	3.86	1.42	1.27	1.47	53.53
Nemertea sp. J	3.37	0	1.35	5.43	1.4	54.93
Oxyurostylis smithi	3.3	0	1.32	1.28	1.37	56.3
Scoloplos rubra	3.24	0	1.3	6.19	1.35	57.65
Aoridae (LPIL)	3.17	0	1.25	1.22	1.29	58.95
Aricidea taylori	2.91	0	1.14	1.18	1.18	60.13
Polypedilum scalaenum group Epler	0	3.11	1.14	1.32	1.18	61.31
Nemertea (LPIL)	2.77	0	1.11	1.28	1.16	62.46

Onuphidae (LPIL)	2.67	0	1.07	1.17	1.11	63.57
Xenanthura brevitelson	2.64	0	1.06	1.26	1.1	64.67
Eteone heteropoda	2.45	0	1.02	1.23	1.06	65.73
Pionosyllis sp.	2.45	0	1.02	1.23	1.06	66.78
Dipolydora sp.	2.45	0	0.98	1.22	1.01	67.8
Langerhansia sp.	2.35	0	0.93	1.28	0.96	68.76
Spiochaetopterus costarum	2.35	0	0.93	1.28	0.96	69.72
Cyathura polita	0	2.54	0.92	1.33	0.96	70.68
cf. Semelidae (LPIL)	2.22	0	0.92	1.27	0.96	71.64
Duridrilus tardus	2.22	0	0.89	1.26	0.93	72.56
Dipolydora socialis	2.17	0	0.89	0.66	0.92	73.49
Tubificoides sp.	2.03	2.83	0.88	1.23	0.91	74.4
Sphaerosyllis sp.	2.03	0	0.81	1.29	0.84	75.25
Podarkeopsis levifuscina	2.03	0	0.8	1.29	0.83	76.08
Ceratonereis sp.	2.03	0	0.8	1.29	0.83	76.92
Lysilla sp.	2.03	0	0.8	1.29	0.83	77.75
Acteocina canaliculata	1.65	0	0.69	0.66	0.72	78.47
Actiniaria (LPIL)	1.44	0	0.59	0.66	0.61	79.08
Odontosyllis sp.	1.44	0	0.59	0.66	0.61	79.69
Turbellaria (LPIL)	0	1.71	0.58	0.67	0.6	80.29
Caryocorbula sp.	0	1.71	0.58	0.67	0.6	80.9
Parandalia tricuspis	1.02	1.12	0.57	0.86	0.59	81.49
Americamysis sp.	0	1.44	0.56	0.67	0.58	82.07
Mytilopsis leucophaeata	0	1.62	0.55	0.67	0.57	82.64
Polymesoda caroliniana	0	1.52	0.52	0.67	0.54	83.18
Listriella sp.	1.21	0	0.51	0.66	0.52	83.7
Lysianopsis alba	1.21	0	0.5	0.66	0.51	84.22
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	1.21	0.47	0.67	0.49	84.7
Hourstonius laguna	0	1.21	0.47	0.67	0.49	85.19
Amphipoda (LPIL)	0	1.21	0.47	0.67	0.49	85.68
Leptochelia sp.	0	1.21	0.47	0.67	0.49	86.16
Bivalvia (LPIL)	0	1.21	0.47	0.67	0.49	86.65
Phyllodoce arenae	1.21	0	0.46	0.66	0.48	87.13
Paracaprella sp.	1.21	0	0.46	0.66	0.48	87.61
Boccardiella sp.	0	1.34	0.46	0.67	0.47	88.08
Gammarus mucronatus group LeCroy	0	1.34	0.46	0.67	0.47	88.55
Uromunna reynoldsi	0	1.34	0.46	0.67	0.47	89.03
Cyrenoida floridana	0	1.34	0.46	0.67	0.47	89.5
Grubeosyllis sp.	1.02	0	0.43	0.66	0.44	89.94
Sphaerosyllis brevifrons	1.02	0	0.43	0.66	0.44	90.38

Groups RK-3.5 & RK-8
Average dissimilarity = 82.49

	Group RK-3.5	Group RK-8				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Apocorophium louisianum	0	9.03	5.22	4.12	6.33	6.33
Laeonereis culveri	0	6.34	4.18	2.06	5.06	11.39
Mediomastus ambiseta	6.07	0	3.89	2.78	4.72	16.11
Grandidierella bonnieroides	3.89	9.46	3.5	1.52	4.24	20.35
Ampelisca sp.	5.38	0	3.33	1.24	4.04	24.4
Xenanthura brevitelson	4.71	0	2.91	1.24	3.53	27.93
Edotia triloba	1.02	5.15	2.69	1.58	3.26	31.19
Ampelisca holmesi	3.42	0	2.29	0.64	2.78	33.96
Halmyrapseudes cf. bahamensis Heard	3.66	0	2.25	1.19	2.73	36.7
Cyclaspis varians	3.09	0	1.92	1.22	2.33	39.02
Hydrobiidae (LPIL)	2.54	3.67	1.89	1.24	2.29	41.31
Streblospio sp.	3.68	3.86	1.8	1.48	2.18	43.49
Polypedilum scalaenum group Epler	0	3.11	1.67	1.3	2.03	45.52
Fabricinuda trilobata	2.45	0	1.57	1.16	1.9	47.42
Hobsonia florida	3.75	6.55	1.56	1.39	1.89	49.31
Tubificoides sp.	0	2.83	1.55	1.18	1.88	51.19
Leitoscoloplos sp.	2.45	0	1.51	1.21	1.83	53.02
Platyhelminthes (LPIL)	2.35	0	1.48	1.23	1.8	54.82

Leptochelia sp.	2.53	1.21	1.46	1.07	1.77	56.59
Anomalocardia auberiana	2.22	0	1.4	1.24	1.7	58.29
Cyathura polita	0	2.54	1.36	1.33	1.65	59.94
Nemertea (LPIL)	2.03	0	1.33	1.23	1.61	61.55
Crepidula plana	2.03	0	1.33	1.23	1.61	63.16
Americorophium sp.	1.96	0	1.32	0.64	1.59	64.76
Capitella capitata	2.22	1.12	1.3	1.04	1.57	66.33
cf. Potamethus sp.	2.03	0	1.26	1.24	1.53	67.85
Monocorophium acherusicum	2	0	1.2	0.64	1.45	69.31
Corophiidae (LPIL)	1.73	0	1.16	0.64	1.41	70.71
Amakusanthura magnifica	1.65	0	1.11	0.64	1.34	72.05
Americamysis sp.	1.02	1.44	1.09	0.92	1.33	73.38
Pseudonototanais sp. B Heard	1.52	0	0.97	0.64	1.18	74.56
Parandalia tricuspis	1.21	1.12	0.92	0.83	1.12	75.68
Prionospio heterobranchia	1.44	0	0.92	0.64	1.11	76.79
Angulus versicolor	1.34	0	0.9	0.64	1.09	77.87
Tellina versicolor	1.34	0	0.86	0.64	1.04	78.91
Turbellaria (LPIL)	0	1.71	0.83	0.67	1.01	79.92
Caryocorbula sp.	0	1.71	0.83	0.67	1.01	80.92
Mytilopsis leucophaeata	0	1.62	0.79	0.67	0.95	81.88
Polymesoda caroliniana	0	1.52	0.74	0.67	0.89	82.77
Aoridae (LPIL)	1.21	0	0.72	0.64	0.88	83.65
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	1.21	0.71	0.67	0.86	84.51
Hourstonius laguna	0	1.21	0.71	0.67	0.86	85.37
Amphipoda (LPIL)	0	1.21	0.71	0.67	0.86	86.23
Bivalvia (LPIL)	0	1.21	0.71	0.67	0.86	87.09
Melinna sp.	1.02	0	0.68	0.64	0.82	87.92
Rictaxis punctostriatus	1.02	0	0.68	0.64	0.82	88.74
Boccardiella sp.	0	1.34	0.65	0.67	0.79	89.53
Gammarus mucronatus group LeCroy	0	1.34	0.65	0.67	0.79	90.31

Groups RK-5 & RK-8
Average dissimilarity = 69.39

	Group RK-5	Group RK-8				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Laeonereis culveri	0	6.34	4.99	1.86	7.18	7.18
Mediomastus ambiseta	5.52	0	4.12	2.62	5.94	13.12
Hobsonia florida	1.21	6.55	3.67	2.06	5.28	18.41
Edotia triloba	2.33	5.15	3.01	1.94	4.34	22.75
Hydrobiidae (LPIL)	0.85	3.67	2.82	1.06	4.06	26.8
Apocorophium louisianum	5.07	9.03	2.77	1.56	3.99	30.79
Tagelus plebeius	3.42	0	2.57	3.15	3.7	34.5
Xenanthura brevitelson	3.04	0	2.16	1.18	3.11	37.6
Streblospio sp.	4.55	3.86	2.11	1.01	3.03	40.64
Ampelisca sp.	2.87	0	2.04	1.2	2.93	43.57
Leptochelia sp.	2.97	1.21	1.99	1.07	2.87	46.45
Melita nitida complex LeCroy	2.44	0	1.94	1.01	2.79	49.24
Polypedilum scalaenum group Epler	0	3.11	1.91	1.29	2.75	51.99
Tubificoides sp.	0	2.83	1.77	1.17	2.56	54.55
Cerapus benthophilus	2.4	0	1.7	1.21	2.45	57
Cyathura polita	0	2.54	1.55	1.32	2.23	59.24
Americamysis sp.	1.71	1.44	1.51	1.37	2.18	61.41
Turbellaria (LPIL)	0.85	1.71	1.24	0.97	1.78	63.2
Parandalia tricuspis	1.39	1.12	1.21	0.82	1.74	64.94
Tubificoid Naididae imm. w/o hair setae (LPIL)	1.28	1.21	1.2	0.82	1.74	66.68
Grandidierella bonnieroides	7.72	9.46	1.15	1.88	1.65	68.33
Bivalvia (LPIL)	0.85	1.21	1.06	0.9	1.53	69.86
Cyclaspis varians	1.34	0	0.95	0.64	1.38	71.23
Caryocorbula sp.	0	1.71	0.93	0.67	1.34	72.58
Capitella capitata	0.85	1.12	0.92	0.9	1.32	73.9
Mytilopsis leucophaeata	0	1.62	0.89	0.67	1.28	75.17
Polymesoda caroliniana	0	1.52	0.83	0.67	1.2	76.37
Hourstonius laguna	0	1.21	0.82	0.66	1.18	77.55

Amphipoda (LPIL)	0	1.21	0.82	0.66	1.18	78.73
Boccardiella sp.	0	1.34	0.73	0.67	1.05	79.79
Gammarus mucronatus group LeCroy	0	1.34	0.73	0.67	1.05	80.84
Uromunna reynoldsi	0	1.34	0.73	0.67	1.05	81.89
Cyrenoida floridana	0	1.34	0.73	0.67	1.05	82.94
cf. Sipuncula (LPIL)	1.02	0	0.72	0.64	1.04	83.99
Melinna sp.	1.02	0	0.72	0.64	1.04	85.03
Leitoscoloplos foliosus	0.85	0	0.72	0.63	1.03	86.07
Rhithropanopeus harrisii	0.85	0	0.72	0.63	1.03	87.1
Acteocina canaliculata	0.85	0	0.72	0.63	1.03	88.13
Pyrgophorus platyrachis	0.85	0	0.72	0.63	1.03	89.17
Ischadium recurvum	0.85	0	0.72	0.63	1.03	90.2

Groups RK-6.5 & RK-8
Average dissimilarity = 63.71

Species	Group RK-6.5 Av.Abund	Group RK-8 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Pyrgophorus platyrachis	6.78	0	4.49	1.88	7.04	7.04
Laeonereis culveri	3.07	6.34	3.59	1.48	5.64	12.68
Cerapus benthophilus	4.09	0	2.73	3.13	4.28	16.96
Hydrobiidae (LPIL)	0	3.67	2.69	1.06	4.22	21.18
Edotia triloba	4.27	5.15	2.57	2.27	4.03	25.21
Apocorophium louisianum	6.58	9.03	2.42	1.84	3.8	29.01
Hobsonia florida	3.15	6.55	2.36	1.66	3.7	32.71
Streblospio sp.	4.13	3.86	1.88	1.16	2.95	35.65
Polypedilum scalaenum group Epler	0	3.11	1.75	1.3	2.74	38.4
Caryocorbula sp.	2.33	1.71	1.67	1.3	2.62	41.02
Tubificoides sp.	0	2.83	1.62	1.18	2.54	43.56
Tubificoid Naididae imm. w/o hair setae (LPIL)	2.33	1.21	1.51	1.05	2.37	45.93
Parandalia tricuspis	2.4	1.12	1.45	1.02	2.27	48.2
Leptochelia sp.	1.81	1.21	1.42	0.88	2.23	50.43
Cyathura polita	0	2.54	1.42	1.32	2.23	52.65
Mediomastus ambiseta	1.98	0	1.38	1.16	2.16	54.81
Onobops jacksoni	2.06	0	1.31	0.64	2.06	56.87
Tanytarsus sp. H Epler	1.96	0	1.25	0.64	1.96	58.84
Turbellaria (LPIL)	1.12	1.71	1.22	0.94	1.91	60.75
Leitoscoloplos fragilis	1.81	0	1.15	0.64	1.8	62.55
Americamysis sp.	0.85	1.44	1.1	0.93	1.72	64.28
Melita nitida complex LeCroy	1.48	0	1.09	0.63	1.71	65.99
Bivalvia (LPIL)	1.02	1.21	1	0.87	1.56	67.55
Apocorophium lacustre	1.48	0	0.95	0.64	1.49	69.04
Leptochelia rapax	1.44	0	0.91	0.64	1.44	70.48
Dicrotendipes lobus	1.44	0	0.91	0.64	1.44	71.91
Capitella capitata	1.02	1.12	0.89	0.85	1.4	73.31
Ampithoidae (LPIL)	1.12	0	0.83	0.63	1.3	74.61
Cymadusa sp.	1.12	0	0.83	0.63	1.3	75.9
Tellinidae (LPIL)	1.12	0	0.83	0.63	1.3	77.2
Mytilopsis leucophaeata	0	1.62	0.82	0.67	1.28	78.49
Sipuncula (LPIL)	1.21	0	0.78	0.64	1.22	79.71
Polydora cornuta	1.21	0	0.77	0.64	1.21	80.91
Almyracuma bacescui	1.21	0	0.77	0.64	1.21	82.12
Tagelus plebeius	1.21	0	0.77	0.64	1.21	83.32
Polymesoda caroliniana	0	1.52	0.77	0.67	1.2	84.53
Hourstonius laguna	0	1.21	0.74	0.66	1.17	85.7
Amphipoda (LPIL)	0	1.21	0.74	0.66	1.17	86.86
Boccardiella sp.	0	1.34	0.67	0.67	1.06	87.92
Gammarus mucronatus group LeCroy	0	1.34	0.67	0.67	1.06	88.98
Uromunna reynoldsi	0	1.34	0.67	0.67	1.06	90.04

Groups RK-0 & RK-9.5
Average dissimilarity = 99.64

	Group RK-0	Group RK-9.5				

Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Apocorophium louisianum	0	6.45	3.83	7.51	3.84	3.84
Grandidierella bonnieroides	0	6.05	3.58	1.3	3.59	7.44
Cirrophorus sp.	5.26	0	3.14	3.87	3.15	10.59
Uromunna reynoldsi	0	5.21	3.11	3.29	3.12	13.71
Hobsonia florida	0	5.16	3.05	3.78	3.06	16.77
Fabricinuda trilobata	4.83	0	2.6	1.02	2.61	19.38
Prionospio heterobranchia	4.45	0	2.54	3.33	2.55	21.93
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	4.23	2.51	6.51	2.52	24.45
Scoletoma sp. A (strom)	4	0	2.37	9.25	2.38	26.83
Axiothella sp.	3.99	0	2.35	12.87	2.35	29.18
Nemertea (LPIL)	3.63	0	2.14	7.53	2.15	31.33
Duridrilus tardus	3.16	0	2.01	1.32	2.02	33.35
Edotia triloba	0	3.4	2.01	1.28	2.02	35.37
Syllis sp.	3.48	0	1.9	1.08	1.9	37.28
Procladius sp.	0	3.18	1.86	1.31	1.87	39.14
Americorophium sp. A LeCroy	0	3.04	1.8	0.66	1.81	40.95
Angulus versicolor	2.83	0	1.79	1.27	1.8	42.75
Capitella capitata	2.67	0	1.7	1.32	1.7	44.45
Mooreonuphis pallidula	2.56	0	1.62	1.33	1.63	46.08
Olivella sp.	2.56	0	1.62	1.33	1.63	47.71
Polypedilum halterale group Epler	0	2.41	1.45	1.31	1.46	49.17
Tanytarsus sp.	0	2.41	1.43	1.31	1.44	50.61
Scolelepis texana	2.13	0	1.35	1.28	1.35	51.96
Melitidae (LPIL)	2.33	0	1.31	1.29	1.32	53.27
Paradialychone sp.	2.49	0	1.27	0.67	1.27	54.55
Pionosyllis sp.	2.19	0	1.24	1.31	1.24	55.79
Apocorophium lacustre	0	2	1.15	0.66	1.16	56.95
Hydrobiidae (LPIL)	0.85	1.59	1.13	0.94	1.14	58.09
Mediomastus ambiseta	1.98	0	1.13	1.33	1.13	59.22
Bulla striata	1.98	0	1.13	1.33	1.13	60.35
Polyplacophora sp. A (Strom)	2.17	0	1.11	0.67	1.11	61.46
Sphaerosyllis sp.	1.98	0	1.1	1.33	1.1	62.57
Phascolion sp.	1.65	0	1.08	0.67	1.08	63.65
Procladius (Holotanypus) sp.	0	1.81	1.04	0.66	1.05	64.7
Grubeosyllis clavata	1.89	0	0.96	0.67	0.97	65.66
Sphaerosyllis bilobata	1.44	0	0.94	0.67	0.94	66.61
Magelona pettiboneae	1.39	0	0.91	0.67	0.91	67.52
Tanytarsus sp. G Epler	0	1.44	0.85	0.66	0.85	68.37
Polypedilum scalaenum group Epler	0	1.44	0.83	0.66	0.83	69.21
Lucinidae (LPIL)	1.34	0	0.83	0.67	0.83	70.03
Capitella jonesi	1.28	0	0.79	0.67	0.79	70.83
Oxyurostylis smithi	1.21	0	0.75	0.67	0.75	71.58
Chaetognatha (LPIL)	1.21	0	0.75	0.67	0.75	72.32
Platyhelminthes (LPIL)	0	1.21	0.74	0.66	0.74	73.06
Laeonereis culveri	0	1.21	0.74	0.66	0.74	73.8
Mytilopsis leucophaeata	0	1.21	0.74	0.66	0.74	74.54
Leitoscoloplos fragilis	1.12	0	0.73	0.67	0.74	75.28
Turbellaria (LPIL)	0	1.21	0.72	0.66	0.72	75.99
Gammarus sp.	0	1.21	0.72	0.66	0.72	76.71
Leptochelia sp.	0	1.21	0.72	0.66	0.72	77.43
Chironomus sp.	0	1.21	0.72	0.66	0.72	78.15
Abra aequalis	0	1.21	0.72	0.66	0.72	78.87
Amphipoda (LPIL)	0	1.21	0.7	0.66	0.7	79.57
Ampelisca holmesi	1.12	0	0.69	0.67	0.7	80.26
Gyptis brevipalpa	1.34	0	0.68	0.67	0.68	80.95
Caulleriella sp.	1.34	0	0.68	0.67	0.68	81.63
Paracaprella tenuis	1.34	0	0.68	0.67	0.68	82.31
Kalliapseudes sp.	1.34	0	0.68	0.67	0.68	83
Crepidula plana	1.34	0	0.68	0.67	0.68	83.68
Crassinella lunulata	1.34	0	0.68	0.67	0.68	84.36
Janua sp.	1.02	0	0.63	0.67	0.63	84.99
Americhelidium sp. A Lecroy	1.02	0	0.63	0.67	0.63	85.62
Actiniaria (LPIL)	1.12	0	0.57	0.67	0.57	86.2

Mooreonuphis sp.	1.12	0	0.57	0.67	0.57	86.77
Exogone sp.	1.12	0	0.57	0.67	0.57	87.35
Opisthosyllis longidentata	1.12	0	0.57	0.67	0.57	87.92
Microspio pigmentata	1.12	0	0.57	0.67	0.57	88.49
Tanaidomorpha (LPIL)	1.12	0	0.57	0.67	0.57	89.07
Polyplacophora sp. B (Strom)	1.12	0	0.57	0.67	0.57	89.64
cf. Semelidae (LPIL)	1.12	0	0.57	0.67	0.57	90.22

Groups RK-2 & RK-9.5
Average dissimilarity = 98.28

	Group RK-2	Group RK-9.5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Fabricinuda trilobata	10.25	0	4.35	5.5	4.42	4.42
Axiothella sp.	6.71	0	2.87	2.51	2.92	7.34
Apocorophium louisianum	0	6.45	2.72	12.44	2.77	10.11
Mediomastus ambiseta	6.24	0	2.62	5.6	2.67	12.77
Grandidierella bonnieroides	0	6.05	2.55	1.31	2.59	15.37
Capitella capitata	5.95	0	2.53	3.18	2.57	17.94
Mooreonuphis pallidula	5.6	0	2.35	3.74	2.39	20.33
Monticellina dorsobranchialis	5.32	0	2.24	21.19	2.28	22.62
Prionospio heterobranchia	5.27	0	2.23	4.42	2.27	24.88
Uromunna reynoldsi	0	5.21	2.21	3.59	2.25	27.13
Angulus versicolor	4.71	0	1.99	9.53	2.03	29.16
Melinna sp.	4.48	0	1.88	8.24	1.92	31.07
Ampelisca sp.	4.43	0	1.86	18.59	1.89	32.97
Halmyrapseudes cf. bahamensis Heard	4.24	0	1.81	1.03	1.85	34.81
Cyclaspis varians	4.29	0	1.81	22.68	1.84	36.66
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	4.23	1.79	8.48	1.82	38.47
Potamethus spathiferus	4.21	0	1.77	4.38	1.8	40.28
Merisca sp.	4.09	0	1.75	2.4	1.78	42.05
Syllis sp.	4	0	1.7	5.64	1.73	43.78
Hobsonia florida	1.28	5.16	1.64	1.77	1.67	45.45
Scolelepis texana	3.87	0	1.64	4.06	1.67	47.12
Piromis roberti	3.79	0	1.59	8.2	1.62	48.74
Nemertea sp. J	3.37	0	1.41	9.89	1.44	50.18
Oxyurostylis smithi	3.3	0	1.38	1.32	1.41	51.59
Scoloplos rubra	3.24	0	1.36	20.1	1.39	52.98
Procladius sp.	0	3.18	1.33	1.33	1.35	54.33
Aoridae (LPIL)	3.17	0	1.3	1.26	1.32	55.66
Americorophium sp. A LeCroy	0	3.04	1.28	0.67	1.3	56.96
Edotia triloba	1.21	3.4	1.27	1.25	1.29	58.25
Aricidea taylori	2.91	0	1.19	1.21	1.21	59.47
Nemertea (LPIL)	2.77	0	1.16	1.32	1.18	60.65
Onuphidae (LPIL)	2.67	0	1.11	1.21	1.13	61.78
Xenanthura brevitelson	2.64	0	1.11	1.3	1.13	62.91
Eteone heteropoda	2.45	0	1.07	1.27	1.08	64
Pionosyllis sp.	2.45	0	1.07	1.27	1.08	65.08
Polypedilum halterale group Epler	0	2.41	1.03	1.33	1.05	66.13
Dipolydora sp.	2.45	0	1.02	1.26	1.04	67.17
Tanytarsus sp.	0	2.41	1.02	1.33	1.04	68.21
Langerhansia sp.	2.35	0	0.97	1.31	0.99	69.19
Spiochaetopterus costarum	2.35	0	0.97	1.31	0.99	70.18
cf. Semelidae (LPIL)	2.22	0	0.96	1.31	0.98	71.16
Duridrilus tardus	2.22	0	0.93	1.3	0.95	72.11
Dipolydora socialis	2.17	0	0.93	0.67	0.95	73.06
Sphaerosyllis sp.	2.03	0	0.85	1.33	0.87	73.93
Podarkeopsis levifuscina	2.03	0	0.84	1.33	0.86	74.78
Ceratonereis sp.	2.03	0	0.84	1.33	0.86	75.64
Lysilla sp.	2.03	0	0.84	1.33	0.86	76.49
Tubificoides sp.	2.03	0	0.84	1.33	0.86	77.35
Apocorophium lacustre	0	2	0.83	0.67	0.84	78.19
Procladius (Holotanypus) sp.	0	1.81	0.75	0.67	0.76	78.95
Acteocina canaliculata	1.65	0	0.72	0.67	0.74	79.69

Hydrobiidae (LPIL)	0	1.59	0.68	0.67	0.7	80.38
Actiniaria (LPIL)	1.44	0	0.62	0.67	0.63	81.01
Odontosyllis sp.	1.44	0	0.62	0.67	0.63	81.64
Tanytarsus sp. G Epler	0	1.44	0.61	0.67	0.62	82.25
Polypedilum scalaenum group Epler	0	1.44	0.6	0.67	0.61	82.86
Listriella sp.	1.21	0	0.53	0.67	0.54	83.4
Platyhelminthes (LPIL)	0	1.21	0.52	0.67	0.53	83.93
Laeonereis culveri	0	1.21	0.52	0.67	0.53	84.46
Mytilopsis leucophaeata	0	1.21	0.52	0.67	0.53	84.98
Lysianopsis alba	1.21	0	0.52	0.67	0.53	85.51
Turbellaria (LPIL)	0	1.21	0.51	0.67	0.52	86.03
Gammarus sp.	0	1.21	0.51	0.67	0.52	86.55
Leptochelia sp.	0	1.21	0.51	0.67	0.52	87.07
Chironomus sp.	0	1.21	0.51	0.67	0.52	87.59
Abra aequalis	0	1.21	0.51	0.67	0.52	88.1
Amphipoda (LPIL)	0	1.21	0.5	0.67	0.51	88.61
Phyllodoce arenae	1.21	0	0.48	0.67	0.49	89.1
Paracaprella sp.	1.21	0	0.48	0.67	0.49	89.59
Grubeosyllis sp.	1.02	0	0.45	0.67	0.45	90.05

Groups RK-3.5 & RK-9.5
Average dissimilarity = 87.53

Species	Group RK-3.5 Av.Abund	Group RK-9.5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Apocorophium louisianum	0	6.45	4.32	10.99	4.94	4.94
Mediomastus ambiseta	6.07	0	4.09	3.92	4.68	9.61
Ampelisca sp.	5.38	0	3.51	1.33	4.01	13.62
Uromunna reynoldsi	0	5.21	3.51	3.46	4	17.63
Grandidierella bonnieroides	3.89	6.05	3.2	1.37	3.65	21.28
Xenanthura brevitelson	4.71	0	3.06	1.33	3.5	24.78
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	4.23	2.83	8.6	3.23	28.01
Streblospio sp.	3.68	0	2.47	3.73	2.82	30.83
Ampelisca holmesi	3.42	0	2.41	0.67	2.75	33.58
Halmyrapseudes cf. bahamensis Heard	3.66	0	2.37	1.27	2.71	36.29
Procladius sp.	0	3.18	2.1	1.33	2.39	38.69
Americorophium sp. A LeCroy	0	3.04	2.03	0.67	2.32	41.01
Edotia triloba	1.02	3.4	2.03	1.4	2.32	43.32
Cyclaspis varians	3.09	0	2.02	1.31	2.31	45.63
Fabricinuda trilobata	2.45	0	1.65	1.24	1.89	47.52
Hydrobiidae (LPIL)	2.54	1.59	1.64	1.29	1.88	49.39
Polypedilum halterale group Epler	0	2.41	1.64	1.33	1.87	51.27
Tanytarsus sp.	0	2.41	1.62	1.33	1.85	53.12
Leitoscoloplos sp.	2.45	0	1.59	1.29	1.82	54.93
Capitella capitata	2.22	0	1.53	1.31	1.75	56.68
Leptochelia sp.	2.53	1.21	1.52	1.17	1.74	58.42
Anomalocardia auberiana	2.22	0	1.48	1.33	1.69	60.11
Nemertea (LPIL)	2.03	0	1.4	1.33	1.6	61.71
Crepidula plana	2.03	0	1.4	1.33	1.6	63.31
Americorophium sp.	1.96	0	1.38	0.67	1.58	64.89
Platyhelminthes (LPIL)	2.35	1.21	1.38	1.18	1.57	66.46
cf. Potamethus sp.	2.03	0	1.32	1.33	1.51	67.97
Apocorophium lacustre	0	2	1.3	0.67	1.48	69.45
Monocorophium acherusicum	2	0	1.26	0.67	1.44	70.9
Corophiidae (LPIL)	1.73	0	1.22	0.67	1.4	72.29
Procladius (Holotanypus) sp.	0	1.81	1.17	0.67	1.34	73.63
Amakusanthura magnifica	1.65	0	1.16	0.67	1.33	74.96
Pseudonototanais sp. B Heard	1.52	0	1.02	0.67	1.17	76.13
Hobsonia florida	3.75	5.16	0.99	1.19	1.13	77.25
Prionospio heterobranchia	1.44	0	0.97	0.67	1.1	78.36
Tanytarsus sp. G Epler	0	1.44	0.96	0.67	1.1	79.46
Angulus versicolor	1.34	0	0.94	0.67	1.08	80.53
Polypedilum scalaenum group Epler	0	1.44	0.93	0.67	1.07	81.6
Tellina versicolor	1.34	0	0.9	0.67	1.03	82.63

Laeonereis culveri	0	1.21	0.83	0.67	0.95	83.58
Mytilopsis leucophaeata	0	1.21	0.83	0.67	0.95	84.53
Turbellaria (LPIL)	0	1.21	0.81	0.67	0.92	85.45
Gammarus sp.	0	1.21	0.81	0.67	0.92	86.37
Chironomus sp.	0	1.21	0.81	0.67	0.92	87.3
Abra aequalis	0	1.21	0.81	0.67	0.92	88.22
Amphipoda (LPIL)	0	1.21	0.78	0.67	0.9	89.11
Parandalia tricuspis	1.21	0	0.76	0.67	0.87	89.98
Aoridae (LPIL)	1.21	0	0.76	0.67	0.87	90.85

Groups RK-5 & RK-9.5
Average dissimilarity = 75.77

Species	Group RK-5 Av.Abund	Group RK-9.5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Mediomastus ambiseta	5.52	0	4.33	4.05	5.71	5.71
Uromunna reynoldsi	0	5.21	4.15	3.3	5.47	11.18
Streblospio sp.	4.55	0	3.61	6.39	4.76	15.95
Hobsonia florida	1.21	5.16	3.16	1.72	4.17	20.12
Grandidierella bonnieroides	7.72	6.05	2.76	1.06	3.64	23.76
Tagelus plebeius	3.42	0	2.7	8.29	3.56	27.32
Procladius sp.	0	3.18	2.47	1.32	3.26	30.58
Tubificoid Naididae imm. w/o hair setae (LPIL)	1.28	4.23	2.43	1.54	3.21	33.78
Americorophium sp. A LeCroy	0	3.04	2.4	0.66	3.17	36.95
Xenanthura brevitelson	3.04	0	2.27	1.28	2.99	39.94
Ampelisca sp.	2.87	0	2.14	1.31	2.83	42.77
Edotia triloba	2.33	3.4	2.08	1.39	2.75	45.52
Leptochelia sp.	2.97	1.21	2.06	1.22	2.72	48.23
Melita nitida complex LeCroy	2.44	0	2.03	1.12	2.68	50.92
Polypedilum halterale group Epler	0	2.41	1.94	1.32	2.56	53.48
Tanytarsus sp.	0	2.41	1.91	1.32	2.52	56
Cerapus benthophilus	2.4	0	1.79	1.33	2.36	58.36
Apocorophium lacustre	0	2	1.53	0.66	2.01	60.38
Hydrobiidae (LPIL)	0.85	1.59	1.5	0.9	1.98	62.36
Americamysis sp.	1.71	0	1.39	1.32	1.84	64.19
Procladius (Holotanypus) sp.	0	1.81	1.38	0.66	1.82	66.01
Turbellaria (LPIL)	0.85	1.21	1.16	0.91	1.54	67.55
Apocorophium louisianum	5.07	6.45	1.15	1.54	1.52	69.07
Tanytarsus sp. G Epler	0	1.44	1.13	0.66	1.5	70.57
Polypedilum scalaenum group Epler	0	1.44	1.1	0.66	1.45	72.02
Parandalia tricuspis	1.39	0	1.04	0.67	1.38	73.39
Cyclaspis varians	1.34	0	1	0.67	1.32	74.72
Platyhelminthes (LPIL)	0	1.21	0.99	0.66	1.31	76.02
Laeonereis culveri	0	1.21	0.99	0.66	1.31	77.33
Mytilopsis leucophaeata	0	1.21	0.99	0.66	1.31	78.63
Gammarus sp.	0	1.21	0.95	0.66	1.26	79.89
Chironomus sp.	0	1.21	0.95	0.66	1.26	81.15
Abra aequalis	0	1.21	0.95	0.66	1.26	82.41
Amphipoda (LPIL)	0	1.21	0.92	0.66	1.22	83.62
cf. Sipuncula (LPIL)	1.02	0	0.76	0.67	1.01	84.63
Melinna sp.	1.02	0	0.76	0.67	1.01	85.63
Leitoscoloplos foliosus	0.85	0	0.75	0.67	0.99	86.63
Rhithropanopeus harrisii	0.85	0	0.75	0.67	0.99	87.62
Acteocina canaliculata	0.85	0	0.75	0.67	0.99	88.61
Pyrgophorus platyrachis	0.85	0	0.75	0.67	0.99	89.6
Ischadium recurvum	0.85	0	0.75	0.67	0.99	90.59

Groups RK-6.5 & RK-9.5
Average dissimilarity = 70.52

Species	Group RK-6.5 Av.Abund	Group RK-9.5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Pyrgophorus platyrachis	6.78	0	4.72	2.19	6.69	6.69
Uromunna reynoldsi	0	5.21	3.7	3.38	5.25	11.94

Streblospio sp.	4.13	0	2.95	3.68	4.18	16.12
Cerapus benthophilus	4.09	0	2.87	5.3	4.07	20.19
Grandidierella bonnieroides	8.57	6.05	2.51	0.92	3.56	23.75
Laeonereis culveri	3.07	1.21	2.38	0.93	3.38	27.13
Procladius sp.	0	3.18	2.21	1.32	3.13	30.27
Americorophium sp. A LeCroy	0	3.04	2.14	0.66	3.04	33.31
Hobsonia florida	3.15	5.16	1.82	1.27	2.58	35.89
Parandalia tricuspis	2.4	0	1.73	1.33	2.46	38.35
Polypedilum halterale group Epler	0	2.41	1.73	1.32	2.46	40.81
Apocorophium lacustre	1.48	2	1.72	0.92	2.44	43.25
Tanytarsus sp.	0	2.41	1.71	1.32	2.42	45.67
Caryocorbula sp.	2.33	0	1.69	1.33	2.39	48.06
Edotia triloba	4.27	3.4	1.56	1.28	2.21	50.28
Leptochelia sp.	1.81	1.21	1.52	0.95	2.16	52.44
Mediomastus ambiseta	1.98	0	1.45	1.26	2.05	54.49
Tubificoid Naididae imm. w/o hair setae (LPIL)	2.33	4.23	1.43	1.25	2.03	56.52
Onobops jacksoni	2.06	0	1.38	0.67	1.96	58.48
Tanytarsus sp. H Epler	1.96	0	1.32	0.67	1.87	60.34
Procladius (Holotanypus) sp.	0	1.81	1.24	0.66	1.75	62.1
Leitoscoloplos fragilis	1.81	0	1.21	0.67	1.72	63.81
Hydrobiidae (LPIL)	0	1.59	1.16	0.66	1.64	65.46
Melita nitida complex LeCroy	1.48	0	1.14	0.67	1.62	67.08
Turbellaria (LPIL)	1.12	1.21	1.11	0.86	1.57	68.65
Apocorophium louisianum	6.58	6.45	1.08	3.01	1.54	70.18
Tanytarsus sp. G Epler	0	1.44	1.01	0.66	1.44	71.62
Polypedilum scalaenum group Epler	0	1.44	0.98	0.66	1.39	73.02
Leptochelia rapax	1.44	0	0.96	0.67	1.36	74.38
Dicrotendipes lobus	1.44	0	0.96	0.67	1.36	75.75
Platyhelminthes (LPIL)	0	1.21	0.88	0.66	1.25	76.99
Mytilopsis leucophaeata	0	1.21	0.88	0.66	1.25	78.24
Ampithoidae (LPIL)	1.12	0	0.87	0.67	1.23	79.47
Cymadusa sp.	1.12	0	0.87	0.67	1.23	80.71
Tellinidae (LPIL)	1.12	0	0.87	0.67	1.23	81.94
Gammarus sp.	0	1.21	0.85	0.66	1.21	83.15
Chironomus sp.	0	1.21	0.85	0.66	1.21	84.36
Abra aequalis	0	1.21	0.85	0.66	1.21	85.57
Amphipoda (LPIL)	0	1.21	0.83	0.66	1.17	86.74
Sipuncula (LPIL)	1.21	0	0.82	0.67	1.16	87.9
Polydora cornuta	1.21	0	0.81	0.67	1.15	89.04
Almyracuma bacescui	1.21	0	0.81	0.67	1.15	90.19

Groups RK-8 & RK-9.5
Average dissimilarity = 62.44

	Group RK-8	Group RK-9.5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Laeonereis culveri	6.34	1.21	4.23	1.48	6.77	6.77
Uromunna reynoldsi	1.34	5.21	3.37	1.33	5.4	12.18
Edotia triloba	5.15	3.4	3.07	1.39	4.91	17.09
Grandidierella bonnieroides	9.46	6.05	3.07	0.94	4.91	22
Apocorophium louisianum	9.03	6.45	2.79	3.7	4.47	26.47
Hydrobiidae (LPIL)	3.67	1.59	2.7	1.01	4.32	30.8
Streblospio sp.	3.86	0	2.48	1.24	3.97	34.76
Tubificoid Naididae imm. w/o hair setae (LPIL)	1.21	4.23	2.47	1.34	3.96	38.72
Procladius sp.	0	3.18	2.45	1.2	3.93	42.65
Americorophium sp. A LeCroy	0	3.04	2.39	0.63	3.82	46.47
Polypedilum halterale group Epler	0	2.41	1.93	1.19	3.1	49.57
Tanytarsus sp.	0	2.41	1.9	1.19	3.04	52.62
Polypedilum scalaenum group Epler	3.11	1.44	1.88	1.06	3.02	55.63
Tubificoides sp.	2.83	0	1.84	1.17	2.94	58.58
Hobsonia florida	6.55	5.16	1.76	1.58	2.81	61.39
Cyathura polita	2.54	0	1.6	1.32	2.57	63.96
Apocorophium lacustre	0	2	1.51	0.63	2.43	66.38
Turbellaria (LPIL)	1.71	1.21	1.46	0.91	2.33	68.72

Mytilopsis leucophaeata	1.62	1.21	1.43	0.89	2.3	71.01
Procladius (Holotanypus) sp.	0	1.81	1.37	0.63	2.19	73.21
Leptochelia sp.	1.21	1.21	1.23	0.8	1.97	75.18
Amphipoda (LPIL)	1.21	1.21	1.22	0.8	1.95	77.13
Tanytarsus sp. G Epler	0	1.44	1.13	0.63	1.81	78.94
Americamysis sp.	1.44	0	1.01	0.67	1.62	80.56
Platyhelminthes (LPIL)	0	1.21	0.99	0.63	1.58	82.14
Caryocorbula sp.	1.71	0	0.96	0.67	1.54	83.68
Gammarus sp.	0	1.21	0.95	0.63	1.52	85.2
Chironomus sp.	0	1.21	0.95	0.63	1.52	86.72
Abra aequalis	0	1.21	0.95	0.63	1.52	88.24
Polymesoda caroliniana	1.52	0	0.85	0.67	1.37	89.6
Hourstonius laguna	1.21	0	0.85	0.67	1.36	90.97

Groups RK-0 & RK-10.5
Average dissimilarity = 100.00

	Group RK-0	Group RK-10.5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Polypedilum halterale group Epler	0	7.18	4.04	7.07	4.04	4.04
Americorophium sp. A LeCroy	0	6.91	3.93	9.31	3.93	7.97
Apocorophium louisianum	0	6.35	3.55	4.48	3.55	11.52
Hobsonia florida	0	5.61	3.2	8.22	3.2	14.72
Cirrophorus sp.	5.26	0	3.04	3.58	3.04	17.76
Uromunna reynoldsi	0	5.32	2.95	3.59	2.95	20.71
Fabricinuda trilobata	4.83	0	2.52	1.01	2.52	23.23
Prionospio heterobranchia	4.45	0	2.46	3.13	2.46	25.69
Ablabesmyia rhamphe group Epler	0	4.26	2.43	7.54	2.43	28.12
Scoletoma sp. A (strom)	4	0	2.29	6.71	2.29	30.41
Axiothella sp.	3.99	0	2.27	7.76	2.27	32.68
Nemertea (LPIL)	3.63	0	2.07	5.95	2.07	34.75
Duridrilus tardus	3.16	0	1.94	1.3	1.94	36.69
Procladius (Holotanypus) sp.	0	3.62	1.93	1.31	1.93	38.62
Syllis sp.	3.48	0	1.84	1.07	1.84	40.45
Angulus versicolor	2.83	0	1.73	1.25	1.73	42.18
Capitella capitata	2.67	0	1.64	1.3	1.64	43.82
Gammarus sp.	0	3.05	1.62	1.3	1.62	45.44
Aulodrilus pigueti	0	2.96	1.58	1.31	1.58	47.01
Mooreonuphis pallidula	2.56	0	1.57	1.31	1.57	48.58
Olivella sp.	2.56	0	1.57	1.31	1.57	50.15
Tanytarsus sp. G Epler	0	2.92	1.55	1.28	1.55	51.7
Ceratopogonidae (LPIL)	0	2.54	1.36	1.31	1.36	53.06
Caecidotea sp.	0	2.03	1.33	0.66	1.33	54.38
Amnicola dalli	0	2.45	1.3	1.28	1.3	55.69
Scolelepis texana	2.13	0	1.3	1.26	1.3	56.98
Melitidae (LPIL)	2.33	0	1.27	1.27	1.27	58.25
Paradialychone sp.	2.49	0	1.23	0.66	1.23	59.48
Pionosyllis sp.	2.19	0	1.2	1.3	1.2	60.68
Gammarus cf. tigrinus LeCroy	0	1.81	1.18	0.66	1.18	61.86
Mediomastus ambiseta	1.98	0	1.09	1.31	1.09	62.95
Bulla striata	1.98	0	1.09	1.31	1.09	64.04
Polyplacophora sp. A (Strom)	2.17	0	1.07	0.66	1.07	65.12
Sphaerosyllis sp.	1.98	0	1.06	1.31	1.06	66.18
Phascolion sp.	1.65	0	1.04	0.66	1.04	67.22
Grubeosyllis clavata	1.89	0	0.93	0.66	0.93	68.15
Sphaerosyllis bilobata	1.44	0	0.9	0.66	0.9	69.06
Magelona pettiboneae	1.39	0	0.88	0.66	0.88	69.93
Lucinidae (LPIL)	1.34	0	0.8	0.66	0.8	70.73
Capitella jonesi	1.28	0	0.76	0.66	0.76	71.49
Oxyurostylis smithi	1.21	0	0.72	0.66	0.72	72.21
Chaetognatha (LPIL)	1.21	0	0.72	0.66	0.72	72.93
Leitoscoloplos fragilis	1.12	0	0.71	0.66	0.71	73.64
Ampelisca holmesi	1.12	0	0.67	0.66	0.67	74.31
Tubificoid Naididae imm. w/ hair setae (LPIL)	0	1.02	0.66	0.66	0.66	74.97

Procladius sp.	0	1.02	0.66	0.66	0.66	75.64
Gyptis brevipalpa	1.34	0	0.66	0.66	0.66	76.3
Caulleriella sp.	1.34	0	0.66	0.66	0.66	76.96
Paracaprella tenuis	1.34	0	0.66	0.66	0.66	77.62
Kalliapseudes sp.	1.34	0	0.66	0.66	0.66	78.28
Crepidula plana	1.34	0	0.66	0.66	0.66	78.94
Crassinella lunulata	1.34	0	0.66	0.66	0.66	79.6
Oecetis sp. E Floyd	0	1.21	0.66	0.66	0.66	80.26
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	1.21	0.63	0.66	0.63	80.89
Ampelisca sp.	0	1.21	0.63	0.66	0.63	81.51
Polymesoda caroliniana	0	1.21	0.63	0.66	0.63	82.14
Abra aequalis	0	1.21	0.63	0.66	0.63	82.77
Janua sp.	1.02	0	0.61	0.66	0.61	83.38
Americhelidium sp. A Lecroy	1.02	0	0.61	0.66	0.61	83.98
Pagastiella sp.	0	1.02	0.55	0.66	0.55	84.54
Tanytarsus sp. T Epler	0	1.02	0.55	0.66	0.55	85.09
Cernotina sp.	0	1.02	0.55	0.66	0.55	85.65
Actiniaria (LPIL)	1.12	0	0.55	0.66	0.55	86.2
Mooreonuphis sp.	1.12	0	0.55	0.66	0.55	86.76
Exogone sp.	1.12	0	0.55	0.66	0.55	87.31
Opisthosyllis longidentata	1.12	0	0.55	0.66	0.55	87.86
Microspio pigmentata	1.12	0	0.55	0.66	0.55	88.42
Tanaidomorpha (LPIL)	1.12	0	0.55	0.66	0.55	88.97
Polyplacophora sp. B (Strom)	1.12	0	0.55	0.66	0.55	89.53
cf. Semelidae (LPIL)	1.12	0	0.55	0.66	0.55	90.08

Groups RK-2 & RK-10.5
Average dissimilarity = 98.01

	Group RK-2	Group RK-10.5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Fabricinuda trilobata	10.25	0	4.23	5.1	4.32	4.32
Polypedilum halterale group Epler	0	7.18	2.92	7.82	2.98	7.29
Americorophium sp. A LeCroy	0	6.91	2.82	21.03	2.88	10.18
Axiothella sp.	6.71	0	2.79	2.46	2.85	13.02
Apocorophium louisianum	0	6.35	2.56	4.46	2.62	15.64
Mediomastus ambiseta	6.24	0	2.55	5.17	2.6	18.24
Capitella capitata	5.95	0	2.46	3.09	2.51	20.75
Mooreonuphis pallidula	5.6	0	2.29	3.6	2.34	23.09
Monticellina dorsobranchialis	5.32	0	2.18	11.53	2.23	25.32
Prionospio heterobranchia	5.27	0	2.17	4.21	2.22	27.54
Uromunna reynoldsi	0	5.32	2.14	3.5	2.18	29.72
Angulus versicolor	4.71	0	1.94	7.84	1.98	31.7
Melinna sp.	4.48	0	1.84	7.05	1.87	33.57
Hobsonia florida	1.28	5.61	1.77	2.26	1.8	35.37
Halmyrapseudes cf. bahamensis Heard	4.24	0	1.77	1.03	1.8	37.18
Cyclaspis varians	4.29	0	1.76	11.79	1.8	38.98
Ablabesmyia rhamphe group Epler	0	4.26	1.75	13.1	1.78	40.76
Potamethus spathiferus	4.21	0	1.73	4.17	1.76	42.52
Merisca sp.	4.09	0	1.7	2.36	1.73	44.25
Syllis sp.	4	0	1.65	5.22	1.69	45.94
Scolelepis texana	3.87	0	1.6	3.89	1.63	47.57
Piromis roberti	3.79	0	1.55	7.03	1.58	49.15
Procladius (Holotanypus) sp.	0	3.62	1.41	1.32	1.44	50.6
Nemertea sp. J	3.37	0	1.38	8	1.41	52
Ampelisca sp.	4.43	1.21	1.35	1.69	1.38	53.38
Oxyurostylis smithi	3.3	0	1.35	1.31	1.38	54.75
Scoloplos rubra	3.24	0	1.33	11.34	1.35	56.11
Aoridae (LPIL)	3.17	0	1.27	1.25	1.29	57.4
Gammarus sp.	0	3.05	1.19	1.31	1.21	58.62
Aricidea taylori	2.91	0	1.16	1.2	1.18	59.8
Aulodrilus pigueti	0	2.96	1.16	1.33	1.18	60.98
Tanytarsus sp. G Epler	0	2.92	1.14	1.29	1.16	62.14
Nemertea (LPIL)	2.77	0	1.13	1.31	1.16	63.3

Onuphidae (LPIL)	2.67	0	1.08	1.2	1.11	64.41
Xenanthura brevitelson	2.64	0	1.08	1.29	1.11	65.51
Eteone heteropoda	2.45	0	1.04	1.26	1.06	66.57
Pionosyllis sp.	2.45	0	1.04	1.26	1.06	67.63
Ceratopogonidae (LPIL)	0	2.54	1	1.32	1.02	68.64
Dipolydora sp.	2.45	0	0.99	1.25	1.02	69.66
Amnicola dalli	0	2.45	0.96	1.29	0.98	70.63
Langerhansia sp.	2.35	0	0.94	1.3	0.96	71.6
Spiochaetopterus costarum	2.35	0	0.94	1.3	0.96	72.56
cf. Semelidae (LPIL)	2.22	0	0.94	1.3	0.96	73.52
Caecidotea sp.	0	2.03	0.92	0.67	0.94	74.46
Duridrilus tardus	2.22	0	0.91	1.29	0.93	75.38
Dipolydora socialis	2.17	0	0.91	0.66	0.93	76.31
Sphaerosyllis sp.	2.03	0	0.83	1.32	0.85	77.16
Podarkeopsis levifuscina	2.03	0	0.82	1.32	0.84	77.99
Ceratonereis sp.	2.03	0	0.82	1.32	0.84	78.83
Lysilla sp.	2.03	0	0.82	1.32	0.84	79.66
Tubificoides sp.	2.03	0	0.82	1.32	0.84	80.5
Gammarus cf. tigrinus LeCroy	0	1.81	0.81	0.67	0.83	81.33
Acteocina canaliculata	1.65	0	0.71	0.66	0.72	82.05
Actiniaria (LPIL)	1.44	0	0.6	0.66	0.61	82.66
Odontosyllis sp.	1.44	0	0.6	0.66	0.61	83.27
Listriella sp.	1.21	0	0.52	0.66	0.53	83.8
Lysianopsis alba	1.21	0	0.5	0.66	0.51	84.31
Oecetis sp. E Floyd	0	1.21	0.48	0.67	0.49	84.8
Phyllodoce arenae	1.21	0	0.47	0.66	0.48	85.28
Paracaprella sp.	1.21	0	0.47	0.66	0.48	85.76
Edotia triloba	1.21	0	0.47	0.66	0.48	86.24
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	1.21	0.46	0.67	0.47	86.72
Polymesoda caroliniana	0	1.21	0.46	0.67	0.47	87.19
Abra aequalis	0	1.21	0.46	0.67	0.47	87.66
Tubificoid Naididae imm. w/ hair setae (LPIL)	0	1.02	0.46	0.67	0.47	88.13
Procladius sp.	0	1.02	0.46	0.67	0.47	88.6
Grubeosyllis sp.	1.02	0	0.43	0.66	0.44	89.04
Sphaerosyllis brevifrons	1.02	0	0.43	0.66	0.44	89.48
Fabriciinae (LPIL)	1.02	0	0.43	0.66	0.44	89.92
Parandalia tricuspis	1.02	0	0.43	0.66	0.44	90.37

Groups RK-3.5 & RK-10.5
Average dissimilarity = 94.26

	Group RK-3.5	Group RK-10.5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Polypedilum halterale group Epler	0	7.18	4.54	10.5	4.82	4.82
Americorophium sp. A LeCroy	0	6.91	4.41	19.49	4.68	9.5
Apocorophium louisianum	0	6.35	3.97	5.2	4.22	13.71
Mediomastus ambiseta	6.07	0	3.94	3.55	4.18	17.9
Uromunna reynoldsi	0	5.32	3.31	3.96	3.51	21.41
Ampelisca sp.	5.38	1.21	3.17	1.39	3.36	24.77
Xenanthura brevitelson	4.71	0	2.95	1.31	3.13	27.9
Ablabesmyia rhamphe group Epler	0	4.26	2.73	10.25	2.9	30.8
Grandidierella bonnieroides	3.89	0	2.42	1.22	2.57	33.37
Streblospio sp.	3.68	0	2.38	3.41	2.52	35.9
Ampelisca holmesi	3.42	0	2.32	0.66	2.46	38.36
Halmyrapseudes cf. bahamensis Heard	3.66	0	2.29	1.25	2.42	40.78
Procladius (Holotanypus) sp.	0	3.62	2.15	1.32	2.28	43.06
Cyclaspis varians	3.09	0	1.95	1.29	2.06	45.12
Gammarus sp.	0	3.05	1.81	1.31	1.92	47.03
Aulodrilus pigueti	0	2.96	1.76	1.32	1.87	48.9
Tanytarsus sp. G Epler	0	2.92	1.73	1.29	1.83	50.73
Hydrobiidae (LPIL)	2.54	0	1.68	1.31	1.79	52.52
Leptochelia sp.	2.53	0	1.65	1.2	1.75	54.27
Fabricinuda trilobata	2.45	0	1.59	1.22	1.69	55.95
Leitoscoloplos sp.	2.45	0	1.53	1.27	1.63	57.58

Ceratopogonidae (LPIL)	0	2.54	1.52	1.32	1.61	59.19
Caecidotea sp.	0	2.03	1.51	0.67	1.61	60.79
Platyhelminthes (LPIL)	2.35	0	1.5	1.3	1.59	62.39
Capitella capitata	2.22	0	1.48	1.29	1.57	63.95
Amnicola dalli	0	2.45	1.45	1.29	1.54	65.49
Anomalocardia auberiana	2.22	0	1.42	1.31	1.51	67
Gammarus cf. tigrinus LeCroy	0	1.81	1.35	0.67	1.43	68.43
Nemertea (LPIL)	2.03	0	1.35	1.31	1.43	69.85
Crepidula plana	2.03	0	1.35	1.31	1.43	71.28
Americorophium sp.	1.96	0	1.33	0.66	1.41	72.69
cf. Potamethus sp.	2.03	0	1.28	1.31	1.35	74.05
Monocorophium acherusicum	2	0	1.22	0.66	1.29	75.34
Hobsonia florida	3.75	5.61	1.19	6.63	1.26	76.6
Corophiidae (LPIL)	1.73	0	1.17	0.66	1.25	77.84
Amakusanthura magnifica	1.65	0	1.12	0.66	1.19	79.03
Pseudonototanais sp. B Heard	1.52	0	0.98	0.66	1.04	80.08
Prionospio heterobranchia	1.44	0	0.93	0.66	0.99	81.06
Angulus versicolor	1.34	0	0.91	0.66	0.96	82.02
Tellina versicolor	1.34	0	0.87	0.66	0.92	82.94
Tubificoid Naididae imm. w/ hair setae (LPIL)	0	1.02	0.76	0.67	0.8	83.75
Procladius sp.	0	1.02	0.76	0.67	0.8	84.55
Oecetis sp. E Floyd	0	1.21	0.74	0.67	0.78	85.33
Parandalia tricuspis	1.21	0	0.73	0.66	0.78	86.11
Aoridae (LPIL)	1.21	0	0.73	0.66	0.78	86.89
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	1.21	0.7	0.67	0.74	87.63
Polymesoda caroliniana	0	1.21	0.7	0.67	0.74	88.37
Abra aequalis	0	1.21	0.7	0.67	0.74	89.11
Melinna sp.	1.02	0	0.69	0.66	0.73	89.84
Edotia triloba	1.02	0	0.69	0.66	0.73	90.57

Groups RK-5 & RK-10.5
Average dissimilarity = 89.72

	Group RK-5	Group RK-10.5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Grandidierella bonnieroides	7.72	0	5.84	6.72	6.51	6.51
Polypedilum halterale group Epler	0	7.18	5.32	9.63	5.93	12.44
Americorophium sp. A LeCroy	0	6.91	5.18	10.67	5.77	18.21
Mediomastus ambiseta	5.52	0	4.15	3.52	4.63	22.84
Uromunna reynoldsi	0	5.32	3.87	4.1	4.31	27.15
Streblospio sp.	4.55	0	3.46	4.77	3.86	31.01
Hobsonia florida	1.21	5.61	3.37	2.18	3.76	34.77
Ablabesmyia rhamphe group Epler	0	4.26	3.21	7.53	3.58	38.35
Tagelus plebeius	3.42	0	2.59	5.44	2.89	41.23
Procladius (Holotanypus) sp.	0	3.62	2.48	1.32	2.77	44
Leptochelia sp.	2.97	0	2.26	1.25	2.52	46.52
Xenanthura brevitelson	3.04	0	2.18	1.26	2.43	48.95
Gammarus sp.	0	3.05	2.09	1.31	2.33	51.28
Aulodrilus pigueti	0	2.96	2.04	1.32	2.27	53.55
Tanytarsus sp. G Epler	0	2.92	2	1.29	2.22	55.77
Melita nitida complex LeCroy	2.44	0	1.95	1.09	2.17	57.94
Ampelisca sp.	2.87	1.21	1.84	1.14	2.05	59.99
Caecidotea sp.	0	2.03	1.83	0.66	2.04	62.03
Edotia triloba	2.33	0	1.77	1.24	1.98	64.01
Ceratopogonidae (LPIL)	0	2.54	1.75	1.31	1.96	65.96
Cerapus benthophilus	2.4	0	1.72	1.3	1.92	67.88
Amnicola dalli	0	2.45	1.68	1.29	1.87	69.75
Gammarus cf. tigrinus LeCroy	0	1.81	1.62	0.66	1.81	71.56
Apocorophium louisianum	5.07	6.35	1.44	1.85	1.61	73.16
Americamysis sp.	1.71	0	1.33	1.29	1.49	74.65
Tubificoid Naididae imm. w/o hair setae (LPIL)	1.28	1.21	1.21	0.85	1.35	76
Parandalia tricuspis	1.39	0	1	0.66	1.12	77.11
Cyclaspis varians	1.34	0	0.96	0.66	1.07	78.19
Tubificoid Naididae imm. w/ hair setae (LPIL)	0	1.02	0.91	0.66	1.02	79.2

Procladius sp.	0	1.02	0.91	0.66	1.02	80.22
Oecetis sp. E Floyd	0	1.21	0.86	0.66	0.96	81.18
Polymesoda caroliniana	0	1.21	0.8	0.66	0.9	82.07
Abra aequalis	0	1.21	0.8	0.66	0.9	82.97
cf. Sipuncula (LPIL)	1.02	0	0.73	0.66	0.82	83.79
Melinna sp.	1.02	0	0.73	0.66	0.82	84.6
Pagastiella sp.	0	1.02	0.72	0.66	0.8	85.4
Tanytarsus sp. T Epler	0	1.02	0.72	0.66	0.8	86.21
Cernotina sp.	0	1.02	0.72	0.66	0.8	87.01
Leitoscoloplos foliosus	0.85	0	0.72	0.66	0.8	87.81
Rhithropanopeus harrisii	0.85	0	0.72	0.66	0.8	88.61
Acteocina canaliculata	0.85	0	0.72	0.66	0.8	89.41
Pyrgophorus platyrachis	0.85	0	0.72	0.66	0.8	90.22

Groups RK-6.5 & RK-10.5
Average dissimilarity = 86.96

Species	Group RK-6.5 Av.Abund	Group RK-10.5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Grandidierella bonnieroides	8.57	0	5.84	5.82	6.72	6.72
Polypedilum halterale group Epler	0	7.18	4.78	9.71	5.5	12.21
Americorophium sp. A LeCroy	0	6.91	4.65	13.38	5.35	17.56
Pyrgophorus platyrachis	6.78	0	4.54	2.11	5.22	22.78
Uromunna reynoldsi	0	5.32	3.48	3.97	4	26.78
Edotia triloba	4.27	0	2.89	4.28	3.32	30.11
Ablabesmyia rhamphe group Epler	0	4.26	2.88	8.74	3.31	33.42
Streblospio sp.	4.13	0	2.84	3.34	3.26	36.68
Cerapus benthophilus	4.09	0	2.76	4.43	3.17	39.86
Procladius (Holotanypus) sp.	0	3.62	2.25	1.32	2.59	42.45
Laeonereis culveri	3.07	0	1.98	0.66	2.28	44.73
Gammarus sp.	0	3.05	1.89	1.31	2.18	46.9
Aulodrilus pigueti	0	2.96	1.85	1.32	2.12	49.03
Tanytarsus sp. G Epler	0	2.92	1.81	1.29	2.08	51.11
Hobsonia florida	3.15	5.61	1.7	1.12	1.96	53.06
Parandalia tricuspis	2.4	0	1.67	1.3	1.92	54.98
Caryocorbula sp.	2.33	0	1.62	1.3	1.86	56.84
Caecidotea sp.	0	2.03	1.61	0.66	1.85	58.69
Ceratopogonidae (LPIL)	0	2.54	1.59	1.31	1.83	60.52
Tubificoid Naididae imm. w/o hair setae (LPIL)	2.33	1.21	1.53	1.12	1.76	62.28
Amnicola dalli	0	2.45	1.52	1.29	1.75	64.03
Gammarus cf. tigrinus LeCroy	0	1.81	1.43	0.66	1.64	65.67
Mediomastus ambiseta	1.98	0	1.39	1.23	1.6	67.27
Onobops jacksoni	2.06	0	1.33	0.66	1.53	68.8
Tanytarsus sp. H Epler	1.96	0	1.27	0.66	1.46	70.26
Apocorophium louisianum	6.58	6.35	1.18	0.92	1.35	71.61
Leitoscoloplos fragilis	1.81	0	1.17	0.66	1.34	72.95
Leptochelia sp.	1.81	0	1.17	0.66	1.34	74.29
Melita nitida complex LeCroy	1.48	0	1.1	0.66	1.26	75.55
Apocorophium lacustre	1.48	0	0.97	0.66	1.11	76.66
Ampelisca sp.	0.85	1.21	0.96	0.93	1.1	77.76
Leptochelia rapax	1.44	0	0.93	0.66	1.07	78.83
Dicrotendipes lobus	1.44	0	0.93	0.66	1.07	79.89
Ampithoidae (LPIL)	1.12	0	0.83	0.66	0.96	80.85
Cymadusa sp.	1.12	0	0.83	0.66	0.96	81.81
Tellinidae (LPIL)	1.12	0	0.83	0.66	0.96	82.77
Tubificoid Naididae imm. w/ hair setae (LPIL)	0	1.02	0.8	0.66	0.92	83.69
Procladius sp.	0	1.02	0.8	0.66	0.92	84.62
Sipuncula (LPIL)	1.21	0	0.79	0.66	0.91	85.52
Polydora cornuta	1.21	0	0.78	0.66	0.9	86.42
Almyracuma bacescui	1.21	0	0.78	0.66	0.9	87.32
Tagelus plebeius	1.21	0	0.78	0.66	0.9	88.21
Oecetis sp. E Floyd	0	1.21	0.77	0.66	0.89	89.1
Turbellaria (LPIL)	1.12	0	0.73	0.66	0.84	89.94
Polymesoda caroliniana	0	1.21	0.73	0.67	0.84	90.79

Groups RK-8 & RK-10.5
Average dissimilarity = 82.78

Species	Group RK-8 Av.Abund	Group RK-10.5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Grandidierella bonnieroides	9.46	0	6.95	3.85	8.4	8.4
Polypedilum halterale group Epler	0	7.18	5.28	3.41	6.38	14.78
Americorophium sp. A LeCroy	0	6.91	5.15	3.33	6.22	21
Laeonereis culveri	6.34	0	5	1.76	6.04	27.04
Uromunna reynoldsi	1.34	5.32	3.24	1.63	3.91	30.95
Ablabesmyia rhamphe group Epler	0	4.26	3.19	3.12	3.86	34.81
Edotia triloba	5.15	0	3.15	1.28	3.81	38.62
Hydrobiidae (LPIL)	3.67	0	3.06	1.01	3.7	42.31
Apocorophium louisianum	9.03	6.35	2.74	1.72	3.31	45.63
Procladius (Holotanypus) sp.	0	3.62	2.45	1.22	2.96	48.59
Streblospio sp.	3.86	0	2.39	1.22	2.89	51.48
Gammarus sp.	0	3.05	2.06	1.21	2.49	53.97
Aulodrilus pigueti	0	2.96	2.01	1.22	2.43	56.4
Tanytarsus sp. G Epler	0	2.92	1.97	1.2	2.38	58.78
Polypedilum scalaenum group Epler	3.11	0	1.91	1.28	2.3	61.08
Caecidotea sp.	0	2.03	1.84	0.62	2.22	63.3
Tubificoides sp.	2.83	0	1.77	1.16	2.14	65.44
Ceratopogonidae (LPIL)	0	2.54	1.73	1.21	2.09	67.53
Hobsonia florida	6.55	5.61	1.66	4.05	2	69.53
Amnicola dalli	0	2.45	1.66	1.2	2	71.54
Gammarus cf. tigrinus LeCroy	0	1.81	1.63	0.62	1.97	73.51
Cyathura polita	2.54	0	1.55	1.3	1.87	75.38
Polymesoda caroliniana	1.52	1.21	1.22	0.89	1.47	76.85
Tubificoid Naididae imm. w/o hair setae (LPIL)	1.21	1.21	1.13	0.81	1.36	78.21
Americamysis sp.	1.44	0	0.98	0.66	1.18	79.39
Turbellaria (LPIL)	1.71	0	0.93	0.66	1.12	80.51
Caryocorbula sp.	1.71	0	0.93	0.66	1.12	81.64
Tubificoid Naididae imm. w/ hair setae (LPIL)	0	1.02	0.92	0.62	1.11	82.75
Procladius sp.	0	1.02	0.92	0.62	1.11	83.86
Mytilopsis leucophaeata	1.62	0	0.88	0.66	1.07	84.92
Oecetis sp. E Floyd	0	1.21	0.85	0.64	1.02	85.95
Hourstonius laguna	1.21	0	0.82	0.66	0.99	86.94
Amphipoda (LPIL)	1.21	0	0.82	0.66	0.99	87.93
Leptochelia sp.	1.21	0	0.82	0.66	0.99	88.92
Bivalvia (LPIL)	1.21	0	0.82	0.66	0.99	89.9
Ampelisca sp.	0	1.21	0.79	0.64	0.96	90.86

Groups RK-9.5 & RK-10.5
Average dissimilarity = 62.15

Species	Group RK-9.5 Av.Abund	Group RK-10.5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Grandidierella bonnieroides	6.05	0	4.77	1.29	7.67	7.67
Americorophium sp. A LeCroy	3.04	6.91	4.2	2.24	6.76	14.44
Polypedilum halterale group Epler	2.41	7.18	3.6	2.46	5.79	20.23
Ablabesmyia rhamphe group Epler	0	4.26	3.35	8.96	5.39	25.62
Edotia triloba	3.4	0	2.68	1.27	4.31	29.92
Tubificoid Naididae imm. w/o hair setae (LPIL)	4.23	1.21	2.51	1.52	4.03	33.96
Procladius (Holotanypus) sp.	1.81	3.62	2.36	1.12	3.8	37.76
Procladius sp.	3.18	1.02	2.18	1.52	3.5	41.26
Aulodrilus pigueti	0	2.96	2.11	1.32	3.4	44.66
Gammarus sp.	1.21	3.05	1.97	1.23	3.17	47.84
Tanytarsus sp. G Epler	1.44	2.92	1.95	1.17	3.14	50.98
Caecidotea sp.	0	2.03	1.92	0.67	3.08	54.06
Tanytarsus sp.	2.41	0	1.91	1.29	3.07	57.14
Ceratopogonidae (LPIL)	0	2.54	1.82	1.32	2.93	60.07
Amnicola dalli	0	2.45	1.74	1.29	2.8	62.87
Gammarus cf. tigrinus LeCroy	0	1.81	1.7	0.67	2.74	65.61

Apocorophium lacustre	2	0	1.53	0.66	2.45	68.07
Uromunna reynoldsi	5.21	5.32	1.47	1.39	2.37	70.44
Hydrobiidae (LPIL)	1.59	0	1.3	0.66	2.1	72.53
Apocorophium louisianum	6.45	6.35	1.27	1.54	2.05	74.58
Abra aequalis	1.21	1.21	1.23	0.83	1.98	76.56
Polypedilum scalaenum group Epler	1.44	0	1.1	0.66	1.76	78.33
Platyhelminthes (LPIL)	1.21	0	0.99	0.66	1.59	79.92
Laeonereis culveri	1.21	0	0.99	0.66	1.59	81.51
Mytilopsis leucophaeata	1.21	0	0.99	0.66	1.59	83.11
Tubificoid Naididae imm. w/ hair setae (LPIL)	0	1.02	0.96	0.67	1.54	84.65
Turbellaria (LPIL)	1.21	0	0.95	0.66	1.53	86.18
Leptochelia sp.	1.21	0	0.95	0.66	1.53	87.72
Chironomus sp.	1.21	0	0.95	0.66	1.53	89.25
Hobsonia florida	5.16	5.61	0.95	1.63	1.53	90.78

Groups RK-0 & RK-11.2
Average dissimilarity = 99.61

	Group RK-0	Group RK-11.2				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Gammarus cf. tigrinus LeCroy	0	6.72	4.07	4.48	4.09	4.09
Cirrophorus sp.	5.26	0	3.22	3.76	3.23	7.31
Fabricinuda trilobata	4.83	0	2.66	1.02	2.67	9.98
Prionospio heterobranchia	4.45	0	2.6	3.31	2.61	12.59
Polypedilum halterale group Epler	0	4.16	2.55	3.38	2.56	15.15
Americorophium sp. A LeCroy	0	4.21	2.55	4.02	2.56	17.71
Scoletoma sp. A (strom)	4	0	2.43	8.12	2.44	20.14
Axiothella sp.	3.99	0	2.4	10.55	2.41	22.55
Turbellaria (LPIL)	0	3.87	2.38	3.29	2.39	24.94
Nemertea (LPIL)	3.63	0	2.19	6.89	2.2	27.14
Duridrilus tardus	3.16	0	2.06	1.31	2.07	29.21
Cernotina sp.	0	3.37	2.04	5.64	2.05	31.26
Uromunna reynoldsi	0	3.24	1.96	7.86	1.97	33.22
Syllis sp.	3.48	0	1.94	1.08	1.94	35.17
Angulus versicolor	2.83	0	1.83	1.27	1.84	37.01
Capitella capitata	2.67	0	1.74	1.32	1.75	38.75
Mooreonuphis pallidula	2.56	0	1.66	1.32	1.67	40.42
Olivella sp.	2.56	0	1.66	1.32	1.67	42.09
Scolelepis texana	2.13	0	1.38	1.27	1.38	43.48
Cryptotendipes sp.	0	2.35	1.37	1.29	1.38	44.85
Stenochironomus sp.	0	2.35	1.37	1.29	1.38	46.23
Melitidae (LPIL)	2.33	0	1.34	1.29	1.34	47.57
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	2.22	1.3	1.29	1.31	48.88
Dicrotendipes sp.	0	2.22	1.3	1.29	1.31	50.18
Paradialychone sp.	2.49	0	1.29	0.67	1.3	51.48
Caecidotea sp.	0	2.03	1.27	1.31	1.27	52.75
Pionosyllis sp.	2.19	0	1.27	1.31	1.27	54.02
Aulodrilus pigueti	0	2.03	1.24	1.3	1.25	55.27
Coelotanypus tricolor	0	2.03	1.19	1.31	1.19	56.46
Mediomastus ambiseta	1.98	0	1.15	1.33	1.16	57.62
Bulla striata	1.98	0	1.15	1.33	1.16	58.78
Polyplacophora sp. A (Strom)	2.17	0	1.13	0.67	1.13	59.91
Sphaerosyllis sp.	1.98	0	1.12	1.33	1.13	61.04
Phascolion sp.	1.65	0	1.11	0.66	1.11	62.15
Dicrotendipes neomodestus	0	1.65	0.98	0.66	0.99	63.13
Grubeosyllis clavata	1.89	0	0.98	0.67	0.98	64.12
Sphaerosyllis bilobata	1.44	0	0.96	0.66	0.97	65.08
Magelona pettiboneae	1.39	0	0.93	0.66	0.93	66.02
Lucinidae (LPIL)	1.34	0	0.85	0.67	0.85	66.87
Bivalvia (LPIL)	0.85	1.02	0.81	0.89	0.82	67.68
Capitella jonesi	1.28	0	0.81	0.67	0.81	68.5
Tanytarsus sp. T Epler	0	1.34	0.77	0.66	0.77	69.27
Oxyurostylis smithi	1.21	0	0.76	0.67	0.77	70.03
Chaetognatha (LPIL)	1.21	0	0.76	0.67	0.77	70.8

Leitoscoloplos fragilis	1.12	0	0.75	0.66	0.76	71.55
Cyrnellus fraternus	0	1.21	0.72	0.66	0.72	72.27
Ampelisca holmesi	1.12	0	0.71	0.67	0.71	72.99
Gyptis brevipalpa	1.34	0	0.69	0.67	0.7	73.68
Caulleriella sp.	1.34	0	0.69	0.67	0.7	74.38
Paracaprella tenuis	1.34	0	0.69	0.67	0.7	75.08
Kalliapseudes sp.	1.34	0	0.69	0.67	0.7	75.77
Crepidula plana	1.34	0	0.69	0.67	0.7	76.47
Crassinella lunulata	1.34	0	0.69	0.67	0.7	77.16
Tribelos fuscicorne	0	1.21	0.69	0.66	0.7	77.86
Glossiphoniidae (LPIL)	0	1.02	0.66	0.66	0.67	78.53
Apocorophium sp.	0	1.02	0.66	0.66	0.67	79.19
Neurocordulia alabamensis	0	1.02	0.66	0.66	0.67	79.86
Janua sp.	1.02	0	0.64	0.67	0.64	80.5
Americhelidium sp. A Lecroy	1.02	0	0.64	0.67	0.64	81.14
Sphaeromatidae (LPIL)	0	1.02	0.6	0.66	0.61	81.75
Cricotopus sp.	0	1.02	0.6	0.66	0.61	82.36
Orthocladiinae (LPIL)	0	1.02	0.6	0.66	0.61	82.96
Actiniaria (LPIL)	1.12	0	0.58	0.67	0.59	83.55
Mooreonuphis sp.	1.12	0	0.58	0.67	0.59	84.13
Exogone sp.	1.12	0	0.58	0.67	0.59	84.72
Opisthosyllis longidentata	1.12	0	0.58	0.67	0.59	85.3
Microspio pigmentata	1.12	0	0.58	0.67	0.59	85.89
Tanaidomorpha (LPIL)	1.12	0	0.58	0.67	0.59	86.47
Polyplacophora sp. B (Strom)	1.12	0	0.58	0.67	0.59	87.06
cf. Semelidae (LPIL)	1.12	0	0.58	0.67	0.59	87.64
Phoronida (LPIL)	1.12	0	0.58	0.67	0.59	88.23
Sphaeroma terebrans	0	1.02	0.58	0.66	0.58	88.81
Collembola (LPIL)	0	1.02	0.58	0.66	0.58	89.4
Dubiraphia vittata	0	1.02	0.58	0.66	0.58	89.98
Polypedilum beckae	0	1.02	0.58	0.66	0.58	90.56

Groups RK-2 & RK-11.2
Average dissimilarity = 100.00

Species	Group RK-2 Av.Abund	Group RK-11.2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Fabricinuda trilobata	10.25	0	4.41	5.37	4.41	4.41
Axiothella sp.	6.71	0	2.91	2.49	2.91	7.32
Gammarus cf. tigrinus LeCroy	0	6.72	2.88	5.04	2.88	10.2
Mediomastus ambiseta	6.24	0	2.66	5.5	2.66	12.86
Capitella capitata	5.95	0	2.57	3.15	2.57	15.43
Mooreonuphis pallidula	5.6	0	2.39	3.7	2.39	17.82
Monticellina dorsobranchialis	5.32	0	2.28	16.77	2.28	20.09
Prionospio heterobranchia	5.27	0	2.26	4.36	2.26	22.36
Angulus versicolor	4.71	0	2.02	8.96	2.02	24.38
Melinna sp.	4.48	0	1.91	7.9	1.91	26.29
Ampelisca sp.	4.43	0	1.89	15.44	1.89	28.18
Halmyrapseudes cf. bahamensis Heard	4.24	0	1.84	1.03	1.84	30.02
Cyclaspis varians	4.29	0	1.84	17.31	1.84	31.86
Americorophium sp. A LeCroy	0	4.21	1.8	4.43	1.8	33.66
Potamethus spathiferus	4.21	0	1.8	4.32	1.8	35.47
Polypedilum halterale group Epler	0	4.16	1.8	3.86	1.8	37.26
Merisca sp.	4.09	0	1.77	2.38	1.77	39.03
Syllis sp.	4	0	1.72	5.49	1.72	40.76
Turbellaria (LPIL)	0	3.87	1.67	3.77	1.67	42.43
Scolelepis texana	3.87	0	1.67	4	1.67	44.1
Piromis roberti	3.79	0	1.62	7.87	1.62	45.72
Cernotina sp.	0	3.37	1.44	6.96	1.44	47.16
Nemertea sp. J	3.37	0	1.44	9.34	1.44	48.59
Oxyurostylis smithi	3.3	0	1.41	1.32	1.41	50
Uromunna reynoldsi	0	3.24	1.38	12.94	1.38	51.38
Scoloplos rubra	3.24	0	1.38	16.25	1.38	52.77
Aoridae (LPIL)	3.17	0	1.32	1.25	1.32	54.09

Aricidea taylori	2.91	0	1.21	1.21	1.21	55.3
Nemertea (LPIL)	2.77	0	1.18	1.32	1.18	56.48
Onuphidae (LPIL)	2.67	0	1.13	1.2	1.13	57.61
Xenanthura brevitelson	2.64	0	1.13	1.3	1.13	58.74
Eteone heteropoda	2.45	0	1.08	1.27	1.08	59.82
Pionosyllis sp.	2.45	0	1.08	1.27	1.08	60.9
Dipolydora sp.	2.45	0	1.04	1.25	1.04	61.94
Langerhansia sp.	2.35	0	0.98	1.31	0.98	62.92
Spiochaetopterus costarum	2.35	0	0.98	1.31	0.98	63.91
Cryptotendipes sp.	0	2.35	0.98	1.3	0.98	64.89
Stenochironomus sp.	0	2.35	0.98	1.3	0.98	65.87
cf. Semelidae (LPIL)	2.22	0	0.98	1.31	0.98	66.85
Duridrilus tardus	2.22	0	0.95	1.3	0.95	67.8
Dipolydora socialis	2.17	0	0.95	0.67	0.95	68.74
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	2.22	0.93	1.31	0.93	69.67
Dicrotendipes sp.	0	2.22	0.93	1.31	0.93	70.6
Caecidotea sp.	0	2.03	0.89	1.33	0.89	71.49
Aulodrilus pigueti	0	2.03	0.88	1.33	0.88	72.37
Sphaerosyllis sp.	2.03	0	0.86	1.33	0.86	73.23
Podarkeopsis levifuscina	2.03	0	0.85	1.33	0.85	74.08
Ceratonereis sp.	2.03	0	0.85	1.33	0.85	74.94
Lysilla sp.	2.03	0	0.85	1.33	0.85	75.79
Tubificoides sp.	2.03	0	0.85	1.33	0.85	76.64
Coelotanypus tricolor	0	2.03	0.85	1.33	0.85	77.49
Acteocina canaliculata	1.65	0	0.74	0.67	0.74	78.23
Dicrotendipes neomodestus	0	1.65	0.7	0.67	0.7	78.93
Actiniaria (LPIL)	1.44	0	0.63	0.67	0.63	79.55
Odontosyllis sp.	1.44	0	0.63	0.67	0.63	80.18
Hobsonia florida	1.28	0	0.56	0.67	0.56	80.73
Tanytarsus sp. T Epler	0	1.34	0.55	0.67	0.55	81.28
Listriella sp.	1.21	0	0.54	0.67	0.54	81.82
Lysianopsis alba	1.21	0	0.53	0.67	0.53	82.35
Cyrnellus fraternus	0	1.21	0.51	0.67	0.51	82.86
Tribelos fuscicorne	0	1.21	0.5	0.67	0.5	83.36
Phyllodoce arenae	1.21	0	0.49	0.67	0.49	83.84
Paracaprella sp.	1.21	0	0.49	0.67	0.49	84.33
Edotia triloba	1.21	0	0.49	0.67	0.49	84.82
Glossiphoniidae (LPIL)	0	1.02	0.46	0.67	0.46	85.28
Apocorophium sp.	0	1.02	0.46	0.67	0.46	85.74
Neurocordulia alabamensis	0	1.02	0.46	0.67	0.46	86.2
Bivalvia (LPIL)	0	1.02	0.46	0.67	0.46	86.65
Grubeosyllis sp.	1.02	0	0.45	0.67	0.45	87.11
Sphaerosyllis brevifrons	1.02	0	0.45	0.67	0.45	87.56
Fabriciinae (LPIL)	1.02	0	0.45	0.67	0.45	88.01
Parandalia tricuspis	1.02	0	0.45	0.67	0.45	88.46
Leptochelia rapax	1.02	0	0.45	0.67	0.45	88.92
Eulimastoma sp.	1.02	0	0.45	0.67	0.45	89.37
Lyonsia floridana	1.02	0	0.45	0.67	0.45	89.82
Ophiuroidea (LPIL)	1.02	0	0.45	0.67	0.45	90.27

Groups RK-3.5 & RK-11.2
Average dissimilarity = 99.53

	Group RK-3.5	Group RK-11.2				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Gammarus cf. tigrinus LeCroy	0	6.72	4.6	5.04	4.62	4.62
Mediomastus ambiseta	6.07	0	4.2	3.79	4.22	8.85
Ampelisca sp.	5.38	0	3.6	1.33	3.61	12.46
Xenanthura brevitelson	4.71	0	3.14	1.33	3.16	15.61
Polypedilum halterale group Epler	0	4.16	2.89	3.54	2.9	18.52
Americorophium sp. A LeCroy	0	4.21	2.88	4.42	2.9	21.42
Turbellaria (LPIL)	0	3.87	2.69	3.42	2.71	24.12
Grandidierella bonnieroides	3.89	0	2.58	1.23	2.59	26.71
Hobsonia florida	3.75	0	2.57	14.51	2.58	29.29

Streblospio sp.	3.68	0	2.53	3.63	2.54	31.84
Ampelisca holmesi	3.42	0	2.48	0.66	2.49	34.32
Halmyrapseudes cf. bahamensis Heard	3.66	0	2.43	1.26	2.44	36.77
Cernotina sp.	0	3.37	2.31	6.86	2.32	39.08
Uromunna reynoldsi	0	3.24	2.21	12.96	2.23	41.31
Cyclaspis varians	3.09	0	2.07	1.31	2.08	43.39
Hydrobiidae (LPIL)	2.54	0	1.8	1.32	1.8	45.19
Leptochelia sp.	2.53	0	1.75	1.22	1.76	46.95
Fabricinuda trilobata	2.45	0	1.7	1.23	1.7	48.66
Leitoscoloplos sp.	2.45	0	1.63	1.29	1.64	50.29
Platyhelminthes (LPIL)	2.35	0	1.6	1.31	1.61	51.9
Capitella capitata	2.22	0	1.57	1.3	1.58	53.48
Cryptotendipes sp.	0	2.35	1.54	1.3	1.55	55.03
Stenochironomus sp.	0	2.35	1.54	1.3	1.55	56.58
Anomalocardia auberiana	2.22	0	1.51	1.32	1.52	58.1
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	2.22	1.46	1.31	1.47	59.57
Dicrotendipes sp.	0	2.22	1.46	1.31	1.47	61.04
Caecidotea sp.	0	2.03	1.44	1.32	1.44	62.49
Nemertea (LPIL)	2.03	0	1.43	1.32	1.44	63.93
Crepidula plana	2.03	0	1.43	1.32	1.44	65.37
Americorophium sp.	1.96	0	1.42	0.66	1.43	66.8
Aulodrilus pigueti	0	2.03	1.41	1.32	1.42	68.22
cf. Potamethus sp.	2.03	0	1.36	1.32	1.36	69.58
Coelotanypus tricolor	0	2.03	1.33	1.33	1.34	70.92
Monocorophium acherusicum	2	0	1.29	0.66	1.3	72.22
Corophiidae (LPIL)	1.73	0	1.25	0.66	1.26	73.48
Amakusanthura magnifica	1.65	0	1.19	0.66	1.2	74.68
Dicrotendipes neomodestus	0	1.65	1.11	0.67	1.11	75.79
Pseudonototanais sp. B Heard	1.52	0	1.05	0.66	1.05	76.85
Prionospio heterobranchia	1.44	0	0.99	0.66	1	77.84
Angulus versicolor	1.34	0	0.97	0.66	0.97	78.81
Apocorophium sp.	1.02	1.02	0.94	0.83	0.94	79.76
Tellina versicolor	1.34	0	0.92	0.66	0.93	80.69
Tanytarsus sp. T Epler	0	1.34	0.86	0.67	0.87	81.55
Cyrnellus fraternus	0	1.21	0.81	0.67	0.81	82.37
Parandalia tricuspis	1.21	0	0.78	0.66	0.78	83.15
Aoridae (LPIL)	1.21	0	0.78	0.66	0.78	83.93
Tribelos fuscicorne	0	1.21	0.78	0.67	0.78	84.72
Glossiphoniidae (LPIL)	0	1.02	0.76	0.67	0.76	85.47
Neurocordulia alabamensis	0	1.02	0.76	0.67	0.76	86.23
Bivalvia (LPIL)	0	1.02	0.76	0.67	0.76	86.99
Melinna sp.	1.02	0	0.73	0.66	0.74	87.73
Edotia triloba	1.02	0	0.73	0.66	0.74	88.47
Rictaxis punctostriatus	1.02	0	0.73	0.66	0.74	89.21
Cymadusa compta	1.02	0	0.7	0.66	0.7	89.91
Americamysis sp.	1.02	0	0.7	0.66	0.7	90.62

Groups RK-5 & RK-11.2
Average dissimilarity = 97.14

	Group RK-5	Group RK-11.2				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Grandidierella bonnieroides	7.72	0	6.28	10.7	6.47	6.47
Gammarus cf. tigrinus LeCroy	0	6.72	5.47	4.69	5.63	12.09
Mediomastus ambiseta	5.52	0	4.46	3.9	4.59	16.69
Apocorophium louisianum	5.07	0	4.1	7.38	4.22	20.91
Streblospio sp.	4.55	0	3.72	5.68	3.83	24.74
Polypedilum halterale group Epler	0	4.16	3.44	3.28	3.54	28.28
Americorophium sp. A LeCroy	0	4.21	3.43	4.17	3.53	31.81
Tagelus plebeius	3.42	0	2.78	7	2.87	34.68
Cernotina sp.	0	3.37	2.74	6.07	2.82	37.5
Uromunna reynoldsi	0	3.24	2.63	9.28	2.71	40.2
Turbellaria (LPIL)	0.85	3.87	2.56	1.72	2.63	42.84
Leptochelia sp.	2.97	0	2.44	1.28	2.51	45.34

Xenanthura brevitelson	3.04	0	2.33	1.27	2.4	47.75
Ampelisca sp.	2.87	0	2.2	1.3	2.27	50.02
Melita nitida complex LeCroy	2.44	0	2.1	1.11	2.16	52.18
Edotia triloba	2.33	0	1.91	1.26	1.96	54.14
Cerapus benthophilus	2.4	0	1.84	1.32	1.9	56.04
Cryptotendipes sp.	0	2.35	1.82	1.3	1.87	57.91
Stenochironomus sp.	0	2.35	1.82	1.3	1.87	59.78
Dicrotendipes sp.	0	2.22	1.72	1.3	1.78	61.55
Caecidotea sp.	0	2.03	1.72	1.31	1.77	63.32
Aulodrilus pigueti	0	2.03	1.68	1.3	1.73	65.05
Tubificoid Naididae imm. w/o hair setae (LPIL)	1.28	2.22	1.62	1.15	1.67	66.72
Coelotanypus tricolor	0	2.03	1.57	1.32	1.62	68.34
Americamysis sp.	1.71	0	1.44	1.31	1.48	69.82
Dicrotendipes neomodestus	0	1.65	1.31	0.66	1.35	71.16
Bivalvia (LPIL)	0.85	1.02	1.09	0.87	1.12	72.29
Parandalia tricuspis	1.39	0	1.07	0.66	1.1	73.39
Cyclaspis varians	1.34	0	1.03	0.66	1.06	74.45
Tanytarsus sp. T Epler	0	1.34	1.01	0.66	1.04	75.5
Cyrnellus fraternus	0	1.21	0.96	0.66	0.98	76.48
Hobsonia florida	1.21	0	0.92	0.66	0.95	77.43
Tribelos fuscicorne	0	1.21	0.91	0.66	0.94	78.37
Glossiphoniidae (LPIL)	0	1.02	0.91	0.66	0.94	79.31
Apocorophium sp.	0	1.02	0.91	0.66	0.94	80.25
Neurocordulia alabamensis	0	1.02	0.91	0.66	0.94	81.19
Sphaeromatidae (LPIL)	0	1.02	0.8	0.66	0.83	82.01
Cricotopus sp.	0	1.02	0.8	0.66	0.83	82.84
Orthocladiinae (LPIL)	0	1.02	0.8	0.66	0.83	83.67
cf. Sipuncula (LPIL)	1.02	0	0.78	0.66	0.81	84.48
Melinna sp.	1.02	0	0.78	0.66	0.81	85.29
Leitoscoloplos foliosus	0.85	0	0.78	0.66	0.8	86.09
Rhithropanopeus harrisii	0.85	0	0.78	0.66	0.8	86.89
Acteocina canaliculata	0.85	0	0.78	0.66	0.8	87.69
Pyrgophorus platyrachis	0.85	0	0.78	0.66	0.8	88.49
Ischadium recurvum	0.85	0	0.78	0.66	0.8	89.29
Crassostrea virginica	0.85	0	0.78	0.66	0.8	90.09

Groups RK-6.5 & RK-11.2
Average dissimilarity = 95.72

	Group RK-6.5	Group RK-11.2				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Grandidierella bonnieroides	8.57	0	6.24	7.22	6.52	6.52
Gammarus cf. tigrinus LeCroy	0	6.72	4.87	4.85	5.09	11.6
Pyrgophorus platyrachis	6.78	0	4.85	2.18	5.06	16.67
Apocorophium louisianum	6.58	0	4.82	3.31	5.03	21.7
Edotia triloba	4.27	0	3.09	4.81	3.23	24.92
Polypedilum halterale group Epler	0	4.16	3.06	3.42	3.2	28.12
Americorophium sp. A LeCroy	0	4.21	3.05	4.28	3.19	31.31
Streblospio sp.	4.13	0	3.03	3.54	3.17	34.47
Cerapus benthophilus	4.09	0	2.95	5.04	3.08	37.55
Cernotina sp.	0	3.37	2.44	6.41	2.55	40.1
Hobsonia florida	3.15	0	2.39	1.18	2.5	42.6
Uromunna reynoldsi	0	3.24	2.34	10.57	2.45	45.05
Turbellaria (LPIL)	1.12	3.87	2.12	1.48	2.21	47.26
Laeonereis culveri	3.07	0	2.11	0.66	2.21	49.47
Parandalia tricuspis	2.4	0	1.78	1.32	1.86	51.33
Caryocorbula sp.	2.33	0	1.73	1.32	1.81	53.14
Cryptotendipes sp.	0	2.35	1.63	1.3	1.7	54.84
Stenochironomus sp.	0	2.35	1.63	1.3	1.7	56.54
Dicrotendipes sp.	0	2.22	1.54	1.3	1.61	58.15
Caecidotea sp.	0	2.03	1.52	1.32	1.59	59.74
Aulodrilus pigueti	0	2.03	1.49	1.31	1.56	61.3
Mediomastus ambiseta	1.98	0	1.49	1.25	1.56	62.86
Tubificoid Naididae imm. w/o hair setae (LPIL)	2.33	2.22	1.43	1.16	1.5	64.36

Onobops jacksoni	2.06	0	1.42	0.66	1.48	65.84
Coelotanypus tricolor	0	2.03	1.41	1.32	1.47	67.31
Tanytarsus sp. H Epler	1.96	0	1.35	0.66	1.41	68.72
Leitoscoloplos fragilis	1.81	0	1.24	0.66	1.3	70.01
Leptochelia sp.	1.81	0	1.24	0.66	1.3	71.31
Melita nitida complex LeCroy	1.48	0	1.18	0.66	1.23	72.54
Dicrotendipes neomodestus	0	1.65	1.17	0.66	1.22	73.76
Apocorophium lacustre	1.48	0	1.03	0.66	1.07	74.84
Bivalvia (LPIL)	1.02	1.02	1	0.83	1.04	75.88
Leptochelia rapax	1.44	0	0.99	0.66	1.03	76.91
Dicrotendipes lobus	1.44	0	0.99	0.66	1.03	77.94
Collembola (LPIL)	0.85	1.02	0.91	0.89	0.95	78.9
Tanytarsus sp. T Epler	0	1.34	0.91	0.66	0.95	79.84
Ampithoidae (LPIL)	1.12	0	0.9	0.66	0.94	80.78
Cymadusa sp.	1.12	0	0.9	0.66	0.94	81.72
Tellinidae (LPIL)	1.12	0	0.9	0.66	0.94	82.65
Cyrnellus fraternus	0	1.21	0.85	0.66	0.89	83.54
Sipuncula (LPIL)	1.21	0	0.84	0.66	0.88	84.42
Polydora cornuta	1.21	0	0.83	0.66	0.87	85.29
Almyracuma bacescui	1.21	0	0.83	0.66	0.87	86.15
Tagelus plebeius	1.21	0	0.83	0.66	0.87	87.02
Tribelos fuscicorne	0	1.21	0.82	0.66	0.86	87.88
Glossiphoniidae (LPIL)	0	1.02	0.8	0.66	0.84	88.71
Apocorophium sp.	0	1.02	0.8	0.66	0.84	89.55
Neurocordulia alabamensis	0	1.02	0.8	0.66	0.84	90.39

Groups RK-8 & RK-11.2
Average dissimilarity = 95.70

	Group RK-8	Group RK-11.2				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Grandidierella bonnieroides	9.46	0	7.49	4.18	7.83	7.83
Apocorophium louisianum	9.03	0	6.5	5.04	6.79	14.62
Gammarus cf. tigrinus LeCroy	0	6.72	5.45	2.68	5.7	20.31
Laeonereis culveri	6.34	0	5.41	1.78	5.65	25.97
Hobsonia florida	6.55	0	4.85	5.99	5.06	31.03
Polypedilum halterale group Epler	0	4.16	3.44	2.23	3.59	34.62
Americorophium sp. A LeCroy	0	4.21	3.42	2.56	3.57	38.19
Edotia triloba	5.15	0	3.35	1.29	3.5	41.69
Hydrobiidae (LPIL)	3.67	0	3.33	1.02	3.48	45.17
Cernotina sp.	0	3.37	2.73	2.89	2.86	48.03
Turbellaria (LPIL)	1.71	3.87	2.69	1.38	2.81	50.84
Streblospio sp.	3.86	0	2.54	1.23	2.65	53.49
Uromunna reynoldsi	1.34	3.24	2.16	1.52	2.25	55.74
Polypedilum scalaenum group Epler	3.11	0	2.03	1.29	2.12	57.86
Tubificoides sp.	2.83	0	1.88	1.17	1.97	59.83
Cryptotendipes sp.	0	2.35	1.8	1.18	1.88	61.71
Stenochironomus sp.	0	2.35	1.8	1.18	1.88	63.6
Caecidotea sp.	0	2.03	1.72	1.17	1.8	65.39
Dicrotendipes sp.	0	2.22	1.71	1.18	1.79	67.18
Aulodrilus pigueti	0	2.03	1.68	1.17	1.75	68.94
Cyathura polita	2.54	0	1.64	1.32	1.72	70.65
Coelotanypus tricolor	0	2.03	1.56	1.2	1.63	72.28
Tubificoid Naididae imm. w/o hair setae (LPIL)	1.21	2.22	1.56	1.02	1.63	73.92
Dicrotendipes neomodestus	0	1.65	1.3	0.63	1.36	75.28
Bivalvia (LPIL)	1.21	1.02	1.26	0.84	1.31	76.59
Americamysis sp.	1.44	0	1.04	0.66	1.09	77.68
Tanytarsus sp. T Epler	0	1.34	1	0.63	1.05	78.73
Caryocorbula sp.	1.71	0	0.98	0.67	1.03	79.75
Cyrnellus fraternus	0	1.21	0.95	0.63	0.99	80.75
Mytilopsis leucophaeata	1.62	0	0.93	0.67	0.97	81.72
Glossiphoniidae (LPIL)	0	1.02	0.92	0.62	0.96	82.68
Apocorophium sp.	0	1.02	0.92	0.62	0.96	83.64
Neurocordulia alabamensis	0	1.02	0.92	0.62	0.96	84.6

Tribelos fuscicorne	0	1.21	0.91	0.63	0.95	85.54
Hourstonius laguna	1.21	0	0.88	0.66	0.91	86.46
Amphipoda (LPIL)	1.21	0	0.88	0.66	0.91	87.37
Leptochelia sp.	1.21	0	0.88	0.66	0.91	88.29
Polymesoda caroliniana	1.52	0	0.87	0.67	0.91	89.2
Sphaeromatidae (LPIL)	0	1.02	0.8	0.63	0.84	90.04

Groups RK-9.5 & RK-11.2
Average dissimilarity = 82.58

Species	Group RK-9.5 Av.Abund	Group RK-11.2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Gammarus cf. tigrinus LeCroy	0	6.72	5.71	5.09	6.92	6.92
Apocorophium louisianum	6.45	0	5.51	8.48	6.67	13.58
Grandidierella bonnieroides	6.05	0	5.14	1.31	6.22	19.81
Hobsonia florida	5.16	0	4.37	4.08	5.29	25.1
Americorophium sp. A LeCroy	3.04	4.21	3.78	4.23	4.58	29.68
Edotia triloba	3.4	0	2.89	1.3	3.49	33.17
Cernotina sp.	0	3.37	2.86	6.99	3.47	36.64
Procladius sp.	3.18	0	2.66	1.32	3.22	39.86
Turbellaria (LPIL)	1.21	3.87	2.43	1.46	2.94	42.8
Tanytarsus sp.	2.41	0	2.06	1.32	2.49	45.3
Cryptotendipes sp.	0	2.35	1.89	1.31	2.29	47.59
Stenochironomus sp.	0	2.35	1.89	1.31	2.29	49.88
Tubificoid Naididae imm. w/o hair setae (LPIL)	4.23	2.22	1.8	1.07	2.18	52.06
Dicrotendipes sp.	0	2.22	1.8	1.31	2.18	54.24
Caecidotea sp.	0	2.03	1.8	1.32	2.18	56.42
Aulodrilus pigueti	0	2.03	1.76	1.32	2.13	58.55
Uromunna reynoldsi	5.21	3.24	1.72	1.35	2.09	60.63
Polypedilum halterale group Epler	2.41	4.16	1.71	1.15	2.07	62.7
Apocorophium lacustre	2	0	1.64	0.66	1.99	64.69
Coelotanypus tricolor	0	2.03	1.64	1.33	1.99	66.67
Procladius (Holotanypus) sp.	1.81	0	1.48	0.66	1.79	68.47
Hydrobiidae (LPIL)	1.59	0	1.41	0.66	1.71	70.17
Dicrotendipes neomodestus	0	1.65	1.37	0.67	1.65	71.83
Tanytarsus sp. G Epler	1.44	0	1.22	0.66	1.48	73.31
Polypedilum scalaenum group Epler	1.44	0	1.18	0.66	1.43	74.74
Platyhelminthes (LPIL)	1.21	0	1.07	0.66	1.29	76.03
Laeonereis culveri	1.21	0	1.07	0.66	1.29	77.33
Mytilopsis leucophaeata	1.21	0	1.07	0.66	1.29	78.62
Tanytarsus sp. T Epler	0	1.34	1.05	0.67	1.28	79.9
Gammarus sp.	1.21	0	1.03	0.66	1.24	81.14
Leptochelia sp.	1.21	0	1.03	0.66	1.24	82.39
Chironomus sp.	1.21	0	1.03	0.66	1.24	83.63
Abra aequalis	1.21	0	1.03	0.66	1.24	84.88
Cyrnellus fraternus	0	1.21	1	0.67	1.21	86.09
Amphipoda (LPIL)	1.21	0	0.99	0.66	1.2	87.29
Glossiphoniidae (LPIL)	0	1.02	0.96	0.67	1.16	88.45
Apocorophium sp.	0	1.02	0.96	0.67	1.16	89.61
Neurocordulia alabamensis	0	1.02	0.96	0.67	1.16	90.76

Groups RK-10.5 & RK-11.2
Average dissimilarity = 71.20

Species	Group RK-10.5 Av.Abund	Group RK-11.2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Apocorophium louisianum	6.35	0	4.99	5.6	7.01	7.01
Hobsonia florida	5.61	0	4.55	7.64	6.4	13.41
Gammarus cf. tigrinus LeCroy	1.81	6.72	3.76	1.88	5.28	18.69
Ablabesmyia rhamphe group Epler	4.26	0	3.45	7.22	4.85	23.54
Turbellaria (LPIL)	0	3.87	3.21	2.91	4.51	28.05
Procladius (Holotanypus) sp.	3.62	0	2.65	1.32	3.72	31.78
Caecidotea sp.	2.03	2.03	2.33	1.4	3.27	35.04
Polypedilum halterale group Epler	7.18	4.16	2.27	2.22	3.19	38.23

Gammarus sp.	3.05	0	2.23	1.31	3.13	41.36
Americorophium sp. A LeCroy	6.91	4.21	2.14	2.57	3.01	44.37
Tanytarsus sp. G Epler	2.92	0	2.13	1.29	2.99	47.36
Cernotina sp.	1.02	3.37	1.97	1.4	2.77	50.13
Ceratopogonidae (LPIL)	2.54	0	1.87	1.31	2.63	52.76
Aulodrilus pigueti	2.96	2.03	1.84	1.46	2.59	55.35
Cryptotendipes sp.	0	2.35	1.82	1.28	2.55	57.9
Stenochironomus sp.	0	2.35	1.82	1.28	2.55	60.45
Amnicola dalli	2.45	0	1.79	1.29	2.52	62.96
Dicrotendipes sp.	0	2.22	1.72	1.28	2.42	65.38
Uromunna reynoldsi	5.32	3.24	1.63	1.37	2.29	67.67
Tubificoid Naididae imm. w/o hair setae (LPIL)	1.21	2.22	1.57	1.09	2.21	69.88
Coelotanypus tricolor	0	2.03	1.57	1.3	2.21	72.09
Dicrotendipes neomodestus	0	1.65	1.31	0.66	1.84	73.93
Tanytarsus sp. T Epler	1.02	1.34	1.3	0.9	1.83	75.76
Tubificoid Naididae imm. w/ hair setae (LPIL)	1.02	0	0.99	0.66	1.4	77.16
Procladius sp.	1.02	0	0.99	0.66	1.4	78.55
Cyrnellus fraternus	0	1.21	0.96	0.66	1.34	79.9
Oecetis sp. E Floyd	1.21	0	0.92	0.66	1.29	81.19
Glossiphoniidae (LPIL)	0	1.02	0.91	0.65	1.28	82.47
Apocorophium sp.	0	1.02	0.91	0.65	1.28	83.75
Neurocordulia alabamensis	0	1.02	0.91	0.65	1.28	85.04
Bivalvia (LPIL)	0	1.02	0.91	0.65	1.28	86.32
Tribelos fuscicorne	0	1.21	0.91	0.66	1.28	87.6
Ampelisca sp.	1.21	0	0.86	0.66	1.2	88.81
Polymesoda caroliniana	1.21	0	0.86	0.66	1.2	90.01

Appendix D

Descriptive Summary Statistics

Table D-1. Pithlachascotee River Sediment Data collected May 2009

Descriptive Summary Statistics

Variable	N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
%>3"	10	0	0	0	0	0	0	0	0
% Coarse Gravel	10	0.15	0.15	0.474	0	0	0	0	1.5
% Fine	10	2.53	1.75	5.55	0	0	0	2.55	17.2
% Coarse Gravel_1	10	1.02	0.61	1.929	0	0	0	1.375	6.2
% Medium	10	2.22	0.496	1.569	0.3	0.9	1.8	3.225	5.2
% Fine_1	10	81.1	2.57	8.14	65.1	77.18	80.7	86.67	93.3
% Silt	10	6.3	0.941	2.976	2.1	2.975	7.45	8.475	10.5
% Clay	10	6.68	0.603	1.906	3.8	4.9	7	8.4	9.3
% Silt plus Clay	10	12.98	1.49	4.71	6.4	7.55	13.8	16.73	19.8

N is the number of observations. Q1 is the first quartile value. Q3 is the third quartile value.

Table D-2. Pithlachascotee River Physicochemical Data

Descriptive Summary Statistics									
Variable	**N**	**Mean**	**SE Mean**	**StDev**	**Minimum**	**Q1**	**Median**	**Q3**	**Maximum**
Depth of Collection (	28	1.189	0.127	0.671	0.5	0.5	1	1.575	2.5
Temperature (C)	28	27.31	0.296	1.564	23.99	26.47	27.605	28.58	29.37
pH	28	7.526	0.0339	0.1795	7.24	7.43	7.515	7.668	7.89
Conductivity	28	31213	3242	17155	926	14286	38723	45505	50901
Salinity	28	19.91	2.16	11.44	0.48	8.28	24.69	29.62	33.49
DO%	28	45.88	2.48	13.14	17.3	31.68	50.3	56.03	67.2
DO mg/l	28	3.159	0.141	0.745	1.35	2.567	3.305	3.68	4.6
Total Site Depth	9	1.956	0.195	0.585	1.2	1.55	1.7	2.65	2.8
N is the number of observations. Q1 is the first quartile value. Q3 is the third quartile value.									

Table D-3. Pithlachascotee River Macroinvertebrate Metrics, May 2009

Descriptive Summary Statistics for Unpooled Data									
Variable	**N**	**Mean**	**SE Mean**	**StDev**	**Minimum**	**Q1**	**Median**	**Q3**	**Maximum**
N_Taxa	27	20.48	1.89	9.8	5	15	18	24	47
N_Individuals	27	410.1	60.8	315.8	78	176	288	512	1365
Margalefs d	27	3.368	0.297	1.545	0.712	2.237	2.974	4.072	7.374
Pielous Evenness	27	0.682	0.02	0.1037	0.5254	0.618	0.6628	0.748	0.889
Shannon Diversity(loge)	27	1.981	0.0829	0.4305	1.1738	1.675	1.8899	2.217	3.0448
Shannon Diversity(log2)	27	2.858	0.12	0.621	1.693	2.416	2.727	3.199	4.393
Shannon Diversity(log10)	27	0.86	0.036	0.187	0.5098	0.727	0.8208	0.963	1.3224
Simpsons d (1-λ)	27	0.762	0.0185	0.0964	0.5964	0.684	0.7496	0.841	0.9365
N is the number of observations. Q1 is the first quartile value. Q3 is the third quartile value.									

Table D-4. Pithlachascotee River Macroinvertebrate Metrics, May 2009

Descriptive Summary Statistics for Pooled Data									
Variable	**N**	**Mean**	**SE Mean**	**StDev**	**Minimum**	**Q1**	**Median**	**Q3**	**Maximum**
N_Taxa	9	39.56	5.78	17.35	24	26	36	53.5	71
N_Individuals	9	1230	231	694	356	752	1051	1858	2372
Margalefs d	9	5.494	0.748	2.245	3.341	3.43	5.093	7.431	9.199
Pielous Evenness	9	0.6477	0.0186	0.0557	0.5638	0.5989	0.6489	0.6986	0.7346
Shannon Diversity(loge)	9	2.3292	0.0978	0.2933	1.8786	2.1392	2.2119	2.6678	2.7167
Shannon Diversity(log2)	9	3.36	0.141	0.423	2.71	3.086	3.191	3.849	3.919
Shannon Diversity(log10)	9	1.0116	0.0425	0.1274	0.8159	0.9291	0.9606	1.1586	1.1799
Simpsons d (1-λ)	9	0.8153	0.0158	0.0474	0.7428	0.7657	0.8228	0.8525	0.8803
N is the number of observations. Q1 is the first quartile value. Q3 is the third quartile value.									

Appendix E

Bray-Curtis Similarity Matrices

Table E-1. Pithlachascotee River Macroinvertebrate Data, May 2009

Bray-Curtis Similarity Matrix for the Unpooled Macroinvertebrate Data

	RK-0-A	RK-0-B	RK-0-C	RK-2-A	RK-2-B	RK-2-C	RK-3.5-A	RK-3.5-B	RK-3.5-C	RK-5-A	RK-5-B	RK-5-C
RK-0-A	0	0	0	0	0	0	0	0	0	0	0	0
RK-0-B	14.49487	0	0	0	0	0	0	0	0	0	0	0
RK-0-C	42.78351	21.9949	0	0	0	0	0	0	0	0	0	0
RK-2-A	21.58261	31.83175	22.0632	0	0	0	0	0	0	0	0	0
RK-2-B	16.46018	29.96965	18.86427	45.57727	0	0	0	0	0	0	0	0
RK-2-C	23.45151	21.71252	21.65476	49.68831	60.10482	0	0	0	0	0	0	0
RK-3.5-A	14.50168	8.647763	13.52576	13.34355	20.40486	21.50236	0	0	0	0	0	0
RK-3.5-B	4.397394	5.039799	6.28196	23.72418	16.74736	21.05458	17.62831	0	0	0	0	0
RK-3.5-C	8.839436	8.644176	9.941438	21.28006	19.37108	26.51368	26.99248	50.51146	0	0	0	0
RK-5-A	0	2.455441	2.43943	4.923744	3.998792	5.199355	15.36952	26.20016	24.36821	0	0	0
RK-5-B	3.791447	3.461839	4.050799	15.84047	15.73645	22.13416	20.22411	40.41616	45.82175	46.25699	0	0
RK-5-C	3.760458	2.182695	6.023169	9.075737	9.370316	11.51826	23.04679	33.17735	31.49645	55.18337	51.22507	0
RK-6.5-A	0	2.129299	1.930591	3.300073	4.41465	4.107558	11.24205	24.56356	17.64304	48.99572	38.79741	58.46161
RK-6.5-B	6.04734	2.420521	6.432111	7.495822	7.489906	8.205308	13.82072	26.39616	21.90368	36.58498	45.67497	52.89383
RK-6.5-C	0	0	2.552971	1.269649	0	1.870819	8.051642	13.93916	7.599318	32.34462	25.66924	42.92955
RK-8-A	3.184036	0	2.101307	2.497651	4.466112	4.236032	9.619996	14.72039	13.96713	21.0009	20.18574	33.06111
RK-8-B	1.502649	0	0	0	3.60488	3.339661	9.792555	18.08592	14.31107	33.35953	26.75909	44.63543
RK-8-C	2.262494	0	0	0	2.534555	0	8.442262	19.54377	15.34903	33.72378	28.95096	38.81302
RK-9.5-A	0	0	0	0	2.579375	0	7.251416	6.417263	3.623379	11.32814	7.12225	26.45198
RK-9.5-B	0	0	0	0	2.420913	2.14276	5.612158	16.23455	7.932167	26.0219	22.94902	41.84962
RK-9.5-C	1.988179	0	0	0	2.352731	2.326109	12.76844	20.92466	13.59992	30.9848	26.54476	49.31648
RK-10.5-A	0	0	0	0	2.809918	0	4.162413	4.613377	4.159344	7.390142	5.89881	10.60416
RK-10.5-B	0	0	0	0	2.415893	0	3.277189	3.707178	3.275286	6.132193	6.355681	14.09673
RK-10.5-C	0	0	0	1.909265	4.266	1.994589	2.951171	6.110591	5.899255	5.350179	8.921592	19.04096
RK-11.2-A	0	0	0	0	0	0	0	0	0	0	0	5.253258
RK-11.2-B	2.355586	0	0	0	0	0	0	2.790463	0	0	2.556889	2.528782
RK-11.2-C	0	0	0	0	0	0	0	0	0	0	0	7.140736

Table E-1. Pithlachascotee River Macroinvertebrate Data, May 2009

Bray-Curtis Similarity Matrix for the Unpooled Macroinvertebrate Data

RK-6.5-A	RK-6.5-B	RK-6.5-C	RK-8-A	RK-8-B	RK-8-C	RK-9.5-A	RK-9.5-B	RK-9.5-C	RK-10.5-A	RK-10.5-B	RK-10.5-C	RK-11.2-A	RK-11.2-B	RK-11.2-C
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62.54863	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33.4269	29.33639	0	0	0	0	0	0	0	0	0	0	0	0	0
42.56596	37.62337	26.55972	0	0	0	0	0	0	0	0	0	0	0	0
52.32912	43.27305	30.79815	60.95612	0	0	0	0	0	0	0	0	0	0	0
36.46573	35.31313	39.14573	34.40065	34.05196	0	0	0	0	0	0	0	0	0	0
26.69921	21.71208	7.194871	18.46292	23.43698	12.04504	0	0	0	0	0	0	0	0	0
50.12851	41.56847	24.04193	44.17639	53.86928	34.48993	34.73582	0	0	0	0	0	0	0	0
46.93359	42.35495	26.67847	38.95338	42.06249	52.31388	33.47791	51.93311	0	0	0	0	0	0	0
15.22676	9.836835	4.082707	10.8694	12.09625	13.49399	41.5528	20.50553	20.12612	0	0	0	0	0	0
23.51059	18.01229	3.875855	18.08366	19.59546	10.50738	50.39194	28.52523	30.79139	44.36794	0	0	0	0	0
24.90387	19.57982	3.548069	19.57451	21.33303	9.163054	54.58063	30.33912	34.71773	38.76255	79.2472	0	0	0	0
2.949569	6.935287	0	4.345102	2.384016	0	23.43002	6.770759	11.21097	30.66829	23.50854	18.27992	0	0	0
0	7.348026	0	7.144622	2.672924	0	21.49897	3.213093	9.313947	45.2459	25.04427	18.95442	47.7737	0	0
4.545205	6.032939	0	4.574724	3.611633	0	21.63435	7.345264	13.83833	32.85684	15.14999	14.33451	48.1332	46.30882	0

Table E-2. Pithlachascotee River Macroinvertebrate Data, May 2009

Bray-Curtis Similarity Matrix for the Pooled Macroinvertebrate Data

	RK-0	RK-2	RK-3.5	RK-5	RK-6.5	RK-8	RK-9.5	RK-10.5	RK-11.2
RK-0	0	0	0	0	0	0	0	0	0
RK-2	31.8704	0	0	0	0	0	0	0	0
RK-3.5	13.1229	28.7601	0	0	0	0	0	0	0
RK-5	5.00288	16.3424	39.7218	0	0	0	0	0	0
RK-6.5	4.22774	6.41916	20.0109	49.9847	0	0	0	0	0
RK-8	2.14557	4.23891	17.395	34.4265	46.8775	0	0	0	0
RK-9.5	0.66547	2.14304	15.2218	32.2511	38.436	45.7052	0	0	0
RK-10.5	0	2.15034	4.175	12.485	15.4836	19.3929	49.6656	0	0
RK-11.2	0.77072	0	1.2018	4.89615	5.70411	8.18289	15.8956	27.5677	0

Appendix F

Distribution of Important Taxa in Relation to River Kilometer and Salinity

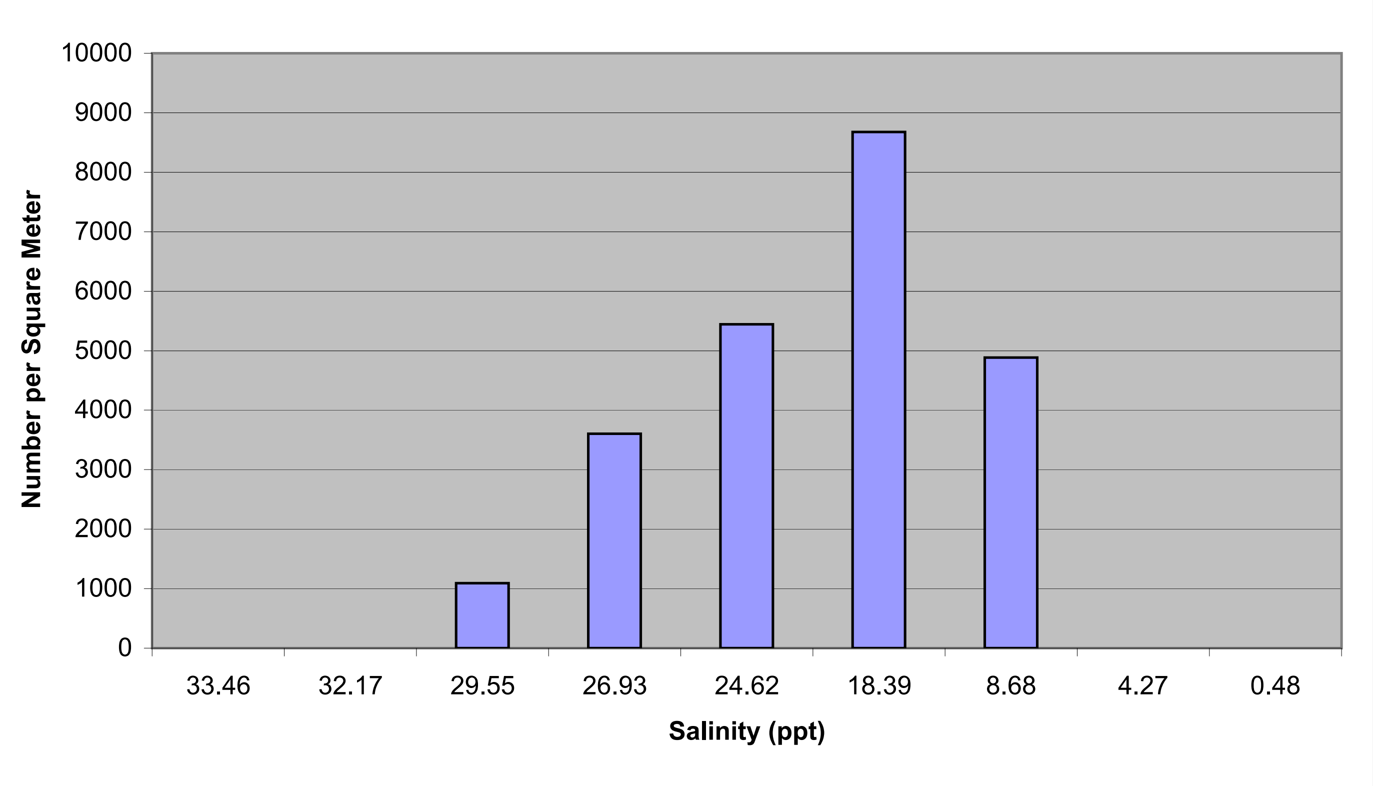


Figure F-1. Distribution of Grandidierella bonnieroides in relation to salinity in the Pithlachascotee River, May 2009.

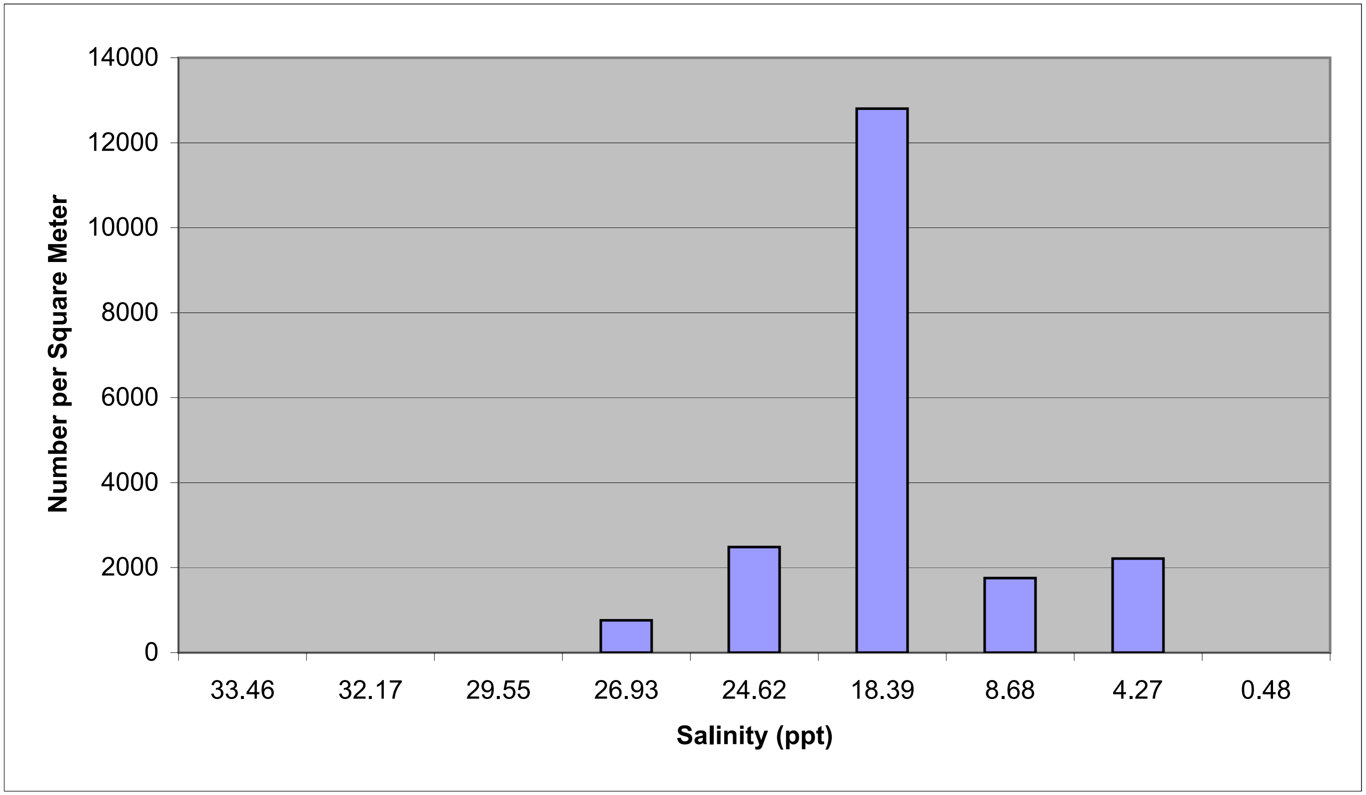


Figure F-2. Distribution of Apocorophium louisianum in relation to salinity in the Pithlachascotee River, May 2009.

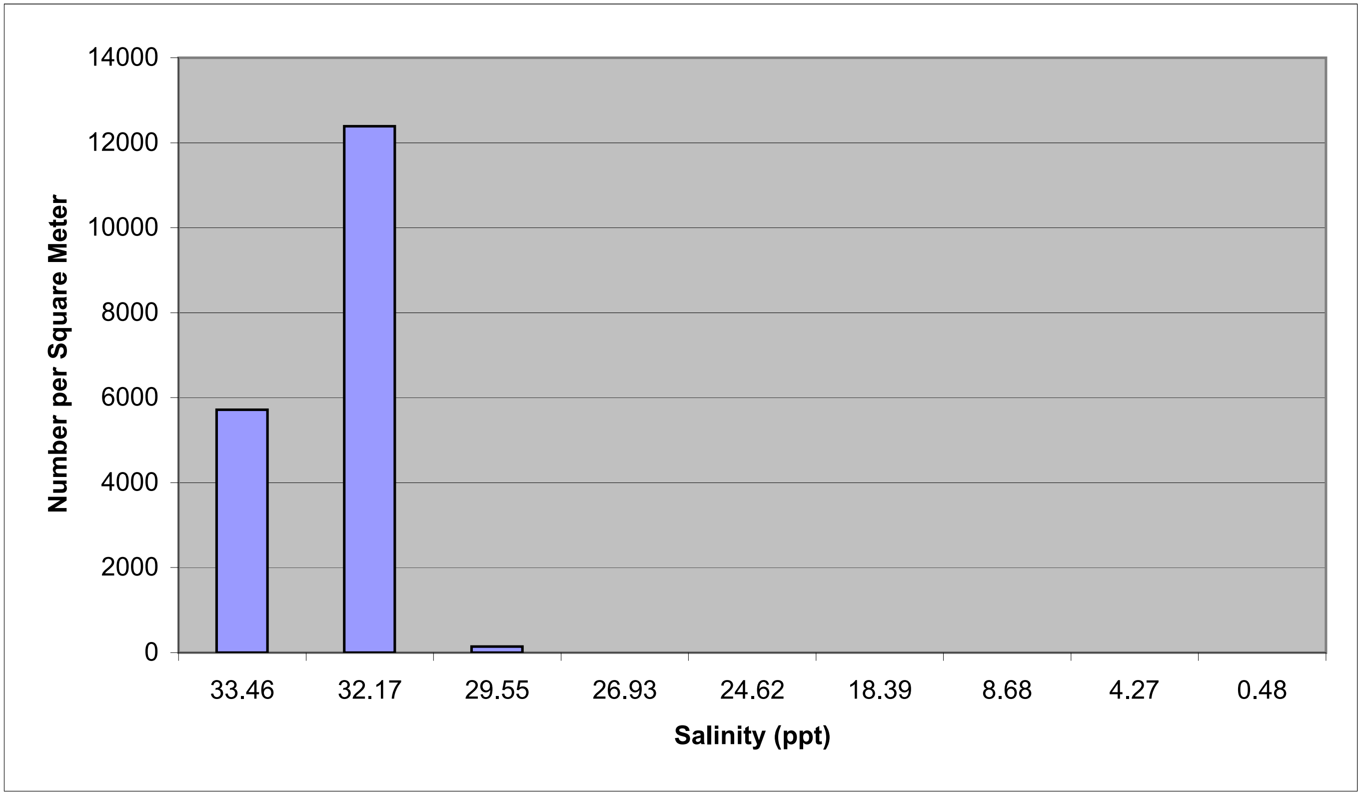


Figure F-3. Distribution of Fabricinuda trilobata in relation to salinity in the Pithlachascotee River, May 2009.

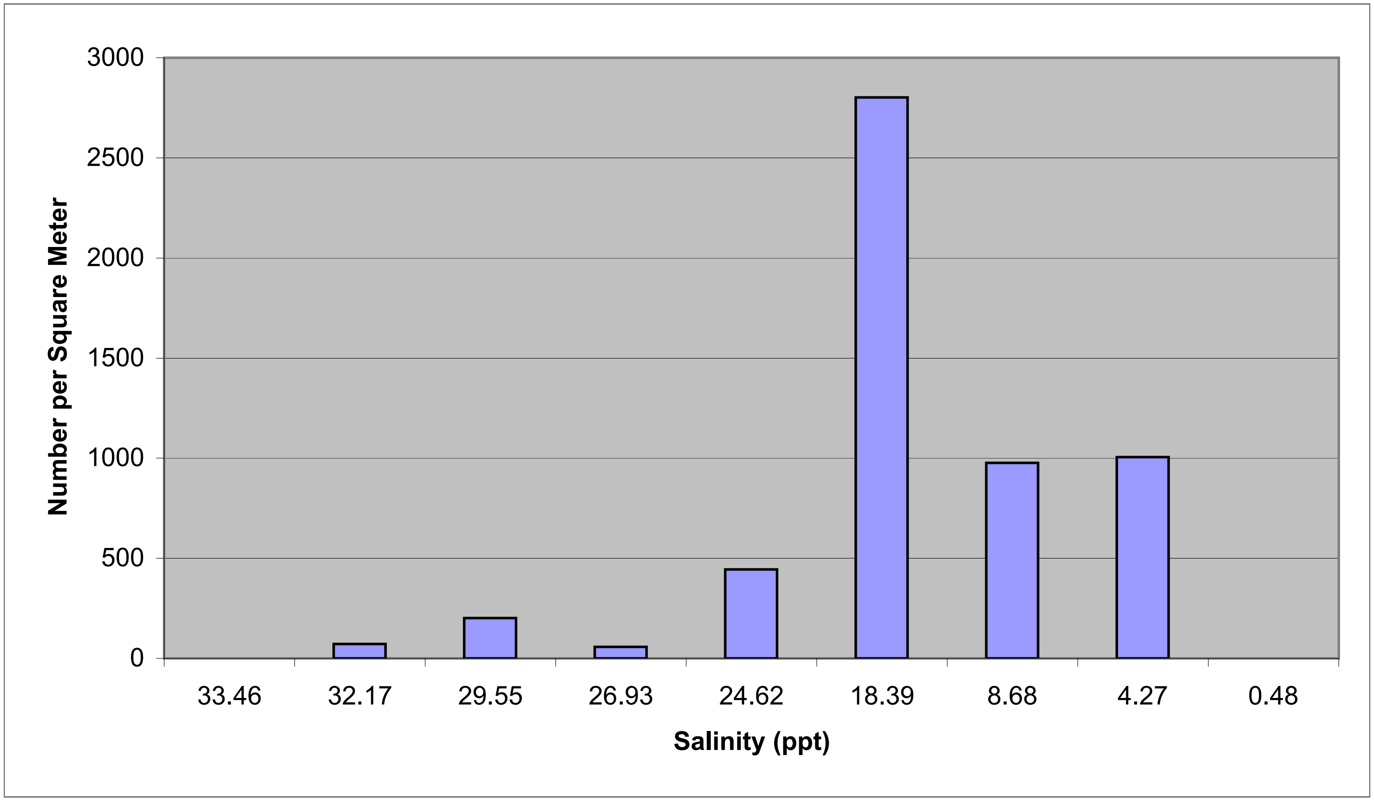


Figure F-4. Distribution of Hobsonia florida in relation to salinity in the Pithlachascotee River, May 2009.

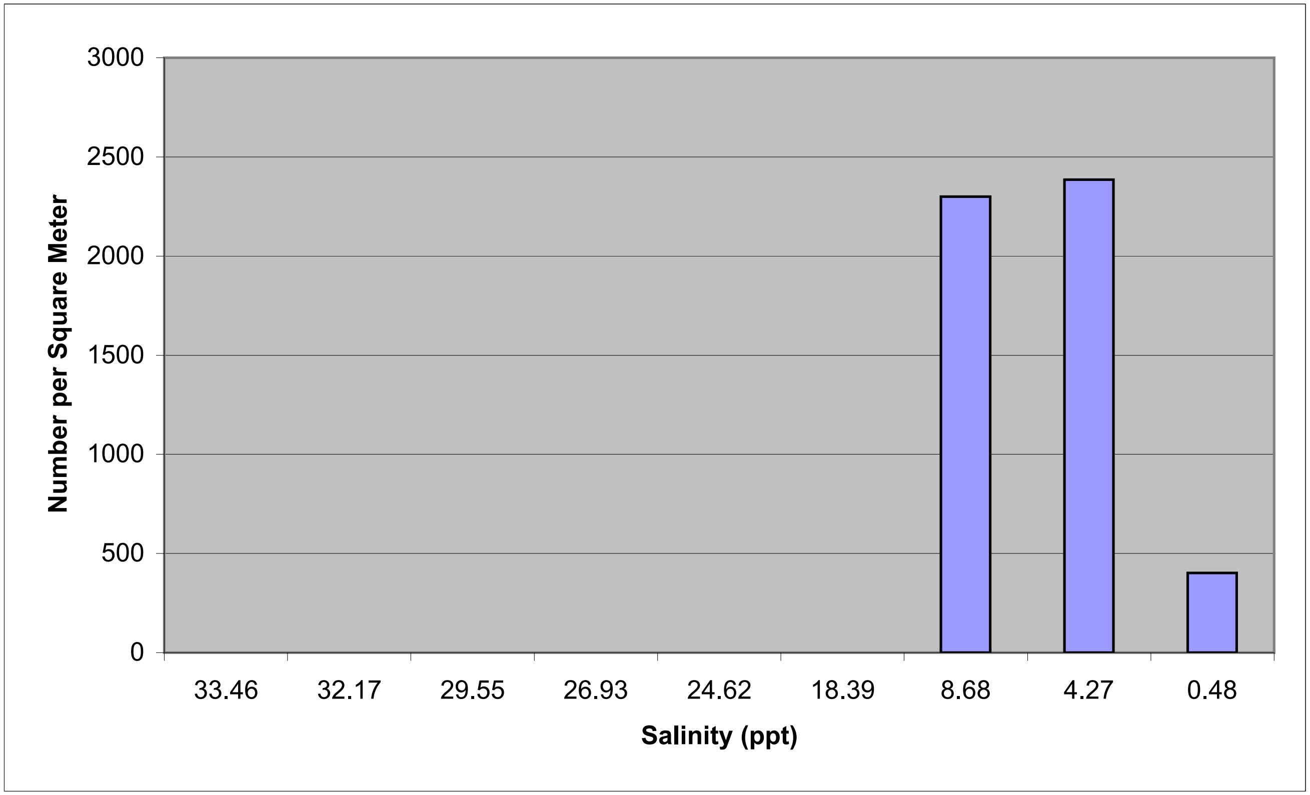


Figure F-5. Distribution of Americorophium sp. A Lecroy in relation to salinity in the Pithlachascotee River, May 2009.

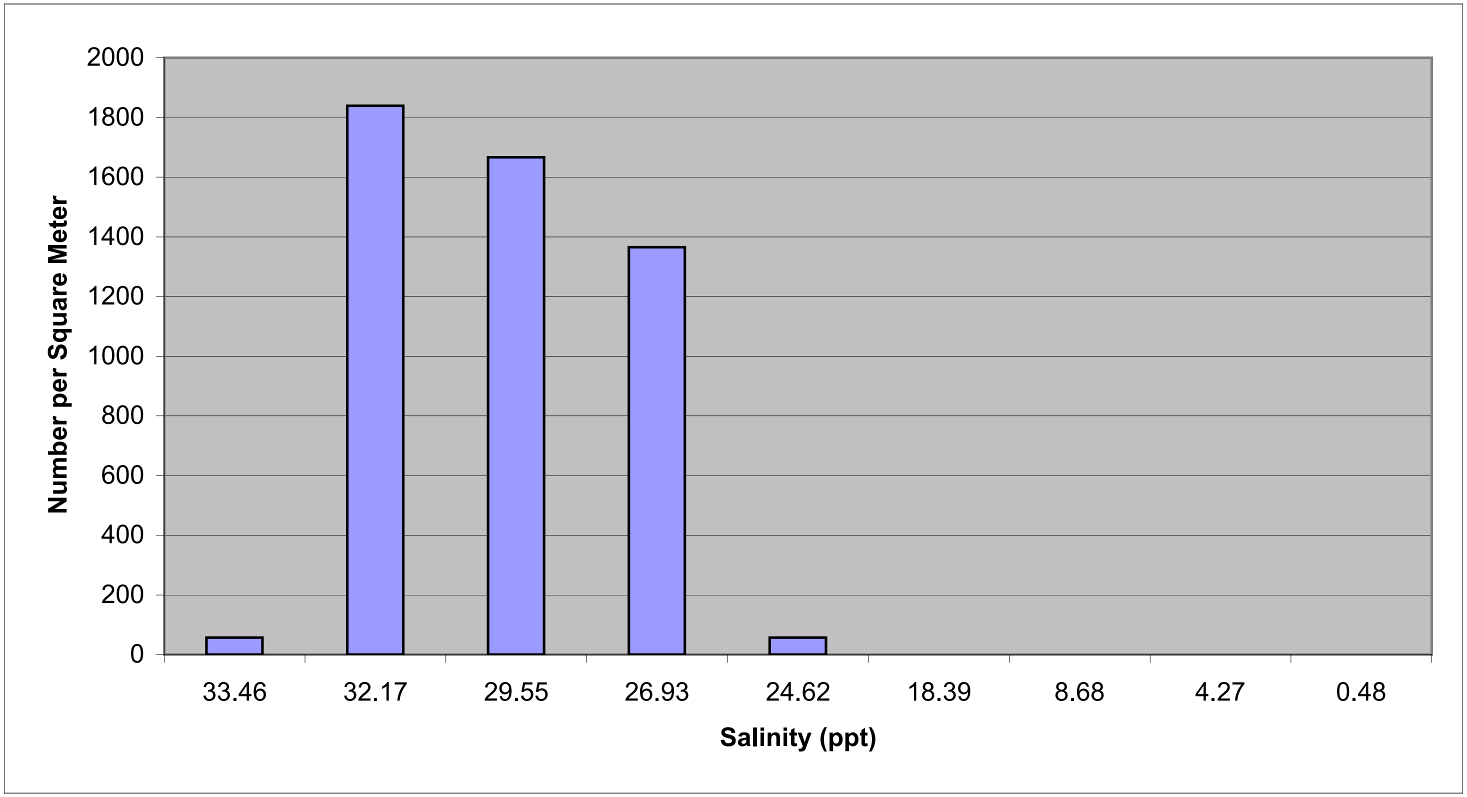


Figure F-6. Distribution of Mediomastus ambiseta in relation to salinity in the Pithlachascotee River, May 2009.

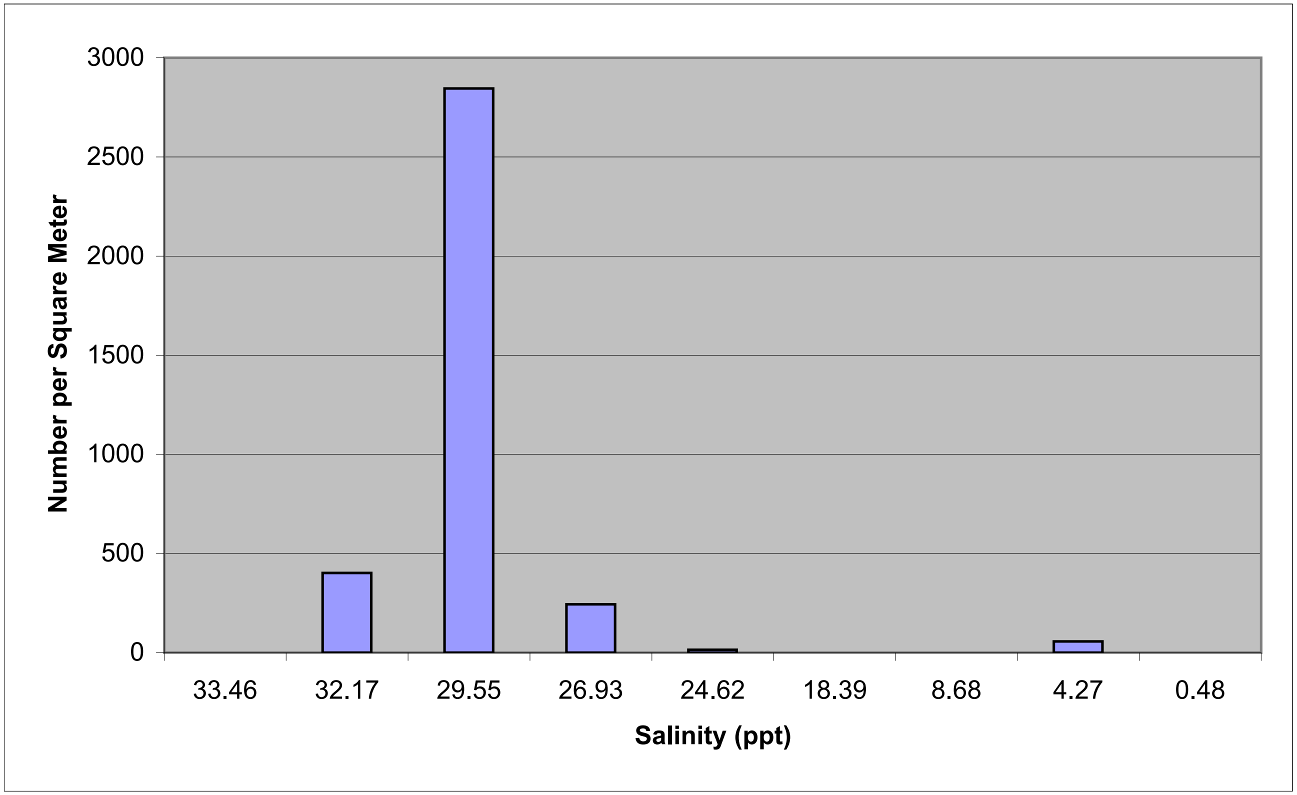


Figure F-7. Distribution of Ampelisca sp. in relation to salinity in the Pithlachascotee River, May 2009.

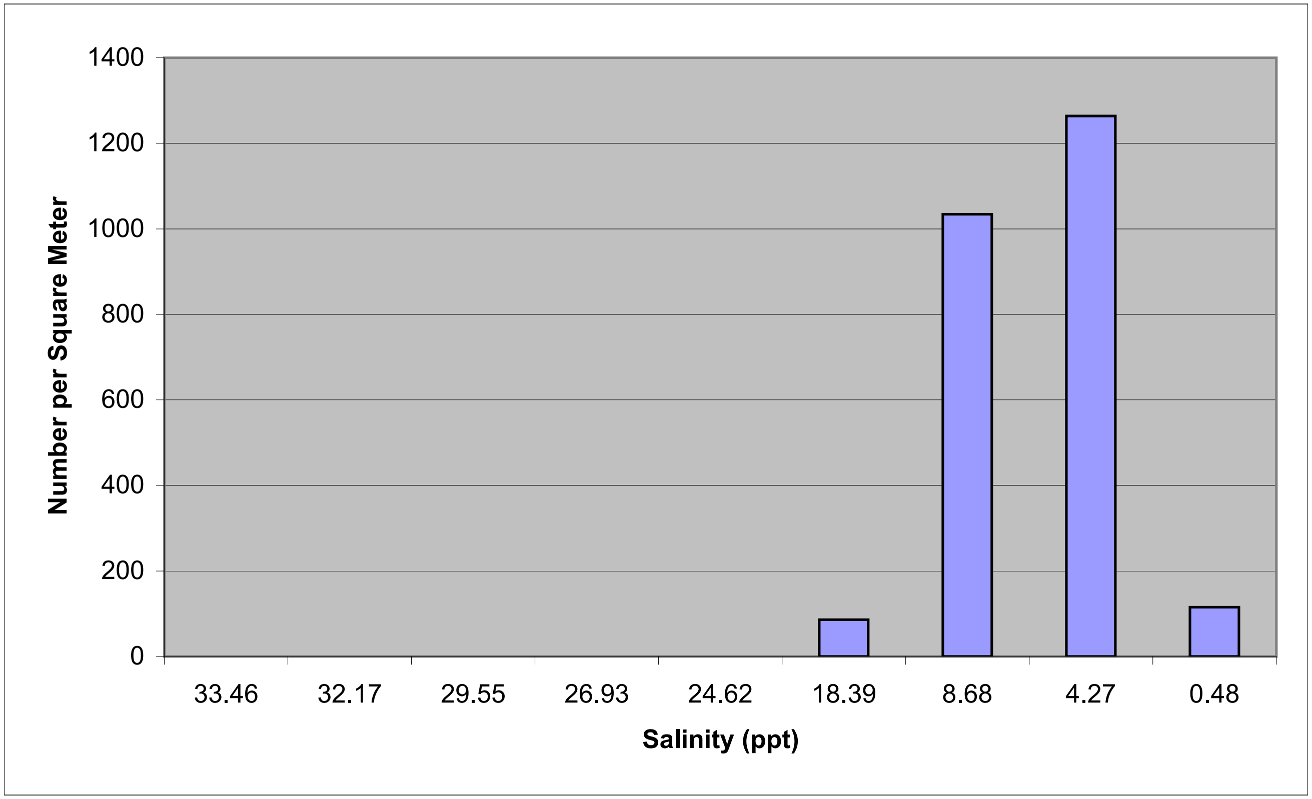


Figure F-8. Distribution of Uromunna reynoldsi in relation to salinity in the Pithlachascotee River, May 2009.

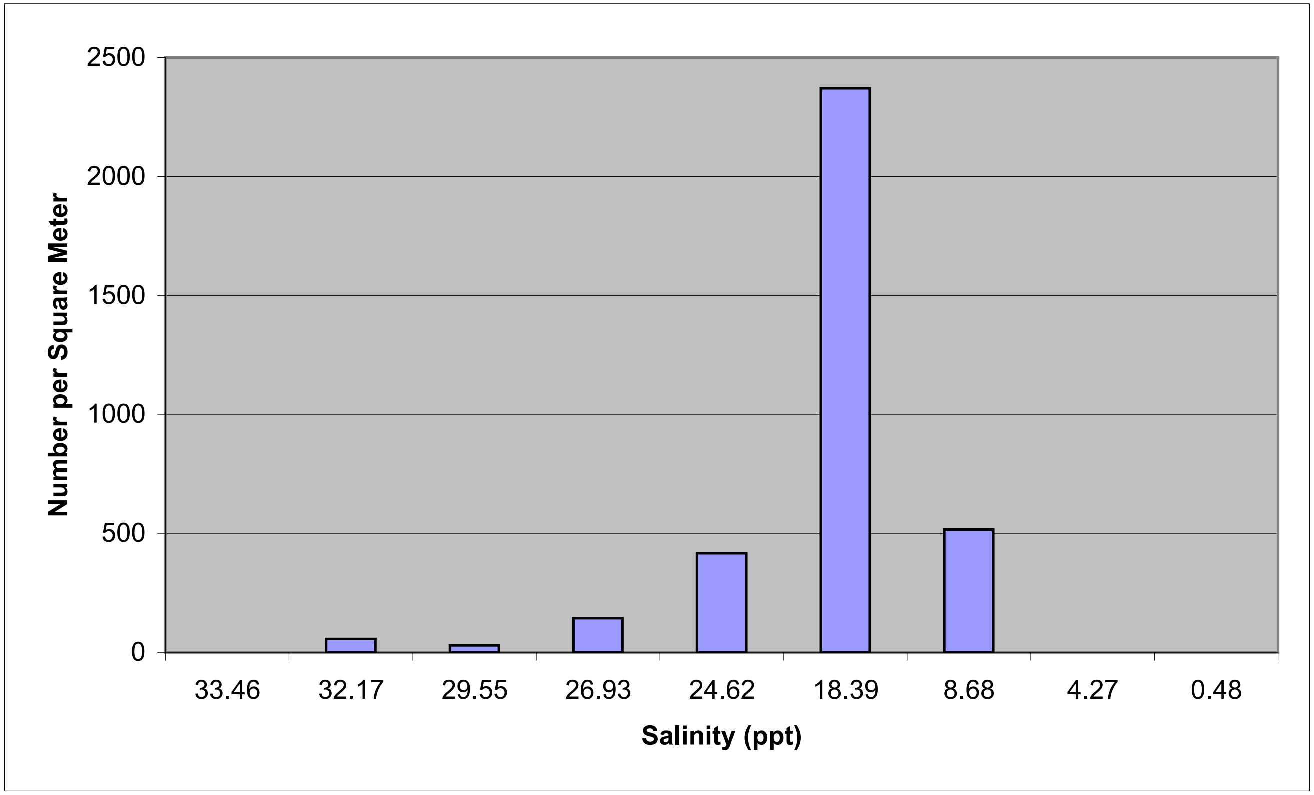


Figure F-9. Distribution of Edotia triloba in relation to salinity in the Pithlachascotee River, May 2009.

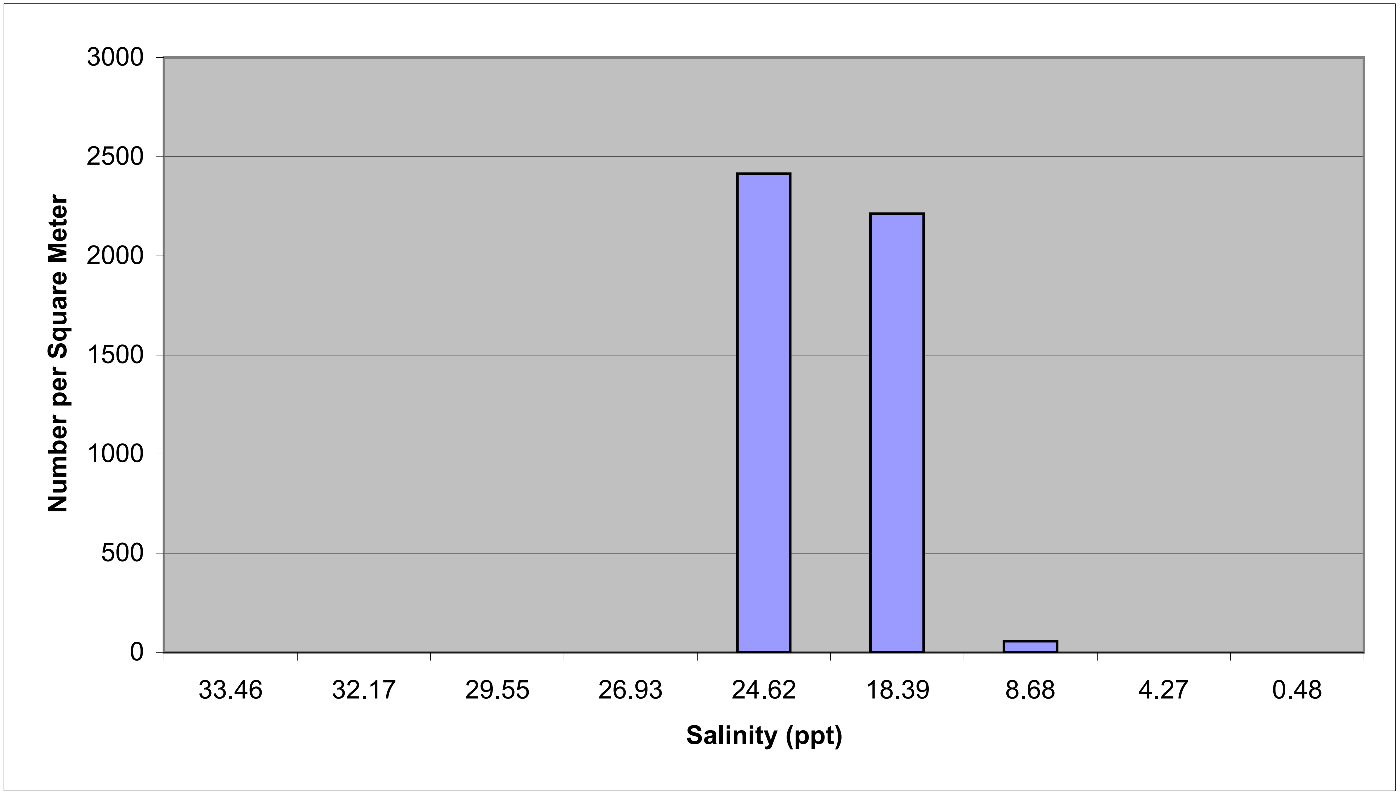


Figure F-10. Distribution of Laeonereis culveri in relation to salinity in the Pithlachascotee River, May 2009.

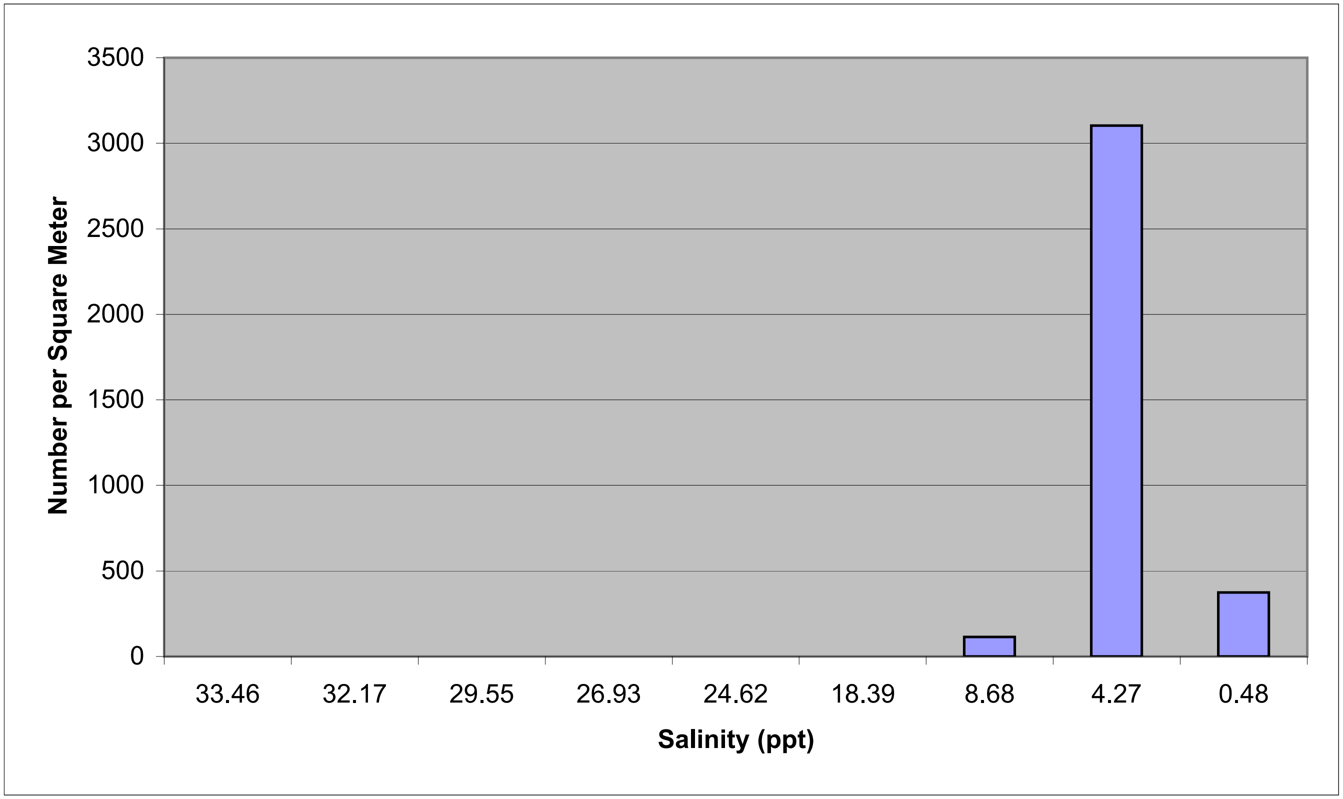


Figure F-11. Distribution of Polypedilum halterale group Epler in relation to salinity in the Pithlachascotee River, May 2009.

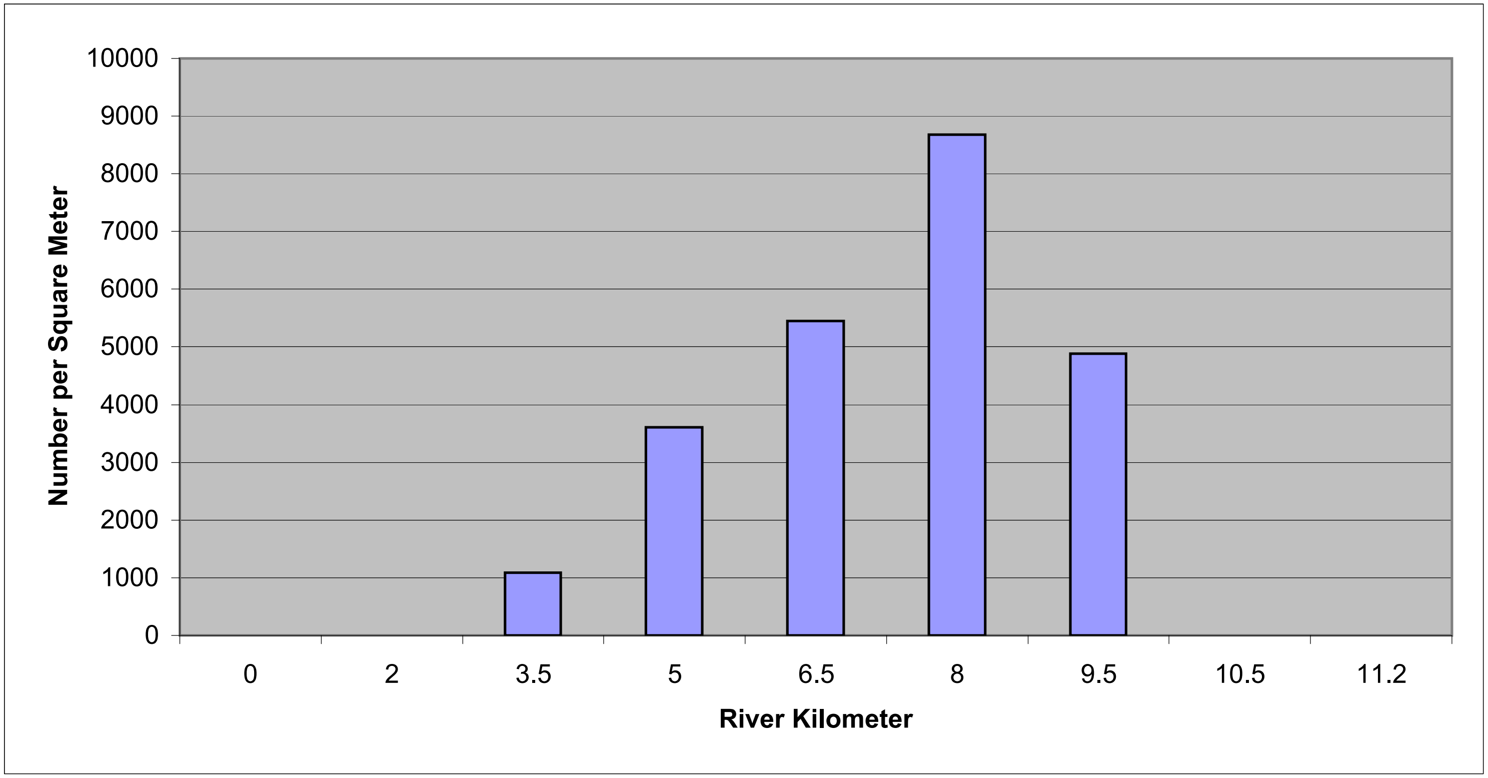


Figure F12. Longitudinal distribution of Grandidierella bonnieroides in the Pithlachascotee River, May 2009.

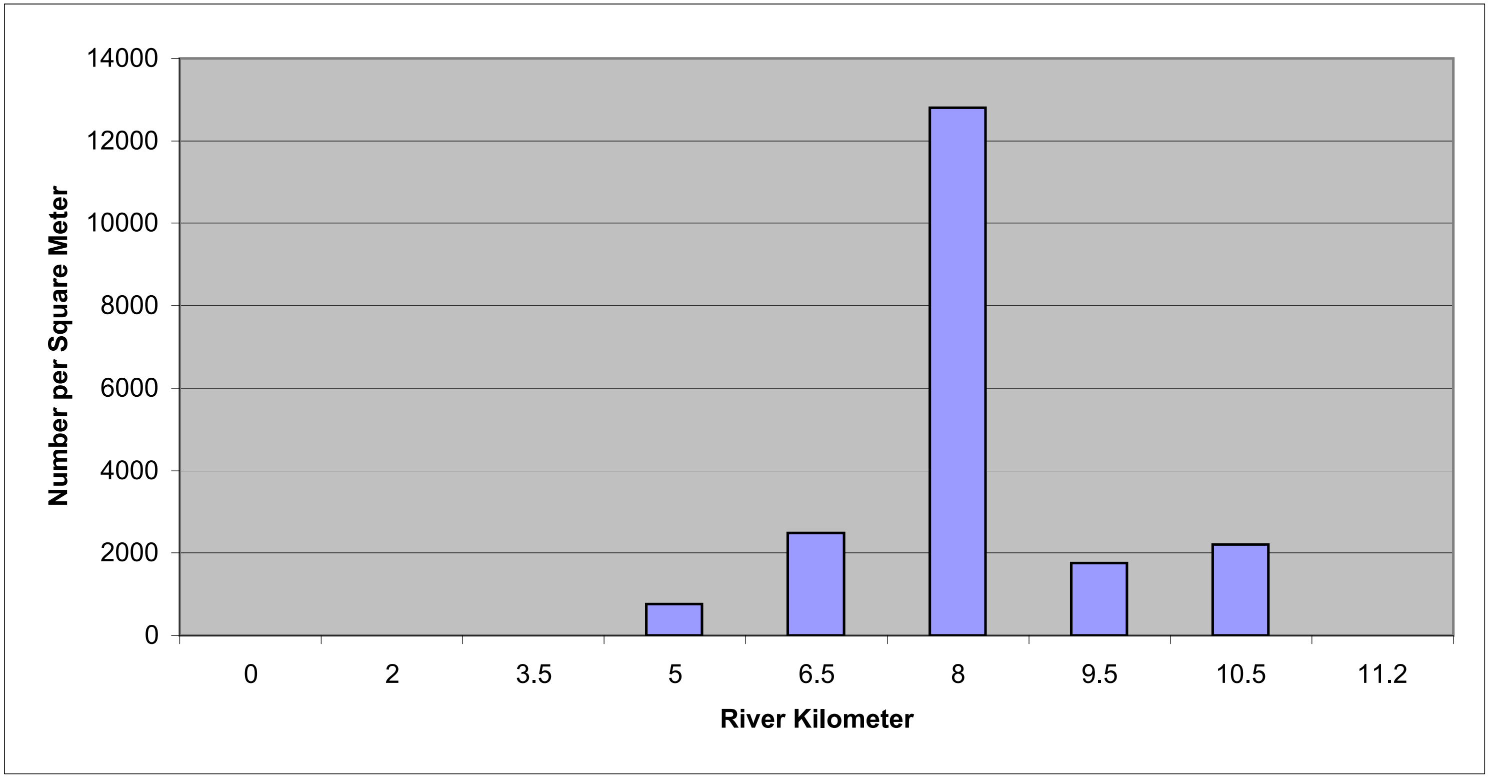


Figure F-13. Longitudinal distribution of Apocorophium louisianum in the Pithlachascotee River, May 2009.

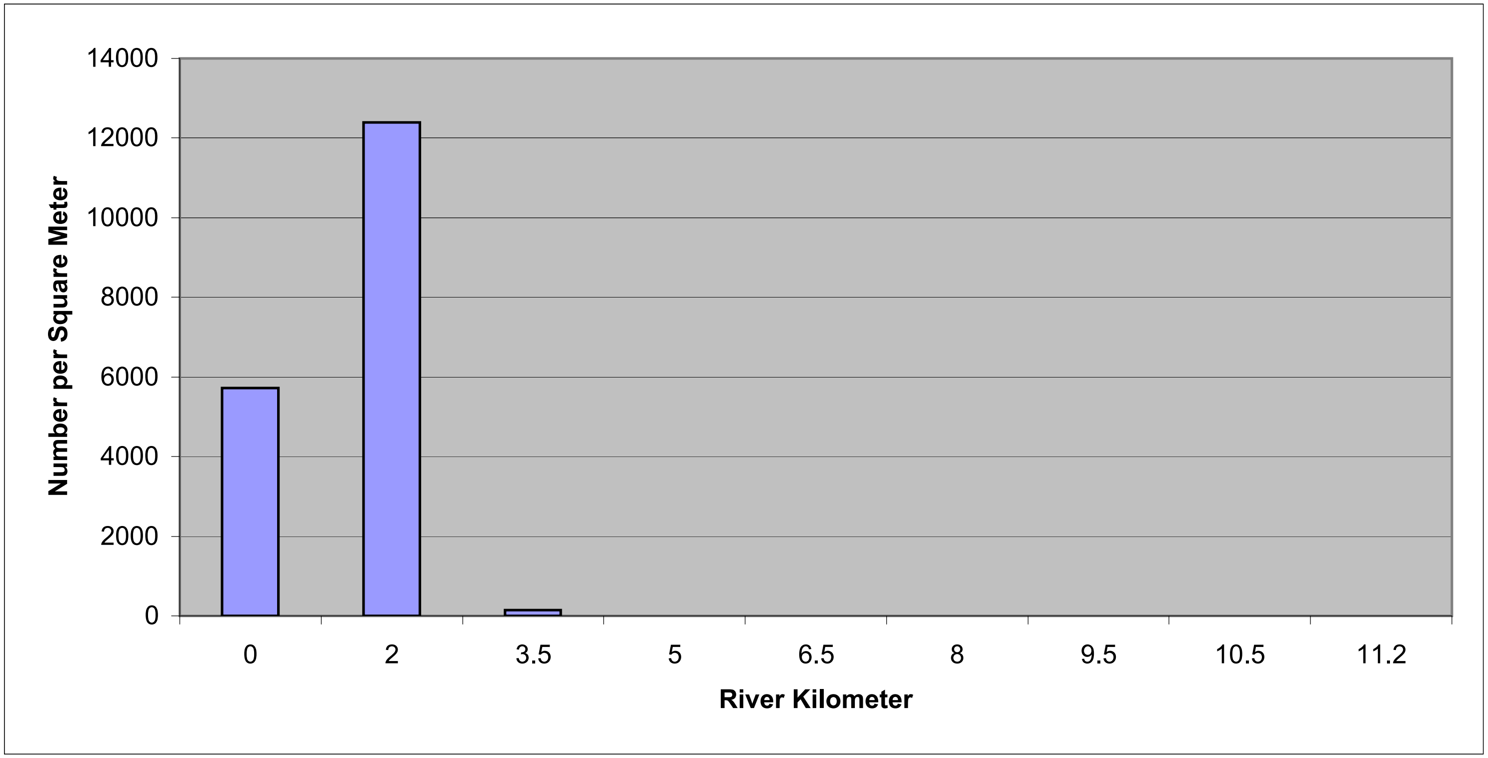


Figure F-14. Longitudinal distribution of Fabricinuda trilobata in the Pithlachascotee River, May 2009.

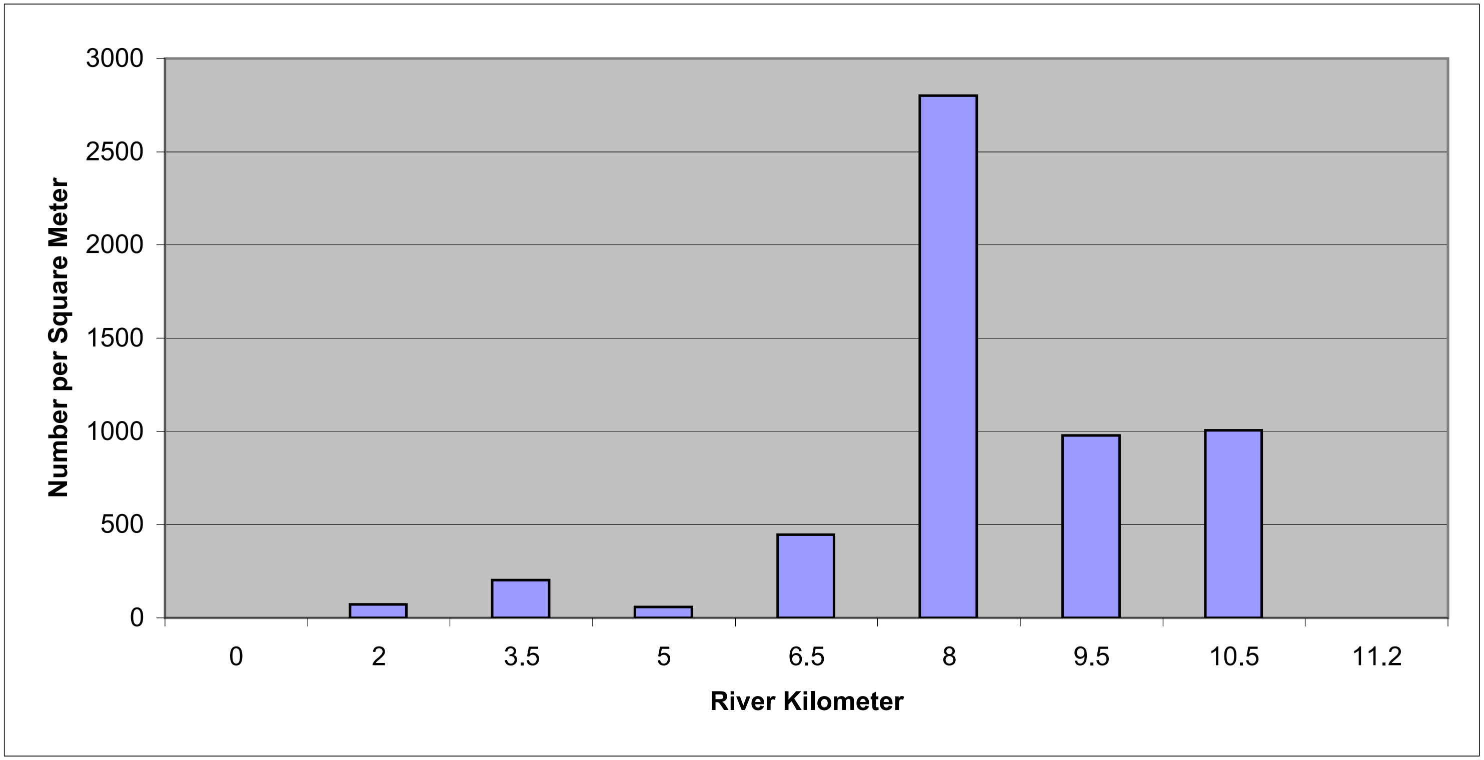


Figure F-15. Longitudinal distribution of Hobsonia florida in the Pithlachascotee River, May 2009.

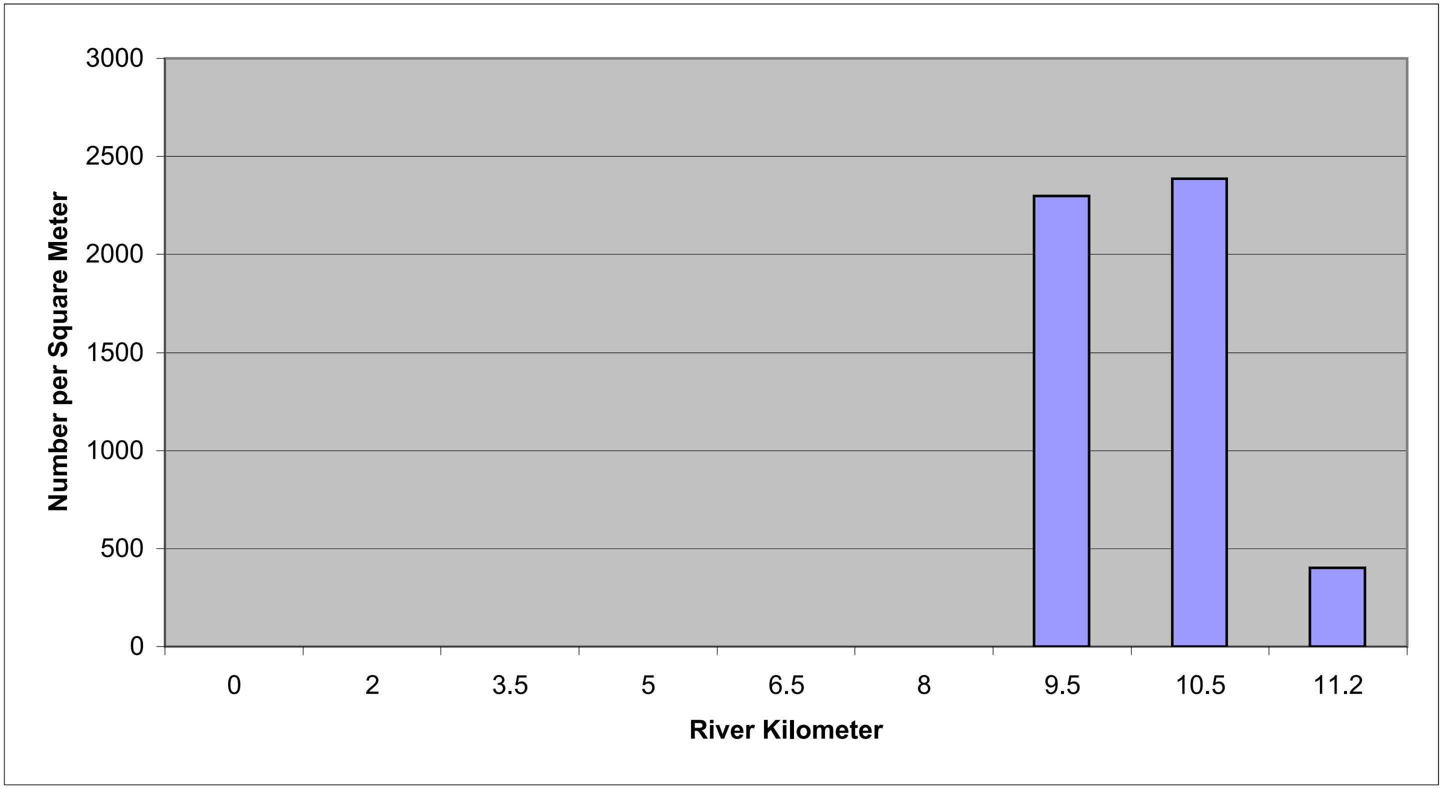


Figure F-16. Longitudinal distribution of Americorophium sp. A Lecroy in the Pithlachascotee River, May 2009.

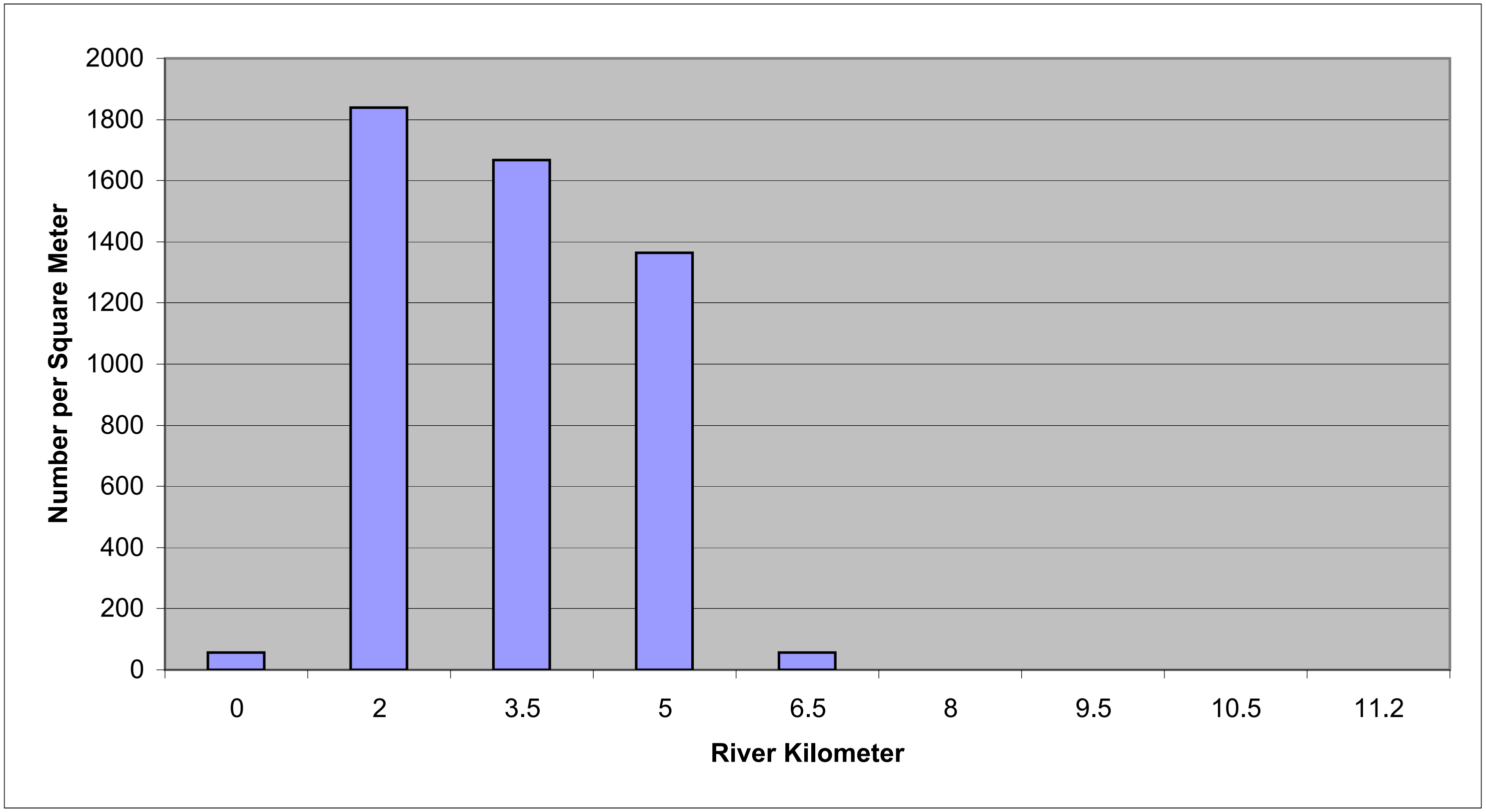


Figure F-17. Longitudinal distribution of Mediomastus ambiseta in the Pithlachascotee River, May 2009.

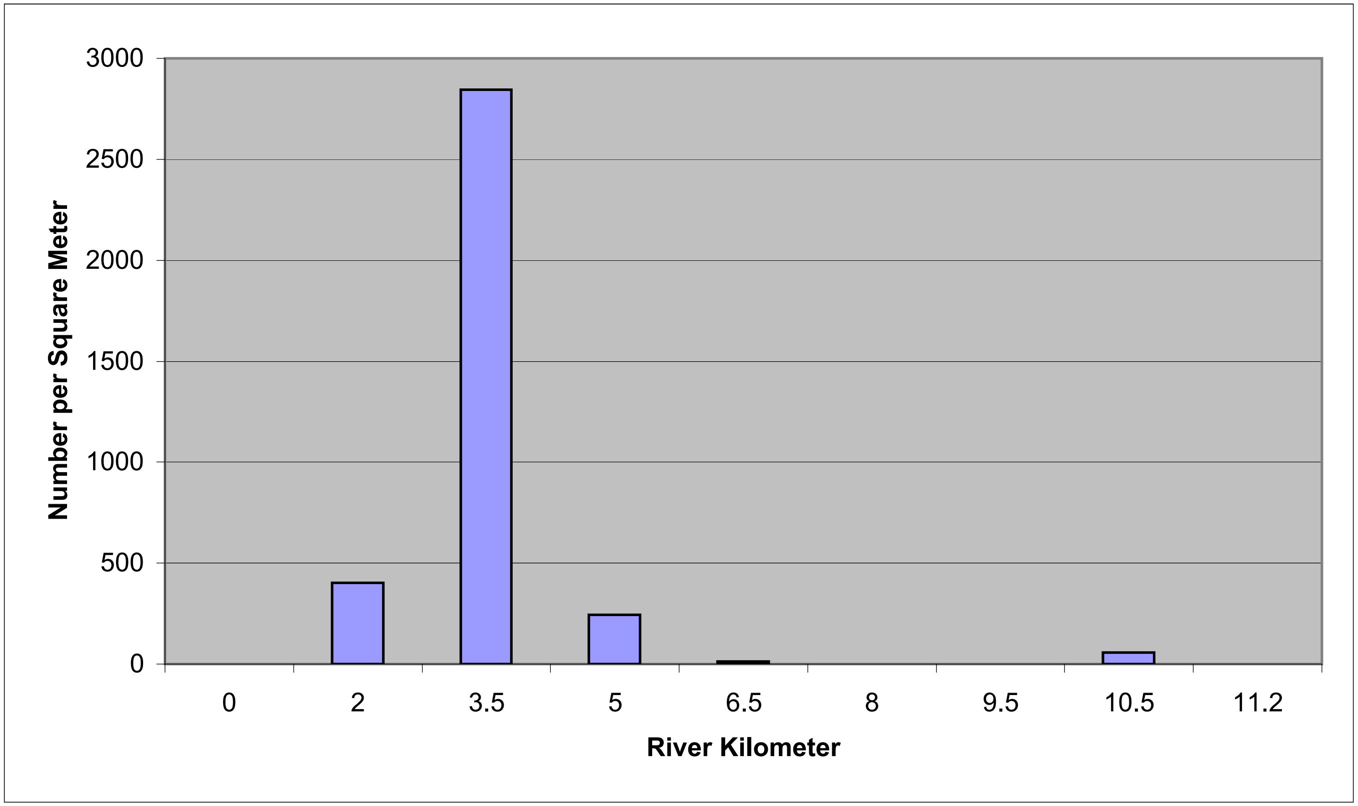


Figure F-18. Longitudinal distribution of Ampelisca sp. in the Pithlachascotee River, May 2009.

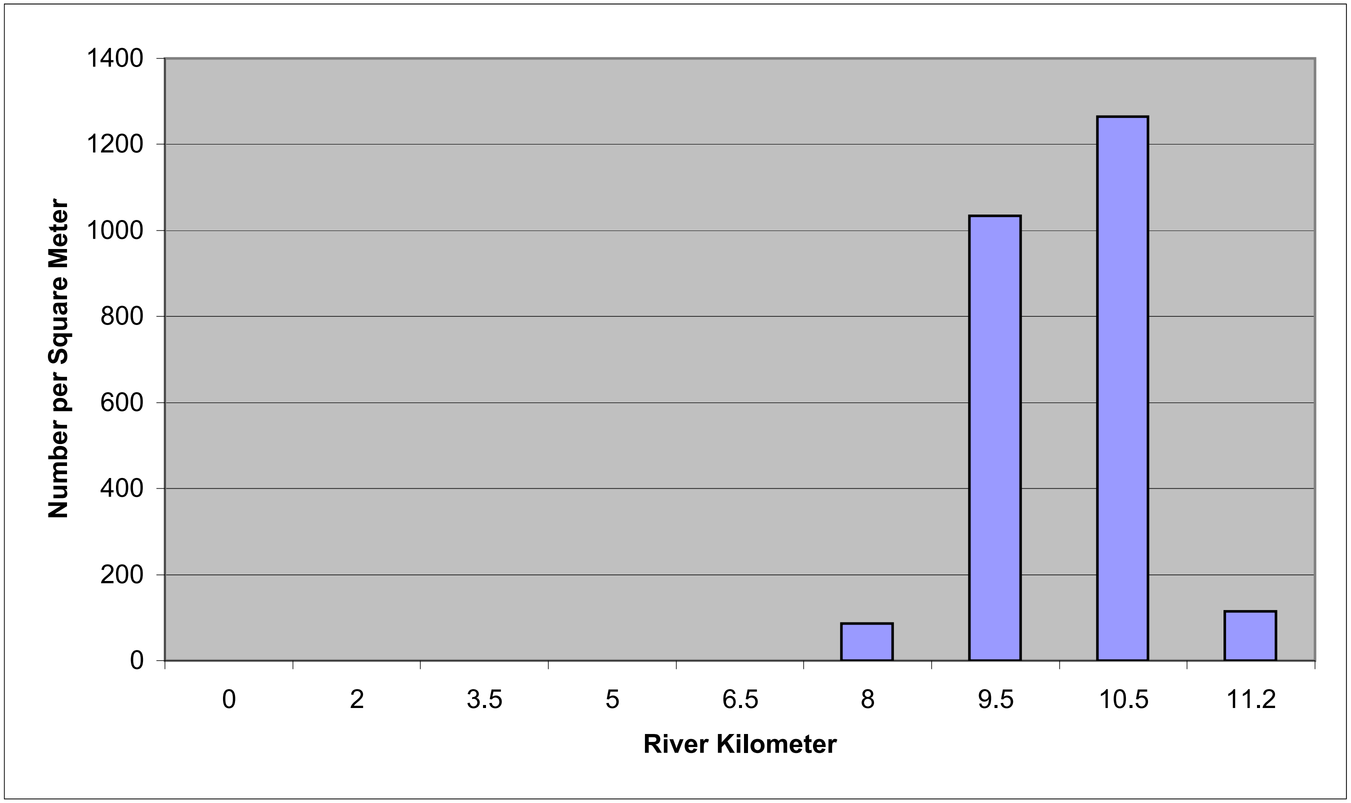


Figure F-19. Longitudinal distribution of Uromunna reynoldsi in the Pithlachascotee River, May 2009.

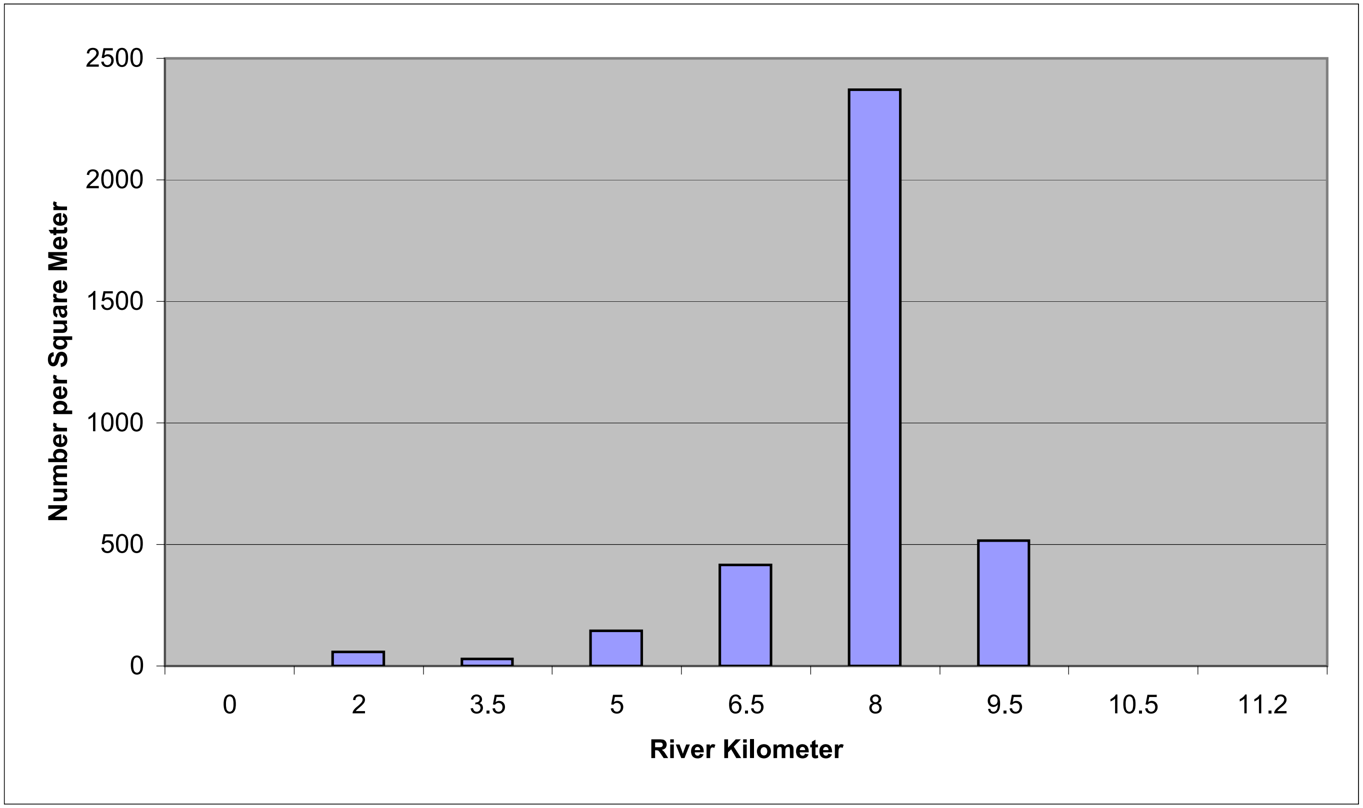


Figure F-20. Longitudinal distribution of Edotia triloba in the Pithlachascotee River, May 2009.

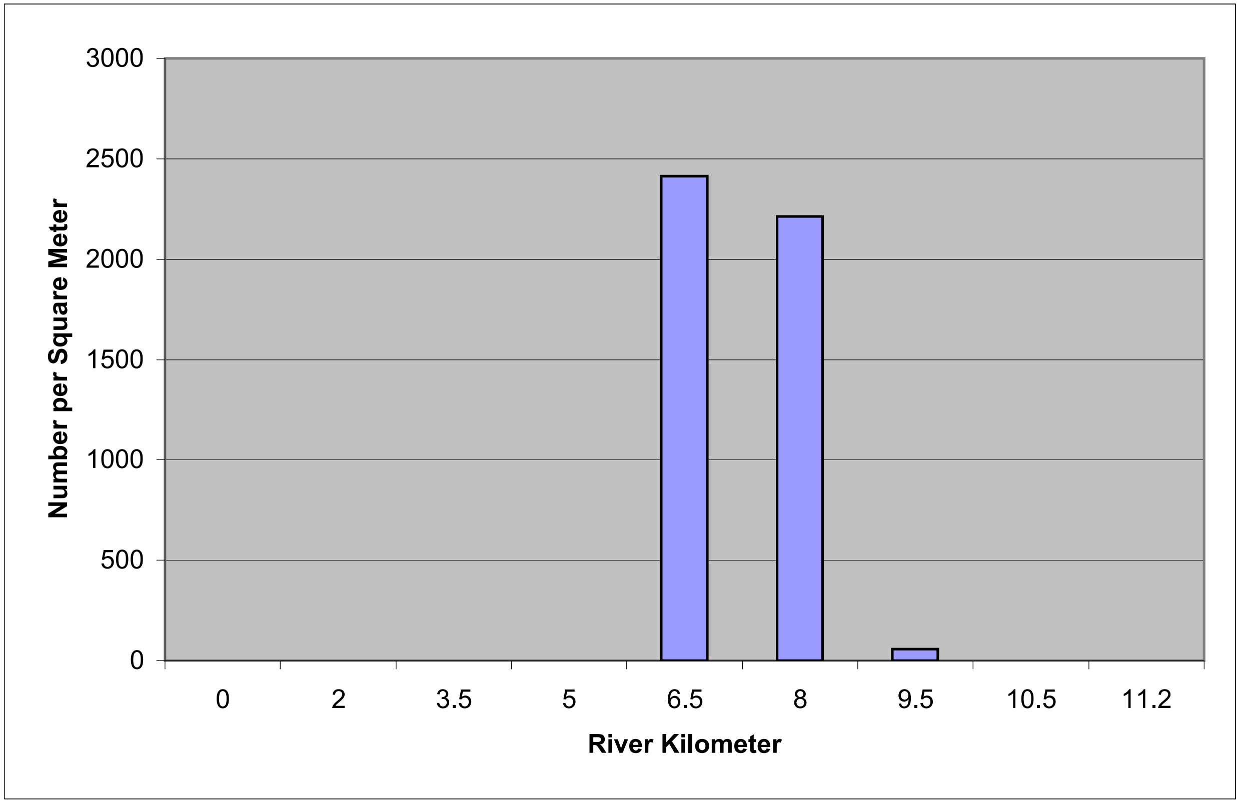


Figure F-21. Longitudinal distribution of Laeonereis culveri in the Pithlachascotee River, May 2009.

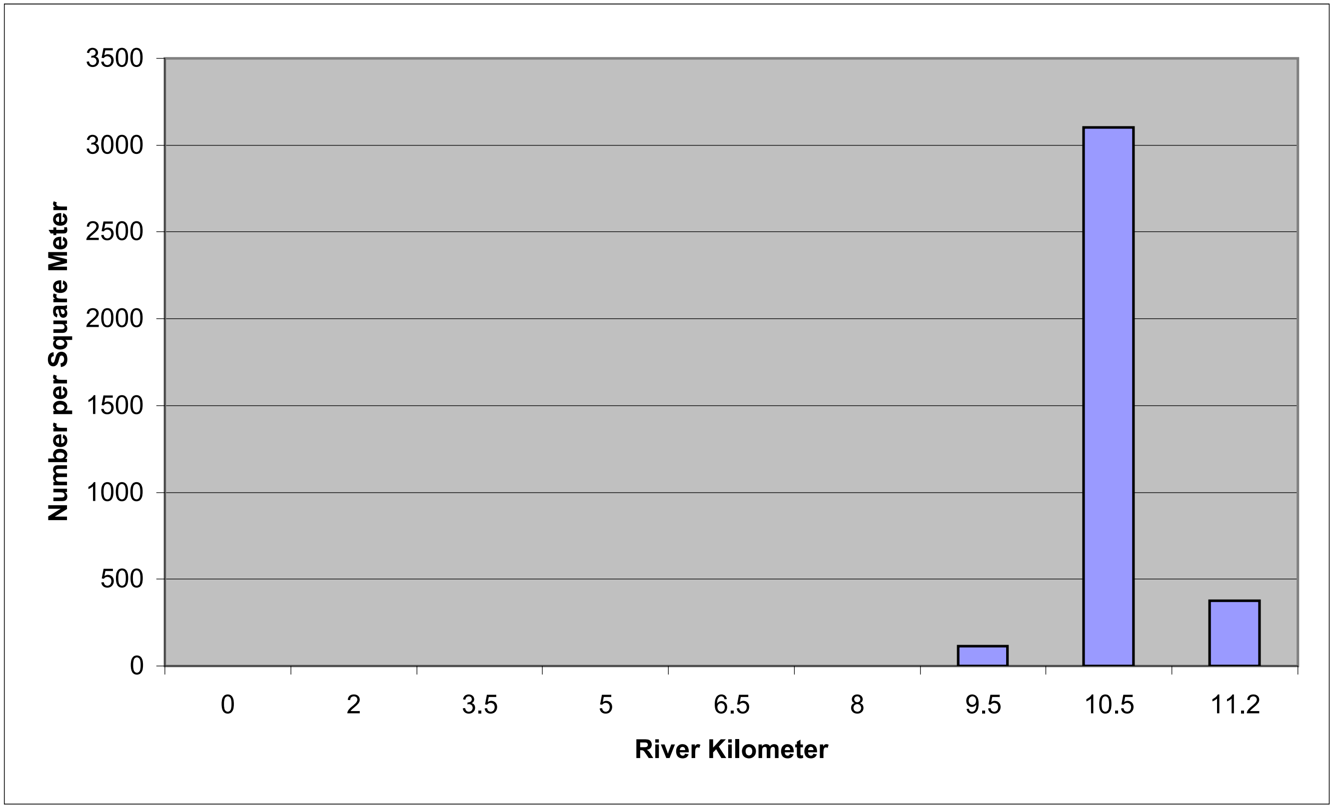


Figure F-22. Longitudinal distribution of Polypedilum halterale group Epler in the Pithlachascotee River, May 2009.

APPENDIX 3C

Entrix, Inc. 2009. Shoreline and vegetation mapping of the Pithlachascotee River in support of the determination of minimum flows and levels. Tampa, Florida. Prepared for the Southwest Florida Water Management District, Brooksville, Florida.

SHORELINE AND VEGETATION MAPPING OF THE PITHLACHASCOTEE RIVER IN SUPPORT OF THE DETERMINATION OF MINIMUM FLOWS AND LEVELS

March 2009

Prepared for:

Michael S. Flannery
Southwest Florida Water Management District
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Brooksville, FL 34604-6899

Prepared by:

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Senior Project Scientist/ Vice President

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EXECUTIVE SUMMARY

On 27 and 29 October 2008, ENTRIX, Inc. completed a mapping effort of emergent shoreline vegetation along the Pithlachascotee River, a ±25 mile long river originating in central Pasco County. The objective of the vegetation mapping was to provide a shoreline vegetative characterization at a level sufficient to for detection in vegetative shifts in response to modeled changes in river salinity in support of establishing minimum flows and levels for the river. The mapping covered approximately 6.5 miles of river, commencing at the mouth of the river at the Gulf of Mexico and continuing to a termination point ±1,500 feet west of Rowan Road. In total, 15.5 miles of shoreline were mapped as a part of this survey effort. All data collection was performed from the waterside of the shoreline using a small, shallow draft boat, a sub-meter GPS and visible landmarks to approximate the changes in vegetative cover. The shoreline mapping was limited to vegetation in communities directly adjacent to the water (<2 meters from edge of open water). A minimum mapping unit of 5m linear segments was used.

The survey documented 33 dominant/subdominant plant species growing along the shoreline of the river, resulting 47 different classifications to depict the changes in shoreline vegetative cover. Of the documented vegetation, five species were classified as predominantly salt tolerant vegetation and seven were classified as predominantly freshwater vegetation. The remaining 21 dominant plant species, over 65 percent, were tolerant of a wide range of salinity (brackish conditions). The survey also documented that over 75 percent (8.2 of the 10.9 miles) of the surveyed shoreline was highly urbanized. Most shoreline between the mouth of the river and Grand Boulevard in New Port Richey consisted of seawalls with little or no vegetation.

1.0 INTRODUCTION

At the request of the Southwest Florida Water Management District (SWFWMD), ENTRIX, Inc. has completed a mapping effort of emergent shoreline vegetation along the Pithlachascotee River. The limits of the project were restricted to the lower reaches of the river and included the area commencing at the mouth of the river at the Gulf of Mexico and continuing approximately 6.54 miles upstream to a termination point ±1,500 feet west of Rowan Road. All vegetation mapping was completed at a level sufficient to provide the District with a vegetation characterization to allow for detection in vegetative shifts in response to modeled changes in river salinity in support of establishing minimum flows and levels (MFL) for the river.

2.0 STUDY AREA DESCRIPTION

The Pithlachascotee River is approximately 25 miles in length and is generally classified as a blackwater creek originating in central Pasco County (Figure 1 – Location Map). The river originates in its headwaters located at Crews Lake in rural central Pasco County, with a terminus at the Gulf of Mexico in Port Richey, FL. The upper reaches of the river are characterized by a shallow, low flow system (<10 cfs) bordered by rural land uses consisting predominantly of agriculture and open space (Dames & Moore, 1991). Conversely, the lower portion of the river is a tidally influenced waterbody which traverses through the highly urbanized communities of Port Richey and New Port Richey (Dames & Moore, 1991). The ecological condition and vegetative composition of the Pithlachascotee River shoreline is highly variable depending on location and intensity adjacent land uses. For example, the upper reaches of the river are characterized by natural or only slightly altered shorelines and include a dominance of native freshwater species and large expanses of forested and herbaceous wetlands, while the lower reaches are characterized by developed, hardened shoreline, including extensive seawalls and riprap, and vegetation tolerant of high salinity conditions. An aerial photograph depicting the surrounding landuse changes along the lower portion of the river is presented in Figure 2.

3.0 SURVEY METHODS

An initial reconnaissance of the study area was performed on 27 August 2008 to identify suitable river access points, navigation conditions, and to collect preliminary information on dominant vegetation composition along the river shore. In addition, data collection methods were investigated to determine ways to refine and streamline the field mapping process. The preliminary data collection exercise was performed from the waterside of the shoreline using two ecologists and a small, shallow draft boat. Vegetation data collected during this preliminary exercise identified dominant vegetation and primary vegetation gradients along the Pithlachascotee River shoreline.

Upon completion of the preliminary review and establishment of a refined data collection methodology, BRA commenced with the detailed vegetation mapping of the river shoreline. All data collection was performed on 27 and 29 October 2008 from the waterside of the shoreline using a small, shallow draft boat. The shoreline mapping was limited to vegetation in communities directly adjacent to the water (<2 meters from edge of open water) using a minimum mapping unit (MMU) of 5m linear segments. Data collection consisted of using a sub-meter GPS unit and visible landmarks to define approximate boundaries of vegetation classes on an aerial photograph, field notes detailing species composition and percent coverage categories using a standardized notation system, and photographing representative areas of the shoreline. The GPS data pertaining to locations of vegetative class boundaries was then geo-referenced and used in the creation of the vegetation polyline segments.

Shoreline vegetation was classified in categories based on dominant and subdominant species located in canopy, sub-canopy, and groundcover. In this study, canopy/overstory trees were defined as all species over 4 inches (10 cm) in diameter at “breast height” (4.5 ft above the ground). Sub-canopy shrubs or understory trees were defined as those woody species smaller than canopy/overstory trees and greater than 1 inch in diameter. Groundcover was defined as all non-woody species growing within 1 meter of the ground. Altered shorelines were classified as to the condition of the bank (e.g. seawall, rip-rap, oyster, or beach). If no vegetation was present, bare substrate was categorized as mud, sand, rock, or a combination thereof. For each mapping unit designation, if a dominant species was not observed, all species within the designation were listed equally. When a change in species dominance was noted, a new designation was applied.

Upon completion of the mapping, all vegetation polyline segments were digitized using a 2006 aerial photograph (UTM Zone 17, HARN 1983, meters) and attributed according to the field data using the data from the field map and notes and GPS data. Quality control of the GIS vegetation map was performed to verify that all polyline segments were correctly located and labeled. Field data was reviewed to assure that information was correctly transferred from source to the final map. The GIS files were checked to assure that all polyline segments were labeled and that attributes in all fields are correct.

4.0 RESULTS AND DISCUSSION

The shoreline vegetation mapping of the Pithlachascotee River was completed over a two day period in October 2008. The mapping was limited to 6.54 miles of river, from the mouth of the river at the Gulf of Mexico to a termination point approximately 1,500 feet west of Rowan Road where the river became unnavigable as a result of debris and fallen trees. In total, 15.5 miles of shoreline were mapped as a part of this survey. The limits of the survey area are depicted in Figure 3a and Figure 3b.

4.1. Shoreline Characterization

The observed vegetation and species composition was strongly influenced by river salinity and human shoreline alterations, such as seawall. Generally speaking, the lower reaches of the river are subjected to daily tidal cycles and water chemistry is greatly influenced by the Gulf of Mexico and the associated marine conditions. Accordingly, observed plant species were dominated by those species tolerant of high salinity conditions, such as mangroves. Salinity measurements taken at the Hwy 19 bridge crossing in Port Richey, approximately 1.3 miles upstream from the Gulf of Mexico (Figure 4), recorded salinity levels at approximately 21 parts per thousand (ppt) which represents a polyhaline condition (Clewell et al. 2002). In contrast, the upper reaches of the river, east of Madison Street, although tidally influenced, is generally beyond the average salinity influence of the Gulf of Mexico, with the river comprised of forested wetlands vegetated by freshwater species such as sweet-bay (*Magnolia virginiana*) and swamp bay (*Persea palustris*), although the toe of the salt wedge has been documented up to 7 miles upstream under drought conditions (Wolfe, 1990). At the Grand Boulevard bridge crossing in New Port Richey, approximately 4.2 miles upstream from the Gulf of Mexico and 0.75 miles downstream from commencement of the forested wetlands (Figure 5), salinity levels were approximately 7 ppt at the time of survey indicating mesohaline conditions (Clewell et al. 2002). Within this portion of the river, vegetation typically associated with brackish and freshwater habitats, such as leather fern (*Acrostichum danaeifolium*) and southern cattail (*Typha domingensis*), was prevalent along the shoreline.

Although not surprising, one notable observation made during the mapping effort was the predominance of hardened shoreline throughout the highly urbanized areas of the river in Port Richey and New Port Richey. Specifically, this mapping effort found that over 75 percent (8.2 of the 10.9 miles) of surveyed shoreline between the mouth of the river and Grand Boulevard in New Port Richey consisted of seawalls with little or no vegetation. Conversely, the remaining survey area east of Grand Boulevard, approximately 4.6 miles of shoreline, was comprised primarily of natural, vegetated shoreline. Seawalls in this portion of the river were present on less than 0.5 mile (10 percent) of shoreline. This change in shoreline alteration also generally coincided with change in species salinity tolerance, with high salinity tolerant vegetation more common in areas of extensive seawall coverage and species with lower salt tolerance in the remaining area.

4.2 Plant Species Observed

The Pithlachascotee River shoreline mapping documented 33 dominant/subdominant plant species growing along the shoreline of the river which resulted in the creation of 47 different classifications to depict the changes in shoreline vegetative cover. These classifications ranged from seawall with no vegetation in the lower, highly developed reaches of the river to freshwater forested wetlands in the upper reaches. Of the documented vegetation, five species were classified as predominantly salt tolerant vegetation, including red (*Rhizophora mangle*) and black mangroves (*Avicennia germinans*), while seven were classified as predominantly freshwater vegetation such as sweet-bay and swamp bay. The remaining 21 dominant plant species were tolerant of varying levels of salinity (brackish conditions). For this mapping effort, observed vegetation was classified according to approximate salinity tolerance using the categories of mesohalophyte, oligohalophyte, or glycophyte in accordance with Clewell et al. (2002). The mesohalophyte designation is assigned to those species that can tolerate a wide range of salinity levels (5ppt – 18ppt) which are generally restricted to the lower reaches of the river while the glycophyte designation is given to those species that show immediate physiological stress to lower levels of salinity (<0.5ppt). The oligohalophyte designation is provided to those species which tolerate an intermediate range of salinity (0.5ppt – 5ppt). Vegetation observed along the river was predominately comprised on native species, although five of the 33 are classified as either Category I (n=4) or Category II (n=1) exotic/nuisance species by the Florida Exotic Pest Plant Council (http://www.fleppc.org/list/07list.htm) and were present in limited coverage along the river. A list of all dominant species recorded as apart of the mapping effort and the assigned salinity tolerance of each is presented in Table1. A list of each shoreline polyline classification and associated vegetation is presented in Table 2. Individual maps depicting sub-sections of the Pithlachascotee River with polyline representations of observed shoreline vegetation and/or substrate condition are presented in Appendix A.

5.0 CONCLUSION

The Pithlachascotee River is a unique system located in central Pasco County which flows for approximately 25 miles from Crews Lake to a termination point at the Gulf of Mexico in Port Richey, FL. The lands surrounding the river include a mosaic of upland habitats ranging from rural low intensity development, agriculture, and preserved lands to the highly urbanized and hardened shorelines of Port Richey and New Port Richey. The results of the shoreline vegetative mapping found that the lower and upper areas are either comprised of highly saline or freshwater environments and associated vegetation, respectively, while the majority of the river area surveyed is classified a brackish system capable of sustaining a wide range of salt tolerant vegetation. It is within this central brackish area that the greatest species diversity was noted, with approximately 65 percent of the observed vegetation species documented within this habitat type. As the SWFWMD works to set minimum freshwater base flows required to maintain a healthy ecosystem it is within this brackish area that changes in river salinity and associated vegetation resulting from increasing or decreasing freshwater flows will be most evident as future development and management affect the river. This report is intended to provide a baseline assessment of existing vegetation shifts based on current river conditions to allow the SWFWMD to achieve the objective of establishing a MFL to maintain a healthy river environment.

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FIGURES

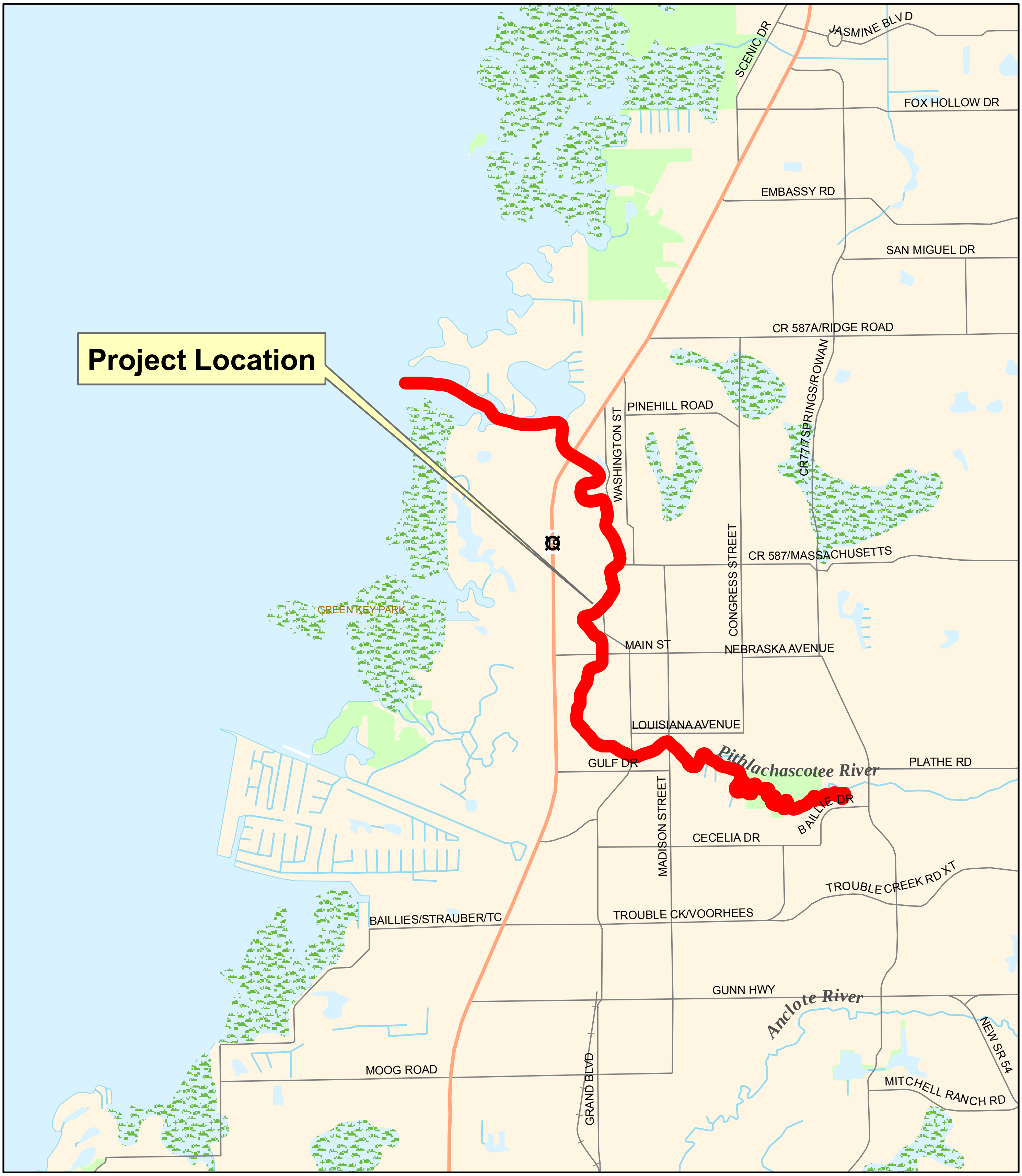

Figure 1 - Location Map

Pithlachascotee River Vegetation Mapping
Pasco County, Florida

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Coordinate System:
NAD 1983 UTM Zone 10N feet

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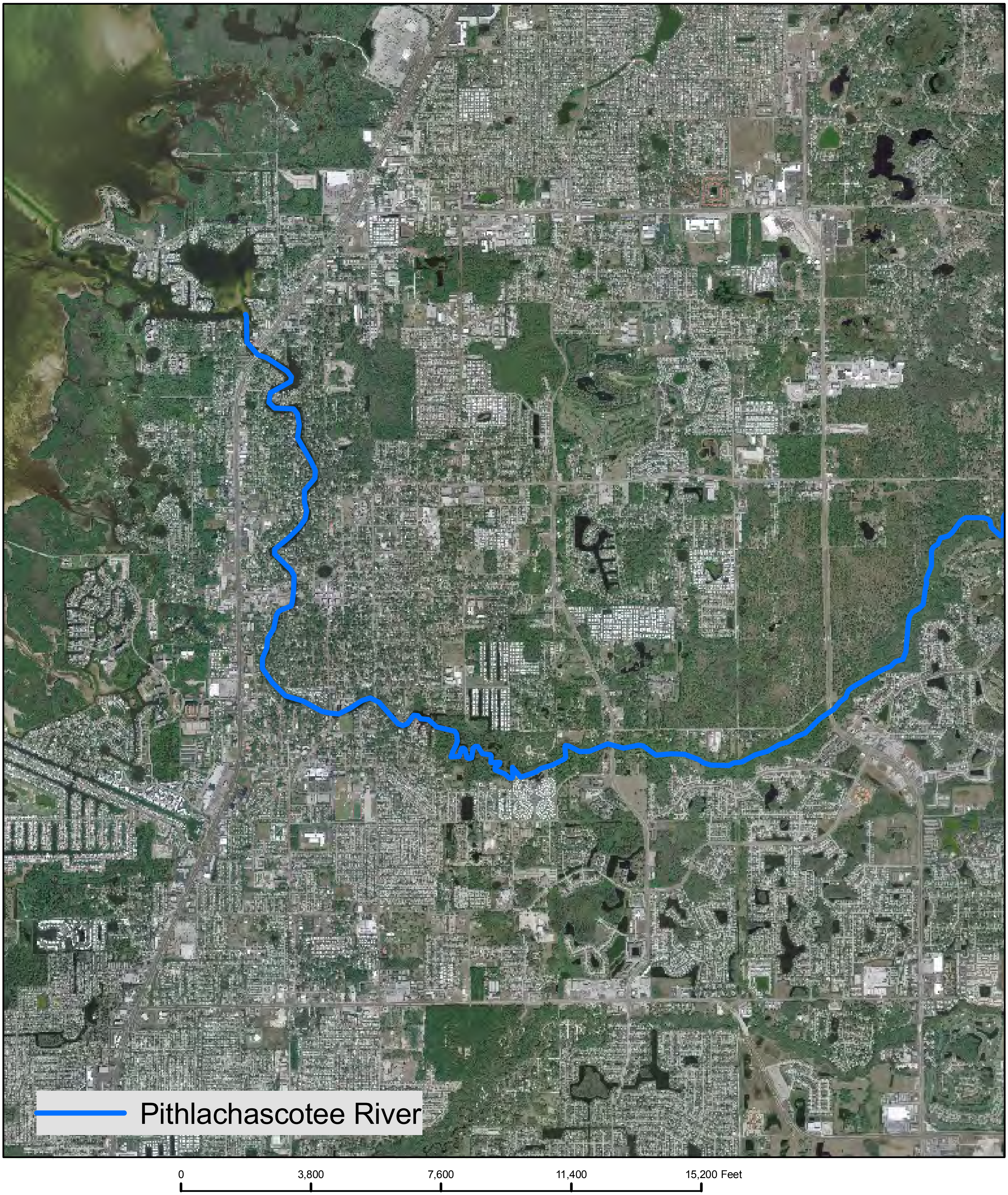

Figure 2 - Aerial Photograph

Pithlachascotee River Vegetation Mapping
Pasco County, Florida

Image:2007

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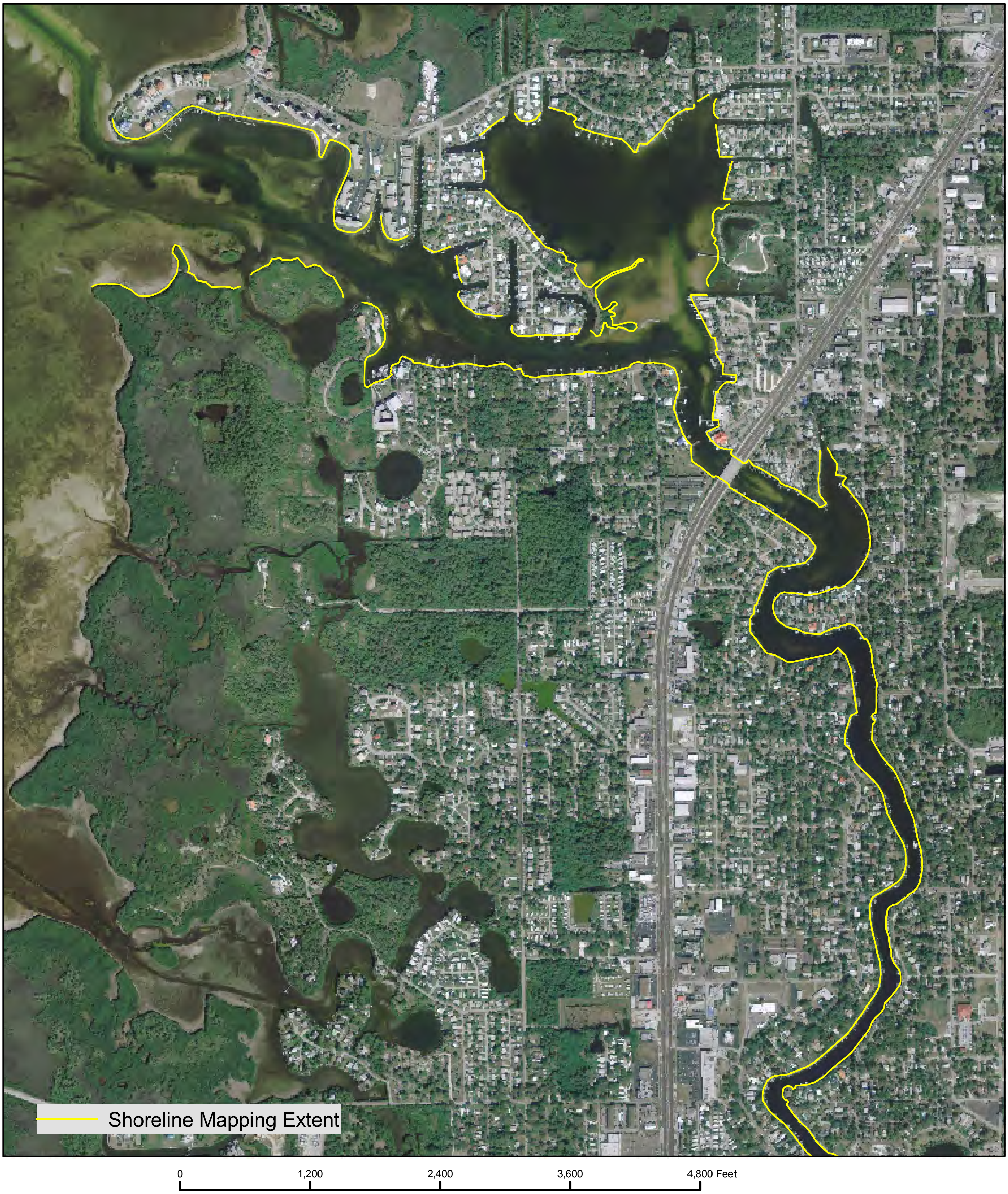

Figure 3a - Mapping Limits

Pithlachascotee River Vegetation Mapping
Pasco County, Florida

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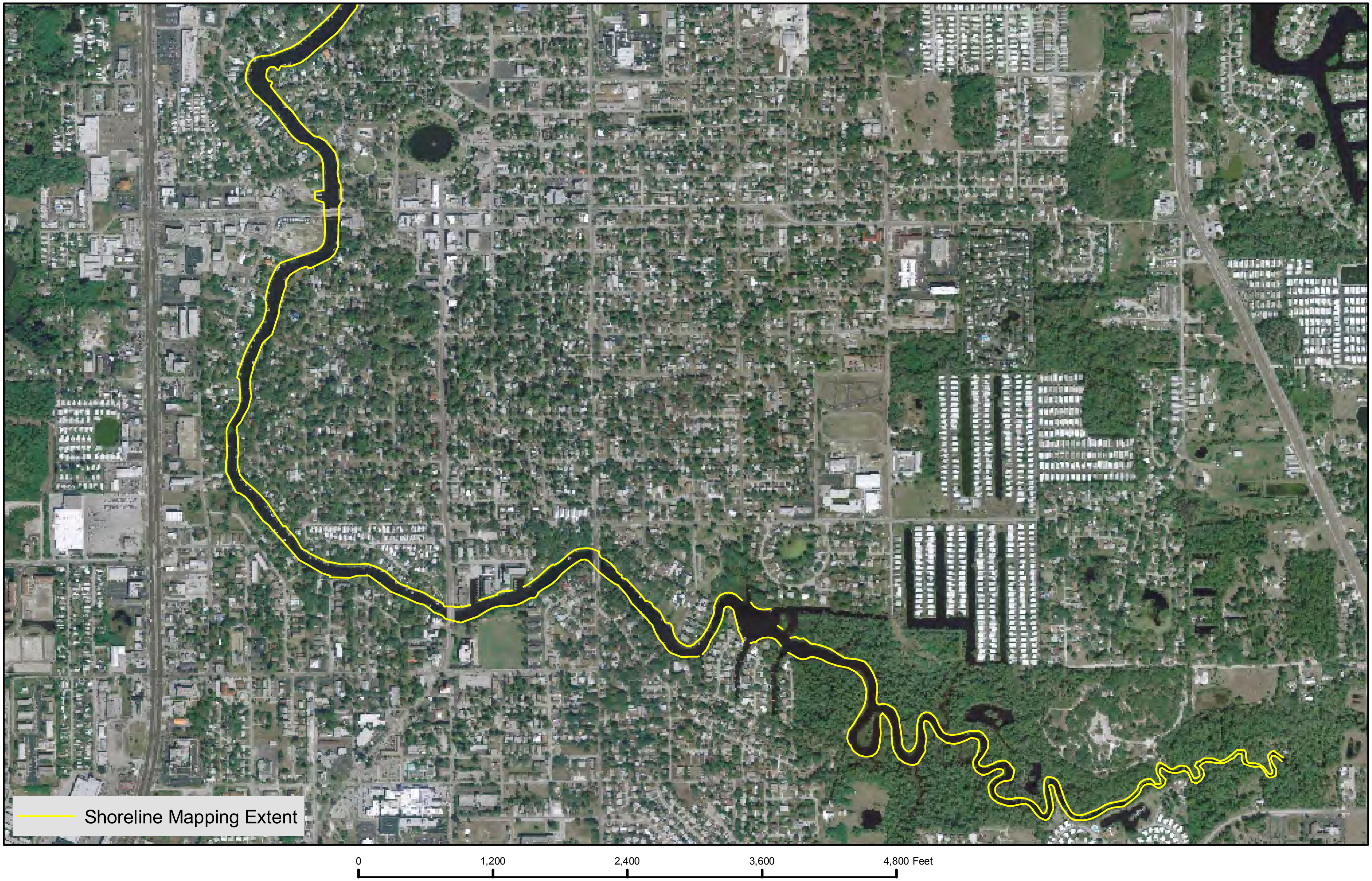

Figure 3b - Mapping Limits

Pithlachascotee River Vegetation Mapping
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Image:2007

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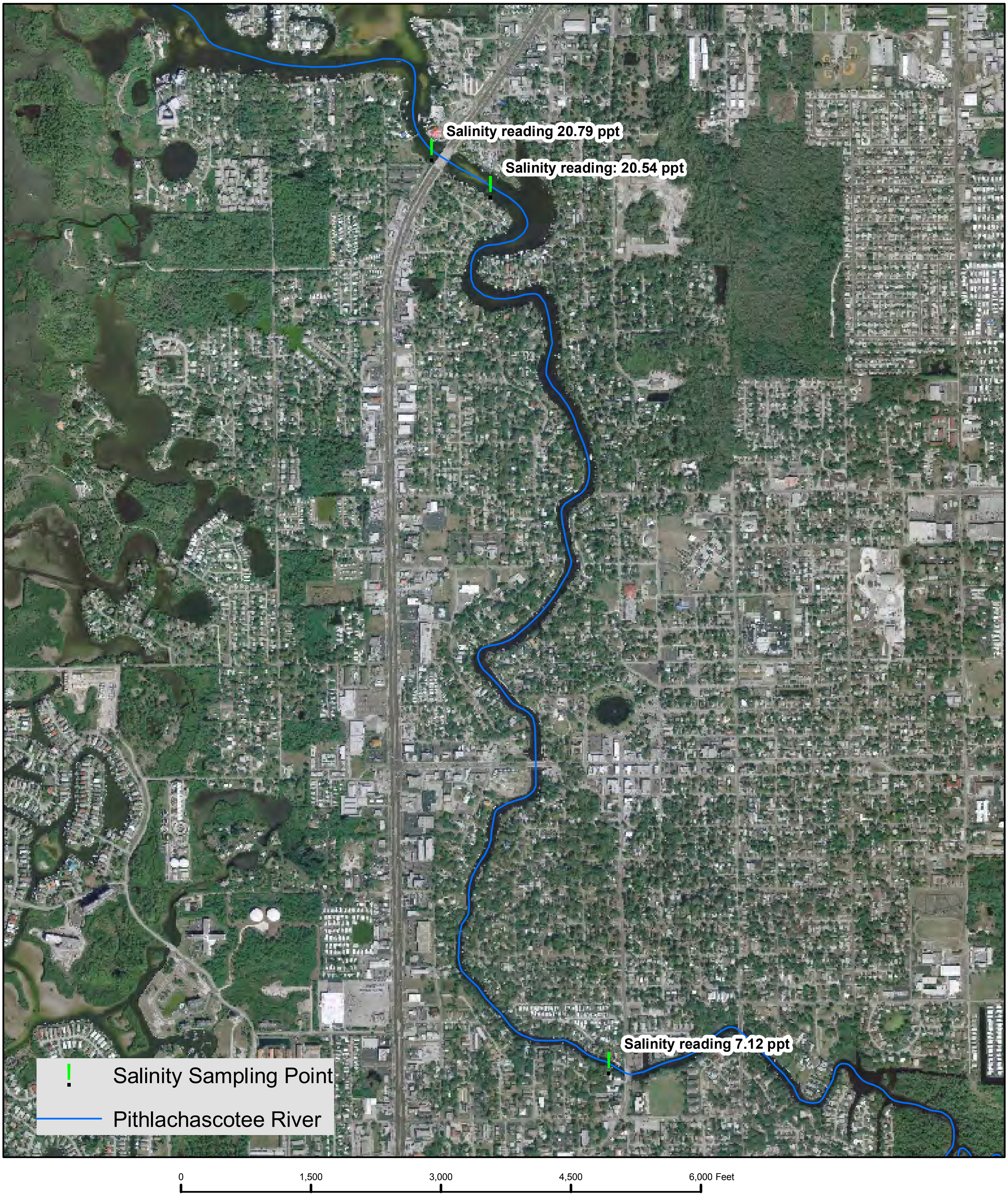

Figure 4 - Salinity Measurements

Pithlachascotee River Vegetation Mapping
Pasco County, Florida

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TABLES

Table 1. Plant Species Observed with Approximate Salinity Designation (Mesohalophyte, Oligohalophyte, or Glycophyte)

Plant Species Observed		
Scientific Name	**Common Name**	**Salinity Designation**
Acer rubrum	red maple	G
Acrostichum danaeifolium	leather fern	O
Avicennia germinans	black mangrove	M
Baccharis halimifolia	groundsel bush	G, O
Bacopa monnieri	smooth waterhyssop	G, O
Carpinus caroliniana	hornbeam	G
Casuarina equisetifolia [1]	australian pine	G, O, M
Cephalanthus occidentalis	button bush	G
Cinnamomum camphora [1]	camphor tree	G
Cladium jamaicense	saw grass	G, O
Crinum americanum	swamp lilly	G, O
Distichlis spicata	salt grass	M
Fimbrystalis castanea	saltmarsh fringe-rush	O, M
Juncus roemerianus	needle rush	O, M
Juniperus virginiana	eastern red cedar	G, O
Magnolia virginiana	sweet-bay	G, O
Myrica cerifera	wax myrtle	G, O
Nyssa sylvatica var. *biflora*	black gum	G, O
Panicum repens [1]	torpedo grass	G, O
Persea palustris	swamp bay	G, O
Prunus umbellata	hog plum	G
Quercus laurifolia	laurel oak	G, O
Quercus nigra	water oak	G, O

Scientific Name	Common Name	Salinity Designation
Quercus virginiana	live oak	G, O
Rhizophora mangle	red mangrove	O, M
Sabal palmetto	cabbage palm	G, O
Sambucus nigra var. canadensis	elderberry	G
Schinus terebinthifolius [1]	brazilian pepper	G, O, M
Serenoa repens	saw palmetto	G, O, M
Taxodium distichum	bald cypress	G, O
Typha domingensis	southern cattail	G, O
Ulmus americana	american elm	G
Wedelia trilobata [2]	wedelia	G, O, M

1. Exotic vegetation classified as Category I invasive exotic by the Florida Exotic Pest Plant Council.
2. Exotic vegetation classified as Category II invasive exotic by the Florida Exotic Pest Plant Council.

Table 2. Pithlachascotee River shoreline polyline designations and associated vegetation.

Designation	Shoreline Description	Total Length (ft)	Total Percent Coverage
1	Seawall	45,619.15	55.7
2	*Rhizophora mangle, Avicennia germinans, Schinus terebinthifolius*	439.46	0.5
3	*Rhizophora mangle, Avicennia germinans, Distichlis spicata*	8,431.28	10.3
4	*Schinus terebinthifolius, Rhizophora mangle, Avicennia germinans, Sabal palmetto, Distichlis spicata*	701.81	0.9
5	*Rhizophora mangle*	228.69	0.3
6	Sand	256.2	0.3
7	*Rhizophora mangle, Avicennia germinans,*	2,828.94	3.5
8	*Juncus roemerianus, Rhizophora mangle, Avicennia germinans, Distichlis spicata*	1,153.24	1.4
9	*Rhizophora mangle, Avicennia germinans, Schinus terebinthifolius, Distichlis spicata*	318.65	0.4
10	*Quercus virginiana, Schinus terebinthifolius, Rhizophora mangle, Avicennia germinans, Sabal palmetto*	116.51	0.1
11	*Schinus terebinthifolius*	72.93	0.1
12	*Schinus terebinthifolius, Rhizophora mangle, Avicennia germinans, Juncus roemerianus, Crinum americanum*	267.22	0.3

Designation	Shoreline Description	Total Length (ft)	Total Percent Coverage
13	*Typha domingensis, Rhizophora mangle, Avicennia germinans*	73.15	0.1
14	*Quercus virginiana, Fimbrystalis castanea, Rhizophora mangle, Avicennia germinans, Typha domingensis, Sabal palmetto, Juncus roemerianus, Taxodium distichum*	867.68	1.1
15	*Rhizophora mangle, Avicennia germinans, Juncus roemerianus*	156.46	0.2
16	*Acrostichum danaeifolium, Schinus terebinthifolius, Sabal palmetto, Rhizophora mangle, Avicennia germinans, Fimbrystalis castanea, Typha domingensis, Juncus roemerianus*	388.7	0.5
17	*Rhizophora mangle, Avicennia germinans, Quercus virginiana, Sabal palmetto, Fimbrystalis castanea, Crinum americanum, Acrostichum danaeifolium, Schinus terebinthifolius*	282.79	0.3
18	*Juncus roemerianus, Rhizophora mangle, Avicennia germinans, Typha domingensis, Acrostichum danaeifolium, Sabal palmetto, Juniperus virginiana*	198.95	0.2
19	Riprap	473.07	0.6
20	*Acrostichum danaeifolium, Typha domingensis, Rhizophora mangle, Avicennia germinans, Fimbrystalis castanea*	309.79	0.4
21	*Schinus terebinthifolius, Cladium jamaicense,* some *Sabal palmetto* and *Quercus virginiana* in canopy	125.08	0.2
22	*Schinus terebinthifolius, Panicum repens, Bacopa monnieri, Fimbrystalis castanea*	96.97	0.1
23	*Cladium jamaicense, Acrostichum danaeifolium / Juncus roemerianus* dominant, some *Schinus terebinthifolius, (1)Myrica cerifera*	225.91	0.3
24	*Acrostichum danaeifolium, Schinus terebinthifolius, Sabal palmetto, Quercus virginiana, Persea palustris(1), Wedelia trilobata*	99.06	0.1

Designation	Shoreline Description	Total Length (ft)	Total Percent Coverage
25	*Cladium jamaicense, Wedelia trilobata, Schinus terebinthifolius*	352.19	0.4
26	*Cladium jamaicense, Acrostichum danaeifolium, Myrica cerifera, Persea palustris*	48.25	0.1
27	*Juncus roemerianus, Acrostichum danaeifolium, some Cladium jamaicense, Persea palustris, Myrica cerifera, Sabal palmetto, Quercus virginiana, Juniperus virginiana, Serenoa repens*	2,434.80	3.0
28	*Schinus terebinthifolius, Acrostichum danaeifolium,* some *Cladium jamaicense, Persea palustris, Myrica cerifera, Sabal palmetto, Quercus virginiana, Juniperus virginiana, Serenoa repens*	68.8	0.1
29	*Schinus terebinthifolius, Myrica cerifera, Baccharis halimifolia, Acrostichum danaeifolium* dominates ground cover, *Sabal palmetto, Quercus virginiana, Juniperus virginiana,*	109.7	0.1
30	*Sabal palmetto* dominates canopy, some *Persea palustris,* some *Acer rubrum,* some *Magnolia virginiana, Myrica cerifera, Baccharis halimifolia, Acrostichum danaeifolium* dominates ground cover	3,092.15	3.8
31	*Cladium jamaicense* dominates ground cover, no significant canopy or sub-canopy	950.91	1.2
32	*Cladium jamaicense* dominates ground cover, *Juncus roemerianus, Crinum americanum*	316.67	0.4
33	*Acrostichum danaeifolium* dominates ground cover. *Myrica cerifera, Acer rubrum, Persea palustris,* and *Juniperus virginiana* found in sub-canopy. Canopy consists of some *Acer rubrum, Nyssa sylvatica, and Taxodium distichum.* Canopy dominated by *Quercus virginiana, Quercus laurifolia, Quercus nigra. Juniperus virginiana* and *Sabal palmetto* not as dominant.	1,332.35	1.6

Designation	Shoreline Description	Total Length (ft)	Total Percent Coverage
34	Groundcover drops out. *Schinus terebinthifolius, Baccharis halimifolia, Myrica cerifera*, and *Prunus umbellata* in sub canopy. *Quercus virginiana, Sabal palmetto, Magnolia virginiana*, and *Juniperus virginiana* make up canopy.	342.95	0.4
35	*Serenoa repens, Osmunda cinnamomea* in ground cover. *Myrica cerifera sub-canopy. Quercus virginiana, Sabal palmetto, Magnolia virginiana, Juniperus virginiana* make up canopy	199.19	0.2
36	*Acrostichum danaeifolium* dominates groundcover. *Schinus terebinthifolius, Baccharis halimifolia, Myrica cerifera*, and *Prunus umbellata* in sub canopy. *Quercus virginiana, Quercus laurifolia, Sabal palmetto, Magnolia virginiana, Juniperus virginiana* canopy	955.71	1.2
37	Sparse *Acrostichum danaeifolium* groundcover, sub-canopy dominated by *Myrica cerifera* but also containing *Cephalanthus occidentalis, Sambucus nigra var. canadensis, Baccharis halimifolia* and *Prunus umbellata.* Canopy contains *Carpinus caroliniana, Quercus nigra, Quercus laurifolia, Sabal palmetto, Magnolia virginiana*, some *Ulmus americana, Cinnamomum camphora, Quercus virginiana*, and *Acer rubrum*	4209.52	5.1
38	Groundcover dominated by *Cladium jamaicense*, with some *Juncus roemerianus* also present. Sub-canopy and canopy containing some *Sabal palmetto, Juniperus virginiana*, and *Persea palustris*	649.77	0.8
39	Canopy consists of *Juniperus virginiana, Quercus virginiana*, and *Sabal palmetto. Myrica cerifera* dominate sub-canopy. *Acrostichum danaeifolium* ground cover.	294.04	0.4
40	*Typha domingensis*	205.48	0.3
41	*Fimbrystalis castanea, Rhizophora mangle, Acrostichum danaeifolium*	143.93	0.2
42	*Casuarina equisetifolia, Schinus terebinthifolius, Cinnamomum camphora, Rhizophora mangle*	270.9	0.3

Designation	Shoreline Description	Total Length (ft)	Total Percent Coverage
43	*Rhizophora mangle, Juncus roemerianus, Acrostichum danaeifolium*	124.06	0.2
44	*Sabal palmetto, Juniperus virginiana, Rhizophora mangle, Avicennia germinans, Acrostichum danaeifolium*	149.21	0.2
45	*Fimbrystalis castanea, Sabal palmetto, Acrostichum danaeifolium*	156.12	0.2
46	*Juncus roemerianus* dominant with some *Rhizophora mangle* and some *Fimbrystalis castanea*	73.6	0.1
47	Unnatural edge with some *Acrostichum danaeifolium, Myrica cerifera, Persea palustris, Magnolia virginiana, Quercus laurifolia, Sabal palmetto*	1,633.14	2.0

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Appendix A

Pithlachascotee River Shoreline Vegetation Maps

Shoreline Vegetation Map 1
Pithlachascotee River
Pasco County, FL

P	*Rhizophora mangle, Avicennia germinans, Distichlis spicata*
S	p~åÇ
T	*Rhizophora mangle, Avicennia germinans,*

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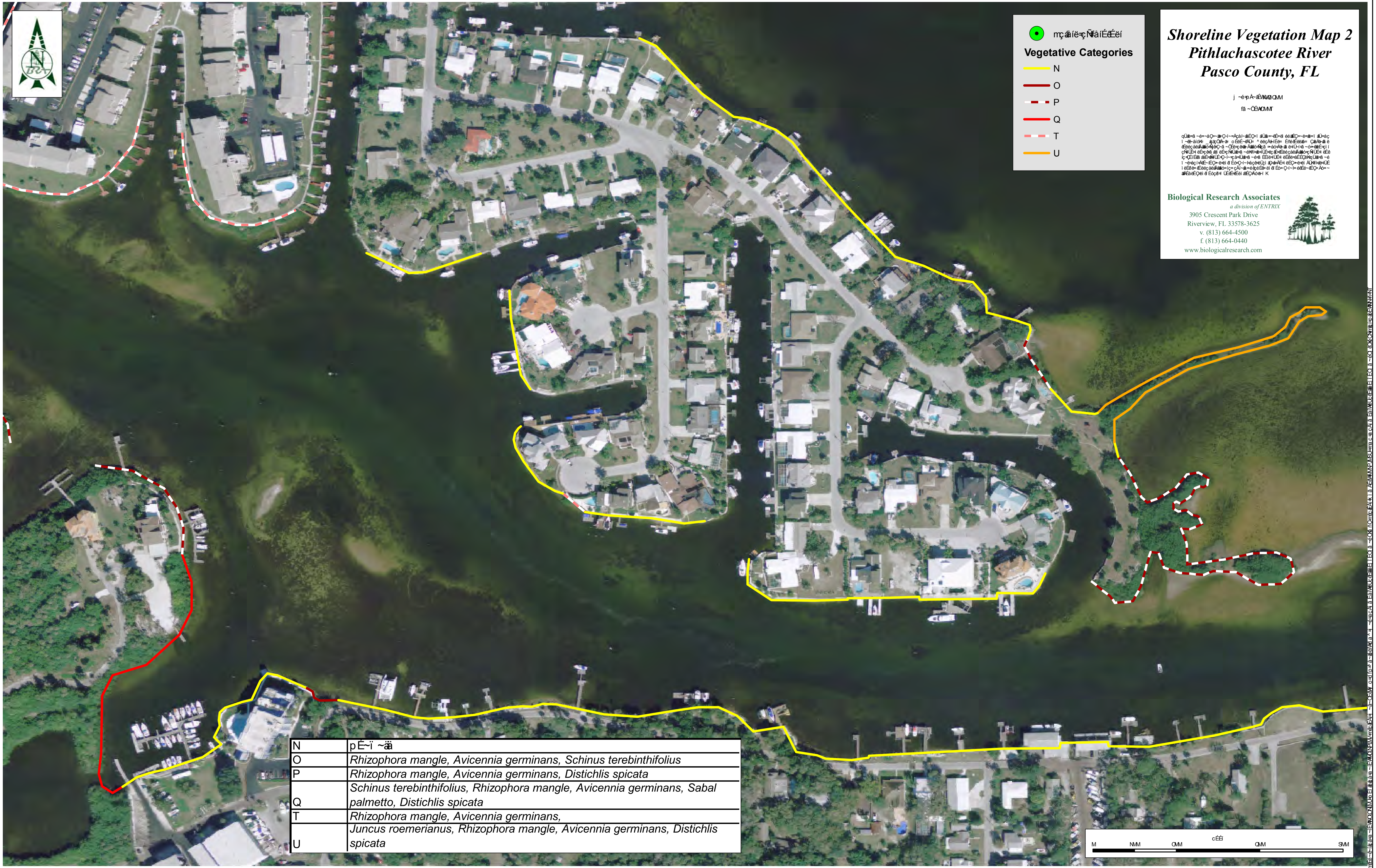

Shoreline Vegetation Map 2
Pithlachascotee River
Pasco County, FL

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Vegetative Categories

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O	*Rhizophora mangle, Avicennia germinans, Schinus terebinthifolius*
P	*Rhizophora mangle, Avicennia germinans, Distichlis spicata*
Q	*Schinus terebinthifolius, Rhizophora mangle, Avicennia germinans, Sabal palmetto, Distichlis spicata*
T	*Rhizophora mangle, Avicennia germinans,*
U	*Juncus roemerianus, Rhizophora mangle, Avicennia germinans, Distichlis spicata*

Shoreline Vegetation Map 3
Pithlachascotee River
Pasco County, FL

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P	*Rhizophora mangle, Avicennia germinans, Distichlis spicata*
S	p~åÇ
U	*Juncus roemerianus, Rhizophora mangle, Avicennia germinans, Distichlis spicata*

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Shoreline Vegetation Map 4
Pithlachascotee River
Pasco County, FL

Map Scale: 1:4,200

Image date: 2007

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● Point of Interest

Vegetative Categories

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- 3
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Salinity reading 20.79; Manatees

Salinity reading 20.54

1	Seawall
3	*Rhizophora mangle, Avicennia germinans, Distichlis spicata*
9	*Rhizophora mangle, Avicennia germinans, Schinus terebinthifolius, Distichlis spicata*

Shoreline Vegetation Map 5
Pithlachascotee River
Pasco County, FL

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Vegetative Categories

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T	*Rhizophora mangle, Avicennia germinans,*

Shoreline Vegetation Map 6
Pithlachascotee River
Pasco County, FL

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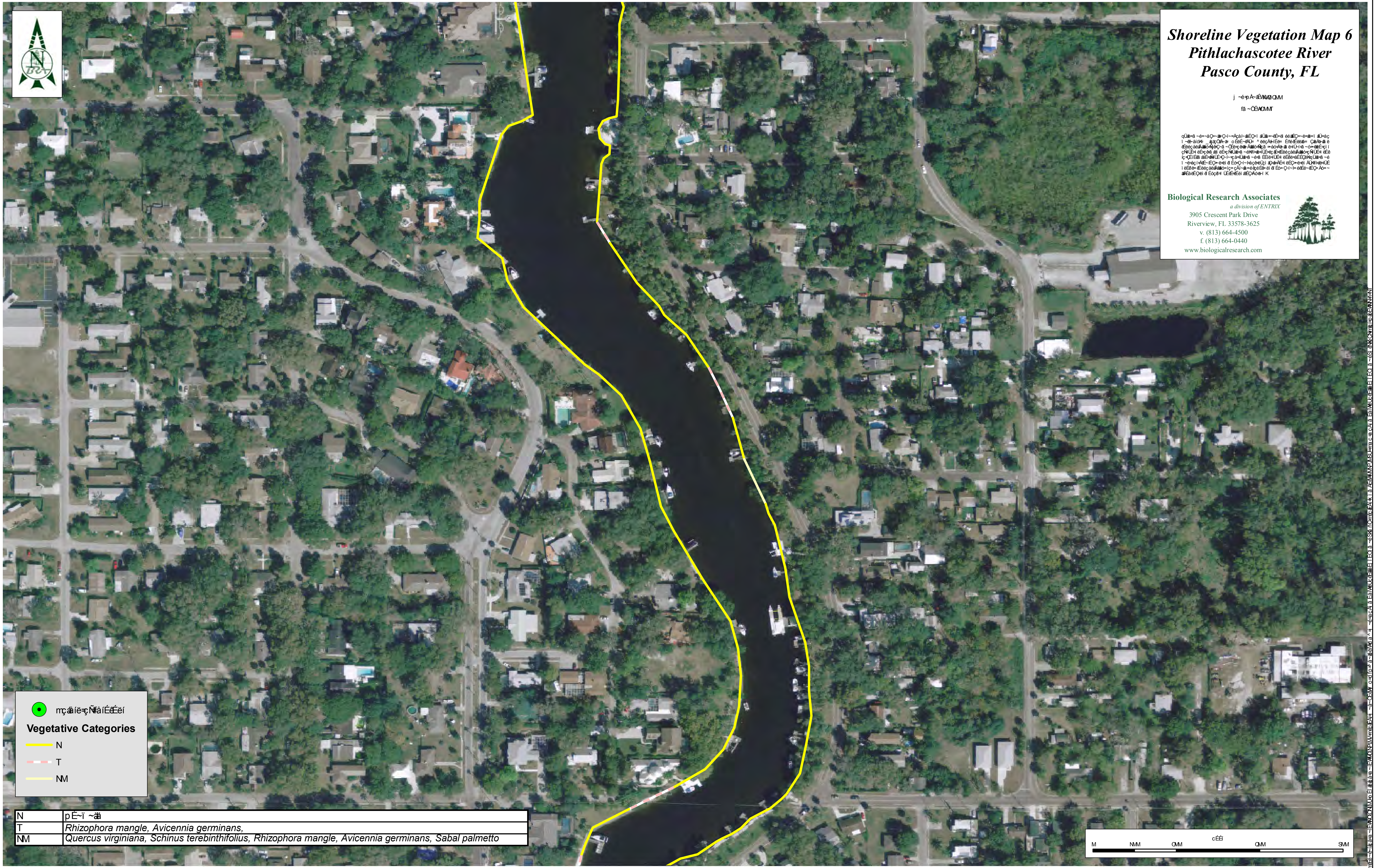

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T	*Rhizophora mangle, Avicennia germinans,*
NM	*Quercus virginiana, Schinus terebinthifolius, Rhizophora mangle, Avicennia germinans, Sabal palmetto*

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Shoreline Vegetation Map 7
Pithlachascotee River
Pasco County, FL

Map Scale: 1:4,000

Imagery: 2007

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● Point of Interest

Vegetative Categories

- N
- P
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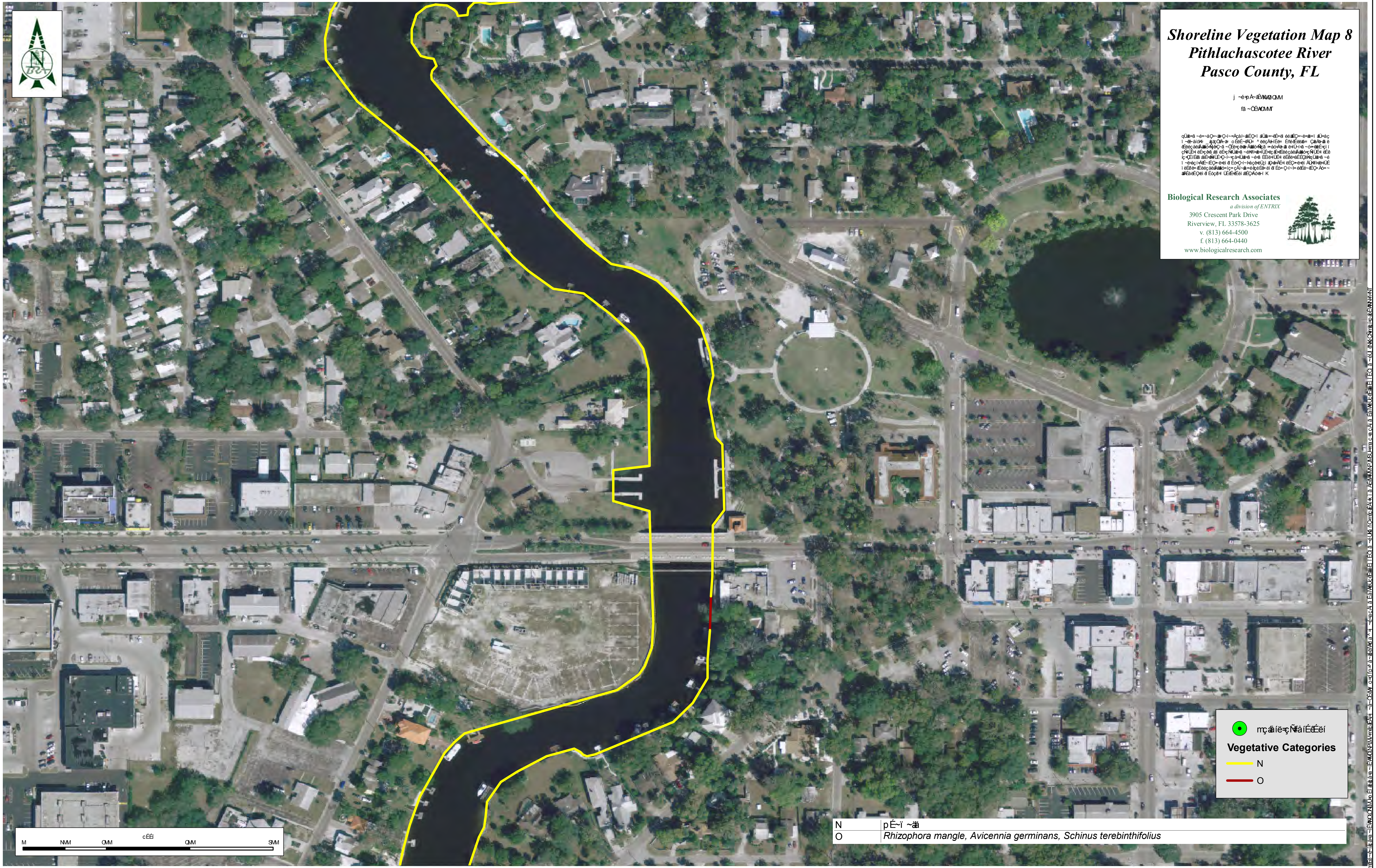
N	Seawall
P	*Rhizophora mangle, Avicennia germinans, Distichlis spicata*
T	*Rhizophora mangle, Avicennia germinans,*



Shoreline Vegetation Map 8
Pithlachascotee River
Pasco County, FL

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Vegetative Categories

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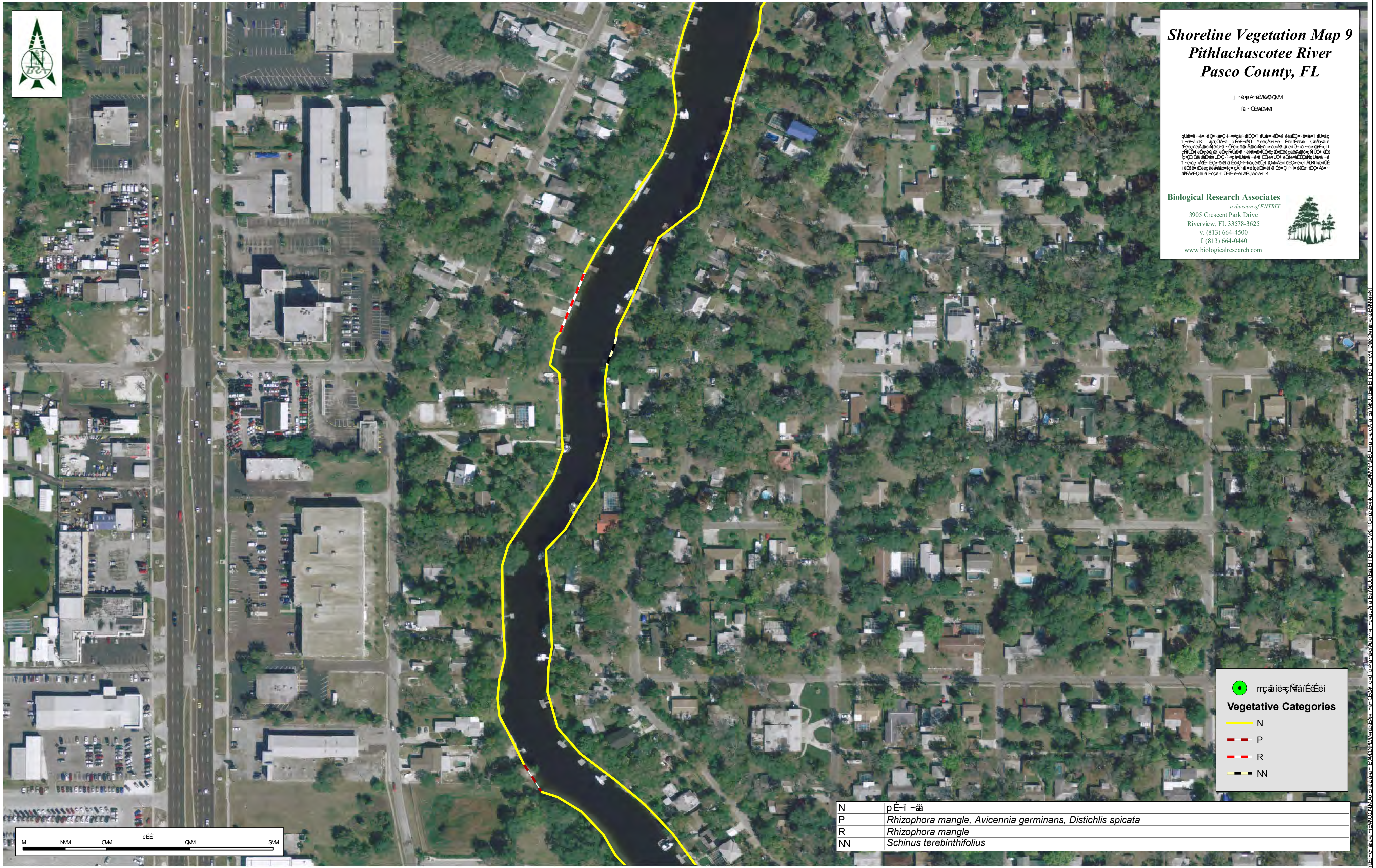
O	*Rhizophora mangle, Avicennia germinans, Schinus terebinthifolius*



Shoreline Vegetation Map 9
Pithlachascotee River
Pasco County, FL

Map Scale: 1:2400

Image: 2007

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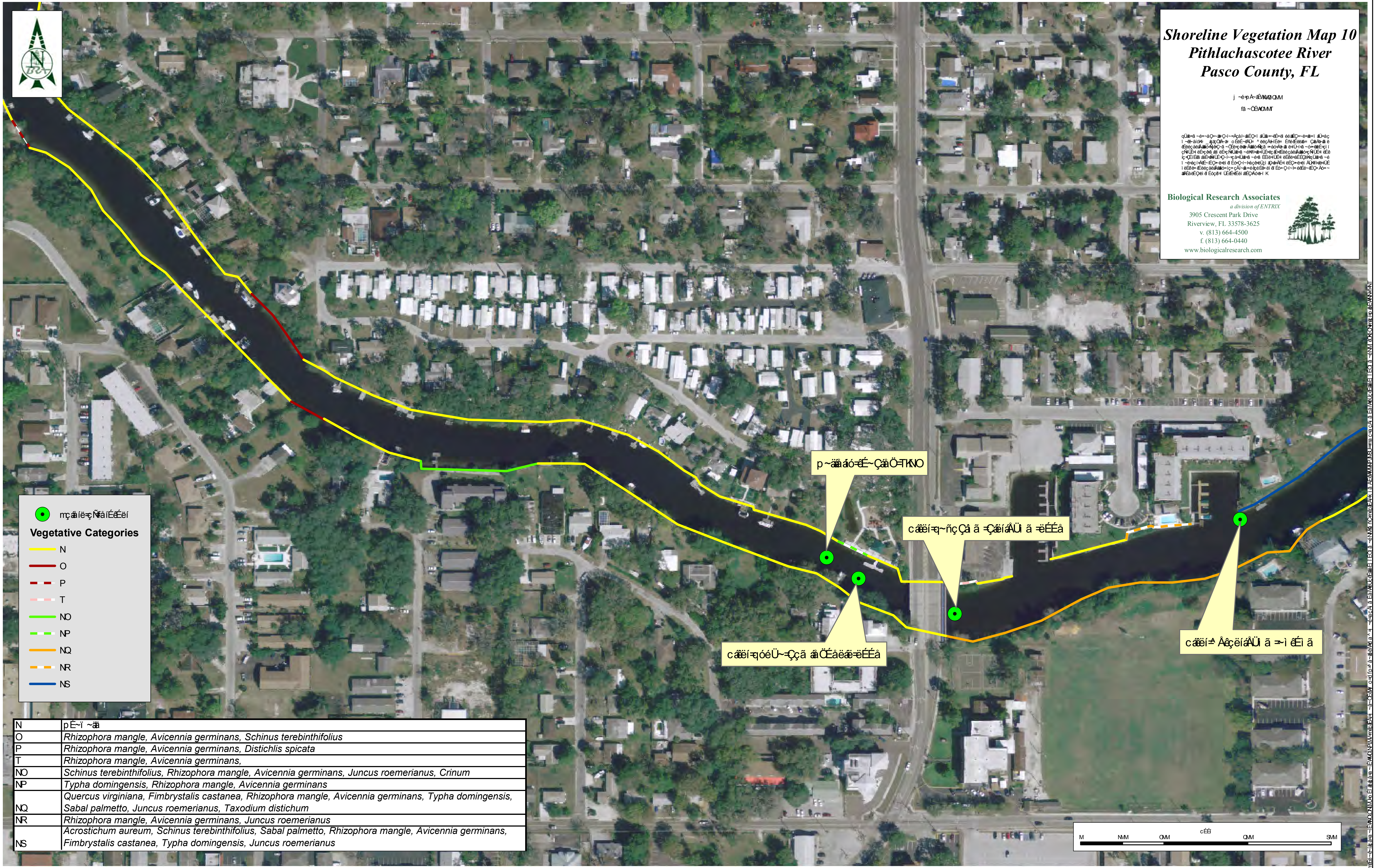
● Points of Interest

Vegetative Categories

- 1
- 3
- 5
- 11

1	Seawall
3	*Rhizophora mangle, Avicennia germinans, Distichlis spicata*
5	*Rhizophora mangle*
11	*Schinus terebinthifolius*



Shoreline Vegetation Map 10
Pithlachascotee River
Pasco County, FL

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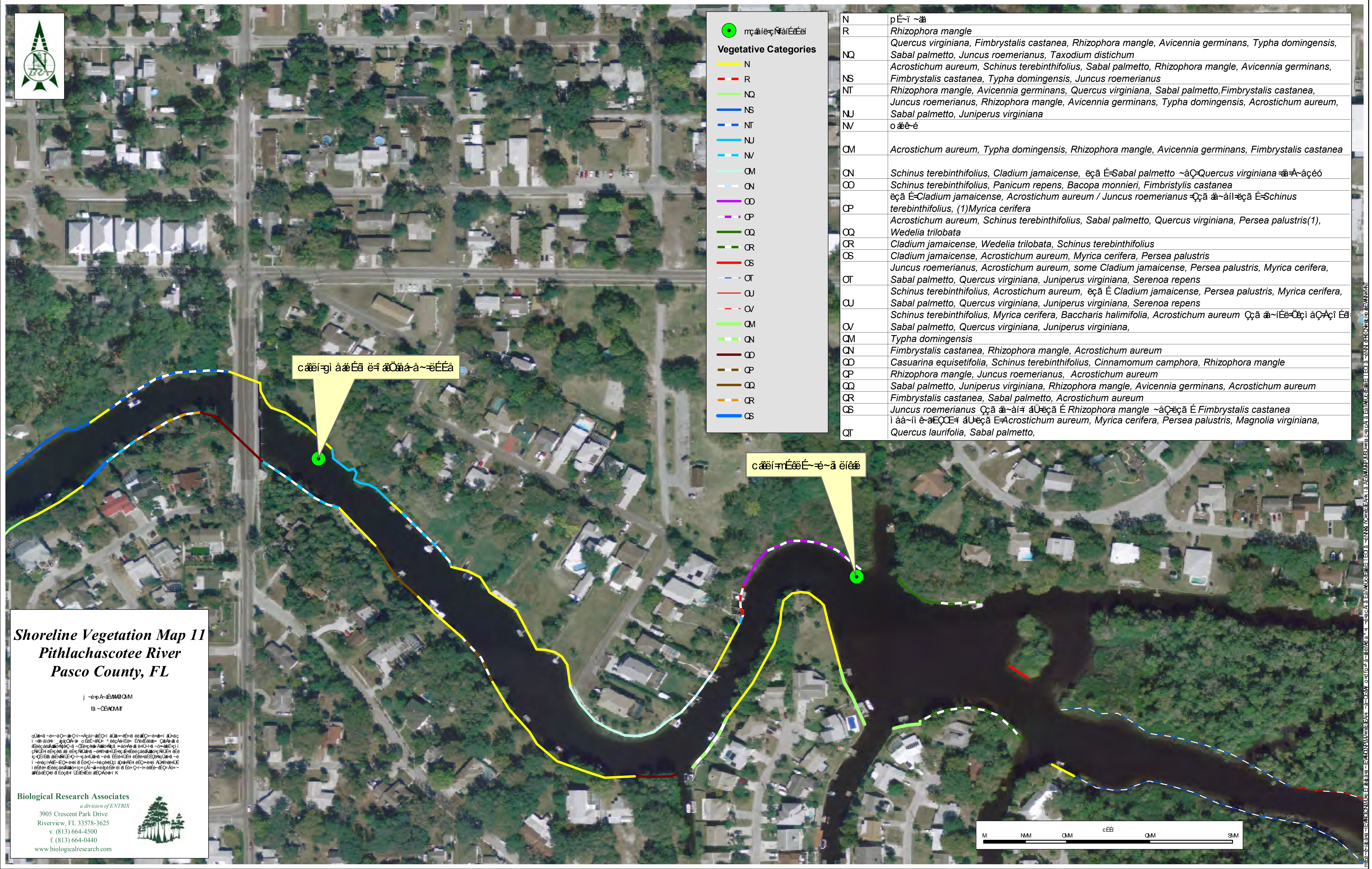
Vegetative Categories

- N
- O
- P
- T
- NO
- NP
- NQ
- NR
- NS

N	pÉï ~ää
O	*Rhizophora mangle, Avicennia germinans, Schinus terebinthifolius*
P	*Rhizophora mangle, Avicennia germinans, Distichlis spicata*
T	*Rhizophora mangle, Avicennia germinans,*
NO	*Schinus terebinthifolius, Rhizophora mangle, Avicennia germinans, Juncus roemerianus, Crinum*
NP	*Typha domingensis, Rhizophora mangle, Avicennia germinans*
NQ	*Quercus virginiana, Fimbrystalis castanea, Rhizophora mangle, Avicennia germinans, Typha domingensis, Sabal palmetto, Juncus roemerianus, Taxodium distichum*
NR	*Rhizophora mangle, Avicennia germinans, Juncus roemerianus*
NS	*Acrostichum aureum, Schinus terebinthifolius, Sabal palmetto, Rhizophora mangle, Avicennia germinans, Fimbrystalis castanea, Typha domingensis, Juncus roemerianus*



N	pÉ~ï~ää
R	*Rhizophora mangle*
NQ	*Quercus virginiana, Fimbrystalis castanea, Rhizophora mangle, Avicennia germinans, Typha domingensis, Sabal palmetto, Juncus roemerianus, Taxodium distichum*
NS	*Acrostichum aureum, Schinus terebinthifolius, Sabal palmetto, Rhizophora mangle, Avicennia germinans, Fimbrystalis castanea, Typha domingensis, Juncus roemerianus*
NT	*Rhizophora mangle, Avicennia germinans, Quercus virginiana, Sabal palmetto,Fimbrystalis castanea,*
NU	*Juncus roemerianus, Rhizophora mangle, Avicennia germinans, Typha domingensis, Acrostichum aureum, Sabal palmetto, Juniperus virginiana*
NV	o áéê~é
OM	*Acrostichum aureum, Typha domingensis, Rhizophora mangle, Avicennia germinans, Fimbrystalis castanea*
ON	*Schinus terebinthifolius, Cladium jamaicense,* ëçã É=*Sabal palmetto* ~åÇ=*Quercus virginiana* =áå=Å~åçéó
OO	*Schinus terebinthifolius, Panicum repens, Bacopa monnieri, Fimbristylis castanea*
OP	ëçã É=*Cladium jamaicense, Acrostichum aureum / Juncus roemerianus* =Çç㠒å~åíI=ëçã É=*Schinus terebinthifolius, (1)Myrica cerifera*
OQ	*Acrostichum aureum, Schinus terebinthifolius, Sabal palmetto, Quercus virginiana, Persea palustris(1), Wedelia trilobata*
OR	*Cladium jamaicense, Wedelia trilobata, Schinus terebinthifolius*
OS	*Cladium jamaicense, Acrostichum aureum, Myrica cerifera, Persea palustris*
OT	*Juncus roemerianus, Acrostichum aureum, some Cladium jamaicense, Persea palustris, Myrica cerifera, Sabal palmetto, Quercus virginiana, Juniperus virginiana, Serenoa repens*
OU	*Schinus terebinthifolius, Acrostichum aureum,* ëçã É *Cladium jamaicense, Persea palustris, Myrica cerifera, Sabal palmetto, Quercus virginiana, Juniperus virginiana, Serenoa repens*
OV	*Schinus terebinthifolius, Myrica cerifera, Baccharis halimifolia, Acrostichum aureum* Çç㠒å~íÉë=Öêçìå ÇÅçîÉê *Sabal palmetto, Quercus virginiana, Juniperus virginiana,*
QM	*Typha domingensis*
QN	*Fimbrystalis castanea, Rhizophora mangle, Acrostichum aureum*
QO	*Casuarina equisetifolia, Schinus terebinthifolius, Cinnamomum camphora, Rhizophora mangle*
QP	*Rhizophora mangle, Juncus roemerianus, Acrostichum aureum*
QQ	*Sabal palmetto, Juniperus virginiana, Rhizophora mangle, Avicennia germinans, Acrostichum aureum*
QR	*Fimbrystalis castanea, Sabal palmetto, Acrostichum aureum*
QS	*Juncus roemerianus* Çç㠒å~åí= ïáíÜ=ëçã É *Rhizophora mangle* ~åÇ=ëçã É *Fimbrystalis castanea*
QT	ì åå~íì ê~äÉÇ=E= ïáíÜ=ëçã É=*Acrostichum aureum, Myrica cerifera, Persea palustris, Magnolia virginiana, Quercus laurifolia, Sabal palmetto,*

Shoreline Vegetation Map 11
Pithlachascotee River
Pasco County, FL

j ~é=p Å~äÉW=NWTIQMM

fã ~ÖÉêó=OMMT

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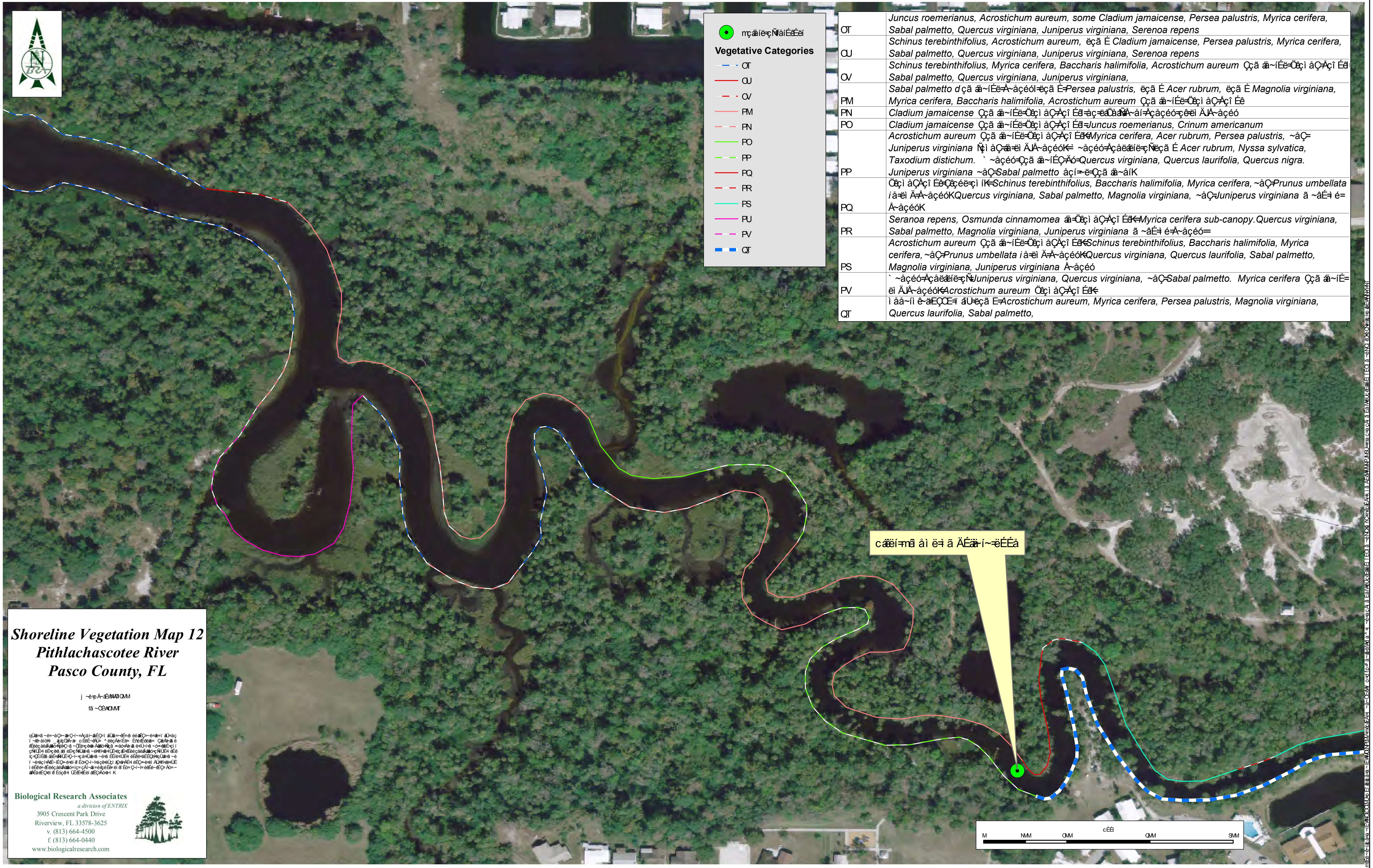

OT	*Juncus roemerianus, Acrostichum aureum, some Cladium jamaicense, Persea palustris, Myrica cerifera, Sabal palmetto, Quercus virginiana, Juniperus virginiana, Serenoa repens*
OU	*Schinus terebinthifolius, Acrostichum aureum,* ëçãÉ *Cladium jamaicense, Persea palustris, Myrica cerifera, Sabal palmetto, Quercus virginiana, Juniperus virginiana, Serenoa repens*
OV	*Schinus terebinthifolius, Myrica cerifera, Baccharis halimifolia, Acrostichum aureum* Ççãáå~íÉë=Öêçìå ÇÅçîÉê *Sabal palmetto, Quercus virginiana, Juniperus virginiana,*
PM	*Sabal palmetto d*çãáå~íÉë=Å~åçéól=ëçãÉ=*Persea palustris,* ëçãÉ *Acer rubrum,* ëçãÉ *Magnolia virginiana, Myrica cerifera, Baccharis halimifolia, Acrostichum aureum* Ççãáå~íÉë=Öêçìå ÇÅçîÉê
PN	*Cladium jamaicense* Ççãáå~íÉë=Öêçìå ÇÅçîÉê=åç=ëÜêìÄ=çê=Å~åçéó=çê=ëìÄJÅ~åçéó
PO	*Cladium jamaicense* Ççãáå~íÉë=Öêçìå ÇÅçîÉê=*Juncus roemerianus, Crinum americanum*
PP	*Acrostichum aureum* Ççãáå~íÉë=Öêçìå ÇÅçîÉêK=*Myrica cerifera, Acer rubrum, Persea palustris,* ~åÇ=*Juniperus virginiana* Ñçêã=ëìÄJÅ~åçéóK= ~åçéó=Åçåëáëíë=çÑ=ëçãÉ *Acer rubrum, Nyssa sylvatica, Taxodium distichum.* ` ~åçéó=Ççãáå~íÉÇ=Äó=*Quercus virginiana, Quercus laurifolia, Quercus nigra. Juniperus virginiana* ~åÇ=*Sabal palmetto* åçí=~ë=Ççãáå~åíK
PQ	Öêçìå ÇÅçîÉê=Çêçéë=çìíK=*Schinus terebinthifolius, Baccharis halimifolia, Myrica cerifera,* ~åÇ=*Prunus umbellata* ëìÄJÅ~åçéóK*Quercus virginiana, Sabal palmetto, Magnolia virginiana,* ~åÇ=*Juniperus virginiana* ã~âÉ=ìé=Å~åçéóK
PR	*Seranoa repens, Osmunda cinnamomea* áå=Öêçìå ÇÅçîÉêK=*Myrica cerifera sub-canopy.Quercus virginiana, Sabal palmetto, Magnolia virginiana, Juniperus virginiana* ã~âÉ=ìé=Å~åçéó=
PS	*Acrostichum aureum* Ççãáå~íÉë=Öêçìå ÇÅçîÉêK=*Schinus terebinthifolius, Baccharis halimifolia, Myrica cerifera,* ~åÇ=*Prunus umbellata* ëìÄ=Å~åçéóK=*Quercus virginiana, Quercus laurifolia, Sabal palmetto, Magnolia virginiana, Juniperus virginiana* Å~åçéó
PV	` ~åçéó=Åçåëáëíë=çÑ=*Juniperus virginiana, Quercus virginiana,* ~åÇ=*Sabal palmetto. Myrica cerifera* Ççãáå~íÉ=ëìÄJÅ~åçéóK=*Acrostichum aureum* Öêçìå ÇÅçîÉêK
QT	ìåå~íì ê~äÉÇÖÉ=ïáíÜ=ëçãÉ=*Acrostichum aureum, Myrica cerifera, Persea palustris, Magnolia virginiana, Quercus laurifolia, Sabal palmetto,*

Shoreline Vegetation Map 12
Pithlachascotee River
Pasco County, FL

j~é=p Å~äÉW=NWOIQMM

fã ~ÖÉW=OMMT

qÜáë=ã~é=~åÇ=~ää=Ç~í~=Åçå í~áåÉÇ=ïáíÜáå=~êÉ=ëìééäáÉÇ=~ë=áë=ïáíÜ=åç ï~êê~åíóK=_áçäçÖáÅ~ä=oÉëÉ~êÅÜ=^ëëçÅá~íÉë=ÉñéêÉëëäó=ÇáëÅä~áãë êÉëéçåëáÄáäáíó=Ñçê=Ç~ã~ÖÉë=çê=äá~Äáäáíó=Ñêçã=~åó=Åä~áãë=íÜ~í=ã~ó=~êáëÉ=çìí çÑ=íÜÉ=ìëÉ=çê=ãáëìëÉ=çÑ=íÜáë=ã~éK=fí=áë=íÜÉ=ëçäÉ=êÉëéçåëáÄáäáíó=çÑ=íÜÉ=ìëÉê íç=ÇÉíÉêãáåÉ=áÑ=íÜÉ=Ç~í~=çå=íÜáë=ã~é=ãÉÉíë=íÜÉ=ìëÉêÛë=åÉÉÇëK=qÜáë=ã~é ï~ë=åçí=ÅêÉ~íÉÇ=~ë=ëìêîÉó=Ç~í~=åçê=ëÜçìäÇ=áí=ÄÉ=ìëÉÇ=~ë=ëìÅÜK=fí=áë=íÜÉ ìëÉêÛë=êÉëéçåëáÄáäáíó=íç=çÄí~áå=éêçéÉê=ëìêîÉó=Ç~í~=éêÉé~êÉÇ=Äó=~ äáÅÉåëÉÇ=ëìêîÉóçê=ïÜÉêÉ=êÉèìáêÉÇ=Äó=ä~ïK

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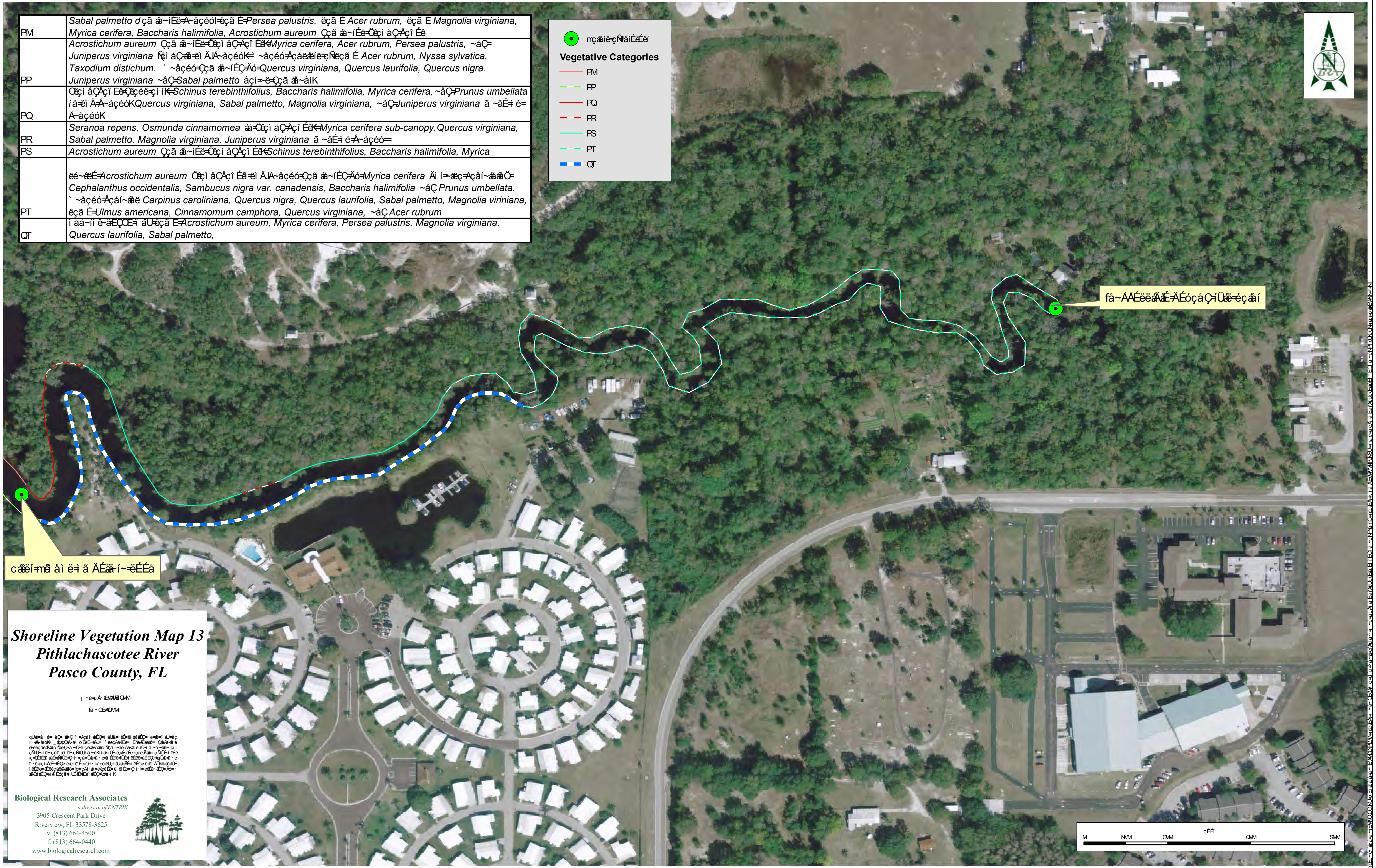
PM	*Sabal palmetto* dçã áå~íÉë=Å~åçéóI=ëçã É=*Persea palustris,* ëçã É *Acer rubrum,* ëçã É *Magnolia virginiana, Myrica cerifera, Baccharis halimifolia, Acrostichum aureum* Çç ã áå~íÉë=Öêçì åÇ=Åçî Éê
PP	*Acrostichum aureum* Çç ã áå~íÉë=Öêçì åÇ=Åçî ÉêK=*Myrica cerifera, Acer rubrum, Persea palustris,* ~åÇ= *Juniperus virginiana* Ñçì åÇ=áå=ëì ÄJÅ~åçéóK= ~åçéó=Åçåëáëíë=çÑ=ëçã É *Acer rubrum, Nyssa sylvatica, Taxodium distichum.* ` ~åçéó=Çç ã áå~íÉÇ=Äó=*Quercus virginiana, Quercus laurifolia, Quercus nigra. Juniperus virginiana* ~åÇ=*Sabal palmetto* åçí=~ë=Çç ã áå~åíK
PQ	Öêçì åÇ=Åçî Éê=Çêçéë=çì íK=*Schinus terebinthifolius, Baccharis halimifolia, Myrica cerifera,* ~åÇ=*Prunus umbellata* i å=ëì Ä=Å~åçéóK*Quercus virginiana, Sabal palmetto, Magnolia virginiana,* ~åÇ=*Juniperus virginiana* ã ~âÉ=ì é= Å~åçéóK
PR	*Seranoa repens, Osmunda cinnamomea* áå=Öêçì åÇ=Åçî ÉêK=*Myrica cerifera sub-canopy.Quercus virginiana, Sabal palmetto, Magnolia virginiana, Juniperus virginiana* ã ~âÉ=ì é=Å~åçéó=
PS	*Acrostichum aureum* Çç ã áå~íÉë=Öêçì åÇ=Åçî ÉêK=*Schinus terebinthifolius, Baccharis halimifolia, Myrica*
PT	ëé~êëÉ=*Acrostichum aureum* Öêçì åÇ=Åçî Éê=ëì ÄJÅ~åçéó=Çç ã áå~íÉÇ=Äó=*Myrica cerifera* Äì í=~äëç=Åçåí~áåáåÖ= *Cephalanthus occidentalis, Sambucus nigra var. canadensis, Baccharis halimifolia* ~åÇ *Prunus umbellata.* ` ~åçéó=Åçåí~áåë *Carpinus caroliniana, Quercus nigra, Quercus laurifolia, Sabal palmetto, Magnolia viriniana,* ëçã É=*Ulmus americana, Cinnamomum camphora, Quercus virginiana,* ~åÇ *Acer rubrum*
QT	ì åå~íì ê~ä=ÄÉÇ=ï áíÜ=ëçã É=*Acrostichum aureum, Myrica cerifera, Persea palustris, Magnolia virginiana, Quercus laurifolia, Sabal palmetto,*



Shoreline Vegetation Map 13
Pithlachascotee River
Pasco County, FL

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APPENDIX 4A

Janicki Environmental, Inc. 2011. Estimation of baseline flow conditions for the Pithlachascotee River and Brooker Creek. St. Petersburg, Florida. Prepared for the Southwest Florida Water Management District, Brooksville, Florida.

Estimation of Baseline Flow Conditions for the Pithlachascotee River and Brooker Creek

MHeyl Edits page 3-2
and 3-4

Prepared for:

Southwest Florid Water Management District
2379 Broad Street
Brooksville, FL 34604-6899

Prepared by:

Janicki Environmental, Inc.
1155 Eden Isle Drive NE
St. Petersburg, Florida 33704

June 1, 2011

Table of Contents

1 Background

Florida's five water management districts are directed by state law to establish minimum flows and levels (MFLs) for surface waters and aquifers within their jurisdictions. Minimum flows are defined in Florida Statutes (Section 373.042) as "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." Minimum flows are based on technical evaluations that determine the amount of water that can be withdrawn from a stream, watercourse, or aquifer without causing unacceptable environmental impacts.

Section 373.042 F.S. further states that minimum flows and levels shall be calculated "using the best information available. When appropriate, minimum flows and levels may be calculated to reflect seasonal variations. The Department [of Environmental Protection] and the governing board [of the relevant water management district] shall also consider, and at their discretion may also provide for, the protection of non-consumptive uses in the establishment of minimum flows and levels."

Guidance regarding the establishment of minimum flows and levels is provided in the Florida Water Resource Implementation Rule (specifically Rule 62-40.473, Florida Administrative Code), which states that "consideration shall be given to natural seasonal fluctuations in water flows or levels, nonconsumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic and wetlands ecology, including:

1) Recreation in and on the water;
2) Fish and wildlife habitats and the passage of fish;
3) Estuarine resources;
4) Transfer of detrital material;
5) Maintenance of freshwater storage and supply;
6) Aesthetic and scenic attributes;
7) Filtration and absorption of nutrients and other pollutants;
8) Sediment loads;
9) Water quality; and
10) Navigation."

Florida Statues further state that "When establishing minimum flows and levels pursuant to 373.042, the department or governing board shall consider changes and structural alterations to watersheds, surface waters and aquifers and the effects such changes or alterations have had, and the constraints such changes or alterations have placed, on the hydrology of the affected watershed, surface water, or aquifer, provided that nothing in this paragraph shall allow significant harm as provided by s. 373.042(1) caused by withdrawals" (Section 373.0421(1)). In essence, the District's are to evaluate and account for existing structural alterations on a watercourse when assessing the potential for withdrawals to cause significant harm. However, the effects of existing withdrawals are not to be considered when developing minimum flows and levels. In essence, during the determination of minimum flows and levels, existing water uses are not be 'grandfathered' when assessing the potential for withdrawals to cause significant harm.

In keeping with this approach, a baseline flow condition that does not include the effects of existing withdrawals must be identified to examine the relationships of resource functions with streamflow in order to determine the amount of withdrawals that will not result in significant harm to the water resource.

1.1 Objective

The objective of this task is to develop baseline flow records for United States Geological Survey (USGS) gage sites on the Pithlachascotee River and Brooker Creek. The two gages are the Pithlachascotee River near New Port Richey, FL (USGS 02310300) and Brooker Creek near Tarpon Springs, FL (USGS 02307359). Model simulations using the District's Northern Tampa Bay Integrated Model (the INTB Model) indicate that groundwater pumping in the region has reduced flows in both of the Pithlachascotee River and Brooker Creek. The INTB model was run for a 12-year period from 1989 to 2000, producing output for modeled daily flows at the aforementioned gages on the two systems. Using the same climatic data, the model was run for a baseline condition in which there were no groundwater withdrawals and an impacted condition which reflected actual groundwater pumping during the modeling period. The differences between the daily streamflow records for these two modeled conditions reflect the effects of groundwater pumping on the flows of these two systems.

The District intends to use the daily output from the INTB model to develop corrected baseline flow records for the Pithlachascotee River and Brooker Creek for the purposes of determining minimum flows and levels (MFLs) for these systems. It was concluded that the baseline flow scenario from the INTB model should not be used directly as the baseline flow for the MFLs analysis, because the daily flows in the model output vary slightly from the temporal variations of actual daily flows recorded by the USGS. Instead, the preferred approach is to analyze the relationship between baseline and impacted flows in the model output for each system and develop a statistical relationship to predict modeled daily baseline flows as a function of modeled impacted flows and other appropriate explanatory variables. The regression(s) developed from model output will then be applied to the actual flow records measured by the USGS to predict a baseline flow record for MFLs purposes.

2 Summary of Data

As was mentioned in section one, flows at the two gages have been altered over the past several decades. In addition to the gaged flow records for the two gages, we also have access to predicted daily flows from two INTB model runs at the two gages, the modeled impacted run (which is reflective of ambient conditions during the period 1989-2000) and the modeled baseline (which is reflective of ambient conditions, but without any groundwater pumping). By examining the output from the two model runs, it is possible to get a better understanding of the impact of groundwater pumping on flows at the two gages. Lastly, the daily pumpage for the wellfields in the study area were provided for the period of record of the INTB model runs (1989-2000).

2.1 Gaged Flows

Daily gaged flow records were obtained and analyzed for the following gages as per the scope of work:

- Pithlachascotee River near New Port Richey, FL (02310300) and
- Brooker Creek near Tarpon Springs, FL (02307359).

2.1.1 Pithlachascotee Gaged Flows

The Pithlachascotee River near New Port Richey, FL (02310300) gage is on the Pithlachsctoee River, east of New Port Richey, FL (Latitude 28°15'19", Longitude 82°39'37"). The drainage area of the gage is approximately 182 mi^2 (USGS website). Flow measurements began on April 1, 1963 and have continued to present. The gage location was changed on May 27, 1981. The current location is 1.1 miles upstream of the original gage location.

To better understand how flows have changed over the period of record, a plot of flow duration curves by decade in presented in Figure 2-1. Additionally, summary statistics by decade are presented in Table 2-1. As can be clearly seen in Figure 2-1 and Table 2-1, the flows at the Pithlachascotee River near New Port Richey, FL (02310300) gage have declined substantially since the 1960’s. As discussed above, the gage location changed in 1981, therefore these flow duration curves are not directly comparable as the drainage area changed. However, declines were documented before the gage was moved (1960’s to 1970’s) and after the gage was moved (1990’s to 2000’s). Though low flows have been present during the entire period of record, zero flow days appeared in the 1980’s and the number of zero flow days has increased during the 1990’s and 2000’s. Changes in the flow duration curves are noticeable throughout the entire range of the flow duration curves, although the differences are definitely more pronounced at the lower end of the curves (less than the median).

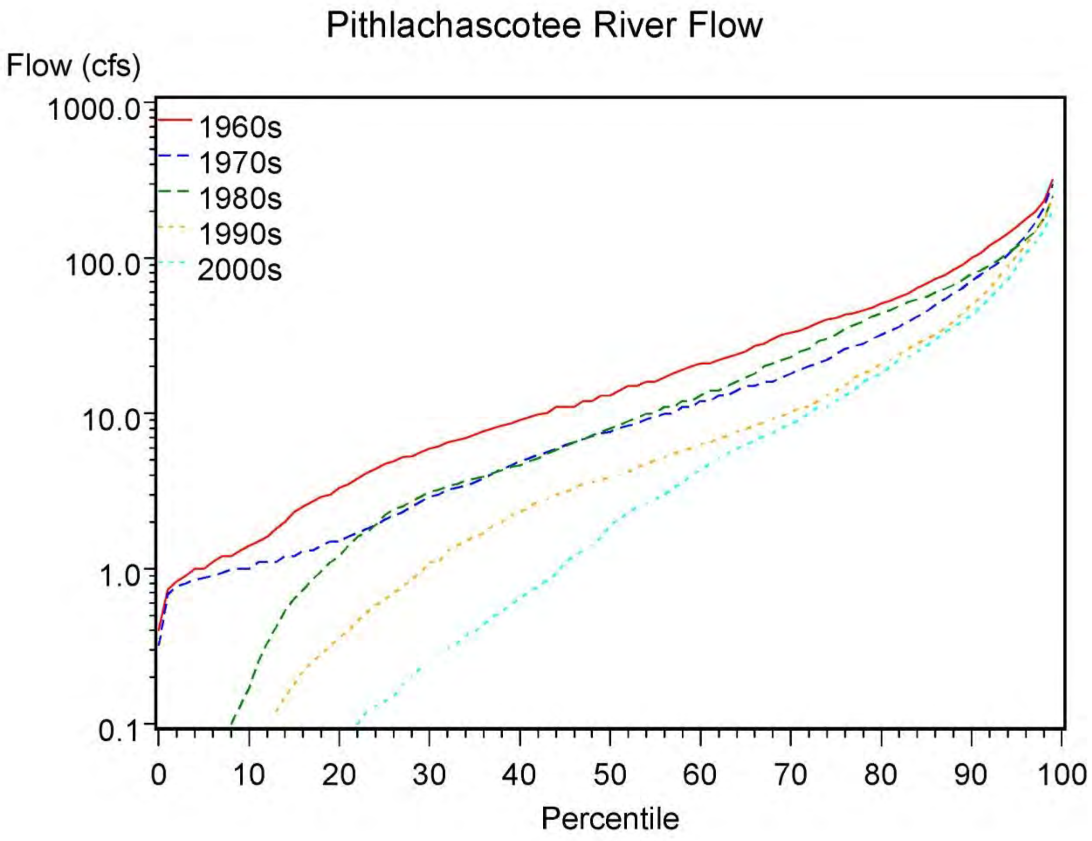


Figure 2-1. Pithlachascotee River flow duration curves by decade.

Table 2-1. Pithlachascotee River Flow statistics by decade

		Statistic (cfs)							
Period	**n**	**mean**	**1 %**	**10 %**	**25 %**	**50 %**	**75 %**	**90 %**	**99 %**
1960s	**2467**	**37.7**	**0.7**	**1.4**	**4.7**	**13**	**41**	**100**	**319**
1970s	**3652**	**27.1**	**0.7**	**1.0**	**2.1**	**7.6**	**24**	**71**	**299**
1980s	**3653**	**29.4**	**0.0**	**0.2**	**2.2**	**8.0**	**32**	**79**	**249**
1990s	**3652**	**20.2**	**0.0**	**0.1**	**0.6**	**3.9**	**14**	**50**	**245**
2000s	**3653**	**16.7**	**0.0**	**0.0**	**0.1**	**1.9**	**12**	**43**	**203**

2.1.2 Brooker Creek Gaged Flows

The Brooker Creek near Tarpon Springs, FL gage (02307359) is located on Brooker Creek, east of Lake Tarpon (Latitude 28°05'45", Longitude 82°41'15"). The drainage area of the gage is approximately 30 mi^2 (USGS website). Flow measurements began on September 1, 1950 and have continued to the present.

To better understand how flows have changed over the period of record, a plot of flow duration curves by decade in presented in Figure 2-2. Additionally, summary statistics by decade are presented in Table 2-2. As can be clearly seen in Figure 2-1 and Table 2-1, the flows at the Brooker Creek near Lake Tarpon, FL (02307359) gage have declined substantially since the 1950's. Unlike the Pithlachascotee River gage which has shown a consistent downward trend in the flow duration curves over time, the Brooker Creek flow duration curves do not show a consistent trend. Flows were clearly highest in the 1950's and are substantially lower in the recent decades (1990's and 2000's). However, flows below the median were lowest in the 1970's. Overall, the median flows have been reduced by almost an order of magnitude between the 1950's and the 2000's (9.9 cfs in the 1950's to 1.2 cfs in the 2000's).

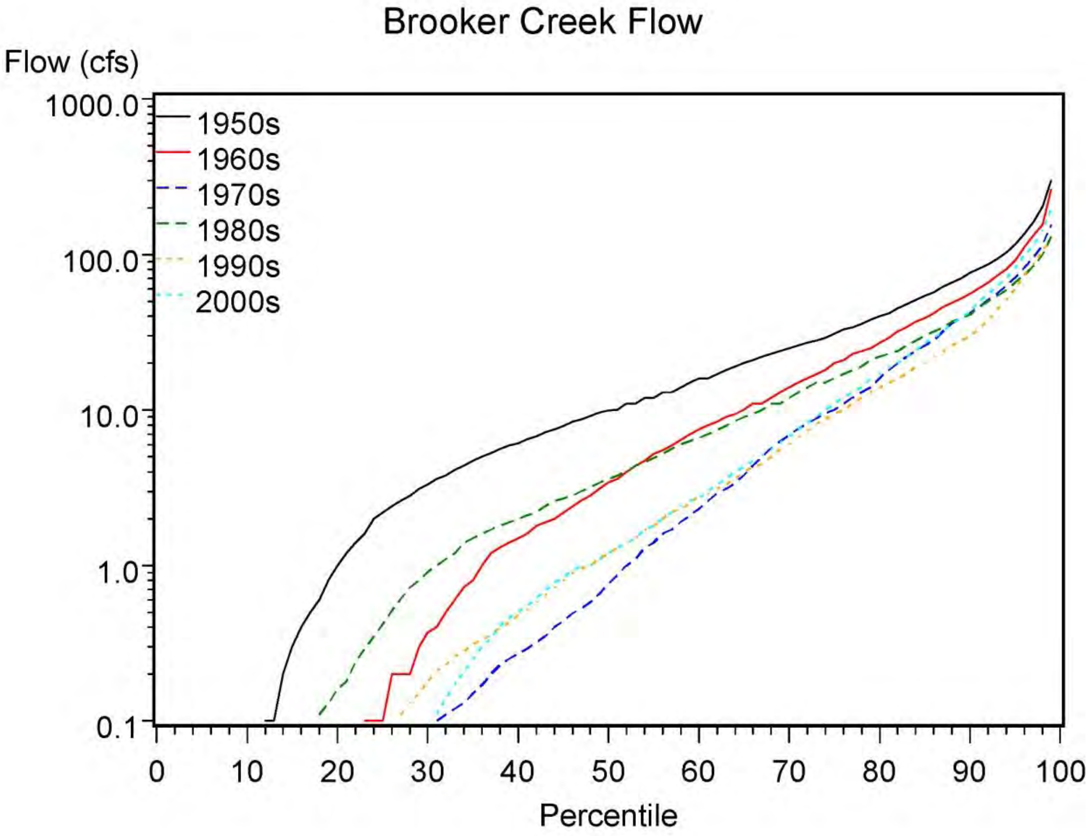


Figure 2-2. Brooker Creek flow duration curves by decade.

Table 2-2. Brooker Creek Flow statistics by decade

		Statistic (cfs)							
Period	**n**	**mean**	**1 %**	**10 %**	**25 %**	**50 %**	**75 %**	**90 %**	**99 %**
1950s	**3287**	**29.7**	**0.0**	**0.0**	**2.2**	**9.9**	**31**	**76**	**300**
1960s	**3653**	**22.9**	**0.0**	**0.0**	**0.1**	**3.4**	**20**	**56**	**262**
1970s	**3652**	**14.2**	**0.0**	**0.0**	**0.1**	**0.8**	**10**	**42**	**155**
1980s	**3653**	**15.5**	**0.0**	**0.0**	**0.4**	**3.6**	**16**	**41**	**132**
1990s	**3652**	**11.7**	**0.0**	**0.0**	**0.1**	**1.2**	**9.5**	**30**	**128**
2000s	**3653**	**15.7**	**0.0**	**0.0**	**0.0**	**1.2**	**11**	**43**	**197**

2.2 Modeled Flows

In addition to the gaged flow records described above, output from the INTB model at the location of the Pithlachascotee River near New Port Richey, FL gage (02310300) and the Brooker Creek near Tarpon Springs, FL gage (02307359) was provided by the District. The model was run from 1989 through 2000 for two scenarios and the output is comprised of daily flows at the two locations. The Modeled Impacted scenario reflects the ambient conditions and is therefore comparable to the actual gaged flows. The Modeled Baseline scenario reflects the ambient conditions, but with the groundwater pumpage added back (i.e., groundwater pumpage set to zero).

2.2.1 Pithlachascotee River Modeled Flows

Flow duration curves for the two INTB model scenarios are presented in Figure 2-3, along with summary statistics in Table 2-3. As anticipated, the Impacted Scenario is most similar to the flow duration curve of the 1990’s (Figure 2-1 and Table 2-1), indicating that the INTB model does a good job of representing the observed flows. The flow duration curve of the Baseline Scenario is most similar those of the 1970’s and 1980’s (Figure 2-1 and Table 2-1). Based on the mean flows, as calculated from the predicted flows for the two scenarios, the flows from the Impacted Scenario are approximately 31% less than the flows from the Baseline Scenario. Also of note is the fact that there has been an approximately three-fold increase in the number of extreme low flow (≤ 0.1 cfs) days between the Baseline Scenario (7% of the time) and the Impacted Scenario (21% of the time).

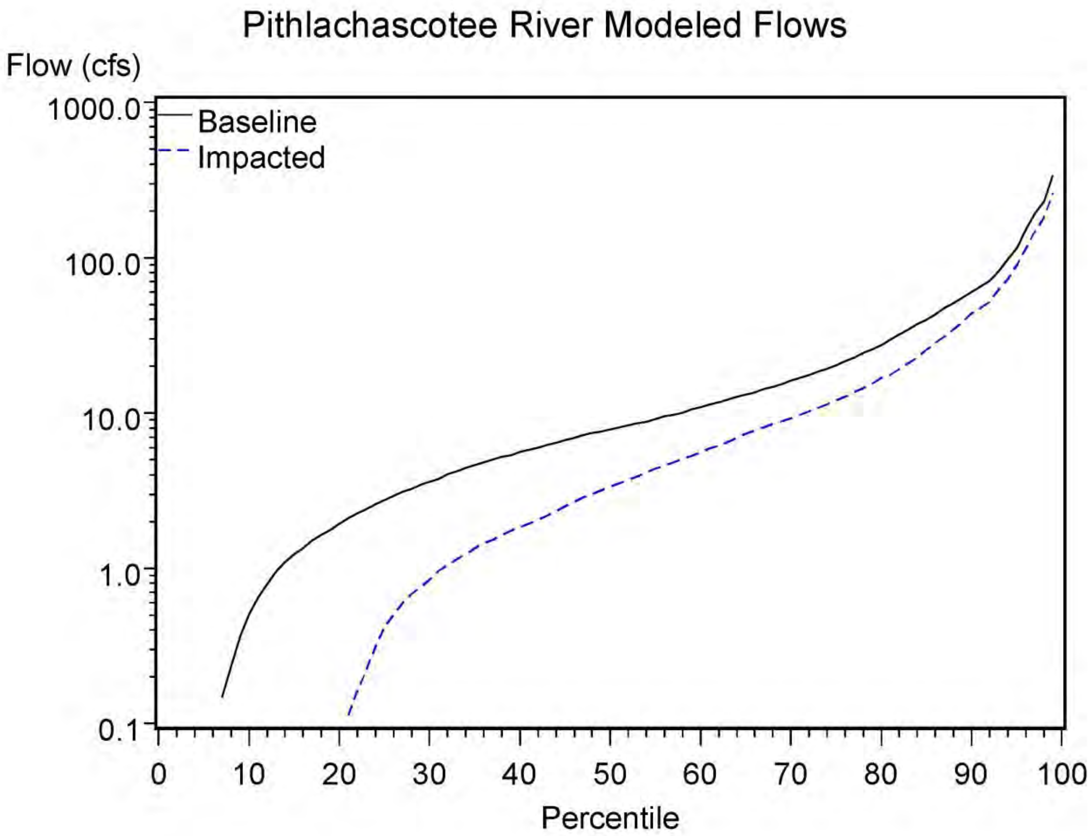


Figure 2-3. Pithlachascotee River modeled flow duration curves.

Table 2-3. Pithlachascotee River Flow statistics from INTB model scenarios

		Statistic (cfs)							
Scenario	**n**	**mean**	**1 %**	**10 %**	**25 %**	**50 %**	**75 %**	**90 %**	**99 %**
Impacted	4363	18.7	0.0	0.0	0.4	3.4	12.0	43.7	259.5
Baseline	4363	27.0	0.0	0.5	2.7	7.8	20.2	60.1	336.1

2.2.2 Comparison of Pithlachascotee River Gaged and Modeled Flows

A plot of the daily gaged flow versus the INTB model Impacted Scenario is presented in Figure 2-4. Because the majority of the flows are less than 100 cfs, the plot was replotted for 0-100 cfs (Figure 2-5). As can be seen from these plots, the points form a cloud around the one-to-one line, indicating that the model is a reasonable representation of the observed flows.

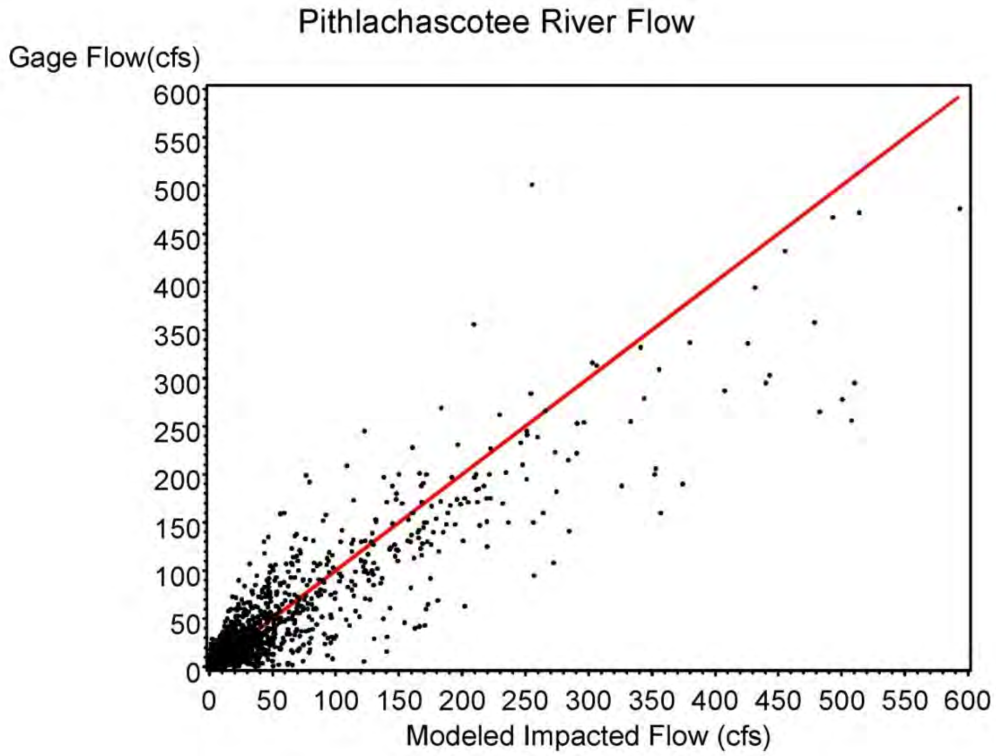


Figure 2-4. Pithlachascotee River flow versus INTB Model Impacted flow.

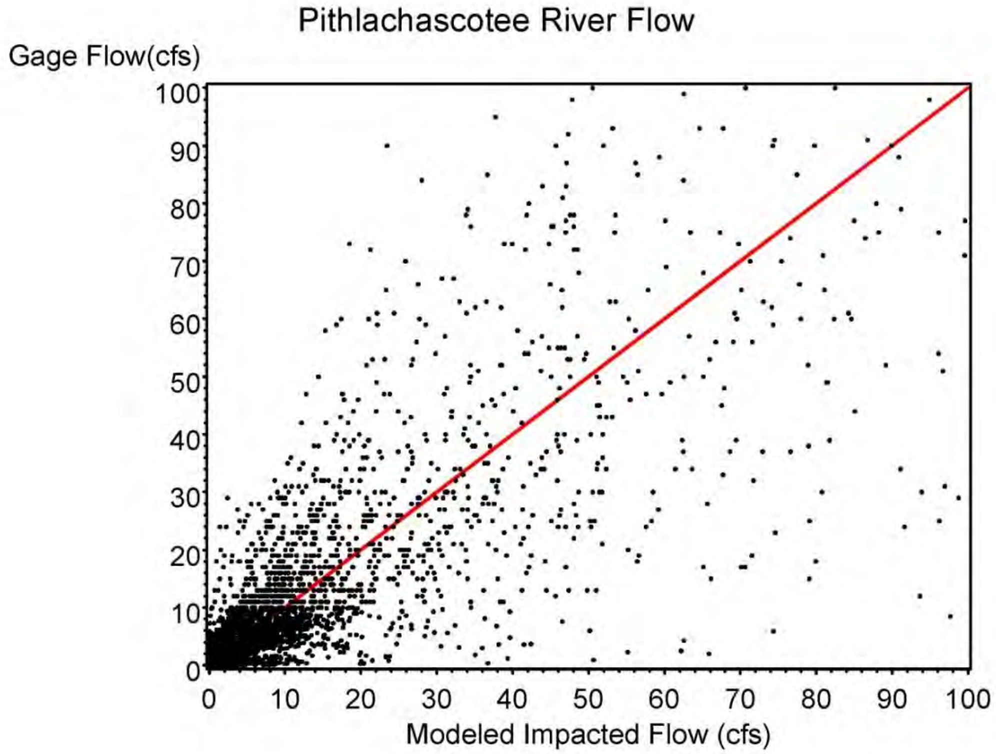


Figure 2-5. Pithlachascotee River flow versus INTB Model Impacted flow (0-100 cfs).

2.2.3 Brooker Creek Modeled Flows

Flow duration curves for the two scenarios are presented in Figure 2-6, along with summary statistics in Table 2-4. As anticipated, the Impacted Scenario is most similar to the flow duration curve of the 1990's (Figure 2-2 and Table 2-2), indicating that the INTB model is a reasonable representation of the observed flows. Based on the mean flows, as calculated from the predicted flows for the two scenarios, the flows from the Impacted Scenario are approximately 52% less than the flows from the Baseline Scenario. Also of note is the fact that there has been an approximately four-fold increase in the number of extreme low flow (≤ 0.1 cfs) days between the Baseline Scenario (9% of the time) and the Impacted Scenario (38% of the time).

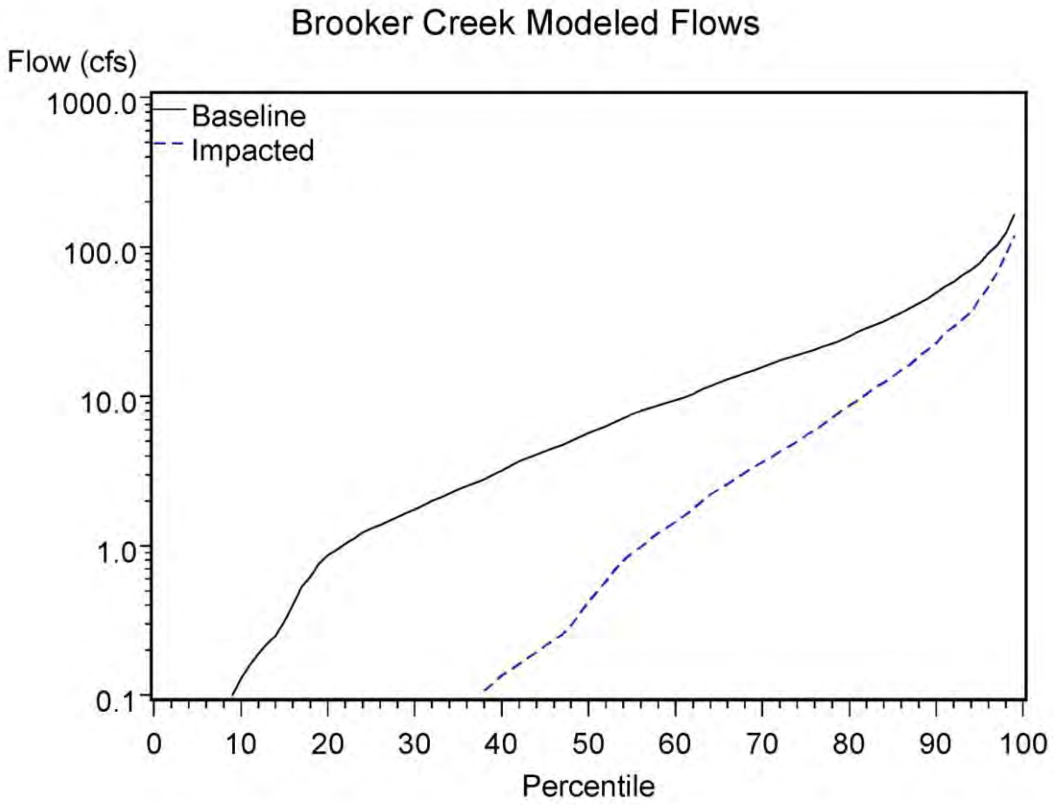


Figure 2-6. Brooker Creek modeled flow duration curves.

Table 2-4. Brooker Creek Flow statistics from INTB model scenarios

		Statistic (cfs)							
Scenario	**n**	**mean**	**1 %**	**10 %**	**25 %**	**50 %**	**75 %**	**90 %**	**99 %**
Impacted	**4363**	**8.8**	**0.0**	**0.0**	**0.0**	**0.4**	**5.5**	**22.7**	**119.0**
Baseline	**4363**	**18.5**	**0.0**	**0.1**	**1.3**	**5.7**	**19.7**	**49.4**	**163.5**

2.2.4 Comparison of Brooker Creek Gaged and Modeled Flows

A plot of the daily gaged flow versus the INTB model Impacted Scenario is presented in Figure 2-7. Because the majority of the flows are less than 100 cfs, the plot was replotted for 0-100 cfs (Figure 2-8). There are a few points where the gaged flows is greater than 100 cfs and the modeled flows are less than 10 cfs, more than an order of magnitude difference, but this represents six data points out of more than 4,000. In general, the points form a cloud around the one-to-one line, indicating that the model is a reasonable representation of the observed flows.

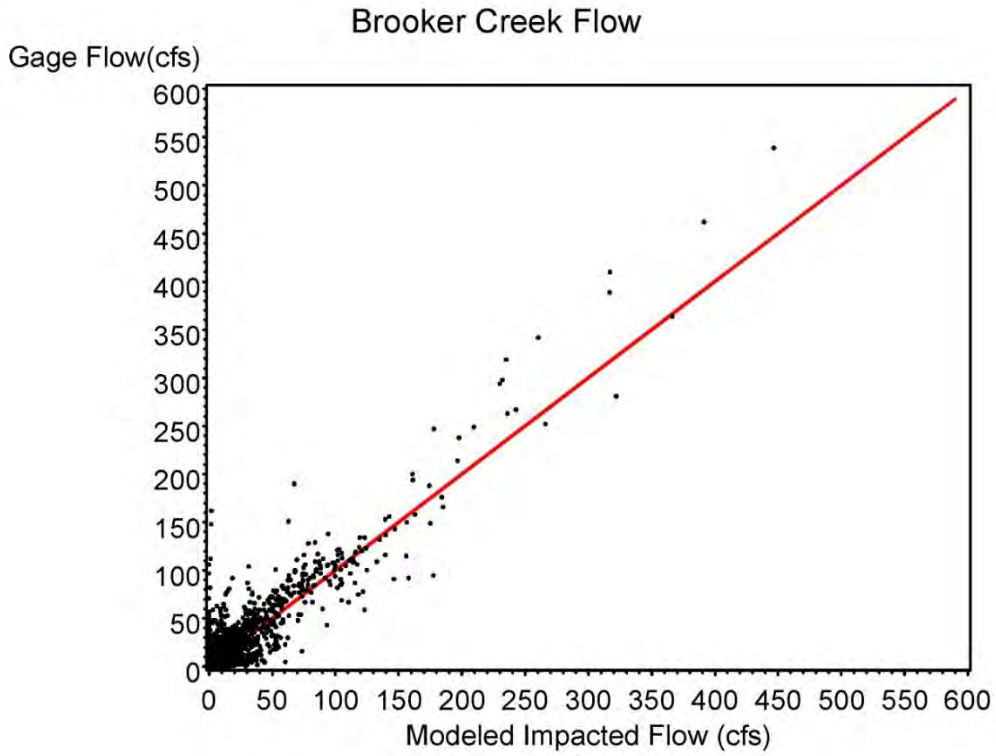


Figure 2-7. Brooker Creek flow versus INTB Model Impacted flow.

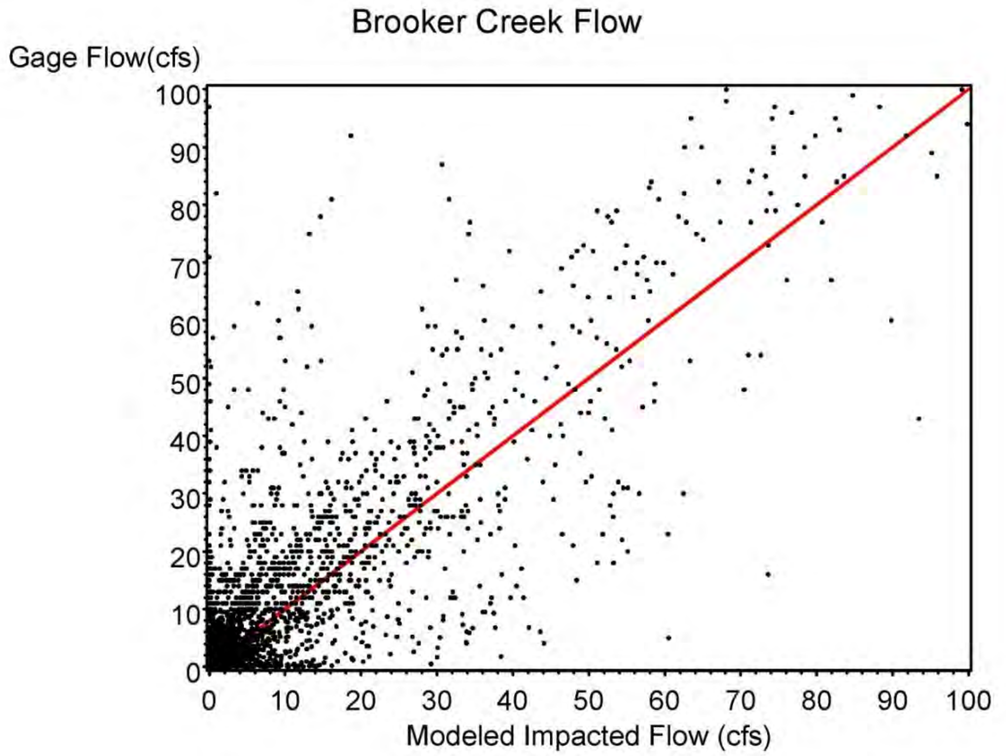


Figure 2-8. Brooker Creek flow versus INTB Model Impacted flow (0-100 cfs).

2.3 Wellfield Pumpage Data

Daily wellfield pumpage data was provided by district staff for the following wellfields:

- Starkey-North Pasco
- Cross Bar–Cypress Creek
- Eldridge–Wilde
- South Pasco
- Section 21
- Cosme-Odessa

In addition to the wellfield pumpage data, the results of six separate model runs were provided. These model runs were made by District staff in order to quantify the influence that the different wellfields have on the system. For each run, a single wellfield was turned off and the results were compared to the Impacted Scenario to determine the change in flow at the gage locations as a result of the wellfield not being active. The results of these model runs are discussed in the sections that follow.

2.3.1 Response to Pumpage - Pithlachascotee River Gage

As mentioned above, a series of model runs were made where a single wellfield was turned off. The results of these model runs were then compared to the Impacted Scenario to quantify the change in flow that can be attributed to the pumping from the wellfield. An analysis of the results of these scenarios is presented in Table 2-5 for the Pithlachascotee gage. The second column (Average Pumpage) is the average pumpage at the wellfield for the duration of the model run (1989-2000). The third column (Mean Flow Impact (cfs)) is the average change in flow seen at the gage as a result of that particular wellfield being turned off. The last column (Mean Flow Impact (cfs/mgd)) is the average change in flow for every one mgd of pumpage from the particular wellfield. While the average pumpage was highest at the Cross Bar-Cypress Creek wellfield, on average the mean flow impact per mgd of pumpage was highest at the Starkey-North Pasco wellfield. There was a negligible impact seen at the Eldridge-Wilde and South Pasco wellfields and no detectable impact from the Section 21 and Cosme-Odessa wellfields.

Table 2-5. Pithlachascotee River Response to Well Pumpage

Wellfield	Average Pumpage (mgd)	Mean Flow Impact (cfs)	Mean Flow Impact (cfs/mgd)
Starkey-North Pasco	14.36	4.4	0.31
Cross Bar-Cypress Creek	57.49	2.5	0.04
Eldridge-Wilde	27.59	0.2	0.01
South Pasco	15.53	0.2	0.01
Section 21	10.81	0.0	0
Cosme-Odessa	10.66	0.0	0

2.3.2 Response to Pumpage – Brooker Creek Gage

The results of the pumpage being shut off for various wellfields on the flow at the Brooker Creek gage are presented in Table 2-6. While the average pumpage was highest at the Cross Bar-Cypress Creek wellfield, there was no detectable influence from this wellfield on Brooker Creek flows on average. There was little impact per mgd of pumpage from the Starkey-North Pasco, South Pasco, and Section 21 wellfields. The Eldridge-Wilde and Cosme-Odessa wellfields had equivalent impacts per mgd of pumpage, 0.18 and 0.16 cfs/mgd, respectively.

Table 2-6. Brooker Creek Response to Well Pumpage			
Wellfield	**Average Pumpage (mgd)**	**Mean Flow Impact (cfs)**	**Mean Flow Impact (cfs/mgd)**
Starkey-North Pasco	**14.36**	**0.07**	**0.01**
Cross Bar-Cypress Creek	**57.49**	**0**	**0**
Eldridge-Wilde	**27.59**	**5.07**	**0.18**
South Pasco	**15.53**	**0.52**	**0.03**
Section 21	**10.81**	**0.33**	**0.03**
Cosme-Odessa	**10.66**	**1.76**	**0.16**

3 Regression Development

Linear regression is a parametric statistical technique that is used to explore the relationship between two or more variables. In ordinary least-squares regression, the relationship between the dependent variable (y-axis) and independent variable (x-axis) is developed. This is done by fitting a straight line through the set of points such that the sum of squared residuals of the model is as small as possible. That is to say, the vertical distances between the individual points and the fitted line are minimized.

In linear regression, it is assumed that the data are independent samples from the population that is being sampled. For example, the data should come from samples that are representative of the spatial and temporal variability of the system. Another important assumption of linear regression is that the error term of the model is normally distributed, with constant variance. Often times, one or more of the variables exhibits a non-linear relationship with the other variables. While there are non-linear regression techniques that can be employed, one should attempt to transform the data before resorting to nonlinear methods. Often, linear relationships can be developed using transformed data and these models will satisfy the assumptions of linear regression. For this effort, the right-skewed nature of flow data is well documented in the scientific literature, therefore flows and pumpage data were log transformed in an effort to normalize the data.

Diagnostic statistics and plots are commonly used to determine if the regression model meets the assumptions of linear regression. The most commonly used statistics are the statistical significance of the model parameters and the coefficient of determination (R^2). The statistical significance of the model parameters tests whether the slope and intercept of the model are significantly different from zero. The coefficient of determination is a measure of the variance in the dependent variable that is explained by the model. A plot of the residuals versus the independent variable can be used to judge if the assumption of constant variance is met. Additional plots of residuals versus other variables can also be instructive. For example, a time-series plot of the residuals can be used to assess whether or not the residuals vary seasonally. Additional diagnostics can be run to identify outliers and test for leverage or influential points. Data points that are identified by these additional diagnostics should be further investigated to determine if they are the result of a data entry error or other problems that merit removing them from the analysis.

Statistical relationships were developed between the dependent variable (baseline flow) and independent variables (impacted flows and groundwater pumpage). As discussed above, groundwater pumpage is expected to have a lag effect on flow in the rivers (i.e. water pumped from a wellfield today will result in decreased flows in the river at some point in the future). Therefore, a series of lag-average pumpages were calculated for the individual wellfields, including 7-day, 14-day, 30-day, 60-day, 90-day, 120-day, 150-day, and 180-day moving averages. These variables were included as potential explanatory variables.

The general form of the regressions was:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$$

where y = ln (baseline flow at the gage)
x_1 = ln (impacted flow at the gage)
x_2 = ln (lag average pumpage)
$\beta_0, \beta1_1, \beta_2$ = regression coefficents
ε = error term.

3.1 Pithlachascotee River

A regression model between INTB baseline flows and INTB impacted flows and 150-day average pumpage from the Starkey-North Pasco wellfield was developed. Although preliminary analysis showed a potential relationship with pumpage from the Cross Bar-Cypress Creek wellfield, this term was not significant and therefore was not included in the final regression. The residuals from this model were examined to identify any potential issues of other explanatory variables that might contribute to the overall variance accounted for by the model. The residual analysis revealed that a large number of low flow days in the INTB impacted flow scenario was negatively impacting the fit of the regression. Analysis revealed that this corresponded to a baseline flow of approximately 1.6 cfs. Therefore, it was decided to substitute the INTB baseline scenario for predictions that were made on days when the baseline flow was less than 1.6 cfs and to use the regression model to predict flows when the baseline was greater than 1.6 cfs. The residual analysis also revealed a curvature that is indicative of quadratic behavior. Therefore, a quadratic term was added to the regression equation. The final regression equation is:

0.84*(lnQpump150)

$$\ln(Q_{base}) = -1.15 + 0.48 \ln Q_{imp} + 0.06 \left(\ln Q_{imp}\right)^2 + 0.84\, Q_{pump150}$$

where Q_{base} = INTB modeled baseline flow at the gage
Q_{imp} = INTB modeled impacted flow at the gage
$Q_{pump150}$ = 150-day average pumpage from the Starkey-North Pasco wellfield

The model was fit with over 3,000 observations and resulted in an R^2 value of 0.97. The regression was highly significant with a probability of a greater |F| value of < 0.0001. The slope and parameter coefficients were all highly significant. A plot of regression predicted versus INTB modeled baseline flows is presented in Figure 3-1 and Figure 3-2 (0-100 cfs only). Residual plots for the Pithlachascotee River regression model are presented in Appendix 1.

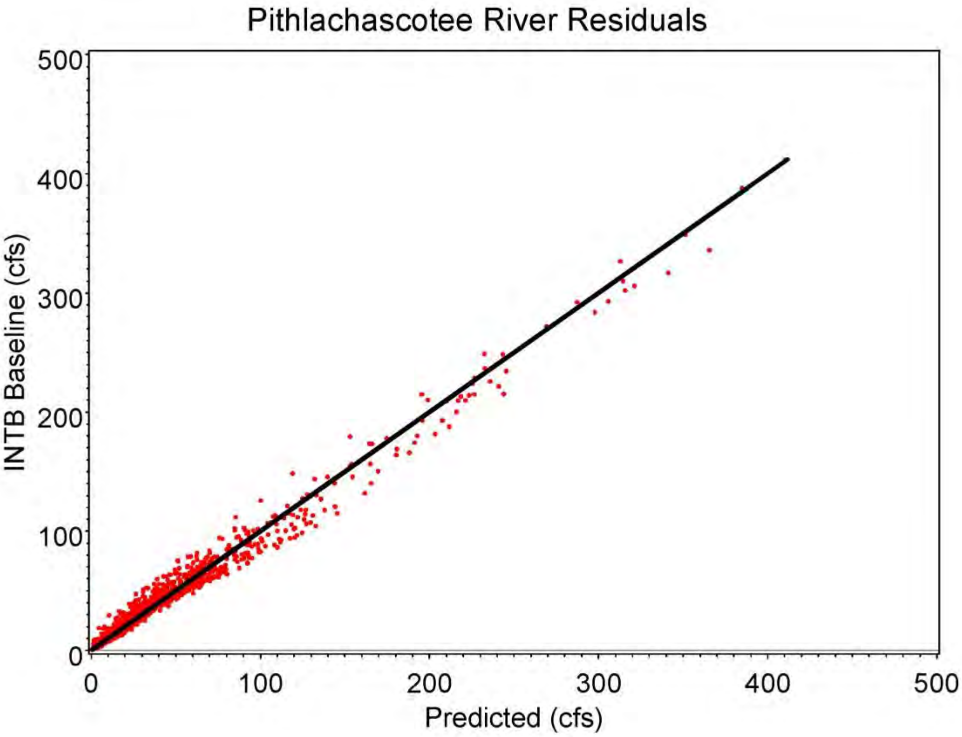


Figure 3-1. Pithlachascotee River regression predictions versus INTB Baseline flows.

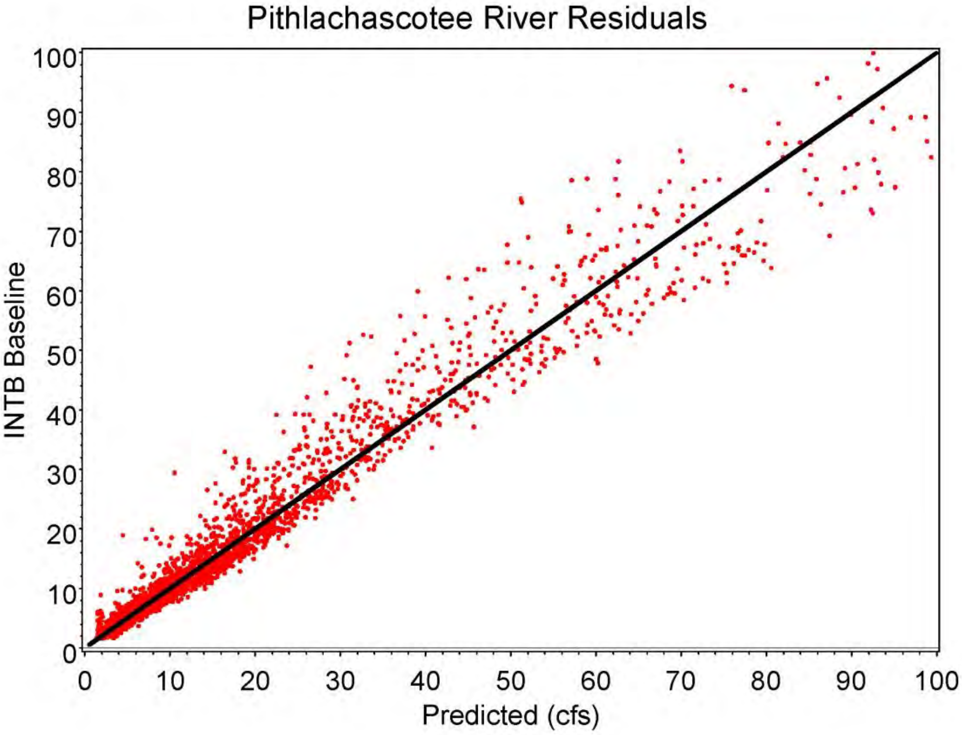


Figure 3-2. Pithlachascotee River regression predictions versus INTB Baseline flows (0- 100 cfs).

3.2 Brooker Creek

A regression model between INTB baseline flows and INTB impacted flows and 150-day average pumpage from the Eldridge-Wilde and Cosme-Odessa wellfields was developed. The residuals from this model were examined to identify any potential issues of other explanatory variables that might contribute to the overall variance accounted for by the model. The residual analysis revealed that a large number of low flow days in the INTB impacted flow scenario was negatively impacting the fit of the regression. Analysis revealed that this corresponded to a baseline flow of approximately 3.0 cfs. Therefore, it was decided to substitute the INTB baseline scenario for predictions that were made on days when the baseline flow was less than 3.0 cfs and to use the regression model to predict flows when the baseline was greater than 3.0 cfs. The residual analysis also revealed a curvature that is indicative of quadratic behavior. Therefore, a quadratic term was added to the regression equation. The final regression equation is:

1.42*(lnQpump150)

$$\ln(Q_{base}) = -3.74 + 0.48 \ln Q_{imp} + 0.04 \left(\ln Q_{imp}\right)^2 + 1.42\, Q_{pump150}$$

where Q_{base} = INTB modeled baseline flow at the gage
Q_{imp} = INTB modeled impacted flow at the gage
$Q_{pump150}$ = 150-day average pumpage from the Eldridge-Wilde and Cosme-Odessa wellfields

The model was fit with over 3,000 observations and resulted in an R^2 value of 0.90. The regression was highly significant with a probability of a greater |F| value of < 0.0001. The slope and parameter coefficients were all highly significant. A plot of regression predicted versus INTB modeled baseline flows is presented in Figure 3-3 and Figure 3-4 (0-100 cfs only). Residual plots for the Brooker Creek regression model are presented in Appendix 2.

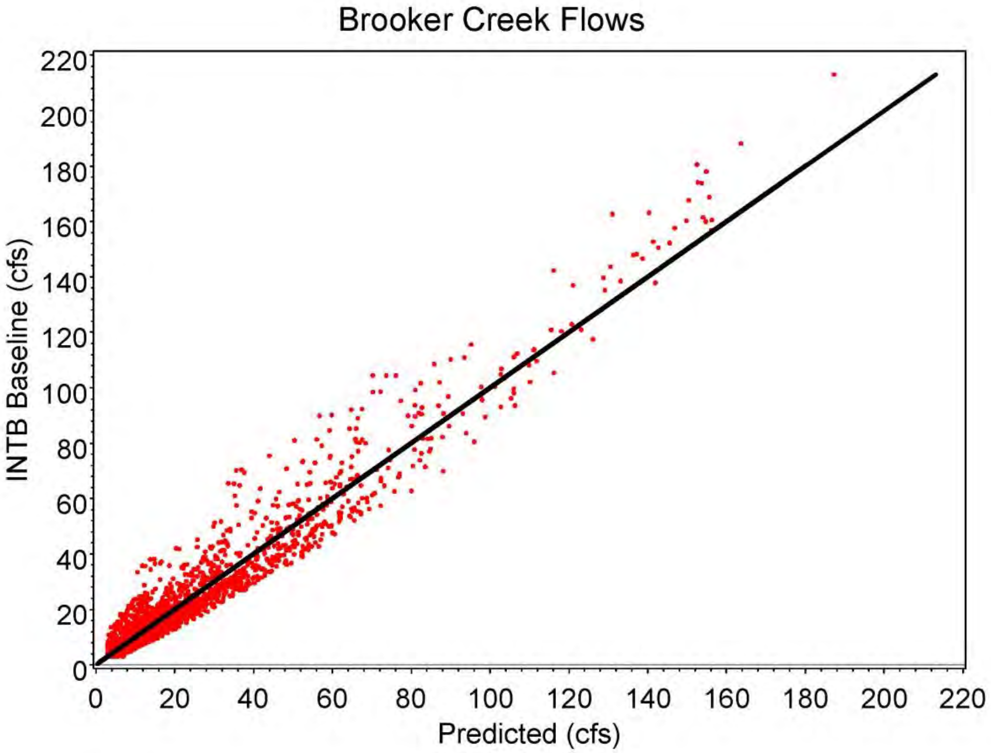


Figure 3-3. Brooker Creek regression predictions versus INTB Baseline flows.

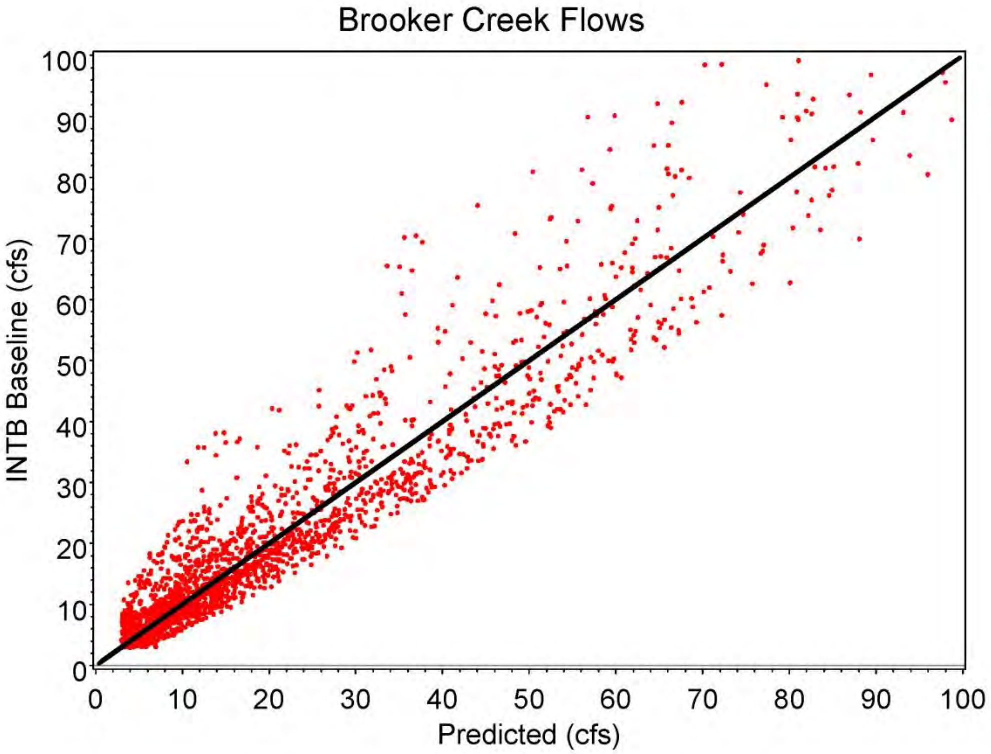


Figure 3-4. Brooker Creek regression predictions versus INTB Baseline flows (0- 100 cfs).

4 Results and Conclusions

The objective of this work order was to develop baseline flow records to be used in MFL development for the Pithlachascotee River and Brooker Creek. Therefore, the regressions developed were applied to the actual gaged flows in order to estimate the baseline flows for the systems prior to groundwater pumpage.

4.1 Results

4.1.1 Baseline Flows – Pithlachascotee River

Substituting the gaged flows into the regression, baseline flows were estimated for the period June 19, 1989 to December 31, 2000. In order to determine if the predicted baseline flows are a reasonable representation of the period 1989-2000 without pumpage, the predicted flows were compare to the INTB Baseline Scenario by using flow duration curves (Figure 4-1) and summary statistics (Table 4-1). Based on the flow duration curves and the statistics, the baseline predicted using the regressions is a reasonable representation of the INTB Baseline Scenario.

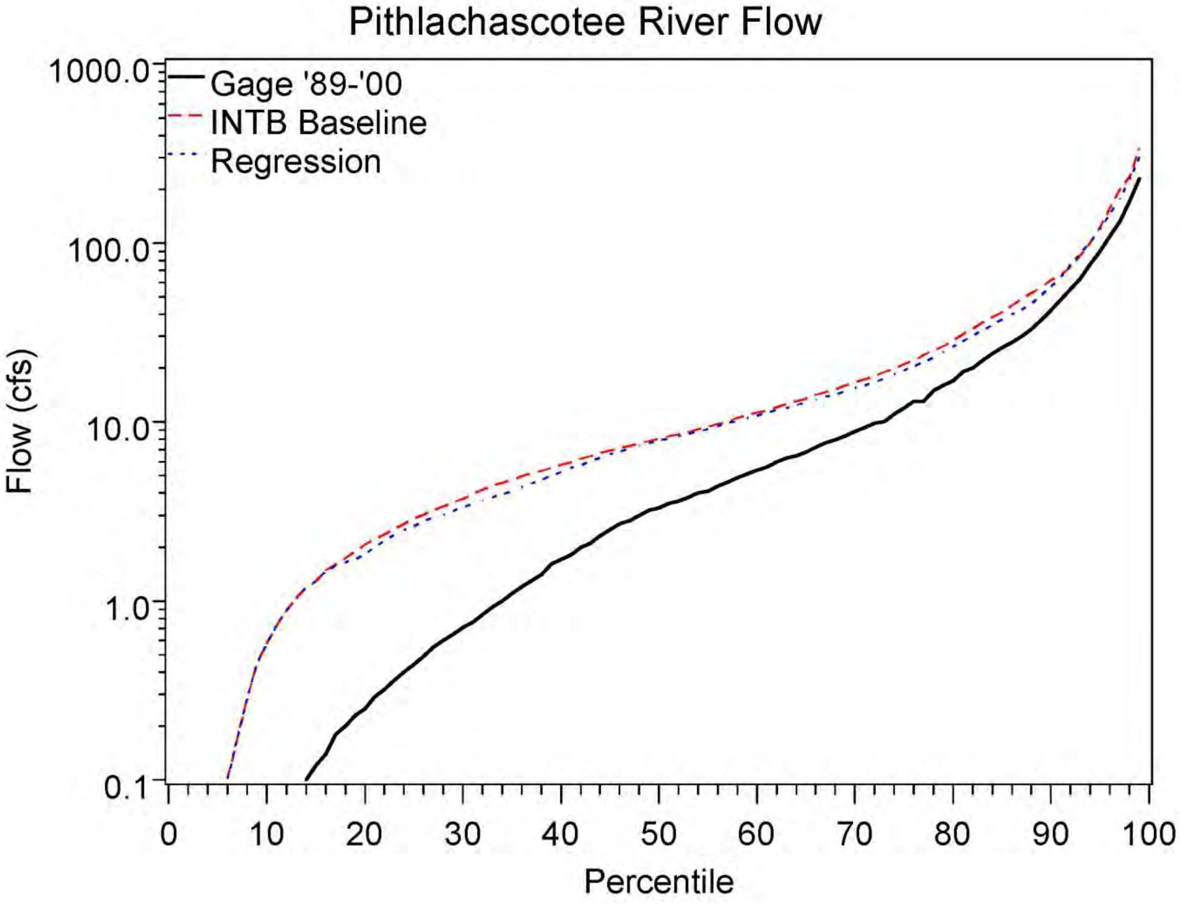


Figure 4-1. Pithlachascotee River flow duration curves for the INTB Baseline Scenario and baseline regression predictions.

Table 4-1. Pithlachascotee River Flow statistics from INTB Baseline Scenario and baseline regression predictions.

	Statistic (cfs)							
Scenario	**mean**	**1 %**	**10 %**	**25 %**	**50 %**	**75 %**	**90 %**	**99 %**
Regression	**26.9**	**0.0**	**0.6**	**2.6**	**7.8**	**19.3**	**57.0**	**302.1**
INTB Baseline	**27.7**	**0.0**	**0.6**	**2.9**	**8.0**	**21.1**	**61.8**	**337.5**

4.1.2 Baseline Flows – Brooker Creek

Substituting the gaged flows into the regression, baseline flows were estimated for the period June 19, 1989 to December 31, 2000. In order to determine if the predicted baseline flows are a reasonable representation of the period 1989-2000 without pumpage, the predicted flows were compare to the INTB Baseline Scenario by using flow duration curves (Figure 4-2) and summary statistics (Table 4-2). Based on the flow duration curves and the statistics, the baseline predicted using the regressions is a reasonable representation of the INTB Baseline Scenario.

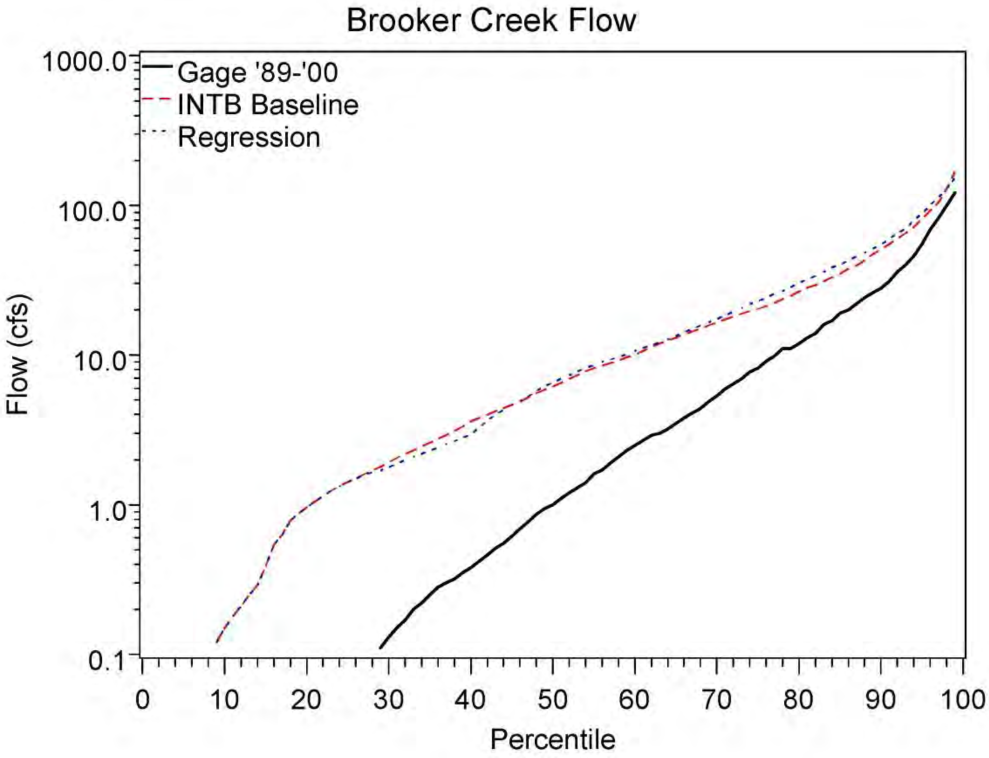


Figure 4-2. Brooker Creek flow duration curves for the INTB Baseline Scenario and baseline regression predictions.

Table 4-2. Brooker Creek Flow statistics from INTB Baseline Scenario and baseline regression predictions.

	Statistic (cfs)							
Scenario	**mean**	**1 %**	**10 %**	**25 %**	**50 %**	**75 %**	**90 %**	**99 %**
Regression	**20.1**	**0.0**	**0.2**	**1.4**	**6.5**	**22.9**	**54.4**	**152.7**
INTB Baseline	**19.2**	**0.0**	**0.2**	**1.4**	**6.1**	**20.3**	**51.0**	**167.6**

4.2 Conclusions

It was concluded that the baseline flow scenario from the INTB model should not be used directly as the baseline flow for the MFLs analysis, because the daily flows in the model output vary slightly from the temporal variations of actual daily flows recorded by the USGS. By developing statistically significant relationships between the INTB Baseline and Impacted scenarios, we were able to predict baseline flows using the gaged flows in place of the INTB impacted flows. This allowed us to develop baseline flows that represent the flow conditions as if groundwater pumping did not occur and the mimic the temporal variations of the gaged flows very well.

Appendix 1

Regression Diagnostics

Pithlachascotee River

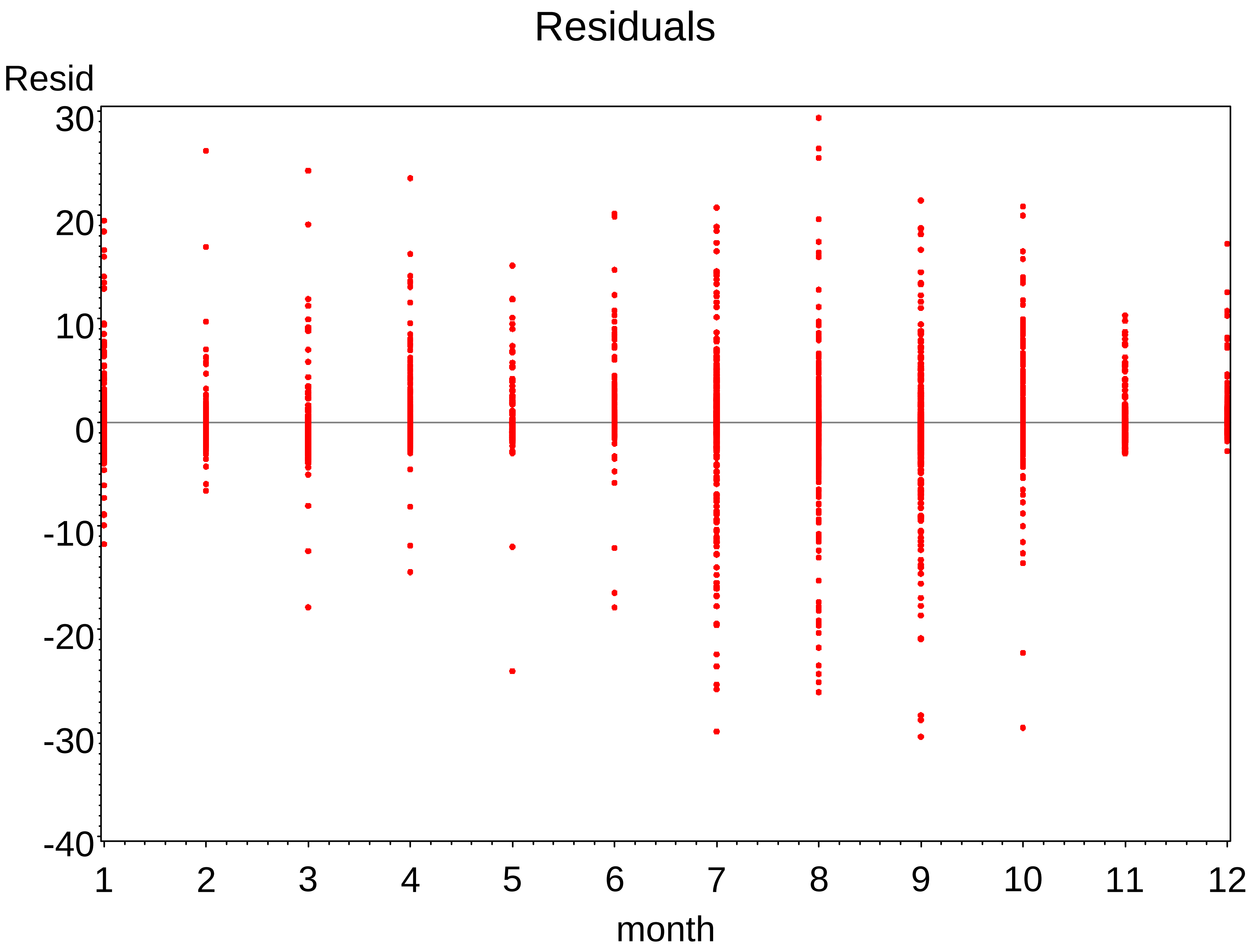
The REG Procedure
Model: MODEL1
Dependent Variable: lnb

Number of Observations Read	3267
Number of Observations Used	3267

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	3	3959.87999	1319.96000	30787.0	<.0001
Error	3263	139.89747	0.04287		
Corrected Total	3266	4099.77746			

Root MSE	0.20706	**R-Square**	0.9659
Dependent Mean	2.36445	**Adj R-Sq**	0.9658
Coeff Var	8.75723		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-1.15061	0.14338	-8.02	<.0001
lni	1	0.48249	0.00207	232.72	<.0001
lni2	1	0.05972	0.00063957	93.38	<.0001
lnp	1	0.83620	0.04711	17.75	<.0001


Residuals
Resid
30
20
10
0
-10
-20
-30
-40
1
2
3
4
5
6
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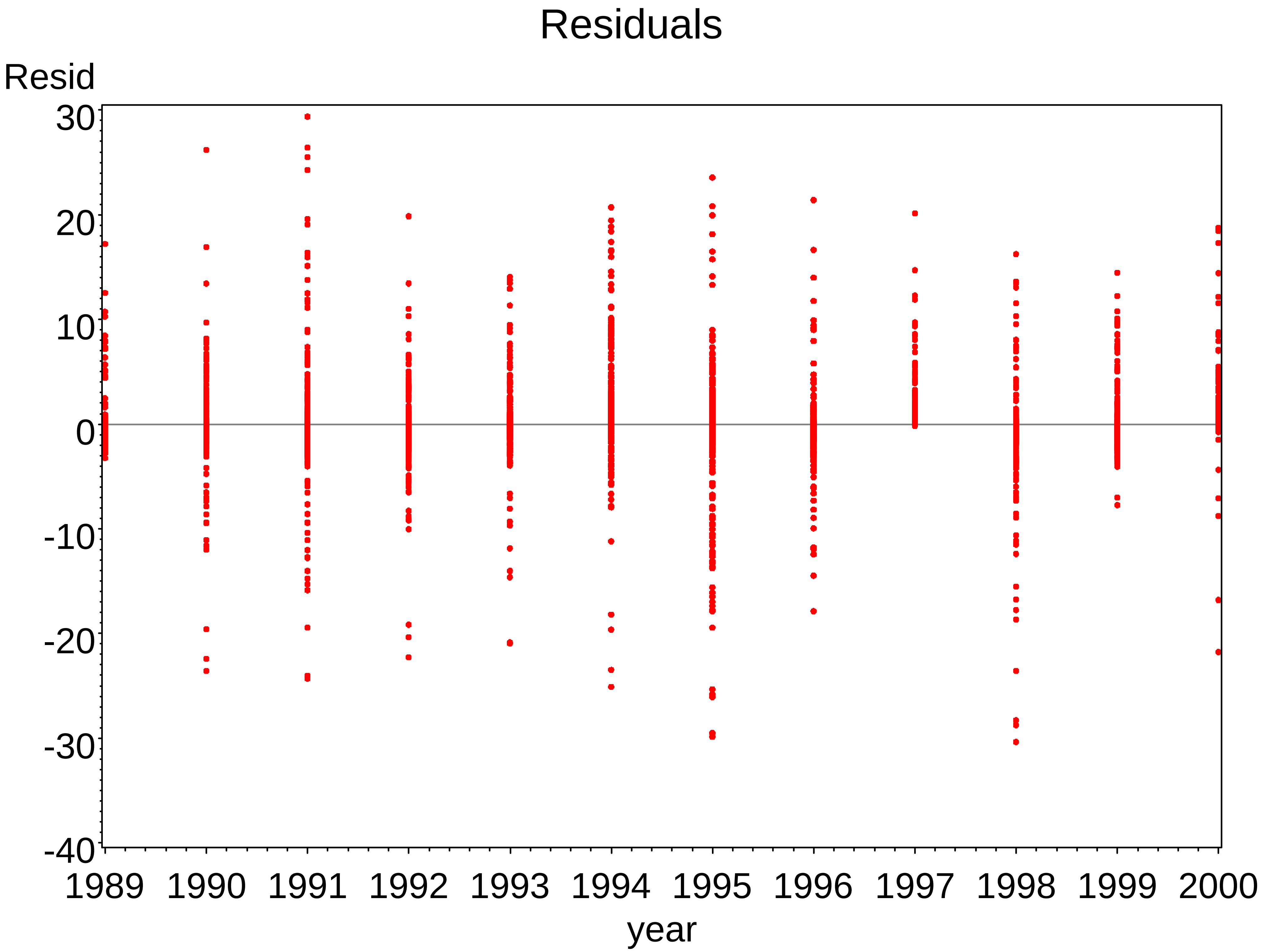
8
9
10
11
12
month


Residuals
Resid
30
20
10
0
-10
-20
-30
-40
1989
1990
1991
1992
1993
1994
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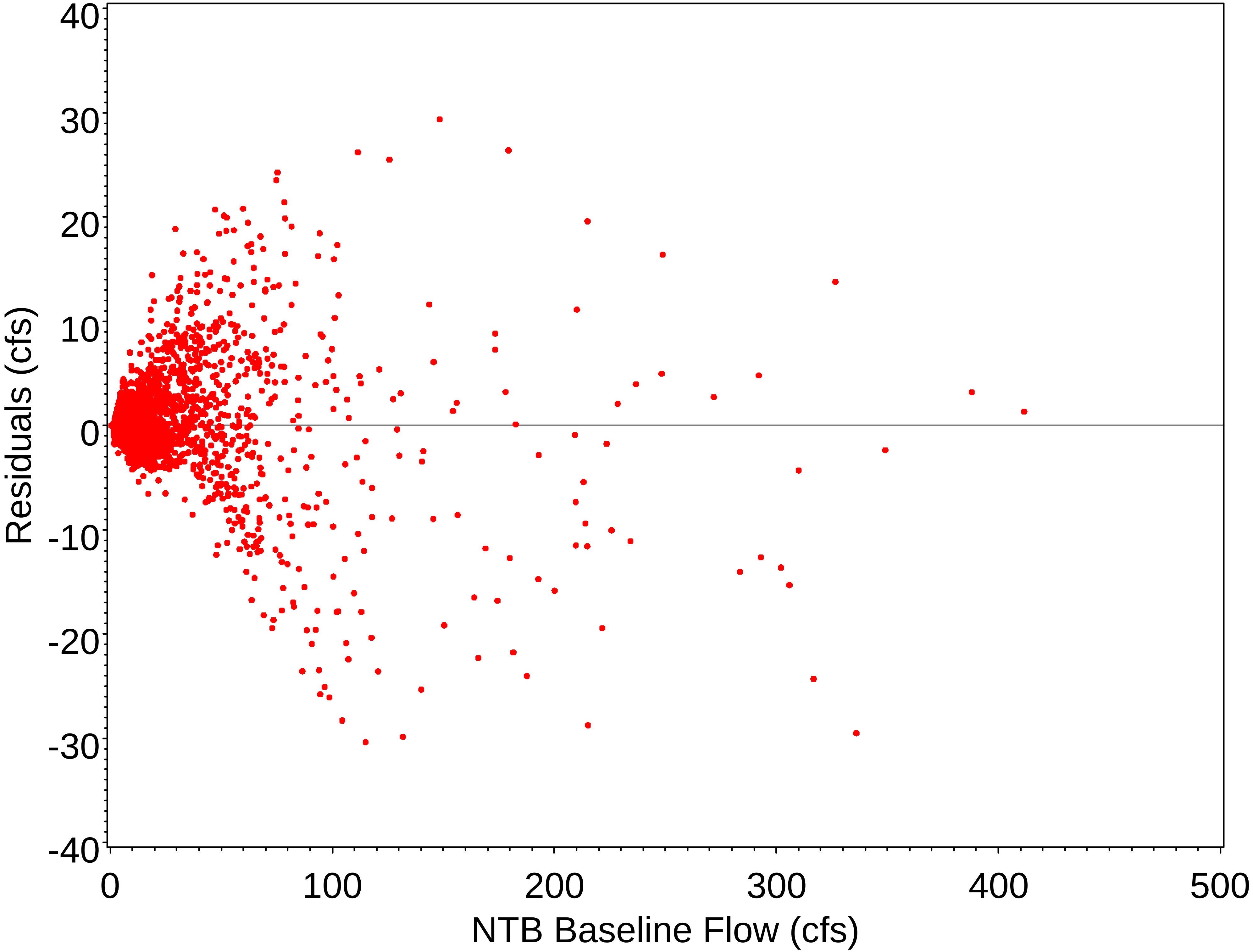
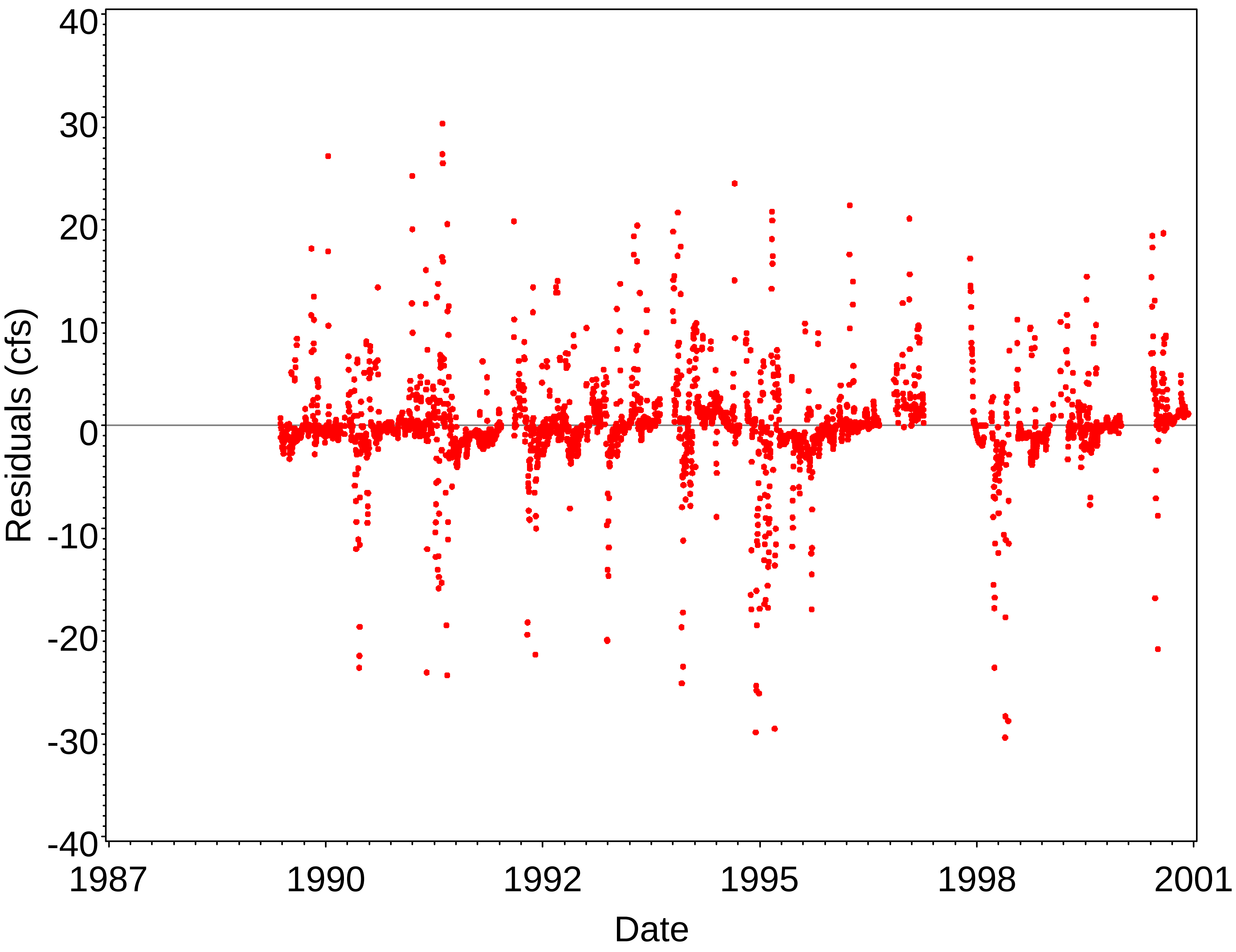
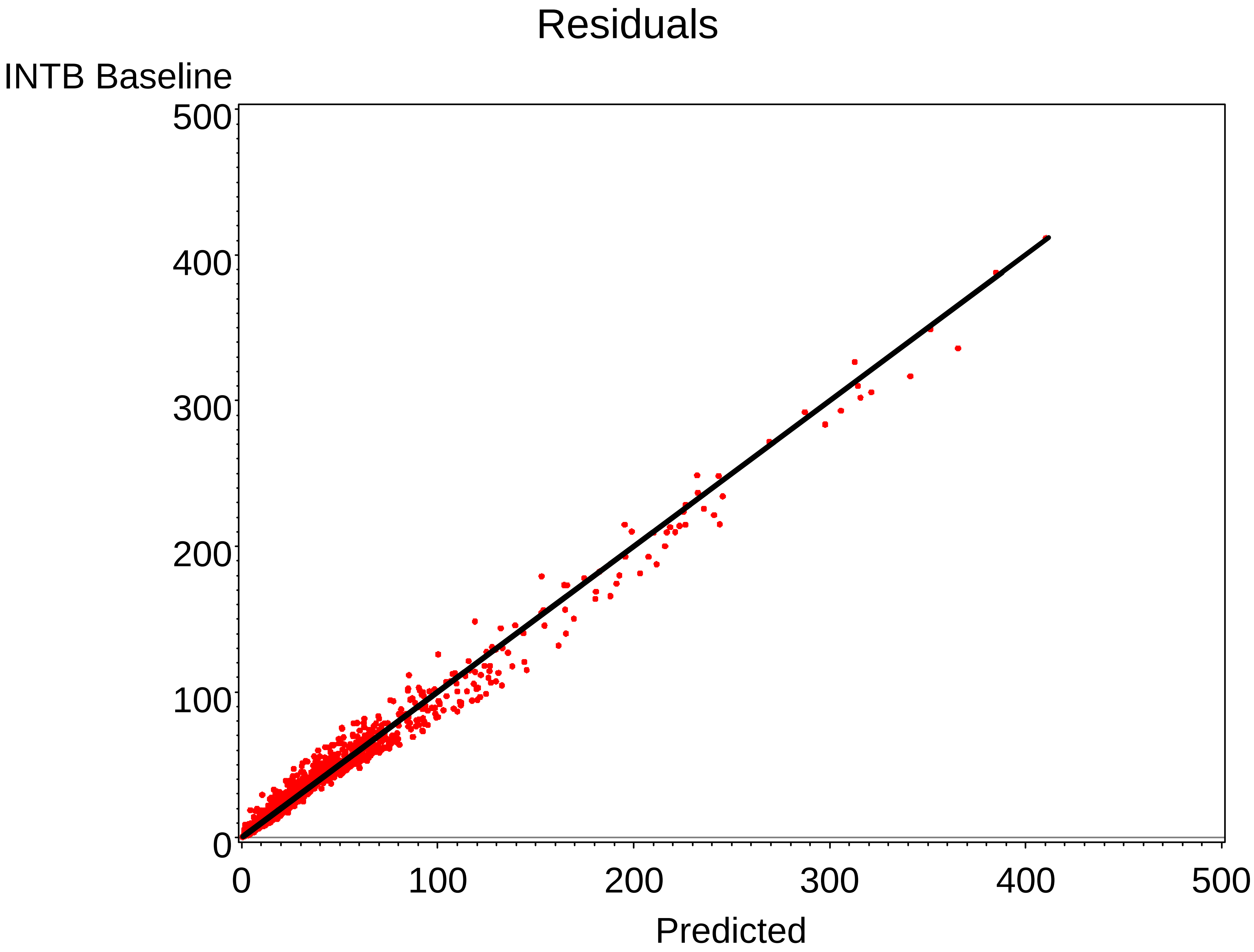
1996
1997
1998
1999
2000
year


40
30
20
10
0
-10
-20
-30
-40
Residuals (cfs)
0
100
200
300
400
500
NTB Baseline Flow (cfs)


40
30
20
10
0
-10
-20
-30
-40
Residuals (cfs)
1987
1990
1992
1995
1998
2001
Date



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300
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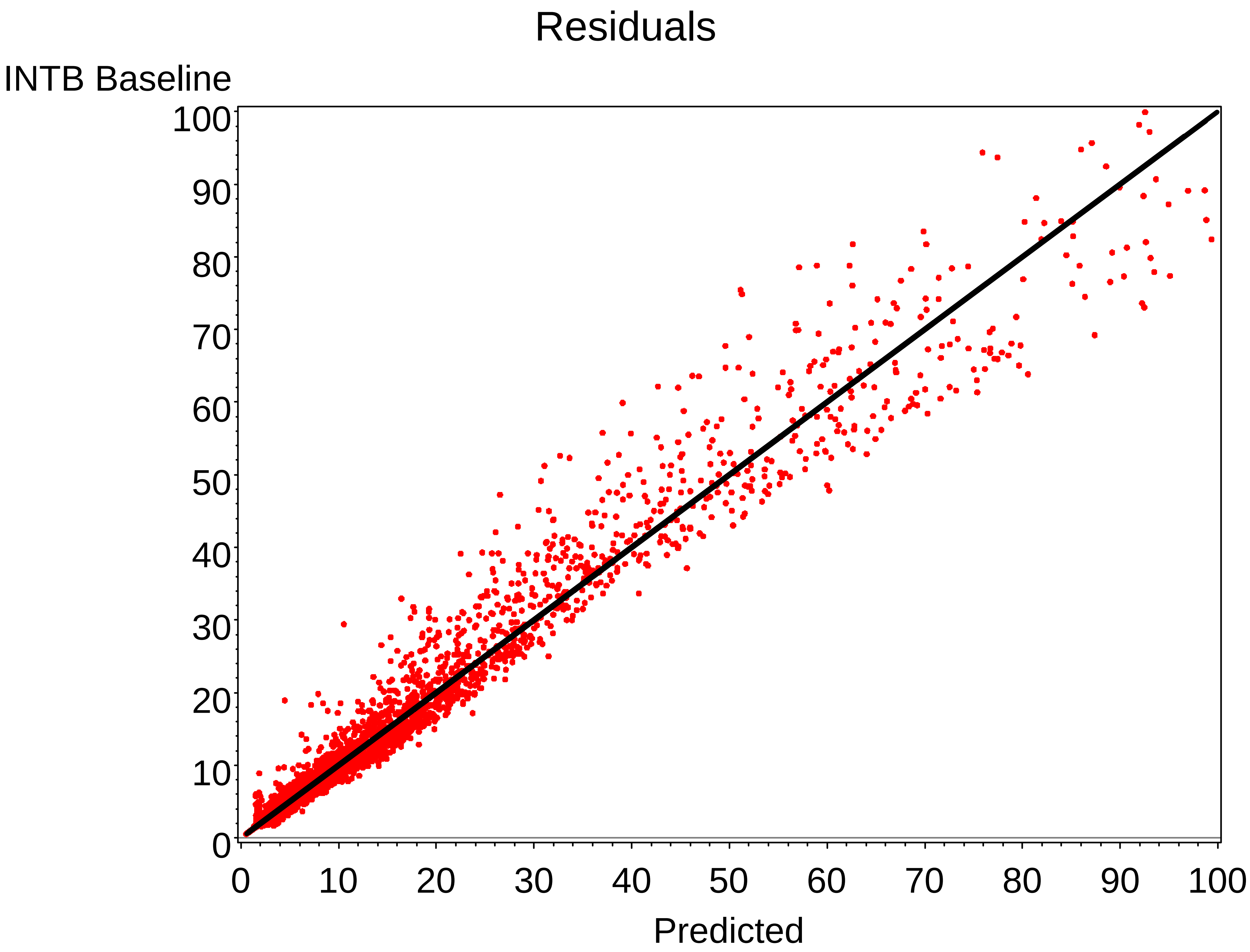
0
100
200
300
400
500
Predicted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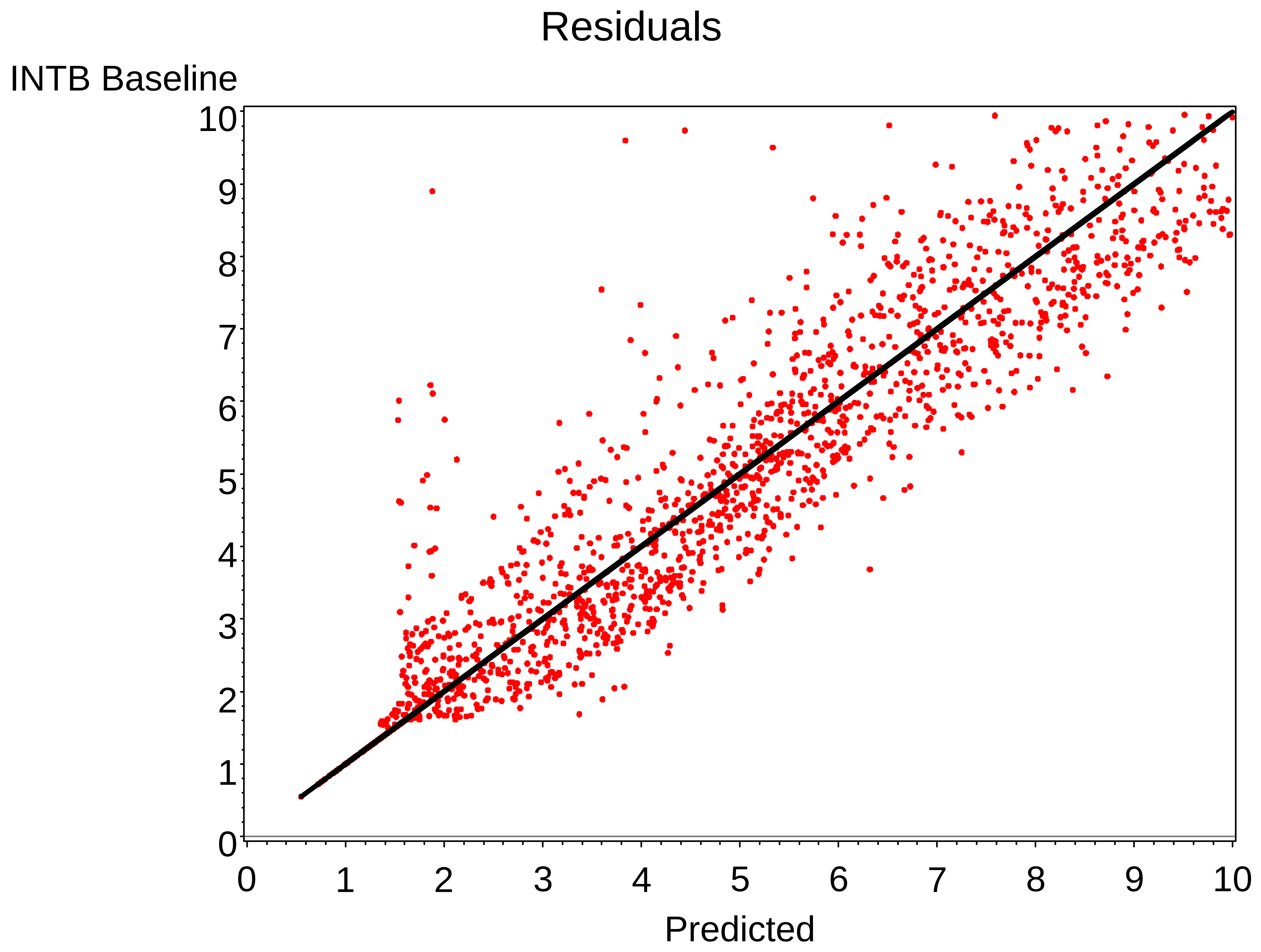
90
100
Predicted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8
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3
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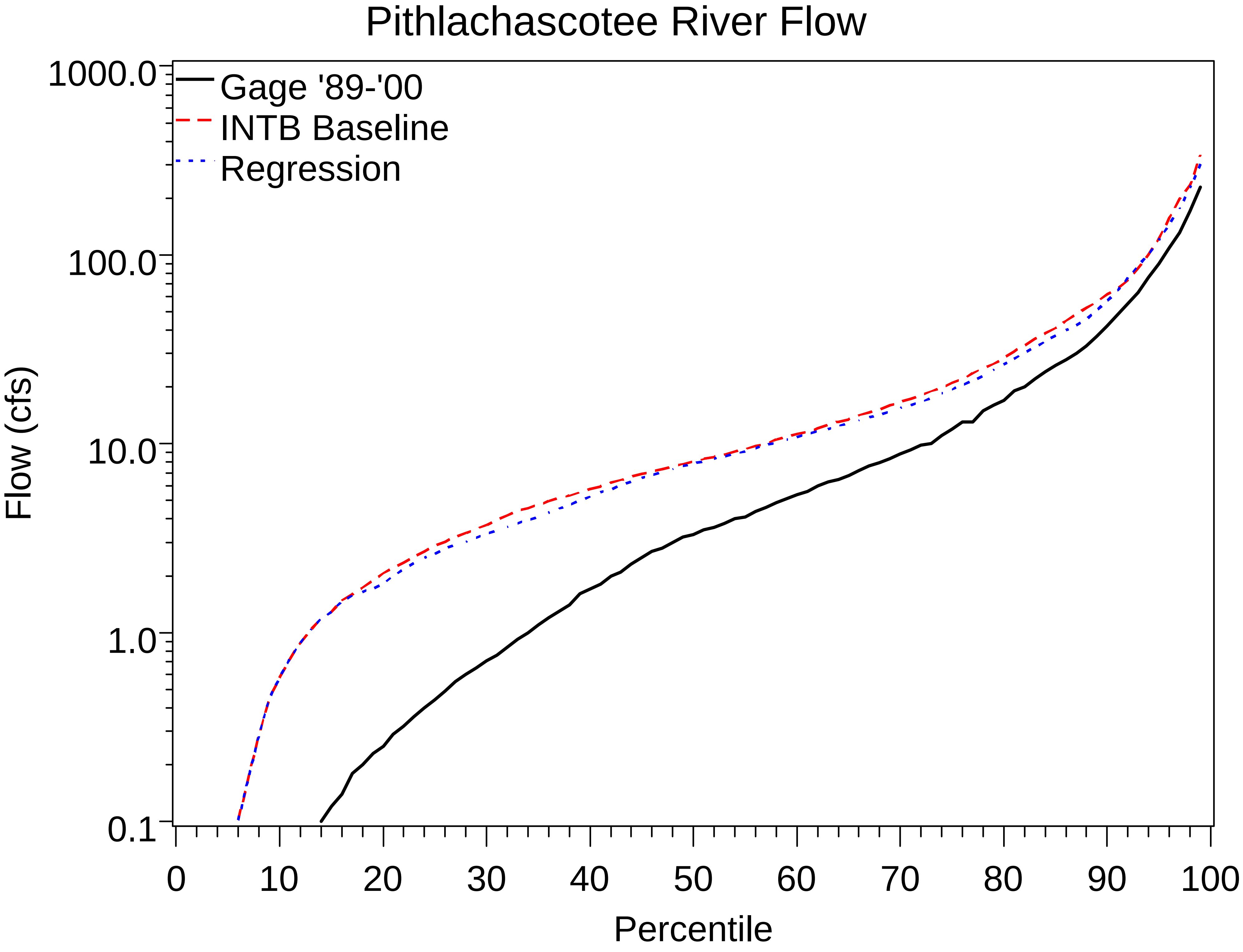
5
6
7
8
9
10
Predicted


Pithlachascotee River Flow
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INTB Baseline
Regression
Flow (cfs)
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100.0
10.0
1.0
0.1
0
10
20
30
40
50
60
70
80
90
100
Percentile

Appendix 2

Regression Diagnostics

Brooker Creek

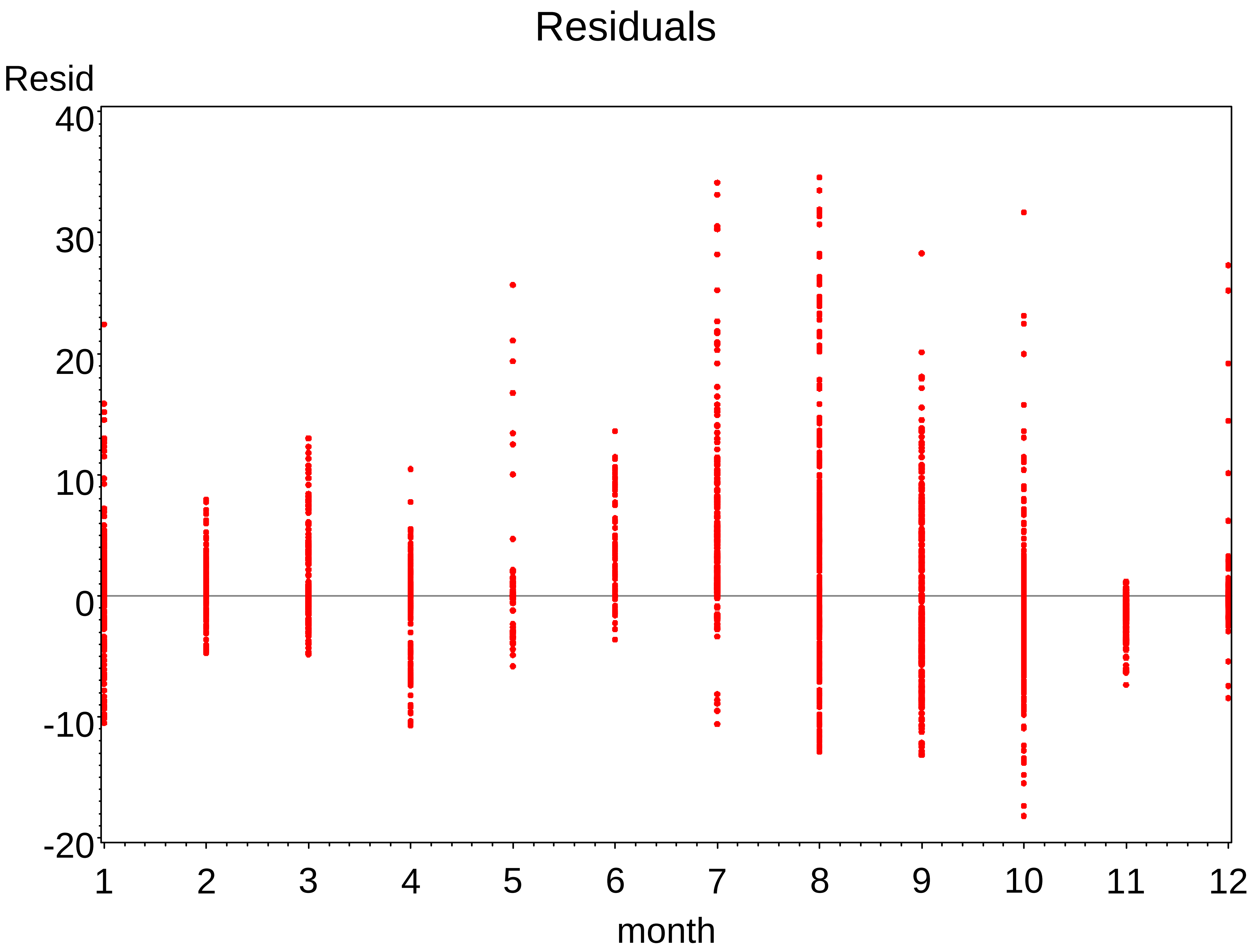
The REG Procedure
Model: MODEL1
Dependent Variable: lnb

Number of Observations Read	2655
Number of Observations Used	2655

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	3	3003.30087	1001.10029	8233.31	<.0001
Error	2651	322.33899	0.12159		
Corrected Total	2654	3325.63986			

Root MSE	0.34870	**R-Square**	0.9031
Dependent Mean	2.37795	**Adj R-Sq**	0.9030
Coeff Var	14.66389		

Parameter Estimates						
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**	**Variance Inflation**
Intercept	1	-3.74816	0.27505	-13.63	<.0001	0
lni	1	0.47552	0.00312	152.33	<.0001	1.00317
lni2	1	0.03635	0.00118	30.89	<.0001	1.00366
lnp	1	1.42515	0.06850	20.81	<.0001	1.00513


Residuals
Resid
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30
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-10
-20
1
2
3
4
5
6
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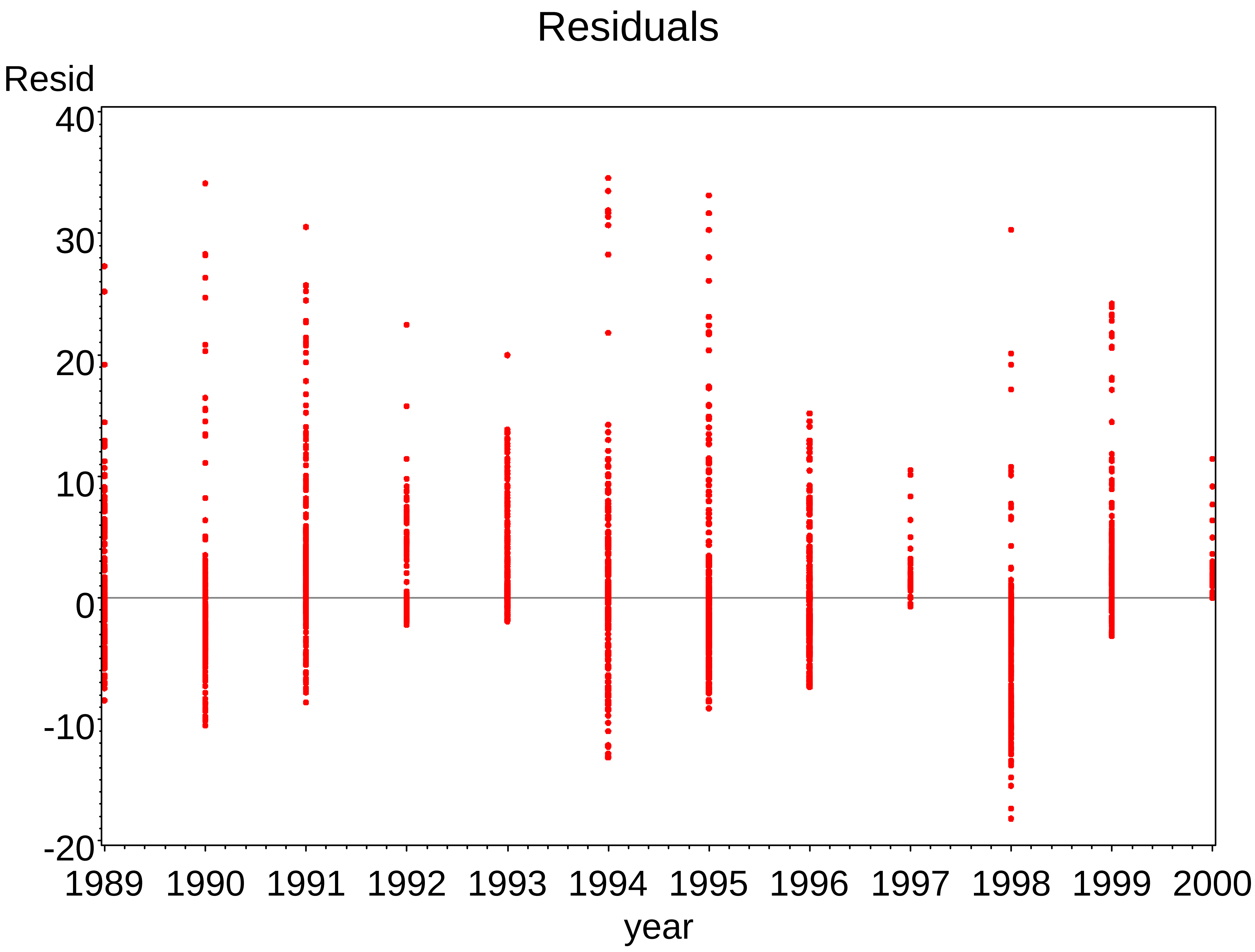
8
9
10
11
12
month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Resid
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1993
1994
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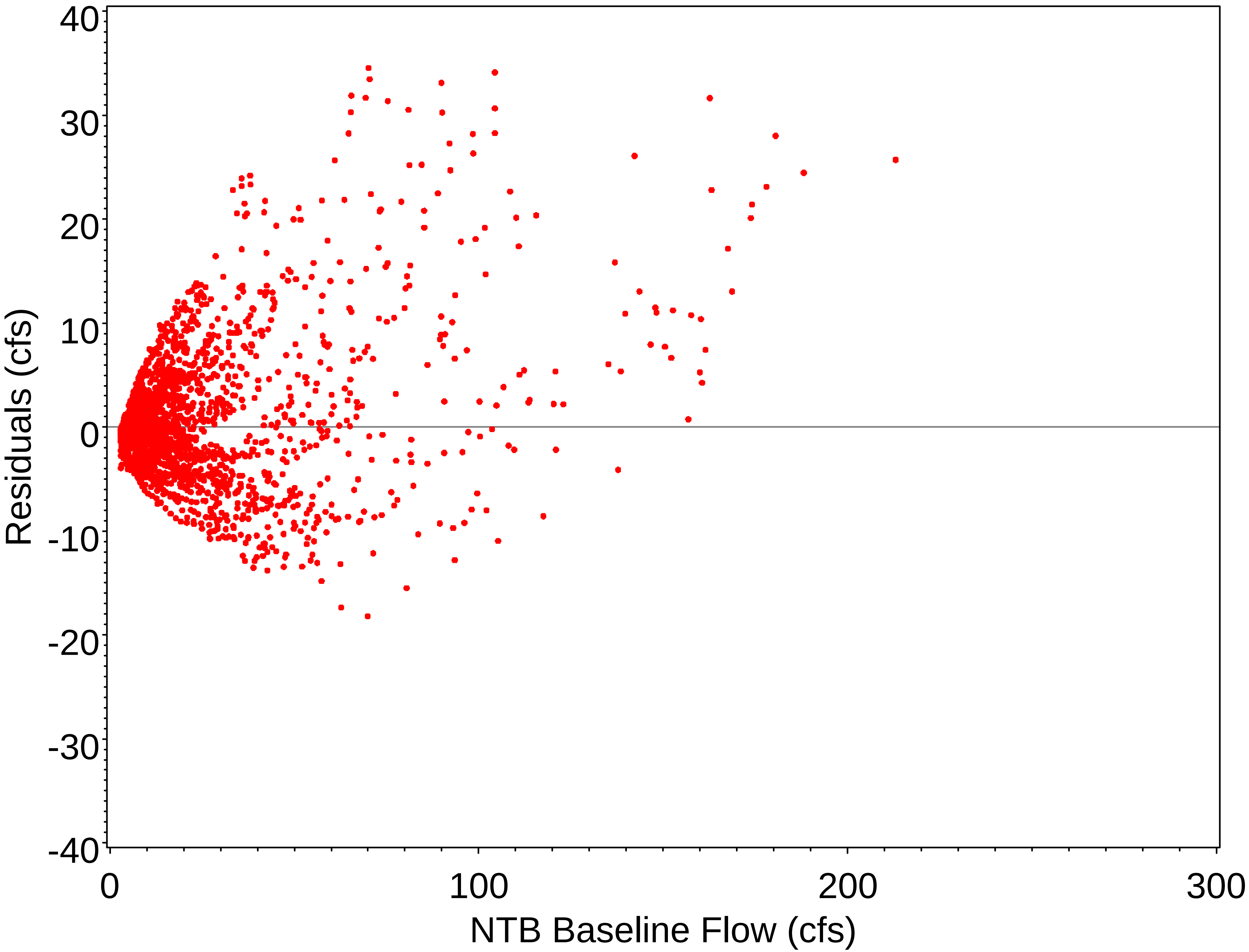
1997
1998
1999
2000
year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-10
-20
-30
-40
Residuals (cfs)
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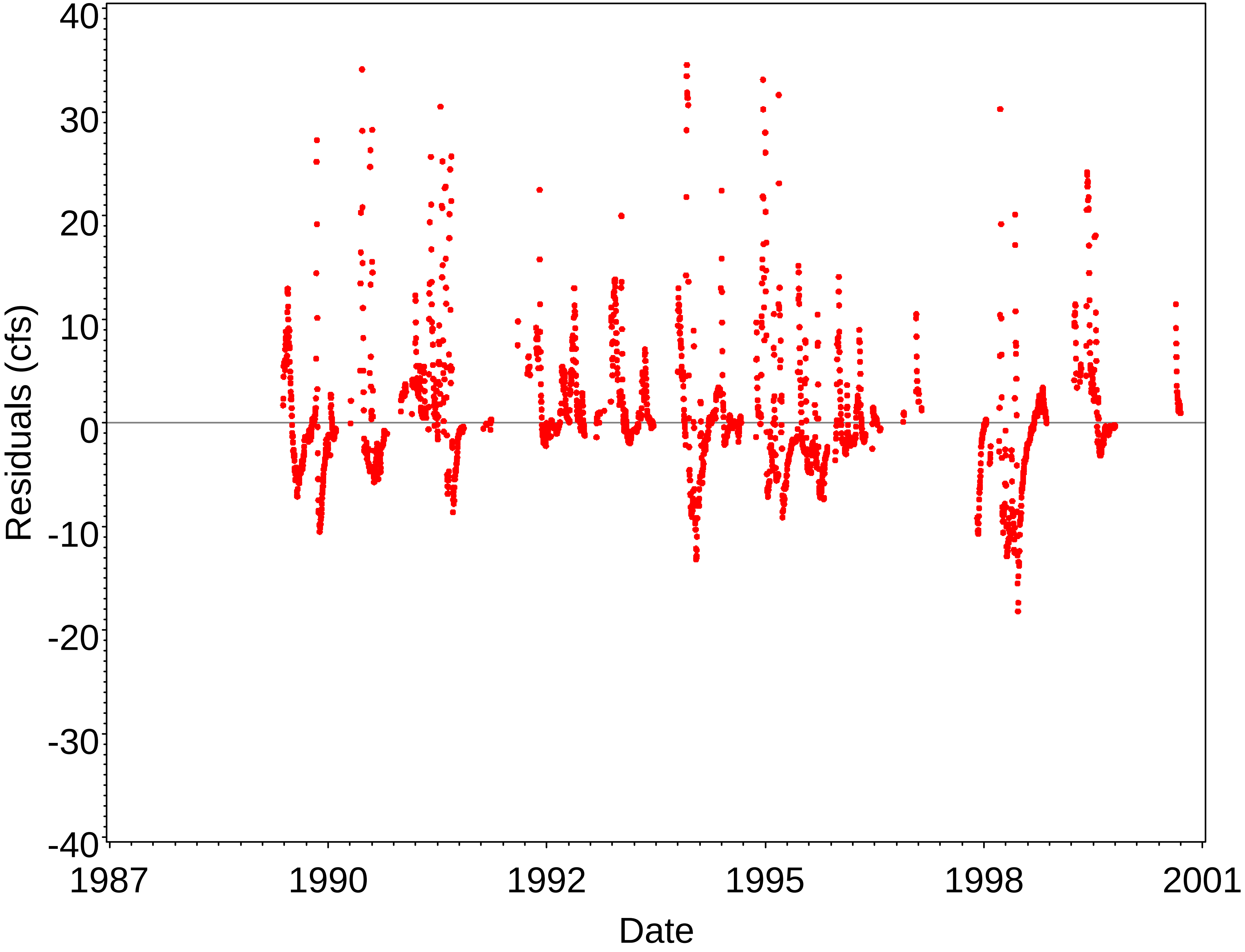
100
200
300
NTB Baseline Flow (cfs)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30
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10
0
-10
-20
-30
-40
Residuals (cfs)
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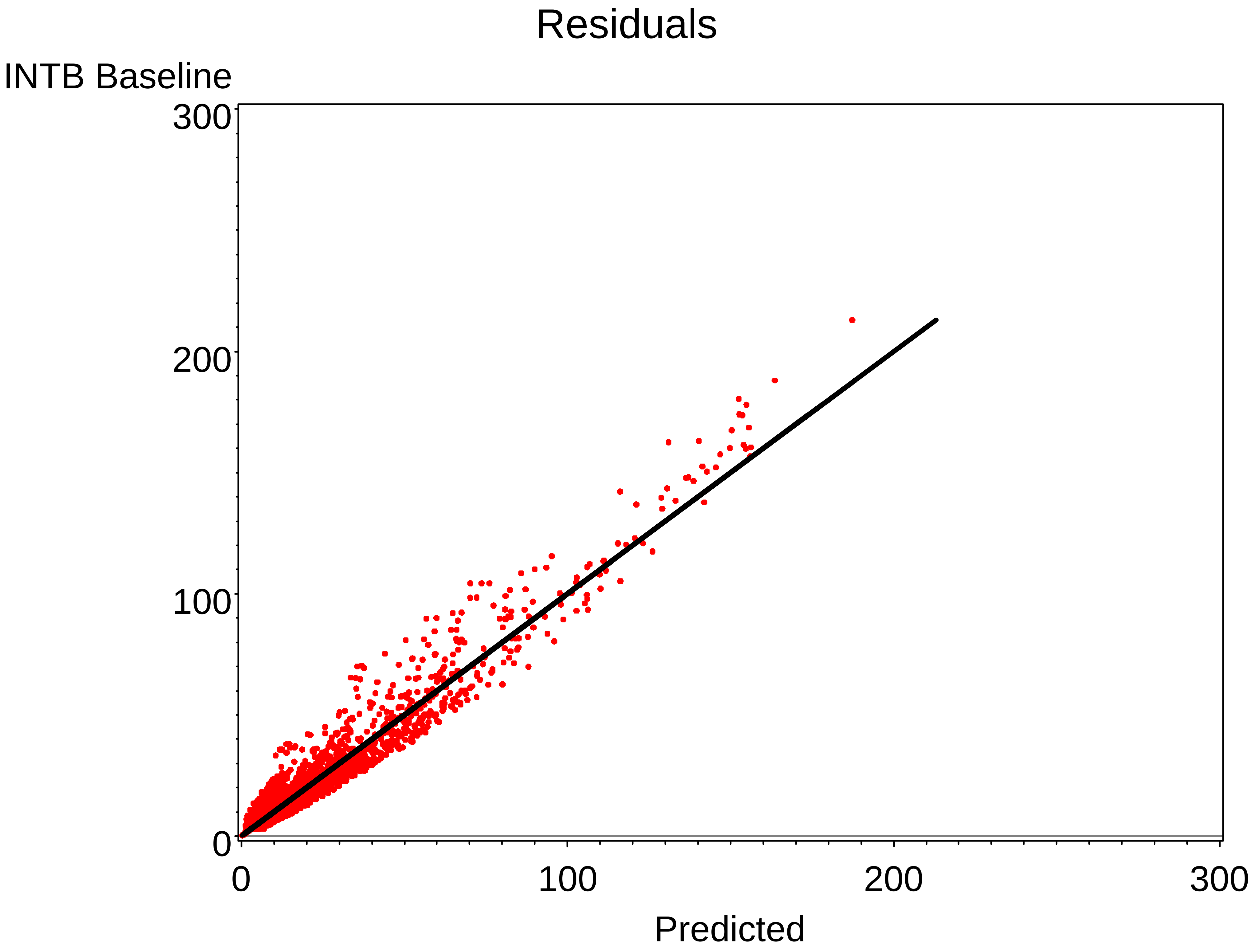
1990
1992
1995
1998
2001
Date


Residuals
INTB Baseline
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200
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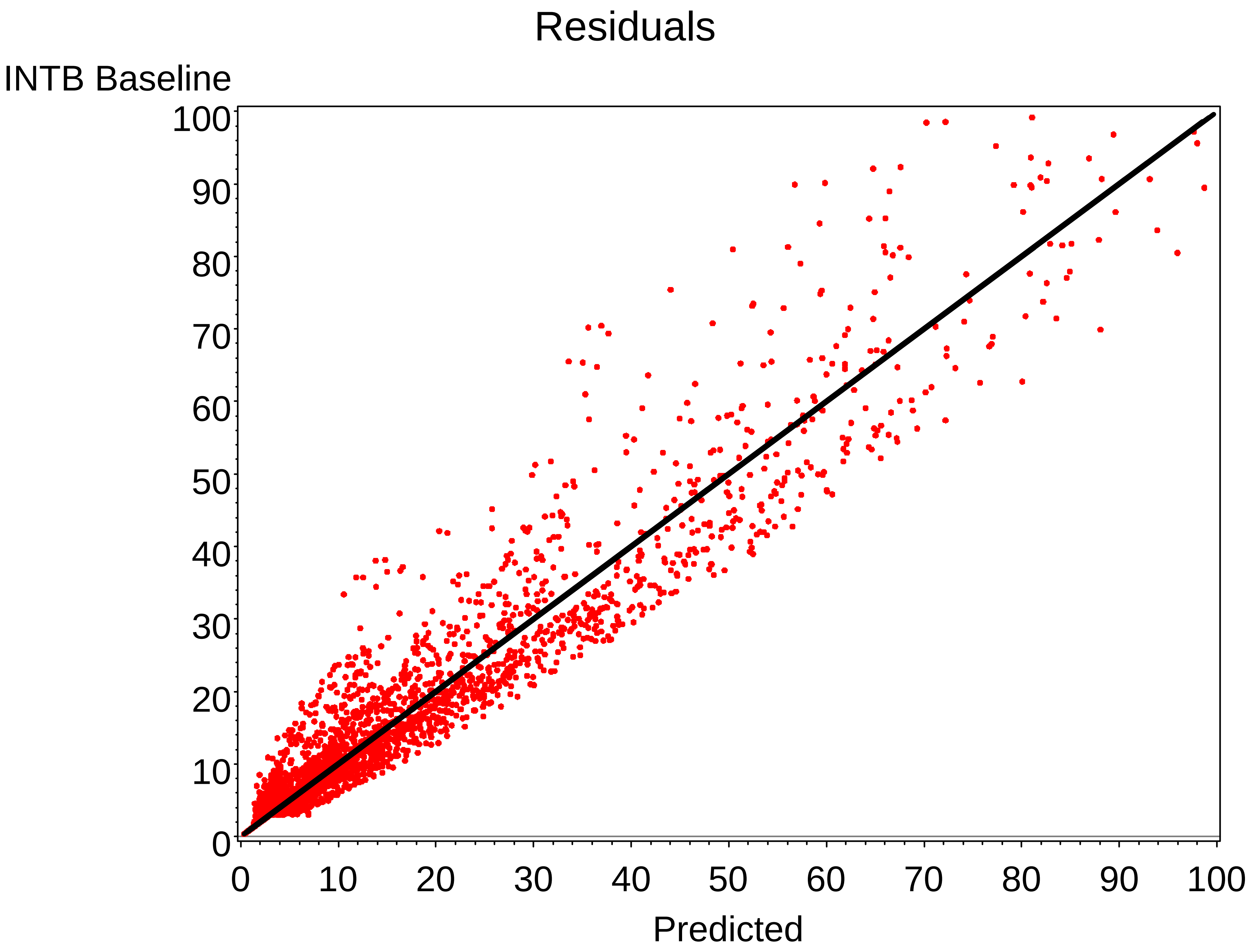
0
0
100
200
300
Predicted


Residuals
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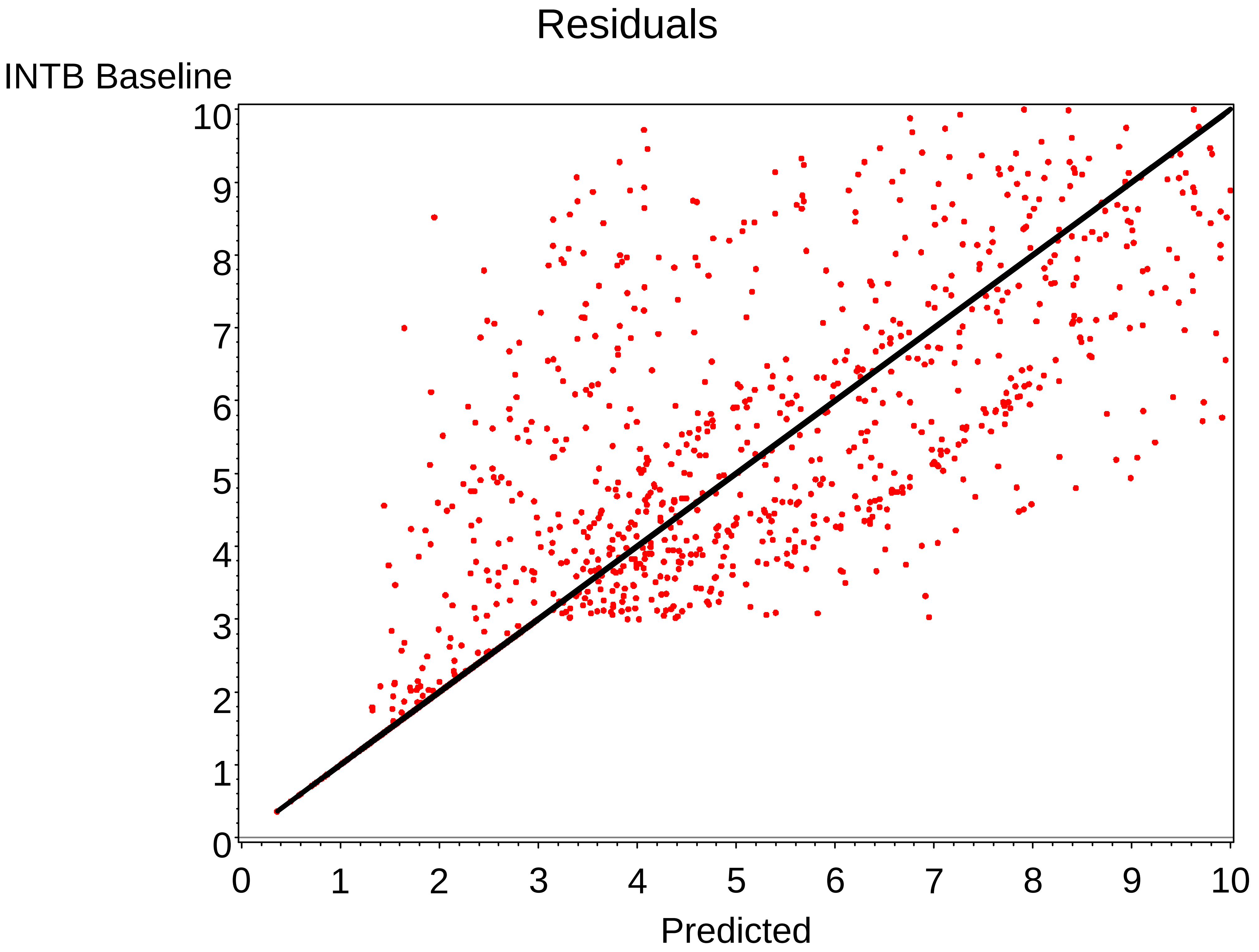
Predicted


Residuals
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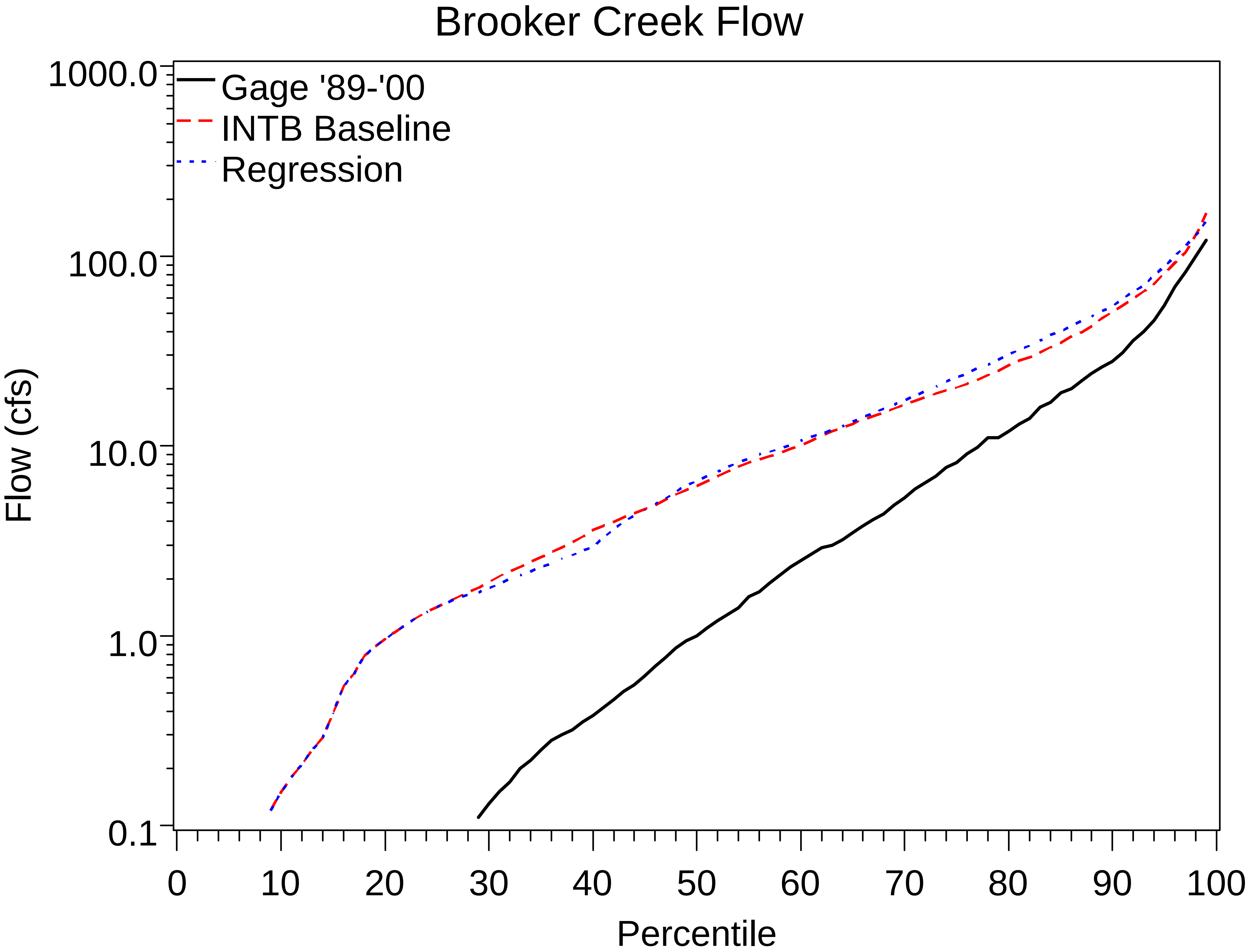
2
3
4
5
6
7
8
9
10
Predicted


Brooker Creek Flow
Gage '89-'00
INTB Baseline
Regression
Flow (cfs)
1000.0
100.0
10.0
1.0
0.1
0
10
20
30
40
50
60
70
80
90
100
Percentile

APPENDIX 4B

Engineering & Applied Science, Inc. 2010. HEC-RAS modeling of the Pithlachascotee River Final Report. Tampa, Florida. Prepared for the Southwest Florida Water Management District, Brooksville, Florida.

HEC-RAS Modeling of Pithlachascotee River

FINAL REPORT

Prepared for:

Southwest Florida Water Management District
2379 Broad Street (U.S. 41 South)
Brooksville, FL 34604-6899

Prepared by:

Engineering & Applied Science, Inc.
13087 Telecom Parkway North
Tampa, FL 33637

May 14, 2010

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ACKNOWLEDGEMENTS

Engineering & Applied Science, Inc. (EAS) performed this project with funding from the Southwest Florida Water Management District (SWFWMD) under Purchase Order No. 08POSOW1795, dated September 3, 2008. At EAS, Srinivas G. Rao, PhD, P.E., served as the project manager and Jiangtao Sun, P.E., served as the project engineer. Timely guidance, data procurement, review of technical memorandums and draft/final report by Dr. Marty Kelly, Dr. Adam Munson, and Jason Hood are greatly appreciated.

Also, EAS would like to thank all of the manager and staff from the numerous Federal, State, and local agencies who generously offered their assistance in providing the wide range of data and information presented in this report. Without their assistance the data collection and review effort would not have been possible. In particular, we would like to acknowledge and thank the following individuals by organizations: Richard Mayer and Jonathan Morales of Southwest Florida Water Management District; and Jack Leonard of Florida Turnpike Enterprise. Finally, we would like to thank the timely technical review comments from Dr. Ahmed Said on the draft report.

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1.0 INTRODUCTION

Engineering & Applied Science, Inc. (EAS) was authorized by the Southwest Florida Water Management District (SWFWMD or the District) to conduct HEC-RAS modeling for establishing Minimal Flows and Levels for the middle Pithlachascotee River (Cotee River) system.

The Pithlachascotee River watershed, which is located in western Pasco and southern Hernando counties, covers approximately 130 square miles (Figure 1.1). The Pithlachascotee River originates in south Hernando County and extends westward, discharging into the Gulf of Mexico near New Port Richey, FL.

The 11 mile long project area is located in the middle portion of the Pithlachascotee River. The upstream end of the project area is located at the United States Geological Survey (USGS) 02310280 Pithlachascotee River near Fivay Junction, at downstream side of bridge on State Highway 52, 1.2 mile west of Fivay Junction, and 21 miles upstream from the river mouth at the Gulf of Mexico. The downstream end of the project area is located at USGS 02310300 Pithlachascotee River near New Port Richey, near left bank on upstream side of bridge on private road, and 10.5 miles upstream from the river mouth.

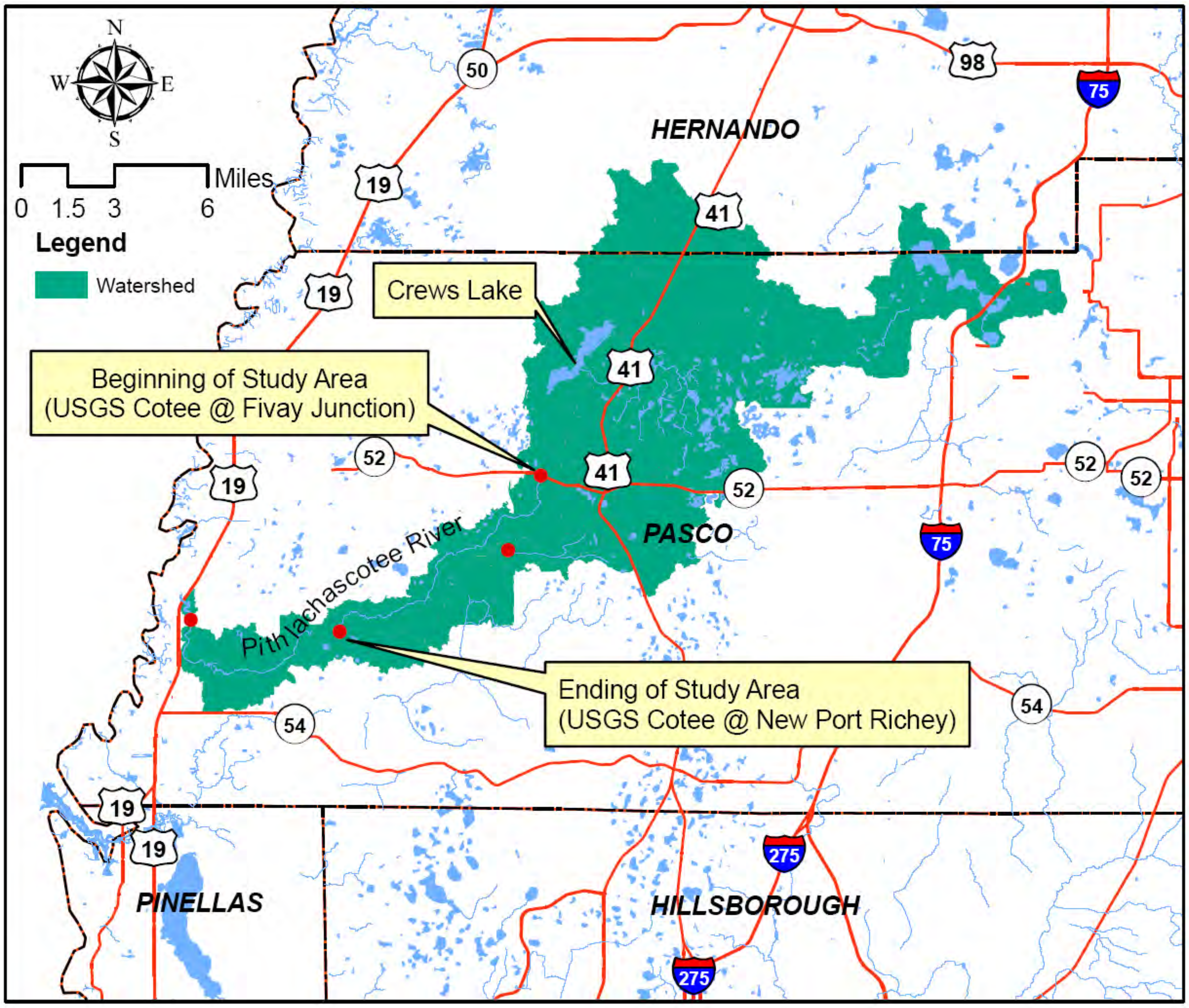

Figure 1.1 Pithlachascotee River Watershed Map

2.0 MODEL DEVELOPMENT

2.1 Cross-Sections

The major data source is the preliminary submittal package of the Watershed Management Program (WMP) for the Baker Creek and Pithlachascotee River Watershed dated on July 26, 2007, provided by Ardaman & Associate, Inc. The cross-sections in WMP study were derived from the previous stormwater modeling or field surveyed since 2004. A total of sixteen (16) cross-sections from the WMP project were adopted in the HEC-RAS modeling for this project.

Another major data source is the vegetation transects survey and the structure survey, which were performed by SWFWMD in 2009 and 2010. There are fifteen (15) vegetation transects surveyed to characterize wetlands and soils within the floodplain and four (4) additional cross-sections surveyed for the selected structures along the river. A total of nineteen (19) cross-sections were added into the river geometry data in HEC-RAS.

The Digital Elevation Model (DEM) in a 5 ft x 5 ft grid was provided by SWFWMD for the project study area, which was derived from the 2004 LiDAR data. The DEM data was used to generate the cross-sections where the field survey is not available or the site is not accessible. Seven (7) additional cross-sections were derived from the DEM data, using the x-section interpolating tools in ArcGIS 9.2.

In summary, a total of forty two (42) cross-sections were generated and used in the HEC-RAS modeling, and the cut lines were digitized in ArcGIS 9.2, as shown on Figure 2.1. Using HEC-GeoRAS 4.1.1, an ArcGIS extension for HEC-RAS, the parameters at the cross-sections were generated and imported into HEC-RAS. The cross-sections were further simplified by eliminating the redundant station-stage points using the tools provided in HEC-RAS.

All elevations used in the HEC-RAS model are in the North American Vertical Datum of 1988 (NAVD 88). All the topographic data, including DEM, structure survey, and vegetation transect survey, was provided in NAVD 88. For the data that was in the National Geodetic Vertical Datum of 1929 (NGVD 29), for example, the USGS gage stage data and rating curves, a site-specific datum conversion factor was determined using the software named “VERTCON” provided by National Oceanic and Atmospheric Administration (NOAA).

2.1.1 Manning’s n Value

The parameterization of Manning’s n is very important to the accuracy of the simulated water surface levels in hydraulic modeling. The selection of the Manning’s n values follows the guidance of HEC-RAS Hydraulic Reference Manual (Table 3-1, Appendix C). The Manning’s n value is highly variable and depends on several factors including: surface roughness; vegetation; channel irregularities; channel alignment; scour and deposition; obstructions; size and shape of the channel; stage and discharge; seasonal changes; temperature; and suspended material and bedload. With the assistance of the 2006 aerial map, 2007 land use map, and the available field observation data, the natural conditions of the main channel and floodplain were evaluated and used for the determination of the Manning’s n value for each cross section. The initial values of Manning’s n were assigned within the suggested range in Table 3-1. The Manning’s n values were further adjusted in the model calibration process.

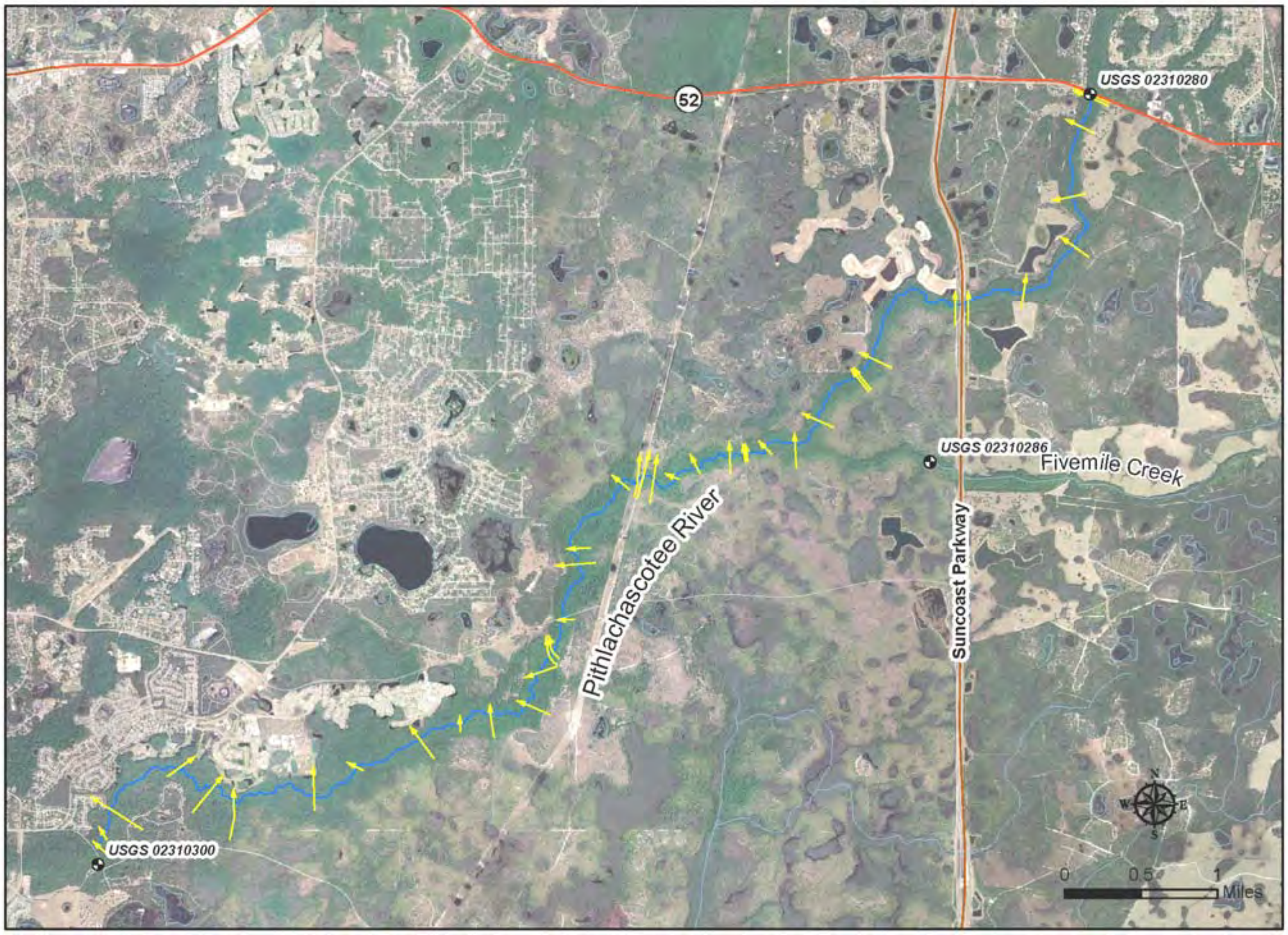

Figure 2.1 Cross-Sections of the Pithlachascotee River

2.1.2 Contraction and Expansion Coefficients

In HEC-RAS Hydraulic Reference Manual, Chapter 2, the expansion and contraction coefficients are discussed: "*Where the change in river cross section is small, and the flow is subcritical, coefficients of contraction and expansion are typically on the order of 0.1 and 0.3, respectively; and when the change in effective cross section area is abrupt such as bridges, contraction and expansion coefficients of 0.3 and 0.5 are often used.*"

The *subcritical* flow regime is used for steady state flow simulation in the HEC-RAS modeling. For most of the river segments of the Pithlachascotee River, the change in effective cross section area is not abrupt. So, the expansion and contraction coefficients of 0.1 and 0.3 were used in this project, except at bridges and culverts, where 0.3 and 0.5 were used (as recommended in HEC-RAS Hydraulic Reference Manual).

2.2 Structures

There are five (5) bridges/culverts crossing in the study area of the Pithlachascotee River, as summarized in Table 2.1. Pertinent data of the structures was obtained from various agencies (SWFWMD, FDOT Turnpike).

For Structure No. 5 at the local trail crossing, a field visit was conducted by the District staff. The sizes and lengths of the culverts were measured on site, but the invert elevations were set at the same elevations of the replaced culverts, as informed by the Operation Department of the District.

For Structure No. 7, the bridge at a private road south side of S.R. 52, the bridge parameters were estimated from the 2004 LiDAR/DEM data and the field photos.

Table 2.1 Summary of the Structures of the Pithlachascotee River

ID	Name	Station in HEC-RAS	Type	Roadway	Agency	Data Source
1	Structure No. 2	4.28	Bridge/Culvert	Trail Crossing	SWFWMD	Field Survey
2	Structure No. 3	5.87	Culvert	Power Corridor	SWFWMD	WMP Study
3	Structure No. 5	7.805	Culvert	Trail Crossing	SWFWMD	Field Estimate
4	Structure No. 6	8.94	Bridge	Suncoast Pkwy	FDOT Turnpike	As-built Plans
5	Structure No. 7	11.03	Bridge	Private Road	SWFWMD	2004 LiDAR/DEM

2.3 Channel Flow Profiles

The USGS stream flow records were collected at USGS gages along the Pithlachascotee River and its major tributary (Fivemile Creek) during the data collection task, as seen in Appendix B. There is no significant surface-groundwater interchange documented in the study area.

A channel flow profile is used to describe the flow changes along the river in a given downstream steady state flow rate. The first step of the procedure is to estimate the proportional relationship between the various upstream USGS gages and the downstream boundary USGS gage. Second, a linear interpolation is applied to determine the value at the cross-sections based on the known values at the upstream/downstream USGS gages. Third, in the statistical analysis of the historical flow data of the USGS gages at the downstream boundaries, the range and distribution of the flow records are summarized, and seventeen (17) fixed flow rates ranged from 2 to 90 upper percentiles are selected for the study area. Finally, the channel flow profiles based on the 17 flow rates at the downstream boundary are created and imported into HEC-RAS.

Three (3) USGS gages are available for the analysis in the study area: USGS 02310300 Pithlachascotee River near New Port Richey (Cotee @ New Port Richey), USGS 02310280 Pithlachascotee River near Fivay Junction (Cotee @ Fivay Junction), and USGS 02310286 Fivemile Creek near Fivay Junction (Fivemile Creek @ Fivay Junction), as seen on Figure 2.1. Historical flow/stage data (daily average) could be downloaded from the USGS website. The channel flow profile analysis for this segment is based on the downstream boundary, i.e., Cotee @ New Port Richey.

The results of the linear regression analysis of Flow @ New Port Richey vs. Flow @ Fivemile Creek are shown on Figure 2.2, and the R^2 value is 0.72. The regression analysis of Flow @ New Port Richey vs. Flow @ Fivay Junction is shown on Figure 2.3, and the R^2 value is 0.72.

Fivemile Creek @ Fivay Junction is about 0.85 mile upstream of the confluence of the Fivemile Creek and the Pithlachascotee River. USGS Fivemile Creek @ Fivay Junction does not represent the total flow into the Pithlachascotee River from the entire Fivemile Creek Watershed; therefore, a multiplier of 1.094, the ratio between the area upstream of the confluence (5690.14 acres) and the area upstream of the gage (5202.73 acres), was used to estimate the contributed flow from the Fivemile Creek at the confluence, i.e., 29.6% (27.1% x 1.094) of flow @ New Port Richey, see Figure 2.4.

As seen in Table 2.2, a total of 17 flow rates at USGS Cotee @ New Port Richey were selected with a range of 2 cfs to 100 cfs (30 to 90 upper percentiles of the historical flow record). According to the regression analysis above, the flow rates at Fivemile Creek @ Fivay Junction and Cotee @ Fivay Junction were calculated and listed in Table 2.2, for the 17 channel flow profiles. The complete table of the channel flow profiles can be found in the HEC-RAS input file.

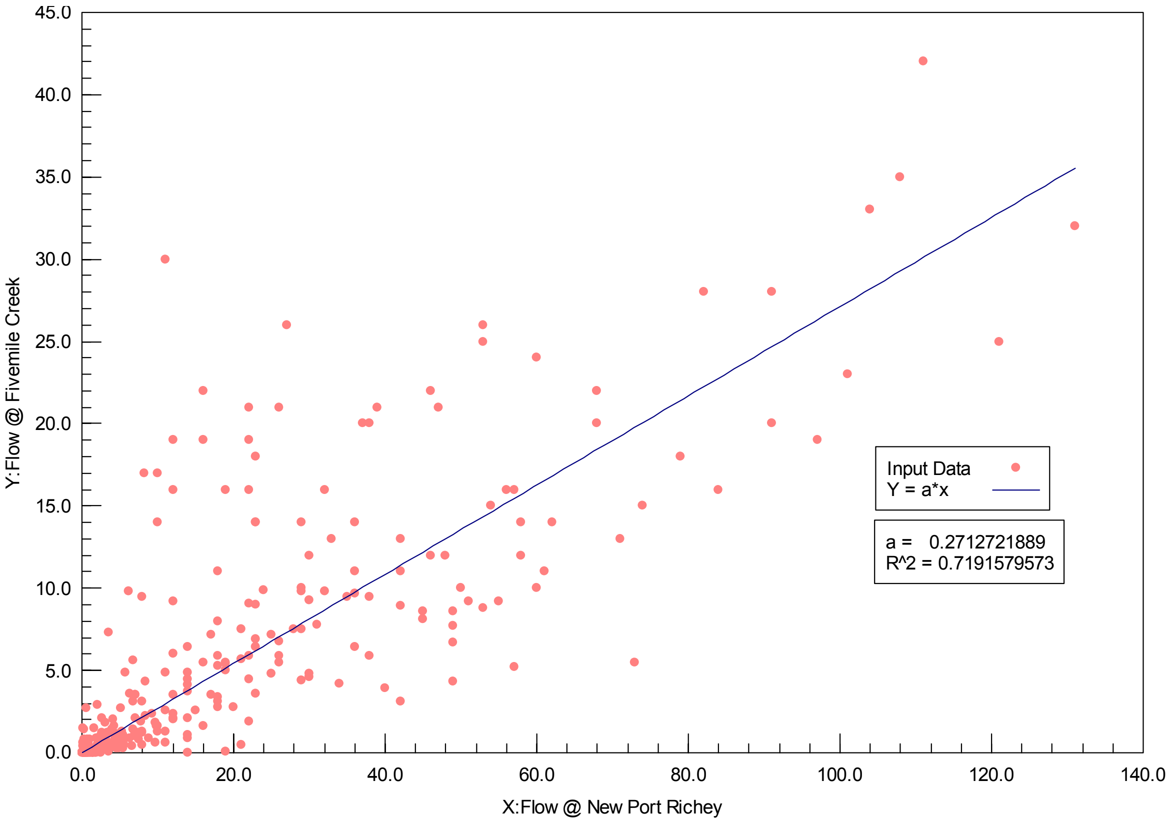

Figure 2.2 Regression Analysis of Flow @ New Port Rickey vs. Flow @ Fivemile Creek

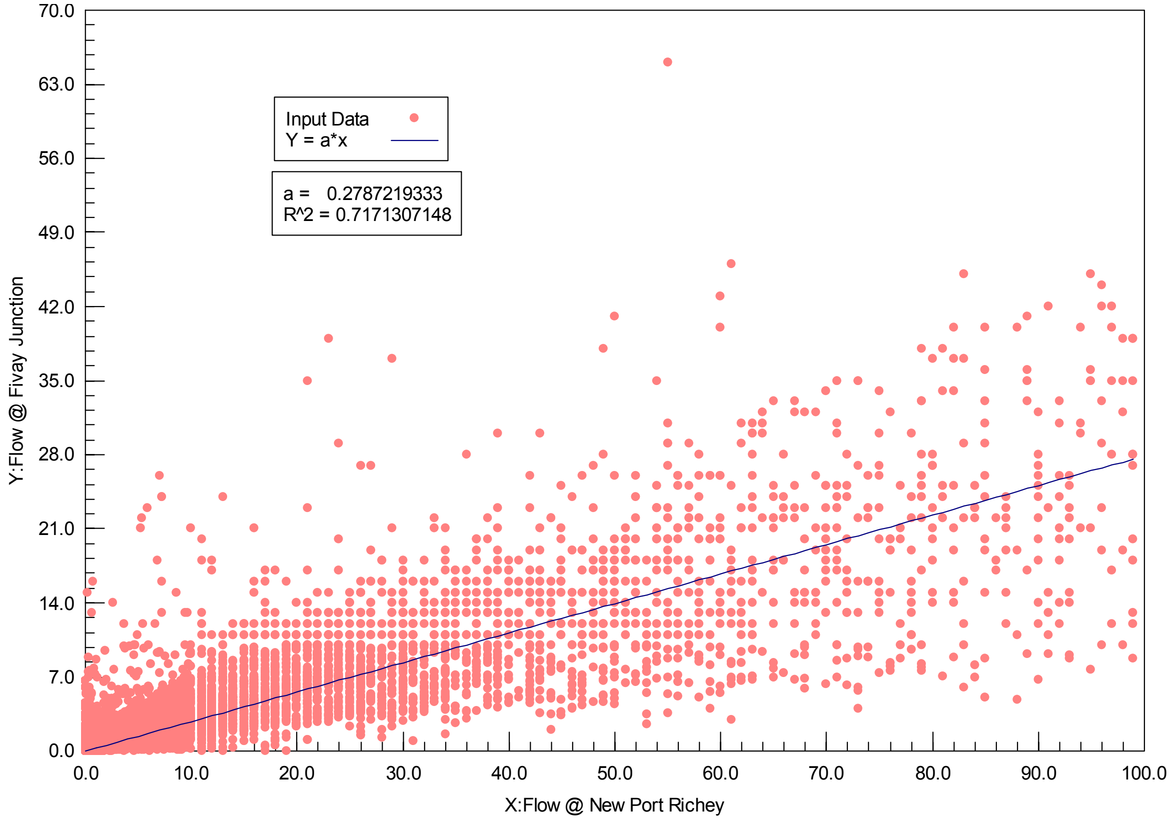

Figure 2.3 Regression Analysis of Flow @ New Port Richey vs. Flow @ Fivay Junction

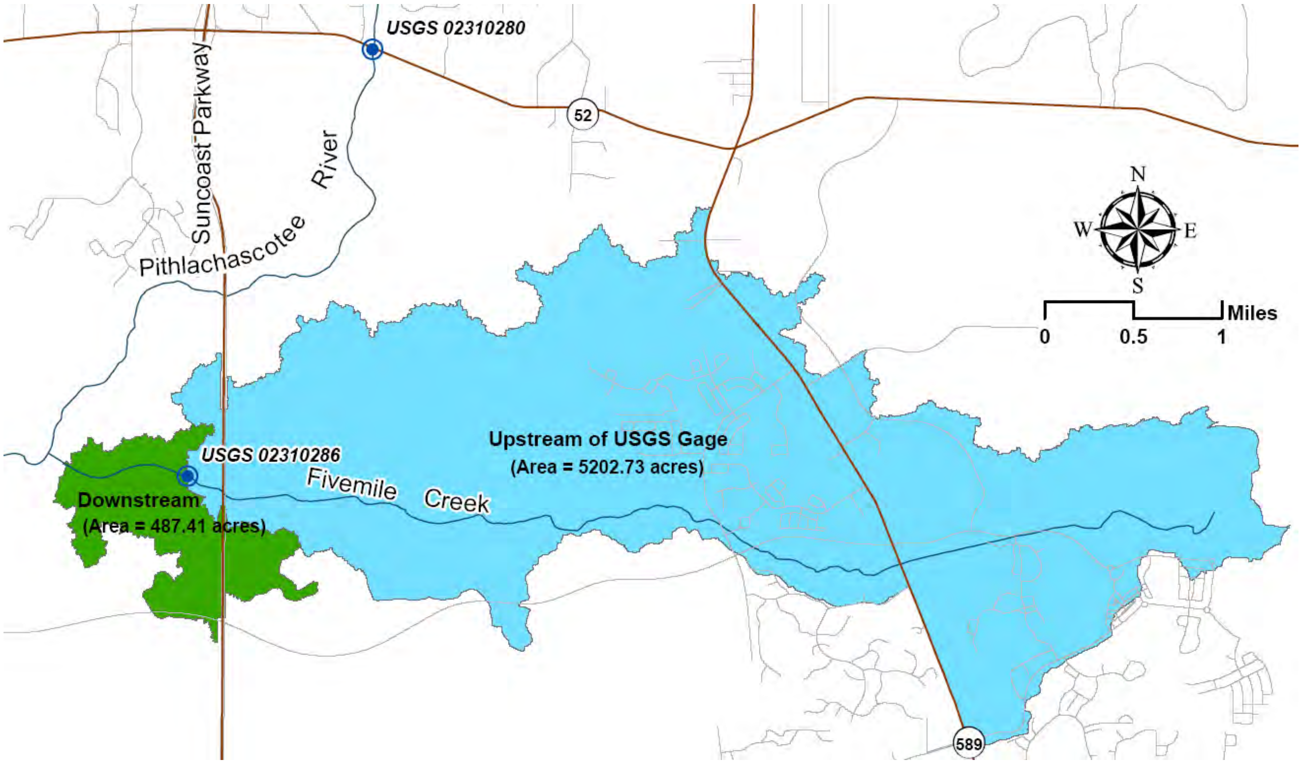

Figure 2.4 Fivemile Creek Subwatershed Map

Table 2.2 Channel Flow Profiles of the Pithlachascotee River

USGS Station		**Cotee @ New Port Richey (02310300)**	**Fivemile Creek @ Fivay Junction (02310286)**	**Cotee @ Fivay Junction (02310280)**
STA in HEC-RAS		**0.00**	**7.12***	**11.04**
Flow Rate (cfs)	**1**	2	0.592	0.558
	2	4	1.184	1.116
	3	6	1.776	1.674
	4	8	2.368	2.232
	5	10	2.96	2.79
	6	12	3.552	3.348
	7	15	4.44	4.185
	8	17	5.032	4.743
	9	20	5.92	5.58
	10	30	8.88	8.37
	11	40	11.84	11.16
	12	50	14.8	13.95
	13	60	17.76	16.74
	14	70	20.72	19.53
	15	80	23.68	22.32
	16	90	26.64	25.11
	17	100	29.6	27.9

* STA 7.12 is the confluence of the Fivemile Creek and the Pithlachascotee River, and the flow rates listed here refer to the flow at the Fivemile Creek.

2.4 Downstream Boundary Conditions

For a steady-state model simulation, a flow-stage rating curve is frequently set as the downstream boundary conditions.

The USGS published flow-stage rating curves could be downloaded from the USGS web site, and were used to generate the downstream boundary conditions and calibration targets, if available.

In general, there are two kinds of rating curves provided by USGS for each gage: 1) Defined Rating Curve, and 2) Shift Corrected Rating Curve with the shift adjustment. The shift adjustment indicates a temporary change of the channel bed caused by scour or fill, growth/removal of vegetation or algae, and/or accumulation/removal of debris. The Shift Corrected Rating Curve may be updated monthly for some gages, or has no changes during a long period for other gages.

The published rating curves are available for USGS Cotee @ New Port Richey at the following USGS web site: *http://waterdata.usgs.gov/nwisweb/data/exsa_rat/02310300.rdb*

The historical flow record (Daily Average from 1981 to 2009), a polynomial regression curve generated by EAS, and the USGS Defined Rating Curve of USGS Cotee @ New Port Richey are shown on Figure 2.5. The polynomial regression curve with a R^2 value of 0.97 is very similar to the USGS Defined Rating Curve at this gage.

Since the USGS Shift Corrected Rating Curve is not available at this gage, the USGS Defined Rating Curve was used as the boundary conditions for the study area. The flow/stage data for the 17 channel flow profiles was estimated as listed in Table 2.3.

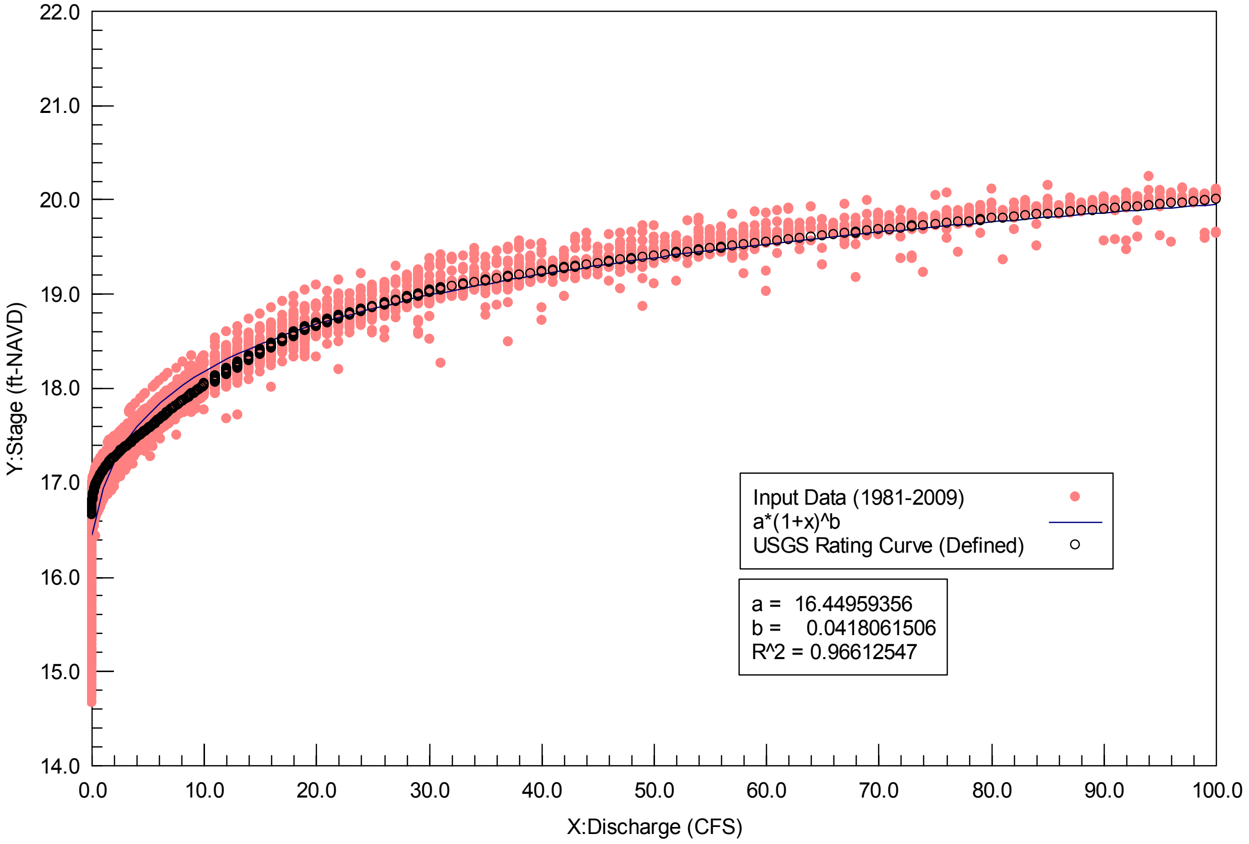

Figure 2.5 Flow-Stage Rating Curves of USGS Cotee @ New Port Richey

Table 2.3 Boundary Conditions at USGS Cotee @ New Port Richey

Profile	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Flow (cfs)	2	4	6	8	10	12	15	17	20	30	40	50	60	70	80	90	100
Stage (ft-NAVD)	17.27	17.48	17.67	17.86	18.045	18.18	18.39	18.515	18.675	19.03	19.235	19.405	19.55	19.68	19.8	19.9	20

3.0 MODEL CALIBRATION

3.1 Calibration Targets

The HEC-RAS model was developed for the middle Pithlachascotee River and simulated for 17 channel flow profiles. Manning's n and other parameters were adjusted at each cross-section to fit the simulated water levels to the calibration targets at the upstream end of the study area, i.e., USGS 02310280 Pithlachascotee River near Fivay Junction.

The difference between the simulated water levels and calibration targets is required to be within ±0.5 ft. No significant changes were noticed between the final and initial Manning's n values during the model calibration process; therefore, the changes are not documented in this report.

No USGS rating curve is available at USGS 02310280 Cotee @ Fivay Junction; therefore, the polynomial regression curve developed from the individual flow measurements (232 records selected) was used as the calibration targets. As seen on Figure 3.1, the regression curve with a R^2 value of 0.96 fits well to the USGS discharge measurements. In Appendix D, the development of the rating curve at this USGS station was discussed in details.

Table 3.1 lists the model calibration results, which indicates the HEC-RAS model results meet the calibration criteria of ±0.5 ft.

3.2 Channel Profile Plots

The water level profiles for all 17 channel flow profiles are presented on Figure 3.2.

4.0 CONCLUSION AND LIMITATIONS

HEC-RAS 4.0, HEC-GeoRAS 4.1.1, ArcGIS 9.2, and other software were used to develop the HEC-RAS model for estimating the MFL's for the middle Pithlachascotee River. There are 42 cross-sections and 5 structures modeled in the 11 river miles long study area. Detailed model calibrations were performed and the difference between the simulated results and the calibration targets falls within the calibration criteria of ±0.5 ft. Therefore, the calibrated HEC-RAS model can be used for habitat study in the middle Pithlachascotee River.

There are several challenges and limitations in the current HEC-RAS modeling, mostly due to the data deficiency, as listed below:

1). Undocumented surface water and groundwater interchange;

2). the stream gauging history is short at USGS Fivemile Creek @ Fivay Junction; and

3). topographic data for several cross-sections and structures were estimated from the 2004 LiDAR data.

The limitation in the present study could be overcome by recalibrating the HEC-RAS model when additional data becomes available.

Table 3.1 Model Calibration on USGS Cotee @ Fivay Junction (STA: 11.04)

Profile	Cotee @ New Port Richey Flow (cfs)	Cotee @ Fivay Junction Flow (cfs)	Calibration Target (ft-NAVD)	Model Results (ft-NAVD)	Diff. (ft)
1	2	0.558	50.30	49.9	**-0.40**
2	4	1.116	50.40	50.08	**-0.32**
3	6	1.674	50.46	50.21	**-0.25**
4	8	2.232	50.51	50.31	**-0.20**
5	10	2.79	50.56	50.4	**-0.16**
6	12	3.348	50.60	50.48	**-0.12**
7	15	4.185	50.65	50.57	**-0.08**
8	17	4.743	50.69	50.62	**-0.07**
9	20	5.58	50.73	50.68	**-0.05**
10	30	8.37	50.85	50.85	**0.00**
11	40	11.16	50.96	50.98	**0.02**
12	50	13.95	51.04	51.09	**0.05**
13	60	16.74	51.12	51.19	**0.07**
14	70	19.53	51.19	51.27	**0.08**
15	80	22.32	51.25	51.35	**0.10**
16	90	25.11	51.31	51.42	**0.11**
17	100	27.9	51.36	51.48	**0.12**

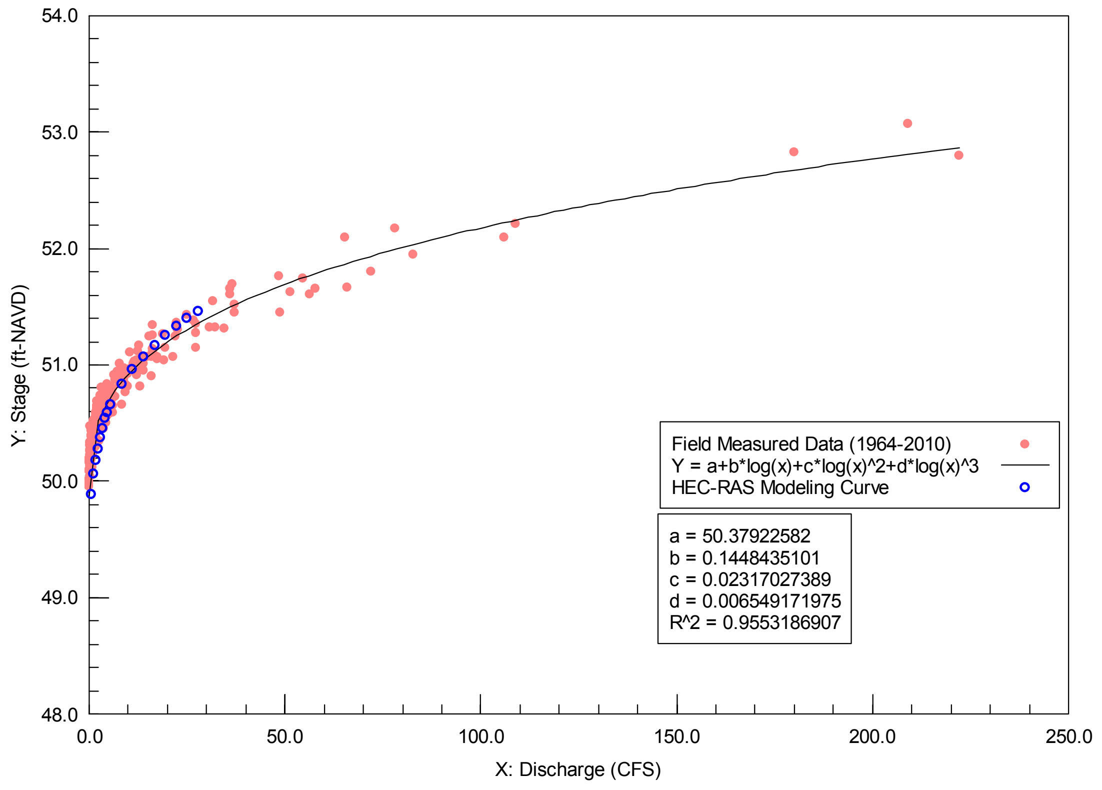

Figure 3.1 Flow-Stage Rating Curves of USGS Cotee @ Fivay Junction

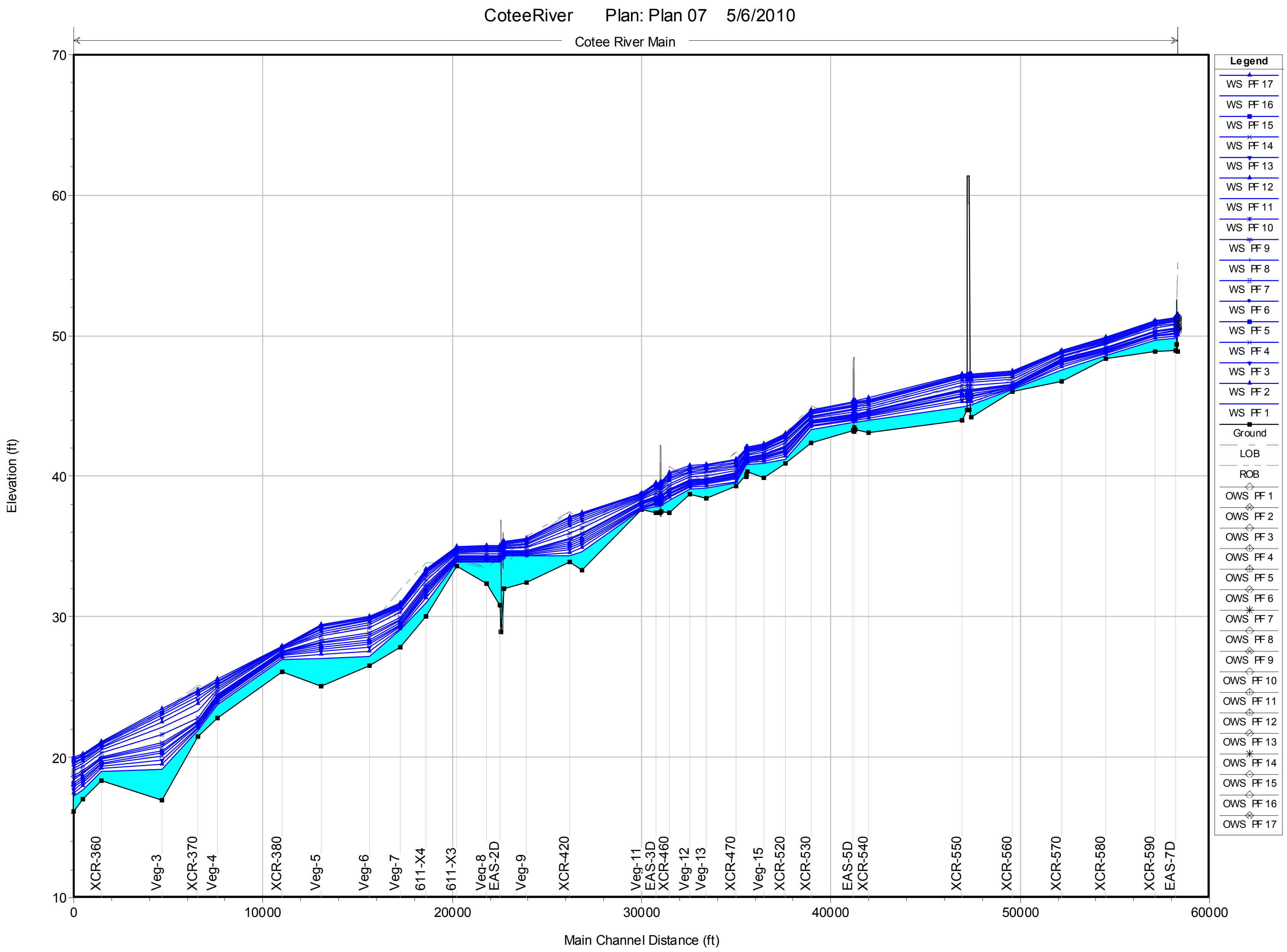

Figure 3.2 Profile Plot of the Pithlachascotee River (New Port Richey – Fivay Junction)

5.0 REFERENCES

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Appendix A Meeting Minutes

PITHLACHASCOTEE RIVER MFL PROJECT – Kick Off Meeting

Location:	SWFWMD, Brooksville, FL
Date:	Wednesday, October 1, 2008, 10:00 am
Attendees:	Dr. Adam Munson, Mr. Jason Hood, Dr. Jonathan Morales - SWFWMD Mr. Sri Rao, Mr. Lawrence Kleiner, P.E., Mr. Jiangtao Sun, P.E. - EAS

The following items were discussed for Pithlachascotee River MFL Project:

- It was agreed that the project should follow the work order issued.
- All agreed Pithlachascotee River should be referred as "Cotee River".
- EAS reviewed the project location map provided by Dr. Adam Munson. This map included three (3) USGS gages within the project area. The location map is attached to this meeting memo.
- A detailed aerial map was prepared by Mr. Jiangtao Sun to show all the potential road/bridge crossings along the 10-mile long Cotee River and the Five Mile Creek tributary to assist in the site visit that followed the kick off meeting. A copy of this map is also attached to this meeting memo.
- Adam informed EAS that an existing power line corridor crosses the Cotee River and there are several culverts under the power line service road.
- The majority of the project is in the Starkey Wilderness Park owned by the District.
- Jason said to refer to the Anclote Watershed Management Plan for spring locations.
- The lower end of the Cotee River within the limits of the study area is adjacent to a residential area, and the upper end is in a forested area.
- Adam said SWFWMD is in the transect survey phase for this project.
- Adam informed EAS that none of the survey work is done under MFL at this time.
- SWFWMD only has LiDAR data at this time for the project area.
- SWFWMD will not have as much data for this project as Withlacoochee MFL project.
- SWFWMD will have only 15 transects surveyed for the 10 mile length of the Cotee River for the HEC-RAS modeling.
- Adam said there is no subsurface (bathymetric) survey for this project, only LiDAR data is available.
- Adam said LiDAR data covering the project area may not be recent, he is not sure if the LiDAR is current or 5-years old. Old LiDAR data is always questionable in the wetland area - Class 11. Adam will find out when the available LiDAR was taken so we can determine how accurate we can expect the LiDAR data to be.
- Sri said EAS may use SWFWMD 1-foot topo to get started on the project.
- Adam said one thing we have to wait for is the flows recorded by USGS gages as they are not calibrated (not natural). He said a lot of river sections may be impacted by the adjacent well field groundwater withdrawal.

- Jason said Len Burke, environmental scientist in Bartow, FL has a permit from HDR to take water from a flooding problem area upstream and put it downstream in the Cotee River. Jason told Sri, HDR may have some cross-sections (may be not enough) for this project as it was approved by SWFWMD.
- Jason said Patricia Dooris, Dooris & Associates would have vegetation transects survey done in the next several months for this project.
- Sri said EAS wants to begin preliminary modeling, and then meet with SWFWMD to tell what EAS needs to complete this MFL project.
- Sri said Jiangtao Sun will look into the web site for a literature search for the Cotee River. Adam and Jason said they are not aware of any previous literature for this 10-mile portion of the Cotee River.
- Jason said he has walked most of the river and noted the existing shoals.
- Sri suggested there may be studies available that would be helpful associated with the Anclote River desal plant project.
- Sri said we will look at existing ERP permits as part of the Data Collection for this project.
- Jiangtao requested the cross-section information for the WMP for this watershed. Adam said he will look into this within the next couple of weeks.
- Jiangtao suggested using the current 2004 LiDAR data as a start of the modeling.

Action items:

Adam to provide EAS:

- Most current LiDAR Data available from the District.
- Any in-house reports covering the Cotee River
- Cross-section data from WMP study

EAS to start:

- Prepare HEC-RAS model based on the most current available data when it is available.

In closing, Adam said SWFWMD will look at HEC-RAS model results to determine the Critical Habitat Elevation, and the flow rate that can sustain the minimum levels.

Appendix B Inventory of Data Collection

The data collected during the project period are summarized below:

Report:

- Tampa Bay/Anclote River Comprehensive Watershed Management Plan, 2002, SWFWMD
- Minimum and Guidance Levels for Tsala Apopka Lake in Citrus County, Florida, Nov 2005 Draft, SWFWMD
- Proposed Minimum Flows and Levels for the Middle Segment of the Peace River, from Zolfo Springs to Arcadia, Oct 2005, SWFWMD
- Upper Peace River, An Analysis of Minimum Flows and Levels, Aug 2002, SWFWMD
- Florida River Flow Patterns and the Atlantic Multidecadal Oscillation, Aug 2004 Draft, SWFWMD

Data:

WMP Study for the Bear Creek/Pithlachascotee River Watershed (M112), dated July, 2008:

- Floodplain Analysis Report
- DTM database (2004 LiDAR data)
- CHAN model input and output, including x-sections and hydraulic structures data
- Basin Delineation Map
- Node-Link Diagram Map
- 100-Year Floodplain Map

GIS Shape File and Images:

- USGS Topographic Map
- USGS 2004 Aerial Photo
- USGS Digital Line Graph Data, 1:24,000
- SWFWMD 2006 Aerial Photo
- SWFWMD 2007 Land Use Map
- SWFWMD Soils Map
- SWFWMD Hydrography Map
- SWFWMD ERP Map
- SWFWMD Road Map
- SWFWMD Drainage Basins Map
- SWFWMD Watershed Boundaries Map
- SWFWMD Well Site Map
- SWFWMD Well Field Map
- SWFWMD Stream Flow Station Map
- SWFWMD Rainfall Station Map
- SWFWMD Evaporation Station Map
- SWFWMD 2004 LiDAR Topo Data in Pasco County (DEM, 1-ft contour, etc.)
- SWFWMD 2007 LiDAR Topo Data in Pasco County (for west partial of the study area only)

Stream Gauging Data for Pithlachascotee River (Cotee River):

- USGS Stream Gauging Data (Flow and Stage):
  - USGS 02310280 Cotee @ Fivay Junction
  - USGS 02310286 Fivemile Creek @ Fivay Junction
  - USGS 02310300 Cotee @ New Port Richey

- USGS Stage-Discharge Rating Curve:
    - USGS 02310286 Fivemile Creek @ Fivay Junction, 12/22/2009
    - USGS 02310300 Cotee @ New Port Richey, 10/22/2009

Bridge Data:

- From FDOT/Turnpike (Received Feb 5, 2009 thru mail)
    - CD1 - Suncoast Pkwy Site Plans/Bridge Plans in .Tiff format
    - CD2 - Suncoast Aerial at Bridge No. 14081

Vegetation Transect Data:

- 15 Vegetation Transects from SWFWMD in spreadsheet & ESRI Shape files, dated 01/19/2010 (Mr. Jason Hood)

Structure Survey Data:

- Structure No.4 (EAS-4), 0.5 mile downstream of the confluence at Fivemile Creek, provided by SWFMWD in spreadsheet & ESRI Shape files on 01/26/2010 (Dr. Jonathan Morales)
- Structure No.2 (EAS-2), 4.3 miles upstream of USGS 02310300 Cotee @ New Port Richey, provided by SWFMWD in spreadsheet & ESRI Shape files on 02/04/2010 (Dr. Jonathan Morales)
- Structure No.5 (EAS-5), 1 mile downstream of Suncoast Pkwy Bridge, field estimated by SWFMWD (Mr. Jason Hood)

Appendix C References on Hydraulic Parameters

Table 3-1 Manning's 'n' Values

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. **Main Channels**			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. **Flood Plains**			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200
3. **Mountain Streams, no vegetation in channel, banks usually steep, with trees and brush on banks submerged**			
a. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. Bottom: cobbles with large boulders	0.040	0.050	0.070

Table 3-1 (Continued) Manning's 'n' Values

Type of Channel and Description	Minimum	Normal	Maximum
B. *Lined or Built-Up Channels*			
1. **Concrete**			
a. Trowel finish	0.011	0.013	0.015
b. Float Finish	0.013	0.015	0.016
c. Finished, with gravel bottom	0.015	0.017	0.020
d. Unfinished	0.014	0.017	0.020
e. Gunite, good section	0.016	0.019	0.023
f. Gunite, wavy section	0.018	0.022	0.025
g. On good excavated rock	0.017	0.020	
h. On irregular excavated rock	0.022	0.027	
2. **Concrete bottom float finished with sides of:**			
a. Dressed stone in mortar	0.015	0.017	0.020
b. Random stone in mortar	0.017	0.020	0.024
c. Cement rubble masonry, plastered	0.016	0.020	0.024
d. Cement rubble masonry	0.020	0.025	0.030
e. Dry rubble on riprap	0.020	0.030	0.035
3. **Gravel bottom with sides of:**			
a. Formed concrete	0.017	0.020	0.025
b. Random stone in mortar	0.020	0.023	0.026
c. Dry rubble or riprap	0.023	0.033	0.036
4. **Brick**			
a. Glazed	0.011	0.013	0.015
b. In cement mortar	0.012	0.015	0.018
5. **Metal**			
a. Smooth steel surfaces	0.011	0.012	0.014
b. Corrugated metal	0.021	0.025	0.030
6. **Asphalt**			
a. Smooth	0.013	0.013	
b. Rough	0.016	0.016	
7. **Vegetal lining**	0.030		0.500

Table 3-1 (Continued) Manning's 'n' Values

Type of Channel and Description	Minimum	Normal	Maximum
C. *Excavated or Dredged Channels*			
1. **Earth, straight and uniform**			
a. Clean, recently completed	0.016	0.018	0.020
b. Clean, after weathering	0.018	0.022	0.025
c. Gravel, uniform section, clean	0.022	0.025	0.030
d. With short grass, few weeds	0.022	0.027	0.033
2. **Earth, winding and sluggish**			
a. No vegetation	0.023	0.025	0.030
b. Grass, some weeds	0.025	0.030	0.033
c. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
d. Earth bottom and rubble side	0.028	0.030	0.035
e. Stony bottom and weedy banks	0.025	0.035	0.040
f. Cobble bottom and clean sides	0.030	0.040	0.050
3. **Dragline-excavated or dredged**			
a. No vegetation	0.025	0.028	0.033
b. Light brush on banks	0.035	0.050	0.060
4. **Rock cuts**			
a. Smooth and uniform	0.025	0.035	0.040
b. Jagged and irregular	0.035	0.040	0.050
5. **Channels not maintained, weeds and brush**			
a. Clean bottom, brush on sides	0.040	0.050	0.080
b. Same as above, highest stage of flow	0.045	0.070	0.110
c. Dense weeds, high as flow depth	0.050	0.080	0.120
d. Dense brush, high stage	0.080	0.100	0.140

Table 3-3

Subcritical Flow Contraction and Expansion Coefficients

	Contraction	Expansion
No transition loss computed	0.0	0.0
Gradual transitions	0.1	0.3
Typical Bridge sections	0.3	0.5
Abrupt transitions	0.6	0.8

Appendix D Response to District's Review Comments on Draft Report

The District reviewer, Dr. Ahmed Said, P.E. has reviewed the draft report of the HEC-RAS Modeling of the Pithlachascotee River, and review comments are attached here:

"I reviewed the report titled "HEC-RAS Modeling of Pithlachascotee River" prepared by the Engineering & Applied Science, Inc. (EAS). In this report EAS developed a model for 11 mile within the middle portion of the Pithlachascotee River. The model includes 42 cross-sections and the model uses regression analysis of 3 USGS stations. The report has good information about the determination of the Manning's coefficient "n" values and the expansion, contraction coefficients. Overall, the report is well written and has only few things that needs to be revised:

1. The USGS 02310280 provides data from 1983-10-01 to 2010-02-08 for stage and discharge. The relation between this station (y) and USGS 02310300 (x), shown in Figure 2.3, needs to be revised based on the period of measurements. The coefficient "a" could be less than 0.27 (I expected it in the range of 0.20 from the beginning to the end of the available data). Table 3.1 may change if needed.

2. The rating curve for the same station (02310280) is shown in Figure 3.1. The stage on the y axis has a maximum of 52 ft NGVD. However, no points on the graph were recorded with a stage more than 51.5 ft NGVD for the range selected. For this station, a stage exceeding 51.5 or 52 ft NGVD is normal and the figure needs to be revised to include more pairs of discharge-stage. This may change the coefficients (a and b) for the equation of the rating curve that was used as a calibration target.

The revision may change the results slightly. The model runs and works just fine. I am ready to answer any questions. Thank you for giving me this opportunity."

Ahmed Said, Ph.D, PE.

EAS has received the review comments by the District (Dr. Ahmed Said, P.E.) on the draft report of Pithlachascotee River HEC-RAS Modeling. Our response to the review comments follows:

1. The USGS 02310280 provides data from 1983-10-01 to 2010-02-08 for stage and discharge. The relation between this station (y) and USGS 02310300 (x), shown in Figure 2.3, needs to be revised based on the period of measurements. The coefficient "a" could be less than 0.27 (I expected it in the range of 0.20 from the beginning to the end of the available data). Table 3.1 may change if needed.

Response: For all three USGS stations in the study area, the cut-off date is selected at 2009-09-30 for this HEC-RAS modeling project as the record data after this date has not been checked and approved by USGS.

In the development of the proportional relationship between USGS 02310280 and USGS 02310300 (Figure 2.3 in the Draft Report), two approaches were selected and evaluated in this analysis: 1) using only the flow record for low flow conditions (over 90% time), i.e., 100 CFS or less at USGS 02310300 at the downstream boundary; see Figure 1; and 2) using all available flow record, see Figure 2. The objective of this project is to assist in the determination of the minimum flows and levels; therefore, the first approach is more appropriate to describe the relationship between these two stations during the low flow conditions.

2. The rating curve for the same station (02310280) is shown in Figure 3.1. The stage on the y axis has a maximum of 52 ft NGVD. However, no points on the graph were recorded with a stage more than 51.5 ft NGVD for the range selected. For this station, a stage exceeding 51.5 or 52 ft NGVD is normal and the figure needs to be revised to include more pairs of discharge-stage. This may change the coefficients (a and b) for the equation of the rating curve that was used as a calibration target.

Response: In the Draft Report, the rating curve used for USGS station 02310280 was generated by using all historical flow/stage data (Daily Average) for this station, as shown on Figure 3. Figure 3.1 in the Draft Report only displays the partial of the same rating curve to highlight the low flow conditions.

EAS also realized that the USGS rating curves were usually developed from individual discharge measurements, not from daily average values as used in the Draft Report. In many streams in Florida, the discharge measurements may be similar to the daily average for the same day, but in other cases, the regression analysis from daily average values may not be appropriate.

There are a total of 307 individual discharge measurements available since 1964. 232 of 307 measurements were rated as good, fair or excellent by USGS and therefore selected to develop the rating curve in the regression analysis, as shown on Figure 4, and the R^2 value is 0.96. Apparently, the new developed rating curve fits better to the measured data in both low and high flow conditions. So, the new developed rating curve will be used in the model calibration. The HEC-RAS model and report will be revised accordingly.

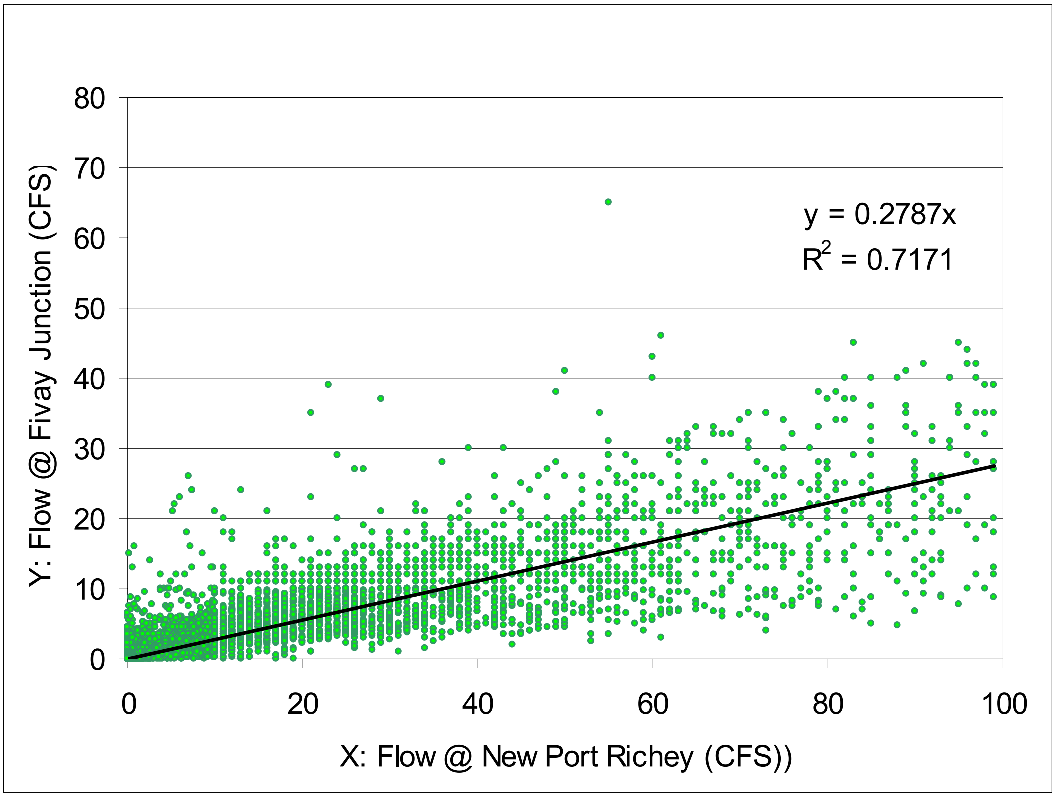

Figure D.1. Regression Analysis of Flow @ New Port Richey vs. Flow @ Fivay Junction (Over 90% Time)

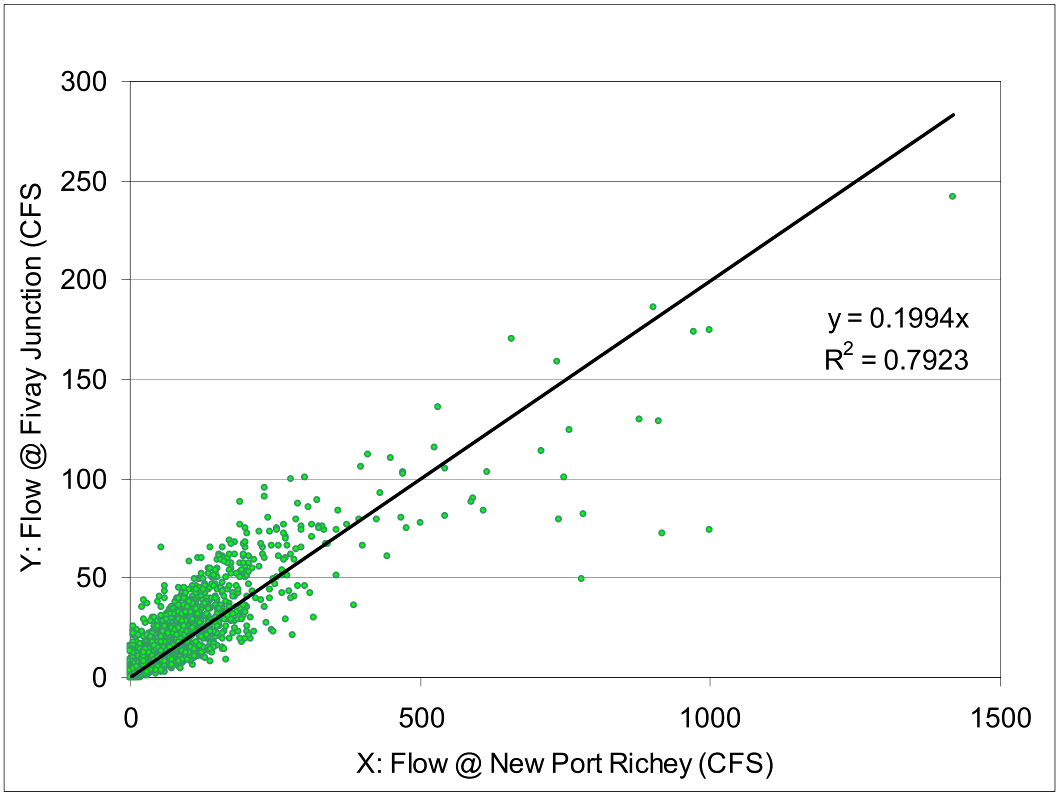

Figure D.2. Regression Analysis of Flow @ New Port Richey vs. Flow @ Fivay Junction (All Time)

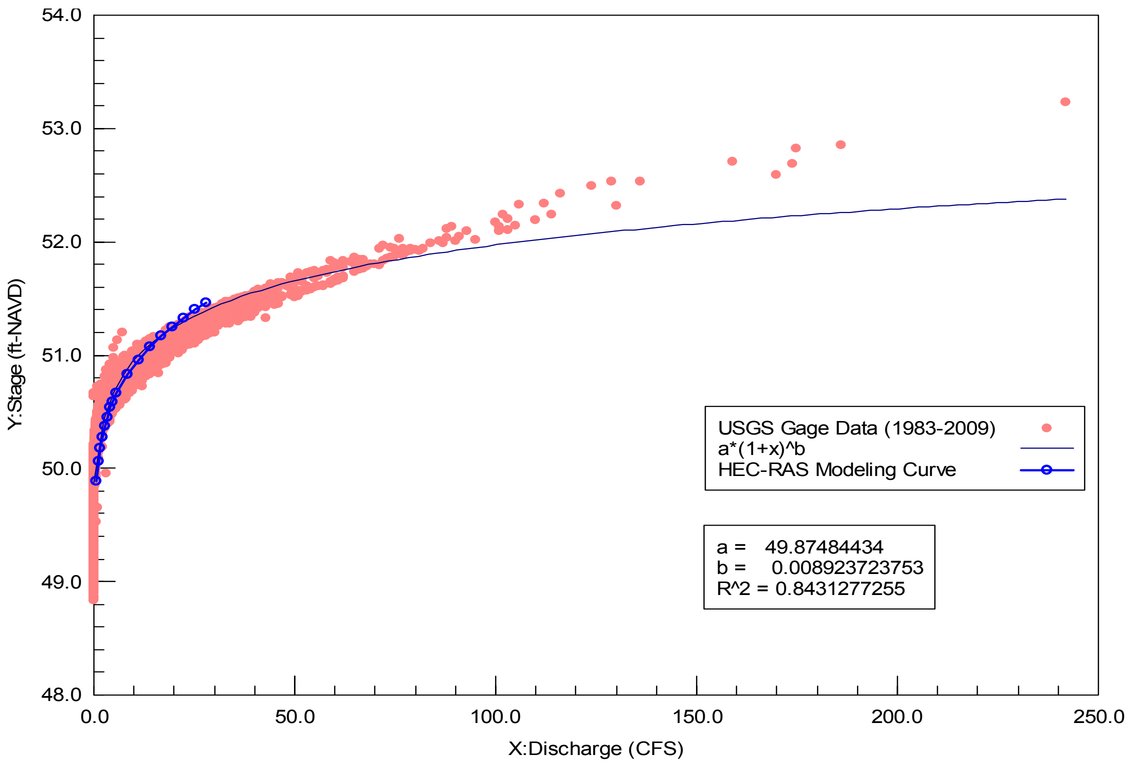

Figure D.3. Flow-Stage Rating Curves of USGS Cotee @ Fivay Junction (Daily Average)

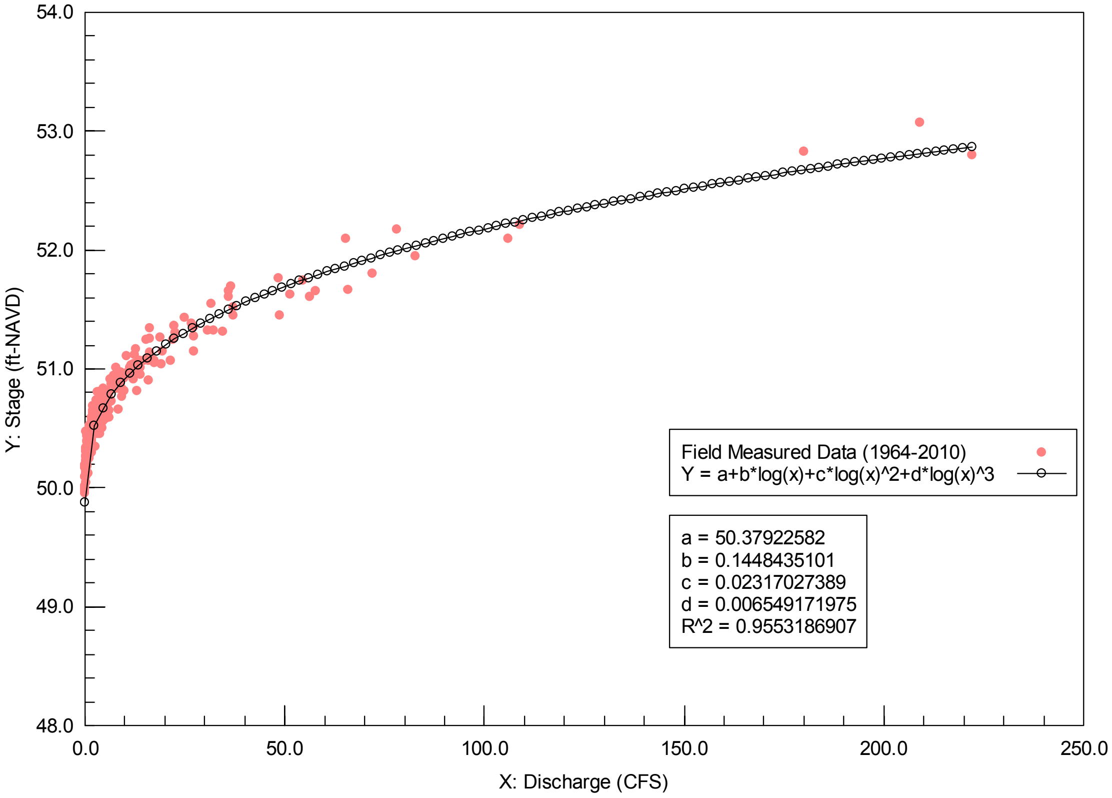

Figure D.4. Flow-Stage Rating Curves of USGS Cotee @ Fivay Junction (Discharge Measurements)

APPENDIX 4C

IFIM/PHABSIM PROTOCOL

Pithlachascotee River

Started with IFG4 deck/file containing all transects and all calibration sets. These were entered from downstream to upstream with a dummy transect.

Three sets of transects were examined:

- Veg 2 #8 from low flow measurement of 3.614 cfs, a medium flow of 12.371 cfs, and a high flow of 22.543 cfs. The range of flows simulated was from 1.4 cfs to 50 cfs.
- Veg 4 data from low flow (1.826 cfs), medium flow (5.684 cfs) and high flow (11.896 cfs). Simulated flows ranged from 0.7 cfs to 24 cfs.
- Veg14 data from low low flow (1.061 cfs), medium flow (17.252 cfs) and high flow (25.802 cfs). Simulated flows ranged from 0.4 cfs to 52 cfs.

The simulated flow ranges used in the time-series analysis were from gaging records between 1990 and 2000. This is a corrected flow record from Janicki.

The following codes were entered on the N/S lines:

CODE	DESCRIPTION
0	**Delimiter**
1	No cover and silt **or** terrestrial vegetation
2	No cover and sand
3	No cover and gravel
4	No cover and cobble
5	No cover and small boulder
6	No cover and boulder, angled bedrock, or woody debris
7	No cover and mud or flat bedrock
8	Overhead vegetation and terrestrial vegetation
9	Overhead vegetation and gravel
10	Overhead vegetation and cobble
11	Overhead vegetation and small boulder, boulder, angled bedrock, or woody debris
12	Instream cover and cobble
13	Instream cover and small boulder, boulder, angled bedrock, or woody debris
14	Proximal instream cover and cobble
15	Proximal instream cover and small boulder, boulder, angled bedrock, or woody debris

16	Instream cover or proximal instream cover and gravel
17	Overhead vegetation or instream cover or proximal instream cover and silt or sand
18	Aquatic Vegetation – macrophytes
100	**Delimiter**

The IFG4 predicted WSL's were placed in a (hand-made) table to be compared with observed WSL's for the given discharges on the CAL lines. The predicted WSL’s were all within 0.2 ft of the observed values [accepted surveying error for the “tourch” technique] and IFG4 was considered to be an adequate predictor.

A second discharge is added to each CAL line (see A.51 from the PHABSIM user's manual). This second discharge is the calculated flow for that transect using the velocities measured. This is used as a secondary adjustment factor when predicting velocities and roughness coefficients.

The IFG4 input decks/files were then converted to several IFG4 input decks/files, each with a single velocity set, corresponding to measured calibration sets. The simulated discharges overlap but encompass the measured discharge for that calibration set.

	VEG2A. in4	VEG2B.in4	VEG2C.in4
Simulated Discharge Range	1.4 – 4.3 cfs	3.9 – 15 cfs	11 - 50 cfs
	BRK4A.in4	BRK4B.in4	BRK4C.in4
Simulated Discharge Range	0.7 – 3.7 cfs	3.3 – 6.2 cfs	5.8 - 24 cfs
	VEG14A.in4	VEG14B.in4	VEG14C.in4
Simulated Discharge Range	0.4 – 4.6 cfs	3.8 – 17 cfs	13 – 52 cfs

For each *.IN4 model, an IFG4 run was made. VAF (Velocity Adjustment Factor) values are checked. The slope of the VAF values must be positive. The VAF value at the discharge for which the velocity set is given should be between 0.85 and 1.15. Ideally, such a tight fit allows expansion of the simulation beyond .4 x the lowest discharge and 2 x the highest discharge. If the VAF values are low, no such expansion is recommended.

- Where VAF slope was a problem for a particular transect, WSL's are adjusted up or down [usually lowering WSL increases VAF value and increasing WSL decreases VAF value for given discharge] (based upon the range of WSL's [right bank, center, and left bank] measured in the field).

In all cases, VAF values were found to be acceptable, but low, since all slopes were positive (ranging from 0.714 to 1.172 in each case).

[Note: the table of VAF values is presented after adjustment of Manning's "n" values for some data points]

Discharge	VEG2a	VEG2b	VEG2c
3.614 (TR1)	0.988	0.972	0.887
12.371	1.005	1.001	0.929
22.543	1.054	1.053	0.984
Discharge	VEG2a	VEG2b	VEG2c
3.614 (TR2)	0.996	0.603	0.737
12.371	1.231	0.714*	0.908
22.543	1.319	1.758	1.008
Discharge	VEG2a	VEG2b	VEG2c
3.614 (TR3)	0.978	0.124	0.621
12.371	1.262	0.164*	0.879
22.543	1.299	0.178	1.003
Discharge	VEG4a	VEG4Sb	VEG4c
0.321 (TR1)	1.028	0.815	0.817
1.451	1.389	0.981	0.972
9.197	1.568	1.018	1.039
Discharge	VEG4a	VEG4Sb	VEG4c
0.321 (TR2)	1.013	0.700	0.490
1.451	1.728	1.089	0.851
9.197	2.083	1.117	1.045
Discharge	VEG14a	VEG14b	VEG14c
0.321 (TR1)	0.999	0.613	0.824
1.451	1.328	0.906	0.862
9.197	1.241	0.895	0.792**

* Unreliable simulation at medium flows (no velocity calibration data); may not be critical to MFL evaluation

** Unreliable simulation at high flows; probably not critical to MFL evaluation

After each *.IN4 file/model was calibrated to produce the best VAF's possible, the roughness values ("n") **calculated by IFG4** for each transect was checked. Those with values greater than 0.2 are chosen for adjustment. For each transect with some "n" values greater than 0.2, the mean value for "n" is calculated. Those "n" values above the median value are replaced with the mean value on the NS lines of the *.IN4 deck/file. This approach tries to adjust the worst problems without making drastic changes in WSL predictions and it is transect-specific [as compared to creating an NMAX line]. Professional judgment was also used, in some cases, to adjust other "n" values, where appropriate.

After "n" adjustments, IFG4 was run, again, with the adjusted roughness values and particular attention was placed on the predictions of velocities at the highest discharges. Each IFG4 output was checked for velocity "hot spots" at the high discharge simulations. Where predicted velocities exceeded 4.5 fps in a single cell **and** adjacent cells had low velocities, higher "n" values for that vertical/cell were added to the NS lines in the *.IN4 deck/file. This inserted "n" value was usually derived from the "n" values predicted by IFG4 for adjacent cells. When several contiguous cells had velocities that ranged from 3 to 6 fps (especially at high discharges), they were considered to be acceptable (i.e., **not** hot spots).

HABTAV was run with the appropriate HSI models for the "A", "B", "C", etc., models and the ZHAQF output files were examined. These contained habitat (WUA) versus discharge relationships for overlapping discharge ranges.

The overlapping ZHAQF values were combined on a spreadsheet (XCEL or SigmaPlot) into a single habitat versus discharge relationship. Weighted averages were used to combine the overlapping WUA values (these were different since different VAF values to adjust predicted velocities were not the same for comparable discharges in different runs). When an abrupt "jump" in the relationship occured, a plot of WUA/Q values is created and a curve smoothing routine (usually a third or fourth-order polynomial regression in SigmaPlot) was used for those values.

The WAU / Discharge results were prepared for the final report of WUA and Discharge and were the values used for time-series analysis.

Time-Series Analysis

Only one set of discharge data was assessed, from 1990-2000.

The TSLIB (time-series library) from the USGS Mid-Continent Research Laboratories was used to conduct the analysis.

Monthly discharge files were created for existing conditions, 10% monthly flow reductions, 20% monthly flow reductions, 30% monthly flow reductions, and 40% monthly flow reductions. For each set of discharge conditions, a monthly time-series was created as the amount of habitat (WUA) available for each discharge for each month. HAQ files (habitat availability) were created for the high discharge events by linear (first-order regression) or curvilinear (second-order polynomial regression) fits. Duration analysis was then accomplished through the percentage of time that the average and median habitat values were met or exceeded for each month over the period of record. Comparisons to existing conditions were made to evaluate the amount of habitat gain or loss under conditions of reduced flow.

For Pithlachascotee River, the time series analysis ranged over discharges from 0 cfs to 1943.6 cfs, between the years 1990 and 2000. Monthly mean flows were utilized, reducing the maximum values simulated to 474.07 cfs.

During this analysis, habitat suitability curves for both “catalog” (USGS Blue Books of habitat suitability) and locally derived HIS’s were compared. Although the catalog and locally derived curves were quite similar, there was sufficient difference in at least one category of local preference (usually in substrate/cover preference, more often than not) that the predicted amount of available habitat was an order of magnitude less for Florida curves as opposed to catalog curves. This result supports conclusions by Gore and Nestler (1988) and Gore et al. (2001) who have indicated that habitat-specific derivations of suitability curves are the most appropriate application for this type of analysis.

The following habitat suitability criteria were used:

Habitat Guilds [as indicators of habitat diversity]:

1. Shallow-Slow
2. Shallow-Fast
3. Deep-Slow
4. Deep-Fast

Largemouth Bass

1. Adult
2. Juvenile
3. Spawning
4. Fry

Bluegill

1. Adult
2. Juvenile
3. Spawning
4. Fry

Spotted Sunfish

1. Adult
2. Juvenile
3. Spawning
4. Fry

Benthic Macroinvertebrates

1. Total Community Diversity

Cyprinidae (minnows)

1. Combined all adult life stages

References:

Gore, J.A., and J.M. Nestler. 1988. Instream flow studies in perspective. *Regulated Rivers* 2: 93-101.

Gore, J.A., J.B. Layzer, and J. Mead. 2001. Macroinvertebrate instream flow studies after 20 years: a role in stream and river restoration. *Regulated Rivers* 17: 527-542.

APPENDIX 4D

SWRF, L.L.C. and Dooris & Associates, LLC. 2010. Characterization of wetland vegetation communities in the corridor of the freshwater portions of the Pithlachascotee River. Tampa and Brooksville, Florida. Prepared for the Southwest Florida Water Management District, Brooksville, Florida.

Characterization of Wetland Vegetation Communities in the Corridors of the Freshwater Portions of the Pithlachascotee River

FINAL REPORT
June 2010

Submitted to
Southwest Florida Water Management District

SWRF LLC

D&A A Certified WBE Company
Dooris & Associates, LLC

CHARACTERIZATION OF WETLAND VEGETATION COMMUNITIES IN THE FRESHWATER SEGMENT OF THE PITHLACHASCOTEE RIVER

FINAL REPORT
June, 2010

Submitted to

Southwest Florida Water Management District
2379 Broad St
Brooksville, FL 34604-6899

Submitted by

SWRF, L.L.C.
PO Box 17878
Tampa, FL 33682-7878

And

Dooris & Associates, LLC
PO Box 10368
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Executive Summary

Chapter 373, Florida Statutes, directs the Southwest Florida Water Management District (DISTRICT or SWFWMD) to develop minimum flows for watercourses within its boundaries in accordance with a Board-adopted priority schedule. A minimum flow or level (MFL) for a watercourse is defined as "The limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area [Chap. 373.042(1)(a)]." The law provides further that MFLs shall be calculated using the best available information. Revised in 1997, the law now requires that when establishing MFLs, changes and structural alterations to watersheds, surface waters and aquifers shall also be considered [Chap. 373.0421(1)(a), (1)b, FS]. The current State Water Policy includes additional guidance for the establishment of MFLs, providing that consideration shall be given to the protection of water resources, natural seasonal fluctuations in water flows and levels, and environmental values associated with coastal, estuarine, aquatic, and wetland ecology.

The DISTRICT is committed to developing scientifically defensible data by means of accepted methodologies and analyses. Data thus collected will be used in support of the establishment of minimum flows on priority watercourses.

This project pertains to the development of data and analyses relating to the ecology, soils, and physical characteristics of the Pithlachascotee River that will be considered in the determination of minimum flows for the River in calendar year 2011 (Board Approved 2010 Minimum Flows and Levels Priority List and Schedule). The purpose of this project is to produce accurate technical data on the composition and distribution of plant communities and the hydric affinities of the soils present at select locations within the Pithlachascotee River floodplain.

All field data collection was performed between the months of June through August 2009. The project has resulted in a report, data files, statistical and ecological analyses and photographs describing conditions in the river floodplain as they relate to the establishment of minimum flows and levels. A total of 15 transects of the river floodplain were established and sampled for this project. The transects were located roughly between the Starkey Environmental Education Center and 0.33 miles downstream of the confluence of the Pithlachascotee River with Five-mile Creek. Quantitative sampling was done using the point-centered quarter method for trees and shrubs. Data were obtained from a total of 544 sample points for trees and shrubs. Visual inspection was used to prepare a list of groundcover species for each community. Data from a total of 408 sample points were obtained for soils. At each point, soils were sampled down to 20 inches using a standard soil boring apparatus and the presence of hydric indicators was recorded. All data collected in the field were entered into files prepared for this project. Following data entry, a quality assurance review was done and backed-up on a minimum of two other electronic devices. All of the data from the field sampling have been provided to the DISTRICT'S Project Manager.

The Pithlachascotee River within the project study reach, with an average topographic gradient of 5.0 feet/linear mile, has relatively little topographic relief. The floodplain zone of the study reach of the River is characterized as also having small topographic gradients. Topographic gradients across the transects were slight and averaged 0.004 ft of vertical drop per foot of horizontal distance along each transect. The cross sections at the transect locations show a complex topography across the channel and floodplain at all transects. This observation is consistent with on-the-ground observations that the Pithlachascotee River floodplain is very flat with a flow way that is highly braided and is characterized by multiple channels and flow ways that are separated by areas of higher elevations.

The Florida Natural Areas Inventory (NWI) plant community classification system was used as a guide to assigning community types to the assemblages of plant species observed along the 15 transects. Using this system, the floodplain vegetation along the transects was grouped into three communities: Floodplain Swamp, Bottomland Forest, and Hydric Hammock.

The characteristics of the tree strata in each community were described by a variety of ecological parameters, including Importance Value, Dominance, Relative Dominance, Frequency, Relative Frequency, Species Diversity, Community (Species) Similarity, Species Richness, Absolute Density, Density, and Wetland Affinity Index. The statistical relationships among four physical parameters (elevation, relative elevation, distance from channel, and soil index number) were explored using Discriminant Function Analysis. The statistical relationships between communities based on Importance Values, Dominance, Frequency and Density using Wilcoxon Signed Rank tests. The shrub strata were examined similarly with the deletion of Importance Values and Dominance.

A summary description of the three communities, listed in order of normal hydroperiod characteristics, follows:

- Floodplain Swamp was dominated by swamp tupelo and bald cypress with American elm and red maple as primary associates as judged by the calculation of Importance Value for all trees species encountered. Laurel oak and water tupelo were next in Importance Value, followed by 18 other tree species in small numbers.
- Bottomland Forest was characterized by the dominance of laurel oak and swamp tupelo, while bald cypress and American elm were the primary associates. Next in Importance Value were red maple and American hornbeam, followed by 15 other species in small numbers.
- Hydric Hammock was dominated by laurel oak and bald cypress with American elm and pignut hickory as primary associates. Twelve other species were present in small numbers.

The data collected described a floodplain that is highly diverse in terms of plant species composition and having three intergrading plant communities. The data collected allowed the development of several important community descriptors which should be useful in determining minimum rates of flow and minimum water elevations. Some of the more important community descriptors include the following:

1. The three communities were not present on all transects and were not represented equally on all transects.

2. Floodplain Swamp and Bottomland Forest were characterized by almost complete coverage by hydric soils, while Hydric Hammock had slightly lower coverage by soils indicative of saturated conditions.
3. Species Richness was highest in the Hydric Hammock and Bottomland Forest (19) and lowest in Floodplain Swamp (16).
4. Floodplain Swamp was the only community having cypress in three of the larger size classes: 26-30 cm, 46-50 cm, and 51-55 cm
5. For trees, Floodplain Swamp had the lowest Index of Species Diversity (ISD) at 0.872 out of a possible 1.0, while the other two communities had ISDs that were approximately equal at 0.91 for Bottomland Forest and 0.92 for Hydric Hammock.
6. The calculations show that a high degree of similarity exists among the communities in terms of the tree species composition as the Index of Similarity ranged from 0.85 to 0.91 out of a possible 1.0. In terms of shrub species, somewhat less similarity was evident among the communities. Floodplain Swamp compared to Hydric Hammock showed a low IS (0.51), while Floodplain Swamp compared to Bottomland Forest showed a high IS (0.82). Bottomland Forest compared to Hydric Hammock also resulted in an IS of 0.51.
7. Based on Importance Values for trees, Floodplain Swamp had the highest Wetland Affinity Index (0.86) and Hydric Hammock had the lowest (0.32). The Index for Bottomland Forest was intermediate between the two other communities (0.74).
8. The tree Absolute Density was virtually the same for the three communities, ranging from approximately 610 trees/hectare to 680 trees/hectare.
9. Floodplain Swamp exceeded the other two communities in terms of trunk diameter of cypress and in the numbers of cypress of all trunk diameters.
10. Hydric Hammock had the smallest cypress tree diameters.
11. Shrub Absolute Density was highest in the Hydric Hammock (~1190 shrubs/hectare) and lowest in Floodplain Swamp (~240 shrubs/hectare).
12. Of the three communities, the density of groundcover species was lowest in the Floodplain Swamp and highest in the Hydric Hammock.
13. Of the 24 species included in the tree strata of the communities, 13 were present in all three communities. Of the 29 species included in the shrub strata of the communities, eight were present in all three communities.
14. Floodplain Swamp had no community-specific species in the tree stratum. Two species were found in only the Bottomland Forest, large specimens of wax myrtle and buttonbush. The following species were observed only in the tree component of the Hydric Hammock: sour orange, persimmon, loblolly bay, Southern magnolia, and highbush blueberry.
15. Four species were found only in the shrub stratum of the Floodplain Swamp: dahoon, Carolina willow, blackberry and wild coffee. Four species were found only in the shrub stratum of the Bottomland Forest, Virginia willow, sour orange, fetterbush, and water tupelo saplings. Four species were found only in the shrub component of the Hydric Hammock: highbush blueberry, four-petaled St John’s Wort, and saplings of red cedar and loblolly bay.
16. The Species Richness for trees for all of the transects together, regardless of community type, was 24, while that for shrubs was 29.

Two hydrologic indicators were used in this project: the lower elevation of moss collars on trees and the waterward extent of saw palmetto. The second indicator was interpreted as marking the edge of the wetland (EOW) community along the transect, and as such, served as a guide to seasonal high water elevations at each transect location. The elevations of the moss collars used as hydrologic indicators were higher than that of the channel bottom. With two exceptions, the elevation of the moss collar indicator for the three communities followed the pattern, from lowest to highest, of Floodplain Swamp, then Bottomland Forest, lastly Hydric Hammock. With two exceptions, the moss collar hydrologic indicator elevations for the Floodplain Swamp were lower than both of the EOW elevations on each transect. With one exception, the moss collar hydrologic indicator elevations for the Hydric Hammock were slightly higher (average = 0.31 ft) than both of the Edge-of-Wetland elevations on all transects where that community was present. In the case of Bottomland Forest, the moss collar hydrologic indicator elevations were inconsistent with respect to the EOW elevations on each transect.

Using the Wilcoxon Signed Rank Test, there were no statistically significant differences in tree distribution calculated for any of the tree parameters, chiefly because the means of the parameters were virtually identical and Standard Deviations exceeded the values of the means. For shrubs, statistically significant differences were seen in shrub Absolute Density (AD). Comparison of Floodplain Swamp to Hydric Hammock showed a significant difference (P=.047) in shrub absolute density. There was also a significant difference (P=.003) in a comparison of Bottomland Forest to Floodplain Swamp for ADs of shrubs. There was not a significant difference between Bottomland Forest and Hydric Hammock with respect to shrub AD.

The Discriminant Function Analysis procedure and the Wilk's *lambda* test were used to determine the physical variables that were most important in differentiating one plant community from another. Results showed that relative elevation was the most important variable followed by soil index of the four variables examined (which also included elevation and distance from river channel). Using the model generated during this analysis, Bottomland Forest was correctly classified 37 times out of 156 for a total of 23.72%. Floodplain Swamp was correctly classified 100 times out of 180 for a total of 55.56% and Hydric Hammock was correctly classified 51 times out of 66 for a total of 77.27%. The model is best able to discriminate Hydric Hammock communities but is less effective in predicting the location of Bottomland Forest.

Bottomland Forest, as a transitional community between Floodplain Swamp and Hydric Hammock, showed less community specificity than the other two communities and was characterized in several transects as having a great deal of similarity to the other two communities in terms of tree species composition..

Plant species composition, alone, cannot differentiate communities definitively.

The Edge-of-Wetland (EOW) markers on the transects defined a linear distance that was useful as a guide for the horizontal extent of floodplain vegetation. EOW distances compared well with wetted perimeter distances. Also, the EOW elevations and the Hydric Hammock moss collar elevations compared well and may be useful as a guide for desirable seasonal high water elevations in the study reach of the River under normal conditions.

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INTRODUCTION

Chapter 373, Florida Statutes, directs the DISTRICT to develop minimum flows for watercourses within its boundaries in accordance with a Board-adopted priority schedule. A minimum flow or level (MFL) for a watercourse is defined as “The limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area [Chap. 373.042(1)(a)].”

The law also provides that MFLs shall be calculated using the best available information. In the establishment of an MFL, non-consumptive uses and seasonal variations may be considered. Revised in 1997, the law currently requires that when establishing MFLs, changes and structural alterations to watersheds, surface waters and aquifers shall also be considered [Chap. 373.0421(1)(a), (1)b, FS]. The current State Water Policy includes additional guidance for the establishment of MFLs, providing that consideration shall be given to the protection of water resources, natural seasonal fluctuations in water flows and levels, and environmental values associated with coastal, estuarine, aquatic, and wetland ecology, including:

- Recreation, in and on the water;
- Fish and wildlife habitats and the passage of fish;
- Estuarine resources;
- Transfer of detrital material;
- Maintenance of freshwater storage and supply;
- Aesthetic and scenic attributes;
- Filtration and absorption of nutrients and other pollutants;
- Sediment loads;
- Water quality; and
- Navigation (Chap.62-40.473, F.A.C.).

The DISTRICT is committed to developing scientifically defensible data by means of accepted methodologies and analyses. Data thus collected will be used in support of the establishment of minimum flows on priority watercourses.

This project pertains to the development of data and analyses relating to the ecology, soils, and physical characteristics of the Pithlachascotee River that will be considered in the determination of minimum flows for the River in calendar year 2011 (Board Approved 2010 Minimum Flows and Levels Priority List and Schedule). The purpose of this project is to produce accurate technical data on the composition and distribution of plant communities and the hydric affinities of the soils present at select locations within the Pithlachascotee River floodplain. The project will result in a report, data files, statistical and ecological analyses and photographs describing conditions in the river floodplain as they relate to the establishment of minimum flows and levels.

METHODS USED IN THE STUDY

FIELD METHODS

Sampling site selection

Following a review of SWFWMD 2007 land use mapping, NWI mapping and consultation with District personnel, staff from SWRF, L.L.C. (SWRF) and Dooris & Associates (D&A) selected and mapped a total of 20 potential vegetation transects. The potential transects were discussed and evaluated during meetings and field visits by the staffs of SWRF, D&A and SWFWMD in December 2008. A final group of 15 vegetation transects were selected from the pool of 20 potential transects. Transects were approved by SWFWMD staff and mapped for use in the project. Figure 1 illustrates the locations of all 15 transects, their lengths and the positions in latitude/longitude of the entry locations for each transect.

As part of the evaluation process, the suitability of each potential transect for use in the project was determined based on four major criteria:

1. how well each transect represented the plant communities within the project area;
2. whether the transect was located on public lands or private lands;
3. total transect length, and
4. degree of difficulty in accessing the transect.

Located within a 5.0-mile (river miles) reach of the Pithlachascotee River, all 15 transects crossed the river corridor and flood plains and were positioned so as to be perpendicular to the stream channels. The easternmost transect, Transect 15, was located at a point 1.29 miles west of the Suncoast Parkway at 28°17’45.2”N x 082°34’18.9”W, while the westernmost transect, Transect 1, was located at a point 5.45 miles west of the Suncoast Parkway at 28°15’22.2”N x 082°38’28.2”W.

Marking transects prior to ecological sampling

Following the final selection of transects, revised maps together with the geographical positions of the termini of each transect were provided to SWFWMD surveyors. In the field, the SWFWMD surveyors cut a narrow trail between the termini of each transect, and then marked the trail with survey tape in preparation for the final positioning of transect markers by D&A staff. Once the surveyors had completed the preliminary marking, D&A staff walked each transect and established markers to be used in the actual collection of data on soils, physical features, and vegetation present on each transect.

An illustration of the organization of a typical transect is provided in Figure 2. To mark each of the various sampling locations on each transect, D&A staff used a consistent notation convention. To delineate the beginning and end points for the plant communities encountered along the transects, markers were inserted into the ground at appropriate points. The markers were numbered by transect number and community marker number. For example, the first marker on Transect 1 for a community type was “TR1-C001,” and the second community marker along the transect was numbered “TR1-C002” and so on; all community markers consisted of 36” orange survey flags and the numbers were written in permanent black ink on the flag.

Within each community, the locations of stations for vegetation sampling were selected along the transect so that a minimum of three sampling stations occurred in all communities. The stations were numbered with the transect number and a station number. For example, the first vegetation sampling station in Transect 1 was numbered “TR1-P001,” while the second station was numbered “TR1-P002” and so on. All sampling station markers consisted of 36” orange survey flags and numbers were written in permanent ink on the flag. Data were obtained from a total of 544 sample points for trees and shrubs. These data sampling points were distributed by community as follows: Floodplain Swamp - 244 points, Bottomland Forest – 212 points, and Hydric Hammock – 88 points. Visual inspection was used to prepare a list of groundcover species for each community.

Three soil sampling points were selected at each vegetation sampling station (P-station), and each point was marked and labeled with the transect number and the sequential soil sampling point number. For example, the first soil sampling point on Transect 1 was numbered “TR1-S001” and the second soil sampling point was numbered “TR1-S002” and so on. All soil markers consisted of 36” orange survey flags and numbers were written in permanent ink on the flag. Data from a total of 408 sample points were obtained for soils.

Hydrologic indicators were marked at select P-stations in each community by inserting a nail with an attached orange survey tape in trees showing each indicator; all hydrologic indicator markers were numbered with the transect number and the indicator number. For example, the first indicator for Transect 1 was numbered as “TR1-H001” and the second indicator was numbered “TR1-H002” and so on for a total of 108 hydrologic indicators for the 15 transects.

A log of all markers was maintained by D&A personnel for each transect showing each marker number for all of the sampling points and their locations together with their relative distances from other markers on the same transect. When the ecological sampling was completed on each transect, all logs were provided to the SWFWMD surveyors and project manager. The SWFWMD surveyors then visited each transect and obtained the latitude, longitude and elevations of the community, vegetation, soils, and hydrologic markers.

As markers were established and the ecological/soils sampling completed, digital photographs were taken from the on-the-ground perspective from several points along the transect. All 97 photographs were labeled, catalogued and provided electronically to the SWFWMD Project Manager.

Community determination

The determination of the communities present on each transect was made by a visual inspection of each transect, looking specifically for species composition and vegetation transitions along the transect. Communities were identified in accordance with community descriptions developed by the Florida Natural Areas Inventory (FNAI) in its 2009 revisions to the 1990 Guide to the Natural Communities of Florida (FNAI, 2009). For the communities identified in this project, there were no changes between the 1990 document and the 2009 revisions. The FNAI system was selected in order to employ a well known and accepted classification system and because the FNAI treatment of floodplain vegetation is particularly descriptive of the species groupings included in each community.

Vegetation sampling

The point centered quarter method was used to sample both the trees and the shrub components of the plant communities identified (Cottam and Curtis, 1956). Sampling was performed at points commencing 15 feet into a community and then every 50 feet for a minimum of three and a maximum of five samples per community. Samples were not collected closer than 15 feet from an adjoining community to avoid sampling the same tree more than once. At each vegetation sample station (P station), the 4-arm point centered quarter (PCQ) apparatus was anchored to the ground with the “A” arm pointing to the transect start and the “B” arm pointing toward the transect end. In each of the four quarters of the apparatus, the species of the nearest tree and the tree’s distance to the center of the apparatus was measured. In addition, the D^{137} (tree diameter at 137cm from the ground) of the nearest tree in each quarter was measured. For this project, trees were defined as woody plants with a diameter breast height (dbh) $\geq$ 2.54 cm. For shrubs, defined as woody plants having a height of $\leq$ 50 cm in height and a dbh $\leq$ 2.54 cm, the distance to nearest shrub in each quarter was measured and the species noted.

A qualitative list of the plant species occurring in the groundcover was also prepared for each community based on visual observations in the vicinities of the P stations.

All data were recorded on field sheets with a specific identifier consisting of the transect number and a sample point designator. The PCQ apparatus was removed and a survey flag marker placed in the same position with the same designator as the field sheet for later determination of elevation and location (latitude/longitude) by surveyors.

Hydrologic indicator determination

While other hydrologic indicators were present on the transects as a whole (lichen lines, lenticels, hummocks), the hydrologic indicator selected for this work was the lower elevation of the moss collars on trees. The use of mosses as hydrologic indicators has both advantages and disadvantages. Advantages include the fact that a few mosses are very sensitive to hydric regimes, and they are immobile, thus reflective of site conditions. Disadvantages include the fact that few regional field databases for mosses versus hydroperiod exist (Adamus, 1990; Carroll, 2003; Carr et al., 2006). Nevertheless, this choice was made because the moss collar was present in all communities along all the transects, making trend identification among transects more meaningful.

The waterward location of saw palmetto, well accepted as both a hydrologic indicator and the location of the edge of wetland (EOW), was also marked as a hydrologic indicator.

Soils assessment

At each PCQ location, three soil samples were taken. Sample one (TR1-S001) was taken five feet from the PCQ point in the direction of the entry terminus of the transect and on the transect line. Sample two (TR1-S002) was taken five feet in the direction of the exit terminus of the transect and sample three (TR1-S003) was taken a further 5 feet in the direction of the exit terminus of the transect (at a total of 10 feet from PCQ point). At each sample location, a minimum 50 cm boring was obtained using an AMS open-end Soil Boring apparatus and the resultant soil core examined. Soil characteristics were determined by visual inspection and recorded on a specific field sheet for each sample location.

Soils were identified as hydric or non-hydric and as flooded or not flooded. Other indicators recorded for each soil column included:

- A1. Histosol
- A2. Histic epipedon
- A3. Black histic
- A4. Hydrogen sulfide
- A5. Stratified layers
- A6. Organic bodies
- A7. 5 cm mucky mineral
- A8. Muck presence
- A9. 1 cm muck
- S5 Sandy Redox
- S6. Stripped matrix (Hurt and Vasilas, 2006).

Based on the presence of hydric indicators, each soil sample was assigned a soil index number from 0 to 4 as follows:

0. Soil exhibited no evidence of flooding or hydric conditions
1. Hydric soils
2. Soil is hydric with muck
3. Soil is hydric and saturated
4. Soil is hydric and saturated with muck.

Elevation data

The SWFWMD surveyors obtained the elevations and locations of the markers that D&A staff had placed along the transect to identify plant communities, vegetation sampling points, soil sampling locations, and hydrologic indicator elevation; the surveyors also provided the bottom elevations of the stream channel where the transects crossed the channel. The survey data were provided by SWFWMD to SWRF and D&A. The elevation data were used to calculate and graph the wetted perimeter of the stream channel and floodplain as represented by each transect, to produce cross sections of each transect, determine the average elevations for each community in each transect, and for use as a parameters in Discriminant Function Analysis.

DATA HANDLING AND STATISTICAL METHODS

Data collected in the field were reviewed for quality control purposes and entered into project-specific electronic files. All files which were backed up on two different media maintained in separate locations. Data were analyzed using appropriate (parametric *versus* non-parametric) techniques. Descriptive statistics, analytical statistics, and select community-level ecological parameters were calculated. Descriptive statistics organized and presented the data collected for each transect and for each community as a whole; community descriptors were obtained by combining the data for each community from each transect. Data were prepared for use in the calculation of numerical analyses and ecological parameters. Analyses included:

- discriminant function analysis (DFA) with supporting tests to determine the relationships among soil elevations, relative elevations, soil index number, and soil sample distance from channel center;
- the Wilcoxon Signed Rank test on tree Importance Values, absolute densities, absolute frequencies and absolute dominance;
- the Wilcoxon Signed Rank test on the absolute densities and frequencies of shrubs;
- the density and relative density for trees and shrubs;
- the dominance (cover) and relative dominance of trees;
- the frequency and relative frequency of trees and shrubs;
- Importance Values (IV) for trees;
- species richness for trees and shrubs;
- Simpson’s Index of Similarity for trees and shrubs;
- Simpson’s Index of Diversity for trees and shrubs;
- Simpson’s Index of Dominance for both trees and shrubs
- Wetland Affinity Index.

Analytical statistics were performed using XLSTAT 2010.2.02 (AddinsoftUSA, New York)

Tables and Figures showing all parameters calculated are provided in this report. All data collected and all analyses conducted were provided to the SWFWMD project manager.

MAPPING

SWRF used ESRI ArcMAP 9.3.1 on a workstation with an Intel Pentium(R) D (3.2-GHz, x86, 32-bit) processor running Windows XP (SP3). The GIS information was imported using ArcMAP's "Add XY Data" function and incorporated using processed data from the provided survey Excel spreadsheets. The Aerial Photographs are from the Southwest Florida Water Management District (2009). Additional GIS information used on the maps was from publically available sources (such as, FGDL and SWFWMD).

CHARACTERIZATION OF THE PITHLACHASCOTEE RIVER

PHYSICAL FEATURES OF THE RIVER WITHIN THE PROJECT AREA

Brief Description of the Pithlachascotee River Watershed

The Pithlachascotee River rises in Hernando County in the southeast quadrant of the US Hwy 41 / Ayers Road intersection. Surface water inputs to the River include precipitation on the River basin proper, runoff from immediately adjacent upland areas, and inflow from the Masaryktown Canal, Gowers Corner Slough and Jumping Gully. The headwaters of the river are located in the Crews Lake Outlet drainage basin at (WBID 1392A1), a 34,107-acre area that includes the northern half of Crews Lake itself. Since the 1940s, Crews Lake has been divided into approximate halves by a berm having a 60” culvert installed that allows water from the northern half of the lake to flow into the southern half of the lake at an elevation of 51.8 feet NGVD. When the lake reaches 56 feet NGVD, the lake surface occupies 1200 acres. The Masaryktown Canal, a flood-control facility owned and operated by the District drains the Crews Lake Outlet basin into the northern half of Crews Lake. Water from the 21,000-acre Jumping Gully drainage basin (WBID 1401) enters the southern half of Crews Lake (Coble 1973). When the potentiometric surface on the Brooksville Ridge is sufficiently high, water is reported to flow from the Hancock Chain of Lakes into the Jumping Gully area, thence to the southern half of Crews Lake (Ghioto and Associates, 1997). Proceeding downstream in the Pithlachascotee River watershed, the southern half of the lake is included in the Crews Lake drainage basin (WBID 1392) which occupies approximately 321 acres. Crews Lake, the Crews Lake Outlet drainage basin and the Jumping Gully drainage basin constitute the headwaters of the Pithlachascotee River. The river itself exits the southern tip of Crews Lake and flows approximately 25 miles south, then southwest and, finally northwest to discharge into the Gulf of Mexico west of the US Hwy 19 Bridge in Port Richey. Along this 25-mile route, the river picks up flows from Gowers Corner Slough (WBID 1423) and Fivemile Creek (WBID 1434) which drain areas of 4,565 acres and 6,057 acres, respectively. Waters from Gowers Corner Slough meet the river between Crews Lake and SR 52, while Fivemile Creek joins the river 2.5 miles south of SR 52 in S24-T25S-R17E. The Pithlachascotee River drainage basin (WBID 1409) occupies 27,124 acres of generally low-lying lands except in the vicinity of US Hwy 19 where former dunes increase the local elevation gradients. The tidal reach of the river (WBID 1409B) drains an area of 1,024 acres, including Miller’s Bayou, and extends approximately 0.61 linear miles upstream from the US Hwy 19 Bridge.

Rates of surface runoff in most of the watershed are generally low as a result of several closed basins and sinkholes (Coble, 1973); the presence of three wellfields within the watershed may also influence rates of surface runoff. Over the period of record (1964 through 2008), the mean annual discharge (cfs) at the USGS station on the Pithlachascotee River (#02310300), representing 180 mi^2, exceeded 54.6 cfs only in four years, 1964, 1982, 1998, and 2004 (Figure 3). In contrast, the mean annual discharge for 2004 at the USGS

Station on the nearby Anclote River (#02310000), representing 72.5 mi^2, was 158.6 cfs. Data from Station 02310300, which is in close proximity to Transect #1, indicate that the two months prior to sampling (April and May 2009) saw discharge rates lower than the POR average monthly discharge at that gage. During the months of sampling (June, July and August 2009), discharge was lower than the POR average monthly discharge for June and August, while July discharge in 2009 was nearly equal to that of the POR average monthly discharge (Figure 4).

Data from the Starkey Wilderness Park precipitation gaging station, which has been operational since 1983, show that the that the two months prior to sampling (April and May 2009) saw rainfall amounts that deviated significantly from the POR average monthly rainfall for those months (Figure 5). The rainfall amount in April 2009 was 1.04 inches less than the POR average monthly amount for April, while the rainfall amount in May 2009 was 4.28 inches higher than the POR for May. During the months of sampling (June, July and August 2009), rainfall amounts in June and August were virtually the same as the POR average monthly rainfall amounts, while the July rainfall amount was 2.65 inches above that of the POR average monthly rainfall for that month (Figure 5). Therefore, the project area experienced above average rainfall amounting to 5.42 inches during the pre-sampling and post-sampling periods.

The Pithlachascotee River watershed may be divided grossly into three areas in terms of its recharge/ discharge characteristics. From the headwaters to a point south of Crews Lake and 1.6 miles north of SR 52, aquifer recharge is estimated at >10 inches/year. From that point to the approximate location of Transect #4, the estimated aquifer recharge decreases to 1.0 – 10.0 inches/year. From the location of Transect #4 to the river mouth, the watershed is characterized as a discharge area having a rate of discharge of 1.0 – 5.0 inches/year (Aucott, 1988; SWFWMD, 1994).

The Pithlachascotee River is designated as Class III waters and available data indicated that the river supports designated uses. No reaches of the river or any of the tributaries are designated as impaired under the Impaired Waters Rule (Chap. 62-303, F.A.C.), and no Total Maximum Daily Loads (TMDLs) have been proposed for any water body in the watershed.

The Project Area

Topography of the Project Area - The Pithlachascotee River within the project area has relatively little topographic relief. From the easternmost transect (#15) and the westernmost Transect (#1), channel bottom elevations range from a high of 40’ (NAVD88) at Transect #15 to 16’ (NAVD88) at Transect #1 (Figure 6), resulting in an average topographic gradient over the study reach of the river of 5.0 feet/linear mile. The steepest gradients between transects occur between transects #3 and #5 where the river channel drops almost 10 feet over 0.98 linear mile and between transects #10 and #11 where a drop of approximately four feet over a distance of 0.47 linear mile occurs.

Topography of the Transects – Cross sections of the river channel and floodplain at the transect locations are provided in Figures 7 through 21. The cross sections show a complex topography across the channel and floodplain at each of the transects. On all transects, there is one primary channel and one to several secondary channels. The cross sectional data is consistent with observations made on the ground that the Pithlachascotee flow way is highly braided with multiple channels separated by areas of higher elevations; some flow ways may not convey flows except during wet conditions. Complexity was judged based upon the number of channels that were $\geq$ 2.0 feet in depth and the total number of flow ways that were identifiable by a visual inspection of the cross sections (Table 1). The transects having the most channels having depths $\geq$ 2.0 feet were: #4, #8 and #11, each of which had three such channels. Transects #1, #9 and #13 each had two channels having depths $\geq$ 2.0 feet, while the remaining transects (#2, #3, #5, #6, #7, #10, #12, #14 and #15) each had one channel having depths $\geq$ 2.0 feet. In terms of the total number of flow ways identifiable in the cross sections, Transect #14 had the largest number of flow ways (16), while Transects #8, #6 and #11 had 11, 8 and 8 total flow ways, respectively. The remaining transects had total numbers of flow ways ranging from four to seven, with Transect #2 having the lowest total number in the range (4). There does not appear to be a trend in the complexity of the transect topography based upon the transect location along the river (upstream *vs.* downstream).

For the transects as a whole, the maximum change in elevation across the transect (exclusive of the river channel itself) varied from 4.6 feet to 1.5 feet (Table 1). The transects having the largest degree of elevation change were #1, 4 and 10 all of which exceeded four feet of change, while transects #7, 12, 14 and 15 had the smallest change in elevation. The mean change in elevation for the 15 transects was 3.03 feet, again exclusive of the channel bottom elevation. A total of seven transects had an elevation change across the transect that was less than the mean of 3.0 feet, five of which were the most upstream transects (#11 through 15). Topographic gradients across the transects were slight and averaged 0.004 feet of vertical drop per foot of horizontal distance along the transect. Transects having the smallest gradients were Transects #4, 6, and 12 (ranging from 0.0027 to 0.0028 feet/foot), while Transects #1, 2, and 9 had the largest gradients (ranging from 0.0053 to 0.0061 feet/foot) (Table 1). Floodplain vegetation in the study reach of the river has established itself in a virtually flat topographic setting. This situation suggests that very small changes in water elevations may be significant in terms of plant community sustainability.

As noted in the Methods Section of this report, the edge of wetland (EOW) was marked as the beginning and end of the transects. In effect, the distance between EOW markers represents the extent of wetland vegetation along each transect and is an indicator of water elevations and hydroperiods along the river floodplain at the transect locations. These distances are provided in Table 1 and illustrated in the transect cross sections in Figures 7 through 21. For the 15 transects, the mean distance from EOW-to-EOW was 793 feet, while the median distance was 648 feet. Transects #1, 4, 6, 8, 10 and 11 had distances between EOWs exceeding the mean, while the distances for the remaining transects were less than the mean. Transects #1, 3, 4, 6, 8, 10 and 11 had distances between EOWs exceeding the median, while the distances for the remaining transects had distances less than the median (Table 1).

The elevations for the EOW on both sides of the River for each transect are illustrated in Figure 22. For 10 transects, the EOW on the negative side of the River (the left river bank as one proceeds downstream) is higher than the EOW on the positive side of the River (the right river bank as one proceeds downstream). The reverse situation prevailed in only Transects #1, 2, 3, 5 and 12, the first four of which are located at the downstream reach of the river. With the exceptions of Transects #1, 3 and 4, the differences in the EOW elevations averaged less than 0.4 ft. Transects #1, 3 and 4 showed differences in EOW elevations ranging from 1.3 ft to 2.7 ft, in that order.

Wetland Plant Communities

Plant communities of the Pithlachascotee River

As described in the Methods section of this report, the FNAI plant community system was used as a guide in classifying the assemblages of plant species observed along the 15 transects all of which were situated in the riparian corridor of the Pithlachascotee River. Using this system, the vegetation along the transects was grouped into three communities: floodplain swamp, bottomland forest and hydric hammock.

FNAI's descriptions of each of the three communities are summarized in Table 2. Community delineations used in this project were based on visual inspections of each transect and were consistent with the species composition descriptions developed by FNAI. For a complete description, please see the FNAI Guide to the Natural Communities of Florida - 2009 Update available at http://www.fnai.org/natcomguide_update.cfm. A cross walk between the three communities used in this study and other community classification systems used in Florida is provided in Table 3.

In the following discussion of plant communities, plant species' common names are used. A complete list of the common and scientific names of all plant species encountered in the sampling for the project is provided in Table 4. That table also includes the FDEP and NWI classifications of all plant species observed.

<u>Floodplain Swamp</u> - In the Pithlachascotee River system, this community is dominated by swamp tupelo (IV=89.11) and bald cypress (IV=35.29). American elm (IV=36.98) and red maple (32.5) are primary associates as judged by the calculation of Importance Value for all trees species encountered (Table 5). Laurel oak (IV=18.88) and water tupelo (11.29) were next in Importance Value, followed by 18 other tree species in small numbers (Figure 23). Figure 24, which concentrates on eight of the most important species in the three communities, illustrates that slash pine is absent in the Floodplain Swamp and the importance of laurel oak is far less than in the other two communities. Tree Species Richness amounted to 16 for this community (Table 5). Tree Absolute Density in the Floodplain Swamp was approximately equal to that of Bottomland Forest (~600 trees/hectare) but slightly lower than that of Hydric Hammock (Figure 25).

The cypress in this community were the largest in terms of trunk diameter of all of the cypress occupying the three communities and consistently exceeded the other two communities in the numbers of cypress in all diameter size classes (Figure 26).

The assemblage of shrub species in this community was the least dense of all three communities (Figure 25) and shrubs were absent on many transects. Shrub Absolute Density was less than half that of the tree component of this community. Dwarf palmetto was the most common species, while wax myrtle (mostly on hummocks) and the saplings of swamp bay and sweetbay were often encountered. Other shrub species included saplings of bald cypress and American elm together with 16 other species present in small numbers. Shrub Species Richness amounted to 22 (Table 6).

Groundcover was very sparse but diverse with a Species Richness of 28 (Table 7).The majority of the groundcover primarily consisted of the seedlings of canopy trees and shrubs, including red maple, dahoon, wax myrtle, laurel oak, bald cypress, and American elm. Common herbaceous species included: Virginia chain fern, bugle weed, and sword fern.

<u>Bottomland Forest</u> - In the project area, this community was characterized by the dominance of laurel oak and swamp tupelo. Laurel oak (IV=77.04) and American elm (IV=53.33) were the primary associates (Table 5, Figure 23). Next in Importance Value were bald cypress (IV=25.32) red maple (IV=18.99) and American hornbeam (IV=18.65), followed by 15 other species in small numbers. Figure 24 illustrates that slash pine is present in very small numbers in Bottomland Forest, while laurel oak is more important than in Floodplain Swamp and approximately equal in importance in Hydric Hammock. Tree Species Richness equaled 19 for the Bottomland Forest (Table 5). Tree Absolute Density in the Bottomland Forest was approximately equal to that of Floodplain Swamp (~600 trees/hectare) but slightly lower than that of Hydric Hammock (Figure 25).

The cypress in this community were the second largest in terms of trunk diameter of the cypress occupying the other two communities and consistently equaled or exceeded the Hydric Hammock community in the numbers of cypress in all diameter size classes (Figure 26).

The shrub component of this community was approximately equal to the Absolute Density of the tree component of this community (Figure 25) and was dominated by dwarf palmetto. Wax myrtle and sweetgum followed dwarf palmetto in shrub Absolute Density (Table 6). Eighteen other species were present in small numbers. The Species Richness for this community amounted to 22 (Table 6).

Groundcover occurred in patches and some parts of transects had no groundcover species, while other parts of the transects had very dense groundcover. The groundcover Species Richness of this community as a whole (31) exceeded those of the other two communities (Table 7).The majority of the groundcover primarily consisted of the seedlings of canopy trees and shrubs, including red maple, swamp dogwood, persimmon, sweetgum, sweetbay, wax myrtle, water tupelo, swamp tupelo, bald cypress, and American elm. Seedling beautyberry and dwarf palmetto occurred in the Bottomland Forest in about half of the transects. Important herbaceous species included: swamp fern, Long's sedge, inundated beakrush, lizard's tail, and sword fern.

Hydric Hammock – This community had a tree Species Richness equaling that of Bottomland Forest (19) and exceeding that of Floodplain Swamp (16) (Table 7). Dominated by laurel oak (IV=74.35), this community also had significant numbers of bald cypress (IV=35.29), American elm (IV=31.52) and pignut hickory (IV=27.72). Twelve other species were present in small numbers (Table 5). Figure 24 shows that slash pine and pignut hickory were more common than in the other communities but that red maple was less important than in the other communities. The tree Absolute Density of Hydric Hammock was the highest of the three communities but was lower than that of the shrub component of the community (Figure 25).

The cypress in this community were the smallest in terms of trunk diameter of the cypress occupying the other two communities and consistently were less than or equal to the Bottomland Forest community in the numbers of cypress in all diameter size classes (Figure 26).

The shrub component of this community was notable in having an Absolute Density that was much higher than both the Absolute Density of tree component of the community, itself, and the shrub Absolute Densities of the other two communities (Figure 25). Further, Hydric Hammock had a shrub Species Richness that was the lowest of all three communities (13). The dominant species was dwarf palmetto followed by saw palmetto, cabbage palm and swamp bay. Nine other species were present in low numbers (Table 6).

Groundcover was consistently dense in this community along the transects and groundcover Species Richness of this community (15) was the lowest of the three communities (Table 7). In contrast with the other two communities, seedlings of canopy trees did not constitute the majority of the groundcover. The dominant species were herbaceous and included: wild coffee, woods grass, and swamp fern, together with several vines (Virginia creeper, Saw greenbrier, muscadine grape, poison ivy). Seedling saw palmetto and dwarf palmetto occurred in low numbers in the Hydric Hammock community in most of the transects.

Community – level Comparisons

All three communities were highly diverse in their tree strata. The Simpson's Index of Species Diversity (ISD) was calculated using the tree species present in each community together with the number of each species occurring in each community. Of the three communities, Floodplain Swamp had the lowest ISD at 0.872 out of a possible 1.0, while the other two communities had ISDs that were approximately equal: 0.908 for Bottomland Forest and 0.917 for Hydric Hammock (Table 8).

The Simpson's Index of Similarity (IS) comparing the tree species in the three communities was calculated (Table 9). The calculations show that a high degree of similarity exists among the communities in terms of the tree species composition as the IS ranged from 0.85 to 0.91 out of a possible 1.0. That is, the three communities share several plant species in common. The IS does not take into account any quantitative ecological parameters except Species Richness; it disregards densities, frequencies and Importance Values. Consequently, its information value resides in its ability to indicate the proportion of species that communities have in common in the context of the total number of species in each community. It is useful here in that it tells us that species composition alone is not able to differentiate the communities from each other, and it suggests that quantitative measures must be combined with simple composition data in order to separate communities definitively.

In repeating the IS calculation for the shrub densities of the three communities, somewhat less similarity was evident among the communities (Table 9). Floodplain Swamp compared to Hydric Hammock showed a low IS (0.51), while Floodplain Swamp compared to Bottomland Forest showed a high IS (0.82). Bottomland Forest compared to Hydric Hammock also resulted in an ISD of 0.51. The IS values obtained from the shrub data were lower than those for the tree comparisons. Again, species composition alone cannot clearly differentiate the three communities and quantitative data must be combined with simple composition information to separate communities. Also, the shrub component of a community may be of greater information value than the tree component in differentiating forested floodplain communities as evidenced by the lower IS values in comparisons of Hydric Hammock with the other two communities.

The distribution of the size classes of bald cypress may be an indicator of community type (see above discussion in the plant community descriptions). In addition to the observations already mentioned, it should be noted that Floodplain Swamp was the only community having trees in three of the larger size classes: 26-30 cm, 46-50 cm, and 51-55 cm (Figure 26). So, this community not only had more cypress throughout all of the size classes, it also had the greatest number of trees (11 individuals) in the larger size classes (>40 cm). By comparison, the other two communities combined had only three individuals in the larger size classes. Therefore, the number and size of the cypress in the Pithlachascotee River floodplain system, together with other species composition data, may help to differentiate plant communities from each other.

A plant species' tolerance for wet soil conditions is often described by a notation developed by the National Wetland Inventory and refined for Florida by the Florida Department of Environmental Protection (Gilbert et al., 1995; NWI 1996). Plants that are facultative (FAC) or upland (UPL) species are said to be able to tolerate drier soil conditions than plants that are obligate (OBL) wetland plant species. Among the plants observed in this assessment, a total of eight species are classified by FDEP as facultative plants that tolerate drier conditions: blackberry, cabbage palm, fireweed, four-petaled St John's Wort, persimmon, sword fern, wax myrtle, and wild coffee (See Table 4). In the Floodplain Swamp community, FAC species were found in the shrub stratum and included blackberry, cabbage palm, persimmon, wax myrtle, and wild coffee. Two FAC species, cabbage palm and wax myrtle, were observed in the Bottomland Forest community as both trees and shrubs. In the Hydric Hammock community, a total of three FAC species were observed, two species in the tree stratum (cabbage palm, persimmon) and two in the shrub stratum (cabbage palm, four-petaled St John's Wort). It should be noted that FDEP does not classify some species that are known facultative species that prefer drier conditions, including: red cedar, saw palmetto, and sour orange. Of these species, saw palmetto was present in all three communities, but in much higher densities in the Hydric Hammock community. Red cedar and sour orange were also present as trees in only the Hydric Hammock community. Sour orange occurred in very low numbers as a shrub in the Bottomland Forest.

Wetland Affinity Index (Lewis, 1995) is a measure of the wetland character of a community, and it is based on the Importance Values and wetland category (obligate, facultative-wet, facultative, facultative+, and facultative-upland) of the tree species. It is calculated as follows:

$$WAI = \frac{(IV_{OBL}+IV_{FACW}+IV_{FACW+}) + (IV_{FAC} + IV_{FAC+} + IV_{FACU})}{IV_{TOTAL}}$$

The WAI for Floodplain Swamp was 0.86, while the WAI for Bottomland was 0.74 and the WAI for Hydric Hammock was 0.32.

No species occurred solely in the tree component of the Floodplain Swamp community. Two species were found only in the tree stratum of the Bottomland Forest, wax myrtle and buttonbush. Both of these species can attain tree size and the individuals included in the tree component of the Bottomland Forest were large specimens meeting the tree criteria described in the Methods section of this report. In many cases, wax myrtle individuals were situated on hummocks, giving this FAC species an opportunity to avoid frequent inundation while occupying Bottomland Forest or Floodplain Swamp. The following species were observed only in the tree component of the Hydric Hammock: sour orange, persimmon, loblolly bay, Southern magnolia, and highbush blueberry (Table 10). All of these species, while present, had very low Importance Values in the Hydric Hammock

Four species were found only in the shrub stratum of the Floodplain Swamp: dahoon, Carolina willow, blackberry and wild coffee. The Absolute Densities of these species were very low, ranging between 1.05 and 4.21 (Table 10). Four species were found only in the shrub stratum of the Bottomland Forest, Virginia willow, sour orange, fetterbush, and water tupelo saplings. The Absolute Densities of these species were very low, ranging between 3.08 and 6.17. Four species were found only in the shrub component of the Hydric Hammock: highbush blueberry, four-petaled St John's Wort, and saplings of red cedar and loblolly bay The Absolute Densities of these four species were much higher than the low Absolute Densities of the community-specific shrubs for the other two communities, ranging between 13.56 and 54.24 (Table 6).

Of the 24 species included in the tree strata of the communities, 13 were present in all three communities (Tables 5 and 10). Usually the Importance Values (IV) of such a species were different in one or more of the communities. In the case of laurel oak, that observation together with its high Importance Values in both Bottomland Forest and Hydric Hammock are consistent with the capacity of this FACW species (*Quercus laurifolia* Michx.) to tolerate a wide range of moisture and soil conditions. It should be explained that, although silviculturally considered one species, *Quercus laurifolia* Michx. has been referred to by other common names including diamond-leaf oak, swamp laurel oak, laurel-leaf oak, and *Q. obtusa* (Burns and Honkala, 1990). *Q. laurifolia* Michx. has been has been distinguished by some (Hall, 1987) from a more drought tolerant plant of very similar appearance called laurel oak (*Q. hemisphaerica* Bartr.). However, Wunderlin (1998) recognizes synonymy among *Q. laurifolia, Q. obtusa*, and *Q. hemisphaerica*. In this project, we use *Q. laurifolia* Michx. While present in all three communities, laurel oak was less important in Floodplain Swamp (IV = 18.88) than in the other two communities where it had approximately the same Importance Values ($IV_{\text{Bottomland Forest}}$ = 77.04 and $IV_{\text{Hydric Hammock}}$ = 74.35).

Of the 29 species included in the shrub strata of the communities, nine were present in all three communities (Tables 6 and 10). In comparing Absolute Densities (ADs) of shrubs, certain data may be useful in differentiating communities. For example, while present in all three communities, beautyberry (a $FACU^-$ species) was far less dense in Floodplain Swamp (AD = 1.05) than in the other two communities where it had approximately the same ADs Values ($AD_{\text{Bottomland Forest}}$ = 27.77 and $AD_{\text{Hydric Hammock}}$ = 27.12). Perhaps a more striking example is that of sweetgum (a FACW species) which was less important in Floodplain Swamp (AD = 4.21) than in Bottomland Forest ($AD_{\text{Bottomland Forest}}$ = 33.94) or Hydric Hammock ($AD_{\text{Hydric Hammock}}$ = 67.80).

Statistics for Community – level Observations

Two types of statistical analyses were performed on data collected for this report, the Wilcoxon Signed Rank test and Discriminant Function Analysis. Tests were performed comparing Bottomland Forest to Floodplain Swamp, Bottomland forest to Hydric Hammock, and Floodplain Swamp to Hydric Hammock for both trees and shrubs. For trees, the parameters that were compared were: absolute density, absolute dominance, absolute frequency and importance value. In the case of shrubs, absolute density and absolute frequency were compared as the calculations for dominance and importance value require data on stem diameter which were not collected for shrubs. The results of the statistical analyses are provided separately to the District with the data in Excel spreadsheets. These results are presented summarized here (Tables 11 -15).

Wilcoxon Signed Rank Test - The Wilcoxon signed rank test is a non-parametric analog of the paired t-test and is used to determine if statistically significant differences exist between the means of paired samples.

Trees: There were no statistically significant differences in tree distribution calculated for any of the tree parameters.

Shrubs: There were no statistically significant differences among the three communities for shrub absolute frequencies. On the other hand, a comparison of Floodplain Swamp to Hydric Hammock showed a significant difference (P=.047) in shrub absolute density. There was also a significant difference (P=.003) in a comparison of Bottomland Forest to

Floodplain Swamp for absolute densities of shrubs. There was not a significant difference between Bottomland Forest and Hydric Hammock with respect to shrub absolute density.

Discriminant Function Analysis - Discriminant Function Analysis (DFA), also known as Discriminant Analysis, is an analytical tool that has been used since 1936 (Fisher, 1936). DFA may be used to determine which variables are able to discriminate between groups (such as plant communities) and to produce a predictive model indicating the likelihood of success in using the discriminant predictive equation produced.

In the case of this study on the Pithlachascotee River, we would like to determine if several variables are able to help us discriminate between the three communities of interest, Bottomland Forest, Floodplain Swamp, and Hydric Hammock. The variables used in the DFA procedure are all obtained from the soil samples collection points. The variables used are:

- elevation (in feet, NAVD88),
- relative elevation (the difference between the elevation of the soil sample and the channel bottom of that transect (in feet),
- distance of the soil sample from the channel center (in feet), and
- soil index number described elsewhere in this report.

Summary values for each of the variables used in DFA are shown in Table 11. Mean summary values for each of the variables by community are listed in Table 12. Table 13 shows the results of the Wilks' *lambda* test for the significance of contribution of each of the four variables to the discriminant function. In this test, the lower the value of *lambda,* the more significant is the contribution of the variable to the discriminant model. As can be seen from the p value, all four parameters contribute significantly to the discriminant function. Relative elevation and soil index variables are most significant.

There are two discriminant functions produced when the number of groups to be discriminated is three (g-1). In the Discriminant Analysis provided, the two functions are F1 and F2. The first function, F1, is the most powerful for differentiation of the communities. Table 14 shows the correlation coefficients for each of the variable categories. The higher the absolute value, the better the variable is at differentiating the communities. The result of this analysis shows that the relative elevation is the most important variable, followed by soil index. Distance from channel is less important followed by elevation.

Table 15 is the classification table (confusion matrix) produced as a result of the Discriminant Analysis. The Wilks' *lambda* test is used to test the significance of the Discriminant model as a whole. The model was found to be significant in discriminating between communities ($p < .0001$). If the predictive model were perfect, all of the samples would lie in the shaded boxes. That is, they would all be correct classifications. The rows in the table are the observed categories, while the columns are the predicted categories.

Correct classifications are found in the shaded boxes in Table 15. Bottomland Forest was correctly classified 37 times out of 156 for a total of 23.72%. Floodplain Swamp was correctly classified 100 times out of 180 for a total of 55.56% and Hydric Hammock was correctly classified 51 times out of 66 for a total of 77.27%. Overall, correct classifications amounted to 46.77%.

The Discriminant function misclassified Bottomland Forest as Floodplain Swamp 36 times and as Hydric Hammock 3 times (Bottomland Forest column).

It would appear that the model is best able to discriminate Hydric Hammock communities but is less effective in predicting the location of Bottomland Forest.

The Bottomland Forest community is situated between the Floodplain Swamp to waterward and the Hydric Hammock to landward. It can be viewed as a transitional community between the other two communities. Therefore, it could be expected that it would have some of the same characteristics of the other two communities, helping to explain the lower ability of the DFA to predict the occurrence and location of Bottomland Forest. There are two other factors to consider here also. First, the variables used in the DFA were of a physical nature (elevation, soils, distances), while the identification of plant communities on-the-ground by the ecologist was based on visual inspection of the plant species present along the transect. Some differences in the outcome of the DFA could be expected, then, based upon the use of physical *versus* biological information in the DFA. Second, the floodplain is highly complex and each transect traverses areas of lower, then higher, elevations as it crossed multiple flow ways and actual channels. This complexity promotes the establishment of very small patches of plant species characteristic of one community within another community. As one proceeds from the edge of wetland through the Hydric Hammock and Bottomland Forest to the Floodplain Swamp, it is common to encounter plants of the Hydric Hammock in the Bottomland Forest in the slightly higher elevations of the Bottomland Forest. And, plants of the Floodplain Swamp can be found in the slightly lower elevations associated with the multiple flow ways in the Bottomland Forest.

Transect-level Observations

The three communities were not represented equally on each of the 15 transects (Figure 27). For example, Hydric Hammock was absent on six of the transects (#5, 6, 7, 10, 12, 13). Bottomland Forest was absent on only Transect #14, while Floodplain Swamp was absent on only Transect #15. Accordingly, the length of the transect occupied by each of the three communities varied considerably. Floodplain Swamp occupied $\geq$50% of the lengths of eight transects (#2, 4, 5, 6, 7, 9, 13, 14), and Bottomland Forest covered $\geq$50% of only three transects (#10, 12, 15). Hydric Hammock occupied 50% of only one transect (#11). On some transects, Bottomland Forest occupied <10% of the transect length on Transects #2, 4 and 11). The other two communities, when present, always covered >10% of the transect length.

As expected, the average community elevation declined from upstream to downstream (Figure 28). When all three communities were present on a given transect, the average elevation for the three communities generally followed the pattern, from lowest to highest elevation: Floodplain Swamp, then Bottomland Forest, lastly, Hydric Hammock. There were two exceptions to this pattern: Transect #11 where all three communities had average elevations within 0.7ft of each other, and on Transect #9 where the average elevation of Hydric Hammock was actually 0.5ft lower than that of Bottomland Forest.

Using the average elevation data and transect cross section, illustrations were prepared showing, for each of the 15 transects, the wetted perimeter together with the average elevation for each community (Figures 29 – 43; Table 16). The extent to which a given community will experience inundation is related to the elevation of the water with respect to the elevation of the community. For example, for Transect #1, the most downstream transect, the Floodplain Swamp will not start to become inundated until the water elevation approaches 19' (NAVD88). At the average elevation for that community, 19.3' (NAVD88), the wetted perimeter covers approximately 140 feet. At a water elevation of 20.00' (NAVD88), the average elevation for the Bottomland Forest, the wetted perimeter extends for a length of 380 feet, while at the average elevation of the Hydric Hammock, the wetted perimeter occupies a length of 700 feet. Transect #1 is characterized by having an incised channel but that is not the case in some of the more upstream transects. For Transect #15, which lacks a Floodplain Swamp community, the community at the lowest elevation is the Bottomland Forest. This community will begin to experience inundation at approximately 41' (NAVD88), and at the average elevation of the community (41.6' NAVD88, the wetted perimeter extends for a length of 340 feet. As the water level rises to the average elevation of the Hydric Hammock (42.4' NAVD88, the wetted perimeter expands to cover a length of approximately 490 feet. The wetted perimeter length can be compared to the EOW distance for each transect presented in Table 3. In all but one transect (#3), the extent of the wetted perimeter and the EOW-to-EOW distances were approximately equal. In the case of Transect #3, the surveyed line extended beyond the EOW, making it appear that the wetted perimeter was longer than was actually the case. As the EOW and the wetted perimeter lengths were virtually the same, it may be useful to utilize EOW lengths as a parameter for determining the desirable extent of surface water in a floodplain system for the maintenance of plant communities.

The Species Richness for trees on the transects as a whole, regardless of community type, was 24, while that for shrubs was 29 (Table 5). The Species Richness for the groundcover on the transects as a whole, regardless of community type and despite that fact that the data on groundcover species was collected only qualitatively, was 46 (Table 7).

The Absolute Densities (ADs) for trees and for shrubs showed no statistically significant spatial trends or any consistency in terms of the AD of trees *versus* the AD of shrubs (Figure 44). Tree and shrub densities were highly variable and influenced by factors other than the transect's upstream-to-downstream location in the study reach of the river.

Hydrologic Indicators used in this study & relationship to bottom elevations

The lower elevation of the moss collars on mature tree species was used as the hydrologic indicator for this assessment. Figure 45 and Table 17 show the elevations of this hydrologic indicator for each community on each transect with respect to the bottom elevation for each transect. As expected, the elevations of the indicator were higher than that of the channel bottom. Also, with two exceptions, the elevation of the indicator for the three communities followed the pattern, from lowest to highest, of Floodplain Swamp, then Bottomland Forest, lastly Hydric Hammock. The two exceptions were Transects #9 and #11. On Transect #9, the elevation of the indicator for the Hydric Hammock was lower than that for Bottomland Forest, and on Transect #11, the elevation of the indicator for the Bottomland Forest was slightly below that for Floodplain Swamp.

The waterward limit of the saw palmetto or Edge-of-Wetland (EOW) also was marked and the elevations were obtained. The moss collar hydrologic indicator elevations for the Floodplain Swamp were lower than both of the EOW elevations on each transect except on Transects #4 and 11 where the moss collar elevations fell between the EOW elevations and on Transect #13 where the moss collar elevation was higher than both of the EOW elevations.

In the case of Bottomland Forest, the moss collar indicator elevations were inconsistent with respect to the EOW elevations on each transect and were lower than some EOW elevations and higher than others. This situation is to be expected as this community is transitional between Floodplain Swamp and Hydric Hammock.

With one exception (Transect #9), the moss collar hydrologic indicator elevations for the Hydric Hammock were higher than both of the EOW elevations on all transects where that community was present. The difference in the moss collar elevations *versus* the higher of the two EOW elevations ranged from 0.1 to 0.5 ft and averaged 0.31ft. In the case of Transect #9, the moss collar elevation of 35.7 ft was lower than the higher of the two EOW elevations by 0.9 ft.

In addition to moss collars and the waterward extent of saw palmetto, other hydrologic indicators were present on trees and shrubs on the transects including: lichen lines, cypress buttresses, hummocks, lenticels. None were ubiquitous throughout all three communities as were moss collars which were present on both trees and the larger shrubs.

Soils

Soil series in the study reach of the river (USDA SCS 1982) are illustrated in Figure 46 and Tables 18 through 33. Much of the study reach is located in the soils of the Chobee Series which are soils typical of swamps, tidal marshes and river floodplains. On both sides of the river and bordering the Chobee series soils are soils of the Tavares-Adamsville-Narcoossee series, which are characteristic of upland areas, and soils of the Smyrna-Sellers-Myakka Series which are typical of flatwoods and depressional areas. The majority of the lengths of all transects occupy Chobee soils (Table 18). The second most common soil and the soils in which eight of the transects have their end points is Smyrna fine sand followed by Myakka fine sand in which 6 transects have their end points. Other soils occurring at the end points of the transects include: Cassia fine sand, Wauchula fine sand (0-5% slopes), Narcoossee fine sand and Pomona fine sand. Of all of the soils encountered along the transects, Chobee is a considered a hydric soil, although both Myakka fine sand and Smyrna fine sands can have hydric components also (Carlisle *et al.*, 1978).

As described in the Methods section of this report, each soil sample was assigned a soil index number from 0 to 4 based on the presence of hydric indicators as follows:

0. Soil exhibited no evidence of flooding or hydric conditions
1. Hydric soils
2. Soil is hydric with muck
3. Soil is hydric and saturated
4. Soil is hydric and saturated with muck.

Based on the soil index numbers generated from the 408 soil samples collected in this study (Tables 19 through 33), hydric soils were by far the most commonly encountered soils along all 15 transects. In the Floodplain Swamp community, 99.5% of the soil samples were classified in Index numbers 1, 2, 3 or 4, while soils having an Index number 0 occurred in only 0.5% of the samples (N=183). In the Bottomland Forest community, 100% of the soil samples were classified in Index numbers 1, 2, 3 or 4 (N=160). In the Hydric Hammock community, 96.9% of the soil samples were classified in Index numbers 1, 2, 3 or 4, while soils having an Index number 0 occurred in 3.1% of the samples (N=65) (Figure 47). Therefore, Floodplain Swamp and Bottomland Forest were characterized by almost complete coverage by hydric soils, while Hydric Hammock had slightly lower coverage by soils indicative of saturated conditions.

CONCLUSIONS

The Pithlachascotee River within the project study reach, with an average topographic gradient of 5.0 feet/linear mile, has relatively little topographic relief. The floodplain zone of the study reach of the River is characterized as also having small topographic gradients, and the gradients across the transects averaged 0.004 feet of vertical drop per foot of horizontal distance along the transect. The floodplain cross sections at the transect locations show a complex topography which was consistent with observations made on the ground that the Pithlachascotee flow way is highly braided with multiple channels separated by areas of higher elevations.

The floodplain vegetation in the study reach of the Pithlachascotee River can be divided into three communities using the FNAI plant community definitions: Floodplain Swamp, Bottomland Forest, and Hydric Hammock.

Floodplain Swamp was dominated by swamp tupelo and bald cypress with American elm and red maple as primary associates as judged by the calculation of Importance Value for all trees species encountered. Laurel oak and water tupelo were next in Importance Value, followed by 18 other tree species in small numbers.

Bottomland Forest was characterized by the dominance of laurel oak and swamp tupelo, while bald cypress and American elm were the primary associates. Next in Importance Value were red maple and American hornbeam, followed by 15 other species in small numbers.

Hydric Hammock was dominated by laurel oak and bald cypress, with American elm and pignut hickory as primary associates. Twelve other species were present in small numbers.

Significant community vegetation descriptors varied as follows:

1. The three communities were not present on all transects and were not represented equally on all.
2. Floodplain Swamp and Bottomland Forest were characterized by almost complete coverage by hydric soils, while Hydric Hammock had slightly lower coverage by soils indicative of saturated conditions.
3. The tree Absolute Density was virtually the same for the three communities and ranged from approximately 610 trees/hectare to 680 trees/hectare.
4. Species Richness was highest in the Hydric Hammock and Bottomland Forest (19) and lowest in Floodplain Swamp (16).
5. Floodplain Swamp exceeded the other two communities in terms of trunk diameter of cypress and in the numbers of cypress of all trunk diameters.
6. Floodplain Swamp was the only community having cypress in three of the larger size classes: 26-30 cm, 46-50 cm, and 51-55 cm
7. Hydric Hammock had the smallest cypress tree diameters.
8. For trees, Floodplain Swamp had the lowest Index of Species Diversity (ISD) at 0.872 out of a possible 1.0, while the other two communities had ISDs that were approximately equal at 0.91 for Bottomland Forest and 0.92 for Hydric Hammock.

9. Shrub Absolute Density was highest in the Hydric Hammock (~1190 shrubs/hectare) and lowest in Floodplain Swamp (~240 shrubs/hectare).
10. Floodplain Swamp had the least dense groundcover, while Hydric Hammock had the densest groundcover of the three communities.
11. Of the 24 species included in the tree strata of the communities, 13 were present in all three communities. Of the 29 species included in the shrub strata of the communities, eight were present in all three communities.
12. The calculations show that a high degree of similarity exists among the communities in terms of the tree species composition as the Index of Similarity ranged from 0.85 to 0.91 out of a possible 1.0. In terms of shrub species, somewhat less similarity was evident among the communities. Floodplain Swamp compared to Hydric Hammock showed a low IS (0.51), while Floodplain Swamp compared to Bottomland Forest showed a high IS (0.82). Bottomland Forest compared to Hydric Hammock also resulted in an IS of 0.51.
13. Floodplain Swamp had no community-specific species in the tree stratum. Two species were found in only the Bottomland Forest, large specimens of wax myrtle and buttonbush. The following species were observed only in the tree component of the Hydric Hammock: sour orange, persimmon, loblolly bay, Southern magnolia, and highbush blueberry.
14. Four species were found only in the shrub stratum of the Floodplain Swamp: dahoon, Carolina willow, blackberry and wild coffee. Four species were found only in the shrub stratum of the Bottomland Forest, Virginia willow, sour orange, fetterbush, and water tupelo saplings. Four species were found only in the shrub component of the Hydric Hammock: highbush blueberry, four-petaled St John’s Wort, and saplings of red cedar and loblolly bay.
15. The Species Richness for trees for all of the transects together, regardless of community type, was 24, while that for shrubs was 29.
16. Based on Importance Values for trees, Floodplain Swamp had the highest Wetland Affinity Index (0.86) and Hydric Hammock had the lowest (0.32). The Index for Bottomland Forest was intermediate between the two other communities (0.74).

The elevations of the moss collars used as hydrologic indicators were higher than that of the channel bottom. With two exceptions, the elevation of the moss collar indicator for the three communities followed the pattern, from lowest to highest, of Floodplain Swamp, then Bottomland Forest, lastly Hydric Hammock. With two exceptions, the moss collar hydrologic indicator elevations for the Floodplain Swamp were lower than both of the EOW elevations on each transect. With one exception, the moss collar hydrologic indicator elevations for the Hydric Hammock were slightly higher (average = 0.31 ft) than both of the Edge-of-Wetland elevations on all transects where that community was present. In the case of Bottomland Forest, the moss collar hydrologic indicator elevations were inconsistent with respect to the EOW elevations on each transect.

Using the Wilcoxon Signed Rank Test, there were no statistically significant differences in tree distribution calculated for any of the tree parameters, chiefly because the means of the parameters were virtually identical and Standard Deviations exceeded the values of the means. For shrubs, statistically significant differences were seen in the comparison of shrub Absolute Density (AD) of Bottomland Forest to Hydric Hammock (P=.047). There was also a significant difference (P=.003) in a comparison of Bottomland Forest to Floodplain Swamp for ADs of shrubs. There was not a significant difference between Bottomland Forest and Hydric Hammock with respect to shrub AD.

The Discriminant Function Analysis procedure and the Wilk's *lambda* test were used to determine the physical variables that were most important in differentiating one plant community from another. Results showed that relative elevation was the most important variable followed by soil index of the four variables examined (which also included elevation and distance from river channel). Using the model generated during this analysis, Bottomland Forest was correctly classified 37 times out of 156 for a total of 23.72%. Floodplain Swamp was correctly classified 100 times out of 180 for a total of 55.56% and Hydric Hammock was correctly classified 51 times out of 66 for a total of 77.27%. The model is best able to discriminate Hydric Hammock communities but is less effective in predicting the location of Bottomland Forest.

Bottomland Forest, as a transitional community between Floodplain Swamp and Hydric Hammock, showed less community specificity than the other two communities.

Plant species composition, alone, cannot differentiate communities definitively.

The Edge-of-Wetland (EOW) markers on the transects define a linear distance that is useful as a guide for the horizontal extent of floodplain vegetation. EOW distances compare well with wetted perimeter distances. The EOW elevations and the Hydric Hammock moss collar elevations compare well and may be useful as a guide for desirable seasonal high water elevations in the study reach of the River under normal conditions.

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Pithlachascotee River Transect #1, from PHABSIM location looking downstream, July 2009

TABLES

Pithlachascotee River Transect #1, July 2009

Table 1. Descriptive information for the 15 Pithlachascotee River MFL transects as determined from cross sections.

Transect #	Length (feet)*	Elevation change (feet)	Gradient (feet/foot)	Flow ways having depths > 2.0 feet	Number of flow ways in transect cross section
1	854	4.5	0.0053	2	5
2	544	3.3	0.0061	1	4
3	776	3.4	0.0044	1	5
4	1706	4.6	0.0027	3	6
5	648	2.8	0.0043	1	7
6	1407	3.9	0.0028	1	8
7	533	1.8	0.0034	1	7
8	1050	3.5	0.0033	3	11
9	604	3.4	0.0056	2	7
10	829	4.3	0.0052	1	5
11	810	2.6	0.0032	3	8
12	551	1.5	0.0027	1	6
13	589	2.5	0.0042	2	7
14	469	1.5	0.0032	1	16
15	525	1.8	0.0034	1	5

**Length refers to the distance (feet) between the edges of wetland on each side of the river.*

Table 1, continued.

Transect #	Elevation at top of bank (ft NAVD88)		Distance of transect from bridge at Starkey Blvd (mi)
	Right bank	Left bank	
1	18.9	20.1	0.62
2	19.3	19.5	0.65
3	24.5	23.8	1.17
4	25.3	24.8	1.37
5	28.8	28.9	2.30
6	30.9	29.6	2.75
7	30.7	30.4	2.98
8	33.6	34.0	3.70
9	35.7	34.9	3.91
10	36.7	36.3	4.28
11	38.8	38.9	4.68
12	40.1	39.4	4.97
13	39.9	39.4	5.01
14	41.3	41.0	5.39
15	42.0	41.1	5.56

Table 2. FNAI description of the three plant communities identified in the Pithlachascotee River MFL assessment.

FLOODPLAIN SWAMP
Description: Floodplain swamp is a closed-canopy forest of hydrophytic trees occurring on frequently or permanently flooded hydric soils adjacent to stream and river channels and in depressions and oxbows within floodplains. **Characteristic Plant Species:** The canopy is sometimes a pure stand of bald cypress (*Taxodium distichum*), but more commonly bald cypress shares dominance with one or more of the following tupelo species: water tupelo (*Nyssa aquatica*), swamp tupelo (*N*. *sylvatica* var. *biflora*), or ogeechee tupelo (*N. ogeche*). The "knees" arising from the root systems of both cypress and tupelo are common features in floodplain swamp. Other canopy trees capable of withstanding frequent inundation may be present but rarely dominant, including water hickory (*Carya aquatica*), overcup oak (*Quercus lyrata*), red maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), and swamp laurel oak (*Q. laurifolia*). Shrubs and smaller trees such as Carolina ash (*Fraxinus caroliniana*), planer tree (*Planera aquatica*), black willow (*Salix nigra*), titi (*Cyrilla racemiflora*), Virginia willow (*Itea virginica*), common buttonbush (*Cephalanthus occidentalis*), cabbage palm (*Sabal palmetto*), and dahoon (*Ilex cassine*) may be present.
BOTTOMLAND FOREST
Description: Bottomland forest is a deciduous or mixed deciduous/evergreen closed-canopy forest on terraces and levees within riverine floodplains and in shallow depressions. Found in situations intermediate between swamps (which are flooded most of the time) and uplands, the canopy may be quite diverse with both deciduous and evergreen hydrophytic to mesophytic trees. **Characteristic Plant Species:** Dominant species include sweetgum (*Liquidambar styraciflua*), spruce pine (*Pinus glabra*), loblolly pine (*Pinus taeda*), sweetbay (*Magnolia virginiana*), swamp laurel oak (*Quercus laurifolia*), water oak (*Q. nigra*), live oak (*Q. virginiana*), swamp chestnut oak (*Q. michauxii*), and sugarberry (*Celtis laevigata*). More flood tolerant species that are often present include American elm (*Ulmus americana*) and red maple (*Acer rubrum*), as well as occasional swamp tupelo (*Nyssa sylvatica* var. *biflora*) and bald cypress (*Taxodium distichum*). Evergreen bay species such as loblolly bay (*Gordonia lasianthus*), and sweetbay are often mixed in the canopy and understory in acidic or seepage systems. Smaller trees and shrubs often include American hornbeam (*Carpinus caroliniana*), swamp dogwood (*Cornus foemina*), possumhaw (*Ilex decidua*), dahoon (*I*. *cassine*), dwarf palmetto (*Sabal minor*), swamp bay (*Persea palustris*), wax myrtle (*Myrica cerifera*), and highbush blueberry (*Vaccinium corymbosum*).

HYDRIC HAMMOCK
Description: Hydric hammock is a well developed evergreen hardwood and/or palm forest with a variable understory often dominated by palms and ferns occurring on moist soils, often with limestone very near the surface. While species composition varies, the community generally has a closed canopy of oaks and palms, an open understory, and a sparse to a moderate groundcover of grasses and ferns. **Characteristic Plant Species:** The canopy is dominated by swamp laurel oak (*Quercus laurifolia*) and/or live oak (*Q. virginiana*) with varying amounts of cabbage palm (*Sabal palmetto*), American elm (*Ulmus americana*), sweetbay (*Magnolia virginiana*), red cedar (*Juniperus virginiana*), red maple (*Acer rubrum*), sugarberry (*Celtis laevigata*), sweetgum (*Liquidambar styraciflua*), and water oak (*Q. nigra*). Cabbage palm is a common to dominant component of hydric hammock throughout most of Florida. Loblolly pine (*Pinus taeda*) may be frequent in some areas, but slash pine (*Pinus elliottii*) is less frequently encountered. In addition to saplings of canopy species, the understory may contain a number of small trees and shrubs. American hornbeam (*Carpinus caroliniana*) is often frequent, and a variety of other woody species may be present including swamp dogwood (*Cornus foemina*), small-leaf viburnum (*Viburnum obovatum*), common persimmon (*Diospyros virginiana*), swamp bay (*Persea palustris*), wax myrtle (*Myrica cerifera*), dwarf palmetto (*Sabal minor*), American beautyberry (*Callicarpa americana*), and needle palm (*Rhapidophyllum hystrix*).

Note: The material in this table is quoted from: Florida Natural Areas Inventory. 2009. *Draft Guide to the Natural Communities of Florida.* FDEP. Tallahassee, FL.

Table 3. Cross walk between the FNAI system and other plant community classification systems used in Florida.

FLOODPLAIN SWAMP
Crosswalk and Synonyms: Davis: 7/Cypress Swamp Forests 8/Swamp Forests, mostly of Hardwoods SCS: 17/Cypress Swamp 21/Swamp Hardwoods Myers and Ewel: Freshwater Swamp Forests - floodplain forests FLUCCS: 613/Gum Swamp 615/Stream and Lake Swamps 621/Cypress 624/Cypress - Pine - Cabbage Palm
BOTTOMLAND FOREST
Crosswalk and Synonyms: Davis 8/Swamp Forests, mostly of Hardwoods SCS 20/Bottomland Hardwoods Myers and Ewel Freshwater: Swamp Forests - floodplain forests FLUCCS: 615/Stream and Lake Swamps (Bottomland) 617/Mixed Wetland Hardwoods 623/Atlantic White Cedar 630/Wetland Forested Mixed
HYDRIC HAMMOCK
Crosswalk and Synonyms: Davis: 8/Swamp Forests 12/Hardwood Forests SCS: 12/Wetland Hardwood Hammocks 13/Cabbage Palm Hammocks Myers and Ewel: Hydric hammocks FLUCCS: 617/Mixed Wetland Hardwoods

Table 4. Scientific names, classifications and common names for plant species observed on the Pithlachascotee River MFL Transects.

Tree Species	FDEP classification[1]	NWI classification[2]	Common name[3]
Acer rubrum	FACW	OBL	Red maple
Carpinus caroliniana	FACW	FAC	American hornbeam
Carya glabra		FACU	Pignut hickory
Cephalanthus occidentalis	OBL	OBL	Buttonbush
Citrus aurantium		FACU	Sour orange
Cornus foemina	FACW	FACW-	Swamp dogwood
Diospyros virginiana	FAC	FAC	Persimmon
Fraxinus caroliniana	OBL	OBL	Carolina ash
Gordonia lasianthus	FACW	FACW	Loblolly bay
Ilex cassine	OBL	FACW	Dahoon
Liquidambar styraciflua	FACW	FAC+	Sweetgum
Magnolia grandiflora		FAC+	Southern magnolia
Magnolia virginiana	OBL	FACW+	Sweetbay
Myrica cerifera	FAC	FAC+	Southern bayberry
Nyssa aquatica	OBL	OBL	Water tupelo
Nyssa sylvatica var. *biflora*	OBL	OBL	Swamp tupelo
Persea palustris	OBL		Swamp bay
Pinus elliottii		FACW	Slash pine
Quercus laurifolia	FACW	FACW	Laurel oak/swamp laurel oak
Quercus nigra	FACW	FAC	Water oak
Sabal palmetto	FAC	FAC+	Cabbage palm
Taxodium distichum	OBL	OBL	Bald cypress
Ulmus americana	FACW	FACW	American elm
Vaccinium corymbosum	FACW	FACW	Highbush blueberry

Total tree species = 25

Shrub Species	FDEP classification[1]	NWI classification[2]	Common name[3]
Acer rubrum	FACW	OBL	Red maple
Callicarpa americana		FACU-	Beautyberry
Cephalanthus occidentalis	OBL	OBL	Buttonbush
Citrus aurantium		FACU-	Sour orange
Cornus foemina	FACW	FACW-	Swamp dogwood
Diospyros virginiana	FAC	FAC	Persimmon
Fraxinus caroliniana	OBL	OBL	Carolina ash
Gordonia lasianthus	FACW	FACW	Loblolly bay
Hypericum tetrapetalum	FAC	FACW	Four-petaled St John's Wort
Ilex cassine	OBL	FACW	Dahoon
Itea virginica	OBL	FACW+	Virginia tea
Juniperus virginiana		FACU-	Red cedar
Liquidambar styraciflua	FACW	FAC+	Sweetgum
Lyonia lucida	FACW	FACW	Fetterbush
Magnolia virginiana	OBL	FACW+	Sweetbay
Myrica cerifera	FAC	FAC+	Southern bayberry
Nyssa aquatica	OBL	OBL	Water tupelo
Nyssa sylvatica var. *biflora*	OBL	OBL	Swamp tupelo
Persea palustris	OBL		Swamp bay
Psychotria nervosa	FAC	FACW	Wild coffee
Quercus laurifolia	FACW	FACW	Laurel oak
Rubus argutus	FAC	FACU^{+}	Sawtooth blackberry
Sabal minor	FACW	FACW	Dwarf palmetto
Sabal palmetto	FAC	FAC+	Cabbage palm
Salix caroliniana	OBL	OBL	Carolina willow
Serenoa repens		FACU	Saw palmetto

Taxodium distichum	OBL	OBL	Bald cypress
Ulmus americana	FACW	FACW	American elm
Vaccinium corymbosum	FACW	FACW	Highbush blueberry

Total shrub species = 29

Groundcover species	FDEP classification[1]	NWI classification[2]	Common name[3]
Acer rubrum	FACW	OBL	Red maple
Berchemia scandens		FACW	Alabama supple jack
Blechnum serrulatum		FACW+	Swamp fern
Boehmeria cylindrica	OBL	FACW+	False nettle
Callicarpa americana		FACU-	Beautyberry
Carex longii		OBL	Long's sedge
Carex verrucosa		OBL	Warty sedge
Cephalanthus occidentalis	OBL	OBL	Buttonbush
Cirsium nuttallii	FACW	FAC	Nuttall's thistle
Cladium jamaicensis	OBL		Sawgrass
Cornus foemina	FACW	FACW-	Swamp dogwood
Cynodon dactylon		FACU	Bermuda grass
Dicanthelium ensifolium		NC	none
Diospyros virginiana	FAC	FAC	Persimmon
Erechtites hieracifolia	FAC	FAC-	Fireweed
Eupatorium capillifolium	FAC	FACU	Dog fennel
Eupatorium leptophyllum	OBL	FAC+	False fennel
Hydrocotyle umbellata	FACW	OBL	pennywort
Hypericum myrtifolium		FACW	Dwarf St John's Wort
Ilex cassine	OBL	FACW	dahoon
Liquidambar styraciflua	FACW	FAC+	Sweetgum
Lycopus rubellus	OBL	OBL	bugleweed

Magnolia virginiana	OBL	FACW+	Sweetbay
Myrica cerifera	FAC	FAC+	Southern bayberry
Nephrolepsis exaltata	FAC	FACU+	Sword fern
Nyssa aquatica	OBL	OBL	Water tupelo
Nyssa sylvatica var. *biflora*	OBL	OBL	Swamp tupelo
Oplismenus hirtellus		FACU+	Woods grass
Osmunda regalis	OBL	OBL	Royal fern
Paederia foetida		FACU	Skunk vine
Panicum hemitomon	OBL	OBL	Maidencane
Parthenocissus quinquefolia		FAC	Virginia creeper
Psychotria nervosa	FAC	FACW	Wild coffee
Quercus laurifolia	FACW	FACW	Laurel oak
Rhyncospora inundata	OBL	OBL	Inundated beakrush
Sabal minor	FACW	FACW	Dwarf palmetto
Sabatia calycina	OBL	OBL	Coastal rose gentian
Saururus cernuus	OBL	OBL	Lizard's tail
Serenoa repens		FACU	Saw palmetto
Smilax bona-nox		FAC	Saw greenbrier
Taxodium distichum	OBL	OBL	Bald cypress
Toxicodendron radicans		FACU	Poison ivy
Ulmus americana	FACW	FACW	American elm
Viola sororia		FAC	Common blue violet
Vitis rotundifolia		FAC	Muscadine grape
Woodwardia virginica	FACW	OBL	Virginia chain fern

Total groundcover species = 46

References for plant classification and nomenclature:

[1] Gilbert, K. M., J. D. Tobe, R.W. Cantrell, M. E. Sweeley, and J.R. Cooper. 1995. *The Florida Wetlands Delineation Manual.* Florida Dept. of Environmental Protection. Tallahassee, FL. 197pp.

[2] Reed, Jr., P. B. 1997. *National List of Plants that Occur in Wetlands.* National Wetlands Inventory. U.S. Fish & Wildlife Service. Washington, DC. 209pp.

[3] Wunderlin, R. P. 1998. *Guide to the Vascular Plants of Florida.* University Presses of Florida. Gainesville, FL.

Table 5. Tree Importance Values by Community

	Bottomland Forest	Floodplain Swamp	Hydric Hammock
Acer rubrum	18.99	32.50	6.57
Carpinus caroliniana	18.65	8.78	15.71
Carya glabra	4.30	1.00	27.72
Cephalanthus occidentalis	1.11		
Citrus aurantium			2.91
Cornus foemina	6.66	6.20	9.81
Diospyros virginiana			3.98
Fraxinus caroliniana	10.15	9.08	
Gordonia lasianthus			3.98
Ilex cassine	8.76	6.81	2.90
Liquidambar styraciflua	4.19	4.62	8.69
Magnolia grandiflora			6.08
Magnolia virginiana	10.76	3.14	
Myrica cerifera	1.10		
Nyssa aquatica	14.01	11.29	9.48
Nyssa sylvatica	53.33	89.11	13.62
Persea palustris	11.95	5.80	
Pinus elliottii	3.69		17.21
Quercus laurifolia	77.04	18.88	74.35
Quercus nigra	4.97	3.21	3.37
Sabal palmetto	5.38	3.69	23.92
Taxodium distichum	25.32	58.91	35.29
Ulmus americana	19.62	36.98	31.52
Vaccinium corymbosum			2.88
Species Richness	19	16	19
Wetland Affinity index	0.74	0.86	0.32

Table 6. Shrub Absolute Density (ABS) by community (shrubs/hectare).

	Bottomland Forest	**Floodplain Swamp**	**Hydric Hammock**
Acer rubrum	9.26	1.05	
Callicarpa americana	27.77	1.05	27.12
Cephalanthus occidentalis	9.26	6.33	27.12
Citrus aurantium	3.09		
Cornus foemina	9.26	6.33	
Diospyros virginiana	15.43	1.05	
Fraxinus caroliniana	12.34	4.22	
Gordonia lasianthus			40.68
Hypericum tetrapetalum			13.56
Ilex cassine		4.21	
Itea virginica	3.09		
Juniperus virginiana			13.56
Liquidambar styraciflua	33.95	4.22	67.80
Lyonia lucida	6.17		
Magnolia virginiana	24.69	8.44	81.37
Myrica cerifera	151.21	59.07	
No shrubs	18.51	36.92	176.29
Nyssa aquatica	3.086		
Nyssa sylvatica	6.17	3.16	
Persea palustris	74.06	21.09	108.49
Psychotria		2.11	
Quercus laurifolia	6.17	3.16	
Rubus argutus		1.05	
Sabal minor	197.50	68.56	244.09
Sabal palmetto	15.43	6.33	108.49
Salix caroliniana		1.05	
Serenoa repens	18.52	3.16	230.54
Taxodium distichum	6.17	7.38	
Ulmus americana	3.09	7.38	
Vaccinium corymbosum			54.24

Table 7. Groundcover species present in each community.

Common name	Scientific name	Hydric Hammock	Bottomland Forest	Floodplain Swamp
Red maple	*Acer rubrum*		X	X
Alabama supple jack	*Berchemia scandens*	X		
Swamp fern	*Blechnum serrulatum*		X	X
False nettle	*Boehmeria cylindrica*		X	
Beautyberry	*Callicarpa americana*		X	
Long's sedge	*Carex longii*		X	X
Warty sedge	*Carex verrucosa*			
Buttonbush	*Cephalanthus occidentalis*	X		
Nuttall's thistle	*Cirsium nuttallii*			X
Sawgrass	*Cladium jamaicensis*			X
Swamp dogwood	*Cornus foemina*		X	
Bermuda grass	*Cynodon dactylon*		X	
none	*Dicanthelium ensifolium*	X	X	X
Persimmon	*Diospyros virginiana*		X	
Fireweed	*Erechtites hieracifolia*		X	X
Dog fennel	*Eupatorium capillifolium*		X	
False fennel	*Eupatorium leptophyllum*			X
pennywort	*Hydrocotyle umbellata*		X	X
Dwarf St John's Wort	*Hypericum myrtifolium*	X		
dahoon	*Ilex cassine*			X
Sweetgum	*Liquidambar styraciflua*		X	
bugleweed	*Lycopus rubellus*			X
Sweetbay	*Magnolia virginiana*		X	
Southern bayberry	*Myrica cerifera*		X	X (hummocks)
Sword fern	*Nephrolepsis exaltata*		X	X
Water tupelo	*Nyssa aquatica*		X	

Swamp tupelo	*Nyssa sylvatica* var. *biflora*		**X**	
Woods grass	*Oplismenus hirtellus*		**X**	
Royal fern	*Osmunda regalis*	**X**		
Skunk vine	*Paederia foetida*			**X**
Maidencane	*Panicum hemitomon*			**X**
Virginia creeper	*Parthenocissus quinquefolia*	**X**	**X**	**X**
Wild coffee	*Psychotria nervosa*	**X**	**X**	**X**
Laurel oak	*Quercus laurifolia*			**X**
Inundated beakrush	*Rhyncospora inundata*		**X**	**X**
Dwarf palmetto	*Sabal minor*	**X**	**X**	
Coastal rose gentian	*Sabatia calycina*		**X**	
Lizard’s tail	*Saururus cernuus*	**X**	**X**	**X**
Sawgrass	*Serenoa repens*	**X**		**X**
Saw greenbrier	*Smilax bona-nox*	**X**	**X**	**X**
Bald cypress	*Taxodium distichum*		**X**	**X**
Poison ivy	*Toxicodendron radicans*	**X**	**X**	**X**
American elm	*Ulmus americana*		**X**	**X**
Common blue violet	*Viola sororia*	**X**		**X**
Muscadine grape	*Vitis rotundifolia*	**X**	**X**	**X**
Virginia chain fern	*Woodwardia virginica*	**X**	**X**	**X**
SPECIES RICHNESS		**15**	**31**	**28**

Table 8. Simpson's Index of Species Diversity for Trees and Shrubs by Community

	Hydric Hammock	Floodplain Swamp	Bottomland Forest
TREES	0.91	0.87	0.91
SHRUBS	0.88	0.85	0.84

Table 9. Similarity Index of Trees and Shrubs by Community

TREES	Hydric Hammock	Floodplain Swamp	Bottomland Forest
Hydric Hammock	1.00	0.87	0.85
Floodplain Swamp	0.87	1.00	0.91
Bottomland Forest	0.85	0.91	1.00

Table 9, continued . Shrubs

SHRUBS	Hydric Hammock	Floodplain Swamp	Bottomland Forest
Hydric Hammock	1.00	0.51	0.51
Floodplain Swamp	0.51	1.00	0.82
Bottomland Forest	0.51	0.82	1.00

Table 10. Species of trees and shrubs found in only one community.

TREES		SHRUBS	
species	**community**	**species**	**community**
Cephalanthus occidentalis	Bottomland forest	*Citrus aurantium*	Bottomland forest
Citrus aurantium	Hydric hammock	*Gordonia lasianthus*	Hydric hammock
Diospyros virginiana	Hydric hammock	*Hypericum tetrapetalum*	Hydric hammock
Gordonia lasianthus	Hydric hammock	*Ilex cassine*	Floodplain swamp
Magnolia grandiflora	Hydric hammock	*Itea virginica*	Bottomland forest
Myrica cerifera	Bottomland forest	*Juniperus virginiana*	Hydric hammock
Vaccinium corymbosum	Hydric hammock	*Lyonia lucida*	Bottomland forest
		Nyssa aquatica	Bottomland forest
		Psychotria nervosa	Floodplain swamp
		Rubus argutus	Floodplain swamp
		Salix caroliniana	Floodplain swamp
		Vaccinium corymbosum	Hydric hammock

Table 11. Summary values for each of the variables used in DFA.

Variable	Observations	Minimum	Maximum	Mean	Standard deviation
Elevation	402	18.700	42.500	32.000	7.024
Relative elevation	402	0.100	8.400	2.989	1.792
Soil Index	402	0.000	4.000	1.706	0.980
Distance from channel	402	8.500	1344.800	284.734	272.600

Table 12. Summary mean values for each of the variables by community.

Class \ Variable	Elevation	Relative elevation	Soil Index	Distance from channel
Bottomland Forest	33.135	3.094	1.667	290.515
Floodplain Swamp	31.912	2.397	1.972	251.920
Hydric Hammock	29.556	4.356	1.076	360.561

Table 13. Wilks' lambda test for significant contribution to the discriminant function.

Variable	Lambda	F	DF1	DF2	p-value
Elevation	0.970	6.204	2	399	0.002
Relative elevation	0.854	34.114	2	399	< 0.0001
Soil Index	0.898	22.601	2	399	< 0.0001
Distance from channel	0.981	3.950	2	399	0.020

Table 14. Correlation coefficients for each of the variable categories with community.

	F1	F2
Elevation	-0.185	0.815
Relative elevation	0.794	-0.158
Soil Index	-0.662	0.167
Distance from channel	0.290	-0.058

Table 15. Confusion matrix for the estimation sample:

from \ to	Bottomland Forest	Flood plain Swamp	Hydric Hammock	Total	% correct
Bottomland Forest	**37**	48	71	156	23.72%
Floodplain Swamp	36	**100**	44	180	55.56%
Hydric Hammock	3	12	**51**	66	77.27%
Total	76	160	166	402	46.77%

Wilks' Lambda test = 0.744; F (observed) = 15.776; F (critical) = 1.950; P <.0001

Table 16. Mean Elevation in Feet (NAVD88) of Communities in the Pithlachascotee River Transects.

Transect Number	Bottomland Forest	Hydric Hammock	Flood Plain Swamp
1	20.0	21.7	19.3
2	20.5	20.9	19.1
3	23.3	24.9	22.8
4	27.8	28.8	26.4
5	29.3	🟥	28.7
6	31.2	🟥	29.3
7	31.1	🟥	30.9
8	33.4	34.2	33.1
9	35.8	35.3	34.4
10	37.7	🟥	36.1
11	38.3	38.5	39.0
12	40.1	🟥	39.9
13	39.8	🟥	40.1
14	🟥	41.8	41.2
15	41.6	42.4	🟥

🟥 = Community Not Found

Table 17. Mean Hydrologic Indicator Elevations by Transect and Community with Channel Bottom Elevation.

	Transect number						
Community	1	2	3	4	5	6	7
Floodplain Swamp	19.4	20.4	23.1	26.9	29	30	31.1
Hydric Hammock	22.3	22	25.6	29.4	🟥	🟥	🟥
Bottomland Forest	21.1	20.9	23.7	28.3	30.6	32.4	31.7
Channel Bottom Elevation	16.2	17	16.9	22.5	25.1	26.5	27.8

	Transect number							
Community	8	9	10	11	12	13	14	15
Floodplain Swamp	33.4	35.3	37.2	39.3	40.2	41.6	41.4	🟥
Hydric Hammock	35.1	35.7	🟥	🟥	🟥	🟥	42.3	42.9
Bottomland Forest	33.8	36.8	38.5	38.7	40.4	41	🟥	41.9
Channel Bottom Elevation	32.1	33.1	33.3	37.6	38.9	38.5	40.1	39.9

All hydrologic indicators are bottom elevation of moss collars. Red highlighting indicates that the community was absent.

Table 18. Soils occurring on the 15 Pithlachascotee River MFL transects.

Transect #	Most common soil along the transect	Soil at transect end point on positive side of river	Soil at transect end point on positive side of river
1	Chobee, frequently flooded	Cassia fs	Myakka fs
2	Chobee, frequently flooded	Chobee, frequently flooded	Chobee, frequently flooded
3	Chobee, frequently flooded	Myakka fs	Chobee, frequently flooded
4	Chobee, frequently flooded	Wauchula fs (o-5% slopes)	Narcoossee fs
5	Chobee, frequently flooded	Chobee, frequently flooded	Chobee, frequently flooded
6	Chobee, frequently flooded	Myakka fs	Pomona fs
7	Chobee, frequently flooded	Chobee, frequently flooded	Smyrna fs
8	Chobee, frequently flooded	Myakka fs	Smyrna fs
9	Chobee, frequently flooded	Myakka fs	Smyrna fs
10	Chobee, frequently flooded	Myakka fs	Smyrna fs
11	Chobee, frequently flooded	Myakka fs	Myakka fs
12	Chobee, frequently flooded	Chobee, frequently flooded	Smyrna fs
13	Chobee, frequently flooded	Chobee, frequently flooded	Smyrna fs
14	Chobee, frequently flooded	Chobee, frequently flooded	Smyrna fs
15	Chobee, frequently flooded	Chobee, frequently flooded	Smyrna fs

Positive side of the river is the river bank that is on one’s right side as one proceeds downstream.
Negative side of the river is the river bank that is on one’s left side as one proceeds downstream.
Notation: fs indicates “fine sand.”

Table 19. Pithlachascotee River- Soils Data - Transect 1

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR01-S001	21.7				X	
TR01-S002	20.2				X	
TR01-S003	20.0				X	
TR01-S004	19.8				X	
TR01-S005	20.2				X	
TR01-S006	20.6				X	
TR01-S007	19.3				X	
TR01-S008	19.1				X	
TR01-S009	19.2				X	
TR01-S010	19.5				X	
TR01-S011	19.7				X	
TR01-S012	19.8				X	
TR01-S013	20.8				X	
TR01-S014	20.9		X			
TR01-S015	20.9		X			
TR01-S016	21.9		X			
TR01-S017	22.1		X			
TR01-S018	22.2		X			
TR01-S019	22.5		X			
TR01-S020	22.4		X			
TR01-S021	22.4		X			
TR01-S022	22.0		X			
TR01-S023	22.0		X			
TR01-S024	21.8		X			
TR01-S025	19.5				X	
TR01-S026	19.7				X	
TR01-S027	19.7				X	
TR01-S028	19.2				X	
TR01-S029	19.4				X	
TR01-S030	19.7				X	
TR01-S031	18.7				X	
TR01-S032	19.0				X	
TR01-S033	19.1				X	
TR01-S034	20.9		X			
TR01-S035	21.3		X			
TR01-S036	21.5		X			

Table 20. Pithlachascotee River- Soils Data - Transect 2

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR02-S001	21.4		X			
TR02-S002	21.6		X			
TR02-S003	21.7		X			
TR02-S004	20.0		X			
TR02-S005	20.4		X			
TR02-S006	20.3		X			
TR02-S007	19.1				X	
TR02-S008	19.1				X	
TR02-S009	19.0				X	
TR02-S010	19.2					X
TR02-S011	19.2				X	
TR02-S012	19.3				X	
TR02-S013	19.0		X			
TR02-S014	19.2		X			
TR02-S015	18.8		X			
TR02-S016	19.7		X			
TR02-S017	19.1		X			
TR02-S018	19.0		X			
TR02-S019	20.4		X			
TR02-S020	20.4		X			
TR02-S021	20.5		X			

Table 21. Pithlachascotee River- Soils Data - Transect 3

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR03-S001	22.9				X	
TR03-S002	22.5				X	
TR03-S003	22.5				X	
TR03-S004	22.2				X	
TR03-S005	22.5				X	
TR03-S006	22.7				X	
TR03-S007	23.0				X	
TR03-S008	23.4				X	
TR03-S009	23.5		X			
TR03-S010	24.0		X			
TR03-S011	24.1		X			
TR03-S012	24.7		X			
TR03-S013	25.2		X			
TR03-S014	25.3		X			
TR03-S015	25.2		X			
TR03-S016	25.1		X			
TR03-S017	25.2		X			
TR03-S018	24.9		X			
TR03-S019	23.6		X			
TR03-S020	22.9				x	
TR03-S021	24.0		X			
TR03-S022	23.4		X			
TR03-S023	23.3		X			
TR03-S024	23.1		X			
TR03-S025	23.3		X			
TR03-S026	23.3		X			
TR03-S027	22.8		X			

Table 22 . Pithlachascotee River- Soils Data - Transect 4

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR04-S001	28.6		X			
TR04-S002	28.4		X			
TR04-S003	28.3		X			
TR04-S004	27.7		X			
TR04-S005	27.8		X			
TR04-S006	27.8		X			
TR04-S007	28.4		X			
TR04-S008	28.7		X			
TR04-S009	28.8		X			
TR04-S010	29.0		X			
TR04-S011	29.0		X			
TR04-S012	28.7		X			
TR04-S013	28.9		X			
TR04-S014	28.7		X			
TR04-S015	28.7		X			
TR04-S016	27.0		X			
TR04-S017	26.9		X			
TR04-S018	26.8		X			
TR04-S019	26.2					X
TR04-S020	26.3					X
TR04-S021	26.4					X
TR04-S022	26.0					X
TR04-S023	26.0					X
TR04-S024	26.0					X
TR04-S025	26.4		X			
TR04-S026	26.3		X			
TR04-S027	26.3		X			
TR04-S028	26.4		X			
TR04-S029	26.5		X			
TR04-S030	26.4		X			
TR04-S031			X			
TR04-S032			X			
TR04-S033	25.6		X			

Table 23. Pithlachascotee River- Soils Data - Transect 5

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR05-S001	30.4		X			
TR05-S002	30.0		X			
TR05-S003	30.0		X			
TR05-S004	29.4		X			
TR05-S005	29.0		X			
TR05-S006	29.2		X			
TR05-S007	28.4				X	
TR05-S008	28.6				X	
TR05-S009	28.7				X	
TR05-S010	29.1		X			
TR05-S011	28.1				X	
TR05-S012					X	
TR05-S013	28.9				X	
TR05-S014	29.0				X	
TR05-S015	28.5				X	
TR05-S016	28.4				X	
TR05-S017	28.4				X	
TR05-S018	28.2				X	
TR05-S019	28.9				X	
TR05-S020	28.8				X	
TR05-S021	28.9				X	
TR05-S022	29.0		X			
TR05-S023	28.9		X			
TR05-S024	28.7				X	

Table 24. Pithlachascotee River- Soils Data - Transect 6

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR06-S001	31.7				X	
TR06-S002	31.7				X	
TR06-S003	31.6				X	
TR06-S004	32.6		X			
TR06-S005	31.5		X			
TR06-S006	31.7		X			
TR06-S007	32.0		X			
TR06-S008	31.5		X			
TR06-S009	31.1				X	
TR06-S010	30.0				X	
TR06-S011	29.8				X	
TR06-S012	29.9				X	
TR06-S013	29.6					X
TR06-S014	30.0					X
TR06-S015	28.9					X
TR06-S016	29.6					X
TR06-S017	29.2					X
TR06-S018	29.1					X
TR06-S019	29.1					X
TR06-S020	28.7					X
TR06-S021	28.7					X
TR06-S022	28.7					X
TR06-S023	29.1					X
TR06-S024	28.9					X
TR06-S025	30.3		X			
TR06-S026	30.3		X			
TR06-S027	30.3		X			
TR06-S028	30.3				X	
TR06-S029	30.1				X	
TR06-S030	30.1				X	

Table 25. Pithlachascotee River- Soils Data - Transect 7

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR07-S001	31.6		X			
TR07-S002	31.3		X			
TR07-S003	31.0		X			
TR07-S004	31.2		X			
TR07-S005	31.6		X			
TR07-S006	31.1		X			
TR07-S007	31.0		X			
TR07-S008	30.9		X			
TR07-S009	31.0		X			
TR07-S010	31.1		X			
TR07-S011	31.1		X			
TR07-S012	31.0		X			
TR07-S013	31.0		X			
TR07-S014	30.8		X			
TR07-S015	30.7		X			
TR07-S016	30.8		X			
TR07-S017	30.8		X			
TR07-S018	31.0		X			
TR07-S019	30.8		X			
TR07-S020	30.8		X			
TR07-S021	30.6		X			
TR07-S022	30.6		X			
TR07-S023	30.7		X			
TR07-S024	30.8		X			
TR07-S025	31.1		X			
TR07-S026	30.8		X			
TR07-S027	30.7		X			
TR07-S028	30.8		X			
TR07-S029	31.0		X			
TR07-S030	31.2		X			

Table 26. Pithlachascotee River- Soils Data - Transect 8

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR08-S001	33.6		X			
TR08-S002	33.7		X			
TR08-S003	33.4		X			
TR08-S004	33.1		X			
TR08-S005	33.5		X			
TR08-S006	33.4		X			
TR08-S007	33.0		X			
TR08-S008	32.6					X
TR08-S009	32.4					X
TR08-S010	32.9		X			
TR08-S011	32.5		X			
TR08-S012	32.5		X			
TR08-S013	33.5		X			
TR08-S014	33.3		X			
TR08-S015	33.2		X			
TR08-S016	34.0		X			
TR08-S017	34.0		X			
TR08-S018	34.0		X			
TR08-S019	33.8		X			
TR08-S020	32.8		X			
TR08-S021	32.2		X			
TR08-S022	32.5		X			
TR08-S023	33.6		X			
TR08-S024	32.9		X			
TR08-S025	32.6		X			
TR08-S026	33.7		X			
TR08-S027	33.7		X			
TR08-S028	33.1		X			
TR08-S029	33.4		X			
TR08-S030	33.9		X			
TR08-S031	34.2		X			
TR08-S032	34.0		X			
TR08-S033	33.9		X			
TR08-S034	34.7		X			
TR08-S035	34.4		X			
TR08-S036	34.3		X			

Table 27. Pithlachascotee River- Soils Data - Transect 9

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR09-S001	35.7		X			
TR09-S002	35.7		X			
TR09-S003	35.7		X			
TR09-S004	35.1		X			
TR09-S005	35.2		X			
TR09-S006	35.3		X			
TR09-S007	35.3		X			
TR09-S008	35.1		X			
TR09-S009	35.0		X			
TR09-S010	34.7		X			
TR09-S011	34.7		X			
TR09-S012	34.7		X			
TR09-S013	34.8		X			
TR09-S014	34.2			X		
TR09-S015	34.3		X			
TR09-S016	34.9		X			
TR09-S017	34.4		X			
TR09-S018	34.3		X			
TR09-S019	33.4			X		
TR09-S020	33.8		X			
TR09-S021	34.1		X			
TR09-S022	34.2		X			
TR09-S023	34.5		X			
TR09-S024	35.1		X			
TR09-S025	34.8		X			
TR09-S026	34.9		X			
TR09-S027	35.1		X			
TR09-S028	36.5		X			
TR09-S029	36.8		X			
TR09-S030	36.6		X			

Table 28. Pithlachascotee River- Soils Data - Transect 10

		Soil index				
Soil number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR10-S001	37.4		X			
TR10-S002	37.3		X			
TR10-S003	37.5		X			
TR10-S004	38.3		X			
TR10-S005	38.4		X			
TR10-S006	38.4		X			
TR10-S007	37.8		X			
TR10-S008	37.8		X			
TR10-S009	37.7		X			
TR10-S010	37.2		X			
TR10-S011	36.9		X			
TR10-S012	36.8		X			
TR10-S013	36.3		X			
TR10-S014	36.3		X			
TR10-S015	36.2		X			
TR10-S016	36.4		X			
TR10-S017	35.4		X			
TR10-S018	35.4		X			
TR10-S019	36.7			X		
TR10-S020	36.7			X		
TR10-S021	36.7			X		
TR10-S022	34.2				X	
TR10-S023	35.6		X			
TR10-S024	36.4		X			
TR10-S025	36.3		X			
TR10-S026	36.3		X			
TR10-S027	36.4		X			
TR10-S028	37.7		X			
TR10-S029	37.7		X			
TR10-S030	37.8		X			

Table 29. Pithlachascotee River- Soils Data - Transect 11

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR11-S001	39.4		X			
TR11-S002	39.3		X			
TR11-S003	39.3		X			
TR11-S004	39.0		X			
TR11-S005	39.0		X			
TR11-S006	39.1		X			
TR11-S007	39.1		X			
TR11-S008	38.9			X		
TR11-S009	39.0			X		
TR11-S010				X		
TR11-S011			X			
TR11-S012	38.8		X			
TR11-S013	38.8		X			
TR11-S014	38.2		X			
TR11-S015	38.0			X		
TR11-S016	38.4			X		
TR11-S017	38.2			X		
TR11-S018			X			
TR11-S019	38.3			X		
TR11-S020	38.5			X		
TR11-S021	38.7		X			

Table 30. Pithlachascotee River- Soils Data - Transect 12

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR12-S001	40.1			X		
TR12-S002	40.1			X		
TR12-S003	40.2			X		
TR12-S004	40.2			X		
TR12-S005	40.3			X		
TR12-S006	40.1			X		
TR12-S007	40.0			X		
TR12-S008	39.9			X		
TR12-S009	39.9			X		
TR12-S010	40.1			X		
TR12-S011	40.1			X		
TR12-S012	39.9			X		
TR12-S013	40.3			X		
TR12-S014	40.0			X		
TR12-S015	39.9			X		
TR12-S016	39.7				X	
TR12-S017	39.3				X	
TR12-S018	39.2				X	
TR12-S019	40.0			X		
TR12-S020	40.1			X		
TR12-S021	39.8			X		
TR12-S022	40.4			X		
TR12-S023	40.3			X		
TR12-S024	40.2			X		

Table 31. Pithlachascotee River- Soils Data - Transect 13

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR13-S001	40.9			X		
TR13-S002	40.9			X		
TR13-S003	40.8			X		
TR13-S004	40.6			X		
TR13-S005	40.6			X		
TR13-S006	40.5			X		
TR13-S007	40.2			X		
TR13-S008	40.1			X		
TR13-S009	40.0			X		
TR13-S010	39.5			X		
TR13-S011	39.4			X		
TR13-S012	39.5			X		
TR13-S013	39.5			X		
TR13-S014	39.5			X		
TR13-S015	39.4			X		
TR13-S016	38.8					X
TR13-S017	39.9			X		
TR13-S018	40.0			X		
TR13-S019	39.5			X		
TR13-S020	39.8			X		
TR13-S021	40.0			X		
TR13-S022	40.1			X		
TR13-S023	40.2			X		
TR13-S024	40.7		X			

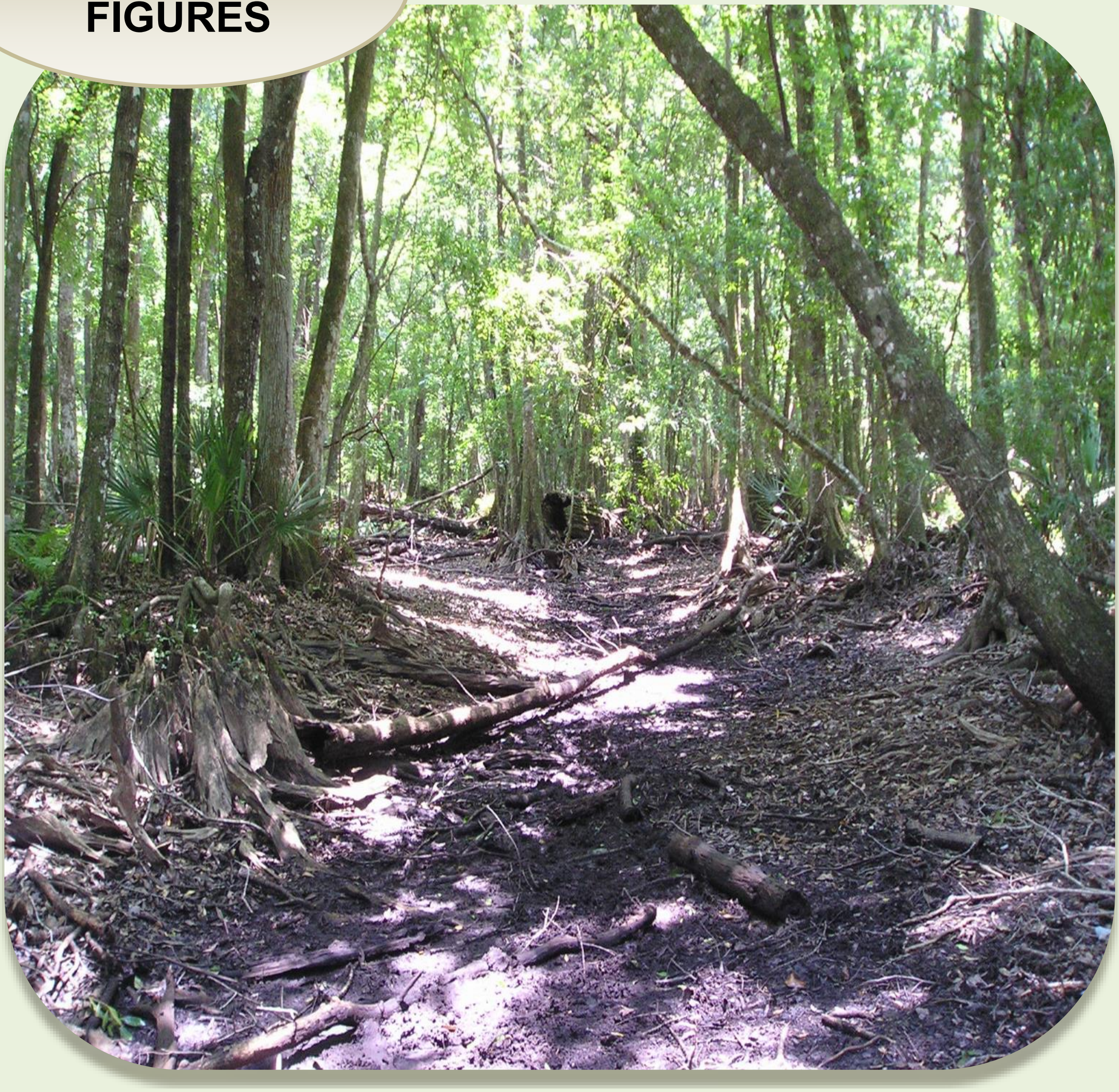
Table 32. Pithlachascotee River- Soils Data - Transect 14

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR14-S001	41.9			X		
TR14-S002	41.7		X			
TR14-S003	41.4		X			
TR14-S004	41.2		X			
TR14-S005	41.3		X			
TR14-S006	41.5		X			
TR14-S007	41.1			X		
TR14-S008	40.9			X		
TR14-S009	40.7			X		
TR14-S010	41.0			X		
TR14-S011	41.3			X		
TR14-S012	41.1			X		
TR14-S013	41.2		X			
TR14-S014	41.4		X			
TR14-S015	41.2		X			
TR14-S016	41.5			X		
TR14-S017	41.5		X			
TR14-S018	41.7		X			
TR14-S019	41.6		X			
TR14-S020	42.2	X				
TR14-S021	42.0	X				

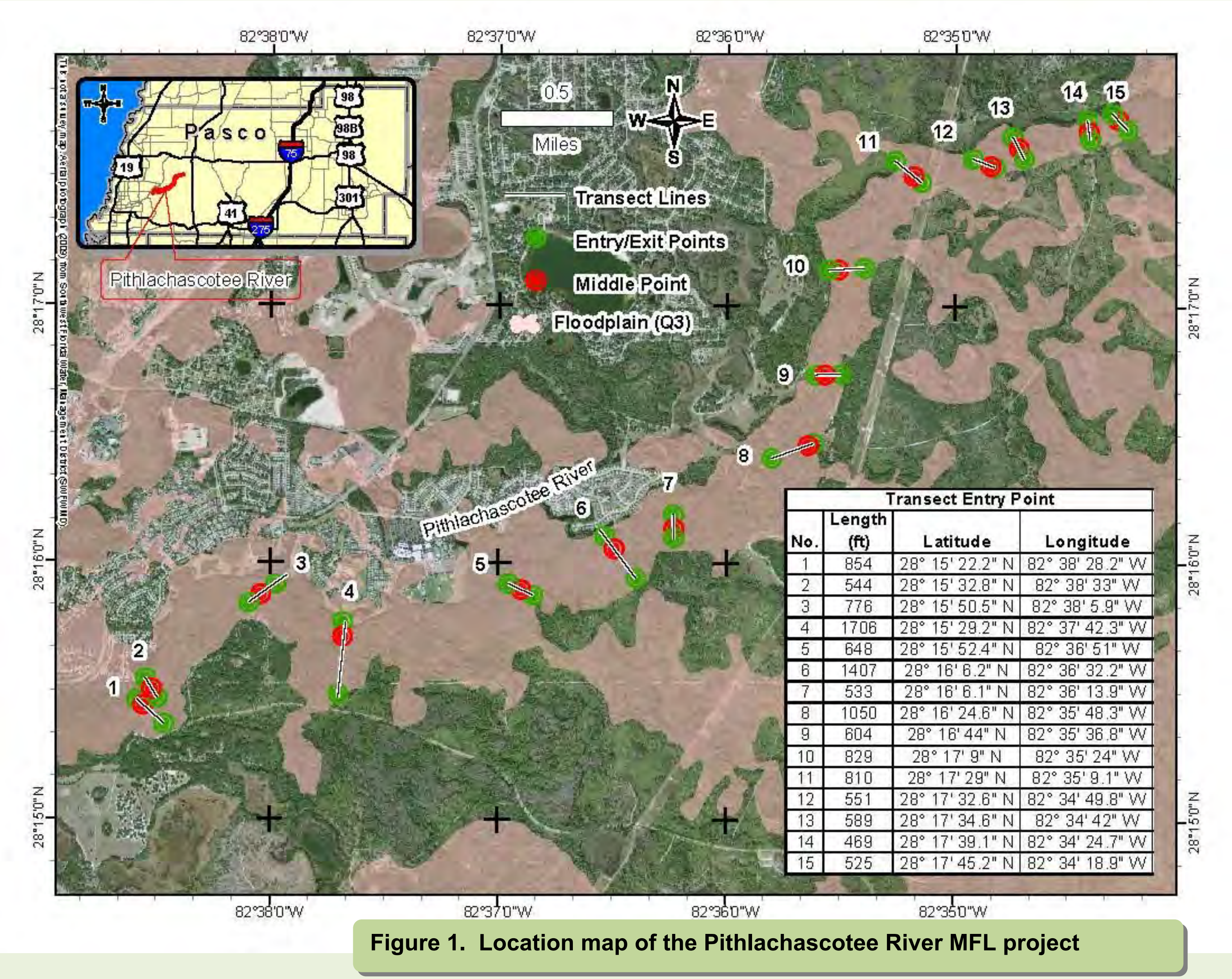
Table 33. Pithlachascotee River- Soils Data - Transect 15

		Soil index				
Soil Number	Elevation	0 - Not hydric	1 - Hydric	2 - hydric with muck	3 - hydric, saturated	4 - hydric, muck, saturated
TR15-S001	42.5		X			
TR15-S002	42.5		X			
TR15-S003	42.3			X		
TR15-S004	41.9			X		
TR15-S005	41.8			X		
TR15-S006	41.7			X		
TR15-S007	41.3			X		
TR15-S008	41.4			X		
TR15-S009	41.5			X		
TR15-S010	41.9			X		
TR15-S011	41.5			X		
TR15-S012	41.2			X		
TR15-S013	41.0					X
TR15-S014	41.0					X
TR15-S015	41.0					X
TR15-S016	41.4					X
TR15-S017	41.2					X
TR15-S018	41.3					X
TR15-S019	42.5		X			
TR15-S020	42.4			X		
TR15-S021	42.3			X		

FIGURES



Pithlachascotee River Transect #9, July 2009



Transect Entry Point			
No.	Length (ft)	Latitude	Longitude
1	854	28° 15' 22.2" N	82° 38' 28.2" W
2	544	28° 15' 32.8" N	82° 38' 33" W
3	776	28° 15' 50.5" N	82° 38' 5.9" W
4	1706	28° 15' 29.2" N	82° 37' 42.3" W
5	648	28° 15' 52.4" N	82° 36' 51" W
6	1407	28° 16' 6.2" N	82° 36' 32.2" W
7	533	28° 16' 6.1" N	82° 36' 13.9" W
8	1050	28° 16' 24.6" N	82° 35' 48.3" W
9	604	28° 16' 44" N	82° 35' 36.8" W
10	829	28° 17' 9" N	82° 35' 24" W
11	810	28° 17' 29" N	82° 35' 9.1" W
12	551	28° 17' 32.6" N	82° 34' 49.8" W
13	589	28° 17' 34.6" N	82° 34' 42" W
14	469	28° 17' 39.1" N	82° 34' 24.7" W
15	525	28° 17' 45.2" N	82° 34' 18.9" W

Figure 1. Location map of the Pithlachascotee River MFL project

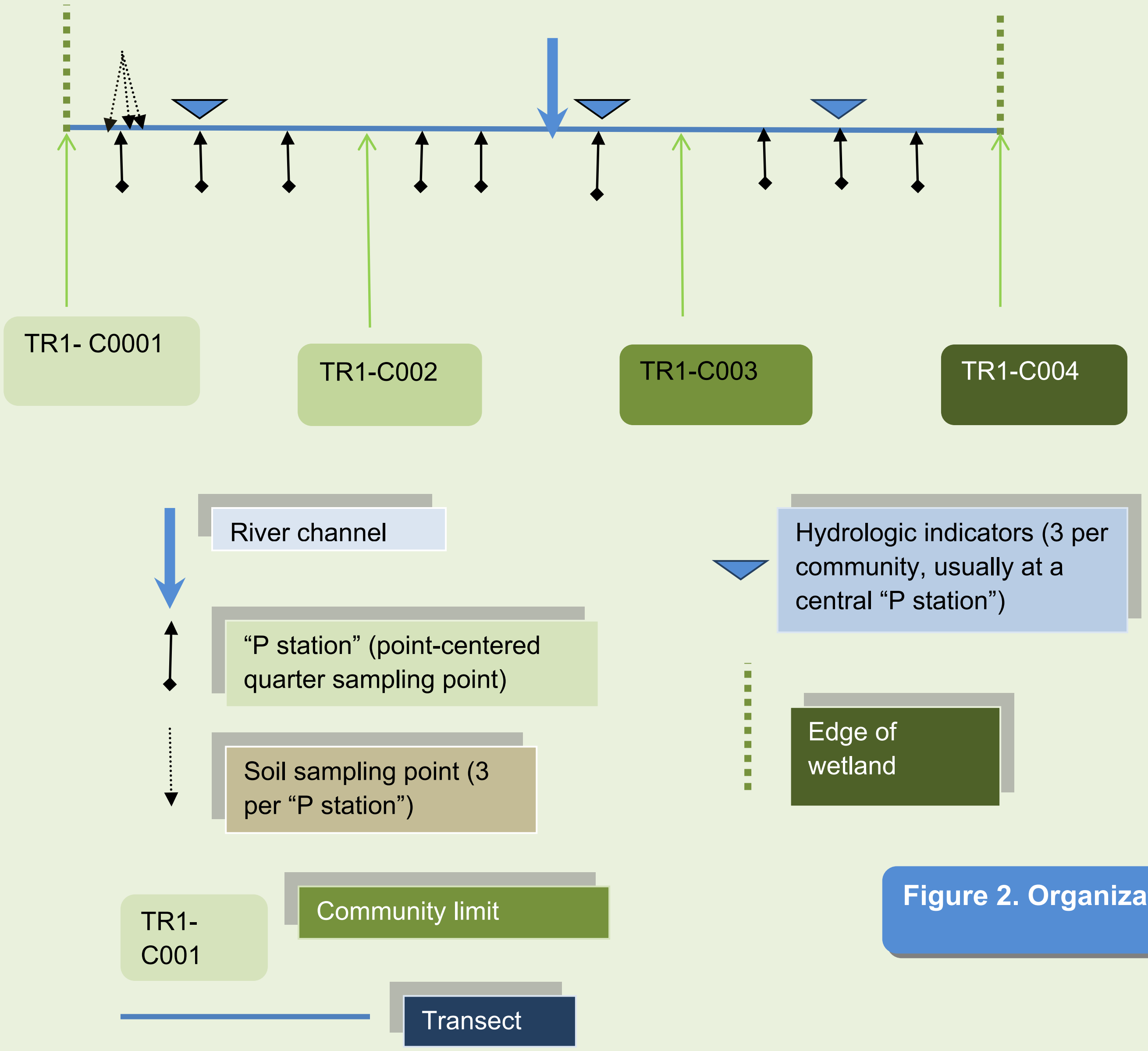


Figure 2. Organization of typical transect.

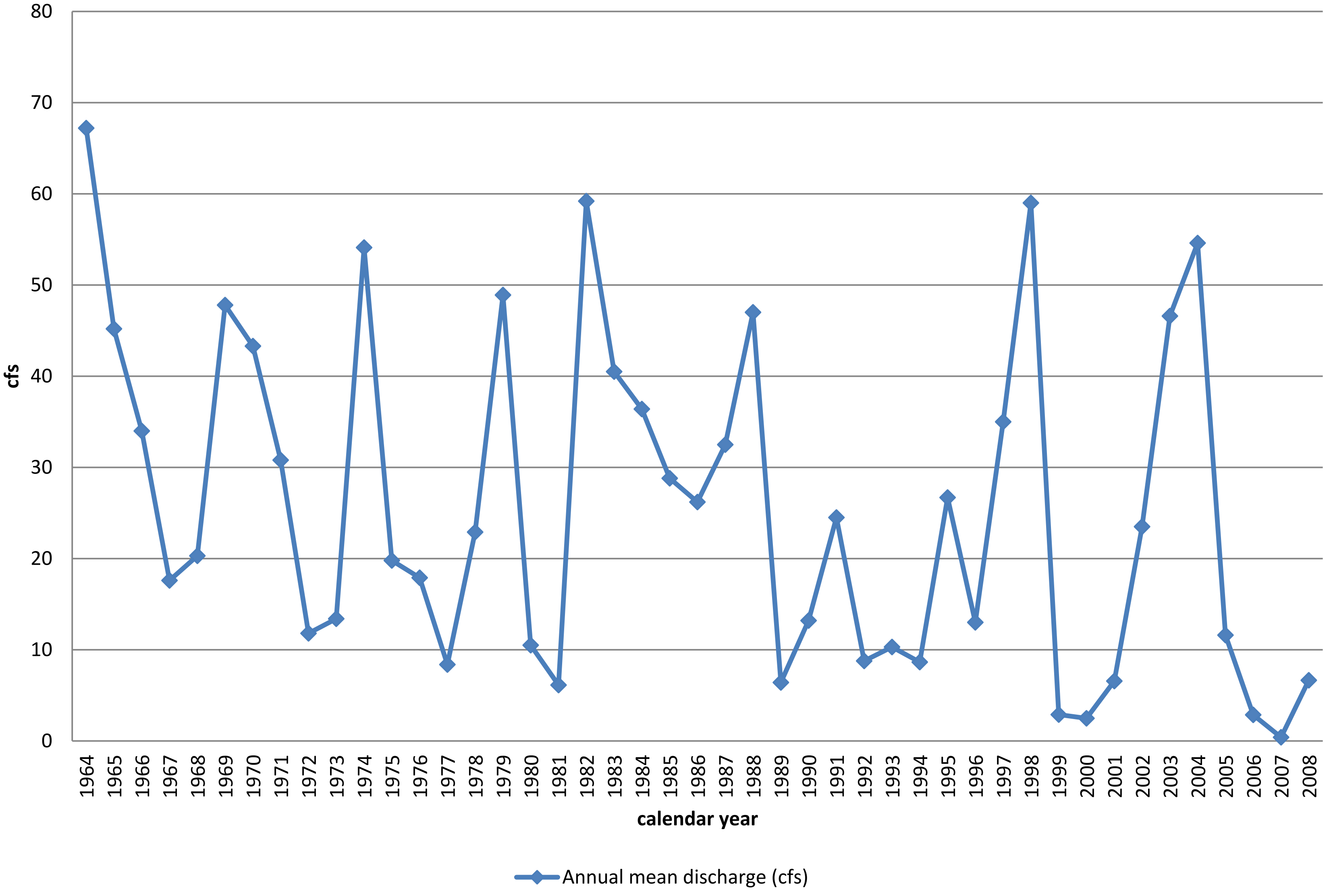
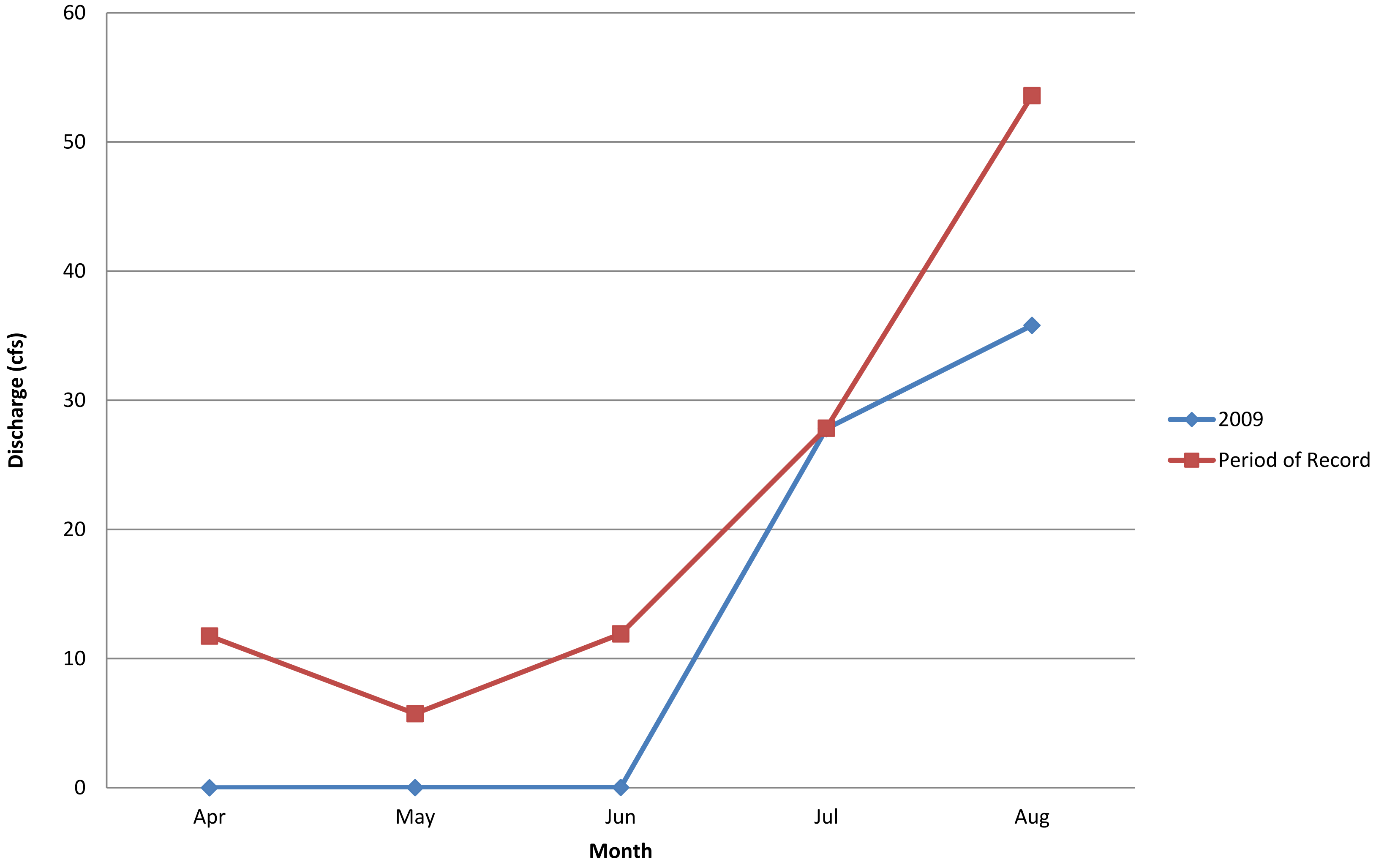


Figure 3. Mean annual discharge (cfs), USGS 0231300

Figure 4. Pithlachascotee River Average Monthly Discharge for Sampling Period (2009) and Period of Record



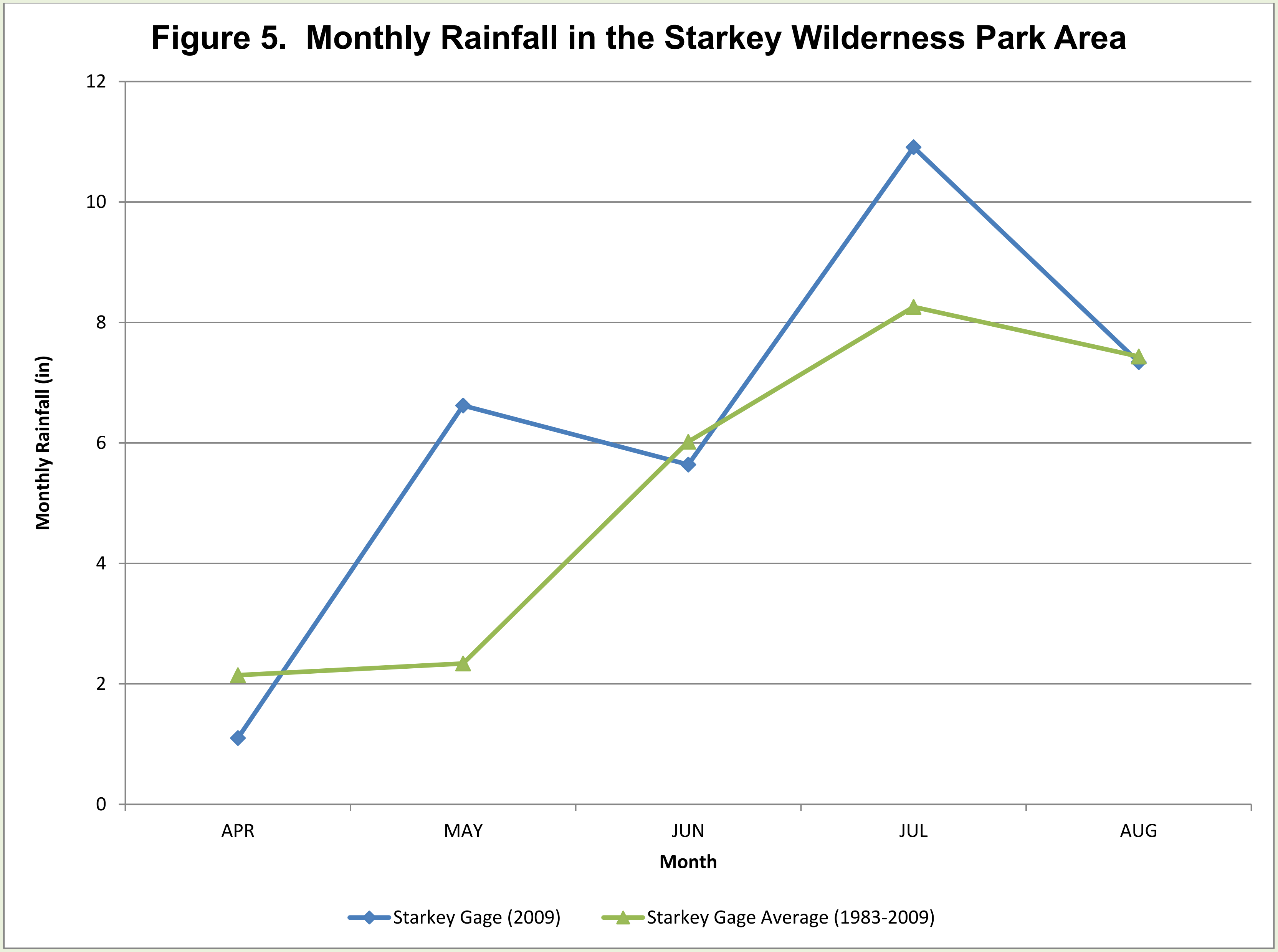


Figure 5. Monthly Rainfall in the Starkey Wilderness Park Area
Monthly Rainfall (in)
0
2
4
6
8
10
12
APR
MAY
JUN
JUL
AUG
Month
Starkey Gage (2009)
Starkey Gage Average (1983-2009)

Figure 6. Bottom Elevation of Pithlachascottee River Channel in Study Area

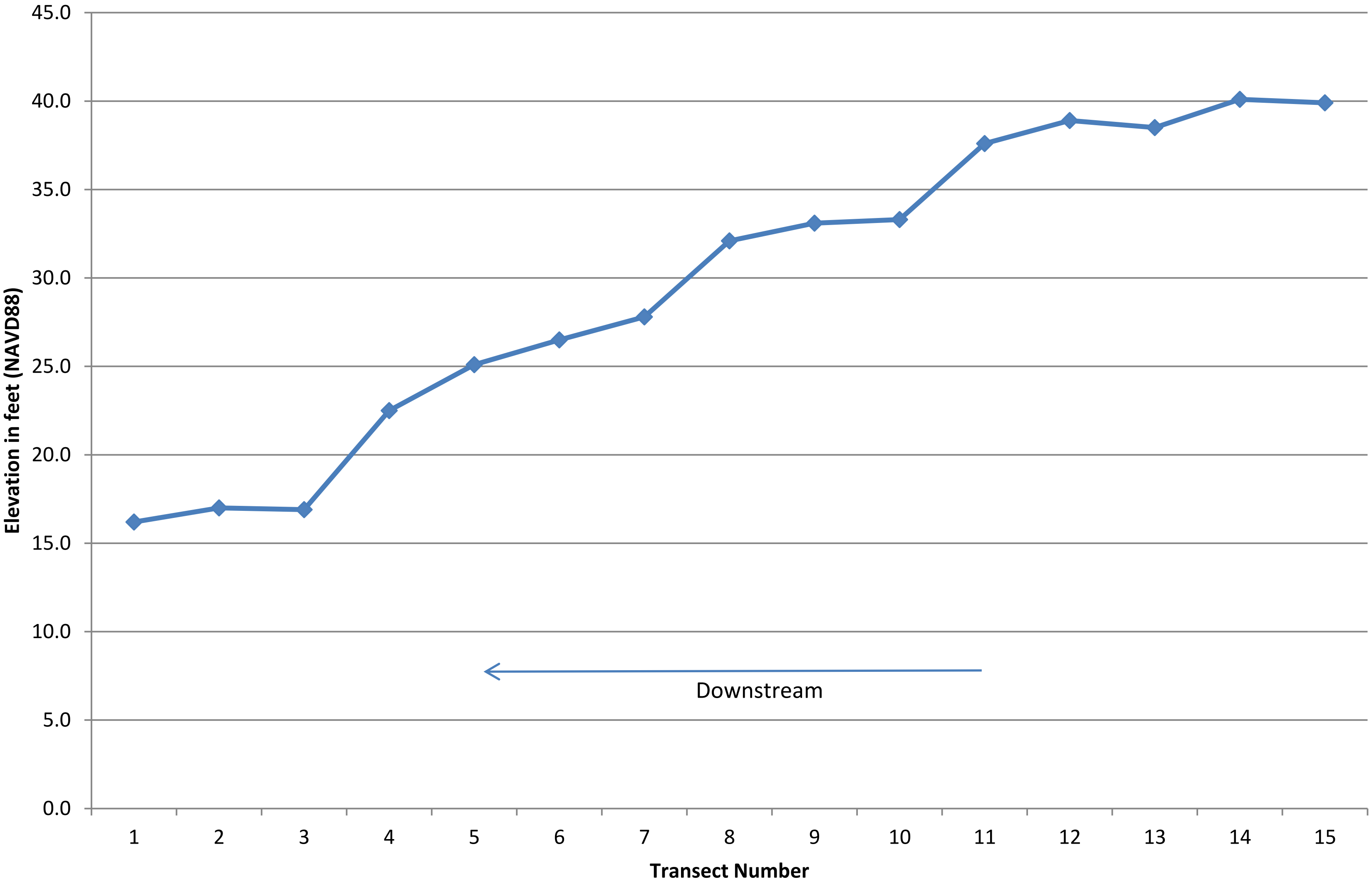


Figure 7. Pithlachascotee River, Transect 1

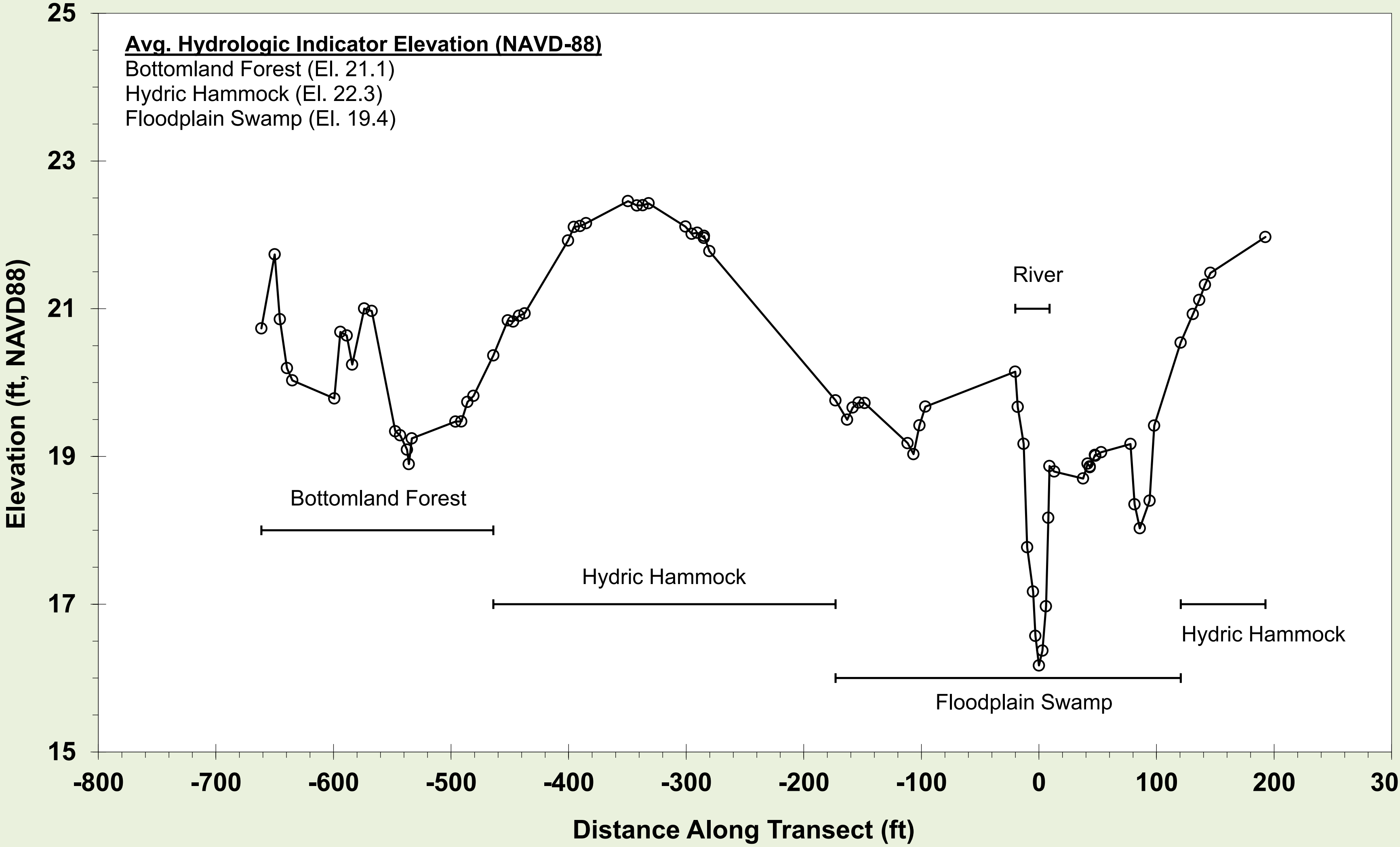


Figure 8. Pithlachascotee River, Transect 2

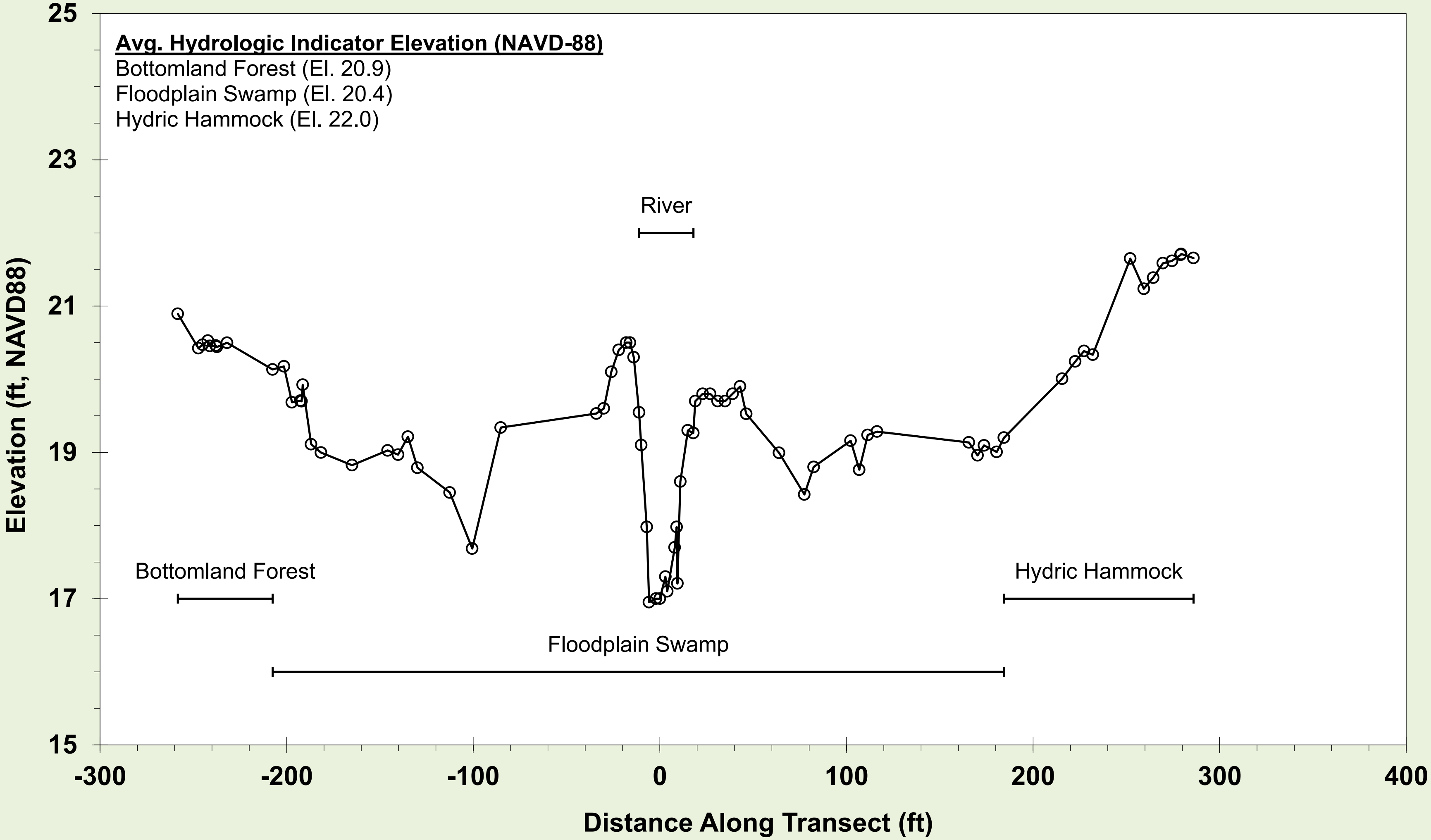


Figure 9. Pithlachascotee River, Transect 3

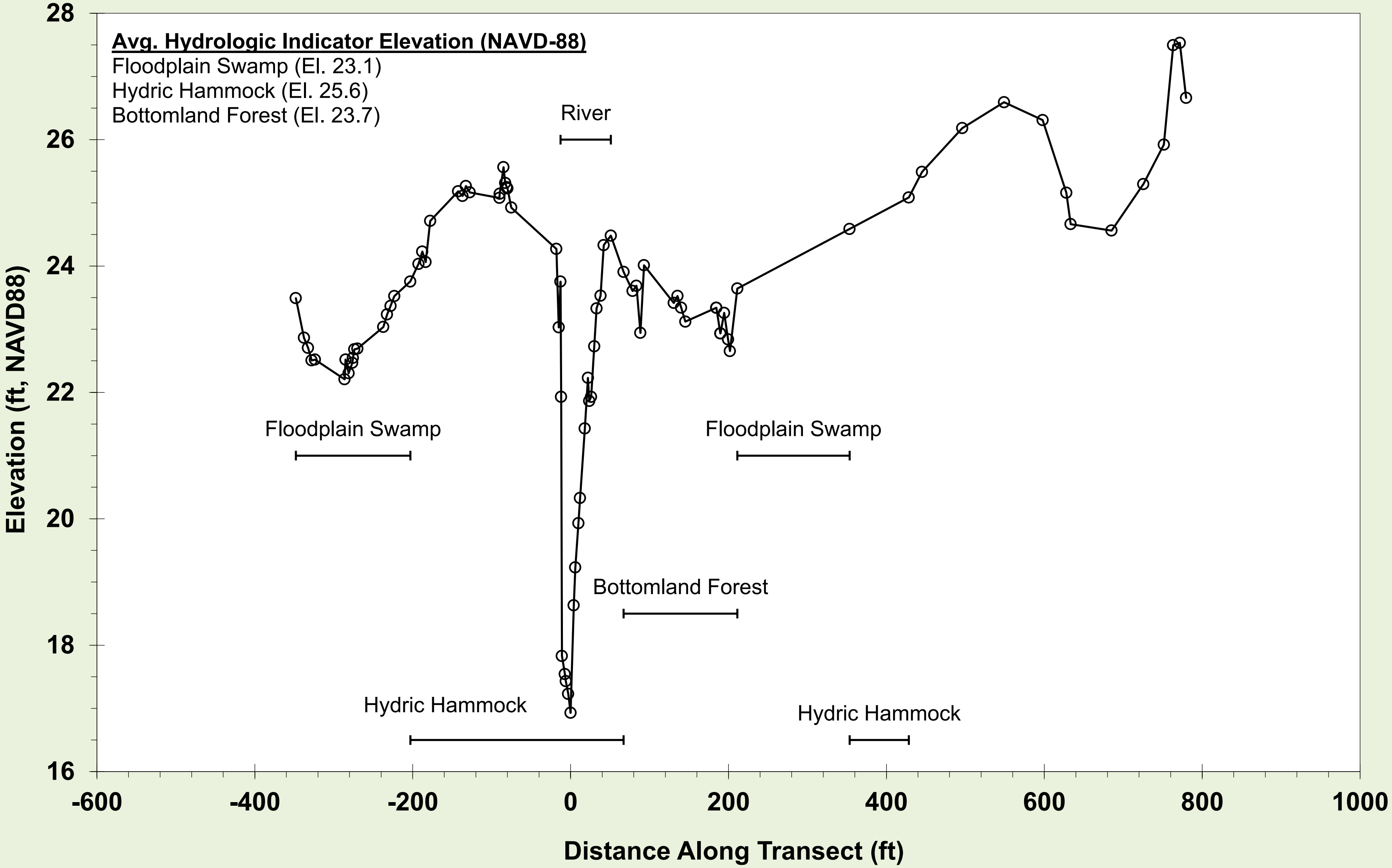


Figure 10. Pithlachascotee River, Transect 4

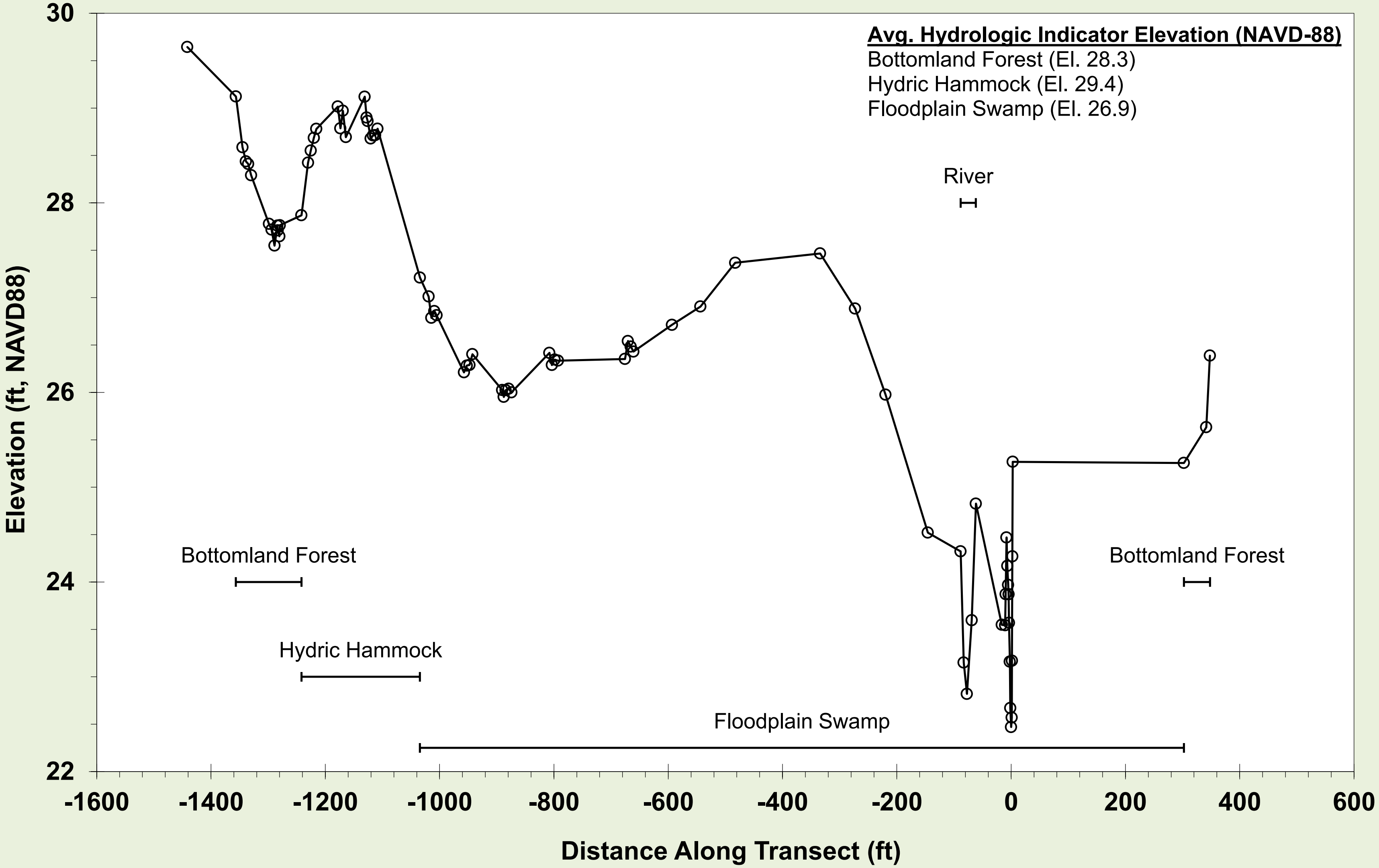


Figure 11. Pithlachascotee River, Transect 5

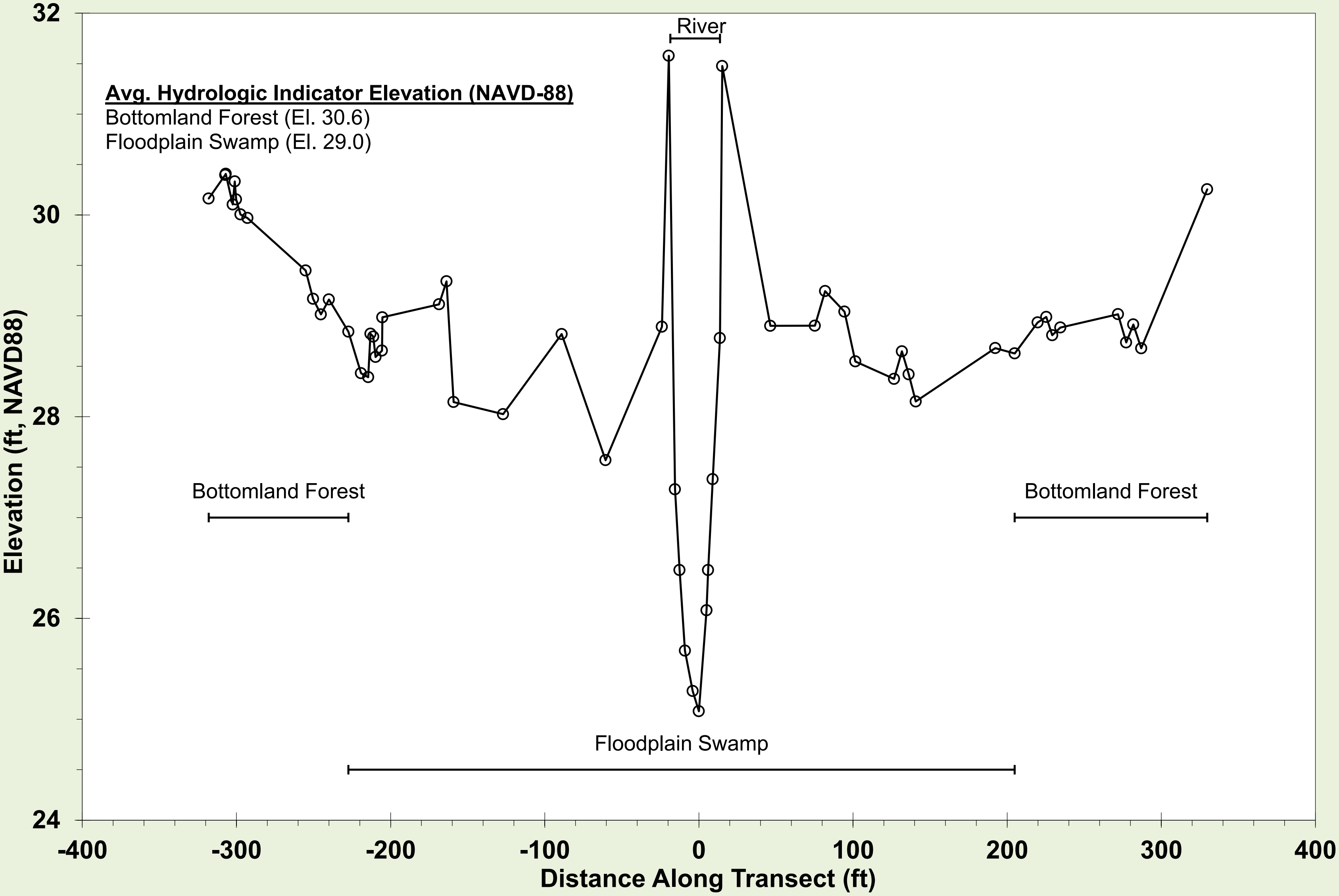


Figure 12. Pithlachascotee River, Transect 6

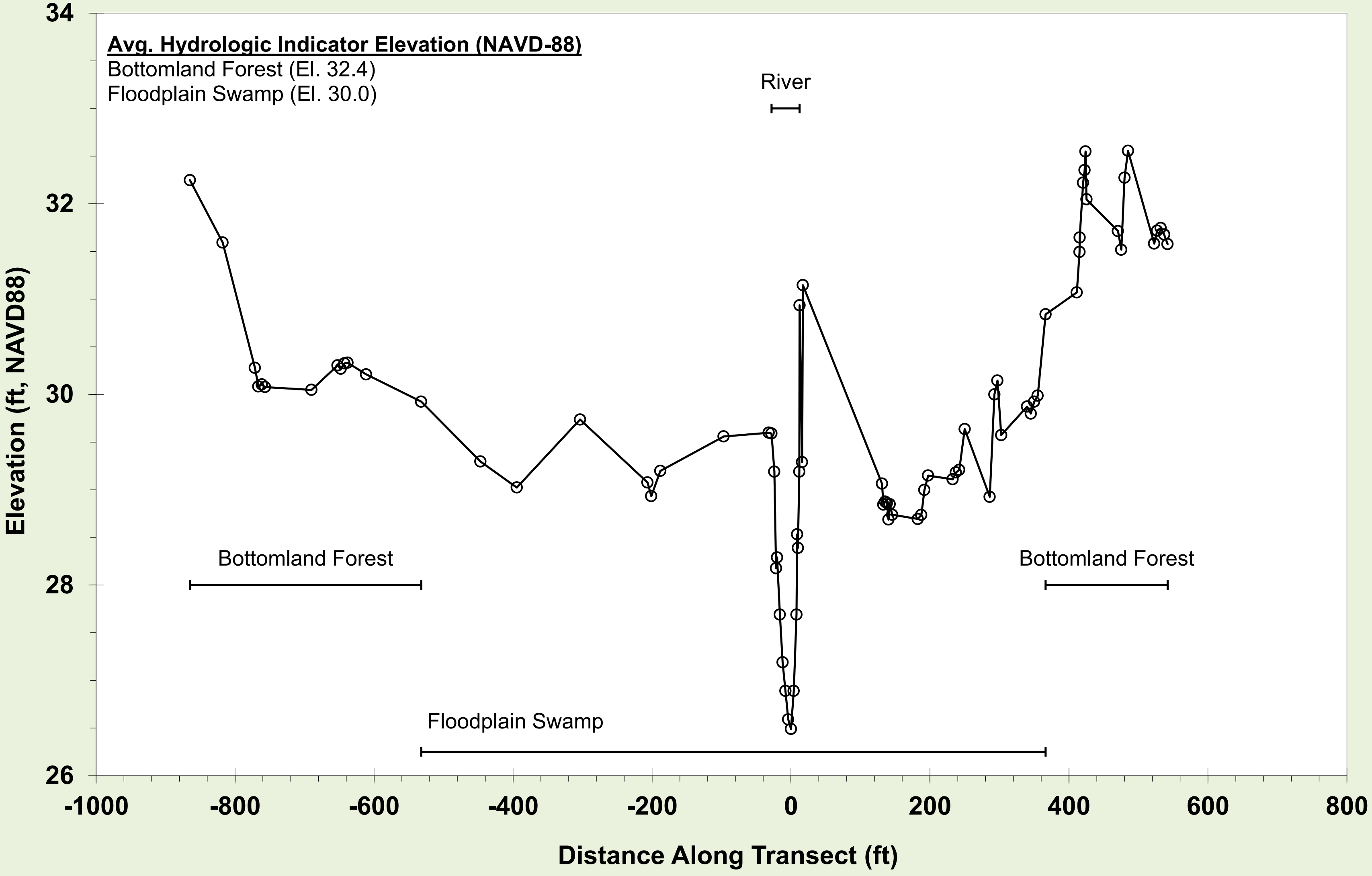


Figure 13. Pithlachascotee River, Transect 7

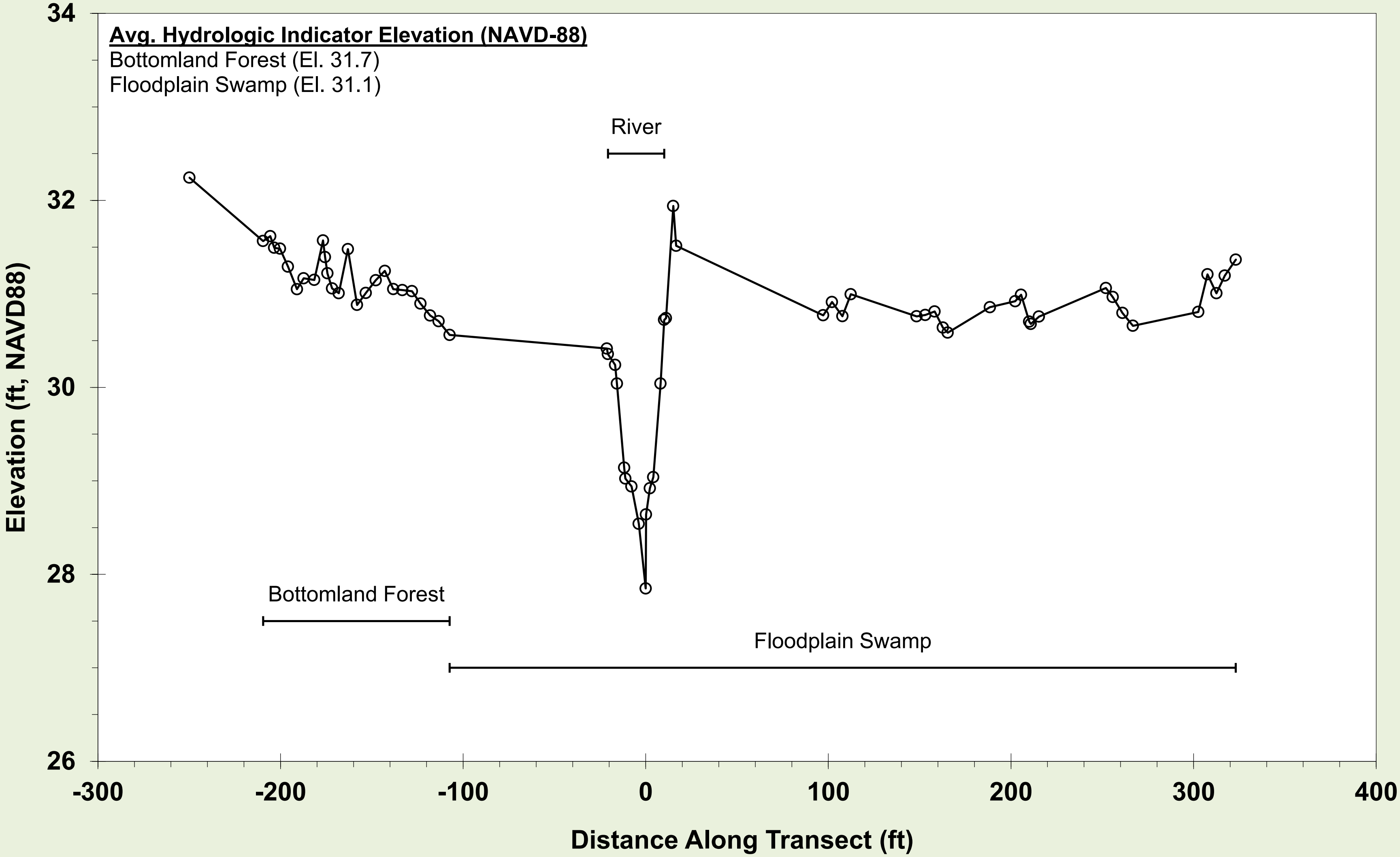


Figure 14. Pithlachascotee River, Transect 8

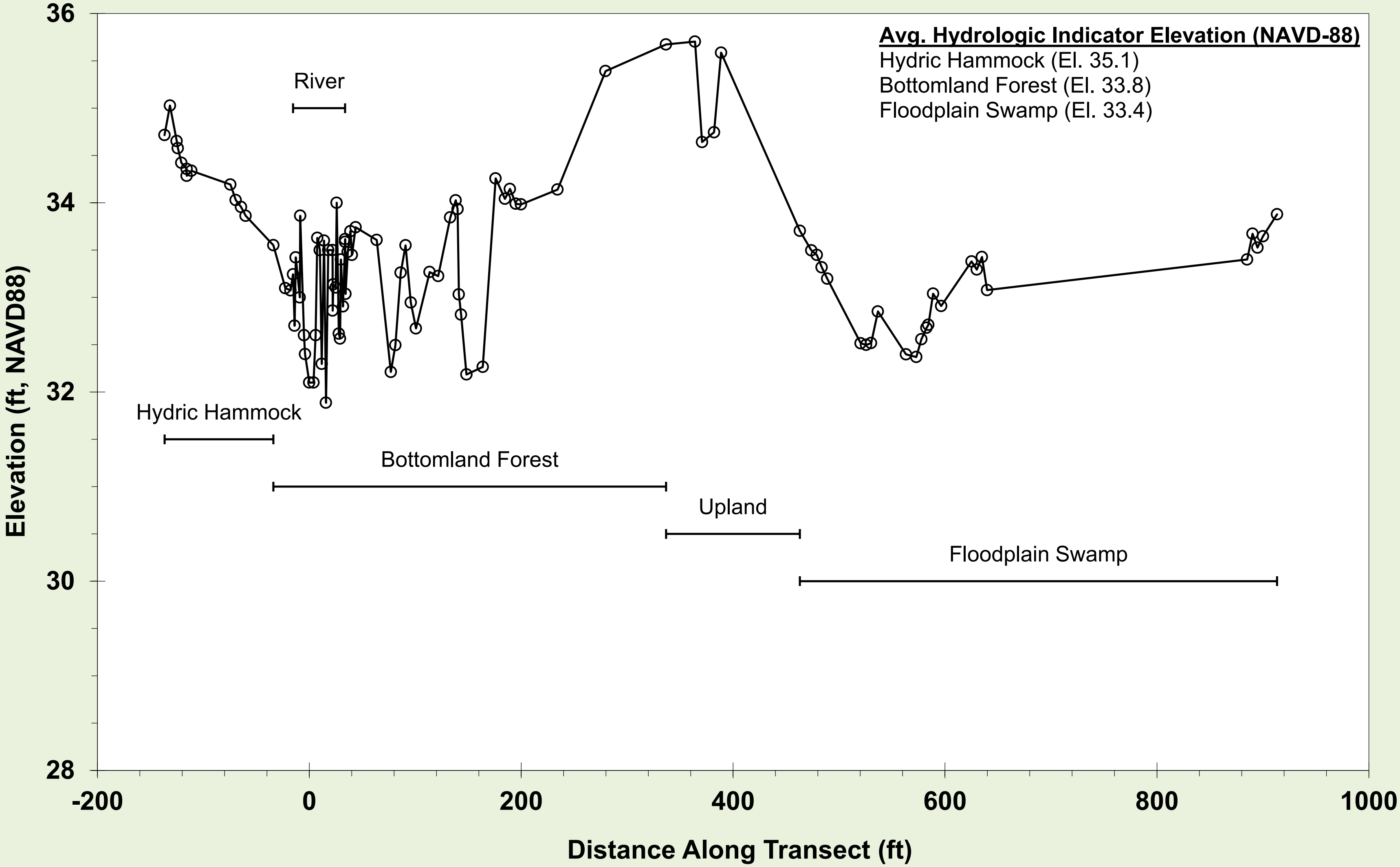


Figure 15. Pithlachascotee River, Transect 9

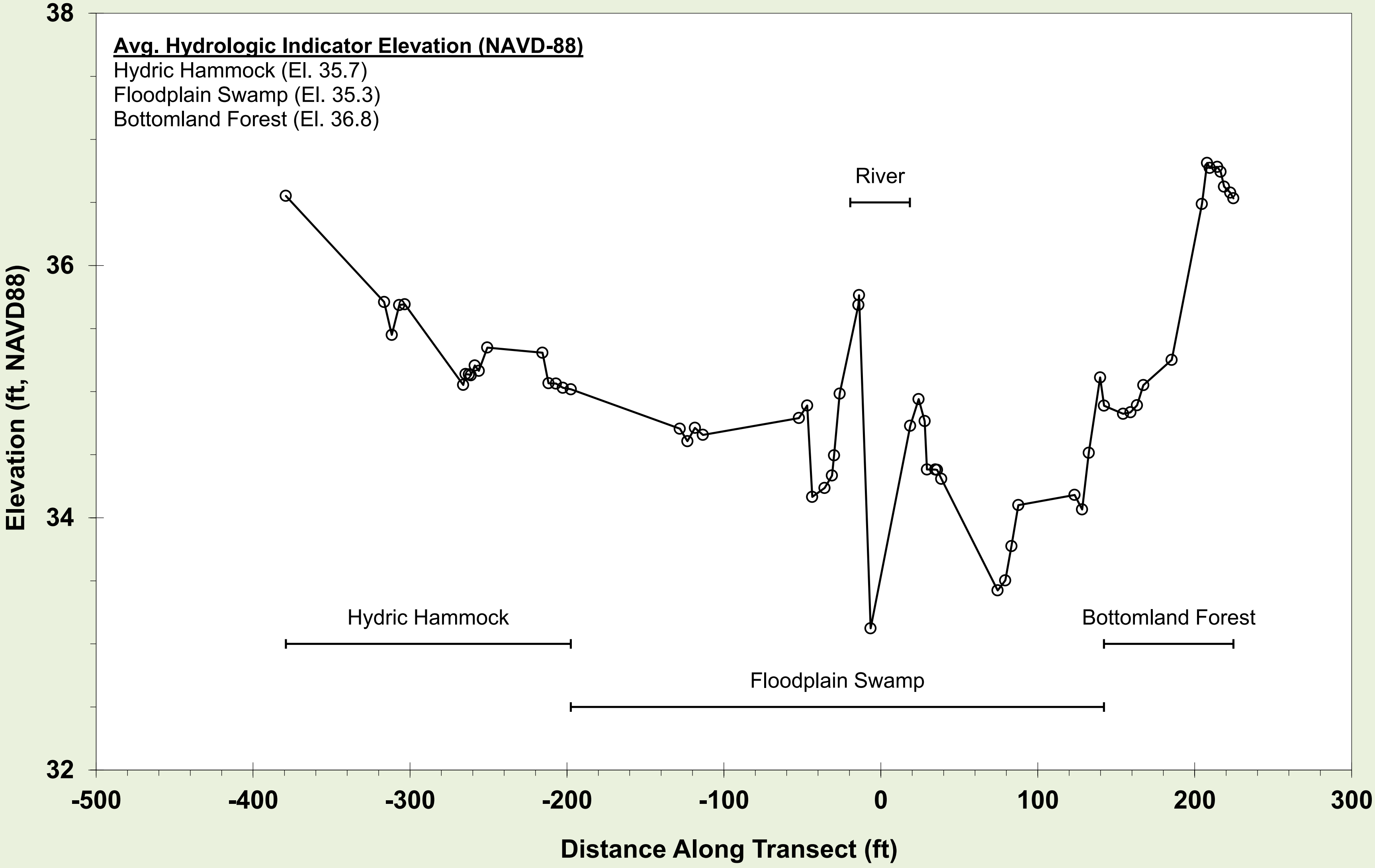


Figure 16. Pithlachascotee River, Transect 10

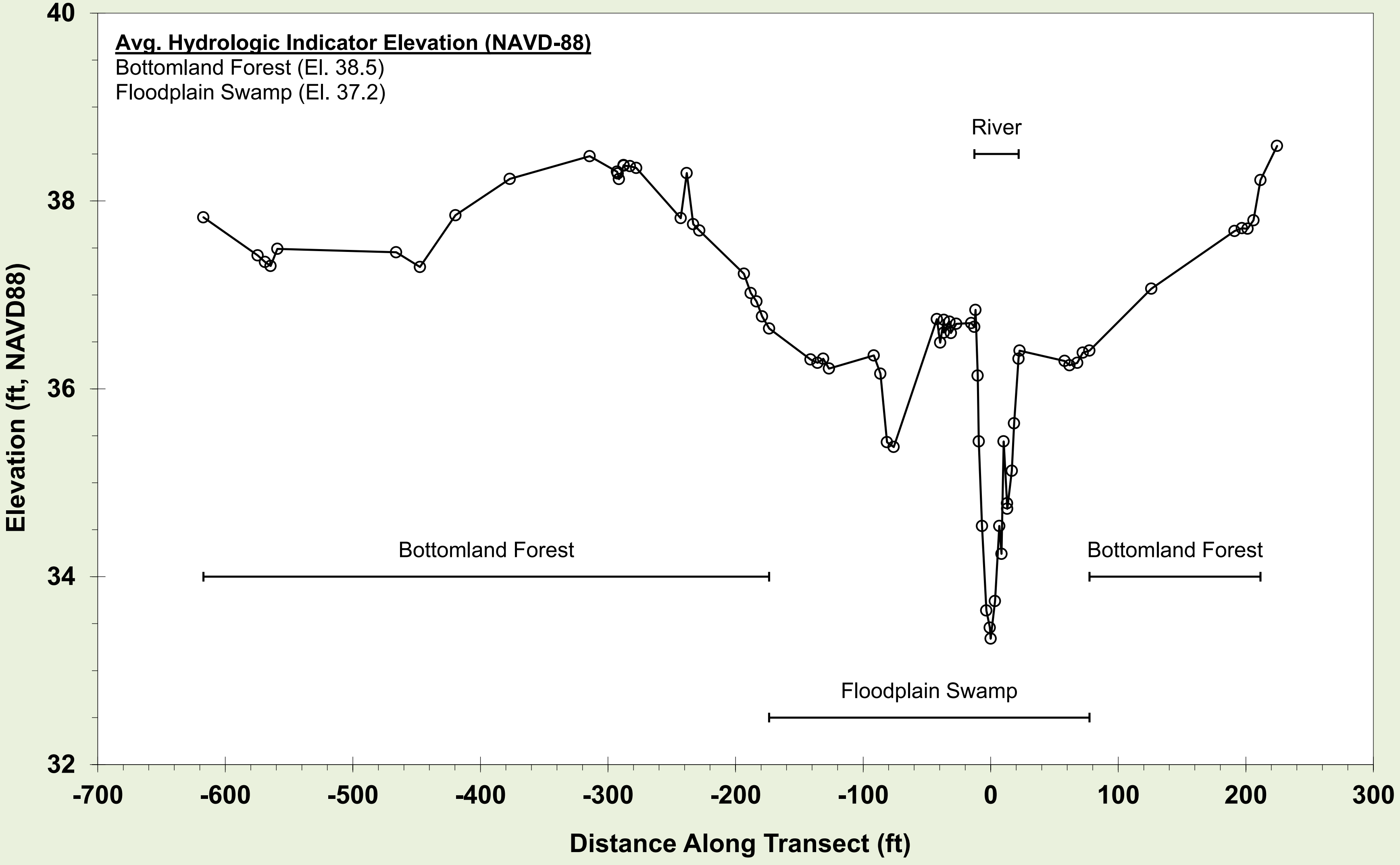


Figure 17. Pithlachascotee River, Transect 11

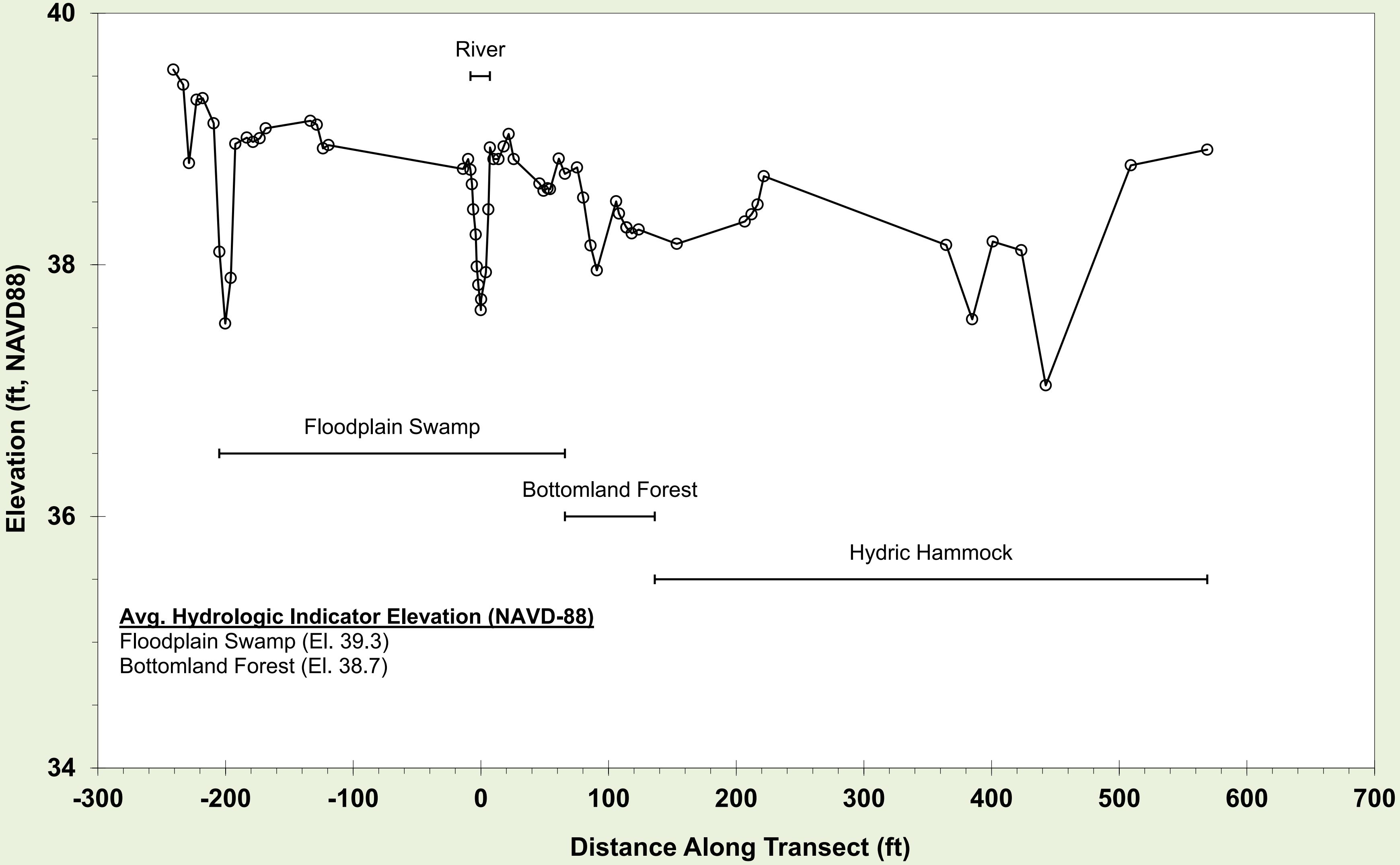


Figure 18. Pithlachascotee River, Transect 12

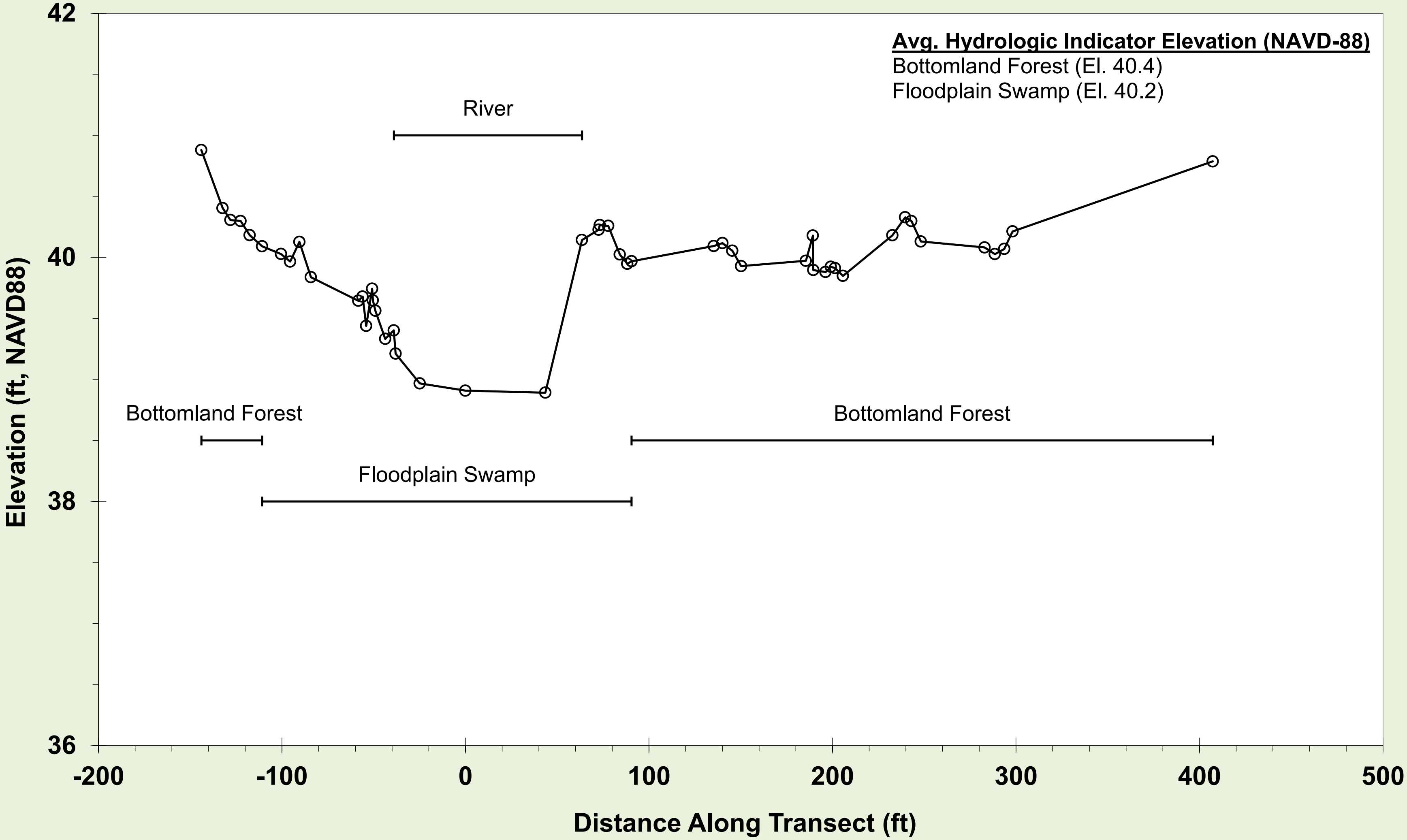


Figure 19. Pithlachascotee River, Transect 13

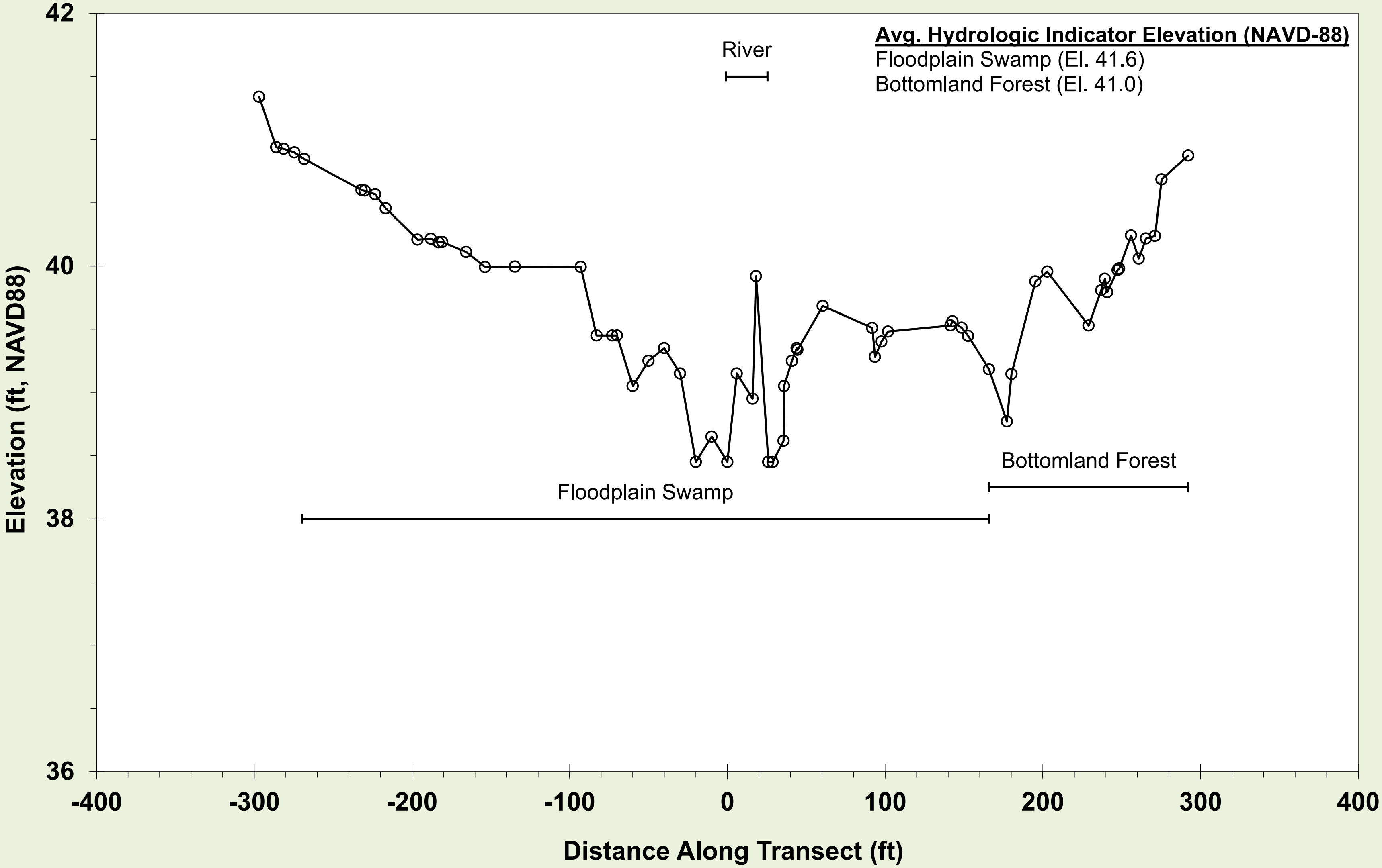


Figure 20. Pithlachascotee River, Transect 14

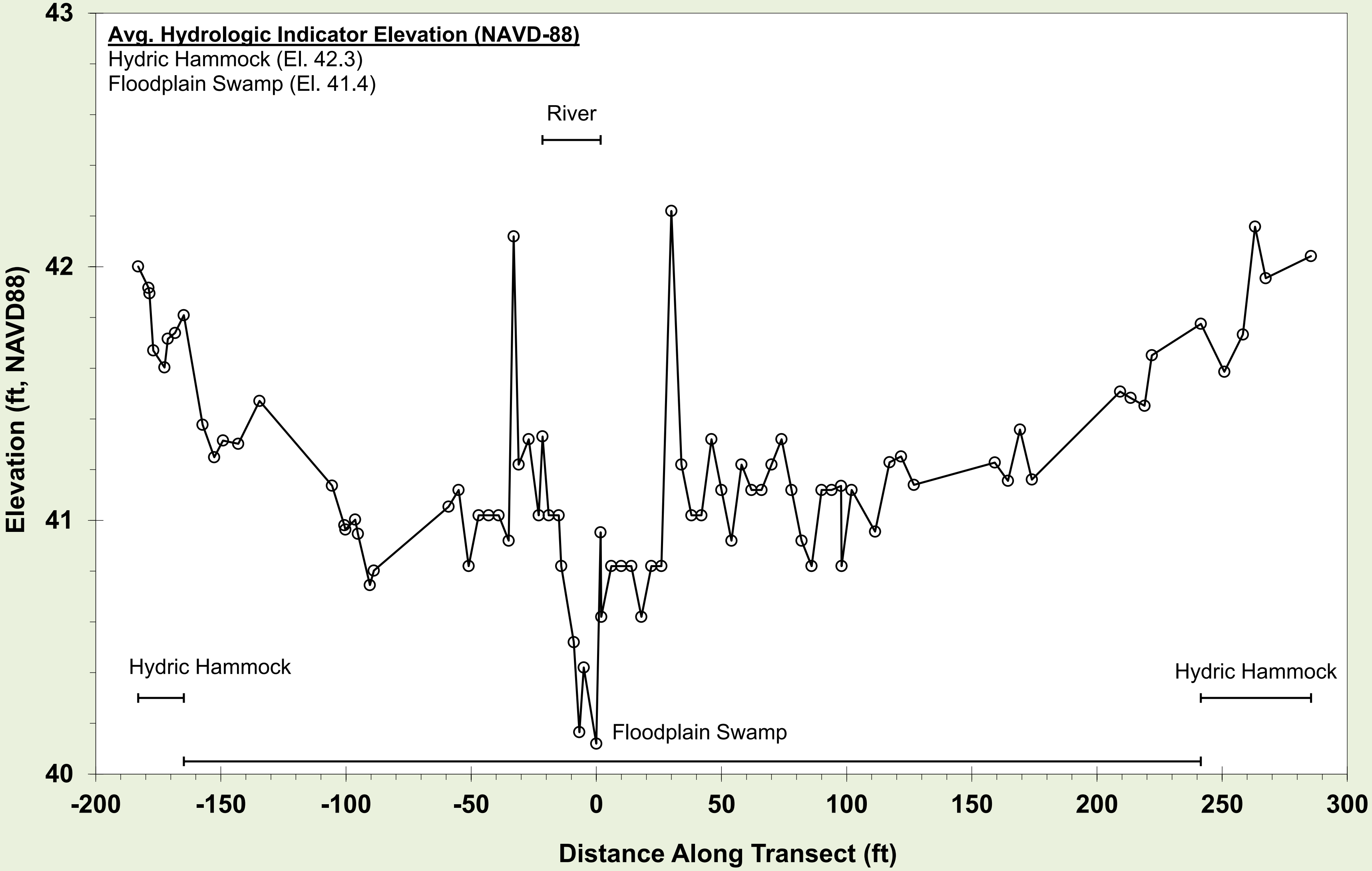
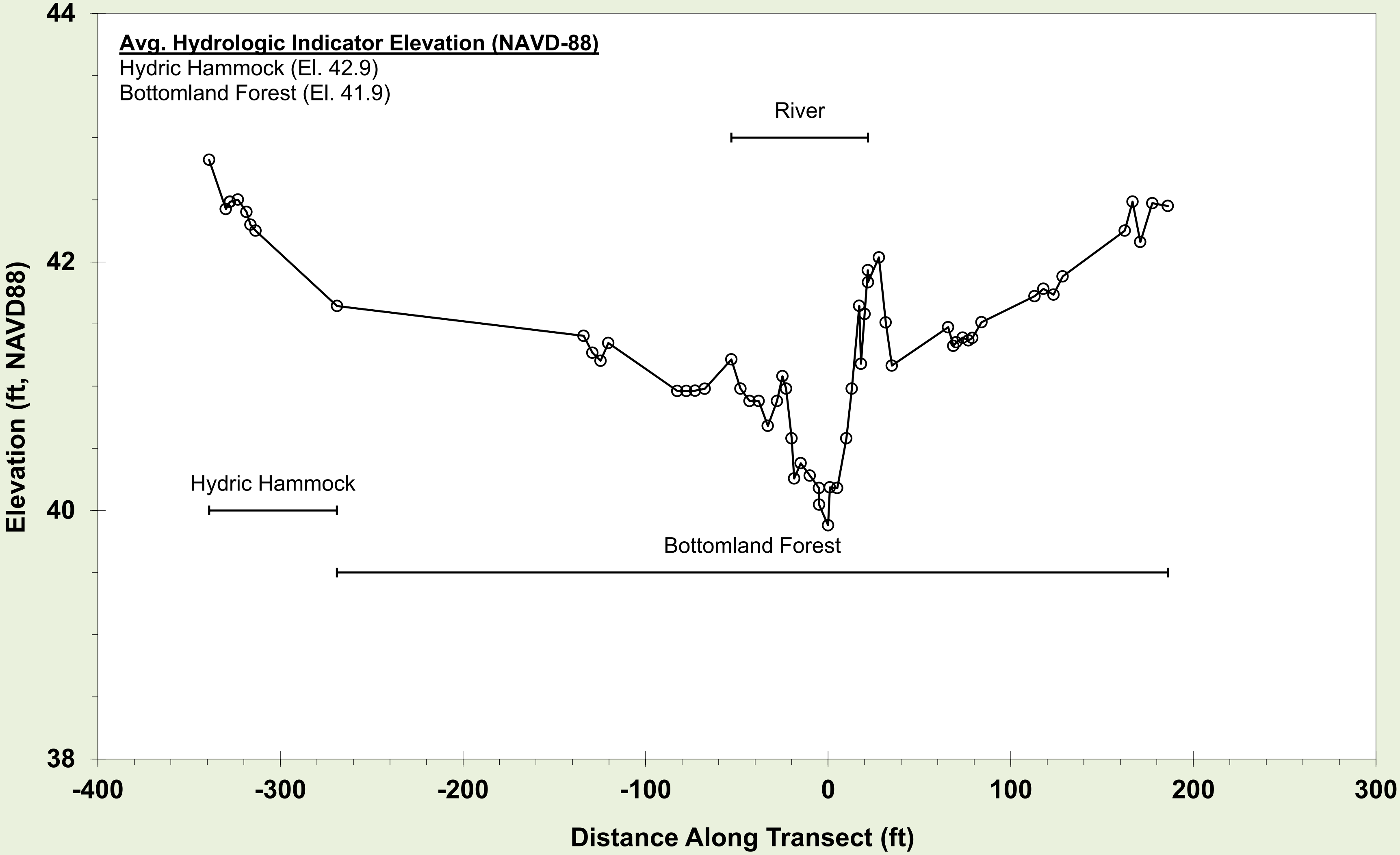


Figure 21. Pithlachascotee River, Transect 15



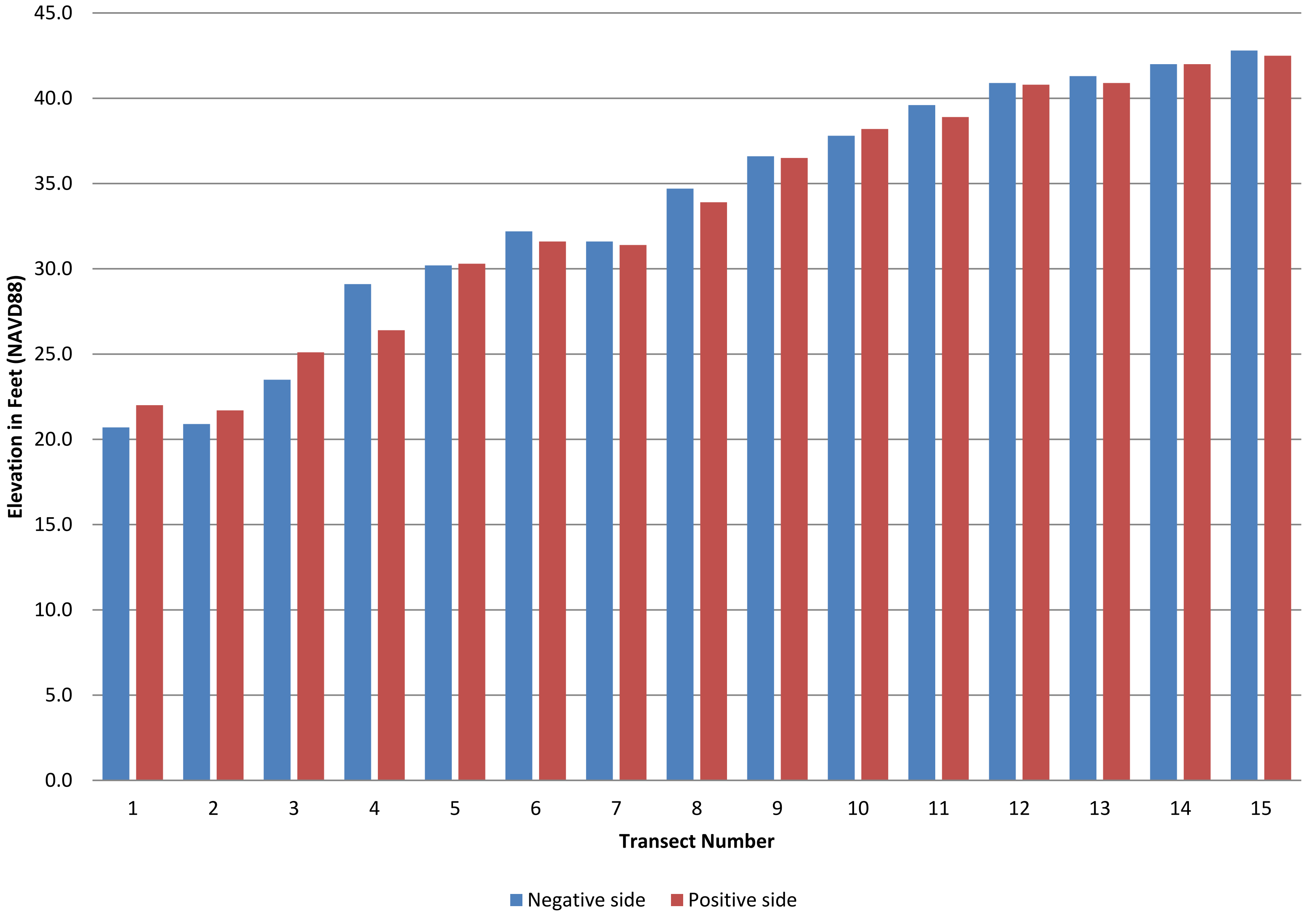


Figure 22. Edge of Wetland Elevations on Both Sides of Transects

Figure 23. Importance Values of Tree Species by Community

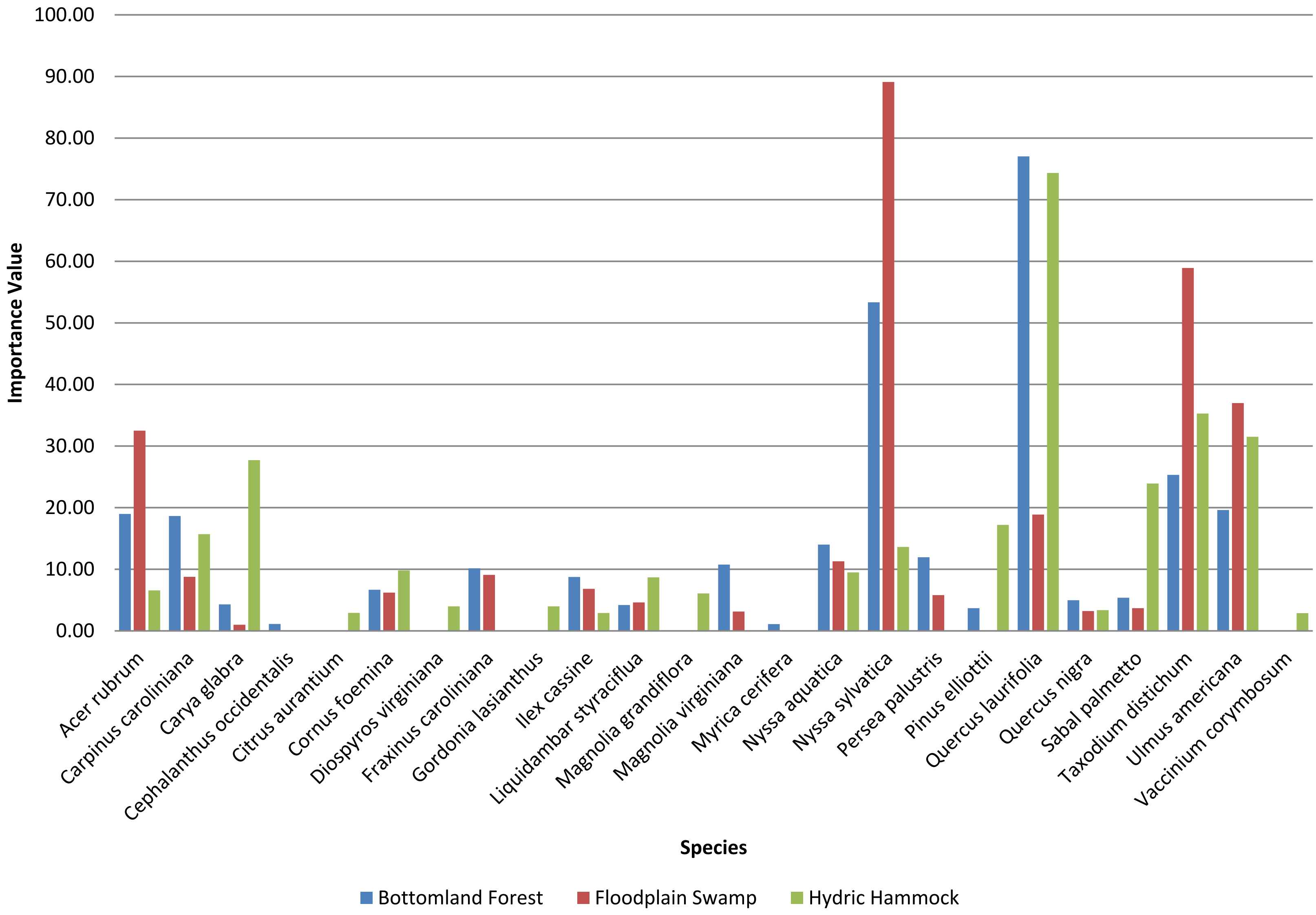


Figure 24. Importance Values by Community for Selected Tree Species

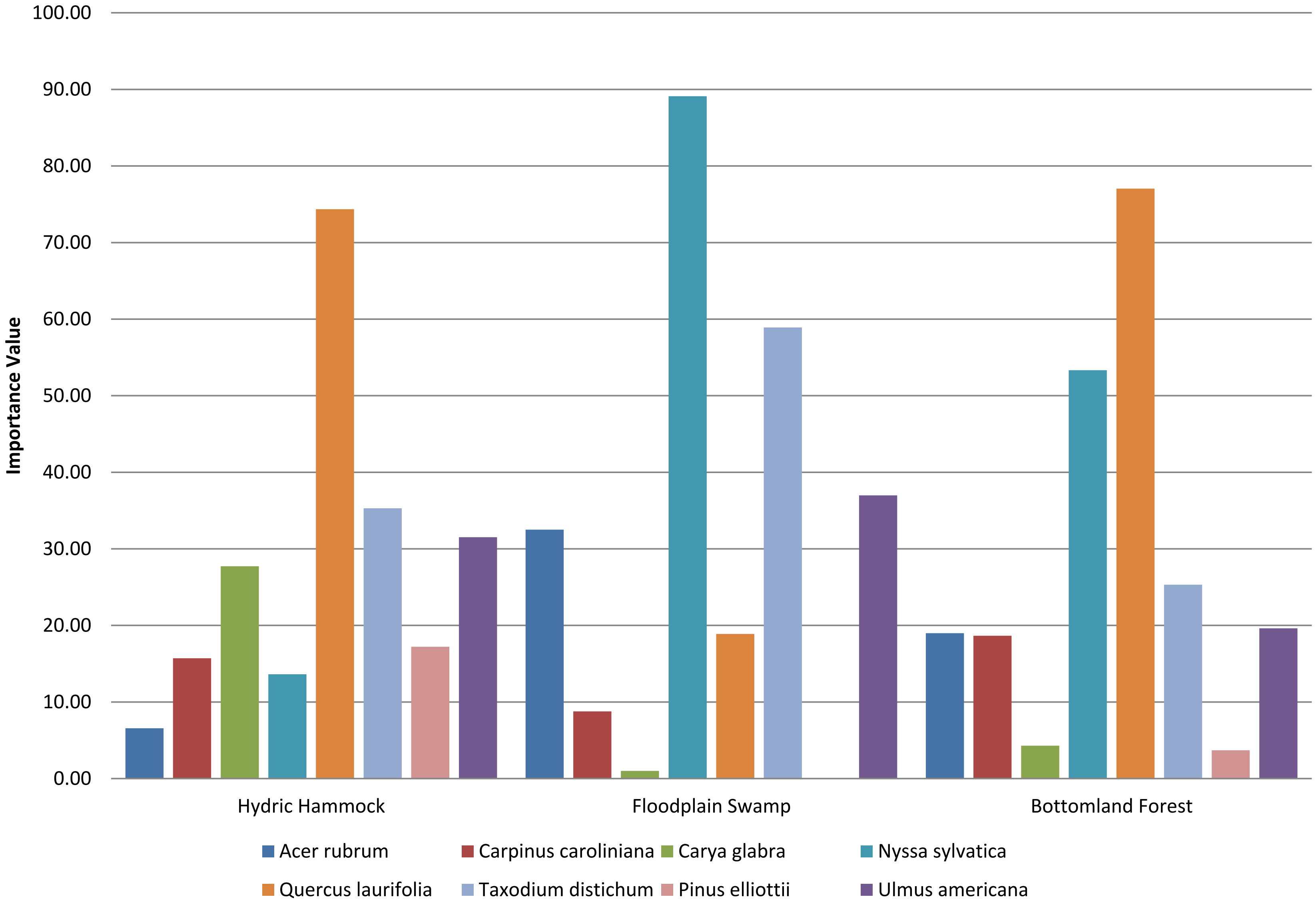


Figure 25. Tree and Shrub Absolute Densities by Community

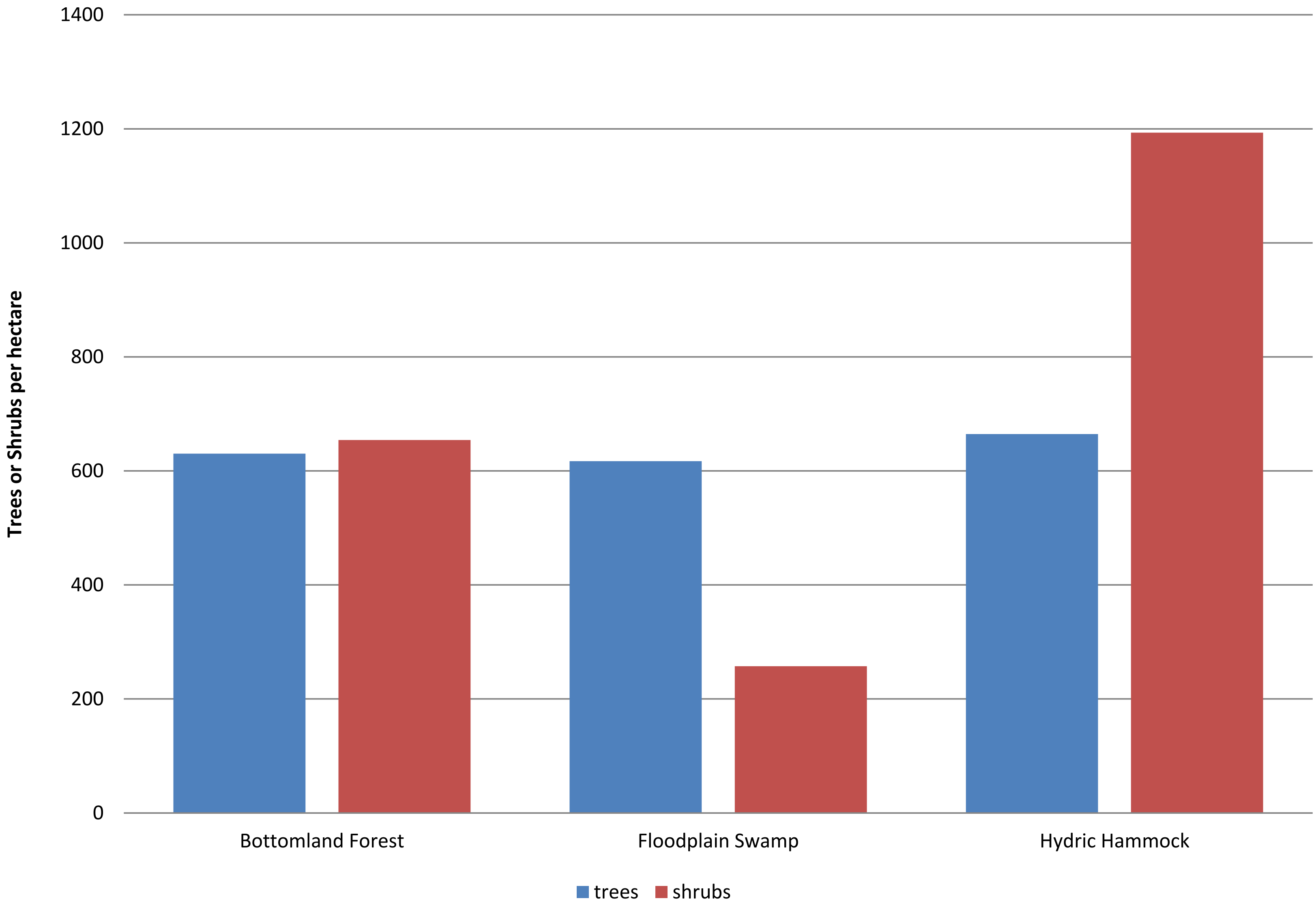
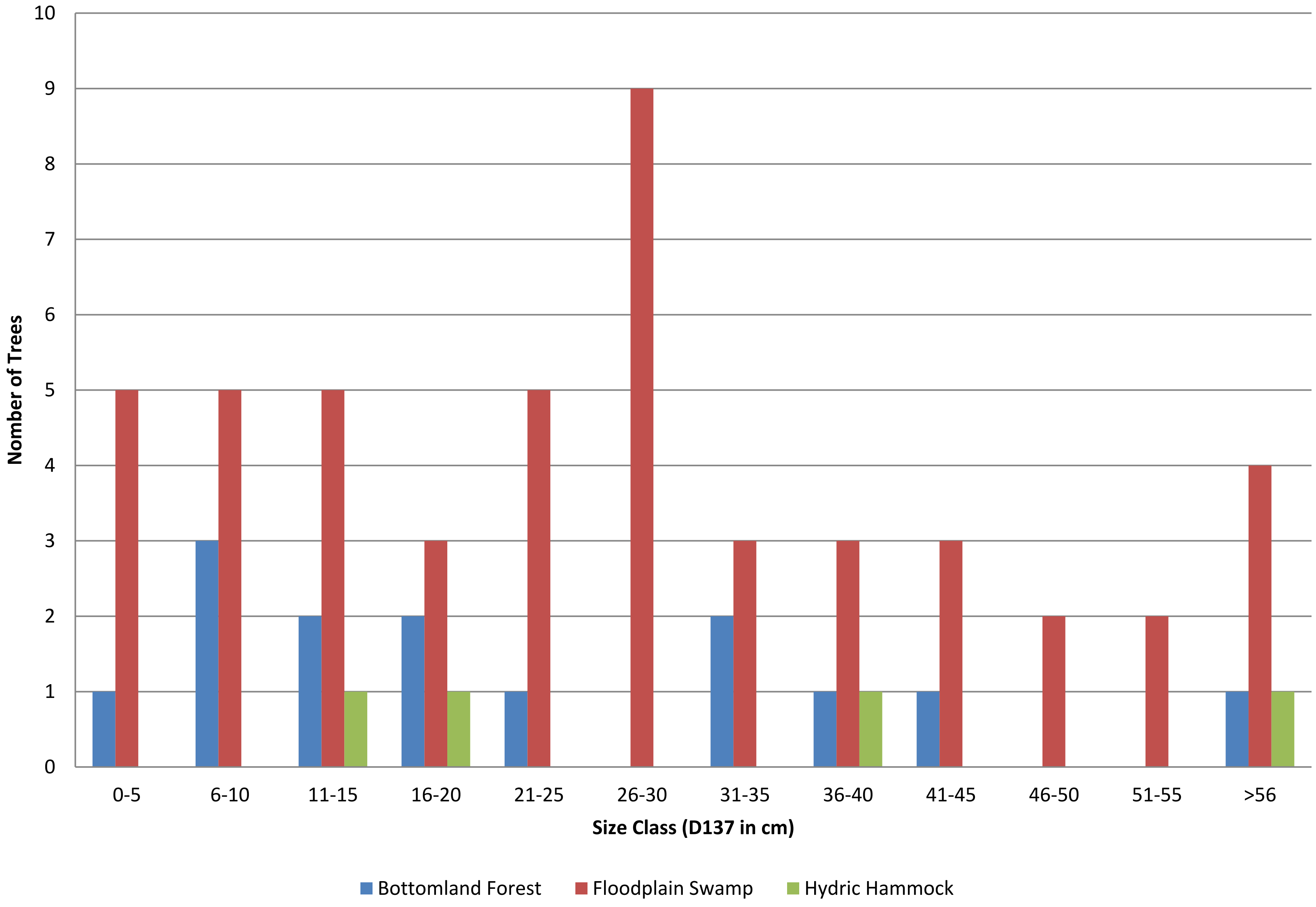


Figure 26. D^{137} Class sizes of *Taxodium distichum* by Community



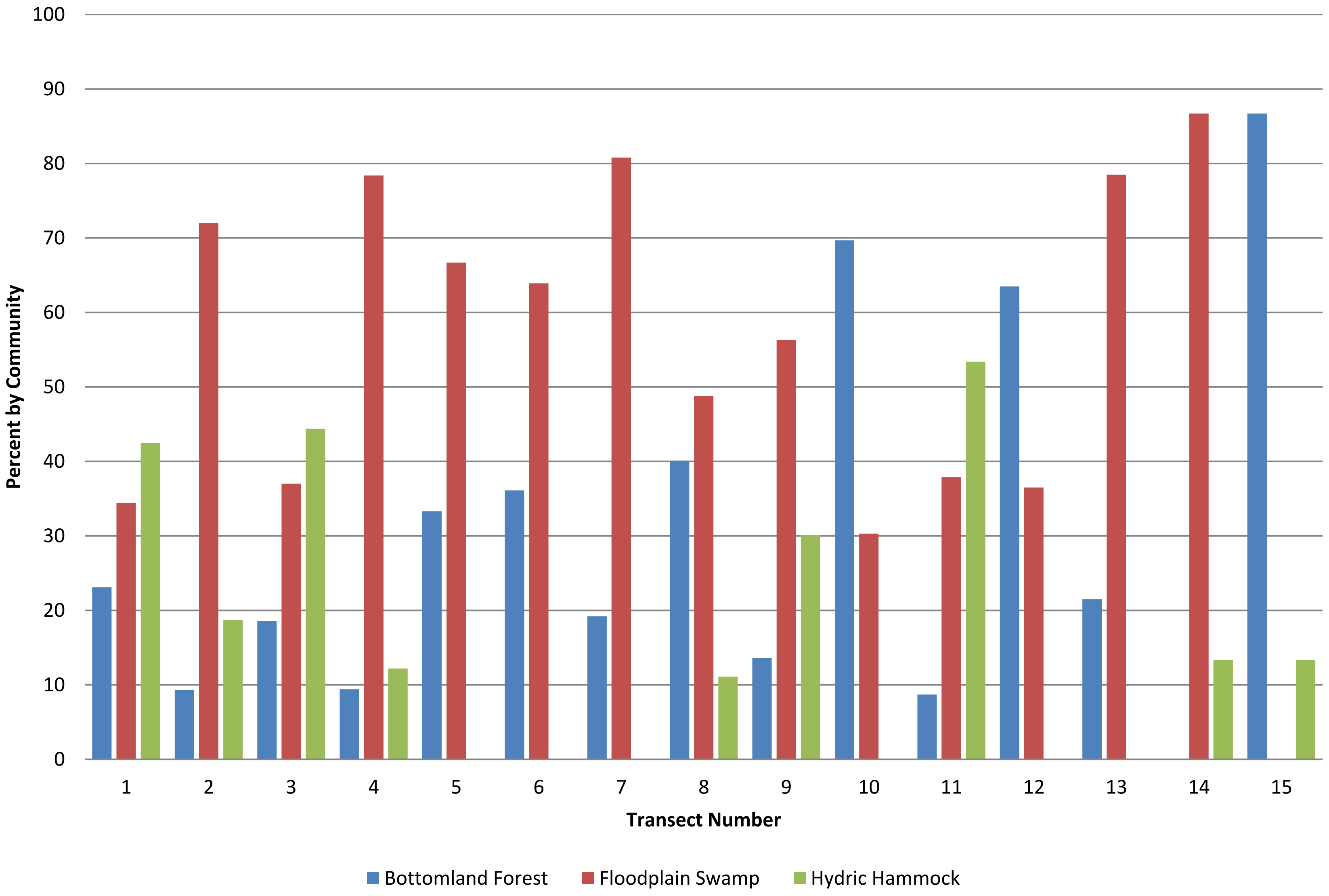


Figure 27. Percent Linear Coverage of Transect by Community

Figure 28. Average Community Elevation by Transect (NAVD88)

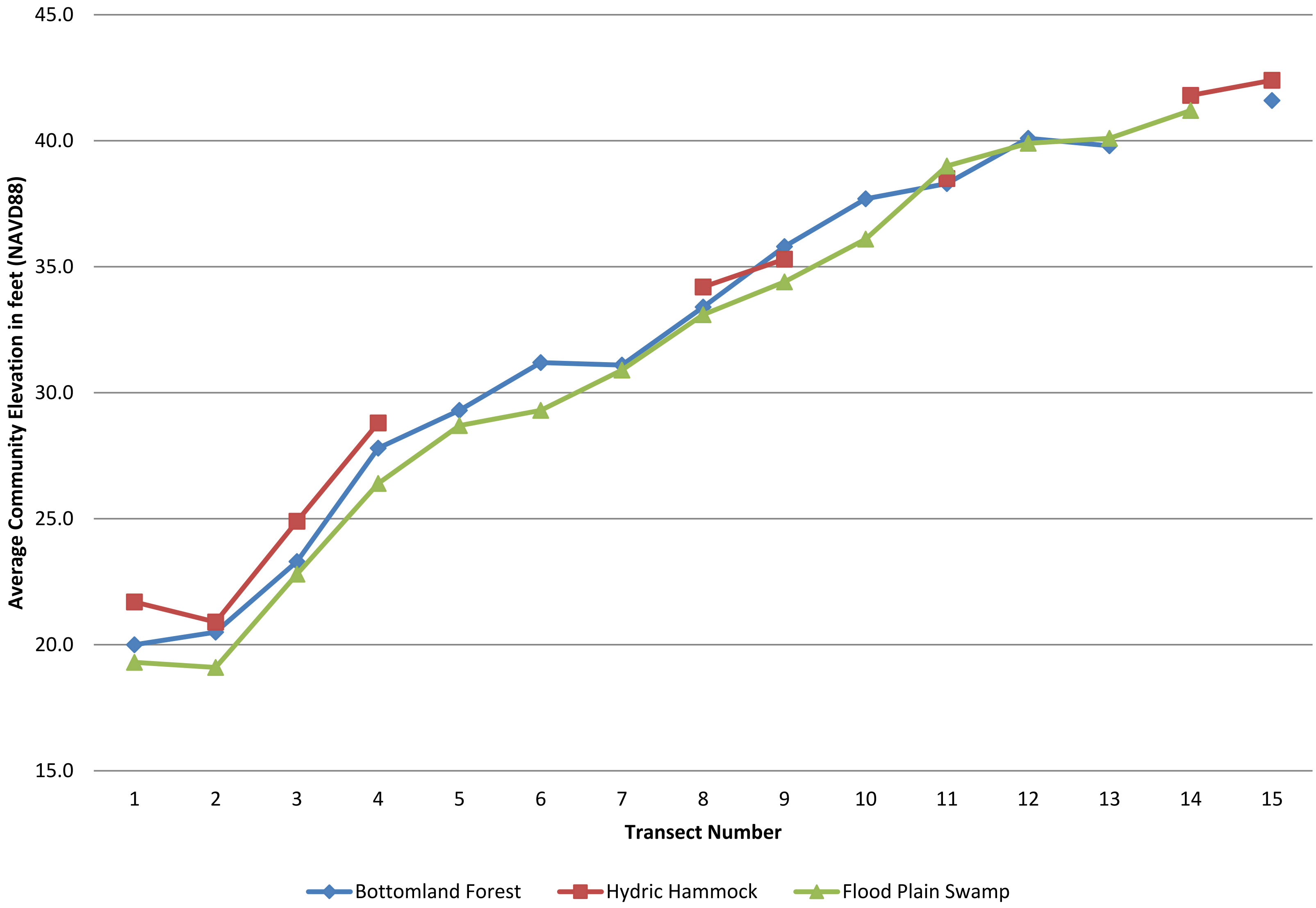


Figure 29. Wetted Perimeter for Transect 1

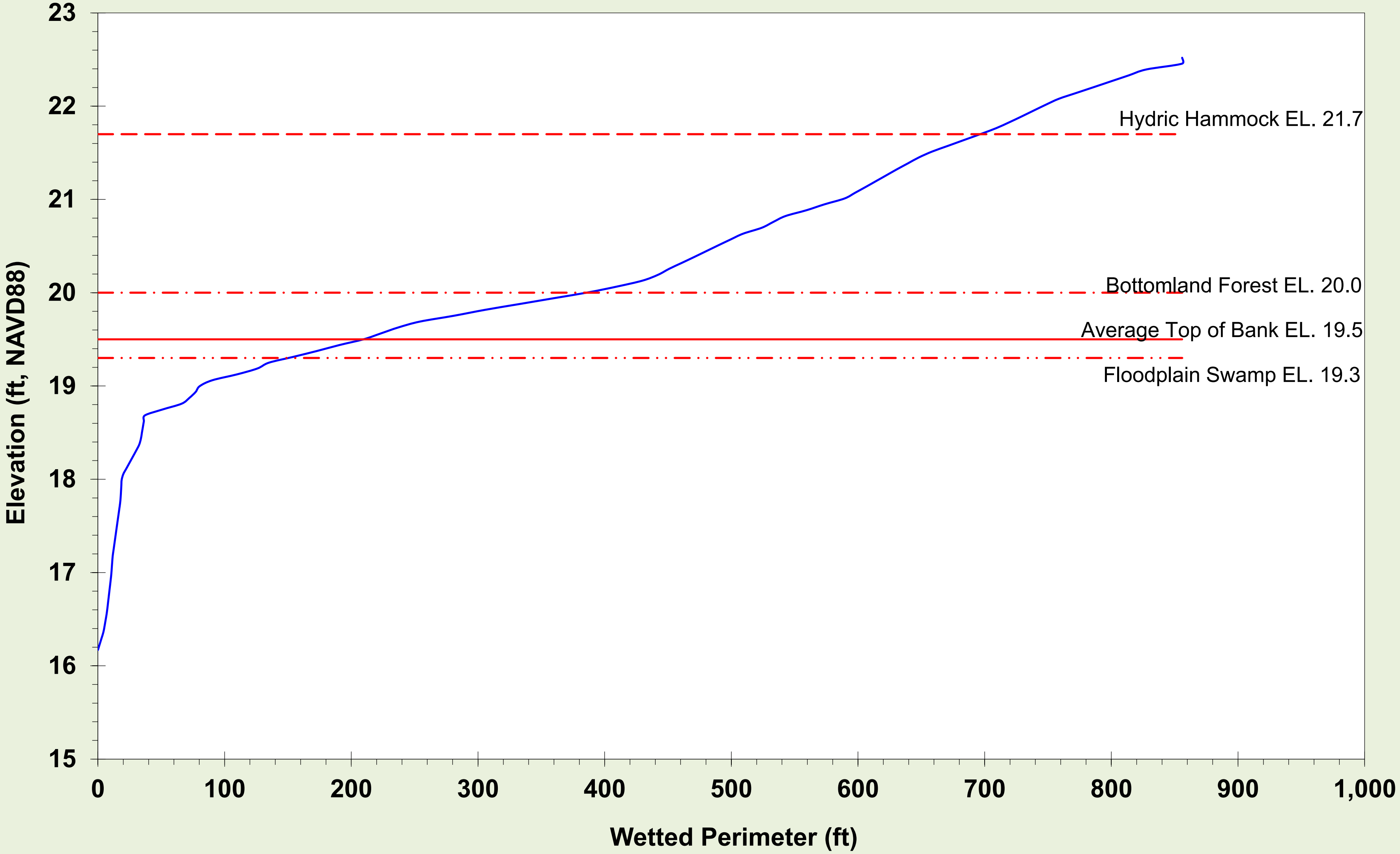


Figure 30. Wetted Perimeter for Transect 2

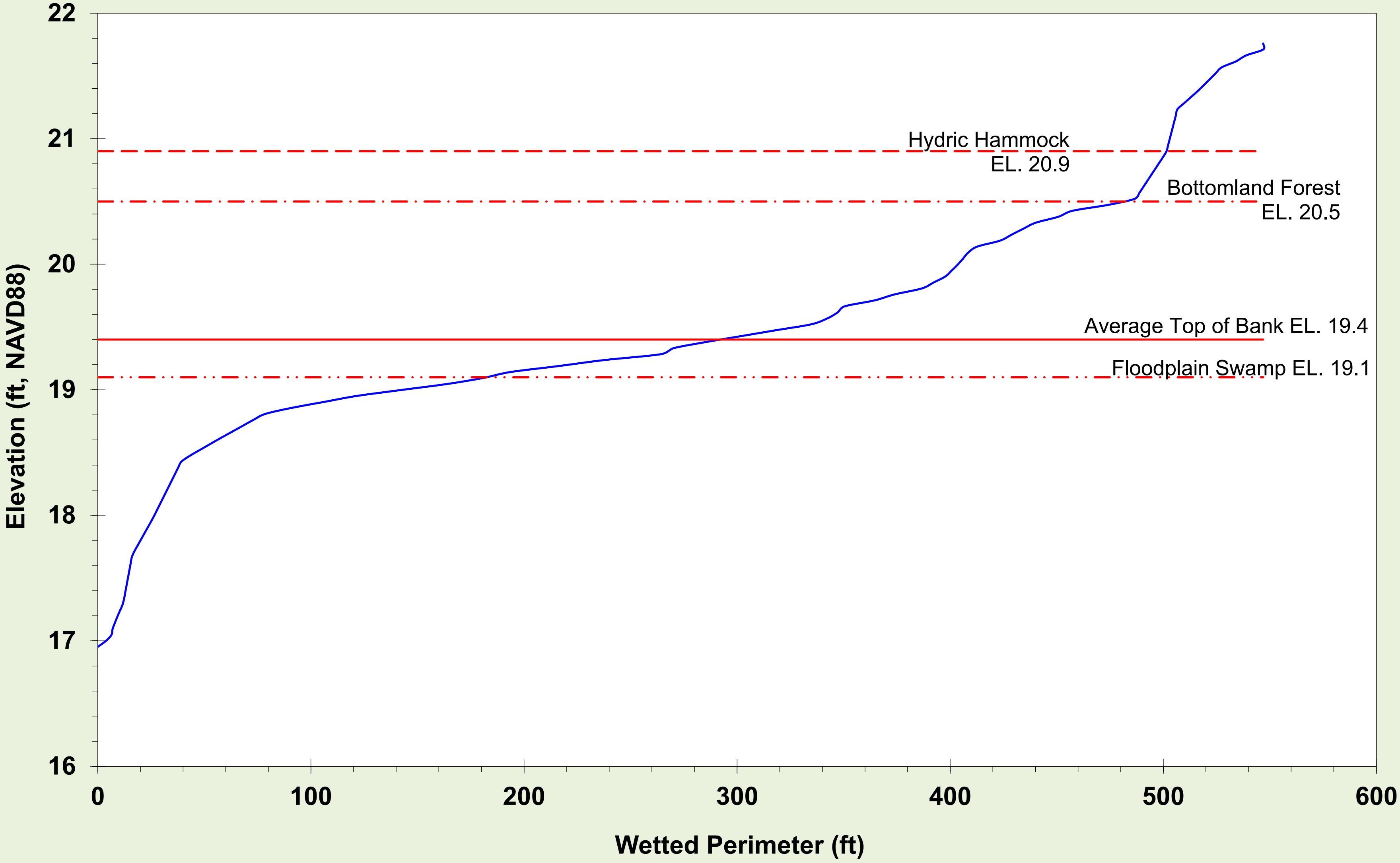


Figure 31. Wetted Perimeter for Transect 3

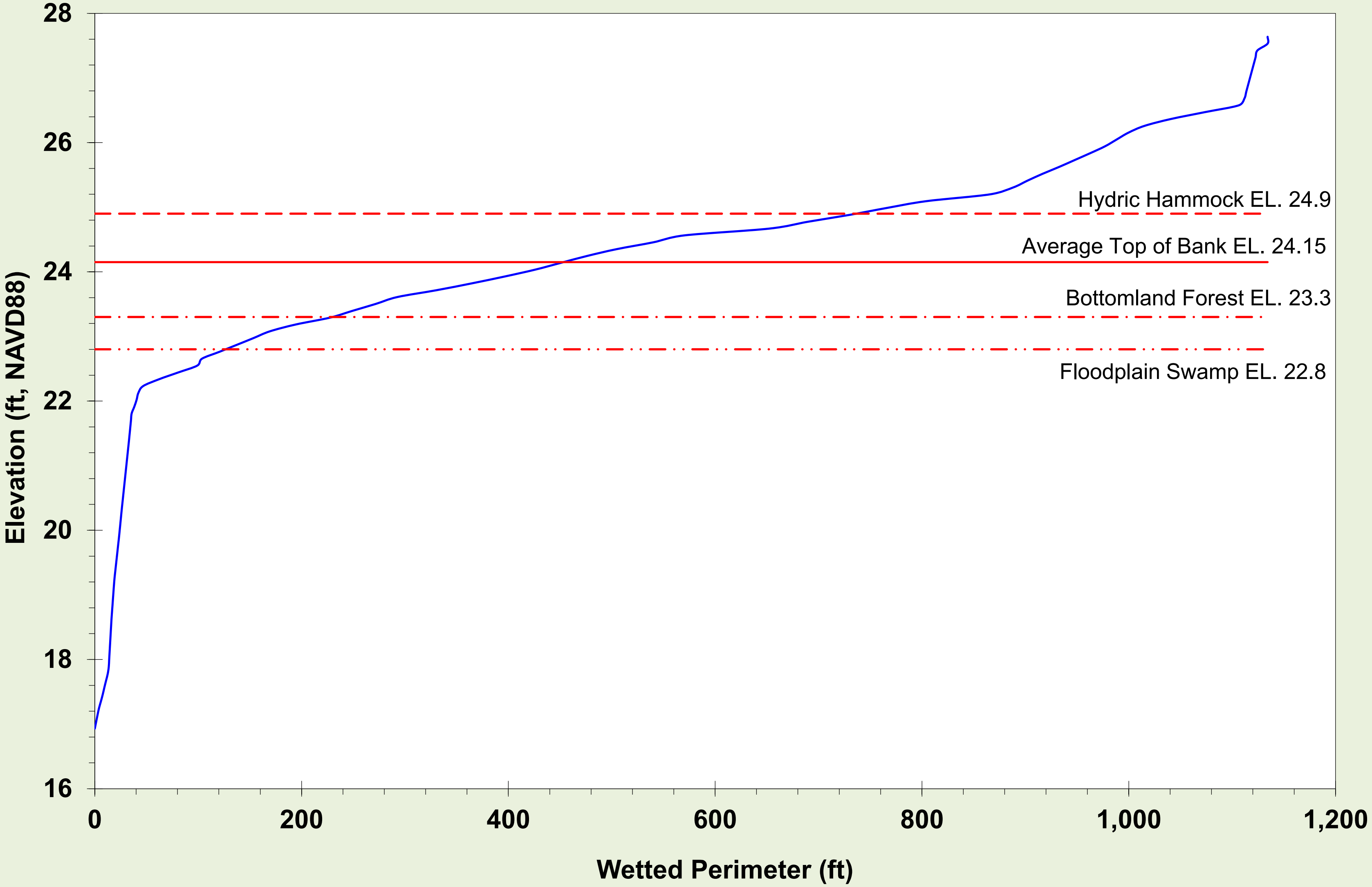


Figure 32. Wetted Perimeter for Transect 4

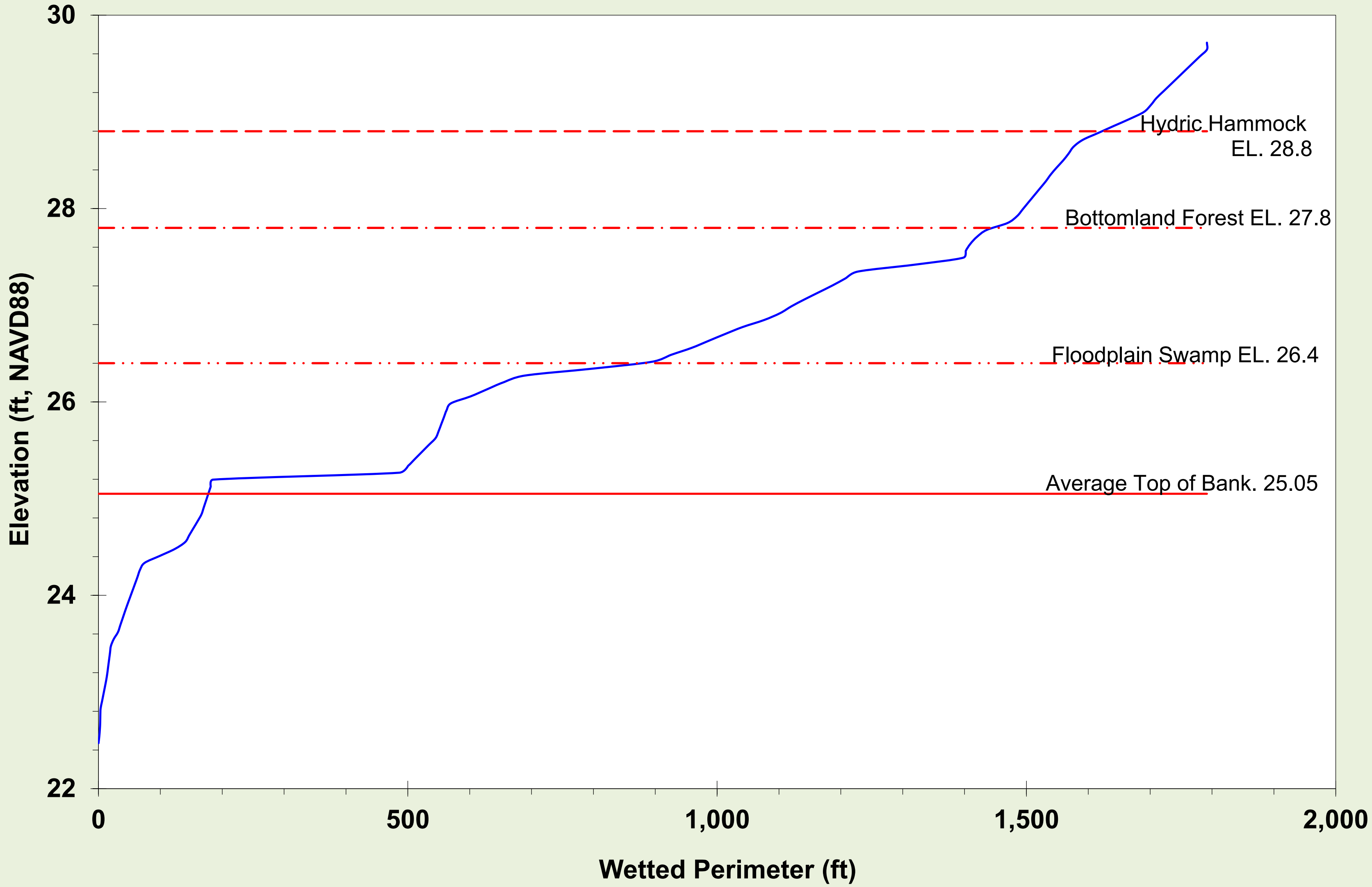


Figure 33. Wetted Perimeter for Transect 5

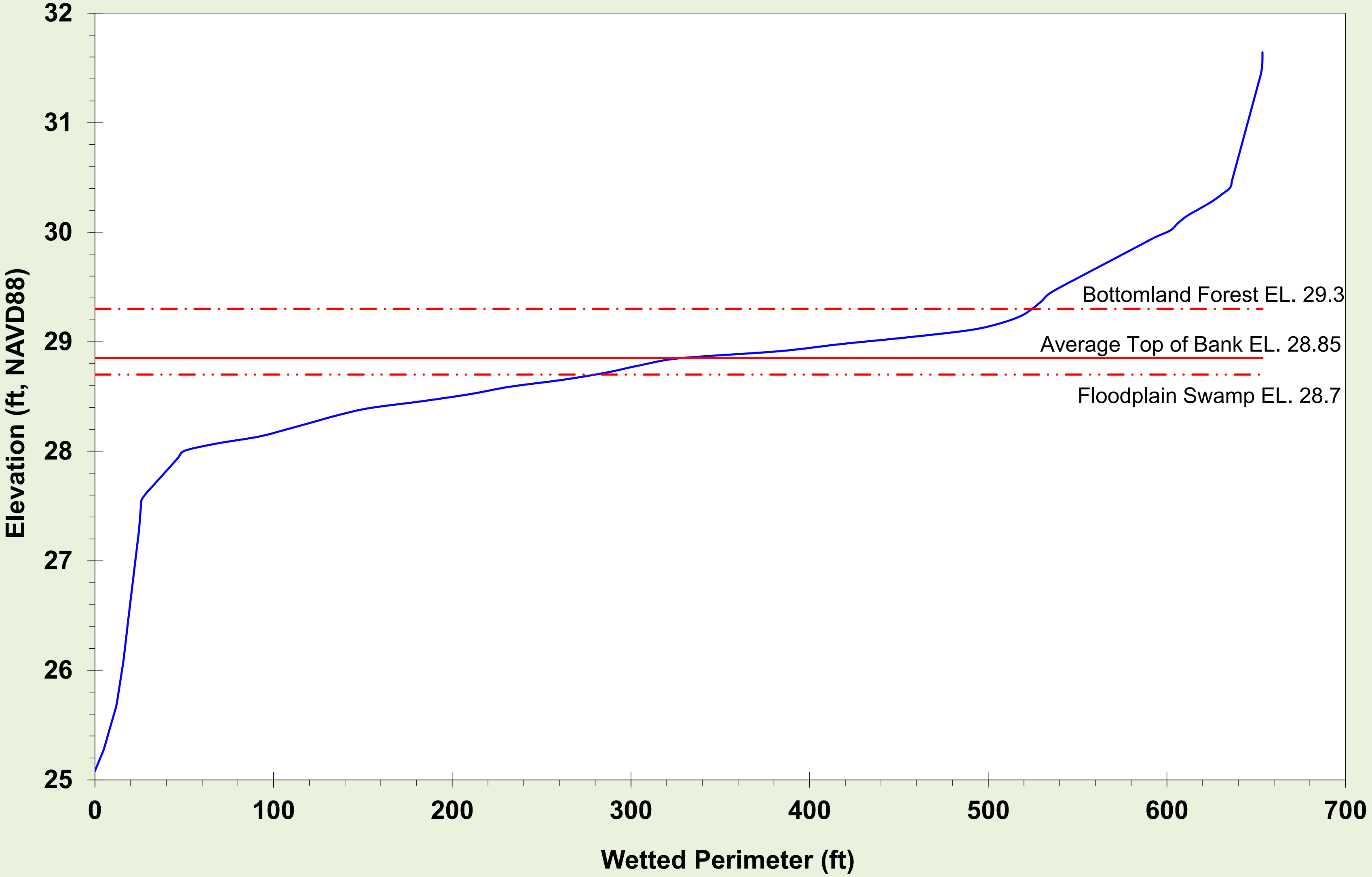


Figure 34. Wetted Perimeter for Transect 6

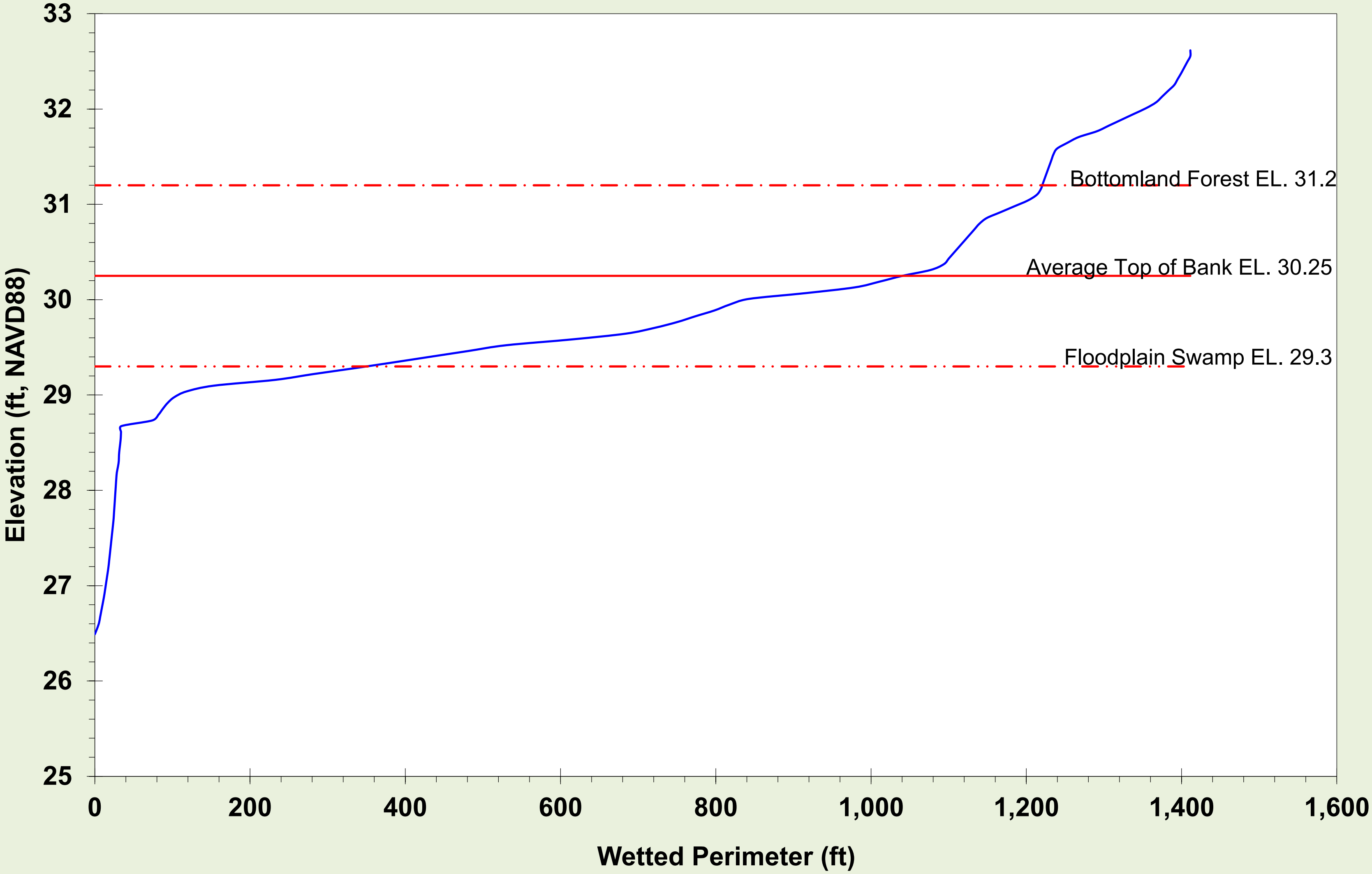


Figure 35. Wetted Perimeter for Transect 7

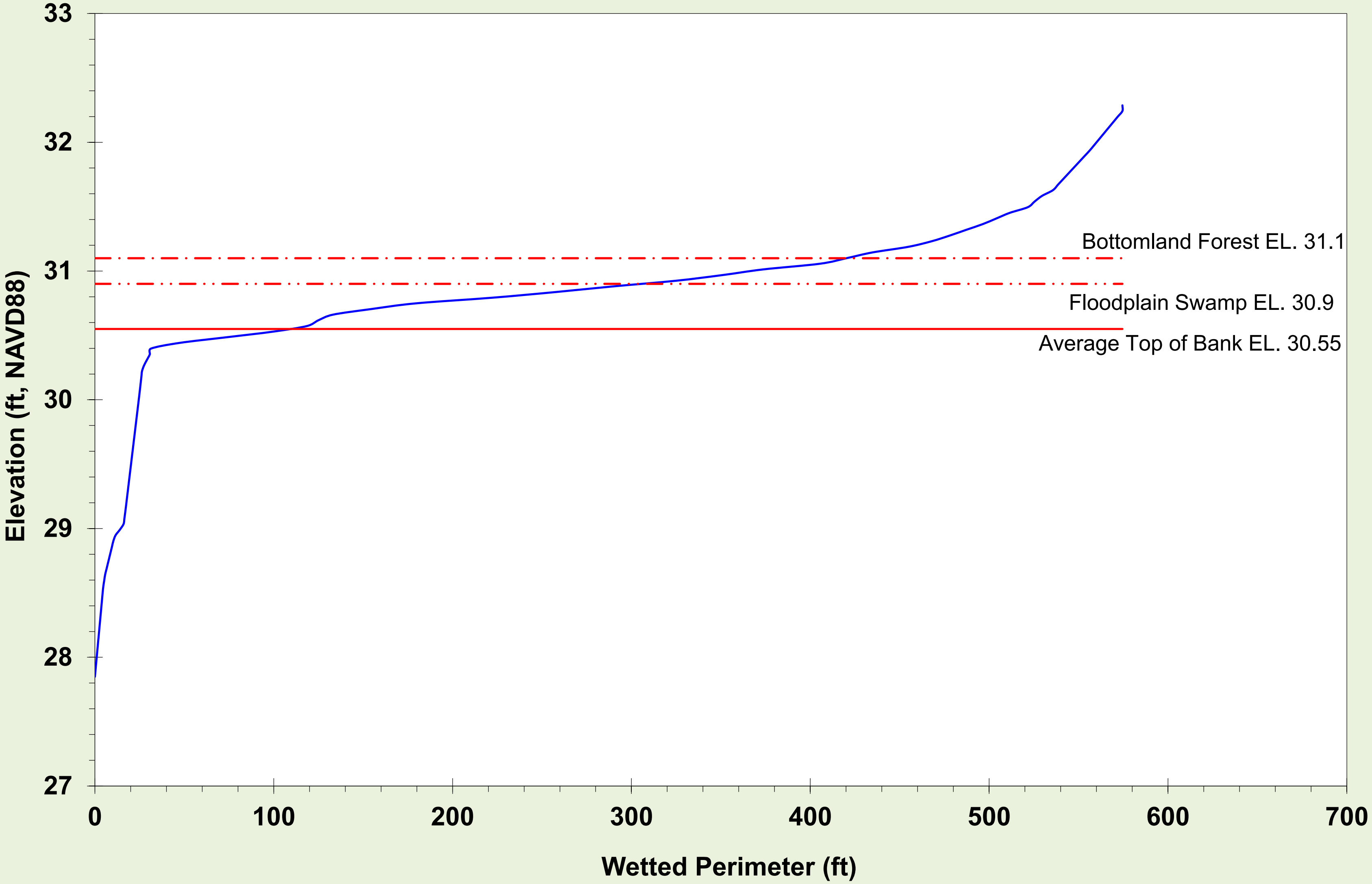


Figure 36. Wetted Perimeter for Transect 8

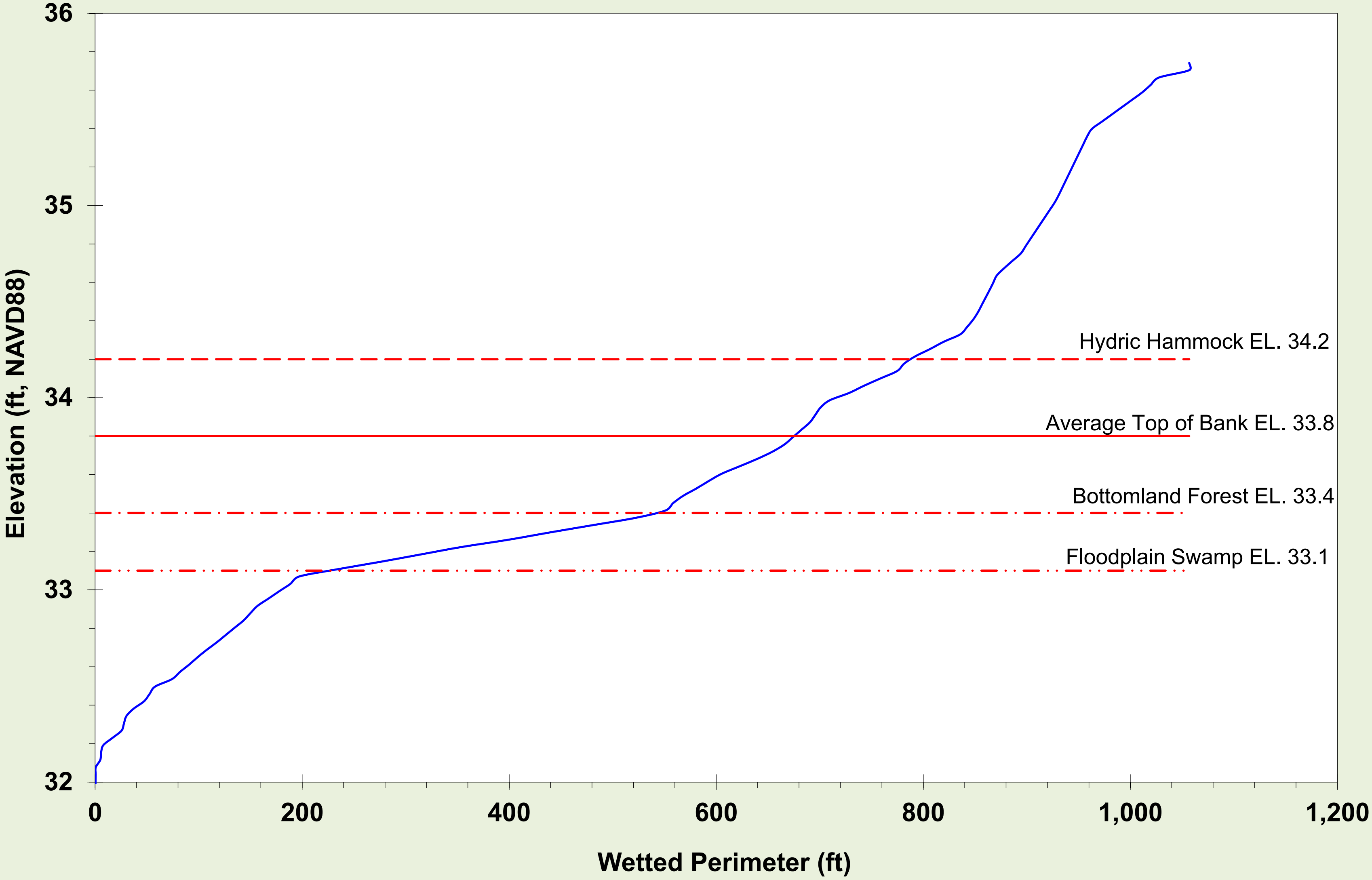


Figure 37. Wetted Perimeter for Transect 9

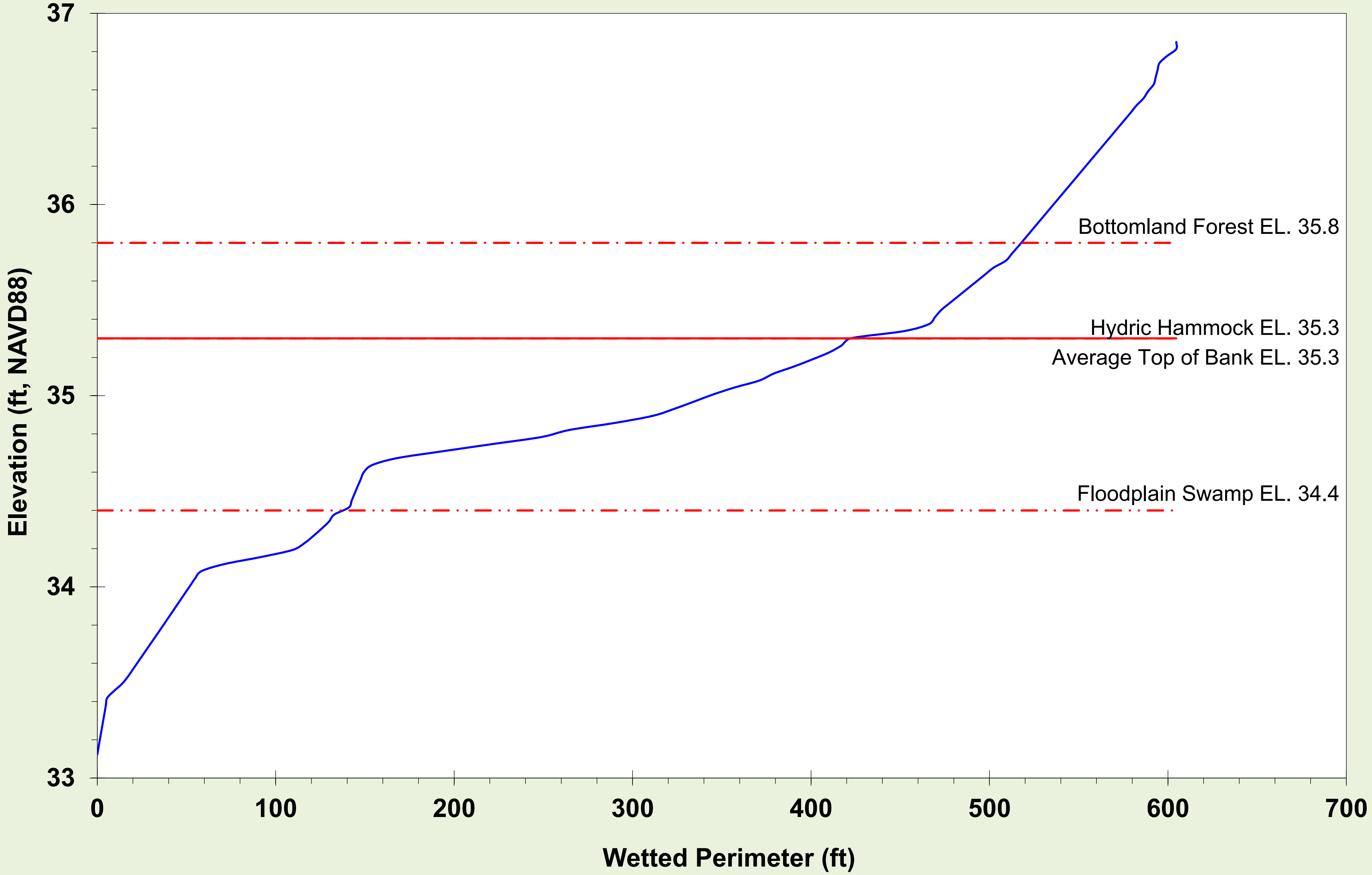


Figure 38. Wetted Perimeter for Transect 10

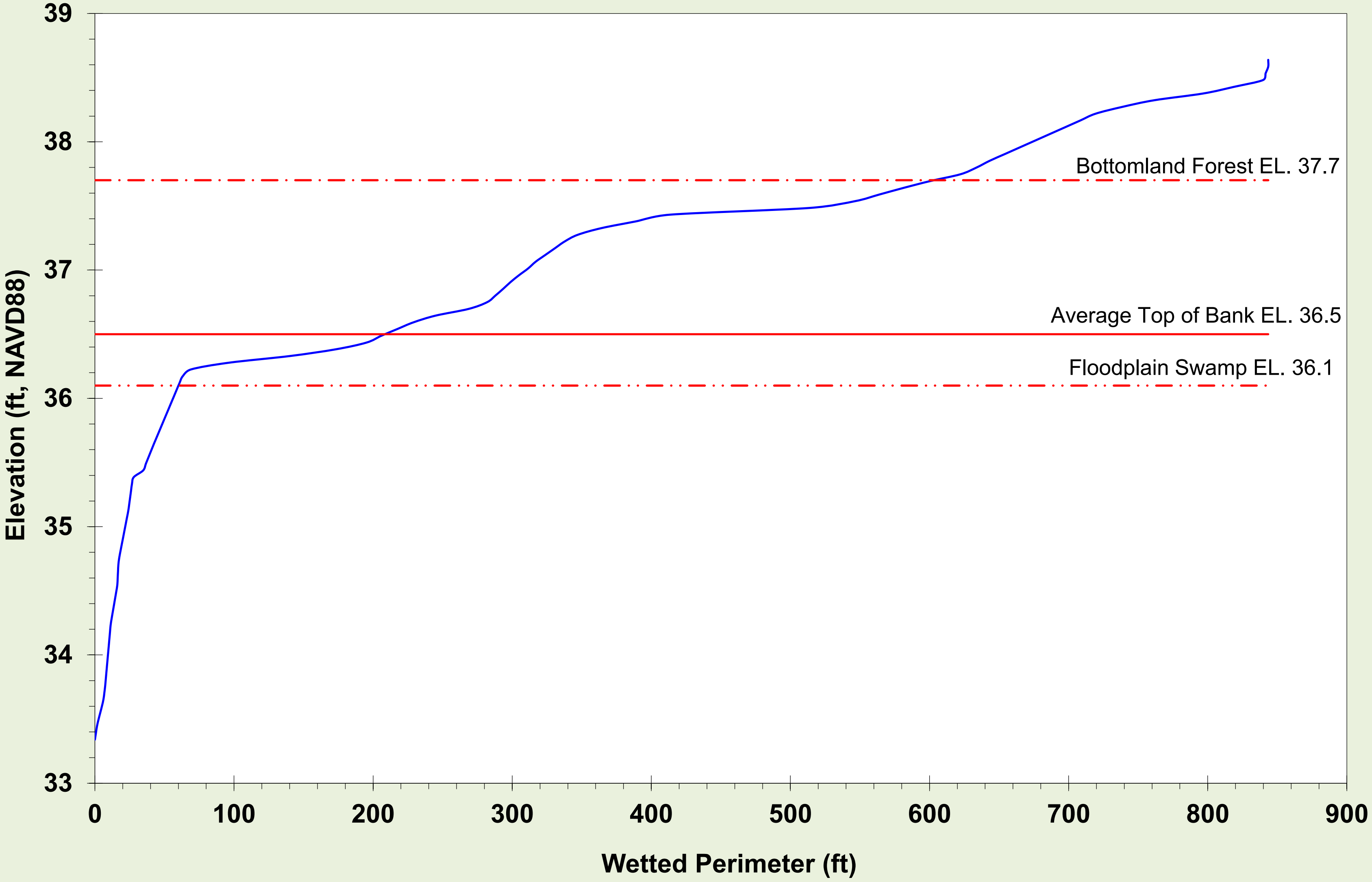


Figure 39. Wetted Perimeter for Transect 11

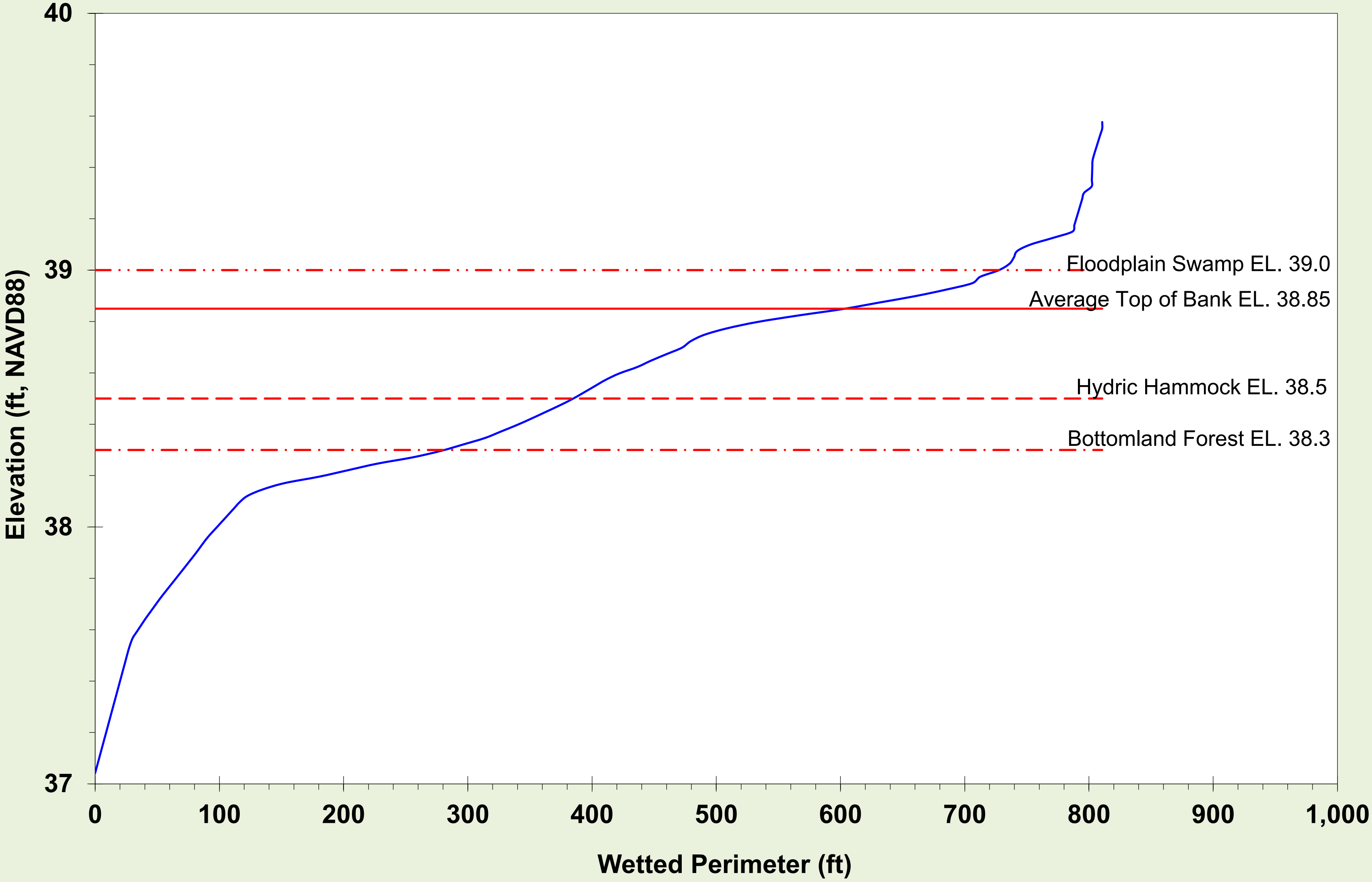


Figure 40. Wetted Perimeter for Transect 12

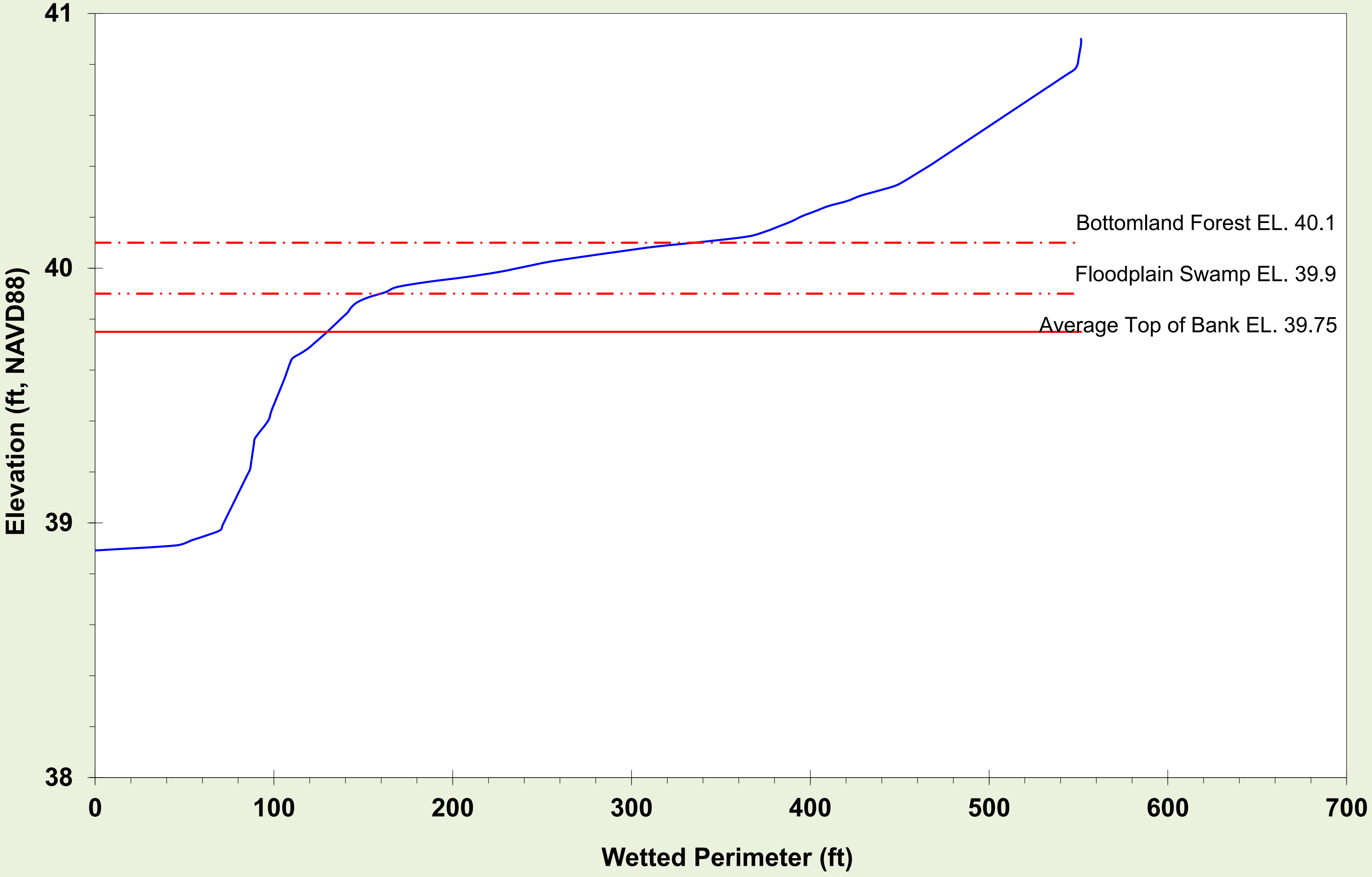


Figure 41. Wetted Perimeter for Transect 13

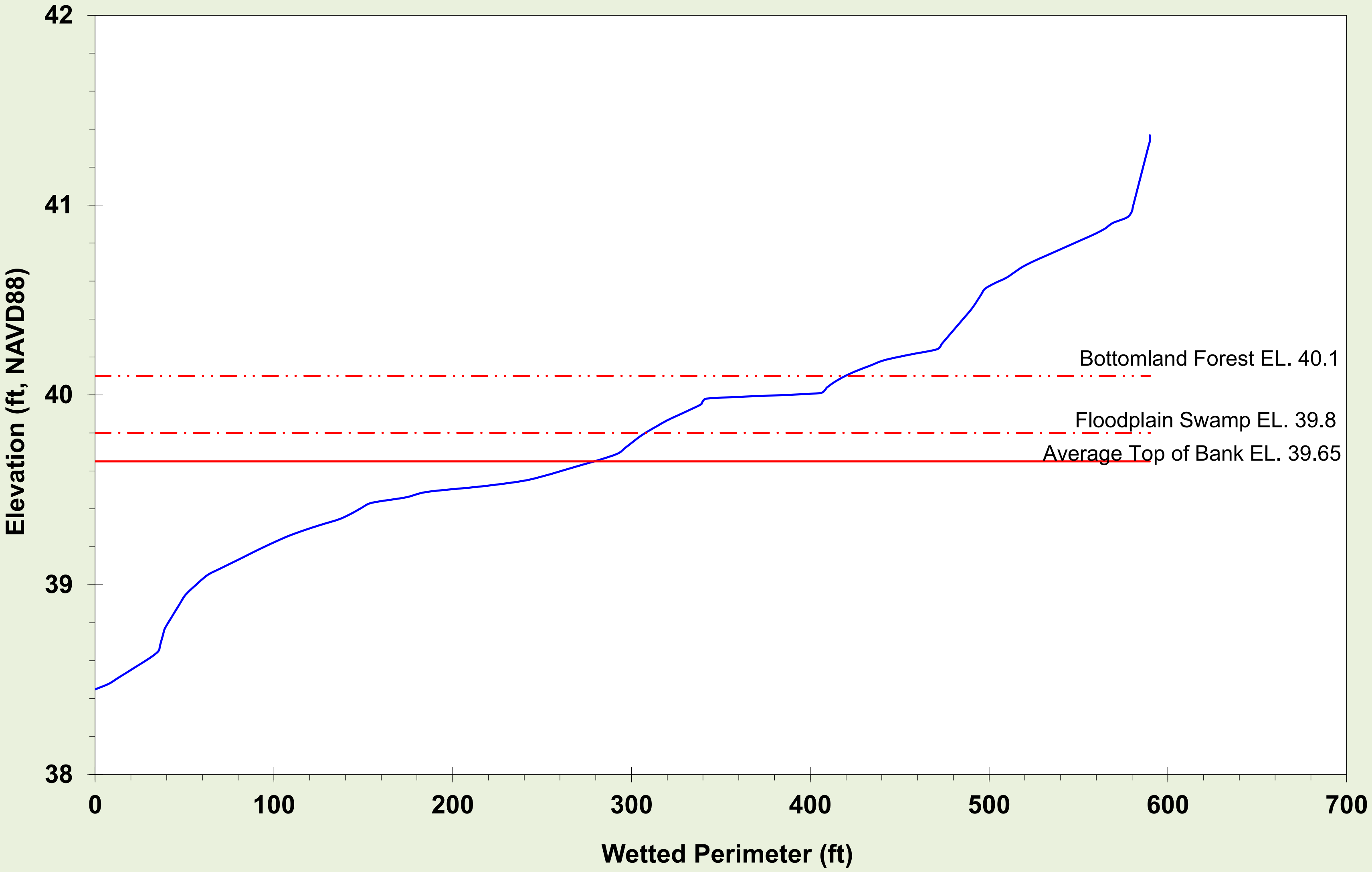


Figure 42. Wetted Perimeter for Transect 14

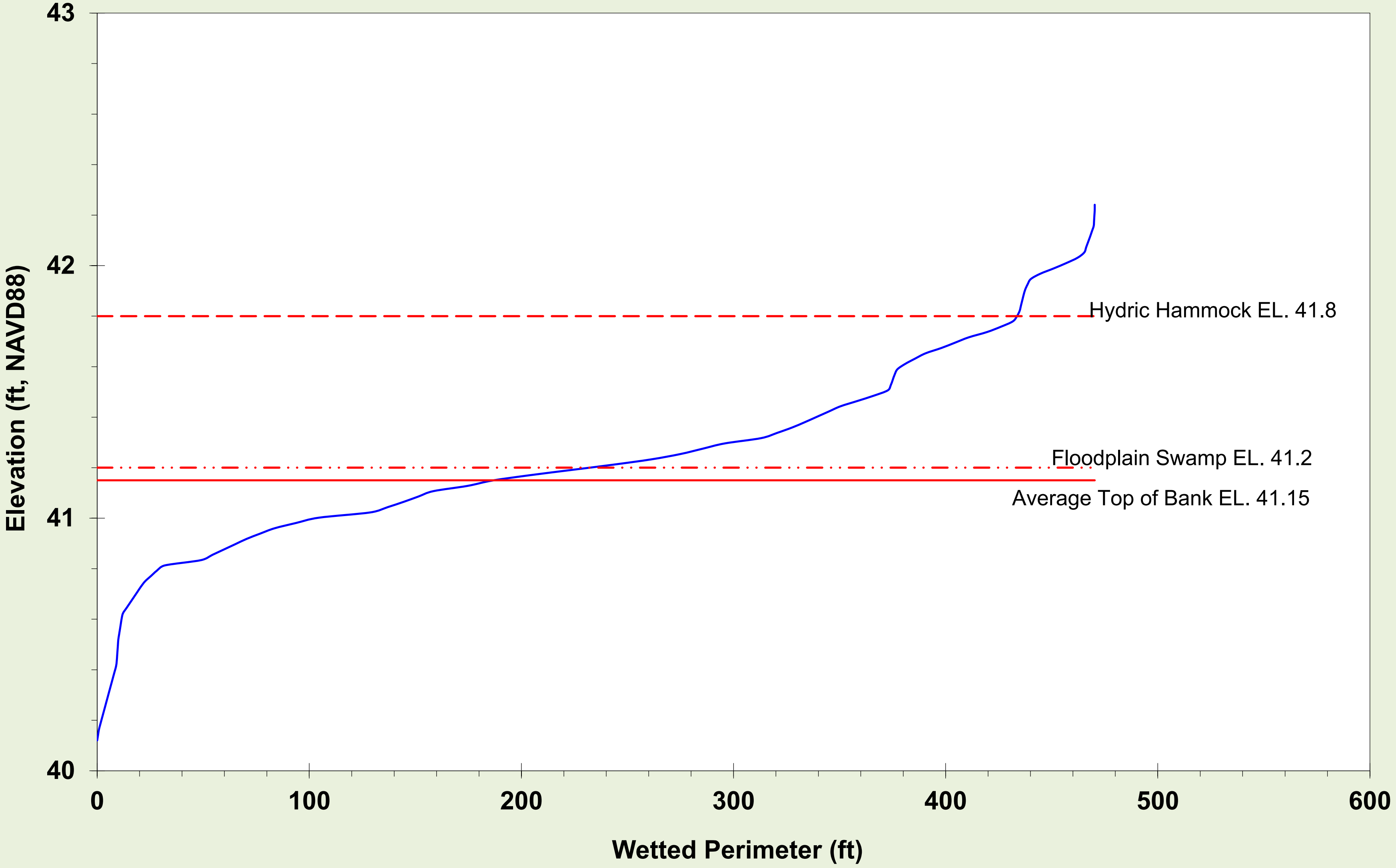


Figure 43. Wetted Perimeter for Transect 15

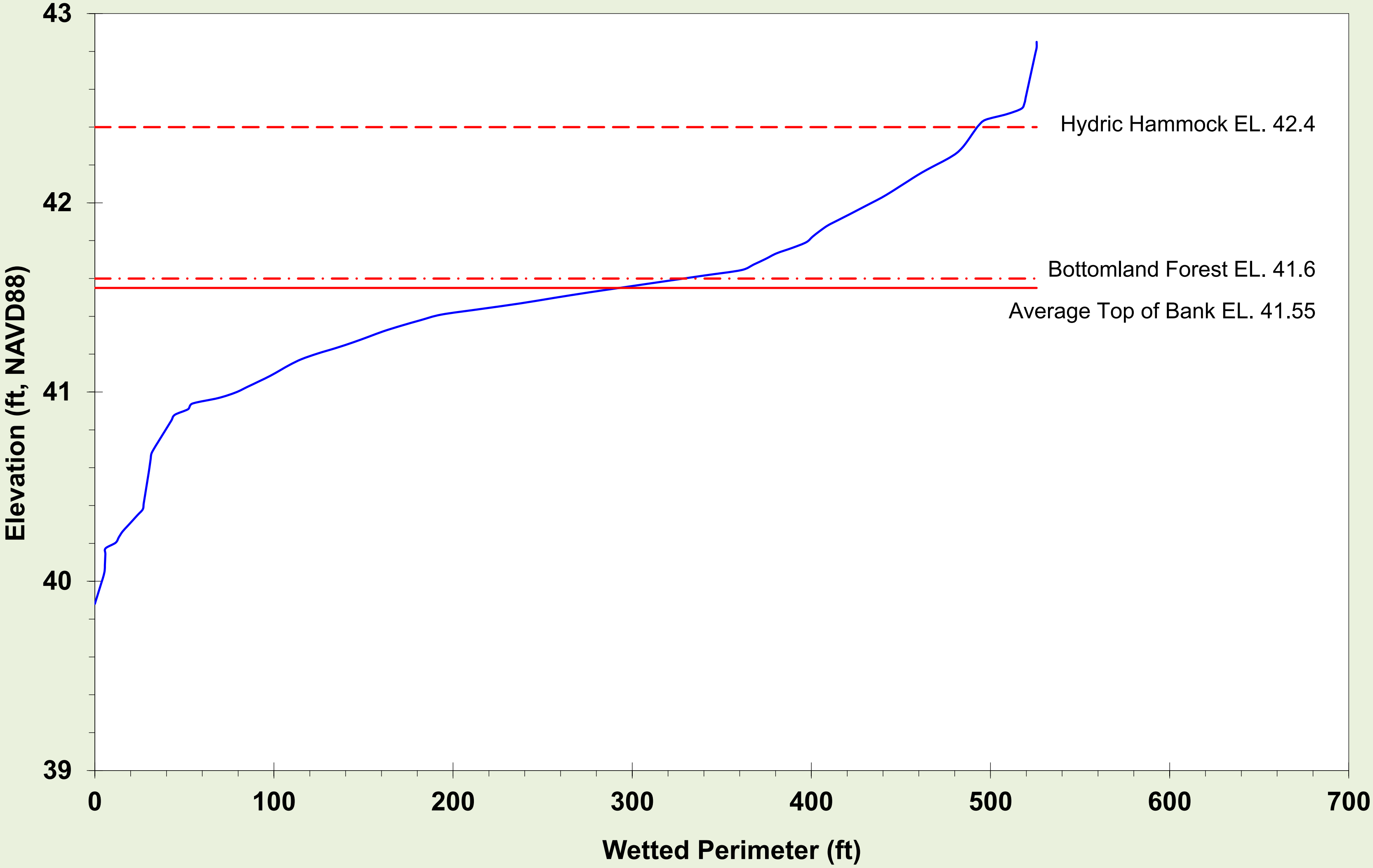


Figure 44. Tree and Shrub Absolute Densities by Transect

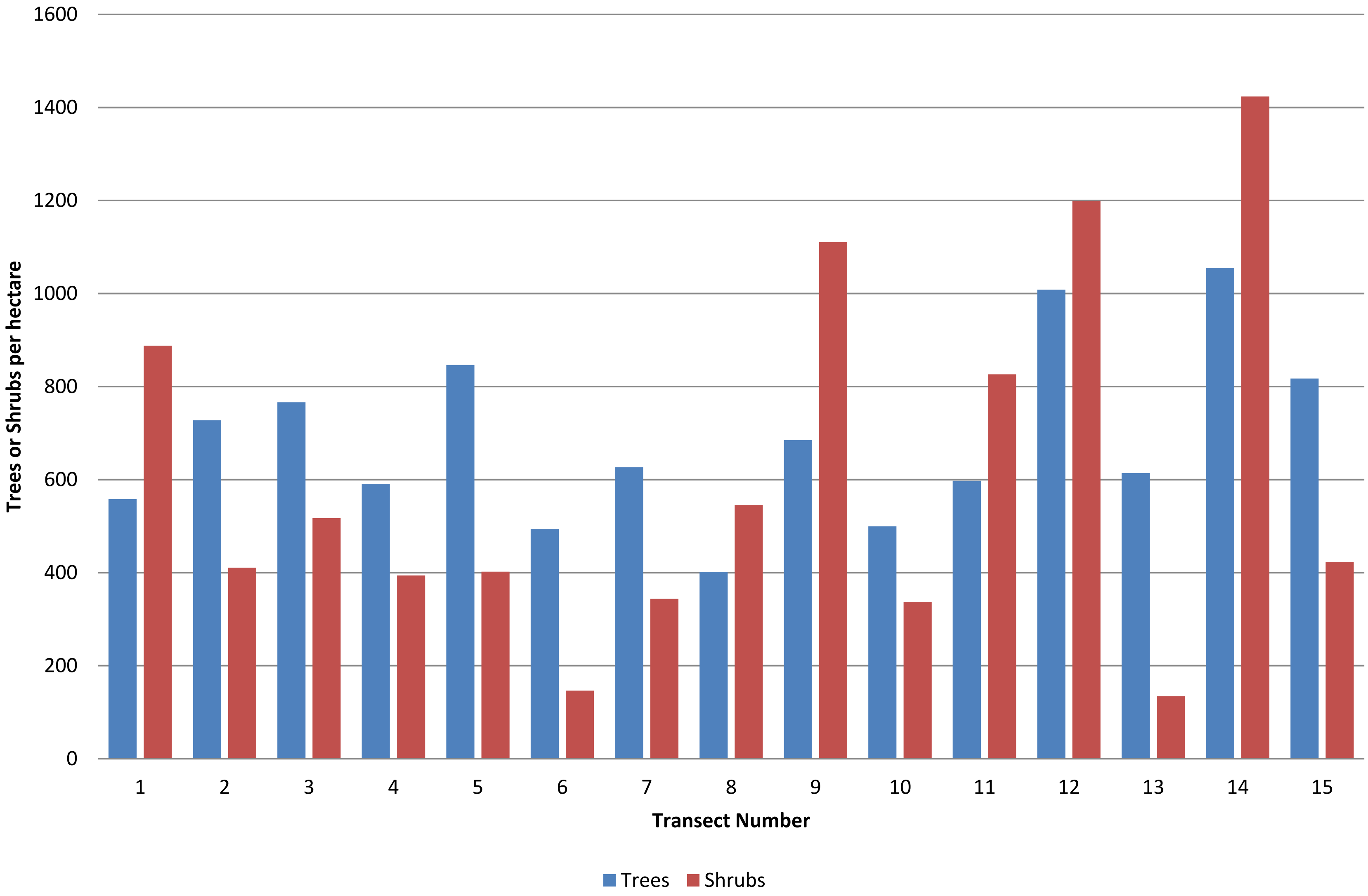
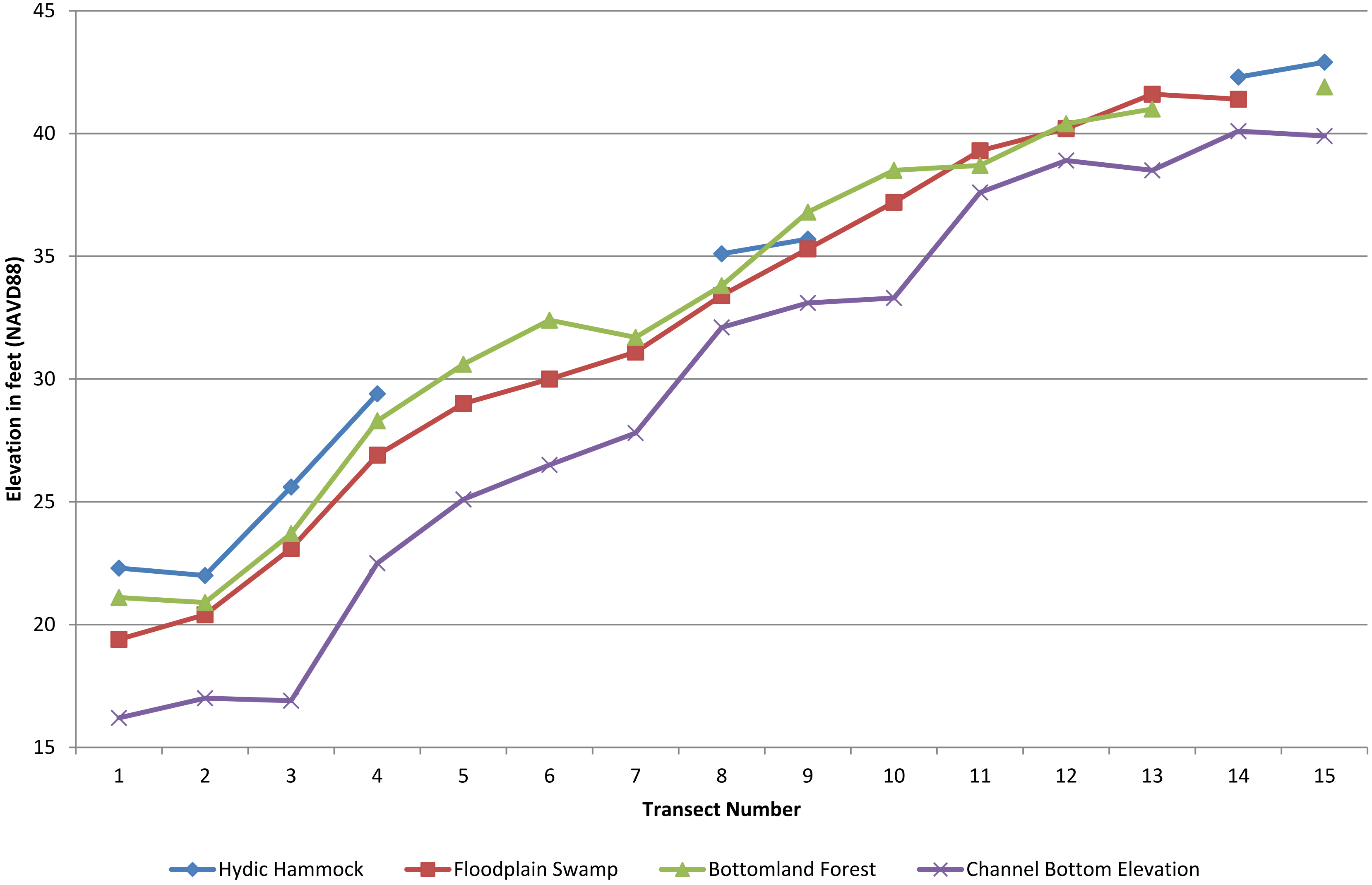


Figure 45. Mean Hydrologic Indicator Elevation by Community and Transect and Channel Bottom Elevation



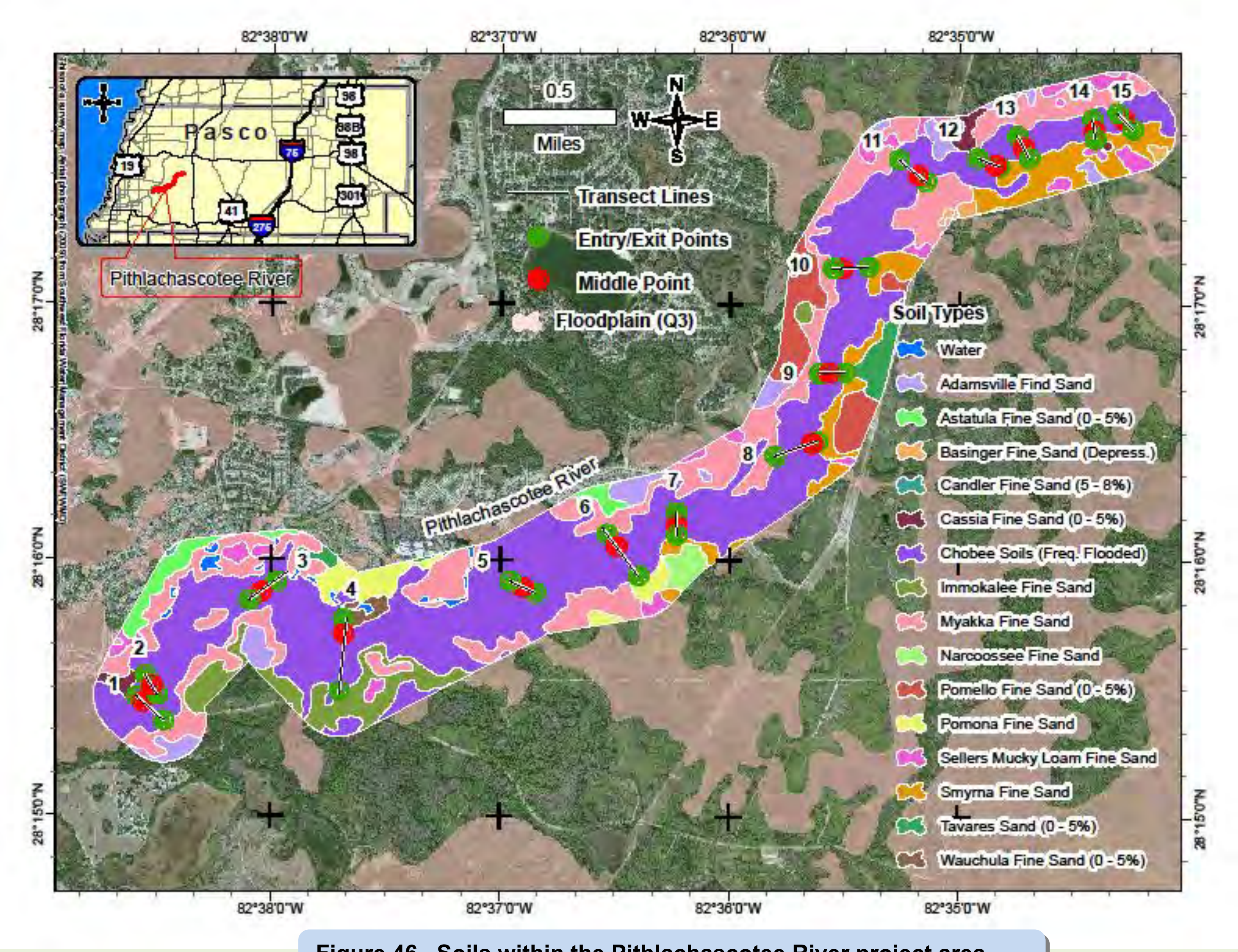
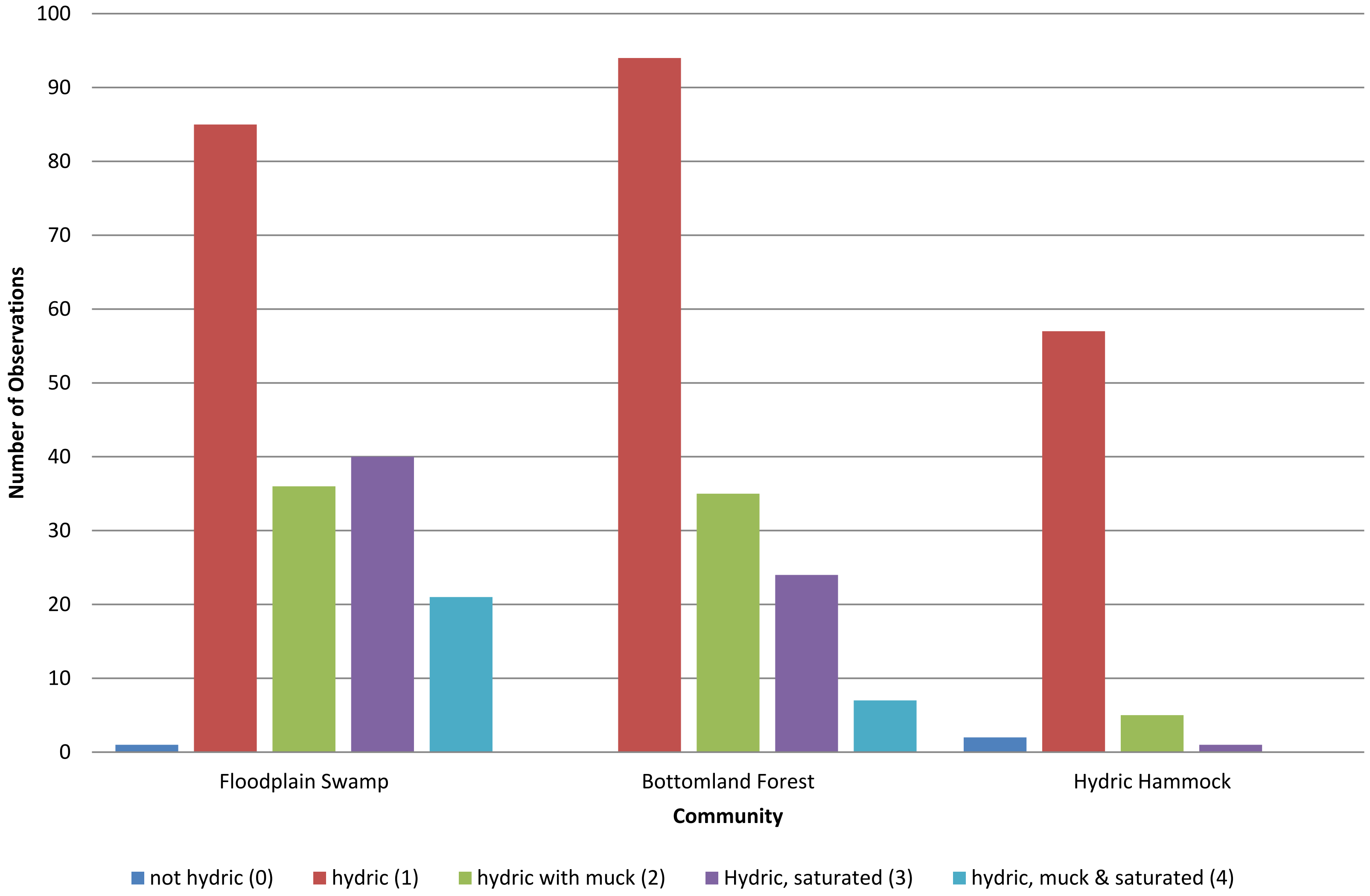


Figure 46. Soils within the Pithlachascotee River project area.

Figure 47. Pithlachascotee River: Number of Each Soil Type



APPENDIX 4E

Output from the Proc Reg Procedure in SAS corresponding to regressions for predicting isohaline locations in the Pithlachascotee River.

```
                              The REG Procedure
                                Model: MODEL1
                          Dependent Variable: Ln_Km

                   Number of Observations Read          29
                   Number of Observations Used          29

                          Stepwise Selection: Step 1


      Variable Sqrt_avg_cfs Entered: R-Square = 0.8792 and C(p) = 7.3952


                             Analysis of Variance

                                    Sum of           Mean
Source                   DF        Squares         Square    F Value    Pr > F

Model                     1        1.76177        1.76177     196.46    <.0001
Error                    27        0.24213        0.00897
Corrected Total          28        2.00390


                     Parameter     Standard
     Variable         Estimate        Error   Type II SS  F Value  Pr > F

     Intercept         2.30664      0.02546     73.61456  8208.79  <.0001
     Sqrt_avg_cfs     -0.07152      0.00510      1.76177   196.46  <.0001

                       Bounds on condition number: 1, 1
--------------------------------------------------------------------------------

                          Stepwise Selection: Step 2


          Variable TIDE Entered: R-Square = 0.9030 and C(p) = 3.0000


                             Analysis of Variance

                                    Sum of           Mean
Source                   DF        Squares         Square    F Value    Pr > F

Model                     2        1.80957        0.90478     121.05    <.0001
Error                    26        0.19433        0.00747
Corrected Total          28        2.00390


                     Parameter     Standard
     Variable         Estimate        Error   Type II SS  F Value  Pr > F
```

```
     Intercept         2.24350      0.03411     32.33132  4325.69  <.0001
     Sqrt_avg_cfs     -0.07630      0.00503      1.72178   230.36  <.0001
     TIDE              0.06975      0.02758      0.04780     6.40  0.0178

                    Bounds on condition number: 1.1645, 4.6581
--------------------------------------------------------------------------------


     All variables left in the model are significant at the 0.1500 level.

               All variables have been entered into the model.



                          Summary of Stepwise Selection

      Variable     Variable                             Number  Partial   Model
  Step Entered     Removed      Label                   Vars In R-Square R-Square

    1  Sqrt_avg_cfs                                         1    0.8792   0.8792
    2  TIDE                     MEAN TIDE AT SAMPLE         2    0.0239   0.9030

                          Summary of Stepwise Selection

                        Step  C(p)      F Value    Pr > F

                          1   7.3952     196.46    <.0001
                          2   3.0000       6.40    0.0178
```

```
                            The REG Procedure
                              Model: MODEL1
                        Dependent Variable: Ln_Km

                 Number of Observations Read          28
                 Number of Observations Used          28

                        Stepwise Selection: Step 1


      Variable Sqrt_avg_cfs Entered: R-Square = 0.7865 and C(p) = 4.1353


                           Analysis of Variance

                                      Sum of           Mean
 Source                   DF         Squares         Square    F Value    Pr > F

 Model                     1         1.93326        1.93326      95.77    <.0001
 Error                    26         0.52482        0.02019
 Corrected Total          27         2.45808


                     Parameter     Standard
      Variable        Estimate        Error   Type II SS  F Value  Pr > F

      Intercept        2.13654      0.03966     58.59252  2902.71  <.0001
      Sqrt_avg_cfs    -0.07643      0.00781      1.93326    95.77  <.0001

                     Bounds on condition number: 1, 1
--------------------------------------------------------------------------------

                        Stepwise Selection: Step 2


          Variable TIDE Entered: R-Square = 0.8103 and C(p) = 3.0000


                           Analysis of Variance

                                      Sum of           Mean
 Source                   DF         Squares         Square    F Value    Pr > F

 Model                     2         1.99175        0.99587      53.39    <.0001
 Error                    25         0.46634        0.01865
 Corrected Total          27         2.45808


                     Parameter     Standard
      Variable        Estimate        Error   Type II SS  F Value  Pr > F
```

```
      Intercept         2.06925      0.05383     27.56729  1477.86  <.0001
      Sqrt_avg_cfs     -0.08281      0.00833      1.84443    98.88  <.0001
      TIDE              0.08022      0.04531      0.05848     3.14  0.0888

                   Bounds on condition number: 1.2305, 4.9222
--------------------------------------------------------------------------------


      All variables left in the model are significant at the 0.1500 level.

                All variables have been entered into the model.



                         Summary of Stepwise Selection

       Variable     Variable                         Number  Partial   Model
  Step Entered      Removed      Label               Vars In R-Square R-Square

    1  Sqrt_avg_cfs                                      1    0.7865   0.7865
    2  TIDE                      MEAN TIDE AT SAMPLE     2    0.0238   0.8103

                         Summary of Stepwise Selection

                       Step  C(p)      F Value    Pr > F

                         1   4.1353      95.77    <.0001
                         2   3.0000       3.14    0.0888
```

```
                               The REG Procedure
                                 Model: MODEL1
                           Dependent Variable: Ln_Km

                    Number of Observations Read          28
                    Number of Observations Used          28

                           Stepwise Selection: Step 1


       Variable Sqrt_avg_cfs Entered: R-Square = 0.6870 and C(p) = 8.9763


                              Analysis of Variance

                                     Sum of           Mean
 Source                   DF        Squares         Square    F Value    Pr > F

 Model                     1        2.62225        2.62225      57.07    <.0001
 Error                    26        1.19469        0.04595
 Corrected Total          27        3.81694


                      Parameter     Standard
      Variable         Estimate        Error   Type II SS  F Value  Pr > F

      Intercept         1.84059      0.06021     42.94315   934.57  <.0001
      Sqrt_avg_cfs     -0.08902      0.01178      2.62225    57.07  <.0001

                        Bounds on condition number: 1, 1
--------------------------------------------------------------------------------

                           Stepwise Selection: Step 2


           Variable TIDE Entered: R-Square = 0.7627 and C(p) = 3.0000


                              Analysis of Variance

                                     Sum of           Mean
 Source                   DF        Squares         Square    F Value    Pr > F

 Model                     2        2.91122        1.45561      40.18    <.0001
 Error                    25        0.90572        0.03623
 Corrected Total          27        3.81694


                      Parameter     Standard
      Variable         Estimate        Error   Type II SS  F Value  Pr > F
```

```
     Intercept         1.64683      0.08697     12.98877   358.52  <.0001
     Sqrt_avg_cfs     -0.09798      0.01093      2.90924    80.30  <.0001
     TIDE              0.18929      0.06702      0.28897     7.98  0.0092

                  Bounds on condition number: 1.0919, 4.3678
--------------------------------------------------------------------------------


     All variables left in the model are significant at the 0.1500 level.

               All variables have been entered into the model.



                           Summary of Stepwise Selection

      Variable     Variable                          Number  Partial   Model
  Step Entered      Removed      Label               Vars In R-Square R-Square

    1  Sqrt_avg_cfs                                      1    0.6870   0.6870
    2  TIDE                      MEAN TIDE AT SAMPLE     2    0.0757   0.7627

                           Summary of Stepwise Selection

                         Step  C(p)      F Value    Pr > F

                           1   8.9763      57.07    <.0001
                           2   3.0000       7.98    0.0092
```

```
                               The REG Procedure
                                 Model: MODEL1
                           Dependent Variable: Ln_Km

                    Number of Observations Read          23
                    Number of Observations Used          23

                           Stepwise Selection: Step 1


       Variable Sqrt_avg_cfs Entered: R-Square = 0.6470 and C(p) = 4.7601


                              Analysis of Variance

                                     Sum of           Mean
 Source                   DF        Squares         Square    F Value    Pr > F

 Model                     1        5.65168        5.65168      38.49    <.0001
 Error                    20        3.08392        0.14685
 Corrected Total          22        8.73560


                      Parameter     Standard
      Variable         Estimate        Error   Type II SS  F Value  Pr > F

      Intercept         1.52005      0.11633     25.07491   170.75  <.0001
      Sqrt_avg_cfs     -0.13452      0.02168      5.65168    38.49  <.0001

                        Bounds on condition number: 1, 1
--------------------------------------------------------------------------------

                           Stepwise Selection: Step 2


           Variable TIDE Entered: R-Square = 0.7028 and C(p) = 3.0000


                              Analysis of Variance

                                     Sum of           Mean
 Source                   DF        Squares         Square    F Value    Pr > F

 Model                     2        6.13972        3.06986      23.65    <.0001
 Error                    20        2.59588        0.12979
 Corrected Total          22        8.73560


                      Parameter     Standard
      Variable         Estimate        Error   Type II SS  F Value  Pr > F
```

```
      Intercept         1.18853      0.20295      4.45131    34.30  <.0001
      Sqrt_avg_cfs     -0.14542      0.02115      6.13804    47.29  <.0001
      TIDE              0.27771      0.14321      0.48804     3.76  0.0667

                   Bounds on condition number: 1.0761, 4.3046
--------------------------------------------------------------------------------


      All variables left in the model are significant at the 0.1500 level.

                All variables have been entered into the model.



                         Summary of Stepwise Selection

       Variable     Variable                         Number  Partial   Model
  Step Entered      Removed      Label               Vars In R-Square R-Square

    1  Sqrt_avg_cfs                                      1    0.6470   0.6470
    2  TIDE                      MEAN TIDE AT SAMPLE     2    0.0559   0.7028

                         Summary of Stepwise Selection

                       Step  C(p)      F Value    Pr > F

                         1   4.7601      38.49    <.0001
                         2   3.0000       3.76    0.0667
```

```
                               The REG Procedure
                                 Model: MODEL1
                           Dependent Variable: Ln_Km

                    Number of Observations Read          30
                    Number of Observations Used          30

                           Stepwise Selection: Step 1


       Variable Sqrt_avg_cfs Entered: R-Square = 0.8320 and C(p) = 1.4020


                              Analysis of Variance

                                     Sum of           Mean
 Source                    DF        Squares         Square    F Value    Pr > F

 Model                      1        1.42345        1.42345     138.69    <.0001
 Error                     28        0.28738        0.01026
 Corrected Total           29        1.71083


                      Parameter     Standard
      Variable         Estimate        Error   Type II SS  F Value  Pr > F

      Intercept         2.30777      0.02702     74.86579  7294.34  <.0001
      Sqrt_avg_cfs     -0.06051      0.00514      1.42345   138.69  <.0001

                        Bounds on condition number: 1, 1
--------------------------------------------------------------------------------


      All variables left in the model are significant at the 0.1500 level.

 No other variable met the 0.1500 significance level for entry into the model.



                         Summary of Stepwise Selection

       Variable     Variable                            Number  Partial    Model
  Step Entered      Removed      Label                  Vars In R-Square R-Square

    1  Sqrt_avg_cfs                                         1     0.8320   0.8320

                         Summary of Stepwise Selection

                       Step   C(p)      F Value    Pr > F

                         1    1.4020     138.69    <.0001
```

```
                              The REG Procedure
                                Model: MODEL1
                          Dependent Variable: Ln_Km

                   Number of Observations Read          29
                   Number of Observations Used          29

                          Stepwise Selection: Step 1


      Variable Sqrt_avg_cfs Entered: R-Square = 0.7044 and C(p) = 1.0577


                             Analysis of Variance

                                    Sum of           Mean
Source                   DF        Squares         Square    F Value    Pr > F

Model                     1        1.35818        1.35818      64.32    <.0001
Error                    27        0.57009        0.02111
Corrected Total          28        1.92826


                     Parameter     Standard
     Variable         Estimate        Error   Type II SS  F Value  Pr > F

     Intercept         2.17018      0.04021     61.49509  2912.48  <.0001
     Sqrt_avg_cfs     -0.06030      0.00752      1.35818    64.32  <.0001

                       Bounds on condition number: 1, 1
--------------------------------------------------------------------------------


     All variables left in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.



                        Summary of Stepwise Selection

      Variable     Variable                             Number  Partial   Model
 Step Entered      Removed      Label                   Vars In R-Square R-Square

   1  Sqrt_avg_cfs                                          1    0.7044   0.7044

                        Summary of Stepwise Selection

                      Step   C(p)       F Value    Pr > F

                        1    1.0577       64.32    <.0001
```

```
                            The REG Procedure
                              Model: MODEL1
                        Dependent Variable: Ln_Km

                 Number of Observations Read          28
                 Number of Observations Used          28

                        Stepwise Selection: Step 1


     Variable Sqrt_avg_cfs Entered: R-Square = 0.6548 and C(p) = 17.2324


                           Analysis of Variance

                                      Sum of           Mean
Source                   DF          Squares         Square    F Value    Pr > F

Model                     1          1.88040        1.88040      49.31    <.0001
Error                    26          0.99147        0.03813
Corrected Total          27          2.87187


                     Parameter     Standard
     Variable         Estimate        Error   Type II SS  F Value  Pr > F

     Intercept         1.90649      0.05308     49.18906  1289.91  <.0001
     Sqrt_avg_cfs     -0.07391      0.01053      1.88040    49.31  <.0001

                     Bounds on condition number: 1, 1
--------------------------------------------------------------------------------

                        Stepwise Selection: Step 2


          Variable TIDE Entered: R-Square = 0.7907 and C(p) = 3.0000


                           Analysis of Variance

                                      Sum of           Mean
Source                   DF          Squares         Square    F Value    Pr > F

Model                     2          2.27072        1.13536      47.22    <.0001
Error                    25          0.60115        0.02405
Corrected Total          27          2.87187


                     Parameter     Standard
     Variable         Estimate        Error   Type II SS  F Value  Pr > F
```

```
      Intercept         1.68480      0.06931     14.20677   590.82  <.0001
      Sqrt_avg_cfs     -0.08570      0.00886      2.25201    93.65  <.0001
      TIDE              0.22446      0.05571      0.39032    16.23  0.0005

                   Bounds on condition number: 1.1224, 4.4898
--------------------------------------------------------------------------------


      All variables left in the model are significant at the 0.1500 level.

                All variables have been entered into the model.



                         Summary of Stepwise Selection

       Variable     Variable                         Number  Partial   Model
  Step Entered      Removed      Label               Vars In R-Square R-Square

    1  Sqrt_avg_cfs                                      1    0.6548   0.6548
    2  TIDE                      MEAN TIDE AT SAMPLE     2    0.1359   0.7907

                         Summary of Stepwise Selection

                       Step  C(p)      F Value    Pr > F

                         1  17.2324      49.31    <.0001
                         2   3.0000      16.23    0.0005
```

```
                               The REG Procedure
                                 Model: MODEL1
                          Dependent Variable: Ln_Km

                   Number of Observations Read          25
                   Number of Observations Used          25

                          Stepwise Selection: Step 1


       Variable Sqrt_avg_cfs Entered: R-Square = 0.3775 and C(p) = 6.2596


                             Analysis of Variance

                                     Sum of           Mean
 Source                   DF        Squares         Square    F Value    Pr > F

 Model                     1        3.02776        3.02776      13.95    0.0011
 Error                    23        4.99259        0.21707
 Corrected Total          24        8.02035


                      Parameter     Standard
      Variable         Estimate        Error   Type II SS  F Value  Pr > F

      Intercept         1.51018      0.13964     25.38868   116.96  <.0001
      Sqrt_avg_cfs     -0.09785      0.02620      3.02776    13.95  0.0011

                       Bounds on condition number: 1, 1
--------------------------------------------------------------------------------

                          Stepwise Selection: Step 2


           Variable TIDE Entered: R-Square = 0.4976 and C(p) = 3.0000


                             Analysis of Variance

                                     Sum of           Mean
 Source                   DF        Squares         Square    F Value    Pr > F

 Model                     2        3.99106        1.99553      10.90    0.0005
 Error                    22        4.02929        0.18315
 Corrected Total          24        8.02035


                      Parameter     Standard
      Variable         Estimate        Error   Type II SS  F Value  Pr > F
```

```
     Intercept         1.09264      0.22271      4.40834    24.07  <.0001
     Sqrt_avg_cfs     -0.11047      0.02469      3.66734    20.02  0.0002
     TIDE              0.36417      0.15879      0.96330     5.26  0.0317

                  Bounds on condition number: 1.0523, 4.2091
--------------------------------------------------------------------------------


     All variables left in the model are significant at the 0.1500 level.

               All variables have been entered into the model.



                        Summary of Stepwise Selection

      Variable     Variable                         Number  Partial   Model
  Step Entered      Removed      Label              Vars In R-Square R-Square

    1  Sqrt_avg_cfs                                     1    0.3775   0.3775
    2  TIDE                      MEAN TIDE AT SAMPLE    2    0.1201   0.4976

                        Summary of Stepwise Selection

                      Step  C(p)      F Value    Pr > F

                        1   6.2596      13.95    0.0011
                        2   3.0000       5.26    0.0317
```

```
                               The REG Procedure
                                 Model: MODEL1
                           Dependent Variable: Ln_Km

                    Number of Observations Read          30
                    Number of Observations Used          30

                           Stepwise Selection: Step 1


       Variable Sqrt_avg_cfs Entered: R-Square = 0.8400 and C(p) = 1.3867


                              Analysis of Variance

                                     Sum of           Mean
 Source                   DF        Squares         Square    F Value    Pr > F

 Model                     1        1.53895        1.53895     147.00    <.0001
 Error                    28        0.29312        0.01047
 Corrected Total          29        1.83207


                      Parameter     Standard
      Variable         Estimate        Error   Type II SS  F Value  Pr > F

      Intercept         2.30405      0.02729     74.62473  7128.36  <.0001
      Sqrt_avg_cfs     -0.06292      0.00519      1.53895   147.00  <.0001

                        Bounds on condition number: 1, 1
--------------------------------------------------------------------------------


      All variables left in the model are significant at the 0.1500 level.

 No other variable met the 0.1500 significance level for entry into the model.



                         Summary of Stepwise Selection

       Variable     Variable                         Number  Partial   Model
  Step Entered      Removed      Label               Vars In R-Square R-Square

    1  Sqrt_avg_cfs                                      1    0.8400   0.8400

                         Summary of Stepwise Selection

                       Step  C(p)      F Value    Pr > F

                         1   1.3867     147.00    <.0001
```

```
                              The REG Procedure
                                Model: MODEL1
                          Dependent Variable: Ln_Km

                   Number of Observations Read          30
                   Number of Observations Used          30

                          Stepwise Selection: Step 1


      Variable Sqrt_avg_cfs Entered: R-Square = 0.7639 and C(p) = 1.0110


                             Analysis of Variance

                                    Sum of           Mean
Source                   DF        Squares         Square    F Value    Pr > F

Model                     1        1.67493        1.67493      90.57    <.0001
Error                    28        0.51779        0.01849
Corrected Total          29        2.19272


                     Parameter     Standard
     Variable         Estimate        Error   Type II SS  F Value  Pr > F

     Intercept         2.16888      0.03627     66.12545  3575.79  <.0001
     Sqrt_avg_cfs     -0.06564      0.00690      1.67493    90.57  <.0001

                       Bounds on condition number: 1, 1
--------------------------------------------------------------------------------


     All variables left in the model are significant at the 0.1500 level.

No other variable met the 0.1500 significance level for entry into the model.



                        Summary of Stepwise Selection

      Variable     Variable                                Number  Partial   Model
 Step Entered      Removed      Label                      Vars In R-Square R-Square

   1  Sqrt_avg_cfs                                             1    0.7639   0.7639

                        Summary of Stepwise Selection

                      Step   C(p)      F Value    Pr > F

                        1    1.0110      90.57    <.0001
```

```
                              The REG Procedure
                                Model: MODEL1
                          Dependent Variable: Ln_Km

                   Number of Observations Read          29
                   Number of Observations Used          29

                          Stepwise Selection: Step 1


     Variable Sqrt_avg_cfs Entered: R-Square = 0.6741 and C(p) = 15.3805


                             Analysis of Variance

                                    Sum of           Mean
Source                   DF        Squares         Square    F Value    Pr > F

Model                     1        2.10964        2.10964      55.85    <.0001
Error                    27        1.01981        0.03777
Corrected Total          28        3.12945


                     Parameter     Standard
     Variable         Estimate        Error   Type II SS  F Value  Pr > F

     Intercept         1.87086      0.05255     47.86745  1267.32  <.0001
     Sqrt_avg_cfs     -0.07823      0.01047      2.10964    55.85  <.0001

                       Bounds on condition number: 1, 1
--------------------------------------------------------------------------------

                          Stepwise Selection: Step 2


          Variable TIDE Entered: R-Square = 0.7902 and C(p) = 3.0000


                             Analysis of Variance

                                    Sum of           Mean
Source                   DF        Squares         Square    F Value    Pr > F

Model                     2        2.47282        1.23641      48.96    <.0001
Error                    26        0.65663        0.02525
Corrected Total          28        3.12945


                     Parameter     Standard
     Variable         Estimate        Error   Type II SS  F Value  Pr > F
```

```
     Intercept         1.65724      0.07085     13.81688   547.10  <.0001
     Sqrt_avg_cfs     -0.08950      0.00906      2.46419    97.57  <.0001
     TIDE              0.21454      0.05657      0.36318    14.38  0.0008

                  Bounds on condition number: 1.1205, 4.4822
--------------------------------------------------------------------------------


     All variables left in the model are significant at the 0.1500 level.

               All variables have been entered into the model.



                        Summary of Stepwise Selection

      Variable     Variable                         Number  Partial   Model
  Step Entered      Removed      Label              Vars In R-Square R-Square

    1  Sqrt_avg_cfs                                    1     0.6741   0.6741
    2  TIDE                      MEAN TIDE AT SAMPLE     2     0.1161   0.7902

                        Summary of Stepwise Selection

                      Step  C(p)      F Value    Pr > F

                        1  15.3805      55.85    <.0001
                        2   3.0000      14.38    0.0008
```

```
                               The REG Procedure
                                 Model: MODEL1
                           Dependent Variable: Ln_Km

                    Number of Observations Read          23
                    Number of Observations Used          23

                           Stepwise Selection: Step 1


       Variable Sqrt_avg_cfs Entered: R-Square = 0.6128 and C(p) = 6.6741


                              Analysis of Variance

                                     Sum of           Mean
 Source                   DF        Squares         Square    F Value    Pr > F

 Model                     1        3.96450        3.96450      33.24    <.0001
 Error                    21        2.50479        0.11928
 Corrected Total          22        6.46929


                      Parameter     Standard
      Variable         Estimate        Error   Type II SS  F Value  Pr > F

      Intercept         1.57482      0.10484     26.91429   225.65  <.0001
      Sqrt_avg_cfs     -0.11266      0.01954      3.96450    33.24  <.0001

                        Bounds on condition number: 1, 1
--------------------------------------------------------------------------------

                           Stepwise Selection: Step 2


           Variable TIDE Entered: R-Square = 0.6984 and C(p) = 3.0000


                              Analysis of Variance

                                     Sum of           Mean
 Source                   DF        Squares         Square    F Value    Pr > F

 Model                     2        4.51807        2.25904      23.16    <.0001
 Error                    20        1.95122        0.09756
 Corrected Total          22        6.46929


                      Parameter     Standard
      Variable         Estimate        Error   Type II SS  F Value  Pr > F
```

```
     Intercept         1.22552      0.17462      4.80530    49.25  <.0001
     Sqrt_avg_cfs     -0.12464      0.01837      4.48884    46.01  <.0001
     TIDE              0.29498      0.12384      0.55357     5.67  0.0273

                  Bounds on condition number: 1.0809, 4.3236
--------------------------------------------------------------------------------


     All variables left in the model are significant at the 0.1500 level.

               All variables have been entered into the model.



                        Summary of Stepwise Selection

      Variable     Variable                        Number  Partial   Model
  Step Entered      Removed      Label              Vars In R-Square R-Square

    1  Sqrt_avg_cfs                                    1     0.6128   0.6128
    2  TIDE                      MEAN TIDE AT SAMPLE   2     0.0856   0.6984

                        Summary of Stepwise Selection

                      Step  C(p)      F Value    Pr > F

                        1   6.6741      33.24    <.0001
                        2   3.0000       5.67    0.0273
```

APPENDIX 4F

Plots of Predicted vs. Observed Locations of Water Column and Surface Isohalines in the Pithlachascotee River.

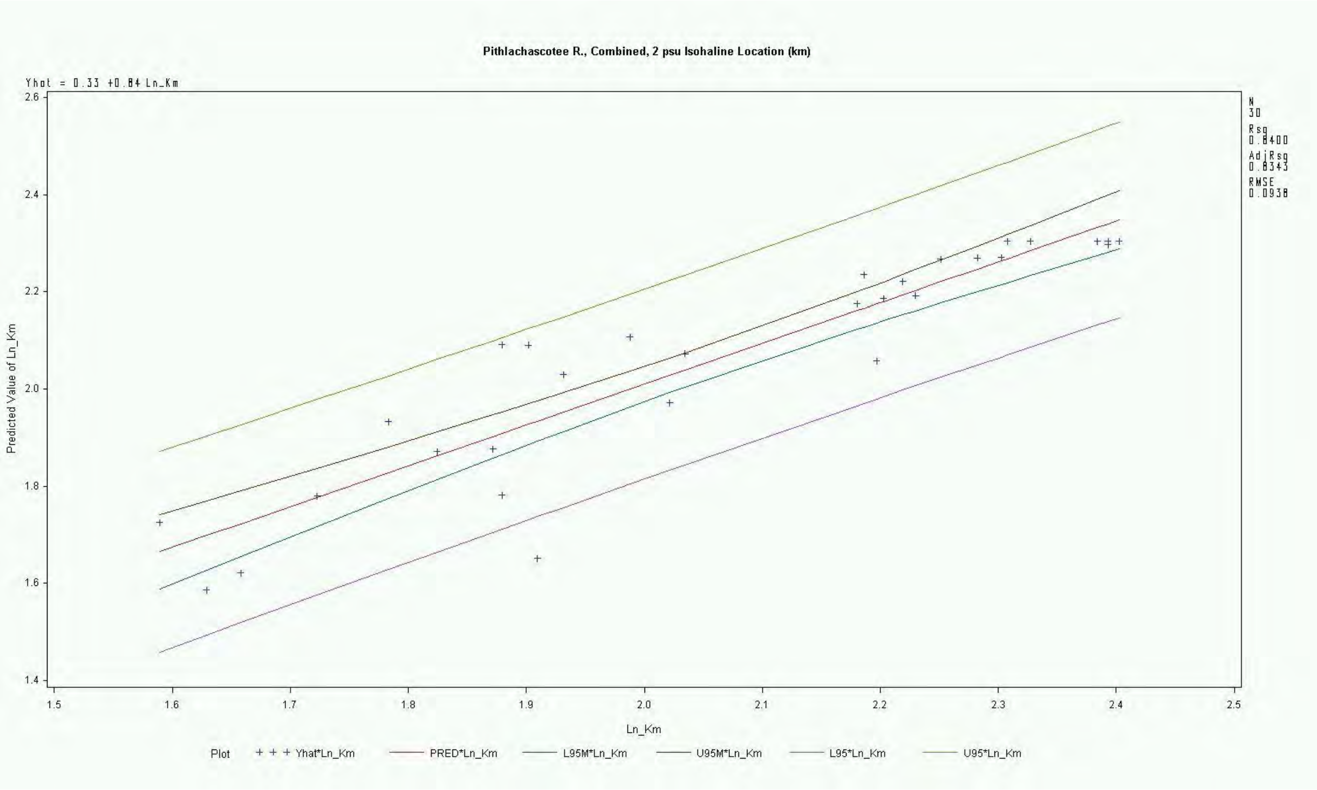


Figure 4B 05. Comparison between model predicted and observed isohaline position (as natural log RKm) for Pithlachascotee River, 2 psu, combined water column isohaline.

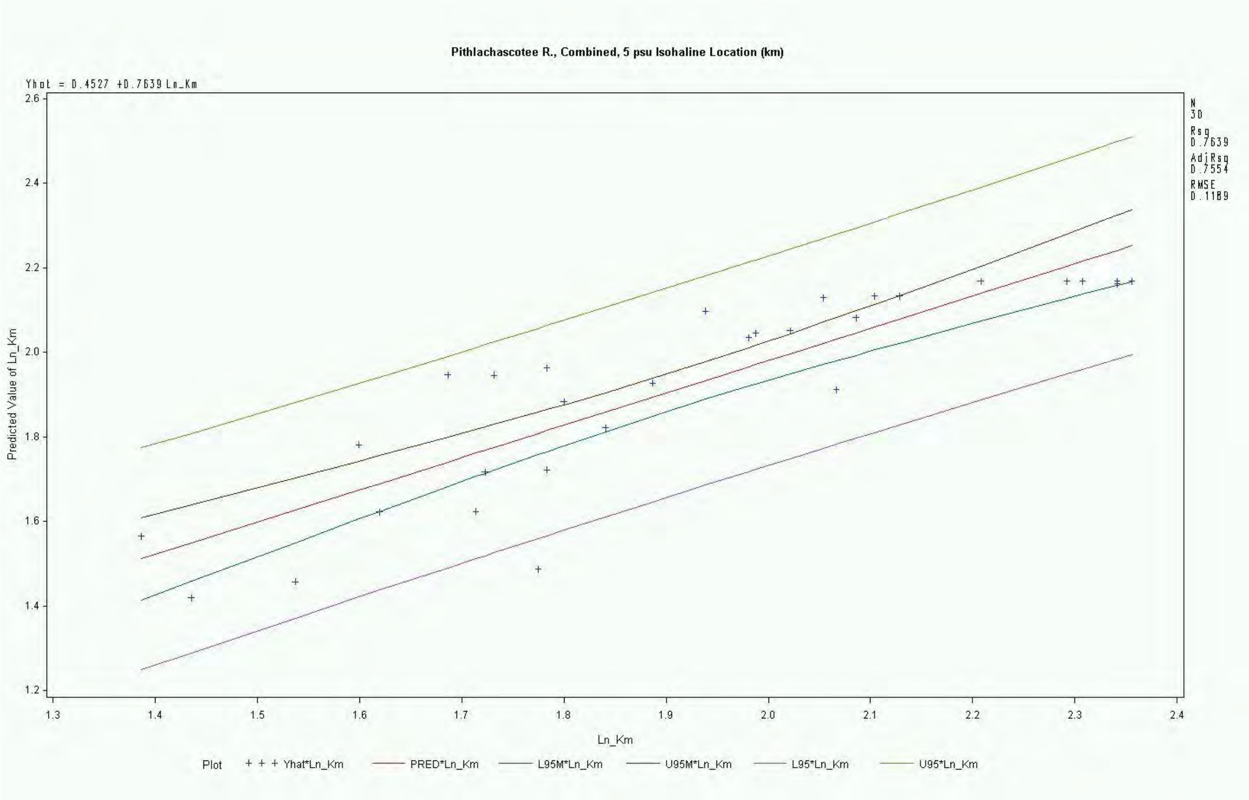


Figure 4B 06. Comparison between model predicted and observed isohaline position (as natural log RKm) for Pithlachascotee River, 5 psu, combined water column isohaline.

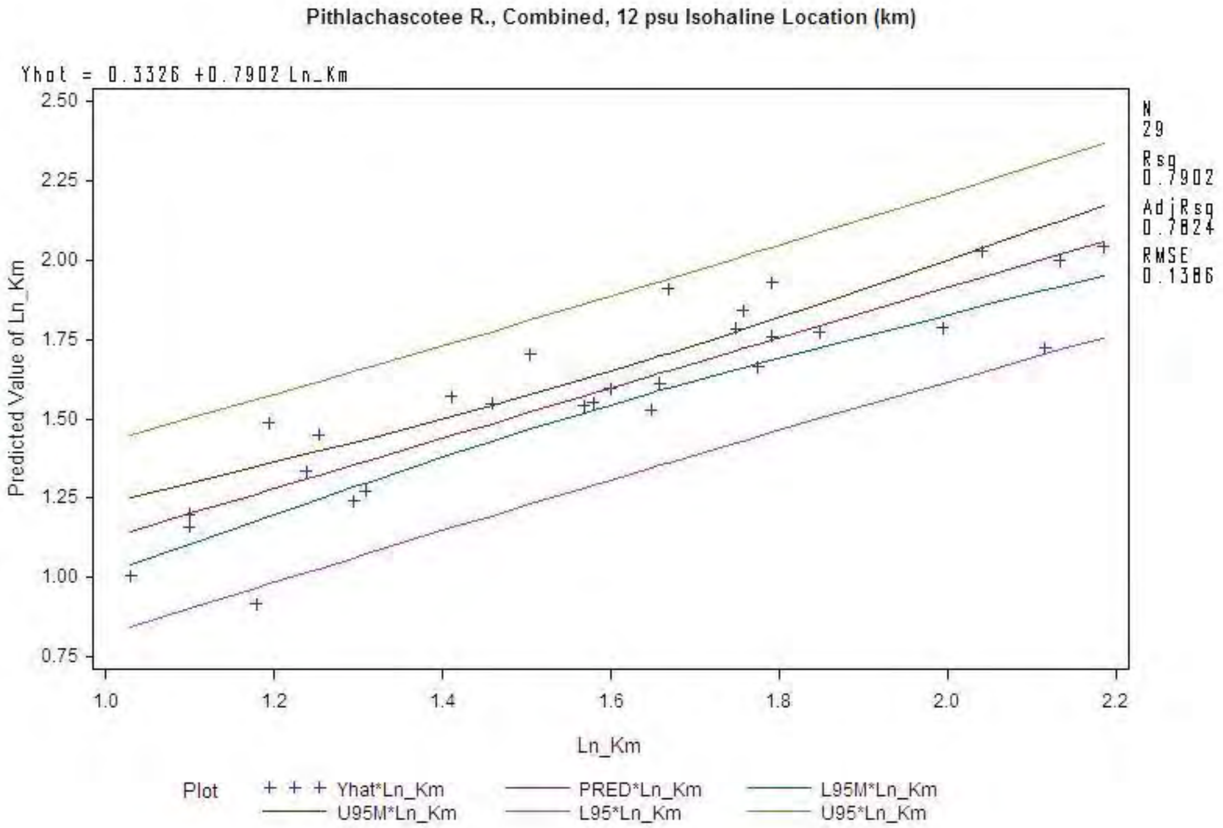


Figure 4B 07. Comparison between model predicted and observed isohaline position (as natural log RKm) for Pithlachascotee River, 12 psu, combined water column isohaline.

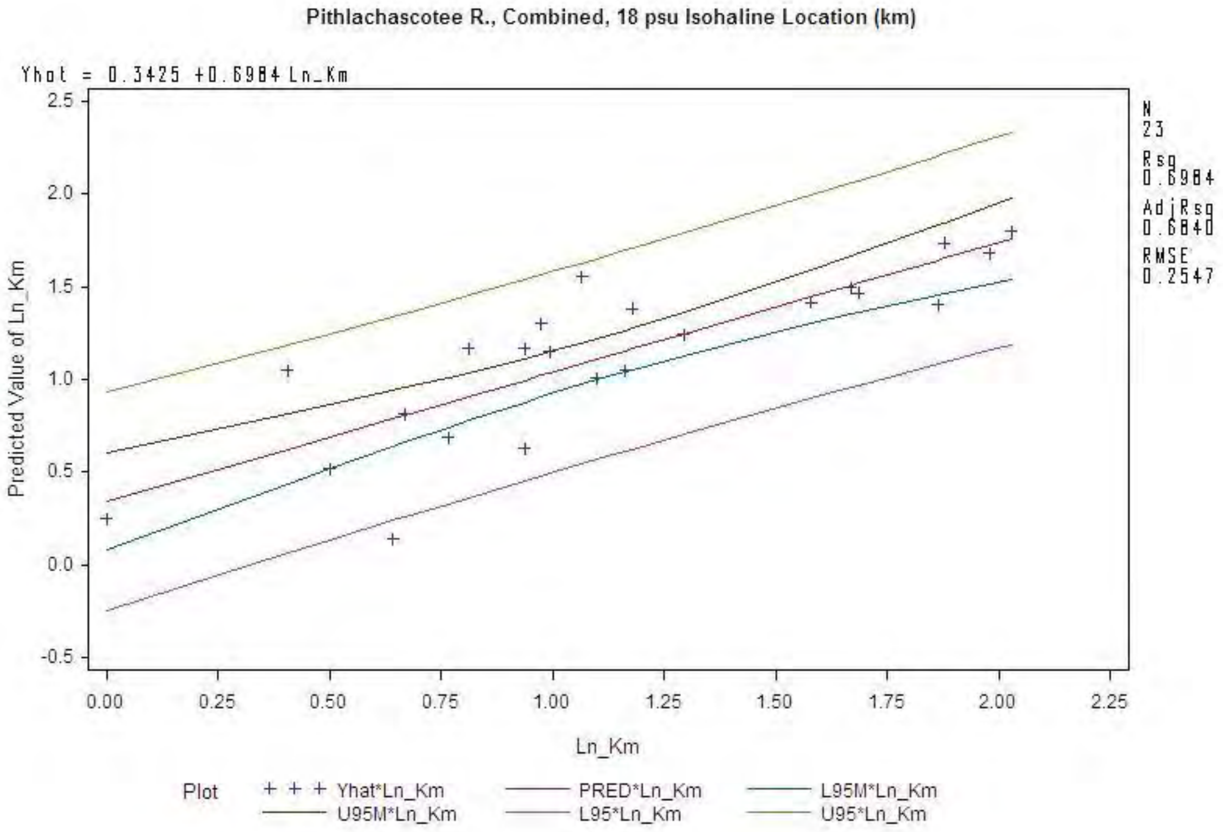


Figure 4B 08. Comparison between model predicted and observed isohaline position (as natural log RKm) for Pithlachascotee River, 18 psu, combined water column isohaline.

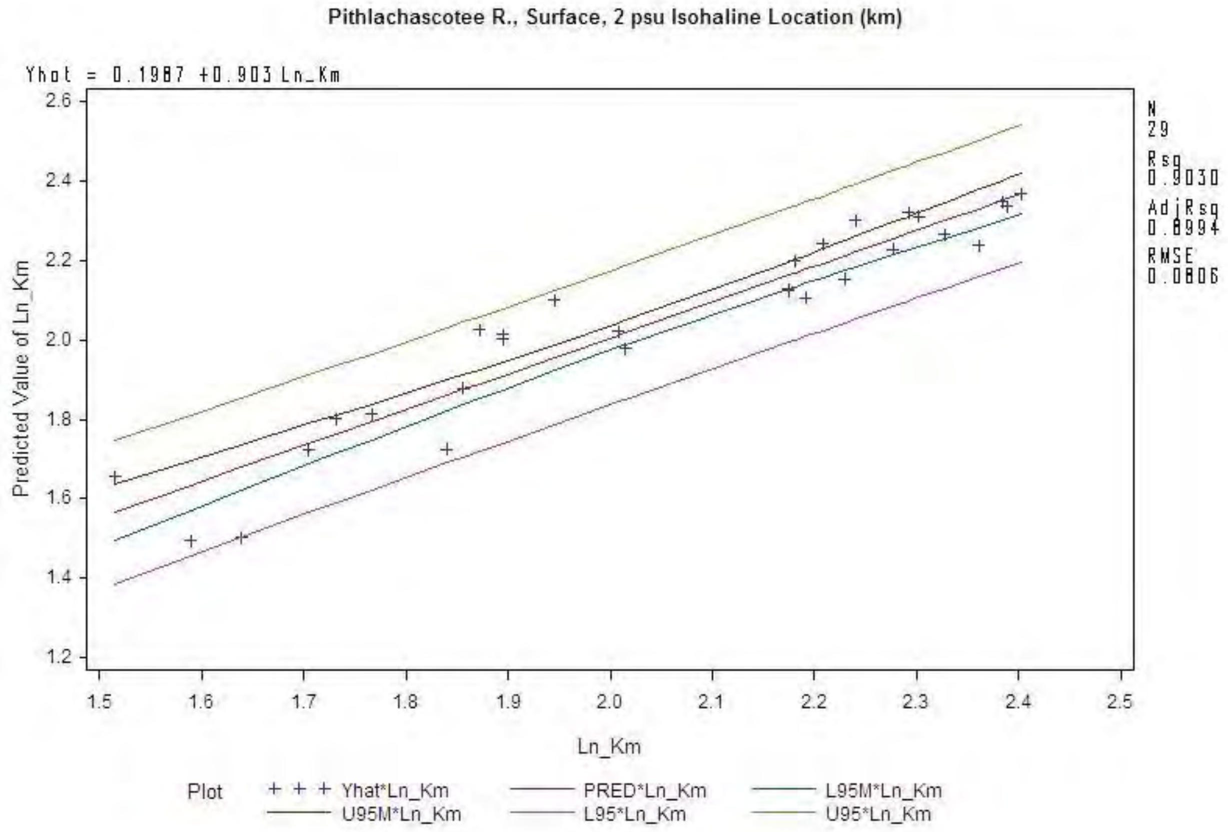


Figure 4B 09. Comparison between model predicted and observed isohaline position (as natural log RKm) for Pithlachascotee River, 2 psu, surface isohaline.

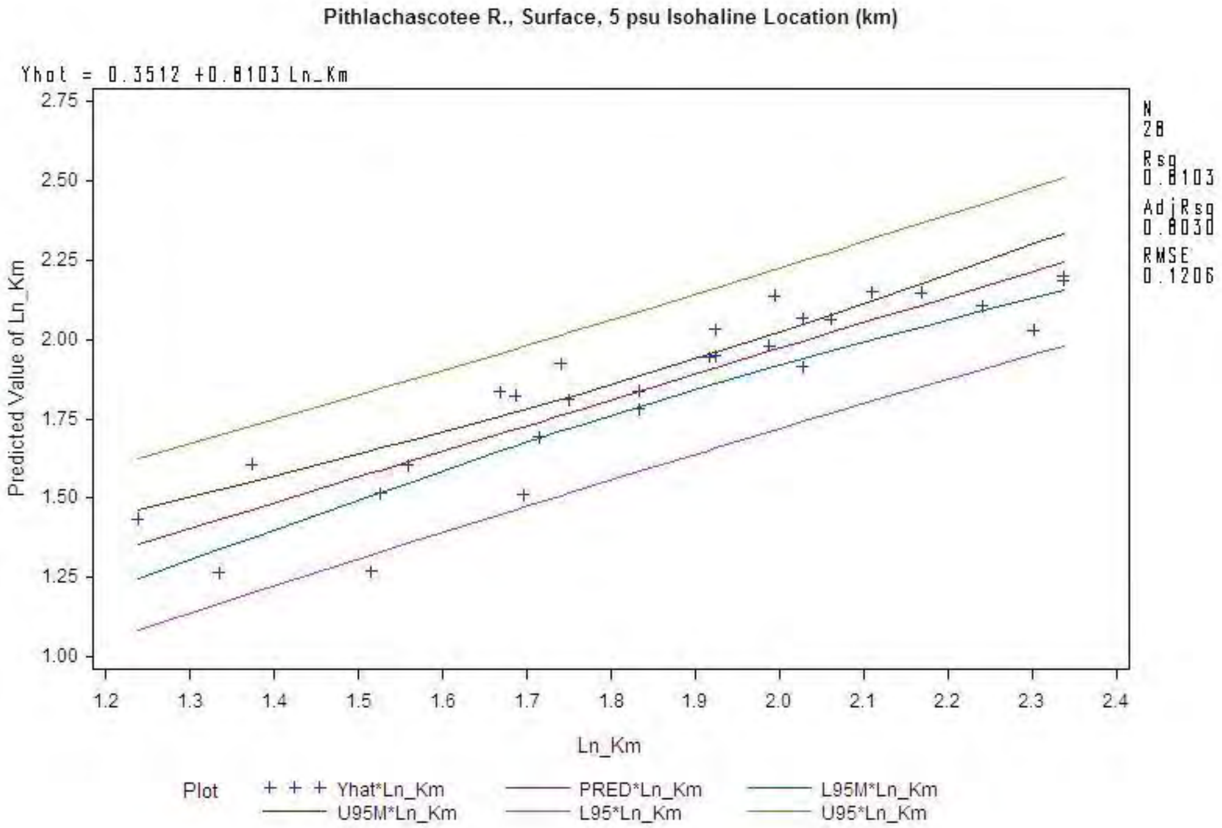


Figure 4B 10. Comparison between model predicted and observed isohaline position (as natural log RKm) for Pithlachascotee River, 5 psu, surface isohaline.

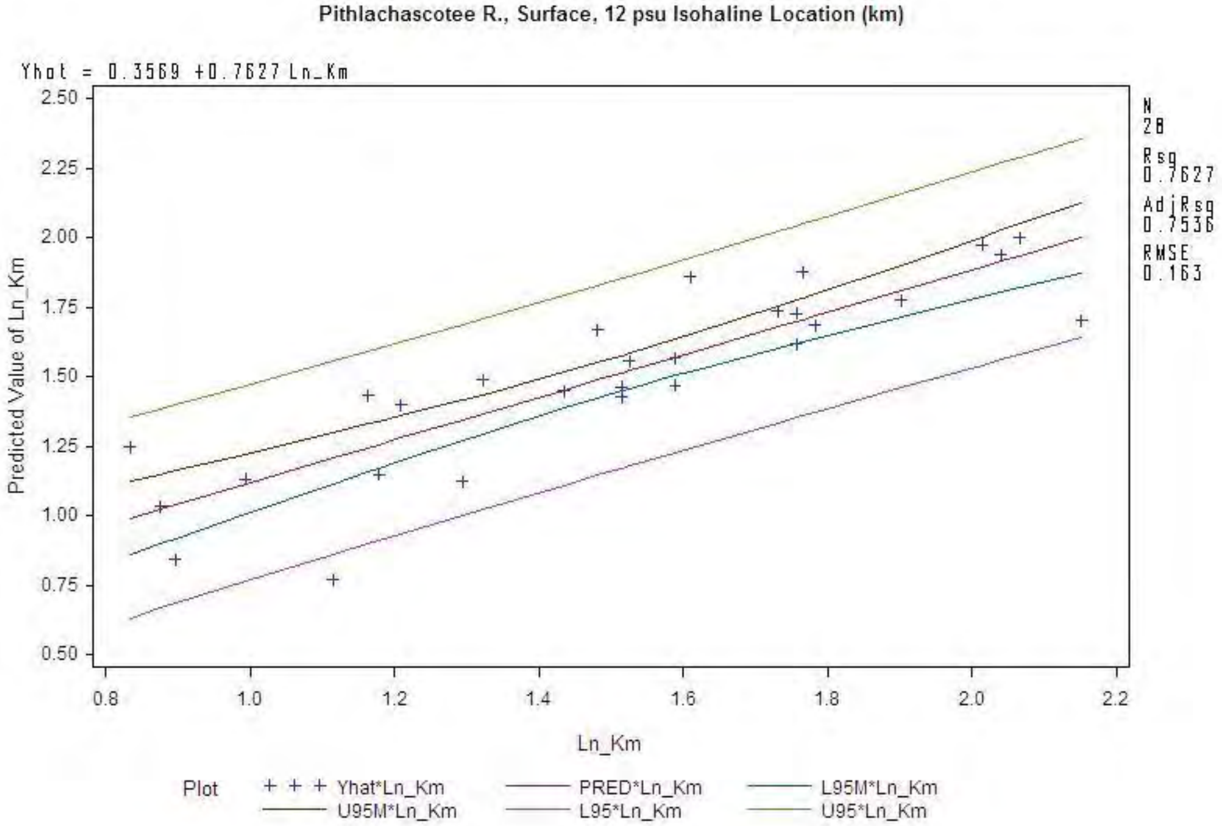


Figure 4B 11. Comparison between model predicted and observed isohaline position (as natural log RKm) for Pithlachascotee River, 12 psu, surface isohaline.

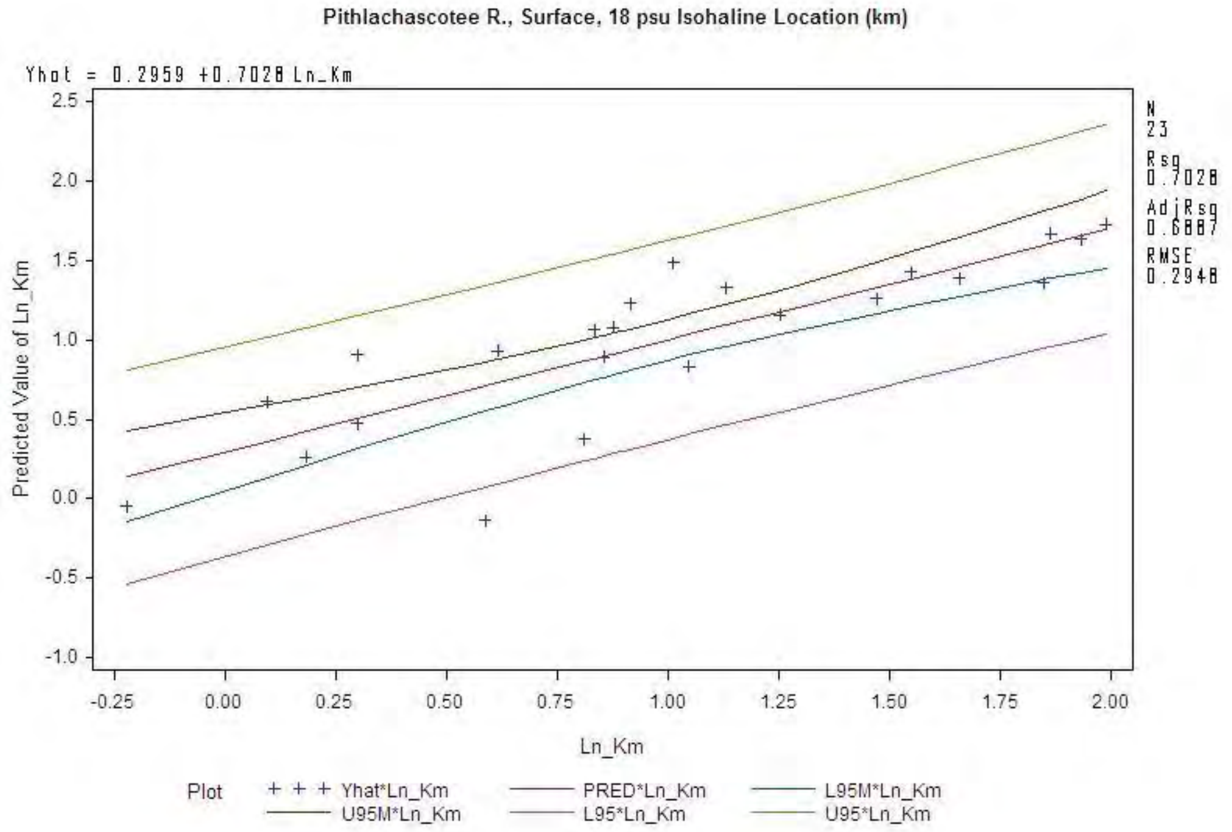
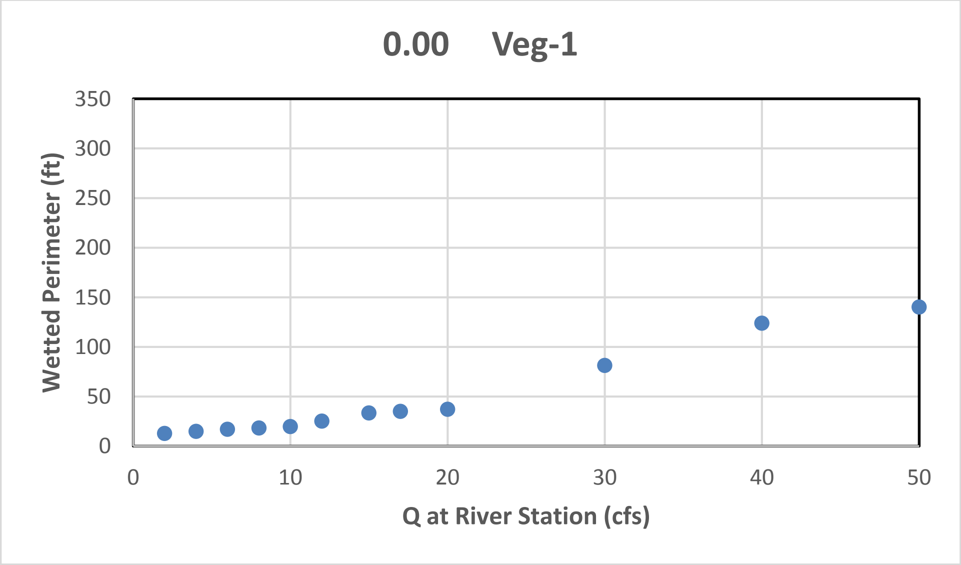


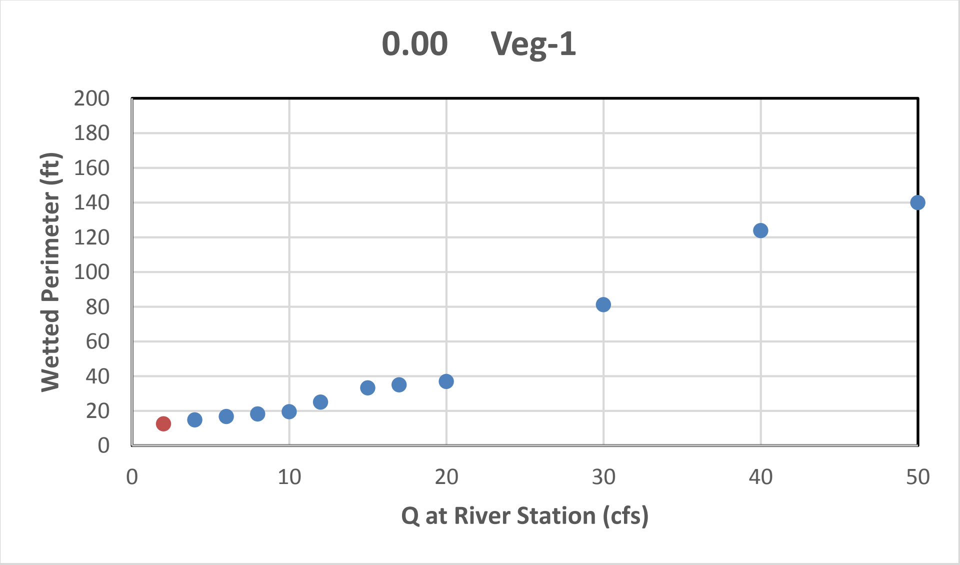
Figure 4B 12. Comparison between model predicted and observed isohaline position (as natural log RKm) for Pithlachascotee River, 18 psu, surface isohaline.

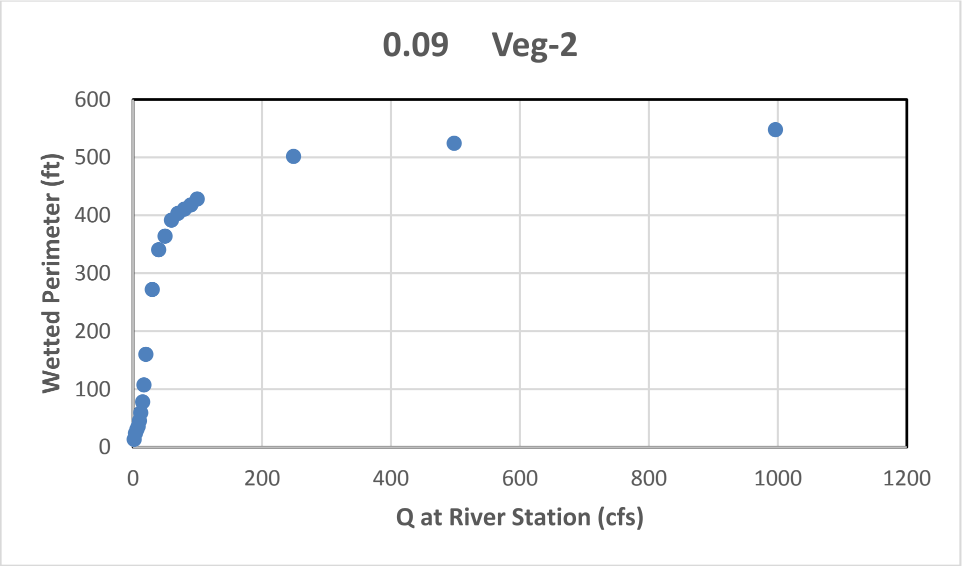
APPENDIX 5A

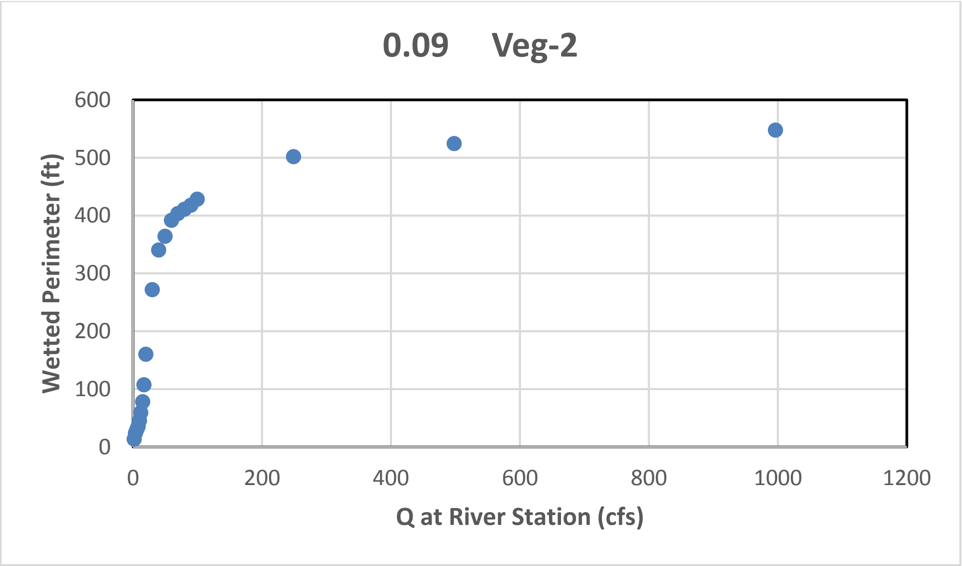
Wetted perimeter plots.

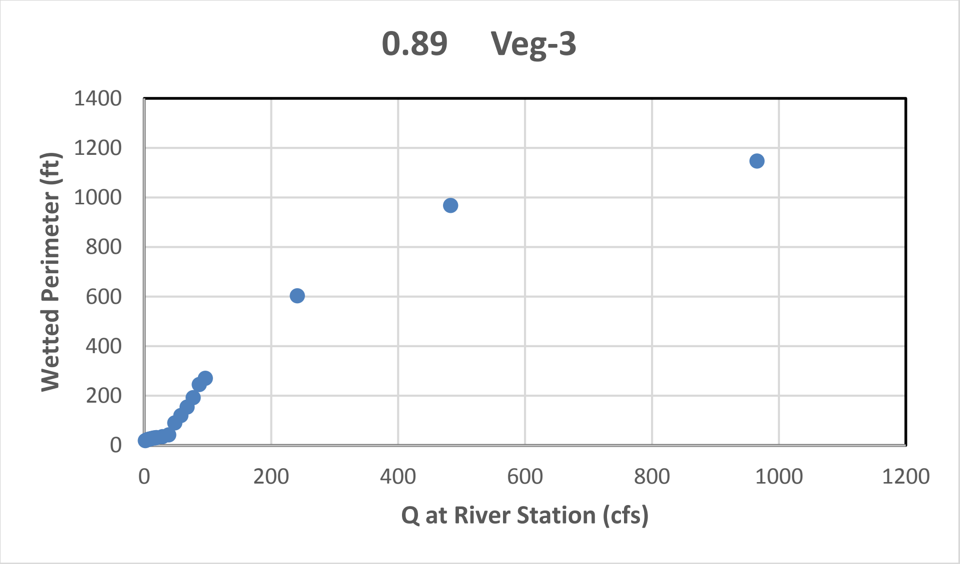
The plots below represent wetted perimeter versus discharge at HEC-RAS river stations based on miles upstream of the USGS Pithlachascotee River near New Port Richey, FL gage. Plot headers include numeric river mile upstream from the gage site and site name. Two plots with differing axes scales are shown for each site. Orange symbols denote the flow at the HEC-RAS stations used to identify the site specific Lowest Wetted Perimeter Inflection Point.

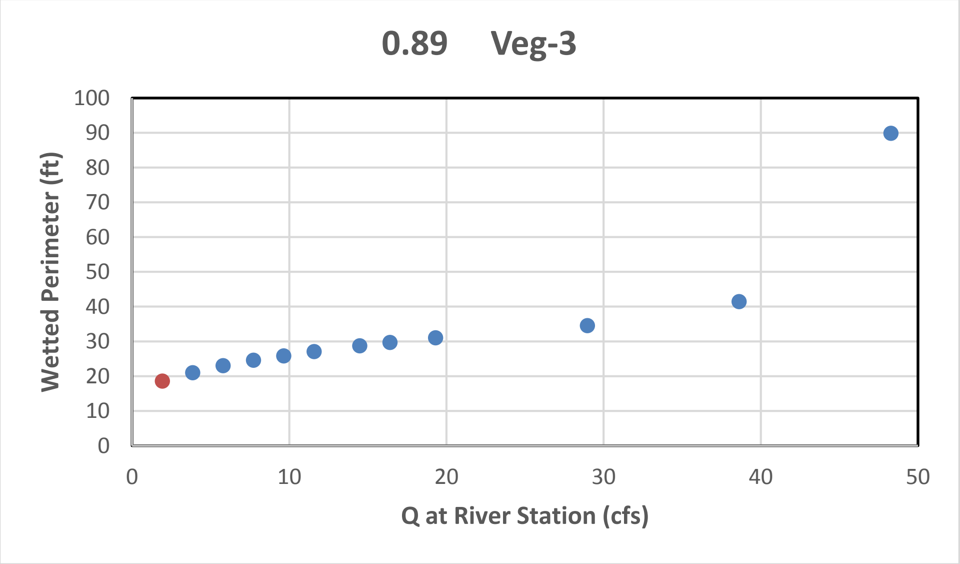


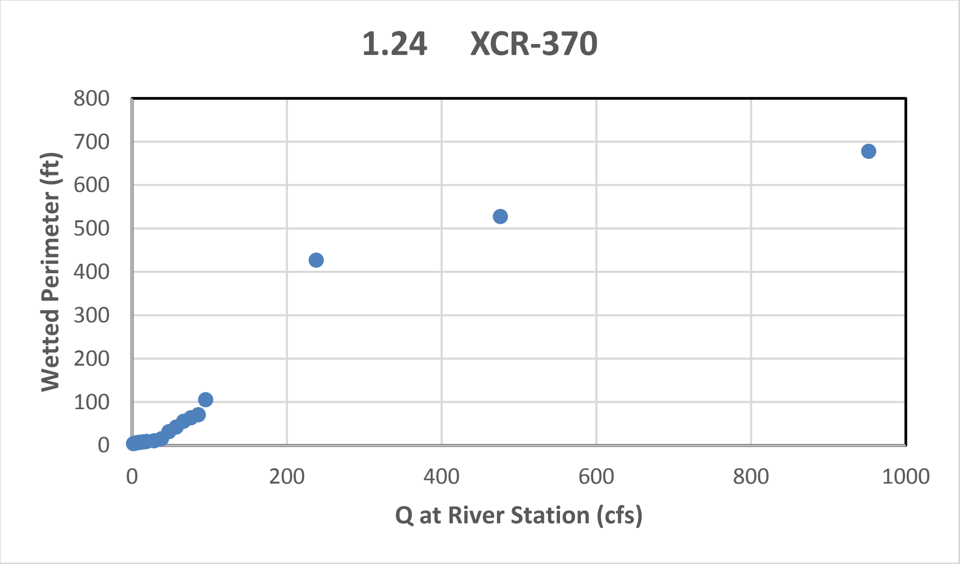


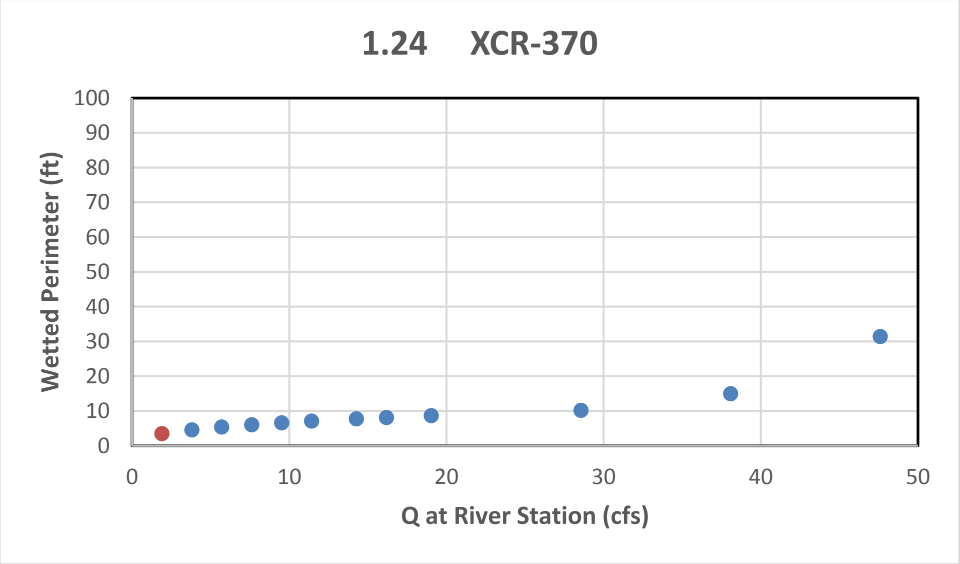

0.09 Veg-2
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
Q at River Station (cfs)

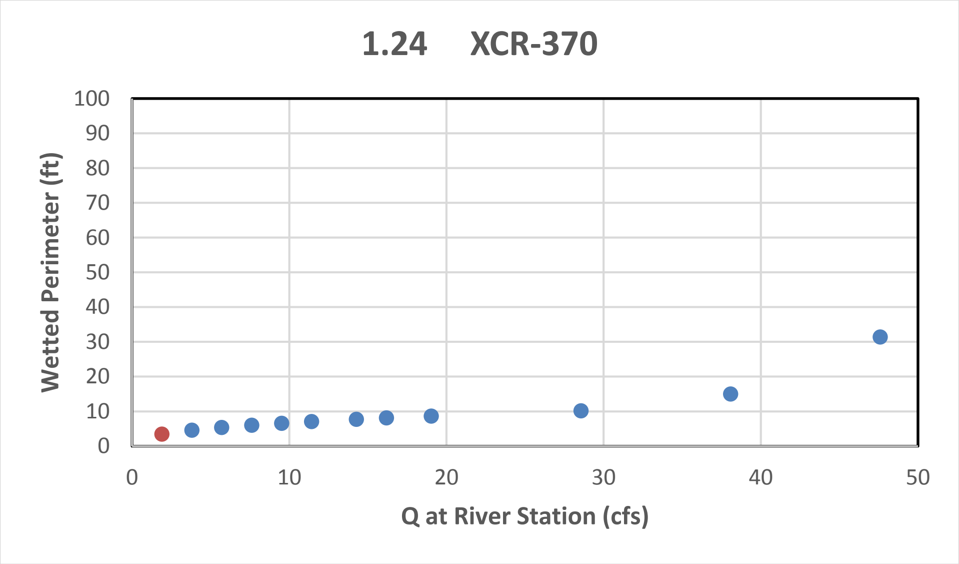

0.09 Veg-2
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
Q at River Station (cfs)

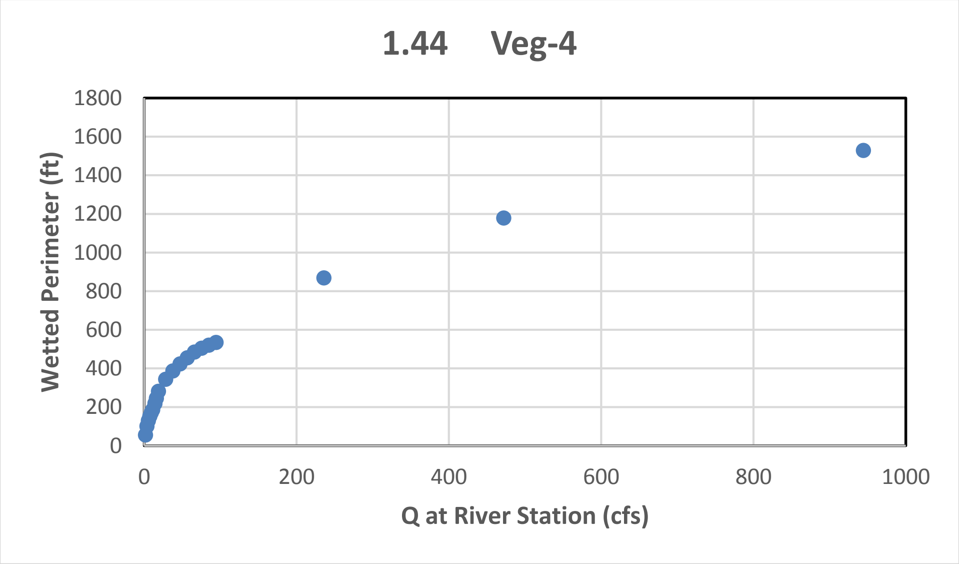

0.89 Veg-3
Wetted Perimeter (ft)
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
Q at River Station (cfs)

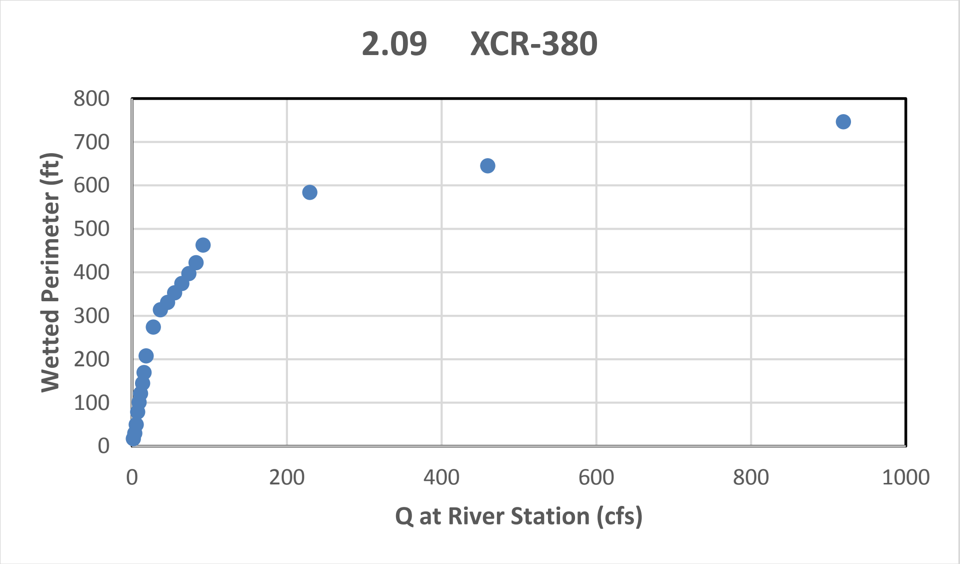

0.89 Veg-3
Wetted Perimeter (ft)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Q at River Station (cfs)

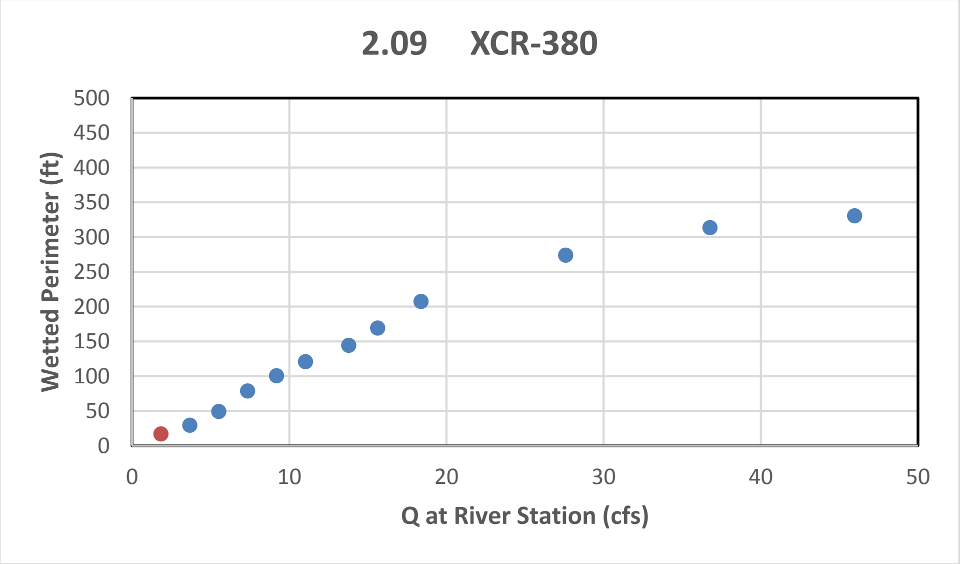

1.24 XCR-370
Wetted Perimeter (ft)
800
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
Q at River Station (cfs)

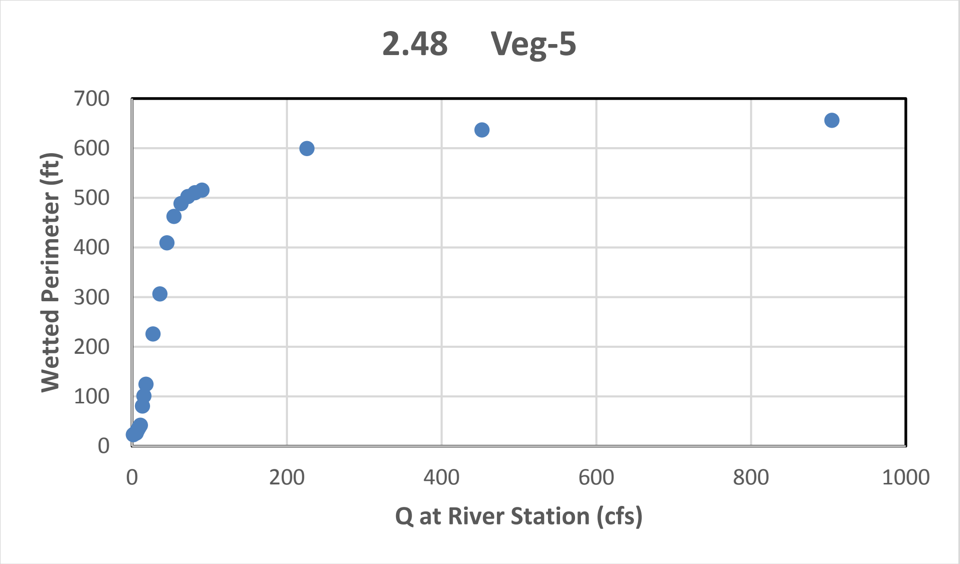

1.24 XCR-370
Wetted Perimeter (ft)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Q at River Station (cfs)

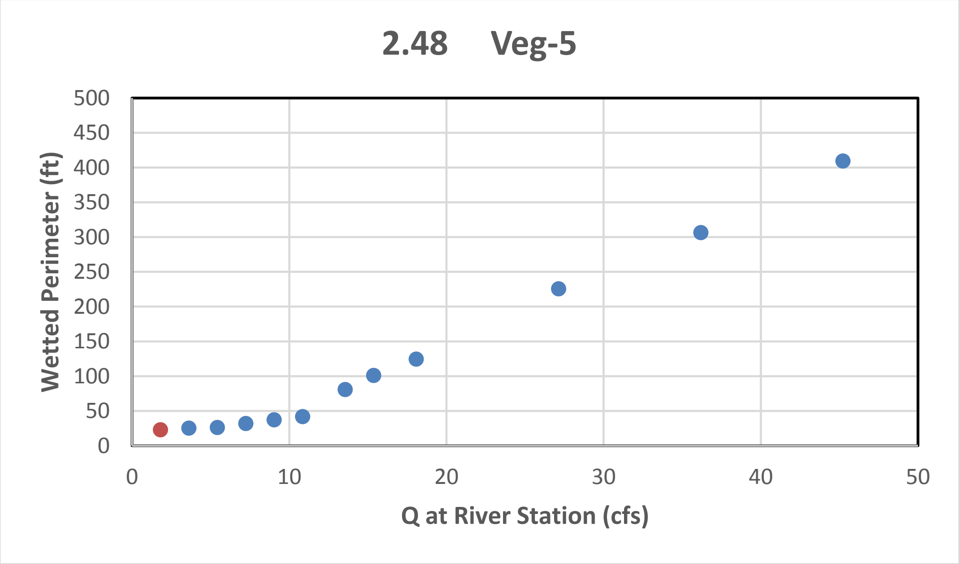

1.24 XCR-370
Wetted Perimeter (ft)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Q at River Station (cfs)

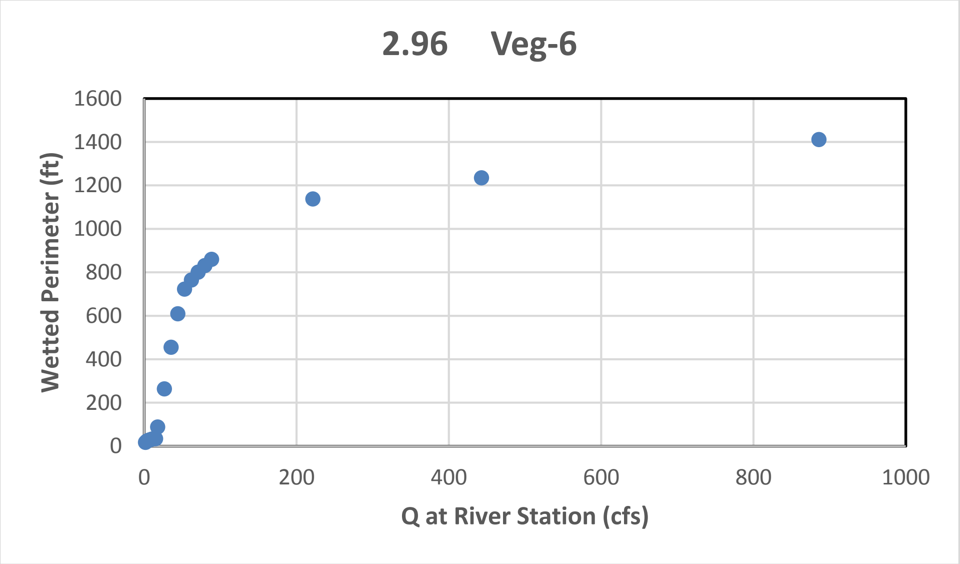

1.44 Veg-4
Wetted Perimeter (ft)
1800
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
Q at River Station (cfs)

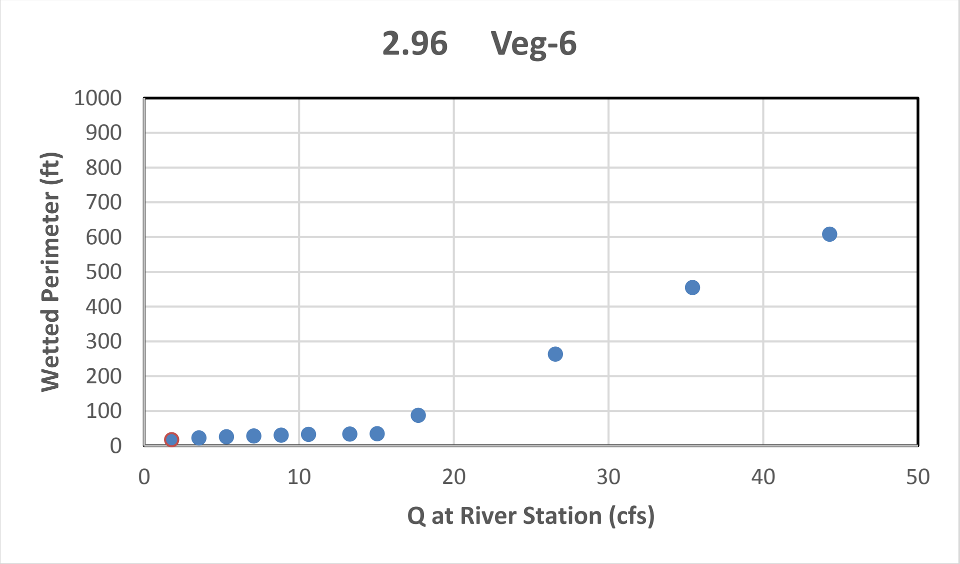

2.09 XCR-380
Wetted Perimeter (ft)
800
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
Q at River Station (cfs)

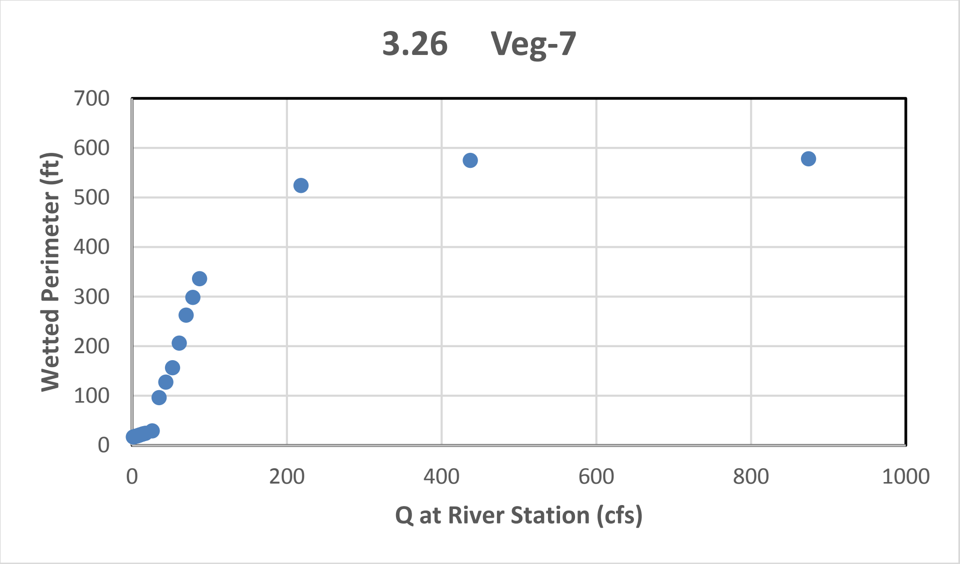

2.09 XCR-380
Wetted Perimeter (ft)
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
Q at River Station (cfs)

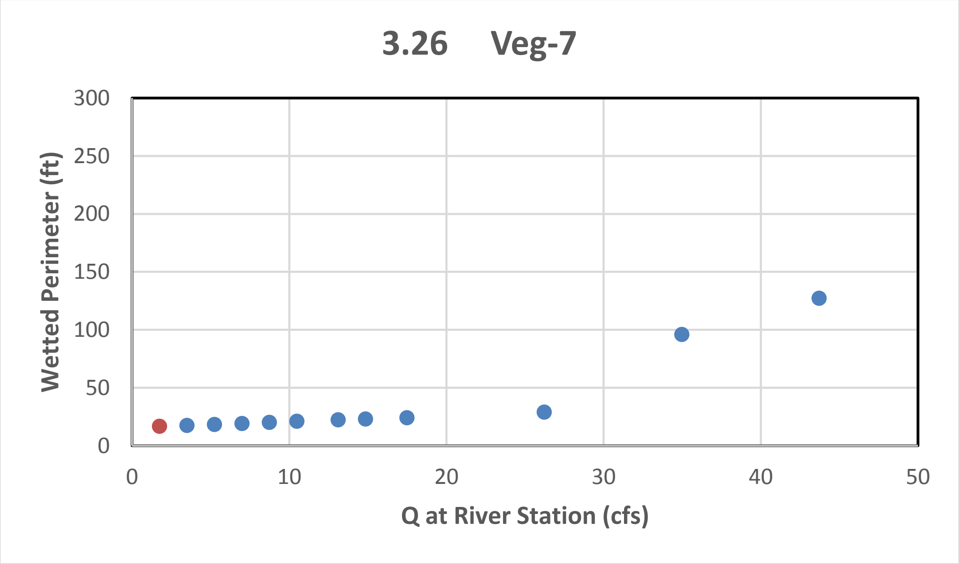

2.48 Veg-5
Wetted Perimeter (ft)
0
100
200
300
400
500
600
700
Q at River Station (cfs)
0
200
400
600
800
1000

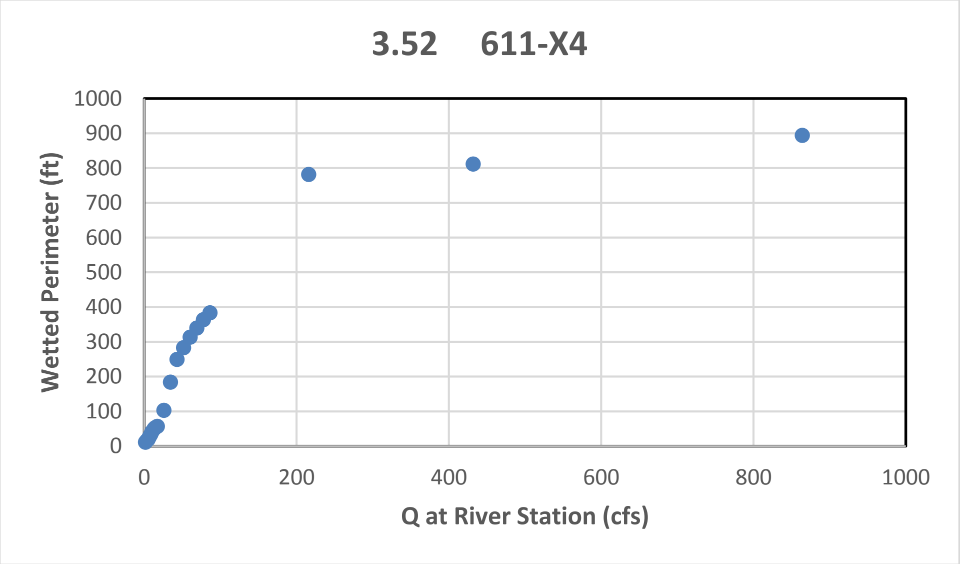

2.48 Veg-5
Wetted Perimeter (ft)
0
50
100
150
200
250
300
350
400
450
500
Q at River Station (cfs)
0
10
20
30
40
50

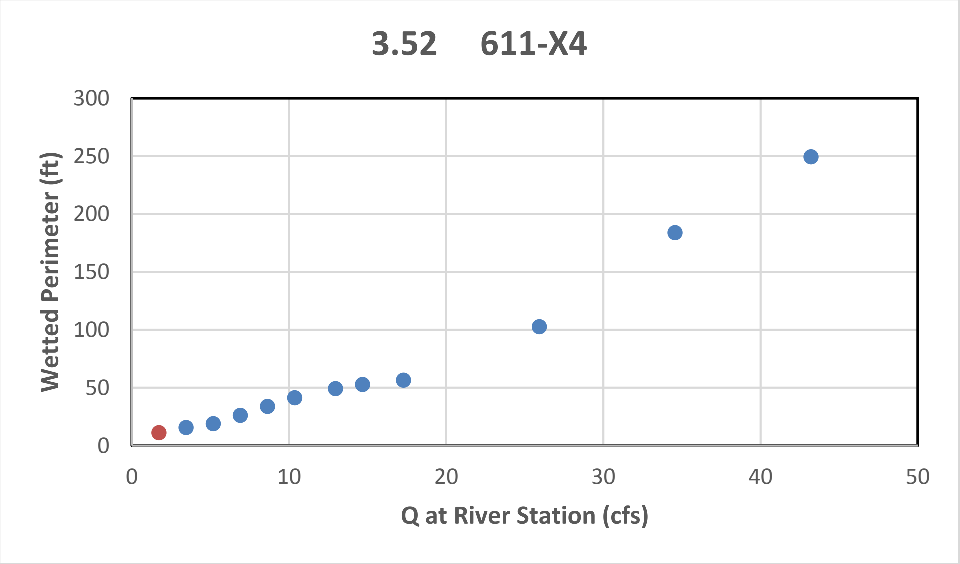

2.96 Veg-6
Wetted Perimeter (ft)
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
Q at River Station (cfs)

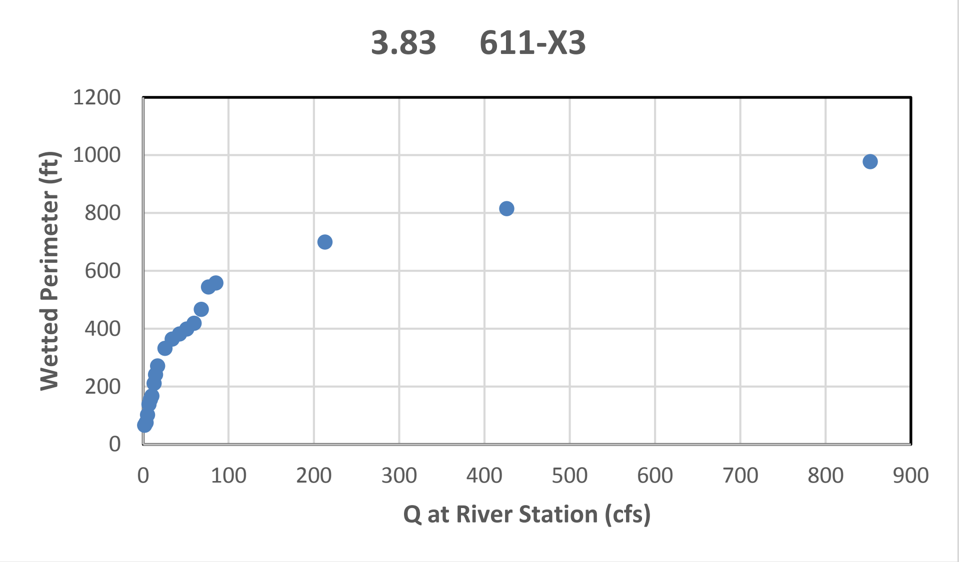

2.96 Veg-6
Wetted Perimeter (ft)
1000
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

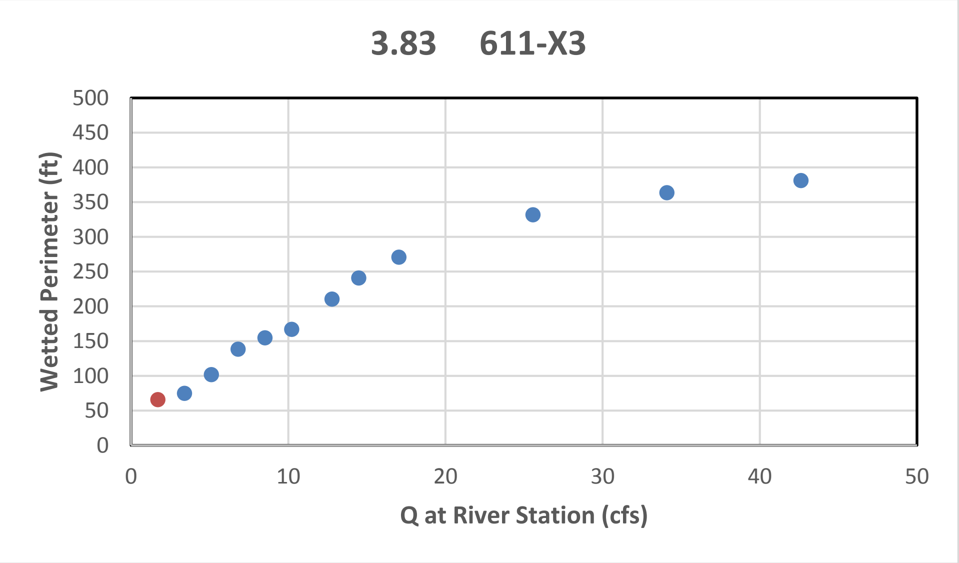

3.26 Veg-7
Wetted Perimeter (ft)
0
100
200
300
400
500
600
700
0
200
400
600
800
1000
Q at River Station (cfs)

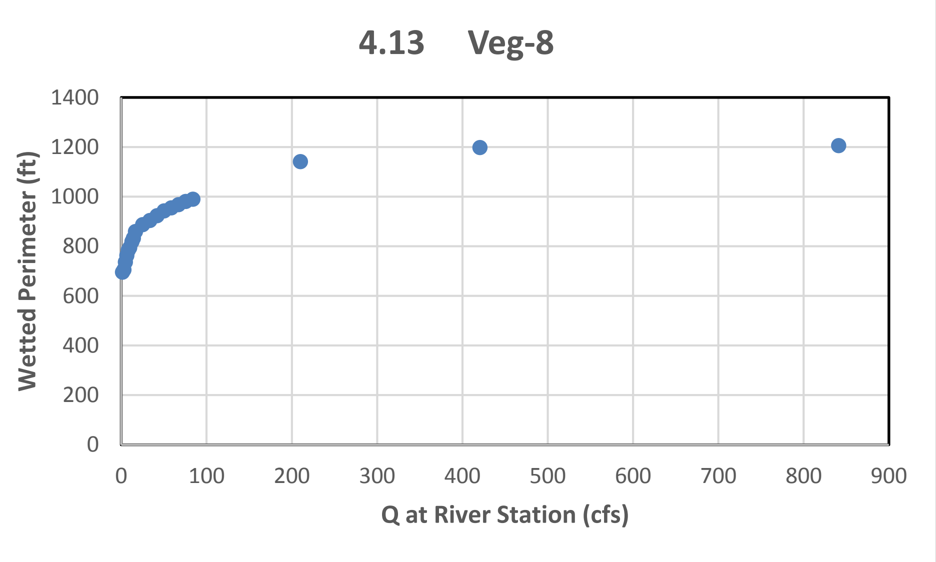

3.26 Veg-7
Wetted Perimeter (ft)
0
50
100
150
200
250
300
0
10
20
30
40
50
Q at River Station (cfs)

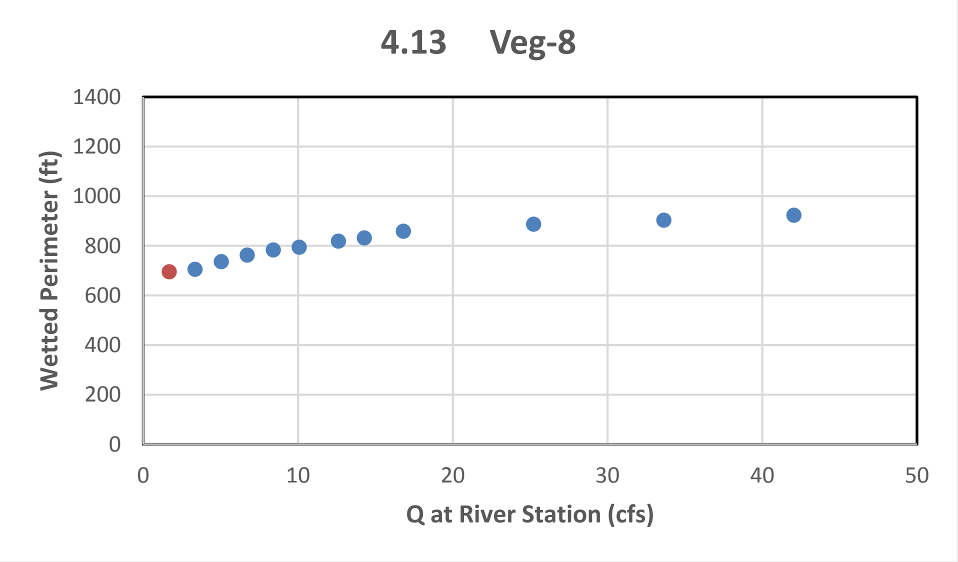

3.52 611-X4
Wetted Perimeter (ft)
1000
900
800
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
Q at River Station (cfs)

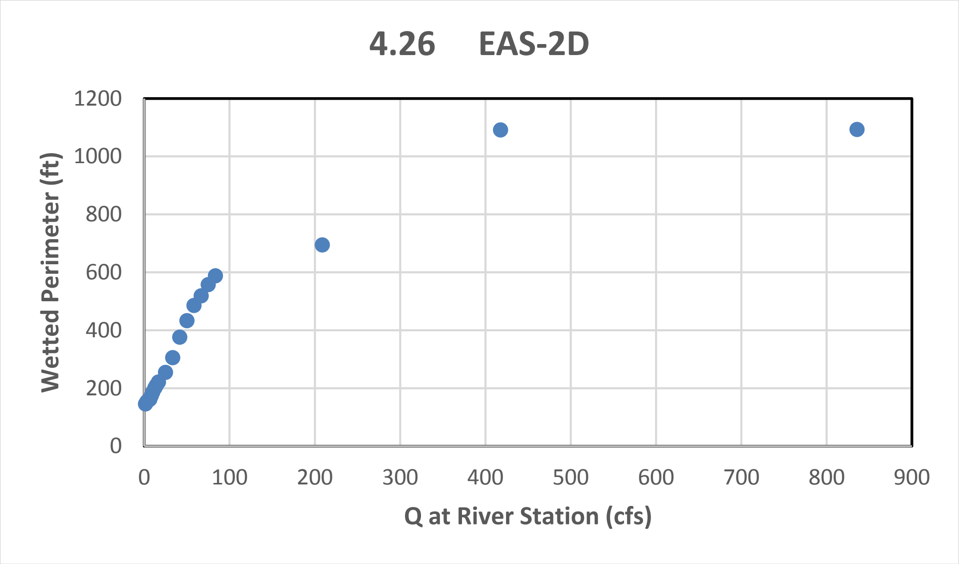

3.52 611-X4
Wetted Perimeter (ft)
300
250
200
150
100
50
0
0
10
20
30
40
50
Q at River Station (cfs)

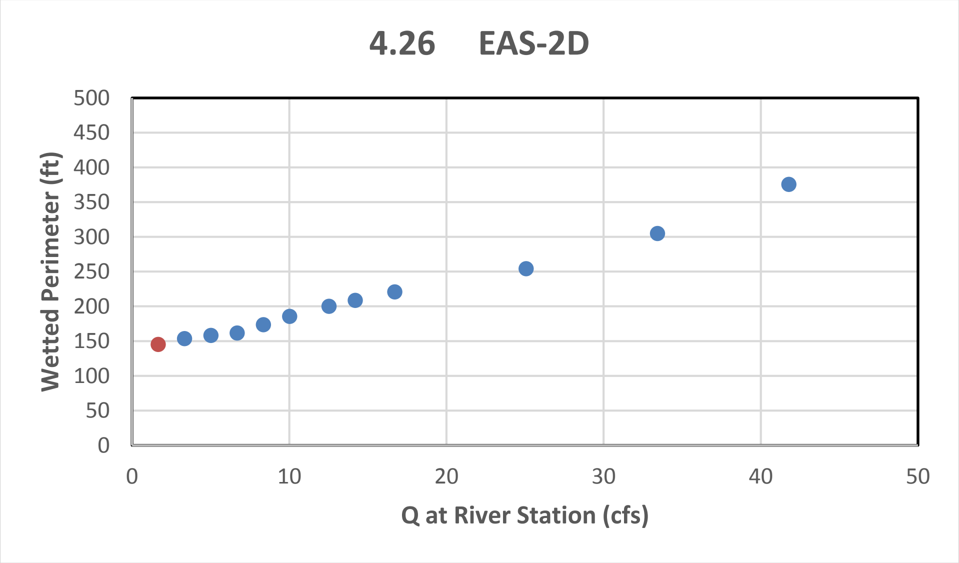

3.83 611-X3
Wetted Perimeter (ft)
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

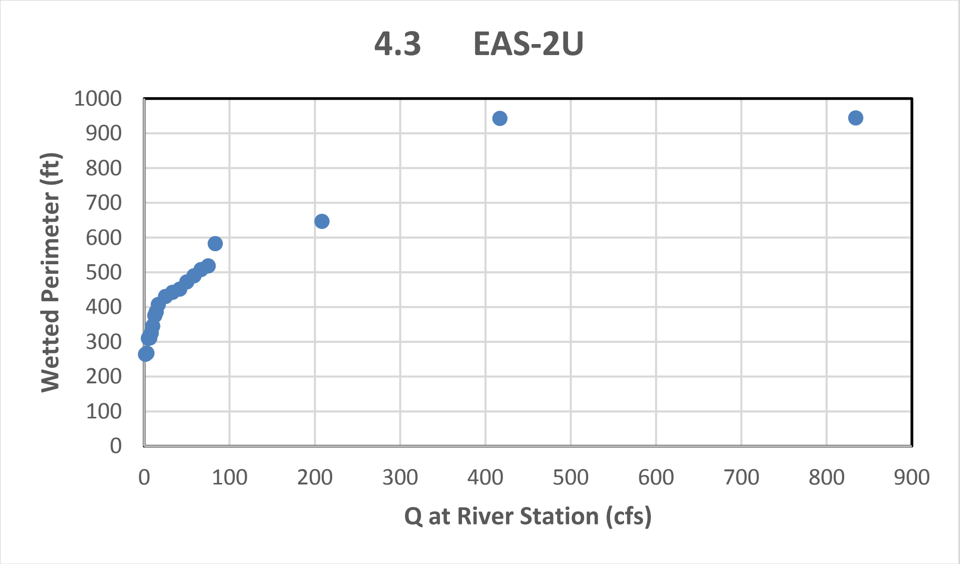

3.83 611-X3
Wetted Perimeter (ft)
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
Q at River Station (cfs)

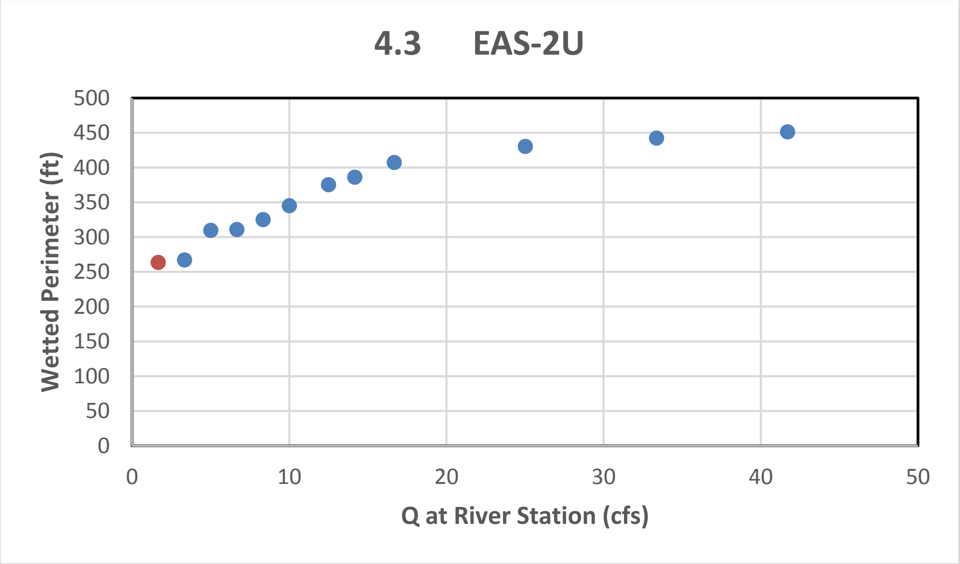

4.13 Veg-8
Wetted Perimeter (ft)
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

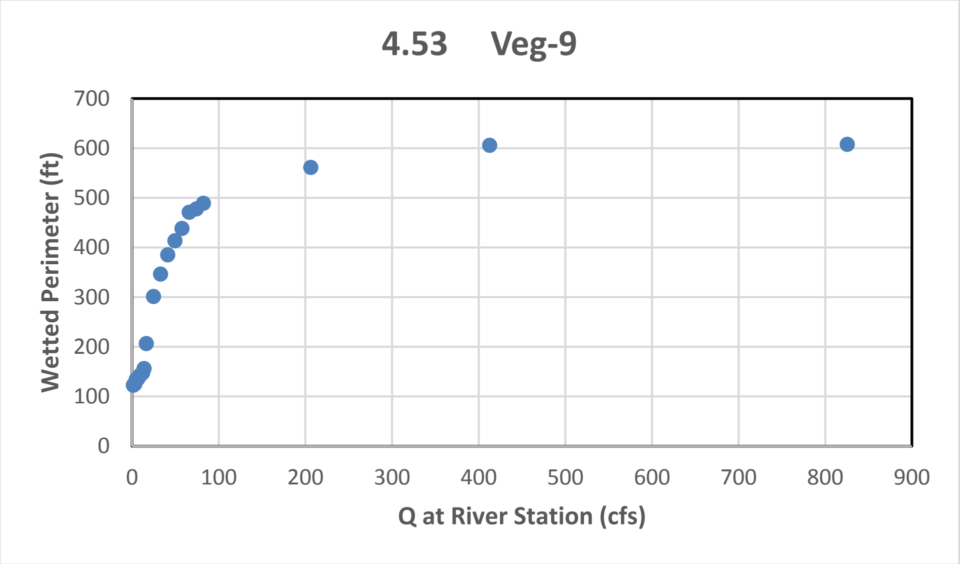

4.13 Veg-8
Wetted Perimeter (ft)
1400
1200
1000
800
600
400
200
0
0
10
20
30
40
50
Q at River Station (cfs)

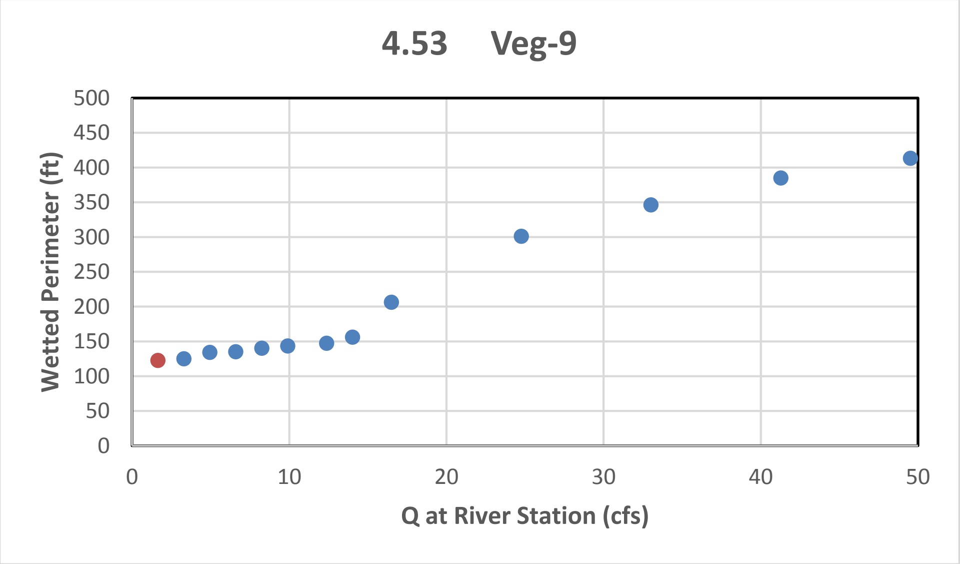

4.26 EAS-2D
Wetted Perimeter (ft)
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

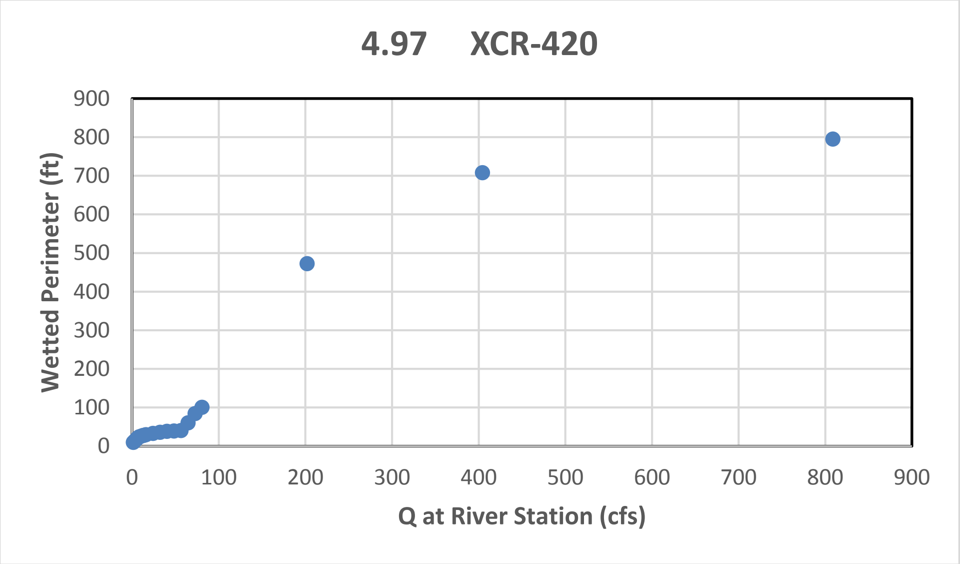

4.26 EAS-2D
Wetted Perimeter (ft)
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
Q at River Station (cfs)

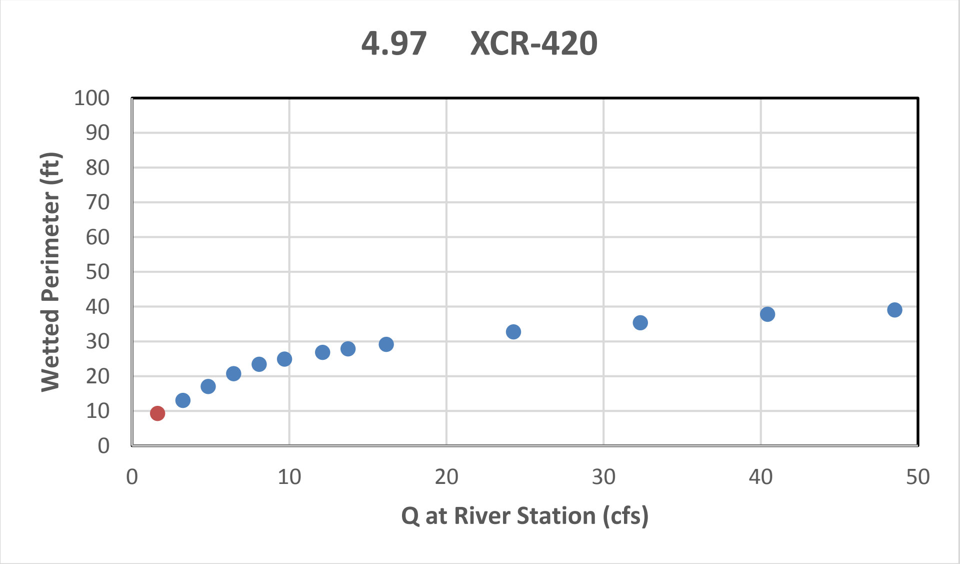

4.3 EAS-2U
Wetted Perimeter (ft)
1000
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

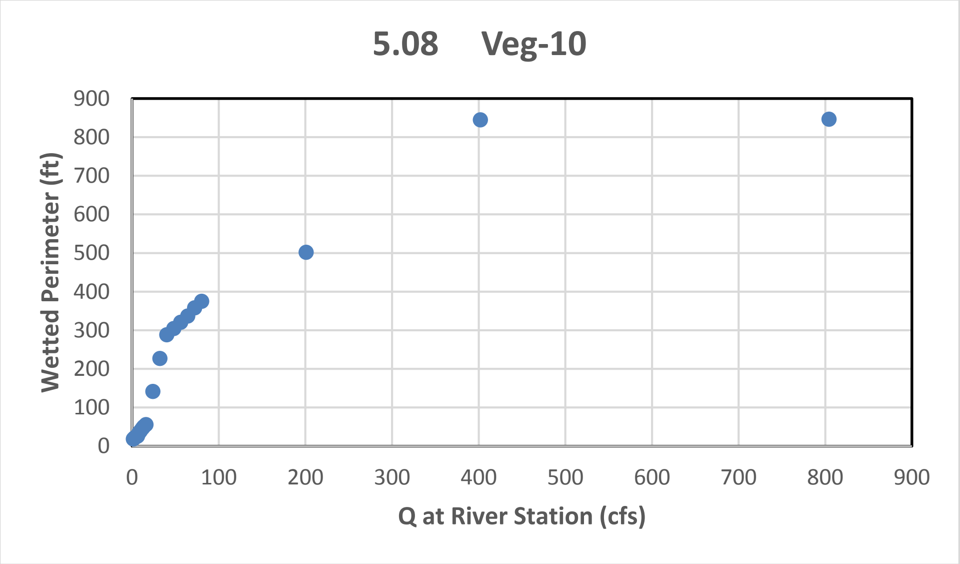

4.3 EAS-2U
Wetted Perimeter (ft)
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
Q at River Station (cfs)

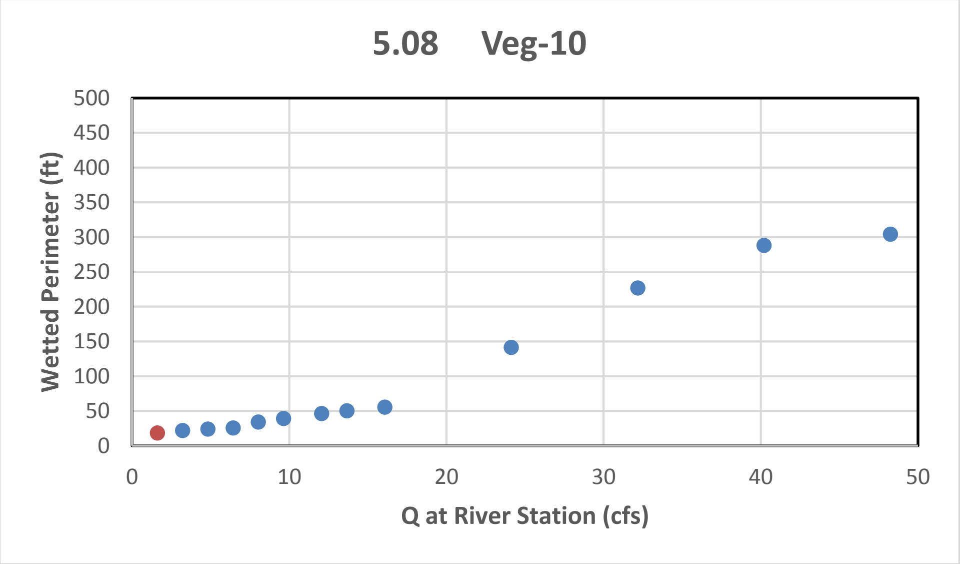

4.53 Veg-9
Wetted Perimeter (ft)
0
100
200
300
400
500
600
700
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

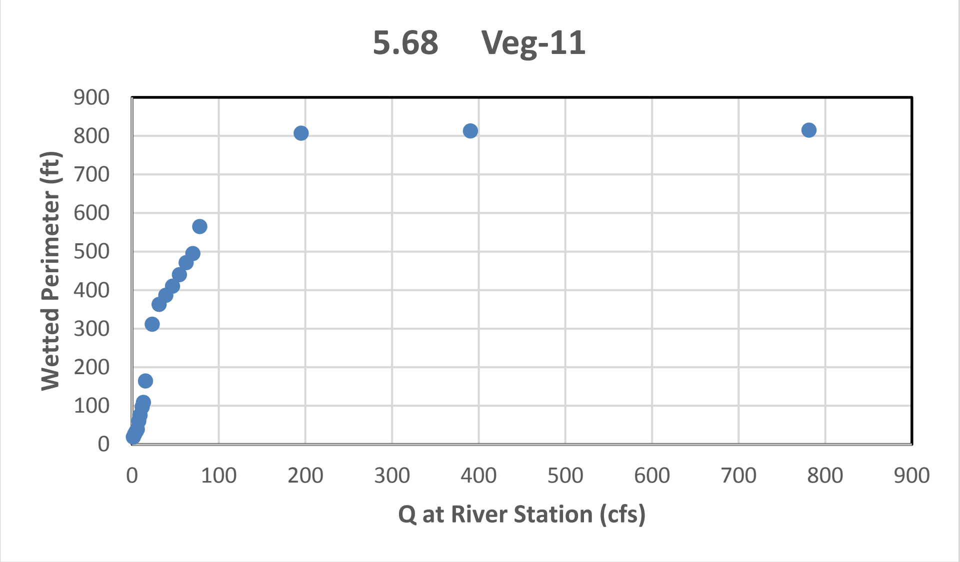

4.53 Veg-9
Wetted Perimeter (ft)
0
50
100
150
200
250
300
350
400
450
500
0
10
20
30
40
50
Q at River Station (cfs)

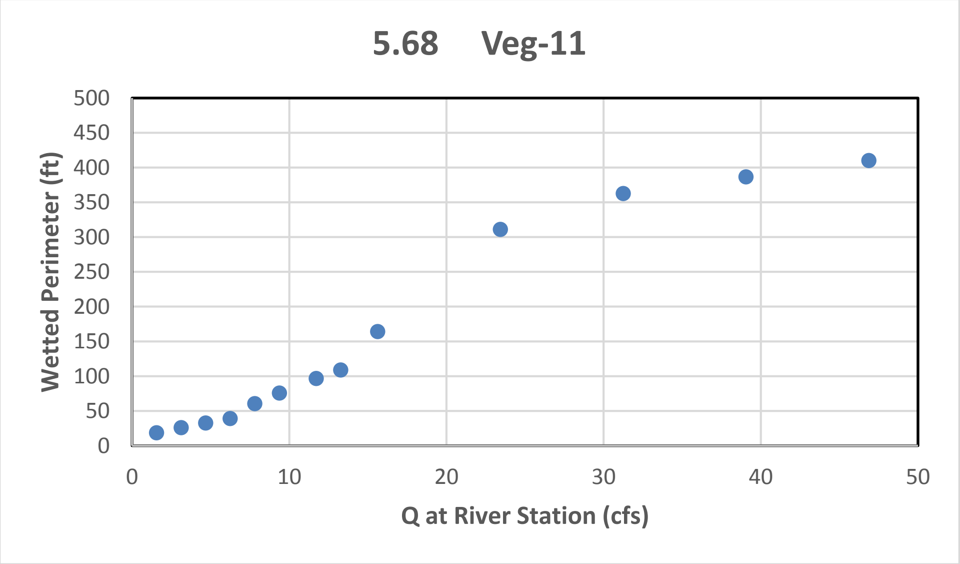

4.97 XCR-420
Wetted Perimeter (ft)
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

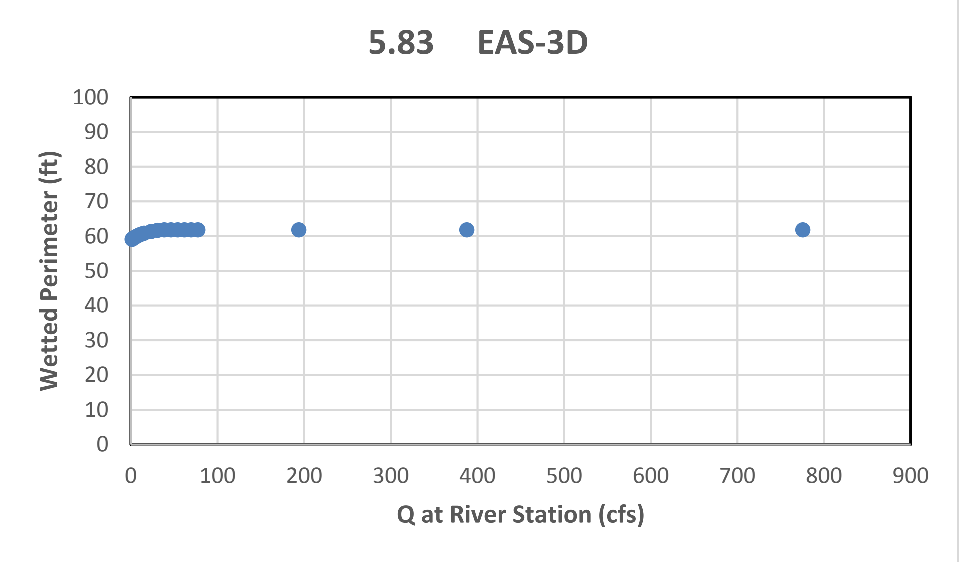

4.97 XCR-420
Wetted Perimeter (ft)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Q at River Station (cfs)

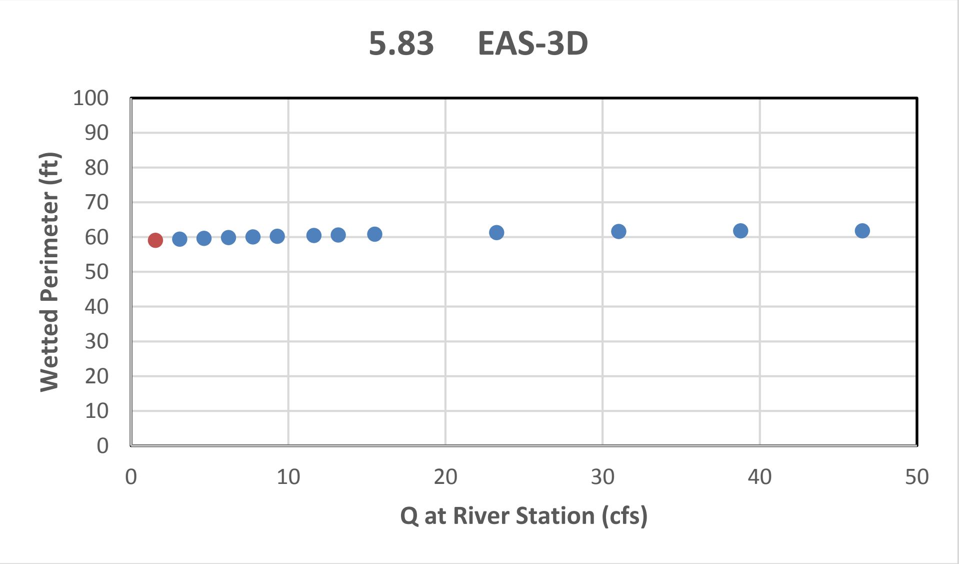

5.08 Veg-10
Wetted Perimeter (ft)
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

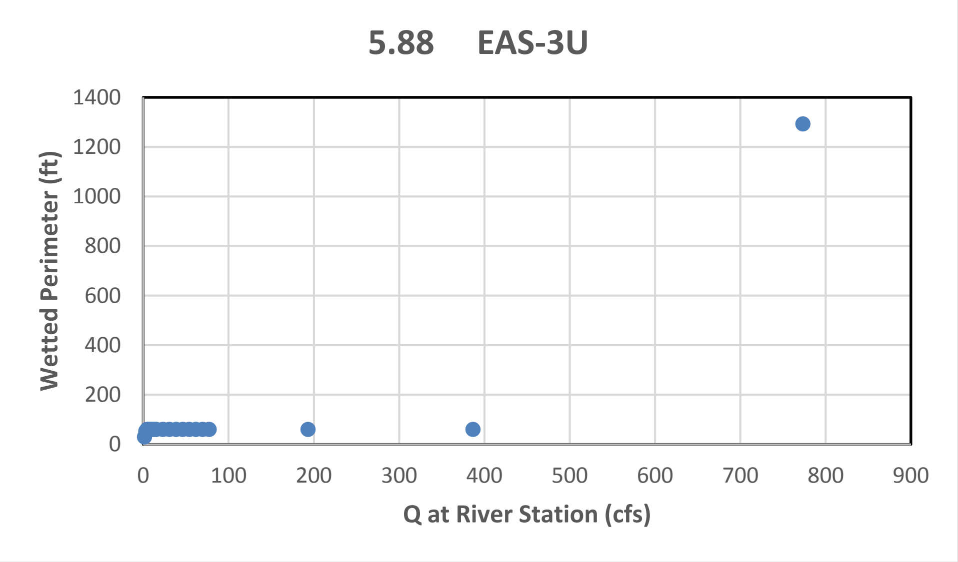

5.08 Veg-10
Wetted Perimeter (ft)
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
Q at River Station (cfs)

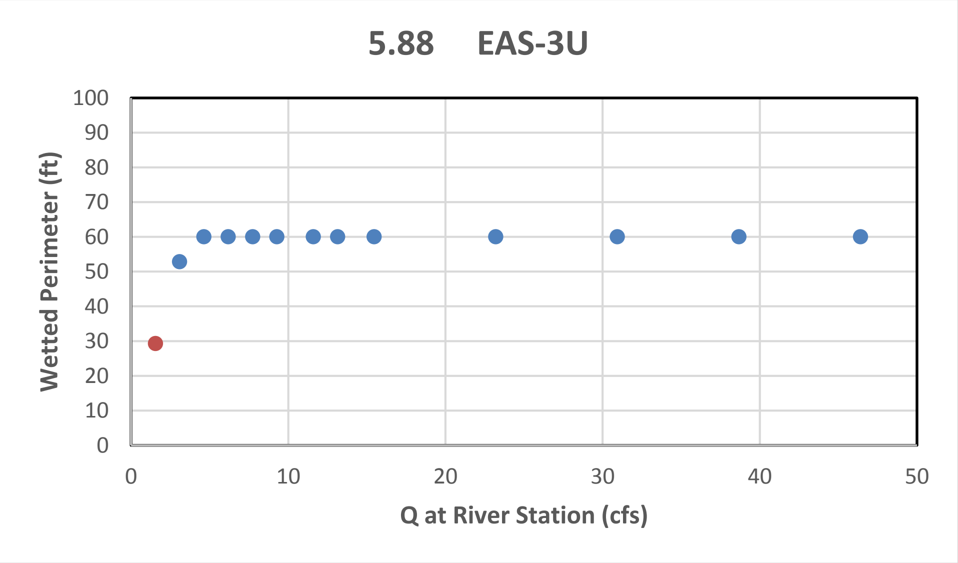

5.68 Veg-11
Wetted Perimeter (ft)
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

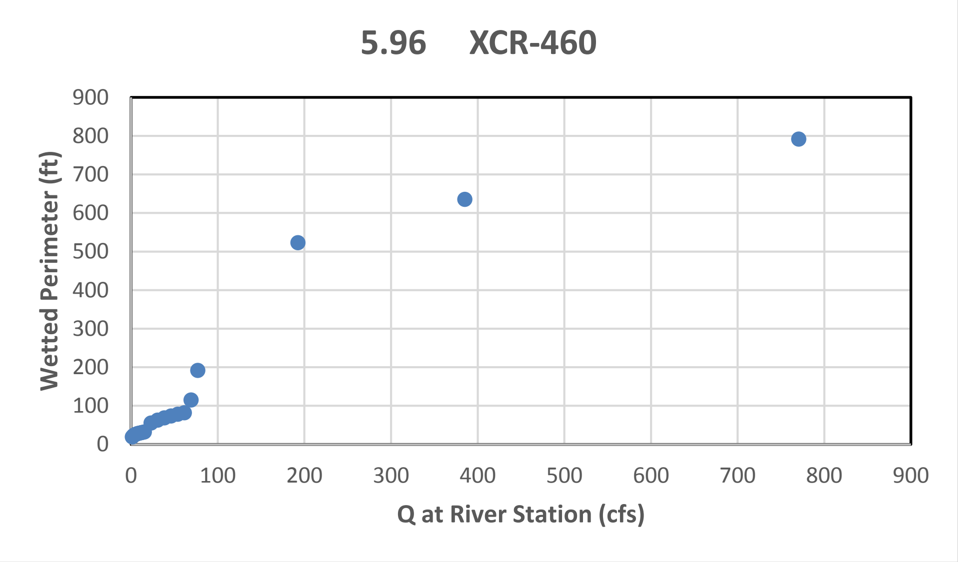

5.68 Veg-11
Wetted Perimeter (ft)
500
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
Q at River Station (cfs)

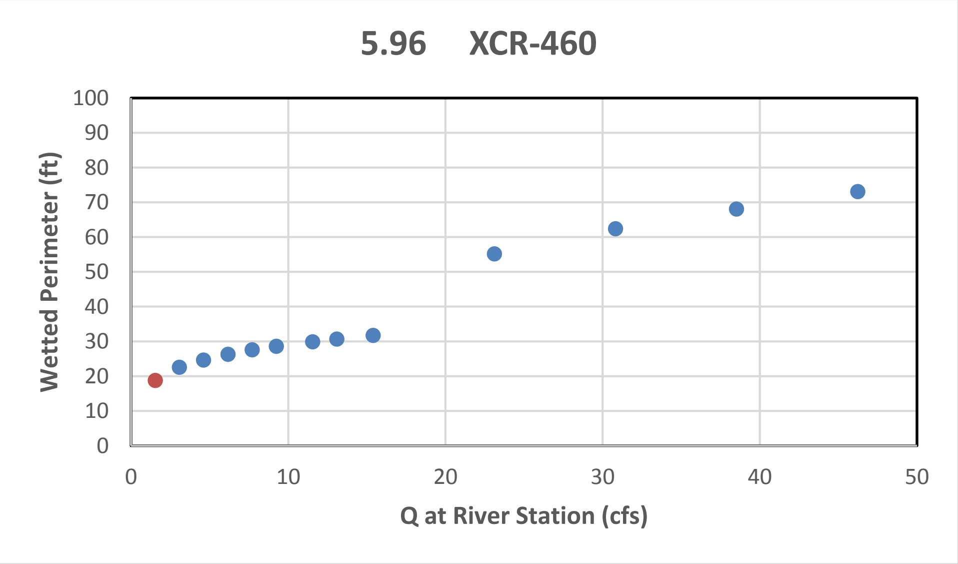

5.83 EAS-3D
Wetted Perimeter (ft)
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

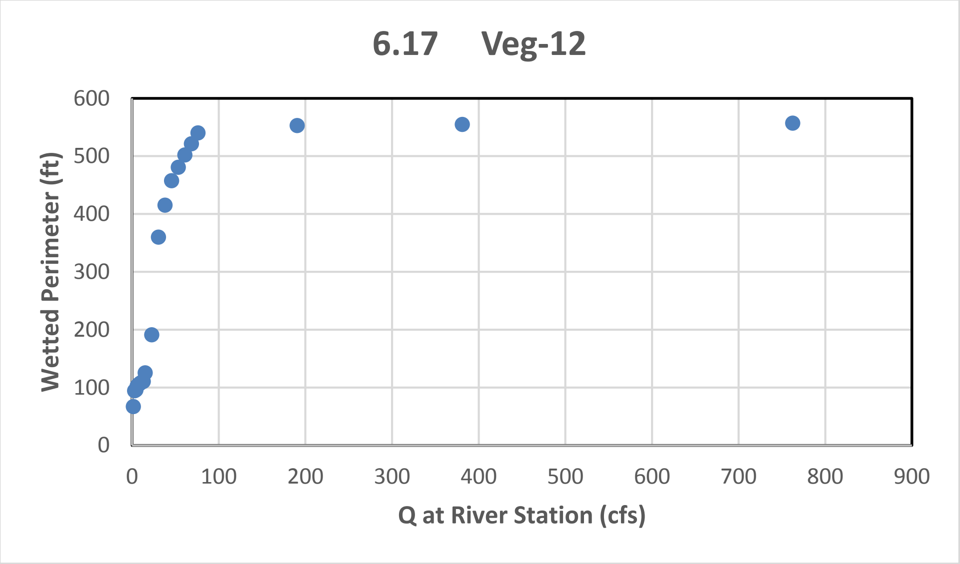

5.83 EAS-3D
Wetted Perimeter (ft)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Q at River Station (cfs)

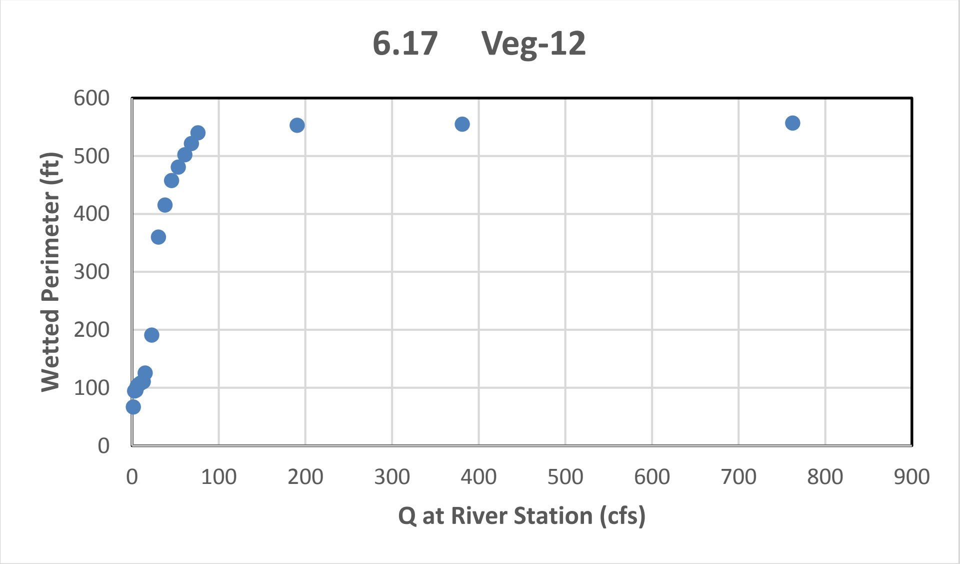

5.88 EAS-3U
Wetted Perimeter (ft)
1400
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

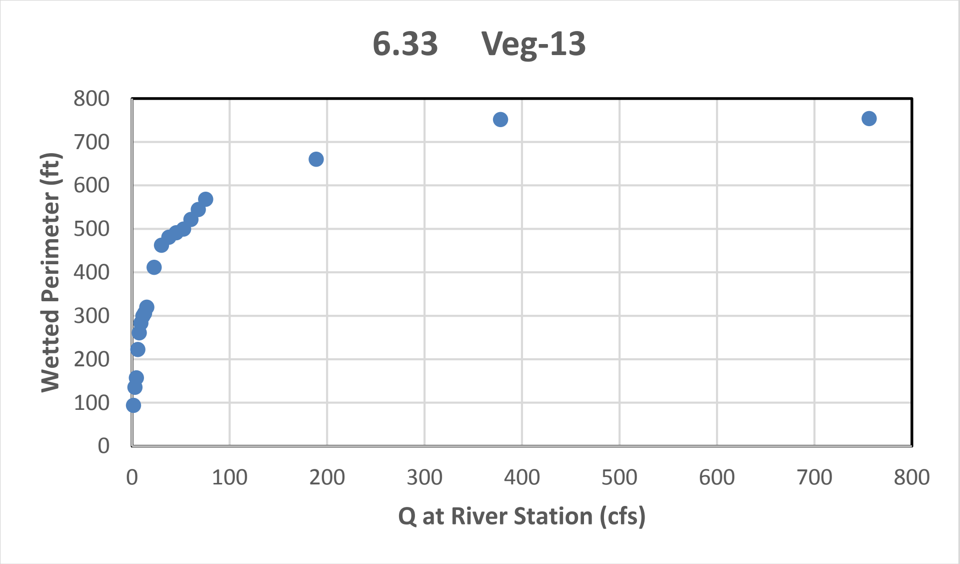

5.88 EAS-3U
Wetted Perimeter (ft)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Q at River Station (cfs)

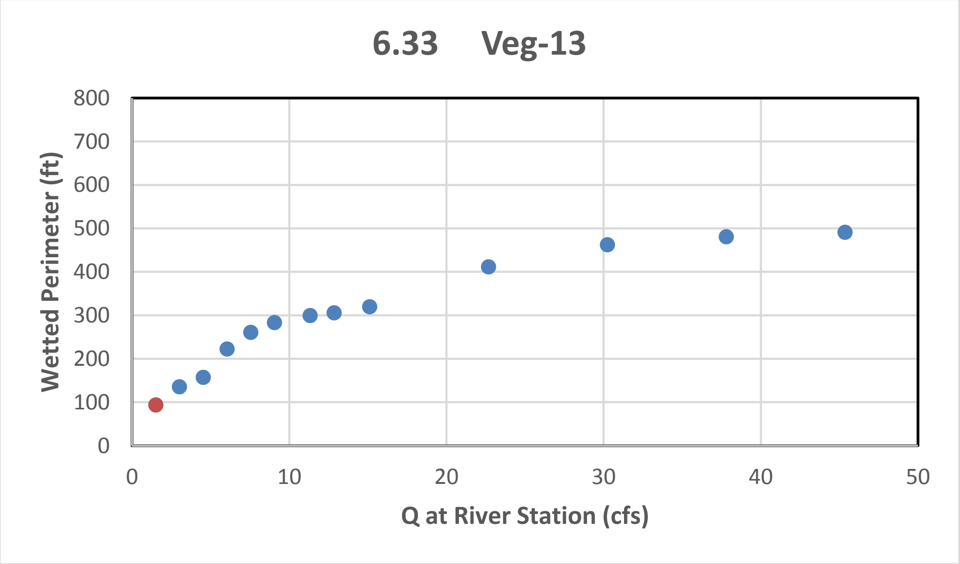

5.96 XCR-460
Wetted Perimeter (ft)
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

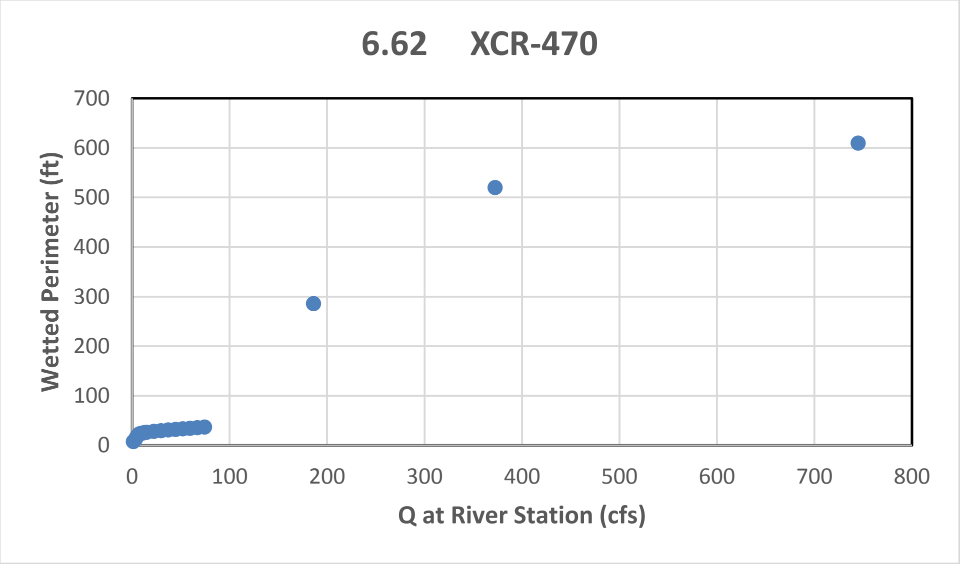

5.96 XCR-460
Wetted Perimeter (ft)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Q at River Station (cfs)

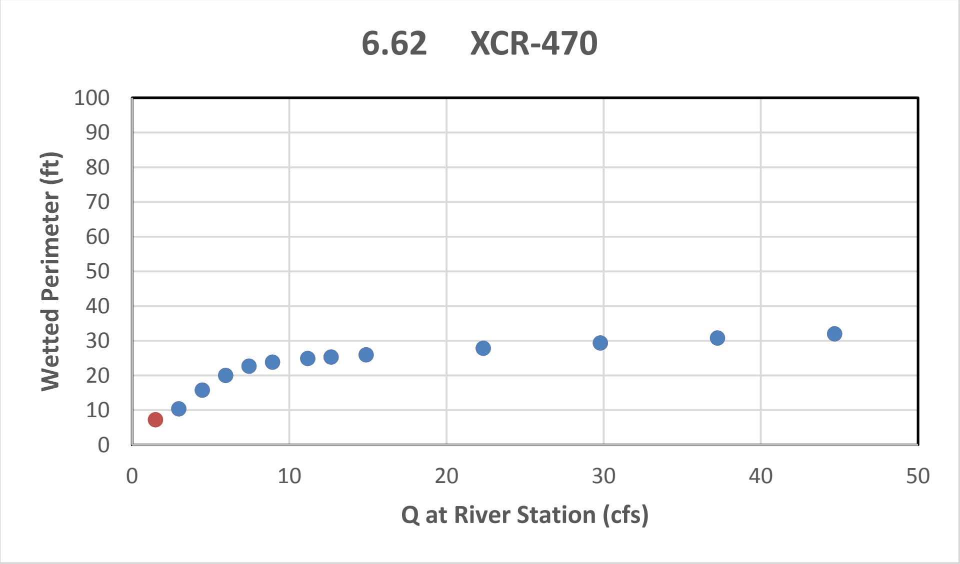

6.17 Veg-12
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

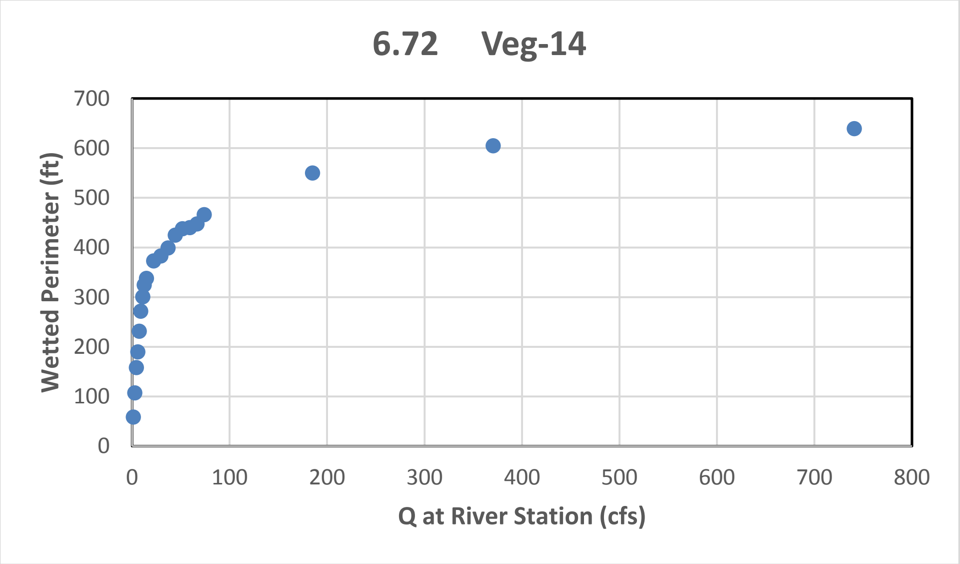

6.17 Veg-12
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
900
Q at River Station (cfs)

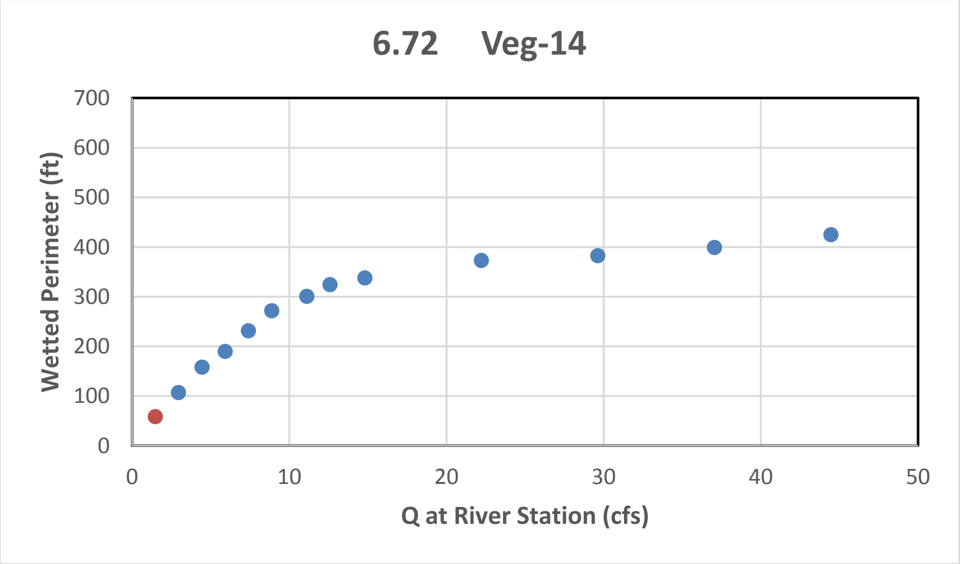

6.33 Veg-13
Wetted Perimeter (ft)
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
Q at River Station (cfs)

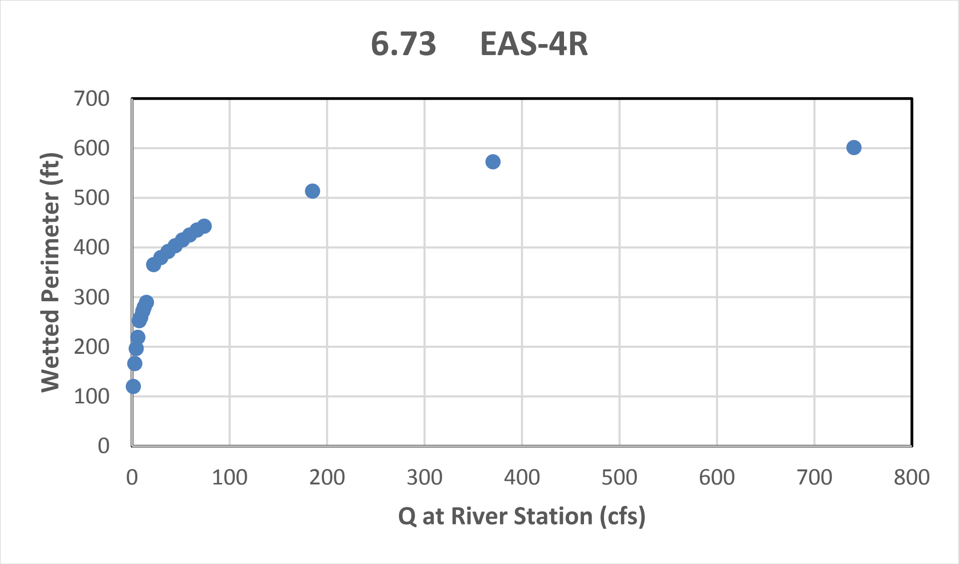

6.33 Veg-13
Wetted Perimeter (ft)
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

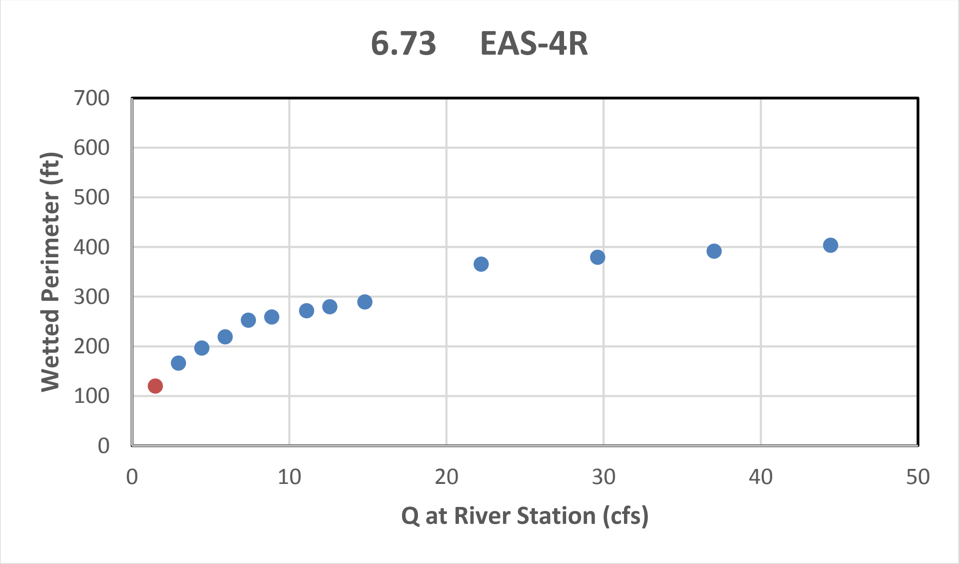

6.62 XCR-470
Wetted Perimeter (ft)
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
Q at River Station (cfs)

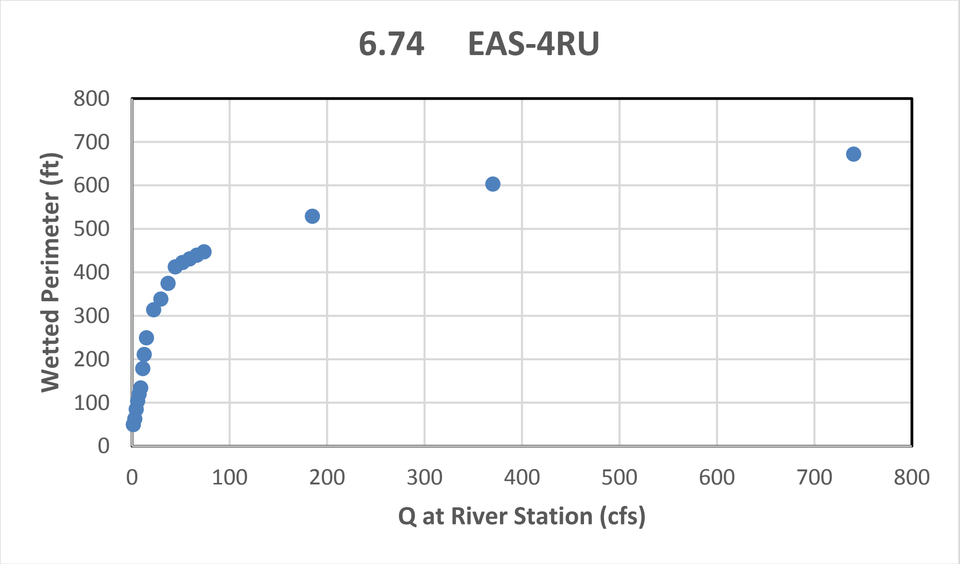

6.62 XCR-470
Wetted Perimeter (ft)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Q at River Station (cfs)

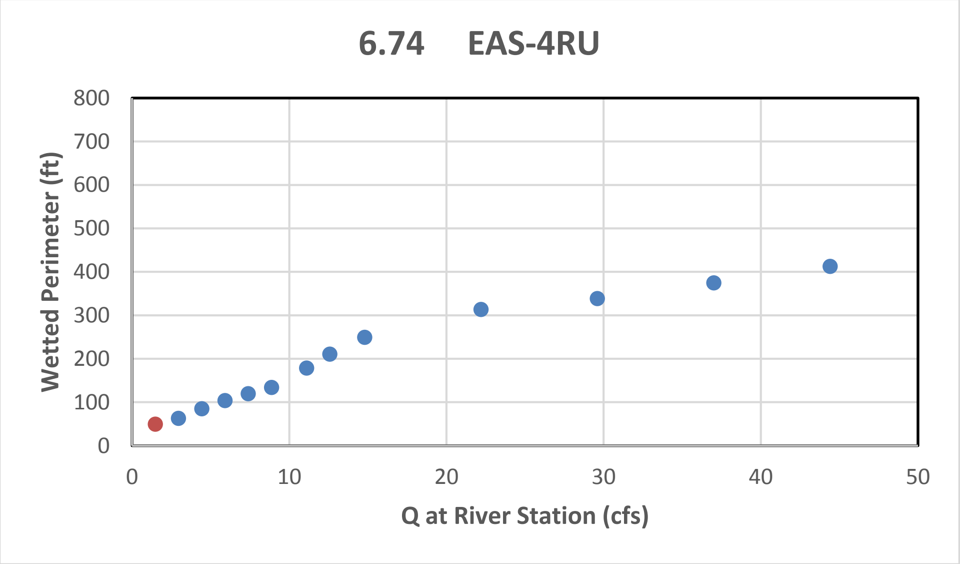

6.72 Veg-14
Wetted Perimeter (ft)
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
Q at River Station (cfs)

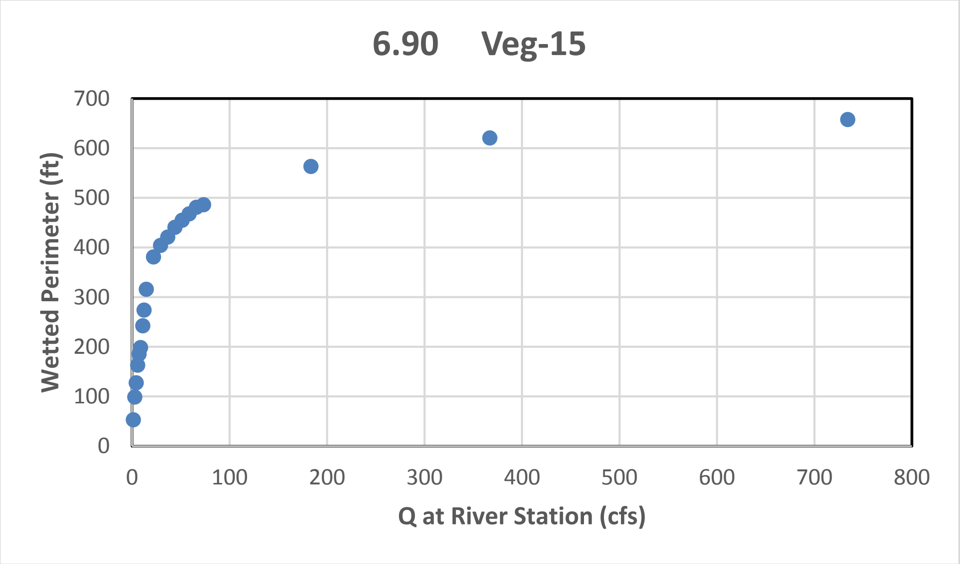

6.72 Veg-14
Wetted Perimeter (ft)
700
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

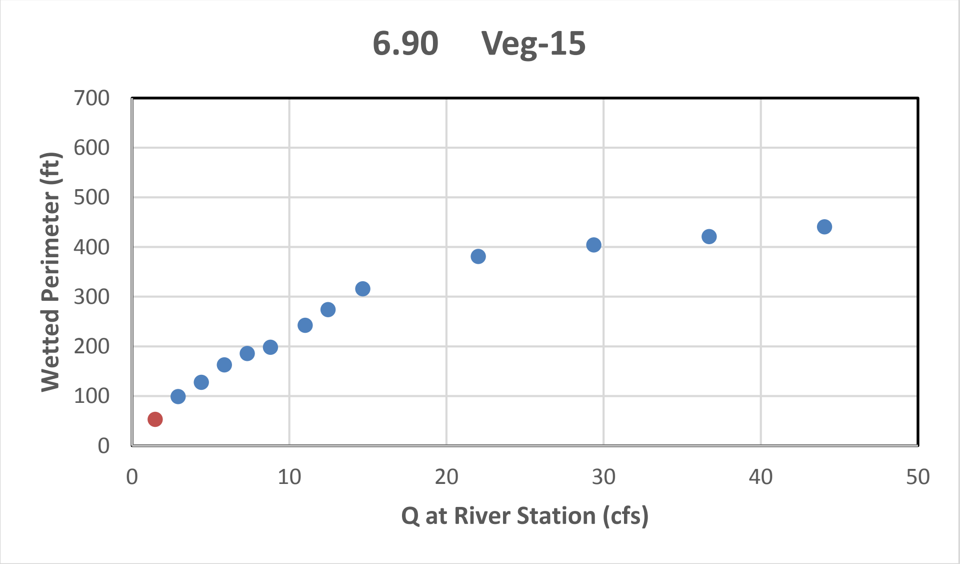

6.73 EAS-4R
Wetted Perimeter (ft)
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
Q at River Station (cfs)

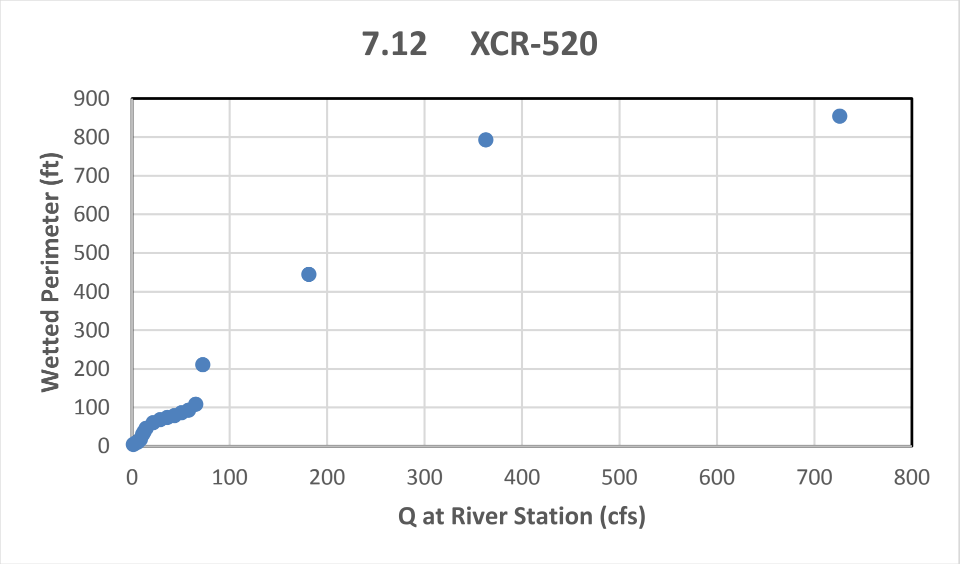

6.73 EAS-4R
Wetted Perimeter (ft)
700
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

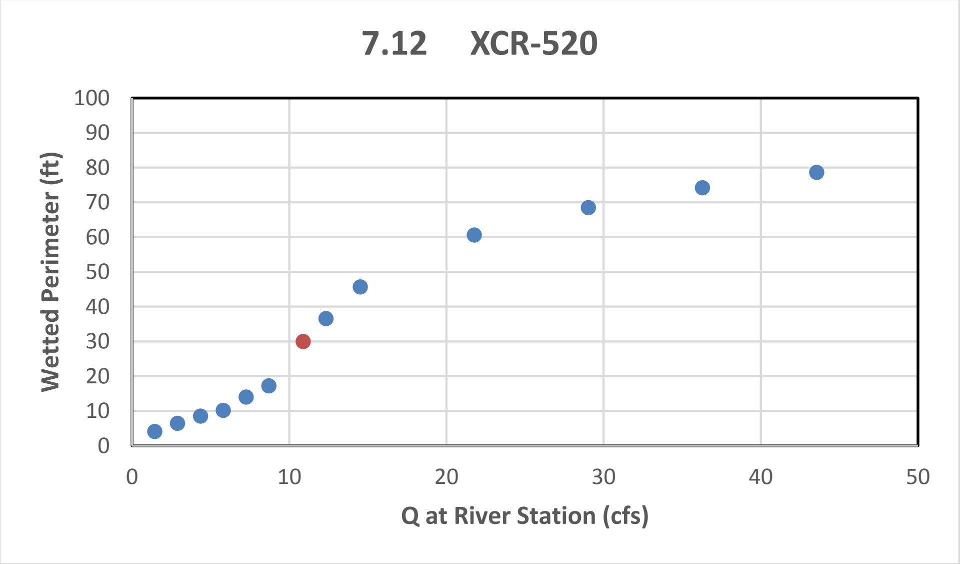

6.74 EAS-4RU
Wetted Perimeter (ft)
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
Q at River Station (cfs)

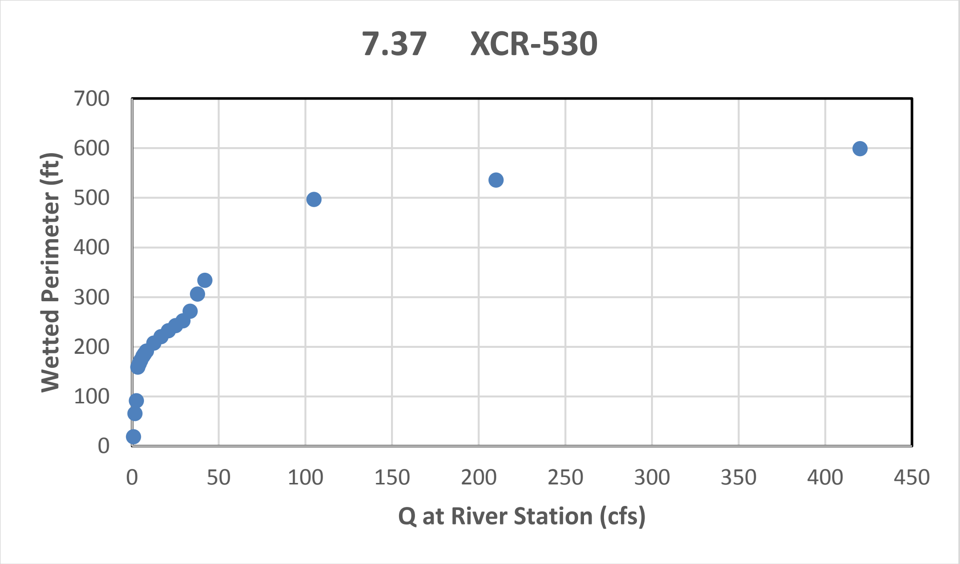

6.74 EAS-4RU
Wetted Perimeter (ft)
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

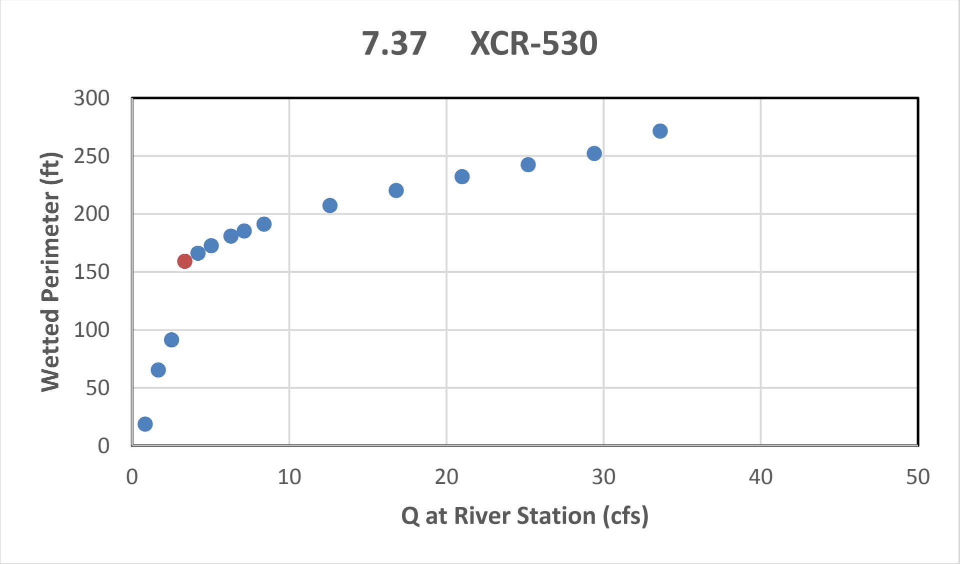

6.90 Veg-15
Wetted Perimeter (ft)
0
100
200
300
400
500
600
700
Q at River Station (cfs)
0
100
200
300
400
500
600
700
800

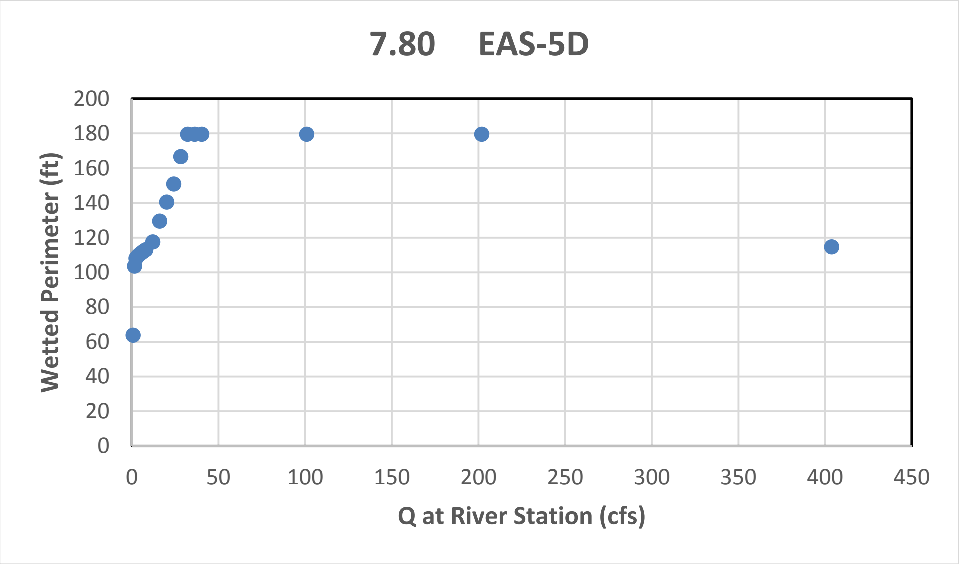

6.90 Veg-15
Wetted Perimeter (ft)
0
100
200
300
400
500
600
700
Q at River Station (cfs)
0
10
20
30
40
50

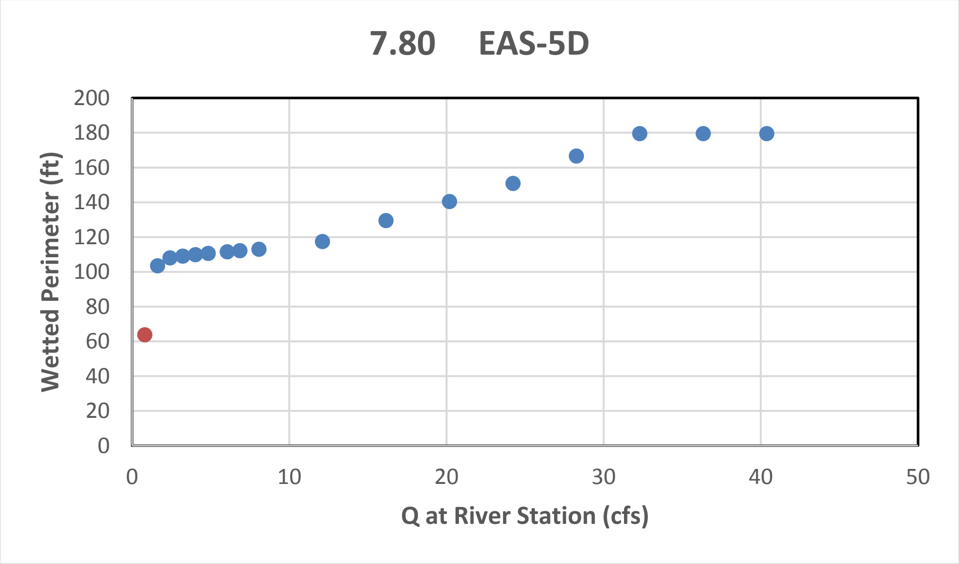

7.12 XCR-520
Wetted Perimeter (ft)
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
Q at River Station (cfs)

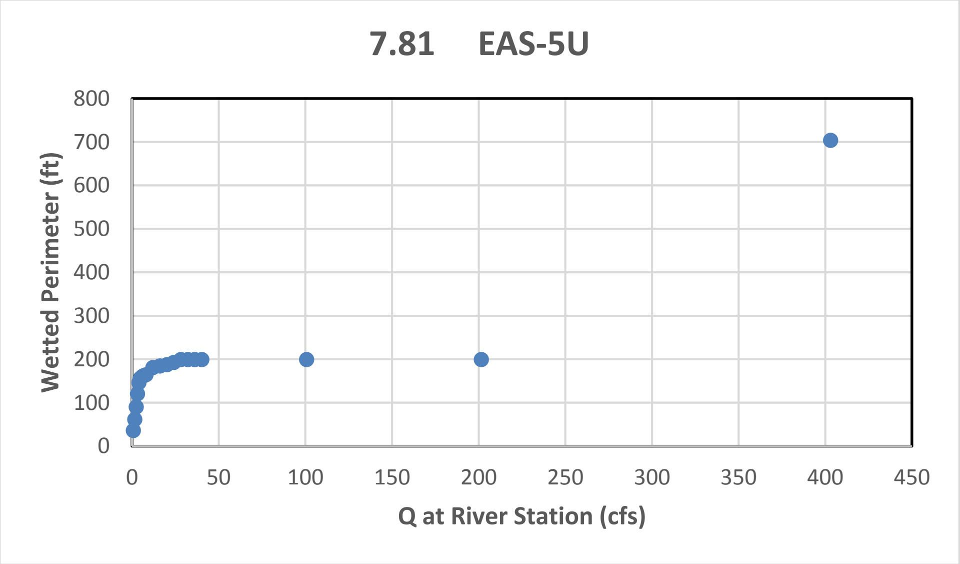

7.12 XCR-520
Wetted Perimeter (ft)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Q at River Station (cfs)

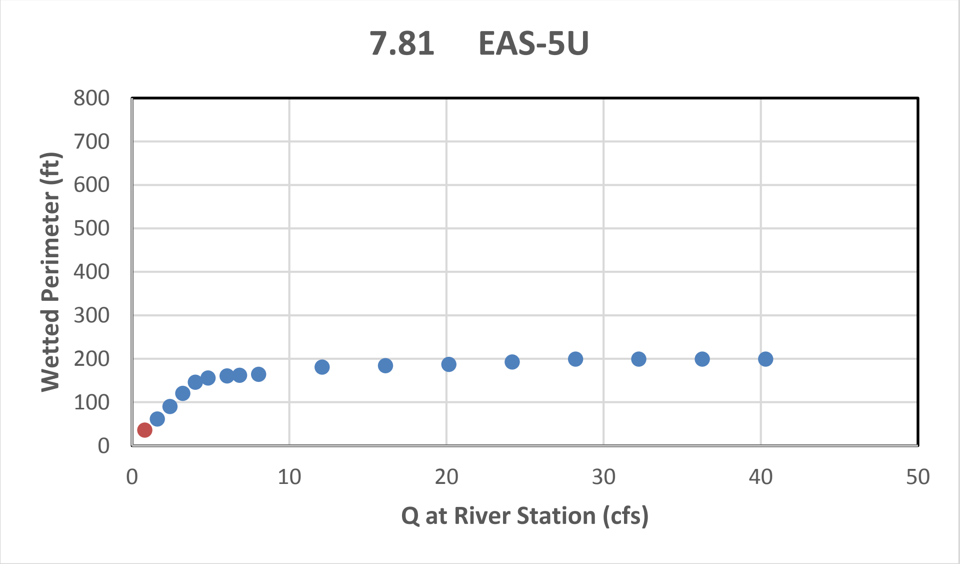

7.37 XCR-530
Wetted Perimeter (ft)
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
450
Q at River Station (cfs)

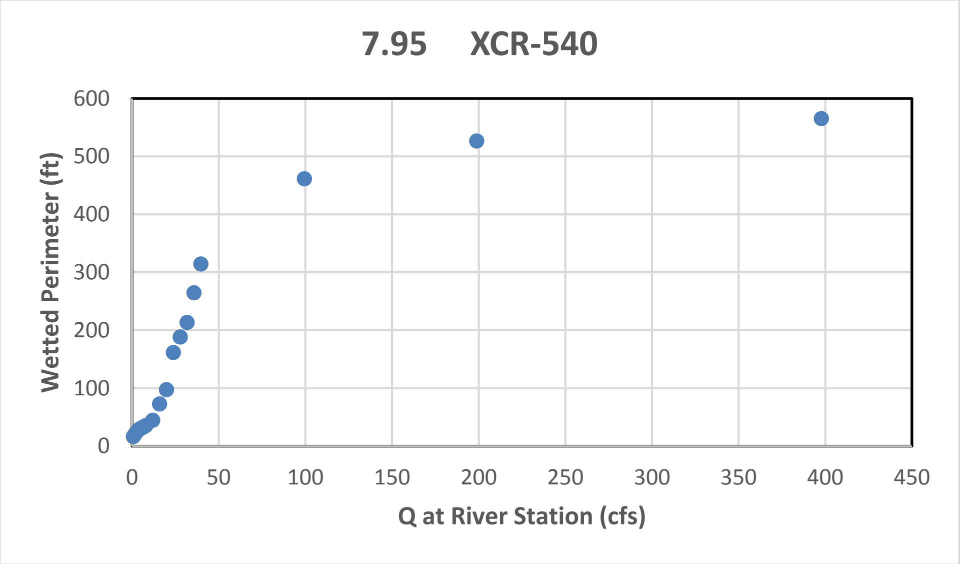

7.37 XCR-530
Wetted Perimeter (ft)
300
250
200
150
100
50
0
0
10
20
30
40
50
Q at River Station (cfs)

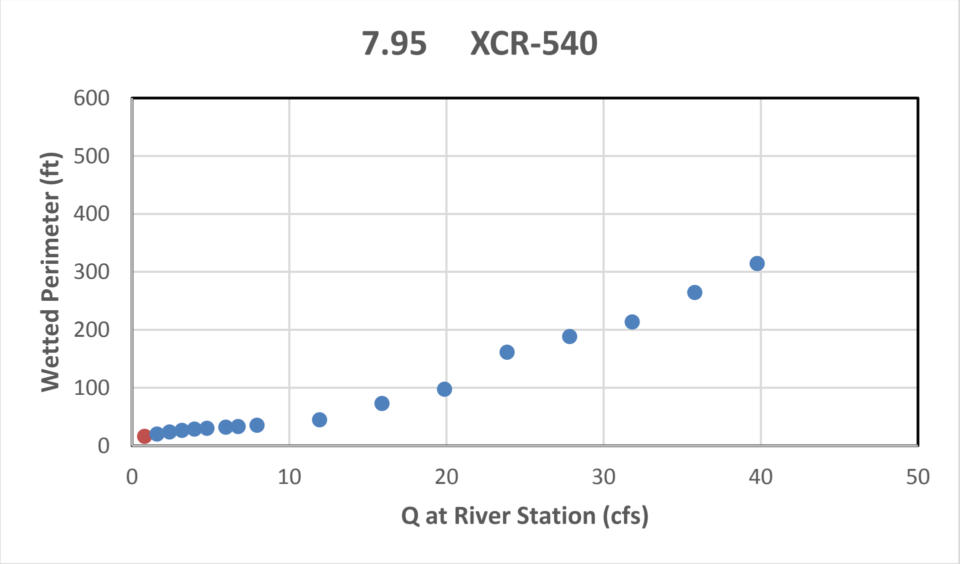

7.80 EAS-5D
Wetted Perimeter (ft)
200
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
400
450
Q at River Station (cfs)

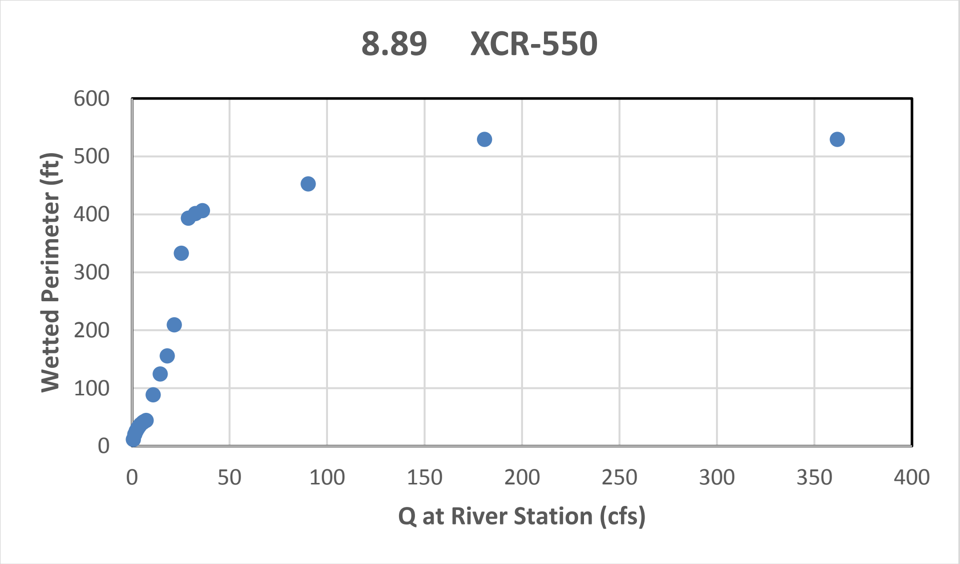

7.80 EAS-5D
Wetted Perimeter (ft)
200
180
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
Q at River Station (cfs)

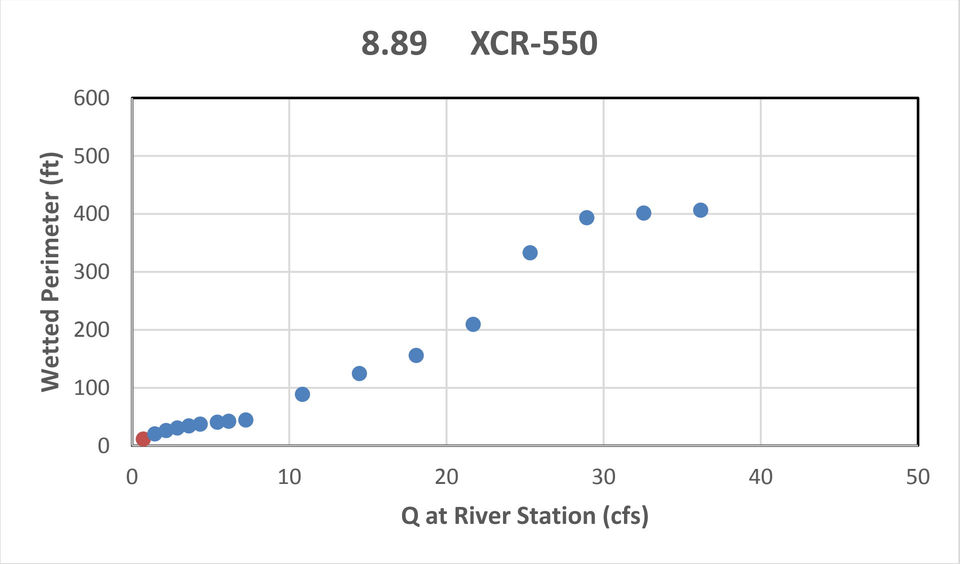

7.81 EAS-5U
Wetted Perimeter (ft)
800
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
450
Q at River Station (cfs)

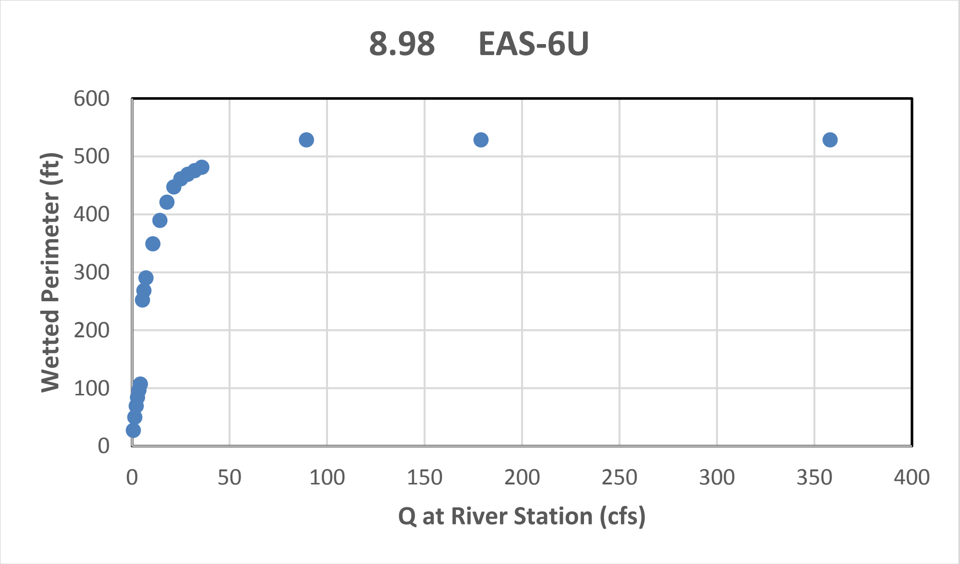

7.81 EAS-5U
Wetted Perimeter (ft)
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

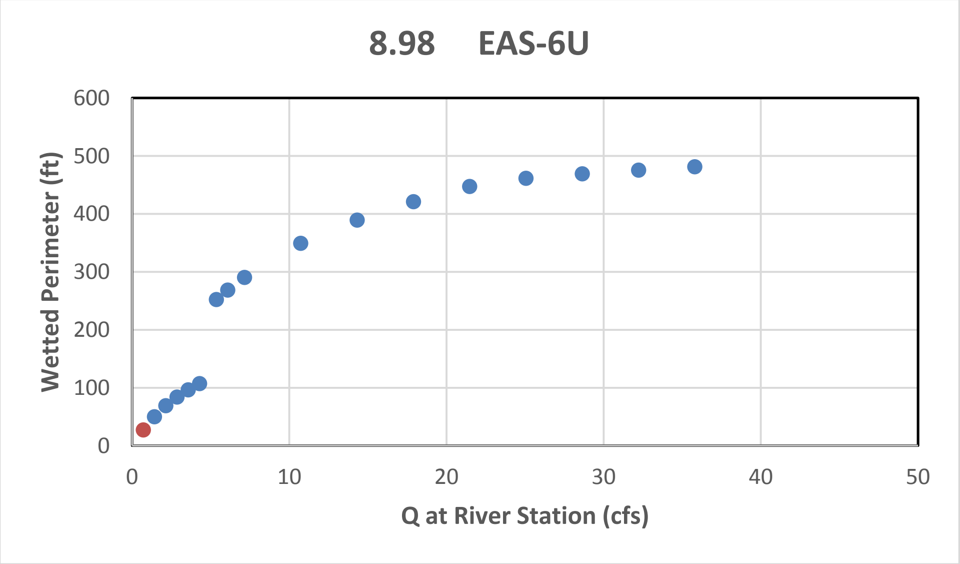

7.95 XCR-540
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
450
Q at River Station (cfs)

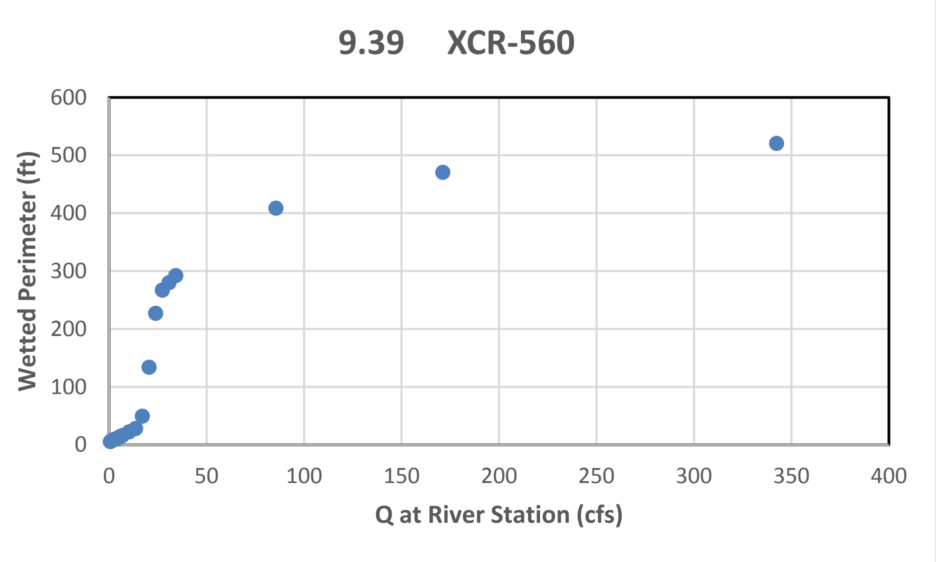

7.95 XCR-540
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

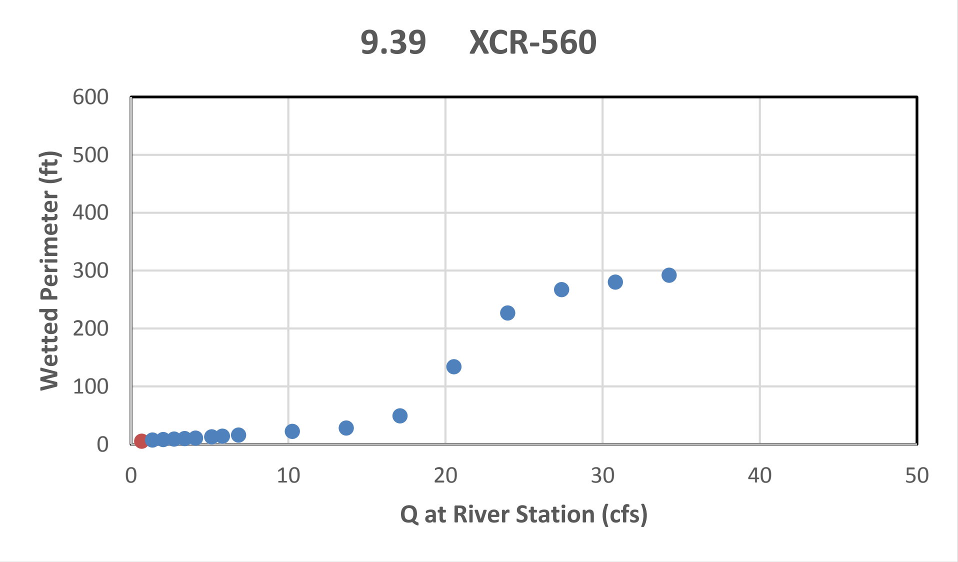

8.89 XCR-550
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
Q at River Station (cfs)

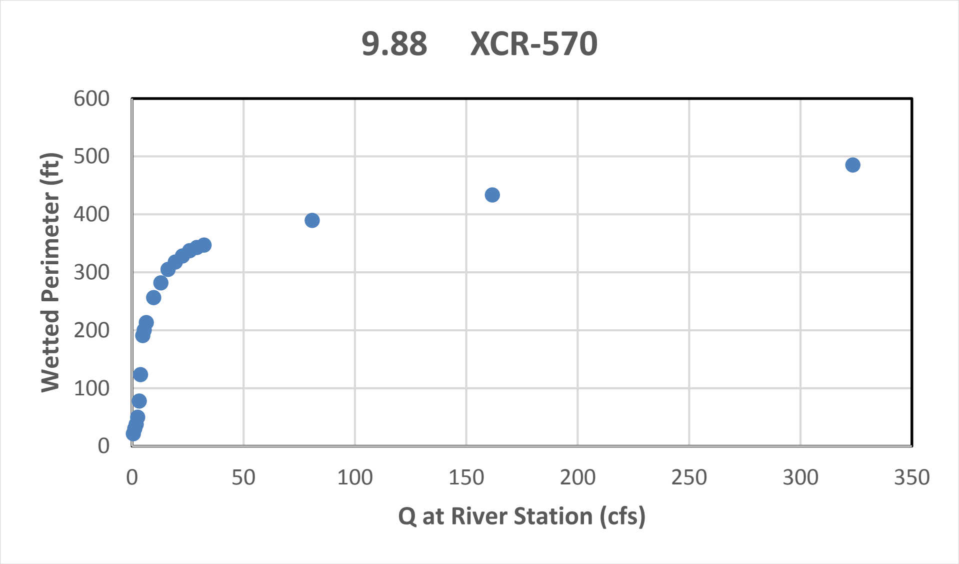

8.89 XCR-550
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

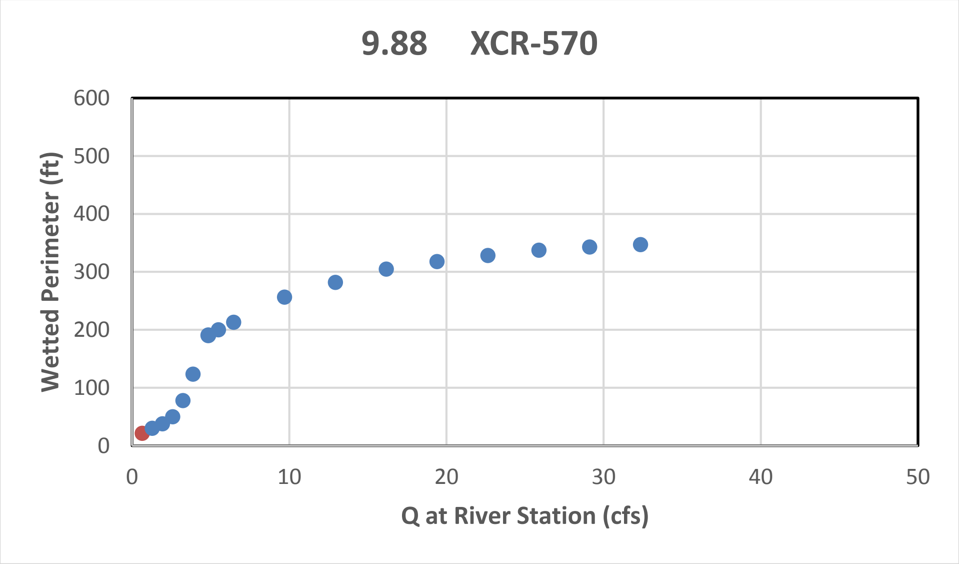

8.98 EAS-6U
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
Q at River Station (cfs)

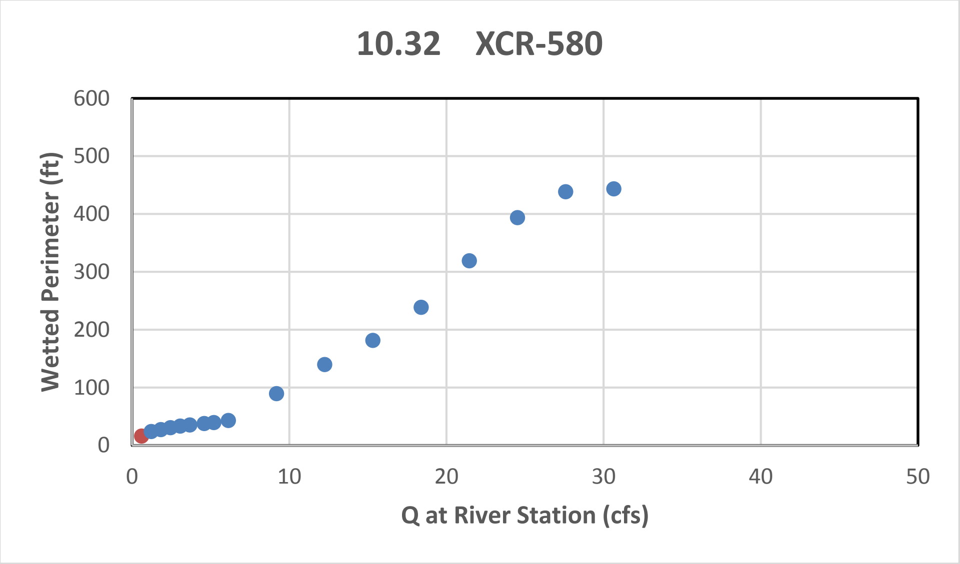

8.98 EAS-6U
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

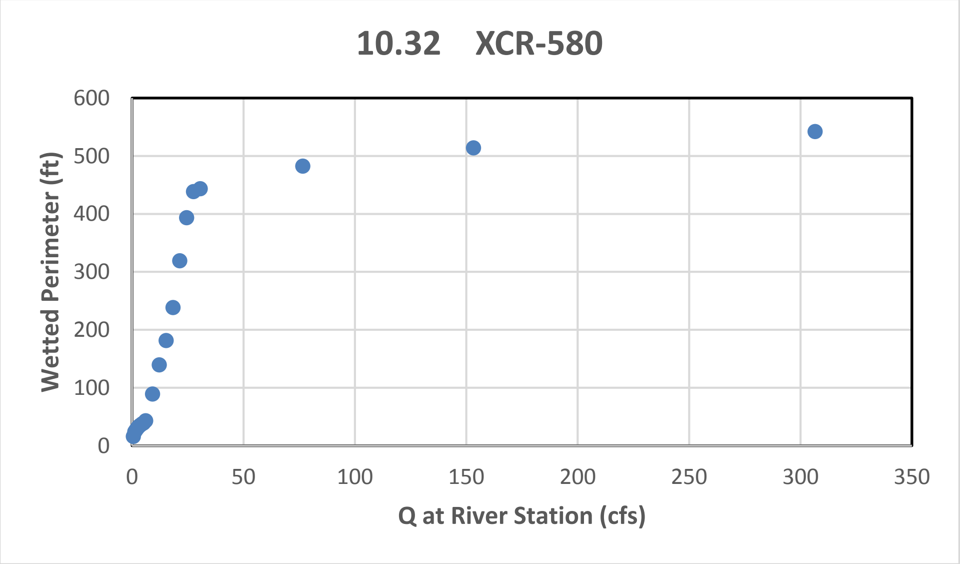

9.39 XCR-560
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
Q at River Station (cfs)

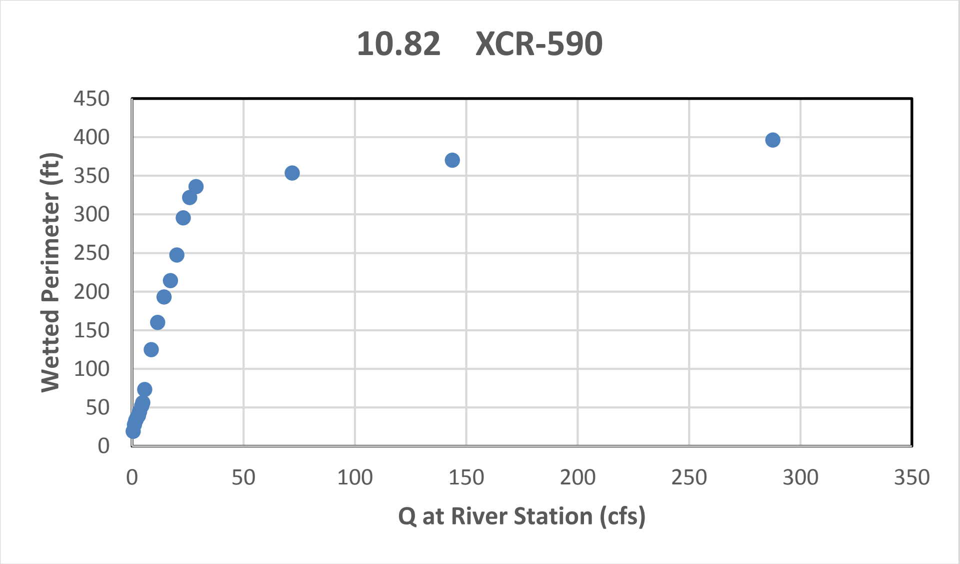

9.39 XCR-560
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

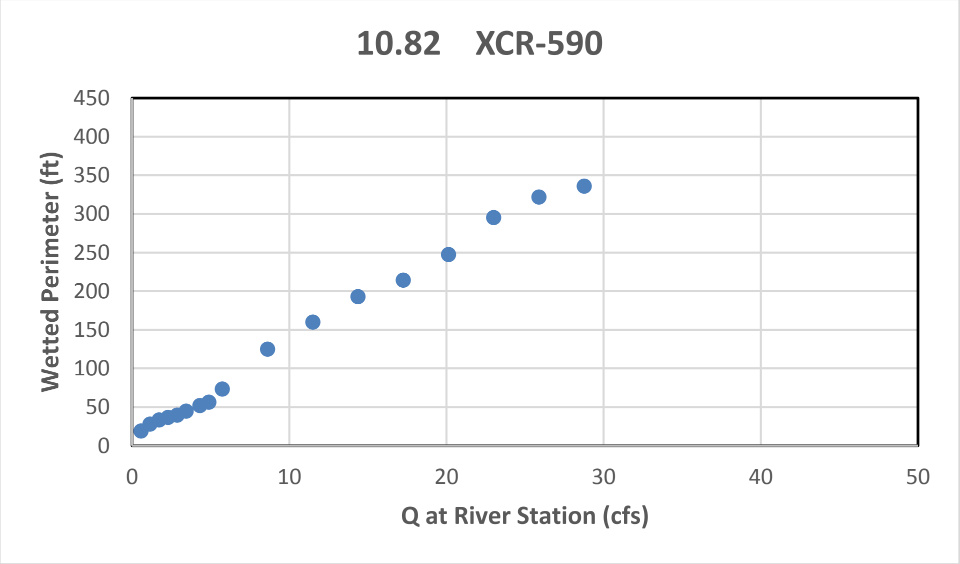

9.88 XCR-570
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
Q at River Station (cfs)

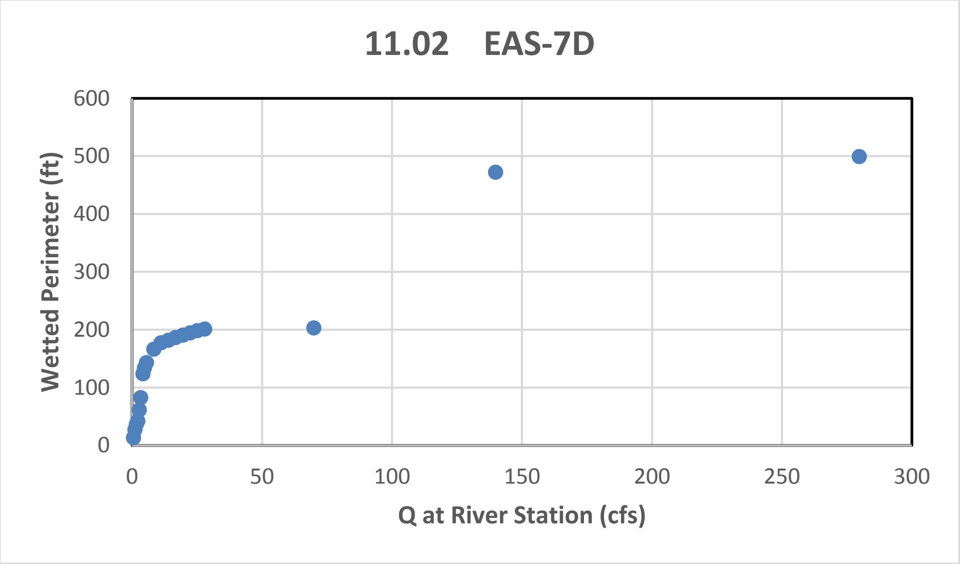

9.88 XCR-570
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

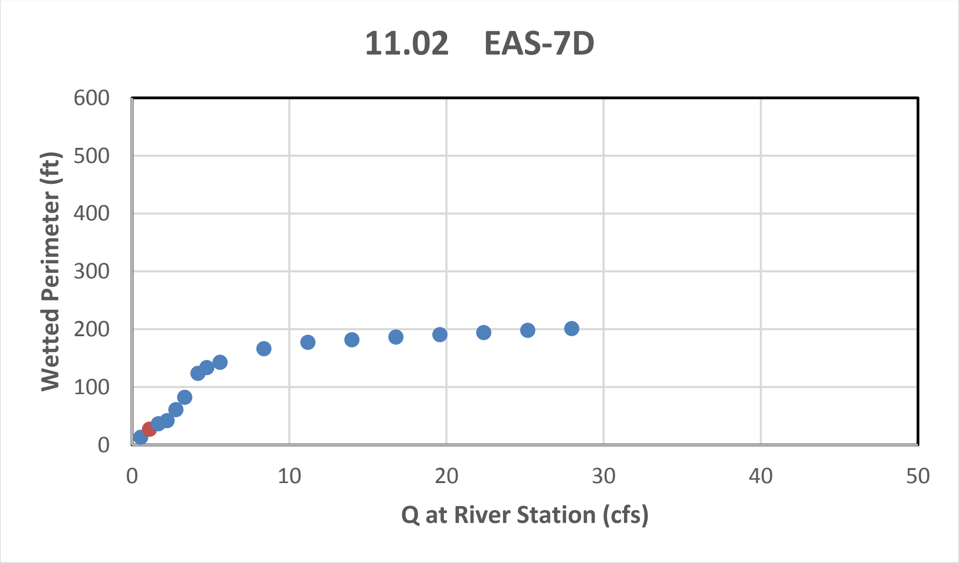

10.32 XCR-580
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)

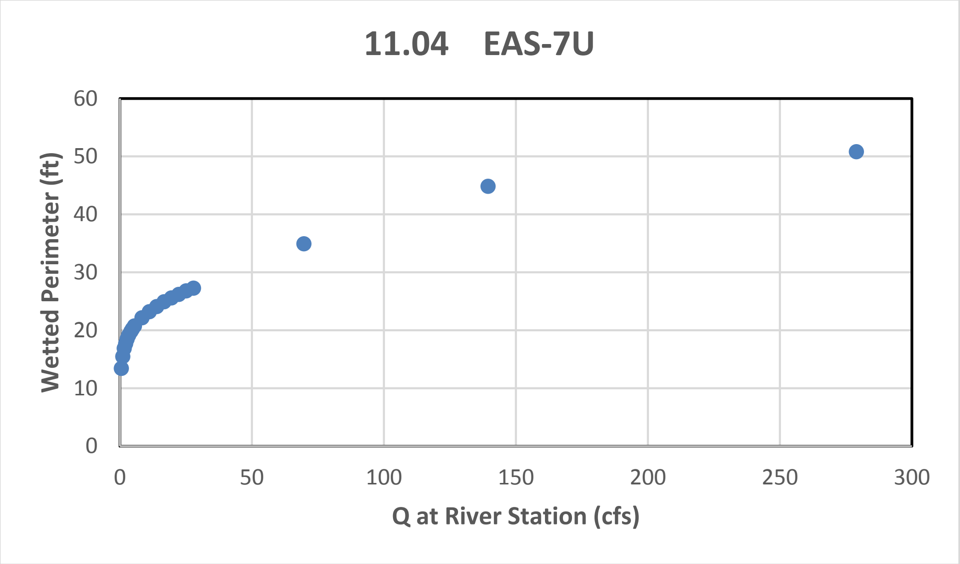

10.32 XCR-580
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
Q at River Station (cfs)

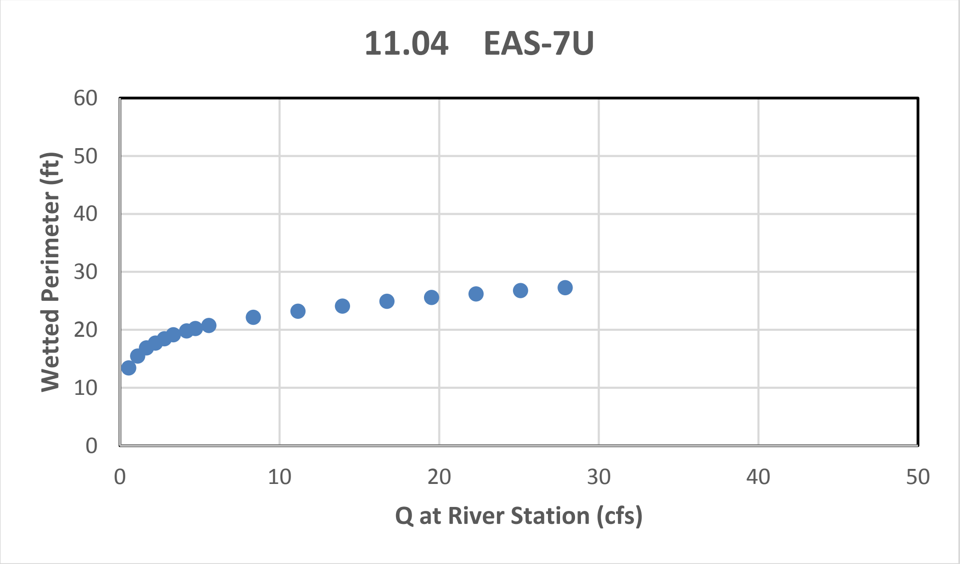

10.82 XCR-590
Wetted Perimeter (ft)
450
400
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
Q at River Station (cfs)


10.82 XCR-590
Wetted Perimeter (ft)
450
400
350
300
250
200
150
100
50
0
0
10
20
30
40
50
Q at River Station (cfs)


11.02 EAS-7D
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
50
100
150
200
250
300
Q at River Station (cfs)


11.02 EAS-7D
Wetted Perimeter (ft)
600
500
400
300
200
100
0
0
10
20
30
40
50
Q at River Station (cfs)


11.04 EAS-7U
Wetted Perimeter (ft)
0
10
20
30
40
50
60
0
50
100
150
200
250
300
Q at River Station (cfs)

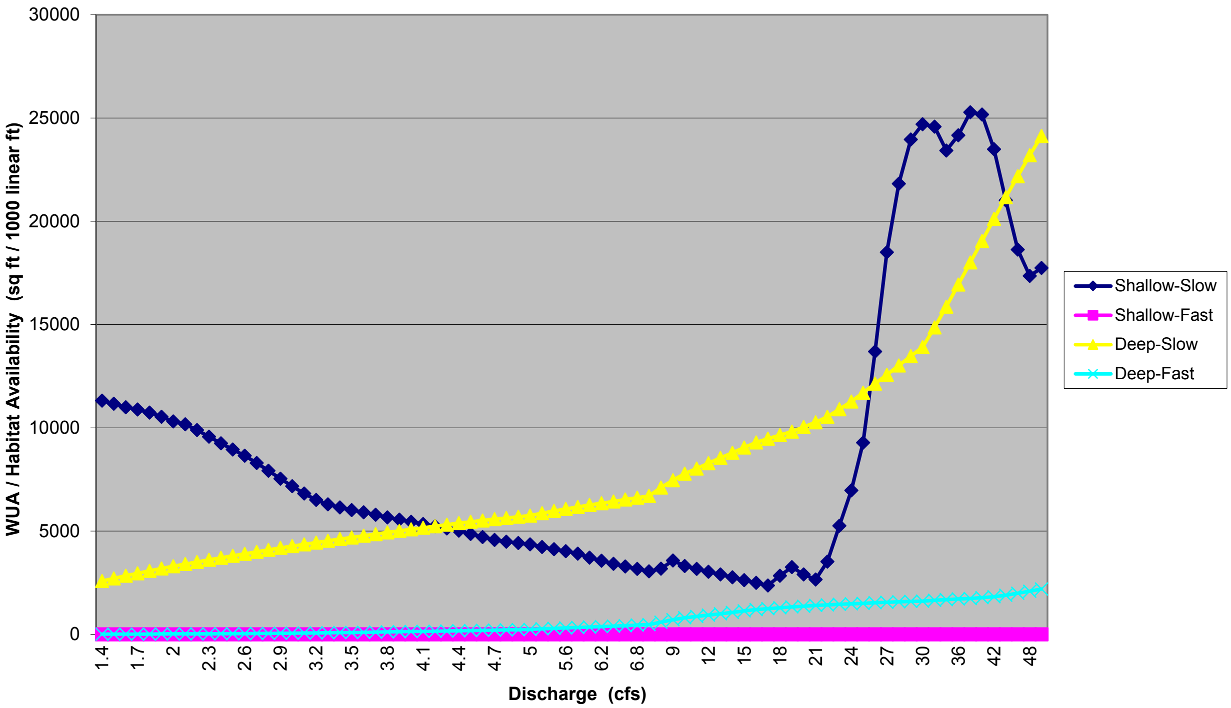

11.04 EAS-7U
Wetted Perimeter (ft)
0
10
20
30
40
50
60
0
10
20
30
40
50
Q at River Station (cfs)

APPENDIX 5B

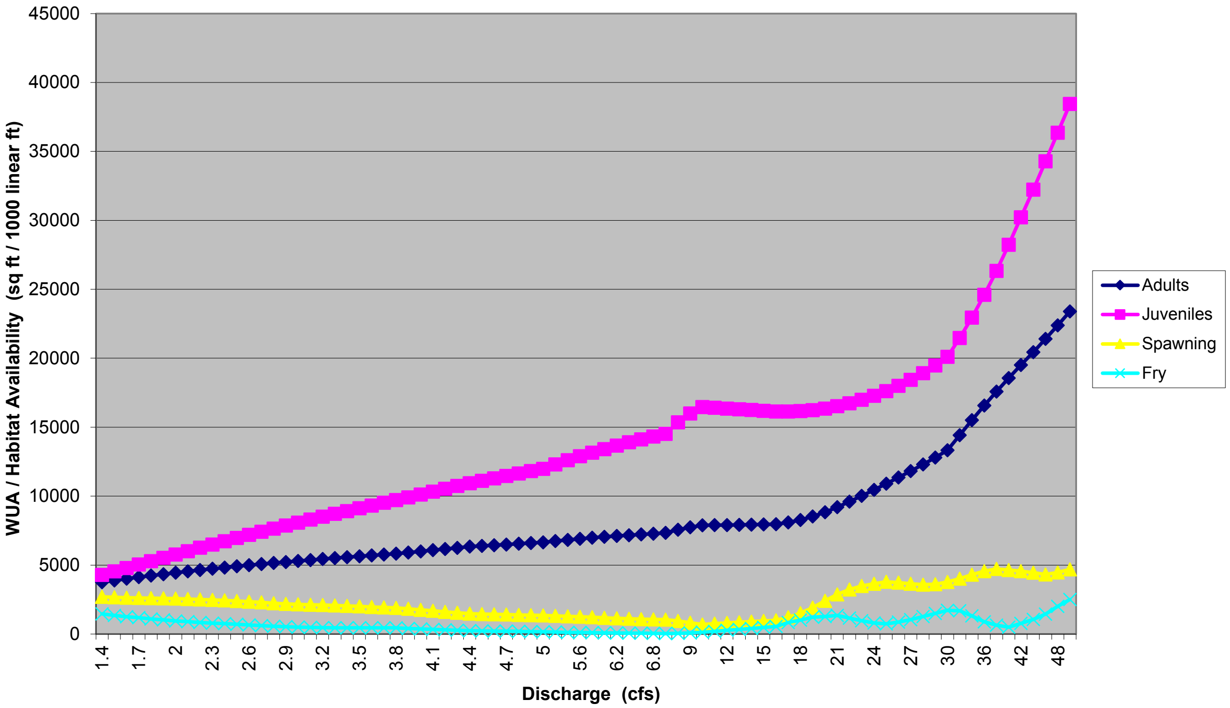
PHABSIM Results

Plots of weighted usable area as a function of discharge and habitat gain/loss by month as a function of baseline flow reductions are provided by for three sites. Site Veg 2 is identified as PHABSIM CTE 1, Site Veg 4 is identified as PHABSIM CTE 2, and Site Veg 14 is identified as PHABSIM CTE 3 in the body of the report.

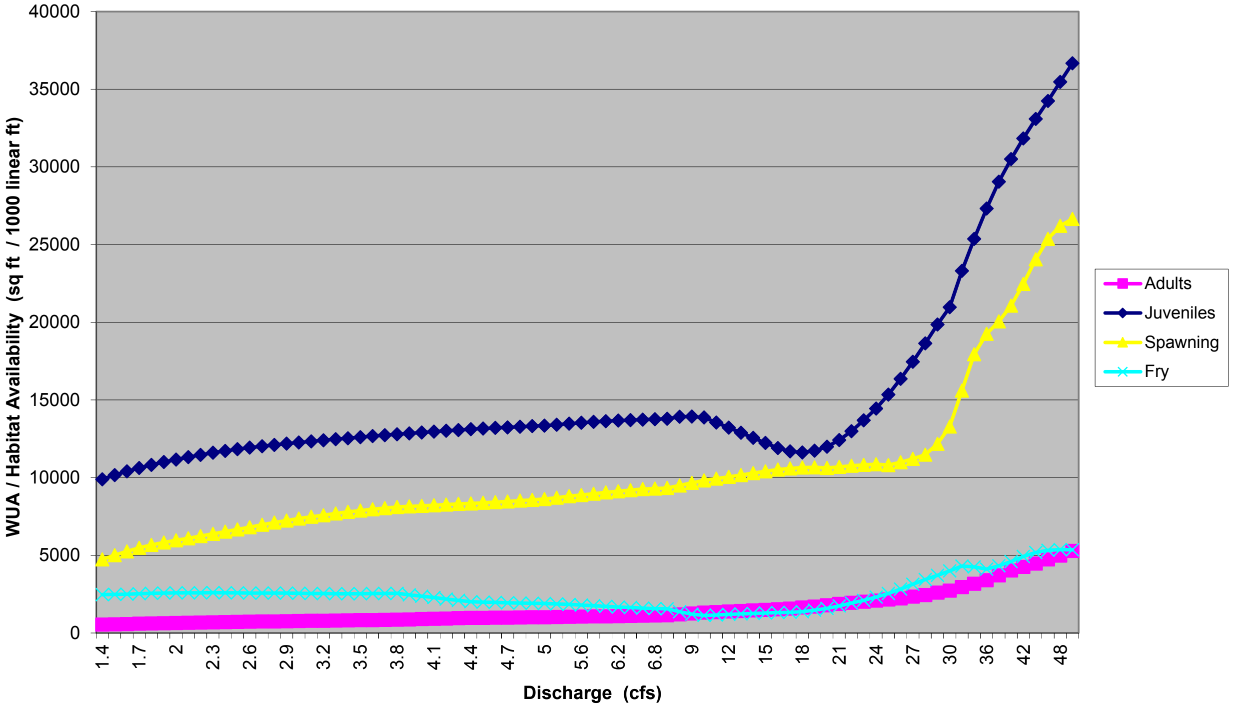
Pithlachasscotee River - Veg2
Fish Habitat Guilds



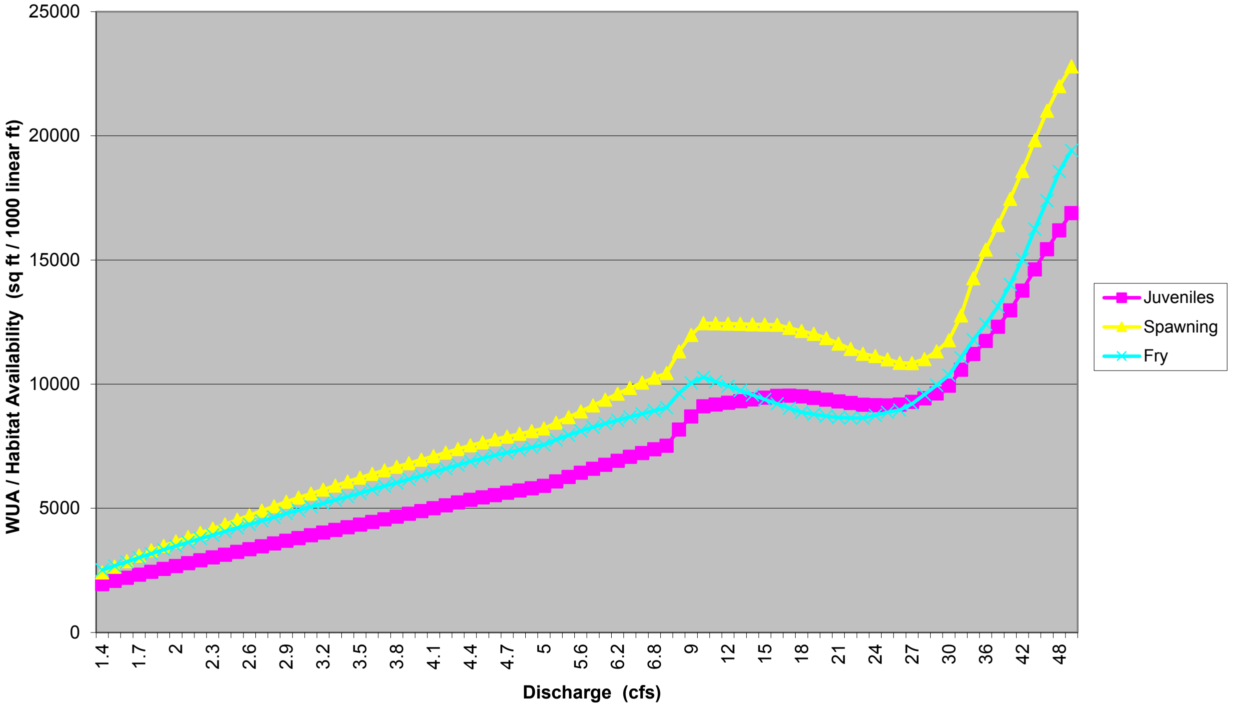
Pithlachasscotee River - Veg2
Largemouth Bass



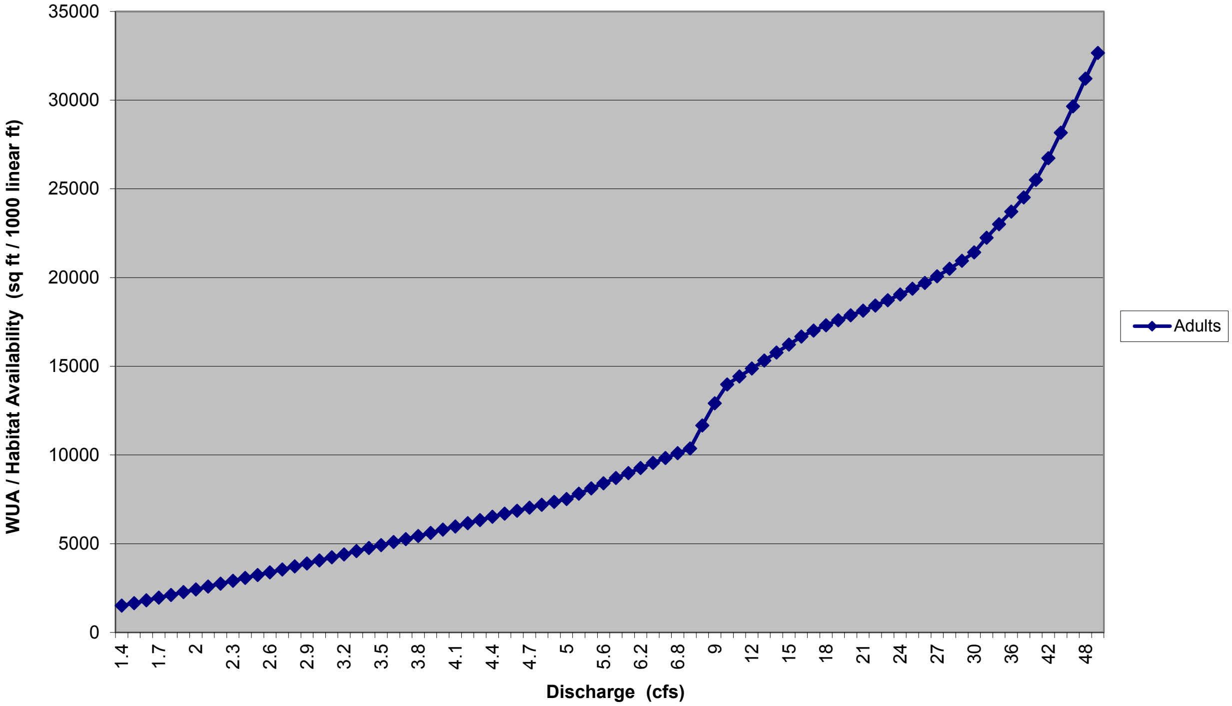
Pithlachasscotee River - Veg2
Bluegill Sunfish



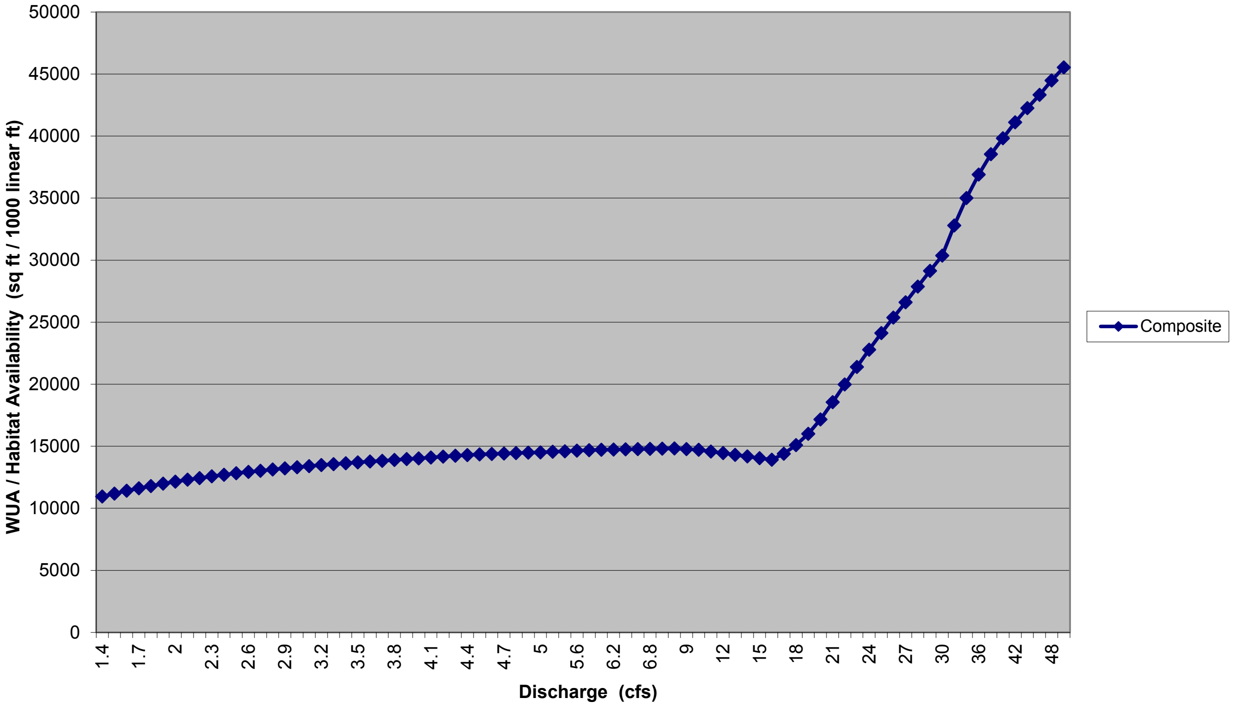
Pithlachasscotee River - Veg2
Spotted Sunfish

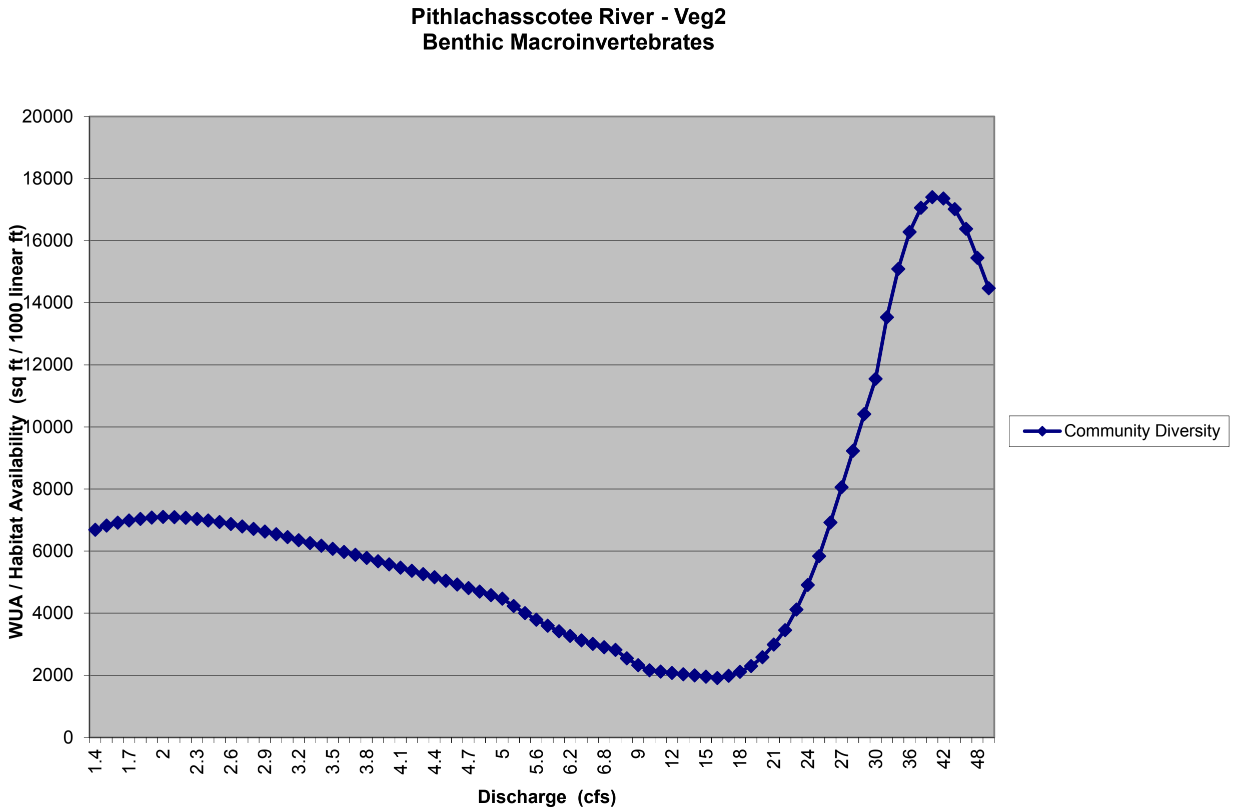


Pithlachasscotee River - Veg2
Spotted Sunfish

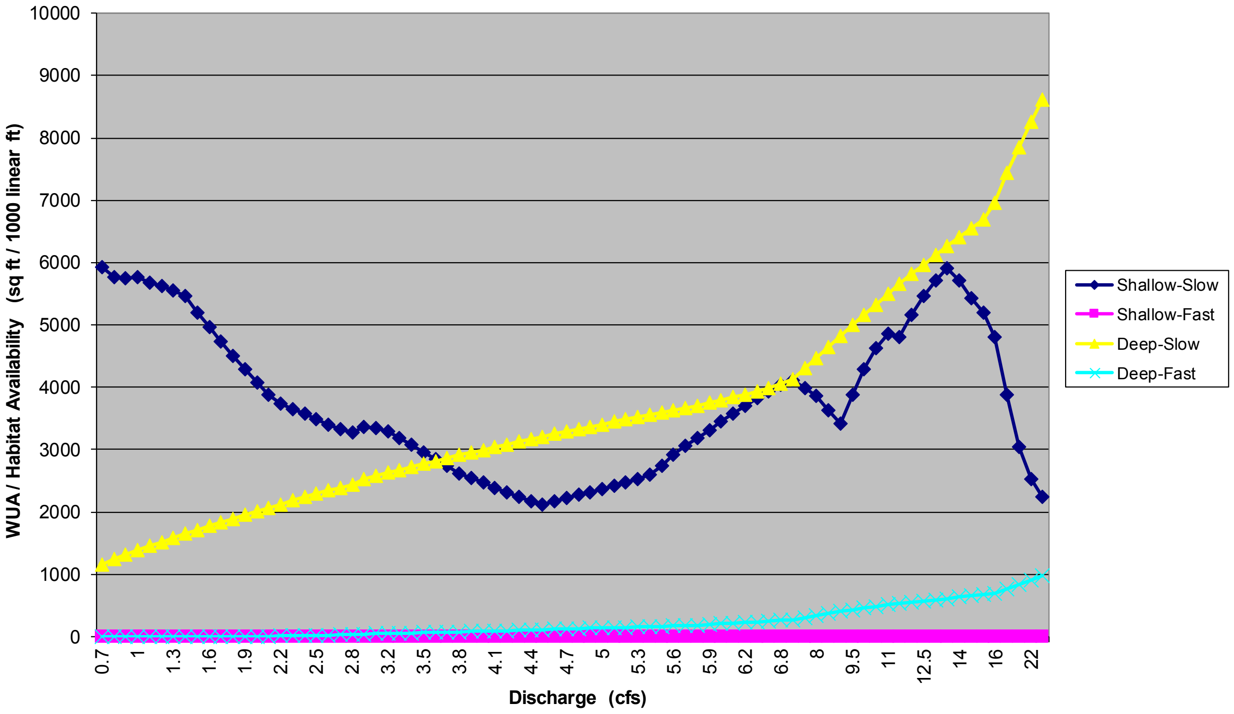


Pithlachasscotee River - Veg2
Cyprinidae - Minnows, Chubs, Dace, Shiners

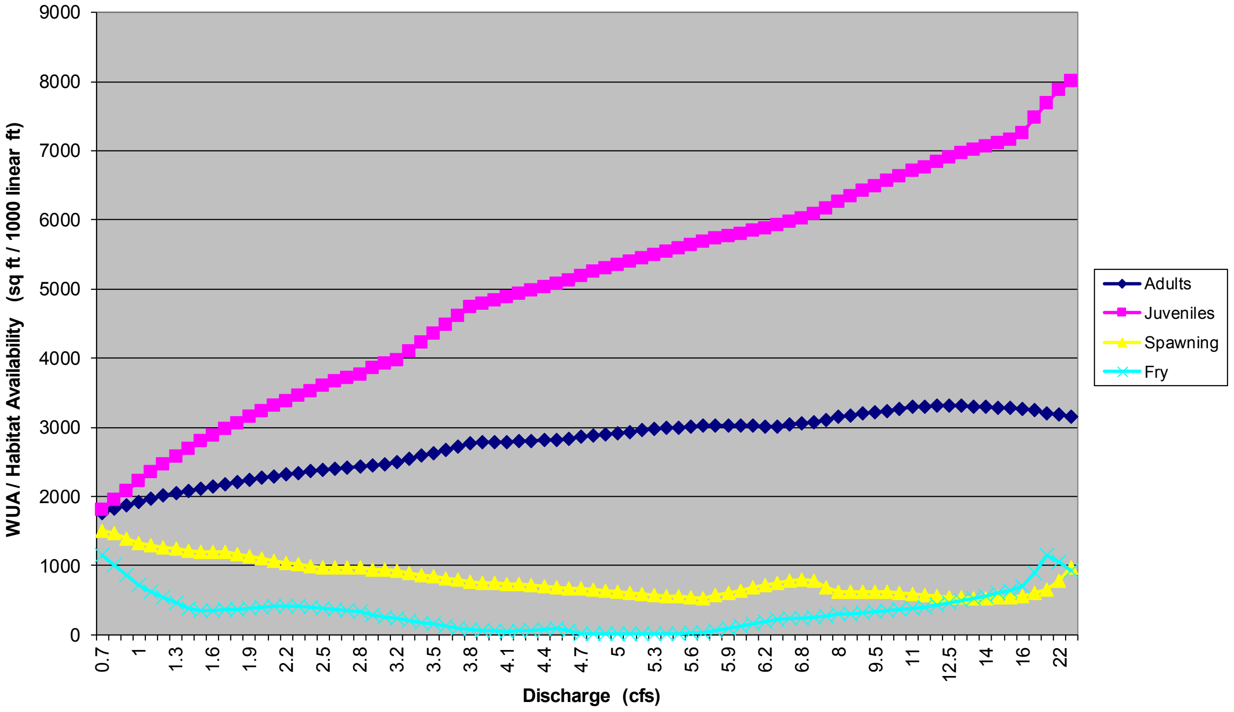


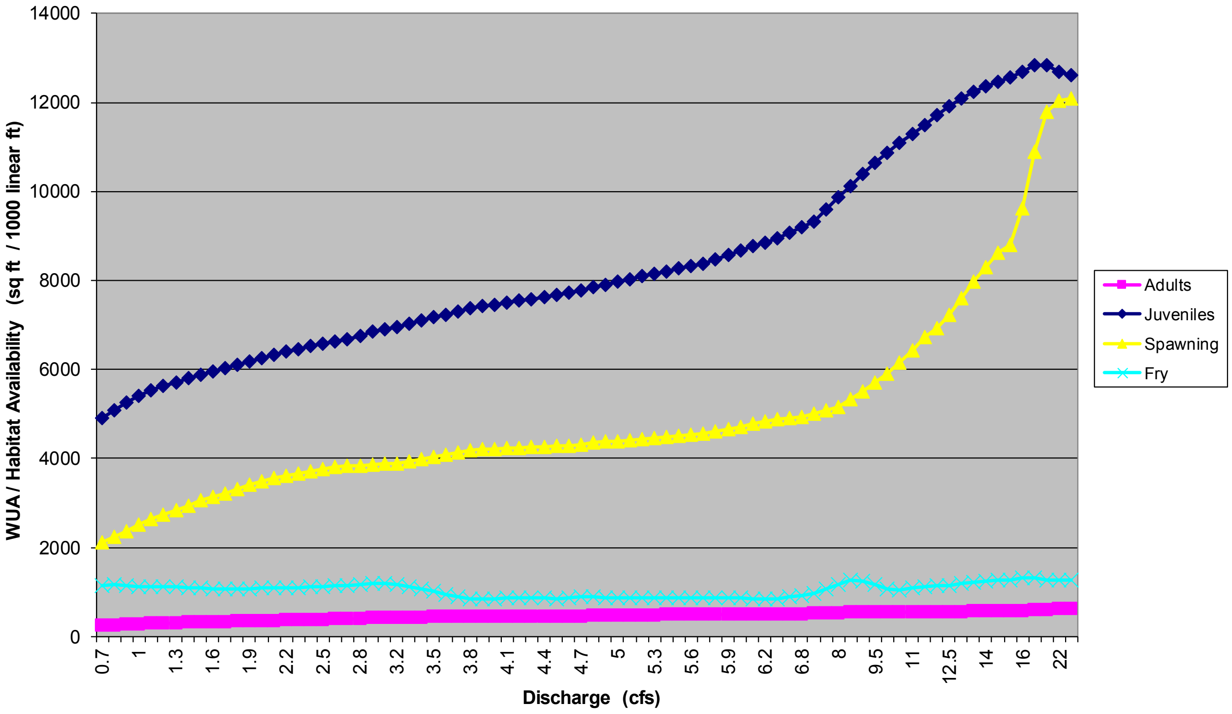

Pithlachasscotee River - Veg2
Benthic Macroinvertebrates
WUA / Habitat Availability (sq ft / 1000 linear ft)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1.4
1.7
2
2.3
2.6
2.9
3.2
3.5
3.8
4.1
4.4
4.7
5
5.6
6.2
6.8
9
12
15
18
21
24
27
30
36
42
48
Discharge (cfs)
Community Diversity

Pithlachascotee River - Veg4
Fish Habitat Guilds

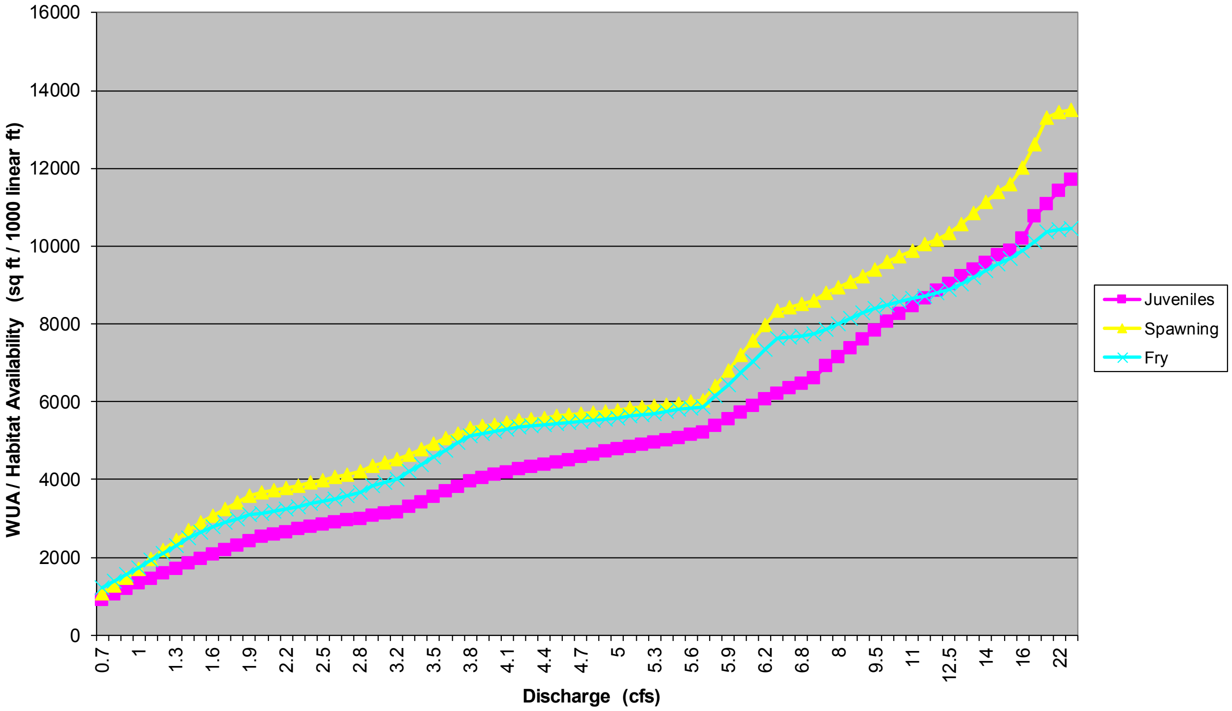


Pithlachascotee River - Veg4
Largemouth Bass

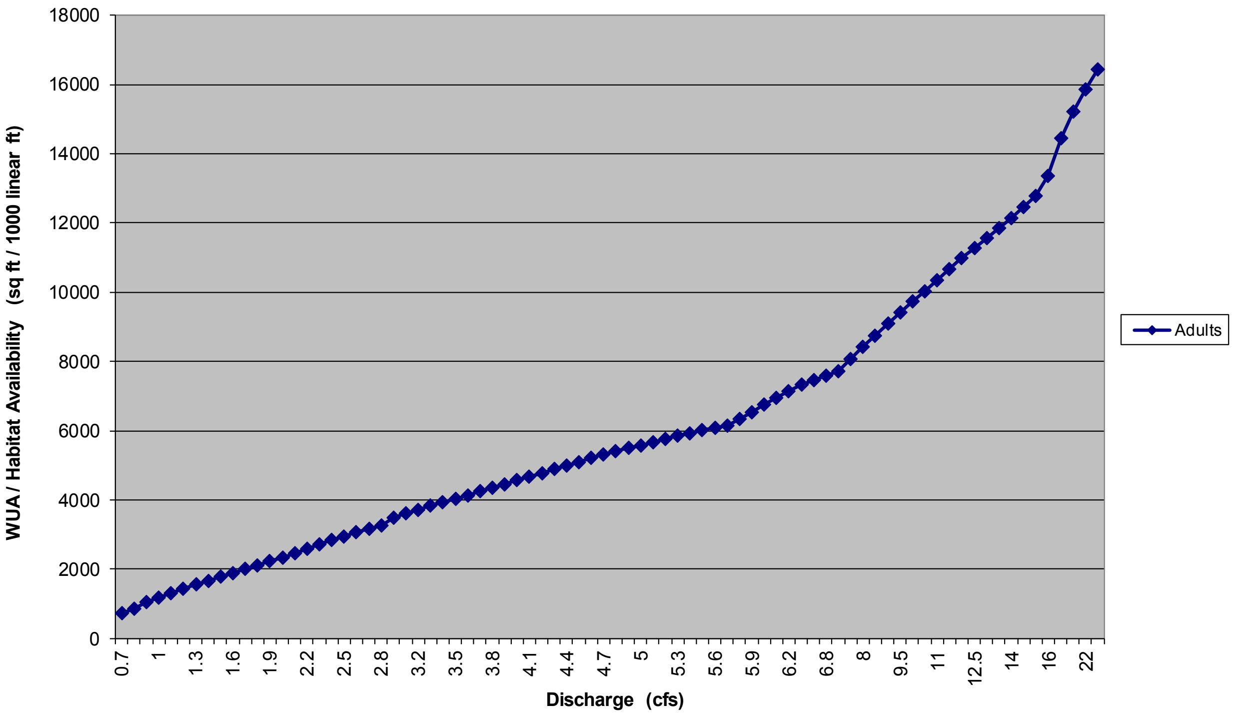


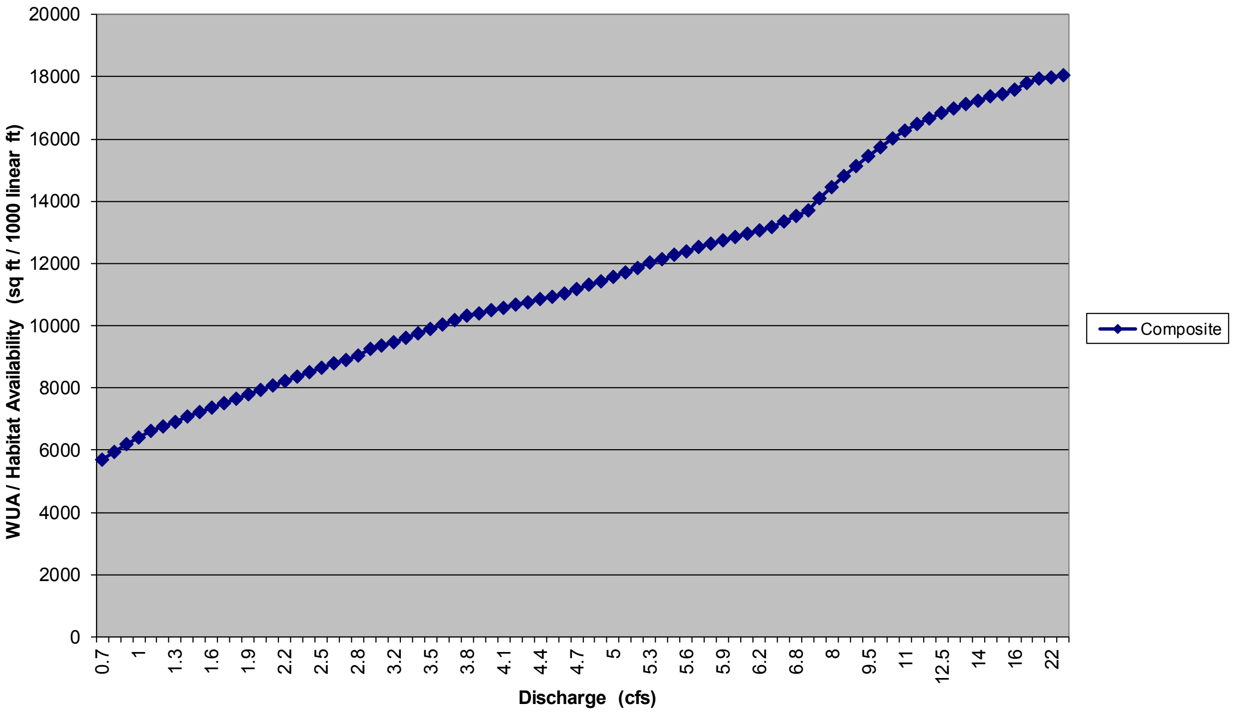


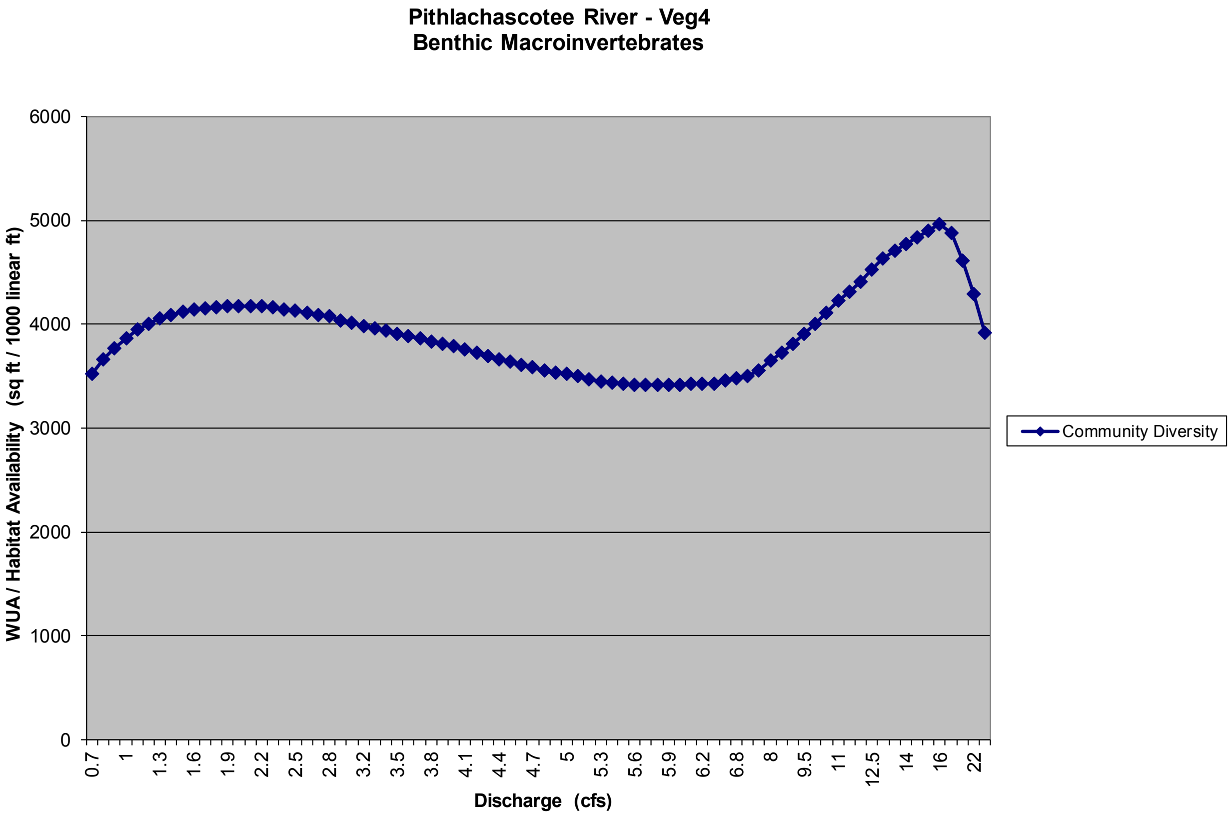
Pithlachascotee River - Veg4
Bluegill Sunfish

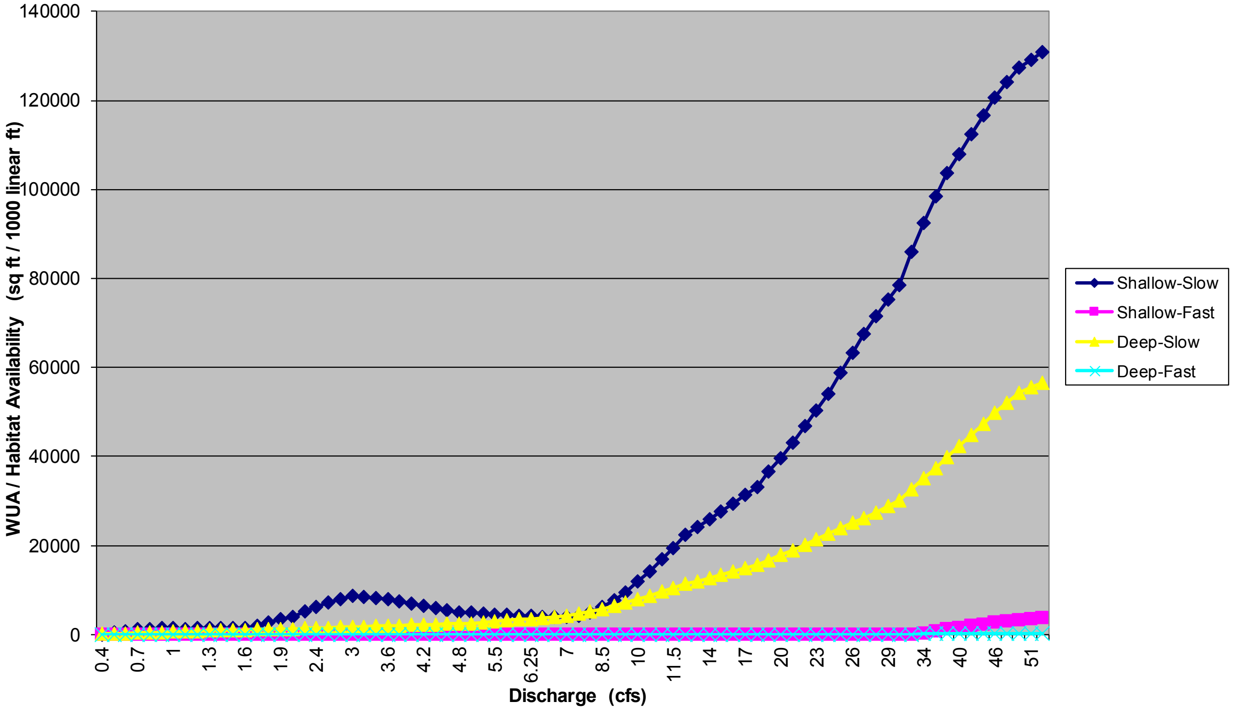


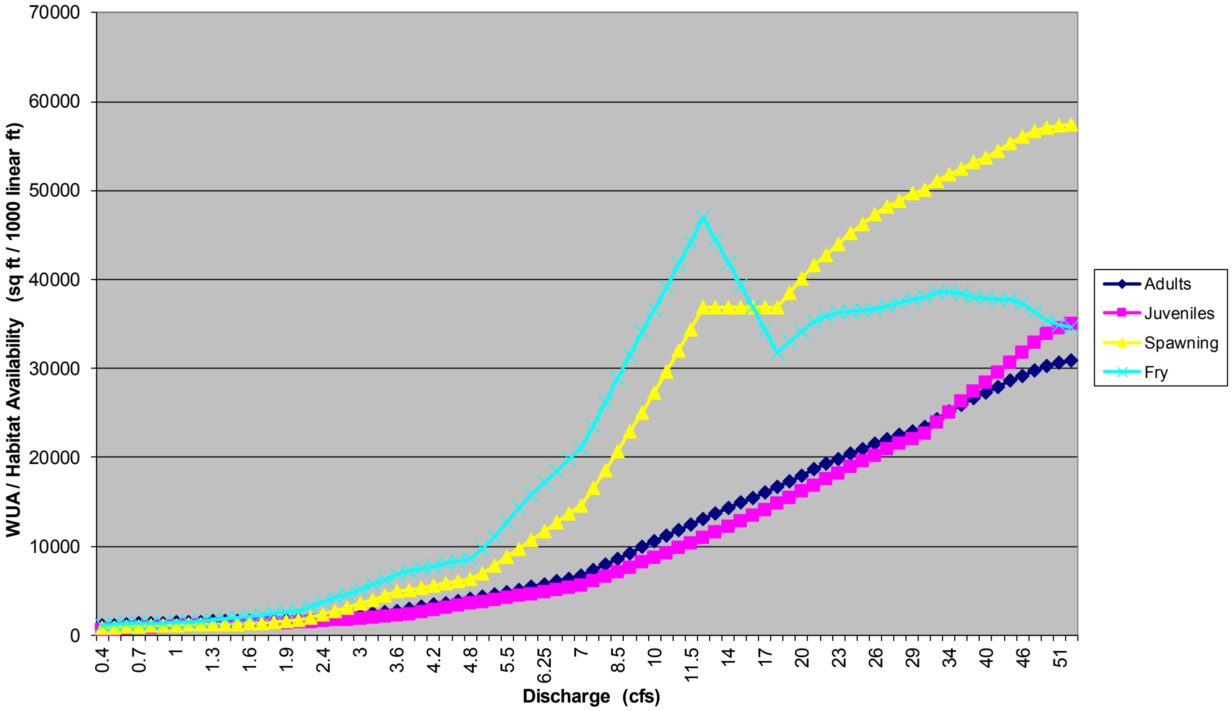
Pithlachascotee River - Veg4
Spotted Sunfish

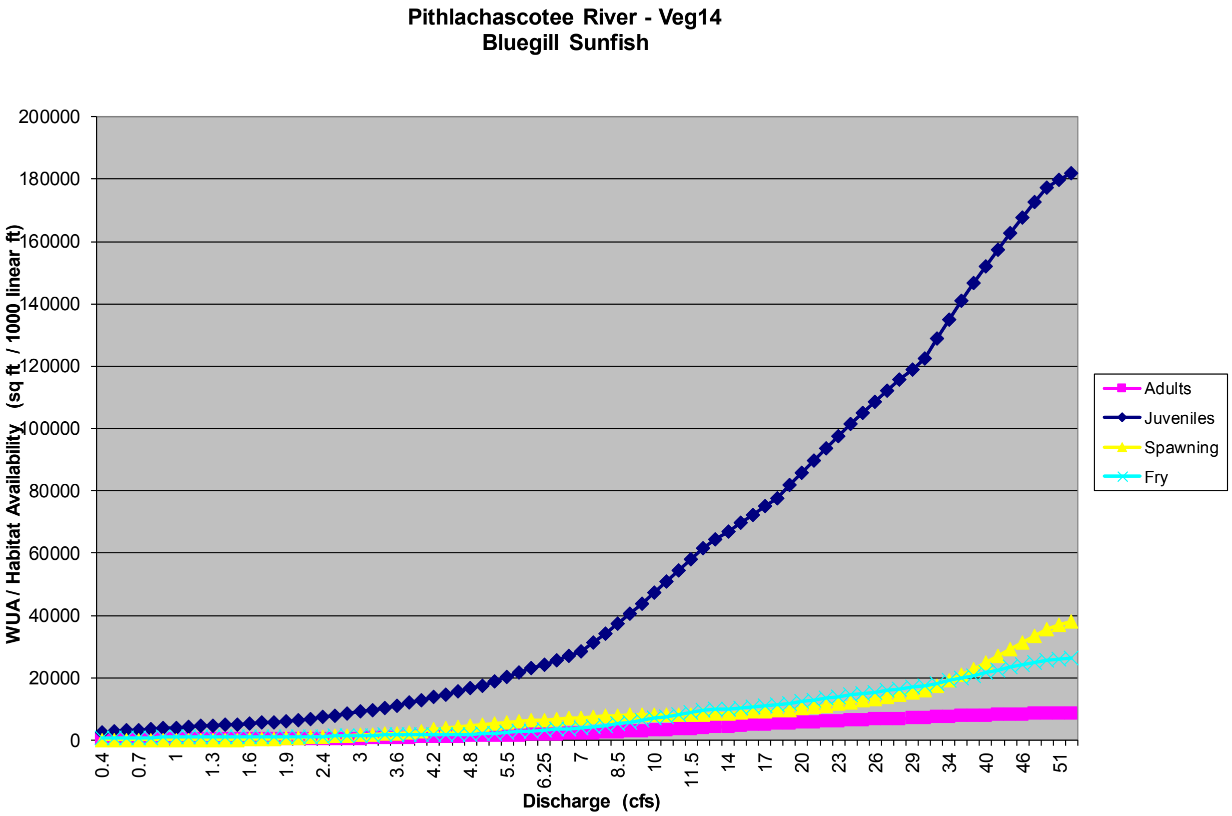

Pithlachascotee River - Veg4
Spotted Sunfish

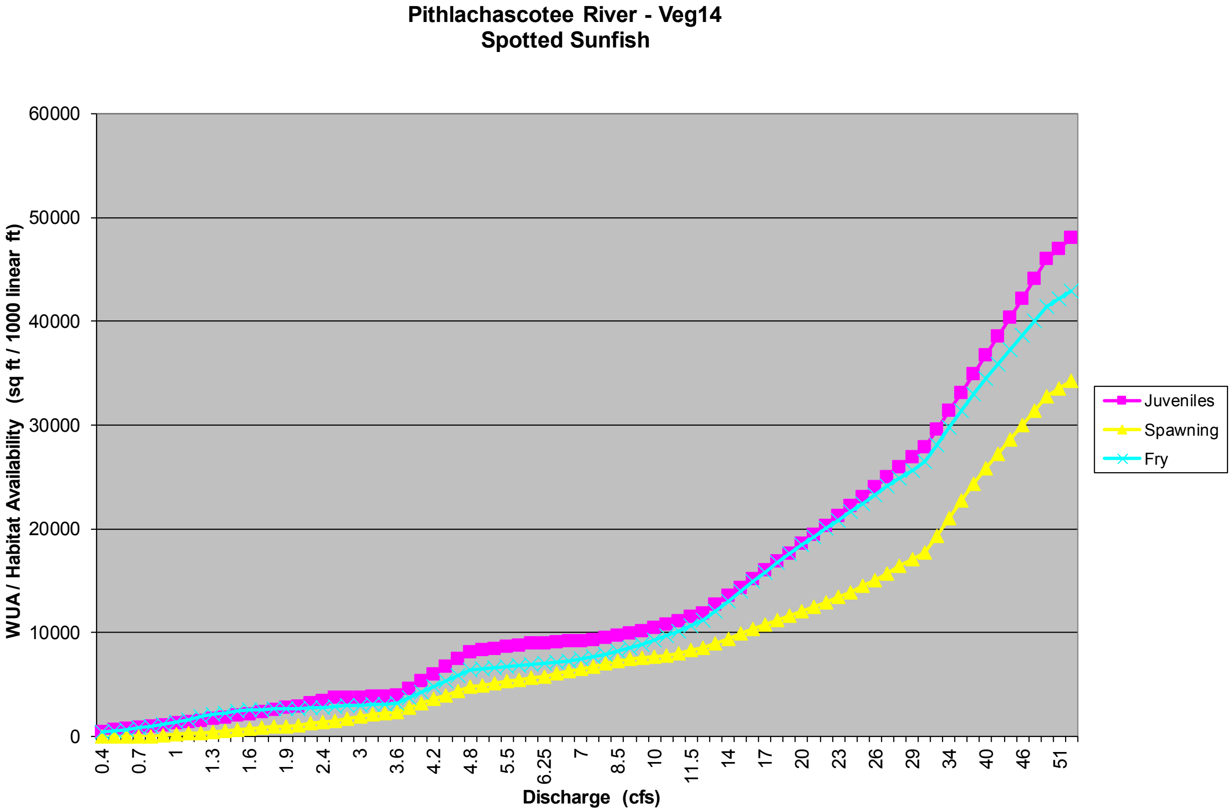

Pithlachascotee River - Veg4
Cyprinidae - Minnows, Chubs, Dace, Shiners

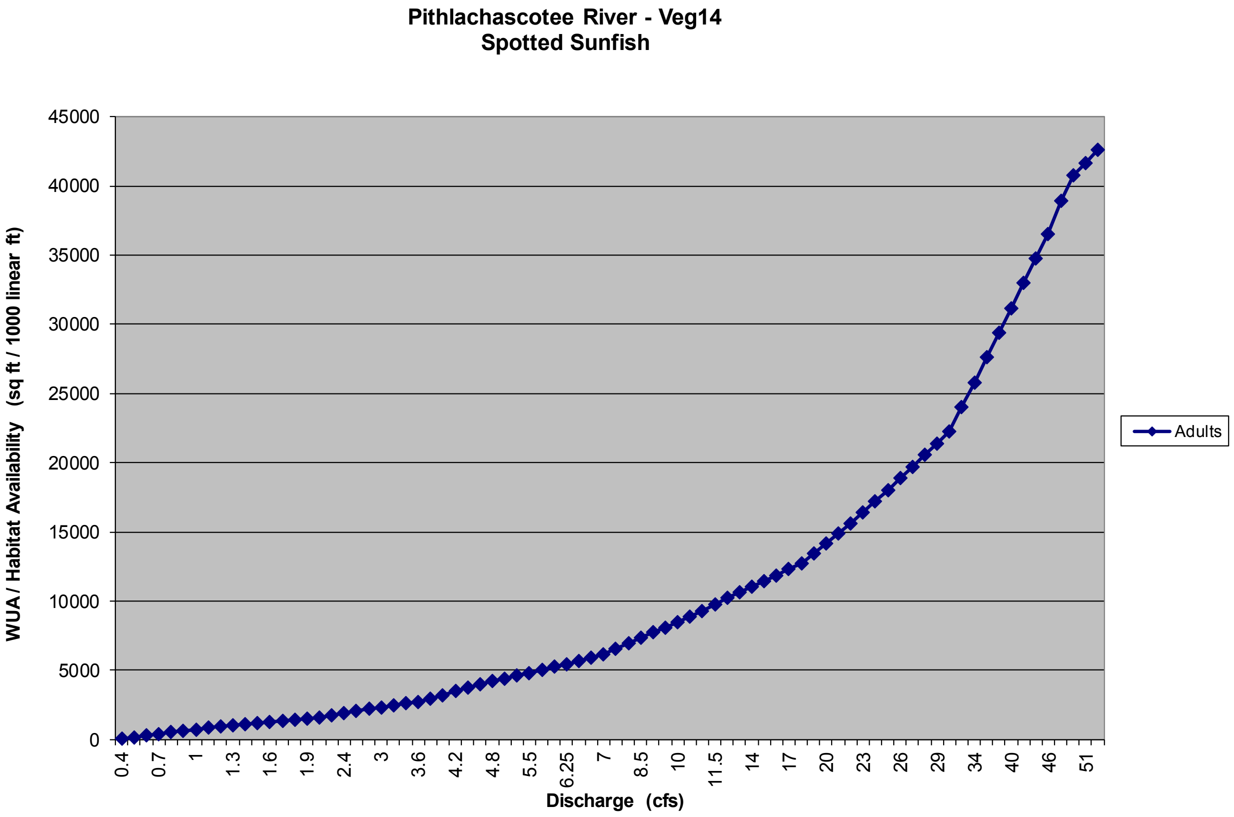

Pithlachascotee River - Veg4
Benthic Macroinvertebrates
WUA / Habitat Availability (sq ft / 1000 linear ft)
6000
5000
4000
3000
2000
1000
0
0.7
1
1.3
1.6
1.9
2.2
2.5
2.8
3.2
3.5
3.8
4.1
4.4
4.7
5
5.3
5.6
5.9
6.2
6.8
8
9.5
11
12.5
14
16
22
Discharge (cfs)
Community Diversity

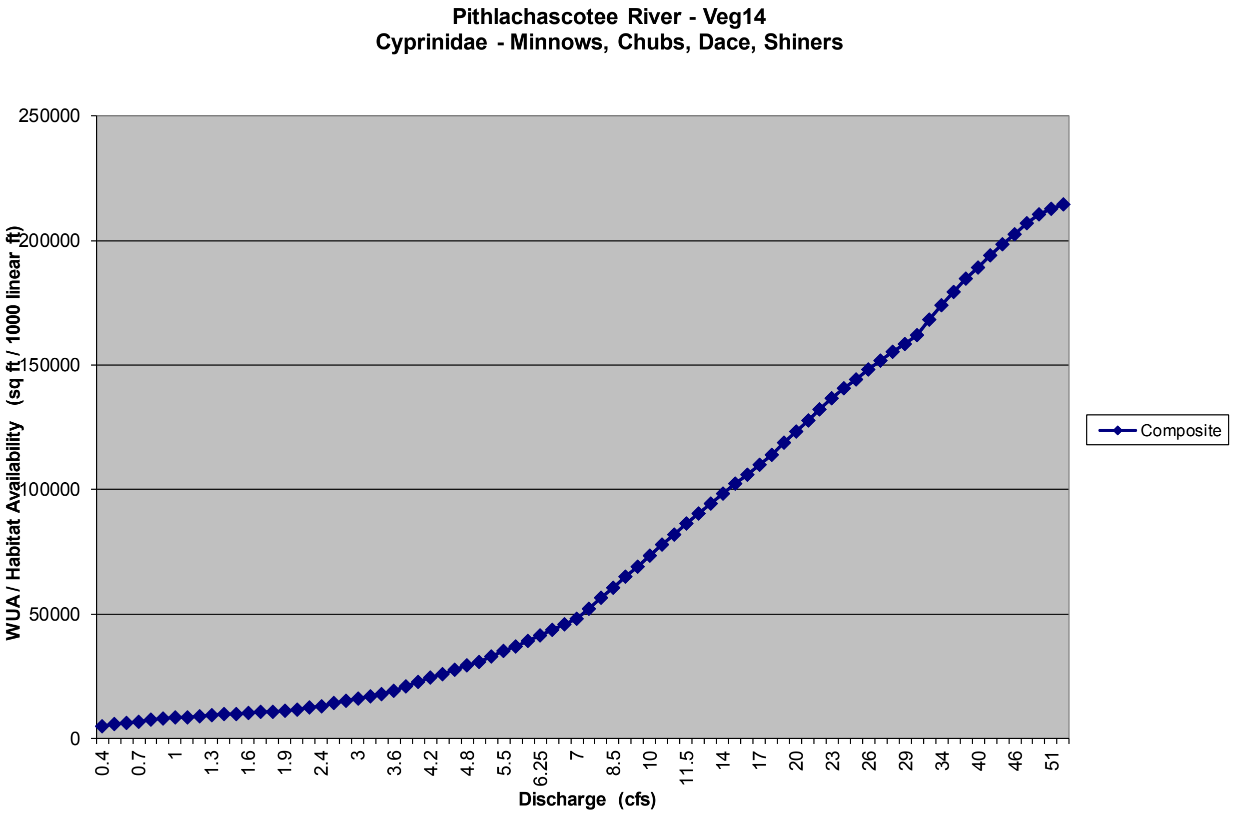

Pithlachascotee River - Veg14
Fish Habitat Guilds

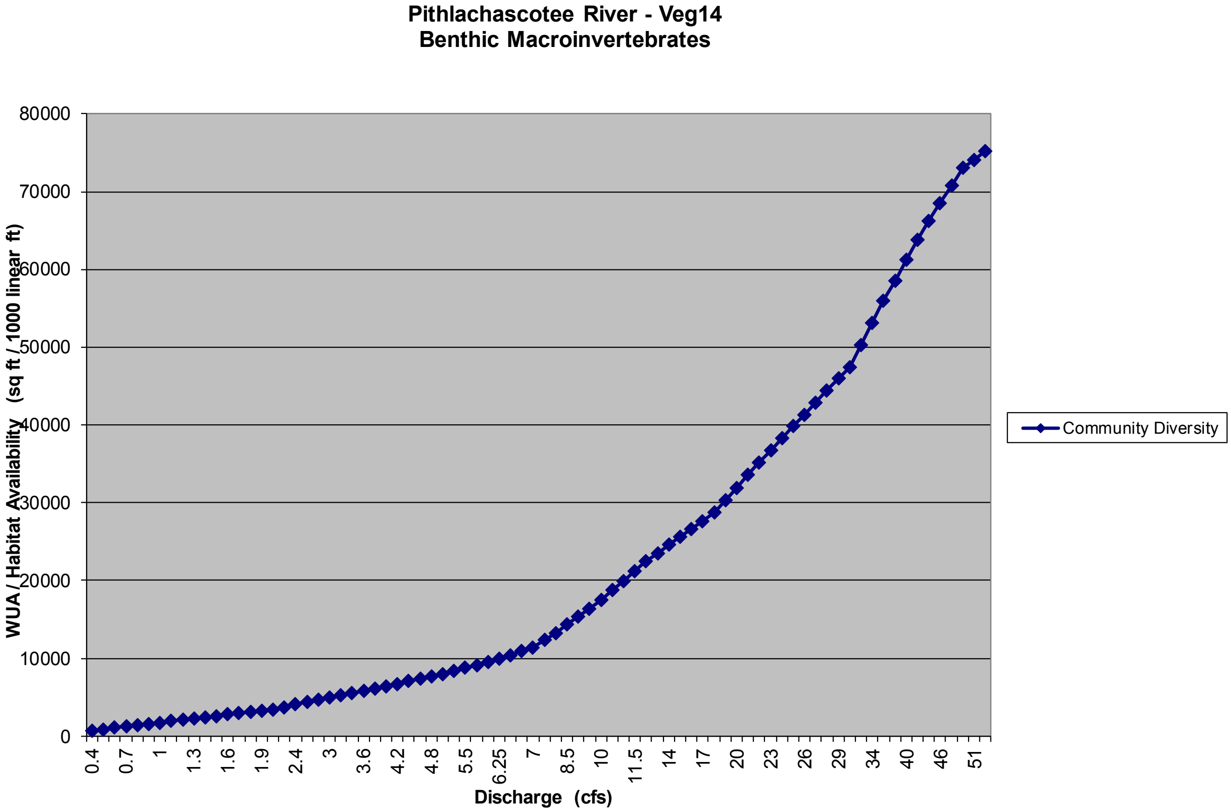

Pithlachascotee River - Veg14
Largemouth Bass


Pithlachascotee River - Veg14
Bluegill Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Discharge (cfs)
0.4
0.7
1
1.3
1.6
1.9
2.4
3
3.6
4.2
4.8
5.5
6.25
7
8.5
10
11.5
14
17
20
23
26
29
34
40
46
51
Adults
Juveniles
Spawning
Fry

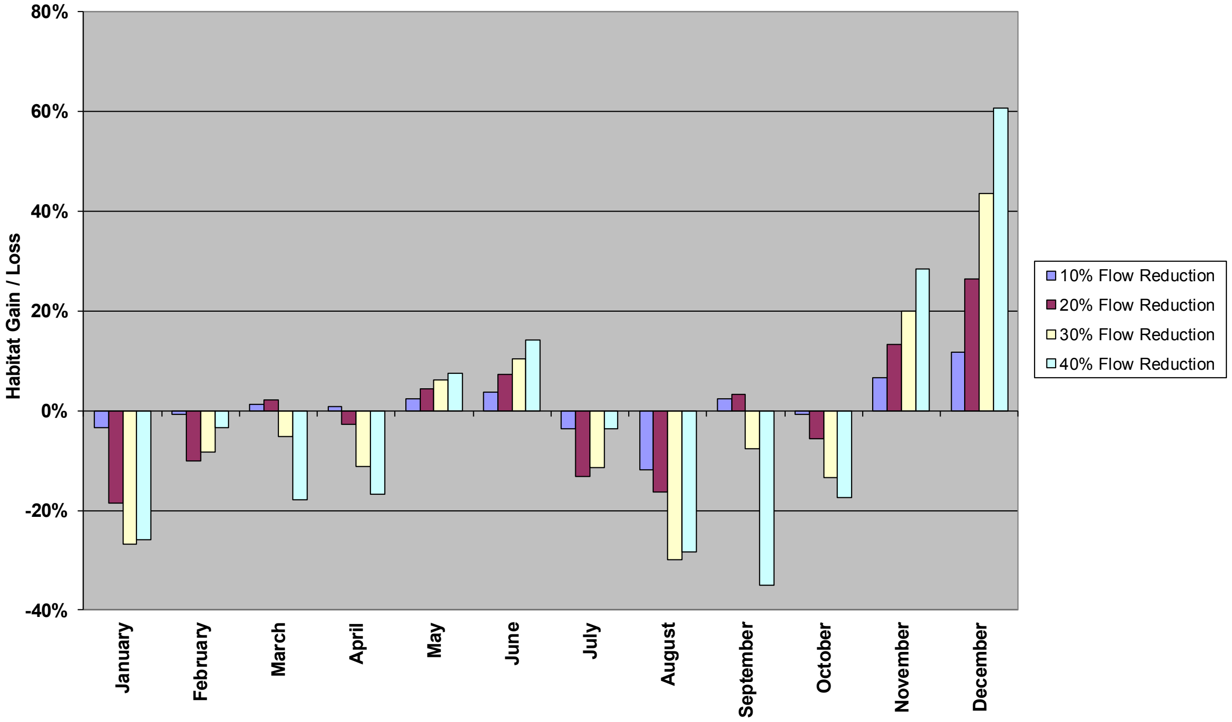

Pithlachascotee River - Veg14
Spotted Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
60000
50000
40000
30000
20000
10000
0
Discharge (cfs)
0.4
0.7
1
1.3
1.6
1.9
2.4
3
3.6
4.2
4.8
5.5
6.25
7
8.5
10
11.5
14
17
20
23
26
29
34
40
46
51
Juveniles
Spawning
Fry


Pithlachascotee River - Veg14
Spotted Sunfish
WUA / Habitat Availability (sq ft / 1000 linear ft)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0.4
0.7
1
1.3
1.6
1.9
2.4
3
3.6
4.2
4.8
5.5
6.25
7
8.5
10
11.5
14
17
20
23
26
29
34
40
46
51
Discharge (cfs)
Adults

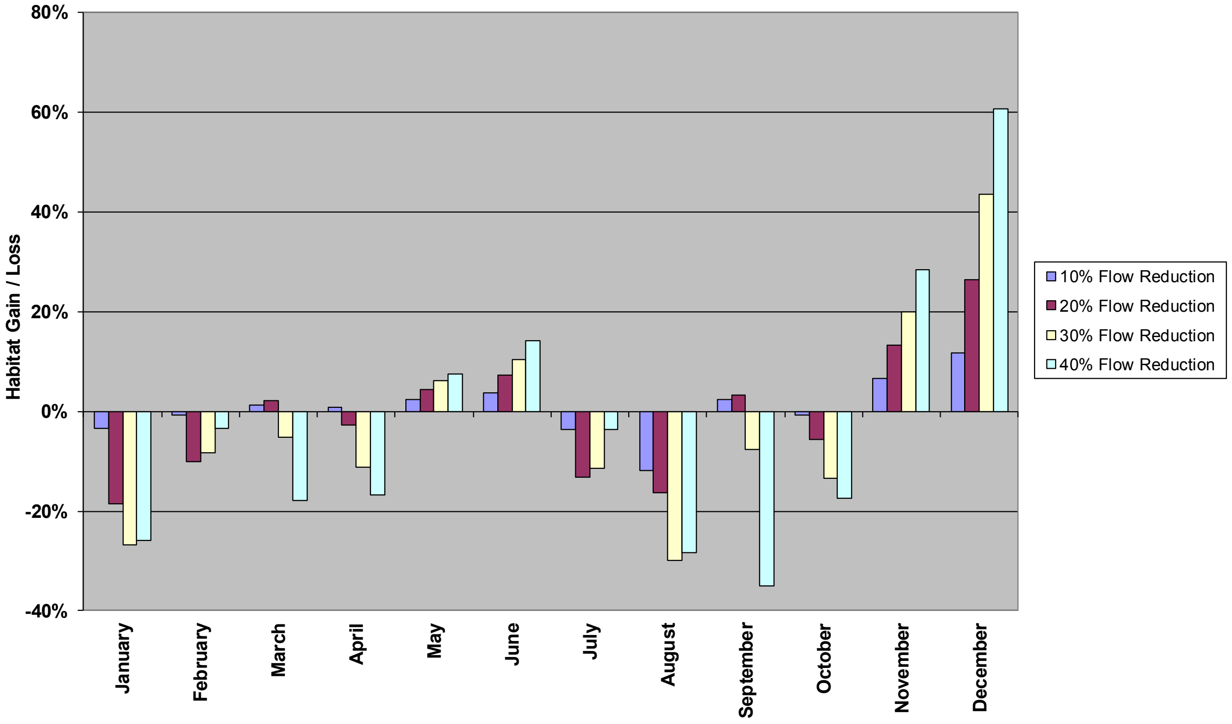

Pithlachascotee River - Veg14
Cyprinidae - Minnows, Chubs, Dace, Shiners
WUA / Habitat Availability (sq ft / 1000 linear ft)
250000
200000
150000
100000
50000
0
0.4
0.7
1
1.3
1.6
1.9
2.4
3
3.6
4.2
4.8
5.5
6.25
7
8.5
10
11.5
14
17
20
23
26
29
34
40
46
51
Discharge (cfs)
Composite

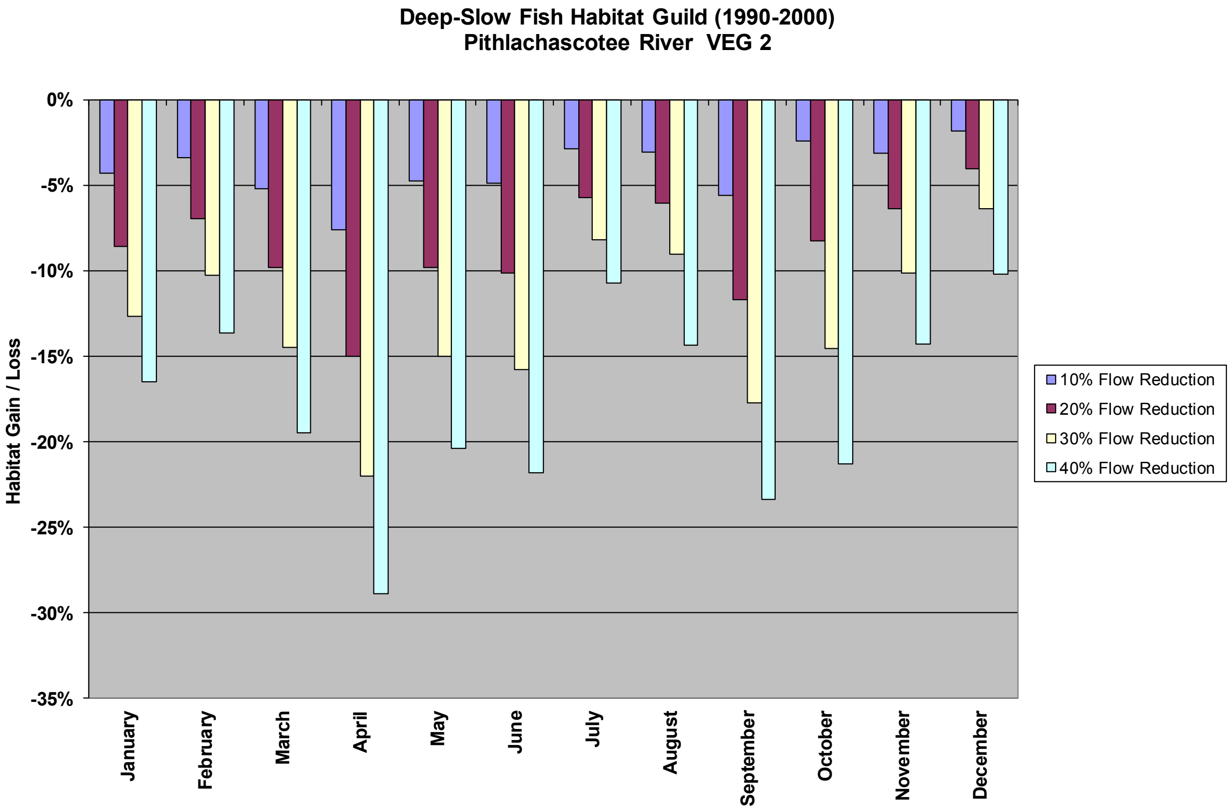

Pithlachascotee River - Veg14
Benthic Macroinvertebrates
WUA / Habitat Availability (sq ft / 1000 linear ft)
80000
70000
60000
50000
40000
30000
20000
10000
0
0.4
0.7
1
1.3
1.6
1.9
2.4
3
3.6
4.2
4.8
5.5
6.25
7
8.5
10
11.5
14
17
20
23
26
29
34
40
46
51
Discharge (cfs)
Community Diversity

Shallow-Slow Fish Habitat Guild (1990-2000)
Pithlachascotee River - VEG 2

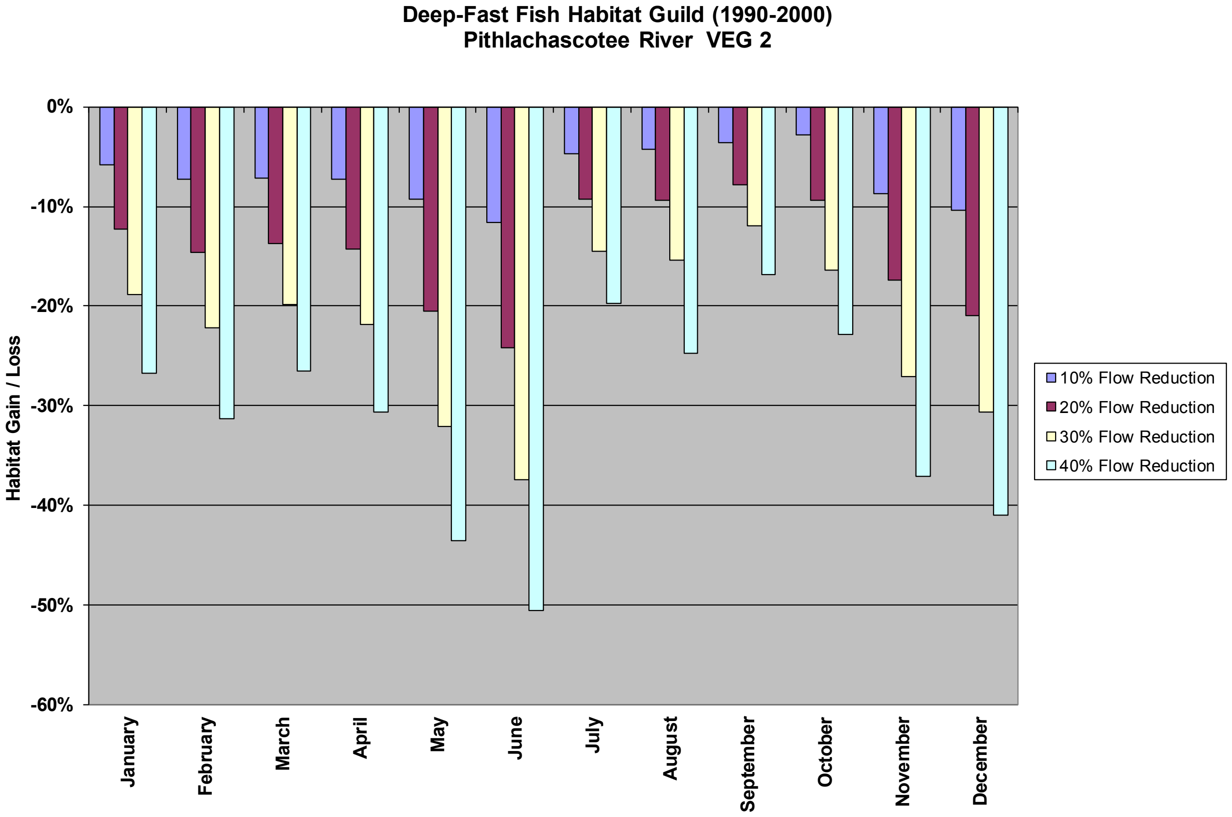


Shallow-Slow Fish Habitat Guild (1990-2000)
Pithlachascotee River - VEG 2



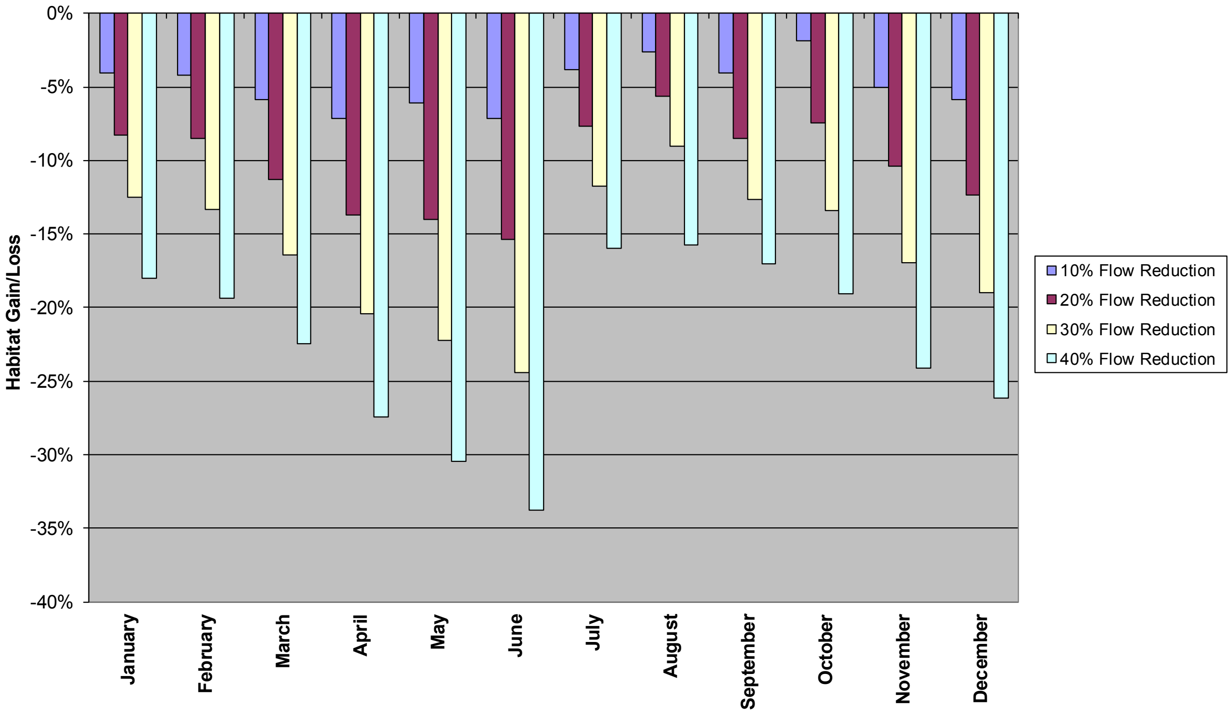


Deep-Slow Fish Habitat Guild (1990-2000)
Pithlachascotee River VEG 2
0%
-5%
-10%
-15%
-20%
-25%
-30%
-35%
Habitat Gain / Loss
January
February
March
April
May
June
July
August
September
October
November
December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

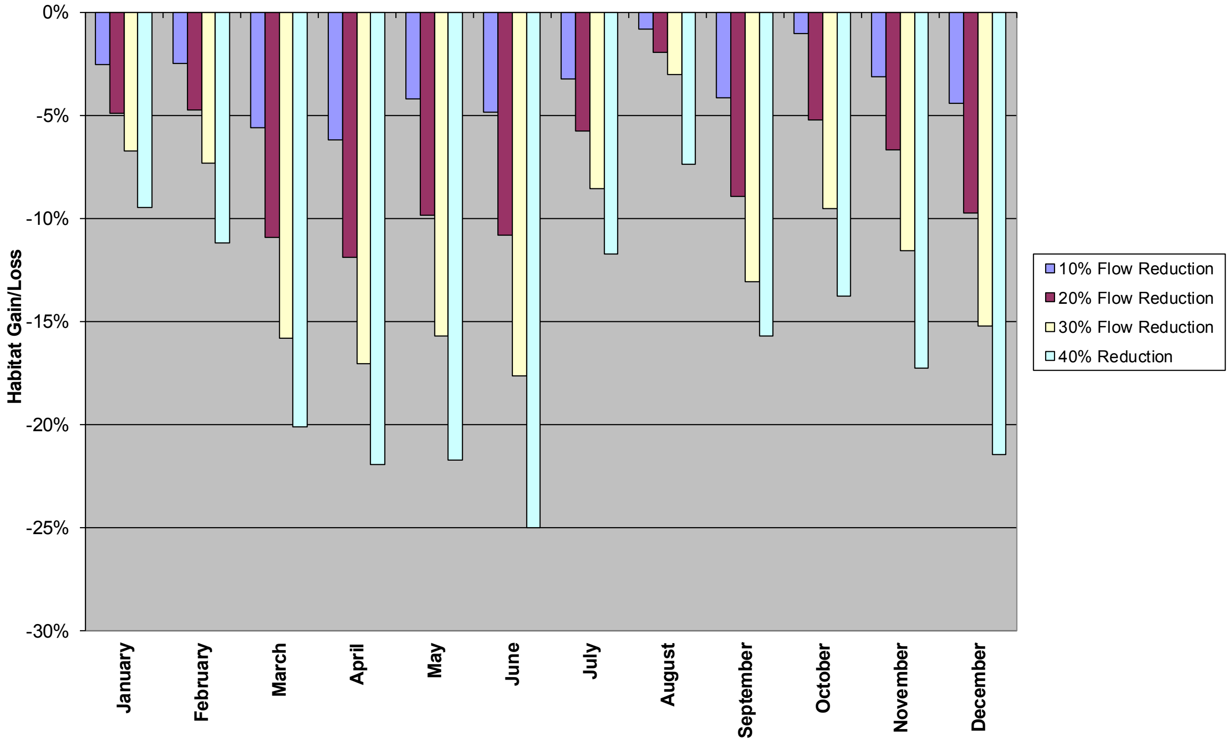


Deep-Fast Fish Habitat Guild (1990-2000)
Pithlachascotee River VEG 2
0%
-10%
-20%
-30%
-40%
-50%
-60%
Habitat Gain / Loss
January
February
March
April
May
June
July
August
September
October
November
December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

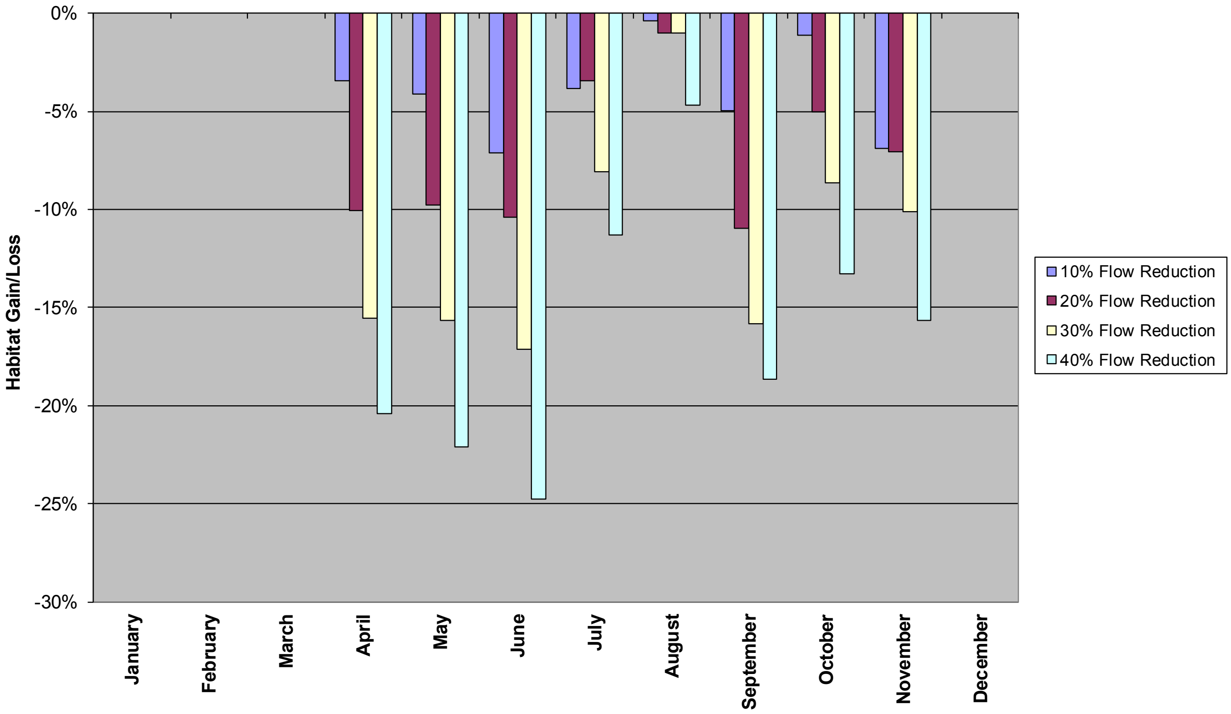
Adult Spotted Sunfish Adults (1990-2000)
Pithlachascotee River VEG 2



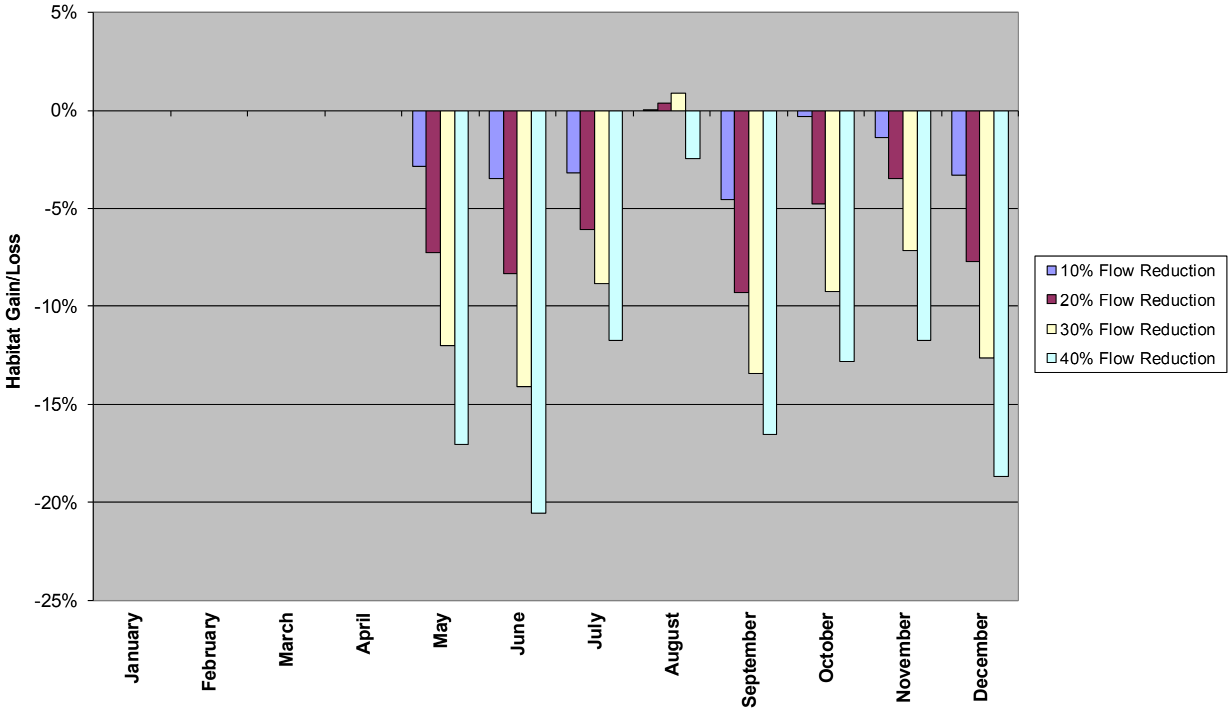
Spotted Sunfish Juveniles (1990-2000)
Pithlachascotee River VEG 2

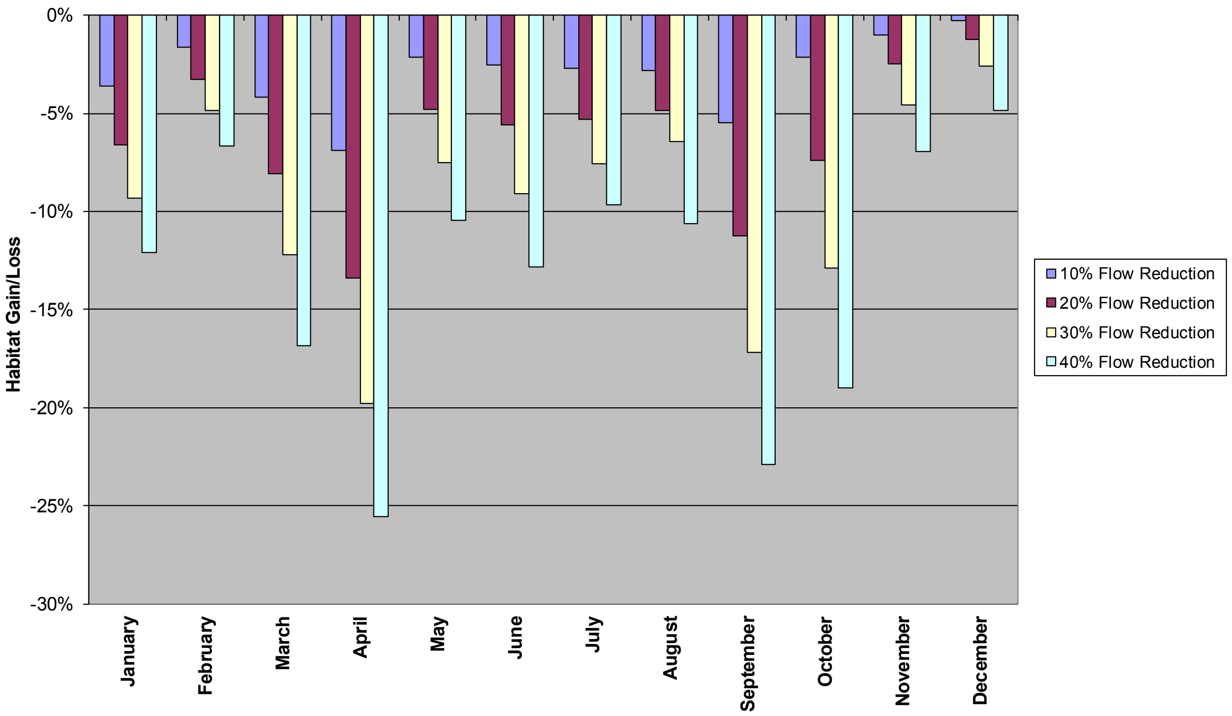


Spotted Sunfish Spawning (1990-2000
Pithlachascotee River VEG 2

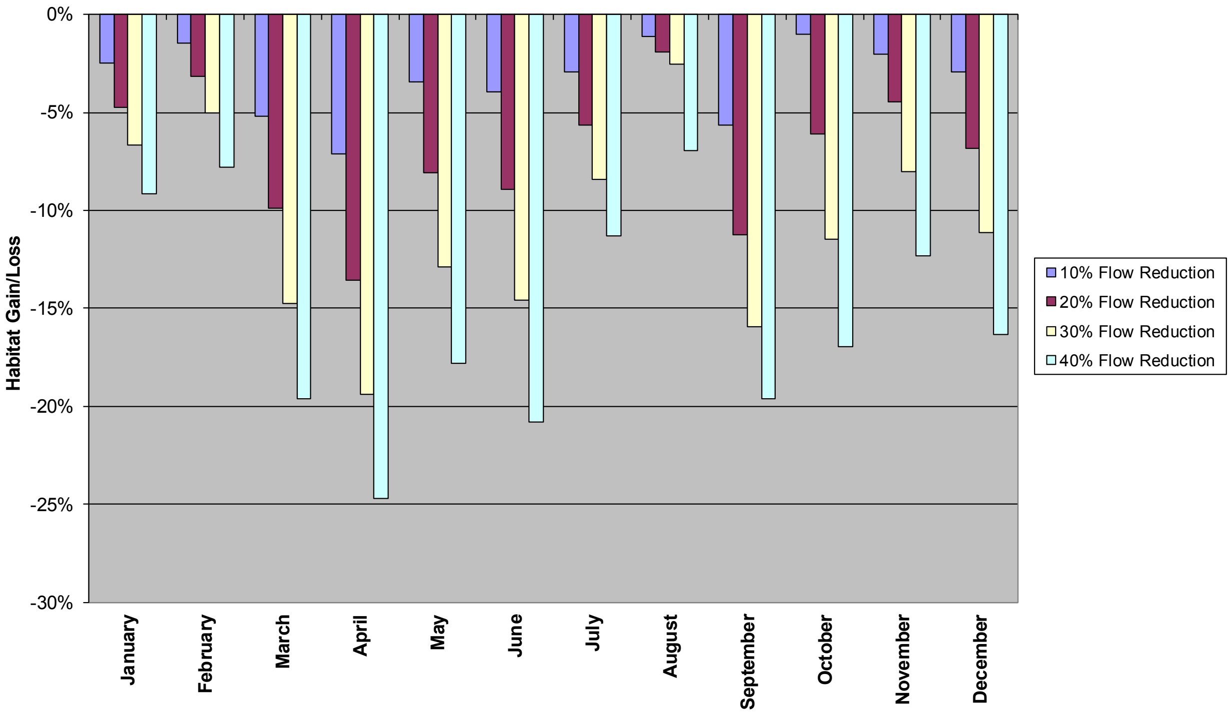


Spotted Sunfish Fry (1990-2000)
Pithlachascotee River VEG 2



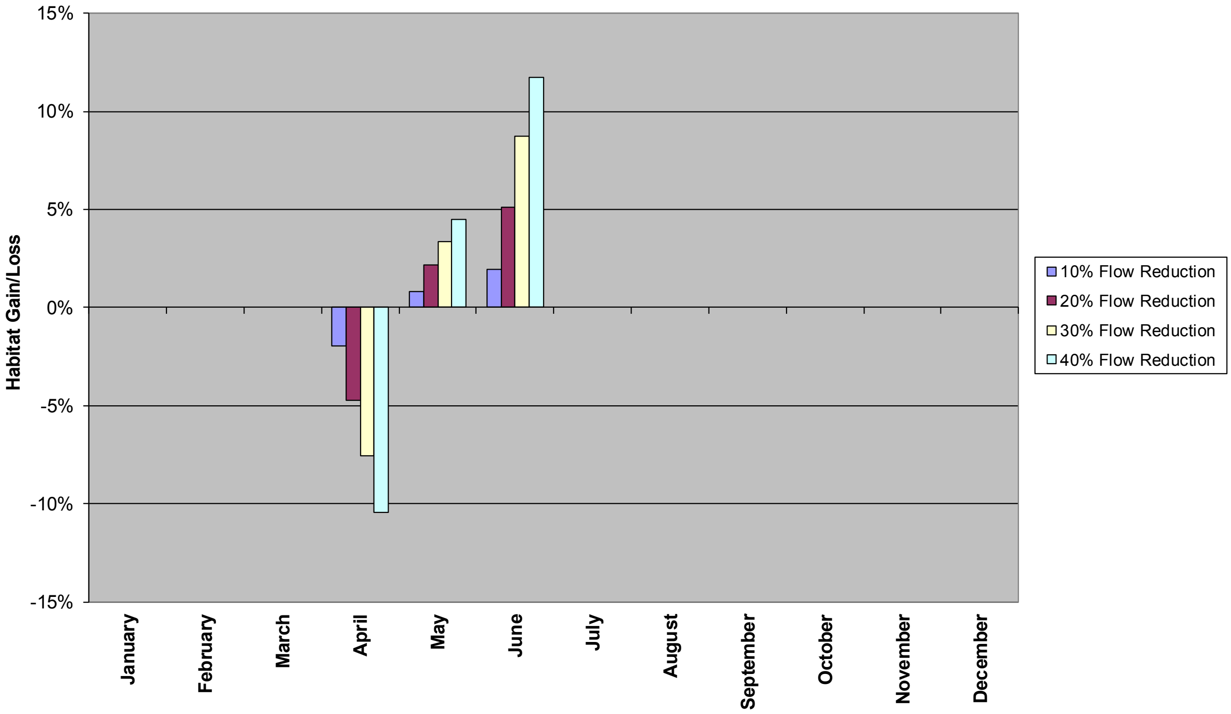


Laregemouth Bass Adults (1990-2000)
Pithlachascotee River VEG 2

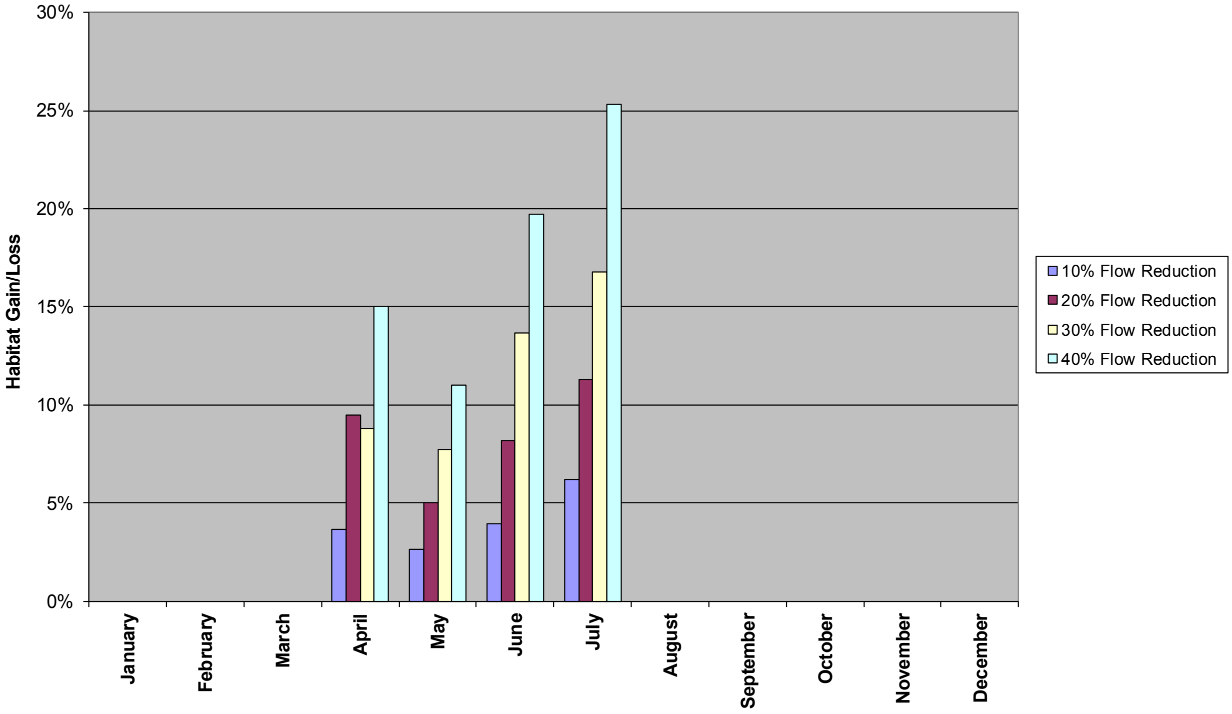


Largemouth Bass Juveniles (1990-2000)
Pithlachascotee River VEG 2

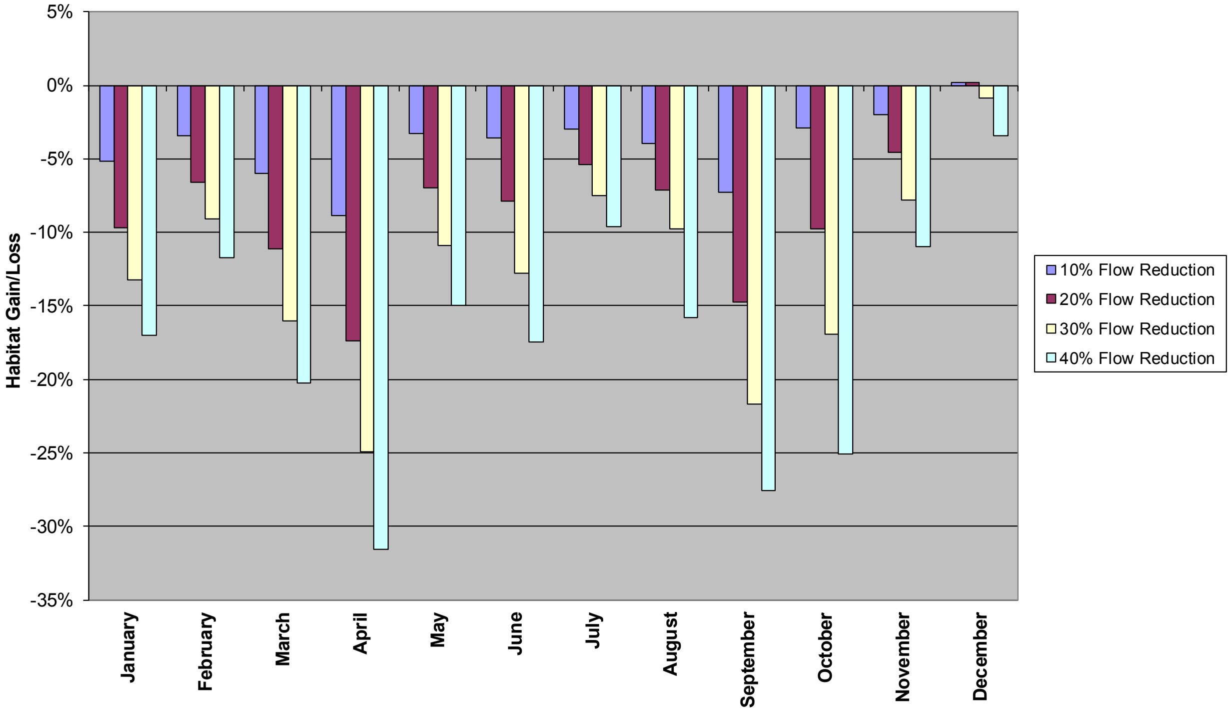
Largemouth Bass Spawning (1990-2000)
Pithlachascotee River VEG 2



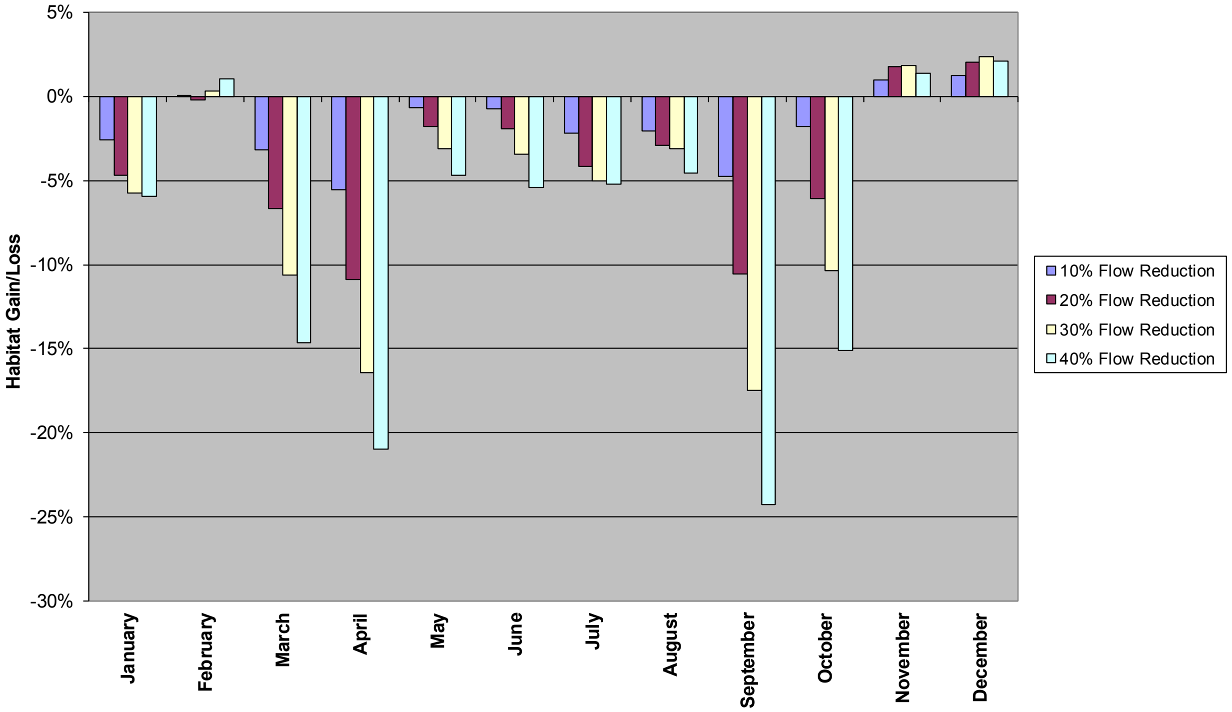
Largemouth Bass Fry (1990-2000)
Pithlachascotee River VEG 2



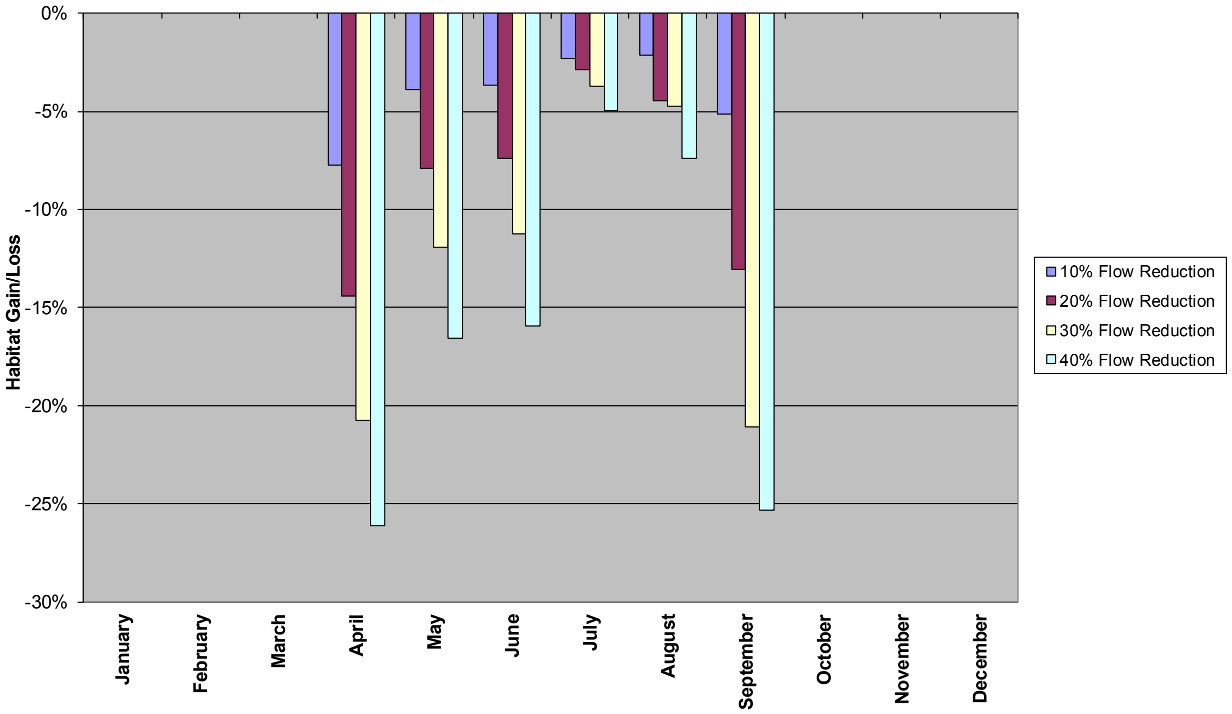
Bluegill Sunfish Adults (1990-2000)
Pithlachascotee River VEG 2



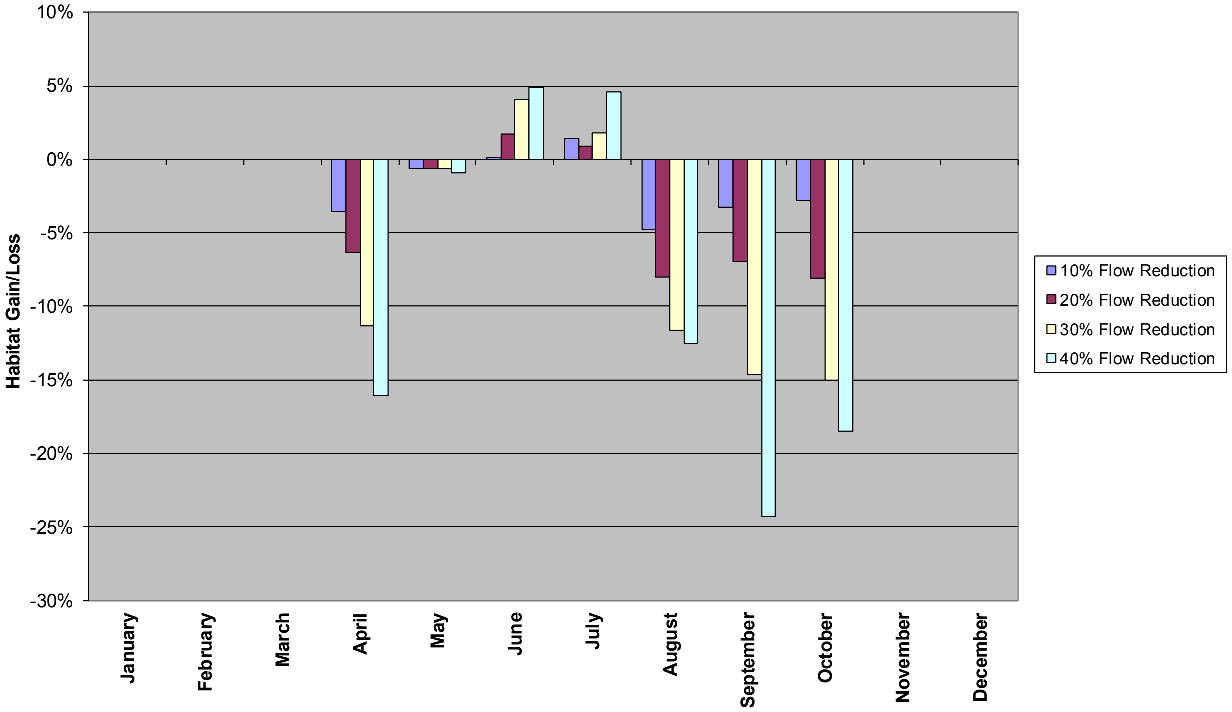
Bluegill Sunfish Juveniles (1990-2000)
Pithlachascotee River VEG 2



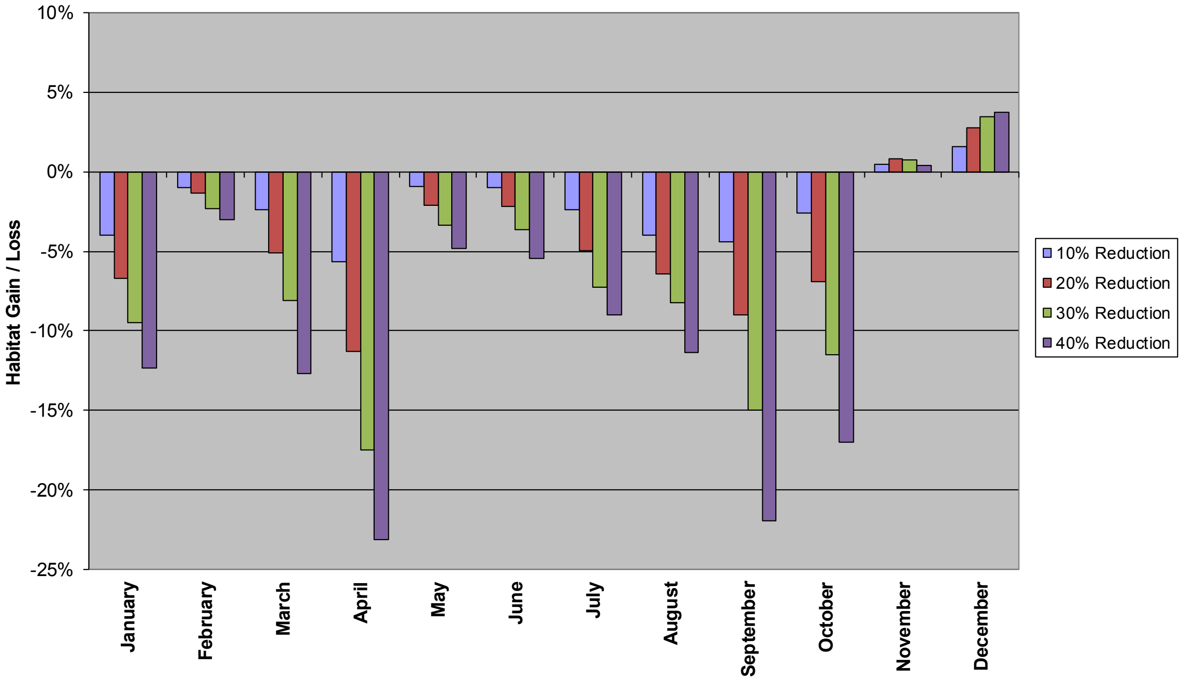
Bluegill Sunfish Spawning (1990-2000)
Pithlachascotee River VEG 2



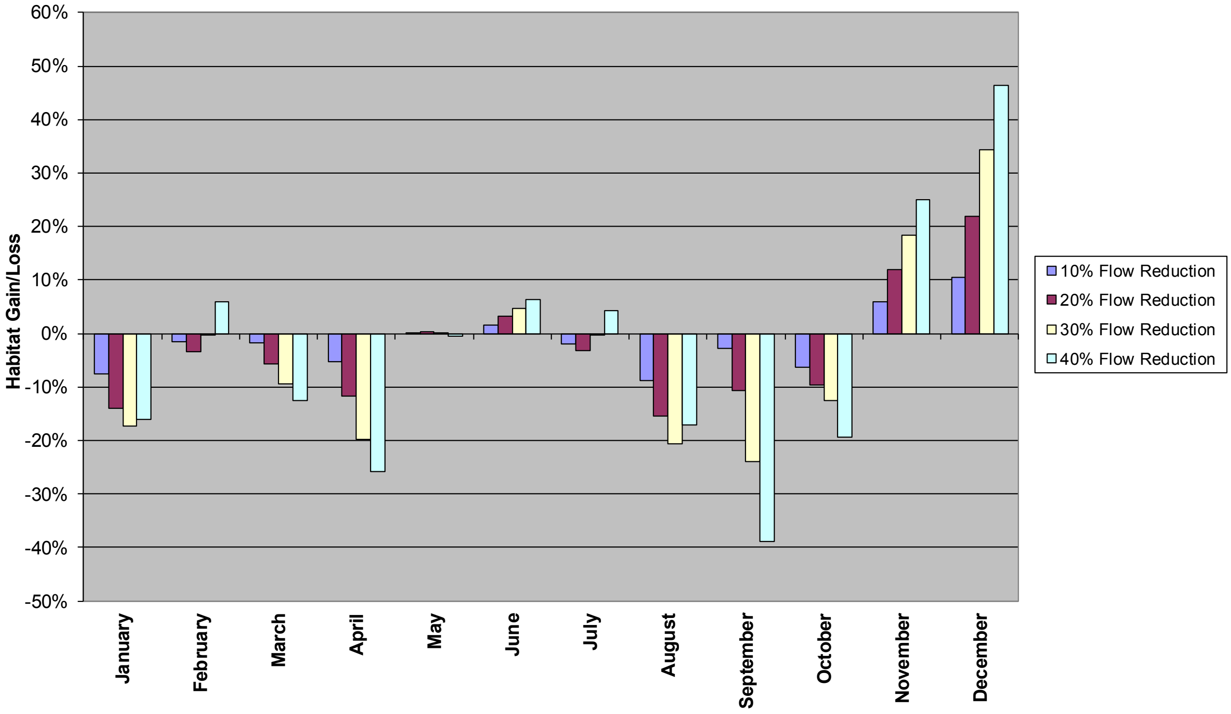
Bluegill Sunfish Fry (1990-2000)
Pithlachascotee River VEG 2

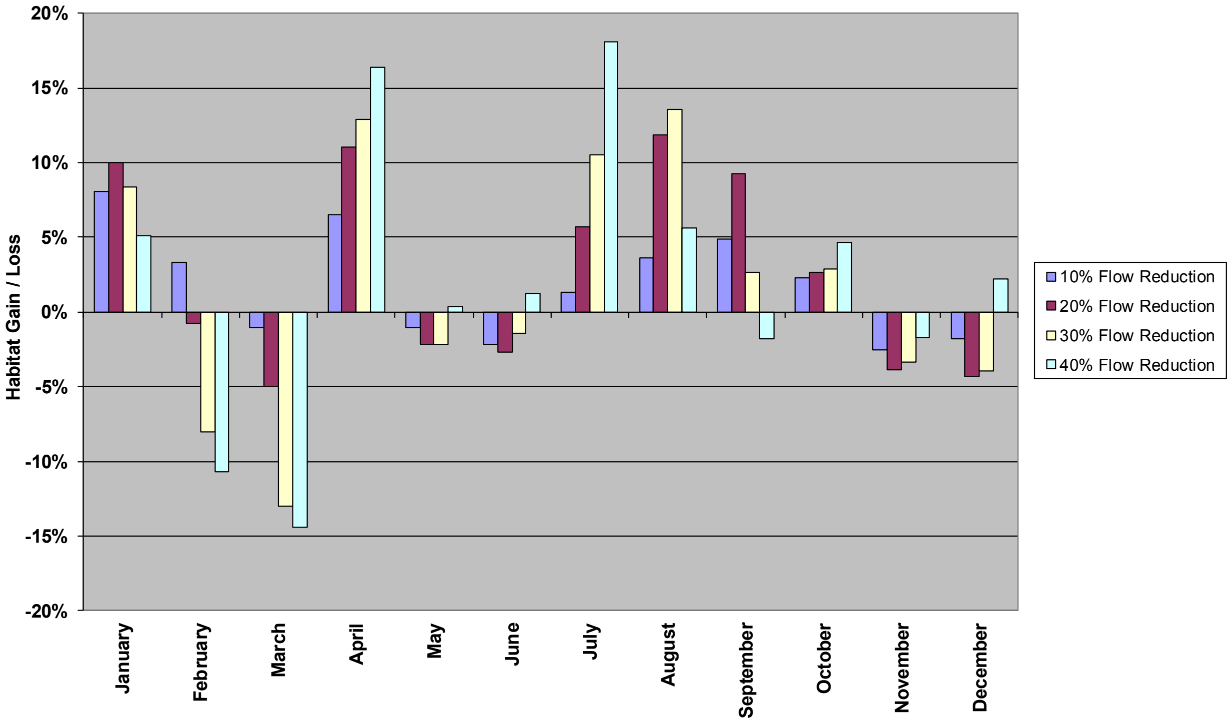


Cyprinidae - (1990-2000)
Pithlachascotee River VEG 2

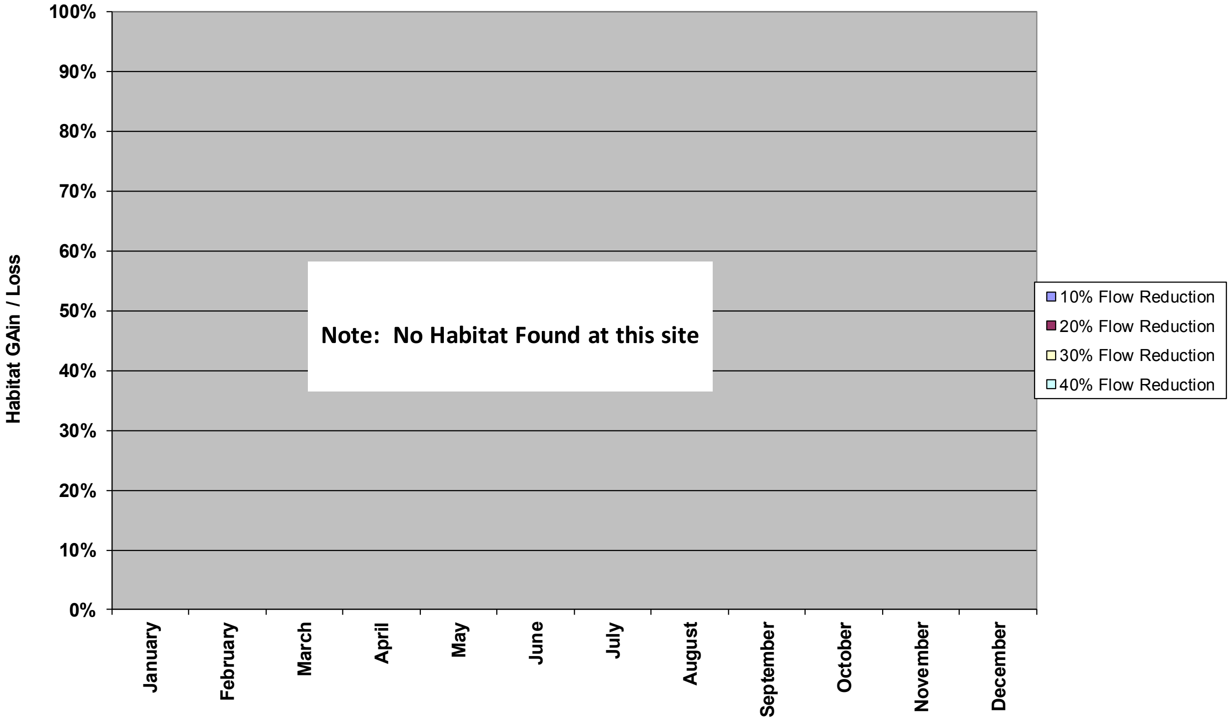


Benthic Macroinvertebrates (1990-2000)
Pithlachascotee River VEG 2





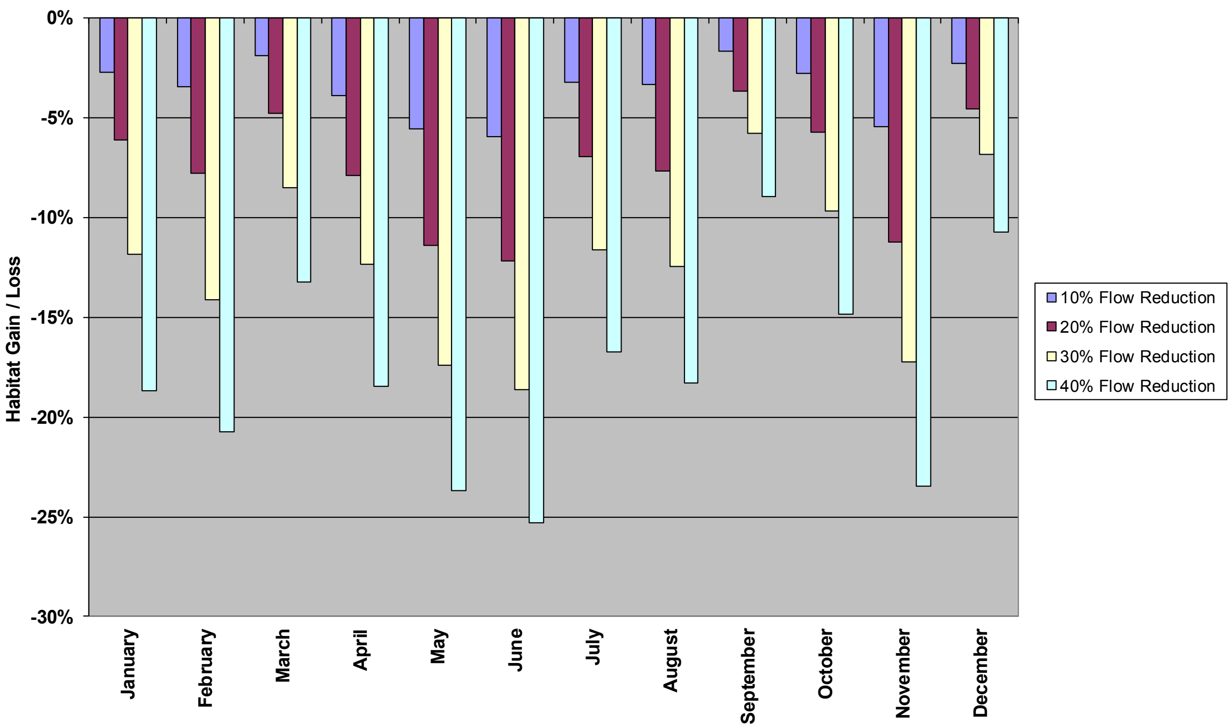
Shallow-Slow Fish Habitat Guild (1990-2000)
Pithlachascotee River - VEG 4



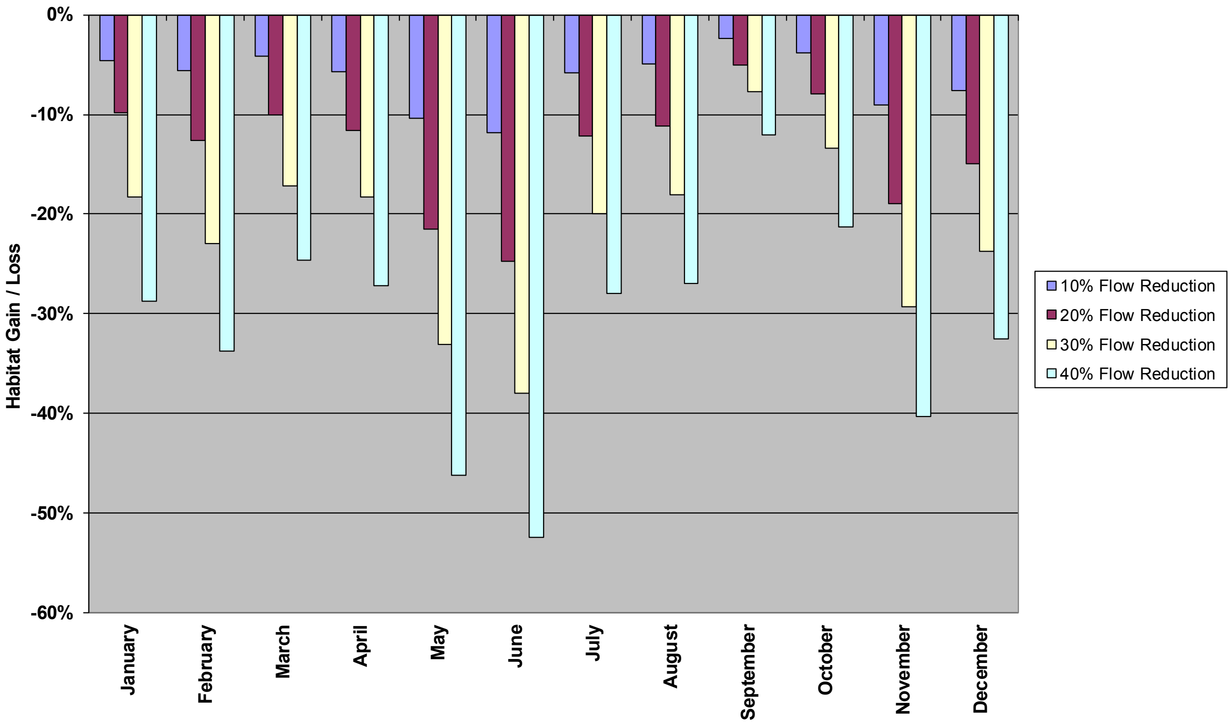
Shallow-Fast Fish Habitat Guild (1990-2000)
Pithlachascotee River VEG 4

Note: No Habitat Found at this site

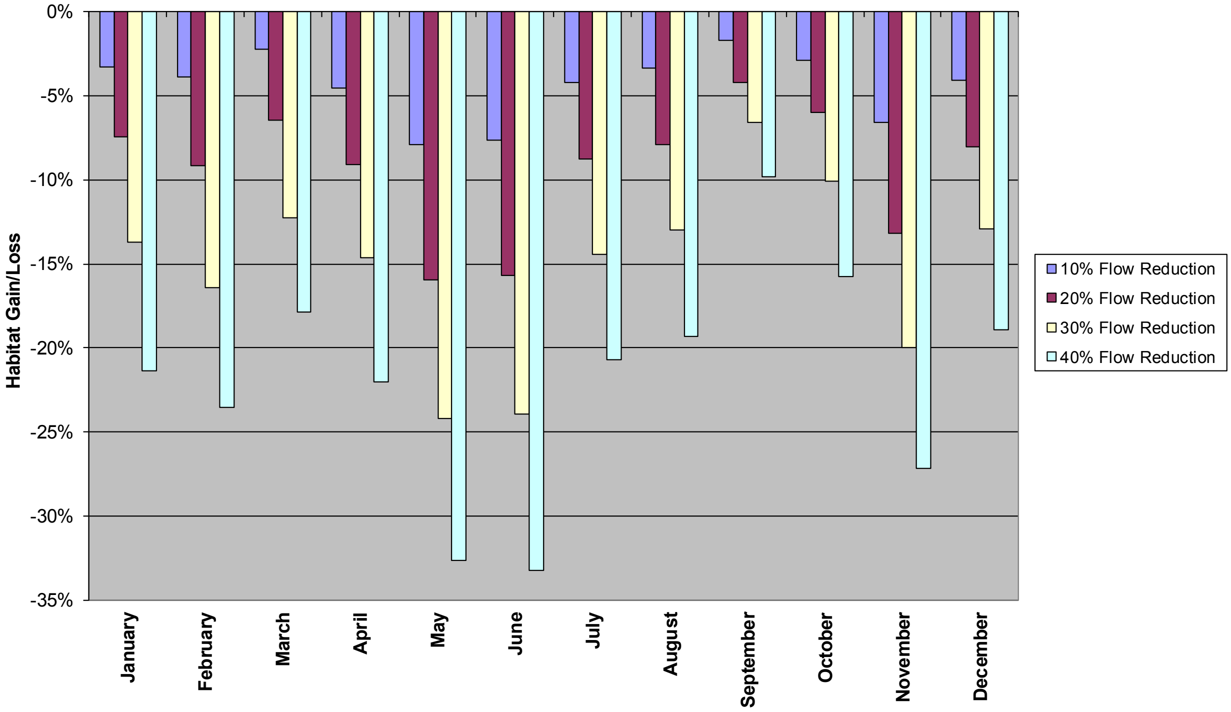
Deep-Slow Fish Habitat Guild (1990-2000)
Pithlachascotee River VEG 4



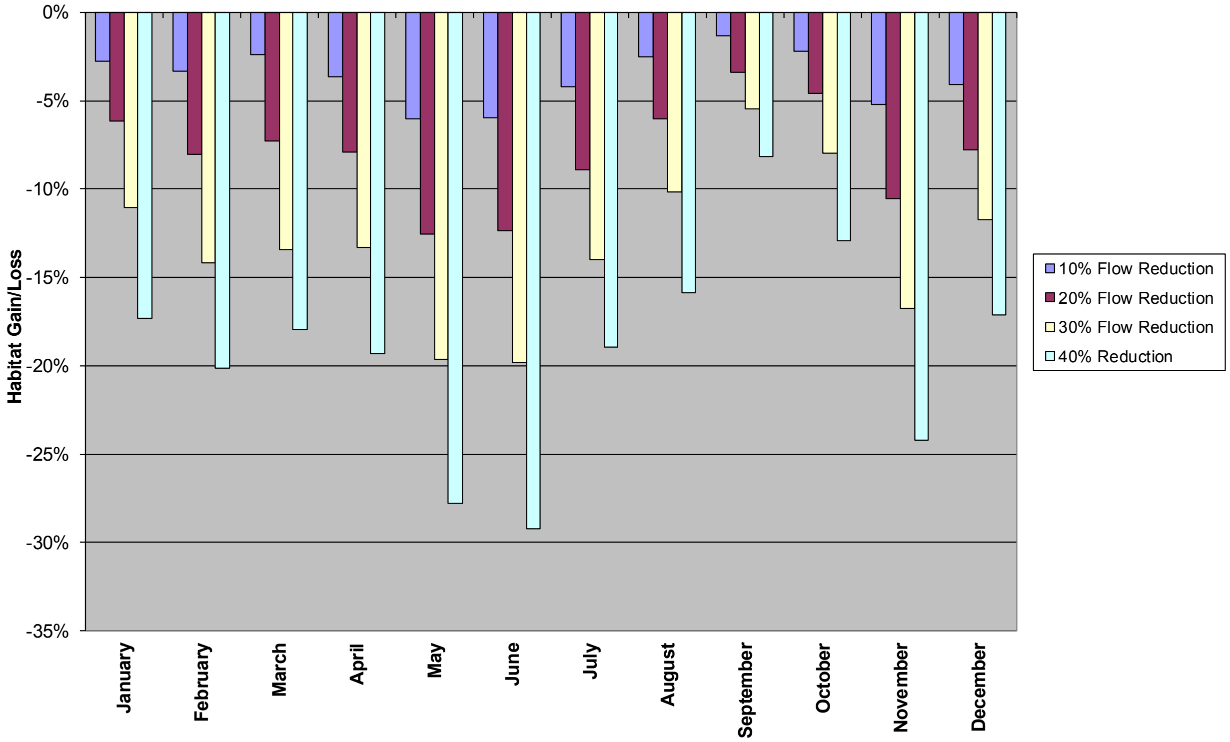
Deep-Fast Fish Habitat Guild (1990-2000)
Pithlachascotee River VEG 4

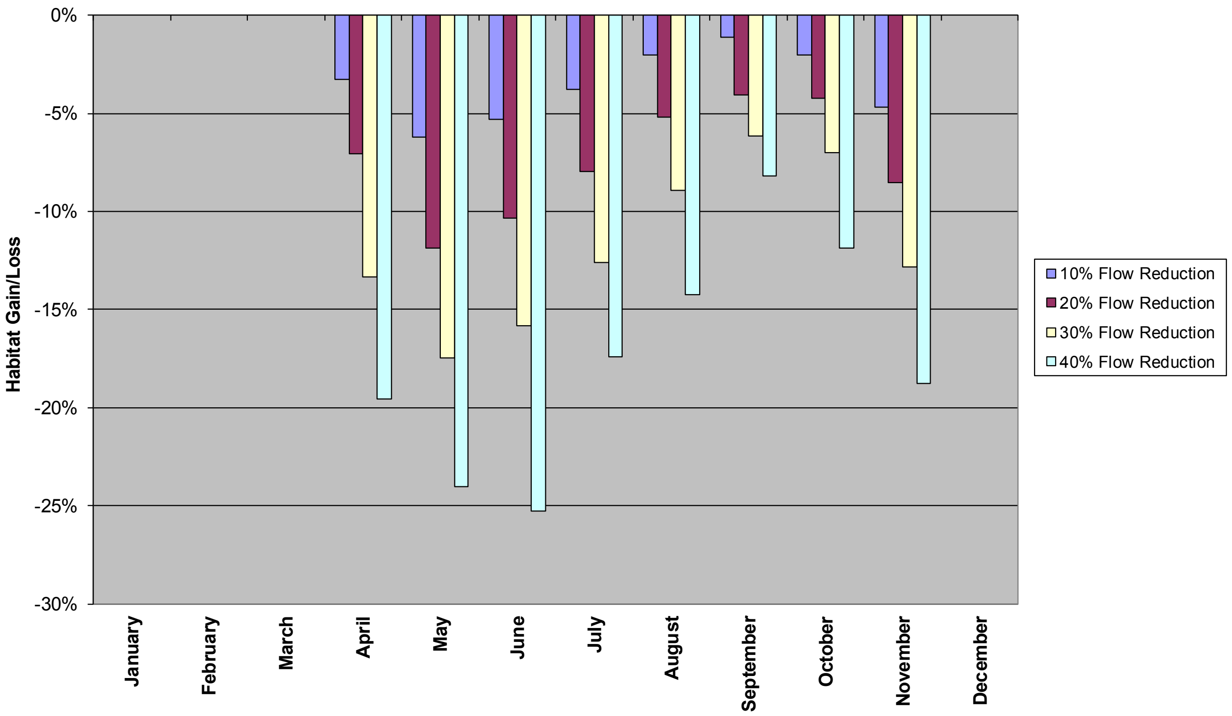


Adult Spotted Sunfish Adults (1990-2000)
Pithlachascotee River VEG 4

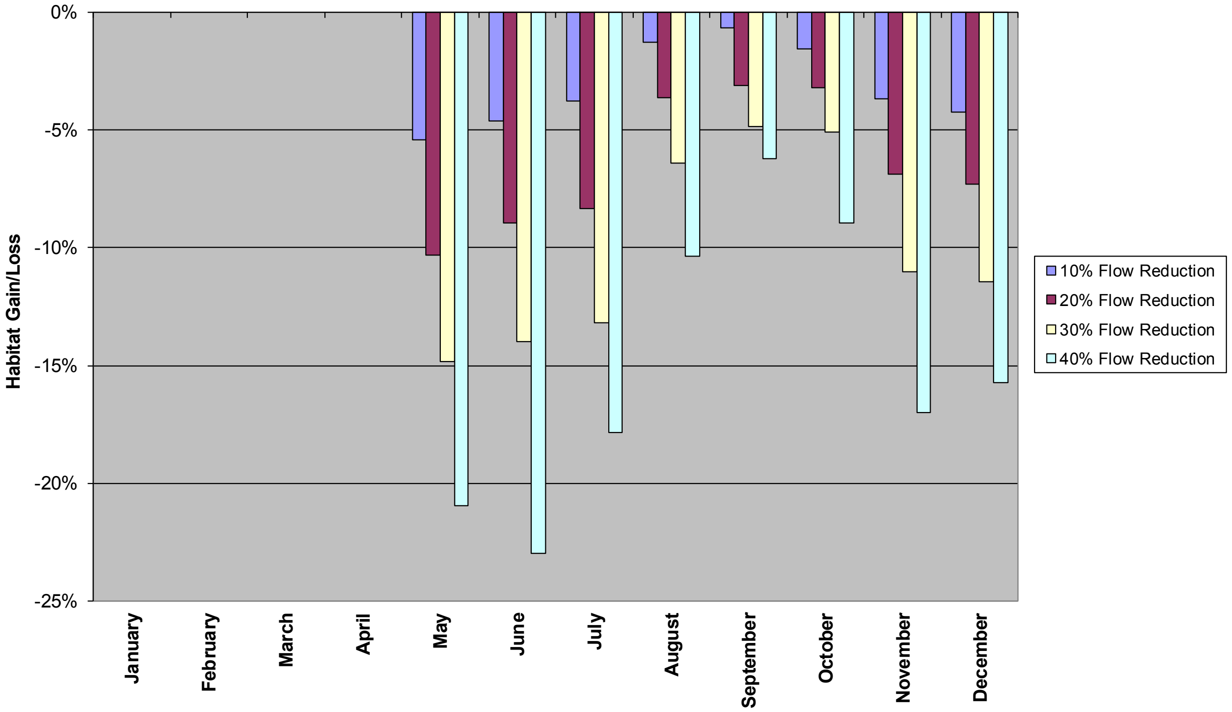


Spotted Sunfish Juveniles (1990-2000)
Pithlachascotee River VEG 4



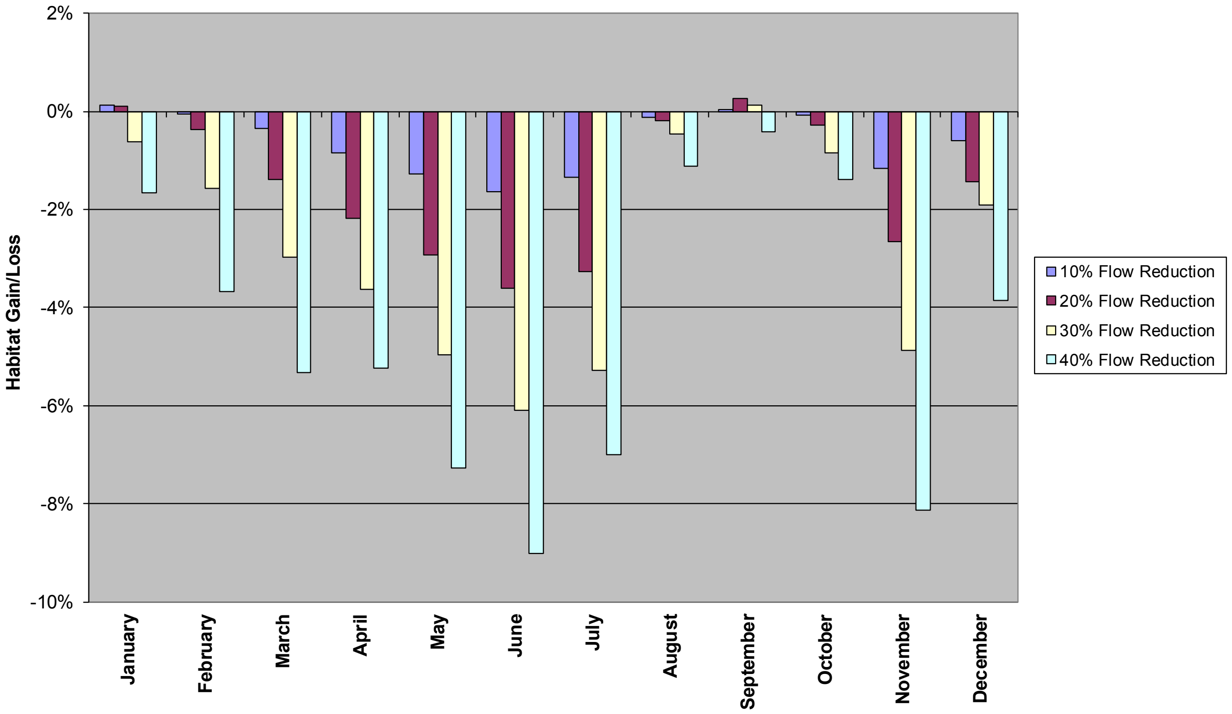


Spotted Sunfish Spawning (1990-2000
Pithlachascotee River VEG 4

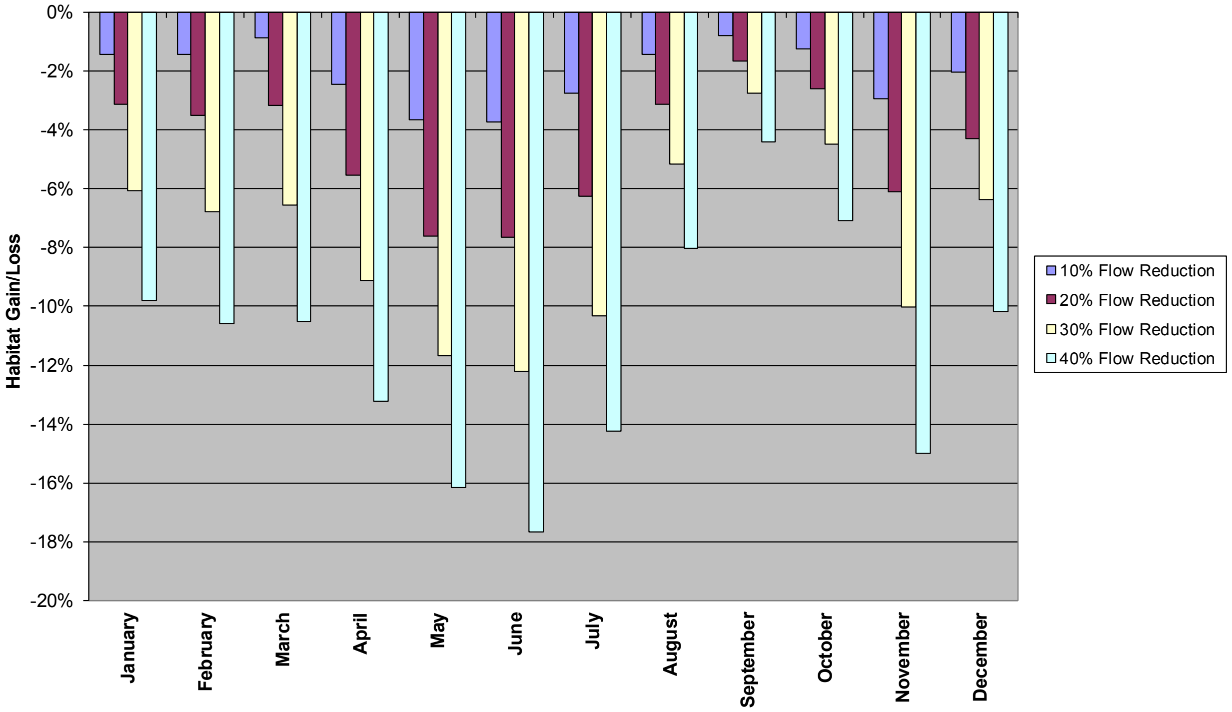


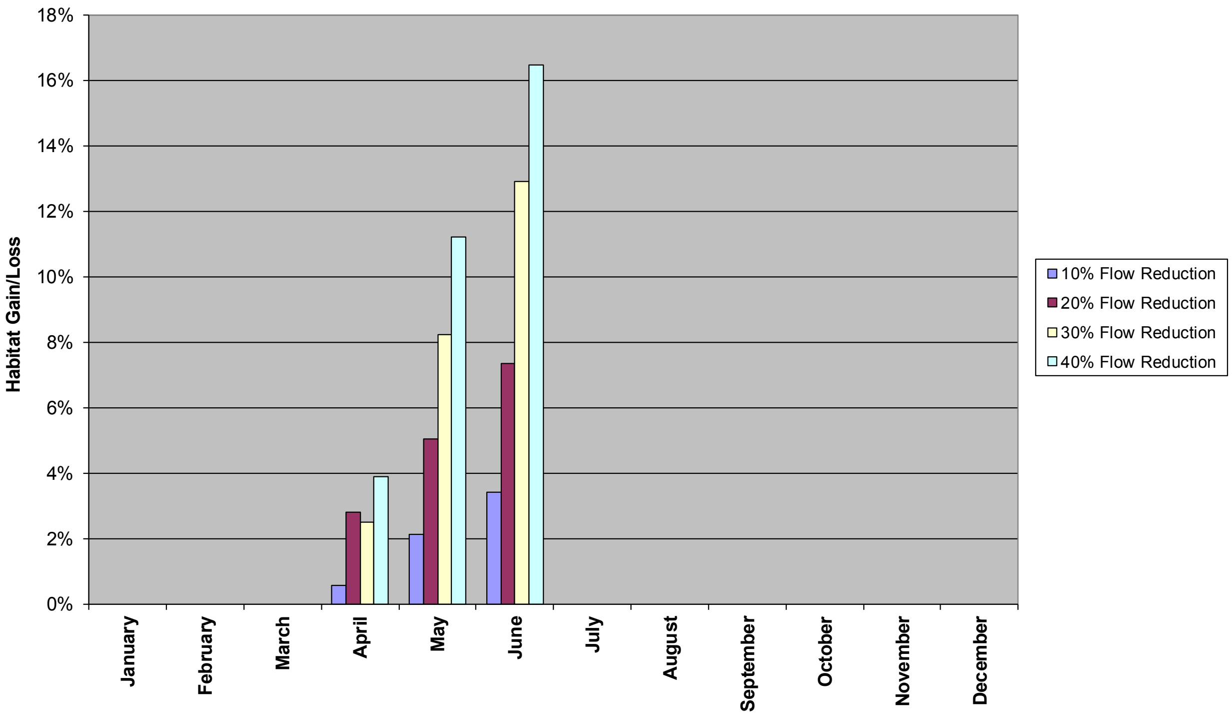
Spotted Sunfish Fry (1990-2000)
Pithlachascotee River VEG 4

Laregemouth Bass Adults (1990-2000)
Pithlachascotee River VEG 4

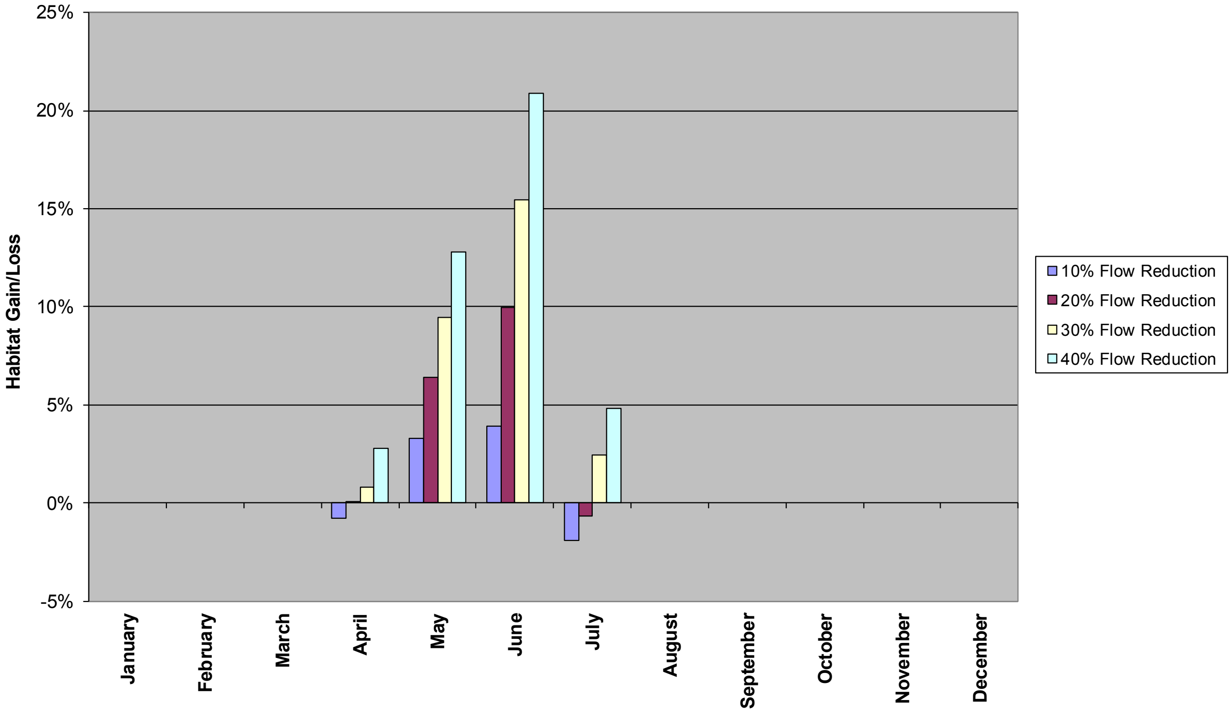


Largemouth Bass Juveniles (1990-2000)
Pithlachascotee River VEG 4

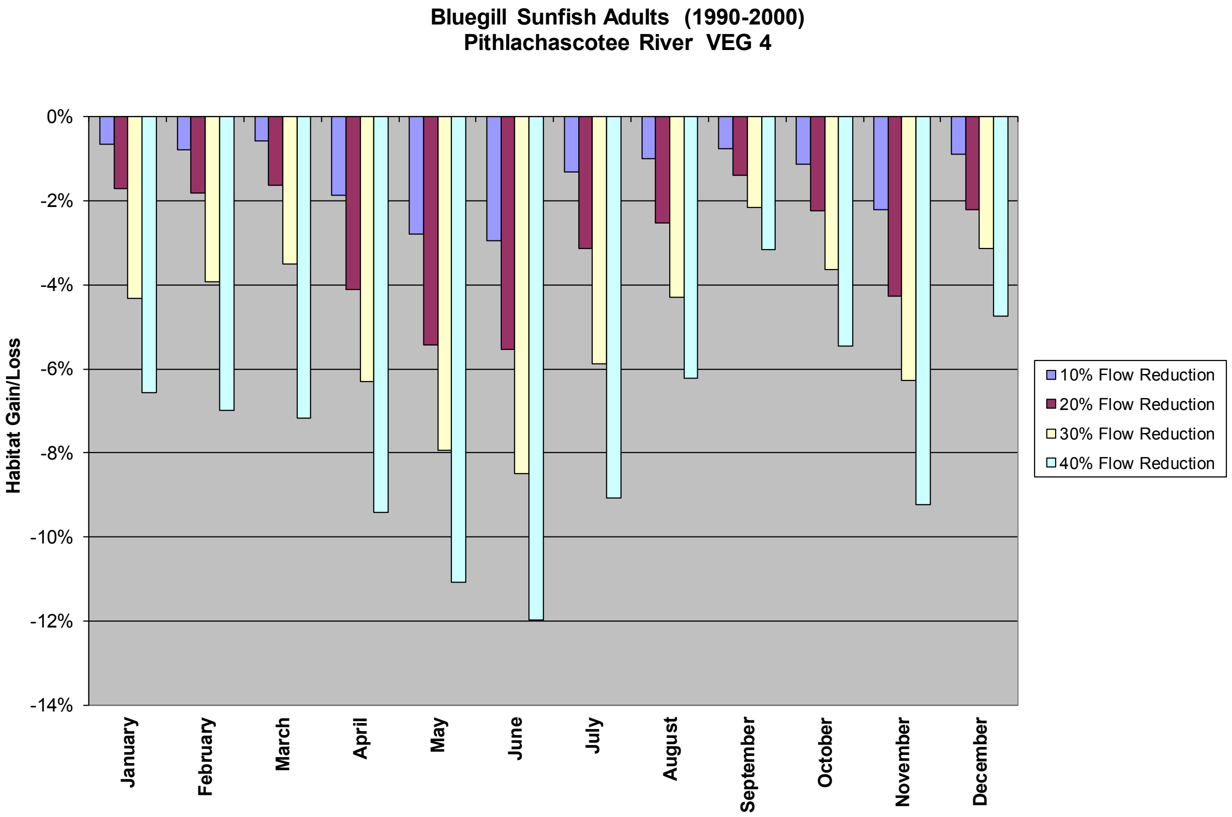


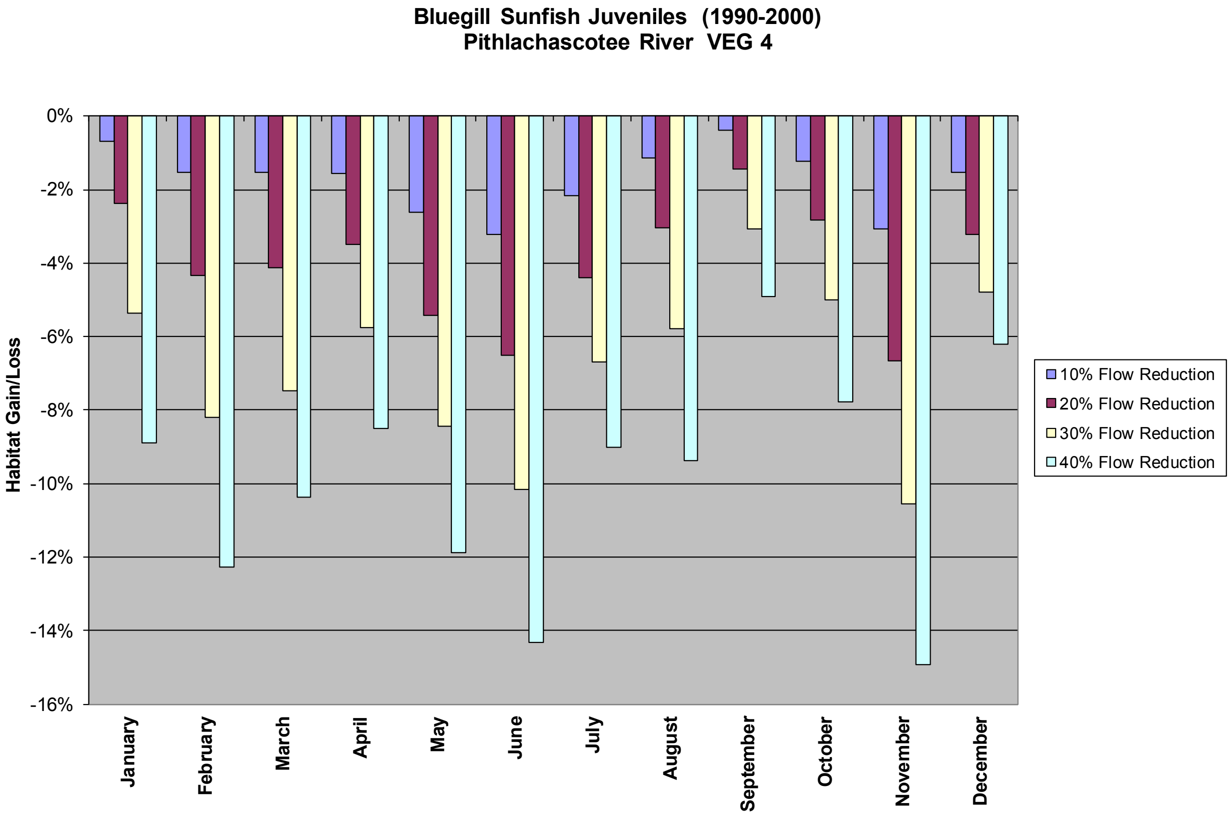


Largemouth Bass Spawning (1990-2000)
Pithlachascotee River VEG 4

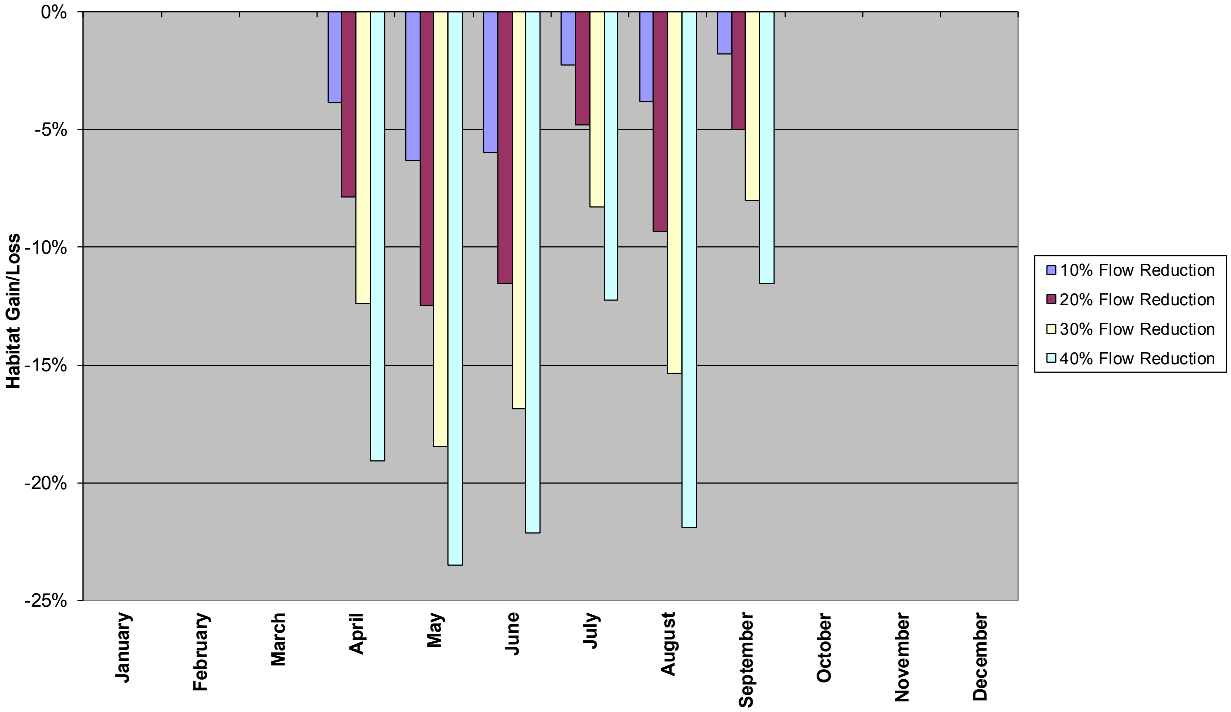


Largemouth Bass Fry (1990-2000)
Pithlachascotee River VEG 4

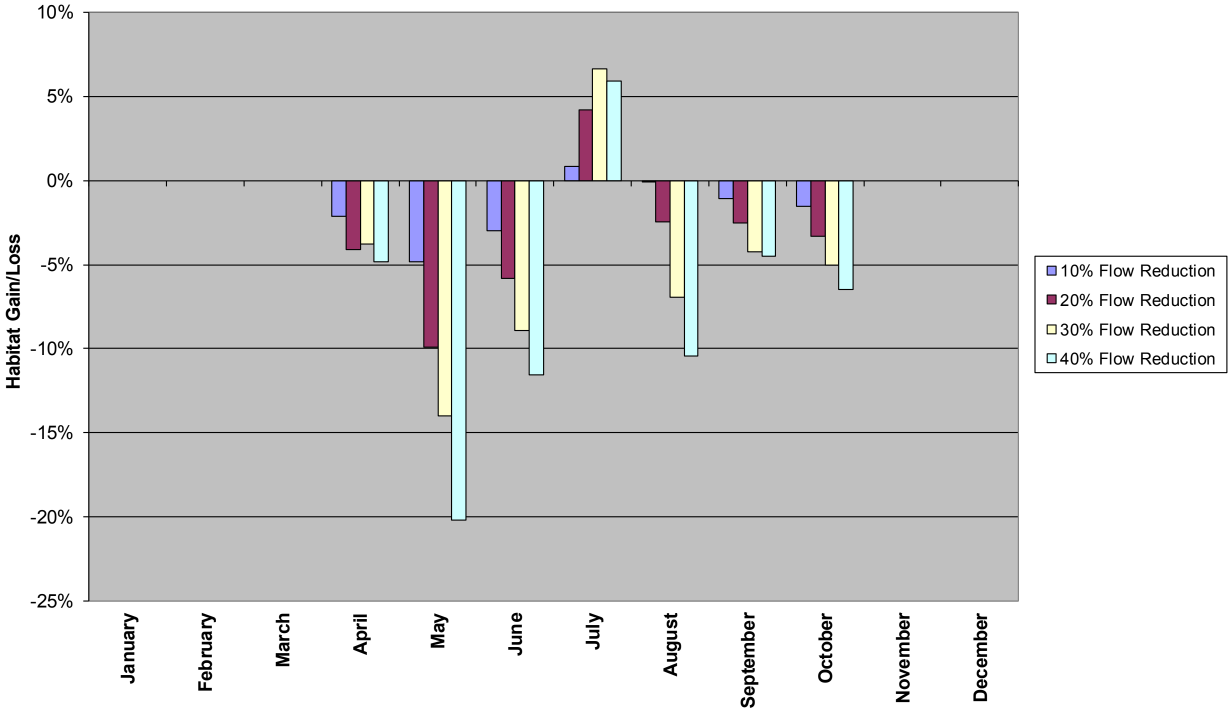

Bluegill Sunfish Adults (1990-2000)
Pithlachascotee River VEG 4
Habitat Gain/Loss
0%
-2%
-4%
-6%
-8%
-10%
-12%
-14%
January
February
March
April
May
June
July
August
September
October
November
December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction


Bluegill Sunfish Juveniles (1990-2000)
Pithlachascotee River VEG 4
Habitat Gain/Loss
0%
-2%
-4%
-6%
-8%
-10%
-12%
-14%
-16%
January
February
March
April
May
June
July
August
September
October
November
December
10% Flow Reduction
20% Flow Reduction
30% Flow Reduction
40% Flow Reduction

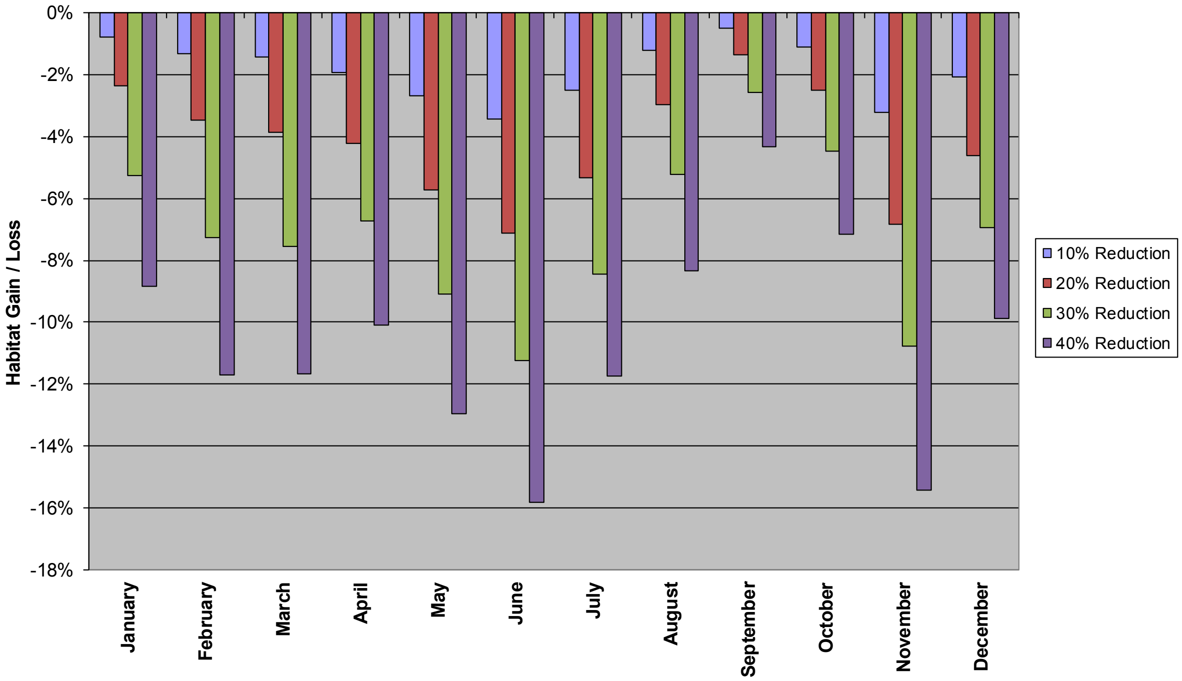
Bluegill Sunfish Spawning (1990-2000)
Pithlachascotee River VEG 4



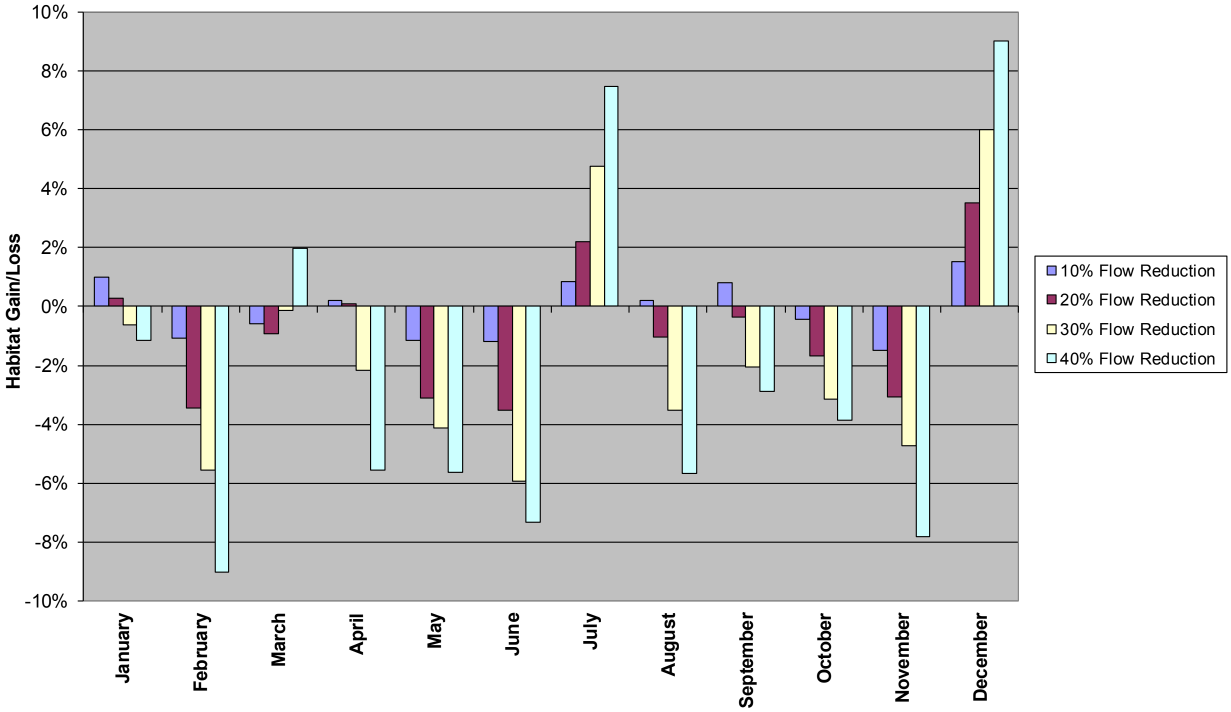
Bluegill Sunfish Fry (1990-2000)
Pithlachascotee River VEG 4



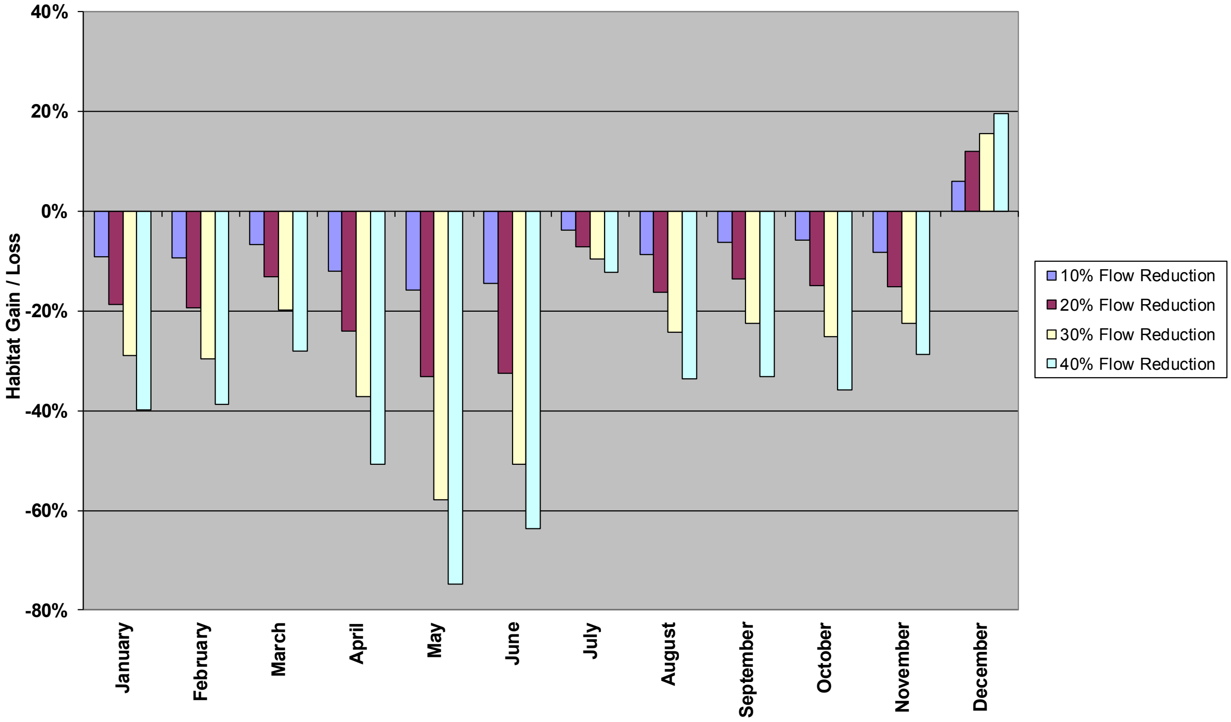
Cyprinidae - (1990-2000)
Pithlachascotee River VEG 4



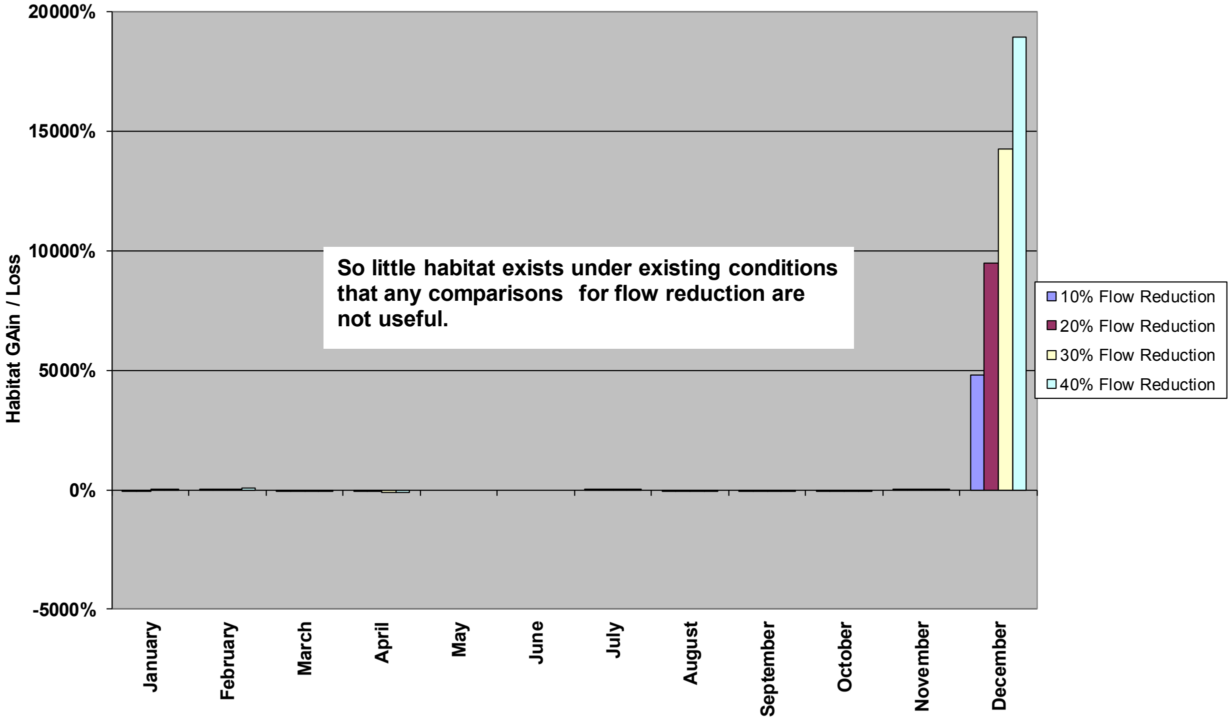
Benthic Macroinvertebrates (1990-2000)
Pithlachascotee River VEG 4



Shallow-Slow Fish Habitat Guild (1990-2000)
Pithlachascotee River - VEG 14

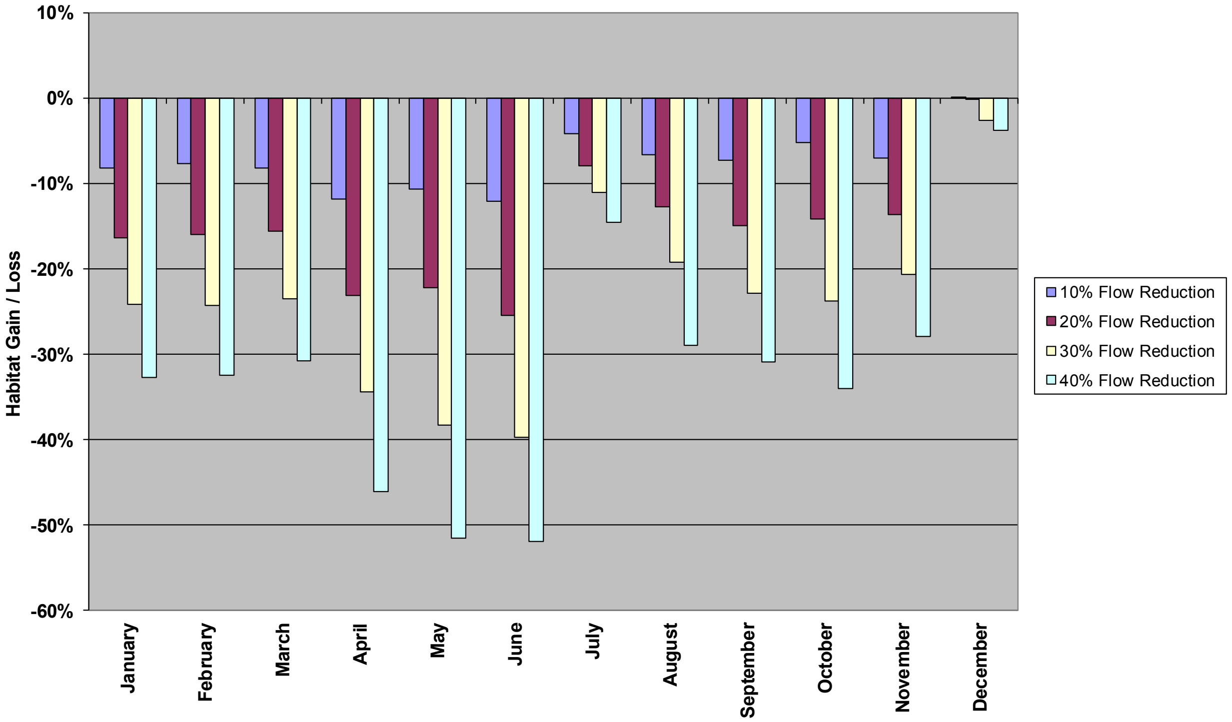


Shallow-Fast Fish Habitat Guild (1990-2000)
Pithlachascotee River VEG 14

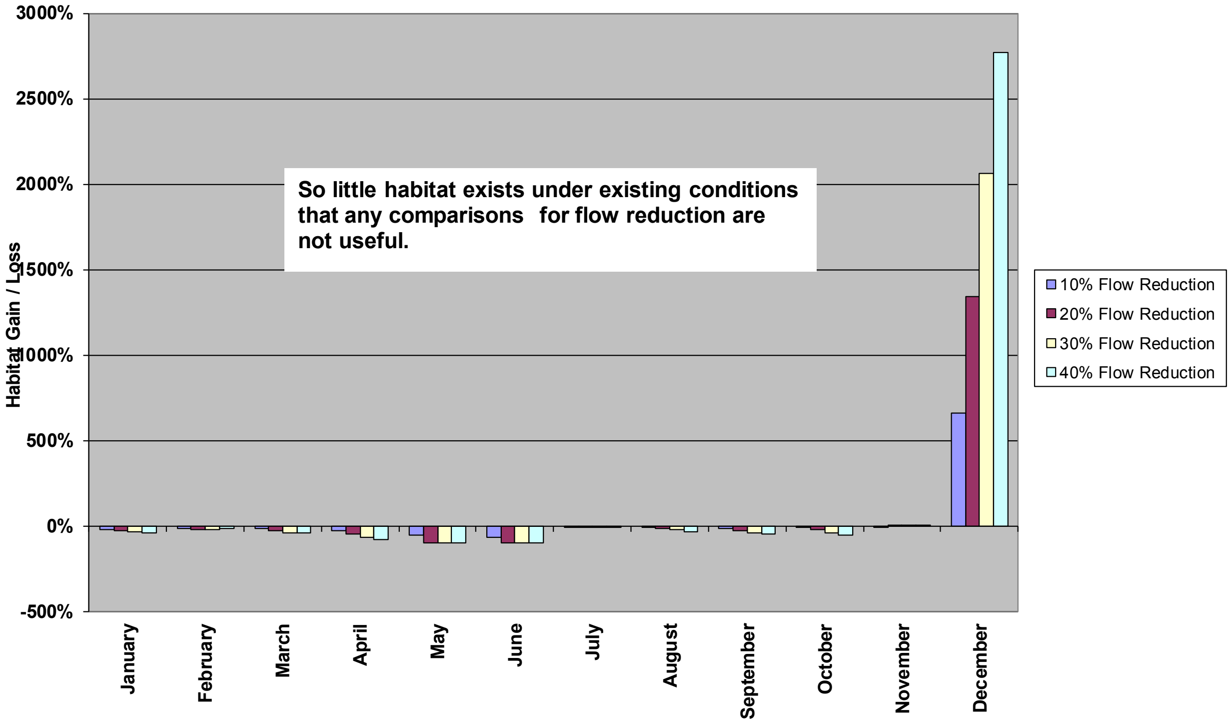


So little habitat exists under existing conditions that any comparisons for flow reduction are not useful.

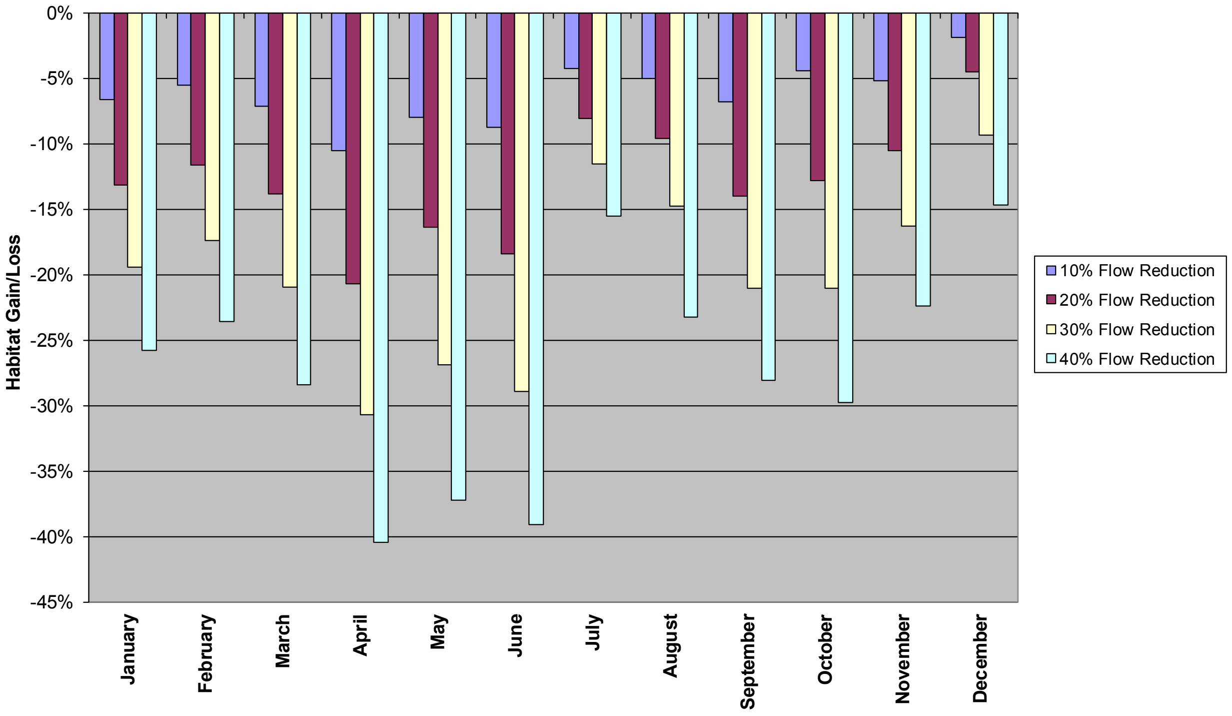
Deep-Slow Fish Habitat Guild (1990-2000)
Pithlachascotee River VEG 14



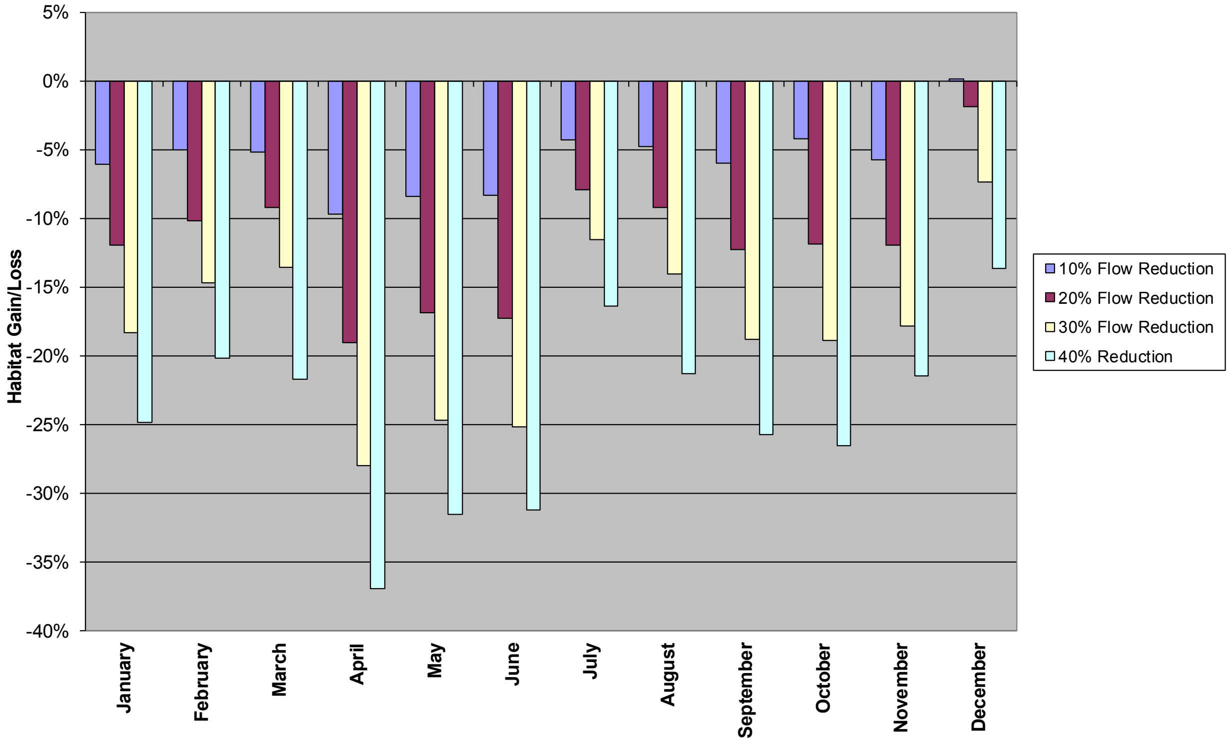
Deep-Fast Fish Habitat Guild (1990-2000)
Pithlachascotee River VEG 14

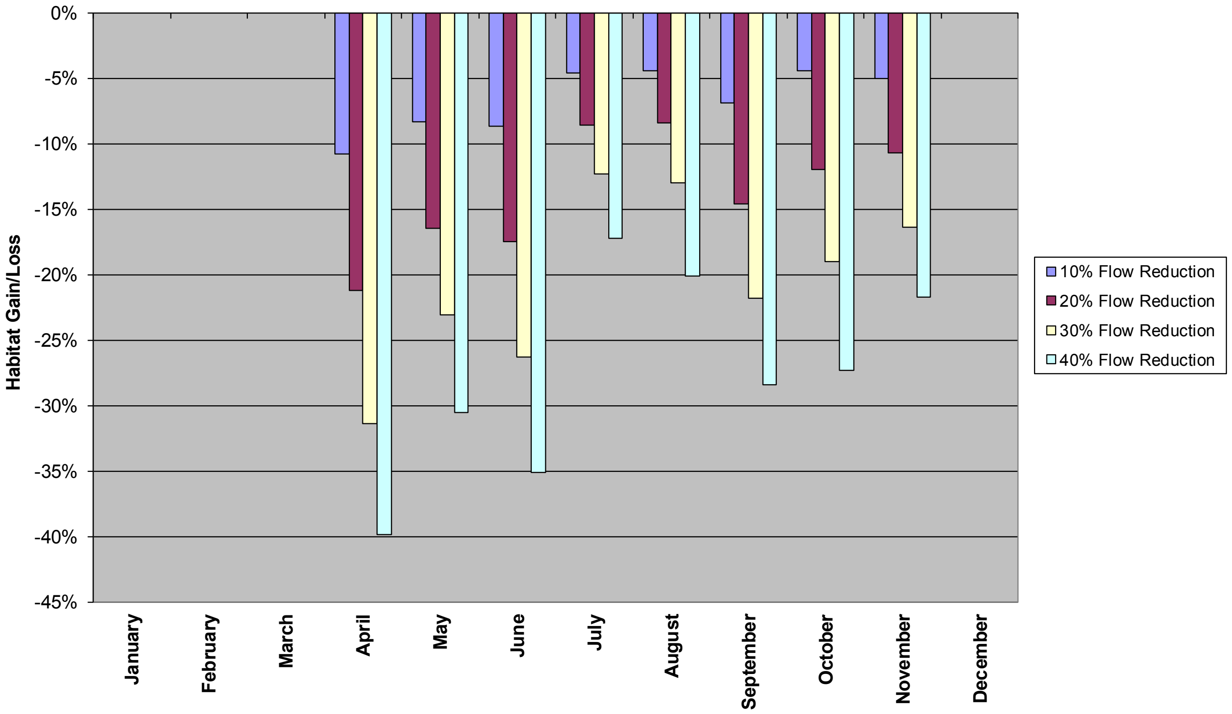

So little habitat exists under existing conditions that any comparisons for flow reduction are not useful.

Adult Spotted Sunfish Adults (1990-2000)
Pithlachascotee River VEG 14

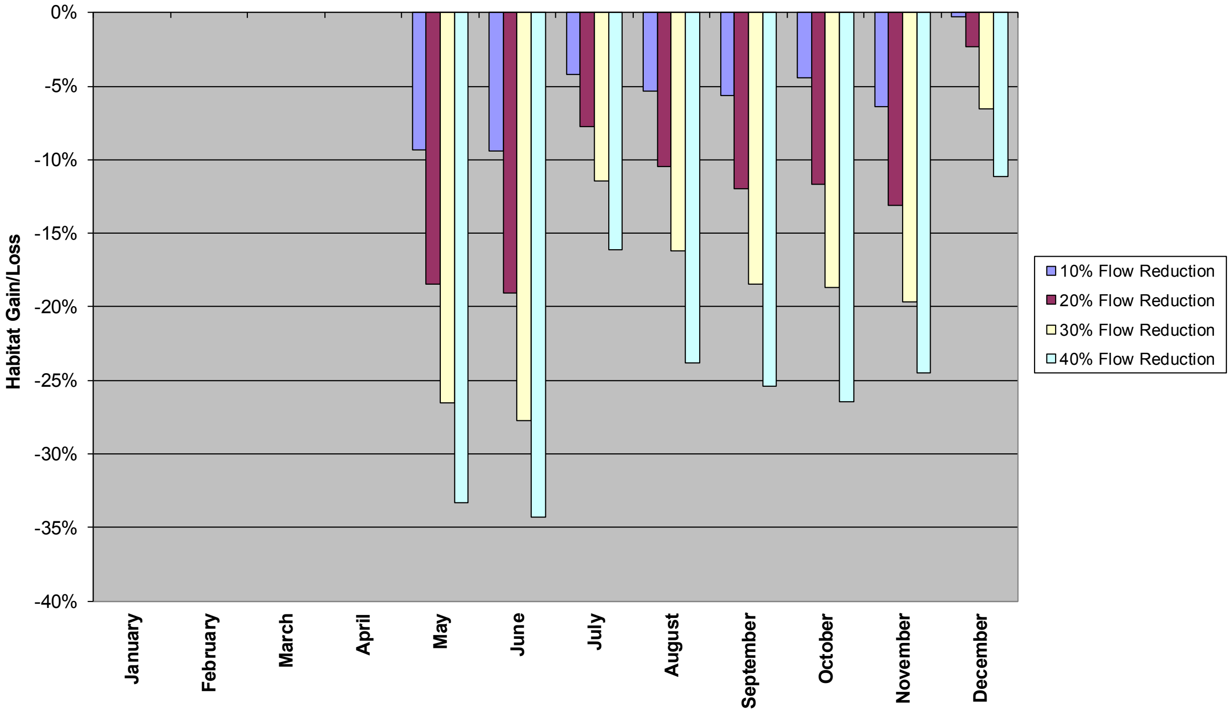


Spotted Sunfish Juveniles (1990-2000)
Pithlachascotee River VEG 14



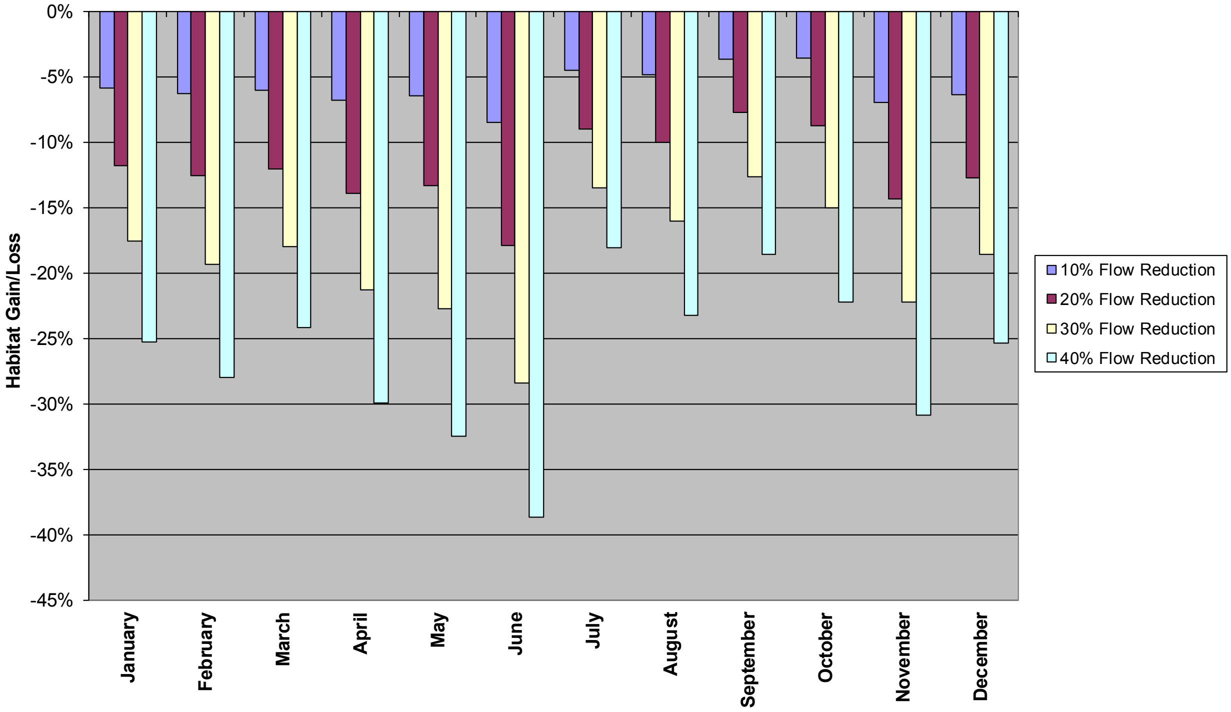


Spotted Sunfish Spawning (1990-2000
Pithlachascotee River VEG 14

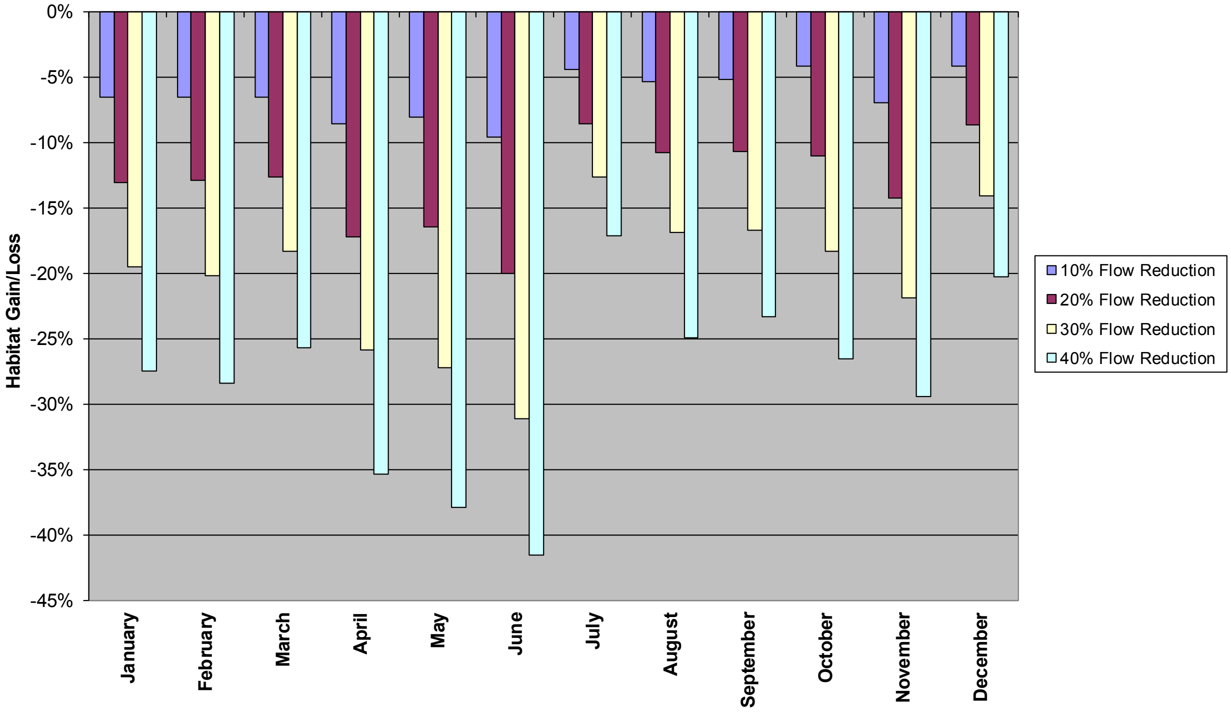


Spotted Sunfish Fry (1990-2000)
Pithlachascotee River VEG 14

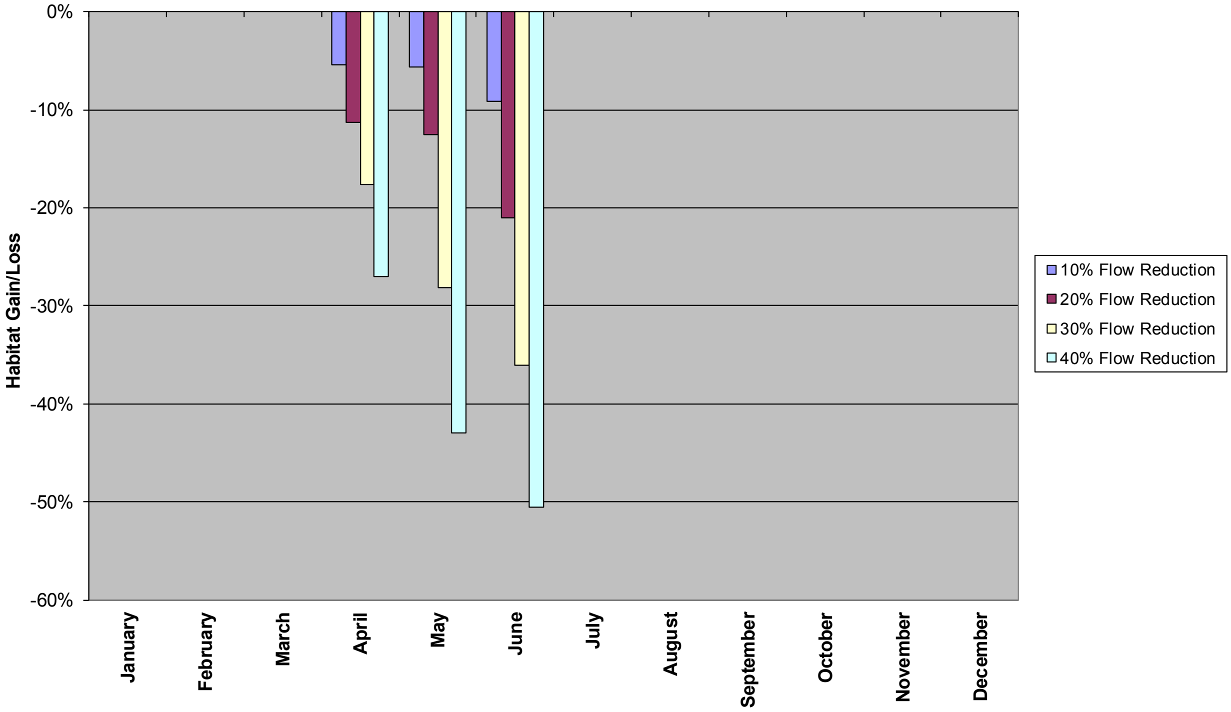
Laregemouth Bass Adults (1990-2000)
Pithlachascotee River VEG 14



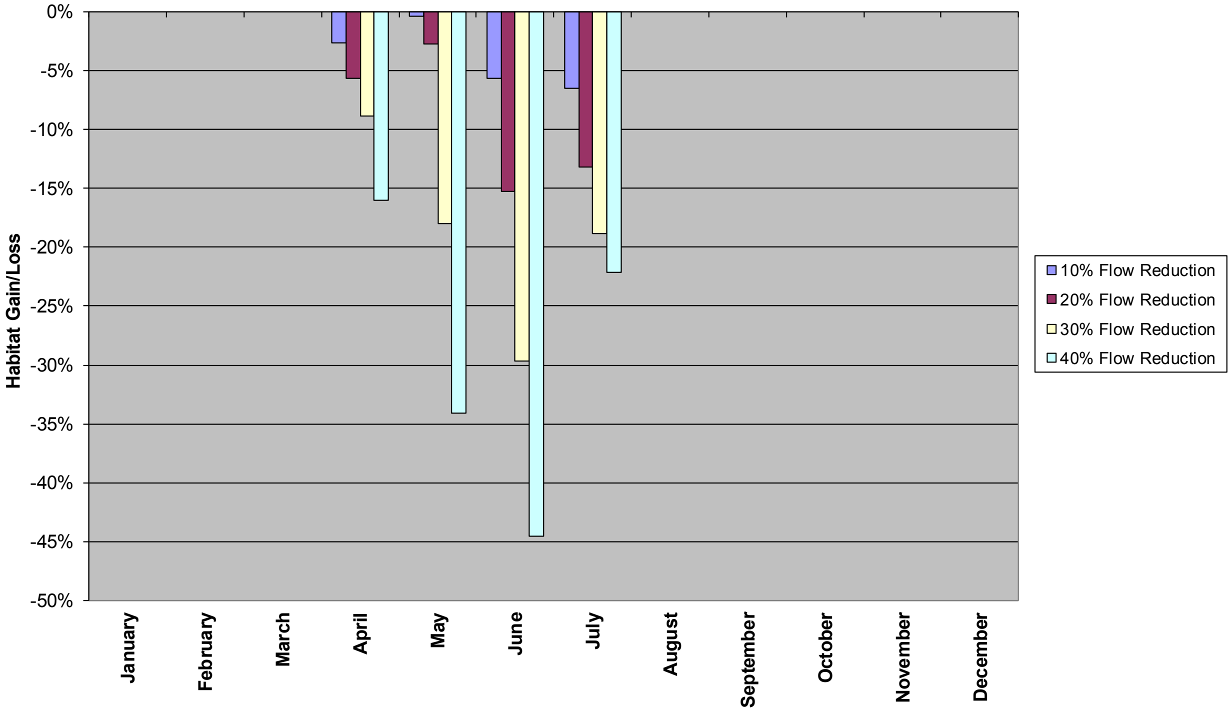
Largemouth Bass Juveniles (1990-2000)
Pithlachascotee River VEG 14



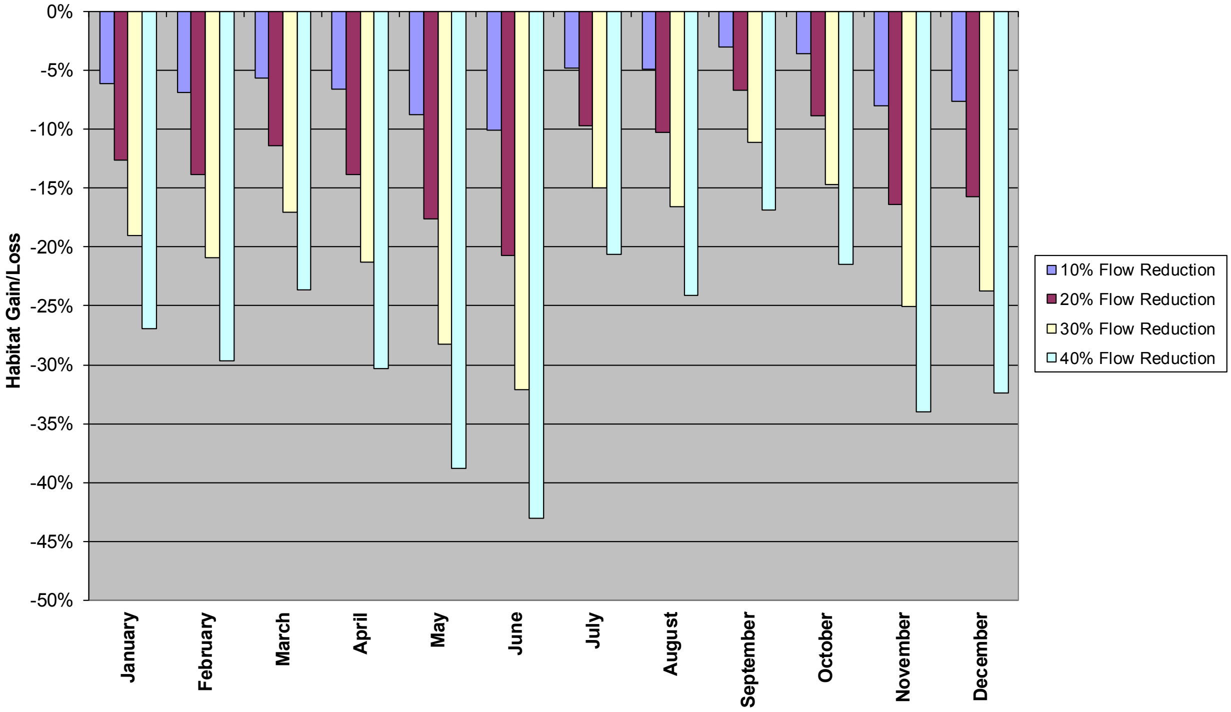
Largemouth Bass Spawning (1990-2000)
Pithlachascotee River VEG 14



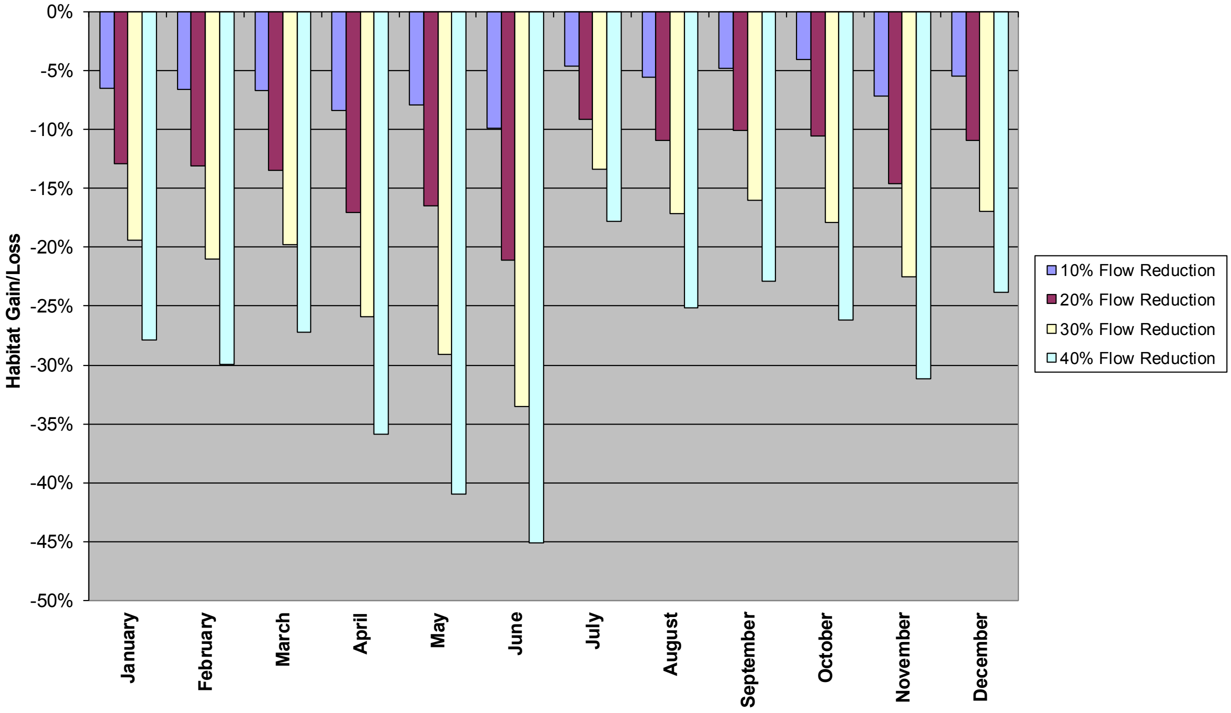
Largemouth Bass Fry (1990-2000)
Pithlachascotee River VEG 14



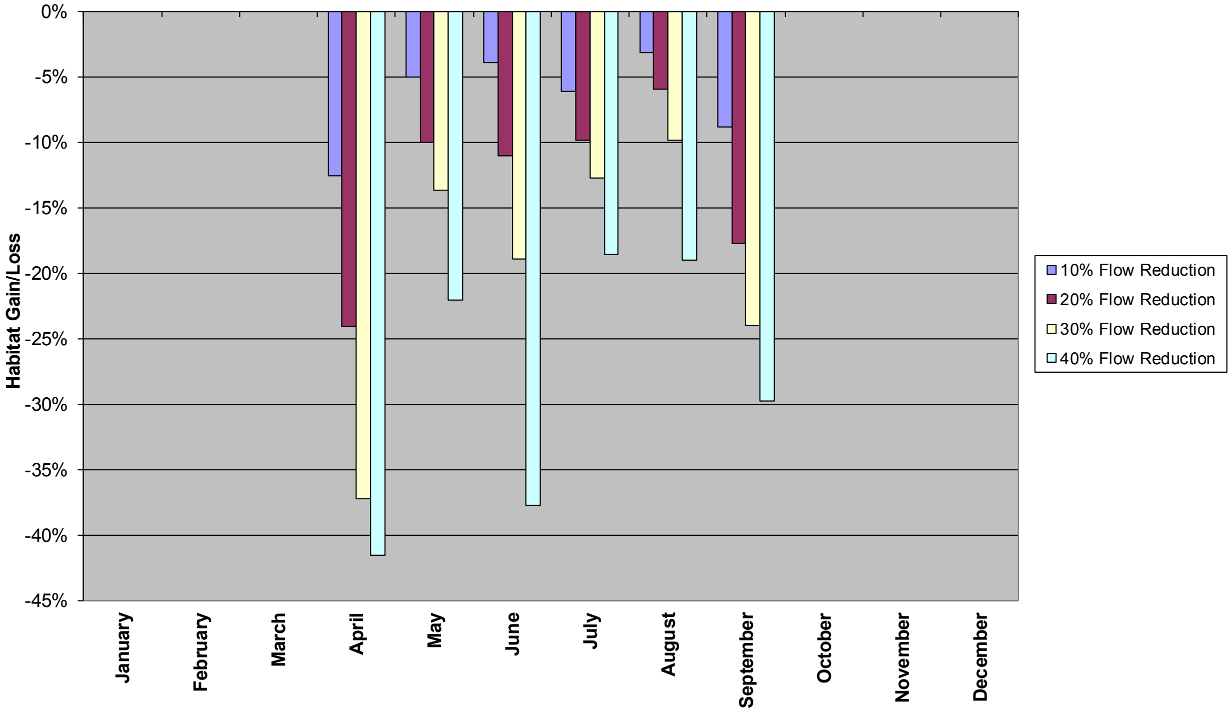
Bluegill Sunfish Adults (1990-2000)
Pithlachascotee River VEG 14



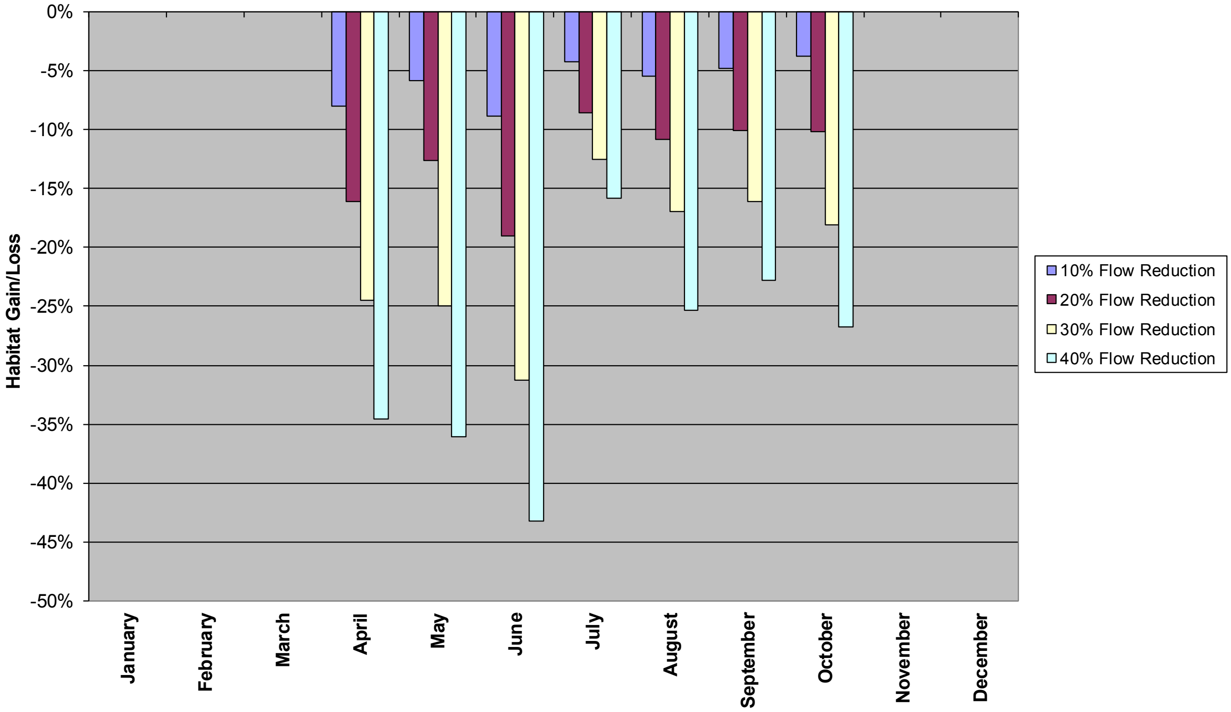
Bluegill Sunfish Juveniles (1990-2000)
Pithlachascotee River VEG 14

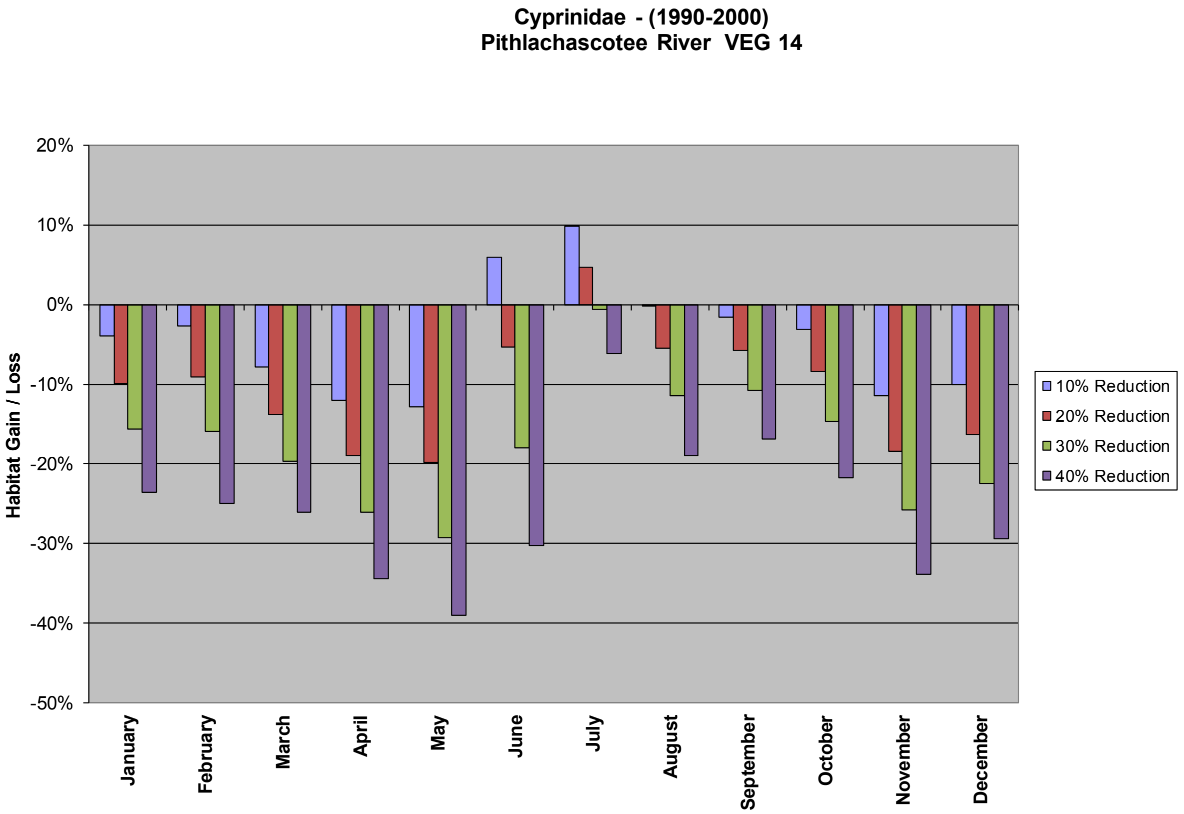


Bluegill Sunfish Spawning (1990-2000)
Pithlachascotee River VEG 14

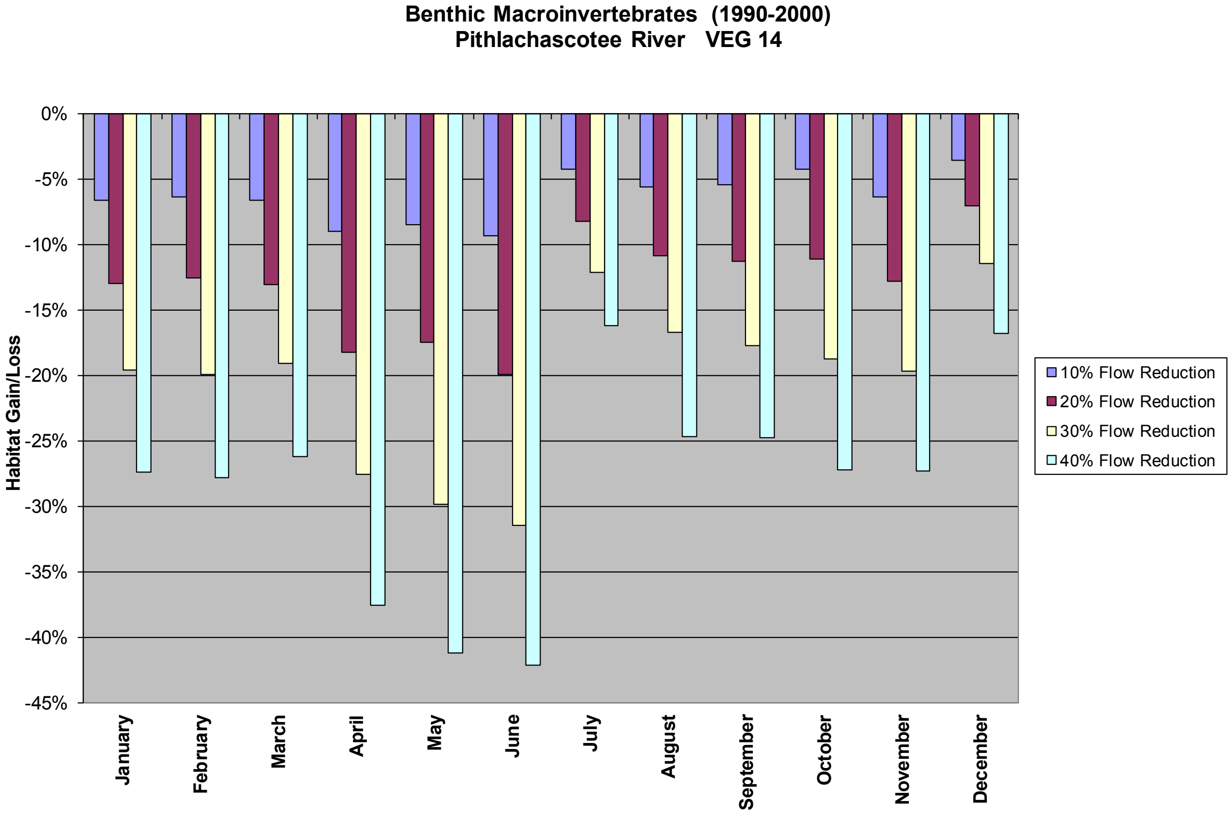


Bluegill Sunfish Fry (1990-2000)
Pithlachascotee River VEG 14





Cyprinidae - (1990-2000)
Pithlachascotee River VEG 14



Benthic Macroinvertebrates (1990-2000)
Pithlachascotee River VEG 14

APPENDIX 6A

Email and attachment from Carolyn Voyles to Mike Heyl, dated November 18, 2014. Subject: DEP comment on the draft Pithlachascotee River MFL report. Florida Department of Environmental Protection. Tallahassee, Florida.

From: Voyles, Carolyn [mailto:Carolyn.Voyles@dep.state.fl.us]
Sent: Tuesday, November 18, 2014 6:26 PM
To: Mike Heyl
Cc: Greenwood, Kathleen; Beck, Tom; Llewellyn, Janet

Subject: DEP Comments on the Draft Pithlachascotee River MFL Report

Hi Mike,

Attached are DEP's comments on the draft Pithlachascotee River MFL Report. The comments came from staff in DEP's TMDL and Biology Sections, as well as the Office of Water Policy. We are concerned that some of the approaches used in this report appear to be different from earlier MFL methodologies. We hope that our comments will be helpful as the district moves forward with MFL development for this river.

If you have any questions, please let me know.

--Carolyn

Carolyn Voyles
Office of Water Policy
FL Dept. of Environmental Protection
3900 Commonwealth Blvd., MS 46
Tallahassee, FL 32399-3000
(850) 245-3150 (office)
(850) 245-3145 (fax)

Recommended Minimum Flows for the Pithlachascotee River – Peer Review Draft
DEP Comments – 11-18-14

1. The report would benefit from a thorough editorial review. Throughout the document there are a number of editorial errors related to grammar, spelling, figure legends, table formatting (e.g. tables overlapping report text), and literature citations that need to be addressed in the report. Some examples are (but not limited to):

   - Miller's Bayou, first mentioned on page 3-1 and mentioned a number of times afterwards, does not appear on any map in the document.

   - The legends in Figures 5-1 and 5-2 are not meaningful; the colored lines need to have associated descriptions, and the items in the legend should be presented in numeric order.

   - In Chapter 5, there is more than one WAR 2010 document, and the specific document being referenced usually is not identified.

   - There are <u>many</u> table and figure reference errors in Chapter 7.

2. In Figure 2-2, the USGS flow gage near New Port Richey does not appear to be labeled correctly. The gage number is 02310300, but the gage is labeled as 02310800 in the figure. For clarity, it would be helpful to include in the labels the gage name along with the gage number for all the gages shown. It also would be helpful to label the geographic features identified in Section 2.2, such as Fivemile Creek, on this map.

3. Section 2.6 presents a summary of land use information for the years 1974, 1990, and 2007. Land use data are also available for 2011 and would better represent current land use in the watershed. Also, in this section, the map legends for Figures 2-4 through 2-6 are nearly illegible and they should be exported at a higher resolution to correct this problem.

4. Figure 2-13, shows a frequency distribution curve for flows at the Pithlachascotee River near New Port Richey gage for the period of record (April 1963 – September 2013). Table 7-1 presents percentile values at the same gage location. What is the dataset period for the gaged flow percentiles shown in the second column in the table? The flow percentiles in the second column do not appear to match the percentiles displayed in Figure 2-13.

5. In Table 2-15, the results appear reversed for the early and recent time periods. (Compare this table with the text in the last paragraph of page 2-31 and with Figure 2-31.)

6. Section 2.10 mentions that analyses of the residuals negatively affected the fit regression at low flows, so the regression was limited to flows greater than 1.6 cfs, and the model output was used when flows were less than 1.6 cfs. Please discuss further the ramifications of this methodology.

7. Section 2.13 briefly discusses the statistically significant trends in the Pithlachascotee, and states that chloride, iron, magnesium, potassium and sodium are indicative of rock, and cites FGS 2009 for this assessment. The cited work is not in the references, nor is it listed as Copeland et al within the references. This is a minor point; however, the fact that Copeland et al 2009 (see table below) does not indicate that chloride or sodium are indicative of the rock matrix should be addressed. Furthermore, these constituents can be indicative of fertilizers (nutrients) from runoff or from seawater (see Ward 2001 and Pilson 1998 below). Additionally, Copeland et al 2009 list fluoride as indicative of the rock matrix. Unlike the other five elements, this one has a significantly decreasing trend. These trends should be further explored and explained. Also, the rates of increase or decrease of the analytes would be helpful considering how small the slopes are (Table 2-19).

Table 5 from FGS 2009:

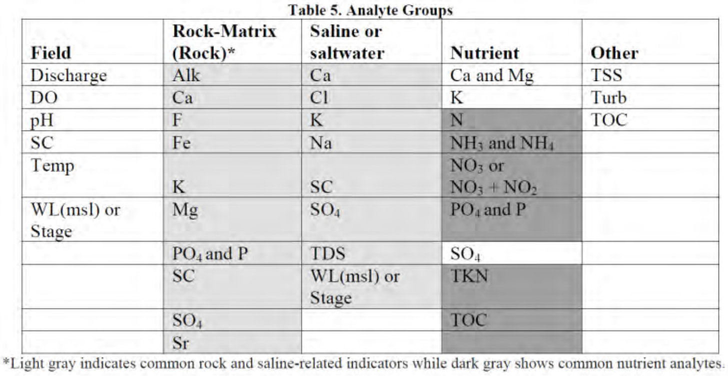
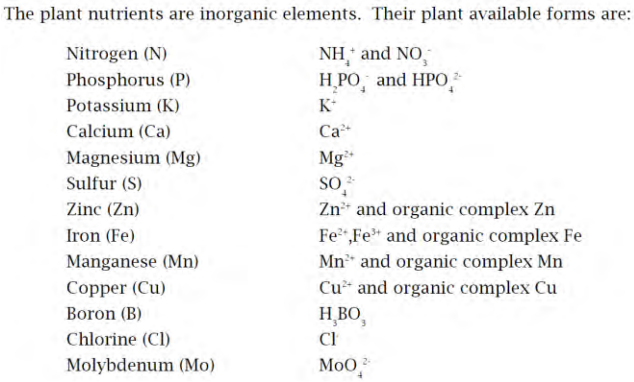


Table 5. Analyte Groups

Field	**Rock-Matrix (Rock)***	**Saline or saltwater**	**Nutrient**	**Other**
Discharge	Alk	Ca	Ca and Mg	TSS
DO	Ca	Cl	K	Turb
pH	F	K	N	TOC
SC	Fe	Na	NH_3 and NH_4	
Temp	K	SC	NO_3 or $NO_3 + NO_2$	
WL(msl) or Stage	Mg	SO_4	PO_4 and P	
	PO_4 and P	TDS	SO_4	
	SC	WL(msl) or Stage	TKN	
	SO_4		TOC	
	Sr			

*Light gray indicates common rock and saline-related indicators while dark gray shows common nutrient analytes.

Ward 2001:



The plant nutrients are inorganic elements. Their plant available forms are:

Nitrogen (N)	NH_4^+ and NO_3^-
Phosphorus (P)	$H_2PO_4^-$ and HPO_4^{2-}
Potassium (K)	K^+
Calcium (Ca)	Ca^{2+}
Magnesium (Mg)	Mg^{2+}
Sulfur (S)	SO_4^{2-}
Zinc (Zn)	Zn^{2+} and organic complex Zn
Iron (Fe)	Fe^{2+},Fe^{3+} and organic complex Fe
Manganese (Mn)	Mn^{2+} and organic complex Mn
Copper (Cu)	Cu^{2+} and organic complex Cu
Boron (B)	H_3BO_3
Chlorine (Cl)	Cl^-
Molybdenum (Mo)	MoO_4^{2-}

Pilson 1998:

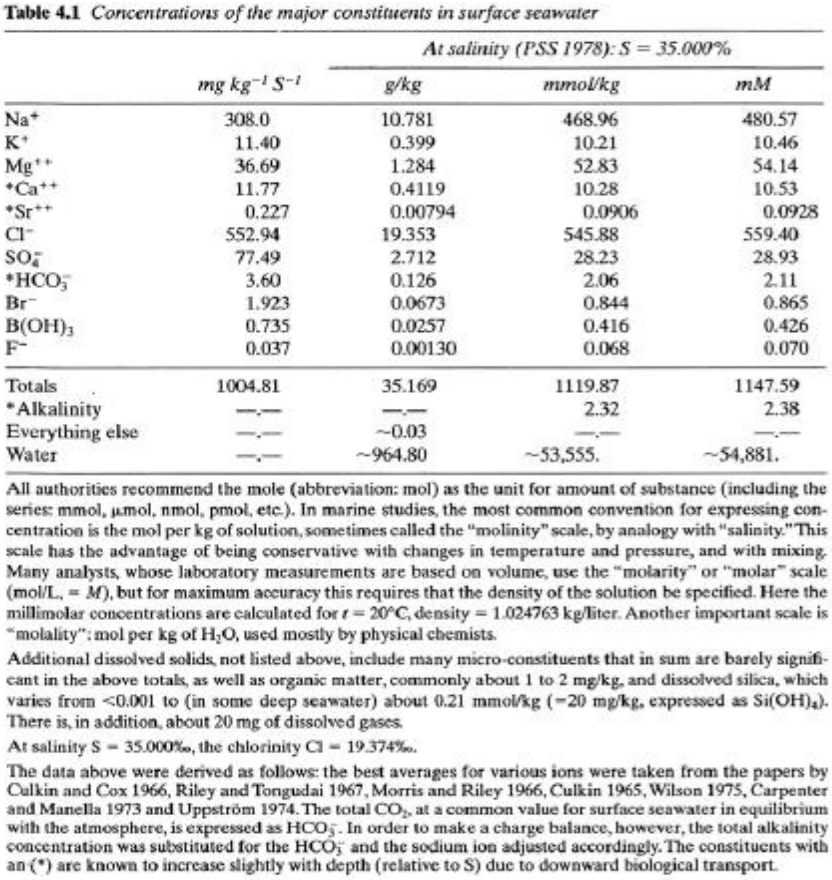


Table 4.1 *Concentrations of the major constituents in surface seawater*

		At salinity (PSS 1978): S = 35.000%		
	mg kg⁻¹ S⁻¹	*g/kg*	*mmol/kg*	*mM*
Na^+	308.0	10.781	468.96	480.57
K^+	11.40	0.399	10.21	10.46
Mg^{++}	36.69	1.284	52.83	54.14
*Ca^{++}	11.77	0.4119	10.28	10.53
*Sr^{++}	0.227	0.00794	0.0906	0.0928
Cl^-	552.94	19.353	545.88	559.40
$SO_4^=$	77.49	2.712	28.23	28.93
*HCO_3^-	3.60	0.126	2.06	2.11
Br^-	1.923	0.0673	0.844	0.865
$B(OH)_3$	0.735	0.0257	0.416	0.426
F^-	0.037	0.00130	0.068	0.070
Totals	1004.81	35.169	1119.87	1147.59
*Alkalinity	—.—	—.—	2.32	2.38
Everything else	—.—	~0.03	—.—	—.—
Water	—.—	~964.80	~53,555.	~54,881.

All authorities recommend the mole (abbreviation: mol) as the unit for amount of substance (including the series: mmol, µmol, nmol, pmol, etc.). In marine studies, the most common convention for expressing concentration is the mol per kg of solution, sometimes called the "molinity" scale, by analogy with "salinity." This scale has the advantage of being conservative with changes in temperature and pressure, and with mixing. Many analysts, whose laboratory measurements are based on volume, use the "molarity" or "molar" scale (mol/L, = *M*), but for maximum accuracy this requires that the density of the solution be specified. Here the millimolar concentrations are calculated for $t = 20°C$, density = 1.024763 kg/liter. Another important scale is "molality": mol per kg of H_2O, used mostly by physical chemists.

Additional dissolved solids, not listed above, include many micro-constituents that in sum are barely significant in the above totals, as well as organic matter, commonly about 1 to 2 mg/kg, and dissolved silica, which varies from <0.001 to (in some deep seawater) about 0.21 mmol/kg (~20 mg/kg, expressed as $Si(OH)_4$). There is, in addition, about 20 mg of dissolved gases.

At salinity S = 35.000‰, the chlorinity Cl = 19.374‰.

The data above were derived as follows: the best averages for various ions were taken from the papers by Culkin and Cox 1966, Riley and Tongudai 1967, Morris and Riley 1966, Culkin 1965, Wilson 1975, Carpenter and Manella 1973 and Uppström 1974. The total CO_2, at a common value for surface seawater in equilibrium with the atmosphere, is expressed as HCO_3^-. In order to make a charge balance, however, the total alkalinity concentration was substituted for the HCO_3^- and the sodium ion adjusted accordingly. The constituents with an (*) are known to increase slightly with depth (relative to S) due to downward biological transport.

8. Regarding page 4-11, paragraph 2, how might sessile benthic communities be affected by not incorporating bottom isohalines into the final MFL analysis? How does this statement affect the information presented in Section 6.10.2?

9. Section 4.5 discusses the relationship between dissolved oxygen (DO) and freshwater inflow in the lower river. The report indicates that the freshwater segment (WBID 1409) has been assessed as impaired by EPA using the 5.0 mg/L DO standard. The report also mentions that FDEP has new DO standards based on percent saturation. It would be informative to explain in the report that neither the tidal nor the freshwater Pithlachascotee River WBIDs are listed as verified impaired for DO. Additionally, based on the latest preliminary assessment information, provided in the IWR Run 49 database, the tidal and freshwater segments are not identified as verified impaired when applying the new DO criteria. Additional information about the FDEP's current assessment of the river can be obtained by contacting Kevin O'Donnell (Kevin.ODonnell@dep.state.fl.us) in DEP's Watershed Assessment Program.

10. Chapter 5

    a. The biological data presented within the report appear to be from one sampling period, and do not include freshwater benthic macroinvertebrate data. DEP has conducted the stream condition index (SCI) at several sites in the freshwater portion of the Pithlachascotee and could provide the data should the District be interested.

    b. As the report indicates, the water levels under which the MFL studies were conducted were historically low water levels. Was there any attempt to discover the biological condition during historic higher flow periods, or even during the baseline period (though flows were reduced by withdrawals), to assess the biological potential within the river? I understand that the basis for the MFL determinations is habitat availability, so it is unclear what role this biological summary plays in the MFL development.

11. We followed the discussion in Section 6.8.1 regarding low thresholds. However, we did not understand the following statement in the Executive Summary (page xvii): "The low flow threshold does not apply to the management of groundwater withdrawals." This concept is new and is not discussed in Section 6.8.1 or elsewhere in the report. What does it mean? Aren't the waters of the river hydrologically connected to waters in the Upper Floridan aquifer? Is the district saying that groundwater withdrawals can occur even if they cause river drawdowns that end up below 25 cfs? If so, please explain further this interpretation.

12. It is unclear how the information in Chapters 6 and 7 are related to the different Block periods.

13. Figures 7-3 and 7-4 are difficult to interpret. The graphs might be easier to interpret if the results are presented in stacked columns. Also, please identify which transects are under discussion.

14. Section 7.3.2.3: In this section and for the remainder of the document, it is clear that the percent reduction that is proposed would cause a 15% loss of habitat, *on average*. That means that half of the river miles included in the assessments would lose more than 15% habitat or more than 15% of days of floodplain inundation. Using a lower percentile of the data for assessed transects would provide greater assurance that no greater than 15% of habitats are lost. For example, Table 7-3 shows that the allowable percent reduction of flow to maintain exposed roots ranged from 12-47%, with a mean of 19%. The 19% reduction proposed in this report (for Block 2) only protects 50% of transects measured. A flow reduction of 14% or 15% would protect 90% and 75% of transects, respectively. For other habitats, the mean flow reduction is presented as the recommended MFL, and would similarly only protect half of assessed portions of the river.

This methodology is different from the percent of flow methodology used in developing earlier MFLs, and use of a lower percentile seems warranted. For roots and snag habitats (see Table 7-3), why wasn't 9% chosen as the allowable flow reduction, since this is the smallest reduction that would protect 15% of the snag habitat, and presumably would protect the exposed root habitat (which had the smallest percentage at 12%) as well? Additionally, why weren't different analyses for Blocks 2 and 3 conducted? In Figure 6-2, the flows for these two blocks seem to be very different.

The following statement (pages 7-9 and 7-10) does not seem to be supported:

> "Using the baseline flows, long-term inundation analyses indicated that allowable percent-of-flow reductions of 19% and 22%, respectively, could occur without reducing the number of days of inundation of the habitats by 15% of [sic] more (Table 7-6 [sic])."

Those percentages might occur without reducing the *mean* number of days of inundation.

For this and other locations in the document where the *mean* is used, please provide the district's rationale for protecting only 50% of habitat, etc. 85% of the time.

15. On page 7-12, the transect map mentioned in the text needs to be included in the main document, as it affects Table 7-4, and Figures 7-8 and 7-10.
16. Section 7.3.3.4: It was difficult to discern the results of flow reduction on individual floodplain transects assessed with the tables and figures provided. Table 7-5 showed ranges of percent flow reduction associated with up to a 15% reduction of inundated days by floodplain feature, not individual transect, so there was a wide range for each one. If each point in Figure 7-11 represents a floodplain transect, then the approach of taking the mean flow reduction, even broken out by flow regime, may not sufficiently protect the floodplain hydroperiod. Please provide the district's rationale for not examining the inundation for individual transects.
17. In Section 7.5.2, the Figures appear to show 100% flow at 0 cfs. Please explain.
18. Chapter 7 presents the recommended minimum flows for the freshwater reach, however, it is not clear in the report how the flow results should be summarized to determine compliance with the low flow threshold of 25 cfs. In Table 7-7, five and ten year moving mean and median flows are presented for results measured during the baseline period of 1990 to 2000. The mean and median results presented are considerably different. The report should identify which measure of central tendency (mean or median) and duration period (five-year or ten year) is the most appropriate to use for comparison to the low flow threshold, and provide the rationale for selection.
19. In Chapter 7, the maximum allowable percent-of-flow reductions for the seasonal blocks are not expressed clearly. This chapter should clearly identify the time frame to use for calculating the flow reductions. The Executive Summary indicates that the criteria for the seasonal block components are maximum allowable daily flow reductions and Figure 7-12 presents reductions of mean daily flows, however, the Chapter 7 text does not identify the applicable time frame.
20. In Figure 8-3, the lines are most divergent at low flows. If the model is unreliable below 5 cfs, how will the district determine how much recovery is needed and the degree of recovery achieved?
21. It is unclear when the proposed MFL and its recovery strategy might be adopted. The report says the recovery strategy should be incorporated into the overall Permit Recovery Assessment Plan that is part of Tampa Bay Water's Consolidated Permit, scheduled for renewal in 2020. Rule 62-40.473(5)(b), F.A.C., requires the district to simultaneously adopt a needed recovery strategy with adoption of the MFL, or to modify an existing recovery strategy. Is the district planning to modify the Northern Tampa Bay recovery strategy along with adoption of the MFL for the Pithlachascotee River? When does the district anticipate this happening?

APPENDIX 6B

Memorandum to file by Doug Leeper, dated August 12, 2016. Subject: staff response to comments submitted by the Florida Department of Environmental Protection on November 14, 2014 concerning the District's draft report on proposed minimum flows and levels for the Pithlachascotee River. Southwest Florida Water Management District. Brooksville, Florida.

August 12, 2016

MEMORANDUM

TO: File

FROM: Doug Leeper, MFLs Program Lead, Springs and Environmental Flows Section, Southwest Florida Water Management District

SUBJECT: Staff response to comments submitted by the Florida Department of Environmental Protection on November 18, 2014 concerning the District's draft report on proposed minimum flows and levels for the Pithlachascotee River

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Overview

On November 18, 2014, Carolyn Voyles, with the Florida Department of Environmental Protection (DEP) Office of Water Policy submitted comments and recommendations from staff in the DEP TMDL and Biology Sections and the Office of Water Policy concerning the District's draft summary report on proposed minimum flows for the Pithlachascotee River.

The submitted comments and questions are reproduced in the following section of this memorandum along with District responses. As noted in several of the responses, the comments/questions provided by the DEP were used to support preparation of an updated draft report that will be provided to the peer review panel the District intends to convene for independent scientific review of minimum flows proposed for the river. The original comments document submitted by the DEP and this summary response memorandum will be included as an appendix to the updated draft report and will be provided to the peer review panel.

DEP Comments/Questions and District Responses

1. DEP Comment/Question 1:

The report would benefit from a thorough editorial review. Throughout the document there are a number of editorial errors related to grammar, spelling, figure legends, table formatting (e.g. tables overlapping report text), and literature citations that need to be addressed in the report. Some examples are (but not limited to):

- Miller's Bayou, first mentioned on page 3-1 and mentioned a number of times afterwards, does not appear on any map in the document.
- The legends in Figures 5-1 and 5-2 are not meaningful; the colored lines need to have associated descriptions, and the items in the legend should be presented in numeric order.
- In Chapter 5, there is more than one WAR 2010 document, and the specific document being referenced usually is not identified.
- There are many table and figure reference errors in Chapter 7.

District Response for DEP Comment/Question 1:
We agree that the original draft report included numerous formatting and editorial errors that required attention. We have developed an updated draft report that hopefully addresses these issues. With regard to the specific errors identified in the comment above, the following revisions were addressed.

- Labels for Miller's Bayou (and the Gulf of Mexico) were added to Figure 3-1.
- Figures 5-1 and 5-2 from the original draft report have been eliminated from the body of the updated report. The original figures are retained in a 2009 report by Entrix, Inc., that has been included as an appendix to the updated report. The numeric labels associated with the map symbols used in Figures 5-1 and 5-2 were not changed to "descriptive labels" in the Entrix (2009) report due to the complexity of some of the categorical information presented in the figures.
- Citations of Water and Air (2010) were changed to reference Water and Air Research, Inc. (2010a) in relevant text that now included in chapter 3 of the updated report.
- Table and figure referenced in Chapter 7 were reviewed for errors as were other tables and figures throughout the updated report.

2. DEP Comment/Question 2:

In Figure 2-2, the USGS flow gage near New Port Richey does not appear to be labeled correctly. The gage number is 02310300, but the gage is labeled as 02310800 in the figure. For clarity, it would be helpful to include in the labels the gage name along with the gage number for all the gages shown. It also would be helpful to label the geographic features identified in Section 2.2, such as Fivemile Creek, on this map.

District Response for DEP Comment/Question 2:
Figures in the updated report showing the mislabeled U.S. Geological Survey gages were corrected and gage names were added for active gages. In addition, labels for Fivemile Creek and the Pithlachascotee River were added to the figure included in the updated report.

3. DEP Comment/Question 3:

Section 2.6 presents a summary of land use information for the years 1974, 1990, and 2007. Land use data are also available for 2011 and would better represent current land use in the watershed. Also, in this section, the map legends for Figures 2-4 through 2-6 are nearly illegible and they should be exported at a higher resolution to correct this problem.

District Response for FDEP Comment/Question 3:
Land use/cover information and the associated figure and summary table have been reformatted and are now included in the updated report.

4. DEP Comment/Question 4:

Figure 2-13, shows a frequency distribution curve for flows at the Pithlachascotee River near New Port Richey gage for the period of record (April 1963 – September 2013). Table 7-1 presents percentile values at the same gage location. What is the dataset period for the gaged flow percentiles shown in the second column in the table? The flow percentiles in the second column do not appear to match the percentiles displayed in Figure 2-13.

District Response for DEP Comment/Question 4:

Figure 2-13 (2-8 in the current version of the updated report) shows a cumulative frequency distribution curve for flows at the Pithlachascotee River near New Port Richey gage for the period from April 1, 1963 through September 30, 2013. The flow percentiles included in Table 7-1 are for the same site, but are based on the baseline flow record used for the minimum flows analyses, i.e., from June 19, 1989 through December 31, 2009. This information is presented in tables 4-1 and 4-2 in the updated report.

5. DEP Comment/Question 5:

In Table 2-15, the results appear reversed for the early and recent time periods. (Compare this table with the text in the last paragraph of page 2-31 and with Figure 2-31.)

District Response for DEP Comment/Question 5:

The flow percentile value presented for the two time periods in Table 2-15 of the original draft report was reversed. However, to improve readability, this table was eliminated from the updated report.

6. DEP Comment/Question 6:

Section 2.10 mentions that analyses of the residuals negatively affected the fit regression at low flows, so the regression was limited to flows greater than 1.6 cfs, and the model output was used when flows were less than 1.6 cfs. Please discuss further the ramifications of this methodology.

District Response for DEP Comment/Question 6:

Discussion concerning development of the baseline flow record is included in section 4.3 of the updated report. We have not included much additional discussion of the information presented.

7. DEP Comment/Question 7:

Section 2.13 briefly discusses the statistically significant trends in the Pithlachascotee, and states that chloride, iron, magnesium, potassium and sodium are indicative of rock, and cites FGS 2009 for this assessment. The cited work is not in the references, nor is it listed as Copeland et al within the references. This is a minor point; however, the fact that Copeland et al 2009 (see table below) does not indicate that chloride or sodium are indicative of the rock matrix should be addressed. Furthermore, these constituents can be indicative of fertilizers (nutrients) from runoff or from seawater (see Ward 2001 and Pilson 1998 below). Additionally, Copeland et al 2009 list fluoride as indicative of the rock matrix. Unlike the other five elements, this one has a significantly decreasing trend. These trends should be further explored and explained. Also, the rates of increase or decrease of the analytes would be helpful considering how small the slopes are (Table 2-19).

Table 5 from FGS 2009:

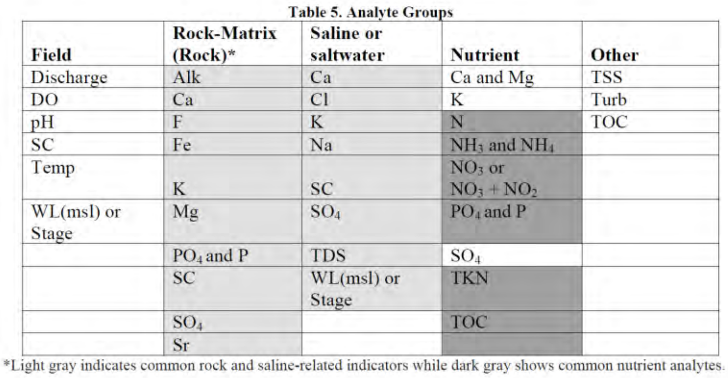
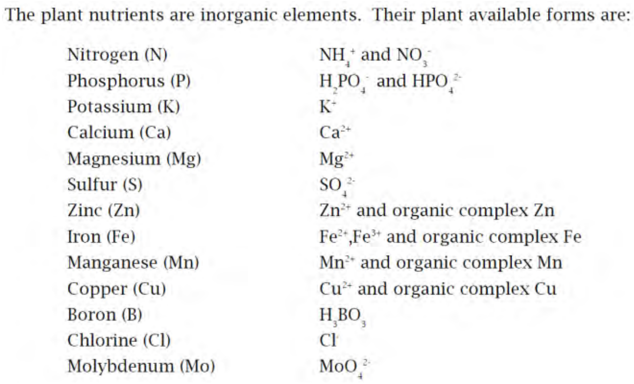


Table 5. Analyte Groups

Field	Rock-Matrix (Rock)*	Saline or saltwater	Nutrient	Other
Discharge	Alk	Ca	Ca and Mg	TSS
DO	Ca	Cl	K	Turb
pH	F	K	N	TOC
SC	Fe	Na	NH_3 and NH_4	
Temp	K	SC	NO_3 or $NO_3 + NO_2$	
WL(msl) or Stage	Mg	SO_4	PO_4 and P	
	PO_4 and P	TDS	SO_4	
	SC	WL(msl) or Stage	TKN	
	SO_4		TOC	
	Sr			

*Light gray indicates common rock and saline-related indicators while dark gray shows common nutrient analytes.

Ward 2001:



The plant nutrients are inorganic elements. Their plant available forms are:

Nitrogen (N)	NH_4^+ and NO_3^-
Phosphorus (P)	$H_2PO_4^-$ and HPO_4^{2-}
Potassium (K)	K^+
Calcium (Ca)	Ca^{2+}
Magnesium (Mg)	Mg^{2+}
Sulfur (S)	SO_4^{2-}
Zinc (Zn)	Zn^{2+} and organic complex Zn
Iron (Fe)	Fe^{2+},Fe^{3+} and organic complex Fe
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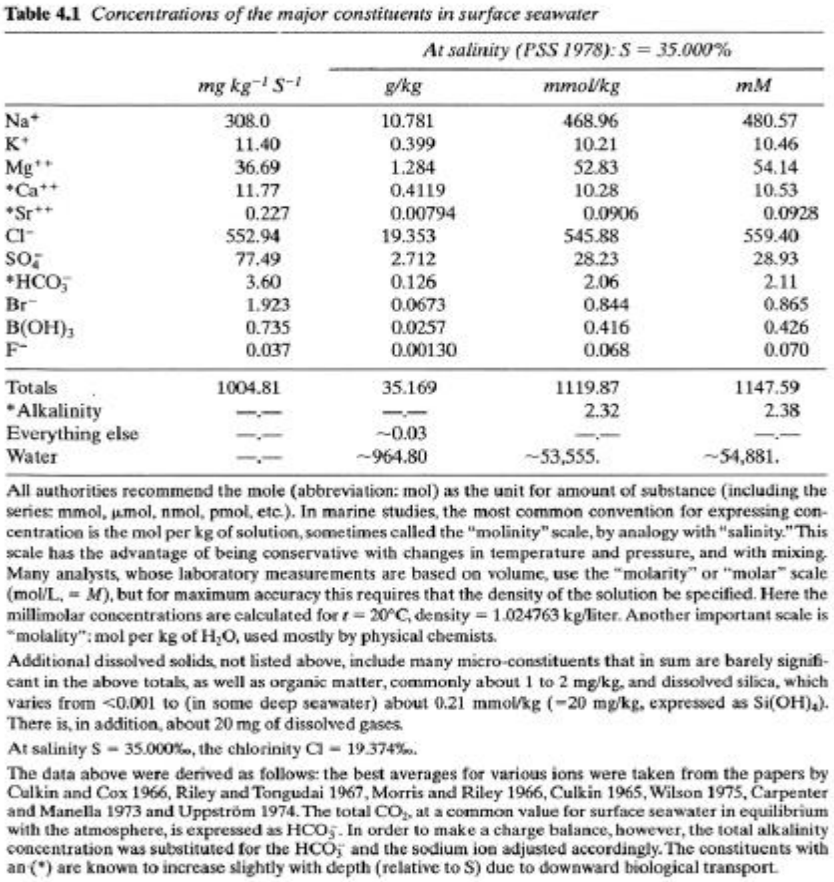

Table 4.1 *Concentrations of the major constituents in surface seawater*

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Totals	1004.81	35.169	1119.87	1147.59
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Everything else	—.—	~0.03	—.—	—.—
Water	—.—	~964.80	~53,555.	~54,881.

All authorities recommend the mole (abbreviation: mol) as the unit for amount of substance (including the series: mmol, μmol, nmol, pmol, etc.). In marine studies, the most common convention for expressing concentration is the mol per kg of solution, sometimes called the "molinity" scale, by analogy with "salinity." This scale has the advantage of being conservative with changes in temperature and pressure, and with mixing. Many analysts, whose laboratory measurements are based on volume, use the "molarity" or "molar" scale (mol/L, = *M*), but for maximum accuracy this requires that the density of the solution be specified. Here the millimolar concentrations are calculated for $t = 20°C$, density = 1.024763 kg/liter. Another important scale is "molality": mol per kg of H_2O, used mostly by physical chemists.

Additional dissolved solids, not listed above, include many micro-constituents that in sum are barely significant in the above totals, as well as organic matter, commonly about 1 to 2 mg/kg, and dissolved silica, which varies from <0.001 to (in some deep seawater) about 0.21 mmol/kg (=20 mg/kg, expressed as $Si(OH)_4$). There is, in addition, about 20 mg of dissolved gases.

At salinity S = 35.000‰, the chlorinity Cl = 19.374‰.

The data above were derived as follows: the best averages for various ions were taken from the papers by Culkin and Cox 1966, Riley and Tongudai 1967, Morris and Riley 1966, Culkin 1965, Wilson 1975, Carpenter and Manella 1973 and Uppström 1974. The total CO_2, at a common value for surface seawater in equilibrium with the atmosphere, is expressed as HCO_3^-. In order to make a charge balance, however, the total alkalinity concentration was substituted for the HCO_3^- and the sodium ion adjusted accordingly. The constituents with an (*) are known to increase slightly with depth (relative to S) due to downward biological transport.

<u>District Response for DEP Comment/Question 7:</u>

Summary information on water quality has been revised and reorganized in the updated report to improve clarity and address suggestions concerning water quality trends observed for the river. This revised text is included in section 2.9 of the current version of the updated report.

8. <u>DEP Comment/Question 8:</u>

Regarding page 4-11, paragraph 2, how might sessile benthic communities be affected by not incorporating bottom isohalines into the final MFL analysis? How does this statement affect the information presented in Section 6.10.2?

District Response for DEP Comment/Question 8:
As noted on page 4-11 in section 4-4 of the original draft report, surface and water column isohalines were considered to be more representative of overall river salinity, because the calculation of bottom isohaline locations was subject to differences in the maximum depth of sampling at each station where data used for regression development were collected. Accordingly, predictions regarding the location of bottom isohalines were not incorporated in the final minimum flows analysis and are not discussed further in the updated draft report. However, as noted in the salinity habitat modeling methods section in Chapter 4 and associated results in Chapter 5 of the updated report, predicted water column isohaline locations were used to assess potential flow-related changes in bottom area in contact with specified salinities.

9. DEP Comment/Question 9:

Section 4.5 discusses the relationship between dissolved oxygen (DO) and freshwater inflow in the lower river. The report indicates that the freshwater segment (WBID 1409) has been assessed as impaired by EPA using the 5.0 mg/L DO standard. The report also mentions that FDEP has new DO standards based on percent saturation. It would be informative to explain in the report that neither the tidal nor the freshwater Pithlachascotee River WBIDs are listed as verified impaired for DO. Additionally, based on the latest preliminary assessment information, provided in the IWR Run 49 database, the tidal and freshwater segments are not identified as verified impaired when applying the new DO criteria. Additional information about the FDEP's current assessment of the river can be obtained by contacting Kevin O'Donnell (Kevin.ODonnell@dep.state.fl.us) in DEP's Watershed Assessment Program.

District Response for DEP Comment/Question 9:
We have revised the discussion of dissolved oxygen concentrations and water quality that is included in the updated report to reflect the current impairment status of the river.

10. DEP Comment/Question 10:

Chapter 5

a. The biological data presented within the report appear to be from one sampling period, and do not include freshwater benthic macroinvertebrate data. DEP has conducted the stream condition index (SCI) at several sites in the freshwater portion of the Pithlachascotee and could provide the data should the District be interested.

b. As the report indicates, the water levels under which the MFL studies were conducted were historically low water levels. Was there any attempt to discover the biological condition during historic higher flow periods, or even during the baseline period (though flows were reduced by withdrawals), to assess the biological potential within the river? I understand that the basis for the MFL determinations is habitat availability, so it is unclear what role this biological summary plays in the MFL development.

District Response for DEP Comment/Question 10a:
Chapter 5 of the original draft report addressed biological characteristics of the lower river and as noted by the Florida DEP is based on limited sampling. Sampling which would permit robust characterization of specific macroinvertebrate populations in the freshwater portion of the river was not conducted as part of the minimum flows investigation.

The inadvertent omission of the freshwater macroinvertebrate information for the river that has been developed by the Florida DEP was rectified through reference to the 2009 “Upper Pithlachascotee River Ecosummary” prepared by the Florida Department of Environmental Protection in a revised water quality section in Chapter 2 of the updated draft report.

District Response for DEP Comment/Question 10b:
Information on the biological assemblages observed in the river system were presented in the original and are included in the updated report to broadly characterize existing biological conditions. This information is considered relevant to and supportive of the habitat assessments that were used for development of the proposed MFLs.

11. DEP Comment/Question 11:

We followed the discussion in Section 6.8.1 regarding low thresholds. However, we did not understand the following statement in the Executive Summary (page xvii): “The low flow threshold does not apply to the management of groundwater withdrawals.” This concept is new and is not discussed in Section 6.8.1 or elsewhere in the report. What does it mean? Aren’t the waters of the river hydrologically connected to waters in the Upper Floridan aquifer? Is the district is saying that groundwater withdrawals can occur even if they cause river drawdowns that end up below 25 cfs? If so, please explain further this interpretation.

District Response for DEP Comment/Question 11:
Minimum low flow thresholds are discussed in several portions of the updated draft report (e.g., in sections of chapters 1 and 4). We use minimum low flow thresholds to address restrictions in surface water withdrawals due to their more immediate and direct effect on river flows. In contrast, groundwater withdrawals are expected to exert more diffuse, indirect and temporally variable effects on flows based on their magnitude, proximity to the river channel, and local hydrogeologic characteristics.

12. DEP Comment/Question 12:

It is unclear how the information in Chapters 6 and 7 are related to the different Block periods.

District Response for DEP Comment/Question 12:
Chapters 6 and 7 in the original draft report have been substantially revised as chapters 4 and 5 in the updated draft report.

13. DEP Comment/Question 13:

Figures 7-3 and 7-4 are difficult to interpret. The graphs might be easier to interpret if the results are presented in stacked columns. Also, please identify which transects are under discussion.

District Response for DEP Comment/Question 13:
Figures 7-3 and 7-4 in the original report have been eliminated from the updated draft report. We agree that they are confusing and have substituted two additional figures in the updated draft report to try to better convey relevant information on the habitats of the upper river.

14. DEP Comment/Question 14:

Section 7.3.2.3: In this section and for the remainder of the document, it is clear that the percent reduction that is proposed would cause a 15% loss of habitat, *on average*. That means that half of the river miles included in the assessments would lose more than 15% habitat or more than 15% of days of floodplain inundation. Using a lower percentile of the data for assessed transects would provide greater assurance that no greater than 15% of habitats are lost. For example, Table 7-3 shows that the allowable percent reduction of flow to maintain exposed roots ranged from 12-47%, with a mean of 19%. The 19% reduction proposed in this report (for Block 2) only protects 50% of transects measured. A flow reduction of 14% or 15% would protect 90% and 75% of transects, respectively. For other habitats, the mean flow reduction is presented as the recommended MFL, and would similarly only protect half of assessed portions of the river.

This methodology is different from the percent of flow methodology used in developing earlier MFLs, and use of a lower percentile seems warranted. For roots and snag habitats (see Table 7-3), why wasn't 9% chosen as the allowable flow reduction, since this is the smallest reduction that would protect 15% of the snag habitat, and presumably would protect the exposed root habitat (which had the smallest percentage at 12%) as well? Additionally, why weren't different analyses for Blocks 2 and 3 conducted? In Figure 6-2, the flows for these two blocks seem to be very different.

The following statement (pages 7-9 and 7-10) does not seem to be supported:

> "Using the baseline flows, long-term inundation analyses indicated that allowable percent-of-flow reductions of 19% and 22%, respectively, could occur without reducing the number of days of inundation of the habitats by 15% of [sic] more (Table 7-6 [sic])."

Those percentages might occur without reducing the _*mean*_ number of days of inundation.

For this and other locations in the document where the *mean* is used, please provide the district's rationale for protecting only 50% of habitat, etc. 85% of the time.

District Response for DEP Comment/Question 14:
As was the case for the Pithlachascotee River, we routinely develop allowable percent-of-flow reductions for establishing minimum flows using summary information (means, median, etc.). For example, the allowable percent-of-flow values included in Table 7-3 of the original draft report were used to develop a mean percent-of-flow reduction associated with the inundation of this important habitat type. We consider the individual values to be a sample of the population of exposed root habitat in the upper river, and correspondingly base our interpretation of the results on the summary mean value for the sample.

As we typically do, we used PHABSIM analyses and inundation of woody habitats to develop allowable percent-of-flow reductions for Blocks 1 and 2 and assessed inundation of floodplain areas to identify allowable percent-of-flow reductions and a Minimum High Flow Threshold for use during Block 3 for the upper, freshwater segment of the river.

15. DEP Comment/Question 15:

On page 7-12, the transect map mentioned in the text needs to be included in the main document, as it affects Table 7-4, and Figures 7-8 and 7-10.

District Response for DEP Comment/Question 15:
A vegetation "transect map" referenced for text on page 7-12 of the original draft report, was included in the original report as Figure 6-5 and is included in the updated draft report in Chapter 4.

16. DEP Comment/Question 16:

Section 7.3.3.4: It was difficult to discern the results of flow reduction on individual floodplain transects assessed with the tables and figures provided. Table 7-5 showed ranges of percent flow reduction associated with up to a 15% reduction of inundated days by floodplain feature, not individual transect, so there was a wide range for each one. If each point in Figure 7-11 represents a floodplain transect, then the approach of taking the mean flow reduction, even broken out by flow regime, may not sufficiently protect the floodplain hydroperiod. Please provide the district's rationale for not examining the inundation for individual transects.

District Response for DEP Comment/Question 16:
Information presented in Section 7.3.3.4 of the original draft has been revised and included in a sub-section of Chapter 5 in the updated report. Our approach for maintaining inundation of floodplain habitats is based on using a sample of floodplain sites (transects) to assess changes in flows that would result in more than a 15% change in the number of days of inundation of features and habitats occurring across the range of elevations associated with the floodplain. We did assess inundation patterns at individual transects using measured elevation data and the HEC-RAS model. As indicated in the "floodplain response" plot included as Figure 7-11 in the original draft report (and included in revised form in Chapter 5 of the updated report), we used the floodplain *sample* information to identify two allowable flow reduction percentages for flows during Block 3 that are expected to be protective of floodplain habitat.

17. DEP Comment/Question 17:

In Section 7.5.2, the Figures appear to show 100% flow at 0 cfs. Please explain.

District Response for DEP Comment/Question 17:
Figures 7-14 and 7-15 in the original draft report show the percentage of shoreline associated with low salinity (<2 and < 5 psu) salinities for flow reduction scenarios relative to the corresponding shoreline associated with the low salinities for the baseline flow condition. At very low flows, i.e., at or near 0 cfs, these low salinity zones are, understandably, very small or non-existent for the baseline condition -- no freshwater inflow into the lower river would result in increased landward movement of Gulf water. Therefore, at very low flow conditions we would expect to see little difference in low salinity habitat for the baseline and any flow reduction scenario.

18. DEP Comment/Question 18:

Chapter 7 presents the recommended minimum flows for the freshwater reach, however, it is not clear in the report how the flow results should be summarized to determine compliance with the low flow threshold of 25 cfs. In Table 7-7, five and ten year moving mean and median flows are presented for results measured during the baseline period of 1990 to 2000. The mean and median results presented are considerably different. The report should identify which measure of central tendency (mean or median) and duration period (five-year or ten year) is the most appropriate to use for comparison to the low flow threshold, and provide the rationale for selection.

District Response for DEP Comment/Question 18:
The low flow threshold proposed for the Pithlachascotee River was developed and is intended to be used for limiting surface water withdrawals. This flow threshold would be directly applicable to daily flows/withdrawals. The long-term flow statistics included in the original draft report represent minimum five and ten year moving mean and median flows that may be expected to occur with implementation of minimum flows for the river. Based on available information, these long-term flow statistics are routinely developed as tools for assessing the status of minimum flow water bodies. The statistics are

developed by reducing the baseline flow record by allowable, block-specific percent-of-flow reductions, with the additional limitation that flows are not reduced below the Minimum Low Flow Threshold. All computed statistics are considered appropriate for minimum flow status assessments. In the updated draft minimum flows report, we have noted that the limited period of record for the baseline flows for the Pithlachascotee River limits the usefulness of five and ten-year flow statistics for assessing the status of the proposed minimum flows. This issue is addressed in a new chapter in the updated report that describes an expanded minimum flows status assessment process for the river.

19. DEP Comment/Question 19:

In Chapter 7, the maximum allowable percent-of-flow reductions for the seasonal blocks are not expressed clearly. This chapter should clearly identify the time frame to use for calculating the flow reductions. The Executive Summary indicates that the criteria for the seasonal block components are maximum allowable daily flow reductions and Figure 7-12 presents reductions of mean daily flows, however, the Chapter 7 text does not identify the applicable time frame.

District Response for DEP Comment/Question 19:
For development of minimum flow rules that include block-specific percent-of-flow reductions, we have routinely associated the block-specific flows with the previous day’s flow. This is how we anticipate structuring proposed rule amendments for minimum flows associated with the upper segment of the river. Proposed rule amendments for the lower river will be structures similarly, although we anticipate associating allowable percent-of-flow reductions with the previous day’s flow or the previous four-day mean flow when flows are, respectively, below or above a Minimum High Flow Threshold. This information is summarized in Chapter 5 of the updated draft report.

20. DEP Comment/Question 20:

In Figure 8-3, the lines are most divergent at low flows. If the model is unreliable below 5 cfs, how will the district determine how much recovery is needed and the degree of recovery achieved?

District Response for DEP Comment/Question 20:
Will do the best we can, based on consideration of all available information. Our updated draft report includes a detailed summary of the comprehensive suite of information we used and anticipate using in the future to assess the status of minimum flows in the river.

21. DEP Comment/Question 21:

It is unclear when the proposed MFL and its recovery strategy might be adopted. The report says the recovery strategy should be incorporated into the overall Permit Recovery Assessment Plan that is part of Tampa Bay Water’s Consolidated Permit, scheduled for renewal in 2020. Rule 62-40.473(5)(b), F.A.C., requires the district to simultaneously adopt a needed recovery strategy with adoption of the MFL, or to modify an existing recovery strategy. Is the district planning to modify the Northern Tampa Bay recovery strategy along with adoption of the MFL for the Pithlachascotee River? When does the district anticipate this happening?

District Response for DEP Comment/Question 21:
Our updated draft report includes a chapter devoted to the discussion of determining the status of minimum flows in the river and the need for any recovery/prevention strategies. In the updated report, we note that the river is no in recovery, but should any adopted minimum flows not be met in the future, the adopted Comprehensive Environmental Resources Recovery Plan for the Northern Tampa

Bay Water Use Caution Area and the Hillsborough River Strategy (Rule 40D80-073, F.A.C.) would be applicable.

APPENDIX 6C

Letter from Tom Champeau to Doug Leeper, dated December 1, 2014. Regarding: proposed minimum flows and levels for the Pithlachascotee River – peer review draft. Florida Fish and Wildlife Conservation Commission. Tallahassee, Florida.

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December 1, 2014

Mr. Doug Leeper
Resource Evaluation Section
Southwest Florida Water Management District
7601 U.S. Highway 301
Tampa, FL 33637-6759
Doug .Leeper@sfwmd.state.fl.us

Re: Proposed Minimum Flows and Levels for the Pithlachascotee River – Peer Review Draft

Dear Mr. Leeper:

The Florida Fish and Wildlife Conservation Commission (FWC) has coordinated our agency's review of the Southwest Florida Water Management District's (SWFWMD) Proposed Minimum Flows and Levels (MFLs) for the Pithlachascotee River draft report and provides the following comments and recommendations.

SWFWMD Summary of MFL Approach

The draft report proposes minimum flows and levels for both the freshwater and tidal reaches of the Pithlachascotee River, which originates from Crews Lake in northern Pasco County and flows south and west approximately twenty-seven miles before entering the Gulf of Mexico near Port Richey, Florida.

The Pithlachascotee River lies within the Northern Tampa Bay Water Use Caution Area, where hydrologic analyses and integrated surface water/groundwater modeling indicate that flows in the river have been reduced by groundwater withdrawals. Recent cutbacks in groundwater use associated with the Northern Tampa Bay Recovery Plan have reduced the effects of groundwater withdrawals on flows in the river. However, simulations using the Integrated Northern Tampa Bay Model indicate that there are still some effects of groundwater withdrawals on the river's flow regime.

The District modeled flow reduction recommendations without causing significant harm (defined as < 15% reduction of available habitat). This analysis found that based on median flows, the current flows are slightly below the recommended minimum flows for the freshwater segment of the river, as the median flow for the 90 million gallons per day (mgd) scenario was 6.3 cubic feet per second (cfs) compared to a median flow of 7.1 cfs for the freshwater minimum flows. Flows for the 90 mgd scenario remain below the recommended freshwater minimum flows until very high flow rates in the river occur.

The median flow for the 90 mgd scenario (6.3 cfs) is very close to the median flow corresponding to the estuarine minimum flows (6.4 cfs). Flows for the 90 mgd scenario meet the estuarine minimum flows at higher flow rates in the river, but at flows below the median, where there is much less confidence in the modeling results, flows for the 90 mgd scenario are below the recommended estuarine minimum flows.

The MFL analyses indicate that a recovery strategy is needed for the Pithlachascotee River. Minimum flows are recommended for three seasonal blocks that typically correspond to periods of low, medium, and high flows in the river. The recommended MFL for the river is as follows:
Freshwater Segment (upstream of Rowan Road at river KM 11):
Block 1 (April 25-June 23) – 18% reduction of daily flow
Block 2 (October 17-April 24) – 17% reduction of daily flow
Block 3 (June 24-October 16) – 16% of daily flow below a rate of 50 cfs and 9% above 50 cfs.

Lower Estuarine Segment (downstream of Rowan Road at river KM 11):
All blocks – 25% reduction of flow below a daily rate of 60 cfs and 35% above a four-day mean flow value of 60 cfs.

Additionally, a low flow threshold of 25 cfs was recommended that would prohibit surface water withdrawals.

Because the recommended minimum flows for the freshwater reach of the river are more restrictive (lower allowable withdrawal percentages) than those for the estuarine reach, an overall recovery strategy for the river should be oriented to meeting the freshwater minimum flows. Meeting those minimum flows should meet the estuarine minimum flows as well. Also, meeting the recovery target for the freshwater minimum flows, which is based on modeled median flow conditions, should help restore low and high flows in the river as well.

However, these findings are considered preliminary because they were conducted over a period with slightly below average rainfall and assumed a distribution of wellfield pumpage that occurred in 2008. Using the recommended minimum flows and hydrologic evaluation criteria presented in this report, the need for a recovery strategy for the Pithlachascotee River should be re-evaluated to include updated climatic and water use data. These analyses should be conducted as part of the Permit Recovery Assessment Plan for the Northern Tampa Bay Area that is required of Tampa Bay Water as part of their consolidated water use permit for withdrawals from the eleven central network wellfields.

If those updated analyses also indicate that a recovery strategy for the Pithlachascotee River is needed, Florida Statues require that a timetable be established to allow for the development of sufficient alternate supplies or conservation measures. Because the water use that has affected the Pithlachascotee River has come from an integrated water supply system, recovery of the Pithlachascotee River should be considered and balanced with the required minimum flows and levels for other natural resources in the region.

FWC Comments and Recommendations

Overall, FWC staff felt the District provided a good summary and analysis of available data in providing the recommended MFL. In general, there were no comments regarding the modeling and statistical analysis used to derive these recommendations. The approach appears cautionary while mimicking natural flow patterns during seasonal variations (block system) and by using percent-of-flow, which limits the amount of withdrawals under low and moderate flow periods while still allowing floodplain inundation under high flow periods.

The following are a list of general questions FWC staff would like to be addressed to better understand the approaches taken and hopefully provide some insight to strengthen the proposed MFL during the SWFWMD's review:

1) Overall trends in rainfall patterns have shown a decline in annual rainfall during the period of this evaluation. While climatic events such as hurricanes are not predictable, it appears overall the amount of precipitation in the area, as well as the state, is declining. Understandably, this is not predictable but assuming we will see more frequent dry years, how will this impact the proposed MFL and what actions will be taken to monitor/evaluate this?

2) Previous MFL's have addressed potential impacts of sea level rise; however, this current proposal does not. With the potential of sea level rise, does the modeling predict changes in the various salinity zones (Venice system) as a result of flow reductions to the estuarine portion of the river?

3) A benthic macro invertebrate assessment was done on the estuarine portion of the river; however, a similar study was not conducted on the freshwater portion. A reference was provided to Warren but no data for the freshwater macro invertebrate community was provided. As a biological indicator, we wonder why this was not addressed in the analysis.

4) What is the basis for the 0.6-foot fish passage criteria? While it probably provides adequate depth in most cases, we do not have any reference other than best professional judgment and recommendations from other states. We would like for this to be further evaluated to determine if the recommendation is adequate.

5) In reference to 6.9.2.1 Development of Habitat Suitability Curves (HSC):

   A) Why are three different types of Habitat Suitability Curves used (HSC Types I, II, and III) and does each curve provide different results?

   B) Fish species used in deriving the HSC assumes that these species are present in the system. Thus, potential impacts on the fish community as a result of reduced flows are an assumption without knowing which species are present and abundant. Does the SWFWMD have documentation of fish species present in the river?

C) It is unclear as to why an HSC was used for redbreast sunfish and modified for a spotted sunfish when it appears that a Type III curve was already developed for spotted sunfish. Please explain why this was done and what was done to modify it (reference page 6-20).

D) What are the species represented in your fish guilds as referenced by shallow-fast (SF) and deep slow (DS)? The appendix does not provide sufficient details.

6) From the PHABSIM output on page 7-6, cyprinidae are referenced as a species/life stage/guild. Cyprinidae is a large family and grouping all fish in this family could have some biases. For example, golden shiners have different habitat and flow requirements than an iron colored shiner. Please explain the species used in this analysis and how it was classified by habitat preference and flow.

We appreciate the opportunity to provide input on this MFL document. If you need any further assistance, please do not hesitate to contact Jane Chabre either by phone at (850) 410-5367 or at FWCConservationPlanningServices@MyFWC.com. If you have specific technical questions regarding the content of this letter, please contact Ms. Stasey Whichel at (850) 617-9531 or by email at stasey.whichel@MyFWC.com.

Sincerely,

Tom Champeau

Tom Champeau, Director
Division of Freshwater Fisheries Management

tc/sw
ENV 1
Pithlachascotee River Draft MFL Report_19767_111914
cc: Mr. Bill Pouder, FWC, bill.pouder@MyFWC.com

APPENDIX 6D

Memorandum to file by Doug Leeper, dated May 29, 2015. Subject: staff response to comments submitted by the Florida Fish and Wildlife Conservation Commission on December 1, 2014 concerning the District's draft report on proposed minimum flows and levels for the Pithlachascotee River. Southwest Florida Water Management District. Brooksville, Florida..

May 29, 2015

MEMORANDUM

TO: File

FROM: Doug Leeper, Chief Advisory Environmental Scientist, Resource Evaluation Section
Southwest Florida Water Management District

SUBJECT: Staff response to comments submitted by the Florida Fish and Wildlife Conservation Commission on December 1, 2014 concerning the District's draft report on proposed minimum flows and levels for the Pithlachascotee River

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Overview

On December 1, 2014, Tom Champeau, Director of the Division of Freshwater Fisheries Management for the Florida Fish and Wildlife Conservation Commission (FWCC) submitted a letter to the Southwest Florida Water Management District that included comments and recommendations from FWCC staff on the District's summary report on proposed minimum flows for the Pithlachascotee River.

The letter included several questions that FWCC would like to see addressed to improve presentation of the methods used for developing the proposed minimum flows and to strengthen the information used to support the minimum flow recommendations.

Questions submitted by the FWCC are reproduced in the following section of this memorandum along with District responses. As noted in several of the responses, the questions provided by the FWCC will support preparation of an updated version of the summary report that will be provided to the Peer Review Panel the District intends to convene for independent scientific review of minimum flows proposed for the river. The original FWCC letter and this summary response memorandum will also be provided to the Peer Review Panel.

FWCC Questions and District Responses

FWCC Question 1:
"Overall trends in rainfall patterns have shown a decline in annual rainfall during the period of this evaluation. While climatic events such as hurricanes are not predictable, it appears overall the amount of precipitation in the area, as well as the state, is declining. Understandably, this is not predictable but assuming we will see more frequent dry years, how will this impact the proposed MFL and what actions will be taken to monitor/evaluate this?"

District Response/Comments for FWCC Question 1:
Minimum flows and levels (MFLs) are established and implemented to identify the limits at which further withdrawals would be significantly harmful to the water resources or ecology of the area. Established MFLs are expected long-term flows or levels that if achieved are expected to prevent withdrawal-related significant harm. When establishing MFLs, the District attempts to account for

natural climatic variability while providing consideration for existing structural alterations. This is also the case for evaluation of the status of water bodies with adopted MFLs.

The District's current approach for assessing the status of MFLs water bodies involves use of criteria and approaches or tools specified in the MFL rules associated with individual water bodies, and typically additional criteria or tools. A preferred approach for a water body usually involves use of the tool or tools that were used for development of the MFLs that are applicable to the water body. For the Pithlachascotee River, it is anticipated that the Integrated Northern Tampa Bay (INTB) model and measured hydrologic data, including gaged streamflow, rainfall, water-use information and groundwater levels will be used to assess the status of flows in the river relative to the applicable established MFLs. We also expect to explore development of additional tools that may allow improved characterization of flow expectations given variation in rainfall and other climatic factors.

Status assessments for MFLs water bodies are completed when proposed MFLs are developed and recommended for adoption into rule, on an annual basis, on a five-year cycle as part of the District regional water supply planning process, and on an as-needed basis to support permitting and project activities.

FWCC Question 2:
"Previous MFL's have addressed potential impacts of sea level rise; however, this current proposal does not. With the potential of sea level rise, does the modeling predict changes in the various salinity zones (Venice system) as a result of flow reductions to the estuarine portion of the river?"

District Response/Comments for FWCC Question 2:
In response to this question from the FWCC, staff is assessing predicted conditions for MFLs criteria in the lower Pithlachascotee River based on sea level conditions projected for the end of the current 20-year regional water supply planning horizon. Preliminary results from the analyses do not indicate the need for adjustment of the proposed MFLs for the lower river. Staff will incorporate final result from the analyses along with a description of the methods used for their development in the updated version of the summary report that will be provided to the Peer Review Panel convened for independent scientific review of proposed minimum flows for the river.

FWCC Question 3:
"A benthic macro invertebrate assessment was done on the estuarine portion of the river; however, a similar study was not conducted on the freshwater portion. A reference was provided to Warren but no data for the freshwater macroinvertebrate community was provided. As a biological indicator, we wonder why this was not addressed in the analysis."

District Response/Comments for FWCC Question 3:
Staff note that PHABSIM analyses for the Pithlachascotee River were conducted for potential flow-related changes in habitat suitability criteria associated with freshwater macroinvertebrate community diversity. In addition, analysis of potential changes in wetted perimeter, woody habitats and floodplain habitats was completed based in part on the importance of these factors on the occurrence and persistence of freshwater macroinvertebrates. Staff acknowledges, however, that sampling which would permit characterization of specific macroinvertebrate populations in the freshwater portion of the river was not conducted as part of the MFLs investigation.

Staff also acknowledges the inadvertent omission of some published freshwater macroinvertebrate information from the summary MFLs report. Staff will include information contained in the 2009 "Upper Pithlachascotee River Ecosummary" prepared by the Florida Department of Environmental Protection in the updated version of the summary report that is to be provided to the Peer Review Panel.

FWCC Question 4:

"What is the basis for the 0.6-foot fish passage criteria? While it probably provides adequate depth in most cases, we do not have any reference other than best professional judgment and recommendations from other states. We would like for this to be further evaluated to determine if the recommendation is adequate."

District Response/Comments for FWCC Question 4:

Staff developed the 0.6-foot depth criterion for fish passage as part of the work supporting establishment of low-flow MFLs for the upper Peace River. The criterion was developed based on FWCC fish occurrence data for the Peace River, estimation of fish depths (i.e., heights) based on allometric relationships develop from published illustrations of adult fish, and similarity between estimated depths for common fish taxa in the Peace River and a fish depth criterion that was used by the St. Johns River Water Management District for MFLs development. The peer-review panel convened for assessment of the proposed MFLs for the upper Peace River noted in their summary findings report that the minimum flow targets developed based on the fish passage criterion are scientifically reasonable and defensible for supporting hydrologic connection of isolated segments of the river and promoting fish passage.

Detailed information pertaining to development of the criterion is included in Section 6.2 and Appendix F of the District report entitled, "Upper Peace River – An Analysis of Minimum Flows and Levels, August 25, 2002 Draft", which is available on the River Systems & Springs tab of the District's Minimum Flows and Levels (Environmental Flows) Documents and Reports internet web page at: http://www.swfwmd.state.fl.us/projects/mfl/mfl_reports.php. The 2002 upper Peace River MFLs peer review report by J. A. Gore, C. Dahm and C. Klimas entitled, "A Review of "Upper Peace River: An Analysis of Minimum Flows and Levels", is also available from the web page.

FWCC Question 5A:

"In reference to 6.9.2.1 Development of Habitat Suitability Curves (HSC):

A) Why are three different types of Habitat Suitability Curves used (HSC Types I, II, and III) and does each curve provide different results?"

District Response/Comments for FWCC Question 5A:

In the context of PHABSIM analyses, habitat suitability curves (criteria) are grouped into three categories (I, II and II), with the categorization based on the type of data and data summarization approaches used to generate the curves. The three curve types are discussed on pages 6-19 and 6-20 and in Appendix 6C of the draft Pithlachascotee MFLs report. Additional information on habitat suitability curves is available from a variety of published resources, including "PHABSIM for Windows - User's Manual and Exercises" USGS Open-File Report 2001-340, Fort Collins, CO) which is available at: https://www.fort.usgs.gov/publication/15000.

Habitat suitability curves are constructed and use based on the most appropriate information for individual applications. Those constructed with the most data and typically with the most site-specific or local data are likely to be the most appropriate. It may be expected that differing types of curves and those of the same type developed with differing data sets could yield differing results.

FWCC Question 5B:

"In reference to 6.9.2.1 Development of Habitat Suitability Curves (HSC):"

B) Fish species used in deriving the HSC assumes that these species are present in the system. Thus, potential impacts on the fish community as a result of reduced flows are an assumption without knowing which species are present and abundant. Does the SWFWMD have documentation of fish species present in the river?"

District Response/Comments for FWCC Question 5B:

Staff is not aware on any available information on the fish assemblage in the Pithlachascotee River. However, we note that habitat availability assessments completed with PHABSIM were made based on criteria associated with specific fish taxa (largemouth bass, bluegill, spotted sunfish, cyprinid minnows) that are widely distributed in Florida waters and generalized criteria associated with macroinvertebrate community diversity and habitat guilds, with the latter used as indicators of habitat diversity.

FWCC Question 5C:

"In reference to 6.9.2.1 Development of Habitat Suitability Curves (HSC):

C) It is unclear as to why an HSC was used for redbreast sunfish and modified for a spotted sunfish when it appears that a Type III curve was already developed for spotted sunfish. Please explain why this was done and what was done to modify it (reference page 6-20)."

District Response/Comments for FWCC Question 5C:

Staff acknowledges that text in the summary MFLs report describing development of habitat suitability curves for spotted sunfish could use some clarification. Type I curves for various life-history stages of the species were developed and used for the District's earlier work on minimum flows for some river systems. Subsequent to this early work, District-funded fish sampling efforts were used in conjunction with the originally developed Type I curves to develop curves that may be reasonably characterized as Type II or Type III curves. These curves were used for analyses addressing habitat suitability for spotted sunfish in the Pithlachascotee River.

Staff plans to revise text associated with description of HSC curve development in the updated version of the report that will be provided to the Peer Review Panel that will be convened for review of proposed minimum flows for the river.

FWCC Question 5D:

"In reference to 6.9.2.1 Development of Habitat Suitability Curves (HSC):

D) What are the species represented in your fish guilds as referenced by shallow-fast (SF) and deep slow (DS)? The appendix does not provide sufficient details."

District Response/Comments for FWCC Question 5D:

The district uses the habitat guild curves as generalized indicators of habitat diversity associated with ranges of flow velocity, water depth and substrate type. They are used to improve understanding of results based on taxon-specific curves and to address potential habitat changes for taxa currently lacking specific life-history stage curves. The habitat guild criteria are based on information developed for a suite of fish and habitat types occurring in a number of streams in Virginia. Their use for the Pithlachascotee River and other Florida systems is considered appropriate as they specify habitat characteristics that may be expected to be populated by local fish fauna.

FWCC Question 6:

“From the PHABSIM output on page 7-6, cyprinidae are referenced as a species/life stage/ guild. Cyprinidae is a large family and grouping all fish in this family could have some biases. For example, golden shiners have different habitat and flow requirements than an iron colored shiner. Please explain the species used in this analysis and how it was classified by habitat preference and flow.”

District Response/Comments for FWCC Question 6:

The Type II HSC developed for Cyprinidae was developed based on electrofishing at a number of Florida streams. The sampling involved quantification of all cyprinid minnows, without segregation by species, in association with observed flow velocities, water depth and substrate types. The curve is therefore based on total occurrence of cyprinids in the sampled Florida systems. It may be considered a generalized curve applicable for all Cyprinidae, and could certainly be refined for individual taxa or for specific water bodies based on data availability.

APPENDIX 6E

Letter and attachment from R. Warren Hogg to Doug Leeper, dated April 6, 2015. Regarding: proposed minimum flows for the Pithlachascotee River – technical comments on District reports used to establish proposed minimum flows. Tampa Bay Water. Clearwater, Florida.

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TAMPA BAY WATER
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Delivered by E-Mail and U.S. Mail

April 6, 2015

Mr. Douglas A. Leeper
Chief Advisory Environmental Scientist
Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34604-6899

Re: Proposed Minimum Flows for the Pithlachascotee River – Technical Comments on District Reports Used to Establish Proposed Minimum Flows

Dear Mr. Leeper,

Tampa Bay Water staff appreciate the opportunity to review and comment on the technical analyses that the District staff have completed to support your Minimum Flows and Levels program. Attached please find a compilation of our technical comments related to the reports authored by the District and others which were used to set the proposed Minimum Flow for the Pithlachascotee River in Pasco County.

We request that you share these comments with your Peer Review Panel for this proposed Minimum Flow once the Panel has been established. If District staff would like to meet and discuss these comments prior to the establishment of the Peer Review Panel, please let me know and we will schedule a meeting(s) at our earliest mutual convenience. We look forward to working with the District staff and the Peer Review Panel during their deliberation on these technical issues.

Sincerely,

R. Warren Hogg

R. Warren Hogg, P.G.
Permitting Manager
Tampa Bay Water

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General Manager Matthew W Jordan

General Counsel Barrie S. Buenaventura, *Pennington, P A*

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Attachment

cc: Eric DeHaven, District
Christine Owen, Tampa Bay Water
Jeff Geurink, Tampa Bay Water
Tirusew Asefa, Tampa Bay Water
Nisai Wanakule, Tampa Bay Water
Chris Shea, Tampa Bay Water

"Recommended Minimum Flows for the Pithlachascotee River", Draft July 8, 2014 and "Appendices - Recommended Minimum Flows for the Pithlachascotee River", Draft August 26, 2014

Evaluation Comments, Tampa Bay Water Staff, 4/06/2015

In a draft report (SWFWMD 2014) with appendices, the Southwest Florida Water Management District (District) explains the process, provides the basis, and defines the values for proposed minimum flows for the Pithlachascotee River (PR). Tampa Bay Water appreciates the opportunity to review the documents and meet with staff (June 3, 2014) prior to the District formally initiating rule making. Through this letter, Tampa Bay Water offers its comments and concerns regarding the proposed minimum flows and the technical processes used to define the flows. In an effort to clearly communicate our comments and concerns, both a summary (beginning of letter) and an expanded set of comments (end of letter) are provided. Tampa Bay Water requests that the District share these comments with the peer review panel when the panel is engaged to proceed.

In the context of developing a Baseline (unimpacted) streamflow time series, the District has attempted to incorporate the effects of all present day structural alterations within the watershed while removing the influence of all well pumping within the watershed.

Conceptual Description of Watershed Hydrology

In the PR watershed and in other watersheds of west-central Florida which exhibit extended periods of no flow or low flow, streamflow response and/or changes to streamflow response are influenced by physical, climatic, and hydrologic factors which include,

- Watershed characteristics: land use, imperviousness, soils, land surface slope
- Climate variability: inter-annual, seasonality, intensity-duration-frequency, spatial
- Antecedent storage: canopy, soil surface, soil moisture, water bodies, depth-to-water table; generally, surface runoff and streamflow increase as antecedent storages increase (*i.e.*, wetter conditions)
- Relationship between soil moisture and depth-to-water table (DTW): generally, soil moisture (and surface runoff) increases as DTW decreases
- Relationship between baseflow and DTW: generally, for rivers receiving ground water from the surficial aquifer system (SAS), baseflow increases as DTW decreases
- Well pumping: Generally, streamflow increases as a result of reductions in well pumping, dependent on pumping rate change and proximity of pumping wells to river and tributaries. Surface runoff and baseflow comprise the two major components of streamflow. For the PR, reductions in well pumping cause much larger increases in surface runoff compared to baseflow. Total change to streamflow as a result of well pumping change follows a seasonal pattern which matches the seasonal pattern of streamflow.

Summary of Comments and Concerns

Our review of the proposed process, basis and values for the PR minimum flows is summarized using four themes. The summary is supported by the expanded comments at the end of this letter. Through the following summary, we intend to convey the broad picture of our concerns with the proposed minimum flows for the PR.

- **Historic climate variability**: Together over a long pre-development period, historic climate variability and watershed characteristics define variability in streamflow characteristics and channel/floodplain geometry and biology. It is therefore considerably important to incorporate full (*i.e.*, many decades) historic climate variability into the development of minimum flows and into compliance assessments of minimum flows. Full historic climate variability was not captured by the PR Baseline (unimpacted) streamflow time series which spanned a short investigation period (~ decade) with low rainfall and low streamflow when compared to the long-term mean/median for both parameters. The District has assessed inundation of mean elevations of woody habitat using a Baseline streamflow time series which has depressed inundation frequency characteristics compared to the long-term mean/median characteristics. The depressed inundation frequency characteristics of the designated Baseline period do not hydrologically align with the physical, vertical positioning of beneficial habitat that is positioned in part due to the effects of full historic climate variability and results in underestimation of percent allowable flow reduction. Assuming the beneficial habitat of the PR was formed (*i.e.*, spatial and vertical positioning) in part due to the effects of full historic climate variability, is it acceptable to define the minimum flow using a Baseline streamflow time series which does not represent the flow condition that formed the habitat? Refer to Item 1 for expanded comments.
- **Uncertainty in model outputs influences minimum flows**: Proposed minimum flow values include some measure of uncertainty. In other words, for a flow block of a particular river, the proposed minimum flow value is contained within a range of probable magnitude (uncertainty). The uncertainty or range of probable magnitude of minimum flow values for the PR is very difficult to quantify because at least five models are sequentially linked together to define the proposed minimum flows (Figure 5, Figure 6). In order to produce a recommended minimum flow for the PR that is technically sound and defensible, the sources of uncertainty (Table 1) must be minimized at each step in the sequence to minimize the likelihood that the proposed minimum flows have a wide range of probable magnitude. Refer to Item 2 for expanded comments. The proposed minimum flows for the PR may have a high range of probable magnitude (uncertainty) because:
    - corrections for model error and biases in model outputs were not made,
    - extrapolated model applications were used without first demonstrating the technical plausibility of the concept,
    - the sensitivity of key model terms and parameters were not defined and used to guide decision making,
    - hydrological input and biological indicators may not be physically matched during the assessment of habitat reduction, and
    - all components of freshwater flow to the lower PR (estuary) were not included.
- **Uncertainty in MFL measures and goals influences minimum flows**: The District has stated that specific measures and goals provide appropriate metrics to establish minimum flows for the PR. The specific measures and goals established by the District for the PR each include some measure of uncertainty. Sources of uncertainty can weaken the reliability and precision of the selected minimum flow evaluation metrics. Absent from SWFWMD (2014) is a discussion and assessment of the following three sources of uncertainty that can have a significant influence on the selected minimum flow evaluation metrics (refer to Item 3 for expanded comments):
    - intermittent compared to perennially flowing river,
    - assessment of present-day adverse impact using the PR habitat field data, and
    - correlation of adjusted Baseline flow to existing in-stream habitat.

- **Compliance assessment process**: The compliance assessment process must be adopted by rule simultaneously with adoption of minimum flows so that the regulated community can ascertain current and future compliance with the rule. A question that must be answered is if the use of the integrated surface water/groundwater model should be the only tool used to assess compliance with the proposed minimum flows. It is likely that multiple assessment techniques will be needed to assess compliance on a regular basis and at the time of permit renewals. Refer to Item 4 for expanded comments.

Expanded Comments and Concerns

For each of the four themes summarized above, we offer the following expanded comments.

1. Historic climate variability: Together over a long pre-development period, historic climate variability and watershed characteristics define variability in streamflow magnitude and inundation frequency, physical geometry of the river channel and floodplain, and vertical positioning within channel and floodplain of beneficial habitat for fish and other fauna.
    a. Assessment of Baseline period: *It is considerably important to incorporate full (i.e., many decades) historic climate variability into the development of minimum flows and into compliance assessments of established minimum flows.* Full historic climate variability was not captured by the PR Baseline (unimpacted) streamflow time series covering the short 11 year investigation period spanning 1990 through 2000. For the investigation period, recorded rainfall was several inches below the long-term average annual mean (SWFWMD 2014). For the investigation period, the District acknowledged the short period of investigation and the presence of low rainfall (pages 2-45, 6-3), but justified using the stated investigation period on the basis that it covered a suitable range of flows. However, the District's evaluation of PR minimum flows was directly related to inundation frequency, a temporal measure of flow reaching or exceeding physical, temporally-static habitat threshold depths/elevations. Inundation frequency is the persistence of flow at a threshold which is related to the timing and magnitude of rainfall and system storage but not to the range in flow. The District has assessed inundation of the mean elevations of woody habitat (page 7-9, Table on page 7-10) using a streamflow time series which has depressed inundation frequency characteristics compared to the long-term mean/median characteristics (item 1b). *The depressed inundation frequency characteristics of the designated Baseline period do not hydrologically align with the physical, vertical positioning of beneficial habitat that is positioned in part due to the effects of full historic climate variability and results in underestimation of percent allowable flow reduction.*
    b. Demonstration of full historic climate variability: Recently, Tampa Bay Water completed 1000 realizations (simulations) of the INTB model with each realization spanning 22 years. The only difference between each realization was rainfall input. Each of the 1000 rainfall realizations is unique and the ensemble of all 1000 rainfall realizations captures the historic temporal and spatial climate variability across the INTB model domain (Geomatrix-AMEC 2010). Well pumping rates for all 1000 realizations are the same and all rates vary monthly to represent a plausible future condition (profiled from historical data). Average annual Consolidated Wellfield (CWF) pumping is set at 90.0 mgd with a temporal and spatial distribution matching actual conditions for calendar year 2008. Average annual pumping rate for all other wells (non-CWF) is set at 356.3 mgd resulting in total well pumping of 446.3 mgd.

Monthly pumping rates for non-CWF wells are set at the ensemble monthly average rate from the period 2002-2006. The first two years of each realization were not evaluated to avoid influences from initial conditions and well pumping rate transitions. These model results are referred to as CWF at 90 mgd under the influence of historic climate variability (CWF90_2008). A second set of 1000 simulations was completed using the same 1000 rainfall realizations but turning well pumping off in the central west-central Florida ground-water basin (CWCFGWB) portion of the INTB model domain which left total well pumping at 289.2 mgd. The second set of 1000 simulations is referred to as GWB0 which represents well pumping conditions similar to the District's Baseline. *Results of the GWB0 and CWF90_2008 realizations are used here as a tool to demonstrate the influence of full historic climate variability on*: i) streamflow variability, ii) definition of Baseline (unimpacted) streamflow, and iii) compliance assessment for minimum flows.

i. Influence of historic climate variability on PR streamflow: From the GWB0 realizations, weekly averages of the daily simulated streamflow results for the PR at New Port Richey are summarized using a flow percent exceedance graph (Figure 1). In the absence of well pumping, the estimated range of flows due to full historic climate variability is represented by the box and whisker plots at 2% intervals including the median (dot inside open circle), inter-quartile range or IQR (solid rectangle), outside the IQR (whisker), and outliers (open circles at whisker ends). Over the full range of historic climate variability from GWB0 realizations, Figure 1 indicates that the weekly average flow for percent exceedance at 50% ranges from approximately 6 to 18 cfs with a median of about 11 cfs. Figure 1 clearly demonstrates the *influence of historic climate variability on PR streamflow and the importance of incorporating full historic climate variability into the process of developing minimum flows.*

ii. Baseline period: In Figure 2, a red line with plus symbols (+) has been placed on a copy of Figure 1 to represent the percent exceedance curve of the District's Baseline weekly average flow time series with zero pumping (1990 – 2000). The District's Baseline flow falls below the median flow of GWB0 realizations over the entire flow range except the highest 10% of flows. Flow results from 1000 realizations of historic rainfall (GWB0) compared to the Baseline in Figure 2 indicates that Baseline flows are less than the GWB0 medians over all but the highest flow regimes. *Therefore, the depressed inundation frequency characteristics of the Baseline period do not hydrologically align with the physical, vertical positioning of beneficial habitat that is positioned in part due to the effects of full historic climate variability and results in underestimation of percent allowable flow reduction.*

iii. Compliance period: In Figure 2**Error! Reference source not found.**, a maroon line with "x" symbols has been placed on a copy of Figure 1 to represent the percent exceedance curve of streamflow with zero pumping over the District's Compliance Period (1996 – 2006). This decade of flows is characterized by extremes. More than half of the flow profile (percent exceedances greater than 40%) have flows less than the GWB0 medians and the lowest flows are less than flows during 1990-2000. By contrast, the highest flows of the Compliance Period are at the outer extent of the GWB0 outliers. *Because of the high degree of variability in streamflow related to climate variability, we believe it is critical to define the compliance assessment process as part of the adoption of the MFL*

iv. <u>Influence of historic climate variability on PR streamflow change due to well pumping:</u> As described in item 1b, realization sets GWB0 and CWF90_2008 use the same 1000 rainfall realizations but different well pumping. Paired by rainfall realization, the PR flow difference (GWB0 minus CWF90_2008) due to a specific well pumping scenario can be estimated for all 1000 realizations. PR flow change due to the CWF90_2008 well pumping scenario, within the context of full historic climate variability, is summarized in Figure 3 using box and whisker plots at 2% intervals. PR flow change for the same well pumping scenario is also presented in Figure 3 for the District's Baseline (1990-2000) and Compliance (1996-2006) periods. The ensemble monthly PR flow change due to well pumping, in the context of full historic climate variability, indicates flow change increases with increasing flow which is related to increasing rainfall (Figure 4). The wet season has the highest flow change and the dry season has the lowest flow change. These results reinforce the conceptual description of the PR watershed hydrology which was summarized in the introductory paragraphs of these comments. *Because of the high degree of variability in streamflow related to climate variability, it is critical to define the compliance assessment process as part of the adoption of the MFL. Furthermore, both the minimum flow development process and the compliance assessment process must incorporate the effects of climate variability.*

c. Throughout the report, it is stated that the PR is a low-flow system, especially during the Block 1 time period and that multiple analyses are confounded by the abundance of days with flows less than 5 cfs (actual and simulated flow data). It is stated on page 8-5 that relative model errors are greater when modeled flow is less than 5 cfs; however the model is offered as the primary tool to be used in assessing compliance with the proposed minimum flows. Given these limitations and concerns, is this approach to establish minimum flows appropriate for low-flow systems and if so, should the model be used as the only method to assess compliance with the proposed minimum flows? What role should empirical flow data or other analytical methods have in the compliance assessment process?

2. <u>Uncertainty in model outputs influences minimum flows</u>: Proposed minimum flow values include some measure of uncertainty. In other words, for a flow block of a particular river, the proposed minimum flow value is contained within a range of probable magnitude (uncertainty) which has typically not been quantified or is very difficult to quantify. The uncertainty or range of probable magnitude of minimum flow values for the PR is very difficult to quantify because at least five models are sequentially linked together to define the proposed minimum flows (Figure 5, Figure 6). Faced with this understanding, the sources of uncertainty (Table 1) must be minimized at each step in the sequence to minimize the likelihood that the proposed minimum flows have a wide range of probable magnitude. Uncertainty in the minimum flows increase with: increasing error in each model employed, decreasing sensitivity (ratio of change in model response to change in model input) of key model inputs, and incomplete definition of temporal and spatial distributions or functional relationships for model inputs. For each model used in the sequence (Figure 5) of minimum flow development for the PR, sources of uncertainty which influence minimum flows are described.

a. <u>INTB model</u>: The Baseline (unimpacted) streamflow time series was defined, in part, by using two well pumping scenarios of the INTB model. For the INTB model, sources of uncertainty include all data inputs of the calibrated model as defined in Geurink and Basso (2013), model response error, and execution and processing of the scenarios. *Specific concerns include zero well pumping scenarios, flow correction for model error, and use of first two years of a simulation following a stress transition*:

   i. Because all MFLs have regulatory implications, the District should demonstrate that the INTB model produces plausible hydrologic responses for a zero well pumping rate (~240 mgd reduction as stated in SWFWMD 2014, but TBW has determined the well pumping reduction was 212 mgd) scenarios covering large areas (wellfields or regions). *A series of tests should be designed, implemented, and assessed to ascertain limits if any of using the INTB model in this extrapolated manner where pumping stress magnitude is considerably lower than was used in the calibration and verification periods.*
   ii. <u>Simulated flows should be corrected for model error</u> prior to using the data as input to another model and prior to calculating the flow difference between two INTB scenarios. Using the flow difference at a flow gauge location between two INTB model scenarios, without first correcting the flow for each scenario for model error, assumes the INTB model error at a flow gauge location is uniform along the vertical profile of observed flow. However, non-uniform INTB model flow error vs observed flow exists at flow gauges used to calibrate the INTB model. For a scenario example with large reduction in well pumping rates, scenario simulated flow rates will be elevated compared to calibrated (historical) conditions. This means the scenario model with the large pumping rate reduction is operating more often in a higher flow rate region which could have a different flow error than at lower flow rates.
   iii. When any stress change is imposed on the INTB model, the <u>first two years of simulated results should not be used for analysis</u>. Through internal testing of the INTB model, Tampa Bay Water has concluded that it takes more than 1.5 but less than two years to remove the influence of initial conditions or stress transitions due to the storage in the surface water and ground water systems of the INTB domain. *The District has used INTB flows within the first two years of the simulation to define minimum flows which will skew the resulting Baseline flow data.*

b. <u>Flow regression model</u>: The flow regression model produced the Baseline (unimpacted) streamflow time series used for all PR minimum flow development. Using time series from the same two INTB model scenarios referenced in Item 2.a as inputs, the flow regression model was developed to predict an unimpacted streamflow time series from an impacted streamflow time series over the same time span. Several questions and potential deficiencies are highlighted including model structure, limits on temporal span, and lack of validation and residuals analysis. *Tampa Bay Water reconstructed the regression model and found significant bias for flows less than 50 cfs (low to intermediate flow) which could significantly influence minimum flows. We will provide this analysis to the District or Peer Review Panel upon request.* Tampa Bay Water recommends that the following specific technical concerns on the flow regression model be investigated as part of the peer review process:

   i. What specific characteristics of the daily flow "temporal variation" of the INTB model were deemed unusable but were reproduced by the regression equation instead? In other words, what specific flow characteristics were not captured by the INTB model that were captured by the regression model?
   ii. INTB model flow at a daily time scale has been known to be less accurate than weekly and monthly flow due to the lagging flow responses on the simulation (Geurink and Basso 2013). Any analysis based on daily flow is

prone to larger error results especially when extreme input, such as a zero-pumpage scenario, is used.

iii. In Sections 3.1 and 3.2 (Janicki 2011), it was decided to replace the regression model values with INTB values when regression model values were less than 1.6 cfs.

    1. The reasoning of rejecting the use of the INTB modeled flows and then incorporating the low-flow data into the time series should be explained. Is this a valid approach given the limitations of the data and analyses?
    2. Even though the INTB model was rejected prior to the regression analysis, the validity of the regression model was measured on the basis of how well it matched the INTB model (Figures 3-1, 3-2, 4-1, Table 4-1, Residual plots in Appendix 1). How can the INTB model be at the same time rejected to be used for daily flows and then used to validate the regression model for daily flows?
    3. How can it be concluded or implied that the regression model produces an improved version of daily flow time series (Section 4.2) for the baseline when the only other data source for the baseline is the INTB model?
    4. To generate daily flow adjustment due to pumping, was it considered to use the ensemble of INTB model flow differences (pumping vs zero pumping scenario) within each of the 3 seasonal flow blocks for all simulation years (or preferably for a reasonable number of stochastic rainfall realizations of sufficient length instead of one deterministic period)?

iv. What are the pitfalls associated with performing regression modeling on model output? Both the dependent variable INTB modeled baseline flow (Q*base*) and the predictor variable INTB modeled impacted flow (Q*imp*) result from the same model – variability in flow response will not be comparable to empirical data. This will result in a relatively high Coefficient of Determination (R^2) and increased statistical significance as compared to regression models developed from empirical data.

v. No physical justification for the quadratic term is provided – it seems to have been included for curve fitting, leading to the possibility that the model is overly complex and has been "over fit" for the sample data.

vi. The author has developed a relatively "complex" equation from the point of having a transformation and a non-linear term in the equation. Checking the validity of a regression equation is usually done using samples that were not part of the curve fitting. This ensures that the regression will hold in other situations as well as if the data used were to be perturbed with an error (white noise), the regression coefficients stay the same. This helps the regression equation "not to learn too much from the data". Were these analysis performed but omitted from the report?

vii. Multi-collinearity of predictor variables was not discussed. Correlated independent variables may affect the regression coefficients, although they won't affect the predictive power or accuracy of the regression.

viii. Regression performed on time series data tends to yield an inflated R-square value due to serial correlation. One can test this by reanalyzing the regression model using a one value per month time series. Note that the collinearity effect may still exist depending on the strength of the monthly lag correlation.

ix. The regression model uses a log-transform value of flow as an independent variable; it would be reasonable to show the plots related to flow such as Figures 2-7 and 2-8 in log-scale. Also, because of the log-transform, one needs to realize that the regression model will possess bias in errors toward the high flow as shown in Figures 3-2 and 3-4. The residual by month in the appendices also shows high variation in residuals in the months where rainfall is expected, which will likely be correlated to monthly rainfall variances.

x. Because of the intercept term, the regression model for the Pithlachascotee River has already yielded a predicting bias of 0.317 cfs. We also believe that the effect of variance of Qpump150 on residual is significant and biased. No plot of residual against independent variables was found in the appendices. There is no discussion on why a 150-day window was selected. This aggregate variable will show strong serial correlation for a daily time step time series.

xi. As District staff noted during our meeting on June 3, 2014 pumpage is included twice in the regression model – in these terms:
    1. Qimp = INTB modeled impacted flow at the gage
    2. Qpump150 = 150-day average pumpage from the Starkey-North Pasco wellfield

xii. During that meeting, District staff stated that when the pumping parameter was removed from the equation, the result did not change. This issue should be further discussed. Most model selection criterion such as the Bayesian Information Criterion (BIC) actually penalizes the model for being more complex in the sense of having more parameters to fit the regression. Therefore, the model with the least parameters would have been selected.

xiii. The importance of rainfall in the analysis cannot be overstated. Regression variables cannot be selected without looking at the physical mechanism behind them. Based on the relationship established (equations in sections 3.1 and 3.2), it can lead one to believe that if pumpage is zero, Qbase and Qimp would effectively be equivalent and one could solve the resulting quadratic equation to give a constant Qbase, which is effectively saying that if there is no pumpage, no matter what the rainfall may be (since it is not in the equation), you could get constant baseline flow, which is an erroneous conclusion.

xiv. The author provides plots of residuals and mentions the F value, but no other regression output is provided in the report. A standard output table with p values, regression coefficients, the Variance Inflation Factor etc. should be presented and assessed.

xv. The time series plots of the residuals should be included in the report. At the June 3, 2014 meeting, District staff said that the plots looked fine; however, the plots should be included in the report. When validating a regression or any other model, it is important to see such factors as a) residual time series, b) autocorrelations of residuals, and c) residual plots versus predicted values so that statistical assumptions used to find the regression lines can be verified.

Other residual plots (see Appendix) aggregated over calendar years clearly shows bias for the years 1997, 1998, and 1999 highlighting the effect of rain in those years that are marked by La Niña and El Niño conditions. Therefore, the question of not accounting for rainfall or assuming it would be the same regardless of the time series used to develop the regression relationship is a serious one.

xvi. This approach should be validated by comparison to an out-of-sample dataset (e.g. more recent data).

xvii. If the regression results themselves (final time series used for MFL calculation) include an overestimate of pumpage impact, this might be detectable by some analysis of the relationship between rainfall and regression model output. Also, analysis of any trends in the synthetic time series would be useful.

c. <u>HEC-RAS model</u>: The simulated stage-flow relationship from the HEC-RAS model was used as input to the PHABSIM model and to the Long-Term Inundation Analysis (LTIA) model. Inputs to the HEC-RAS model included Flow Regression model time series and various hydraulic characteristics of the PR channel/floodplain corridor. *Specific concerns include the dry bias in Baseline flow (see Item 2.b), bias in simulated low-flow stage, and simulated stage at minimum flow evaluation transects was not evaluated with observed data*:

   i. For flows less than 30 cfs, simulated stages from the HEC-RAS model are biased low. No stage bias correction was applied at the evaluation transects before being input to either the PHABSIM model or the LTIA model. *The implication of this bias for flows less than 30 cfs is over estimation of the impact of flow loss on habitat inundation.* In other words, attainment of 15% temporal habitat reduction occurs for a smaller flow reduction compared to when the stage bias is removed.

   ii. Simulated stage was not evaluated with observed data at minimum flow evaluation transects. Uncertainties in spatial distribution of parameter values such as Manning n and lateral flow contribution along the river corridor result in uncertainties in the spatial distribution of simulated stage-discharge. The most upstream end of the simulated channel corridor, at the Fivay Junction gauge, is the only location at which calibrated stage was evaluated. Minimum flow evaluation transects are located several river miles downstream with no evaluation of calibrated stage values. *Implication of no calibration at evaluation transects means the estimation of simulated stage bias must be extrapolated using model performance at only the calibration transect at the upstream end of the river.*

d. <u>PHABSIM model</u>: The PHABSIM model was used to simulate changes to habitat availability for seven fish species using a flow range from Baseline (Flow Regression model) to a 40% reduction in Baseline. Simulated habitat availability output from PHABSIM was averaged over three PHABSIM cross-sections by fish species and seasonal flow block. Simulated habitat availability output from PHABSIM for the most sensitive fish species is the final interpretive result of this model. Inputs to the PHABSIM model included HEC-RAS simulated stage-flow, habitat suitability curves by fish species, and various hydraulic and vegetative characteristics for the PHABSIM cross-sections which are located at shoals. *Specific concerns include the dry bias in Baseline flow (see Item 2.b), the apparent physical disconnect of habitat assessments at shoals for Blocks 1 and 2, stage biases from HEC-RAS, and absence of calibration and sensitivity assessments of PHABSIM*:

    1. Within the context of an intermittent stream, selection of PHABSIM cross-sections at shoal locations for fish habitat assessment appears problematic. Below 25 cfs for the PR, it is assumed that the proposed fish passage threshold places fish in isolated pools along the river corridor and the shoal locations are temporarily not conducive as fish habitats. Using the median flow results from the GWB0 simulations for 25 cfs (no well pumping simulation, item 1b), it is estimated that 25 cfs is equaled or exceeded about 30% of the time. This means that some fraction of the fish population along the freshwater portion of the river is annually constrained in isolated pools as a result of climate variability alone. These isolated pools may dry completely causing fish mortality. Since much of the flow time series of Blocks 1 and 2 are less than 25 cfs, *assessment of habitat availability at the shoal locations appears to be disconnected from the physical system for this intermittent flowing river.*
    2. Depending on sensitivity, the *implication of low stage bias from HEC-RAS for flows less than 30 cfs could have considerable influence on interpretation of habitat inundation changes as flow is reduced.*
    3. Because the PHABSIM model results play a key role in defining minimum flows, it is critical that calibration and sensitivity assessments be provided for each transect and some reasonable combination of species and flow blocks. *Sensitivity assessments of the PHABSIM model will help give an understanding of the range of probable magnitude (uncertainty) for the allowable percent flow reduction.*

e. <u>Long-Term Inundation Analysis (LTIA) model</u>: The LTIA model simulated long-term temporal change in habitat inundation. Inputs to the LTIA model include Flow Regression model time series, simulated HEC-RAS stage-flow, and cross-sections at vegetative transects. Very little information is provided in the District report about this spreadsheet model which ultimately defines allowable percent flow reductions for Blocks 2 and 3. *Specific concerns include the dry bias in Baseline flow (see Item 2.b), stage biases from HEC-RAS, and absence of documentation, calibration and sensitivity assessments of LTIA*:

    1. Depending on sensitivity, the *implication of low stage bias from HEC-RAS for flows less than 30 cfs could have considerable influence on interpretation of habitat inundation changes as flow is reduced.*
    2. Because the LTIA model results play a key role in defining minimum flows, it is critical that documentation be completed, and calibration and sensitivity assessments should be provided for each transect and flow block. *Sensitivity assessments of the LTIA model will help give an understanding of the range of probable magnitude (uncertainty) for the allowable percent flow reduction.*

f. <u>Estuary Regression models</u>: The Estuary Regression models were used to define relationships between various evaluation criteria and Baseline (unimpacted) freshwater inflow. Percent reductions in Baseline flow resulted in percent reductions in evaluation criteria which were compared to critical thresholds to define minimum flows for the lower PR. Although it appears the District used the same Baseline flow time series (at New Port Richey USGS gauge) to evaluate the lower PR as was used to evaluate the upper PR, freshwater inflow to the lower PR is not limited to flow through the New Port Richey gauge location. There are approximately 5 river miles of watershed over which freshwater inflows via surface runoff and ground-water inflow can enter the PR. The District's report reveals a noticeable low flow contribution at the old New Port Richey gauge location that does not exist at the new location. Regardless of the source of the contribution, the freshwater flow should not be ignored. *The implication for leaving out freshwater flow coming into the PR at locations downstream of the New Port Richey gauge is to over-estimate the influence of reductions in freshwater inflows.*

3. Uncertainty in MFL measures and goals influences minimum flows: The District has stated that specific measures and goals provide appropriate metrics to establish minimum flows for the PR. The specific measures and goals established by the District for the PR each include some measure of uncertainty. Sources of uncertainty can weaken the reliability and precision of the selected minimum flow evaluation metrics. *Absent from the District's report (SWFWMD 2014) is a discussion and assessment of the following three sources of uncertainty that can have a significant influence on the selected minimum flow evaluation metrics: (1) intermittent compared to perennially flowing river, (2) assessment of present-day adverse impact using the PR habitat field data, and (3) correlation of adjusted Baseline flow to existing in-stream habitat.*
   a. Intermittent flowing river: To date, the District has developed minimum flows for perennial rivers. The PR is the first intermittent flowing river for which the District has proposed minimum flows. In SWFWMD (2014), the District justifies application of the MFL measures and goals for the PR on the basis of having previously applied them to develop minimum flows for several perennial rivers. *What evidence was considered that led the District to apply the MFL measures, goals, and analyses that were developed for perennial rivers to this intermittent/low-flow river? Are these MFL measures, goals, and analyses correctly applied to an intermittent/low-flow river?*
   b. Assessment of present-day adverse impact using the PR habitat field data: Recently collected habitat field data (2009-2010) for the PR corridor (SWRF and Dooris & Associates Report included as Appendix 6D of Recommended Minimum Flows for the Pithlachascotee River) was not used by the District to assess the asserted measures and goals that were used to develop proposed minimum flows for the PR. These data characterize apparently healthy floodplain swamp, bottomland hardwood and hydric hammock plant communities adjacent to the Pithlachascotee River. *Using the aforementioned field data and coinciding climatic and hydrologic data, Tampa Bay Water has the following questions and requests*: (1) Is there evidence of adverse impact to the PR corridor habitat that is intended to be protected through minimum flows? (2) If evidence of adverse impact exists, describe the evidence and the cause of the impact. (3) Did the District consider the development of a flow regime required to maintain the floodplain plant communities and avoid succession to vegetation associated with a drying trend? Floodplain vegetation is sensitive to the hydrologic flow regime (Darst et al 2008) and there is considerable literature on hydrologic characteristics of floodplain forests. A required flow regime maintaining the structure and composition of the floodplain forest would have direct ecological benefit and would correlate well with instream habitat requirements. (4) Are changes to MFL measures and goals for the PR as defined in SWFWMD (2014) warranted based on the immediately preceding assessments?
   c. Correlation of adjusted Baseline flow to existing in-stream habitat: River channel/floodplain geometry and habitat have been principally defined by pre-development conditions in the absence of both land development and well pumping. The District has created a Baseline streamflow that removes the effects of pumpage and incorporates the land use changes that have occurred within the PR watershed. Since only one of the two sets of physical changes to streamflow have been removed from the Baseline flow and this time series was then applied to the current physical river channel and floodplain, can the developed Baseline flow be reasonably used to assess the effects of changes in the ecology of the PR channel and floodplain? Does

the hydrological input (Baseline) match the existing biological indicators when assessing habitat inundation?

d. In Section 6.7 it is mentioned that peer review panels for previous MFL reports have recommended that "...the District commit the necessary resources to evaluate the effectiveness of a 15 percent change in spatial or temporal habitat availability as a threshold for identifying significant harm..." Is this work scheduled or ongoing? What evidence did the District consider in applying this threshold to the establishment of a Minimum Flow for the PR?

4. Compliance assessment process: The compliance assessment process should be adopted by rule simultaneously with adoption of minimum flows and should be thoroughly described in the Rule. Although the compliance assessment in SWFWMD (2014) lacks specificity, it can be used as a starting point. Rule-adopted compliance assessment elements should include at a minimum but not be limited to: (1) naming of specific evaluation tools, (2) complete description of how evaluation tools are to be modified and results summarized for compliance assessments, (3) length of compliance assessment period, (4) decision about compliance assessment by flow block, by combination of flow blocks, or by lumping all flow blocks together, (5) describe mechanics of calculating percent flow reduction over compliance assessment period, and (6) influence of prevailing climate condition over the compliance assessment period. The compliance process must also include provisions that protect the flow in the PR from further changes due to land use alterations within the watershed; if this is not accomplished, the responsibility for any future diminishment of flow in the PR due to causes other than well pumpage will be unfairly assessed to those entities holding Water Use Permits. The District should consider multiple assessment methods and the use of empirical data to assess compliance with the proposed Minimum Flows for the PR. Section 8.2 of SWFWMD states that a "final determination of whether a minimum flows recovery strategy is needed for the Pithlachascotee River should be incorporated into the Permit Recovery Assessment Plan for the Northern Tampa Bay area that is being prepared by Tampa Bay Water as part of their Consolidated Permit...". This assessment will be completed at the same time as our permit renewal in the year 2020. If the need for a recovery strategy will be assessed at the time of permit renewal, Tampa Bay Water will have no opportunity to make operational adjustments to see if the proposed Minimum Flow can be achieved. It seems disconnected to assess compliance with a Minimum Flow at the time of renewal of a major municipal water supply permit; a compliance method must be created and adopted at the time that the Minimum Flow rule is adopted so that Tampa Bay Water and other permittees can assess the implications of the rule as it is adopted and into the future. This will provide the greatest likelihood of all permittees successfully complying with the rule. *The implication of not simultaneously adopting compliance assessment by rule leaves an ambiguous and undefined process by which the regulated community cannot ascertain compliance with the rule.*

5. Streamflow unit response: In the appendices, the District described an application of streamflow unit response to estimate the temporal impact of ground-water pumping. Since the District did not use the unit response approach to define the Baseline flow time series for the PR, the text should be removed. The validity of applying a unit response concept to west-central Florida streamflow has not been demonstrated by the District or others.

References

Darst, M.R., Light, H.M., 2008, Drier Forest Composition Associated with Hydrologic Change in the Apalachicola River Floodplain, Florida: U.S. Geological Survey Scientific Investigations Report 2008-5062, 81 p., plus 12 apps

Geomatrix-AMEC 2010. "Generation of Monte Carlo realization of rainfall time series." Prepared for Tampa Bay Water. Oakland, CA.

Geurink, J.S. and Basso, R. (2013). "Development, calibration, and evaluation of the Integrated Northern Tampa Bay Hydrologic Model." Prepared for Tampa Bay Water and the Southwest Florida Water Management District, Clearwater, FL.

SWFWMD (2014). "Recommended minimum flows for the Pithlachascotee River." Prepared for the Southwest Florida Water Management District, Brooksville, FL.

Tampa Bay Water (2011). "Operation Plan Update." *Appendix A: Development and validation of the new unit response matrix for the Optimized Regional Operations Plan (OROP) model.* Prepared for the Southwest Florida Water Management District, Clearwater, FL.

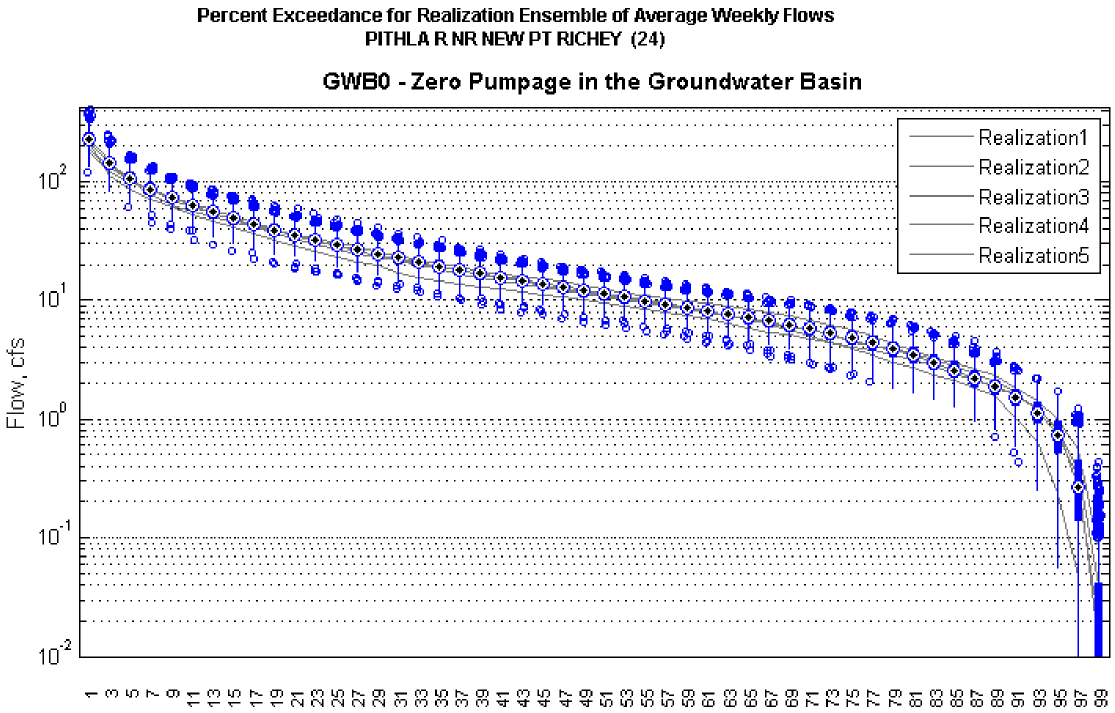


Figure 1 GWB0 Ensemble Summary of Weekly Average Streamflow for Pithlachascotee River at New Port Richey; 20-Year INTB Model Simulations for 1000 Realizations of Historic Rainfall With Zero Well Pumping

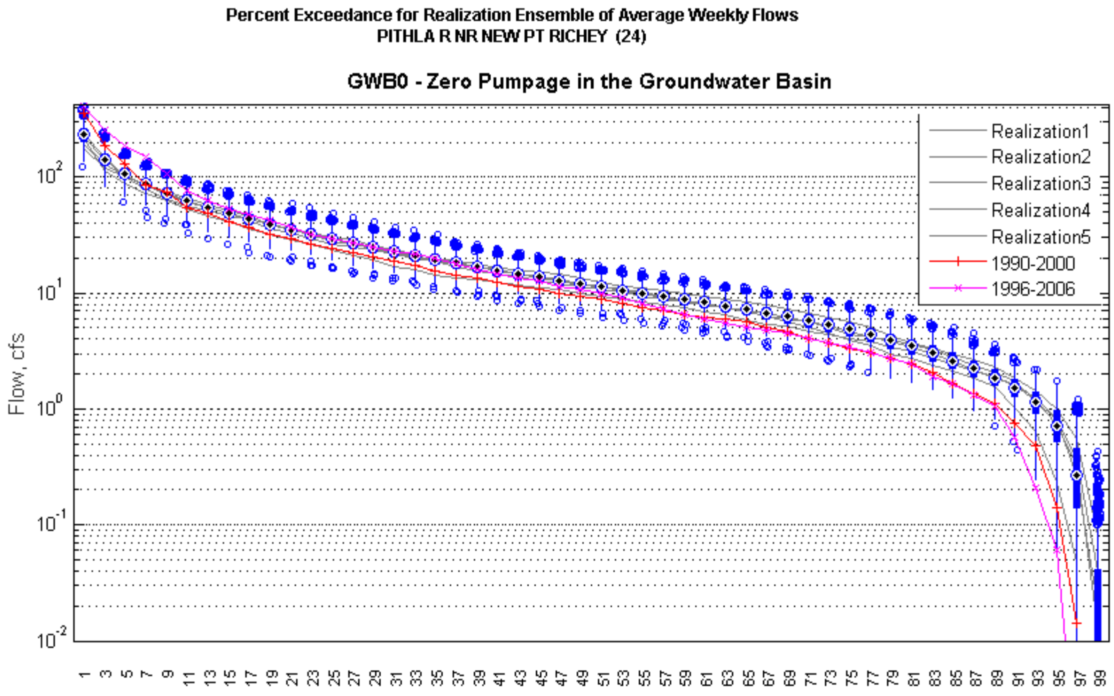


Figure 2 District Baseline Flow Period Over 1990-2000 and District Compliance Flow Period Over 1996-2006, Both With Zero Well Pumping, for Pithlachascotee River at New Port Richey (PR) Plotted on the GWB0 Ensemble Summary of Weekly Average PR Flow with Zero Well Pumping

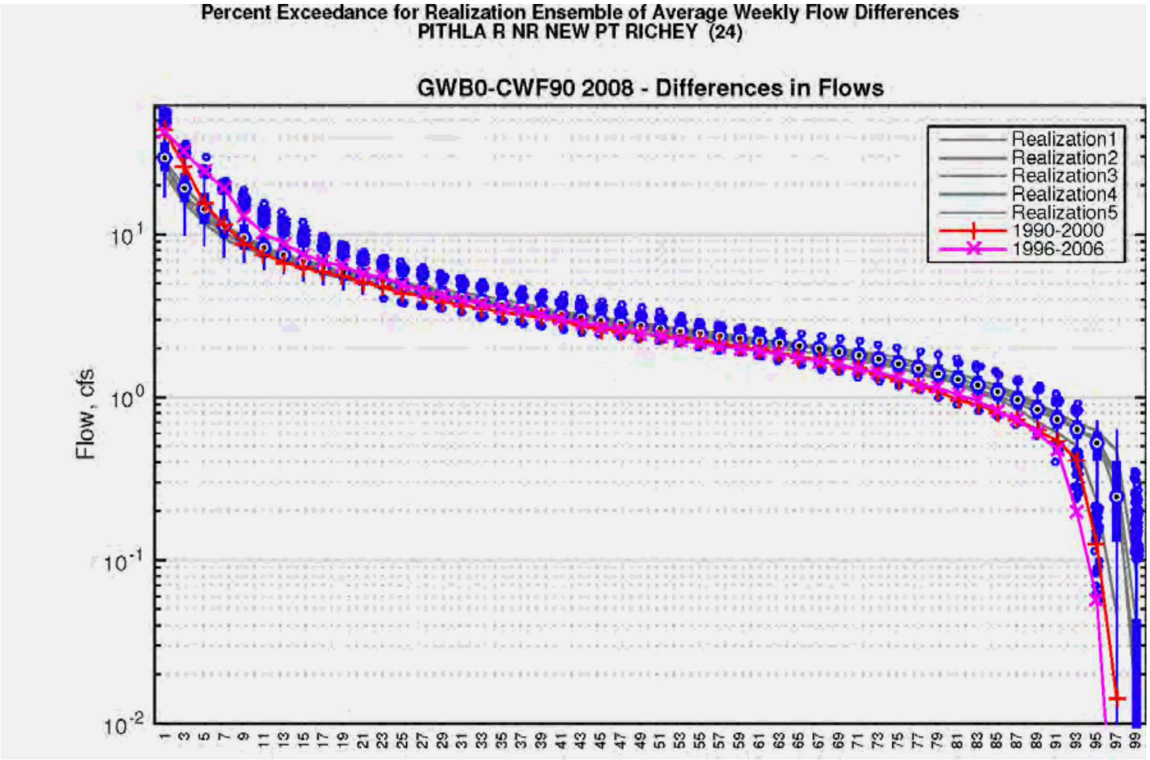


Figure 3 Ensemble Summary of Weekly Average Streamflow Change for Pithlachascotee River at NPR Due to Well Pumping in the Context of Climate Variability; 20-Year INTB Model Simulations for 1000 Realizations of Historic Rainfall; Flow Difference is Scenarios GWB0 Minus CWF90_2008

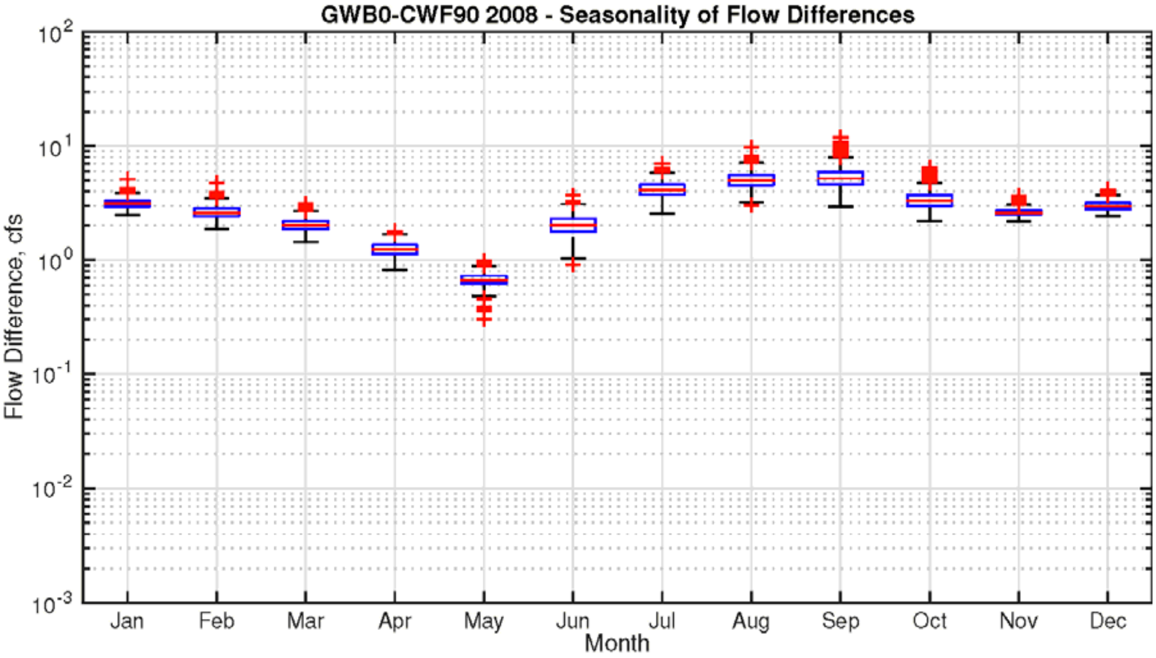


Figure 4 Ensemble Monthly Summary of Weekly Average Streamflow Change for Pithlachascotee River at NPR Due to Well Pumping in the Context of Climate Variability; 20-Year INTB Model Simulations for 1000 Realizations of Historic Rainfall; Flow Difference is Scenarios GWB0 Minus CWF90_2008

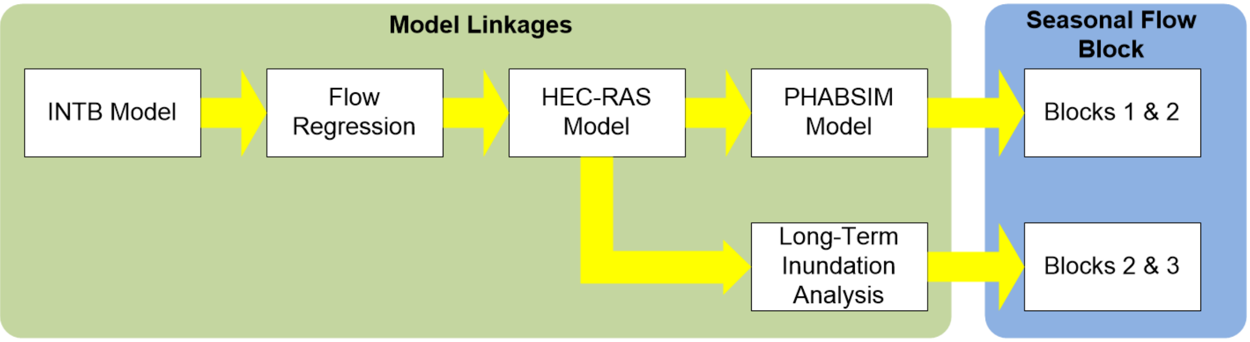
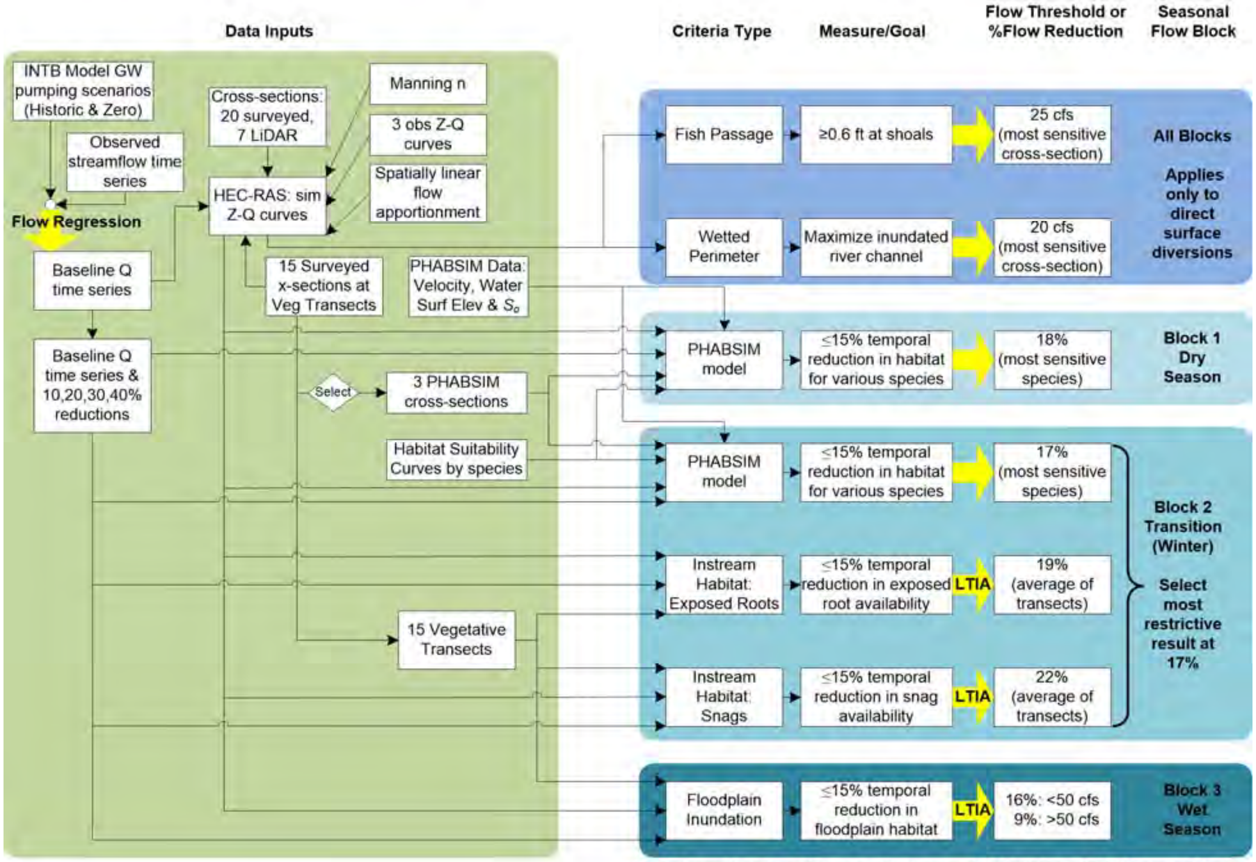


Figure 5 Summary of Model Linkages and Sequence of Models Employed to Develop Minimum Flows for Each Seasonal Flow Block of the Freshwater Portion for the Pithlachascotee River



LTIA: Long-term inundation analysis, completed within a District spreadsheet.

Figure 6 Data Inputs, Model Linkages and Sequence of Models Employed to Develop Minimum Flows for Each Seasonal Flow Block of the Freshwater Portion for the Pithlachascotee River

Table 1 Sources of Uncertainty in the Process Used to Develop Minimum Flows for Each Seasonal Flow Block of the Freshwater Portion for the Pithlachascotee River

	MFL Flow Threshold or Percent Flow Reduction			
Sources of Uncertainty	**All Blocks Direct SW Diversions**	**Block 1 Dry Season**	**Block 2 Transition (Winter)**	**Block 3 Wet Season**
Data Inputs and Model Outputs				
Flows from INTB model GW pumping scenarios*	✓	✓	✓	✓
Observed streamflow time series	✓	✓	✓	✓
Impacted to Unimpacted flow regression	✓	✓	✓	✓
Baseline flow time series	✓	✓	✓	✓
% reductions for Baseline flow time series		✓	✓	
Surveyed cross sections (20)	✓	✓	✓	✓
LiDAR cross sections (7)	✓	✓	✓	✓
Surveyed x-sect at Veg. Transects (15)	✓	✓	✓	✓
Manning n for channel and floodplain	✓	✓	✓	✓
Observed stage-flow curves (3)	✓	✓	✓	✓
Spatially-linear flow apportionment along channel	✓	✓	✓	✓
HEC-RAS model simulated stage-flow curves	✓	✓	✓	✓
Vegetative Transects (15): ecologic & soil survey			✓	✓
PHABSIM cross-sections (3): selected from 15 Veg Transects		✓	✓	
PHABSIM field data: velocity, water surface elevation & slope		✓	✓	
PHABSIM Habitat Suitability Curves by species		✓	✓	
PHABSIM model output representing habitat change		✓	✓	
Long-term inundation analysis with spreadsheet		☐	✓	✓
Criteria Type or Goal				
≥ 0.6 ft at shoals	✓			
Wetted perimeter	✓			
≤ 15% temporal reduction in habitat for various species		✓	✓	
≤ 15% temporal reduction in exposed root availability			✓	
≤ 15% temporal reduction in snag availability			✓	
≤ 15% temporal reduction in floodplain habitat				✓

* Refer to Geurink and Basso (2013) for data inputs and model error summary.

APPENDIX 6F

Memorandum to file by Doug Leeper and Ron Basso, dated June 29, 2015. Subject: District staff response to evaluation comments submitted by Tampa Bay Water staff on April 6, 2015 concerning “Recommended Minimum Flows for the Pithlachascotee River”, Draft July 8, 2014 and “Appendices – Recommended Minimum Flows for the Pithlachascotee River” Draft August 26, 2015. Southwest Florida Water Management District. Brooksville, Florida.

June 29, 2015

MEMORANDUM

TO: File
FROM: Doug Leeper, Chief Advisory Environmental Scientist, Resource Evaluation Section
Ron Basso, Chief Hydrogeologist, Resource Evaluation Section
SUBJECT: District staff response to evaluation comments submitted by Tampa Bay Water Staff on April 6, 2015 concerning "Recommended Minimum Flows for the Pithlachascotee River", Draft July 8, 2014 and "Appendices – Recommended Minimum Flows for the Pithlachascotee River" Draft August 26, 2015.

Overview

On April 6, 2015, Warren Hogg, the Permitting Manager for Tampa Bay Water (TBW) submitted a letter and 17 page comments document to the Southwest Florida Water Management District that addressed technical comments from TBW staff on District reports used to establish proposed minimum flows for the Pithlachascotee River. In the letter and comments document, TBW staff requested that their comments be provided to the Peer Review Panel the District intends to convene for the independent scientific review of proposed minimum flows for the river.

In accordance with this request and to enhance the peer review process, District staff will provide TBW's comments to the Peer Review Panel. To further support the peer review process, District staff have developed responses to TBW's comments and plan to provide the responses to the Peer Review Panel. The District's responses are summarized in this memorandum and are organized in association with excerpts from TBW's April 6, 2015 submittal. Yellow highlighting has been added to portions of the excerpts to emphasize the specific comments and suggestions addressed in the District responses.

Excerpts from Tampa Bay Water's April 6, 2015 Submittal and District Responses

Sub-Section: Summary of Comments and Concerns

Excerpt from Page 2, Paragraph 1:

- **Historic climate variability**: Together over a long pre-development period, historic climate variability and watershed characteristics define variability in streamflow characteristics and channel/floodplain geometry and biology. It is therefore considerably important to incorporate full (*i.e.*, many decades) historic climate variability into the development of minimum flows and into compliance assessments of minimum flows. Full historic climate variability was not captured by the PR Baseline (unimpacted) streamflow time series which spanned a short investigation period (~ decade) with low rainfall and low streamflow when compared to the long-term mean/median for both parameters. The District has assessed inundation of mean elevations of woody habitat using a Baseline streamflow time series which has depressed inundation frequency characteristics compared to the long-term mean/median characteristics. The depressed inundation frequency characteristics of the designated Baseline period do not hydrologically align with the physical, vertical positioning of beneficial habitat that is positioned in part due to the effects of full historic climate variability and results in underestimation of percent allowable flow reduction. Assuming the beneficial habitat of the PR was formed (*i.e.*, spatial and vertical positioning) in part due to the effects of full historic climate variability, is it acceptable to define the minimum flow using a Baseline streamflow time series which does not represent the flow condition that formed the habitat? Refer to Item 1 for expanded comments.

Response: Staff acknowledges that long-term baseline flow records that integrate a wide range of climatic conditions are desirable for development of minimum flows and levels (MFLs). Data availability, however, often limits limit the period of record for which baseline flows can be developed. This was the case for the baseline flow record developed for the Pithlachascotee River. Staff agrees that the 11 year baseline flow record was developed for a relatively dry period, but notes that the record includes periods of high and low rainfall and streamflow.

With regard to use of baseline flow record that TBW believes is not “hydrological-aligned” with existing stream morphology and associated habitats, staff notes that the approach used for developing minimum flow thresholds involves identification of unacceptable deviation in flow-associated criteria (e.g., the availability of instream habitat and the number of days of inundation of floodplain features) relative to the condition associated with the baseline flows. This relativistic approach provides the best means for evaluating potential flow-related changes in river systems, including those such as the Pithlachascotee River that are impacted by water withdrawals.

Excerpt from Page 2, Paragraph 2:

- **Uncertainty in model outputs influences minimum flows**: Proposed minimum flow values include some measure of uncertainty. In other words, for a flow block of a particular river, the proposed minimum flow value is contained within a range of probable magnitude (uncertainty). The uncertainty or range of probable magnitude of minimum flow values for the PR is very difficult to quantify because at least five models are sequentially linked together to define the proposed minimum flows (Figure 5, Figure 6). In order to produce a recommended minimum flow for the PR that is technically sound and defensible, the sources of uncertainty (Table 1) must be minimized at each step in the sequence to minimize the likelihood that the proposed minimum flows have a wide range of probable magnitude. Refer to Item 2 for expanded comments. The proposed minimum flows for the PR may have a high range of probable magnitude (uncertainty) because:
  - corrections for model error and biases in model outputs were not made,
  - extrapolated model applications were used without first demonstrating the technical plausibility of the concept,
  - the sensitivity of key model terms and parameters were not defined and used to guide decision making,
  - hydrological input and biological indicators may not be physically matched during the assessment of habitat reduction, and
  - all components of freshwater flow to the lower PR (estuary) were not included.

Response: Staff notes that Figures 5 and 6 included TBW’s comments and referenced in the excerpt above are not entirely accurate. Although HEC-RAS model output can be used in the Physical Habitat Simulation Model (PHABSIM) suite of models for assessment of instream habitat, it was not used for the PHABSIM analyses supporting development of minimum flows for the Pithlachascotee River. Rather, stage-flow relationships were developed for the PHABSIM analyses based on measured streamflow characteristics at specific study sites and application of the hydraulic modeling component of the PHABSIM model suite. This issue does not however, affects staff’s agreement with TBW that a sequential use of models was essential for development of the minimum flows proposed for the river.

Staff acknowledges that the proposed minimum flows for the Pithlachascotee River include uncertainty associated with potential data measurement and modeling errors and has made reasonable efforts to minimize this uncertainty.

With regard to TBW's concern that "corrections for model error and biases in model outputs", staff notes the approach used for development of the minimum flow recommendations is based on comparison of differences between modeled baseline flows and modeled conditions associated with reduced baseline flows. Specifically regarding use of INTB model results, staff notes that corrections for "model error" are not typically conducted. We note that all models contain errors in accuracy, and model error is simply accepted as a result of not knowing all variables within the system as part of the calibration process. Further, the District and TBW accepted the calibration of the INTB model which was verified as a "well-calibrated model" by peer review experts. With regard to use of back-transformation correction factors for regression models developed using log-transformed values, staff acknowledges that this potential bias was not corrected for regression models used to support development of the recommended minimum flows for the river. Staff notes that the HEC-RAS model developed to support the minimum flow analyses was calibrated to achieve the specified calibration targets (i.e., simulated water levels were within 0.5 feet of the calibration targets) for 17 channel flow profiles and no bias-correction was considered necessary for use of hydraulic model results.

With regard to the comment that "extrapolated model applications were used without first demonstrating the technical plausibility of the concept", staff assumes that TBW is addressing use of no-pumping scenarios for simulations completed with the Integrated Northern Tampa Bay (INTB) model. The INTB model was developed jointly by TBW and the District to evaluate water resource issues in this region. As partners we have both expended considerable staff time and funds to produce, calibrate, and peer review this application. District staff believes this is currently the best available tool to evaluate groundwater impacts to the Pithlachascotee River. Staff understand TBW's concern regarding non-pumping scenarios but of all the numerical model tools available, believe this one is best-suited to incorporate changes due to zero pumping conditions especially compared to traditional groundwater only models. Ron Basso, with the District, and Jeff Geurink with TBW examined the INTB model's response to wellfield shutdown tests during the calibration of the model. Water level change comparisons based on prior information showed close matches between INTB predicted drawdown and observed changes. At this time, District staff do not plan to run additional INTB model scenarios to verify this concept. We are, however, open to TBW running the model under a mutually-approved procedure to test this concept and are open to adjusting our impact analysis if the results suggest the need to do so.

With regard to the concern that "the sensitivity of key model terms and parameters were not defined and used to guide decision making" staff notes that because many of the analyses used to identify the proposed minimum flows involved comparison of modeled response to flow reductions from baseline conditions, the sensitivity of the modeled response factors was, to some extent, assessed.

With regard to the concern that "hydrological input and biological indicators may not be physically matched" for habitat assessments supporting identification of appropriate minimum flows, staff notes that the baseline flow record are used to characterize inundation and other habitat conditions associated with the non-withdrawal impacted flow conditions and deviations from these conditions, i.e., for reduced baseline flow conditions. The approach was developed to identify minimum flow thresholds based on relative change from baseline conditions, regardless of whether or not baseline conditions currently exist. In some cases baseline flows may "match", i.e., be associated with the processes or conditions that led to the development and would support the persistence of existing biological indicators. This is not, however, a necessity for application of the District's approach to establishing minimum flows.

With regard to the concern that "all components of freshwater flow" to the lower Pithlachascotee River were not characterized or used for the minimum flow analyses, staff notes that the statistical models used for the estuarine analysis based on gaged streamflow are reasonable and adequate for characterization of salinity habits in the river. Further, staff notes that inclusion of ungagged flow estimates would involve additional error associated with estimation of ungagged flows. In addition, the regression models used for predicting isohaline locations were, like most of the analyses employed for development of the proposed minimum flows, evaluated using a relativistic approach that involved comparison of predictions based on baseline and reduced baseline flows.

Excerpt from Page 2, Paragraph 3:

- **Uncertainty in MFL measures and goals influences minimum flows**: The District has stated that specific measures and goals provide appropriate metrics to establish minimum flows for the PR. The specific measures and goals established by the District for the PR each include some measure of uncertainty. Sources of uncertainty can weaken the reliability and precision of the selected minimum flow evaluation metrics. Absent from SWFWMD (2014) is a discussion and assessment of the following three sources of uncertainty that can have a significant influence on the selected minimum flow evaluation metrics (refer to Item 3 for expanded comments):
    - intermittent compared to perennially flowing river,
    - assessment of present-day adverse impact using the PR habitat field data, and
    - correlation of adjusted Baseline flow to existing in-stream habitat.

Response: Staff agrees that the draft District report may not explicitly address the three factors identified in the excerpt above, but does not believe their inclusion in the report is necessary and notes that their omission does not reduce the validity of the analyses used to support the proposed flow recommendations.

With regard to the "intermittent compared to perennially flowing river" comment, staff notes the approach used for development of the minimum flow recommendations is based on identification of reductions in baseline flows that are not expected to result in significant harm. The approach is applicable to perennial and intermittent lotic systems. The Pithlachascotee River is not the first intermittent stream for which the District has develop minimum flow recommendations. Baseline flows developed for establishing minimum flows for the upper Myakka River were used to characterize that river as an intermittently flowing system. In fact, a low flow threshold of 0 cfs was established for the river segment.

The observed, flow record for the Pithlachascotee River includes a relatively high occurrence of days with zero flow. In comparison, the baseline flow record exhibits fewer days when flow is zero, indicating that the intermittent character of the river is influenced by water withdrawals. Regardless of the natural or impacted intermittent/perennial nature the river, staff believes the approach used for development of the proposed minimum flows is appropriate given that it involves identification of a low flow threshold that is evaluated relative to expectations associated with baseline flows and identification of potential significant harm thresholds that are based on comparison of conditions associated with the baseline flows, regardless of whether they are intermittent or perennial.

With regard to “assessment of present-day adverse impact using the P[ithlachascotee] R[iver] habitat field data”, staff notes that use of criteria associated with up to a 15% change from conditions associated with baseline flows was used to develop minimum flow recommendations for the river and has repeatedly been used on lotic systems within the District with adopted minimum flows that have been subjected to independent, scientific peer review. In addition, as described in the draft report on the proposed minimum flows for the Pithlachascotee River, field-collected data and modeling tools were used by staff to evaluate flow changes that could lead to exceedance of the change criteria and by definition could result in significant harm. The draft report also summarizes differences between observed flows in the river and baseline flows, with differences attributed to impacts associated with water withdrawals.

With regard to “correlation of adjusted Baseline flow to existing in-stream habitat”, staff believes the baseline flow record can be used to characterize inundation and habitat patterns associated with the non-withdrawal impacted flow conditions and deviations from these conditions (i.e., reduced baseline flow conditions) at the study sites within the Pithlachascotee riparian corridor that were selected to be representative of the river segment. The approach was developed to identify minimum flow thresholds based on relative change from baseline conditions, regardless of whether or not baseline conditions currently exist. In some cases baseline flows may “match”, i.e., be associated with the processes or conditions that led to the development and would support the persistence of existing biological indicators and habitat. This “matching” condition is not, however, a necessity for application of the District’s approach to establishing minimum flows.

Excerpt from Page 3, Paragraph 1:

- **Compliance assessment process**: The compliance assessment process must be adopted by rule simultaneously with adoption of minimum flows so that the regulated community can ascertain current and future compliance with the rule. A question that must be answered is if the use of the integrated surface water/groundwater model should be the only tool used to assess compliance with the proposed minimum flows. It is likely that multiple assessment techniques will be needed to assess compliance on a regular basis and at the time of permit renewals. Refer to Item 4 for expanded comments.

Response: Staff agrees that an approach for evaluating the status of an MFLs water body should be developed when applicable MFLs are developed and the MFLs are adopted into rule. When developing MFLs, the current and future status of the MFLs water body must be assessed as state law requires implementation of recovery or prevention strategies in cases where existing flows or levels are below or are project within 20 years to fall below an applicable minimum flow or level. Recovery/prevention strategies must be included in a regional water supply plan developed by the District, but do not have to be incorporated into rule. Similarly, the description of an MFLs water body status assessment process (i.e., compliance approach) does not necessarily have to be included in rule, although it can be.

The District may include language in MFLs rules that address how the status of the applicable MFLs will be assessed. This language may identify specific tools that may be used, but is more typically constructed to allow flexibility regarding the development and use of new assessment tools and approaches while not requiring rule changes.

In addition to the MFLs status assessments that are completed concurrent with MFLs development and for regional water supply planning purposes on a five-year cycle, status assessments are also completed on an annual basis and on an as needed basis for permit/project evaluations.

The District's current approach for assessing the status of MFLs water bodies involves use of criteria and approaches or tools that may be specified in rule and typically, additional criteria or tools. A preferred approach for a water body usually involves use of the tool or tools that were used for development of the MFLs applicable to the water body. For the Pithlachascotee River, it is anticipated that the INTB model, and measured hydrologic data, including gaged streamflow, rainfall, water-use information and groundwater levels will be used to assess the status of flows in the river relative to the applicable established minimum flows. The District is certainly open to suggestions that TBW or other stakeholders may have regarding development and use of tools supporting MFLs status assessments.

Sub-Section: Expanded Comments and Concerns

1. Historic climate variability:

Excerpt from Page 3, Paragraph 3:

a. Assessment of Baseline period: *It is considerably important to incorporate full (i.e., many decades) historic climate variability into the development of minimum flows and into compliance assessments of established minimum flows.* Full historic climate variability was not captured by the PR Baseline (unimpacted) streamflow time series covering the short 11 year investigation period spanning 1990 through 2000. For the investigation period, recorded rainfall was several inches below the long-term average annual mean (SWFWMD 2014). For the investigation period, the District acknowledged the short period of investigation and the presence of low rainfall (pages 2-45, 6-3), but justified using the stated investigation period on the basis that it covered a suitable range of flows. However, the District's evaluation of PR minimum flows was directly related to inundation frequency, a temporal measure of flow reaching or exceeding physical, temporally-static habitat threshold depths/elevations. Inundation frequency is the persistence of flow at a threshold which is related to the timing and magnitude of rainfall and system storage but not to the range in flow. The District has assessed inundation of the mean elevations of woody habitat (page 7-9, Table on page 7-10) using a streamflow time series which has depressed inundation frequency characteristics compared to the long-term mean/median characteristics (item 1b). *The depressed inundation frequency characteristics of the designated Baseline period do not hydrologically align with the physical, vertical positioning of beneficial habitat that is positioned in part due to the effects of full historic climate variability and results in underestimation of percent allowable flow reduction.*

Response: Staff acknowledges that long-term baseline flow records that incorporate a high degree of climatic variability are desirable for development of MFLs. Data availability, however, often limits the period of record for which baseline flows can be developed. This was the case for the 11-year baseline flow record developed for the Pithlachascotee River. Staff agrees with TBW's comment that the baseline flow record was developed for a relatively dry period, but notes that the record includes periods of relatively high and low rainfall and streamflow.

With regard to use of baseline flow record that TBW believes is not "hydrologically aligned" with existing stream morphology and associated habitats, staff notes that the approach used for identifying minimum flow thresholds involves identification of unacceptable deviation in flow-associated criteria (e.g., availability of instream habitat and the number of days of inundation of woody habitat) relative to the condition associated with the baseline flows. This relativistic approach provides the best means for evaluating potential flow-related changes in river systems, including those such as the Pithlachascotee River that are impacted by water withdrawals.

Excerpt from Page 4, Paragraph 3:

ii. Baseline period: In Figure 2, a red line with plus symbols (+) has been placed on a copy of Figure 1 to represent the percent exceedance curve of the District's Baseline weekly average flow time series with zero pumping (1990 –2000). The District's Baseline flow falls below the median flow of GWB0 realizations over the entire flow range except the highest 10% of flows. Flow results from 1000 realizations of historic rainfall (GWB0) compared to the Baseline in Figure 2 indicates that Baseline flows are less than the GWB0 medians over all but the highest flow regimes. *Therefore, the depressed inundation frequency characteristics of the Baseline period do not hydrologically align with the physical, vertical positioning of beneficial habitat that is positioned in part due to the effects of full historic climate variability and results in underestimation of percent allowable flow reduction.*

Response: Staff acknowledges that baseline flows used for development of the minimum flow recommendations are representative of a relatively dry period, but also note that the baseline record includes periods of relatively high and low rainfall and streamflow. Also, it is noted that the approach used for evaluation of habitat inundation patterns are based on identifying unacceptable deviation in flow-associated criteria relative to the condition associated with the baseline flows.

Excerpt from Page 4, Paragraph 4:

iii. Compliance period: In Figure 2**Error! Reference source not found.**, a maroon line with "x" symbols has been placed on a copy of Figure 1 to represent the percent exceedance curve of streamflow with zero pumping over the District's Compliance Period (1996 – 2006). This decade of flows is characterized by extremes. More than half of the flow profile (percent exceedances greater than 40%) have flows less than the GWB0 medians and the lowest flows are less than flows during 1990-2000. By contrast, the highest flows of the Compliance Period are at the outer extent of the GWB0 outliers. *Because of the high degree of variability in streamflow related to climate variability, we believe it is critical to define the compliance assessment process as part of the adoption of the MFL.*

Response: Staff agrees with TBW that development and application of a status assessment process (i.e., an MFLs compliance evaluation process) is necessary and appropriate when establishing MFLs.

Excerpt from Page 5, Paragraph 1:

iv. Influence of historic climate variability on PR streamflow change due to well pumping: As described in item 1b, realization sets GWB0 and CWF90_2008 use the same 1000 rainfall realizations but different well pumping. Paired by rainfall realization, the PR flow difference (GWB0 minus CWF90_2008) due to a specific well pumping scenario can be estimated for all 1000 realizations. PR flow change due to the CWF90_2008 well pumping scenario, within the context of full historic climate variability, is summarized in Figure 3 using box and whisker plots at 2% intervals. PR flow change for the same well pumping scenario is also presented in Figure 3 for the District's Baseline (1990-2000) and Compliance (1996-2006) periods. The ensemble monthly PR flow change due to well pumping, in the context of full historic climate variability, indicates flow change increases with increasing flow which is related to increasing rainfall (Figure 4). The wet season has the highest flow change and the dry season has the lowest flow change. These results reinforce the conceptual description of the PR watershed hydrology which was summarized in the introductory paragraphs of these comments. *Because of the high degree of variability in streamflow related to climate variability, it is critical to define the compliance assessment process as part of the adoption of the MFL Furthermore, both the minimum flow development process and the compliance assessment process must incorporate the effects of climate variability.*

Response: Staff agrees with TBW that development and application of a status assessment process (i.e., an MFLs compliance assessment process) is necessary when establishing MFLs. We note that the approach used for development of proposed minimum flows for the Pithlachascotee River does account for climatic variability by using a baseline flow record that spans an 11 year time period. We acknowledge, however, that a longer-term baseline flow record would be more likely to integrate or incorporate a wider range of climatic conditions, but was not used based on limitations in data availability.

Excerpt from Page 5, Paragraph 2:

c. Throughout the report, it is stated that the PR is a low-flow system, especially during the Block 1 time period and that multiple analyses are confounded by the abundance of days with flows less than 5 cfs (actual and simulated flow data). It is stated on page 8-5 that relative model errors are greater when modeled flow is less than 5 cfs; however the model is offered as the primary tool to be used in assessing compliance with the proposed minimum flows. Given these limitations and concerns, is this approach to establish minimum flows appropriate for low-flow systems and if so, should the model be used as the only method to assess compliance with the proposed minimum flows? What role should empirical flow data or other analytical methods have in the compliance assessment process?

Response: Staff notes that although the INTB Model may not be optimal for assessing the lowest flows within the Pithlachascotee River, the model was considered useful for developing minimum flow recommendations and is similarly expected to be useful for assessing the status of river flows relative to applicable minimum flows established for the system. Staff considered information obtained from model simulations and the other data used for development of the proposed minimum flows to be the best information available. Staff notes that in addition to use of the INTB model, the assessment of flows in the river relative to applicable minimum flows is expected to involve use of empirical flow data and other hydrologic data, and application of additional analytical methods that may be developed.

Sub-Section: Expanded Comments and Concerns

2. Uncertainty in model outputs influences minimum flows:

Excerpt from Page 5, Paragraph 3:

2. Uncertainty in model outputs influences minimum flows: Proposed minimum flow values include some measure of uncertainty. In other words, for a flow block of a particular river, the proposed minimum flow value is contained within a range of probable magnitude (uncertainty) which has typically not been quantified or is very difficult to quantify. The uncertainty or range of probable magnitude of minimum flow values for the PR is very difficult to quantify because at least five models are sequentially linked together to define the proposed minimum flows (Figure 5, Figure 6). Faced with this understanding, the sources of uncertainty (Table 1) must be minimized at each step in the sequence to minimize the likelihood that the proposed minimum flows have a wide range of probable magnitude. Uncertainty in the minimum flows increase with: increasing error in each model employed, decreasing sensitivity (ratio of change in model response to change in model input) of key model inputs, and incomplete definition of temporal and spatial distributions or functional relationships for model inputs. For each model used in the sequence (Figure 5) of minimum flow development for the PR, sources of uncertainty which influence minimum flows are described.

Response: Staff notes that Figures 5 and 6 from TBW's comments referenced in the excerpt above are not entirely accurate. Although HEC-RAS model output can be used in the PHABSIM suite of models for assessment of instream habitat, it was not used for the PHABSIM analyses supporting development of minimum flows for the Pithlachascotee River.

Excerpt from Page 6, Paragraph 2:

i. Because all MFLs have regulatory implications, the District should demonstrate that the INTB model produces plausible hydrologic responses for a zero well pumping rate (~240 mgd reduction as stated in SWFWMD 2014, but TBW has determined the well pumping reduction was 212 mgd) scenarios covering large areas (wellfields or regions). *A series of tests should be designed, implemented, and assessed to ascertain limits if any of using the INTB model in this extrapolated manner where pumping stress magnitude is considerably lower than was used in the calibration and verification periods.*

Response: The INTB model was developed jointly by TBW and the District to evaluate water resource issues in this region. As partners we have both expended considerable staff time and funds to produce, calibrate, and peer review this application. District staff believes this is the best tool for evaluating groundwater impacts to the Pithlachascotee River. Staff understand TBW's concern regarding non-pumping scenarios, but of all the numerical model tools available, believe this one is best-suited to incorporate changes due to zero pumping conditions, especially in comparison with traditional groundwater-only models. Ron Basso, with the District, and Jeff Geurink with TBW examined the INTB modeled response to wellfield shutdown tests during the calibration of the model. Water level change comparisons made at the time based on prior information showed close matches between INTB predicted drawdown and observed changes. At this time, District staff do not plan to run additional INTB model scenarios to verify this concept. We are, however, open to TBW running the model under a mutually-approved procedure to test this concept and are open to adjusting our impact analysis if the results suggest the need to do so.

Excerpt from Page 6, Paragraph 3:

ii. Simulated flows should be corrected for model error prior to using the data as input to another model and prior to calculating the flow difference between two INTB scenarios. Using the flow difference at a flow gauge location between two INTB model scenarios, without first correcting the flow for each scenario for model error, assumes the INTB model error at a flow gauge location is uniform along the vertical profile of observed flow. However, nonuniform INTB model flow error vs observed flow exists at flow gauges used to calibrate the INTB model. For a scenario example with large reduction in well pumping rates, scenario simulated flow rates will be elevated compared to calibrated (historical) conditions. This means the scenario model with the large pumping rate reduction is operating more often in a higher flow rate region which could have a different flow error than at lower flow rates.

Response: Corrections for "model error" are not typically done when viewing the results of scenario runs completed with the INTB model. All models contain errors in accuracy. Model error is simply accepted as a result of not knowing all variables within the system as part of the calibration process. Both agencies accepted the calibration of the INTB model which was verified as a "well-calibrated model" by peer review experts.

Excerpt from Page 6, Paragraph 4:

iii. When any stress change is imposed on the INTB model, the first two years of simulated results should not be used for analysis. Through internal testing of the INTB model, Tampa Bay Water has concluded that it takes more than 1.5 but less than two years to remove the influence of initial conditions or stress transitions due to the storage in the surface water and ground water systems of the INTB domain. *The District has used INTB flows within the first two years of the simulation to define minimum flows which will skew the resulting Baseline flow data.*

Response: Review of INTB model results actually show that the predicted impact from pumping is slightly less if the full simulation record is incorporated into the analysis. Staff could exclude the first year or two of the 1989-2000 simulation and revise the impact accordingly, although completion of this activity is not anticipated at this time. The 1996-2006 model included the "hot start" option so this period should not be applicable to this situation.

Excerpt from Page 6, Paragraph 5:

b. Flow regression model: The flow regression model produced the Baseline (unimpacted) streamflow time series used for all PR minimum flow development. Using time series from the same two INTB model scenarios referenced in Item 2.a as inputs, the flow regression model was developed to predict an unimpacted streamflow time series from an impacted streamflow time series over the same time span. Several questions and potential deficiencies are highlighted including model structure, limits on temporal span, and lack of validation and residuals analysis. *Tampa Bay Water reconstructed the regression model and found significant bias for flows less than 50 cfs (low to intermediate flow) which could significantly influence minimum flows. We will provide this analysis to the District or Peer Review Panel upon request.* Tampa Bay Water recommends that the following specific technical concerns on the flow regression model be investigated as part of the peer review process:

Response: Staff agree that the peer review process should evaluate this methodology.

Excerpt from Page 6, Paragraph 6:

i. What specific characteristics of the daily flow "temporal variation" of the INTB model were deemed unusable but were reproduced by the regression equation instead? In other words, what specific flow characteristics were not captured by the INTB model that were captured by the regression model?

Response: It was the intent of the regression methodology to adjust the flow record to an unimpacted regime. The reference to the INTB model output temporal variation was based on our understanding of the day-to-day simulation of flow conditions and the variability inherent in simply using a time-series of model simulated flows on a daily basis to adjust the observed record. The regression analysis parsed the simulated flow record into percentiles as an aggregate of the simulation period data. Simulated flows below 5 cfs were excluded from the analysis since they were considered too low to be reliable in the calibration process.

Excerpt from Page 6, Paragraph 7 and Page 7, Paragraph 1:

ii. INTB model flow at a daily time scale has been known to be less accurate than weekly and monthly flow due to the lagging flow responses on the simulation (Geurink and Basso 2013). Any analysis based on daily flow is prone to larger error results especially when extreme input, such as a zero-pumpage scenario, is used.

Response: Staff acknowledges that daily flow predicted with the INTB Model is less accurate than modeled flow aggregated at longer time-scales. However, daily flows are necessary for some analyses used to establish minimum flows, (e.g., for inundation analyses associated with woody habitat and floodplain features) and the daily flows derived using the INTB Model were considered the best available data for characterization of daily baseline flows.

Excerpt from Page 7, Paragraphs 2 and 3:

iii. In Sections 3.1 and 3.2 (Janicki 2011), it was decided to replace the regression model values with INTB values when regression model values were less than 1.6 cfs.

1. The reasoning of rejecting the use of the INTB modeled flows and then incorporating the low-flow data into the time series should be explained. Is this a valid approach given the limitations of the data and analyses?

Response: On page 2-42 of the draft Pithlachascotee minimum flows report, staff noted that "[a]nalyses of regression residuals found that a large number of low flow days in the impacted model scenario negatively affected the fit of the regression, with this primarily occurring at modeled baseline flows less than 1.6 cfs. It was therefore concluded to limit the regression to baseline flows of greater than 1.6 cfs, and use direct model output when baseline flows were less than 1.6 cfs." Staff believe this approach is reasonable. To enhance understanding regarding the regression approach used for development of baseline flows for river the 2011 report by Janicki Environmental (citation information provided below) will be included in the appendices of a updated version of the summary minimum flows report that will be provided to the peer review panel the District plans to convene for independent scientific review of proposed minimum flows for the river.

Reference cited in the response above:
Janicki Environmental, Inc. 2011. Estimation of baseline flow conditions for the Pithlachascotee River and Brooker Creek. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

<u>Excerpt from Page 7, Paragraph 4:</u>

2. Even though the INTB model was rejected prior to the regression analysis, the validity of the regression model was measured on the basis of how well it matched the INTB model (Figures 3-1, 3-2, 4-1, Table 4-1, Residual plots in Appendix 1). How can the INTB model be at the same time rejected to be used for daily flows and then used to validate the regression model for daily flows?

Response: Although streamflow predicted for the existing conditions scenario produced by the INTB model agreed fairly well with observed streamflow, there were short-term differences in the timing of various flow events which were difficult for the model to capture given the complexity of hydrologic interactions in the river watershed. It was therefore concluded that the baseline flow scenario from the INTB model should not be used directly as the baseline flow for the minimum flows analysis. Rather, the regression approach outlined in the draft minimum flows report and in Janicki Environmental, Inc. (2011) was developed using INTB model predicted baseline (withdrawals excluded) and impacted (withdrawals included) flows, along with 150-day average pumping values from the Starkey-North Pasco Wellfield. Because the regression model was based on INTB modeled baseline and impacted flow values, assessments of the regression model using INTB predicted flows was considered appropriate.

<u>Excerpt from Page 7, Paragraph 5:</u>

2. How can it be concluded or implied that the regression model produces an improved version of daily flow time series (Section 4.2) for the baseline when the only other data source for the baseline is the INTB model?

Response: The conclusion from Section 4.2 of Janicki Environmental, Inc. (2011) referenced in the comments above state that "the baseline flow scenario from the NTB model should not be used directly as the baseline flow for the minimum flows analysis, because the daily flows in the model output vary slightly from the temporal variations of actual daily flows recorded by the USGS. By developing statistically significant relationships between the [I]NTB Baseline and Impacted scenarios, we were able to predict baseline flows using the gaged flows in place of the [I]NTB impacted flows. This allowed us to develop baseline flows that represent the flow conditions as if groundwater pumping did not occur and the[y] mimic the temporal variations of the gaged flows very well." As described in the draft Pithlachascotee minimum flows report, the regression equation was used along with observed impacted flows at the gage to develop the baseline flow record used for the minimum flows analyses.

Excerpt from Page 7, Paragraph 6:

2. To generate daily flow adjustment due to pumping, was it considered to use the ensemble of INTB model flow differences (pumping vs zero pumping scenario) within each of the 3 seasonal flow blocks for all simulation years (or preferably for a reasonable number of stochastic rainfall realizations of sufficient length instead of one deterministic period)?

Response: Use of differences between INTB model-predicted baseline and impacted flows for individual seasonal blocks was not considered for development of the baseline flow used for the minimum flows analyses. Similarly, use of synthetic rainfall conditions (i.e., realizations) was not used for development of the baseline flow record.

Excerpt from Page 7, Paragraph 8:

iv. What are the pitfalls associated with performing regression modeling on model output? Both the dependent variable INTB modeled baseline flow (Q*base*) and the predictor variable INTB modeled impacted flow (Q*imp*) result from the same model – variability in flow response will not be comparable to empirical data. This will result in a relatively high Coefficient of Determination (R2) and increased statistical significance as compared to regression models developed from empirical data.

Response: Staff are not aware of any "pitfalls" associated with developing and using regression models based on model output. With regard to variability in modeled output vs. variability in empirical data, staff note that INTB modeled "existing condition" flows listed in Table 2-17 within the draft Pithlachascotee minimum flows report correspond well with U.S. Geological Survey (USGS) gaged flows (empirical data).

Excerpt from Page 7, Paragraph 9:

v. No physical justification for the quadratic term is provided – it seems to have been included for curve fitting, leading to the possibility that the model is overly complex and has been "over fit" for the sample data.

Response: Residual analyses were conducted following development of the regression model to identify possible issues with the model. The analysis suggested a curvilinear response that was considered indicative of quadratic behavior and this behavior was used to justify inclusion of a quadratic term in the regression equation.

Excerpt from Page 7, Paragraph 10:

vi. The author has developed a relatively "complex" equation from the point of having a transformation and a non-linear term in the equation. Checking the validity of a regression equation is usually done using samples that were not part of the curve fitting. This ensures that the regression will hold in other situations as well as if the data used were to be perturbed with an error (white noise), the regression coefficients stay the same. This helps the regression equation "not to learn too much from the data". Were these analysis performed but omitted from the report?

Response: Validation of the regression equation with data not used for model development was not conducted based on limited availability of the INTB-modeled data used for regression model development.

Excerpt from Page 7, Paragraph 11:

vii. Multi-collinearity of predictor variables was not discussed. Correlated independent variables may affect the regression coefficients, although they won't affect the predictive power or accuracy of the regression

Response: Multicollinearity of predictor variables for the regression equation used to develop baseline flows for the minimum flows analyses were considered and are noted in Section 2.10 of the draft Pithlachascotee report. In response to possible multicollinearity issues, an alternative regression (Equation 2) that predicted baseline flows as a function of impacted flows, but did not include a groundwater withdrawal term was developed. The baseline flows predicted using the alternative regression were very similar to the values predicted with the original regression (Equation 1; see Figure 2-35 in the draft minimum flows report). It was therefore concluded that the minor differences between predictions derived with the two regressions would have negligible effects in on the analyses used to support development of the proposed minimum flows, and the analyses were based on predictions derived using the original regression.

Excerpt from Page 7, Paragraph 12 and Page 8, Paragraph 1:

viii. Regression performed on time series data tends to yield an inflated R-square value due to serial correlation. One can test this by reanalyzing the regression model using a one value per month time series. Note that the collinearity effect may still exist depending on the strength of the monthly lag correlation.

Response: Staff note that the type of analyses described in the comment above were not completed for the regression equation used to support development of the proposed minimum flows.

Excerpt from Page 8, Paragraph 2:

ix. The regression model uses a log-transform value of flow as an independent variable; it would be reasonable to show the plots related to flow such as Figures 2-7 and 2-8 in log-scale. Also, because of the log-transform, one needs to realize that the regression model will possess bias in errors toward the high flow as shown in Figures 3-2 and 3-4. The residual by month in the appendices also shows high variation in residuals in the months where rainfall is expected, which will likely be correlated to monthly rainfall variances.

Response: Staff agrees that plotting selected data sets using log-scales may be appropriate, but does not believe these types of formatting changes are essential to reporting associated with development of the proposed minimum flows. Staff also agrees that back-transformation correction factors may be developed for regression equations developed using log-transformed variables, and acknowledges that they were not developed for the regression used to develop baseline flows for the river.

Excerpt from Page 8, Paragraph 3:

x. Because of the intercept term, the regression model for the Pithlachascotee River has already yielded a predicting bias of 0.317 cfs. We also believe that the effect of variance of Qpump150 on residual is significant and biased. No plot of residual against independent variables was found in the appendices. There is no discussion on why a 150-day window was selected. This aggregate variable will show strong serial correlation for a daily time step time series.

Response: Staff notes that the 0.3 cfs "prediction bias" identified by TBW is not of the magnitude that would negate use of the regression approach used for development of the baseline flow record for the river. With regard to potential bias associated with the pumpage term included in the regression equation, staff notes that as discussed in the draft minimum flows report, an alternative equation (Equation 2) developed without the pumpage term yielded predicted flows that were very similar to those predicted with the original equation (Equation 1).

Because groundwater pumpage is expected to have a lag effect on flow in the Pithlachascotee River, a series of lag-average pumpage values were calculated for the individual area wellfields, including 7-day, 14-day, 30-day, 60-day, 90-day, 120-day, 150-day, and 180-day moving averages. These variables were included as potential explanatory variables for development of the regression model that was ultimately identified for predicting baseline flows for the river. These details are provided in Janicki Environmental, Inc. (2011). Although this report is cited in the draft Pithlachascotee minimum flows report, staff believe it should be included as an appendix to the report in future versions of the document and intends to do so for the revised version of the document to be provided to the peer review panel convened to review the proposed minimum flows.

Excerpt from Page 8, Paragraphs 4 and 5:

xi. As District staff noted during our meeting on June 3, 2014 pumpage is included twice in the regression model – in these terms:
  1. Qimp = INTB modeled impacted flow at the gage
  2. Qpump150 = 150-day average pumpage from the Starkey-North Pasco wellfield

xii. During that meeting, District staff stated that when the pumping parameter was removed from the equation, the result did not change. This issue should be further discussed. Most model selection criterion such as the Bayesian Information Criterion (BIC) actually penalizes the model for being more complex in the sense of having more parameters to fit the regression. Therefore, the model with the least parameters would have been selected.

Response: As noted in Section 2.10 of the draft Pithlachascotee minimum flows report, staff developed an alternative regression equation (Equation 2) to the equation for predicting baseline flows from impacted flows and withdrawal rates, and both the original equation (Equation 1) and the alternative equation are presented in the draft report. The report notes that based on similarity between predicted flows based on use of the two equations, it was concluded that it was appropriate to use predictions based on Equation 1 for the additional analyses supporting development of proposed minimum flows for the river.

Excerpt from Page 8, Paragraph 6:

xiii. The importance of rainfall in the analysis cannot be overstated. Regression variables cannot be selected without looking at the physical mechanism behind them. Based on the relationship established (equations in sections 3.1 and 3.2), it can lead one to believe that if pumpage is zero, Qbase and Qimp would effectively be equivalent and one could solve the resulting quadratic equation to give a constant Qbase, which is effectively saying that if there is no pumpage, no matter what the rainfall may be (since it is not in the equation), you could get constant baseline flow, which is an erroneous conclusion.

Response: Staff again notes that an alternative regression (Equation 2) that did not include a pumpage term was developed and yielded predicted flows that were very similar to the flows predicted using the regression (Equation 1) that included the pumpage term.

Excerpt from Page 8, Paragraph 7:

xiv. The author provides plots of residuals and mentions the F value, but no other regression output is provided in the report. A standard output table with p values, regression coefficients, the Variance Inflation Factor etc. should be presented and assessed.

Response: Regression diagnostics are provided in Appendix 1 in the 2011 report by Janicki Environmental, Inc. that is cited in the draft Pithlachascotee minimum flows report. Although the 2011 report is cited in the draft Pithlachascotee report, staff believe it should be included as an appendix to the report in future versions of the document.

Excerpt from Page 8, Paragraph 8 and Page 9, Paragraph 1:

xv. The time series plots of the residuals should be included in the report. At the June 3, 2014 meeting, District staff said that the plots looked fine; however, the plots should be included in the report. When validating a regression or any other model, it is important to see such factors as a) residual time series, b) autocorrelations of residuals, and c) residual plots versus predicted values so that statistical assumptions used to find the regression lines can be verified. Other residual plots (see Appendix) aggregated over calendar years clearly shows bias for the years 1997, 1998, and 1999 highlighting the effect of rain in those years that are marked by La Niña and El Niño conditions. Therefore, the question of not accounting for rainfall or assuming it would be the same regardless of the time series used to develop the regression relationship is a serious one.

Response: A time-series of regression residuals is included in the appendices to Janicki Environmental, Inc. (2011), which is referenced in the draft minimum flows report. As noted in previous responses within this memorandum, staff anticipates including the 2011 report as an appendix to a revised version of the draft report.

Excerpt from Page 9, Paragraph 2:

xvi. This approach should be validated by comparison to an out-of-sample_dataset (e.g. more recent data).

Response: Comparison of regression model predicted flows with more recent INTB model predicted baseline (withdrawals excluded) has not been completed.

Excerpt from Page 9, Paragraph 3:

xvii. If the regression results themselves (final time series used for MFL calculation) include an overestimate of pumpage impact, this might be detectable by some analysis of the relationship between rainfall and regression model output. Also, analysis of any trends in the synthetic time series would be useful.

Response: Staff believe the baseline flows developed for the minimum flows analyses are appropriate and reasonable and do not anticipate completing analyses such as those suggested in the comment above.

Excerpt from Page 9, Paragraph 5:

i. For flows less than 30 cfs, simulated stages from the HEC-RAS model are_biased low. No stage bias correction was applied at the evaluation transects_before being input to either the PHABSIM model or the LTIA model. *The_implication of this bias for flows less than 30 cfs is over estimation of* *the impact of flow loss on habitat inundation.* In other words, attainment of 15% temporal habitat reduction occurs for a smaller flow reduction compared to when the stage bias is removed.

Response: Staff notes that the HEC-RAS model developed to support the minimum flows analyses was calibrated to achieve specified calibration targets (i.e., the difference between the simulated water levels were within 0.5 feet of the calibration targets) for 17 channel flow profiles and no bias-correction was considered necessary for use of model results. Staff further notes that although HEC-RAS output may be used for PHABSIM analyses, the hydraulic model included in PHABSIM suite of models rather than HEC-RAS was used to assess flow-related changes in habitat availability for fish and macroinvertebrates, following model calibration based on measured water level and velocity data at individual PHABSIM sites collected during high, medium and low flow conditions. In addition, although HEC-RAS output was used for inundation analyses associated with woody habitats, allowable percent-of-flow reductions associated with the proposed minimum flows for the freshwater, upstream segment of the river for the low and intermediate flow periods (i.e., Blocks 1 and 2) were based on results from the PHABSIM analyses and not on the woody habitat analyses. Staff acknowledges that the long-term inundation analyses for floodplain features was based on HEC-RAS output, but these analyses were used for the high flow period (Block 3), and any potential bias associated with predicted lower flows would be expected to be less of a concern for these analyses.

Excerpt from Page 9, Paragraph 6:

ii. Simulated stage was not evaluated with observed data at minimum flow evaluation transects. Uncertainties in spatial distribution of parameter values such as Manning n and lateral flow contribution along the river corridor result in uncertainties in the spatial distribution of simulated stage-discharge. The most upstream end of the simulated channel corridor, at the Fivay Junction gauge, is the only location at which calibrated stage was evaluated. Minimum flow evaluation transects are located several river miles downstream with no evaluation of calibrated stage values. *Implication of no calibration at evaluation transects means the estimation of simulated stage bias must be extrapolated using model performance at only the calibration transect at the upstream end of the river.*

Response: Staff notes that the HEC-RAS model developed to support the minimum flows analyses adequately achieved the defined calibration stage targets at the upstream gage site. Model calibration at all study transects was not conducted and is not considered necessary for use of the calibrated model.

Excerpt from Page 9, Paragraph 7:

d. PHABSIM model: The PHABSIM model was used to simulate changes to habitat availability for seven fish species using a flow range from Baseline (Flow Regression model) to a 40% reduction in Baseline. Simulated habitat availability output from PHABSIM was averaged over three PHABSIM cross-sections by fish species and seasonal flow block. Simulated habitat availability output from PHABSIM for the most sensitive fish species is the final interpretive result of this model. Inputs to the PHABSIM model included HEC-RAS simulated stage-flow, habitat suitability curves by fish species, and various hydraulic and vegetative characteristics for the PHABSIM cross-sections which are located at shoals. *Specific concerns include the dry bias in Baseline flow (see Item 2.b), the apparent physical disconnect of habitat assessments at shoals for Blocks 1 and 2, stage biases from HEC-RAS, and absence of calibration and sensitivity assessments of PHABSIM*:

Response: Staff notes that HEC-RAS output may be used for PHABSIM analyses, but for development of the Pithlachascotee minimum flows the hydraulic model included in PHABSIM suite of models, rather than HEC-RAS, was used. The PHABSIM hydraulic model was calibrated using measured water level and velocity data at individual PHABSIM sites collected during high, medium and low flow conditions. Any potential bias associated with use of the HEC-RAS model would therefore not affect result from the PHABSIM analyses.

Staff notes that sensitivity analyses for PHABSIM-predicted habitat values have, in effect, been completed for all assessed taxon or taxon life history stages. Differences in predicted weighted usable area (a habitat metric) values for simulations involving the baseline and reduced baseline flows provide an indication of the sensitivity of the habitat metric to changes in flow. This sensitivity is, of course, used to identify flow-related changes in the habitat metric that may exceed the a priori criterion that a 15 percent change in the metric represents a significant harm threshold.

Excerpt from Page 10, Paragraph 1:

i. Within the context of an intermittent stream, selection of PHABSIM cross-sections at shoal locations for fish habitat assessment appears problematic. Below 25 cfs for the PR, it is assumed that the proposed fish passage threshold places fish in isolated pools along the river corridor and the shoal locations are temporarily not conducive as fish habitats. Using the median flow results from the GWB0 simulations for 25 cfs (no well pumping simulation, item 1b), it is estimated that 25 cfs is equaled or exceeded about 30% of the time. This means that some fraction of the fish population along the freshwater portion of the river is annually constrained in isolated pools as a result of climate variability alone. These isolated pools may dry completely causing fish mortality. Since much of the flow time series of Blocks 1 and 2 are less than 25 cfs, *assessment of habitat availability at the shoal locations appears to be disconnected from the physical system for this intermittent flowing river*.

Response: Staff does not agree with the assertions made in the comment above. Modeling with PHABSIM is used to characterize habitat conditions associated with baseline and reduced flows at selected sites that are considered representative of similar sites in the river segment. Again, staff note the emphasis on baseline conditions and the evaluation of relative changes in habitat associated with reduced baseline flows.

Excerpt from Page 10, Paragraph 2:

ii. Depending on sensitivity, the *implication of low stage bias from HEC-RAS for flows less than 30 cfs could have considerable influence on interpretation of habitat inundation changes as flow is reduced*.

Response: Staff again notes that output from the HEC-RAS model developed for the river was not used for the PHABSIM analyses.

Excerpt from Page 10, Paragraph 3:

iii. Because the PHABSIM model results play a key role in defining minimum flows, it is critical that calibration and sensitivity assessments be provided for each transect and some reasonable combination of species and flow blocks. *Sensitivity assessments of the PHABSIM model will help give an understanding of the range of probable magnitude (uncertainty) for the allowable percent flow reduction.*

Response: Staff notes that sensitivity analyses for PHABSIM-predicted habitat values have, in effect, been completed for all assessed taxon or taxon life history stages. Differences in predicted weighted usable area (a habitat metric) values for simulations involving the baseline and reduced baseline flows provide an indication of the sensitivity of the habitat metric to changes in flow. This sensitivity is integral to the identification of flow-related changes in the habitat metric that may exceed the a priori criterion that a 15 percent change in the metric represents a significant harm threshold.

Excerpt from Page 10, Paragraph 4:

e. Long-Term Inundation Analysis (LTIA) model: The LTIA model simulated long-term temporal change in habitat inundation. Inputs to the LTIA model include Flow Regression model time series, simulated HEC-RAS stage-flow, and cross-sections at vegetative transects. Very little information is provided in the District report about this spreadsheet model which ultimately defines allowable percent flow reductions for Blocks 2 and 3. *Specific concerns include the dry bias in Baseline flow (see Item 2.b), stage biases from HEC-RAS, and absence of documentation, calibration and sensitivity assessments of LTIA*:

Response: Staff notes that model used for Long-Term Inundation Analysis of floodplain features is simply a spreadsheet formatted to count the number of days in the baseline and reduced flow records that flows associated with target elevations on the river floodplain are inundated. The analyses based on use of the spreadsheet model are relative comparisons, in that they address changes in the number of days of inundation of selected elevations relative to the baseline flow. Because the Long-Term Inundation Analysis is based in part on HEC-RAS model output, staff notes that calibration information associated with development of the HEC-RAS model in a report prepared for the District by Engineering & Applied Science, Inc. and included as Appendix 6B to the draft Pithlachascotee River minimum flows report, is applicable. Also, given that the Long-Term Inundation Analyses are used to associate changes in the number of days of inundation of floodplain features with changes in baseline flows, the analyses may be considered representative of a sensitivity assessment.

Excerpt from Page 10, Paragraph 5:

i. Depending on sensitivity, the *implication of low stage bias from HEC-RAS for flows less than 30 cfs could have considerable influence on interpretation of habitat inundation changes as flow is reduced.*

Response: HEC-RAS output was used for long-term inundation analyses for woody habitats associated with the river channel and for floodplain features. However, results from PHABSIM analyses, which did not involve use of HEC-RAS output, were used to identify potential percent-of-flow reductions for instream habitats that were more sensitive (i.e., lower) than those identified for HEC-RAS based inundation of woody habitats analyses. The percent-of-flow reductions associated with the more sensitive responses were used to identify acceptable flow reductions for the minimum flows proposed for Blocks 1 and 2, i.e., for seasonal low and medium flow periods. The HEC-RAS based analyses associated with inundation of floodplain features were used to identify potential percent-of-flow reductions for the period of higher flows (Block 3) when potential model-bias associated with predicted lower flows would be expected to be less of a concern.

Excerpt from Page 10, Paragraph 6:

ii. Because the LTIA model results play a key role in defining minimum flows, it is critical that documentation be completed, and calibration and sensitivity assessments should be provided for each transect and flow block. *Sensitivity assessments of the LTIA model will help give an understanding of the range of probable magnitude (uncertainty) for the allowable percent flow reduction.*

Response: Because the Long-Term Inundation Analysis is based in part on HEC-RAS model output staff notes that calibration information associated with development of the HEC-RAS model in a report prepared for the District by Engineering & Applied Science, Inc. and included as Appendix 6B to the draft

Pithlachascotee River minimum flows report, is applicable. Also, given that the Long-Term Inundation Analyses are used to associate changes in the number of days of inundation of floodplain features with changes in baseline flows, the analyses may be considered representative of a sensitivity assessment.

Excerpt from age 10, Paragraph 7 and Page 11, Paragraph 1:

f. Estuary Regression models: The Estuary Regression models were used to define relationships between various evaluation criteria and Baseline (unimpacted) freshwater inflow. Percent reductions in Baseline flow resulted in percent reductions in evaluation criteria which were compared to critical thresholds to define minimum flows for the lower PR. Although it appears the District used the same Baseline flow time series (at New Port Richey USGS gauge) to evaluate the lower PR as was used to evaluate the upper PR, freshwater inflow to the lower PR is not limited to flow through the New Port Richey gauge location. There are approximately 5 river miles of watershed over which freshwater inflows via surface runoff and ground-water inflow can enter the PR. The District's report reveals a noticeable low flow contribution at the old New Port Richey gauge location that does not exist at the new location. Regardless of the source of the contribution, the freshwater flow should not be ignored. *The implication for leaving out freshwater flow coming into the PR at locations downstream of the New Port Richey gauge is to over-estimate the influence of reductions in freshwater inflows*.

Response: Staff notes that because the regression used for associating isohaline locations with river flow was developed using the gaged flow at the New Port Richey gage, it can be used to predict isohaline locations based on gaged flows, regardless of contributions that may be associated with ungaged flows. Staff also note that development of a predictive regression model that includes ungaged flow would involve additional error associated with estimation of ungaged flows. Rather than introduce this potential source of error into the models, ungaged flows were not included in the regression analysis. As noted in the draft Pithlachascotee River minimum flows report, it may be assumed that ungaged flows tend to vary in synchrony with the gaged streamflow response to seasonal rainfall patterns. Finally, staff notes that the regression models used for predicting isohaline locations were, like most of the analyses employed for development of the proposed minimum flows, used in a relativistic approach that involved comparison of predictions based on baseline and reduced baseline flows.

Sub-Section: Expanded Comments and Concerns

3. Uncertainty in MFL measures and goals influences minimum flows:

Excerpt from Page 11, Paragraph 3:

a. Intermittent flowing river: To date, the District has developed minimum flows for perennial rivers. The PR is the first intermittent flowing river for which the District has proposed minimum flows. In SWFWMD (2014), the District justifies application of the MFL measures and goals for the PR on the basis of having previously applied them to develop minimum flows for several perennial rivers. *What evidence was considered that led the District to apply the MFL measures, goals, and analyses that were developed for perennial rivers to this intermittent/low-flow river? Are these MFL measures, goals, and analyses correctly applied to an intermittent/low-flow river?*

Response: The Pithlachascotee River is not the first intermittent stream for which the District has develop minimum flow recommendations. The baseline flows developed for the gage site in the upper Myakka River used for minimum flows development were used to characterize that river as an intermittently flowing system. In fact, a low flow threshold of 0 cfs was established for the river segment.

The observed, flow record for the Pithlachascotee River includes a relatively high occurrence of days with zero flow. In comparison the baseline flow record exhibits fewer days when flow is zero, indicating that the intermittent character of the river is influenced by water withdrawals. Regardless of the natural or impacted intermittent/perennial nature the river, staff believe the approach used for development of the proposed minimum flows is appropriate given that it involves identification of a low flow threshold that is evaluated relative to expectations associated with baseline flows and identification of potential significant harm thresholds that are based on comparison of conditions associated with the baseline flows, regardless of whether they are intermittent or perennial.

Excerpt from Page 11, Paragraph 4:

b. Assessment of present-day adverse impact using the PR habitat field data: Recently collected habitat field data (2009-2010) for the PR corridor (SWRF and Dooris & Associates Report included as Appendix 6D of Recommended Minimum Flows for the Pithlachascotee River) was not used by the District to assess the asserted measures and goals that were used to develop proposed minimum flows for the PR. These data characterize apparently healthy floodplain swamp, bottomland hardwood and hydric hammock plant communities adjacent to the Pithlachascotee River. ***Using the aforementioned field data and coinciding climatic and hydrologic data, Tampa Bay Water has the following questions and requests***: (1) Is there evidence of adverse impact to the PR corridor habitat that is intended to be protected through minimum flows? (2) If evidence of adverse impact exists, describe the evidence and the cause of the impact. (3) Did the District consider the development of a flow regime required to maintain the floodplain plant communities and avoid succession to vegetation associated with a drying trend? Floodplain vegetation is sensitive to the hydrologic flow regime (Darst et al 2008) and there is considerable literature on hydrologic characteristics of floodplain forests. A required flow regime maintaining the structure and composition of the floodplain forest would have direct ecological benefit and would correlate well with instream habitat requirements. (4) Are changes to MFL measures and goals for the PR as defined in SWFWMD (2014) warranted based on the immediately preceding assessments?

Response: Section 7.3.3.2 of the draft Pithlachascotee River minimum flows report indicates that the District used the 2010 SWRF, L.L.C and Dooris & Associates, L.L.C. report to characterize wetland classes and other riparian features of the floodplain. The 2010 report is includes as an appendix to the draft minimum flows report. In addition, staff notes that elevations associated with the vegetation classes and various hydrologic indicators include in the 2010 report were incorporated into the Long-Term Inundation Analysis used for consideration of Block 3 flows.

With regard to the four questions posed in the excerpted comment above, staff notes that:

Questions 1 and 2 – Criteria associated with up to a 15 percent change from conditions associated with baseline flows were used to develop minimum flow recommendations for the Pithlachascotee River and have repeatedly been used for establishment of lotic MFLs within the District that have been subjected to independent, scientific peer review. In addition, as described in the draft Pithlachascotee minimum flows report, modeling tools were used by staff to evaluate flow changes that could lead to exceedance of the 15 percent change criteria and by definition that could result in significant harm. The draft report also summarizes differences between observed flows in the river and baseline flows, with differences attributed to impacts associated with water withdrawals.

Question 3 – With regard to development of a flow regime that would support maintenance of typical floodplain vegetative assemblages, staff note that a baseline flow record that accounts for impacts associated with water withdrawals was developed for the Pithlachascotee River. This baseline flow record is assumed to be supportive of the development and persistence of a natural biological assemblage that could be expected in the absence of withdrawal impacts, given the existing structural alterations and the range of climatic conditions associated with the baseline period. We note that the currently existing floodplain assemblage for the Pithlachascotee River has likely developed in response to existing withdrawal-impacted conditions and pre-withdrawal historic conditions, including those that may be approximated by the baseline flows used in the minimum flow analyses. One goal for developing the baseline flow record and using that record to identify minimum flows for the Pithlachascotee River is to ensure maintenance and if necessary, recovery of a hydrologic regime that supports floodplain vegetation assemblages that are not significantly harmed.

Question 4 – Staff believe the criteria used for development of the proposed minimum flows for the Pithlachascotee River are sufficient for preventing significant harm to the river. However, we continue to investigate the development of additional criteria that can be used for establishing minimum flows and welcome similar efforts of others interested in the protection of our water resources.

Excerpt from Page 11, Paragraph 5 and Page 12, Paragraph 1:

c. Correlation of adjusted Baseline flow to existing in-stream habitat: River channel/floodplain geometry and habitat have been principally defined by predevelopment conditions in the absence of both land development and well pumping. The District has created a Baseline streamflow that removes the effects of pumpage and incorporates the land use changes that have occurred within the PR watershed. Since only one of the two sets of physical changes to streamflow have been removed from the Baseline flow and this time series was then applied to the current physical river channel and floodplain, can the developed Baseline flow be reasonably used to assess the effects of changes in the ecology of the PR channel and floodplain? Does the hydrological input (Baseline) match the existing biological indicators when assessing habitat inundation?

Response: Staff believes the baseline flow record can be used to characterize inundation and habitat patterns associated with the non-withdrawal impacted flow (i.e., baseline) conditions and deviations from these conditions (i.e., reduced baseline flow conditions) at study sites within the Pithlachascotee riparian corridor that were selected to be representative of the river segment. The approach was developed to identify minimum flow thresholds based on relative change from baseline conditions, regardless of whether or not baseline conditions currently exist. In some cases baseline flows may "match", i.e., be associated with the processes or conditions that led to the development and would support the persistence of existing biological indicators. This is not, however, a necessity for application of the District's approach to establishing minimum flows.

Excerpt from Page 12, Paragraph 2:

d. In Section 6.7 it is mentioned that peer review panels for previous MFL reports have recommended that "...the District commit the necessary resources to evaluate the effectiveness of a 15 percent change in spatial or temporal habitat availability as a threshold for identifying significant harm..." Is this work scheduled or ongoing? What evidence did the District consider in applying this threshold to the establishment of a Minimum Flow for the PR?

Response: Given the incremental nature of much environmental change in riverine ecosystems, the District has used a 15 percent change criterion when evaluating flow-based changes in potential habitat or resource. The basis for this management decision lies, in part, with a recommendation put forth by the peer-review panel that considered the District's proposed minimum flows for the upper Peace River. In their report, the panelists note that "[*i*]*n general, instream flow analysts consider a loss of more than 15 percent habitat, as compared to undisturbed or current conditions, to be a significant impact on that population or assemblage*" (Gore *et al.* 2002). The panel's assertion was based on consideration of environmental flow studies employing PHABSIM for analyzing flow, water depth and substrate preferences that define aquatic species habitats. Use of a 15 percent change in habitat or resources as constituting significant harm and therefore, for development of minimum flow recommendations, has been extended by the District to evaluate changes in freshwater fish and invertebrate habitat, days of inundation of floodplains and woody habitats in freshwater river segments, changes in abundances or population center-location tendencies of planktonic (free-floating) and nektonic (actively swimming) fish and invertebrates in estuarine river segments, spatial decreases in the availability of warm-water refuges for manatees during critically cold periods, and decreases in the volume, bottom area and shoreline length associated with specific salinity zones in estuarine river segments.

Peer-review panels convened to evaluate District recommendations subsequent to the findings presented by Gore *et al.* (2002) for the upper Peace River have generally been supportive of the use of a 15 percent change criterion for evaluating effects of potential flow reductions on habitats or resources when determining minimum flows (see peer-review reports at the District's Minimum Flows and Levels (Environmental Flows) Documents and Reports web page at:
http://www.swfwmd.state.fl.us/projects/mfl/mfl_reports.php

In response comments made by Cichra *et al.* (2007) in the peer review of the recommended minimum flows for the upper Hillsborough River, the District has sponsored a review of the percentage flow, habitat and resource changes documented in the environmental flows literature (Jones Edmunds & Associates 2012). In 2011 the District initiated a long-term study of potential environmental effects associated with flow diversion within Gum Slough in Sumter and Marion counties. Pre-diversion data were collected for fish, macroinvertebrates and other taxa, but planned flow manipulations for the system were determined to be infeasible, and the project has been placed on hold until such time that it may be revisited for evaluation of environmental changes potentially associated with natural flow variation.

The District continues to utilize the 15 percent habitat or resource change criteria for developing recommended minimum flows, including for development of the minimum flow recommendations for the Pithlachascotee River as described in section 6.7 of the draft minimum flows report for the system. However, the District acknowledges that allowable percentage changes in habitat or resources other than 15 percent have been used by others for environmental flow determinations. For example, Dunbar *et al.* (1998) in reference to the use of PHABSIM notes, "…*an alternative approach is to select the flow giving 80 percent habitat exceedance percentile*," which is equivalent to an allowable 20 percent decrease from baseline conditions. For another habitat-based environmental flow study, Jowett (1993) used a one-third loss of existing habitat associated with naturally occurring low flows as a guideline for determining flow recommendations. In Texas, the state established environmental flows for Matagorda Bay based on modeling that limited decreases of selected commercially important species to no more than twenty-percent reductions from historical harvest levels (Powell *et al.* 2002).

References cited in the response above:

Cichra, C.E., Dahm, C.N., Locke, A., Shaw, D.T. and Stewart, M. 2007. A review of "Proposed minimum flows and levels for the upper segment of the Hillsborough River, from Crystal Springs to Morris Bridge, and Crystal Springs." Prepared for the Southwest Florida Water Management District. Brooksville, Florida.

Dunbar, M.J., Gustard, A., Acreman, M.C. and Elliott, C.R. 1998. Overseas approaches to setting river flow objectives. Institute of Hydrology. R&D Technical Report W6-161. Oxon, England.

Gore, J.A., Dahm, C. and Klimas, C. 2002. A review of "Upper Peace River: an analysis of minimum flows and levels" August 25, 2002 draft. Published by the Southwest Florida Water Management District. Brooksville, Florida.

Jones Edmunds & Associates, Inc. 2012. Minimum flows literature comparison. Gainesville, Florida. Prepared for the Southwest Florida Water Management District. Brooksville, Florida.
Jowett, I.G. 1993. Minimum flow requirements for instream habitat in Wellington rivers. NZ Freshwater Miscellaneous Report No. 63. National Institute of Water and Atmospheric Research. Christchurch, New Zealand.

Powell, G.L., Matsumoto, J. and Brock, D.A. 2002. Methods for determining minimum freshwater inflow needs of Texas bays and estuaries. Estuaries. 25: 1262-1274.

Excerpt from Page 12, Paragraph 3:

4. Compliance assessment process: The compliance assessment process should be adopted by rule simultaneously with adoption of minimum flows and should be thoroughly described in the Rule. Although the compliance assessment in SWFWMD (2014) lacks specificity, it can be used as a starting point. Rule-adopted compliance assessment elements should include at a minimum but not be limited to: (1) naming of specific evaluation tools, (2) complete description of how evaluation tools are to be modified and results summarized for compliance assessments, (3) length of compliance assessment period, (4) decision about compliance assessment by flow block, by combination of flow blocks, or by lumping all flow blocks together, (5) describe mechanics of calculating percent flow reduction over compliance assessment period, and (6) influence of prevailing climate condition over the compliance assessment period. The compliance process must also include provisions that protect the flow in the PR from further changes due to land use alterations within the watershed; if this is not accomplished, the responsibility for any future diminishment of flow in the PR due to causes other than well pumpage will be unfairly assessed to those entities holding Water Use Permits. The District should consider multiple assessment methods and the use of empirical data to assess compliance with the proposed Minimum Flows for the PR. Section 8.2 of SWFWMD states that a "final determination of whether a minimum flows recovery strategy is needed for the Pithlachascotee River should be incorporated into the Permit Recovery Assessment Plan for the Northern Tampa Bay area that is being prepared by Tampa Bay Water as part of their Consolidated Permit…". This assessment will be completed at the same time as our permit renewal in the year 2020. If the need for a recovery strategy will be assessed at the time of permit renewal, Tampa Bay Water will have no opportunity to make operational adjustments to see if the proposed Minimum Flow can be achieved. It seems disconnected to assess compliance with a Minimum Flow at the time of renewal of a major municipal water supply permit; a compliance method must be created and adopted at the time that the Minimum Flow rule is adopted so that Tampa Bay Water and other permittees can assess the implications of the rule as it is adopted and into the future. This will provide the greatest likelihood of all permittees successfully complying with the rule. *The implication of not simultaneously adopting compliance assessment by rule leaves an ambiguous and undefined process by which the regulated community cannot ascertain compliance with the rule.*

Response: Staff agrees that an approach for assessing the status of MFLs water bodies, i.e., compliance with adopted MFLs, should be developed when MFLs are developed. In fact, when developing MFLs, the current and future status of the MFLs must be assessed as state law requires development of recovery or prevention strategies in cases where MFLs are not met or projected to not be met during the coming 20 years. State law also requires that recovery and prevention strategies be included in district regional water supply plans but does not require or exclude the incorporation of these strategies into rule.

Similarly, inclusion of a status assessment process (i.e., compliance approach) does not necessarily have to be include in rule, although it can be.

The District may include language in MFLs rules that address how the status of the applicable MFLs will be assessed. This language may identify specific tools that may be used, but is more typically constructed to allow flexibility regarding the development and use of new assessment tools and approaches while not requiring rule changes.

As noted above, MFLs status assessments are completed concurrent with MFLs development and for regional water supply planning purposes on a five-year cycle. In addition MFLs status assessments are completed on an annual basis and on an as needed basis for permit/project evaluations.

A preferred assessment approach usually involves use of the tool or tools that were used for development of the MFLs that are applicable to the water body. For the Pithlachascotee River, it is anticipated that the INTB model, which was used for minimum flows development and status assessment as described in the draft report for the river, will be used. In addition, staff anticipate using measured hydrologic data, including gaged streamflow, rainfall records, water-use information, and groundwater levels to assess the status of flows in the river. We also expect to explore development of additional tools that may allow improved characterization of flow expectations given variation in rainfall and other climatic factors.

With regard to TBW's assertion that a minimum flows status assessment process for the Pithlachascotee River include provisions addressing land-use and structural alterations within the watershed, staff notes that type of regulatory activity is authorized under the District's Environmental Resource Permitting Program.

Finally, staff notes that it intends to continue working on an approach that can be used to assess the status of flows in the Pithlachascotee River relative to minimum flows that are expected to be adopted for the system. Further, staff is committed to having an assessment approach for the river developed and well described prior to seeking Governing Board approval to move forward with adoption of proposed rule amendments associated with recommended minimum flows for the river.

Excerpt from Page 12, Paragraph 4:

5. Streamflow unit response: In the appendices, the District described an application of streamflow unit response to estimate the temporal impact of ground-water pumping. Since the District did not use the unit response approach to define the Baseline flow time series for the PR, the text should be removed. The validity of applying a unit response concept to west central Florida streamflow has not been demonstrated by the District or others.

Response: Because it was not utilized in the impact analysis, staff agrees to remove the unit-response language or modify the appendices to reference the INTB modeled impact under more recent conditions.