Appendix I1

Compilation of Public and Stakeholder Comments Through June 2023, Pages 1-531

From:	Napoli, Kelly
To:	Kym Holzwart
Subject:	RE: FPL Clarifying MFL Questions
Date:	Tuesday, January 4, 2022 11:35:52 AM

[EXTERNAL SENDER] Use caution before opening.

Happy New Year, Kym!

I hope you had a great holiday. Thank you for your response. Is possible, FPL would like to schedule a meeting with you and the Regulatory Staff. Danielle Hall, Paul Linton, and I are available January 19th, 20, and 21st, any time after 12 noon. Please let me know if these times work for your team.

Thank you!

Kelly Napoli, EI
Environmental Specialist II
Florida Power & Light | Environmental Services
700 Universe Blvd | JES/JB C5073
Juno Beach FL, 33408
O. 561.694.4015
C. 561.335.6659

FPL.

Please consider the environment before printing this email

From: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Sent: Wednesday, December 22, 2021 9:50 AM
To: Napoli, Kelly <Kelly.Napoli@fpl.com>
Subject: RE: FPL Clarifying MFL Questions

Good Morning Kelly,

I left you a voice message on Monday; however, you may already be out of the office for the holidays. I was out of the office most of last week, and because I am going to be out of the office until after the New Year starting this afternoon, I did not want your email to go unanswered.

I am happy to schedule a meeting with you and your colleagues and with District MFLs and Regulatory staff in January. However, as I mentioned in the past, we are doing additional work related to responding to the peer review panel comments, which will most likely result in a revision to the proposed minimum flows for the Little Manatee River. We will still be doing work in January, so we won't be in the position to discuss the proposed minimum flows. If you still want to meet in January, please provide some dates in mid- to late January, and I will get a meeting setup.

You are welcome to submit comments any time, and I am happy to post them to the peer review web forum (but you can do that as well). Note that topics such as the Emergency Diversion Schedule and how the Cooling Pond is operated under the current permit are regulatory issues and are not considered by the peer review panel during their review of our methods and results related to the proposed minimum flows.

If you would rather wait until we have completed our additional work, I would be happy to reach out to you to set up a meeting to present the revised (should they be) proposed minimum flows for the Little Manatee River (and the meeting will include regulatory staff in case you have any questions related to your current permit). As I have mentioned before, we should have our work completed and be through the peer review process sometime around April to May.

Please let me know how you would like to proceed.
Merry Christmas and Happy New Year,
Kym

Kym Rouse Holzwart, M.S.
Certified Senior Ecologist
Senior Environmental Scientist
Environmental Flows and Levels Section
Natural Systems & Restoration Bureau
Southwest Florida Water Management District
2379 Broad Street
Brooksville, FL 34604
1-800-423-1476, ext. 4295
352-796-7211, ext. 4295
kym.holzwart@swfwmd.state.fl.us

From: Napoli, Kelly <Kelly.Napoli@fpl.com>
Sent: Tuesday, December 14, 2021 12:58 PM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Subject: RE: FPL Clarifying MFL Questions

[EXTERNAL SENDER] Use caution before opening.
Hey Kym,

Thank you for the information. FPL would like to provide the Peer Review team and the District some comments in order to highlight how we operate the Cooling Pond as the only existing legal user of the Little Manatee River.

Also, we would be interested in meeting with you and the Regulatory staff sometime in January to discuss these comments. When you have a moment, I would really appreciate if you could send me the applicable emails to schedule this meeting with.

Thank you!
Kelly Napoli, EI
Environmental Specialist II

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FPL

Please consider the environment before printing this email

From: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Sent: Thursday, December 2, 2021 9:18 AM
To: Napoli, Kelly <Kelly.Napoli@fpl.com>
Subject: RE: FPL Clarifying MFL Questions

Hey Kelly,

I am glad you emailed since I wanted to let you know about some schedule changes in the peer review process for the Little Manatee River proposed minimum flows that have occurred this week:

1. The peer review period is being extended since the District needs time to do work to respond to the peer review panel comments. Therefore, the Dec. 15th and Jan. 5th meetings of the peer review panel have been cancelled (and that should come out in the public noticing very soon and the District's webpage has been updated).
2. Once our work is done and we have completed the draft responses to the peer review panel's comments, we will schedule public meetings with the peer review panel, which will probably occur in March.
3. As I have mentioned in the past, once we are through the peer review process, we will set up a meeting with you to present the proposed minimum flows (probably around the April-May timeframe).

I am happy to forward your email to the appropriate person in our Regulatory department or provide their email to discuss the items you have listed below, just let me know. Note that Regulatory staff are not involved in the development of minimum flows. However, once minimum flows are adopted, they use them as one of their tools when reviewing Water Use Permits. Feel free to give me a call if you have any questions.

Best regards,
Kym

Kym Rouse Holzwart, M.S.
Certified Senior Ecologist
Senior Environmental Scientist
Environmental Flows and Levels Section

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kym.holzwart@swfwmd.state.fl.us

From: Napoli, Kelly <Kelly.Napoli@fpl.com>
Sent: Thursday, December 2, 2021 9:00 AM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Subject: RE: FPL Clarifying MFL Questions

[EXTERNAL SENDER] Use caution before opening.
Good morning Kym!

FPL would like to meet with SWFWMD regulatory staff to discuss two items prior to the next Peer Review Meeting, if possible. Are their any times on December 14th that you and your staff would be available for a meeting?

The items we would like to discuss include the following:

- The District's evaluation of FPL's current Emergency Diversion Schedule (EDS)
- The District's delineation of the Upper and Lower Little Manatee River

Thank you!
Kelly Napoli, EI
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FPL

From: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Sent: Friday, October 22, 2021 7:02 AM
To: Napoli, Kelly <Kelly.Napoli@fpl.com>
Subject: Re: FPL Clarifying MFL Questions

Hey Kelly,

Thanks for taking the time to meet with us yesterday, and I hope my presentation answered your questions (feel free to give me a call if you want to discuss further). Below is the link that has the info (and Teams meeting links) to all of the peer review panel meetings for the Little Manatee River recommended minimum flows. You can get to the WebForum (where the panel does their work in between meetings), if you click on Little Manatee River under the MFL Peer Review on the upper right side of the page.
Happy Friday,
Kym

https://www.swfwmd.state.fl.us/projects/mfls/mfls-public-meetings

MFLs Public Meetings | WaterMatters.org

Information on upcoming and recent public meetings on the District's Minimum Flows and Levels Program will be consolidated on this page.

www.swfwmd.state.fl.us

From: Napoli, Kelly <Kelly.Napoli@fpl.com>
Sent: Thursday, October 21, 2021 4:09 PM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Subject: RE: FPL Clarifying MFL Questions

[EXTERNAL SENDER] Use caution before opening.
Thanks for the meeting today Kym! Whenever you have a chance, could you please send me the Peer Review Meeting Invites for December 15th and January 5th?

Thank you!
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FPL.

From: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Sent: Thursday, October 21, 2021 11:47 AM
To: Napoli, Kelly <Kelly.Napoli@fpl.com>
Subject: RE: FPL Clarifying MFL Questions

Thanks!

From: Napoli, Kelly <Kelly.Napoli@fpl.com>
Sent: Thursday, October 21, 2021 11:05 AM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Subject: FPL Clarifying MFL Questions

[EXTERNAL SENDER] Use caution before opening.

Good morning Kym,

Thanks for the call. I have attached a draft document of our clarifying MFL questions. Thank you for the opportunity to discuss these with you and your team this afternoon.

Thank you!

Kelly Napoli, EI
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FPL

Please consider the environment before printing this email

FPL

February 18th, 2022

Southwest Florida Water Management District
Natural Systems & Restoration Bureau
Environmental Flows and Levels Section
2379 Broad Street
Brooksville, FL 34604

Re: Comments on Proposed Minimum Flow and Level for the Little Manatee River

Ms. Kym Rouse-Holzwart,

Florida Power & Light (FPL) owns and operates the Manatee Power Plant in Manatee County, FL, which withdraws water from the Little Manatee River to supply its cooling pond. This plant has been in operation since the 1970s and supports the generation of clean, reliable power. Recently, the Southwest Florida Water Management District (SWFWMD) issued a Draft Minimum Flow and Level (MFL) for Little Manatee River. As a regulated public service utility dependent on sharing access to water, we recognize the integrity and management of Florida's surface waters are important in providing for navigation, flood protection, water supply, recreation, and environmental needs. FPL appreciates the opportunity to be part of the MFL review process and submits the following comments to the District for consideration in the next version of the Draft Little Manatee River MFL.

Operational Background Information

The FPL Manatee Power Plant has an existing authorized water allocation from the Little Manatee River and is dependent on this allocation for year-round operation. FPL is currently the only permitted diversion from the Little Manatee River. The FPL withdrawal from the Little Manatee River occurs approximately 3.5 river miles upstream of the Wimauma gage (USGS Station 301). At FPL's withdrawal point, the river bed and water slope begin to reduce considerably, indicating that FPL's withdrawals have minimal, if any, impacts on the Upper Little Manatee River and primarily impact the Lower Little Manatee River. Water withdrawn from the river is stored in a 3,800-acre cooling pond that was constructed in the early 1970s. An intake bay and pump station were constructed adjacent to the Little Manatee River to divert and withdraw water from the river in order to manage the water levels within the cooling pond. Water levels within the cooling pond must be maintained within a specific range to ensure reliable operation of the power plant and for dam safety. Specifically, there must be enough water in the cooling pond to maintain high enough water levels throughout a drought year. If the water levels drop below a certain level, the pumps that withdraw water for the power plant cannot operate properly, thus impacting the plant's ability to generate reliable electricity. Additionally, the cooling pond has a maximum water level specification to ensure safe operation of the dam. The importance of maintaining the water within a specified range requires FPL to strategically make surface water withdrawals from the Little Manatee River to ensure operational reliability and safety.

The amount of water withdrawn is determined based on the pond water level, evaporation rate, weather forecast, and permitted diversion schedule. Evaporation accounts for the majority of the water loss experienced in the cooling pond. The primary drivers of evaporation include the heat load from sun, heat load from the power plant, and winds which increase evaporation by replacing saturated air with drier air. Seepage from the cooling pond is captured and returned to the cooling pond. Rainfall makes up for some of these losses, but strategic surface water withdrawals are critical to maintaining the pond at safe and operational levels. In addition, FPL employs the water conservation measures identified in the May 2017 Water Conservation Plan submittal, which was submitted to SWFWMD in accordance with Condition H of the Site Certification. FPL continuously identifies and executes water conservation measures. For example, in 2020, FPL replaced 27,500 feet of cooling pond swale pipe in order to increase the volume of groundwater and surface water seepage captured and returned directly into the cooling pond.

Regulatory Background Information
FPL's allocation is permitted via the Site Certification (PA 02-44D), Section III, Part K Diversion Schedules (Regular and Emergency). This allocation was obtained after a lengthy hydrobiological evaluation. As required by the 2003 Site Certification Condition J, FPL submitted a Hydrobiological Monitoring Program on September 25th, 2003 to both the Florida Department of Environmental Protection and the SWFWMD. The Interpretative Report for the Hydrobiological Monitoring Program was submitted on September 29th, 2009 (Attachment A). These reports include thirty-two years of withdrawal data recording and five years of water quality analyses, habitat mapping, salinity trend analyses, color infra-red aerial photography, tidal stage analysis, and an ecological evaluation of the Little Manatee River downstream of FPL withdrawals. The interpretive report concluded that there have been no adverse effects on the ecology of the Little Manatee River or its estuary from the historic withdrawals for the Manatee Power Plant. Hydraulic analyses indicate that the effects of withdrawals under the diversion schedules associated with the Manatee Power Plant on water levels, water flows, and salinity in the Little Manatee River are all within the natural variability of the river.

The Regular Diversion Schedule (RDS) provides:

1. FPL shall permanently implement the Regular Diversion Schedule (RDS) for withdrawals of water from the Little Manatee River with the following limitations:

- *a) Withdrawals shall not occur when Little Manatee River flow, as measured at FPL's gauging station (at the point of diversion), is less than 40 cubic feet per second (cfs) (25.9 mgd)*
- *b) The maximum authorized diversion is 190 cfs (122.8 mgd)*
- *c) Withdrawals shall be limited to not greater than 10% of the Little Manatee River flow as measured at FPL's gauging station*
- *d) In no case shall the diversion reduce the flow in the Little Manatee River below the point of diversion to less than 40 cfs*

In addition to the RDS, the FPL Manatee Power Plant's Site Certification permits an Emergency Diversion Schedule (EDS) that allows the plant to withdraw water when the cooling pond needs to restore water levels to those acceptable for safe and reliable operations. The EDS has provided critically needed water during drought years. The current EDS provides:

2. FPL is authorized to implement an emergency diversion schedule (EDS) in the event the water level in the cooling pond falls below 62.00 ft. N.G.V.D. subject to the following limitations:

- *a) Withdrawals shall not occur when Little Manatee River flow, as measured at FPL's gauging station (at the point of diversion), is less than 40 cfs (25.9 mgd).*
- *b) The maximum authorized diversion is 190 cfs (122.8 mgd).*
- *c) EDS withdrawals shall be limited according to the Table below*
- *d) In no case shall the diversion reduce the flow in the Little Manatee River below the point of diversion to less than 40 cfs.*
- *e) The river diversion schedule shall revert from the EDS to the RDS upon cooling pond water levels reaching an elevation of 63.00 ft N.G.V.D.*

Little Manatee River Flow in cfs As Measured at the FPL Gauging Station	Maximum Allowed Diversion in cfs
$Q_{riv} < 40$	0
$40 \leq Q_{riv} < 60$	$0.85\ Q_{riv} - 34.0$
$60 \leq Q_{riv} < 100$	$0.325\ Q_{riv} - 2.5$
$100 \leq Q_{riv} < 150$	$0.52\ Q_{riv} - 22.0$
$150 \leq Q_{riv} < 200$	$0.74\ Q_{riv} - 55.0$
$200 \leq Q_{riv} < 400$	$0.485\ Q_{riv} - 4.0$
$400 \leq Q_{riv}$	190

Note: Q_{riv} is the Little Manatee River Flow in cfs as measured at the FPL gauging station.

Finalization of the MFL for the Little Manatee River may require modification of the Manatee Power Plant's Site Certification to ensure the diversion schedules are consistent with the MFL and provide FPL the ability to safely and reliably operate. FPL's initial impression of the MFL is that, for years with average and above average rainfall, the proposed diversion limits for the Upper LMR will provide slightly more water availability. However, for drought years and multi-drought years, FPL is concerned that the proposed diversion limits for the Upper LMR will provide less water availability than the combined water availability under the RDS and EDS. Based on FPL's drought experience, an EDS will be required.

If FPL's diversion schedules are modified upon the publication of the final MFL, FPL requires an updated EDS along with an updated RDS. To maintain safe and reliable operations, FPL utilized the EDS 13.1% of total days between 2004 and 2021. Retaining an EDS is critical in reducing the potential for power plant shut down; as a public utility service provider, FPL must maintain reliable operation. More specifically, an EDS is critical to enabling the site to fill the cooling pond when levels are critically low (NGVD 62 feet). Low levels in the cooling pond occur when dry conditions, combined with the plant's heat load, increase evapotranspiration rates faster than FPL can fill the cooling pond with the current diversion schedules.

In addition to a low limit for cooling pond safety, there is a limit to how high the cooling pond can be filled due to the risk of multiple hurricanes (wind driven waves causing a dam failure due to overtopping) or persistent high water (causing a piping failure of the dam). Due to the potential for very large rainfall from multiple tropical storms, the cooling pond level is raised gradually to a peak stage near the end of the hurricane season. The long dry season, combined with the relatively small flows available for diversion, result in large fluctuations in the cooling pond's water level. The existing water demands of the power plant regularly use most of the available storage capacity of Manatee's cooling pond. The multi-year droughts that occur regularly in Florida can and do lower the pond by more than five feet. For example, near the end of the 1999-2001 drought, the cooling pond reduced to an elevation that only provided one foot of storage above when pumping would no longer be possible, which affects the reliability of power generation. Based on preliminary assessments, FPL expects that an EDS with lower diversion rates and wider operation ranges could address the need for water during drought years.

Comments

COMMENT 1: IMPLEMENTATION OF THE DRAFT LITTLE MANATEE RIVER MFL

The Little Manatee River is approximately 40 miles long from its origins to its mouth in Tampa Bay. FPL's Little Manatee River withdrawal point is located at 27°38'17.63"N and 82°19'38.62"W, which is approximately 3.5 river miles upstream of the Wimauma gage (USGS Station 301) and 18.5 miles above the mouth of the river. At FPL's withdrawal point, the river bed and water slope begin to reduce considerably as compared to the upper reach, indicating that FPL's withdrawals have minimal, if any, impacts on the Upper Little Manatee River. From its mouth to approximately river mile 12, the vegetation is mangroves, salt marsh, and tidal marsh. From river mile 12 and above, the river is generally freshwater with freshwater bottom land stream swamp vegetation. Water flows and levels exhibit significant variability.

The USGS Station 301 was chosen as the delineation factor between the Upper and Lower Little Manatee River. It is unclear how this location was determined to be the delineation point. FPL believes that multiple factors, in addition to the flow measurement, should be included in the justification. As can be seen in Figure 6-5 below, the slope of the Upper Little Manatee River is about 2.5 feet per mile until river mile 19.5, approximately a mile upstream of FPL's withdrawal. The bed slope for the remaining 19 miles to Tampa Bay is a fraction of a foot per mile. The rise of the riverbed prevents FPL withdrawals from affecting the Upper Manatee River and demonstrates that FPL's withdrawals primarily impact the Lower Manatee River. **As FPL's withdrawals will not have substantive impact on the Upper Little Manatee river, FPL requests that the MFL include flexibility so the District may consider applying the Lower Little Manatee River MFL criteria when updating FPL's diversion schedule.** Based on the proposed criteria, FPL expects that the water availability of the Lower LMR would provide enough water to operate reliably and minimize the need to use the EDS.

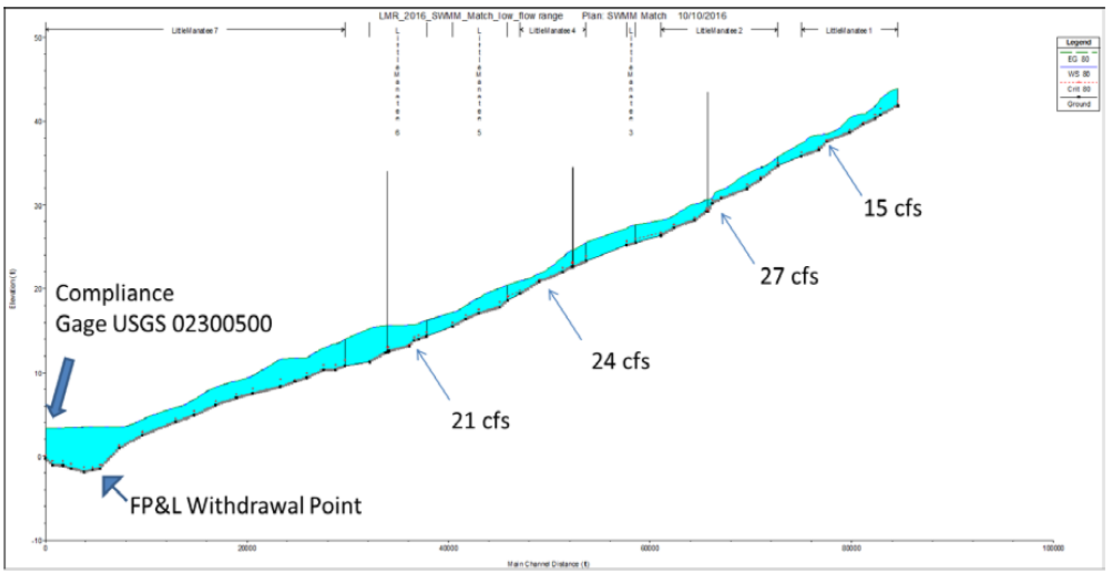

Figure 6-5. Water-surface profile of the main stem of the Upper Little Manatee River with critical shoals for fish passage denoted by arrows and labeled with reach specific flow requirements necessary to maintain hydrologic depth of 0.6 ft (0.18 m) (from JEI 2018a).

Modifying the diversion schedule in accordance with the Lower Little Manatee MFL flow blocks will allow FPL to continue its withdrawal operation without impact to the river or plant reliability. The current RDS permitted in the Site Certification meets the flow regime outlined in the Upper and Lower Little Manatee River flow blocks. Additionally, a diversion schedule consistent with the flow regime outlined for the Lower Little Manatee River would reduce FPL's dependence on the EDS to less than 1 in 10 years. However, if the Upper Little Manatee River flow regime is utilized to modify FPL's diversion schedule, FPL would be heavily reliant upon the EDS during drought years (FPL anticipates the EDS would be utilized every 1 in 5 years). Additionally, based on the Draft Upper Little Manatee River MFL, FPL's current EDS exceeds the available water if FPL must operate under the Upper Little Manatee River flow blocks. Currently, the diversion rates for the EDS range from 28% of the Little Manatee River flows (when the river is > 60 cfs) to 47% of the Little Manatee River flows (when the river is >200 cfs). The Upper Little Manatee MFL only allows 20% withdrawal when the flow is <72 cfs, 13% withdrawal when the flow is <174 cfs, and 11% withdrawal when the flow is >174 cfs. During drought years, when the cooling pond is at a low stage, FPL would be better protected if the Lower Little Manatee River MFL criteria was implemented in the diversion schedule. And, the Hydrobiological Monitoring Program showed effects of withdrawals under the diversion schedules are all within the natural variability of the river. Table 1 below demonstrates the difference in available withdrawals compared to FPL's current EDS.

Table 1: Allowable Withdrawals

Little Manatee River Flow	Current EDS Allowable Withdrawals	Lower Little Manatee River MFL Allowable Withdrawals	Upper Little Manatee River MFL Allowable Withdrawals
<35 cfs	0	0	0
>35 cfs and < 72 cfs	0 to 28.8%	20%	20%
> 72 cfs and < 174 cfs	~28.3 to 41.7%	30%	13%
> 174 cfs	~41.7 to 47.5%	30%	11%

FPL politely requests that the District staff consider FPL's need to withdraw water from the Little Manatee River in order to ensure dam safety and reliable operation of the Manatee Power Plant. Applying the Lower Little Manatee River criteria would reduce, though not eliminate, reliance on the EDS. **FPL also requests that, if the District agrees that FPL withdrawals only impact the Lower Little Manatee River, the District consider including this information in the Draft MFL.** Any regulatory revisions now or in the long term which may reduce the existing authorized water allocation to the cooling pond could have significant repercussions on FPL's ability to safely and reliably provide power.

COMMENT 2: DRAFT MFL SUMMARY TABLE CLARIFICATION

FPL recommends revisions to Table 6-9 to provide regulatory clarity for implementation. Specifically, the last row of the table states that no surface water withdrawals are permitted when flows are less than or equal to 35 cfs for both the upper and lower Little Manatee River; however, Block 1 criteria for flows less than or equal to 35 cfs states "*90% percent of the flow on the previous day.*" Based on the last row of the current MFL Table 6-9, no diversion should be allowed for flows below 35 cfs (Block 1 flows). The following tables demonstrate two scenarios that are the result of the conflicting information for Block 2 flows. The first scenario demonstrates if withdrawals occur solely based on the previous day's average flow. The second scenario demonstrates if withdrawals are based on the previous day's average flow and the 35 cfs withdrawal restriction. Additionally, the criteria should be clear on which portions of the flow are reserved, protected, retained for the river and which flows are available.

Scenario 1

Flow in LMR at US 301	20% of the previous day's LMR Flow at US 301	LMR Flow - 20% withdrawn
(cfs)	(cfs)	(cfs)
35	7	28
36	7.2	28.8
37	7.4	29.6
38	7.6	30.4
39	7.8	31.2
40	8	32
41	8.2	32.8
42	8.4	33.6
43	8.6	34.4
44	8.8	35.2
45	9	36
46	9.2	36.8
47	9.4	37.6
48	9.6	38.4
49	9.8	39.2
50	10	40

Scenario 2

Flow in LMR at US 301	Allowed Diversion to Maintain LMR above 35 cfs	Flow in LMR at US301 after Max Diversion Allowed
(cfs)	(cfs)	(cfs)
35	0	35
36	1	35
37	2	35
38	3	35
39	4	35
40	5	35
41	6	35
42	7	35
43	8	35
44	8.8	35.2
45	9	36
46	9.2	36.8
47	9.4	37.6
48	9.6	38.4
49	9.8	39.2
50	10	40

Given the two conflicting scenarios illustrated above, FPL recommends the following adjustments to Table 6.9 in order to establish regulatory clarity:

TABLE 6-9
Minimum Flow and Level (MFL) Criteria for Little Manatee River (LMR)

River Reach	**Flow Block 1 (<= 35 cfs)**	**Flow Block 2 (> 35 cfs & <= 72 cfs)**	**Flow Block 3A (>72 cfs & <= 174 cfs)**	**Flow Block 3B (> 174 cfs)**
Upper LMR Headwater to US301 Highway	All flow reserved for LMR River	80% of flow reserved for Upper LMR River	87% of flow reserved for Upper LMR River	89% of flow reserved for Upper LMR River
	No flow available for other uses	20% of flow available for other uses	13% of flow available for other uses	11% of flow available for other uses
Lower LMR US301 Highway to Tampa Bay	All flow reserved for LMR River	80% of flow reserved for Lower LMR River	70% of flow reserved for Lower LMR River	70% of flow reserved for Lower LMR River
	No flow available for other uses	20% of flow available for other uses	30% of flow available for other uses	30% of flow available for other uses

Notes
No withdrawals from the Upper Little Manatee River or Lower Little Manatee River allowed when the flow at US301 is equal to or below 35 cfs. For Block 2 the withdrawals will be limited to 20% of the total flow, up until the river flow is 35 cfs. Withdrawals will be based on the flow at US301 as measured by the USGS Site 02300500 at 2400 (midnight).

FPL continues to analyze the site's water needs with the water availability prescribed by this Draft MFL and looks forward to continuing to coordinate with the SWFWMD on development and implementation of the MFL. If you have any questions or need more information, please feel free to contact Kelly Napoli via phone at 561-694-4015 or via email at Kelly.Napoli@fpl.com

Best regards,

Danielle Hall
FPL Environmental Services Manager
561-691-2406

Attachment A

GA DATABASE UPDated

Database Updated Florida Power & Light Company, 19050 State Road 62, Parrish, Florida 34219

FPL

FILE OF RECORD
NO. CT 305547

September 29, 2009

Mr. Michael s. Flannery
Senior Environmental Scientist
Southwest Florida Water Management District
2379 Broad Street
Brooksville, Florida 34609-6899

Re: Florida Power & Light Manatee Plant
Hydrobiological Monitoring Program Interpretive Report
PA-02-44 XXXIII J2.d(3)a(2)

Dear Mr. Flannery:

Enclosed please find the revised Interpretive Report for the Hydrobiological Monitoring Program, Florida Power & Light Company's Manatee Plant expansion.

If you have any questions, please call me at (941) 776-5278.

Sincerely,

Mary Maxwell
Environmental Specialist

Enclosure

CC: Matthew Miller, SWFWMD, Sarasota
File

SOUTHWEST FLORIDA RECEIVED OCT - 1 2009 RRD-SARASOTA MANAGEMENT DISTRICT

Review of FP&L Little Manatee River Hydrobiological Monitoring Program Interpretive Report

Prepared by Sid Flannery, Southwest Florida Water Management District, August 26, 2009

Comments listed below by Page (P), paragraph (PAR), Line (L)

P6 , par 2 - Citation for HSW (2008) needs to be consistent with citation for Watson et al. (2008) in the references. Also, alphabetize the references on page 40.

P 9, par 2 - the text says the initial diversion schedule was based on stage, but Appendix A also shows a diversion schedule based on flows dated November 12, 1975. That is the one I used. This previous, flow based diversion scheduled needs to be referenced in the text or it seems like FP&L was being regulated only on stage for a number of years.

P 13, par 4, - Was maximum daily stage considered as a variable in the regression of maximum salinity? It seems that this would be a better predictor than mean stage. However, maximum stage could be affected by high flows, particularly at I-75. Similarly, mean stage could be affected by high flows, but at I-75 the station would likely be fresh. Did the regression for I-75 have a threshold flow at which the station became fresh? Would FP&L provide scatter plots of the data with the fitted regression lines and confidence intervals shown for the regressions of mean and maximum salinity at US 41 and I-75.

P 16 – The citation for SWFWMD (2002) is not in the References, what report of paper was that?

P 17, the Citation for Flannery (1991) should be for Flannery et al. (1991)

P 23. The figure appears to be average monthly withdrawals, not daily withdrawals. Daily withdrawals would have been more informative.

Interpretive Report for the Hydrobiological Monitoring Program Florida Power and Light Company's Manatee Plant Expansion

Submitted to: Southwest Florida Water Management District
6750 Fruitville Road
Sarasota, Florida 34240

Prepared for: Florida Power & Light Company
Manatee Plant
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1.0 Introduction

Florida Power & Light Company (FPL) is required to develop and implement a hydrobiological monitoring program (HBMP) for their Manatee Plant Expansion Project. The HBMP is required by Conditions of Certification for the Manatee Unit 3 Expansion Project, Final Order No. PA 02-44. The specific conditions requiring the HBMP were provided by the Southwest Florida Water Management District (District) to address potential concerns related to water withdrawal from the Little Manatee River.

Conditions of Certification Condition J.2 and J.3 require submission of data and interpretive reports. This report is submitted in compliance with that permit condition.

This interpretive report is required to provide the water quality monitoring data since the previous data report (April 2007), results of the update aerial photography and habitat mapping, and salinity trend analyses. This report reflects the results of agreements reached at a meeting with District staff and subsequent approval of the report outline by the District. The report contains data collected through Water Year 2008 (WY 2008, ending September 30, 2008).

2.0 Methodology

2.1 Water Quality Monitoring, Data Management and Equipment Maintenance

Two fixed specific conductance recording stations and one tide stage recording station are required by Conditions J.2.a and J.2.b. These stations were located in the lower tidal river channel near the US 41 bridge and near the I-75 bridge (See **Figure 2.1-1**).

Monitoring Station Mobilization

Vanasse Hangen Brustlin, Inc. (VHB) obtained permission to access two private residential docks for the purpose of installing the monitoring equipment. The U.S. 41 station had previously been utilized by the U.S. Geological Survey (USGS) to perform similar monitoring. Subsequent to obtaining site access permission, the required monitoring equipment was assembled and installed in September 2004. Provided below is a list of the monitoring equipment installed at each station.

Equipment List for Each Site

- In-Situ pressure transducer
- MP 9000 sonde
- 2" PVC pipe
- 2" Galvanized pipe
- Nema enclosure
- Staff Gauge
- Anti-fouling Paint
- Lock

Initial calibration of the monitoring equipment provided for the collection of stage, temperature, and conductance data at 15-minute increments using one In-Situ MP Troll 9000 data logger at each site. Two AA batteries power the logger. The loggers date and time stamp each stage, temperature, and conductance value. Stage data are collected using the In-Situ pressure transducer which is a part of the Troll 9000. Temperature and conductance data are collected using In-Situ MP Troll 9000. The sondes probes were placed at what was determined to generally be mid-depth in the water column. The Troll 9000 units were subsequently replaced with YSI sondes after repeated problems.

Each data logger is housed within a Nema enclosure and locked to prevent vandalism. Two-inch PVC pipe is used to house and protect the sondes units as well as the stage pressure transducer. All equipment subject to inundation by salt water was treated with clear anti-fouling paint to reduce or eliminate the potential for marine fouling. A staff gauge was also installed along the outside edge of the monitoring unit as a visual check to make sure that the stage unit is functioning properly and reading accurately. After installation, the sonde units were calibrated against an *in situ* measurement by using a YSI multi-parameter meter.

Although Condition J.2.b. only required that a "continuous tide stage recorder shall also be installed near one of the specific conductance recorders", stage tide recorders have been installed at both stations. This will allow much better salinity modeling for the two locations and will prevent the need to extrapolate the stage data from a single location possibly several miles away from the actual salinity readings.

Monitoring Data Collection

At each station, automated specific conductance and temperature measurements are made using the In-Situ MP Troll 9000/YSI Sondes (salinity recorders). Specific conductance and temperature measurements are made at 15 minutes intervals. A continuous tide stage recorder also measures the tide elevation every 15 minutes at each station. The automated data is date and time stamped and stored in the data logger. The survey of the sites has been completed and stage data are been reported as NGVD (1988).

Monitoring Data Management

Monthly site visits are conducted to download the stage, temperature and conductance data from the data logger at both sites. Data are downloaded from the MP Troll 9000/YSI Sonde using a laptop computer or similar device (i.e., PDA). The downloaded data files are then transported to the office for processing. Raw stage, temperature and conductance data are entered into an Excel spreadsheet with the recorded date and time stamp. Raw data are corrected as necessary based upon the field calibration results (shift adjustment). Specific conductance values are converted to salinity internally by the MP Troll 9000/YSI Sonde.

The stage, temperature, conductivity and salinity data are reduced to mean, minimum and maximum values for each day. The daily value data are tabled to show the mean, minimum and maximum for each day. The 15-minute data are retained and will be provided upon request as these files are lengthy. The daily data are also summarized to calculate the mean, minimum and maximum for each month.

Monitoring Equipment Calibration and Maintenance

Conditions of Certification Condition J.2.c. requires the tide and salinity recorders be regularly maintained and calibrated to referenced standards to ensure data accuracy. The tide and salinity recorders are visited monthly for maintenance and calibration purposes. Initial readings are made of all instruments on arrival at the site. Staff gauges and inside gauges have been established at each site along with "reference points" and "reference marks" to verify that the proper tide stage value is recorded. Temperature and conductance values are taken with a calibrated YSI multi-parameter probe and recorded on arrival at the site. These initial readings are compared with recorder values. Temperature and conductivity sensors are placed in standard solutions and these values are also recorded. The sensors are cleaned and recalibrated if necessary. A final reading is taken and recorded following cleaning of the sensors and before departing the site. These field values are used to apply shift adjustments to the recorded data, if applicable.

Monthly maintenance is also conducted to remove any marine fouling or debris from around the instrumentation. When any equipment is non-functional, it is repaired or replaced promptly in order to limit the amount of lost data. Any replacement equipment is calibrated and coated with anti-fouling paint as done during the initial setup at the site.

2.2 Habitat Mapping Photography, Vegetative Mapping and Analysis

Color Infrared Aerial Photography

Conditions of Certification Condition J.2.d. of the final order requires the acquisition and analysis of color infrared aerial photography of the Little Manatee River. The photography and analysis of the Little Manatee River is limited to the estuarine portion of the river between river miles 3 and 11. In particular, the wetland vegetation located with the 100-year floodplain within this portion of the river is of concern. Figure 2.1-1 depicts the approximate limits of the color infrared aerial photography and vegetative mapping.

The photography has a minimum scale of 1" = 1,000', with 60% forward overlap (to allow for stereoscopic viewing), and shall be georeferenced for scale with all previous and subsequent photography to the same references.

For digital mapping purposes, each 9" x 9" transparency frame was scanned at 600 dpi or better using a flatbed high quality scanner. Digital images were then georectified by image matching using U.S. Geological Survey digital ortho-rectified quarter quadrangles aerial photographs (USGS DOQQs) as the source of geodata. Image georectification was performed using ENVI remote sensing software to achieve a root mean square error (RMSE) of less than 1 meter for each georectified image. The resulting images will be archived as both individual frames in geotiff format, and as a digital mosaic image of the combined frames for the study area. Tonal balancing and enhancements to contrast were performed as-needed to improve the appearance and interpretability of the photomosaic. The digital mosaic was used in the subsequent vegetation mapping task based on visual interpretation combined with ground truthing of areas in the field.

The baseline photography was obtained in October 2004. The Photography evaluated in this report was obtained in November 2007.

Vegetation Mapping

The baseline habitat mapping (VHB, 2005) over the color infrared aerial photography imagery and the November 2007 photography were used to update the vegetation map. The *Florida Land Use, Cover and Forms Classification System* (FLUCFCS) (FDOT, 1999) habitat designation had been superimposed within the limits of the vegetative review area (i.e., the wetland vegetation within the 100-year floodplain of the Little Manatee River from river miles 3 to 11) during the baseline mapping effort.

VHB's biologist conducted a field-reconnaissance of the area of the Little Manatee River between river miles 3 and 11 to verify the species composition of major plant communities located along the river. Using the existing baseline mapping as a starting point, the high resolution infrared aerial photography was used to field-verify and refine existing habitat designations. Distinct communities of more discrete diagnostic plant assemblages were located and described along with any other conspicuous indicator species. Field data collection was conducted on December 19 and 20, 2007.

The refined habitat mapping from the field reconnaissance was then digitized into GIS in a system compatible with the District's GIS system. Subsequent to the field mapping effort, during the interpretive repot meeting with District staff, the District indicated the availability of historic mapping for the Little Manatee River. The original mapping was performed by the Florida Marine Research Institute (1997) and showed broad wetland habitat types. These habitat maps were further refined within a District Technical Report (2002) that documented the plant species composition at 72 shoreline sites. This report also mapped the habitats by dominant species, and/or with a species overlay, that served to refine the FLUCFCS habitats to level VI.

Using the field notes generated during the 2005 and 2007 field reconnaissance, VHB revised the habitat maps for these time periods. The baseline and 2007 updated habitat maps were refined to provide the dominant species information similar to the District's technical report (2002).

2.3 Salinity Trend Analyses

Statistical analyses of salinity were conducted using data from two continuously recording stage and water quality stations. The upstream station (referred to as I-75) is located just below the I-75 bridge at about river mile 7 (11.2 km) and the downstream station (referred to as US 41) is located near US 41 just below river mile 3 (4.8 km). The USGS gage which records stage (ft in NGVD) and flow (Q as cubic ft per sec (CFS)) is located at the US 301 bridge near river mile 15 (river km 24). Data considered in this report from the two water quality stations span three water years (WYs 2006-2008). Collection of new data is continuing in WY 2009. The salinity variates analyzed for this report included daily average and daily maximum salinity (expressed as parts per thousand (ppt)).

A combination of graphical analysis, multiple linear regression (MLR), and time series analysis methods were used to analyze data. The software Statistica version 6.0 was used to perform all statistical analyses and data manipulation.

Data available from the I-75 and US 41 monitoring sites spanned the period from October 1, 2005 through September 30, 2008. FPL provided data on the daily quantities of water that were withdrawn at the FPL Manatee Plant site, which is located between river miles 18 and 19. Data on flow in the Little Manatee River for USGS Station 02300500 near Wimauma (near river mile 15) were obtained directly from the USGS online. Salinity data at this site (specific conductance) extended only to 1982. However, the 1973-1982 salinity was reviewed and the site was confirmed to be a freshwater site with salinities always < 0.5 ppt during this period of record.

The continuous recorder data from the I-75 and US 41 sites collected at 15-min intervals was processed to obtain mean, maximum and minimum salinity values for each day. Data were missing for the I-75 station from May 10 until July 23, 2006, but data during this period were available for the US 41 station and regression equations were identified and developed to permit the estimation of mean and maximum daily salinity data for the I-75 site, as described in the August 2006 Emergency Diversion Salinity report (VHB, 2006). Similarly, flow data were missing for three dates in

June-July, 2006 and were estimated by time series methods using antecedent flow and rainfall data. No missing data were present in the period after July 23, 2006.

Multiple linear regression was used to model the relationships between station salinity statistics and one or more independent variables, to permit the prediction of salinity. These were used to assess the potential impact of the actual FPL withdrawals by comparing the observed and modeled daily salinity means and maxima for flow values with FPL withdrawals versus the salinity model predictions for flow values if no FPL withdrawals had occurred. In addition, model based predictions of the location of the 2 psu (practical salinity unit) isohalines were made for the withdrawal and no-withdrawal scenarios. This modeling was based on isohaline MLR models (coefficients and parameters) recently developed by Watson et al. (2008) for the District based on extensive synthesis and analysis of a large dataset collected by multiple agencies.

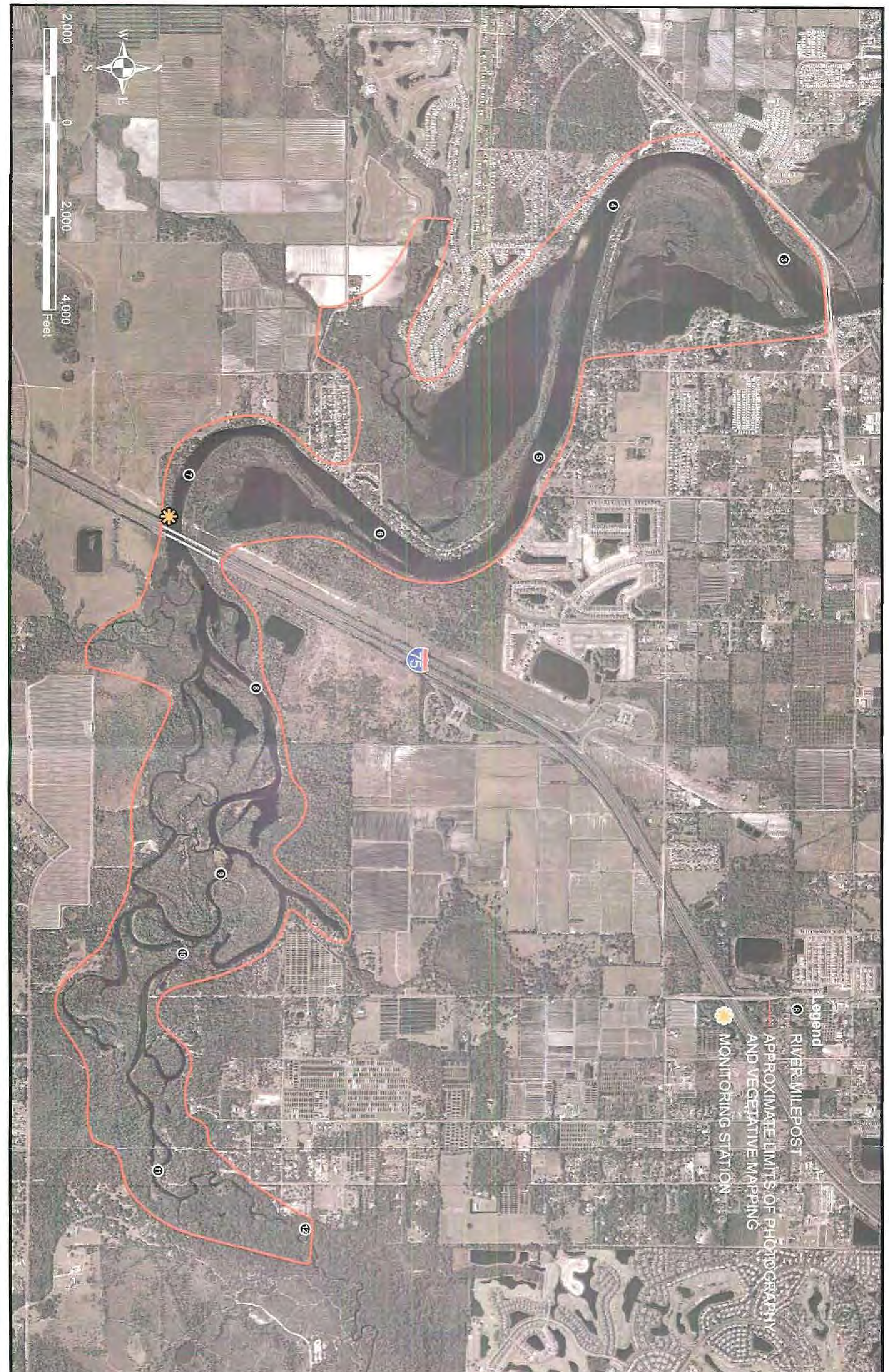
A table of the variables defined in the Statistica datafile was exported to excel format and is reproduced for reference (**Table 2.3-1**). Variables included date of collection, salinity means and maxima for each site, stage, flow (Q) at Wimauma, FPL withdrawals as daily CFS values, lag flows of up to three days, 3-day and 6-day prior moving averages (MAV3 and MAV6) of flow, and the natural logarithm transform of flow, its lags, and the moving average flow values.

Variables derived from statistical models included the daily predicted mean and maximum salinity values for each station, as well as the predicted daily location (in river km) of the 2 ppt isohaline.

MLR modeling explored all logical available potential independent values. Forward stepwise-regression was used. Variable selection was confirmed by examination of best-subsets regression. Nonsignificant variables did not explain a significant amount of total variance and thus were not retained in the final predictive models.

Table 2.3-1. Database variables used in salinity analyses.

Variable	Variable No.	Formula or Variable Description	Comment
Date	1	Date in VHB Database	
MeanSalinity_I75	2		
MaxSalinity_I75	3		
MeanSalinity_US41	4		
MaxSalinity_US41	5		
MO	6	Calendar Month	
DAY	7	Calendar Day of Month	
YR	8	Calendar Year	
USGSDate	9		
Q_Wimauma	10	Flow (CFS) near Wimauma	
Ln(Q)	11	=log(Q_Wimauma)	
fplwithdrawal_cfs	12	FPL daily withdrawal average in CFS	
lag1_MeanSalinity_I75	13		not used
lag1_Ln(Q)	14	lag1 of LN(Q)	
MeanSalinity_I75_1	15	lag 1 mean salinity I75	not used
MaxSalinity_I75_1	16	lag 1 max salinity I75	not used
MeanSalinity_US41_1	17	lag 1 mean salinity US41	not used
MaxSalinity_US41_1	18	lag 1 max salinity US41	not used
LN(Q)_2	19	lag2 of LN(Q)	
LN(Q)_3	20	lag3 of LN(Q)	
LN(Q)_MAV3	21	ln of 3 day prior moving average Q	
LN(Q)_MAV6	22	ln of 6 day prior moving average Q	
ISO_2_RKM	23	=25.306-3.187*V21	
Q_NOFPL	24	=V10+V12	Expected flow if no FPL withdrawal
Ln(Q_NOFPL)	25	=log(Q_NOFPL)	
lag1_lnQNOFPL	26	lag1 of Ln(Q_NOFPL)	
lag2_lnQNOFPL	27		
lag3_lnQNOFPL	28		
lag1_MaxSalinity_I75	29		not used
lag1_MeanSalinity_US41	30		not used
lag1_MaxSalinity_US41	31		not used
PredMaxI75_NoFPL	32	= -6.694*V48+2.485*V46+16.015	
PreMeanI75_NoFPL	33	= -5.4673*V48+2.1798*V46+9.31	
PredMaxUS41_NoFPL	34	= -3.841*V48+0.702*V47+32.749	
PredMeanUS41_NoFPL	35	= -5.948*V48+0.649*V47+35.469	
PredMaxI75_wFPL	36	= -6.694*V22+2.485*V46+16.015	
PredMeanI75_wFPL	37	= -5.4673*V22+2.1798*V46+9.31	
PredMaxUS41_wFPL	38	= -3.841*V22+0.702*V47+32.749	
PredMeanUS41_wFPL	39	= -5.948*V22+0.649*V47+35.469	
lnQ_NoFPL_MAV3	40	=log(Q_NOFPL); 3 pt.prior mov.aver.	
ISO_2_RKM_NOFPL	41	=25.306-3.187*V40	
FLOW_DIFF	42	=V24-V10	
PROPFLOW_DIVERTED	43	=V42/V24	
SCENARDIF_I75MEAN	44	=V37-V33	
SCENARDIF_I75MAX	45	=V36-V32	
MeanStage FT_I75	46	Mean Daily Stage at I75	
MeanStage FT_US41	47	Mean Daily Stage at US41	
lnQ_NoFPL_MAV6	48	log(Q_NOFPL); 6 pt.prior mov.aver.	



Date: 06/09 Revision:	Figure 2.1-1 Hydrobiological Monitoring Program Study Area Hillsborough County, Florida	*Vanasse Hangen Brustlin, Inc.* VHB 8043 Cooper Creek Blvd. Suite 201 University Park, Florida 34201

\\fl-pal\projects\65482.00\graphics\FIGURES\StudyAreaMap.pdf

3.0 Results

3.1 Withdrawals

Make-up water for the cooling pond associated with the FPL Manatee Plant is withdrawn from the surface waters of the Little Manatee River. The rate of surface water withdrawal from the river is derived from a diversion schedule.

3.1.1 Diversion Schedule History

The initial permit for withdrawals from the Little Manatee River the FPL Manatee Power Plant was granted on April 17, 1973. The permit and Plan of Diversion was amended on November 12, 1975. The permit authorizing the plant contained a diversion schedule (Exhibit B) for withdrawals from the Little Manatee River based upon river flow. A copy of the initial and amended diversion schedule is provided in Appendix A.

In association with the Manatee Plant Expansion Project permitting in 2004, the District and FPL agreed to a revised diversion schedule. Page 72 of the permit conditions (attached in Appendix A) provides a narrative description of the new diversion schedules. The diversion schedule was implemented beginning in October 2004 and is referred to as the regular diversion schedule (RDS). The regular diversion schedule is based upon the flow. However, during emergency conditions (when the level of the cooling pond falls below 62 feet mean sea level (msl)) withdrawals are based on the calculations shown in the Condition of Certification until the cooling pond exceeds 63 ft msl. The emergency diversion schedule (EDS) allows FPL to withdraw (depending upon river flows) up to 190 cubic feet per second (cfs) as long as the river flow is not reduced below 40 cfs. Table A-1 (Appendix A) provides the permitted diversion quantities under both the RDS and EDS based upon river stage/discharge at the plant. The stage/discharge relationship at the plant, and diversion curves, are updated annually.

Since implementation of the HBMP and RDS, FPL has converted to the EDS two times through WY 2008. The initial EDS withdrawals occurred between June 13 and July 27, 2006. Specifically, June 13-22, 26, 27 and July 3-27, 2006) (VHB, 2006). FPL implemented withdrawals according to the emergency diversion schedule a second time beginning June 14, 2007. Diversion according to the EDS spanned June 14, 2007 to July 28, 2008, and occurred from June 14 – October 31, January 20 – April 14, 2008, and June 12 – July 28, 2008 (VHB, 2008).

3.1.2 Period-of Record Withdrawals

Figure 3.1-1 depicts FPL's daily average (million gallons per day, mgd) withdrawals for each month in the Little Manatee River for the available period-of-record (December 1, 1976 to September 30, 2008). Additional river withdrawals may have occurred prior to December 1, 1976 because Flannery, et. al. (1991) note that "large non-metered withdrawals from the river by Florida Power and Light Corporation occurred during that year". There were also gaps in the District's withdrawal database for August to November 1995, January 1996, May 1997 and from July to November 1997.

Daily average withdrawals ranged from 55.0 to 0 mgd and averaged 6.1 mgd over the period-of-record. Under the initial diversion schedule, daily withdrawals had a mean of 6.3 mgd.

The mean and median daily average withdrawals for the period-of-record are shown in Figure 3.1.2. Peak withdrawals have generally occurred during the months of July, August and September.

3.1.3 Withdrawals under HBMP Monitoring Program

The HBMP Monitoring period began October 2004 and continued through the end of WY 2008. The implementation of river withdrawals pursuant to the regular diversion schedule began at the start of HBMP monitoring (October 2004).

Figure 3.1-3 depicts FPL's average daily withdrawals by month since conversion to the RDS and includes the two periods of withdrawal according to the EDS. Withdrawals under the RDS (including the two EDS periods) average 4.7 mgd per day and ranged from 33.8 to 0 mgd. The mean and median HBMP period withdrawals by month are shown in Figure 3.1-4.

Peak withdrawals occur during times of high river flow because the permitted withdrawal volume increases with increasing river flow volume. As expected, river flow is generally highest during the wet season (June – September).

3.2 Water Quality

Data downloads, calibration, and maintenance have been conducted monthly since station establishment. Table 3.2-1 provides a list of the dates of field calibration, maintenance and data downloads, along with associated comments since the last data report. The baseline and initial data reports provided the results from establishment through December 2006 and this report provides data subsequent to the initial data report through September 2008.

Since replacement of the originally installed Troll sondes with YSI sondes in 2006, data collection has been much more consistent. There was a stage calibration problem in March 2007, but otherwise no data collection issues were observed. There was some on-going maintenance items and some vandalism, but data collection occurred uninterrupted.

The daily value tables for US 41 and I-75 stations are provided in Appendices B and C, respectively.

The maximum, mean and minimum daily values for each parameter and site have been graphed for the period of record. The stage, temperature and salinity data for US 41 and I-75 are depicted on Figures 3.2-1 through 3.2-3 and 3.2-4 through 3.2-6, respectively.

The average daily mean salinity and the average daily salinity range are listed for each water year in Table 3.2-2. As expected, the average daily mean salinity at the US 41 site is higher than at the I-75 site. In most water years the daily mean salinity at US 41 average over 10 parts per thousand (ppt) more than at I-75. The observed daily range in salinity at the US 41 site was also consistently higher than at the I-75 site, but the daily range at both sites is substantial. The daily range is generally greatest at both sites when river flows is lower and mean average daily salinity is higher.

3.3 Habitat Mapping

3.3.1 Vegetative Mapping Results for 2007 Photography

The color infra-red aerial photography and mapping of vegetative communities in the Little Manatee River estuary with the 100-year flood plain between river mile 3 and river mile 11 was completed on December 20, 2007. False Color Infra-red aerial photography (November 2007) at a minimum scale of 1″ = 1,000′, with a 60% stereo overlap and geo-referenced for scale was utilized in conjunction with field reconnaissance of the river to identify the distribution of major plant communities such as mangroves, salt marshes, brackish marshes and freshwater aquatic and floodplain communities. Within these communities more discrete diagnostic plant assemblages were also located and described, when possible, to identify discreet or individual stands of species or mixtures of species such as red mangrove (*Rhizophora mangel*), black needlerush (*Juncus roemerianus*), sawgrass (*Cladium jamaicense*), cattails (*Typha* spp.), leather ferns (*Acrostichum* spp.), or other conspicuous indicator species. The field reconnaissance for the second mapping event was completed by December 20, 2007.

Results of the (2004) and subsequent habitat mapping efforts are provided in attached Figure 3.3-1 and Figure 3.3-2, respectively. Acreage values of each habitat type as determined during the 2007 habitat mapping efforts are:

Mangrove – 16.5 acres
Salt Marsh – leather fern – 267.8 acres
Salt Marsh – black needle rush – 263.8 acres
Freshwater marsh – cattail – 3.6 acres
Freshwater marsh – pennywort - 0.3 acres
Freshwater marsh – saw grass – 0.2 acres
Bottomland hardwoods – 254.0 acres

3.3.2 Comparison of Baseline and 2007 Mapping Results

Table 3.3.1 provides a summary of the baseline and 2007 vegetative mapping effort. Comparison of the results of the two habitat mapping efforts reveals that acreage values for the mapped habitats were unchanged with the exception of cattail, which increased in cover from 1.5 acres in 2004, to 3.6 acres in 2007, and increase in cover of 2.1 acres. This increase in cover was noted between river miles 8 and 10, and consisted of narrow bands of cattail (approximately 10 feet wide average) aligned along the river banks at the water's edge. The species composition and overall acreage remained unchanged for all areas previously mapped.

3.3.3 Vegetative Mapping Discussion

The vegetative composition and habitat community type remained constant over the nearly three-year period. None of the habitat areas mapped in March 2005 changed during the subsequent survey in December 2007. As such, these communities appear very stable and do not reflect any change in river salinity.

The only observed change was the addition of a narrow cattail strip along portions of the river in the upper third of the mapping area. This strip appears to represent the expansion of vegetation along the deep edge or a new strip of vegetation in formerly unvegetated areas.

Since there was no vegetative change, per se, the new strip of cattail does not appear to reflect any change in salinity. This new deeper vegetation fringe is believed to reflect the below average rainfall and lower river levels in this portion of the river. Lower river levels may have allowed cattail, which are opportunistic, to colonize previously unvegetated and possibly too deep areas. As normal rainfall and higher river stages return, it will be interesting to note if this cattail fringe persists.

3.4 Salinity Trend Analyses

In this section a summary of the observed salinity data and independent stream variables for each monitoring site, as well as the predicted values based on the statistically derived models, are presented. Data is first presented using the streamflow with FPL withdrawals reflected in the data. Since withdrawals are taken just upstream of the USGS gaging station near Wimauma, it was assumed that observations at the gage would reflect the effect of withdrawals by FPL. Based on the flows that would have been measured at the USGS station if no FPL withdrawals had taken place, additional model predictions are presented. To obtain this adjusted Q value, the FPL withdrawal was added to the USGS Q value for each daily record. Finally, the model predicted location of the 2 ppt isohaline is considered with and without FPL withdrawals and the results are discussed.

3.4.1 Observed Salinity Trends Based on Actual FPL Withdrawals

Basic Statistics for key variables over the WY 2006 – WY 2008 period are shown in Table 3.4-1. Observed mean daily salinity at I-75 and US 41 are graphed in Figure 3.4-1. Maximum observed salinities are shown in Figure 3.4-2. Graphical and statistical analyses revealed a strong inverse, non-linear relationship between streamflow and salinity for both sites, and the need to ln-transform Q to obtain a more linear relationship for use in MLR analyses. Models of salinity parameters based on observed Q values recorded at the USGS gage near Wimauma represent salinity and flow values in which the FPL withdrawal effects are included (actual FPL withdrawals).

3.4.2 Predicted Salinity Trends Based on Actual FPL Withdrawals

The final MLR models for mean salinity at I-75 and US 41 are shown in Tables 3.4-2 and 3.4-3. The natural logarithm of the 6 day prior moving average flow (Q_MAV6) was the most important predictor of mean salinity in both models (standardized regression coefficients (Betas) were approximately 0.93). Mean stage at the respective gage was also included in the model and was of positive sign (higher stages were associated with greater salinity values after adjusting for the effect of moving average flow on salinity). A summary of the best subsets regression for mean and maximum salinity at I-75 and US 41 is provided in Appendix D.

Multiple R values were relatively high (.89 and .91 for the I-75 and US 41 sites) and explained 78% and 82% percent of the total variation in salinity. Figure 3.4-3 and 3.4-4 show the observed and expected (modeled) mean salinity for I-75 and US 41, respectively. Other models were examined using best subsets regression (all site results appended). The models selected, which use a single variable to represent flow (LN(Q_MAV6), and one other variable (site stage), are believed best because they explain most of the variation that is possible to explain with the use of a more complex model with greater numbers of variables. The more complex models yield improbable signs of estimated coefficients (some lag Q terms are positive), and other indications of overfitting of the MLR model. Use of multiple lagged flow terms in particular may present multicollinearity problems.

The final MLR models for maximum salinity at I-75 and US 41 are shown in Tables 3.4-4 and 3.4-5. The natural logarithm of the 6 day prior moving average flow (ln (Q_MAV6) was the most important predictor of mean salinity in both maximum salinity models. Maximum stage at the respective gage was also included in the model and was of positive sign (higher stages were associated with greater salinity values after adjusting for the effect of moving average flow on salinity). A summary of the best subsets regression for mean and maximum salinity at I-75 and US 41 is provided in Appendix D.

Multiple R values for the maximum salinity models of .91 and .78 were obtained for the I-75 and US 41 sites, respectively, and explained 78% and 60% percent of the total variation in maximum salinity. Figure 3.4-5 and 3.4-6 show the observed and expected (modeled) maximum salinity for I-75 and US 41, respectively.

3.4.3 Predicted Salinity Trends for Baseline Conditions (No FPL Withdrawals)

Predictions of the salinity values for baseline conditions (defined as the flow conditions that would be expected if no withdrawals from the river by FPL had occurred) were made by substituting the expected baseline river flow values for each day in each MLR model equation described above. Daily total withdrawals by FPL were converted to a cubic ft per second (CFS) value and added to the USGS gage recorded flow value to obtain the baseline flow. The 6-day prior moving average baseline flow was then computed in Statictica (time series module) and ln-transformed. This variate was then input to the MLR model equations to predict the mean and maximum salinities at the I-75 and US 41 stations. Figures 3.4-7 through 3.4-10 show the model predicted mean and maximum salinity values at I-75 and US 41 with and without (baseline) water withdrawals by FPL. These graphs suggest that the expected salinity increases over baseline due to FPL withdrawals are relatively small and generally of short duration. For example, at I-75 the median difference in modeled mean daily salinity for those days in which FPL withdrew water (n=239 days) was 0.80 ppt, with a maximum of 2.38 ppt. For maximum modeled salinity, the median difference was 1.03 ppt, with a maximum of 3.05 ppt.

3.4.4 Predicted 2 PPT Isohaline Based on Actual FPL Withdrawals

The locations or the 2 psu (practical salinity unit) isohaline were predicted for each day under the withdrawal and no-withdrawal scenarios. This modeling was based on isohaline MLR models (coefficients and parameters) recently developed by Watson et al., for the District.

The predictive equation for the 2 psu isohaline is given by:

Position of the 2 psu isohaline (in river km) = 25.306 - 3.187*LN(MAV3(Q))
where LN(MAV3(Q)) is the natural logarithm of the three day prior moving average of flow(Q) reported for the USGS gage site near Wimauma, and 25.306 is the intercept.

Figure 3.4-11 shows the location of the 2 psu isohaline for the study period.

3.4.5 Predicted 2 PSU Isohaline for Baseline Conditions (No FPL Withdrawals)

The location of the 2 psu isohaline if no FPL withdrawals had occurred was predicted by using the expected baseline flow value (explained previously). The predicted values are graphed in Figure 3.4-12 along with the estimated 2 PSU isohaline locations associated with the FPL withdrawals (actual observed flows) for comparison. The difference in the isohaline location attributable to FPL withdrawals reached maximum values of about 0.8 km in 2006, 1.6 in 2007, and 1.5 in 2008 (Figure 3.4-13).

3.4.6 Scatter Plots

Scatter plots of salinity versus flow at the I-75 site are provided in Appendix E. The observed mean and maximum salinity at I-75 were plotted against the discharge at the Wimauma gage and the maximum salinity was plotted against the ln-transformed discharge at the Wimauma gage. Inspection of the data indicates that flows above 600 CFS result in fresh water conditions (<2 ppt salinity) at I-75.

Summary of stepwise regression for mean and maximum salinity at I-75 and US 41 are provided as output tables in Appendix E. The output table shows that for mean salinity at I-75 the mean stage is entered before maximum stage in the model, and that the change in explained variation is about 72.6% for the streamflow variable at Step 1, 5% with mean stage at Step 2, and just 0.2% at Step 3 for maximum stage. Redundancy analysis indicated a problem due to the association between mean and maximum stage, therefore maximum stage was not retained in the final model and there was little loss of explanatory power as a result.

The output table shows that for maximum salinity at I-75 the maximum stage is entered before mean stage in the model, and that the change in explained variation is about 68% for the streamflow variable at Step 1, 9.9% with max. stage at Step 2, and just 0.8% at Step 3 for addition of mean stage. Again, redundancy analysis indicated a problem due to the association between mean and maximum stage, therefore mean stage was not retained in the final model and there was little loss of explanatory power as a result.

The output table for mean and maximum salinity at the US 41 station were not as clear. For mean salinity, the maximum stage is entered before mean stage in the model, and that the change in explained variation is about 81% for the streamflow variable at Step 1, 1.6% with max. stage at Step 2, and just 0.4% at Step 3 for addition of mean stage. For maximum salinity at US 41, the maximum stage and mean stage were essentially the same, with the change in explained variation is about 55% for the streamflow variable at Step 1, 5.0% with max. stage at Step 2, and just 5.3% at Step 3 for addition of mean stage.

Partial regression residual scatter plots are designed to show the relationship between two parameters, after the variable effects of all other predictors have been removed (i.e. are held constant). Included in Appendix E are scatter plots with fitted regression lines and 95% confidence intervals for the predicted and observed mean and maximum salinity at I-74 and US 41. Partial residual plots in which the effects of mean stage on salinity are removed, showing the relationship between transformed streamflow and the model residuals is provided for both sites in Appendix E. Also provided in Appendix E are partial residual plots in which the effects of streamflow are removed, showing the relationship between mean stage and the model residuals. The same partial residual plots were prepared for maximum stage.

3.4.7 Salinity Trend Analysis Discussion

Mean and maximum salinity recorded at the fixed location stations at I-75 and US 41 were successfully modeled as a function of river flow and stage, with flow being primary factor governing salinity. Mean salinity was relatively well fit for both stations by the MLR predictive equations, with multiple R values were relatively high (.89 and .91 for the I-75 and US 41 sites), and explained 78% and 82% percent of the total variation in salinity. Maximum salinity was also modeled yielding multiple R values of .91 and .78 for the I-75 and US 41 sites, and explained 78% and 60% percent of the total variation in maximum salinity.

Graphical comparison of the model predicted salinities with and without the FPL withdrawals suggests that the change in salinities associated with the reduced flows are relatively minor and short-lived, reflecting the permit withdrawal conditions and the tendency to make larger withdrawals when river flow is at relatively high values and salinities are lower.

At I-75 the median difference in modeled mean daily salinity for those days in which FPL withdrew water (n=239 days) was 0.80 ppt, with a maximum of 2.38 ppt. For maximum modeled salinity, the median difference was 1.03 ppt, with a maximum of 3.05 ppt.

The difference in the modeled 2 psu isohaline location attributable to FPL withdrawals reached maximum values of about 0.8 km in 2006, 1.6 in 2007, and 1.5 in 2008. However the median differences were 0.38, 0.52, and 0.27 km for these years. Inspection of the predicted locations of the isohalines over time suggests the impacts would be relatively minor and short-lived. The 2 psu isohaline locations were predicted for the antecedent 32-year period from October 1973 - September 2005 for which USGS flow data are available for the Little Manatee River, using the equation given in Section 3.4.4. The 2 psu isohaline locations observed during the study withdrawal periods are well within the natural range of this isohaline during the prior 32 years.

3.5 Ecological Evaluation of Lower River Relative to FPL Withdrawals

The Little Manatee River is a tributary to the Tampa Bay estuary. An estuary is an area where fresh water mix and are characterized by salinity gradients. The lower portion of the Little Manatee River is also estuarine in nature and has pronounced salinity gradients from the mouth up to approximately river mile 11. The flora and fauna present within this portion of the river tend to become established at various locations based upon their preferred salinity or salinity range tolerance. The volume of fresh water is a primary factor affecting water quality and salinity in a tidal river (Clewell et al., 2002). Significant changes in the salinity of the river can result in a shift of the flora and fauna in response to the change in the salinity gradient.

The District requires FPL to conduct the HBMP to assess the effect, if any, of their river withdrawals. Should FPL's withdrawals be ecologically significant, then a dramatic and/or persistent shift in the salinity regime would observed. This would be reflected by the abundance and distribution of plant communities, with species preferring fresh water or low salinity conditions being displaced with species more tolerable of higher salinity levels.

The mean daily withdrawals over the past four waters years (4.7 mgd) under the HBMP is approximately 75% of that observed prior to the HBMP (6.3 mgd). The implementation of the regular diversion schedule is at least partly responsible for this difference. The observed maximum mean daily withdrawal for a month under the HBMP time period (33.8 mgd) is also less than the pre-HBMP period (55.0 mgd).

This reduction in withdrawal was anticipated with the change from the initial diversion schedule to the RDS.

The results of the vegetation mapping indicate no change. The vegetation community size and location and the species composition of those communities did not change between the two analysis periods. Some new areas of cattail appeared between river miles 8 and 10 within previously unvegetated areas. The District's Technical Report titled *An Analysis of Vegetation-Salinity Relationships in Seven Tidal Rivers on the Coast of West-Central Florida* indicates that southern cattail (*Typha domingensis*) is common "along riverbanks in freshwater and oligohaline zones". This species is also known to colonize disturbed sites and was theorized to reflect current salinity conditions rather than long-term salinity regimes. The presence of cattail in the upper portion of the Little Manatee River estuary is appropriate since low salinities should occur here and this species is characteristic of freshwater to low salinity conditions. As stated earlier, this new fringe of cattail may reflect its colonization of newly suitable bottom areas from the lower water levels associated with reduced rainfall.

The salinity trend analyses and comparison of the predicted 2 ppt isohaline location under withdrawal and no withdrawal scenarios show that FPLs withdrawals are likely resulting in changes to the salinity in the river. Importantly, however, is that these changes in salinity are relatively minor and are short-lived. The largest predicted changes are associated with the larger withdrawals which are also associated with higher river discharges. When viewed on a wider scale the predicted changes in the 2 ppt isohaline are well within the typical salinity fluctuation in the river in about the middle of the typical range. It also is pertinent that the salinity level ranges widely on a daily basis. Since the predicted changes are small, short in duration, occur duration about the mid salinity range, and are within a typical daily fluctuation range, they do not appear to be significant. It should also be noted that historic Little Manatee River stream flow has been supplemented (particularly during April and May) from agricultural irrigation runoff (Flannery et al., 1991).

The flora and fauna within the estuary are usually tolerant of fairly wide and rapid changes in salinity from tides and large storm flow events. As such, changes in salinity would need to be persistent and/or large to displace the established communities. As documented herein, the predicted changes have not been persistent or intense and the vegetative communities show no change since the start of the HBMP. Under the HBMP the RDS also allows less water to be withdrawn than under the pre-HBMP diversion schedule. The RDS would be expected to result in smaller magnitude changes in the predicted 2 ppt isohaline and a more natural fluctuation of the salinity gradient.

In summary, the predicted changes in salinity associated with FPL withdrawals have been small and occur over a short time period. The predicted changes are also well within the normal salinity fluctuation in the river and are not expected to adversely impact the flora or fauna. The lack of change to the vegetation communities supports the conclusion of no adverse impact to the Little Manatee River estuary.

Table 3.2-1. Dates of Field Calibration, Maintenance and Data Download

Date	Comments
January 10, 2007	No problems
February 5, 2007	No problems
March 2, 2007	Depth would not recalibrate.
March 6, 2007	Depth properly recalibrated.
April 2, 2007	No problems
May 3, 2007	No problems
June 8, 2007	No problems
June 28, 2007	No problems
July 25, 2007	Dock temporarily removed, oysters cleaned from inside stilling well.
September 4, 2007	No problems
October 1, 2007	I-75: access box damaged, lock removed, no noticeable damage to device.
October 2, 2007	I-75: new lock installed.
October 29, 2007	No problems
December 3, 2007	No problems
January 17, 2008	No problems
February 1, 2008	No problems
March 7, 2008	No problems
April 4, 2008	No problems
May 8, 2008	No problems
June 11, 2008	Seal on back cap of US-41 sonde broke during cleaning. Replaced.
July 23, 2008	No problems
July 30, 2008	No problems
September 4, 2008	No problems

Table 3.2-2. Average Daily Mean Salinity and Average Daily Salinity Range by Water Year at I-75 and US 41 Sites

	Average Daily Mean Salinity		Average Daily Salinity Range	
Water Year	US 41	I-75	US 41	I-75
2005*	13.67	2.19	8.49	4.28
2006*	16.64	3.43	11.50	6.44
2007	18.06	7.40	12.32	8.93
2008	15.86	6.24	16.61	7.40

* Water Years 2005 and 2006 are missing data for at least part of the year.

Table 3.3-1. Habitat Acreages Documented during the March 2005 and December 2007 Mapping Events

Habitat Type	Habitat Code	Dominant Species	2004	2007	Differences
Mangrove	612		16.5	16.5	0.0
Saltmarsh	642	Leather fern (*Arcostichum*)	267.8	267.8	0.0
Saltmarsh	642	Black needlerush (*Juncus*)	263.8	263.8	0.0
Freshwater marsh	641	Cattail (*Typha*)	1.5	3.6	2.1
Freshwater marsh	641	Pennywort (*Hydrocotyle*)	0.3	0.3	0.0
Freshwater marsh	641	Sawgrass (*Cladium*)	0.2	0.2	0.0
Bottomland Hardwoods	615		254.0	254.0	0.0

Table 3.4-1. Basic Statistics for key variables recorded in the WY 2006 - WY 2008 period.

Variable	Valid N	Mean	Median	Mode	Minimum	Maximum	Percentile 10	Percentile 90	Range	Std.Dev.
MeanSalinity_I75	1096	7.003	6.420	.1800000	0.100	22.325	0.280	14.900	22.225	5.484
MaxSalinity_I75	1096	11.459	11.455	.2100000	0.000	29.800	0.480	21.020	29.800	6.992
MeanSalinity_US41	1044	16.867	17.691	19.11000	1.100	29.307	7.420	24.520	28.207	6.247
MaxSalinity_US41	1044	23.570	24.630	21.80000	4.470	32.240	16.970	28.750	27.770	4.748
Q_Wimauma	1092	105.358	60.000	35.00000	6.400	1470.000	17.000	242.000	1463.600	146.515
Ln(Q)	1092	4.133	4.094	3.555348	1.856	7.293	2.833	5.489	5.437	0.972
LN(Q)_MAV3	1094	4.155	4.116	2.639057	1.877	7.180	2.890	5.557	5.303	0.958
LN(Q)_MAV6	1091	4.186	4.154	2.650892	1.951	7.024	2.953	5.575	5.073	0.938
ISO_2_RKM	1094	12.064	12.187	16.89532	2.422	19.324	7.596	16.094	16.902	3.054
MeanStage FT_I75	1021	-0.150	-0.120	.0100000	-1.780	1.480	-0.660	0.320	3.260	0.394
MeanStage FT_US41	1031	-0.221	-0.230	-.060000	-1.640	3.700	-0.810	0.310	5.340	0.527
MaxStage FT_I75	1021	0.873	0.890	.8900000	-0.750	2.470	0.330	1.420	3.220	0.444
MaxStage FT_US41	1031	0.770	0.780	.9800000	-1.040	5.670	0.120	1.390	6.710	0.575

Table 3.4-2. Multiple Linear Regression Summary for Mean Salinity I-75.

Dependent Variable: MeanSalinity_I75
$R= .88311672$ $R^2= .77989515$ Adjusted $R^2= .77946059$
$F(2,1013)=1794.7$ $p<0.0000$ Std.Error of estimate: 2.3827

N=1016	Beta	Std.Err. of Beta	B	Std.Err. of B	t(1013)	p-level
Intercept			29.36688	0.387459	75.7935	0.00
LN(Q)_MAV6	-0.924593	0.015443	-5.26977	0.088021	-59.8698	0.00
MeanStage FT_I75	0.242948	0.015443	3.12799	0.198836	15.7315	0.00

Table 3.4-3. Multiple Linear Regression Summary for Mean Salinity US 41.

N=974	Dependent Variable: MeanSalinity_US41 R= .90561755 R^2= .82014314 Adjusted R^2= .81977269 F(2,971)=2213.9 p<0.0000 Std.Error of estimate: 2.6602					
	Beta	Std.Err. of Beta	B	Std.Err. of B	t(971)	p-level
Intercept			41.76591	0.385111	108.4516	0.000000
LN(Q)_MAV6	-0.912463	0.013733	-5.89448	0.088717	-66.4413	0.000000
MeanStage FT_US41	0.072480	0.013733	0.85752	0.162481	5.2776	0.000000

Table 3.4-4. Multiple Linear Regression Summary for Maximum Salinity I-75.

N=1016	Dependent Variable: MaxSalinity_I75 R= .88432798 R^2= .78203597 Adjusted R^2= .78160564 F(2,1013)=1817.3 p<0.0000 Std.Error of estimate: 3.1601					
	Beta	Std.Err. of Beta	B	Std.Err. of B	t(1013)	p-level
Intercept			35.33253	0.489896	72.1225	0.00
LN(Q)_MAV6	-0.890694	0.014972	-6.76578	0.113732	-59.4887	0.00
MaxStage FT_I75	0.322011	0.014972	4.90012	0.227841	21.5068	0.00

Table 3.4-5. Multiple Linear Regression Summary for Maximum Salinity US 41.

N=974	Dependent Variable: MaxSalinity_US41 R= .77757325 R^2= .60462015 Adjusted R^2= .60380578 F(2,971)=742.43 p<0.0000 Std.Error of estimate: 3.0447					
	Beta	Std.Err. of Beta	B	Std.Err. of B	t(971)	p-level
Intercept			37.71342	0.447826	84.2144	0.000000
LN(Q)_MAV6	-0.748828	0.020182	-3.73426	0.100643	-37.1038	0.000000
MaxStage FT_US41	0.222896	0.020182	1.87379	0.169661	11.0443	0.000000

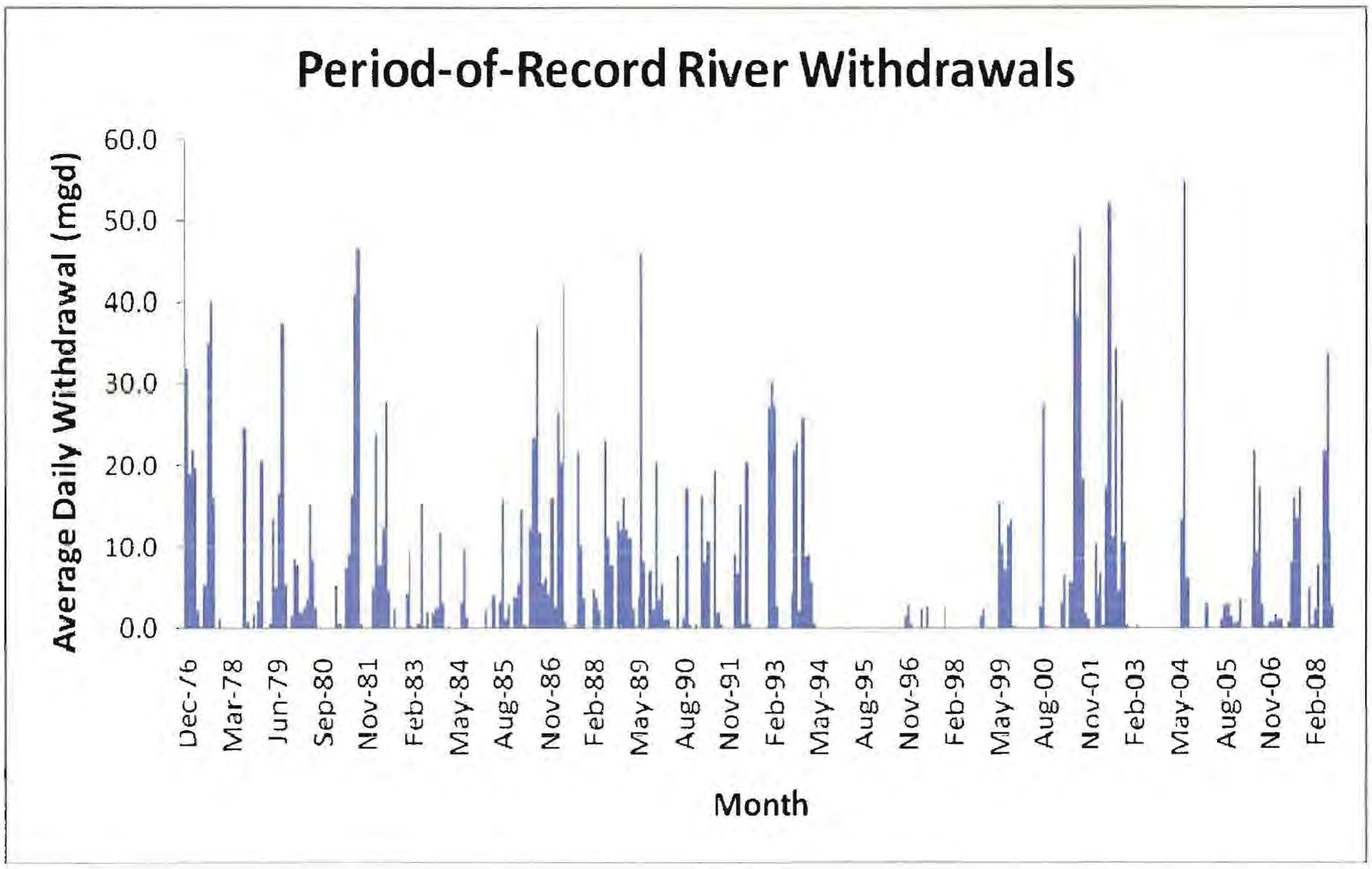


Figure 3.1-1 Average Daily Withdrawals (mgd) from the Little Manatee River for the Period-of-Record (December 1976 – October 2008)

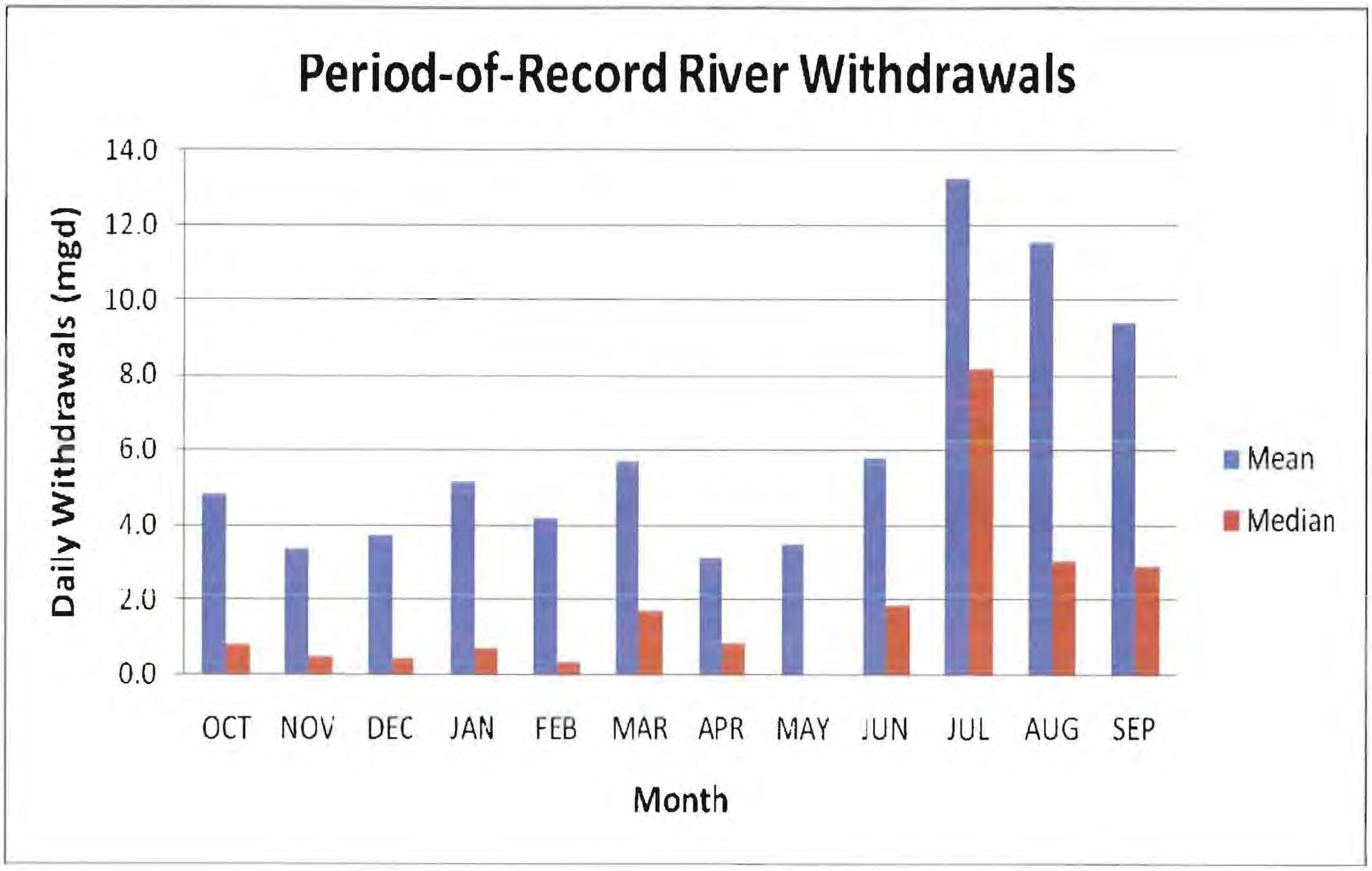


Figure 3.1-2 Mean and Median Average Daily Withdrawals from the Little Manatee River by Month for the Period-of-Record

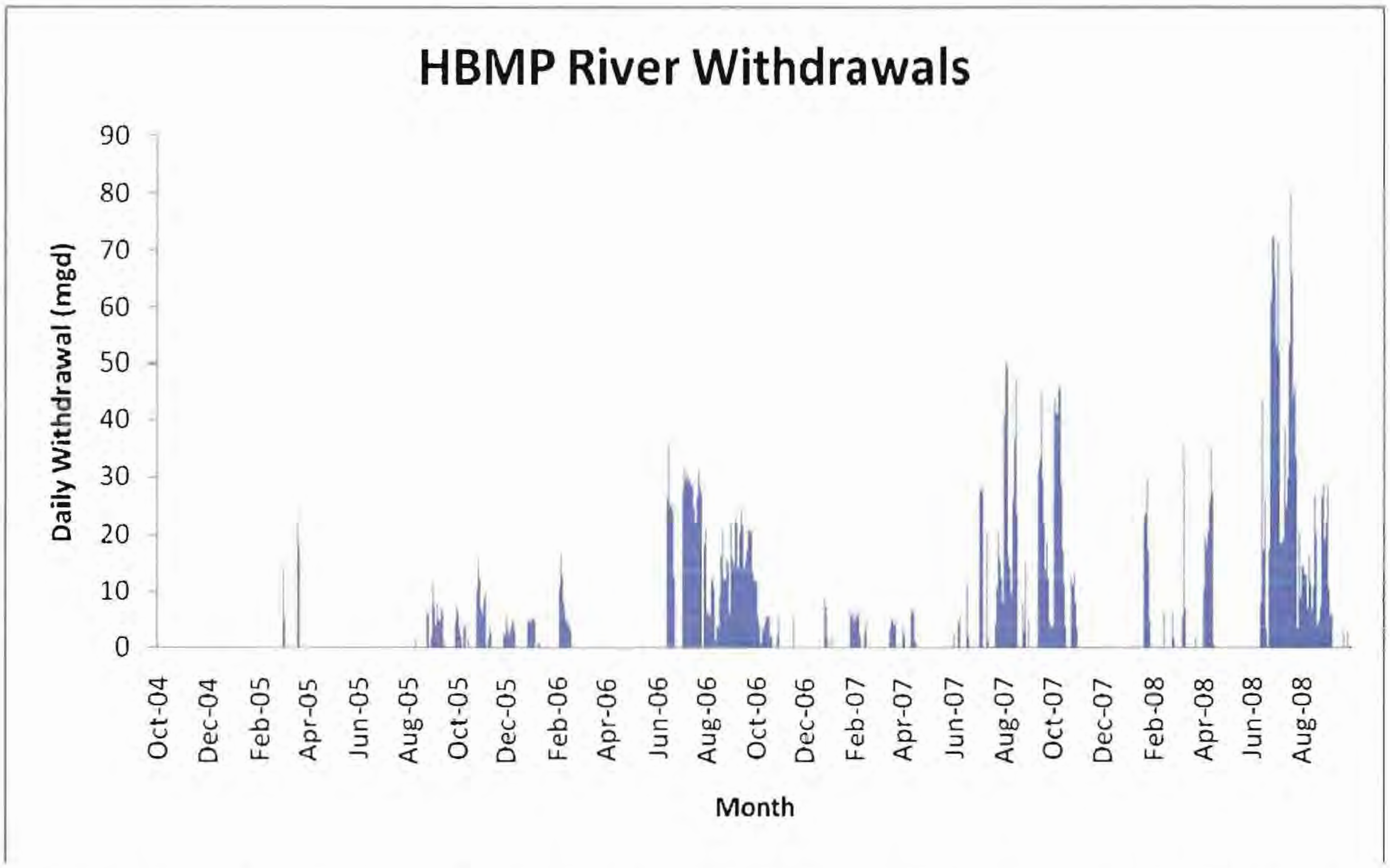


Figure 3.1-3 Daily Withdrawals (mgd) from the Little Manatee River during the Hydrobiological Monitoring Program (WY 2005 to WY 2008)

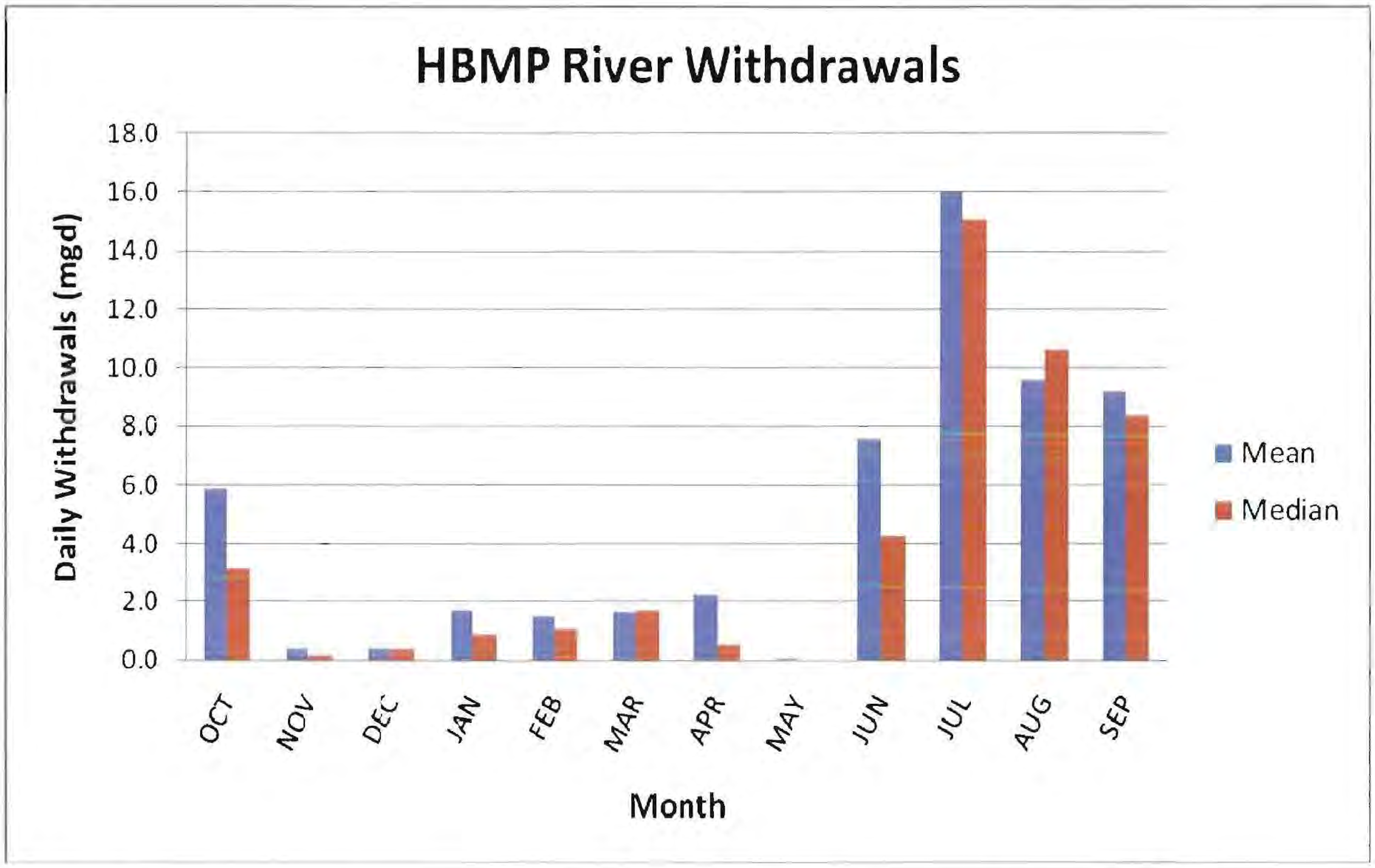


Figure 3.1-4 Mean and Median Average Daily Withdrawals from the Little Manatee River by Month during the Hydrobiological Monitoring Program

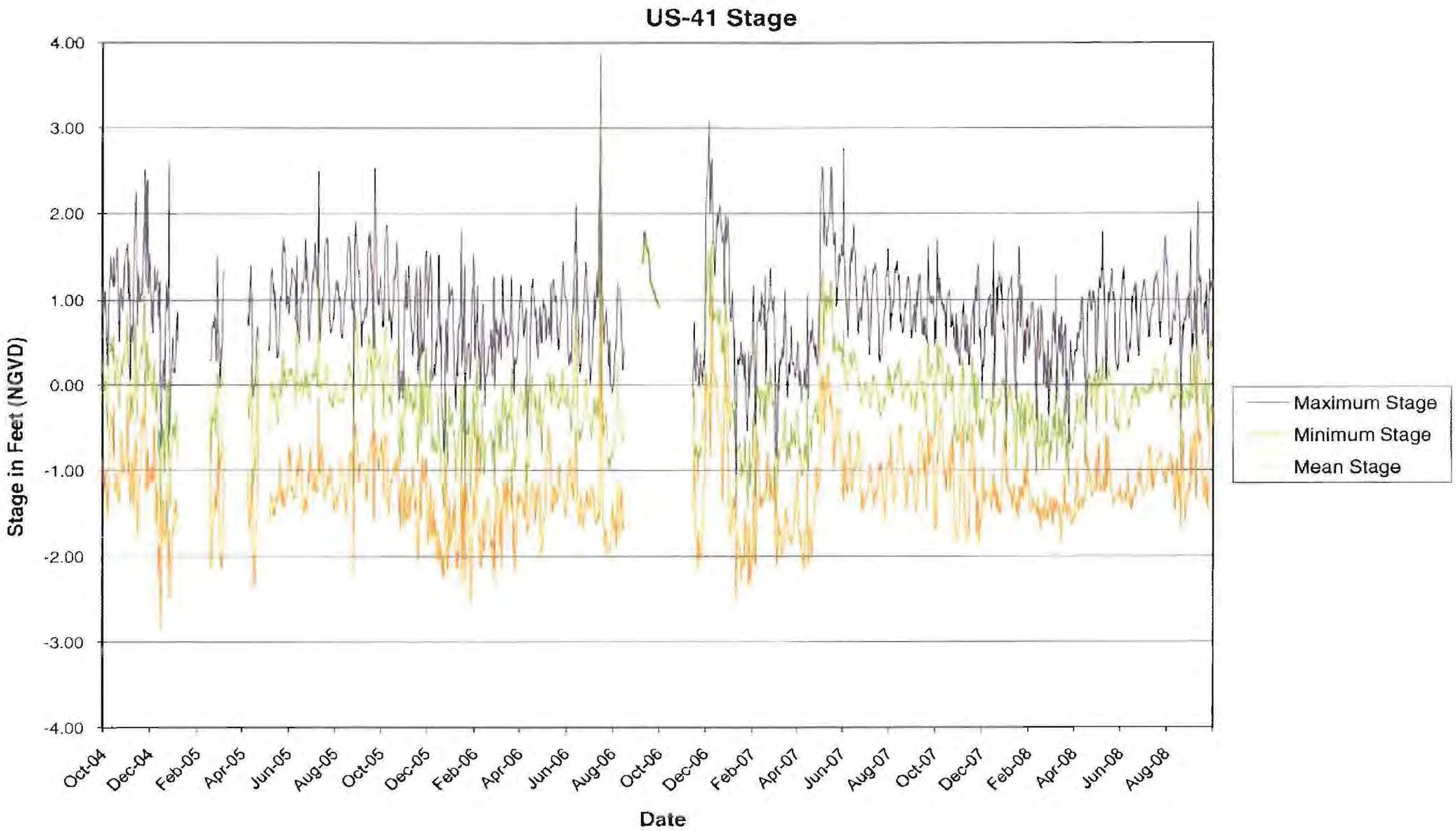


Figure 3.2-1 Maximum, Minimum and Mean Stage for the Period-of-Record for the US 41 Gage

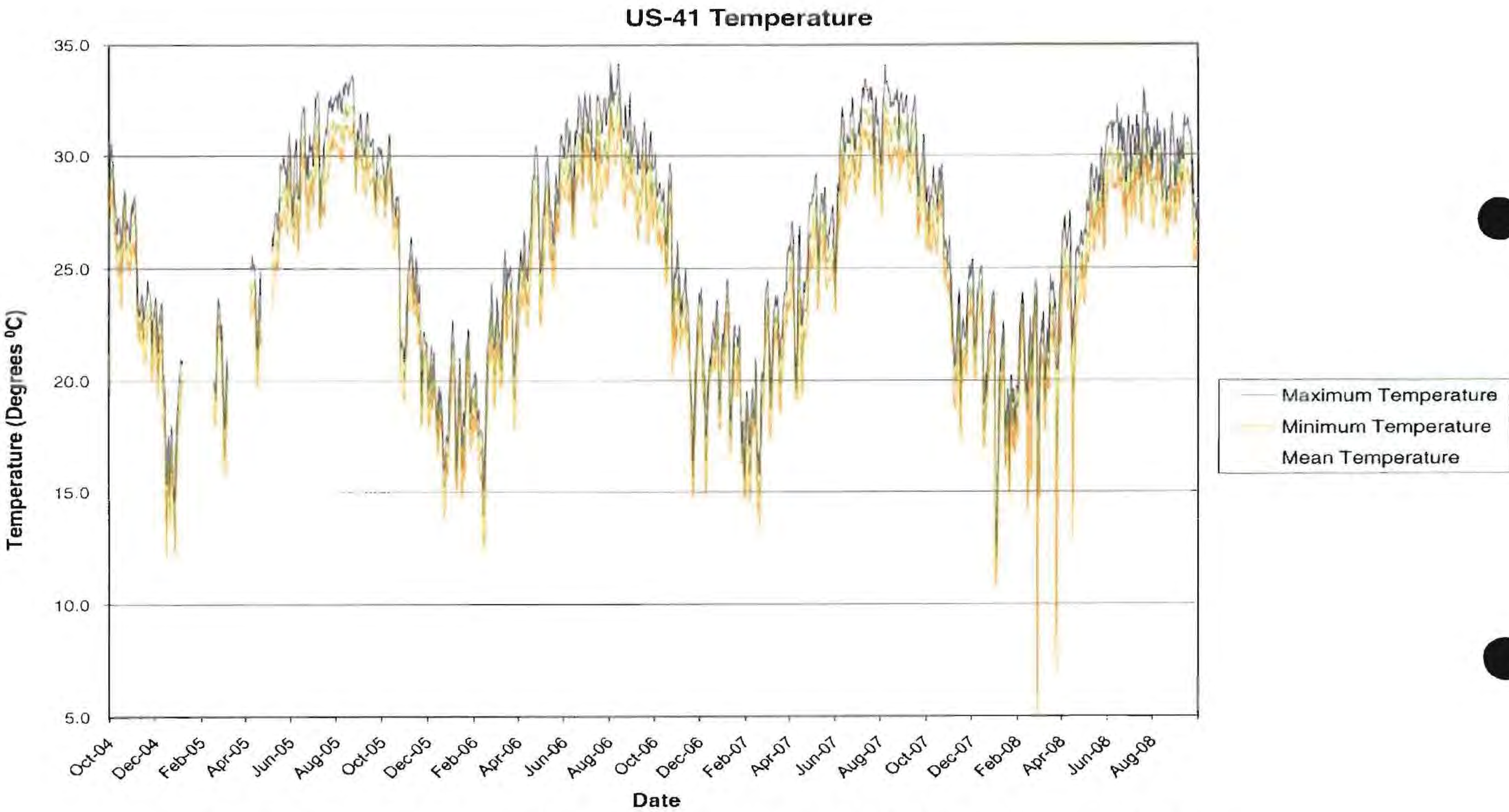


Figure 3.2-2 Maximum, Minimum and Mean Temperature for the Period-of-Record for the US 41 Gage

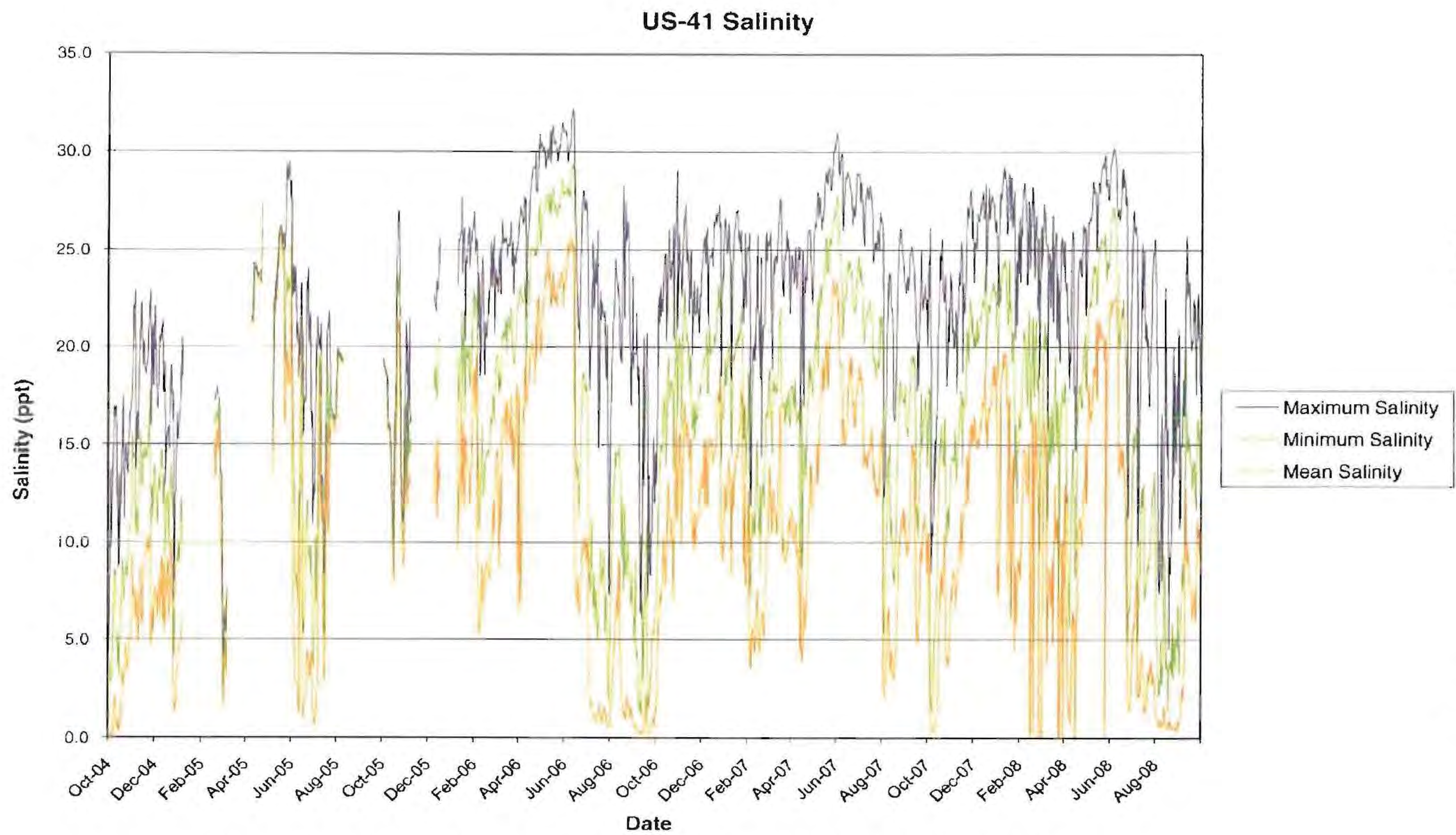


Figure 3.2-3 Maximum, Minimum and Mean Salinity for the Period-of-Record for the US 41 Gage

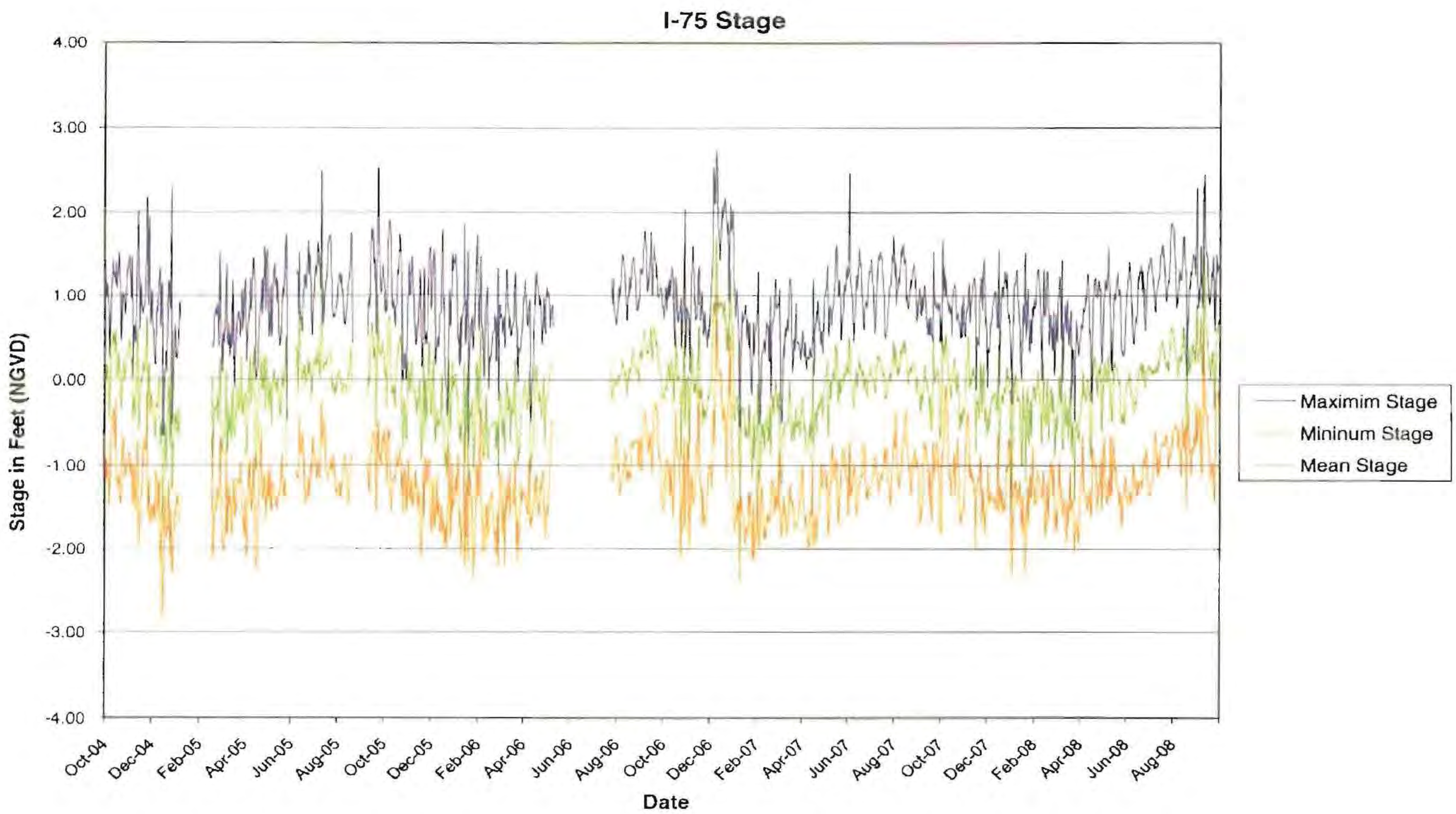


Figure 3.2-4 Maximum, Minimum and Mean Stage for the Period-of-Record for the I-75 Gage

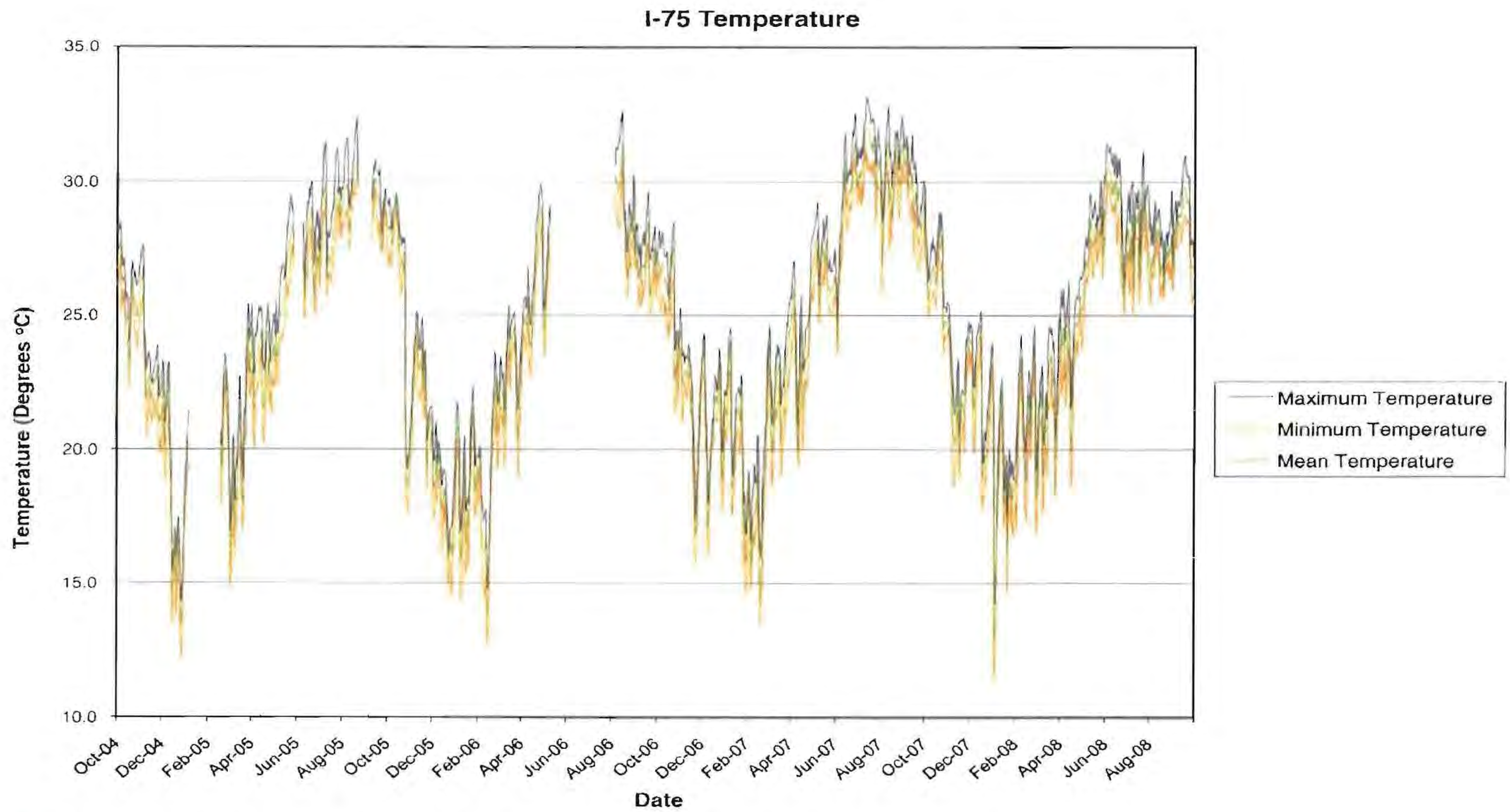


Figure 3.2-5 Maximum, Minimum and Mean Temperature for the Period-of-Record for the I-75 Gage

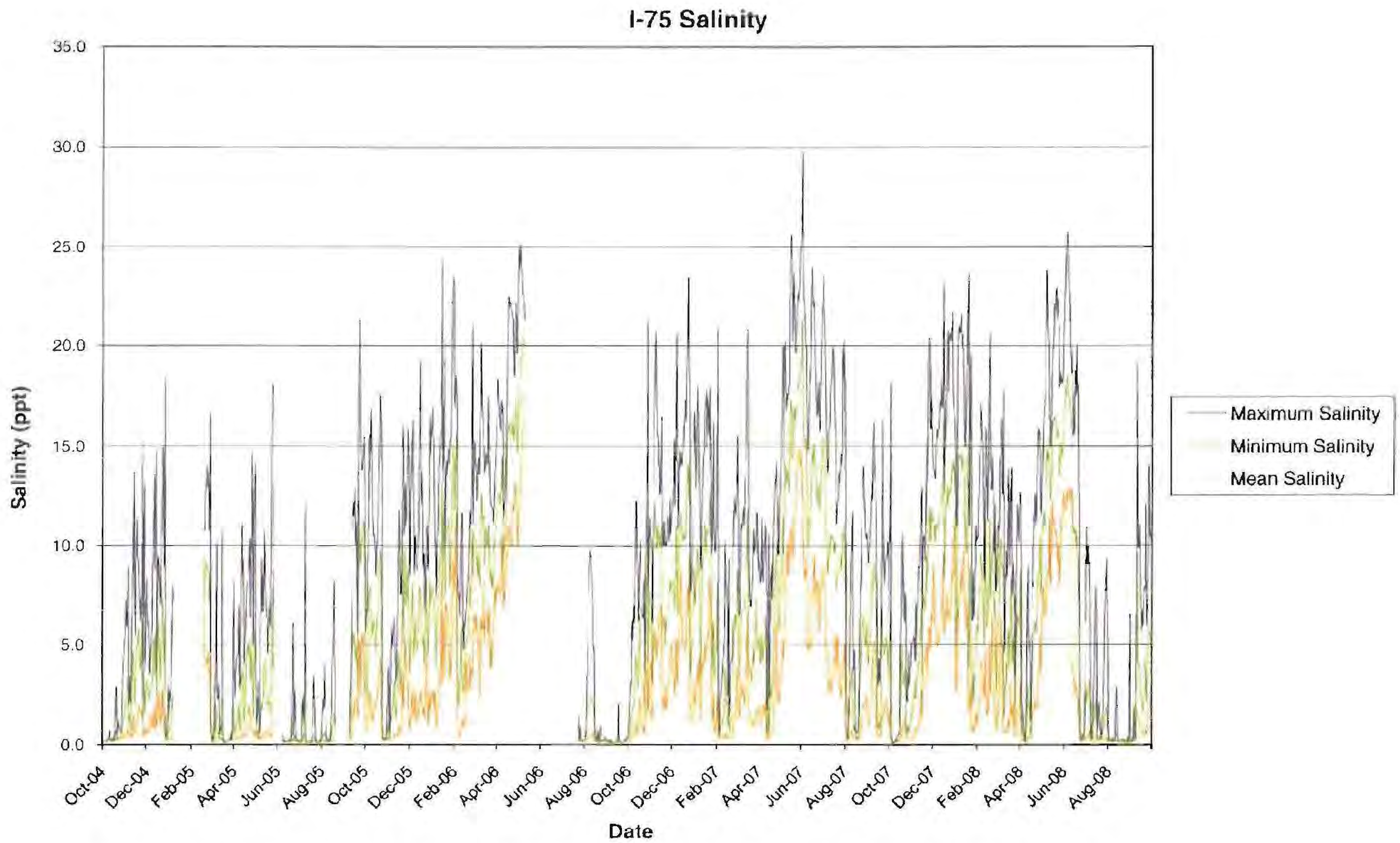
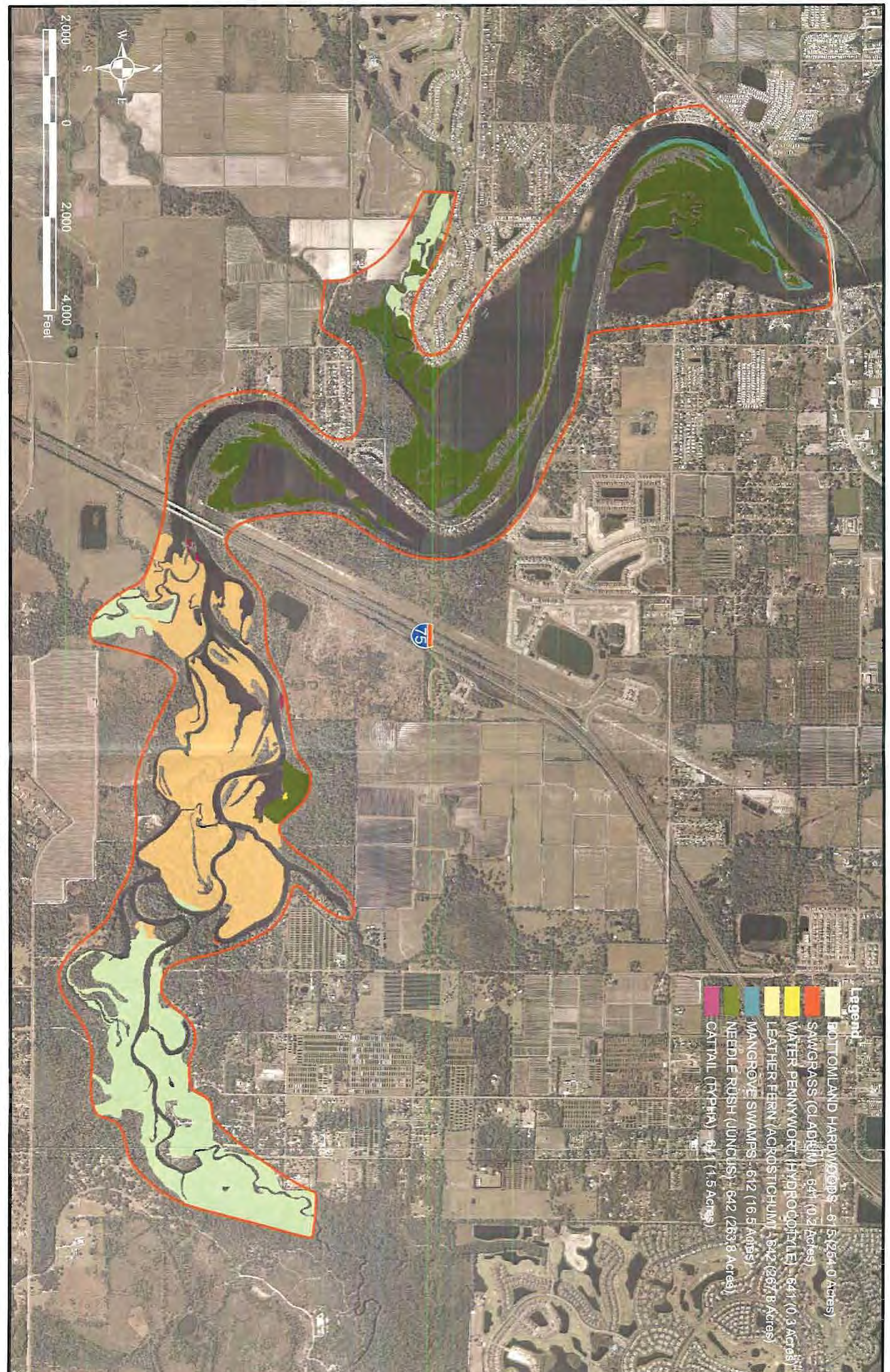
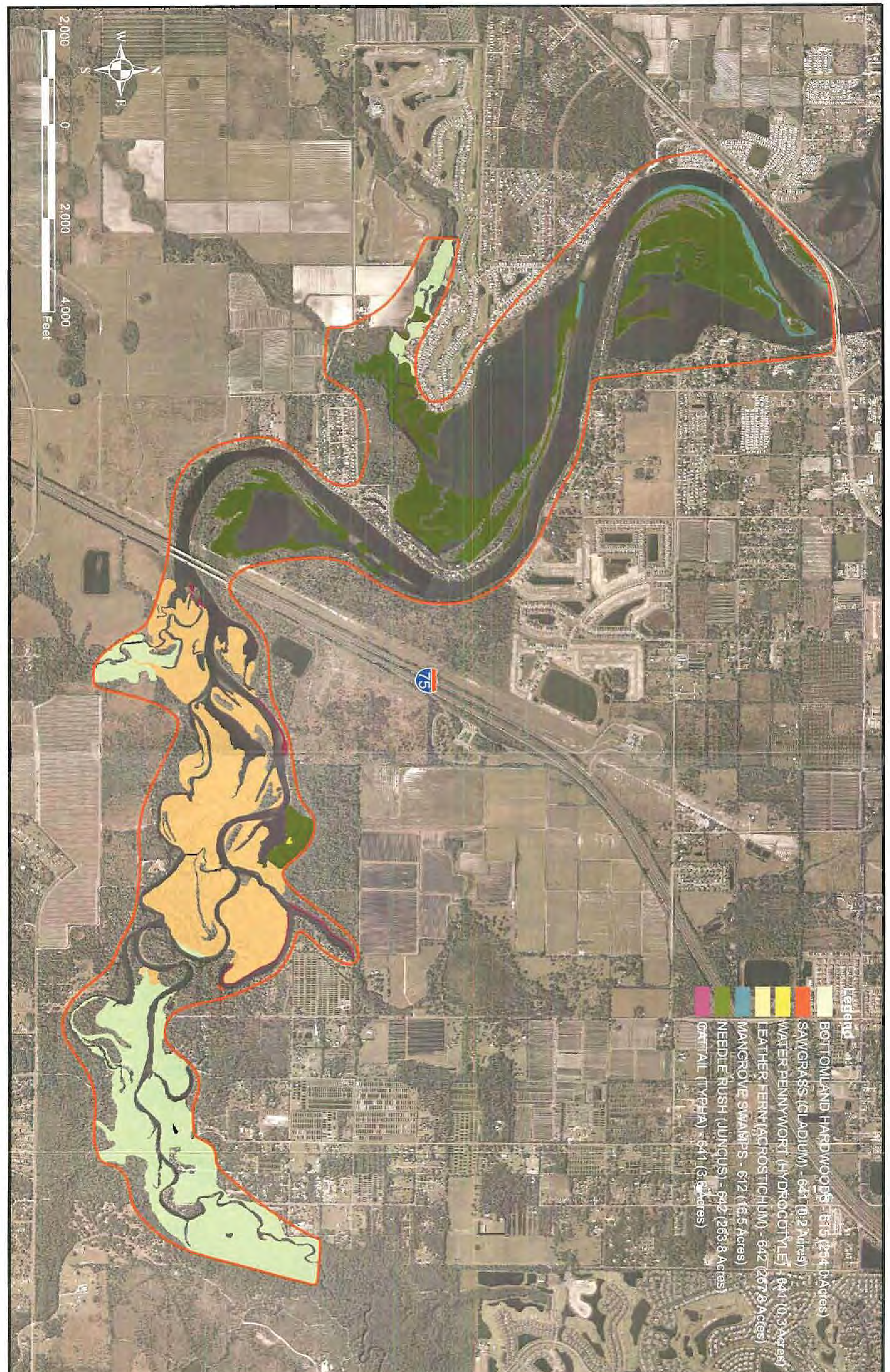


Figure 3.2-6 Maximum, Minimum and Mean Salinity for the Period-of-Record for the I-75 Gage



Date: 06/09 Revision:	Figure 3.3-1 Habitat Map of the Little Manatee River, 2004 Hillsborough County, Florida	*Vanasse Hangen Brustlin, Inc.* 8043 Cooper Creek Blvd. Suite 201 University Park, FL 34201

\\fl-pal\projects\65482\gis\project\2004 Map.mxd



Date: 06/09 Revision:	Figure 3.3-2 Habitat Map of the Little Manatee River, 2007 Hillsborough County, Florida	*Vanasse Hangen Brustlin, Inc.* VHB 8043 Cooper Creek Blvd. Suite 201 University Park, FL 34201

\\fl-pal\projects\65482\gis\project\2007 Map.mxd

Figure 3.4-1. Observed daily mean salinity values for I-75 and US 41 stations.

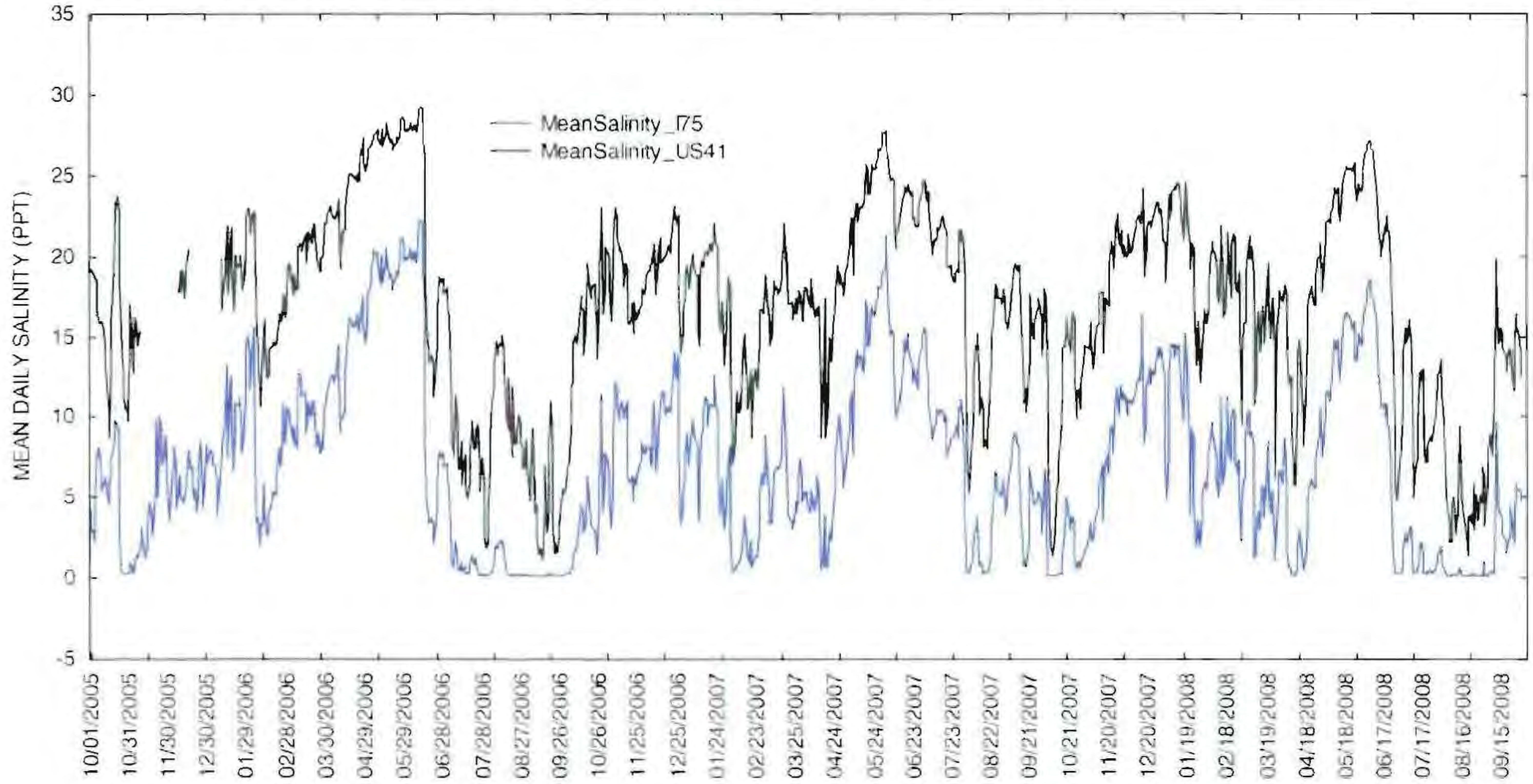


Figure 3.4-2. Observed daily maximum salinity values for I-75 and US 41 stations.

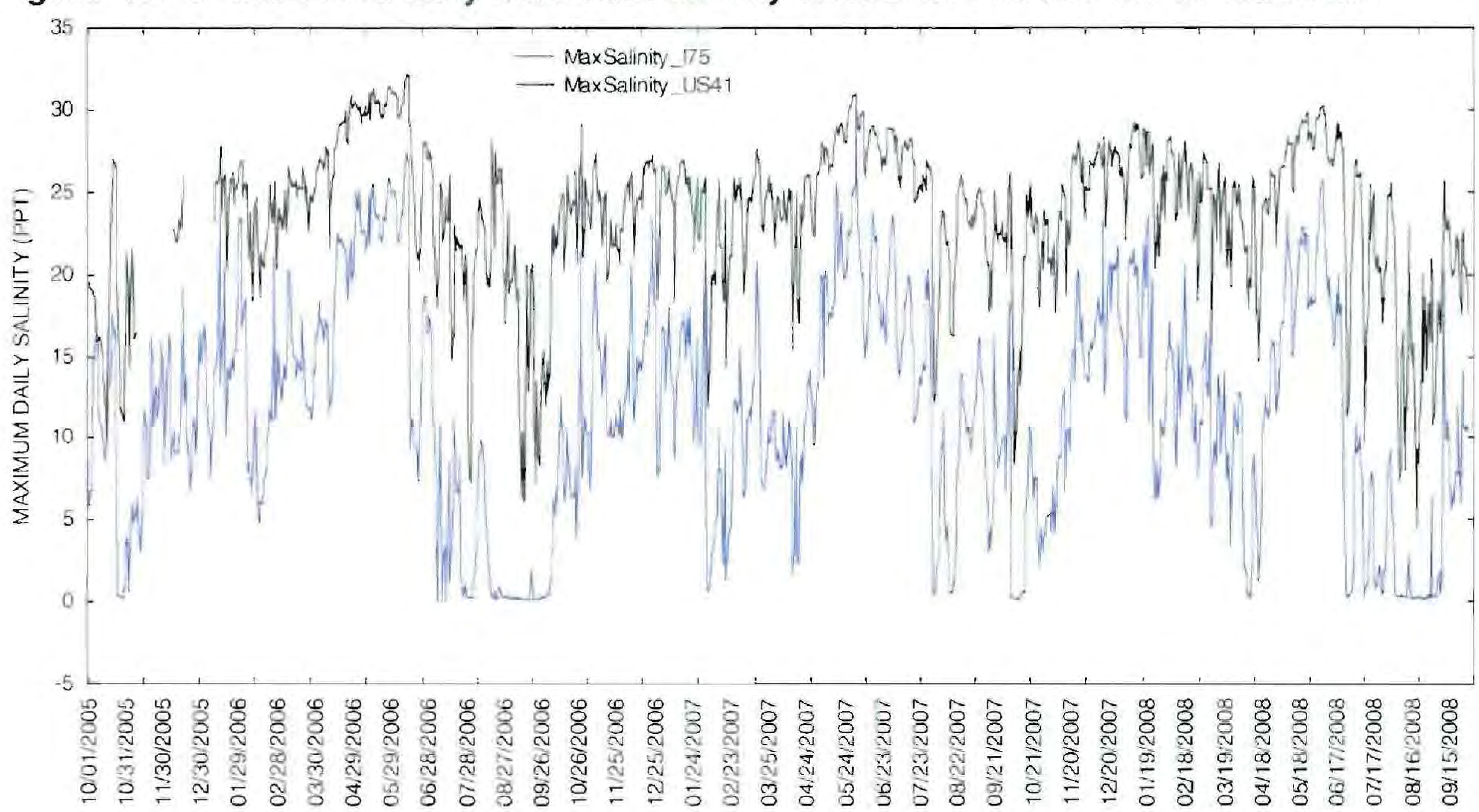


Figure 3.4-3. Observed and expected (modeled) mean salinity for I-75.

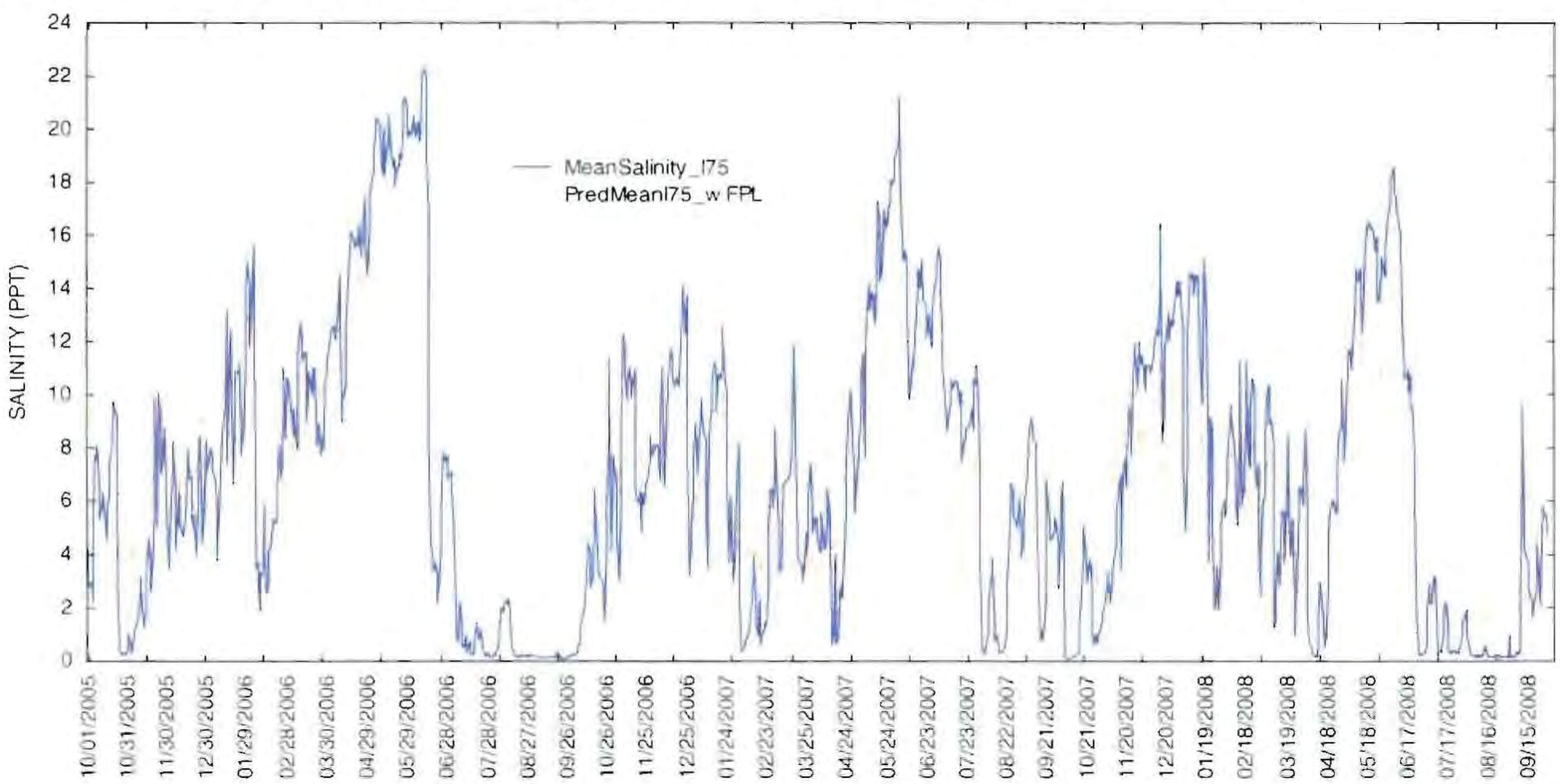


Figure 3.4-4. Observed and expected (modeled) mean salinity for US 41.

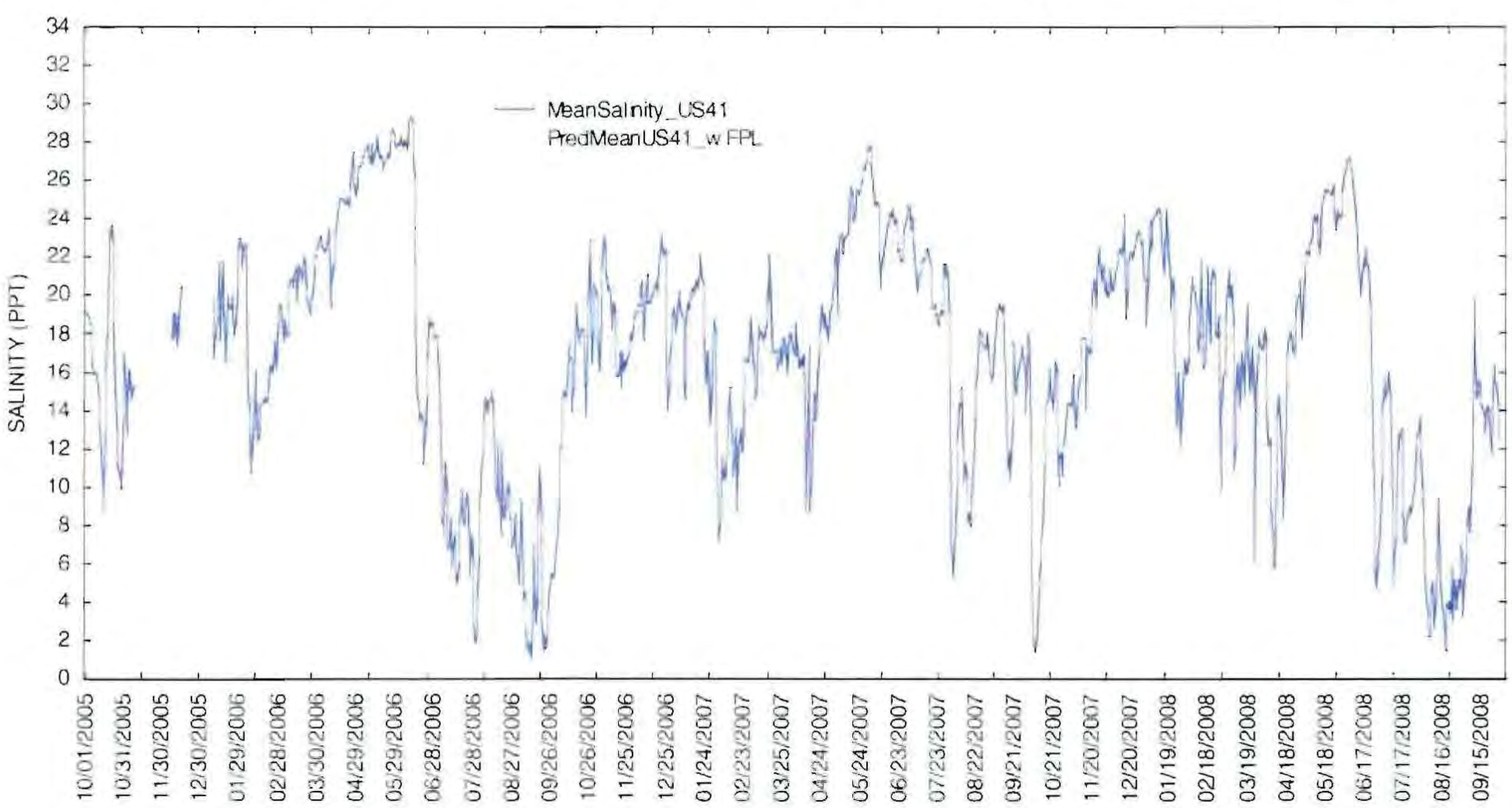


Figure 3.4-5. Observed and expected (modeled) maximum salinity for I-75.

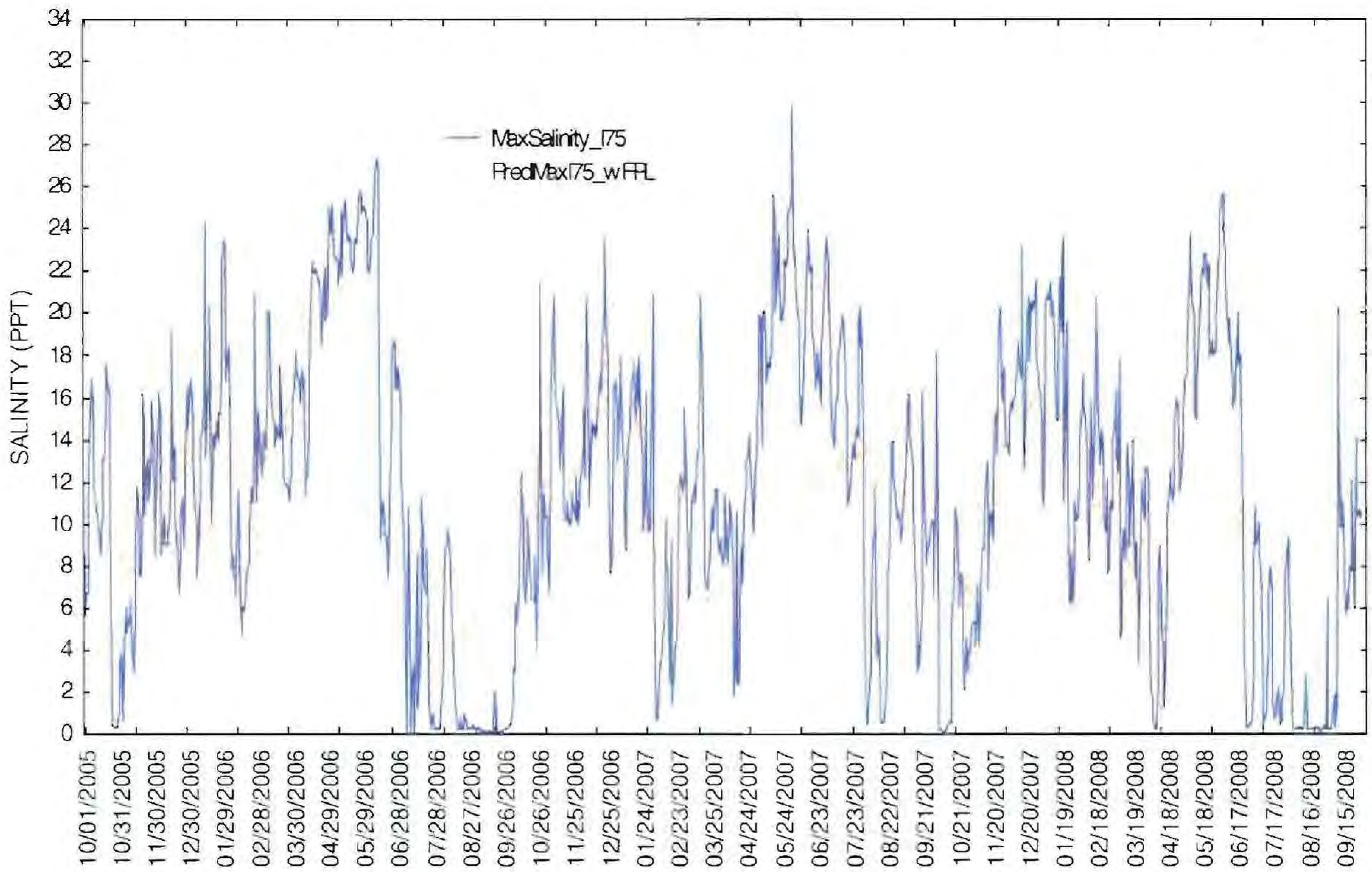


Figure 3.4-6. Observed and expected (modeled) maximum salinity for US 41.

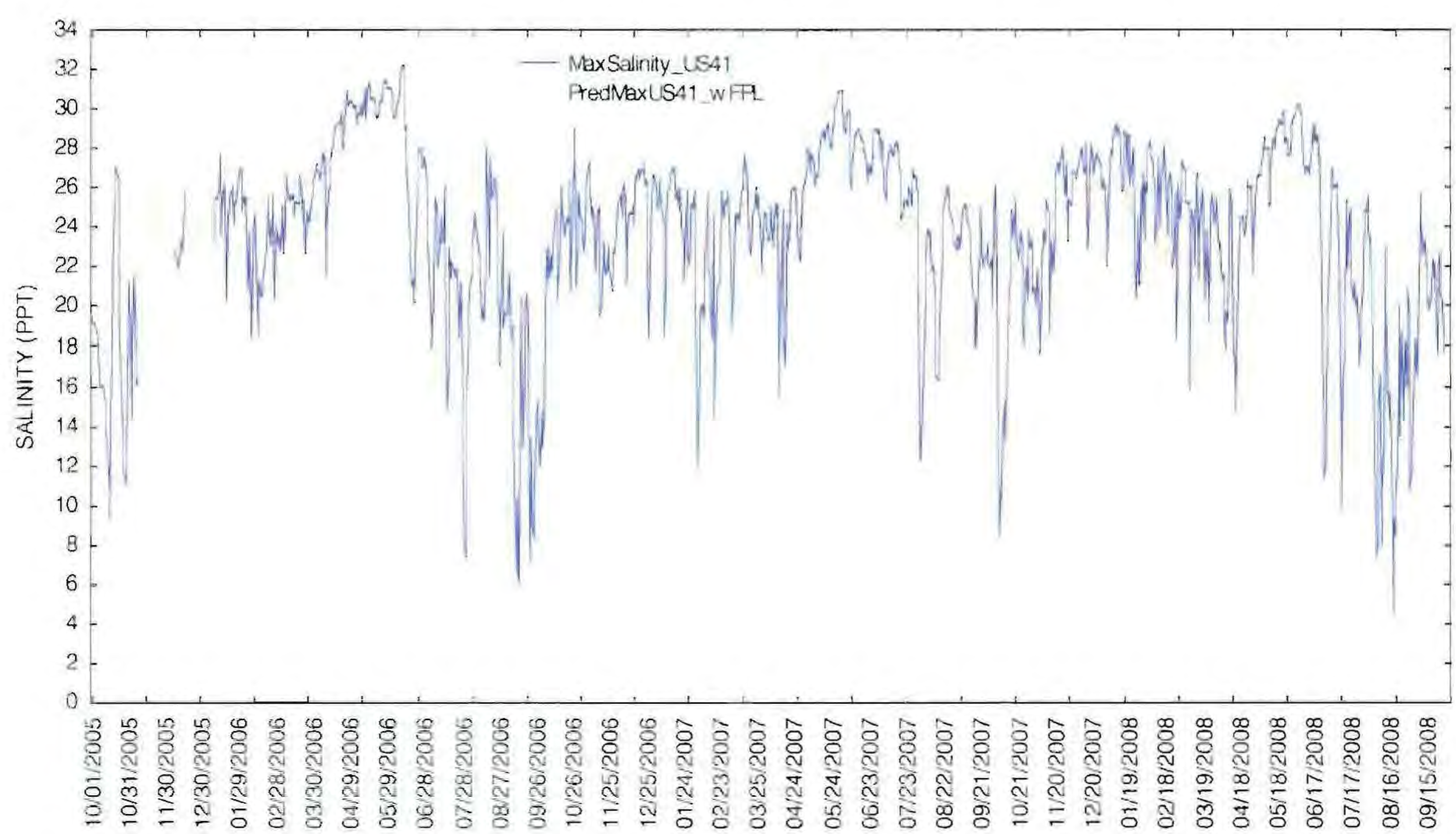


Figure 3.4-7. Model predicted mean daily salinity at I-75 with and without FPL withdrawals.

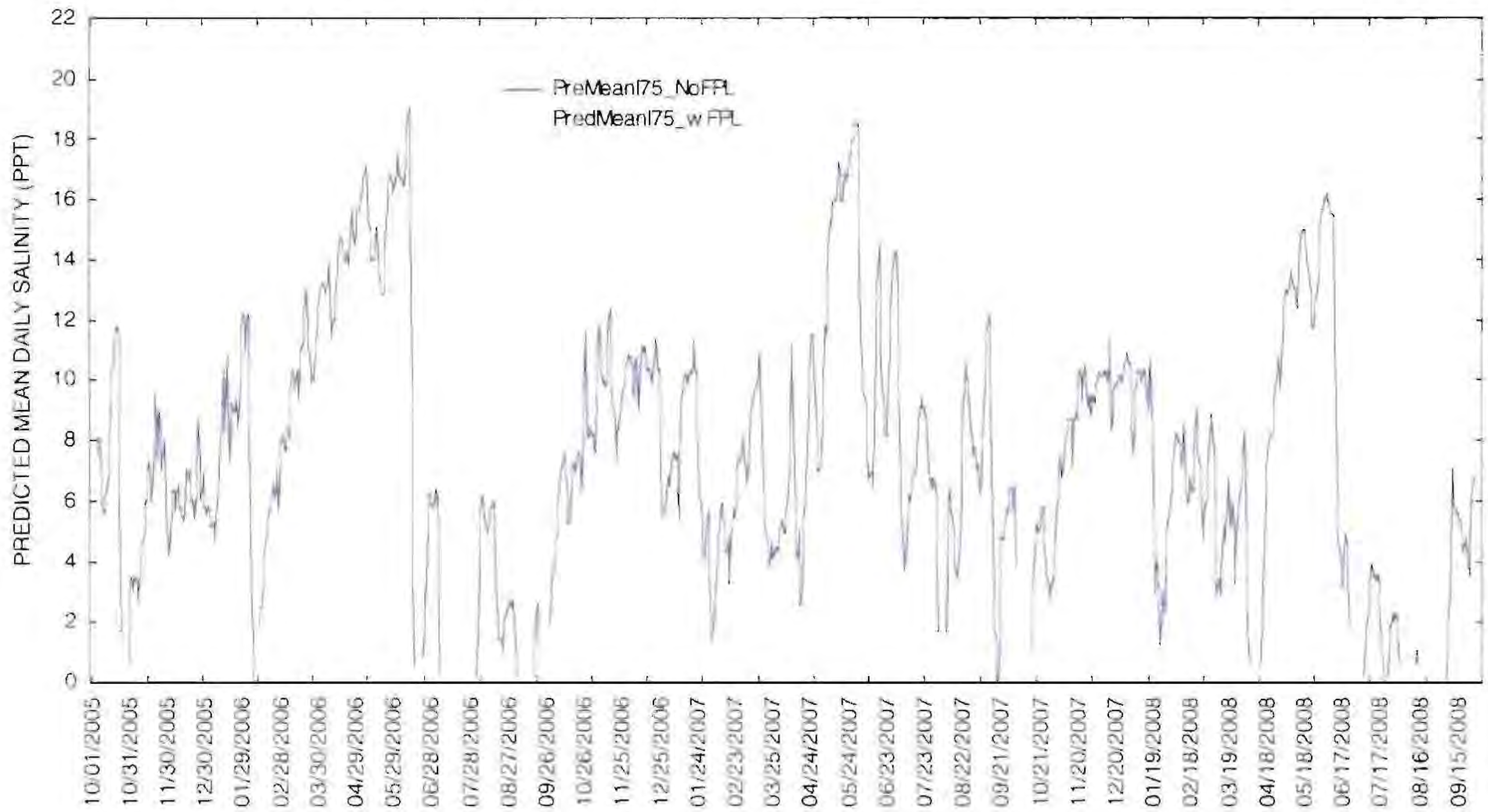


Figure 3.4-8. Model predicted mean daily salinity at US 41 with and without FPL withdrawals.

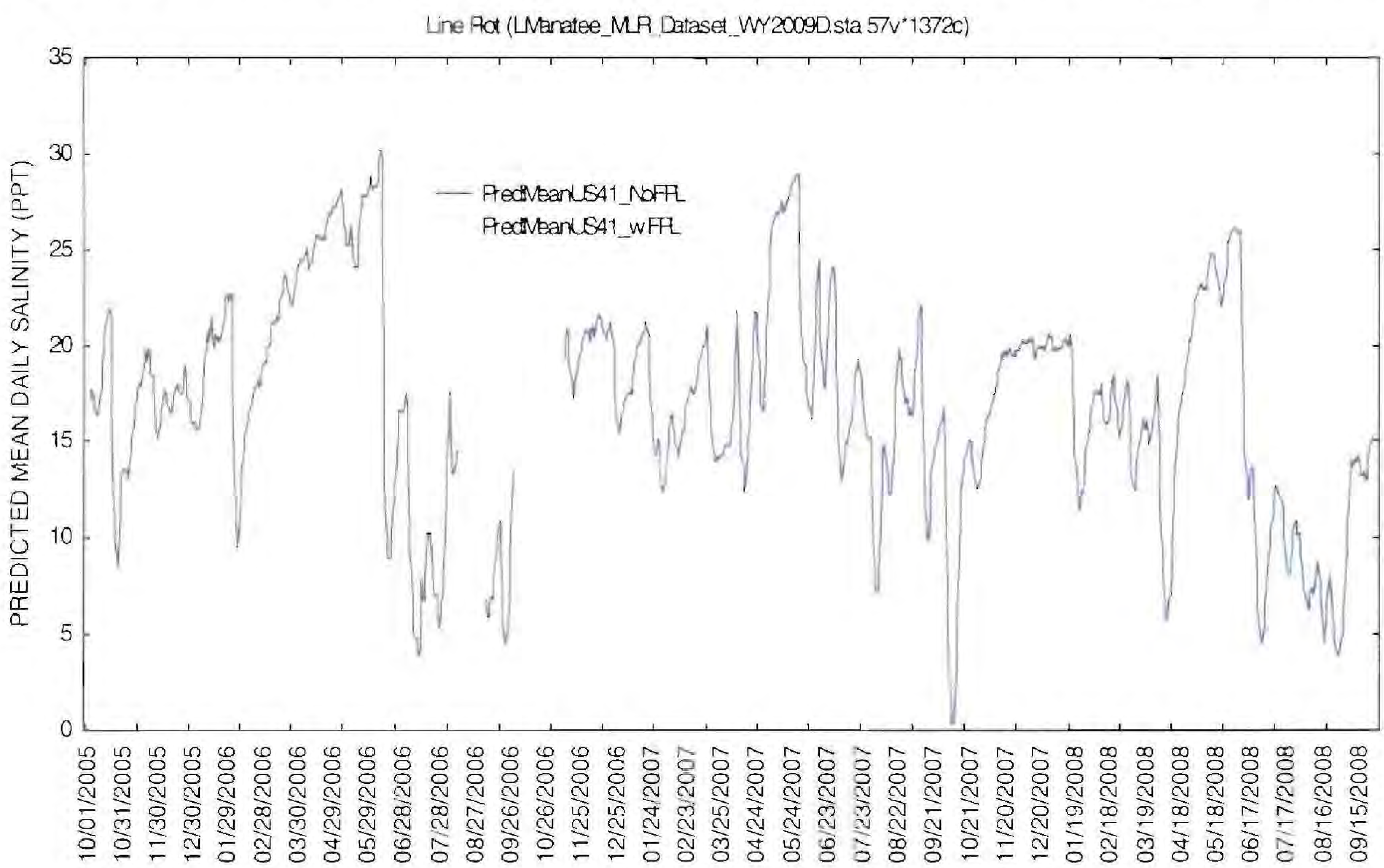


Figure 3.4-9. Model predicted maximum daily salinity at I-75 with and without FPL withdrawals.

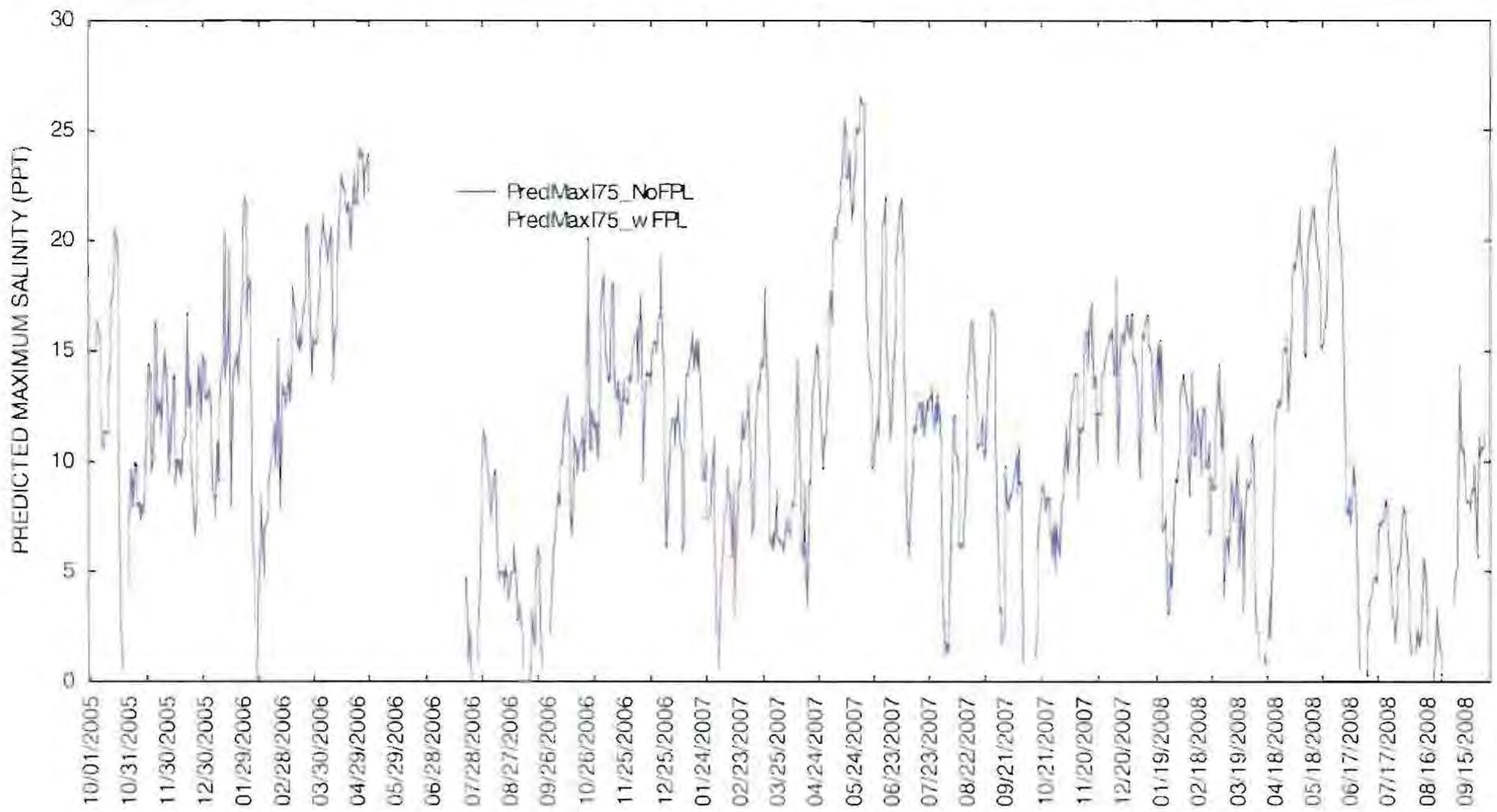


Figure 3.4-10. Model predicted maximum daily salinity at US 41 with and without FPL withdrawals.

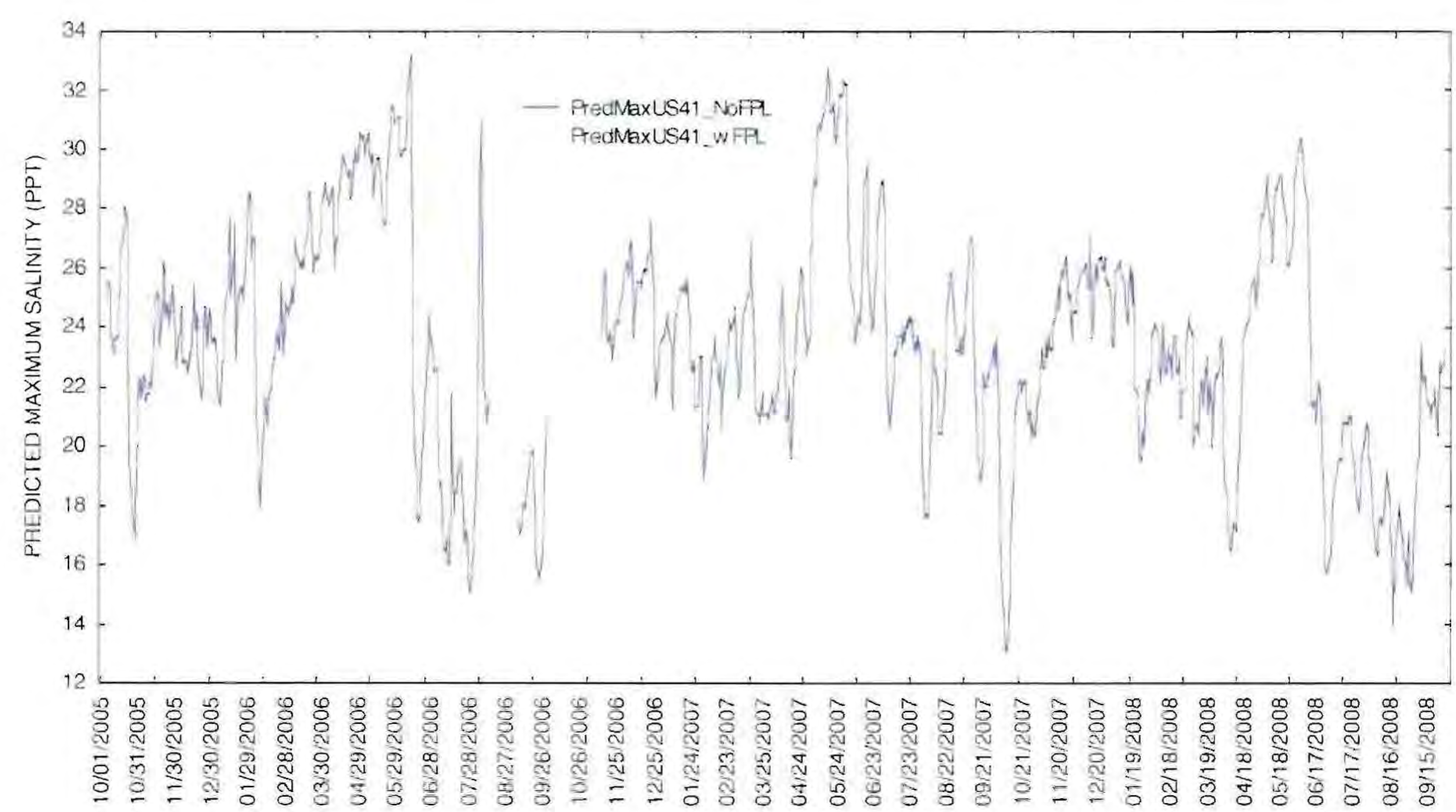


Figure 3.4-11. Predicted 2 psu isohaline position (river km) in Little Manatee River based on actual FPL withdrawals for study period (actual USGS flow also shown using scaling on right hand axis).

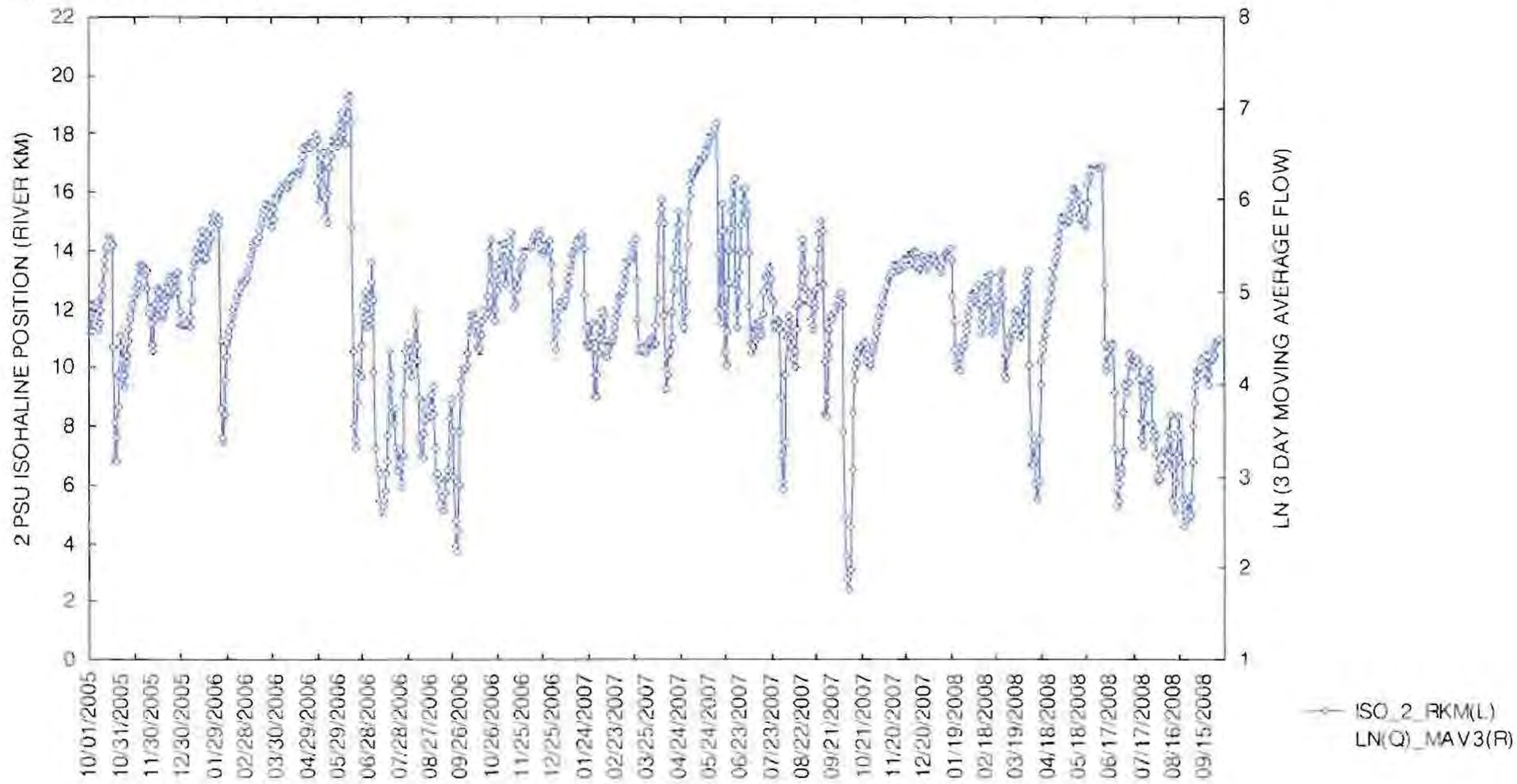


Figure 3.4-12. Predicted 2 psu isohaline positions (river km) in Little Manatee River for actual FPL withdrawals versus baseline (no withdrawals) for study period.

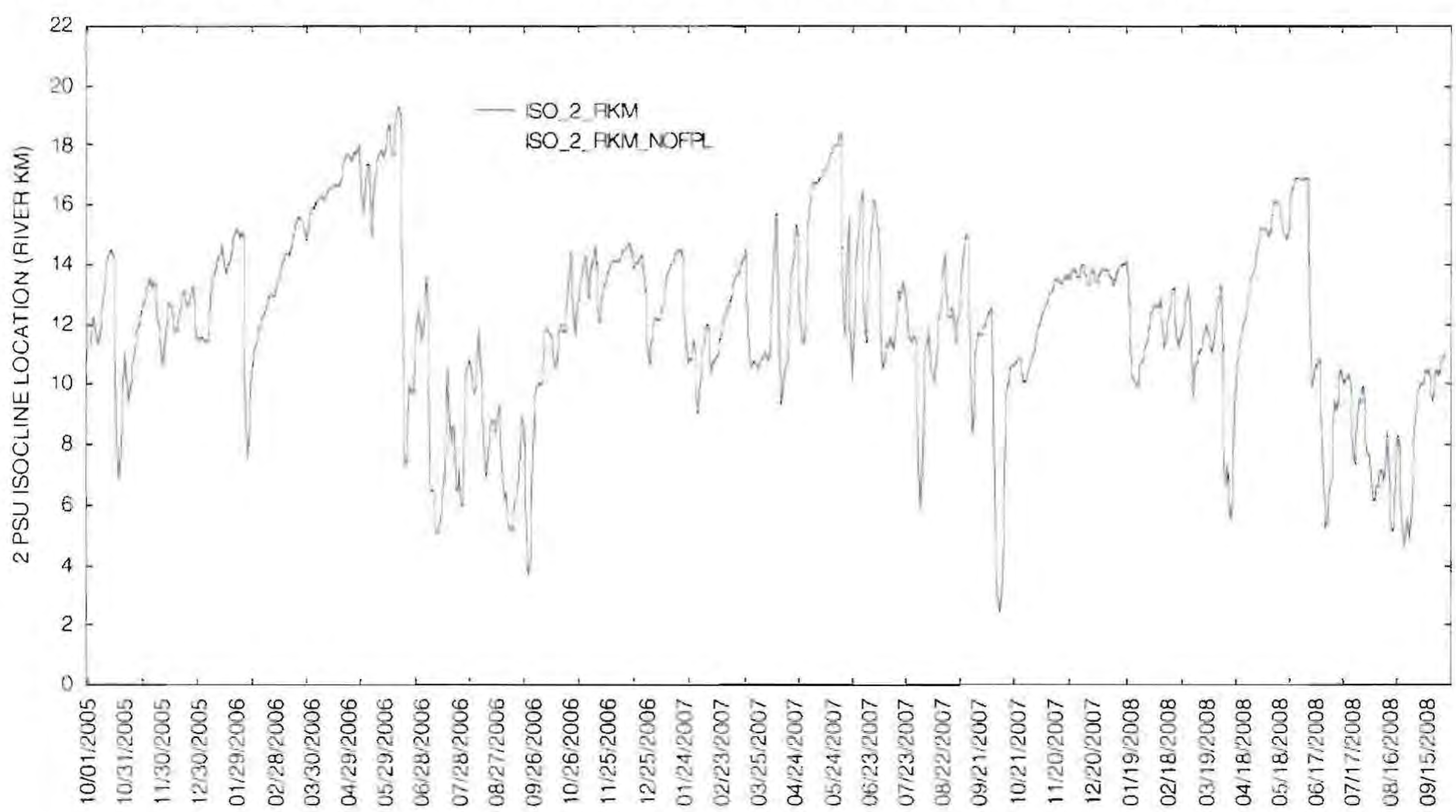
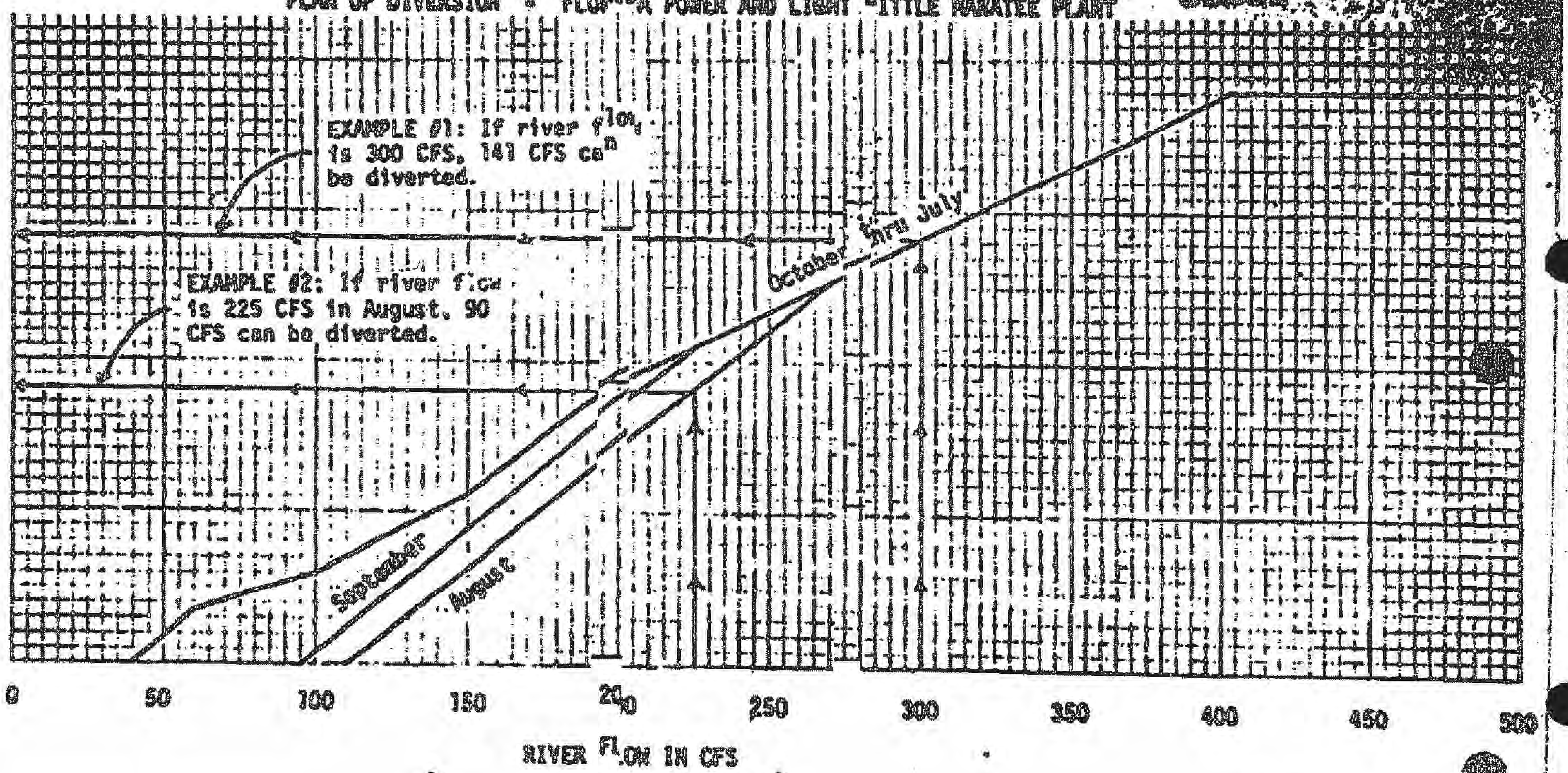


EXHIBIT B (Revised November 12, 1975)

PLAN OF DIVERSION - FLORIDA POWER AND LIGHT LITTLE MANATEE PLANT



DIVERSION RESTRICTIONS

The plan for diversion restrictions as set forth on the above curve would employ a pumping station with a maximum capacity of 190 CFS. The company is authorized to divert that amount of "flow available for diversion" which is indicated by the point on the appropriate curves corresponding to the "river flow" occuring in the Little Manatee River at the point of diversion at the time the diversion takes place. The allowable diversion rate will be determined by the solid curve labeled, "October thru July" in all months except August and September. In no case shall the diversion reduce the river flow to less than 40 CFS. During August and September diversions would be restricted to 80 percent of the river flow in excess of the monthly average minimum flow (112 CFS being the monthly average minimum flow for August and 97 CFS being the monthly average minimum flow for September) or to the October thru July curve, whichever is

Plant Expansion Permit Conditions

1. On October 1, 2004, FPL shall permanently implement the Regular diversion schedule (RDS) for withdrawals of water from the Little Manatee River with the following limitations:

Withdrawals shall not occur when Little Manatee River flow, as measured at FPL's gauging station (at the point of diversion), is less than 40 cfs (25.9 mgd).

The maximum authorized diversion is 190 cfs (122.8 mgd)

Withdrawals shall be limited to not greater than 10% of the Little Manatee River flow as measured at FPL's gauging station.

In no case shall the diversion reduce the flow in the Little Manatee River below the point of diversion to less than 40 cfs.

2. As of October 1, 2004, FPL is authorized to implement an emergency diversion schedule (EDS) in the event the water level in the cooling pond falls below 62.00 ft. N.G.V.D. subject to the following limitations:

a. Withdrawals shall not occur when Little Manatee River flow, as measured at FPL's gauging station (at the point of diversion), is less than 40 cfs (25.9 mgd).

b. The maximum authorized diversion is 190 cfs (122.8 mgd).

c. EDS withdrawals shall be limited according to the Table below:

Little Manatee River Flow in cfs As Measured at the FPL Gauging Station	Maximum Allowed Diversion in cfs
$Q_{riv} < 40$	0
40 $Q_{riv} < 60$	$0.85\ Q_{riv} - 34.0$
60 $Q_{riv} < 100$	$0.325\ Q_{riv} - 2.5$
100 $Q_{riv} < 150$	$0.52\ Q_{riv} - 22.0$
150 $Q_{riv} < 200$	$0.74\ Q_{riv} - 55.0$
200 $Q_{riv} < 400$	$0.485\ Q_{riv} - 4.0$
400 Q_{riv}	190

Note: Q_{riv} is the Little Manatee River Flow in cfs as measured at the FPL gauging station.

d. In no case shall the diversion reduce the flow in the Little Manatee River below the point of diversion to less than 40 cfs.

The river diversion schedule shall revert from the EDS to the RDS upon cooling pond water levels reaching an elevation of 63.00 ft N.G.V.D.

Table A-1 FPL Manatee Plant Regular and Emergency Diversion Schedules

FPL PMT Gauge Station	River Flow	River Flow	Regular Diversion Curve (10% of River Flow)	Emergency Diversion Curve	Emergency Diversion Curve
River Stage (NGVD)	**gpm**	**cfs**	**gpm**	**cfs**	**gpm**
10.0	17,778	39.6	0	0	0
10.1	18,886	42.1	1,889	2	793
10.2	20,057	44.7	2,006	4	1,788
10.3	21,292	47.4	2,129	6	2,838
10.4	22,590	50.3	2,259	9	3,941
10.5	23,952	53.4	2,395	11	5,099
10.6	25,377	56.5	2,538	14	6,310
10.7	26,865	59.9	2,687	17	7,575
10.8	28,417	63.3	2,842	18	8,114
10.9	30,033	66.9	3,003	19	8,639
11.0	31,712	70.7	3,171	20	9,184
11.1	33,455	74.5	3,345	22	9,751
11.2	35,261	78.6	3,526	23	10,338
11.3	37,130	82.7	3,713	24	10,945
11.4	39,063	87.0	3,906	26	11,573
11.5	41,060	91.5	4,106	27	12,222
11.6	43,120	96.1	4,312	29	12,892
11.7	45,243	100.8	4,524	30	13,652
11.8	47,430	105.7	4,743	33	14,789
11.9	49,681	110.7	4,968	36	15,960
12.0	51,995	115.8	5,199	38	17,163
12.1	54,372	121.1	5,437	41	18,399
12.2	56,813	126.6	5,681	44	19,669
12.3	59,318	132.2	5,932	47	20,971
12.4	61,886	137.9	6,189	50	22,306
12.5	64,517	143.7	6,452	53	23,674
12.6	67,212	149.7	6,721	56	25,076
12.7	69,970	155.9	6,997	60	27,092
12.8	72,792	162.2	7,279	65	29,180
12.9	75,677	168.6	7,568	70	31,315
13.0	78,626	175.2	7,863	75	33,498
13.1	81,639	181.9	8,164	80	35,727
13.2	84,714	188.7	8,471	85	38,003
13.3	87,854	195.7	8,785	90	40,326
13.4	91,057	202.9	9,106	94	42,367
13.5	94,323	210.2	9,432	98	43,951
13.6	97,653	217.6	9,765	102	45,566
13.7	101,046	225.1	10,105	105	47,212
13.8	104,503	232.8	10,450	109	48,888

Table A-1 FPL Manatee Plant Regular and Emergency Diversion Schedules (Continued)

FPL PMT Gauge Station	River Flow	River Flow	Regular Diversion Curve (10% of River Flow)	Emergency Diversion Curve	Emergency Diversion Curve
River Stage (NGVD)	gpm	cfs	gpm	cfs	gpm
13.9	108,023	240.7	10,802	113	50,596
14.0	111,607	248.7	11,161	117	52,334
14.1	115,254	256.8	11,525	121	54,103
14.2	118,965	265.1	11,896	125	55,902
14.3	122,739	273.5	12,274	129	57,733
14.4	126,576	282.0	12,658	133	59,594
14.5	130,478	290.7	13,048	137	61,486
14.6	134,442	299.5	13,444	141	63,409
14.7	138,470	308.5	13,847	146	65,363
14.8	142,562	317.6	14,256	150	67,347
14.9	146,717	326.9	14,672	155	69,363
15.0	150,936	336.3	15,094	159	71,409
15.1	155,218	345.8	15,522	164	73,485
15.2	159,563	355.5	15,956	168	75,593
15.3	163,973	365.3	16,397	173	77,731
15.4	168,445	375.3	16,845	178	79,901
15.5	172,981	385.4	17,298	183	82,101
15.6	177,581	395.6	17,758	188	84,331
15.7	182,244	406.0	18,224	190	85,278
15.8	186,970	416.6	18,697	190	85,278
15.9	191,760	427.2	19,176	190	85,278
16.0	196,614	438.1	19,661	190	85,278
16.1	201,531	449.0	20,153	190	85,278
16.2	206,511	460.1	20,651	190	85,278
16.3	211,555	471.3	21,156	190	85,278
16.4	216,663	482.7	21,666	190	85,278
16.5	221,834	494.2	22,183	190	85,278
16.6	227,068	505.9	22,707	190	85,278
16.7	232,366	517.7	23,237	190	85,278
16.8	237,727	529.7	23,773	190	85,278
16.9	243,152	541.7	24,315	190	85,278
17.0	248,641	554.0	24,864	190	85,278
17.1	254,193	566.3	25,419	190	85,278
17.2	259,808	578.9	25,981	190	85,278
17.3	265,487	591.5	26,549	190	85,278
17.4	271,229	604.3	27,123	190	85,278
17.5	277,035	617.2	27,703	190	85,278
17.6	282,904	630.3	28,290	190	85,278

FPL PMT Gauge Station	River Flow	River Flow	Regular Diversion Curve (10% of River Flow)	Emergency Diversion Curve	Emergency Diversion Curve
River Stage (NGVD)	gpm	cfs	gpm	cfs	gpm
17.7	288,837	643.5	28,884	190	85,278
17.8	294,833	656.9	29,483	190	85,278
17.9	300,893	670.4	30,089	190	85,278
18.0	307,016	684.0	30,702	190	85,278
18.1	313,203	697.8	31,320	190	85,278
18.2	319,453	711.7	31,945	190	85,278
18.3	325,767	725.8	32,577	190	85,278
18.4	332,144	740.0	33,214	190	85,278
18.5	338,585	754.4	33,858	190	85,278
18.6	345,089	768.9	34,509	190	85,278
18.7	351,657	783.5	35,166	190	85,278
18.8	358,288	798.3	35,829	190	85,278
18.9	364,983	813.2	36,498	190	85,278
19.0	371,741	828.2	37,174	190	85,278
19.1	378,562	843.4	37,856	190	85,278
19.2	385,448	858.8	38,545	190	85,278
19.3	392,396	874.3	39,240	190	85,278
19.4	399,408	889.9	39,941	190	85,278
19.5	406,484	905.6	40,648	190	85,278
19.6	413,623	921.6	41,362	190	85,278
19.7	420,826	937.6	42,083	190	85,278
19.8	428,092	953.8	42,809	190	85,278
19.9	435,421	970.1	43,542	190	85,278
20.0	442,814	986.6	44,281	190	85,278
20.1	450,271	1,003.2	45,027	190	85,278
20.2	457,791	1,020.0	45,779	190	85,278
20.3	465,374	1,036.9	46,537	190	85,278
20.4	473,021	1,053.9	47,302	190	85,278
20.5	480,732	1,071.1	48,073	190	85,278
20.6	488,506	1,088.4	48,851	190	85,278
20.7	496,343	1,105.9	49,634	190	85,278
20.8	504,244	1,123.5	50,424	190	85,278
20.9	512,208	1,141.2	51,221	190	85,278
21.0	520,236	1,159.1	52,024	190	85,278
21.1	528,328	1,177.1	52,833	190	85,278
21.2	536,483	1,195.3	53,648	190	85,278
21.3	544,701	1,213.6	54,470	190	85,278
21.4	552,983	1,232.0	55,298	190	85,278
21.5	561,328	1,250.6	56,133	190	85,278

Table A-1 FPL Manatee Plant Regular and Emergency Diversion Schedules (Continued)

FPL PMT Gauge Station	River Flow	River Flow	Regular Diversion Curve (10% of River Flow)	Emergency Diversion Curve	Emergency Diversion Curve
River Stage (NGVD)	gpm	cfs	gpm	cfs	gpm
21.6	569,737	1,269.4	56,974	190	85,278
21.7	578,209	1,288.3	57,821	190	85,278
21.8	586,745	1,307.3	58,675	190	85,278
21.9	595,345	1,326.4	59,534	190	85,278
22.0	604,007	1,345.7	60,401	190	85,278
22.1	612,734	1,365.2	61,273	190	85,278
22.2	621,523	1,384.8	62,152	190	85,278
22.3	630,377	1,404.5	63,038	190	85,278
22.4	639,293	1,424.3	63,929	190	85,278
22.5	648,274	1,444.4	64,827	190	85,278
22.6	657,317	1,464.5	65,732	190	85,278
22.7	666,425	1,484.8	66,642	190	85,278
22.8	675,595	1,505.2	67,560	190	85,278
22.9	684,829	1,525.8	68,483	190	85,278
23.0	694,127	1,546.5	69,413	190	85,278
23.1	703,488	1,567.4	70,349	190	85,278
23.2	712,913	1,588.4	71,291	190	85,278
23.3	722,401	1,609.5	72,240	190	85,278
23.4	731,953	1,630.8	73,195	190	85,278
23.5	741,568	1,652.2	74,157	190	85,278
23.6	751,246	1,673.8	75,125	190	85,278
23.7	760,989	1,695.5	76,099	190	85,278
23.8	770,794	1,717.3	77,079	190	85,278
23.9	780,663	1,739.3	78,066	190	85,278
24.0	790,596	1,761.4	79,060	190	85,278
24.1	800,592	1,783.7	80,059	190	85,278
24.2	810,651	1,806.1	81,065	190	85,278
24.3	820,774	1,828.7	82,077	190	85,278
24.5	841,211	1,874.2	84,121	190	85,278
24.6	851,524	1,897.2	85,152	190	85,278

Appendix B

Daily Value Tables for the US 41 Site

Date Processed 10/10/07

Drainage Area mi2

Hydrologic Data Collection, Inc.

Little Manatee River at US Highway 41

Gage Height, Feet, NGVD 1988, Water Year October 2006 to September 2007

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-	-	0.59	1.02	1.02	0.99	0.42	0.89	1.51	1.39	1.05	0.73
2	-	-	0.79	0.88	1.18	1.06	0.53	1.01	2.77	1.32	1.17	0.90
3	-	-	0.86	0.76	0.49	0.20	0.10	2.27	1.50	1.09	0.64	0.95
4	-	-	0.87	0.91	-0.47	-0.46	0.00	2.31	1.21	1.00	0.78	0.63
5	-	-	0.55	1.12	-0.36	-0.84	0.17	2.55	1.06	0.69	0.82	0.84
6	-	-	0.98	0.88	0.12	-0.81	-0.12	2.39	0.91	0.35	0.99	1.10
7	-	-	1.17	0.62	0.72	0.06	-0.21	1.65	0.79	0.45	0.92	0.91
8	-	-	0.14	0.38	0.75	-0.07	-0.03	1.98	0.56	0.70	1.09	1.19
9	-	-	-0.74	-0.61	0.76	0.29	-0.03	1.99	0.91	1.02	1.37	1.31
10	-	-	-0.23	-1.04	0.88	0.31	0.00	1.83	1.11	1.17	1.32	1.28
11	-	-	0.15	-0.20	0.80	0.23	0.20	1.63	1.44	1.37	1.46	1.04
12	-	-	0.21	0.33	0.71	0.43	0.02	1.83	1.60	1.31	1.42	0.83
13	-	-0.07	0.20	0.24	1.09	0.31	-0.05	1.86	1.44	1.43	1.22	0.62
14	-	-0.14	0.30	0.25	0.96	0.37	0.27	2.01	1.57	1.40	1.30	0.59
15	-	0.59	0.25	0.34	0.93	1.14	1.09	2.03	1.87	1.31	1.18	0.79
16	-	0.74	0.64	0.50	0.95	0.79	0.40	2.51	1.87	1.17	0.73	0.58
17	-	0.14	0.64	0.46	0.65	0.83	-0.17	2.54	1.56	0.91	0.83	0.80
18	-	0.04	0.81	0.23	1.29	0.17	0.44	2.20	1.56	0.83	0.66	0.55
19	-	0.40	0.76	0.37	0.01	-0.14	0.50	1.67	1.14	0.30	0.61	0.57
20	-	0.44	0.87	0.26	0.59	-0.02	0.65	1.64	1.01	0.27	0.67	0.50
21	-	0.21	0.98	0.06	0.86	0.26	0.51	1.79	0.66	0.34	0.84	1.63
22	-	-0.02	1.00	0.38	0.90	0.13	0.78	1.46	0.61	0.35	0.97	1.15
23	-	0.12	1.70	-0.12	0.89	0.34	0.66	0.93	0.85	0.57	0.92	1.02
24	-	0.37	0.93	-0.45	1.35	0.70	0.43	0.98	0.92	0.65	1.09	0.96
25	-	0.16	0.66	-0.54	1.37	0.26	0.47	1.15	0.85	0.85	1.19	0.98
26	-	0.09	0.27	-0.17	1.01	0.24	0.32	1.28	0.76	0.89	1.28	1.06
27	-	0.02	-0.26	0.41	1.01	0.26	0.48	1.54	0.98	0.90	1.22	0.95
28	-	0.29	0.41	-0.14	0.87	0.27	0.31	1.45	1.10	1.31	1.12	0.98
29	-	0.22	0.57	0.14		0.12	0.21	1.45	1.27	1.28	0.92	1.04
30	-	0.55	1.11	0.34		0.08	0.36	1.65	1.23	1.60	0.55	0.47
31	-		1.21	0.32		0.25		1.51		1.44	0.59	
Max	-	0.74	1.70	1.12	1.37	1.14	1.09	2.55	2.77	1.60	1.46	1.63
Min	-	-0.14	-0.74	-1.04	-0.47	-0.84	-0.21	0.89	0.56	0.27	0.55	0.47
Mean	-	0.23	0.59	0.26	0.76	0.25	0.29	1.74	1.22	0.96	1.00	0.90

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Gage Height, Feet, NGVD 1988, Water Year October 2006 to September 2007
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-	-	-1.29	-1.41	-1.90	-1.33	-0.98	-1.12	-1.30	-1.28	-0.96	-1.00
2	-	-	-1.52	-1.74	-1.24	-0.93	-1.29	-1.04	-1.38	-1.30	-0.92	-1.08
3	-	-	-1.67	-1.71	-1.65	-1.72	-1.59	-0.89	-0.79	-1.26	-0.52	-1.29
4	-	-	-1.82	-1.60	-2.04	-1.85	-1.79	0.05	-1.01	-1.25	-0.77	-1.46
5	-	-	-2.31	-1.56	-2.10	-2.11	-1.72	-0.04	-1.21	-1.15	-1.10	-1.50
6	-	-	-1.92	-1.32	-1.11	-2.03	-1.91	0.14	-1.17	-0.96	-1.28	-1.35
7	-	-	-1.69	-1.40	-0.58	-1.52	-1.77	-0.48	-1.28	-0.90	-1.37	-1.37
8	-	-	-2.27	-1.30	-0.64	-1.72	-1.98	-0.57	-1.06	-1.06	-1.40	-0.98
9	-	-	-2.31	-1.84	-0.81	-1.76	-2.05	-0.26	-0.62	-1.14	-1.28	-0.57
10	-	-	-1.78	-2.54	-0.97	-1.66	-2.03	0.03	-0.53	-1.20	-1.23	-0.53
11	-	-	-1.34	-1.93	-1.43	-1.75	-2.19	-0.05	-0.67	-1.28	-0.91	-0.61
12	-	-	-1.33	-1.71	-1.28	-2.00	-1.70	0.24	-0.97	-1.43	-0.83	-0.61
13	-	-1.45	-0.96	-1.86	-1.43	-1.92	-1.70	0.26	-1.26	-1.27	-0.83	-0.71
14	-	-1.42	-1.17	-1.90	-1.33	-1.89	-1.73	-0.15	-1.21	-1.21	-0.67	-0.78
15	-	-1.20	-1.45	-1.97	-1.31	-1.83	-0.84	-0.27	-1.19	-1.24	-0.46	-0.89
16	-	-0.70	-1.70	-2.12	-1.25	-1.42	-1.92	-0.10	-0.97	-1.31	-0.50	-1.06
17	-	-1.64	-1.54	-2.29	-1.36	-1.42	-2.09	-0.17	-0.99	-1.15	-0.48	-0.80
18	-	-1.72	-1.64	-2.05	-1.31	-1.62	-1.82	-0.30	-0.94	-1.02	-0.80	-1.25
19	-	-1.85	-1.77	-2.04	-1.31	-1.56	-1.64	-0.64	-0.92	-0.89	-0.91	-1.47
20	-	-1.82	-1.78	-2.12	-0.93	-1.61	-1.78	-0.97	-0.93	-1.01	-0.95	-1.24
21	-	-2.18	-1.59	-2.02	-0.78	-1.75	-2.00	-0.78	-0.60	-0.90	-1.01	-0.50
22	-	-1.68	-1.42	-1.47	-0.84	-1.77	-1.93	-0.62	-0.55	-0.96	-1.17	-0.79
23	-	-2.00	-1.35	-1.68	-1.14	-1.87	-1.62	-0.66	-0.62	-1.08	-1.37	-0.93
24	-	-1.96	-1.46	-1.65	-1.36	-1.78	-1.55	-0.38	-0.73	-1.32	-1.42	-0.77
25	-	-2.00	-0.63	-1.94	-1.10	-1.82	-1.49	-0.26	-1.18	-1.35	-1.22	-0.57
26	-	-1.80	-1.28	-2.31	-1.05	-1.83	-1.30	-0.33	-1.44	-1.41	-1.09	-0.59
27	-	-1.73	-1.66	-2.35	-1.26	-1.77	-0.95	-0.30	-1.25	-1.62	-0.99	-0.65
28	-	-1.48	-1.34	-1.58	-1.33	-1.61	-0.96	-0.55	-1.47	-1.20	-0.91	-0.92
29	-	-1.20	-1.42	-2.31		-1.54	-1.26	-0.73	-1.43	-1.05	-0.89	-1.04
30	-	-1.14	-1.63	-2.09		-1.40	-1.21	-0.76	-1.33	-0.93	-1.06	-1.70
31	-		-1.54	-2.11		-1.20		-0.89		-0.88	-0.99	
Max	-	-0.70	-0.63	-1.30	-0.58	-0.93	-0.84	0.26	-0.53	-0.88	-0.46	-0.50
Min	-	-2.18	-2.31	-2.54	-2.10	-2.11	-2.19	-1.12	-1.47	-1.62	-1.42	-1.70
Mean	-	-1.61	-1.57	-1.87	-1.24	-1.68	-1.63	-0.41	-1.03	-1.16	-0.98	-0.97

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Gage Height, Feet, NGVD 1988, Water Year October 2006 to September 2007
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-	-	-0.29	-0.15	-0.52	-0.18	-0.28	-0.14	0.23	0.05	-0.06	-0.13
2	-	-	-0.32	-0.54	-0.32	-0.28	-0.31	-0.04	0.67	0.02	0.17	-0.14
3	-	-	-0.42	-0.48	-0.85	-0.99	-0.64	0.55	0.34	-0.08	0.08	-0.19
4	-	-	-0.78	-0.30	-1.32	-1.23	-0.81	1.24	0.14	-0.11	-0.02	-0.34
5	-	-	-1.01	-0.18	-1.05	-1.55	-0.73	1.32	0.04	-0.14	-0.13	-0.24
6	-	-	-0.52	-0.23	-0.44	-1.43	-1.00	1.34	0.01	-0.18	-0.05	-0.06
7	-	-	-0.47	-0.36	0.01	-0.82	-1.07	0.42	-0.06	-0.28	-0.12	-0.15
8	-	-	-1.24	-0.42	-0.01	-0.90	-1.06	0.78	-0.07	-0.24	-0.01	0.02
9	-	-	-1.36	-1.09	-0.16	-0.76	-1.05	1.07	0.08	-0.04	0.15	0.21
10	-	-	-0.81	-1.64	-0.04	-0.75	-0.93	1.10	0.20	0.06	0.07	0.32
11	-	-	-0.44	-1.23	-0.38	-0.74	-0.70	0.85	0.37	0.13	0.21	0.13
12	-	-	-0.55	-0.73	-0.15	-0.74	-0.68	1.05	0.39	0.04	0.24	0.11
13	-	-0.71	-0.46	-0.77	-0.08	-0.72	-0.89	1.05	0.18	0.09	0.13	0.02
14	-	-0.67	-0.50	-0.74	-0.04	-0.67	-0.68	0.98	0.23	0.04	0.25	0.03
15	-	-0.42	-0.56	-0.68	-0.23	-0.41	0.04	0.87	0.35	0.02	0.31	-0.10
16	-	-0.07	-0.53	-0.85	-0.43	-0.24	-0.90	1.23	0.47	-0.11	0.18	-0.19
17	-	-0.79	-0.42	-1.12	-0.32	-0.64	-0.99	1.23	0.29	-0.09	0.16	-0.07
18	-	-0.83	-0.39	-0.89	-0.06	-0.96	-0.68	0.99	0.34	-0.07	-0.10	-0.41
19	-	-0.77	-0.60	-0.99	-0.62	-0.82	-0.50	0.45	0.22	-0.29	-0.17	-0.50
20	-	-0.68	-0.56	-1.04	-0.13	-0.69	-0.54	0.34	0.17	-0.38	-0.14	-0.31
21	-	-1.12	-0.34	-0.90	-0.04	-0.67	-0.77	0.62	0.19	-0.33	-0.05	0.59
22	-	-0.78	-0.05	-0.58	0.05	-0.87	-0.52	0.56	-0.04	-0.37	0.01	0.30
23	-	-0.85	-0.08	-0.96	-0.20	-0.75	-0.36	0.40	0.03	-0.31	-0.05	0.11
24	-	-0.75	-0.29	-0.99	-0.02	-0.44	-0.41	0.43	0.04	-0.22	0.02	0.09
25	-	-0.82	0.04	-1.28	0.22	-0.70	-0.28	0.43	-0.10	-0.18	0.03	0.19
26	-	-0.68	-0.47	-1.45	0.13	-0.66	-0.33	0.41	-0.26	-0.14	0.06	0.23
27	-	-0.63	-0.96	-1.05	-0.05	-0.57	-0.20	0.51	-0.15	-0.27	0.01	0.26
28	-	-0.40	-0.61	-0.67	-0.25	-0.52	-0.31	0.41	-0.12	0.02	-0.02	0.09
29	-	-0.41	-0.38	-1.19		-0.65	-0.42	0.39	-0.07	0.01	-0.09	-0.09
30	-	-0.31	-0.28	-0.93		-0.73	-0.49	0.45	-0.06	0.24	-0.26	-0.63
31	-		-0.16	-0.96		-0.40		0.34		0.23	-0.11	
Max	-	-0.07	0.04	-0.15	0.22	-0.18	0.04	1.34	0.67	0.24	0.31	0.59
Min	-	-1.12	-1.36	-1.64	-1.32	-1.55	-1.07	-0.14	-0.26	-0.38	-0.26	-0.63
Mean	-	-0.65	-0.51	-0.82	-0.26	-0.73	-0.62	0.70	0.14	-0.09	0.02	-0.03

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Drainage Area mi2

Little Manatee River at US Highway 41

Gage Height, Feet, NGVD 1988, Water Year October 2007 to September 2008

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.79	0.25	-0.17	0.31	0.42	0.13	0.24	0.51	1.01	1.21	1.45	1.82
2	0.54	0.23	0.28	-0.32	0.46	0.02	0.41	0.94	1.03	1.24	1.17	0.74
3	1.72	0.56	0.31	-0.43	0.53	0.52	0.40	1.15	1.16	1.22	0.97	0.37
4	1.10	0.57	0.21	0.62	0.95	0.78	0.39	1.27	1.28	1.06	0.74	0.60
5	1.31	0.81	0.68	1.08	0.94	0.86	0.62	1.13	1.39	1.00	0.46	0.47
6	1.01	0.90	0.69	1.13	0.98	0.49	0.60	1.13	1.23	0.82	0.55	1.13
7	1.25	0.98	0.89	1.15	0.82	0.62	0.55	1.39	0.90	0.77	0.47	0.96
8	1.10	0.48	0.89	1.21	0.65	1.31	0.73	1.80	0.74	0.56	0.72	0.57
9	0.94	0.41	0.94	1.28	0.45	-0.21	0.65	1.36	0.39	0.57	0.86	0.41
10	0.98	0.84	1.03	0.94	-0.05	0.17	0.99	1.07	0.27	0.80	0.78	1.99
11	0.89	0.37	0.99	0.85	-0.41	0.54	1.03	0.82	0.26	0.83	0.77	2.13
12	0.95	0.71	1.07	0.62	0.54	0.71	0.83	0.18	0.39	0.89	0.76	1.32
13	0.83	0.43	0.65	0.50	0.90	0.46	0.33	0.05	0.52	0.95	1.21	1.20
14	0.86	0.25	0.57	0.00	0.35	0.36	0.35	0.39	0.42	0.93	1.32	1.27
15	0.45	0.23	0.63	-0.18	0.30	0.80	0.05	0.97	0.64	1.22	1.24	0.93
16	0.94	0.56	1.71	0.41	0.37	0.55	-0.42	1.08	1.05	1.21	0.95	0.72
17	1.07	0.57	-0.14	1.02	0.95	0.09	0.01	0.97	0.97	1.27	0.87	0.59
18	1.07	0.81	0.40	0.74	0.80	0.58	0.80	1.15	1.12	1.33	0.67	0.63
19	1.12	0.90	0.77	1.63	0.59	0.62	1.06	1.24	1.10	1.23	-0.43	0.64
20	1.02	0.98	1.15	1.50	-0.01	0.71	1.07	1.36	1.21	1.17	0.17	0.97
21	0.68	0.48	0.83	0.67	0.16	-0.35	1.12	1.13	0.85	0.94	0.35	0.91
22	0.69	1.15	1.24	0.96	0.39	0.18	0.98	0.99	1.18	0.71	0.71	1.20
23	0.84	1.15	1.23	1.19	0.29	0.16	0.87	1.09	0.77	0.55	0.65	0.73
24	0.75	0.98	1.33	1.00	-0.05	-0.08	0.89	0.98	0.48	0.71	0.79	0.29
25	0.56	1.27	1.18	0.32	0.07	-0.70	1.10	0.32	0.33	0.87	0.76	0.62
26	0.48	1.42	1.07	0.25	0.52	0.16	1.10	0.24	0.44	0.88	0.79	1.35
27	0.41	1.27	1.27	0.64	-0.40	0.52	0.98	0.20	0.77	1.14	1.00	1.10
28	0.84	0.56	0.81	0.33	-0.24	0.34	0.97	0.16	0.99	1.39	1.00	1.21
29	0.37	0.66	0.67	0.79	0.31	0.21	0.27	0.23	1.05	1.75	1.06	1.16
30	0.71	0.30	0.71	0.68		0.04	0.14	0.43	1.09	1.66	0.78	1.29
31	0.43		0.58	0.83		0.26		0.77		1.44	1.42	
Max	1.72	1.42	1.71	1.63	0.98	1.31	1.12	1.80	1.39	1.75	1.45	2.13
Min	0.37	0.23	-0.17	-0.43	-0.41	-0.70	-0.42	0.05	0.26	0.55	-0.43	0.29
Mean	0.86	0.70	0.79	0.70	0.40	0.35	0.64	0.85	0.83	1.04	0.81	0.98

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Gage Height, Feet, NGVD 1988, Water Year October 2007 to September 2008
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-1.64	-1.69	-1.49	-0.63	-1.17	-1.38	-1.58	-1.18	-1.26	-1.28	-1.04	-0.62
2	-1.66	-1.18	-0.92	-1.18	-1.44	-1.49	-1.44	-0.73	-1.34	-1.25	-0.99	-1.08
3	-0.77	-0.86	-1.11	-0.93	-1.47	-1.57	-1.23	-0.69	-1.40	-1.24	-0.92	-0.89
4	-0.92	-0.61	-1.37	-1.08	-1.46	-1.62	-1.15	-1.05	-1.37	-1.24	-0.90	-0.80
5	-0.77	-0.57	-1.38	-1.16	-1.46	-1.30	-0.88	-1.24	-1.35	-1.23	-0.80	-0.60
6	-0.61	-0.46	-1.25	-1.24	-1.32	-1.46	-1.49	-1.26	-1.29	-1.20	-0.82	-0.57
7	-0.30	-0.81	-1.29	-1.21	-1.39	-1.48	-1.42	-1.24	-1.26	-1.04	-1.08	-1.04
8	-0.25	-1.24	-1.24	-1.29	-1.40	-1.34	-1.41	-1.23	-1.30	-0.90	-0.90	-1.34
9	-0.28	-1.66	-1.23	-1.25	-1.44	-1.33	-1.33	-1.06	-1.37	-0.72	-0.94	-1.25
10	-0.40	-1.68	-1.24	-1.45	-1.42	-1.46	-1.34	-1.20	-0.98	-0.73	-1.25	0.35
11	-0.83	-1.81	-1.27	-1.29	-1.47	-1.44	-1.39	-1.26	-1.08	-0.97	-1.42	-0.14
12	-1.07	-1.78	-1.33	-1.26	-1.51	-1.40	-1.44	-0.58	-1.25	-1.19	-1.47	-0.54
13	-1.05	-1.77	-1.41	-1.13	-1.31	-1.55	-1.31	-1.18	-1.28	-0.98	-0.94	-0.69
14	-1.11	-1.69	-1.48	-1.39	-1.55	-1.71	-1.38	-1.20	-1.41	-1.23	-0.86	-0.56
15	-1.24	-1.18	-1.19	-1.40	-1.45	-1.85	-1.29	-0.60	-1.46	-1.16	-1.09	-0.66
16	-0.97	-0.86	-1.00	-1.50	-1.54	-1.49	-1.24	-0.66	-1.30	-1.04	-1.30	-0.85
17	-0.95	-0.61	-1.32	-1.34	-1.72	-1.43	-1.19	-1.04	-1.42	-0.97	-1.04	-0.99
18	-0.90	-0.57	-1.26	-1.49	-1.47	-1.49	-0.83	-1.02	-1.31	-0.95	-1.30	-1.19
19	-0.71	-0.46	-1.15	-1.56	-1.42	-1.04	-0.88	-1.17	-1.29	-0.89	-1.70	-1.33
20	-1.27	-0.81	-1.44	-1.18	-1.49	-1.40	-0.98	-1.26	-1.20	-0.90	-1.00	-1.13
21	-0.95	-1.24	-1.26	-1.25	-1.58	-1.48	-1.04	-1.31	-1.31	-0.85	-0.97	-1.08
22	-0.91	-0.96	-1.48	-1.31	-1.23	-1.41	-1.13	-1.41	-1.23	-0.85	-0.53	-1.12
23	-0.57	-1.30	-1.42	-1.19	-1.24	-1.56	-1.27	-1.38	-1.10	-0.83	-1.17	-1.39
24	-0.81	-1.76	-1.41	-1.21	-1.37	-1.43	-1.31	-1.32	-1.05	-0.77	-1.44	-1.45
25	-1.24	-1.41	-1.51	-1.34	-1.56	-1.40	-1.26	-1.33	-1.02	-0.87	-1.60	-0.98
26	-1.68	-1.28	-1.37	-0.98	-1.58	-1.43	-1.22	-1.31	-1.16	-1.08	-1.44	-0.34
27	-1.66	-1.56	-1.02	-1.14	-1.45	-1.47	-1.22	-1.32	-0.89	-1.03	-1.32	-0.29
28	-1.68	-1.85	-0.97	-1.23	-1.47	-1.63	-1.00	-1.29	-1.09	-1.00	-1.33	-0.25
29	-1.81	-1.56	-0.90	-1.01	-1.29	-1.62	-0.87	-1.27	-1.20	-0.99	-1.17	-0.36
30	-1.78	-1.58	-0.53	-0.65		-1.57	-1.23	-1.30	-1.24	-1.17	-1.14	-0.47
31	-1.77		-0.70	-1.17		-1.53		-1.16		-1.12	-1.23	
Max	-0.25	-0.46	-0.53	-0.63	-1.17	-1.04	-0.83	-0.58	-0.89	-0.72	-0.53	0.35
Min	-1.81	-1.85	-1.51	-1.56	-1.72	-1.85	-1.58	-1.41	-1.46	-1.28	-1.70	-1.45
Mean	-1.05	-1.23	-1.22	-1.21	-1.44	-1.48	-1.23	-1.14	-1.24	-1.02	-1.13	-0.79

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Gage Height, Feet, NGVD 1988, Water Year October 2007 to September 2008
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-0.46	-0.65	-0.69	-0.18	-0.19	-0.67	-0.51	-0.30	-0.17	-0.09	0.11	0.36
2	-0.44	-0.41	-0.41	-0.82	-0.50	-0.82	-0.53	0.11	-0.16	-0.05	0.03	-0.18
3	0.54	-0.12	-0.46	-0.71	-0.50	-0.59	-0.43	0.20	-0.16	-0.06	-0.02	-0.18
4	0.36	0.04	-0.59	-0.31	-0.42	-0.40	-0.31	0.17	-0.12	-0.13	-0.08	-0.07
5	0.32	0.09	-0.34	-0.21	-0.33	-0.35	-0.09	-0.01	-0.02	-0.08	-0.11	0.07
6	0.13	0.33	-0.27	-0.12	-0.22	-0.62	-0.38	-0.04	-0.10	-0.10	-0.20	0.37
7	0.45	0.10	-0.15	-0.01	-0.39	-0.47	-0.44	-0.01	-0.21	-0.06	-0.32	0.07
8	0.39	-0.27	-0.21	-0.05	-0.56	0.17	-0.46	0.35	-0.30	-0.10	-0.15	-0.20
9	0.35	-0.47	-0.19	-0.12	-0.68	-0.91	-0.44	0.23	-0.31	-0.06	-0.10	-0.25
10	0.37	-0.45	-0.17	-0.32	-0.86	-0.85	-0.16	0.04	-0.34	0.02	-0.12	1.06
11	0.14	-0.69	-0.18	-0.28	-1.04	-0.53	-0.13	0.02	-0.52	-0.05	-0.19	1.13
12	-0.02	-0.59	-0.20	-0.30	-0.50	-0.27	-0.15	-0.22	-0.52	-0.09	-0.19	0.44
13	-0.04	-0.62	-0.34	-0.30	-0.14	-0.57	-0.36	-0.46	-0.41	0.05	0.14	0.24
14	-0.17	-0.65	-0.36	-0.74	-0.71	-0.64	-0.49	-0.41	-0.48	-0.05	0.19	0.23
15	-0.18	-0.41	-0.06	-0.99	-0.71	-0.42	-0.91	0.06	-0.35	0.12	0.15	0.14
16	0.12	-0.12	0.31	-0.91	-0.74	-0.40	-0.94	0.23	-0.13	0.15	-0.15	-0.01
17	0.15	0.04	-0.87	0.04	-0.56	-0.76	-0.68	0.11	-0.16	0.18	-0.12	-0.09
18	0.24	0.09	-0.61	-0.33	-0.35	-0.48	-0.15	0.13	-0.06	0.22	-0.28	-0.17
19	0.28	0.33	-0.25	-0.22	-0.84	-0.14	0.06	0.09	-0.08	0.16	-1.03	-0.25
20	-0.04	0.10	-0.20	-0.30	-0.97	-0.45	0.14	0.08	0.00	0.17	-0.38	-0.06
21	-0.06	-0.27	-0.20	-0.61	-0.73	-0.98	0.12	-0.05	-0.19	0.03	-0.19	0.03
22	-0.10	0.14	-0.30	-0.23	-0.48	-0.67	0.01	-0.11	-0.06	-0.04	0.01	0.09
23	0.11	-0.20	-0.17	-0.08	-0.42	-0.63	-0.17	-0.08	-0.02	-0.09	-0.28	-0.27
24	0.05	-0.48	-0.17	-0.29	-0.71	-0.85	-0.28	-0.08	-0.13	0.02	-0.29	-0.55
25	-0.31	-0.05	-0.23	-0.70	-0.68	-1.18	-0.02	-0.50	-0.27	-0.01	-0.27	-0.19
26	-0.63	0.09	-0.12	-0.35	-0.42	-0.71	0.06	-0.48	-0.24	-0.09	-0.16	0.35
27	-0.47	-0.20	0.06	-0.24	-0.82	-0.59	0.03	-0.50	-0.08	0.11	-0.05	0.38
28	-0.45	-0.59	0.03	-0.62	-1.01	-0.61	0.17	-0.40	-0.07	0.25	-0.11	0.52
29	-0.69	-0.40	0.00	-0.28	-0.69	-0.67	-0.29	-0.52	-0.03	0.39	-0.09	0.48
30	-0.59	-0.57	0.09	-0.06		-0.78	-0.58	-0.56	-0.06	0.34	-0.25	0.36
31	-0.62		-0.17	-0.10		-0.68		-0.34		0.14	0.04	
Max	0.54	0.33	0.31	0.04	-0.14	0.17	0.17	0.35	0.00	0.39	0.19	1.13
Min	-0.69	-0.69	-0.87	-0.99	-1.04	-1.18	-0.94	-0.56	-0.52	-0.13	-1.03	-0.55
Mean	-0.04	-0.23	-0.24	-0.35	-0.59	-0.60	-0.28	-0.10	-0.19	0.04	-0.14	0.13

Date Processed 10/10/07

Drainage Area mi2

Hydrologic Data Collection, Inc.

Little Manatee River at US Highway 41

Temperature, Water (Deg. C°), Water Year October 2006 to September 2007

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	29.7	26.2	23.5	22.0	18.3	24.1	25.7	28.3	25.4	31.0	30.3	31.9
2	30.2	25.3	23.8	21.5	19.6	24.5	26.1	28.2	24.8	31.0	29.5	32.0
3	29.4	24.7	24.2	22.4	19.3	24.1	26.8	28.4	26.3	31.5	30.4	32.2
4	28.6	24.1	23.6	23.0	18.6	22.6	27.1	29.0	27.6	30.9	31.8	32.5
5	28.2	23.0	21.6	23.0	17.3	21.1	26.6	29.1	28.8	32.1	32.3	32.7
6	28.2	23.5	21.2	24.3	17.1	19.5	25.7	29.2	28.4	31.5	32.7	32.2
7	28.8	23.1	20.9	24.5	18.1	20.1	23.1	28.1	29.2	32.5	33.7	31.5
8	28.8	23.9	20.1	24.5	18.9	20.8	21.4	25.9	30.6	33.0	34.1	30.6
9	28.3	23.9	17.6	23.0	19.4	21.7	20.8	25.4	30.8	33.1	33.2	30.2
10	28.2	24.0	17.5	19.9	19.7	22.4	19.9	26.4	31.8	32.6	33.4	30.1
11	27.9	24.5	19.0	18.2	18.7	23.2	23.1	27.3	32.2	33.4	33.4	30.9
12	28.1	25.0	19.6	18.6	18.3	23.3	25.0	27.6	32.1	33.5	32.9	31.5
13	28.5	23.9	20.1	19.7	19.1	23.8	26.3	28.3	31.5	33.3	33.0	31.8
14	28.1	23.5	20.8	20.6	21.1	23.3	26.9	28.3	30.7	33.0	32.8	32.2
15	26.8	23.4	21.1	21.1	20.4	23.5	25.4	27.6	30.2	33.0	32.2	32.0
16	26.6	22.6	20.6	22.5	17.4	23.8	23.5	27.4	30.6	32.4	32.3	32.8
17	26.1	22.2	21.6	22.5	16.5	22.6	22.5	28.2	30.8	32.7	32.4	32.7
18	27.4	20.9	22.1	21.9	16.7	21.4	22.9	28.6	31.0	33.0	32.4	31.6
19	28.2	19.9	22.6	22.0	15.8	21.0	23.6	27.8	30.5	33.1	32.2	31.1
20	29.0	18.9	22.4	21.9	17.0	21.9	24.4	26.5	30.8	32.5	32.5	28.8
21	29.5	17.4	21.9	21.5	19.0	21.9	24.0	26.5	30.6	33.0	32.8	29.1
22	29.7	16.4	22.0	22.2	20.0	22.0	24.4	26.2	31.9	31.7	32.6	28.2
23	29.2	17.8	23.0	22.5	20.4	23.2	24.5	25.8	31.8	31.0	32.5	29.1
24	27.4	19.1	23.6	22.2	20.1	23.5	24.9	26.6	31.9	30.0	33.0	29.5
25	23.0	20.2	23.5	20.2	20.7	23.9	25.5	26.9	32.7	31.6	32.3	29.5
26	23.7	21.1	22.6	18.1	21.4	24.0	27.1	27.0	32.3	32.7	30.7	29.6
27	24.4	21.6	20.3	17.2	23.6	24.0	27.8	27.3	31.1	32.4	32.2	30.0
28	24.9	22.8	19.2	18.2	24.1	25.2	27.9	27.6	30.4	31.4	32.5	31.0
29	24.7	23.0	19.5	17.4		25.6	27.8	27.8	30.2	31.7	32.7	30.8
30	24.6	23.9	21.0	15.8		25.9	27.8	26.7	31.0	31.4	32.8	29.8
31	25.1		22.1	17.0		26.0		25.9		30.5	32.1	
Max	30.2	26.2	24.2	24.5	24.1	26.0	27.9	29.2	32.7	33.5	34.1	32.8
Min	23.0	16.4	17.5	15.8	15.8	19.5	19.9	25.4	24.8	30.0	29.5	28.2
Mean	27.5	22.3	21.4	20.9	19.2	23.0	24.9	27.4	30.3	32.1	32.4	30.9

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Temperature, Water (Deg. C°), Water Year October 2006 to September 2007
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	27.8	23.5	22.4	21.1	16.0	22.5	23.2	25.0	23.8	29.1	28.9	29.7
2	28.3	24.3	22.4	20.7	18.2	22.9	23.7	25.5	23.1	29.3	28.0	30.0
3	27.5	23.7	23.0	20.4	18.5	22.1	24.0	25.8	23.9	29.0	27.2	30.2
4	27.2	22.2	21.6	21.7	17.2	20.8	24.6	26.3	25.2	29.8	28.7	30.2
5	26.2	21.3	19.7	21.5	15.6	18.5	25.1	26.8	26.2	29.4	29.8	30.3
6	26.1	21.8	19.1	22.0	14.5	17.3	22.9	27.2	27.4	30.6	31.0	29.7
7	26.2	22.3	19.5	23.1	15.4	17.8	21.0	25.9	26.7	30.2	31.0	29.2
8	26.8	22.3	17.2	22.9	16.4	18.5	19.4	23.2	27.3	30.9	31.8	28.7
9	26.3	22.1	15.0	19.8	17.3	19.5	19.3	23.3	28.0	31.1	31.6	28.8
10	25.7	22.1	15.0	17.4	18.0	20.6	19.2	24.2	29.1	31.3	31.0	28.2
11	26.1	22.6	16.4	16.7	17.5	21.3	19.3	25.2	29.5	31.0	31.2	28.5
12	26.4	22.9	18.0	17.0	17.8	21.7	21.4	25.9	30.0	30.8	30.3	29.3
13	26.6	22.2	19.2	18.1	18.0	22.1	22.6	26.1	29.7	31.1	29.7	29.3
14	26.1	21.5	19.8	19.0	18.9	22.3	23.5	26.4	28.2	31.1	30.1	29.2
15	25.6	21.5	20.2	19.6	17.5	21.8	23.6	25.8	27.7	30.5	29.8	30.1
16	24.5	21.8	20.2	20.4	15.4	22.7	21.0	25.3	28.3	30.8	29.1	30.3
17	24.2	20.8	20.2	21.0	14.2	20.7	19.3	26.0	28.2	30.2	29.8	30.5
18	24.7	19.6	21.0	20.9	14.6	19.5	20.0	26.5	28.8	30.7	30.0	30.0
19	26.0	18.9	21.1	20.6	13.4	18.5	21.2	26.3	29.2	30.8	30.5	28.4
20	26.8	16.8	20.9	20.2	14.0	19.4	22.2	24.1	29.0	31.0	30.2	26.8
21	27.4	15.3	20.5	19.3	15.8	19.9	22.1	24.1	28.9	31.1	30.4	26.4
22	27.9	14.7	20.7	20.2	17.7	20.2	22.0	24.4	29.2	29.8	30.1	27.5
23	27.2	15.0	21.3	21.5	18.5	20.8	22.0	24.4	29.6	30.0	30.0	26.9
24	22.0	16.1	22.0	20.0	18.5	21.6	22.7	24.5	29.8	28.1	30.2	27.4
25	20.2	17.6	22.3	18.0	19.0	22.0	23.5	24.6	30.1	28.1	29.7	27.6
26	21.0	18.8	20.3	16.4	20.3	22.2	23.9	24.6	29.8	29.6	29.5	27.6
27	21.7	20.3	18.2	16.2	21.3	22.8	25.2	24.6	29.1	29.8	28.8	28.0
28	23.5	20.4	17.8	17.2	22.1	22.5	25.9	24.9	28.6	29.9	29.5	28.4
29	21.0	21.1	18.2	15.6		23.5	25.4	25.4	28.3	29.8	30.2	29.1
30	22.4	21.7	19.5	14.8		23.3	25.2	25.2	28.6	29.5	30.5	27.9
31	21.9		20.7	14.8		23.4		24.4		29.4	30.3	
Max	28.3	24.3	23.0	23.1	22.1	23.5	25.9	27.2	30.1	31.3	31.8	30.5
Min	20.2	14.7	15.0	14.8	13.4	17.3	19.2	23.2	23.1	28.1	27.2	26.4
Mean	25.2	20.5	19.8	19.3	17.2	21.0	22.5	25.2	28.0	30.1	29.9	28.8

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Temperature, Water (Deg. C°), Water Year October 2006 to September 2007
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	28.9	24.4	22.9	21.8	17.1	23.2	24.4	26.5	24.5	30.1	29.7	31.0
2	29.0	24.7	23.1	21.2	19.2	23.7	24.8	26.8	24.0	30.0	28.7	31.2
3	28.4	24.2	23.6	21.4	18.9	23.1	25.5	27.2	24.9	30.2	28.5	31.2
4	27.8	23.0	23.1	22.4	17.8	21.5	25.9	27.6	26.3	30.3	29.9	31.4
5	27.2	22.3	20.8	22.4	16.4	19.7	25.9	27.9	27.4	30.6	31.0	31.5
6	27.2	22.7	20.1	23.2	15.8	18.7	24.3	28.1	27.9	31.0	31.9	30.9
7	27.6	22.7	20.3	23.9	16.8	19.0	21.9	26.8	27.9	31.4	32.1	30.2
8	27.9	23.1	18.6	23.9	17.7	19.8	20.4	24.4	28.6	32.0	32.4	29.6
9	27.5	23.1	16.4	21.4	18.4	20.5	19.9	24.4	29.2	32.1	32.1	29.4
10	27.1	23.2	16.4	18.4	18.7	21.5	19.5	25.3	30.2	32.1	32.1	29.4
11	27.1	23.6	17.7	17.4	18.1	22.2	20.4	26.1	30.5	32.0	32.1	29.7
12	27.3	23.9	18.8	17.8	18.0	22.5	22.9	26.5	30.9	32.0	31.5	30.4
13	27.7	23.1	19.6	18.8	18.5	22.9	24.0	27.0	30.4	32.1	31.4	30.6
14	27.4	22.4	20.1	19.8	19.9	22.6	24.8	27.1	29.3	32.0	31.4	30.8
15	26.2	22.2	20.5	20.4	18.9	22.7	24.8	26.5	29.0	31.8	30.9	31.1
16	25.5	22.4	20.4	21.4	16.9	23.2	21.8	26.3	29.3	31.5	30.6	31.4
17	25.1	21.5	20.9	21.7	15.4	21.9	20.8	27.0	29.3	31.4	31.1	31.5
18	25.8	20.4	21.5	21.4	15.4	20.2	21.4	27.5	29.8	31.8	31.2	31.0
19	26.9	19.4	21.8	21.3	14.7	19.8	22.4	26.9	29.8	31.8	31.3	29.3
20	27.8	18.3	21.7	21.0	15.5	20.5	23.2	25.5	30.0	31.7	31.4	27.6
21	28.4	16.7	21.3	20.5	17.3	20.9	23.1	25.3	29.8	31.8	31.8	27.5
22	28.8	15.6	21.5	21.4	18.8	21.2	23.2	25.3	30.4	30.9	31.5	27.7
23	28.4	16.5	22.3	22.1	19.4	21.9	23.1	25.2	30.7	30.4	31.2	27.7
24	23.9	17.7	22.9	21.3	19.3	22.6	23.5	25.4	30.8	29.0	31.0	28.2
25	21.8	18.9	22.9	19.1	19.6	22.8	24.4	25.5	31.3	29.5	30.5	28.5
26	22.5	20.0	21.6	17.1	20.7	23.0	25.2	25.5	30.9	30.7	30.1	28.6
27	23.3	21.0	19.3	16.7	22.2	23.3	26.2	25.7	29.9	30.9	30.2	28.9
28	24.1	21.7	18.4	17.7	23.1	23.7	26.7	26.0	29.5	30.7	30.9	29.6
29	23.4	22.1	18.8	16.4		24.4	26.3	26.3	29.3	30.6	31.5	29.9
30	23.6	22.5	20.2	15.5		24.4	26.4	25.9	29.7	30.5	31.8	29.0
31	23.6		21.4	16.0		24.4		25.1		30.0	31.3	
Max	29.0	24.7	23.6	23.9	23.1	24.4	26.7	28.1	31.3	32.1	32.4	31.5
Min	21.8	15.6	16.4	15.5	14.7	18.7	19.5	24.4	24.0	29.0	28.5	27.5
Mean	26.4	21.4	20.6	20.1	18.2	22.0	23.6	26.2	29.0	31.1	31.1	29.8

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Drainage Area mi2

Little Manatee River at US Highway 41

Temperature, Water (Deg. C°), Water Year October 2007 to September 2008

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	28.9	26.0	24.6	23.7	19.6	19.3	25.8	26.6	31.3	30.9	29.3	29.0
2	27.9	26.5	25.3	20.9	19.8	20.6	26.5	26.7	31.3	30.9	30.3	30.0
3	28.4	25.2	25.4	14.0	21.2	21.8	26.7	26.5	31.2	29.2	31.3	30.7
4	28.5	24.7	24.1	12.6	22.5	21.6	27.1	27.5	31.4	30.3	30.8	30.8
5	28.6	23.7	21.4	14.4	22.9	22.7	27.3	28.0	31.4	31.3	30.2	29.6
6	27.2	23.0	21.8	16.6	23.3	22.1	26.3	27.5	31.5	31.4	30.7	30.3
7	28.0	22.0	22.0	18.6	23.8	23.1	26.1	27.5	31.4	30.8	31.7	30.8
8	28.1	21.3	23.2	20.1	23.9	22.3	25.9	27.9	30.5	30.0	31.2	30.8
9	28.5	20.6	23.7	20.6	23.5	20.0	26.3	28.5	31.5	30.3	30.5	30.2
10	28.9	20.9	24.1	21.3	22.3	20.0	26.6	29.4	31.3	31.5	30.6	29.8
11	29.6	21.7	24.3	21.6	21.0	21.1	26.8	29.6	31.4	31.8	31.1	29.8
12	28.9	22.2	24.6	22.0	20.0	22.3	27.6	29.5	31.5	30.8	30.7	31.5
13	28.7	23.0	24.9	22.6	20.3	21.7	26.2	28.9	31.5	30.0	29.7	31.8
14	28.3	23.7	24.9	22.2	19.2	21.2	23.4	28.7	32.3	31.5	28.9	31.3
15	28.1	24.1	25.1	19.8	19.7	22.9	21.5	28.3	31.7	30.7	29.3	31.4
16	27.6	22.9	24.4	17.9	21.1	24.7	21.6	28.7	30.3	29.4	29.9	31.4
17	28.3	20.3	22.0	18.6	21.7	24.6	22.8	29.5	31.3	29.1	31.2	31.7
18	29.2	21.6	18.9	18.6	22.9	24.0	23.3	29.1	31.5	30.6	30.5	31.5
19	29.5	22.3	19.2	19.7	22.4	24.2	24.2	28.4	30.7	31.7	28.0	31.1
20	29.1	22.8	19.2	19.2	20.8	24.4	25.7	27.9	31.7	32.6	28.0	31.1
21	28.5	22.5	20.4	17.0	20.8	24.0	25.7	29.1	30.3	33.0	28.6	30.9
22	29.7	21.9	19.5	18.1	22.8	23.2	25.9	28.4	30.2	32.3	28.6	30.4
23	29.5	22.0	20.8	20.2	22.9	23.7	25.7	29.3	31.2	31.7	28.4	29.8
24	28.5	22.0	21.7	20.2	23.3	23.0	25.5	30.4	31.1	30.0	28.8	29.0
25	26.5	23.0	22.2	19.6	24.4	20.5	26.0	30.3	29.9	31.3	30.7	27.7
26	26.4	24.0	22.1	19.0	24.5	20.5	26.4	28.7	28.8	31.9	31.3	27.7
27	25.9	24.6	22.4	19.6	24.1	21.2	26.7	27.6	29.2	30.9	32.0	27.8
28	26.2	24.5	23.0	18.6	19.5	22.6	26.1	29.7	30.5	31.3	31.6	27.1
29	26.0	25.1	23.7	18.1	18.2	23.9	26.0	29.9	31.1	30.4	31.0	27.3
30	25.2	24.7	23.9	19.0		24.3	26.3	30.5	31.8	29.8	30.2	27.8
31	25.9		24.0	19.7		24.2		30.6		30.4	28.6	
Max	29.7	26.5	25.4	23.7	24.5	24.7	27.6	30.6	32.3	33.0	32.0	31.8
Min	25.2	20.3	18.9	12.6	18.2	19.3	21.5	26.5	28.8	29.1	28.0	27.1
Mean	28.0	23.1	22.8	19.2	21.8	22.4	25.6	28.7	31.0	30.9	30.1	30.0

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Temperature, Water (Deg. C°), Water Year October 2007 to September 2008
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	26.1	24.4	22.9	21.1	18.2	17.2	22.9	23.5	28.5	28.8	27.0	27.1
2	26.2	24.3	23.0	14.0	17.4	14.7	24.1	23.4	28.9	28.3	26.7	27.8
3	25.8	23.5	23.3	10.9	19.0	19.0	24.6	24.1	28.9	27.5	27.4	28.4
4	27.5	22.5	21.1	10.8	20.2	20.8	24.4	24.6	29.2	27.1	28.2	28.9
5	26.5	21.8	20.4	12.1	21.0	20.8	24.9	25.7	29.3	28.1	27.9	28.4
6	26.0	21.3	20.0	14.2	21.0	21.1	24.6	25.4	29.3	28.9	27.9	27.5
7	25.7	21.3	20.3	16.2	21.9	21.1	24.0	25.2	29.2	28.9	28.7	28.8
8	25.8	19.3	21.4	17.8	22.9	19.4	23.9	25.7	28.9	27.9	30.0	29.2
9	26.1	18.9	21.8	18.3	22.2	17.7	23.2	26.5	28.7	27.3	29.1	28.9
10	26.6	18.7	22.4	19.1	20.5	18.0	23.6	27.2	28.5	28.2	28.8	28.1
11	27.1	19.4	22.7	19.6	19.4	19.1	23.9	27.9	28.7	29.4	29.3	28.2
12	26.7	19.6	22.7	20.2	19.1	20.3	24.8	27.3	28.5	29.5	28.8	28.3
13	26.4	20.5	22.9	21.2	19.1	20.0	23.3	26.5	28.8	28.9	28.5	28.7
14	26.2	21.5	23.7	19.8	18.0	19.7	21.1	25.9	28.5	28.9	27.4	29.0
15	25.6	22.0	23.7	17.5	14.2	19.6	19.8	25.7	29.7	29.3	27.2	29.1
16	25.9	19.0	22.0	16.1	15.3	22.0	12.7	26.1	29.0	28.0	27.5	29.5
17	26.3	17.4	18.1	16.6	19.8	22.2	18.8	27.0	28.6	27.0	27.6	29.3
18	27.3	18.9	16.9	18.1	21.1	22.0	19.7	27.5	29.2	27.0	27.9	29.1
19	28.0	19.9	17.2	18.3	21.0	21.9	20.9	27.3	28.9	27.7	26.7	28.8
20	28.0	20.5	17.9	16.1	15.5	22.6	22.5	26.9	28.9	28.8	26.4	28.7
21	27.2	20.9	18.8	14.9	18.7	21.6	22.5	26.5	28.3	29.9	26.8	28.9
22	27.3	21.2	18.9	14.9	19.8	21.3	23.3	27.7	27.6	30.0	27.1	29.2
23	27.6	21.1	18.9	17.3	21.8	21.0	23.3	27.1	28.3	29.5	27.6	28.1
24	26.6	20.2	19.9	19.1	21.9	20.6	23.5	27.8	28.4	28.9	27.0	26.9
25	25.5	20.8	20.3	17.9	22.5	6.9	23.6	28.4	27.3	28.6	27.5	25.3
26	24.3	21.5	20.8	16.9	23.1	14.4	24.1	27.0	26.5	29.8	28.8	25.2
27	25.0	22.5	20.5	17.8	19.6	18.4	24.3	25.9	26.3	29.2	28.5	25.3
28	24.6	23.1	21.4	17.0	5.0	19.9	25.2	25.8	27.5	29.5	28.3	25.9
29	24.6	23.0	22.1	16.7	8.9	21.3	24.8	26.8	28.0	28.5	28.5	26.2
30	24.0	23.8	22.8	17.3		22.5	23.5	27.5	28.3	27.9	27.8	26.1
31	23.9		23.2	18.4		21.7		27.5		27.6	26.9	
Max	28.0	24.4	23.7	21.2	23.1	22.6	25.2	28.4	29.7	30.0	30.0	29.5
Min	23.9	17.4	16.9	10.8	5.0	6.9	12.7	23.4	26.3	27.0	26.4	25.2
Mean	26.1	21.1	21.0	17.0	18.9	19.6	22.9	26.4	28.5	28.5	27.9	28.0

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Temperature, Water (Deg. C°), Water Year October 2007 to September 2008
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	27.6	25.2	23.7	23.2	19.0	18.3	24.2	24.5	29.6	29.5	28.3	27.9
2	27.1	25.3	23.9	17.7	18.8	19.1	25.1	24.7	30.0	29.1	28.2	28.6
3	27.0	24.3	24.1	12.4	20.1	20.3	25.5	25.1	30.0	28.3	29.0	29.3
4	27.9	23.4	22.5	11.9	21.2	21.1	25.7	25.9	30.3	28.5	29.1	29.7
5	27.8	22.6	20.8	13.3	22.0	21.6	25.9	26.6	30.3	29.5	28.8	29.0
6	26.5	22.1	20.9	15.3	22.4	21.6	25.5	26.4	30.3	29.9	29.2	29.1
7	26.7	21.7	21.2	17.3	23.0	21.9	24.9	26.3	30.1	29.5	30.3	30.0
8	26.8	20.4	22.3	18.8	23.4	21.2	24.6	26.7	29.6	29.1	30.7	30.2
9	27.1	19.9	22.8	19.7	22.6	19.1	24.5	27.4	29.5	28.6	29.7	29.5
10	27.6	19.9	23.3	20.4	21.3	19.1	24.7	28.2	29.6	29.9	29.7	28.8
11	28.2	20.6	23.5	20.8	20.3	20.0	25.1	28.7	29.9	30.5	30.0	28.9
12	28.0	21.2	23.8	21.3	19.4	21.2	26.0	28.3	29.9	30.2	29.7	29.4
13	27.7	21.8	24.0	22.1	19.7	20.9	25.1	27.4	29.8	29.4	29.0	29.9
14	27.4	22.7	24.3	20.9	18.8	20.5	22.4	26.9	30.3	29.8	28.3	30.1
15	27.1	23.2	24.5	18.6	18.6	21.0	20.5	26.7	30.4	29.6	28.0	30.3
16	27.0	20.8	23.6	17.1	19.6	23.0	19.3	27.2	29.4	28.7	28.4	30.5
17	27.4	19.0	20.0	17.3	20.8	23.4	20.2	27.9	29.6	28.1	28.9	30.5
18	28.3	20.1	17.7	18.2	22.0	22.9	21.2	28.2	30.1	28.4	28.8	30.4
19	28.9	21.0	17.9	18.9	21.8	22.9	22.5	27.8	29.7	29.3	27.4	30.2
20	28.5	21.3	18.4	18.0	19.9	23.3	23.8	27.3	30.1	30.4	27.1	30.0
21	27.9	21.4	19.5	15.9	19.7	22.7	24.1	27.7	29.4	31.1	27.5	30.0
22	28.2	21.5	19.3	16.7	21.2	21.8	24.6	28.0	28.8	31.2	27.8	29.8
23	28.3	21.6	19.9	18.9	22.4	22.2	24.6	28.0	29.4	30.5	28.1	28.9
24	27.4	21.1	20.8	19.7	22.7	22.1	24.5	28.9	29.5	29.4	28.0	28.0
25	25.8	22.0	21.2	18.7	23.5	16.0	24.7	29.2	28.9	29.9	28.9	26.6
26	25.3	22.9	21.5	18.0	23.9	18.4	25.1	27.8	27.5	30.5	29.6	26.3
27	25.5	23.7	21.5	18.8	22.0	19.8	25.4	26.7	27.9	30.3	29.7	26.6
28	25.4	23.8	22.2	17.9	14.7	21.1	25.7	27.2	28.8	30.2	29.6	26.6
29	25.4	24.2	22.9	17.6	16.0	22.4	25.4	28.0	29.3	29.8	29.6	26.7
30	24.8	24.1	23.4	18.2		23.3	24.7	28.6	29.7	29.1	29.0	26.9
31	25.0		23.6	18.9		23.5		28.8		28.8	27.8	
Max	28.9	25.3	24.5	23.2	23.9	23.5	26.0	29.2	30.4	31.2	30.7	30.5
Min	24.8	19.0	17.7	11.9	14.7	16.0	19.3	24.5	27.5	28.1	27.1	26.3
Mean	27.1	22.1	21.9	18.1	20.7	21.2	24.2	27.3	29.6	29.6	28.8	29.0

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Drainage Area mi2

Little Manatee River at US Highway 41

Conductance, (Microsiemens/cm at 25° C), Water Year October 2006 to September 2007

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	21900	36420	36320	38640	34090	38060	37820	41810	47260	50130	44300	39810
2	23900	36530	38190	37310	35220	38950	38230	42930	45740	47830	36140	40940
3	35110	35420	38460	35690	29430	36950	37760	43230	45380	49910	21810	41210
4	36260	33440	38760	37190	20060	30240	38390	44990	46490	48770	23050	40130
5	33790	36400	34490	38470	16700	27310	40680	46750	48730	48470	24730	40950
6	36960	37510	36320	37850	20190	29250	36980	46840	49240	44700	30310	42650
7	35080	38560	36560	37520	27590	34810	34050	43230	49920	43730	36120	42460
8	35940	39310	32130	37130	27410	34310	33930	42680	43570	46370	40540	42740
9	34730	37390	28150	27160	28760	35990	35350	43280	43360	48450	42810	42720
10	36290	35440	31890	28990	27830	36730	34220	43070	46200	48820	42460	42040
11	38050	36660	32990	33100	29690	36860	36430	41900	47550	49150	43320	42290
12	38470	36360	34520	35320	32450	38760	24900	42770	49500	48560	40280	41870
13	38710	32620	34700	36530	35630	39800	28150	43020	48830	49650	40280	40630
14	32780	32810	35650	37940	31550	39580	34510	44300	48710	50160	40440	37000
15	34090	36830	34270	38790	31430	41210	39360	45050	48750	50530	37730	36600
16	37520	37320	37520	39350	27470	40960	28200	46150	48910	49740	31050	32300
17	39120	29410	37880	39590	24400	39260	25270	47390	48890	48860	30040	36530
18	37490	29270	38810	36810	31280	33720	35970	47270	49220	48400	29860	32590
19	37320	31300	39000	37120	19510	33080	34960	45870	48260	44650	33970	36590
20	37450	32450	38100	36570	24590	32830	36750	46010	48020	43390	36890	37530
21	38970	28890	38230	34900	29460	35900	36100	46380	45830	44690	40540	40530
22	38880	27680	38380	36900	30380	36130	40050	46030	44490	43150	42930	37600
23	42080	28090	39490	35410	30620	37810	39910	44110	46310	43930	43830	36490
24	31880	30520	38460	34310	36240	39420	39880	44210	46340	42000	45150	37940
25	35750	29990	39220	29660	36700	38420	40260	44290	45990	43350	44970	38130
26	37120	30230	33090	31480	35520	39250	38830	45090	47410	44040	43980	39690
27	38740	30710	26400	34250	38210	38260	39030	46210	48900	43600	43720	38820
28	42300	32860	31940	30200	38020	37050	37040	46680	48710	47110	43810	37600
29	31740	33760	33460	28960		34130	36050	47590	48570	46040	43610	39020
30	33910	36170	37770	31940		35460	38560	48120	49130	46880	42670	34730
31	37040		38820	32210		38630		47320		45450	41150	
Max	42300	39310	39490	39590	38210	41210	40680	48120	49920	50530	45150	42740
Min	21900	27680	26400	27160	16700	27310	24900	41810	43360	42000	21810	32300
Mean	35786	33678	35805	35074	29658	36423	35921	44986	47474	46791	38145	39004

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Conductance, (Microsiemens/cm at 25° C), Water Year October 2006 to September 2007
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	3050	24860	21060	20350	15140	18060	19170	20970	36620	34030	25940	19920
2	2540	24330	20430	18550	18790	22600	19760	22490	33830	32600	16580	19120
3	5740	20320	21020	18230	10960	20340	17740	22930	35150	32500	6210	18000
4	9480	15520	24270	19810	7550	18320	17470	23070	31920	33470	4660	19000
5	10940	18160	18380	22150	5410	15800	17840	23610	31600	31220	4350	19020
6	11600	22180	20040	22950	5360	16060	18070	26330	32350	30390	5390	20690
7	13010	26000	23120	21950	7870	18840	17800	22500	31990	25460	7410	21050
8	12280	26040	18950	21890	8500	18990	14610	22420	32470	27920	9270	24970
9	12650	25170	16830	18540	7490	17600	15020	26220	26410	27380	11870	27070
10	13960	23820	19470	12310	7480	17820	14900	28530	29380	26860	13270	26570
11	17630	25200	22360	19030	6510	18150	12940	29050	28740	27520	13170	25340
12	15500	25290	22070	16860	8070	16600	11750	30080	28190	26290	7140	26940
13	15880	23160	22730	18560	9560	17810	8030	32270	27200	27810	6830	23780
14	13380	22810	22380	19660	11810	19560	7650	30060	28470	27330	8340	18360
15	14040	23110	22090	20900	10000	22410	17010	30190	28200	27910	8980	12590
16	18830	23820	21090	21950	8600	26830	6490	31930	31150	27750	6310	10330
17	21370	18550	21600	21970	6770	23270	7270	33500	31700	28520	6170	11990
18	20700	16300	21950	22320	6380	18020	7950	34080	33340	29520	6250	9570
19	18580	15300	22840	23960	6230	16430	12050	31730	34240	28350	7600	11030
20	18830	16040	22900	24020	9070	15000	10530	29550	32660	24840	8880	12540
21	19090	13930	24660	23630	9000	16130	9340	31860	34480	26950	11140	17950
22	17080	16160	26910	27170	9670	14860	11060	33530	31500	25090	13340	16760
23	17720	14270	27360	26430	8470	14450	14210	33410	30550	23620	15250	16380
24	11400	15880	27070	25570	7980	14560	16560	33310	31670	22530	18250	18680
25	16220	16410	29320	21540	12120	14980	18960	36130	29780	23940	19640	20120
26	19130	17260	20210	15090	14850	15030	19390	36450	29300	23970	19830	19690
27	23530	17900	14360	12690	15840	16230	23380	38220	31250	23110	21040	20760
28	25830	19560	14400	18690	16520	17990	24170	37380	31290	24680	21780	19250
29	17960	21080	13570	11020		18330	20930	37150	32370	27320	22610	19120
30	18940	21240	13950	10870		17390	20620	37270	32350	27840	20460	15640
31	23510		17300	12980		18880		37150		28660	22180	
Max	25830	26040	29320	27170	18790	26830	24170	38220	36620	34030	25940	27070
Min	2540	13930	13570	10870	5360	14450	6490	20970	26410	22530	4350	9570
Mean	15497	20322	21119	19730	9714	17979	15089	30431	31338	27593	12585	18741

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Conductance, (Microsiemens/cm at 25° C), Water Year October 2006 to September 2007
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	11600	30870	28890	29180	25650	28990	28490	31620	42800	42720	33570	30000
2	12980	30690	29510	26960	25710	29640	28980	32430	41030	40700	27550	29130
3	15730	27470	29890	27060	18500	26600	28140	33160	40330	41860	13160	28860
4	19870	24250	30180	29520	12960	24200	27860	34750	39900	41770	10290	28380
5	20220	29260	28800	30670	10310	21380	30410	36430	40690	40380	10680	29660
6	23750	31600	28700	30370	11460	21810	27430	37850	41290	38370	15020	32230
7	24850	33810	30110	29720	16390	26270	24730	31290	40940	36330	18950	31720
8	24460	33030	24990	29690	16010	25790	23830	33890	37840	36960	23550	33800
9	24120	31640	23710	23500	15160	26760	24350	36260	35390	38330	27040	34320
10	25630	30370	27000	20720	16720	26900	23570	36970	37470	38320	26710	34190
11	28290	30950	28870	25290	15230	27000	24960	35980	38510	39490	28500	33710
12	27180	30680	27710	27130	19740	27520	18520	37450	40270	39340	22410	34760
13	27090	28780	28230	27330	21630	28660	14730	37890	39730	40040	19430	33370
14	22840	27760	28850	28420	20970	29780	20600	38020	40150	40270	21320	28280
15	24690	29710	29240	29690	17850	32020	27970	37780	40480	40500	19700	22230
16	29300	29210	29190	30340	14950	33820	13920	40860	41580	39220	15550	20640
17	30300	24090	29830	30050	15510	29610	15670	41930	41160	39040	16570	22350
18	28830	23500	30720	30780	17290	25150	21570	41600	42260	38970	15300	19380
19	28020	23620	30260	30140	11920	24820	23270	39030	41840	35380	17460	21330
20	29120	24060	30970	30350	16580	25120	22880	38010	41120	35220	20690	23430
21	30010	20820	32380	30660	17960	25580	21290	39930	41430	35550	25380	29870
22	30070	22780	34130	32620	18960	24230	24710	40400	39180	34370	27720	26170
23	28810	21840	34130	31400	17490	25290	26700	39820	39560	33130	29110	25590
24	21300	23050	33490	30500	21050	26880	28250	40220	39010	31970	32750	27260
25	26620	23300	34150	25370	24190	25580	30860	40760	38840	33020	32700	28640
26	28880	24660	26520	21120	24830	26710	29670	41100	38860	34390	32010	29370
27	32810	25400	20530	23230	25340	27840	31360	42160	40160	34050	31240	30530
28	34440	27140	21890	23590	26190	27620	30570	42260	40520	38250	31530	29900
29	25140	26850	23530	18270		25980	29600	43070	41150	37240	31700	28510
30	27770	28170	25640	20530		25640	29100	43720	42310	38240	31600	24620
31	30830		28150	21040		28860		43070		37040	32910	
Max	34440	33810	34150	32620	26190	33820	31360	43720	42800	42720	33570	34760
Min	11600	20820	20530	18270	10310	21380	13920	31290	35390	31970	10290	19380
Mean	25663	27312	28716	27266	18448	26840	25133	38378	40193	37757	23939	28408

Date Processed 10/29/08

Drainage Area mi2

Hydrologic Data Collection, Inc.

Little Manatee River at US Highway 41

Conductance, (Microsiemens/cm at 25° C), Water Year October 2007 to September 2008

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	39070	37000	36850	36850	32680	34090	37200	38430	49700	45590	39670	33520
2	39980	33110	39770	30390	36730	36440	36490	40660	50670	45950	34290	19450
3	41570	33430	39440	28990	37000	39430	37030	41380	51230	43900	34400	21710
4	33970	31940	36760	32400	40110	39080	34650	42690	52330	44740	24280	27080
5	32930	32640	38440	34370	40220	38620	34810	43230	52240	45990	15810	26490
6	15130	34760	38180	35880	40630	36900	31940	44050	52240	45060	13860	31460
7	19270	34390	39130	37810	40280	37630	29210	44620	51560	39330	15670	29620
8	18350	28550	39220	38960	40760	37170	31690	46550	50080	24960	27520	29570
9	24410	33240	39940	39410	38360	23260	31110	46280	46760	17820	29860	36610
10	26930	34580	40740	39300	33550	32110	40270	47120	44890	29010	15170	42920
11	23980	37470	41060	40200	34280	35540	41880	47520	45620	32070	19860	40620
12	28740	36630	41530	40120	37810	36340	41270	42120	45920	36880	23190	38850
13	28100	39790	40480	40470	37900	32670	28120	41160	44580	43240	39430	40370
14	34860	39100	40420	37160	33280	35190	27150	43700	45500	37700	34230	41290
15	35410	38660	41370	34930	36050	39790	24160	44930	47360	41100	27210	39080
16	39940	30050	42590	37050	38830	33310	21470	46020	49090	42350	25690	37140
17	38160	36700	31500	38120	40490	36190	27990	46060	47850	36570	28650	36110
18	41150	34530	33670	36010	40100	37610	34110	47850	50000	35680	22190	35900
19	42760	34750	36020	39500	37550	38580	36450	47130	47970	38020	8520	35590
20	38800	37100	38390	39310	33730	39000	38100	47240	49570	36890	16420	38250
21	37440	41160	37220	33020	35980	31490	38360	48240	46560	38050	15090	36800
22	37130	42320	37010	35960	37520	34820	38000	47830	47470	33930	18830	38230
23	39820	41940	38410	36970	37560	34600	37690	49040	39380	31370	21510	32320
24	38690	41500	38900	35550	33690	31330	39320	51020	27880	32160	33830	29700
25	31240	43010	38990	28770	35510	27670	41500	48380	20560	33840	23780	35270
26	29020	43540	39110	30770	39730	34480	41330	47530	21260	36180	32890	36980
27	31900	43100	38570	33050	28780	37090	41940	46050	30500	41060	27900	34240
28	34910	40090	38120	29070	28640	37750	41670	45350	33910	42810	26000	33370
29	32540	42220	38420	34840	35140	36980	34950	44840	38100	42780	32900	30650
30	37640	39710	40270	32850		38590	35980	46680	42920	43750	28850	29640
31	36390		39480	36900		39220		47920		41260	35780	
Max	42760	43540	42590	40470	40760	39790	41940	51020	52330	45990	39670	42920
Min	15130	28550	31500	28770	28640	23260	21470	38430	20560	17820	8520	19450
Mean	33233	37234	38710	35645	36651	35580	35195	45536	44123	38066	25590	33961

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Conductance, (Microsiemens/cm at 25° C), Water Year October 2007 to September 2008
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	18670	11370	25030	26220	13400	230	19850	21350	39090	7800	3570	1890
2	18790	13320	26940	10730	12020	190	21290	25710	38050	10640	2580	1430
3	13320	12370	26120	11590	14700	16830	13230	28900	38860	10850	2370	1740
4	7170	14840	23750	11410	16650	21990	9980	28220	39300	10200	2020	2380
5	3100	14230	22390	9710	20190	24630	10520	27450	39270	12390	1760	4450
6	1020	14500	23090	23070	23180	22840	4610	28230	39030	14730	1290	5240
7	850	13950	22410	25190	23420	22440	3510	27600	38980	15290	1390	4030
8	630	11570	23320	26410	23560	13030	2580	29720	39310	7620	2040	5290
9	720	12970	23990	28420	22380	5970	1900	31810	37670	4250	1500	7450
10	1270	13470	25500	27860	19880	9780	1430	31390	35810	4590	1370	23020
11	1220	14900	25950	29380	19040	11510	4860	32300	35620	4350	1340	18660
12	1450	14720	27700	29550	19380	13580	9140	36240	30400	4800	1540	16750
13	1820	16910	27310	29920	22360	12400	11420	29630	24480	8130	3450	17980
14	2510	18500	27430	27290	17590	10760	9890	28710	25890	8600	2700	17320
15	3870	19520	29020	23440	300	11570	9710	34530	26640	8070	1300	16080
16	9540	15200	28540	11580	320	14770	80	36180	26720	7170	1360	15260
17	11150	18370	23060	24090	10870	8100	5980	34880	25220	3050	1260	15160
18	14020	18920	22820	24400	25190	15450	12480	35920	26830	2730	1060	13780
19	16140	20190	20960	22760	21660	20570	16820	34750	25190	2670	1060	12030
20	13670	20000	22740	10190	410	17320	18010	34320	25060	2970	1850	13270
21	14070	20850	24390	8870	22220	16240	18630	34850	22240	4240	1280	13310
22	15880	23830	24180	17780	24960	17850	18920	34350	20890	6790	1830	14390
23	18680	23060	24880	21070	24010	16300	18140	32880	13900	5710	1140	12210
24	17280	20200	25670	15810	21390	14550	16440	34350	8440	6470	1040	11020
25	11120	23930	26380	6850	20470	50	17730	35270	5250	7290	1320	14130
26	7480	26160	27690	12050	18700	110	20450	330	3360	6800	1250	19110
27	7030	26160	28900	12980	17330	6890	21210	30980	3470	8080	1010	17680
28	7530	24540	28020	8670	180	15160	23180	31860	2980	5520	750	18660
29	6690	26320	28220	10910	200	16020	24920	32600	3430	5830	1340	16690
30	7850	25760	30100	13540		9290	19590	35810	5370	6230	1220	15420
31	9260		26500	12980		210		38160		5020	820	
Max	18790	26320	30100	29920	25190	24630	24920	38160	39310	15290	3570	23020
Min	630	11370	20960	6850	180	50	80	330	2980	2670	750	1430
Mean	8510	18354	25581	18539	16412	12472	12883	30945	24892	7061	1607	12194

Date Processed 10/29/08

Hydrologic Data Collection, Inc.

Little Manatee River at US Highway 41

Conductance, (Microsiemens/cm at 25° C), Water Year October 2007 to September 2008

Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	28570	23180	32060	32120	22840	22300	29120	30870	44850	24910	17710	11290
2	30230	23730	33080	25340	22910	22900	28530	33730	45700	27480	11190	6230
3	29310	23520	31890	25020	24560	27500	23300	35180	46100	25490	10620	9220
4	20530	23310	30730	28250	27220	30000	20360	36040	46820	26160	7980	12190
5	13350	23370	31310	27460	29910	31600	21120	36210	46860	28530	6430	14580
6	3490	25890	29780	29560	31690	29720	15380	36810	46060	28370	4350	16370
7	3200	23870	30340	32050	31390	30980	12690	37230	45710	26410	4550	14350
8	2640	21520	31090	33420	31270	27530	9880	39260	44850	16380	8660	15710
9	4340	23320	32450	34290	29420	16090	9840	40000	43150	9290	9460	20320
10	8780	23830	33380	34530	26550	17790	17770	39980	41100	12670	5310	34160
11	9790	25450	34120	35430	25100	22070	22560	40990	41280	13980	5910	30860
12	11220	25680	34710	35480	29810	24870	24770	38700	37580	17010	8240	26160
13	12990	28660	34340	35820	31230	21340	20770	36900	35970	22840	16960	26850
14	14900	28580	34770	32350	25230	21360	19180	36870	35250	21490	15880	28100
15	19540	28590	36540	29410	22950	25440	14620	39750	37240	23190	9200	27580
16	24250	22940	37210	28360	24030	24560	12630	41290	37920	23060	6720	26170
17	24580	28070	27260	32866	29120	23180	17330	41640	37290	15850	7370	25870
18	26740	27520	28140	30280	32230	27630	23260	42690	39270	13070	5290	24980
19	28190	27530	29630	31172	28640	30090	26100	42060	37700	13610	2720	23310
20	25660	27390	30750	28633	25370	26860	28040	41640	37850	15380	7190	25590
21	24740	31210	31360	25420	29420	23350	28740	41970	34040	16710	6730	25300
22	24490	33310	30760	27921	31490	26320	28700	41920	32760	17050	7490	25510
23	28690	31880	31890	28369	31550	26150	27490	42280	25930	16210	6330	22200
24	27310	30800	33120	24809	27790	22520	27090	43600	16460	16990	10490	20600
25	20360	34600	33490	19256	27850	9100	30060	41880	10820	17250	5770	24570
26	16960	35750	34400	22444	29860	21680	31950	38930	8920	18540	9720	27380
27	19350	34690	34190	22707	23380	24560	32260	39880	12030	22160	7920	26280
28	19680	33060	34030	17350	13520	26800	33630	39990	11930	22720	6930	25710
29	17630	34350	34390	20668	19100	26740	30090	40150	14590	23250	9780	23880
30	19970	32770	35050	20830		26870	28520	40890	19350	24300	8800	21730
31	21390		32460	23732		26810		42830		20850	12310	
Max	30230	35750	37210	35820	32230	31600	33630	43600	46860	28530	17710	34160
Min	2640	21520	27260	17350	13520	9100	9840	30870	8920	9290	2720	6230
Mean	18802	27946	32539	28237	27084	24668	23193	39425	33846	20039	8516	22102

Date Processed 10/10/07

Drainage Area mi2

Hydrologic Data Collection, Inc.

Little Manatee River at US Highway 41

Salinity, parts per thousand, Water Year October 2006 to September 2007

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	12.94	24.51	24.27	26.51	25.01	25.23	24.54	25.91	30.99	28.92	25.59	22.78
2	14.23	24.23	25.32	25.83	25.95	25.96	24.04	26.35	30.10	27.43	21.14	23.43
3	22.01	23.50	25.56	24.84	20.87	24.07	23.28	26.17	28.93	28.49	12.29	23.61
4	22.84	22.79	25.71	25.14	14.04	20.56	23.50	27.02	28.80	28.12	12.69	22.90
5	21.23	25.21	24.44	26.45	11.89	18.83	25.15	27.98	29.53	27.26	13.39	23.44
6	23.16	26.23	25.85	25.70	14.47	20.52	23.87	27.86	29.91	25.68	16.49	24.82
7	21.57	26.83	26.23	24.59	19.96	24.66	23.00	26.68	29.89	25.25	20.08	24.80
8	22.52	27.40	22.90	24.24	19.37	23.79	23.75	27.70	26.57	26.55	22.48	25.16
9	21.80	26.00	21.15	18.34	20.18	24.70	25.26	27.63	25.98	27.78	23.88	25.01
10	23.45	24.38	24.00	21.21	19.30	24.67	24.52	26.93	27.04	27.89	23.50	24.41
11	24.68	25.09	24.77	24.61	21.32	24.30	25.15	26.06	27.82	28.18	23.80	24.27
12	24.84	24.64	24.67	25.87	23.79	25.60	15.47	26.66	28.71	27.57	22.00	23.52
13	24.84	21.68	24.63	26.08	25.88	26.10	17.42	26.53	28.62	27.83	21.85	22.55
14	20.25	21.87	25.13	26.60	21.80	26.65	21.74	27.36	28.96	28.13	22.01	20.92
15	21.92	24.63	23.99	26.96	21.72	27.67	24.98	28.32	28.95	28.29	20.59	20.42
16	24.99	25.01	26.50	26.85	20.14	27.46	18.45	28.86	28.75	27.86	16.63	17.75
17	26.09	19.55	26.21	27.09	18.37	26.55	16.97	29.00	28.47	27.22	16.24	20.24
18	24.35	19.97	26.78	25.41	24.62	23.82	24.26	28.56	28.34	26.73	16.33	18.03
19	23.48	22.41	26.95	25.95	14.39	22.98	22.86	28.34	27.97	24.39	18.83	21.37
20	23.59	23.43	26.48	25.60	18.89	22.64	23.58	29.08	27.70	24.56	20.88	22.88
21	24.46	21.68	26.87	24.91	21.08	24.61	23.42	29.26	26.72	25.38	23.11	25.04
22	24.21	21.67	26.88	26.01	21.14	24.53	25.93	29.08	26.27	25.06	24.80	22.52
23	26.34	21.84	27.34	24.06	21.09	25.09	25.95	28.01	27.23	25.45	25.41	21.91
24	20.66	23.10	26.14	23.36	25.74	26.05	26.06	28.07	27.05	24.97	26.12	22.50
25	25.41	21.82	26.42	21.24	25.93	25.02	26.05	28.76	26.71	26.07	26.03	22.45
26	26.20	21.43	22.16	23.77	24.46	25.60	24.62	29.36	27.75	25.74	25.38	23.22
27	27.08	20.73	18.51	25.91	25.45	25.08	24.27	30.08	28.91	25.07	24.91	22.29
28	29.08	22.79	23.00	22.42	25.30	23.79	22.66	30.12	28.92	26.95	24.60	21.91
29	21.00	22.63	23.77	22.10		21.71	22.24	30.48	28.92	26.40	24.13	22.48
30	22.93	24.18	26.33	24.94		22.69	23.68	30.89	28.79	26.66	23.31	20.06
31	25.82		26.66	25.18		24.78		30.86		26.45	23.15	
Max	29.08	27.40	27.34	27.09	25.95	27.67	26.06	30.89	30.99	28.92	26.12	25.16
Min	12.94	19.55	18.51	18.34	11.89	18.83	15.47	25.91	25.98	24.39	12.29	17.75
Mean	23.16	23.37	25.02	24.77	21.15	24.38	23.22	28.19	28.31	26.72	21.34	22.56

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Salinity, parts per thousand, Water Year October 2006 to September 2007
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1.55	15.64	13.25	13.06	10.68	11.23	11.72	11.98	23.31	19.17	14.38	10.36
2	1.27	15.51	12.77	11.96	12.68	14.05	11.63	12.91	21.74	18.28	9.07	9.87
3	3.04	12.91	13.04	11.68	7.21	12.91	10.23	13.17	22.50	18.32	3.17	9.26
4	5.27	9.86	15.34	12.49	4.91	11.74	10.07	13.20	19.67	18.63	2.24	9.66
5	6.22	11.78	11.85	14.04	3.62	10.45	10.23	13.45	19.04	17.43	2.02	9.68
6	6.69	14.41	13.10	14.35	3.58	10.94	10.56	15.09	19.01	16.64	2.52	10.87
7	7.49	17.14	15.32	13.47	5.29	12.75	11.00	12.99	19.01	13.87	3.51	11.26
8	6.88	17.00	12.87	13.34	5.65	12.73	9.24	13.41	19.13	14.55	4.47	13.66
9	7.23	16.29	11.80	11.89	4.88	11.52	9.63	16.20	15.07	14.34	5.87	14.96
10	8.04	15.29	13.75	8.24	4.82	11.52	9.72	17.63	16.38	14.12	6.59	14.73
11	10.37	16.11	15.46	13.60	4.22	11.51	8.41	17.65	15.62	14.50	6.62	14.18
12	8.95	16.04	15.30	11.73	5.24	10.38	7.25	18.18	15.27	13.81	3.50	14.77
13	9.12	14.41	15.30	12.85	6.30	11.19	4.69	19.36	15.03	14.68	3.34	12.84
14	7.69	14.27	15.14	13.41	7.72	12.34	4.36	17.74	15.78	14.47	4.10	9.72
15	8.20	15.04	14.76	14.13	6.46	14.39	9.95	18.03	15.86	14.90	4.45	6.34
16	11.40	15.33	14.01	14.55	5.77	17.11	3.85	19.16	17.74	14.83	3.10	5.12
17	13.21	11.98	14.36	14.30	4.66	15.10	4.32	20.07	18.12	15.46	3.00	5.96
18	12.55	10.68	14.38	14.66	4.40	12.00	4.74	20.29	18.97	15.91	2.98	4.72
19	11.24	10.17	14.86	15.78	4.35	10.95	7.29	18.73	19.45	15.02	3.64	5.69
20	11.22	10.82	14.87	15.84	6.24	9.52	6.23	17.91	18.46	13.23	4.25	6.74
21	11.25	9.61	16.16	15.77	6.13	10.29	5.47	19.72	19.64	14.02	5.40	9.82
22	9.89	11.61	17.67	17.93	6.35	9.41	6.58	20.87	17.73	13.28	6.61	9.28
23	10.25	9.93	17.60	17.17	5.41	9.09	8.68	20.86	17.00	12.79	7.70	8.96
24	6.92	10.86	17.23	17.43	5.08	8.98	10.19	20.89	17.20	12.34	9.55	10.22
25	10.30	10.94	18.93	14.50	7.91	9.29	11.56	22.75	15.98	12.83	10.38	11.05
26	12.19	11.19	13.09	10.57	9.59	9.27	11.80	23.13	15.95	12.81	10.64	10.98
27	15.00	11.41	9.71	8.88	10.06	9.97	14.08	23.59	17.45	12.32	11.18	11.53
28	16.47	12.26	9.82	13.12	10.31	11.22	14.04	22.92	17.62	13.22	11.47	10.41
29	11.10	13.25	9.10	7.78		11.20	12.06	22.70	18.29	14.90	11.86	10.20
30	11.79	13.57	9.14	7.73		10.54	11.76	23.14	18.30	15.21	10.72	8.34
31	14.86		11.21	9.28		11.53		23.32		15.74	11.68	
Max	16.47	17.14	18.93	17.93	12.68	17.11	14.08	23.59	23.31	19.17	14.38	14.96
Min	1.27	9.61	9.10	7.73	3.58	8.98	3.85	11.98	15.03	12.32	2.02	4.72
Mean	9.28	13.18	13.91	13.08	6.41	11.46	9.04	18.42	18.01	14.89	6.45	10.04

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41

Salinity, parts per thousand, Water Year October 2006 to September 2007

Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	6.53	20.21	18.73	19.42	18.79	18.65	17.85	19.11	27.81	24.68	19.05	16.44
2	7.36	19.97	19.05	18.04	17.98	18.89	17.99	19.50	26.87	23.40	15.66	15.88
3	9.15	17.84	19.11	18.04	12.65	17.00	17.18	19.81	25.83	24.05	7.06	15.73
4	11.86	15.91	19.53	19.41	8.82	15.88	16.82	20.71	24.77	23.94	5.30	15.42
5	12.16	19.81	19.55	20.23	7.13	14.48	18.55	21.68	24.71	22.91	5.41	16.13
6	14.44	21.42	19.84	19.66	8.12	15.14	17.16	22.46	24.87	21.49	7.70	17.89
7	15.06	23.04	20.80	18.87	11.67	18.46	16.17	18.80	24.62	20.11	9.88	17.78
8	14.74	22.31	17.63	18.83	11.11	17.73	16.13	21.65	22.26	20.29	12.39	19.25
9	14.62	21.30	17.60	15.43	10.31	18.15	16.73	23.20	20.39	21.06	14.42	19.63
10	15.76	20.30	20.28	14.46	11.39	17.85	16.29	23.23	21.32	21.07	14.21	19.55
11	17.56	20.57	21.12	18.39	10.50	17.63	16.89	22.18	21.83	21.83	15.20	19.11
12	16.77	20.25	19.64	19.66	13.99	17.89	11.46	22.96	22.75	21.72	11.84	19.50
13	16.61	18.87	19.66	19.34	15.22	18.55	8.76	23.05	22.65	22.06	10.17	18.56
14	13.82	18.12	19.92	19.71	14.09	19.53	12.41	23.08	23.45	22.26	11.23	15.45
15	15.36	19.58	20.02	20.38	12.17	21.03	17.35	23.20	23.81	22.48	10.41	11.85
16	18.78	19.13	20.04	20.38	10.54	22.10	8.69	25.44	24.36	21.82	8.11	10.85
17	19.58	15.81	20.26	20.06	11.37	19.68	10.12	25.75	24.04	21.74	8.62	11.82
18	18.30	15.78	20.65	20.77	12.97	17.10	14.12	25.29	24.52	21.52	7.92	10.24
19	17.37	16.27	20.16	20.34	8.68	17.02	14.94	23.85	24.23	19.33	9.12	11.79
20	17.86	17.05	20.77	20.60	12.20	17.01	14.41	23.89	23.70	19.29	10.98	13.51
21	18.27	15.15	22.02	21.08	12.72	17.17	13.41	25.30	23.98	19.49	13.61	17.68
22	18.19	17.14	23.19	22.10	12.98	16.07	15.74	25.65	22.27	19.11	15.09	15.14
23	17.47	16.06	22.79	20.86	11.74	16.52	17.14	25.29	22.41	18.53	16.00	14.79
24	13.59	16.55	21.99	20.58	14.48	17.45	18.05	25.47	22.01	18.36	18.18	15.64
25	18.06	16.24	22.47	17.71	16.65	16.39	19.49	25.79	21.73	18.90	18.30	16.43
26	19.49	16.82	17.51	15.28	16.67	17.15	18.28	26.02	21.88	19.25	17.96	16.82
27	22.10	16.98	13.98	17.12	16.42	17.85	19.03	26.68	23.15	18.94	17.42	17.42
28	22.96	18.00	15.32	16.91	16.73	17.47	18.32	26.58	23.57	21.61	17.35	16.80
29	16.43	17.60	16.45	13.27		16.09	17.83	26.97	24.10	20.98	17.24	15.87
30	18.28	18.35	17.48	15.42		15.87	17.48	27.65	24.62	21.62	17.08	13.79
31	20.53		18.83	15.63		18.07		27.65		21.11	18.06	
Max	22.96	23.04	23.19	22.10	18.79	22.10	19.49	27.65	27.81	24.68	19.05	19.63
Min	6.53	15.15	13.98	13.27	7.13	14.48	8.69	18.80	20.39	18.36	5.30	10.24
Mean	16.10	18.41	19.56	18.64	12.79	17.61	15.83	23.80	23.62	21.13	12.93	15.89

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Drainage Area mi2

Little Manatee River at US Highway 41

Salinity, parts per thousand, Water Year October 2007 to September 2008

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	24.23	23.43	23.32	24.13	23.34	24.40	23.45	24.74	29.48	26.71	23.09	19.71
2	24.86	20.72	25.38	22.08	26.23	25.50	22.89	26.49	29.67	27.01	19.42	10.74
3	26.17	20.96	25.15	25.20	25.72	27.40	23.29	26.38	29.96	25.91	19.04	11.58
4	20.14	19.93	25.12	27.62	27.99	27.11	21.26	26.61	30.22	26.01	13.08	15.08
5	19.20	20.43	26.89	27.90	28.10	26.86	21.61	26.56	30.22	26.21	8.27	14.89
6	8.42	21.89	26.73	27.64	28.43	25.27	19.52	27.10	29.97	25.50	7.39	18.37
7	10.99	21.64	26.68	28.20	27.58	25.22	17.88	27.54	29.62	22.20	8.21	16.63
8	10.33	17.65	26.43	28.94	27.32	25.25	19.72	28.52	29.16	14.07	14.97	16.46
9	13.97	20.86	27.07	29.31	25.89	15.80	19.22	27.90	27.32	9.85	16.58	21.21
10	15.28	21.80	27.46	28.66	23.21	22.68	25.41	27.90	26.70	16.26	8.03	25.74
11	13.18	23.81	27.63	29.08	23.78	24.84	25.95	28.01	26.90	17.74	10.77	24.21
12	16.44	23.21	27.99	28.55	27.47	24.40	25.18	25.21	27.09	20.69	12.70	22.66
13	16.37	25.44	26.90	28.17	26.97	22.03	17.62	24.95	26.52	25.42	23.05	23.20
14	20.88	24.94	26.61	25.78	24.01	24.47	18.04	27.07	26.86	21.98	19.82	23.41
15	21.17	24.63	27.02	26.03	25.74	26.81	16.07	28.34	27.68	24.00	15.55	21.80
16	24.82	18.67	28.41	28.90	27.09	21.30	14.67	28.45	29.13	25.02	14.39	20.57
17	23.51	23.28	22.86	28.76	28.21	23.46	19.50	27.94	28.19	21.30	15.79	19.82
18	25.06	21.76	25.22	26.55	27.88	25.07	23.29	29.02	29.13	20.31	11.89	20.32
19	25.58	21.91	26.68	28.66	25.35	25.87	24.03	29.10	28.32	21.20	4.47	20.21
20	22.90	23.54	28.20	28.67	23.56	25.91	24.44	29.43	28.60	20.03	9.27	22.42
21	22.60	26.40	27.17	26.11	26.21	20.40	24.61	29.29	27.27	20.47	8.40	21.38
22	22.37	27.24	26.56	27.03	26.78	23.80	23.87	29.20	27.69	18.27	10.62	22.20
23	23.79	26.97	27.27	28.02	25.57	22.75	23.65	29.67	22.37	16.97	12.17	18.74
24	23.04	26.65	27.79	25.65	21.93	20.60	24.93	29.88	15.10	18.24	20.04	17.57
25	19.08	27.73	27.55	20.36	22.68	19.23	26.34	28.21	11.24	19.59	13.40	21.97
26	17.99	28.11	27.40	22.29	25.68	25.19	25.98	28.59	11.97	20.59	18.64	22.75
27	19.73	27.78	27.14	24.41	18.42	25.67	26.00	28.27	17.91	23.76	15.39	20.66
28	22.00	25.62	26.18	21.09	20.95	25.44	26.11	27.61	19.54	24.86	14.14	20.21
29	20.29	27.14	25.97	25.90	26.21	24.17	21.65	27.58	22.09	24.74	18.23	18.43
30	23.88	25.34	26.53	23.81		25.02	22.77	28.46	24.95	25.58	15.96	17.72
31	23.01		25.88	26.72		25.46		29.26		23.89	20.90	
Max	26.17	28.11	28.41	29.31	28.43	27.40	26.34	29.88	30.22	27.01	23.09	25.74
Min	8.42	17.65	22.86	20.36	18.42	15.80	14.67	24.74	11.24	9.85	4.47	10.74
Mean	20.04	23.65	26.55	26.46	25.46	24.11	22.30	27.85	25.70	21.75	14.31	19.69

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Salinity, parts per thousand, Water Year October 2007 to September 2008
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	10.20	6.45	15.23	16.55	8.90	0.13	12.38	13.23	22.32	3.98	1.80	0.90
2	10.47	7.66	16.50	6.96	8.13	0.12	12.96	16.17	21.64	5.53	1.25	0.67
3	7.24	7.08	15.98	8.74	9.74	11.32	7.44	18.08	22.10	5.81	1.15	0.82
4	3.72	8.63	15.17	8.93	10.80	14.47	5.69	16.78	22.33	5.45	0.96	1.11
5	1.56	8.26	14.87	7.38	12.95	16.30	5.79	16.22	22.35	6.60	0.84	2.16
6	0.49	8.43	15.36	17.84	14.84	14.92	2.48	16.71	22.31	7.79	0.58	2.54
7	0.40	8.09	14.88	18.61	14.78	14.63	1.86	16.43	22.42	8.17	0.61	1.89
8	0.30	6.62	15.08	18.77	14.78	8.51	1.35	17.72	22.69	3.95	0.93	2.53
9	0.34	7.49	15.34	19.66	14.13	3.69	1.00	18.99	21.83	2.08	0.69	3.72
10	0.61	7.80	16.13	18.85	12.74	6.28	0.73	18.48	20.86	2.21	0.62	12.73
11	0.58	8.69	16.30	19.70	12.53	7.39	2.65	18.77	20.64	2.08	0.61	10.12
12	0.70	8.58	17.25	19.63	12.95	8.64	5.12	21.35	17.00	2.34	0.71	8.92
13	0.88	9.96	16.91	19.59	15.17	7.84	6.44	17.74	13.39	4.12	1.67	9.82
14	1.23	10.97	16.94	18.35	12.15	6.71	5.92	17.30	13.91	4.33	1.32	9.35
15	1.96	11.62	17.94	16.34	0.18	7.42	6.05	21.33	14.60	4.08	0.61	8.54
16	5.07	8.88	18.79	7.92	0.19	9.16	0.05	21.40	14.95	3.70	0.64	7.98
17	5.93	10.91	15.55	17.42	6.92	4.78	3.72	20.40	13.85	1.52	0.58	7.86
18	7.45	11.26	16.39	17.36	16.59	9.63	7.97	21.10	14.74	1.33	0.49	7.07
19	8.59	12.08	14.87	15.91	14.11	13.09	10.72	20.53	13.90	1.30	0.51	6.09
20	7.35	11.96	16.04	6.74	0.25	10.53	10.81	20.50	13.85	1.42	0.90	6.78
21	7.60	12.51	16.90	6.08	15.10	10.21	11.15	20.67	12.43	2.02	0.61	6.80
22	8.55	14.48	16.71	12.69	16.65	11.31	11.28	20.24	11.54	3.29	0.86	7.53
23	10.46	13.96	17.01	14.46	15.36	9.98	10.80	19.33	7.38	2.76	0.53	6.39
24	9.76	12.09	17.22	10.50	13.54	9.32	9.78	20.16	4.25	3.19	0.48	5.87
25	6.20	14.53	17.52	4.35	12.56	0.03	10.60	20.46	2.69	3.56	0.61	7.82
26	4.13	16.01	18.34	8.06	11.40	0.06	12.28	0.15	1.70	3.34	0.57	11.28
27	3.83	15.99	19.08	8.65	11.55	4.30	12.77	18.57	1.70	4.03	0.46	10.24
28	4.09	14.92	18.20	5.72	0.12	9.83	13.86	19.43	1.44	2.71	0.34	10.72
29	3.66	16.09	18.01	7.42	0.13	10.15	15.12	19.56	1.66	2.93	0.61	9.45
30	4.34	15.72	19.17	9.22		5.49	12.04	21.18	2.66	3.18	0.57	8.66
31	5.18		16.60	8.64		0.10		22.42		2.53	0.38	
Max	10.47	16.09	19.17	19.70	16.65	16.30	15.12	22.42	22.69	8.17	1.80	12.73
Min	0.30	6.45	14.87	4.35	0.12	0.03	0.05	0.15	1.44	1.30	0.34	0.67
Mean	4.61	10.92	16.65	12.81	10.66	7.95	7.69	18.43	13.97	3.59	0.76	6.55

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River at US Highway 41
Salinity, parts per thousand, Water Year October 2007 to September 2008
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	16.79	14.12	20.02	20.86	15.85	15.80	18.26	19.39	26.28	13.93	9.85	6.27
2	18.01	14.42	20.73	18.38	15.97	15.88	17.56	21.33	26.62	15.58	6.02	3.22
3	17.56	14.30	19.99	21.06	16.68	18.80	13.98	22.09	26.88	14.56	5.60	4.79
4	11.71	14.16	20.19	23.88	18.23	20.37	12.04	22.31	27.18	14.86	4.11	6.42
5	7.37	14.22	21.45	22.29	19.86	21.29	12.50	22.09	27.18	15.99	3.29	7.86
6	1.81	15.90	20.23	22.93	20.99	19.85	8.95	22.61	26.67	15.77	2.16	8.95
7	1.66	14.55	20.48	23.87	20.49	20.62	7.40	22.93	26.52	14.69	2.23	7.61
8	1.37	13.01	20.53	24.14	20.18	18.43	5.76	24.06	26.26	8.84	4.43	8.34
9	2.31	14.21	21.29	24.35	19.22	10.78	5.75	24.21	25.20	4.85	4.99	11.16
10	4.76	14.55	21.73	24.11	17.69	12.07	10.81	23.81	23.84	6.65	2.65	19.83
11	5.22	15.63	22.17	24.56	17.04	14.94	13.70	24.21	23.81	7.30	2.96	17.75
12	6.08	15.79	22.47	24.31	21.02	16.50	14.81	22.93	21.50	9.06	4.23	14.62
13	7.16	17.78	22.06	24.16	21.96	14.06	12.48	22.15	20.57	12.72	9.39	14.86
14	8.38	17.70	22.21	22.18	17.75	14.31	12.15	22.40	19.90	11.81	8.76	15.55
15	11.27	17.70	23.39	21.11	16.12	16.96	9.40	24.43	21.09	12.86	4.94	15.18
16	14.30	13.92	24.29	21.13	16.53	15.57	8.25	25.20	21.94	12.99	3.53	14.28
17	14.35	17.40	18.76	24.58	19.82	14.54	11.44	25.07	21.44	8.76	3.83	14.09
18	15.44	16.99	20.51	21.96	21.52	17.81	15.38	25.61	22.47	7.07	2.69	13.61
19	16.12	16.98	21.62	22.30	18.99	19.54	16.92	25.40	21.67	7.25	1.35	12.71
20	14.59	16.89	22.22	20.74	17.43	17.15	17.75	25.39	21.56	8.07	3.85	14.17
21	14.23	19.50	22.12	19.22	20.57	14.86	18.11	25.41	19.47	8.68	3.55	13.95
22	13.98	20.94	21.78	20.87	21.41	17.33	17.87	25.20	18.88	8.88	3.99	14.16
23	16.55	19.95	22.35	20.18	20.87	17.05	17.04	25.45	14.47	8.52	3.34	12.39
24	15.96	19.24	22.81	17.09	18.01	14.50	16.86	25.82	8.81	9.19	5.84	11.64
25	12.00	21.84	22.90	13.24	17.73	6.12	18.80	24.56	5.67	9.30	2.98	14.53
26	9.96	22.61	23.39	15.94	19.00	15.32	19.90	23.44	4.77	9.92	5.16	16.40
27	11.47	21.86	23.25	15.89	15.11	16.87	19.97	24.50	6.61	12.10	4.09	15.54
28	11.74	20.73	22.73	12.09	9.62	17.92	20.79	24.34	6.43	12.48	3.56	15.20
29	10.49	21.62	22.63	14.76	14.02	17.35	18.50	24.00	7.92	12.84	5.14	13.96
30	12.06	20.51	22.87	14.62		17.12	17.71	24.22	10.59	13.63	4.63	12.54
31	12.95		20.91	16.64		17.13		25.40		11.61	6.92	
Max	18.01	22.61	24.29	24.58	21.96	21.29	20.79	25.82	27.18	15.99	9.85	19.83
Min	1.37	13.01	18.76	12.09	9.62	6.12	5.75	19.39	4.77	4.85	1.35	3.22
Mean	10.89	17.30	21.74	20.43	18.26	16.35	14.36	23.87	19.41	10.99	4.52	12.39

Appendix C

Daily Value Tables for the I-75 Site

Date Processed 10/10/07

Drainage Area mi2

Hydrologic Data Collection, Inc.

Little Manatee River Below I-75

Gage Height, Feet, NGVD 1988, Water Year October 2006 to September 2007

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.72	0.80	0.72	1.13	0.93	0.87	0.59	0.92	1.22	1.44	1.22	0.90
2	0.88	0.81	0.85	1.02	1.30	1.08	0.53	1.01	2.47	1.34	1.39	1.06
3	1.11	0.70	0.86	0.73	0.74	0.45	0.39	1.05	1.35	1.16	0.89	1.09
4	1.06	0.15	0.91	0.90	-0.16	-0.13	0.26	1.10	1.15	1.11	1.04	0.80
5	0.83	0.82	0.41	1.08	-0.53	-0.50	0.44	1.39	1.09	0.83	1.06	0.76
6	1.12	1.18	0.80	0.91	-0.35	-0.46	0.19	1.28	0.98	0.54	1.23	1.00
7	0.96	1.38	1.15	0.64	0.29	0.41	0.13	0.53	0.93	0.63	1.14	0.83
8	1.19	1.60	0.24	0.40	0.32	0.27	0.28	0.84	0.44	0.86	1.32	1.03
9	1.00	1.30	-0.64	-0.55	0.36	0.58	0.24	0.89	0.60	1.17	1.56	1.13
10	1.21	0.92	-0.12	-0.53	0.48	0.62	0.26	0.78	0.76	1.32	1.47	1.10
11	1.35	0.95	0.24	0.31	0.43	0.51	0.38	0.65	1.11	1.49	1.60	0.89
12	1.31	0.70	0.31	0.81	0.32	0.73	0.30	0.82	1.25	1.43	1.62	0.72
13	1.20	0.76	0.28	0.70	0.70	0.59	0.26	0.85	1.08	1.53	1.38	0.54
14	0.59	0.71	0.35	0.70	0.61	0.60	0.31	1.07	1.25	1.48	1.44	0.55
15	0.40	1.27	0.30	0.75	0.62	1.21	1.20	1.13	1.54	1.44	1.42	0.74
16	1.04	1.35	0.70	0.86	0.64	1.18	0.71	1.56	1.58	1.25	0.93	0.53
17	1.24	0.86	0.69	0.89	0.22	1.06	0.06	1.61	1.35	1.09	1.02	0.74
18	1.04	0.70	0.84	0.48	0.99	0.43	0.57	1.46	1.39	1.01	0.88	0.52
19	0.69	0.90	0.85	0.73	-0.22	0.09	0.65	0.99	1.03	0.52	0.84	0.53
20	0.70	1.06	0.71	0.62	0.38	0.21	0.82	1.01	0.95	0.49	0.91	0.45
21	0.80	0.80	0.98	0.41	0.67	0.49	0.69	1.19	0.65	0.59	1.06	1.53
22	0.83	0.52	0.99	0.67	0.74	0.35	0.94	0.95	0.59	0.59	1.19	1.06
23	0.97	0.62	1.59	0.25	0.75	0.57	0.81	0.47	0.82	0.78	1.13	0.89
24	0.36	0.81	0.92	-0.08	1.18	0.91	0.59	0.58	0.92	0.88	1.26	0.85
25	0.65	0.59	0.64	-0.17	1.20	0.47	0.58	0.71	0.91	1.09	1.33	0.85
26	0.91	0.47	0.34	0.20	0.84	0.43	0.41	0.84	0.85	1.12	1.39	0.92
27	1.27	0.38	-0.16	0.68	0.90	0.45	0.58	1.15	1.14	1.12	1.28	0.82
28	2.05	0.59	0.51	0.28	0.87	0.41	0.41	1.05	1.16	1.49	1.19	0.88
29	0.28	0.49	0.65	0.47		0.33	0.31	1.13	1.30	1.41	1.01	0.91
30	0.39	0.71	1.11	0.62		0.24	0.45	1.34	1.28	1.72	0.68	0.43
31	0.87		1.20	0.66		0.38		1.22		1.55	0.75	
Max	2.05	1.60	1.59	1.13	1.30	1.21	1.20	1.61	2.47	1.72	1.62	1.53
Min	0.28	0.15	-0.64	-0.55	-0.53	-0.50	0.06	0.47	0.44	0.49	0.68	0.43
Mean	0.94	0.83	0.62	0.53	0.54	0.48	0.48	1.02	1.10	1.11	1.18	0.84

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75
Gage Height, Feet, NGVD 1988, Water Year October 2006 to September 2007
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-1.52	-0.83	-1.18	-1.46	-1.77	-1.33	-0.98	-1.15	-1.16	-1.25	-0.77	-0.94
2	-1.46	-0.72	-1.41	-1.75	-1.04	-0.84	-1.11	-1.05	-1.59	-1.23	-0.78	-1.06
3	-1.20	-1.14	-1.59	-1.78	-1.48	-1.50	-1.40	-1.06	-0.68	-1.17	-0.35	-1.25
4	-0.97	-1.97	-1.83	-1.69	-1.88	-1.59	-1.53	-1.19	-1.17	-1.14	-0.63	-1.67
5	-0.95	-1.54	-2.23	-1.63	-1.97	-1.85	-1.61	-1.28	-1.35	-1.08	-0.98	-1.68
6	-0.90	-1.39	-1.96	-1.40	-1.68	-1.76	-1.70	-1.06	-1.25	-0.92	-1.16	-1.50
7	-0.93	-1.06	-1.69	-1.52	-1.26	-1.45	-1.60	-1.62	-1.31	-0.87	-1.27	-1.53
8	-1.04	-1.27	-2.22	-1.43	-1.23	-1.35	-1.83	-1.84	-1.06	-1.02	-1.26	-1.14
9	-1.28	-1.39	-2.34	-1.90	-1.37	-1.57	-1.89	-1.49	-1.09	-1.05	-1.10	-0.74
10	-1.35	-1.49	-1.83	-2.40	-1.50	-1.50	-1.90	-1.17	-0.94	-1.13	-1.07	-0.71
11	-0.96	-1.36	-1.39	-1.53	-1.88	-1.59	-2.02	-1.21	-1.09	-1.19	-0.86	-0.81
12	-1.30	-1.31	-1.39	-1.35	-1.74	-1.84	-1.53	-0.85	-1.32	-1.31	-0.71	-0.77
13	-1.29	-0.88	-1.03	-1.50	-1.89	-1.75	-1.53	-0.73	-1.58	-1.19	-0.65	-0.89
14	-1.63	-0.74	-1.24	-1.55	-1.74	-1.75	-1.59	-1.06	-1.51	-1.14	-0.69	-0.96
15	-1.25	-0.57	-1.49	-1.62	-1.64	-1.69	-0.84	-1.15	-1.51	-1.11	-0.41	-1.06
16	-0.52	-0.08	-1.68	-1.78	-1.55	-1.26	-1.76	-0.95	-1.23	-1.16	-0.34	-1.29
17	-0.35	-0.97	-1.54	-1.93	-1.66	-1.20	-1.96	-0.96	-1.24	-1.07	-0.39	-1.05
18	-0.57	-1.12	-1.62	-1.72	-1.59	-1.42	-1.92	-0.93	-1.17	-0.91	-0.77	-1.46
19	-0.83	-1.31	-1.77	-1.77	-1.61	-1.40	-1.59	-1.45	-1.10	-0.79	-0.89	-1.65
20	-0.88	-1.28	-1.79	-1.83	-1.19	-1.49	-1.67	-1.71	-1.13	-0.95	-0.93	-1.46
21	-0.89	-1.73	-1.63	-1.78	-1.21	-1.43	-1.90	-1.48	-0.77	-0.75	-0.98	-0.70
22	-1.11	-1.22	-1.47	-1.31	-1.12	-1.65	-1.87	-1.28	-0.73	-0.87	-1.14	-0.99
23	-1.24	-1.62	-1.36	-1.44	-1.41	-1.76	-1.58	-1.25	-0.75	-0.94	-1.31	-1.09
24	-2.13	-1.63	-1.52	-1.30	-1.59	-1.70	-1.53	-1.03	-0.82	-1.21	-1.33	-0.92
25	-1.57	-1.70	-0.55	-1.69	-1.33	-1.72	-1.48	-0.82	-1.24	-1.22	-1.10	-0.72
26	-1.41	-1.57	-1.29	-2.05	-1.27	-1.74	-1.31	-0.84	-1.40	-1.23	-0.97	-0.76
27	-1.06	-1.54	-1.73	-2.14	-1.47	-1.71	-0.97	-0.77	-1.24	-1.47	-0.87	-0.79
28	-0.64	-1.33	-1.40	-1.41	-1.50	-1.54	-0.95	-0.94	-1.38	-1.28	-0.82	-1.04
29	-1.77	-1.06	-1.46	-2.10		-1.49	-1.26	-1.09	-1.30	-1.04	-0.79	-1.18
30	-1.57	-1.02	-1.65	-1.90		-1.37	-1.22	-1.09	-1.33	-0.90	-1.03	-1.78
31	-0.99		-1.58	-1.90		-1.19		-1.17		-0.63	-0.92	
Max	-0.35	-0.08	-0.55	-1.30	-1.04	-0.84	-0.84	-0.73	-0.68	-0.63	-0.34	-0.70
Min	-2.13	-1.97	-2.34	-2.40	-1.97	-1.85	-2.02	-1.84	-1.59	-1.47	-1.33	-1.78
Mean	-1.15	-1.23	-1.58	-1.70	-1.52	-1.53	-1.53	-1.15	-1.18	-1.07	-0.88	-1.12

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75
Gage Height, Feet, NGVD 1988, Water Year October 2006 to September 2007
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-0.24	0.04	-0.18	-0.14	-0.37	-0.16	-0.19	-0.10	0.07	0.18	0.15	0.01
2	-0.13	0.06	-0.22	-0.48	-0.04	-0.14	-0.18	0.00	0.50	0.14	0.39	-0.02
3	-0.12	-0.31	-0.35	-0.47	-0.56	-0.69	-0.39	0.00	0.32	0.05	0.32	-0.08
4	-0.06	-0.91	-0.67	-0.30	-1.07	-0.93	-0.58	0.07	0.10	0.03	0.19	-0.33
5	-0.11	-0.30	-0.92	-0.18	-1.23	-1.23	-0.49	0.17	0.01	-0.02	0.05	-0.37
6	0.13	0.06	-0.49	-0.21	-0.99	-1.16	-0.75	0.25	0.01	-0.07	0.14	-0.16
7	0.20	0.42	-0.37	-0.40	-0.52	-0.56	-0.81	-0.67	-0.04	-0.16	0.07	-0.25
8	0.12	0.20	-1.11	-0.43	-0.51	-0.63	-0.83	-0.40	-0.25	-0.12	0.18	-0.09
9	-0.02	0.01	-1.33	-1.09	-0.65	-0.52	-0.83	-0.07	-0.32	0.11	0.36	0.08
10	0.03	-0.15	-0.79	-1.55	-0.49	-0.50	-0.72	-0.01	-0.19	0.23	0.28	0.20
11	0.29	-0.04	-0.42	-0.81	-0.82	-0.49	-0.52	-0.22	0.03	0.32	0.43	0.01
12	0.13	-0.11	-0.55	-0.31	-0.58	-0.52	-0.48	0.02	0.12	0.24	0.47	0.01
13	0.11	-0.15	-0.46	-0.35	-0.53	-0.52	-0.73	0.07	-0.09	0.27	0.31	-0.08
14	-0.29	0.07	-0.50	-0.35	-0.42	-0.49	-0.56	0.10	-0.01	0.22	0.42	-0.07
15	-0.21	0.24	-0.54	-0.31	-0.56	-0.28	0.24	-0.01	0.13	0.20	0.47	-0.19
16	0.34	0.64	-0.51	-0.48	-0.71	-0.01	-0.63	0.40	0.29	0.05	0.34	-0.31
17	0.55	-0.11	-0.39	-0.67	-0.64	-0.33	-0.82	0.43	0.12	0.07	0.30	-0.18
18	0.35	-0.21	-0.36	-0.53	-0.27	-0.71	-0.55	0.26	0.18	0.10	0.02	-0.52
19	0.02	-0.20	-0.55	-0.63	-0.90	-0.64	-0.35	-0.22	0.10	-0.12	-0.05	-0.60
20	0.00	-0.09	-0.53	-0.67	-0.39	-0.50	-0.38	-0.29	0.05	-0.22	-0.03	-0.46
21	0.06	-0.56	-0.30	-0.61	-0.31	-0.49	-0.63	0.02	0.12	-0.18	0.10	0.47
22	0.01	-0.28	-0.04	-0.28	-0.18	-0.71	-0.42	0.01	-0.12	-0.21	0.15	0.18
23	-0.16	-0.41	0.02	-0.64	-0.41	-0.59	-0.27	-0.15	-0.04	-0.13	0.09	0.00
24	-0.91	-0.34	-0.27	-0.69	-0.23	-0.29	-0.34	-0.08	0.02	-0.04	0.19	-0.03
25	-0.33	-0.45	0.04	-0.96	0.01	-0.55	-0.24	-0.06	-0.07	0.02	0.19	0.07
26	-0.09	-0.35	-0.42	-1.16	-0.06	-0.54	-0.30	-0.06	-0.20	0.09	0.22	0.10
27	0.29	-0.36	-0.94	-0.82	-0.22	-0.48	-0.17	0.10	-0.06	-0.03	0.14	0.15
28	0.68	-0.18	-0.62	-0.37	-0.37	-0.43	-0.25	0.03	0.03	0.25	0.10	0.01
29	-0.53	-0.23	-0.38	-0.92		-0.58	-0.34	0.07	0.06	0.22	0.05	-0.16
30	-0.36	-0.18	-0.30	-0.69		-0.64	-0.45	0.19	0.07	0.46	-0.15	-0.70
31	-0.01		-0.18	-0.70		-0.34		0.10		0.44	0.03	
Max	0.68	0.64	0.04	-0.14	0.01	-0.01	0.24	0.43	0.50	0.46	0.47	0.47
Min	-0.91	-0.91	-1.33	-1.55	-1.23	-1.23	-0.83	-0.67	-0.32	-0.22	-0.15	-0.70
Mean	-0.01	-0.14	-0.47	-0.59	-0.50	-0.54	-0.47	0.00	0.03	0.08	0.19	-0.11

Date Processed 10/29/08

Drainage Area mi2

Hydrologic Data Collection, Inc.

Little Manatee River Below I-75

Gage Height, Feet, NGVD 1988, Water Year October 2007 to September 2008

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.73	0.54	-0.09	0.41	0.84	0.55	0.44	0.52	1.04	1.45	1.84	2.30
2	0.38	0.50	0.37	0.09	0.86	0.44	0.65	0.91	1.08	1.44	1.61	1.21
3	1.68	0.83	0.33	-0.29	0.92	0.92	0.65	1.09	1.19	1.45	1.40	0.85
4	1.07	0.80	0.32	0.72	1.26	1.05	0.60	1.20	1.31	1.29	1.19	1.07
5	1.36	0.89	0.66	1.12	1.31	1.23	0.86	1.07	1.41	1.22	0.86	0.94
6	0.99	1.08	0.69	1.12	1.32	0.92	0.80	1.07	1.26	1.08	0.98	1.59
7	1.24	1.16	0.82	1.21	1.16	0.48	0.84	1.24	0.99	1.01	0.91	1.39
8	1.09	0.66	0.90	1.27	1.01	1.44	0.98	1.59	0.85	0.83	1.15	0.97
9	0.94	0.89	0.93	1.31	0.83	-0.02	0.92	1.29	0.52	0.81	1.32	0.86
10	0.92	0.92	1.05	0.98	0.37	0.38	1.26	1.04	0.42	1.06	1.21	2.24
11	0.81	1.13	0.99	0.90	0.01	0.69	1.26	0.80	0.44	1.08	1.18	2.45
12	0.91	1.15	1.05	0.70	0.89	0.90	1.07	0.23	0.62	1.15	1.20	1.62
13	0.79	1.22	0.67	0.60	1.32	0.65	0.56	0.10	0.74	1.22	1.68	1.48
14	0.86	1.17	0.61	0.16	0.79	0.56	0.59	0.44	0.68	1.20	1.71	1.51
15	0.53	1.08	0.65	0.02	0.75	0.96	0.45	0.91	0.86	1.48	1.70	1.22
16	0.98	-0.11	1.59	0.48	0.80	0.72	-0.25	1.03	1.23	1.49	1.34	1.00
17	1.08	0.51	-0.06	0.90	1.29	0.41	0.19	0.95	1.16	1.58	1.31	0.89
18	1.11	0.47	0.46	0.66	1.29	0.59	0.91	1.13	1.30	1.61	1.05	0.96
19	1.14	0.41	0.83	1.48	0.96	0.75	1.10	1.20	1.28	1.47	0:05	0.99
20	1.05	0.42	1.10	1.52	0.40	0.82	1.20	1.28	1.37	1.39	0.61	1.28
21	0.72	0.98	1.10	0.48	0.57	-0.23	1.21	1.11	1.05	1.26	0.78	1.22
22	0.70	1.21	0.97	0.72	0.78	0.36	1.06	1.01	1.31	1.03	1.13	1.47
23	0.79	1.20	1.21	1.09	0.67	0.34	0.97	1.07	1.09	0.93	1.08	1.01
24	0.77	0.82	1.30	0.96	0.35	0.18	0.99	1.01	0.74	1.03	1.30	0.57
25	0.62	1.31	1.17	0.38	0.48	-0.48	1.18	0.44	0.57	1.17	1.25	0.91
26	0.53	1.45	1.08	0.33	0.82	0.39	1.17	0.34	0.66	1.15	1.30	1.49
27	0.49	1.31	1.28	0.71	0.05	0.70	1.06	0.32	1.04	1.41	1.50	1.28
28	0.89	0.65	0.86	0.43	0.21	0.54	1.09	0.28	1.24	1.67	1.46	1.36
29	0.50	0.74	0.73	0.88	0.78	0.40	0.37	0.31	1.34	1.88	1.47	1.31
30	0.99	0.41	0.77	0.76		0.29	0.20	0.53	1.33	1.85	1.25	1.38
31	0.74		0.66	0.96		0.45		0.81		1.84	1.61	
Max	1.68	1.45	1.59	1.52	1.32	1.44	1.26	1.59	1.41	1.88	1.84	2.45
Min	0.38	-0.11	-0.09	-0.29	0.01	-0.48	-0.25	0.10	0.42	0.81	0.05	0.57
Mean	0.88	0.86	0.81	0.74	0.80	0.56	0.81	0.85	1.00	1.31	1.24	1.29

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75

Gage Height, Feet, NGVD 1988, Water Year October 2007 to September 2008

Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-1.76	-1.53	-1.52	-0.71	-1.25	-1.54	-1.56	-1.28	-1.16	-1.36	-0.61	-0.24
2	-1.81	-1.06	-0.98	-1.79	-1.44	-1.77	-1.39	-0.80	-1.42	-1.34	-0.57	-0.72
3	-0.82	-0.74	-1.16	-2.32	-1.46	-1.57	-1.13	-0.65	-1.44	-1.31	-0.57	-0.58
4	-0.87	-0.50	-1.39	-1.97	-1.47	-1.35	-1.09	-1.04	-1.43	-1.23	-0.52	-0.48
5	-0.64	-0.46	-1.45	-1.56	-1.27	-0.93	-0.63	-1.27	-1.36	-1.19	-0.56	-0.34
6	-0.54	-0.36	-1.31	-1.27	-1.05	-1.15	-1.30	-1.30	-1.34	-1.14	-0.51	-0.34
7	-0.05	-0.65	-1.32	-1.15	-1.14	-1.25	-1.31	-1.45	-1.30	-0.96	-0.81	-0.83
8	-0.09	-1.12	-1.38	-1.26	-1.14	-1.31	-1.31	-1.26	-1.45	-0.81	-0.65	-1.10
9	-0.24	-1.02	-1.39	-1.21	-1.20	-1.53	-1.33	-1.14	-1.30	-0.58	-0.58	-1.05
10	-0.42	-1.14	-1.38	-1.45	-1.28	-1.58	-1.51	-1.30	-0.96	-0.68	-0.88	0.62
11	-0.87	-1.07	-1.43	-1.34	-1.38	-1.47	-1.51	-1.38	-1.03	-0.91	-1.06	0.11
12	-1.06	-1.18	-1.38	-1.33	-1.26	-1.37	-1.40	-0.63	-1.14	-1.12	-1.12	-0.31
13	-1.11	-1.13	-1.51	-1.16	-1.05	-1.53	-1.27	-1.29	-1.27	-0.89	-0.62	-0.41
14	-1.23	-1.30	-1.52	-1.42	-1.33	-1.81	-1.43	-1.35	-1.31	-1.11	-0.42	-0.37
15	-1.35	-1.25	-1.30	-1.61	-1.65	-1.92	-1.38	-0.68	-1.36	-1.03	-0.62	-0.46
16	-1.13	-1.98	-0.61	-1.77	-1.85	-1.45	-1.62	-0.71	-1.18	-0.85	-0.79	-0.65
17	-1.12	-1.35	-1.55	-1.33	-1.76	-1.71	-1.41	-1.06	-1.33	-0.75	-0.55	-0.81
18	-1.05	-1.30	-1.31	-1.68	-1.20	-1.52	-0.80	-1.00	-1.20	-0.76	-0.86	-1.05
19	-0.84	-1.14	-1.21	-1.87	-1.41	-1.02	-0.83	-1.15	-1.17	-0.74	-1.52	-1.16
20	-1.34	-1.17	-1.46	-2.01	-1.64	-1.34	-0.92	-1.26	-1.17	-0.74	-0.70	-1.02
21	-1.05	-1.09	-1.28	-2.32	-1.31	-1.52	-0.99	-1.24	-1.21	-0.76	-0.60	-0.99
22	-1.01	-0.86	-1.56	-1.62	-0.97	-1.39	-1.06	-1.29	-1.27	-0.64	-0.26	-0.97
23	-0.66	-1.15	-1.45	-1.25	-0.94	-1.51	-1.11	-1.48	-0.97	-0.69	-0.85	-1.28
24	-0.83	-1.69	-1.49	-1.32	-1.10	-1.52	-1.50	-1.34	-0.93	-0.63	-0.80	-1.42
25	-1.20	-1.39	-1.52	-1.70	-1.16	-2.05	-1.43	-1.33	-0.89	-0.76	-1.10	-0.89
26	-1.60	-1.26	-1.36	-1.15	-1.35	-1.81	-1.25	-1.74	-0.98	-1.03	-0.95	-0.15
27	-1.61	-1.51	-1.02	-1.10	-1.00	-1.79	-1.27	-1.65	-0.77	-0.93	-0.79	-0.15
28	-1.68	-1.84	-1.05	-1.40	-1.76	-1.64	-1.06	-1.32	-0.89	-0.84	-0.84	-0.12
29	-1.56	-1.57	-0.98	-1.14	-1.70	-1.67	-0.91	-1.31	-1.07	-0.89	-0.72	-0.26
30	-1.56	-1.57	-0.67	-0.74		-1.85	-1.52	-1.26	-1.33	-0.78	-0.63	-0.34
31	-1.57		-0.78	-1.27		-1.92		-1.10		-0.76	-0.79	
Max	-0.05	-0.36	-0.61	-0.71	-0.94	-0.93	-0.63	-0.63	-0.77	-0.58	-0.26	0.62
Min	-1.81	-1.98	-1.56	-2.32	-1.85	-2.05	-1.62	-1.74	-1.45	-1.36	-1.52	-1.42
Mean	-1.05	-1.18	-1.28	-1.46	-1.33	-1.54	-1.24	-1.20	-1.19	-0.91	-0.74	-0.59

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75
Gage Height, Feet, NGVD 1988, Water Year October 2007 to September 2008
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	-0.55	-0.42	-0.67	-0.12	-0.08	-0.42	-0.42	-0.34	-0.06	0.12	0.54	0.89
2	-0.55	-0.20	-0.41	-0.95	-0.24	-0.61	-0.41	0.07	-0.04	0.16	0.45	0.27
3	0.53	0.06	-0.49	-1.40	-0.22	-0.33	-0.28	0.21	-0.04	0.16	0.37	0.21
4	0.36	0.22	-0.58	-0.92	-0.15	-0.11	-0.17	0.21	0.01	0.07	0.31	0.31
5	0.40	0.25	-0.40	-0.31	-0.01	0.06	0.13	0.02	0.11	0.11	0.27	0.40
6	0.23	0.51	-0.28	-0.06	0.11	-0.23	-0.15	-0.02	0.02	0.07	0.18	0.73
7	0.56	0.29	-0.18	0.08	-0.06	-0.27	-0.18	-0.03	-0.09	0.12	0.03	0.41
8	0.45	-0.11	-0.23	0.04	-0.20	0.44	-0.22	0.30	-0.20	0.10	0.20	0.12
9	0.35	0.02	-0.20	0.01	-0.33	-0.82	-0.24	0.21	-0.21	0.09	0.28	0.06
10	0.34	-0.04	-0.16	-0.25	-0.52	-0.78	0.00	0.01	-0.24	0.17	0.28	1.34
11	0.09	0.10	-0.18	-0.20	-0.76	-0.44	0.01	-0.04	-0.39	0.10	0.21	1.48
12	-0.05	0.05	-0.16	-0.24	-0.19	-0.14	0.01	-0.23	-0.34	0.09	0.21	0.74
13	-0.08	0.16	-0.34	-0.23	0.22	-0.43	-0.21	-0.49	-0.23	0.24	0.53	0.54
14	-0.18	0.04	-0.35	-0.63	-0.31	-0.54	-0.35	-0.47	-0.29	0.15	0.64	0.51
15	-0.23	-0.01	-0.14	-0.97	-0.45	-0.37	-0.75	0.03	-0.14	0.34	0.62	0.43
16	0.11	-0.86	0.44	-0.99	-0.53	-0.29	-0.92	0.22	0.06	0.38	0.29	0.28
17	0.11	-0.25	-0.90	-0.02	-0.34	-0.70	-0.64	0.14	0.05	0.45	0.32	0.16
18	0.20	-0.24	-0.65	-0.44	0.01	-0.43	-0.05	0.16	0.15	0.46	0.16	0.08
19	0.27	-0.26	-0.28	-0.41	-0.48	-0.07	0.17	0.14	0.13	0.36	-0.65	0.00
20	-0.03	-0.45	-0.23	-0.60	-0.71	-0.30	0.27	0.13	0.21	0.36	0.02	0.21
21	-0.09	-0.07	-0.17	-1.21	-0.41	-0.89	0.24	0.03	0.01	0.25	0.19	0.24
22	-0.15	0.22	-0.28	-0.32	-0.15	-0.57	0.12	-0.05	0.16	0.21	0.37	0.33
23	0.09	-0.06	-0.11	-0.08	-0.08	-0.49	-0.06	-0.04	0.19	0.14	0.08	-0.03
24	0.08	-0.40	-0.08	-0.27	-0.37	-0.70	-0.20	-0.02	0.04	0.21	0.19	-0.35
25	-0.26	0.04	-0.15	-0.76	-0.34	-1.44	0.03	-0.42	-0.09	0.18	0.18	0.03
26	-0.59	0.20	-0.06	-0.41	-0.14	-0.65	0.13	-0.50	-0.09	0.09	0.30	0.56
27	-0.43	-0.06	0.15	-0.24	-0.42	-0.53	0.07	-0.50	0.08	0.30	0.43	0.58
28	-0.37	-0.51	0.04	-0.67	-0.93	-0.48	0.19	-0.38	0.12	0.48	0.34	0.71
29	-0.51	-0.34	0.01	-0.32	-0.53	-0.55	-0.23	-0.49	0.17	0.59	0.33	0.65
30	-0.33	-0.53	0.05	-0.07		-0.70	-0.61	-0.51	0.14	0.64	0.21	0.52
31	-0.40		-0.17	-0.10		-0.67		-0.29		0.57	0.41	
Max	0.56	0.51	0.44	0.08	0.22	0.44	0.27	0.30	0.21	0.64	0.64	1.48
Min	-0.59	-0.86	-0.90	-1.40	-0.93	-1.44	-0.92	-0.51	-0.39	0.07	-0.65	-0.35
Mean	-0.02	-0.09	-0.23	-0.42	-0.30	-0.47	-0.16	-0.09	-0.03	0.25	0.27	0.41

Date Processed 10/10/07

Drainage Area mi2

Hydrologic Data Collection, Inc.

Little Manatee River Below I-75

Temperature, Water (Deg. C°), Water Year October 2006 to September 2007

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	27.3	25.3	23.3	22.2	18.3	24.1	25.6	28.1	25.9	30.9	30.0	31.5
2	27.8	24.9	24.1	22.0	19.1	24.6	26.3	28.2	24.6	30.9	29.1	31.3
3	28.2	24.6	24.3	22.2	19.2	24.3	26.8	28.5	25.8	31.3	28.5	31.3
4	27.9	23.6	24.2	22.9	18.4	23.0	27.1	28.7	27.0	30.8	29.1	31.5
5	27.5	23.5	22.9	23.0	17.2	22.3	26.8	28.8	28.1	31.3	29.7	31.7
6	27.7	23.7	21.7	24.1	16.6	21.1	25.8	29.3	28.0	31.0	30.5	31.5
7	28.1	23.2	21.1	24.4	17.9	20.9	24.3	28.2	28.9	32.1	31.7	31.1
8	28.0	23.5	20.8	24.5	18.3	21.5	22.9	26.6	29.3	32.1	32.2	30.7
9	27.6	23.4	18.2	24.2	18.8	21.7	22.0	26.1	29.8	32.3	32.1	30.4
10	27.3	23.4	18.0	20.5	19.5	22.7	21.0	27.0	30.6	32.4	32.6	30.3
11	27.2	23.6	19.0	19.6	18.9	23.5	20.9	27.4	31.4	33.1	32.8	30.6
12	27.3	23.9	19.7	19.1	18.8	23.6	23.5	27.7	31.8	33.0	31.5	31.3
13	27.2	23.8	19.9	19.7	19.2	23.9	24.7	28.4	31.4	33.0	30.9	31.8
14	27.4	23.4	20.2	20.6	20.5	23.4	25.8	28.6	30.6	32.6	31.2	30.9
15	26.5	23.2	21.1	21.2	20.5	23.8	25.4	27.7	30.0	32.6	30.8	30.5
16	25.9	23.0	21.0	22.1	18.7	23.8	23.7	28.1	30.1	32.3	29.8	30.5
17	25.6	22.4	21.8	22.1	16.7	23.5	22.9	28.4	30.5	32.2	30.3	30.8
18	26.5	22.1	22.5	22.1	16.3	21.7	23.1	28.8	30.5	32.3	30.7	30.0
19	27.2	21.2	22.7	22.3	16.0	21.7	23.9	28.0	30.3	32.3	30.8	30.0
20	27.7	20.3	22.5	22.2	16.7	22.1	24.5	26.9	30.4	32.4	31.5	29.0
21	28.2	19.2	22.2	22.0	18.3	22.4	24.5	26.7	31.2	32.2	31.8	28.5
22	28.5	17.4	22.4	22.5	19.4	22.3	24.6	26.8	31.8	31.7	31.8	28.4
23	28.5	17.9	23.0	22.8	20.0	23.2	24.6	27.1	31.7	31.5	31.6	28.5
24	26.8	18.7	23.7	22.6	20.5	23.8	24.8	26.6	32.0	30.6	31.9	28.8
25	23.7	19.5	23.5	20.8	20.8	24.1	24.9	26.7	32.5	30.9	31.3	29.2
26	23.9	20.3	23.1	19.0	21.2	24.7	26.1	26.6	32.3	31.7	30.5	29.2
27	24.4	21.0	21.1	18.0	23.0	24.6	27.6	26.9	31.4	32.0	31.2	29.7
28	24.4	22.1	19.9	18.4	23.9	25.2	27.8	27.0	30.6	31.3	31.7	30.1
29	24.3	22.5	20.1	17.7		25.5	27.9	27.5	30.8	31.4	32.0	30.1
30	23.8	23.4	21.0	16.9		25.6	28.1	27.1	31.3	31.1	32.4	29.8
31	24.5		22.2	17.0		25.7		26.4		30.5	32.2	
Max	28.5	25.3	24.3	24.5	23.9	25.7	28.1	29.3	32.5	33.1	32.8	31.8
Min	23.7	17.4	18.0	16.9	16.0	20.9	20.9	26.1	24.6	30.5	28.5	28.4
Mean	26.7	22.3	21.7	21.2	19.0	23.4	24.9	27.6	30.0	31.8	31.1	30.3

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75
Temperature, Water (Deg. C°), Water Year October 2006 to September 2007
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	26.6	23.6	22.4	21.2	15.8	22.3	23.6	26.2	23.9	30.0	28.5	30.1
2	26.7	23.8	22.6	20.6	18.4	23.3	24.0	26.5	23.5	29.7	26.2	30.0
3	26.2	22.6	22.9	20.3	18.3	21.9	24.3	26.6	24.1	29.2	25.8	30.1
4	25.7	21.0	22.7	21.6	17.2	21.0	24.8	27.0	25.1	29.9	27.2	30.4
5	25.1	21.2	20.0	22.1	15.4	19.6	25.5	27.2	26.3	29.1	28.2	30.8
6	25.4	21.9	20.0	22.6	14.7	18.7	23.7	27.6	27.5	30.1	29.1	30.4
7	25.6	22.5	20.4	22.9	15.3	19.0	21.9	26.0	26.8	29.5	30.3	29.4
8	25.7	22.4	17.3	22.8	16.1	19.6	20.5	24.9	27.4	30.6	30.8	29.3
9	25.6	22.0	16.1	20.5	16.7	20.2	20.6	24.7	27.7	31.5	30.3	29.0
10	25.1	21.8	16.5	17.7	17.0	20.8	19.8	25.3	28.5	30.8	30.4	28.8
11	25.5	22.3	17.5	17.6	16.4	21.5	19.4	26.1	29.6	31.2	29.7	28.6
12	25.0	22.9	18.2	18.2	17.1	21.2	20.4	26.3	30.2	30.5	27.4	29.3
13	25.5	22.4	19.3	18.3	17.2	21.4	21.8	26.2	29.1	30.8	28.1	29.2
14	25.0	22.2	19.8	19.1	18.2	21.8	23.1	26.8	28.7	30.6	29.0	28.3
15	24.1	21.4	20.2	19.5	18.2	21.8	23.2	26.4	28.2	30.5	28.5	27.2
16	24.8	22.2	20.3	20.1	16.2	22.8	20.3	26.1	28.6	30.7	27.8	28.1
17	24.5	19.9	20.3	20.6	14.2	21.0	20.1	26.9	28.5	30.4	28.7	28.9
18	24.3	19.1	21.0	20.7	14.7	19.5	21.1	27.3	29.1	30.8	29.2	28.9
19	24.9	18.4	21.2	20.8	13.3	19.0	21.9	26.8	29.2	30.1	29.3	28.2
20	25.5	18.0	21.1	20.4	14.1	19.8	22.6	25.5	29.0	30.8	29.9	27.4
21	26.0	16.3	21.0	19.9	15.0	20.3	22.2	25.2	29.3	30.8	30.6	26.8
22	26.4	15.9	21.5	21.1	17.0	20.3	22.6	25.3	29.8	30.6	31.1	26.7
23	26.2	15.8	22.0	21.7	17.8	20.8	22.5	25.1	30.5	29.7	30.7	26.7
24	22.4	16.4	22.4	20.4	17.8	21.6	22.8	25.2	30.8	28.3	29.8	27.1
25	21.3	17.5	22.7	18.3	18.5	21.3	24.0	25.1	30.9	29.3	29.5	27.4
26	21.8	18.7	21.1	15.8	19.9	21.8	24.3	25.0	30.5	30.0	28.9	27.7
27	22.7	19.8	18.6	15.7	20.9	22.6	25.4	25.2	30.0	29.8	28.6	27.7
28	23.6	20.8	17.8	17.5	21.6	22.3	25.9	25.4	29.3	29.9	29.4	28.2
29	21.8	21.4	17.9	15.4		23.0	25.7	25.8	29.3	29.7	29.7	28.6
30	22.5	21.8	18.6	14.9		23.0	25.5	25.7	29.4	29.7	30.2	27.6
31	23.2		20.0	14.5		23.2		25.3		29.3	30.7	
Max	26.7	23.8	22.9	22.9	21.6	23.3	25.9	27.6	30.9	31.5	31.1	30.8
Min	21.3	15.8	16.1	14.5	13.3	18.7	19.4	24.7	23.5	28.3	25.8	26.7
Mean	24.7	20.5	20.1	19.4	16.9	21.2	22.8	25.9	28.3	30.1	29.1	28.6

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75
Temperature, Water (Deg. C°), Water Year October 2006 to September 2007
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	26.9	24.3	22.9	21.7	17.1	23.3	24.8	27.0	25.2	30.4	29.3	30.8
2	27.1	24.5	23.3	21.2	18.9	24.0	25.1	27.2	24.0	30.2	28.1	30.6
3	27.0	23.8	23.7	21.3	18.7	23.3	25.5	27.5	24.8	30.1	26.7	30.7
4	26.7	22.5	23.3	22.3	17.6	22.0	25.8	27.7	25.9	30.4	27.9	31.0
5	26.4	22.5	21.4	22.6	16.2	20.6	26.0	27.9	27.0	30.2	28.8	31.4
6	26.7	22.8	20.9	23.2	15.5	19.9	24.9	28.2	27.7	30.8	30.0	31.1
7	26.9	22.9	20.8	23.8	16.3	20.0	23.2	26.9	27.5	30.8	31.0	30.5
8	26.9	22.8	18.8	24.1	17.2	20.6	21.7	25.5	28.2	31.5	31.4	30.0
9	26.6	22.7	17.1	21.9	17.5	21.0	21.2	25.3	28.7	31.9	31.5	29.8
10	26.3	22.7	17.4	18.6	17.8	21.7	20.4	26.0	29.5	31.9	31.3	29.7
11	26.4	23.0	18.1	18.8	17.7	22.3	20.0	26.6	30.2	32.0	31.4	29.7
12	26.3	23.5	18.9	18.7	17.9	22.6	21.9	27.0	30.8	32.0	29.3	30.3
13	26.3	23.4	19.5	19.1	18.3	22.9	23.1	27.3	30.6	32.0	29.3	30.4
14	26.0	22.9	19.9	19.8	19.4	22.9	24.3	27.6	29.7	31.8	29.8	29.7
15	25.6	22.6	20.5	20.4	18.8	23.1	24.8	27.1	29.1	31.7	29.3	28.5
16	25.5	22.7	20.7	21.1	17.0	23.3	21.7	26.9	29.3	31.5	28.6	28.9
17	25.1	21.4	21.0	21.4	15.6	21.9	21.4	27.5	29.4	31.3	29.3	29.7
18	25.4	20.7	21.7	21.4	15.5	20.7	22.1	27.9	29.7	31.5	29.8	29.6
19	26.1	20.0	22.0	21.5	14.5	20.3	22.8	27.4	29.7	31.1	30.0	28.8
20	26.7	19.1	21.9	21.3	15.2	20.8	23.3	26.3	29.7	31.4	30.5	28.1
21	27.2	17.4	21.7	21.1	16.5	21.3	23.3	26.0	30.0	31.7	31.2	27.8
22	27.6	16.8	22.0	21.8	18.0	21.3	23.4	26.0	30.4	31.0	31.5	27.8
23	27.4	16.8	22.5	22.3	18.6	21.9	23.4	26.0	31.0	30.7	31.2	27.6
24	23.7	17.5	23.0	21.9	19.0	22.5	23.7	26.0	31.3	29.7	31.0	28.1
25	22.6	18.5	23.3	19.7	19.7	22.7	24.5	25.8	31.5	29.8	30.4	28.4
26	22.8	19.6	22.0	17.3	20.5	23.3	25.1	25.9	31.3	30.5	30.1	28.6
27	23.6	20.5	19.7	17.0	21.8	23.6	26.2	26.0	30.5	30.9	29.8	28.8
28	24.0	21.4	19.0	17.9	22.7	23.8	26.8	26.2	30.0	30.7	30.5	29.1
29	22.8	21.9	19.0	16.5		24.4	26.8	26.5	29.8	30.5	31.0	29.3
30	23.4	22.4	19.9	15.8		24.4	26.8	26.5	30.1	30.5	31.3	28.4
31	23.8		21.1	15.9		24.6		25.8		30.1	31.4	
Max	27.6	24.5	23.7	24.1	22.7	24.6	26.8	28.2	31.5	32.0	31.5	31.4
Min	22.6	16.8	17.1	15.8	14.5	19.9	20.0	25.3	24.0	29.7	26.7	27.6
Mean	25.7	21.5	20.9	20.4	17.8	22.3	23.8	26.7	29.1	31.0	30.1	29.4

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**
Drainage Area mi2

Little Manatee River Below I-75
Temperature, Water (Deg. C°), Water Year October 2007 to September 2008
Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	28.6	25.4	24.3	23.9	19.6	20.1	25.3	26.6	31.2	29.4	27.8	28.7
2	28.0	25.4	24.7	21.6	19.7	20.9	26.0	26.6	31.5	29.7	27.7	29.0
3	27.7	25.1	24.6	16.9	20.9	21.7	25.4	26.8	31.4	28.5	28.5	29.1
4	27.3	24.5	24.5	14.2	22.1	21.6	25.3	27.6	31.3	28.9	28.2	29.3
5	26.3	23.8	23.0	14.5	22.7	22.6	26.0	28.0	31.1	29.9	27.7	28.5
6	26.3	23.5	22.3	16.0	23.1	22.5	25.5	27.8	31.2	29.8	28.7	29.1
7	26.9	23.0	22.3	18.1	23.8	23.1	24.7	27.5	31.3	30.0	29.3	29.3
8	27.3	22.3	23.1	19.8	24.2	22.8	24.0	27.7	30.8	28.0	29.2	29.2
9	27.7	21.7	23.5	20.5	23.8	20.8	24.6	28.2	30.7	27.2	28.6	29.1
10	27.4	21.3	24.1	21.1	22.8	20.2	25.4	29.4	30.6	29.1	28.6	29.3
11	28.0	21.5	24.4	21.8	21.8	20.9	25.8	29.6	31.1	29.6	28.8	29.4
12	27.5	21.8	24.4	22.3	21.2	22.0	26.3	29.3	30.3	29.4	29.0	29.8
13	27.6	22.4	24.7	22.7	20.5	22.1	25.5	28.9	30.4	29.0	29.0	30.4
14	27.2	22.9	24.8	22.5	20.0	21.1	23.8	28.6	30.9	29.6	28.4	30.4
15	26.9	23.4	25.1	20.6	19.9	22.2	23.2	28.7	31.1	29.7	27.6	30.8
16	27.5	23.0	24.9	19.3	21.0	24.2	21.5	29.0	30.2	29.0	27.7	30.9
17	27.6	20.5	23.1	18.5	21.7	24.6	22.3	29.3	30.7	27.3	28.2	31.0
18	28.4	20.8	20.4	18.7	22.9	24.6	23.5	29.1	30.9	27.8	27.9	30.5
19	28.7	21.6	19.6	19.9	22.9	24.3	24.1	28.7	30.3	29.1	26.5	30.2
20	28.9	22.2	19.8	19.6	22.4	24.3	25.1	28.2	30.9	30.5	26.8	30.2
21	28.0	22.2	20.7	17.6	21.0	24.5	25.4	28.8	30.0	31.2	27.8	30.2
22	28.6	22.1	20.4	18.2	22.6	23.7	25.7	28.6	29.3	30.9	28.0	30.3
23	28.9	22.1	20.8	20.0	22.9	24.0	25.7	28.8	28.5	30.1	28.1	29.6
24	28.4	22.1	21.1	19.9	23.4	23.2	25.6	29.7	27.4	28.9	27.6	28.2
25	26.7	22.8	21.6	19.4	24.3	21.2	25.6	30.1	27.2	29.3	28.2	27.6
26	25.4	23.9	21.8	19.0	24.7	20.5	25.9	29.2	26.2	29.6	28.0	27.7
27	25.3	24.2	22.3	19.6	24.3	21.3	26.3	28.1	26.7	29.9	28.6	27.9
28	25.3	24.3	22.8	19.3	20.3	22.4	26.4	28.1	27.8	29.9	28.6	27.5
29	25.3	24.8	23.5	18.9	19.3	23.2	26.5	29.8	28.2	29.8	29.7	27.2
30	25.1	24.7	23.9	19.3		24.9	26.4	30.3	29.1	29.2	28.3	27.2
31	25.5		23.9	19.5		24.5		30.3		28.6	26.9	
Max	28.9	25.4	25.1	23.9	24.7	24.9	26.5	30.3	31.5	31.2	29.7	31.0
Min	25.1	20.5	19.6	14.2	19.3	20.1	21.5	26.6	26.2	27.2	26.5	27.2
Mean	27.2	23.0	22.9	19.4	22.1	22.6	25.1	28.6	29.9	29.3	28.2	29.3

Date Processed 10/29/08

Hydrologic Data Collection, Inc.

Little Manatee River Below I-75

Temperature, Water (Deg. C°), Water Year October 2007 to September 2008

Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	27.2	24.5	22.9	21.9	18.1	17.4	23.1	23.9	28.9	27.4	25.7	26.2
2	26.9	24.3	23.6	17.5	17.0	18.1	23.8	24.1	29.6	26.5	25.4	26.7
3	26.4	23.5	23.5	12.0	18.6	19.2	22.0	24.9	29.6	25.9	26.1	27.5
4	25.4	22.8	22.4	11.4	19.5	20.9	22.4	25.6	30.0	25.8	26.7	28.1
5	24.9	21.8	20.5	12.6	20.7	20.9	23.2	26.3	29.9	26.9	26.4	27.6
6	25.2	21.2	20.2	14.0	21.4	21.1	23.3	26.5	29.8	28.0	26.4	27.5
7	25.4	20.3	19.9	16.0	22.1	21.2	22.5	26.2	29.4	27.8	27.5	28.3
8	25.6	18.7	21.2	17.7	22.9	19.4	21.6	26.4	29.3	25.1	28.3	28.6
9	25.6	18.8	21.7	18.7	21.8	17.6	21.9	26.7	28.9	25.1	27.4	28.4
10	25.6	18.7	22.3	19.3	20.6	18.1	22.6	27.2	28.9	26.7	27.2	28.4
11	26.0	19.0	22.6	20.2	19.7	19.2	23.1	27.9	29.2	28.4	27.8	28.2
12	25.8	19.5	23.1	20.8	19.9	20.4	23.8	27.8	28.9	27.8	27.4	27.7
13	25.9	20.5	23.0	21.8	19.7	20.0	23.3	27.0	28.9	27.9	27.4	28.2
14	25.7	21.2	23.6	20.4	17.8	20.0	21.4	26.6	29.4	28.0	26.0	28.6
15	25.2	21.7	24.2	18.2	17.3	19.0	19.6	26.4	29.0	27.7	25.6	28.6
16	25.7	19.3	22.3	17.1	18.1	21.5	18.7	27.2	27.6	26.2	26.1	28.7
17	26.1	19.0	18.1	17.7	19.5	21.5	19.1	27.7	28.3	25.5	25.9	28.8
18	27.2	19.8	17.8	18.3	21.1	21.9	20.7	28.0	28.8	25.8	26.2	28.7
19	27.9	20.3	18.4	18.5	21.0	22.2	21.9	27.7	28.2	26.5	25.6	28.5
20	26.9	20.3	18.1	16.9	19.7	23.1	23.1	26.9	28.1	27.5	25.7	28.5
21	26.7	20.7	19.0	14.7	19.7	21.5	23.2	27.0	26.9	28.4	26.3	28.6
22	26.8	21.1	18.8	16.2	20.6	21.9	23.7	27.6	26.7	29.2	26.9	28.3
23	27.0	21.0	19.2	17.7	22.0	21.6	24.1	27.3	26.1	28.2	27.3	27.6
24	26.1	19.9	20.0	19.1	22.0	20.7	23.6	27.9	26.2	27.5	26.7	26.8
25	24.5	21.3	19.9	17.6	22.5	18.2	23.9	28.5	25.5	27.4	26.6	26.0
26	23.6	22.2	20.5	17.2	23.2	18.9	24.3	27.6	25.2	28.4	27.2	25.9
27	24.3	23.0	20.7	18.4	19.8	19.3	24.3	26.6	25.0	28.0	26.3	25.4
28	24.1	22.8	21.2	17.0	17.9	20.4	25.2	26.3	26.2	27.0	26.5	25.7
29	24.1	23.8	22.1	16.7	16.8	21.3	25.1	26.9	26.6	26.7	26.9	25.6
30	24.1	23.8	22.9	17.8		22.0	23.7	27.8	27.2	26.5	26.4	25.5
31	24.2		23.2	17.7		22.0		28.0		26.2	25.9	
Max	27.9	24.5	24.2	21.9	23.2	23.1	25.2	28.5	30.0	29.2	28.3	28.8
Min	23.6	18.7	17.8	11.4	16.8	17.4	18.7	23.9	25.0	25.1	25.4	25.4
Mean	25.7	21.2	21.2	17.4	20.0	20.3	22.7	26.8	28.1	27.1	26.6	27.6

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75
Temperature, Water (Deg. C°), Water Year October 2007 to September 2008
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	27.8	25.0	23.9	23.5	19.0	18.8	24.2	25.3	29.9	28.3	26.8	27.2
2	27.4	24.8	24.1	19.2	18.7	19.7	25.0	25.3	30.3	28.1	26.3	27.7
3	26.8	24.4	24.1	13.8	19.8	20.5	23.8	25.8	30.5	27.1	27.1	28.2
4	26.3	23.8	23.3	12.8	20.9	21.3	23.9	26.4	30.6	27.0	27.2	28.5
5	25.6	22.9	21.9	13.7	21.9	21.7	24.6	27.0	30.5	28.1	26.9	28.1
6	25.6	22.6	21.5	15.1	22.4	21.8	24.4	27.1	30.4	28.8	27.3	28.2
7	26.0	21.8	21.5	16.9	23.0	22.2	23.4	26.9	30.3	28.9	28.2	28.8
8	26.2	20.6	22.2	18.6	23.4	21.5	22.6	27.0	29.9	27.0	28.8	28.9
9	26.3	20.4	22.7	19.5	22.8	19.1	22.9	27.4	29.5	26.0	28.0	28.7
10	26.6	20.2	23.2	20.3	21.6	19.2	23.7	28.1	29.6	28.0	27.8	28.8
11	26.9	20.4	23.5	21.0	20.7	20.0	24.2	28.6	30.0	28.8	28.3	28.7
12	26.8	20.8	23.8	21.6	20.3	20.9	24.9	28.6	29.6	28.6	28.2	28.8
13	26.7	21.4	24.0	22.2	20.1	20.8	24.7	27.8	29.6	28.4	28.0	29.3
14	26.5	22.1	24.2	21.3	19.0	20.6	22.7	27.7	30.0	28.8	27.4	29.6
15	26.2	22.5	24.6	19.7	18.9	20.7	20.5	27.6	30.2	28.9	26.5	29.8
16	26.6	20.3	24.3	18.2	19.8	22.5	20.1	27.9	29.5	27.9	26.8	29.9
17	26.9	19.8	20.9	18.0	20.9	23.0	20.7	28.3	29.3	26.3	26.8	29.8
18	27.8	20.4	19.1	18.6	22.0	23.2	21.8	28.5	29.9	26.6	27.0	29.6
19	28.3	20.9	19.0	19.0	22.1	23.3	22.8	28.3	29.6	27.6	26.0	29.3
20	28.0	21.3	19.1	18.2	20.8	23.6	23.8	27.7	29.6	28.6	26.2	29.2
21	27.5	21.6	19.8	16.0	20.4	23.0	24.2	27.8	29.2	29.4	26.8	29.3
22	27.7	21.7	19.7	17.1	21.4	22.7	24.6	28.2	27.9	29.7	27.3	29.4
23	28.0	21.7	19.9	18.8	22.5	22.5	24.8	28.0	27.0	29.0	27.6	28.6
24	27.3	21.1	20.5	19.4	22.6	22.4	24.6	28.7	26.5	28.2	27.2	27.6
25	25.3	22.0	20.8	18.4	23.1	19.7	24.7	29.1	26.4	28.4	27.3	26.9
26	24.5	22.9	21.2	18.2	23.9	19.7	25.0	28.3	25.6	28.9	27.6	26.8
27	24.8	23.6	21.5	18.8	22.6	20.2	25.2	27.4	25.9	28.8	27.3	26.9
28	24.8	23.7	22.1	18.3	19.0	21.2	25.8	27.2	26.8	28.4	27.4	26.7
29	24.8	24.2	22.8	18.2	18.2	22.2	25.6	28.1	27.3	27.9	28.1	26.6
30	24.6	24.2	23.4	18.5		23.2	25.2	28.9	28.0	27.5	27.3	26.5
31	24.8		23.6	18.8		23.4		29.1		27.1	26.4	
Max	28.3	25.0	24.6	23.5	23.9	23.6	25.8	29.1	30.6	29.7	28.8	29.9
Min	24.5	19.8	19.0	12.8	18.2	18.8	20.1	25.3	25.6	26.0	26.0	26.5
Mean	26.4	22.1	22.1	18.4	21.1	21.4	23.8	27.7	29.0	28.1	27.3	28.4

Date Processed 10/10/07

Drainage Area mi2

Hydrologic Data Collection, Inc.

Little Manatee River Below I-75

Conductance, (Microsiemens/cm at 25° C), Water Year October 2006 to September 2007

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	810	17680	19920	25781	22612	20120	15930	21820	40100	41600	24520	18670
2	1150	17510	21080	23575	29200	24930	15590	23550	45340	39290	15280	17440
3	3140	14770	22740	19892	14623	21180	14360	25790	37300	37710	990	18720
4	5790	11820	25240	23514	1623	14600	15050	28670	36600	33440	890	19980
5	5550	20830	19470	27888	984	11280	20030	34180	36550	30120	1120	21510
6	10990	26300	23998	26000	1275	11770	15970	34190	34320	26380	4470	23680
7	9400	30360	30486	21990	3666	18670	13800	23860	33630	25290	6080	22950
8	12280	33190	20232	21044	4208	18410	14220	32090	29030	25800	10890	28380
9	10780	30580	15688	16021	5475	19380	16000	32790	26390	29460	18080	29170
10	15600	25460	17975	13537	6530	19920	16990	31020	26550	30380	18950	25900
11	20850	25650	20951	17105	7287	18520	16040	28400	29210	33130	22680	24900
12	19410	25200	20500	20266	8246	21850	11900	29670	33950	33960	9780	23860
13	17410	21830	21692	21435	15374	22760	3210	29570	32670	36160	7610	20040
14	12610	20940	21174	22376	12615	25050	5940	30520	37360	36680	9530	15110
15	10900	24190	21071	25500	12439	32330	17990	30370	40910	36210	5370	10860
16	14810	26830	22972	26200	9741	33240	4300	40160	40770	32660	1250	6010
17	17390	18320	23386	27146	3697	27840	4260	42100	38350	30320	1270	19980
18	14710	17200	25807	22829	13040	16330	14160	40870	39220	29270	1310	21510
19	12000	17180	26536	26473	2231	13030	13040	34310	34040	21040	1790	23680
20	11310	18780	25020	25638	4105	12070	15490	36320	33170	21480	2860	22950
21	11370	16930	28768	23470	6659	12150	12520	38460	29910	23330	9530	28380
22	11230	17210	30435	26880	6636	12990	17870	35930	29770	23160	14520	29170
23	14520	16950	35073	22725	7413	14780	19150	32320	31300	25550	16600	25900
24	7210	19340	28944	20854	15723	18240	21350	32300	32920	24240	23230	24900
25	15240	18740	28077	14717	18158	16420	22120	32430	30490	24840	25250	23860
26	18320	17960	21750	15752	19220	16840	23540	33800	28780	26570	25620	20040
27	24230	17310	12152	22511	18659	17660	22550	36370	33040	26010	23020	15110
28	34080	20560	12768	17242	18667	19630	20650	36030	35070	35730	22140	10860
29	13150	16920	14416	13833		19540	16910	37550	37750	33200	20430	6010
30	17890	19370	22146	13688		16250	16960	40100	39290	36460	20090	12750
31	19200		25514	15076		14760		39690		32420	20540	
Max	34080	33190	35073	27888	29200	33240	23540	42100	45340	41600	25620	29170
Min	810	11820	12152	13537	984	11280	3210	21820	26390	21040	890	6010
Mean	13333	20864	22774	21321	10361	18792	15263	33072	34459	30384	12442	20409

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75

Conductance, (Microsiemens/cm at 25° C), Water Year October 2006 to September 2007

Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	450	7500	8080	4994	2274	3480	3460	4820	23430	17120	6810	3170
2	490	6850	7110	3878	3992	6760	3070	6520	20750	16830	1000	2430
3	490	4780	6490	3612	986	4950	2330	6300	20650	15880	520	2140
4	510	2240	6140	4452	602	4000	2200	6640	15910	12990	490	2550
5	550	3070	4311	6078	552	2760	2300	7300	14850	9990	480	3030
6	560	5230	5750	6991	613	2490	3160	9820	15650	9380	610	4320
7	730	8940	8625	5655	694	5720	3610	8030	15080	8840	850	5110
8	840	10100	5056	7589	702	5430	2730	8080	16830	7990	920	7950
9	830	9300	4685	3779	631	4550	2850	11070	9280	6370	1130	10120
10	1170	7830	6624	2038	617	5210	3770	14010	10270	5750	1410	10020
11	2340	8940	8901	4932	546	4960	2130	14770	9650	6810	1610	8970
12	1690	9330	9941	6466	708	3760	1100	15910	9460	5270	680	9290
13	1560	11150	13635	5870	795	4830	640	18040	9140	5890	600	5830
14	1000	11820	12509	7117	1142	5490	670	15360	9430	6670	660	1550
15	1260	12130	11009	8073	721	7630	1560	15440	10140	7420	640	710
16	2970	12210	8213	8148	610	11510	650	17450	13960	8520	490	630
17	4530	5130	7989	7002	528	6880	610	18530	14900	8970	530	2550
18	3770	3940	8314	8111	538	3250	600	19570	16390	10960	620	3030
19	2880	3640	8084	8676	534	2700	910	17930	17850	8670	640	4320
20	2430	4290	7703	8987	612	2290	1040	16050	13310	7550	700	5110
21	2070	3340	9147	8836	611	2310	1100	17590	15220	11010	770	7950
22	1590	5450	11412	13373	651	2270	1490	19900	15480	10690	1160	10120
23	1750	3240	13285	11893	599	1750	2300	19880	15930	7850	1890	10020
24	1010	3960	11478	11460	633	1830	3330	22510	15520	6000	2930	8970
25	1640	3840	15250	6338	1243	2200	5280	23720	11170	5490	3370	9290
26	2690	5110	4616	1993	2089	2000	8180	24690	12370	5610	4010	5830
27	5710	5770	1984	1669	2270	2700	10960	25200	14990	4800	4420	1550
28	8500	6970	2151	4014	2614	3260	8400	24680	14800	8550	4420	710
29	3040	8340	2193	1009		3210	4700	23850	15720	8380	4110	630
30	3540	9060	2176	1196		3080	4040	23590	15290	8610	4130	1810
31	7120		3382	1549		3620		24550		9870	5320	
Max	8500	12210	15250	13373	3992	11510	10960	25200	23430	17120	6810	10120
Min	450	2240	1984	1009	528	1750	600	4820	9140	4800	480	630
Mean	2249	6783	7621	5993	1040	4093	2972	16187	14447	8862	1868	4990

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75

Conductance, (Microsiemens/cm at 25° C), Water Year October 2006 to September 2007

Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	520	12500	14070	14250	10590	11990	9570	12230	31410	28260	13510	9330
2	610	11580	13900	11240	12160	14810	8910	14180	33210	27460	7260	7970
3	810	8400	13870	11700	4050	11260	7760	14880	27940	25390	780	8790
4	1170	5610	12690	13830	900	8770	7450	16480	25950	22570	560	10270
5	1160	10490	11390	15930	670	6080	9990	19130	25740	20380	620	12540
6	2420	15400	14720	15380	780	6240	8480	20640	26630	19110	1320	13750
7	3260	20370	16920	14290	1210	10810	7360	13690	25830	16680	2300	14050
8	3560	19550	10280	14150	1380	11310	7140	18460	22850	16630	3840	16530
9	3430	18050	9690	8570	1510	11720	8460	22240	18020	18130	6420	16950
10	5360	16500	13020	5730	2140	11820	10140	23910	18300	18670	6350	17080
11	8020	17580	15770	9880	2240	11810	8660	22600	19630	20340	7800	15650
12	7800	18520	16100	13170	3560	11950	2950	23830	21460	19690	2620	15700
13	7350	17410	17500	14250	6160	13190	1080	23750	20530	20200	1610	13770
14	5180	16870	17380	15640	5730	15140	2110	22930	22480	20180	2100	7280
15	5540	17830	16550	17190	3410	18890	7110	22040	24650	20050	1280	2820
16	8630	18460	15810	16910	2150	19790	1270	27550	26370	18590	710	1560
17	11260	11180	16150	14930	1510	13280	1310	29350	25320	19400	790	10270
18	9100	10410	16800	16870	3390	7770	3700	28640	27240	19240	810	12540
19	6480	10580	16410	16850	980	7070	4810	24800	25950	14640	890	13750
20	6110	11040	16700	16610	1600	6550	5130	24760	24720	15730	1150	14050
21	5650	8560	18670	17030	1960	6550	4290	27880	24490	16350	2760	16530
22	5530	10980	21770	19710	2280	5560	6860	28100	22520	16840	6120	16950
23	5490	10170	22040	17210	2200	6160	9380	27110	23570	16730	8380	17080
24	2840	11590	19740	16050	4560	8510	12390	27740	24360	16540	12150	15650
25	7900	11350	22050	10890	8010	7130	15170	28140	23020	16590	12850	15700
26	10530	12050	12380	5810	10190	8650	17330	28650	22280	17890	12390	13770
27	14600	12870	5390	9000	10610	10870	17730	29830	24130	16590	10770	7280
28	18960	14410	6720	8720	9680	12760	15000	29710	25330	19930	10450	2820
29	7360	13370	7880	4510		10290	12010	30340	25970	19520	10010	1560
30	11650	13550	9610	6320		8580	10240	31290	27030	20750	10190	5470
31	13360		12060	6680		9430		31310		18770	12280	
Max	18960	20370	22050	19710	12160	19790	17730	31310	33210	28260	13510	17080
Min	520	5610	5390	4510	670	5560	1080	12230	18020	14640	560	1560
Mean	6505	13574	14646	12881	4129	10475	8126	24071	24564	19285	5518	11582

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Drainage Area mi2

Little Manatee River Below I-75

Conductance, (Microsiemens/cm at 25° C), Water Year October 2007 to September 2008

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	19400	9130	23730	24050	15620	16670	20840	21130	38360	15500	8110	12080
2	18150	9120	22770	18250	15900	16480	20200	23560	40520	19850	760	480
3	30560	9500	22760	14350	19390	21710	13780	26090	42970	16610	820	440
4	10420	9620	21330	23420	22140	22470	4100	28390	44560	17090	510	570
5	420	7620	23100	25740	23630	24850	3270	28920	44960	18700	470	660
6	430	11720	24200	26660	26590	20960	1380	31050	42680	16190	450	2860
7	280	12430	23740	27240	24620	20140	730	35000	40560	14310	460	3940
8	280	7520	24370	28570	24270	27520	520	39210	38180	4020	790	780
9	330	11480	24930	30600	21540	7450	420	37460	34670	590	670	2630
10	400	12290	27070	28910	17100	7990	4330	35710	32570	1830	450	34730
11	480	15280	26880	30270	13270	12820	13620	34860	34500	2240	490	27980
12	800	15160	29390	28130	23490	15570	15780	26980	32120	4800	640	18210
13	830	17920	27370	27530	23300	13330	9720	26170	30000	8040	5490	18360
14	1240	20530	27210	23120	18070	13530	8950	28660	27930	13170	5730	20750
15	990	21580	28420	22210	17030	21620	6290	30580	28850	15040	560	16780
16	9940	11870	36310	24460	21360	20030	2160	33510	33140	12520	460	14270
17	11890	17580	19340	29720	29490	14800	5210	33680	30980	3240	410	11320
18	18100	17820	21840	26880	30710	18060	11620	37580	35580	1530	360	13050
19	19670	17640	23780	31660	24380	20960	16460	36750	31460	2250	380	11690
20	18550	15730	28550	33320	20010	22470	18660	37740	32500	3240	430	15030
21	12920	20490	29300	15400	19690	12760	20940	38730	23510	4620	460	14750
22	11400	24960	25980	22240	21880	14810	20080	36290	21920	1460	560	22450
23	14120	25250	29350	27210	20800	13560	18840	37770	8050	960	590	15020
24	13830	22050	30070	20170	16880	9990	20050	38630	880	1330	700	11190
25	7810	31240	29900	9780	15970	5740	24430	31950	610	3290	360	13330
26	4200	32570	30750	9640	20170	11850	26350	31890	590	4110	420	24130
27	4060	31970	32180	12970	13130	18700	26140	31810	980	10520	350	18630
28	8270	26000	27250	9980	12230	18360	26510	30470	940	14020	350	18770
29	5420	28260	26520	12200	13030	17670	20550	31260	1240	16200	890	18270
30	6960	26310	26680	16420		17160	19850	31480	5300	17330	430	18740
31	7130		25930	15400		20820		34300		13200	600	
Max	30560	32570	36310	33320	30710	27520	26510	39210	44960	19850	8110	34730
Min	280	7520	19340	9640	12230	5740	420	21130	590	590	350	440
Mean	8364	18021	26484	22468	20196	16802	13393	32504	26037	8961	1102	13396

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75

Conductance, (Microsiemens/cm at 25° C), Water Year October 2007 to September 2008

Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	2800	570	11600	16820	2280	2290	5640	8980	23620	600	400	270
2	3320	650	15700	5870	1720	3000	4630	12080	21970	800	320	270
3	1600	750	13840	3700	2470	4530	600	13740	21990	780	360	310
4	390	1180	10030	3990	3150	6960	450	12660	22400	780	380	350
5	230	1240	9520	7140	4600	10210	430	11710	23470	880	380	380
6	200	1730	9090	9510	6970	8080	420	12510	22830	1190	380	410
7	190	1470	7980	10590	7170	8060	400	11420	23110	1290	360	430
8	170	1030	8470	11230	6780	1830	320	13100	23360	370	390	470
9	210	1280	8700	13070	5930	1080	300	15430	22330	450	390	500
10	270	1490	9300	12230	4590	990	330	15310	23130	520	370	2200
11	310	1960	9680	14110	4070	1050	380	15750	23430	550	390	3630
12	350	1790	10950	14590	5240	1360	560	20660	12850	540	390	2970
13	370	2800	10910	15730	7850	1220	830	14530	7490	640	410	2830
14	400	3660	11050	11440	3690	1070	660	14480	7840	660	420	2620
15	410	5180	14450	10510	2300	1330	560	19580	6340	790	360	2360
16	490	2400	15510	8730	2530	2300	500	22100	6370	630	340	1740
17	680	4820	8700	11310	3840	1720	540	20160	5040	430	300	1600
18	1420	6060	9230	9610	8280	2460	1140	20480	6110	430	280	1240
19	2210	7480	10040	8290	5700	5380	2980	18880	5660	430	320	900
20	1550	7860	9720	4390	4360	3210	3350	18620	5350	450	360	1020
21	1660	7660	11820	2510	6580	2560	3800	18900	3960	490	390	1060
22	1910	8750	9920	3190	10470	3530	4140	17700	2230	560	430	1650
23	2700	8170	10320	4780	9080	2050	3750	16340	810	560	450	1210
24	2120	5170	9890	2010	5800	1370	3230	18030	420	550	310	1070
25	830	7840	10480	1150	4690	780	3950	18260	370	570	290	1590
26	550	10400	11660	1430	3500	950	5360	14600	410	560	310	3410
27	540	10250	13890	1460	2900	1350	6090	16260	470	560	260	3770
28	500	8470	13210	1010	1160	2660	7930	18970	490	480	250	3890
29	500	11570	14430	1160	1310	3300	9660	20050	490	510	300	3680
30	530	10760	18290	2840		3360	6140	21090	570	540	260	3420
31	600		17550	1640		3380		22890		450	260	
Max	3320	11570	18290	16820	10470	10210	9660	22890	23620	1290	450	3890
Min	170	570	7980	1010	1160	780	300	8980	370	370	250	270
Mean	968	4815	11482	7292	4793	3014	2636	16622	10830	614	349	1708

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75
Conductance, (Microsiemens/cm at 25° C), Water Year October 2007 to September 2008
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	8570	2810	18850	20300	9290	9260	14730	14830	29740	3740	1200	1800
2	10330	3160	19300	11220	8450	9760	10590	18230	30870	5530	400	300
3	11910	3550	18360	6890	10630	13430	3120	19720	32000	4220	400	300
4	2320	4650	16640	9740	11980	16050	1350	20100	33070	4160	400	400
5	290	4300	17590	16070	13800	16450	1060	19250	33140	5740	400	400
6	270	6210	17300	18780	15580	14230	600	20160	31770	6040	400	700
7	220	5350	17290	20240	14800	14590	500	21600	31440	6310	300	700
8	200	4170	17240	20660	13810	13120	390	25240	30810	1140	400	500
9	250	5670	17850	21390	12370	2220	330	25450	29590	500	400	700
10	310	6000	18720	20670	9810	2480	910	25020	28690	740	400	15400
11	380	7170	19150	21980	8290	4220	3380	26210	28640	830	400	17400
12	450	7700	20210	22290	13360	6710	5340	24420	23240	1150	400	8100
13	510	9960	19990	22190	17060	4840	3650	21740	20690	2200	1200	7500
14	580	11280	20640	17720	9050	5980	3580	21960	19690	3640	1200	7900
15	650	12030	23070	15160	9190	9190	1150	25780	19860	4470	400	7200
16	2440	6190	26390	14220	10340	9350	910	28120	20080	3000	300	5500
17	4490	12120	13150	21393	14430	6440	1870	27840	18490	790	300	4900
18	7470	13090	14140	18904	17780	9740	5130	28770	19830	580	300	4500
19	9510	12880	17150	19327	12600	14110	8240	28310	17430	660	300	3400
20	8260	11420	18300	11963	11560	11450	9870	27990	17600	810	300	4500
21	5810	13300	19500	5630	14610	7000	10530	27920	13860	1010	400	5100
22	5790	16230	17970	13123	16560	9090	10560	26900	10810	800	400	8500
23	7260	15010	19180	12752	16300	7980	9850	26980	3160	690	400	6400
24	6530	13270	19340	7582	12370	4480	9680	27930	630	710	400	4000
25	2420	18250	19250	3145	10990	1680	12710	24350	450	920	300	6100
26	1120	19820	20680	4573	12520	5060	14580	23830	500	1090	300	10600
27	1230	19410	21950	5630	7650	8570	15410	25200	620	2200	200	10000
28	1890	17240	21460	3112	3900	10580	18160	26060	620	2900	200	10100
29	1270	20000	21810	5782	6410	10650	14640	25730	630	3200	300	9800
30	1910	19410	22850	8041		10000	12950	25670	1270	4400	300	8700
31	2110		21730	9042		11590		27550		1900	300	
Max	11910	20000	26390	22290	17780	16450	18160	28770	33140	6310	1200	17400
Min	200	2810	13150	3112	3900	1680	330	14830	450	500	200	300
Mean	3444	10722	19260	13855	11913	9042	6859	24479	18307	2454	429	5713

Date Processed 10/10/07

Drainage Area mi2

Hydrologic Data Collection, Inc.

Little Manatee River Below I-75

Salinity, parts per thousand, Water Year October 2006 to September 2007

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.40	10.43	11.89	16.75	15.89	12.26	9.31	12.59	25.60	23.59	13.41	9.75
2	0.57	10.32	12.64	15.25	20.91	15.51	8.94	13.53	29.80	22.23	8.19	9.11
3	1.63	8.58	13.73	12.86	9.67	12.69	8.11	14.76	23.28	21.03	0.48	9.81
4	3.13	6.76	15.38	15.14	0.96	8.49	8.47	16.47	22.16	18.55	0.41	10.42
5	2.99	12.49	12.18	18.01	0.58	6.44	11.49	19.93	21.60	16.53	0.51	11.31
6	6.21	16.10	15.93	16.61	0.77	6.74	9.18	19.76	20.25	14.24	2.13	12.62
7	5.25	18.85	20.74	13.57	2.29	11.10	8.15	13.60	19.74	13.67	2.93	12.32
8	7.00	20.80	13.49	12.80	2.60	10.93	8.75	19.81	16.88	13.78	5.38	15.70
9	6.08	19.00	10.85	9.52	3.41	11.55	10.20	20.18	15.06	15.74	9.27	16.21
10	9.08	15.54	12.51	8.76	4.07	11.89	11.12	18.56	14.79	16.29	9.77	14.31
11	12.44	15.67	14.89	11.49	4.62	10.99	10.32	16.74	16.17	18.03	11.74	13.55
12	11.51	15.36	13.93	13.89	5.31	13.15	7.53	17.59	18.79	18.46	4.80	12.72
13	10.22	13.13	14.69	14.58	10.29	13.74	1.76	17.37	18.22	19.63	3.71	10.66
14	7.21	12.55	14.15	14.96	8.03	15.27	3.20	17.86	21.53	19.94	4.72	7.82
15	6.17	14.69	14.08	16.96	7.89	20.20	10.58	18.07	23.99	19.63	2.56	5.48
16	8.60	16.46	15.21	17.12	6.32	20.82	2.36	24.82	23.59	17.58	0.58	2.96
17	10.24	10.86	15.30	17.81	2.39	17.13	2.45	25.61	21.95	16.20	0.57	4.27
18	8.54	10.15	16.74	14.87	9.27	9.60	8.66	24.45	22.23	15.60	0.59	3.15
19	6.83	10.14	17.26	17.44	1.41	7.52	7.76	20.20	19.25	10.95	0.82	4.39
20	6.41	11.17	16.23	16.97	2.64	6.93	9.13	22.17	18.54	11.28	1.33	6.43
21	6.45	9.99	19.03	15.64	4.24	6.97	7.26	23.73	16.79	12.21	4.67	16.27
22	6.35	10.18	20.33	17.94	4.14	7.49	10.67	21.99	16.50	12.31	7.34	11.22
23	8.38	10.01	23.55	14.56	4.59	8.60	11.61	19.66	17.31	13.76	8.58	9.15
24	3.97	11.55	18.80	13.20	10.25	10.80	12.98	19.71	18.19	13.17	12.33	8.06
25	8.89	11.16	17.92	9.63	11.85	9.63	13.36	19.93	16.66	13.76	13.75	8.91
26	10.86	10.65	13.68	10.71	12.42	9.89	14.25	20.88	15.69	14.59	14.01	9.27
27	14.72	10.23	7.70	16.22	11.59	10.42	13.27	22.60	18.41	14.13	12.40	9.52
28	21.40	12.32	8.23	12.00	11.58	11.68	11.93	22.30	19.88	19.89	11.68	10.17
29	7.57	9.97	9.47	9.69		11.62	9.57	23.04	21.73	18.43	10.61	10.07
30	10.58	11.53	14.59	9.74		9.51	9.57	24.79	22.45	20.33	10.31	6.64
31	11.42		16.55	10.82		8.57		24.99		18.07	10.63	
Max	21.40	20.80	23.55	18.01	20.91	20.82	14.25	25.61	29.80	23.59	14.01	16.27
Min	0.40	6.76	7.70	8.76	0.58	6.44	1.76	12.59	14.79	10.95	0.41	2.96
Mean	7.78	12.55	14.89	14.05	6.79	11.23	9.06	19.93	19.90	16.57	6.46	9.74

Date Processed 10/10/07

Hydrologic Data Collection, Inc.

Little Manatee River Below I-75
Salinity, parts per thousand, Water Year October 2006 to September 2007
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.22	4.14	4.49	2.91	1.42	1.93	1.82	2.48	14.51	9.01	3.46	1.48
2	0.24	3.75	3.91	2.25	2.41	3.82	1.60	3.41	12.84	8.94	0.48	1.12
3	0.24	2.56	3.55	2.08	0.56	2.67	1.19	3.29	12.22	8.48	0.23	0.98
4	0.25	1.15	3.35	2.52	0.35	2.12	1.12	3.48	9.27	6.73	0.22	1.16
5	0.27	1.61	2.49	3.48	0.33	1.44	1.17	3.83	8.38	5.15	0.22	1.40
6	0.27	2.82	3.42	3.98	0.37	1.29	1.66	5.23	8.64	4.72	0.27	2.05
7	0.36	5.00	5.30	3.14	0.42	3.11	2.00	4.33	8.44	4.36	0.37	2.50
8	0.41	5.70	3.14	4.28	0.41	2.95	1.54	4.47	9.37	3.84	0.40	4.02
9	0.41	5.22	3.01	2.18	0.37	2.44	1.61	6.32	4.74	3.04	0.49	5.18
10	0.58	4.34	4.27	1.20	0.36	2.82	2.20	8.01	5.21	2.76	0.63	5.15
11	1.20	5.00	5.71	3.09	0.32	2.67	1.23	8.37	4.84	3.28	0.72	4.64
12	0.86	5.23	6.31	4.10	0.41	1.99	0.59	9.05	4.74	2.53	0.30	4.68
13	0.79	6.35	8.93	3.71	0.46	2.60	0.34	10.19	4.69	2.83	0.27	2.85
14	0.50	6.75	8.05	4.46	0.66	2.98	0.34	8.53	4.83	3.25	0.29	0.72
15	0.63	6.96	6.95	5.07	0.41	4.23	0.79	8.69	5.35	3.64	0.29	0.32
16	1.54	7.00	5.06	5.04	0.36	6.57	0.34	9.88	7.48	4.21	0.22	0.28
17	2.42	2.77	4.91	4.19	0.32	3.78	0.32	10.47	8.03	4.48	0.23	0.32
18	1.98	2.10	5.03	4.95	0.33	1.71	0.31	11.07	8.80	5.47	0.27	0.33
19	1.50	1.93	4.85	5.29	0.33	1.41	0.47	10.15	9.62	4.34	0.28	0.35
20	1.25	2.29	4.59	5.53	0.37	1.18	0.54	9.27	7.05	3.69	0.30	0.48
21	1.06	1.76	5.53	5.42	0.36	1.19	0.58	10.29	8.09	5.39	0.33	1.46
22	0.80	2.96	6.95	8.29	0.38	1.17	0.78	11.66	8.16	5.37	0.50	1.30
23	0.89	1.71	8.03	7.24	0.34	0.89	1.24	11.78	8.26	3.94	0.85	1.38
24	0.50	2.11	6.77	7.22	0.36	0.93	1.83	13.37	7.88	3.04	1.38	1.85
25	0.83	2.04	9.34	4.02	0.71	1.13	2.91	14.27	5.58	2.68	1.60	2.03
26	1.40	2.76	2.69	1.25	1.19	1.03	4.61	14.56	6.28	2.71	1.95	2.01
27	3.10	3.14	1.16	1.04	1.27	1.40	6.16	14.83	7.84	2.32	2.12	2.30
28	4.73	3.83	1.29	2.52	1.44	1.71	4.41	14.52	7.83	4.22	2.12	2.05
29	1.59	4.65	1.32	0.62		1.68	2.41	13.91	8.35	4.21	1.97	1.63
30	1.86	5.08	1.28	0.75		1.61	2.05	14.06	8.11	4.34	1.96	0.86
31	3.91		1.98	0.99		1.91		14.77		5.02	2.53	
Max	4.73	7.00	9.34	8.29	2.41	6.57	6.16	14.83	14.51	9.01	3.46	5.18
Min	0.22	1.15	1.16	0.62	0.32	0.89	0.31	2.48	4.69	2.32	0.22	0.28
Mean	1.18	3.76	4.63	3.64	0.61	2.21	1.61	9.31	7.85	4.45	0.88	1.90

Date Processed 10/10/07 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75
Salinity, parts per thousand, Water Year October 2006 to September 2007
Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.25	7.19	8.17	8.94	7.22	7.13	5.41	6.75	19.50	15.57	7.13	4.66
2	0.29	6.62	8.07	7.00	8.20	8.77	4.99	7.87	21.30	15.15	3.77	3.96
3	0.40	4.70	8.07	7.29	2.55	6.47	4.27	8.24	17.27	13.90	0.37	4.41
4	0.59	3.06	7.35	8.55	0.52	4.94	4.06	9.16	15.56	12.17	0.25	5.18
5	0.59	6.01	6.81	9.88	0.40	3.34	5.54	10.74	15.06	10.93	0.28	6.38
6	1.28	9.09	9.44	9.39	0.47	3.44	4.75	11.57	15.43	10.09	0.61	7.04
7	1.74	12.27	11.01	8.54	0.74	6.18	4.23	7.60	14.96	8.70	1.06	7.29
8	1.91	11.76	6.69	8.38	0.83	6.49	4.25	10.90	12.89	8.57	1.81	8.77
9	1.83	10.77	6.54	5.11	0.90	6.74	5.18	13.34	9.89	9.36	3.13	9.04
10	2.95	9.76	8.95	3.45	1.30	6.81	6.41	14.20	9.88	9.66	3.10	9.12
11	4.52	10.43	10.82	6.43	1.37	6.80	5.46	13.16	10.53	10.59	3.83	8.29
12	4.40	11.02	10.85	8.79	2.22	6.92	1.67	13.83	11.46	10.23	1.24	8.22
13	4.14	10.29	11.69	9.47	3.97	7.69	0.56	13.70	10.96	10.52	0.75	7.11
14	2.84	9.94	11.48	10.28	3.55	8.91	1.10	13.11	12.37	10.52	0.99	3.65
15	3.02	10.55	10.76	11.23	2.09	11.31	3.99	12.69	13.81	10.47	0.59	1.38
16	4.82	10.97	10.20	10.86	1.34	11.85	0.68	16.32	14.77	9.66	0.32	0.73
17	6.43	6.40	10.35	9.44	0.94	7.76	0.72	17.25	14.09	10.14	0.35	1.17
18	5.12	5.94	10.64	10.75	2.29	4.36	2.14	16.63	15.15	10.01	0.36	0.79
19	3.55	6.05	10.31	10.71	0.61	3.93	2.75	14.33	14.37	7.50	0.39	1.26
20	3.34	6.34	10.53	10.60	1.02	3.62	2.90	14.68	13.62	8.05	0.51	2.29
21	3.08	4.83	11.95	10.95	1.22	3.62	2.40	16.82	13.41	8.35	1.29	6.83
22	3.01	6.29	14.05	12.63	1.38	3.06	3.95	16.93	12.12	8.74	2.97	5.93
23	3.00	5.82	14.12	10.77	1.32	3.42	5.51	16.27	12.63	8.75	4.16	5.04
24	1.49	6.70	12.33	10.07	2.84	4.83	7.37	16.71	13.02	8.81	6.19	4.49
25	4.44	6.54	13.78	6.96	5.07	4.00	8.98	17.01	12.21	8.88	6.67	4.64
26	6.02	6.96	7.59	3.78	6.44	4.91	10.21	17.34	11.80	9.50	6.43	4.91
27	8.54	7.45	3.29	6.16	6.48	6.25	10.22	18.08	13.07	8.68	5.55	5.41
28	11.42	8.41	4.22	5.74	5.75	7.41	8.42	17.94	13.92	10.63	5.29	5.11
29	4.08	7.74	5.02	3.00		5.85	6.64	18.23	14.39	10.40	5.00	4.39
30	6.70	7.85	6.09	4.30		4.81	5.59	18.88	14.92	11.11	5.06	2.76
31	7.73		7.57	4.57		5.31		19.16		10.03	6.18	
Max	11.42	12.27	14.12	12.63	8.20	11.85	10.22	19.16	21.30	15.57	7.13	9.12
Min	0.25	3.06	3.29	3.00	0.40	3.06	0.56	6.75	9.88	7.50	0.25	0.73
Mean	3.66	7.93	9.31	8.19	2.61	6.03	4.68	14.18	13.81	10.18	2.76	5.01

Date Processed 10/29/08

Drainage Area mi2

Hydrologic Data Collection, Inc.

Little Manatee River Below I-75

Salinity, parts per thousand, Water Year October 2007 to September 2008

Daily Maximum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	10.86	5.11	14.37	14.98	10.38	11.08	12.66	12.54	22.11	8.30	4.23	6.51
2	10.14	5.10	13.74	11.66	10.48	10.74	12.05	14.29	23.15	10.94	0.36	0.22
3	18.21	5.33	13.73	10.97	12.63	14.17	7.89	15.74	24.66	9.07	0.37	0.20
4	5.60	5.40	13.34	19.08	14.22	14.64	2.19	16.99	25.62	9.31	0.23	0.26
5	0.20	4.21	14.93	20.40	15.26	16.35	1.72	16.97	25.74	10.07	0.22	0.30
6	0.21	6.69	15.80	21.03	17.11	13.37	0.69	18.32	24.08	8.59	0.21	1.39
7	0.13	7.13	15.38	20.63	15.62	12.54	0.37	21.07	22.70	7.56	0.21	1.90
8	0.13	4.16	15.81	20.70	15.16	17.87	0.26	23.79	21.65	2.00	0.35	0.35
9	0.15	6.56	15.95	21.56	13.37	4.53	0.21	22.21	19.60	0.27	0.30	1.26
10	0.19	7.06	17.22	19.89	10.62	4.95	2.29	20.52	18.58	0.89	0.20	20.22
11	0.22	8.94	17.09	20.57	8.27	8.10	7.77	19.95	19.78	1.06	0.22	15.94
12	0.37	8.85	18.63	18.74	15.95	9.77	8.96	15.19	18.14	2.34	0.29	9.92
13	0.39	10.61	17.08	18.06	15.61	8.29	5.48	14.99	16.88	4.09	2.74	9.88
14	0.59	12.30	16.93	14.99	12.05	8.52	5.13	16.59	15.51	6.93	2.88	11.08
15	0.48	12.97	17.68	14.98	11.25	13.90	3.56	18.19	15.85	7.94	0.26	8.77
16	5.31	6.80	23.23	17.59	14.03	12.27	1.22	19.91	18.74	6.60	0.21	7.32
17	6.46	10.40	12.65	21.75	19.71	8.92	3.04	19.85	17.53	1.62	0.19	5.68
18	10.02	10.55	14.93	19.08	20.63	11.01	7.05	22.12	20.00	0.73	0.17	6.73
19	10.82	10.44	16.46	22.31	15.59	12.99	10.14	21.83	17.67	1.06	0.18	5.97
20	10.11	9.21	20.09	23.61	12.77	13.91	11.26	22.74	18.09	1.51	0.20	7.94
21	6.98	12.27	20.77	11.03	13.06	7.48	12.63	22.90	12.82	2.17	0.21	7.75
22	6.11	15.22	17.71	15.81	14.50	9.08	11.91	21.33	12.14	0.65	0.26	12.10
23	7.63	15.41	20.50	19.58	13.22	8.23	11.10	22.37	4.19	0.44	0.27	7.96
24	7.45	13.29	20.62	13.59	10.39	5.85	11.83	22.25	0.42	0.61	0.32	5.95
25	4.17	19.47	20.19	6.25	9.65	3.38	14.77	17.91	0.29	1.60	0.16	7.30
26	2.21	20.37	20.60	6.23	12.13	7.57	15.94	18.23	0.28	2.00	0.19	14.13
27	2.14	19.95	21.66	8.63	7.67	12.12	15.56	18.64	0.48	5.36	0.16	10.51
28	4.57	15.89	17.80	6.44	7.88	11.72	15.76	18.09	0.45	7.31	0.16	10.64
29	2.91	17.41	17.07	8.11	8.62	10.93	11.92	18.31	0.59	8.57	0.40	10.33
30	3.82	16.09	16.80	11.14		10.15	11.56	18.19	2.66	9.33	0.19	10.67
31	3.92		16.26	10.23		12.68		19.92		7.03	0.28	
Max	18.21	20.37	23.23	23.61	20.63	17.87	15.94	23.79	25.74	10.94	4.23	20.22
Min	0.13	4.16	12.65	6.23	7.67	3.38	0.21	12.54	0.28	0.27	0.16	0.20
Mean	4.60	10.77	17.26	15.79	13.03	10.55	7.90	19.09	14.68	4.71	0.54	7.31

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75
Salinity, parts per thousand, Water Year October 2007 to September 2008
Daily Minimum Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1.36	0.27	6.61	10.22	1.37	1.40	3.18	5.13	12.66	0.28	0.18	0.12
2	1.64	0.32	9.18	3.75	1.04	1.82	2.44	7.04	11.83	0.37	0.15	0.12
3	0.78	0.37	8.01	2.60	1.47	2.75	0.29	7.91	11.85	0.38	0.17	0.14
4	0.19	0.59	5.99	2.91	1.85	4.18	0.23	6.99	12.03	0.38	0.17	0.16
5	0.11	0.62	5.90	5.19	2.68	6.31	0.21	6.44	12.74	0.41	0.17	0.17
6	0.10	0.88	5.66	6.76	4.14	4.89	0.21	6.92	12.44	0.56	0.17	0.18
7	0.09	0.74	4.94	7.21	4.16	4.84	0.20	6.32	12.69	0.61	0.16	0.19
8	0.08	0.52	5.10	7.36	3.89	1.05	0.16	7.31	12.87	0.18	0.17	0.21
9	0.10	0.64	5.17	8.60	3.42	0.61	0.15	8.68	12.33	0.21	0.17	0.22
10	0.12	0.76	5.48	7.82	2.67	0.56	0.16	8.51	12.83	0.24	0.17	1.04
11	0.15	1.00	5.65	9.03	2.41	0.59	0.19	8.64	12.82	0.25	0.17	1.78
12	0.16	0.91	6.41	9.22	3.16	0.75	0.28	11.46	6.78	0.25	0.18	1.42
13	0.18	1.46	6.41	9.77	4.85	0.68	0.41	8.08	3.80	0.29	0.19	1.34
14	0.19	1.93	6.39	7.18	2.29	0.59	0.34	8.11	3.91	0.30	0.19	1.25
15	0.20	2.79	8.49	6.72	1.41	0.76	0.31	11.28	3.17	0.37	0.16	1.11
16	0.23	1.24	9.59	5.78	1.52	1.27	0.28	12.28	3.28	0.30	0.16	0.81
17	0.32	2.60	5.43	7.56	2.29	0.93	0.30	11.12	2.53	0.20	0.14	0.74
18	0.68	3.31	6.05	6.29	5.00	1.35	0.62	11.38	3.07	0.20	0.13	0.57
19	1.06	4.14	6.57	5.35	3.37	3.07	1.64	10.58	2.86	0.20	0.15	0.41
20	0.75	4.37	6.40	2.76	2.60	1.73	1.79	10.57	2.70	0.20	0.17	0.46
21	0.80	4.25	7.70	1.64	4.04	1.42	2.05	10.73	2.01	0.22	0.18	0.48
22	0.92	4.90	6.42	1.99	6.52	1.98	2.23	9.87	1.10	0.25	0.20	0.77
23	1.34	4.55	6.63	2.93	5.35	1.09	2.02	9.10	0.38	0.25	0.20	0.56
24	1.06	2.79	6.21	1.17	3.31	0.75	1.74	9.98	0.20	0.25	0.14	0.50
25	0.41	4.35	6.58	0.67	2.59	0.44	2.14	9.99	0.17	0.26	0.13	0.77
26	0.27	5.89	7.33	0.84	1.91	0.53	2.93	7.95	0.19	0.25	0.14	1.75
27	0.27	5.79	8.81	0.85	1.69	0.76	3.36	9.09	0.23	0.25	0.12	1.96
28	0.24	4.72	8.19	0.60	0.68	1.52	4.37	10.83	0.23	0.22	0.11	2.02
29	0.24	6.59	8.85	0.69	0.78	1.87	5.40	11.38	0.22	0.24	0.13	1.91
30	0.26	6.10	11.30	1.74		1.88	3.42	11.40	0.26	0.25	0.12	1.77
31	0.29		10.74	0.97		1.89		12.68		0.21	0.12	
Max	1.64	6.59	11.30	10.22	6.52	6.31	5.40	12.68	12.87	0.61	0.20	2.02
Min	0.08	0.27	4.94	0.60	0.68	0.44	0.15	5.13	0.17	0.18	0.11	0.12
Mean	0.47	2.65	7.04	4.72	2.84	1.75	1.44	9.28	5.81	0.28	0.16	0.83

Date Processed 10/29/08 **Hydrologic Data Collection, Inc.**

Little Manatee River Below I-75

Salinity, parts per thousand, Water Year October 2007 to September 2008

Daily Mean Values

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	4.56	1.50	11.21	12.53	6.01	6.02	8.73	8.58	16.63	1.91	0.59	0.94
2	5.58	1.68	11.49	7.27	5.46	6.21	6.02	10.72	17.16	2.88	0.20	0.14
3	6.77	1.90	10.98	4.91	6.79	8.58	1.71	11.58	17.83	2.20	0.20	0.16
4	1.19	2.51	10.13	7.41	7.54	10.24	0.70	11.68	18.44	2.17	0.19	0.18
5	0.14	2.31	11.11	12.39	8.59	10.41	0.54	10.97	18.50	2.97	0.19	0.20
6	0.13	3.42	11.03	14.11	9.66	8.87	0.30	11.53	17.66	3.08	0.18	0.33
7	0.10	2.93	11.01	14.62	9.03	9.02	0.25	12.51	17.51	3.21	0.18	0.34
8	0.10	2.25	10.81	14.37	8.31	8.24	0.20	14.80	17.25	0.55	0.21	0.26
9	0.12	3.12	11.10	14.56	7.46	1.30	0.17	14.77	16.63	0.24	0.21	0.36
10	0.15	3.32	11.56	13.77	5.96	1.47	0.47	14.27	16.06	0.34	0.18	8.50
11	0.18	4.01	11.78	14.48	5.08	2.55	1.86	14.85	15.90	0.38	0.19	9.64
12	0.21	4.34	12.42	14.51	8.61	4.08	2.95	13.74	12.78	0.54	0.21	4.25
13	0.24	5.68	12.21	14.23	11.24	2.90	1.97	12.30	11.30	1.08	0.60	3.88
14	0.28	6.50	12.58	11.35	5.82	3.65	2.00	12.48	10.62	1.84	0.58	4.03
15	0.31	6.94	14.07	9.96	5.95	5.71	0.64	14.90	10.67	2.25	0.19	3.63
16	1.24	3.41	16.42	9.67	6.60	5.57	0.50	16.29	10.94	1.50	0.17	2.74
17	2.34	7.00	8.30	15.15	9.24	3.69	1.05	15.98	10.09	0.38	0.16	2.41
18	3.97	7.59	9.38	13.05	11.27	5.72	2.99	16.49	10.75	0.28	0.14	2.22
19	5.05	7.45	11.59	13.21	7.75	8.49	4.86	16.29	9.39	0.30	0.16	1.66
20	4.37	6.53	12.40	8.11	7.24	6.80	5.75	16.29	9.48	0.37	0.18	2.28
21	3.02	7.71	13.09	3.78	9.42	4.02	6.11	16.21	7.36	0.46	0.19	2.57
22	2.99	9.57	12.00	9.14	10.56	5.37	6.05	15.42	5.80	0.36	0.21	4.44
23	3.77	8.80	12.83	8.61	10.13	4.71	5.60	15.54	1.60	0.31	0.22	3.32
24	3.41	7.73	12.77	4.86	7.49	2.54	5.53	15.90	0.30	0.33	0.21	2.07
25	1.25	10.91	12.60	1.93	6.52	0.96	7.40	13.56	0.21	0.43	0.15	3.25
26	0.57	11.90	13.49	2.87	7.38	3.10	8.52	13.48	0.24	0.51	0.16	5.89
27	0.63	11.64	14.31	3.56	4.44	5.38	8.98	14.60	0.30	1.12	0.13	5.48
28	1.00	10.22	13.75	1.92	2.40	6.58	10.60	15.19	0.29	1.47	0.13	5.52
29	0.65	11.97	13.78	3.70	4.12	6.46	8.40	14.71	0.30	1.64	0.17	5.37
30	1.00	11.59	14.28	5.20		5.87	7.42	14.44	0.61	1.94	0.14	4.74
31	1.11		13.48	5.88		6.87		15.54		1.00	0.15	
Max	6.77	11.97	16.42	15.15	11.27	10.41	10.60	16.49	18.50	3.21	0.60	9.64
Min	0.10	1.50	8.30	1.92	2.40	0.96	0.17	8.58	0.21	0.24	0.13	0.14
Mean	1.82	6.21	12.19	9.39	7.45	5.53	3.94	14.05	10.09	1.23	0.22	3.03

Appendix D

Best Subsets Regression for Mean and Maximum Salinity

Summary of Best Subsets Regression, Mean Salinity I75

Subset	R square	N of Vars	Ln(Q)	lag1_Ln(Q)	LN(Q)_2	LN(Q)_3	LN(Q)_MAV3	LN(Q)_MAV6	MeanStage FT I75
1	0.7968	7	-0.876	-0.644	-0.472	0.020	2.005	-1.023	0.201
2	0.7968	6	-0.871	-0.647	-0.456		1.985	-1.000	0.201
3	0.7932	6	-0.445	-0.532		-0.130	1.072	-0.934	0.199
4	0.7923	5	-0.361	-0.475			0.986	-1.106	0.198
5	0.7900	6	-0.474		-0.319	0.057	0.784	-1.009	0.204
6	0.7899	5	-0.455		-0.273		0.709	-0.944	0.204
7	0.7883	6		-0.272	0.069	-0.035	0.248	-0.949	0.194
8	0.7883	5	-0.215			-0.055	0.268	-0.948	0.203
9	0.7883	5		-0.264	0.046		0.269	-0.989	0.194
10	0.7881	5		-0.249		0.006	0.271	-0.967	0.193
11	0.7881	4		-0.249			0.267	-0.956	0.193
12	0.7881	4	-0.188				0.268	-1.025	0.202
13	0.7875	6	-0.039	-0.106	0.086	-0.100		-0.787	0.198
14	0.7874	5		-0.133	0.100	-0.086		-0.823	0.196
15	0.7873	5	-0.055	-0.050		-0.062		-0.779	0.198
16	0.7872	5	-0.075		0.023	-0.063		-0.831	0.200
17	0.7871	4	-0.074			-0.055		-0.817	0.199
18	0.7871	5	-0.016	-0.061	0.034			-0.896	0.197
19	0.7871	4		-0.077	0.044			-0.905	0.197
20	0.7871	4	-0.029	-0.041				-0.870	0.197
21	0.7870	4		-0.078		-0.031		-0.832	0.196
22	0.7870	3		-0.064				-0.876	0.196
23	0.7870	4	-0.047		0.004			-0.898	0.199
24	0.7870	3	-0.047					-0.894	0.199
25	0.7867	5			0.014	0.001	0.010	-0.961	0.198
26	0.7867	4			0.014		0.009	-0.960	0.198
27	0.7867	4			0.019	-0.005		-0.950	0.198
28	0.7867	3			0.017			-0.953	0.198
29	0.7867	4				0.009	0.020	-0.965	0.197
30	0.7867	3					0.014	-0.950	0.197
31	0.7866	3				0.001		-0.938	0.197
32	0.7866	2						-0.937	0.197
33	0.7789	6	-0.743	-0.623	-0.271	-0.475	1.113		0.192
34	0.7709	3	-0.436			-0.539			0.198
35	0.7700	3				-0.400	-0.551		0.189
36	0.7694	3		-0.516		-0.435			0.178
37	0.7622	6	-0.752	-0.707	-0.436	0.022	1.896	-0.936	
38	0.7559	3		-0.374			0.397	-0.895	
39	0.7546	3	-0.355		-0.587				0.182
40	0.7533	2		-0.099				-0.772	
41	0.7525	2			-0.028			-0.841	
42	0.7525	2	-0.014					-0.855	
43	0.7525	2					0.016	-0.883	
44	0.7525	2				-0.009		-0.859	
45	0.7525	1						-0.867	
46	0.7414	2		-0.491		-0.398			
47	0.7387	2				-0.376	-0.507		
48	0.7371	2					-0.903		0.177
49	0.7366	2	-0.389			-0.511			
50	0.7094	1					-0.842		
51	0.7047	1		-0.839					
52	0.7038	1			-0.839				
53	0.6854	1				-0.828			
54	0.6481	1	-0.805						
55	0.0174	1							-0.132

Summary of Best Subsets Regression, Max Salinity I75

Subset	R square	N of Vars	Ln(Q)	lag1_Ln(Q)	LN(Q)_2	LN(Q)_3	LN(Q)_MAV3	LN(Q)_MAV6	MeanStage FT_I75
1	0.7376	7	-0.692	-0.625	-0.385	0.028	1.662	-0.932	0.182
2	0.7375	6	-0.685	-0.629	-0.363		1.633	-0.900	0.182
3	0.7351	6	-0.340	-0.533		-0.094	0.900	-0.860	0.181
4	0.7347	5	-0.279	-0.492			0.837	-0.985	0.181
5	0.7323	6		-0.331	0.042	-0.015	0.274	-0.874	0.177
6	0.7323	5		-0.327	0.032		0.283	-0.891	0.177
7	0.7322	5		-0.317		0.010	0.288	-0.885	0.176
8	0.7322	4		-0.317			0.282	-0.869	0.176
9	0.7312	6	-0.302		-0.237	0.064	0.478	-0.919	0.186
10	0.7312	6	0.002	-0.179	0.077	-0.071		-0.737	0.180
11	0.7312	5		-0.178	0.076	-0.072		-0.735	0.180
12	0.7310	5	-0.281		-0.185		0.393	-0.846	0.186
13	0.7310	5	-0.013	-0.129		-0.037		-0.729	0.180
14	0.7310	5	0.018	-0.147	0.040			-0.814	0.180
15	0.7310	4		-0.135		-0.030		-0.742	0.180
16	0.7310	4		-0.130	0.029			-0.804	0.180
17	0.7309	4	0.003	-0.124				-0.784	0.180
18	0.7309	3		-0.122				-0.784	0.180
19	0.7302	5	-0.109			-0.019	0.094	-0.873	0.185
20	0.7302	4	-0.100				0.094	-0.901	0.185
21	0.7301	5	-0.059		-0.029	-0.009		-0.811	0.183
22	0.7301	4	-0.055		-0.032			-0.820	0.183
23	0.7301	4	-0.060			-0.019		-0.828	0.184
24	0.7301	3	-0.050					-0.855	0.183
25	0.7298	5			-0.025	0.028	-0.015	-0.888	0.182
26	0.7298	4			-0.032	0.037		-0.905	0.182
27	0.7298	4				0.013	-0.033	-0.882	0.182
28	0.7298	4			-0.008		-0.039	-0.856	0.182
29	0.7298	3					-0.041	-0.861	0.182
30	0.7298	3				0.026		-0.926	0.182
31	0.7297	3			-0.017			-0.885	0.182
32	0.7297	2						-0.901	0.182
33	0.7227	6	-0.571	-0.605	-0.203	-0.423	0.848		0.174
34	0.7170	3		-0.526		-0.390			0.163
35	0.7159	3				-0.360	-0.554		0.174
36	0.7135	3	-0.427			-0.509			0.183
37	0.7090	6	-0.579	-0.682	-0.353	0.030	1.562	-0.853	
38	0.7052	3		-0.431			0.400	-0.813	
39	0.7031	3	-0.337		-0.572				0.168
40	0.7026	2		-0.155				-0.689	
41	0.7009	2			-0.058			-0.781	
42	0.7008	2					-0.039	-0.799	
43	0.7007	2	-0.020					-0.819	
44	0.7007	2				0.017		-0.853	
45	0.7007	1						-0.837	
46	0.6933	2		-0.503		-0.356			
47	0.6892	2				-0.339	-0.514		
48	0.6891	2					-0.872		0.164
49	0.6843	2	-0.384			-0.484			
50	0.6654	1					-0.816		
51	0.6639	1		-0.815					
52	0.6588	1			-0.812				
53	0.6345	1				-0.797			
54	0.6049	1	-0.778						
55	0.0182	1							-0.135

Summary of Best Subsets Regression, Mean Salinity US 41

Subset	R square	N of Vars	Ln(Q)	lag1_Ln(Q)	LN(Q)_2	LN(Q)_3	LN(Q)_MAV3	LN(Q)_MAV6	MeanStage FT US41
1	0.8298	7	-0.595	-0.572	-0.342	-0.005	1.421	-0.870	0.077
2	0.8298	6	-0.596	-0.571	-0.346		1.427	-0.876	0.077
3	0.8279	6	-0.287	-0.502		-0.117	0.762	-0.805	0.076
4	0.8272	5	-0.210	-0.450			0.682	-0.960	0.076
5	0.8259	6		-0.327	0.026	-0.045	0.235	-0.820	0.075
6	0.8258	5		-0.317		-0.029	0.243	-0.827	0.074
7	0.8258	5		-0.315	-0.004		0.261	-0.871	0.075
8	0.8258	4		-0.316			0.261	-0.873	0.075
9	0.8251	6	0.002	-0.196	0.054	-0.093		-0.700	0.075
10	0.8251	5		-0.195	0.054	-0.093		-0.699	0.075
11	0.8250	5	-0.009	-0.160		-0.068		-0.695	0.075
12	0.8250	4		-0.165		-0.063		-0.704	0.075
13	0.8247	5	0.021	-0.153	0.004			-0.800	0.075
14	0.8247	4	0.020	-0.150				-0.797	0.075
15	0.8247	4		-0.133	-0.009			-0.786	0.075
16	0.8247	3		-0.135				-0.793	0.075
17	0.8244	6	-0.248		-0.224	0.034	0.364	-0.863	0.079
18	0.8244	5	-0.236		-0.196		0.318	-0.824	0.078
19	0.8243	6	-0.573	-0.586	-0.332	-0.011	1.387	-0.830	
20	0.8243	5	-0.575	-0.585	-0.340		1.399	-0.842	
21	0.8238	5	-0.063		-0.065	-0.023		-0.780	0.077
22	0.8238	4	-0.053		-0.072			-0.804	0.077
23	0.8236	5	-0.066			-0.046	0.000	-0.818	0.078
24	0.8236	4	-0.066			-0.046		-0.818	0.078
25	0.8235	4			-0.046		-0.046	-0.834	0.077
26	0.8235	4			-0.068	0.027		-0.882	0.077
27	0.8235	4	-0.044				0.000	-0.883	0.078
28	0.8235	3	-0.044					-0.883	0.078
29	0.8234	4				-0.026	-0.076	-0.824	0.077
30	0.8234	3			-0.057			-0.868	0.077
31	0.8234	3					-0.059	-0.866	0.077
32	0.8232	3				0.004		-0.927	0.078
33	0.8232	2						-0.923	0.078
34	0.8206	3		-0.341			0.274	-0.844	
35	0.8197	3		-0.183		-0.070		-0.661	
36	0.8194	3	0.029	-0.173				-0.765	
37	0.8194	3		-0.146	-0.015			-0.749	
38	0.8193	2		-0.151				-0.759	
39	0.8182	3	-0.055		-0.084			-0.772	
40	0.8178	2			-0.068			-0.839	
41	0.8178	2					-0.071	-0.835	
42	0.8178	2	-0.044					-0.863	
43	0.8175	2				0.005		-0.909	
44	0.8175	1						-0.904	
45	0.8169	6	-0.483	-0.560	-0.167	-0.428	0.665		0.068
46	0.8084	2		-0.535		-0.392			
47	0.8069	2				-0.364	-0.559		
48	0.8025	2	-0.422			-0.518			
49	0.7944	2	-0.326		-0.592				
50	0.7796	1					-0.883		
51	0.7729	1		-0.879					
52	0.7695	1			-0.877				
53	0.7423	1				-0.862			
54	0.7119	1	-0.844						
55	0.0217	1							-0.147

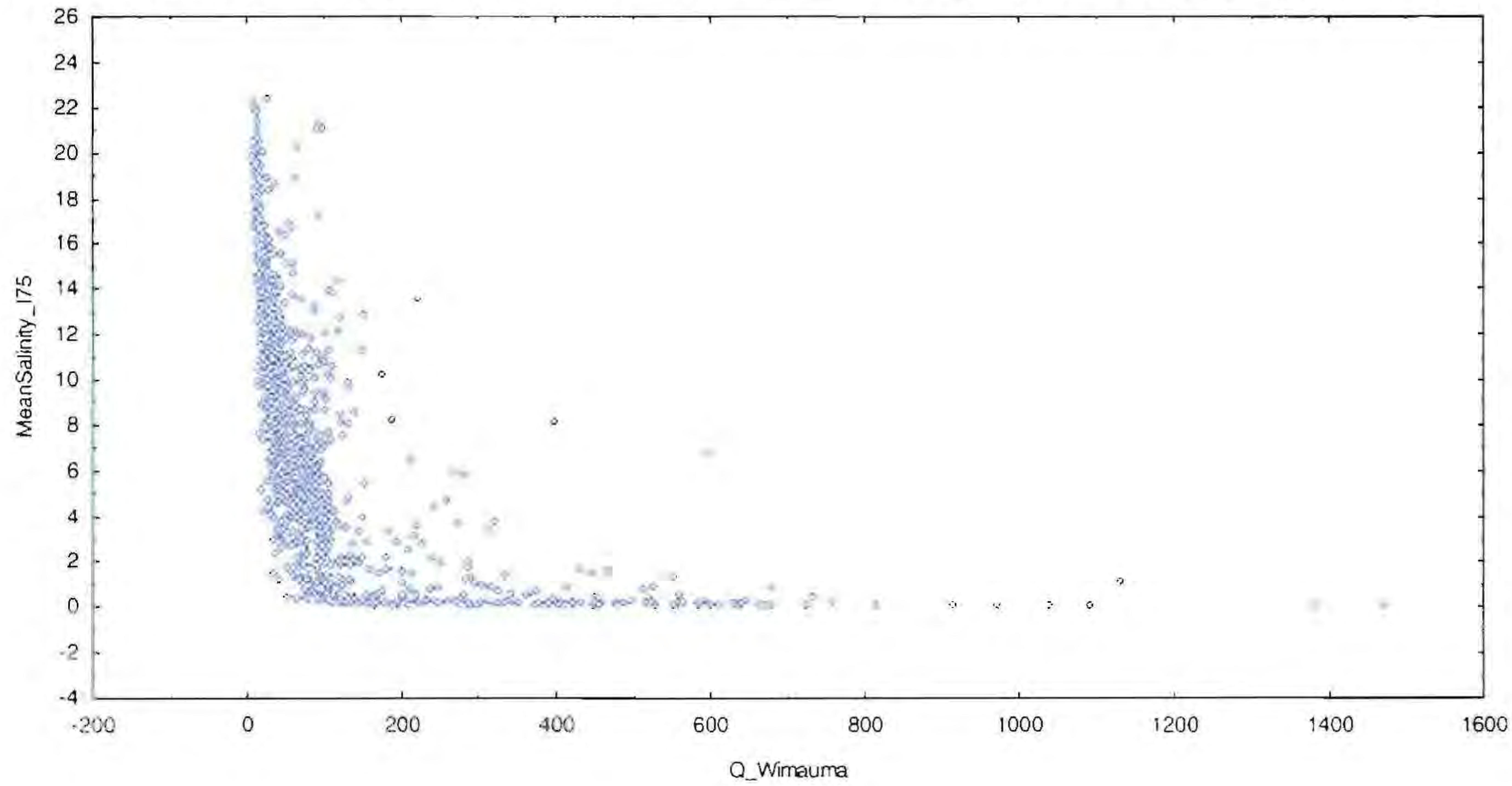
Summary of Best Subsets Regression, Max Salinity US 41

Subset	R square	N of Vars	Ln(Q)	lag1_Ln(Q)	LN(Q)_2	LN(Q)_3	LN(Q)_MAV3	LN(Q)_MAV6	MeanStage FT US41
1	0.5780	7	-0.362	-0.571	-0.131	-0.042	0.898	-0.599	0.108
2	0.5779	6	-0.371	-0.564	-0.164		0.941	-0.646	0.108
3	0.5777	6	-0.244	-0.544		-0.084	0.646	-0.574	0.107
4	0.5773	5	-0.189	-0.507			0.589	-0.686	0.108
5	0.5765	6		-0.422	0.093	-0.066	0.176	-0.569	0.106
6	0.5763	5		-0.404	0.050		0.214	-0.643	0.107
7	0.5762	5		-0.387		-0.009	0.204	-0.593	0.106
8	0.5762	4		-0.386			0.210	-0.608	0.106
9	0.5761	6	0.015	-0.333	0.120	-0.097		-0.491	0.107
10	0.5761	5		-0.323	0.114	-0.102		-0.477	0.107
11	0.5757	5	0.036	-0.288	0.067			-0.596	0.107
12	0.5756	4		-0.255	0.045			-0.574	0.107
13	0.5756	5	-0.009	-0.254		-0.043		-0.481	0.107
14	0.5756	4		-0.258		-0.038		-0.490	0.107
15	0.5755	4	0.010	-0.248				-0.545	0.107
16	0.5755	3		-0.241				-0.543	0.107
17	0.5726	6	-0.015		-0.013	-0.003	-0.158	-0.592	0.110
18	0.5726	5	-0.016		-0.015		-0.154	-0.595	0.110
19	0.5726	5	-0.005			-0.007	-0.179	-0.589	0.110
20	0.5726	5			-0.002	-0.005	-0.183	-0.590	0.110
21	0.5726	4				-0.006	-0.185	-0.589	0.110
22	0.5726	4			-0.005		-0.179	-0.595	0.110
23	0.5726	4	-0.001				-0.179	-0.599	0.110
24	0.5726	3					-0.181	-0.599	0.110
25	0.5725	5	-0.096		-0.082	0.022		-0.628	0.110
26	0.5725	4	-0.105		-0.075			-0.604	0.110
27	0.5721	4	-0.099			-0.008		-0.676	0.111
28	0.5721	3	-0.095					-0.687	0.111
29	0.5719	6	-0.285	-0.563	-0.010	-0.332	0.377		0.102
30	0.5717	4			-0.088	0.096		-0.782	0.110
31	0.5712	3				0.067		-0.839	0.111
32	0.5710	3			-0.046			-0.731	0.111
33	0.5708	2						-0.775	0.111
34	0.5694	3		-0.518		-0.275			0.099
35	0.5671	6	-0.330	-0.591	-0.116	-0.049	0.850	-0.542	
36	0.5664	3				-0.254	-0.535		0.104
37	0.5656	3		-0.421			0.229	-0.567	
38	0.5649	3		-0.285		-0.048		-0.428	
39	0.5648	3		-0.274	0.037			-0.520	
40	0.5647	2		-0.263				-0.496	
41	0.5613	2					-0.198	-0.555	
42	0.5605	2	-0.096					-0.659	
43	0.5602	2		-0.513		-0.257			
44	0.5596	2				0.068		-0.813	
45	0.5594	2			-0.062			-0.688	
46	0.5592	1						-0.748	
47	0.5563	2				-0.239	-0.525		
48	0.5531	2					-0.760		0.096
49	0.5521	2		-0.757					0.087
50	0.5450	1		-0.738					
51	0.5444	1					-0.738		
52	0.5269	1			-0.726				
53	0.4995	1				-0.707			
54	0.4988	1	-0.706						
55	0.0061	1							-0.078

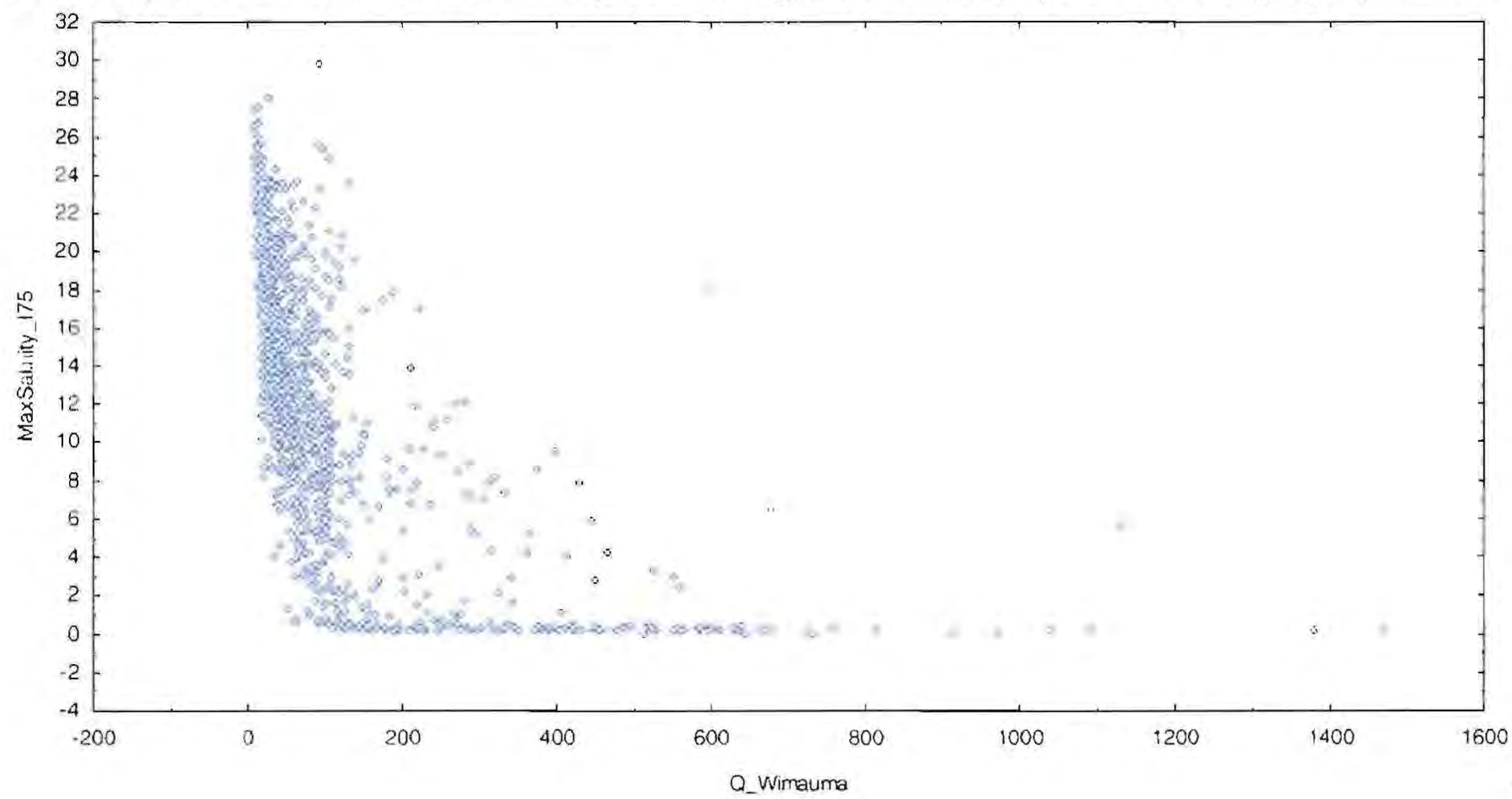
Appendix E

Output Tables and Scatter Plots

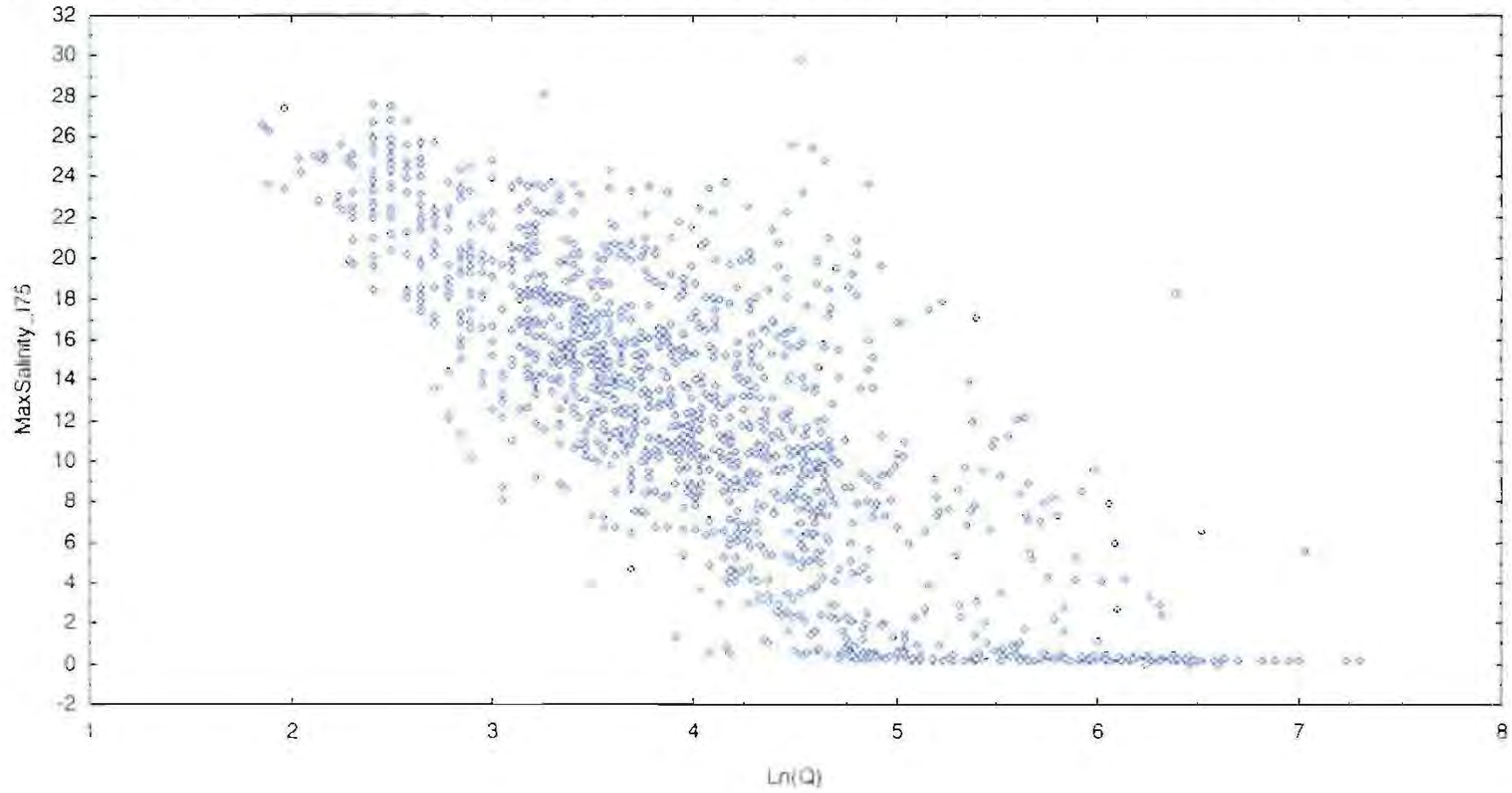
Scatter plot for mean salinity at I-75 against discharge at USGS gage (Wimauma).



Scatter plot for maximum salinity at I-75 against discharge at USGS gage (Wimauma).



Scatter plot for maximum salinity at I-75 against ln-discharge at USGS gage (Wimauma).



Output tables and plots related to salinity at I-75 station

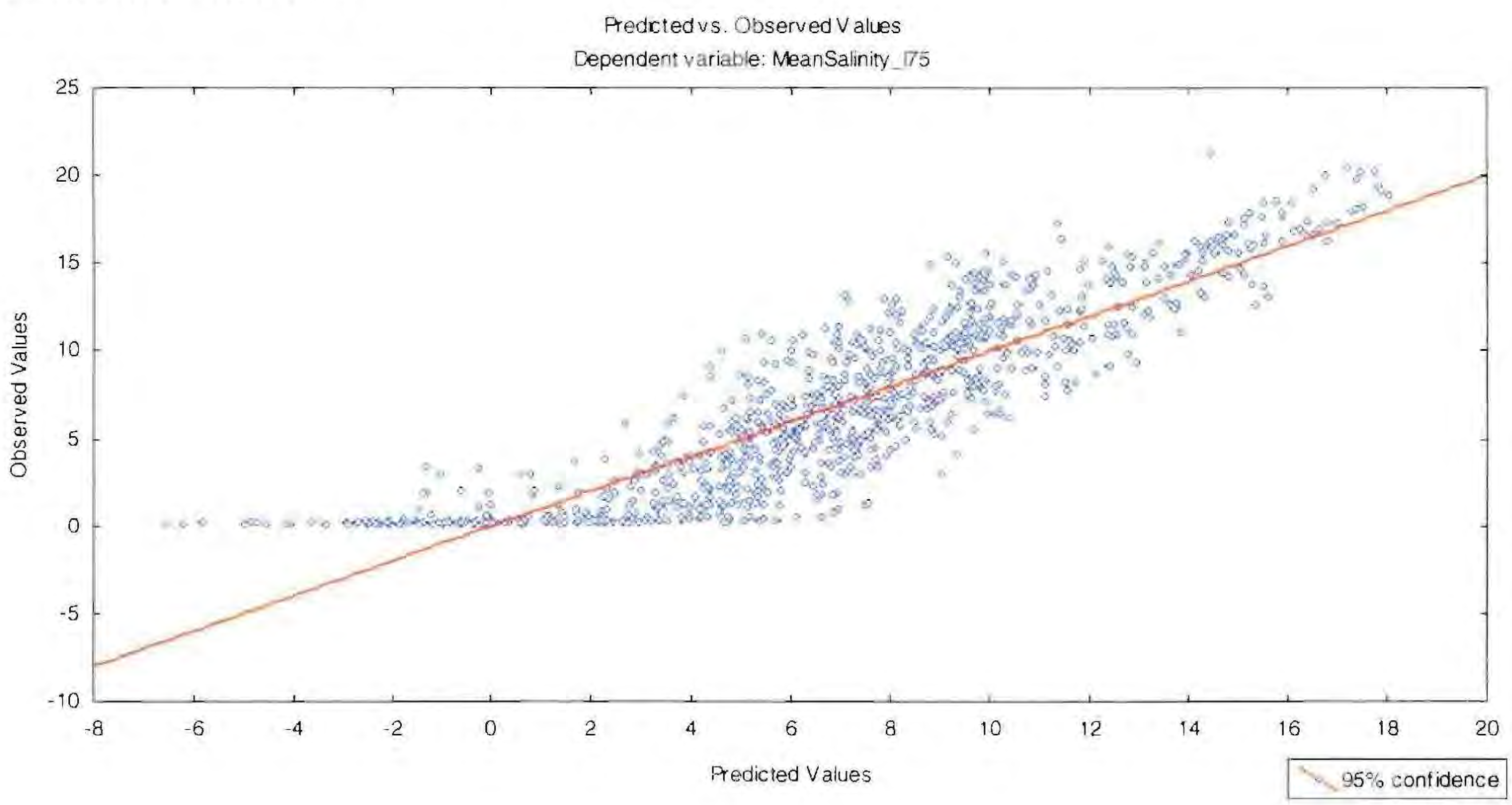
Output table for mean salinity at I-75.

Variable	Summary of Stepwise Regression; DV: MeanSalinity_I75 (LManatee_MLR_D						
	Step +in/-out	Multiple R	Multiple R-square	R-square change	F - to entr/rem	p-level	Variables included
LN(Q)_MAV6	1	0.852128	0.726123	0.726123	2688.387	0.000000	1
MeanStage FT_I75	2	0.883117	0.779895	0.053773	247.480	0.000000	2
MaxStage FT_I75	3	0.884564	0.782454	0.002559	11.905	0.000583	3

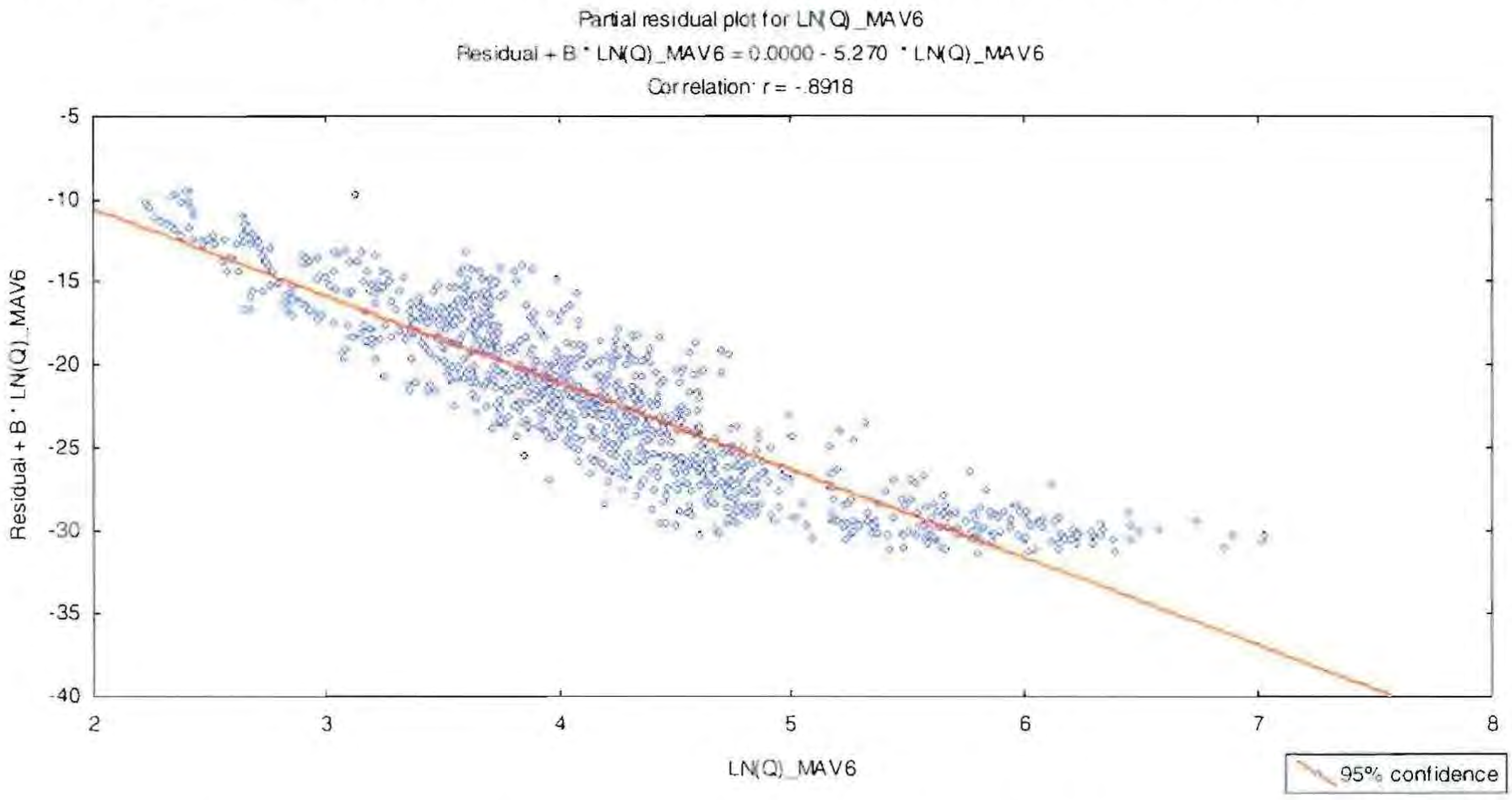
Output table for maximum salinity at I-75.

Variable	Summary of Stepwise Regression; DV: MaxSalinity_I75 (LManatee_MLR_Datase						
	Step +in/-out	Multiple R	Multiple R-square	R-square change	F - to entr/rem	p-level	Variables included
LN(Q)_MAV6	1	0.826143	0.682512	0.682512	2179.821	0.000000	1
MaxStage FT_I75	2	0.884328	0.782036	0.099524	462.543	0.000000	2
MeanStage FT_I75	3	0.889075	0.790454	0.008418	40.656	0.000000	3

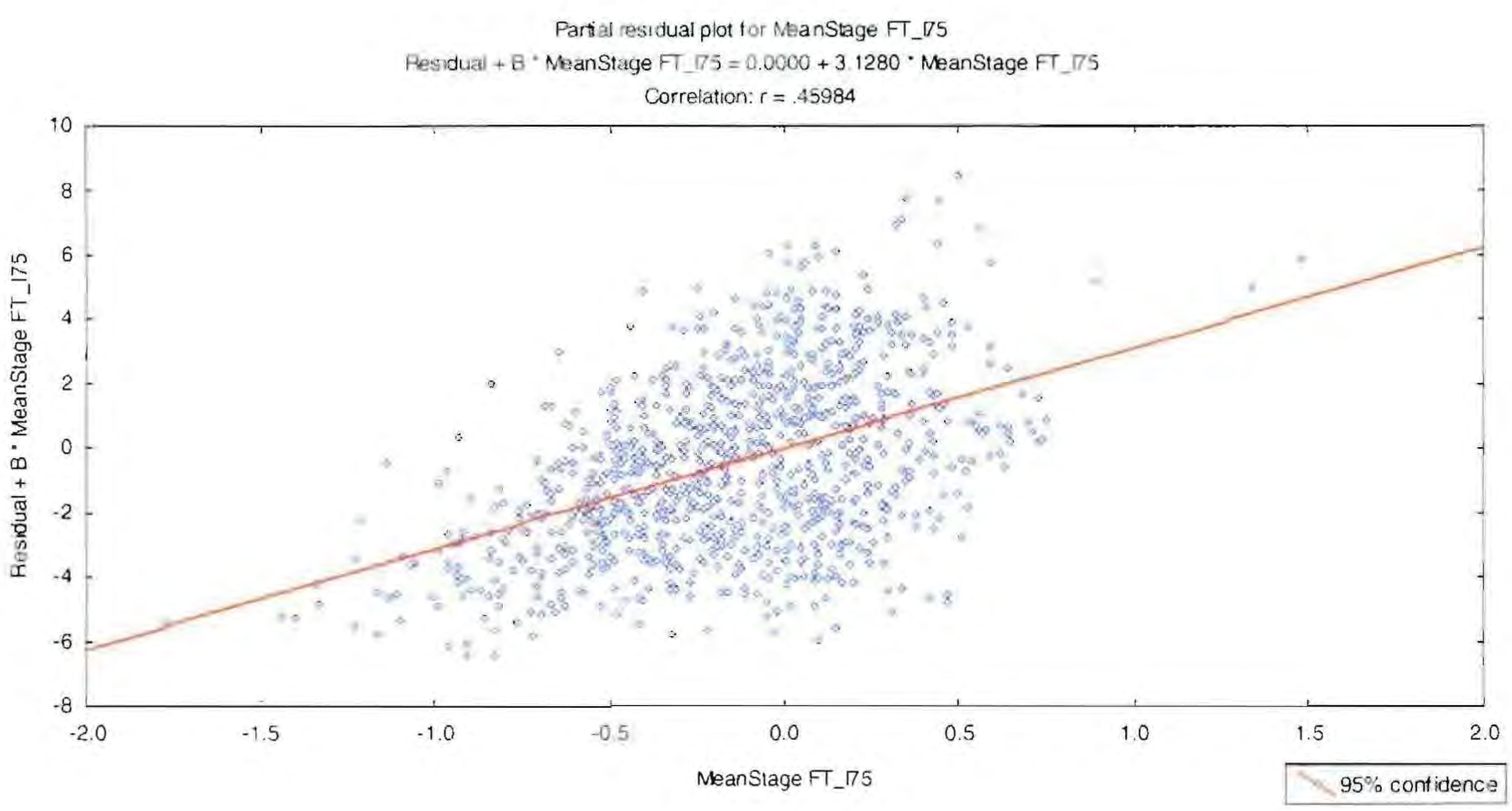
Scatter plot for observed and predicted mean salinity at I-75 with fitted regression lines and confidence intervals.



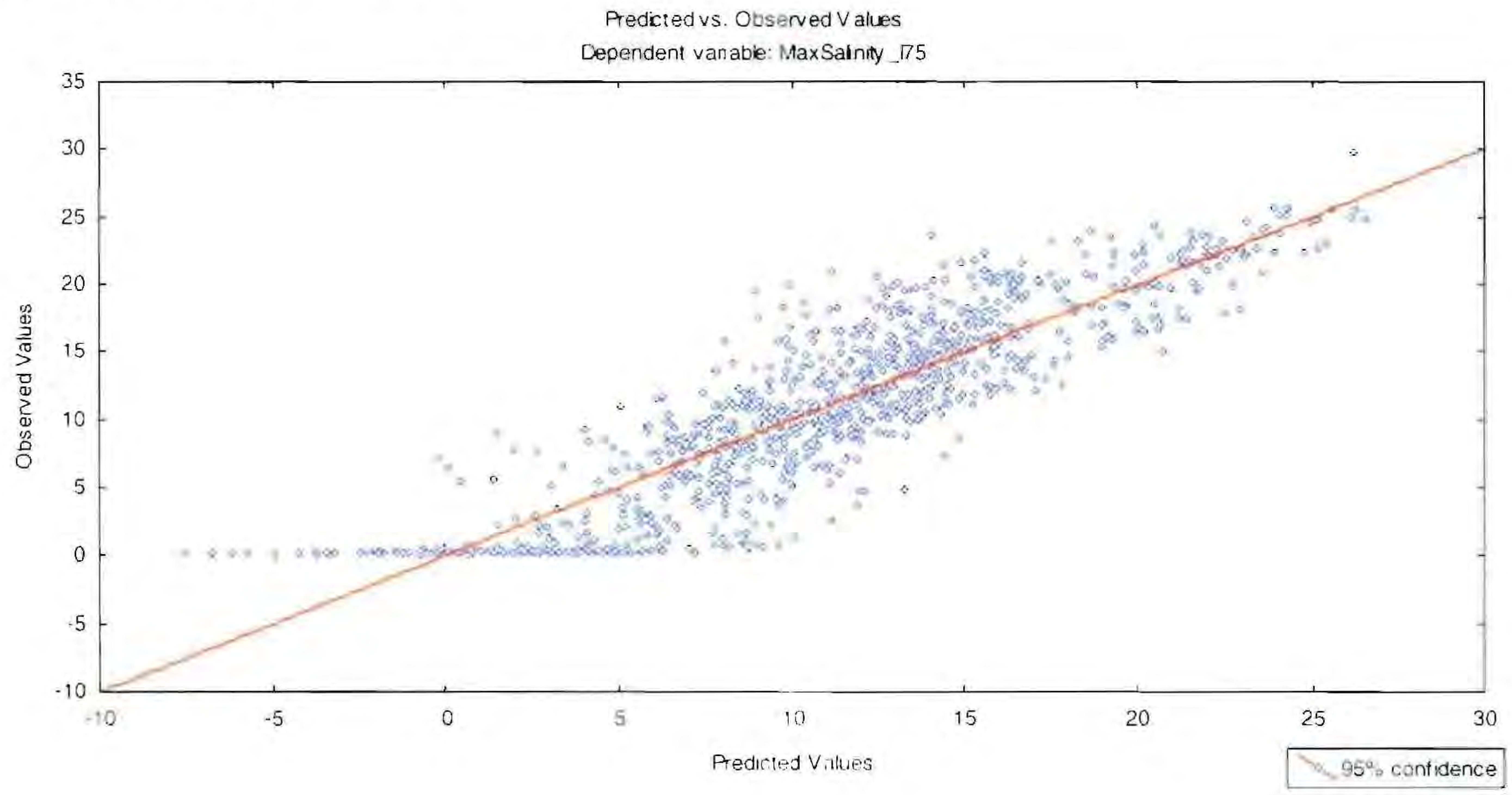
Partial residual scatter plot for lagged discharge (ln(Q)_MAV6) from the USGS gage from mean stage at I-75 with fitted regression lines and confidence intervals.



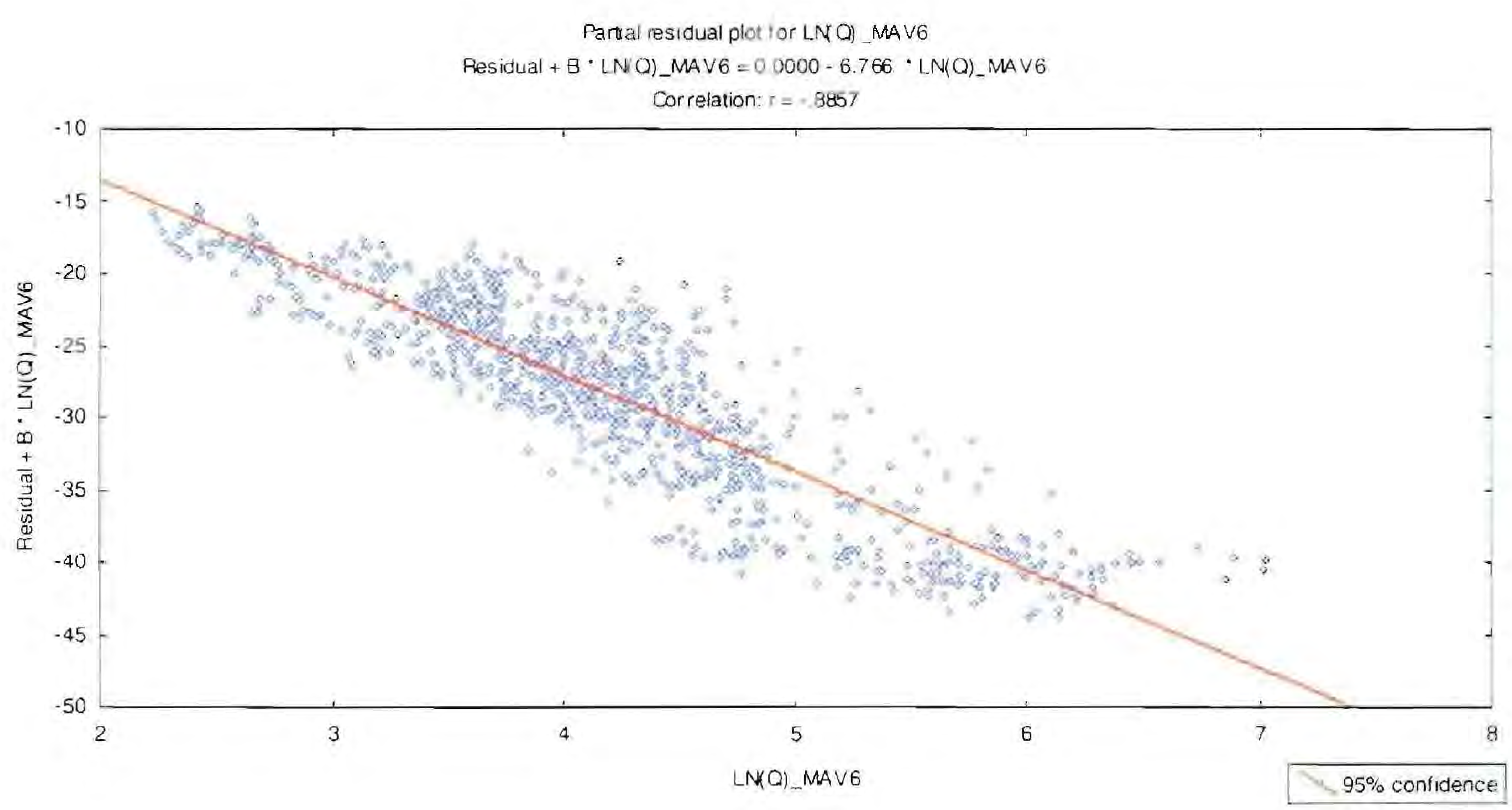
Partial residual scatter plot for mean stage at I-75 with fitted regression lines and confidence intervals.



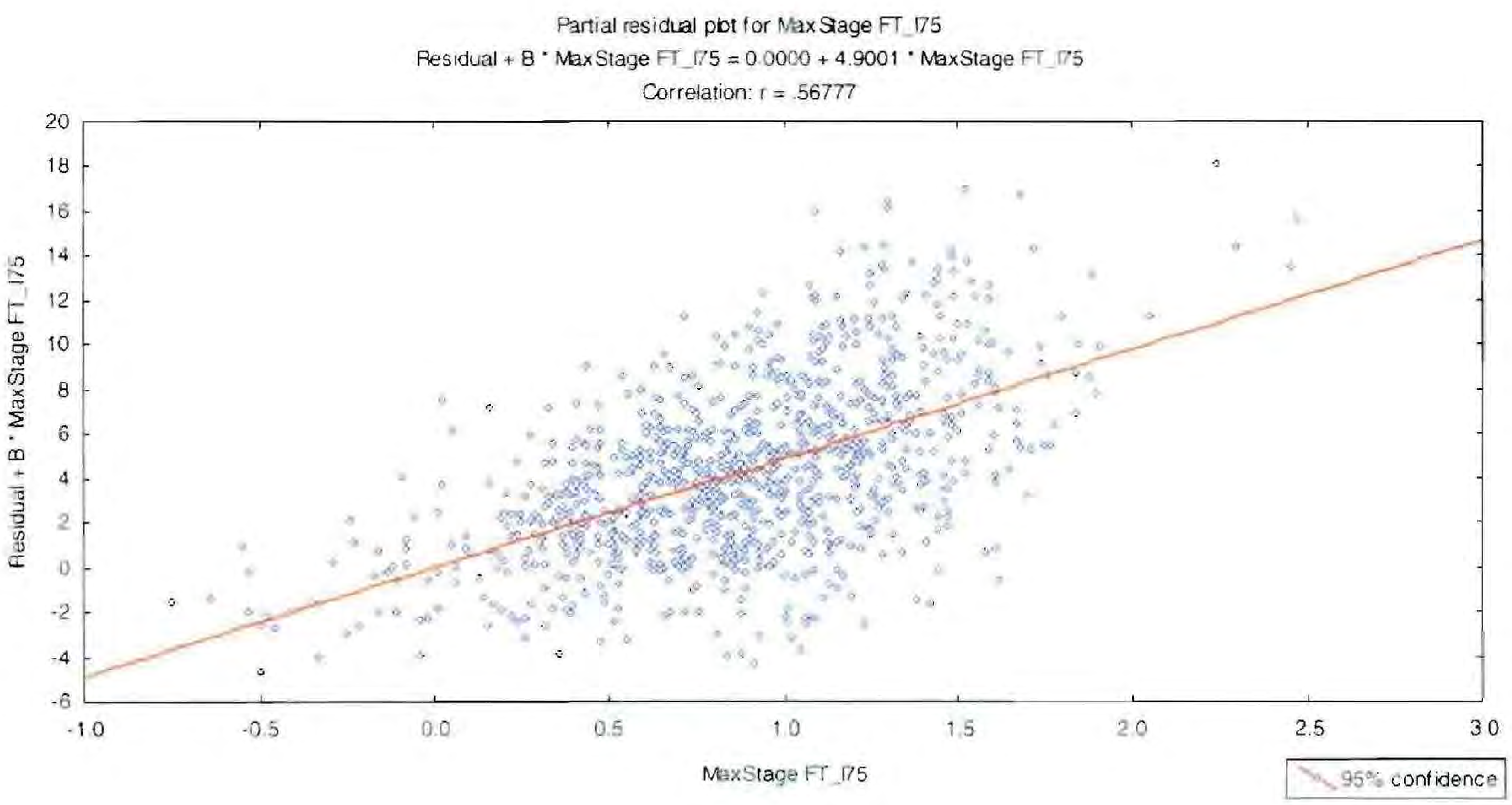
Scatter plot for observed and predicted maximum salinity at I-75 with fitted regression lines and confidence intervals.



Partial residual scatter plot for lagged discharge (ln(Q)_MAV6) from the USGS gage from maximum stage at I-75 with fitted regression lines and confidence intervals.



Partial residual scatter plot for maximum stage at I-75 with fitted regression lines and confidence intervals.



Output and plots related to salinity at US 41 station

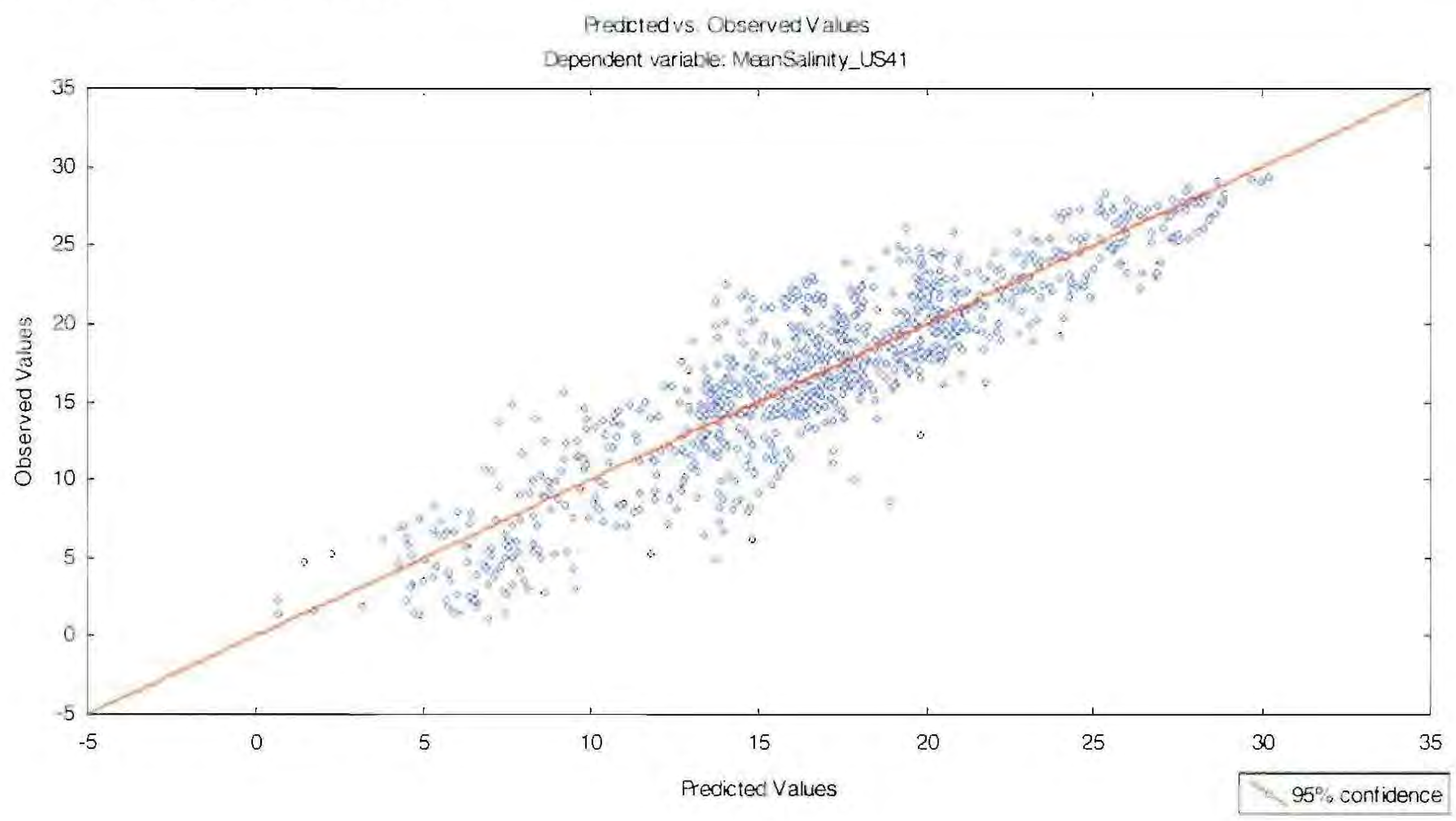
Output table for mean salinity at US 41.

Variable	Summary of Stepwise Regression; DV: MeanSalinity_US41 (LManatee_M						
	Step +in/-out	Multiple R	Multiple R-square	R-square change	F - to entr/rem	p-level	Variables included
LN(Q)_MAV6	1	0.902765	0.814984	0.814984	4281.596	0.000000	1
MaxStage FT_US41	2	0.911672	0.831146	0.016162	92.939	0.000000	2
MeanStage FT_US41	3	0.914236	0.835827	0.004681	27.657	0.000000	3

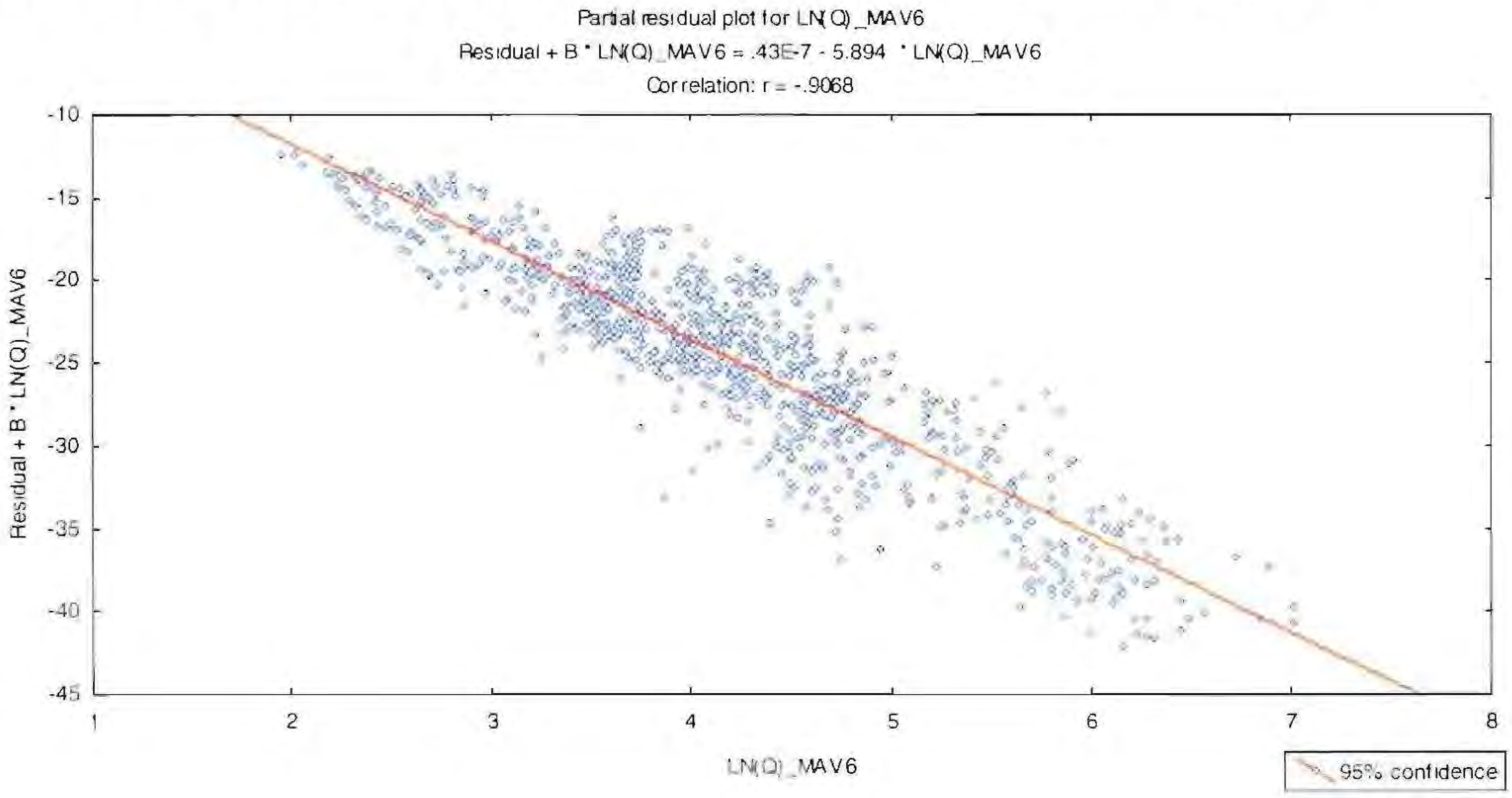
Output table for maximum salinity at US 41.

Variable	Summary of Stepwise Regression; DV: MaxSalinity_US41 (LManatee_ML						
	Step +in/-out	Multiple R	Multiple R-square	R-square change	F - to entr/rem	p-level	Variables included
LN(Q)_MAV6	1	0.744951	0.554953	0.554953	1212.037	0.000000	1
MaxStage FT_US41	2	0.777573	0.604620	0.049668	121.977	0.000000	2
MeanStage FT_US41	3	0.810881	0.657528	0.052908	149.852	0.000000	3

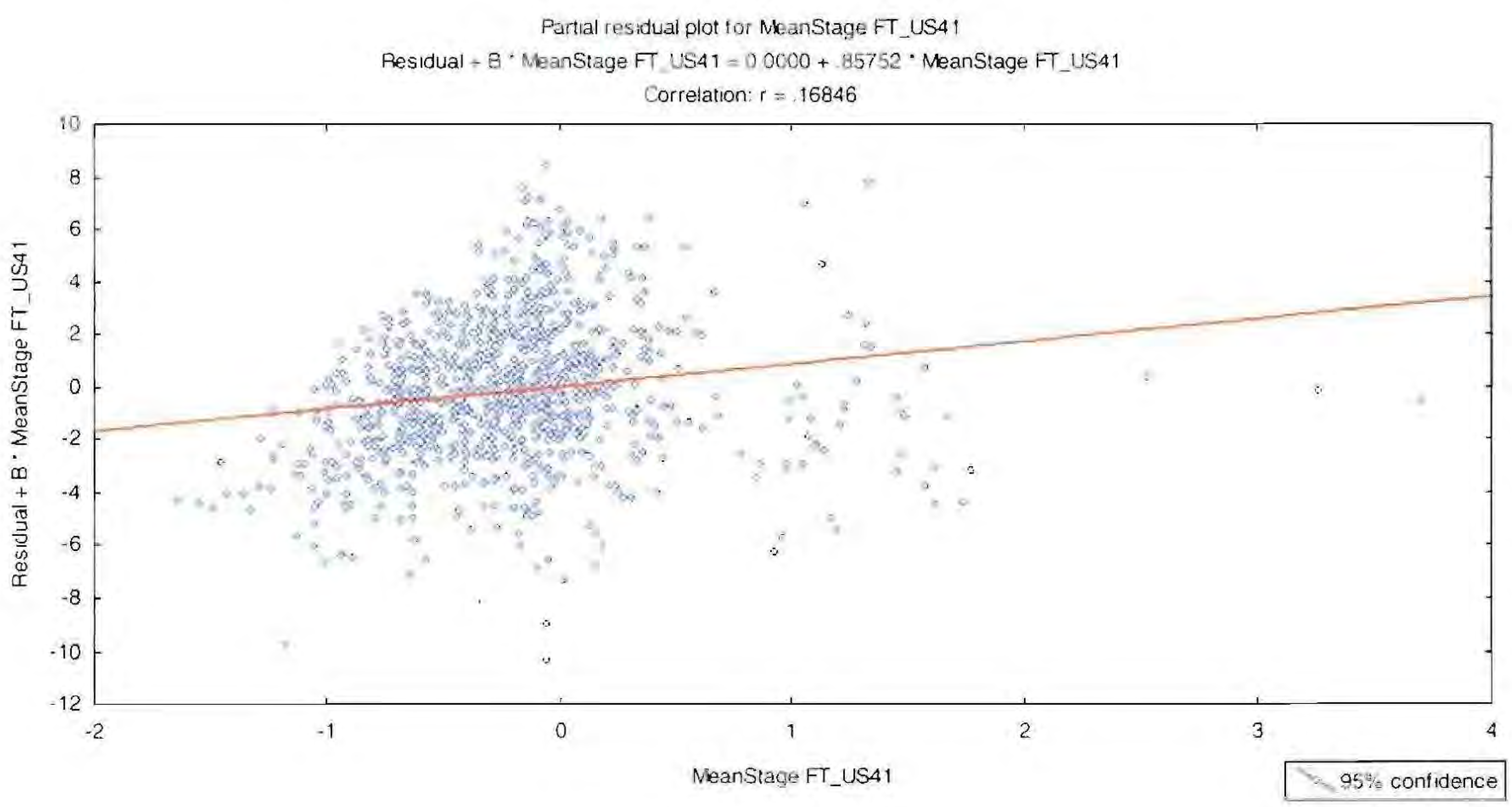
Scatter plot for observed and predicted mean salinity at US 41 with fitted regression lines and confidence intervals.



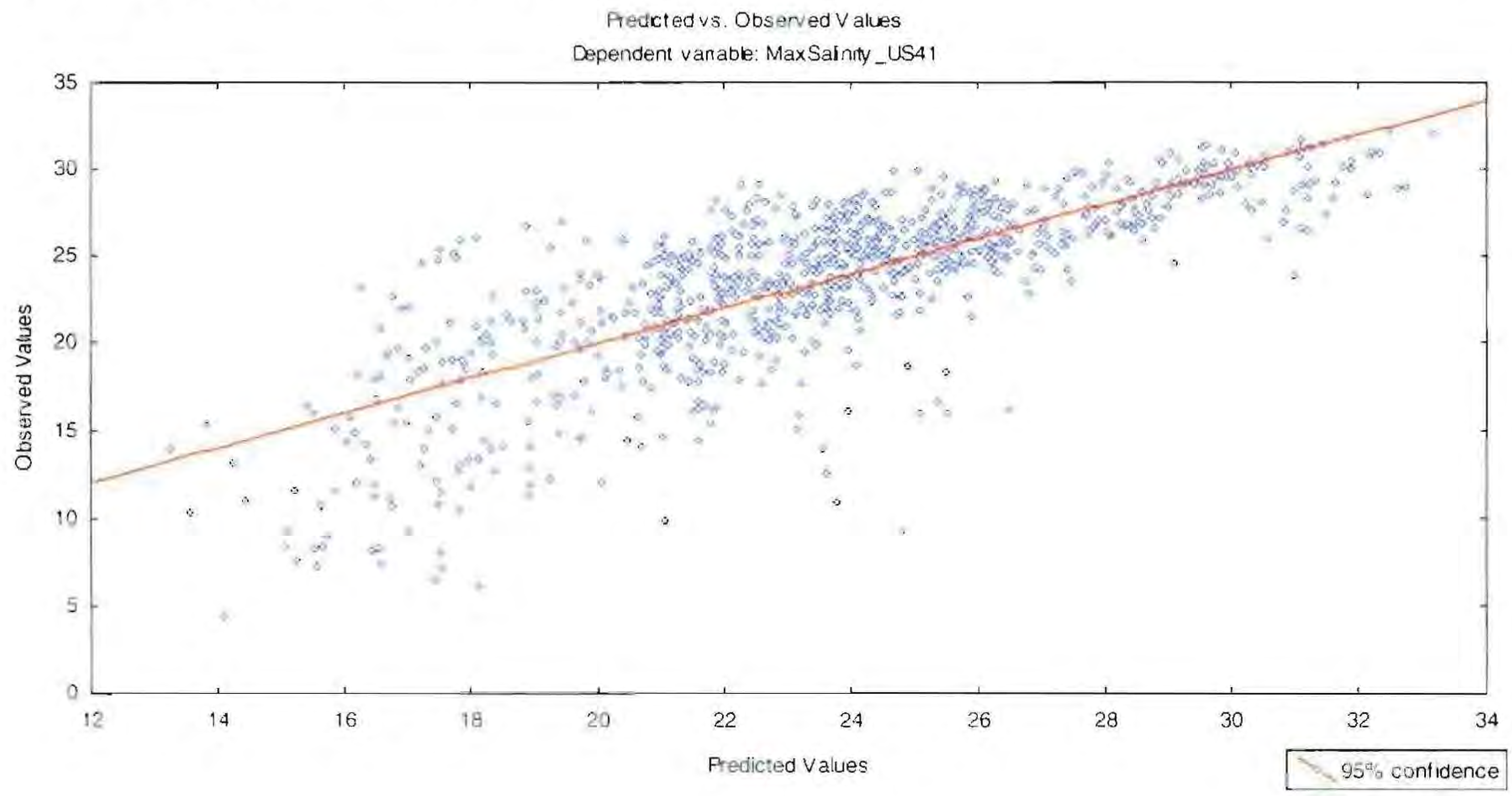
Partial residual scatter plot for lagged discharge (ln(Q)_MAV6) from the USGS gage from mean stage at US 41 with fitted regression lines and confidence intervals.



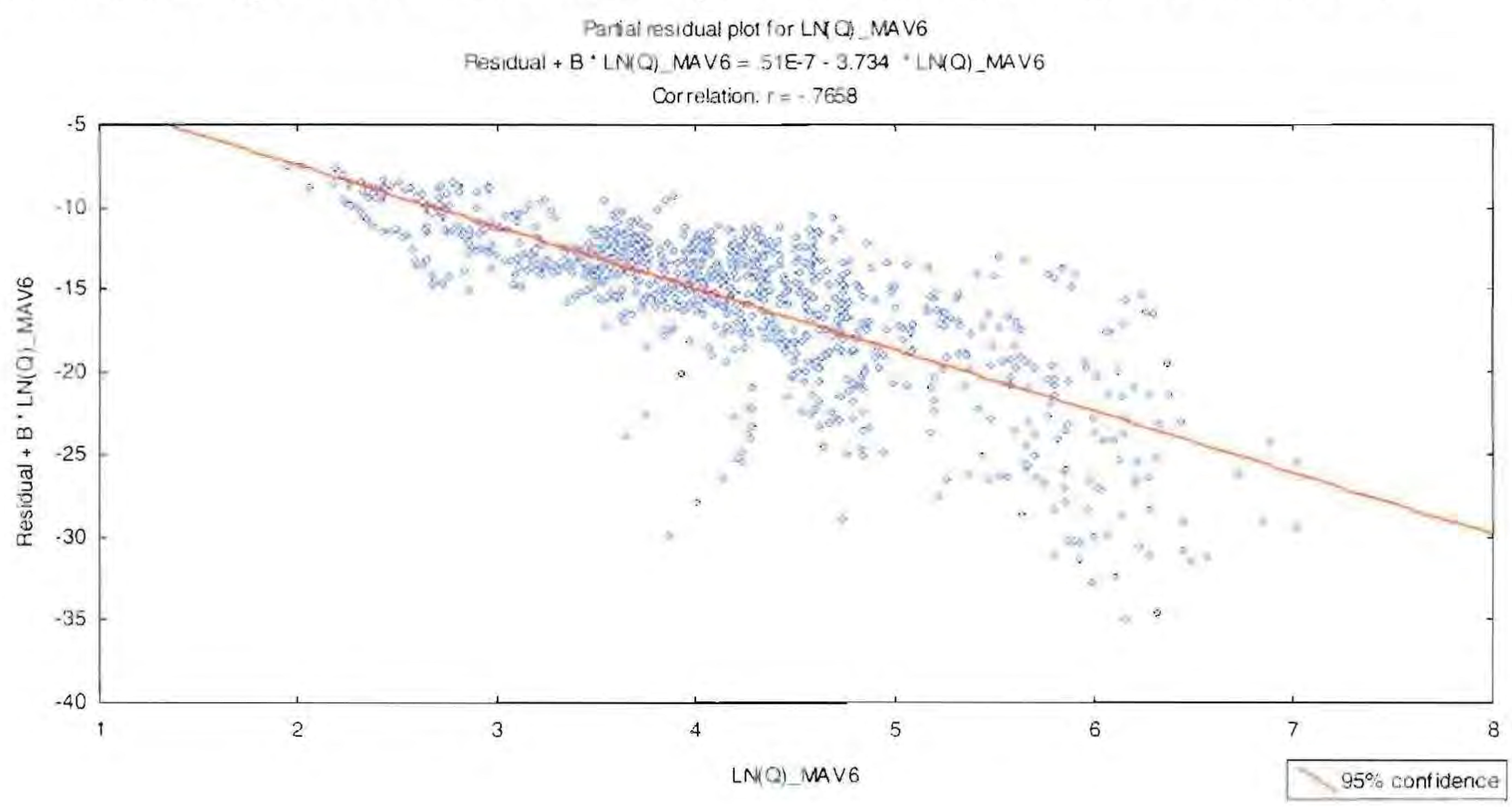
Partial residual scatter plot for mean stage at US 41 with fitted regression lines and confidence intervals.



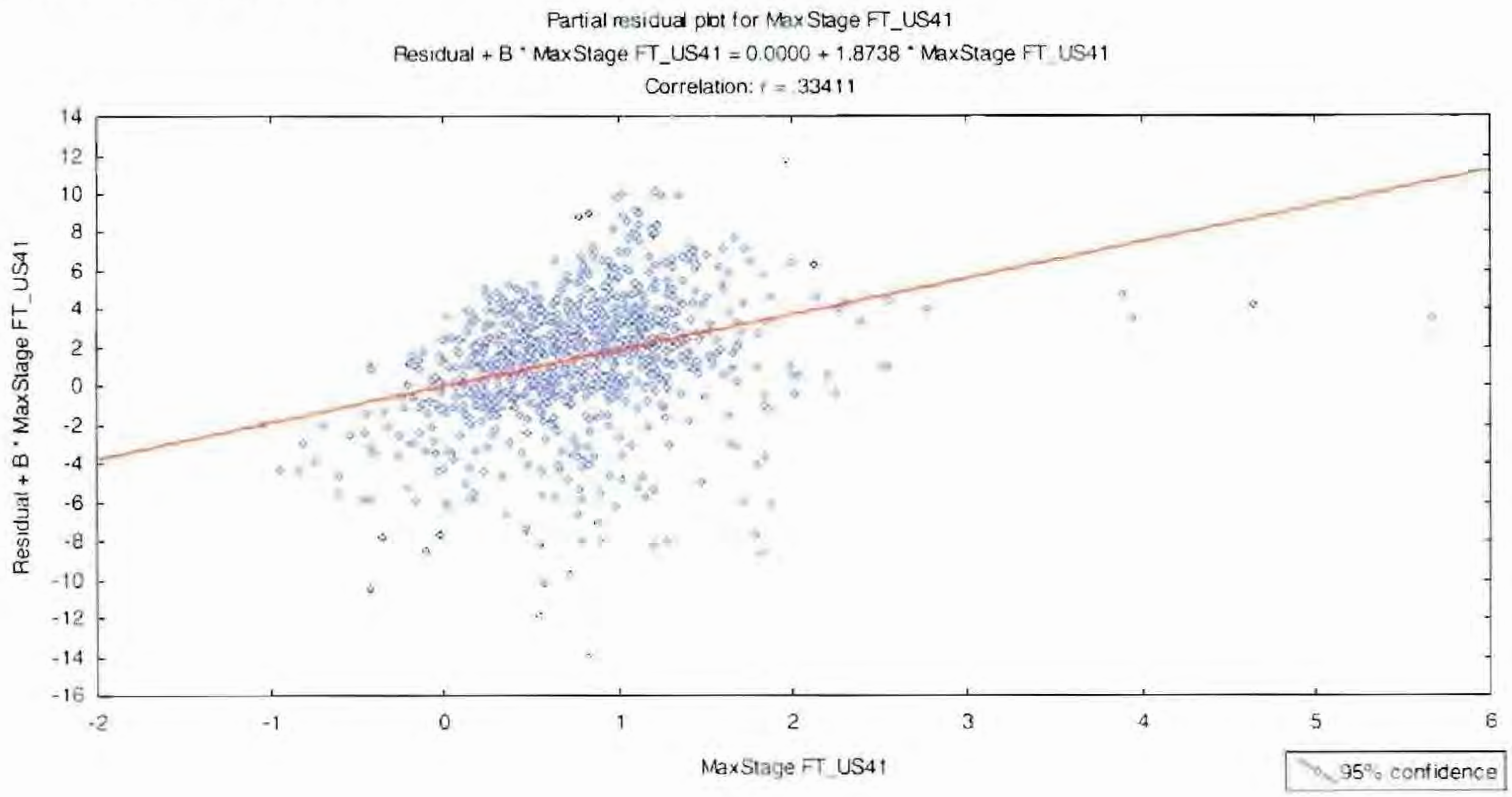
Scatter plot for observed and predicted maximum salinity at US 41 with fitted regression lines and confidence intervals.



Partial residual scatter plot for lagged discharge (ln(Q)_MAV6) from the USGS gage from maximum stage at US 41 with fitted regression lines and confidence intervals.



Partial residual scatter plot for maximum stage at US 41 with fitted regression lines and confidence intervals.



From:	Napoli, Kelly
To:	Kym Holzwart
Subject:	FPL Comments on the Draft Little Manatee River MFL
Date:	Friday, February 18, 2022 3:28:17 PM
Attachments:	FPL Comments on SWFWMD LMR Draft MFL.2022.02.18-signed.pdf

[EXTERNAL SENDER] Use caution before opening.

Good afternoon Kym,

Happy Friday! As you know, Florida Power & Light (FPL) owns and operates the Manatee Power Plant in Manatee County, FL, which withdraws water from the Little Manatee River to supply its cooling pond. FPL is currently the only existing legal user of the Little Manatee River. We met on January 21st, 2022 with your team in order to discuss updates to the MFL and provide some operational background for the site. FPL appreciates the opportunity to submit comments for the current Draft MFL for the Little Manatee River. We hope that these comments provide clarity on FPL's withdrawal needs for both Regulatory Staff and the Peer Review Panel.

Please let me know if you and your team would like to meet again to discuss these comments. As mentioned on our last call, FPL would be more than happy to host a site visit to the Manatee Power Plant. Please let me know if there is still interest.

Have a great weekend,

Kelly Napoli, EI
Environmental Specialist II
Florida Power & Light | Environmental Services
700 Universe Blvd | JES/JB C5073
Juno Beach FL, 33408
O. 561.694.4015
C. 561.335.6659

FPL

From:	Hall, Jaime
To:	Doug Leeper
Cc:	Irving, Robert; DiGruttolo, Laura; Cucinella, Josh; Sempsrott, Michelle; Hight, Jason; Kym Holzwart; Conservation Planning Services; McCue, Allie; Lambert, Carla
Subject:	FWC Comments on Little Manatee River, Hillsborough and Manatee Counties
Date:	Monday, April 11, 2022 9:52:07 AM
Attachments:	FWC Comments on Little Manatee River MFL Update 46722 04112022.pdf

[EXTERNAL SENDER] Use caution before opening.

Please find attached FWC's comments on the above-referenced project.
You will **not** receive a hard-copy version of this letter unless requested.

If you wish to reply to our comments, please send your reply to:
ConservationPlanningServices@myFWC.com

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April 11, 2022

Doug Leeper
Southwest Florida Water Management District
Springs and Environmental Flows Section
2379 Broad Street
Brooksville, FL 34604
Doug.Leeper@WaterMatters.org

RE: Recommended Minimum Flows for the Little Manatee River Draft Report, Southwest Florida Water Management District, Hillsborough and Manatee Counties

Dear Mr. Leeper:

Florida Fish and Wildlife Conservation Commission (FWC) staff have reviewed the above referenced minimum flows and levels (MFL) report and appendices for the Little Manatee River. The following comments and recommendations are provided as technical assistance during your review of the draft MFL under Chapter 373, Florida Statutes (FS), and in accordance with FWC's authorities under Chapter 379, FS.

Executive Summary

The Southwest Florida Water Management District (SWFWMD) has completed the *Recommended Minimum Flows for the Little Manatee River Draft Report* (draft report, (2021) which summarizes minimum flows developed for the Little Manatee River, including both the freshwater and estuarine portions of the river. For purposes of minimum flows development, the freshwater portion or Upper Little Manatee River starts at the headwaters near Fort Lonesome in southeastern Hillsborough County and extends to the U.S. Highway 301 bridge, where the U.S. Geological Survey (USGS) "Little Manatee River at U.S. 301 near Wimauma, FL" (No. 02300500) gage is located. The estuarine portion or Lower Little Manatee River begins at the U.S. Highway 301 bridge and ends where the river flows into Tampa Bay.

The Little Manatee River is one of the most pristine blackwater rivers in Southwest Florida. The watershed of the Little Manatee River is in southern Hillsborough County and the northern portion of Manatee County; it includes the City of Palmetto and the communities of Parrish, Ruskin, Sun City, Wimauma, and Terra Ceia. The Little Manatee River flows west about 40 miles (64 km) from its headwaters east of Fort Lonesome before emptying into Tampa Bay near Ruskin.

The recommended minimum flows for the Little Manatee River were developed as required by Section 373.042, Florida Statutes and were based on relevant environmental values identified in the Florida Water Resource Implementation Rule (Chapter 62-40, Florida Administrative Code). The SWFWMD's approach for developing minimum flows is habitat-based, and because the Little Manatee River includes a great variety of aquatic and wetland habitats that support diverse biological communities, key ecological resources were identified for the development of minimum flows. The resource management goals that were the focus of the technical analyses for the development of minimum flows for the Little Manatee River included the following:

- Determination of a low-flow threshold to provide protection for ecological resources and recreational use of the Little Manatee River during critical low-flow periods.
- Maintenance of seasonal hydrologic connections between the Upper Little Manatee River channel and floodplain to ensure the persistence of floodplain structure and function.
- Maintenance of available instream habitat for fish and benthic macroinvertebrates in the Upper Little Manatee River.
- Maintenance of biologically relevant salinities that protect the distribution of fish species, benthic macroinvertebrates, and shoreline vegetation communities in the Lower Little Manatee River.
- Maintenance of available estuarine habitat for fish in the Lower Little Manatee River.

The criteria used for minimum flows development in the Little Manatee River addressed maintenance of 85% of the most sensitive criterion associated with the resource management goals using flow-based blocks. In addition, a low-flow threshold specific to surface water withdrawals and applicable to all blocks were identified to ensure flow continuity for environmental and human-use values. Finally, assessments were conducted to ensure all relevant environmental values that must be considered when establishing minimum flows would be protected by the minimum flows proposed for the Little Manatee River.

For the Upper Little Manatee River, the recommended minimum flows for Block 1 and Block 2 are based on maintaining available instream habitat. The minimum flows for Block 3 are based on maintaining floodplain inundation. For all flow-based blocks, the most sensitive criterion for the Lower Little Manatee River minimum flows development was the maintenance of available estuarine fish habitat, and the recommended minimum flows were established based on preserving 85% of the available estuarine fish habitat. The recommended minimum flows for the Upper and Lower Little Manatee River are based on flows for the previous day at the USGS U.S. 301 near Wimauma (No. 02300500) gage adjusted for upstream withdrawals.

An adaptive management approach will be used by the SWFWMD to monitor and assess the status of minimum flows established for the Little Manatee River. Changes in the Little Manatee River watershed related to multiple factors, including climate change, could potentially affect flow and additional information relevant to minimum flows development may become available. The draft report states that the SWFWMD is committed to periodic evaluation and, if necessary, revision of minimum flows established for the Little Manatee River.

Comments and Recommendations

FWC staff appreciates the SWFWMD's evaluation of the recommended minimum flows and levels for the Little Manatee River. Specific comments pertaining to current research and fish and wildlife habitat are provided below as technical assistance.

- The FWC's Fish and Wildlife Research Institute (FWRI) has a long history of research and development of techniques to support science-based decision making regarding freshwater inflow effects on fish and macroinvertebrates in southwestern and west-central Florida (Tsou and Matheson 2002, Greenwood 2007; Greenwood et al. 2007; Peebles and Greenwood 2009; Flaherty and Guenther 2011; Stevens et al. 2010, 2013; Olin et al. 2013, 2015; Whaley et al. 2016). FWC staff recommends incorporation of the historical record of work completed in the Little Manatee River in this and subsequent MFL assessments. This review should include reports on historical sampling (Haddad et al. 1989, 1990; Peebles et al. 1991; MacAulay et al. 1993), a thorough discussion of relationships between freshwater inflow and populations of fish and selected macroinvertebrates in the Little Manatee River (MacDonald et al. 2007), and other published studies pertaining to the Little Manatee River (Rydene and Matheson 2003, Ley and Rolls 2018, Trotter et al. 2021). FWC staff recommends that more text be dedicated to the findings of this work (as was done in Janicki Environmental Inc. 2011) as the findings are directly applicable to establishing MFLs for the Little Manatee River.

- The Little Manatee River contains important nursery habitat for several economically important fishery species such as red drum (Whaley et al. 2016) and blue crab (MacDonald et al. 2007; Flaherty and Guenther 2011). Whaley et al. (2016) estimated that during the period from 1996 to 2008, the Little Manatee River contained 10 – 47% of the annual juvenile population of red drum surviving to the larger juvenile stage (50 – 100mm standard length) within the Tampa Bay estuary and adjacent rivers. FWRI's Fisheries-Independent Monitoring (FIM) program has abundant biological data (24-years of data collected monthly, 1996-2019) describing spatiotemporal distribution patterns of numerous fish and invertebrate species inhabiting the estuarine portions of the Little Manatee River, and the characterization of the lower river fish community could be greatly improved by a more thorough analysis of these taxa over the complete time record, instead of focusing on data collected from the most recent year of sampling (2019, p. 92 and Tables 4.8 and 4.9), a period of heavy inflow conditions. For example, it is standard practice to examine annual variation in fish abundance in terms of mean catch-per-unit-effort (number/net, number/unit area) instead of total numbers collected (Figures 4-9, 4-10), and annual patterns in young-of-the-year recruitment for selected species should be discussed in more detail (Figure 4-11).

- The assessment of significant harm (habitat reductions greater than 15%) appears to be solely determined using the Environmental Favorability Function (EFF) modelling to assess changes in favorable habitat. However, the final presentation of this modelling effort concentrated on species data from 2015 – 2019, a period of generally high freshwater inflow conditions. It is not clear in the draft report whether other time periods were also assessed by the model, but not presented. If that is the case, those results should be discussed with a rationale as to why 2015-2019 was used in this report. The examination of percentage reduction in species habitat that may occur during dry periods appears to be missing in the report or the analyses. Species-inflow relationships can be non-linear, and a percent reduction in species habitat under wet conditions will not likely have the same magnitude during dry conditions. Previously published research has shown that abundance of juvenile red drum in the Little Manatee River varies greatly in wet versus dry periods (Whaley et al. 2016). In addition, the Little Manatee River is the least impacted major river system in the Tampa Bay watershed, so withdrawals from this system should be made carefully and include the full complement of data associated with the system, including major end points (1998/1999 El Nino and 2007/2008 severe drought) and perturbations (e.g., cold events such as in 2010, red tide events such as in 2005, 2018; Flaherty and Landsberg 2011, Stevens et al. 2016, Schrandt and MacDonald 2020) that may impact nekton communities, fish recruitment, and mortality.

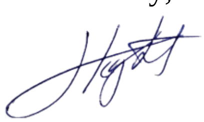
- The magnitude that freshwater inflow modifications may have on the food web of the Little Manatee River does not appear to be addressed in this report. The relationships among freshwater inflow, nutrients, and distribution and abundance of phytoplankton are well established (Peebles 2002; Olin et al. 2013; Stevens et al. 2013). Phytoplankton concentrations are closely related to the distribution and abundance of bay anchovy (Peebles 2002, Olin et al. 2013), a dominant nekton species in the lower rivers, and an important component of the food web (Hollander and Peebles, 2004). In addition, a lower volume of freshwater can affect inundation and nekton use of important riverine floodplains, such as marshes, along the shoreline of the river (see reviews by Robins et al. 2005 and Gillson 2011). These marshes typically provide abundant benthic food sources as well as protection from predation for many nekton species, including some fishery species (Beck et al. 2001 and references therein). Addressing the influence of freshwater flow reduction on the food web (planktonic and benthic pathways) would be helpful in the analysis and report.

- Spatial species modelling regarding minimum flows, such as the EFF modeling by Janicki Environmental Inc. (2011, 2018, SWFWMD 2021), could be improved by consulting with FWRI staff in the FIM program and Center for Spatial Analysis. FWRI staff have related fish populations to flow and other habitat variables in several rivers along the Gulf coast (e.g., Alafia, Anclote, Chassahowtizka, Crystal, Hillsborough, Homosassa, Manatee, Myakka, Peace, and Weeki Wachee Rivers) including the Little Manatee River (MacDonald et al. 2007), so these methods should be investigated and applied as appropriate for each individual river system. For example, in the Alafia River just north of the Little Manatee River, FWRI identified freshwater resident and transient species that recruit into the river from the estuary and offshore as potential indicators of the impacts of differing flow regimes (Flaherty et al. 2013, MacDonald et al. 2013, Matheson et al. 2013). There are also species that tend to focus on a particular river section and others that move up and down the river that could be used to determine impacts of different flow regimes. The transport of juveniles related to flow (not just water level or salinity regime) within the estuarine portions of rivers should also be considered (Norcross and Shaw 1984). In addition, although the conservation of the oligohaline zone is important for nekton, it is unclear why the goal is to maintain the 1-2 practical salinity unit (psu) habitat conditions (river km ~15-19; as noted in the initial peer review report) even though many of the species mentioned were not abundant in the 1-2 psu range. Other research on salinity zones in southwest Florida suggest that the 0.1-1 psu range corresponds with relatively large changes in nekton communities (Greenwood 2007), and several marine species tend to use the lower river as nursery habitat. Furthermore, the report mentions Schireiber and Gill's (1995) three-tiered classification system for assessing important fish habitats, where the tidal freshwater zone of this system would correspond with Greenwood's (2007) findings, but it does not give a rationale as to why the three-tiered system was not used for the nekton. In other MFLs nationwide, the low salinity zone is targeted for management with the assumption that the salinity gradient downstream is maintained. If this is the case here, then it could be stated more explicitly. Also, the reader should be made aware that much of the nursery habitat for estuarine and marine species occurs in the lower river. In general, FWC staff recommends the report more clearly describe how and why these rivers are important to estuarine/marine species and what the effects of reduced freshwater inflow are likely to be.

In summary, given the breadth of the longstanding fisheries data for the Little Manatee River, FWC staff believes the information above should be more clearly described or examined further in the final version of the report.

FWC staff appreciates the early coordination with the SWFWMD staff during the data collection and technical analysis phases of MFL evaluations and looks forward to working through fish and wildlife habitat concerns throughout the final approval process for this MFL. For specific technical questions regarding the content of this letter, please contact Michelle Sempsrott at (407) 452-1995 or by email at Michelle.Sempsrott@MyFWC.com. All other inquiries may be sent to ConservationPlanningServices@MyFWC.com.

Sincerely,



Jason Hight, Director
Office of Conservation Planning Services

jh/ms
Little Manatee River MFL Update_46722_04112022

cc: Kym Holzwart, Southwest Florida Water Management District, Kym.Holzwart@swfwmd.state.fl.us

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June 29, 2023

Mr. Jason Hight
Director
Office of Conservation Planning Services
Florida Fish and Wildlife Conservation Commission
620 South Meridian Street
Tallahassee, FL 32399-1600
Jason.Hight@MyFWC.com

Subject: Response to comments and recommendations included in your April 11, 2022 letter regarding recommended minimum flows for the Little Manatee River

Dear Mr. Hight:

The Southwest Florida Water Management District (District) appreciates the comments and recommendations from the Florida Fish and Wildlife Conservation Commission (FWC) included in your April 11, 2022 letter regarding the recommended minimum flows for the Little Manatee River included in the District's September 2021 draft report.

In response to your letter, District staff met with FWC staff on June 16, 2022, at the FWC Fish and Wildlife Research Institute in St. Petersburg, to discuss issues concerning the proposed minimum flows. We also developed and are providing below, written responses to all FWC comments and recommendations included in your letter. In addition, the September 2021 draft report has been substantially revised to address comments from a panel of independent scientists convened in 2022 for review of the proposed minimum flows, as well as those from the FWC and other stakeholders. The June 2023 draft revised minimum flows report is included with this letter; the revised report, as well as the associated appendices, can also be obtained from: https://www.swfwmd.state.fl.us/projects/mfls/minimum-flows-the-little-manatee-river.

FWC Comments and District Reponses

FWC Comment 1: The FWC's Fish and Wildlife Research Institute (FWRI) has a long history of research and development of techniques to support science-based decision making regarding freshwater inflow effects on fish and macroinvertebrates in southwestern and west-central Florida (Tsou and Matheson 2002, Greenwood 2007; Greenwood et al. 2007; Peebles and Greenwood 2009; Flaherty and Guenther 2011; Stevens et al. 2010, 2013; Olin et al. 2013, 2015; Whaley et al. 2016). FWC staff recommends incorporation of the historical record of work completed in the Little Manatee River in this and subsequent MFL assessments. This review should include reports on historical sampling (Haddad et al. 1989, 1990; Peebles et al. 1991; MacAulay et al. 1993), a thorough discussion of relationships between freshwater inflow and populations of fish and selected macroinvertebrates in the Little Manatee River (MacDonald et al. 2007), and other published studies pertaining to the

Little Manatee River (Rydene and Matheson 2003, Ley and Rolls 2018, Trotter et al. 2021). FWC staff recommends that more text be dedicated to the findings of this work (as was done in Janicki Environmental Inc. 2011) as the findings are directly applicable to establishing MFLs for the Little Manatee River.

District Response to Comment 1: Thank you for providing the comprehensive list of references. Per the FWC's suggestion, additional information from some of the referenced studies, including a couple of figures, has been included in the revised draft report. Additional information regarding the importance of protecting the estuarine fish and nekton and low-salinity habitat in the river was also added. As the introduction to Chapter 4 of the draft report describing the recommended minimum flows for the Little Manatee River states, and as discussed during the meeting June 2022 meeting between FWC and District staff, the summary of the fish and invertebrate community of the Lower Little Manatee River is not meant to be a compilation of all available studies or a historical record of work; rather, it is a brief description of the community as it relates to the criteria and analyses used to develop the minimum flows. Specifically, data that was obtained by the District or that was collected by others that were the basis for the methods used to develop the proposed minimum flows are summarized. As we mentioned during our meeting in June 2022, if the FWC is interested in compiling a summary/bibliography of studies associated with the Little Manatee River, the District would be happy to include that document as an appendix to the minimum flows report.

We agree that the FWC FWRI has a long history of conducting studies and surveys in the Little Manatee River, and we appreciate these efforts to establish relationships between changes in freshwater flow and biota in the river. As per the Florida Water Resource Implementation Rule (specifically Rule 62-40.473, Florida Administration Code), minimum flows must be established by the District through consideration of natural seasonal fluctuations in water flows, non-consumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands 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. Some of these environmental values can be evaluated directly (e.g., fish and wildlife habitats), while others are evaluated indirectly (e.g., aesthetic and scenic attributes).

The District's current approach to developing minimum flows is habitat based. Because each river system is unique and includes a variety of habitats that support biological diversity and provide many important ecosystem functions, key criteria or habitats are selected for consideration, and when possible, the hydrologic requirements for protecting the specific habitats are determined. We assume that protecting the specific habitats also protect the functions and services that these habitats provide. For the Lower Little Manatee River, our goals when developing minimum flows are the:

- Maintenance of biological relevant salinities over a range of flow conditions that protect the distribution of fish species, benthic, nektonic and planktonic invertebrates, and shoreline vegetation communities; and
- Maintenance of available estuarine habitat for fish and nekton.

Minimum flows development is an evolving science. In addition to using the best available information, as required by Section 373.042, Florida Statutes, the District is committed to constantly improving the methods we use to develop minimum flows. As a result, new methods or improvements to previously developed methods are typically incorporated into every minimum flows evaluation.

District efforts to develop minimum flows for the Little Manatee River have been ongoing for a number of years. A significant amount of earlier work on the lower river was focused on investigating relationships between larval fish and selected macroinvertebrate abundances/densities and river flows, and regression equations were developed for use in minimum flow evaluations. While these equations represented the best available science at the time, there were issues associated with their use, such as variability in fish year class strength, and confounding effects of seasonality and physical habitat characteristics that were not accounted for or included in the original regression models (Wessel 2012).

When we re-initiated minimum flows development for the Little Manatee River around 2016, we decided to use an Environmental Favorability Function (EFF) approach as a tool for evaluating effects of changes in freshwater inflow on estuarine fish habitat in the lower river. We consider this habitat-based approach to be an improvement over the previously used methods. In addition, the EFF analysis is similar to the Systems for Environmental Flow Analysis (SEFA) that we use to evaluate effects of reductions in flow on available habitat for freshwater fish and benthic macroinvertebrates in the Upper Little Manatee River. The District relied heavily on the FWRI's Fisheries-Independent Monitoring (FIM) program data (1996 through 2021) to characterize the fish and nekton community of the lower river and to conduct the EFF analysis. As a result of the June 2022 meeting, we worked with FWC FWRI staff to make improvements to the EFF approach.

FWC Comment 2: The Little Manatee River contains important nursery habitat for several economically important fishery species such as red drum (Whaley et al. 2016) and blue crab (MacDonald et al. 2007; Flaherty and Guenther 2011). Whaley et al. (2016) estimated that during the period from 1996 to 2008, the Little Manatee River contained 10 – 47% of the annual juvenile population of red drum surviving to the larger juvenile stage (50 – 100mm standard length) within the Tampa Bay estuary and adjacent rivers. FWRI's Fisheries-Independent Monitoring (FIM) program has abundant biological data (24-years of data collected monthly, 1996-2019) describing spatiotemporal distribution patterns of numerous fish and invertebrate species inhabiting the estuarine portions of the Little Manatee River, and the characterization of the lower river fish community could be greatly improved by a more thorough analysis of these taxa over the complete time record, instead of focusing on data collected from the most recent year of sampling (2019, p. 92 and Tables 4.8 and 4.9), a period of heavy inflow conditions. For example, it is standard practice to examine annual variation in fish abundance in terms of mean catch-per-unit-effort (number/net, number/unit area) instead of total numbers collected (Figures 4-9, 4-10), and annual patterns in young-of-the-year recruitment for selected species should be discussed in more detail (Figure 4-11).

District Response to Comment 2: The District agrees that the Little Manatee River contains important habitat for many life stages for several economically and ecologically important fish and invertebrate species. Based on this understanding, all the methods we used to develop minimum flows for the Little Manatee River are habitat based. For the lower river, our goals for developing minimum flows are maintaining biological relevant salinities over a range of flow conditions that protect the distribution of fish, nekton, plankton, invertebrates, and shoreline vegetations communities; and maintaining available estuarine habitat for fish and nekton.

As mentioned in our response to FWC Comment 1, the District relied heavily on the FIM program data (1996 through 2021) to characterize the fish community of the lower river and to conduct the EFF analysis. Chapter 4 of our revised draft minimum flows report includes a description of the FIM dataset from 1996 through 2021. The annual variation in abundance is described in terms of mean catch-per-unit-effort, and the annual patterns in young-of-the-year recruitment are discussed in more detail than that provided in the previous draft report.

FWC Comment 3: The assessment of significant harm (habitat reductions greater than 15%) appears to be solely determined using the Environmental Favorability Function (EFF) modelling to assess changes in favorable habitat. However, the final presentation of this modelling effort concentrated on species data from 2015 – 2019, a period of generally high freshwater inflow conditions. It is not clear in the draft report whether other time periods were also assessed by the model, but not presented. If that is the case, those results should be discussed with a rationale as to why 2015 – 2019 was used in this report. The examination of percentage reduction in species habitat that may occur during dry periods appears to be missing in the report or the analyses. Species-inflow relationships can be non-linear, and a percent reduction in species habitat under wet conditions will not likely have the same magnitude during dry conditions. Previously published research has shown that abundance of juvenile red drum in the Little Manatee River varies greatly in wet versus dry periods (Whaley et al. 2016). In addition, the Little Manatee River is the least impacted major river system in the Tampa Bay watershed, so withdrawals from this system should be made carefully and include the full complement of data associated with the system, including major end points (1998/1999 El Nino and 2007/2008 severe drought) and perturbations (e.g., cold events such as in 2010, red tide events such as in 2005, 2018; Flaherty and Landsberg 2011, Stevens et al. 2016, Schrandt and MacDonald 2020) that may impact nekton communities, fish recruitment, and mortality.

District Response to Comment 3: For the lower river, two methods were used to develop minimum flows. A hydrodynamic model constructed using the Environmental Fluid Dynamics Code (EFDC) was used to evaluate effects of flow reductions on low-salinity habitats that are important for many life stages of fish and invertebrates, as well as shoreline vegetation communities. An EFF analysis was completed to evaluate the availability of estuarine fish and nekton habitat with reductions in flow. As noted in our response to Comment 3 above and discussed during the June 2022 meeting between FWC and District staff, the EFF analysis was conducted using the period of record (1996 through 2021) FIM program fish data and salinity data. Because available estuarine fish habitat was more sensitive to reductions in flow as compared to low-salinity habitats, the minimum flows proposed for the lower river are based on protecting available estuarine fish habitat.

FWC Comment 4: The magnitude that freshwater inflow modifications may have on the food web of the Little Manatee River does not appear to be addressed in this report. The relationships among freshwater inflow, nutrients, and distribution and abundance of phytoplankton are well established (Peebles 2002; Olin et al. 2013; Stevens et al. 2013). Phytoplankton concentrations are closely related to the distribution and abundance of bay anchovy (Peebles 2002, Olin et al. 2013), a dominant nekton species in the lower rivers, and an important component of the food web (Hollander and Peebles, 2004). In addition, a lower volume of freshwater can affect inundation and nekton use of important riverine floodplains, such as marshes, along the shoreline of the river (see reviews by Robins et al. 2005 and Gillson 2011). These marshes typically provide abundant benthic food sources as well as protection from predation for many nekton species, including some fishery species (Beck et al. 2001 and references therein). Addressing the influence of freshwater flow reduction on the food web (planktonic and benthic pathways) would be helpful in the analysis and report.

District Response to Comment 4: As discussed during the June 2022 meeting and as noted in our response to Comment 1 above, the District must consider ten environmental values when developing minimum flows. Among these values, some, such as water quality and fish and wildlife habitat, can be directly evaluated or considered, while consideration of others, such as aesthetic and scenic attributes, present significant challenges. We are not aware of a method to directly and practically evaluate the effects of reduced flows on food webs. We did assess potential flow-related changes in chlorophyll and nutrients in the lower river (see Chapter 3 of the June 2023 revised draft minimum flows report) and focused primarily on habitat-based metrics for minimum flows development, both in the lower and upper portions of the river. The effects of reduced flows on fish passage, wetted stream bottom, instream habitats for multiple taxa, life stages, and guilds of fish and benthic macroinvertebrates, and inundation of the river floodplain were evaluated to develop minimum flows for the upper river. Evaluating the effects of reductions in flow on the availability of estuarine fish and nekton habitat and ranges of low-salinity habitat was used to develop minimum flows for the lower river. We assert that protecting habitat of the biota of various trophic levels is a reasonable means for protecting the food web of the river.

FWC Comment 5: Spatial species modelling regarding minimum flows, such as the EFF modeling by Janicki Environmental Inc. (2011, 2018, SWFWMD 2021), could be improved by consulting with FWRI staff in the FIM program and Center for Spatial Analysis. FWRI staff have related fish populations to flow and other habitat variables in several rivers along the Gulf coast (e.g., Alafia, Anclote, Chassahowtizka, Crystal, Hillsborough, Homosassa, Manatee, Myakka, Peace, and Weeki Wachee Rivers) including the Little Manatee River (MacDonald et al. 2007), so these methods should be investigated and applied as appropriate for each individual river system. For example, in the Alafia River just north of the Little Manatee River, FWRI identified freshwater resident and transient species that recruit into the river from the estuary and offshore as potential indicators of the impacts of differing flow regimes (Flaherty et al. 2013, MacDonald et al. 2013, Matheson et al. 2013). There are also species that tend to focus on a particular river section and others that move up and down the river that could be used to determine impacts of different flow regimes. The transport of juveniles related to flow (not just water level or salinity regime) within the estuarine portions of rivers should also be considered (Norcross and Shaw 1984). In addition, although the conservation of the oligohaline zone is important for nekton, it is unclear why the goal is to maintain the 1-2 practical salinity unit (psu) habitat conditions (river km ~15-19; as noted in the initial peer review report) even though many of the species mentioned were not abundant in the 1-2 psu range. Other research on salinity zones in southwest Florida suggest that the 0.1-1 psu range corresponds with relatively large changes in nekton communities (Greenwood 2007), and several marine species tend to use the lower river as nursery habitat. Furthermore, the report mentions Schreiber and Gill's (1995) three-tiered classification system for assessing important fish habitats, where the tidal freshwater zone of this system would correspond with Greenwood's (2007) findings, but it does not give a rationale as to why the three-tiered system was not used for the nekton. In other MFLs nationwide, the low-salinity zone is targeted for management with the assumption that the salinity gradient downstream is maintained. If this is the case here, then it could be stated more explicitly. Also, the reader should be made aware that much of the nursery habitat for estuarine and marine species occurs in the lower river. In general, FWC staff recommends the report more clearly describe how and why these rivers are important to estuarine/marine species and what the effects of reduced freshwater inflow are likely to be.

District Response to Comment 5: During the update to the EFF analysis, the District collaborated with FWC FWRI staff. Improvements to the EFF analysis resulting from the collaboration are described in Section 5.4.6 of the June 2023 revised draft report. As noted in our responses to other comments above, our revised draft report includes additional information regarding the importance of protecting the ranges of low-salinity habitat.

FWC Comment 6: In summary, given the breadth of the longstanding fisheries data for the Little Manatee River, FWC staff believes the information above should be more clearly described or examined further in the final version of the report.

District Response to Comment 6: The District appreciates the comments received from the FWC and for FWC staff taking the time to meet with us. We hope that the responses above and our June 2023 revised draft report satisfy any concerns the FWC has with the minimum flows proposed for the Little Manatee River.

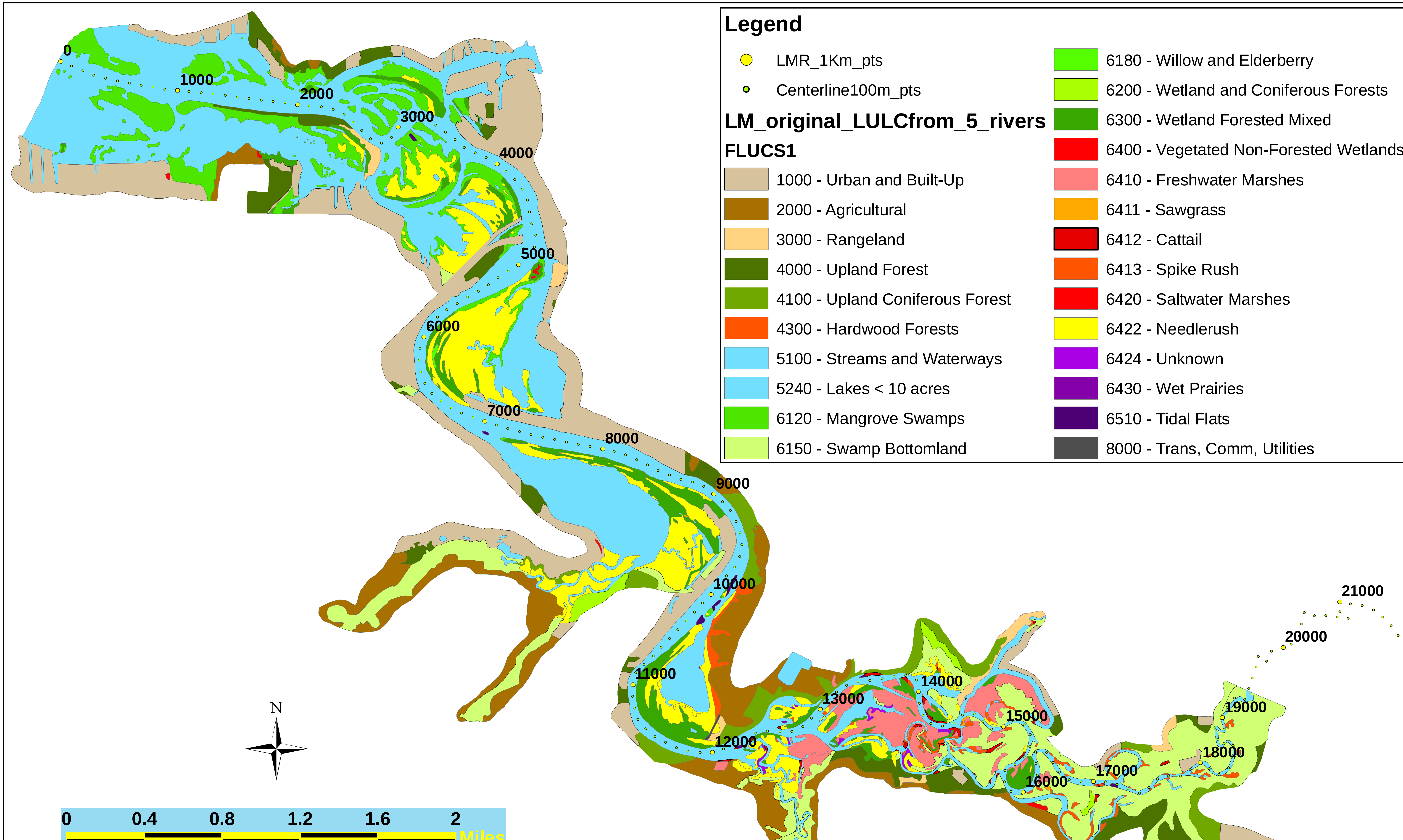
Thanks again for your letter. Please let me know if you have any questions or need additional information.

Sincerely,

Kym Rouse Holzwart, M.S., C.S.E.
Lead Ecologist
Environmental Flows & Levels Section
Natural Systems & Restoration Bureau

cc: Doug Leeper, SWFWMD, Doug.Leeper@swfwmd.state.fl.us
Michelle Sempsrott, FWC, Michelle.Sempsrott@MyFWC.com
Eric Nagid, FWC, Eric.Nagid@MyFWC.com
Philip Stevens, FWC, Philip.Stevens@MyFWC.com

Major Vegetation Communities along the Lower Little Manatee River



Mapping and GIS Section - 4/21/-09

Means, number of observations (N) and periods of data collection for chlorophyll *a* concentrations at four moving salinity-based stations in the tidal reaches of the Little Manatee, Peace, and Alafia Rivers.

		Salinity-based stations			
	N	0.5 psu	6 psu	12 psu	18 psu or 20 psu (Peace only)
		Chlorophyll a (µg/l)			
Little Manatee (12/87 - 01/90)	36	20.5	13.7	8.5	4.0
Peace - same time period as Little Manatee	24	8.9	22.1	31.5	7.9
Peace - same time period as Alafia	36	6.3	23.4	22.6	15.2
Alafia (01/99 - 12/01)	36	15.3	63.4	95.7	43.7

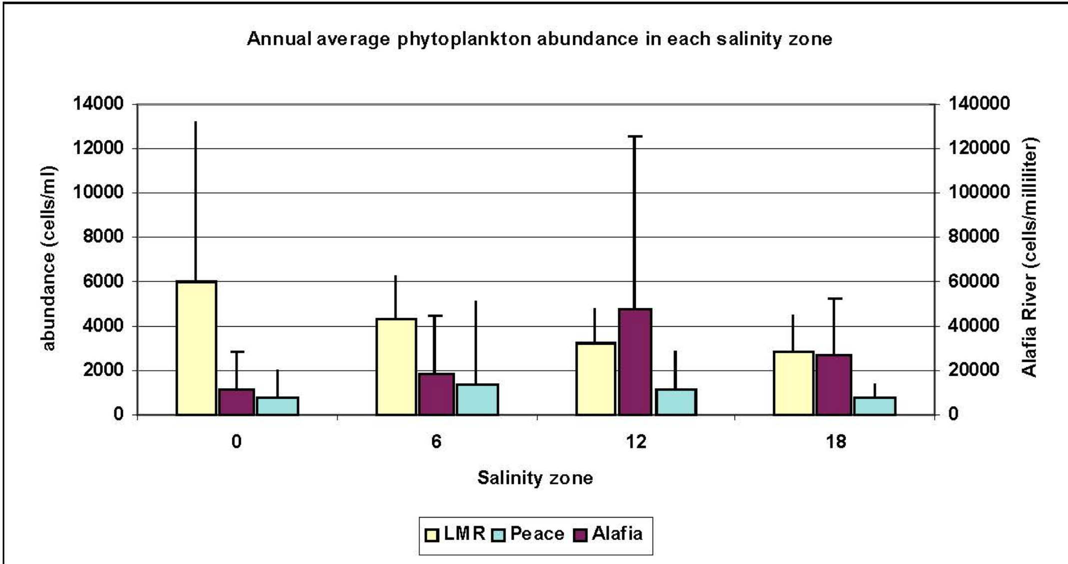


Figure 3: Annual average phytoplankton abundance in the Little Manatee, Peace, and Alafia rivers by salinity zone. The Alafia River data is shown on a separate axis since the counts are more than an order of magnitude greater than in the other rivers.

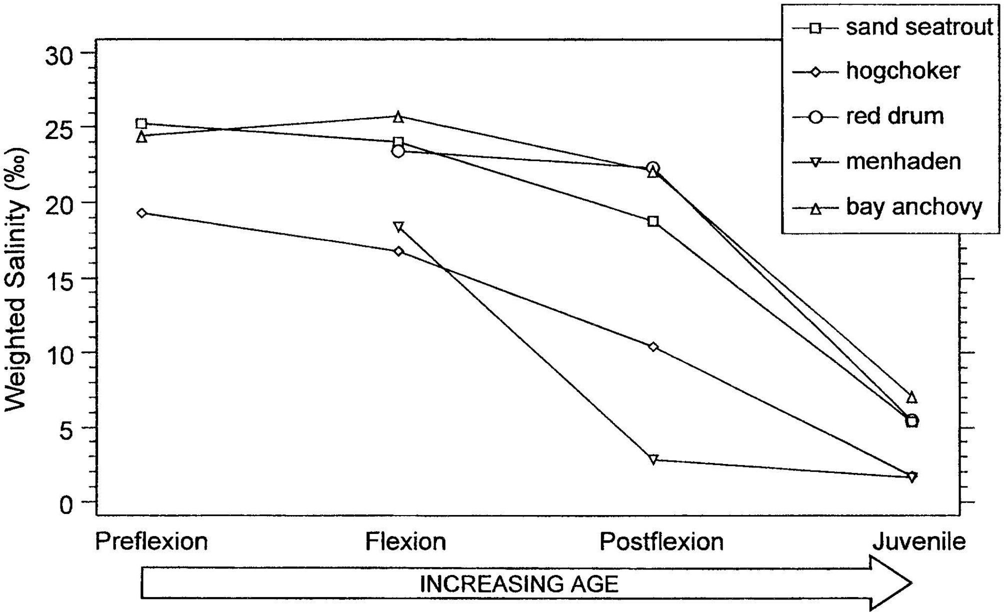


Fig. 5. Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages (Peebles and Flannery 1992).

***Sciaenops ocellatus* (Red drum), Seines**

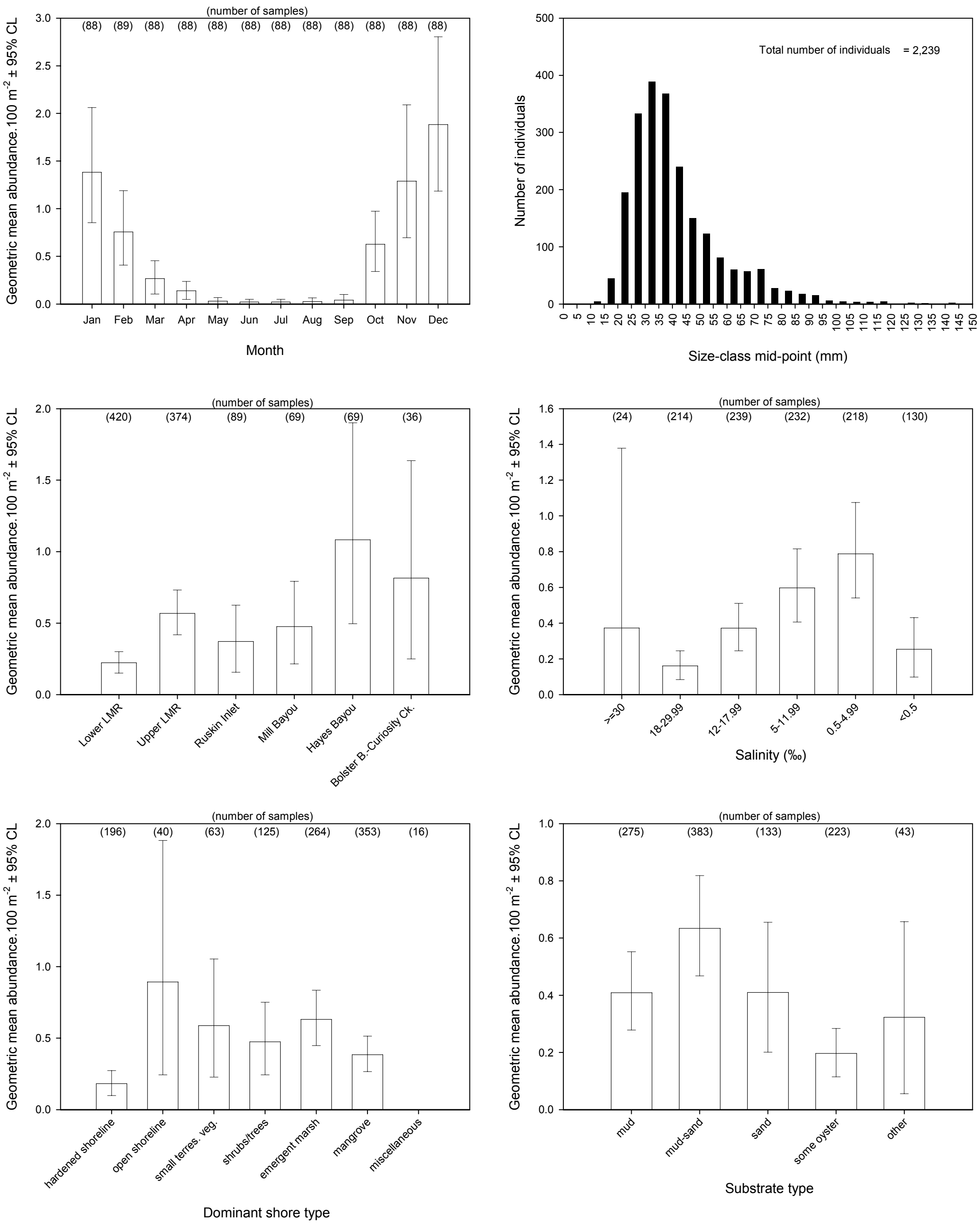


Figure 71. Abundance of *Sciaenops ocellatus* (red drum) in shoreline habitats of the Little Manatee River watershed (FIM SRS survey, January 1996–December 2006).

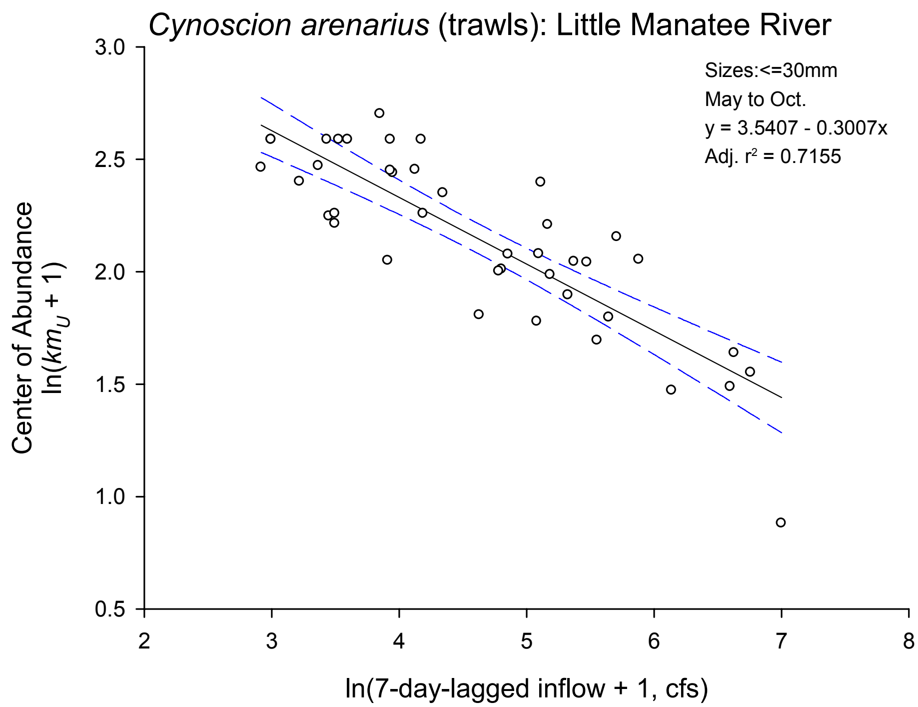


Figure 93. Distribution response of *Cynoscion arenarius* (sand seatrout), <=30mm in the Little Manatee River CZM survey area to 7-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

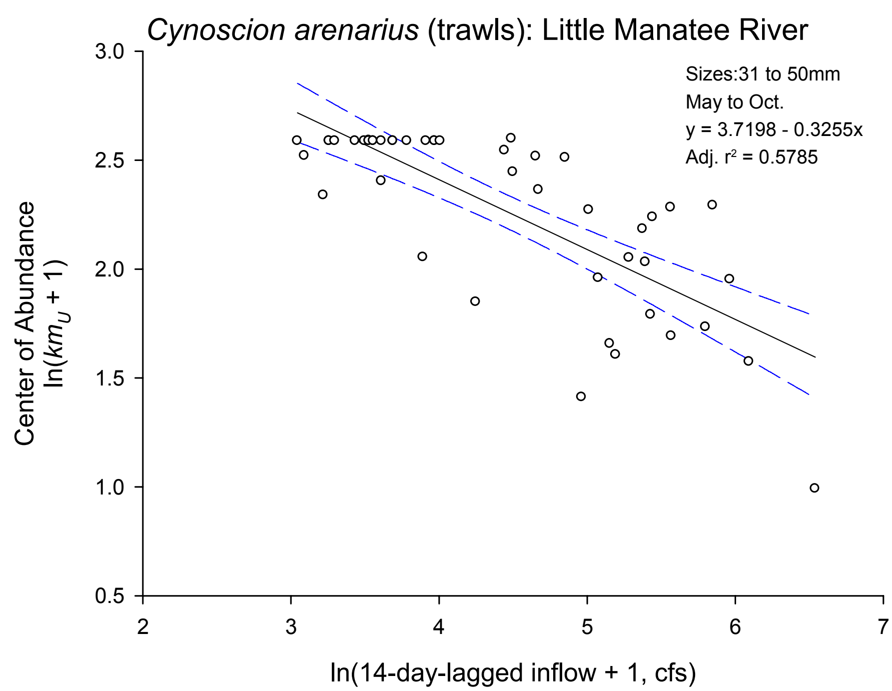


Figure 94. Distribution response of *Cynoscion arenarius* (sand seatrout), 31 to 50mm in the Little Manatee River CZM survey area to 14-day-lagged inflow. Solid lines: predicted values; dashed lines: 95% CI.

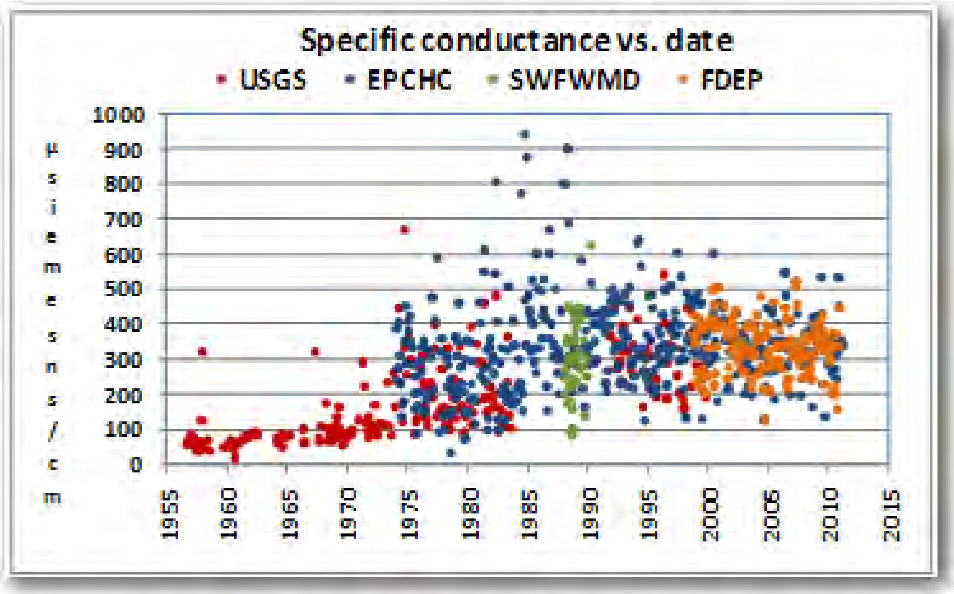


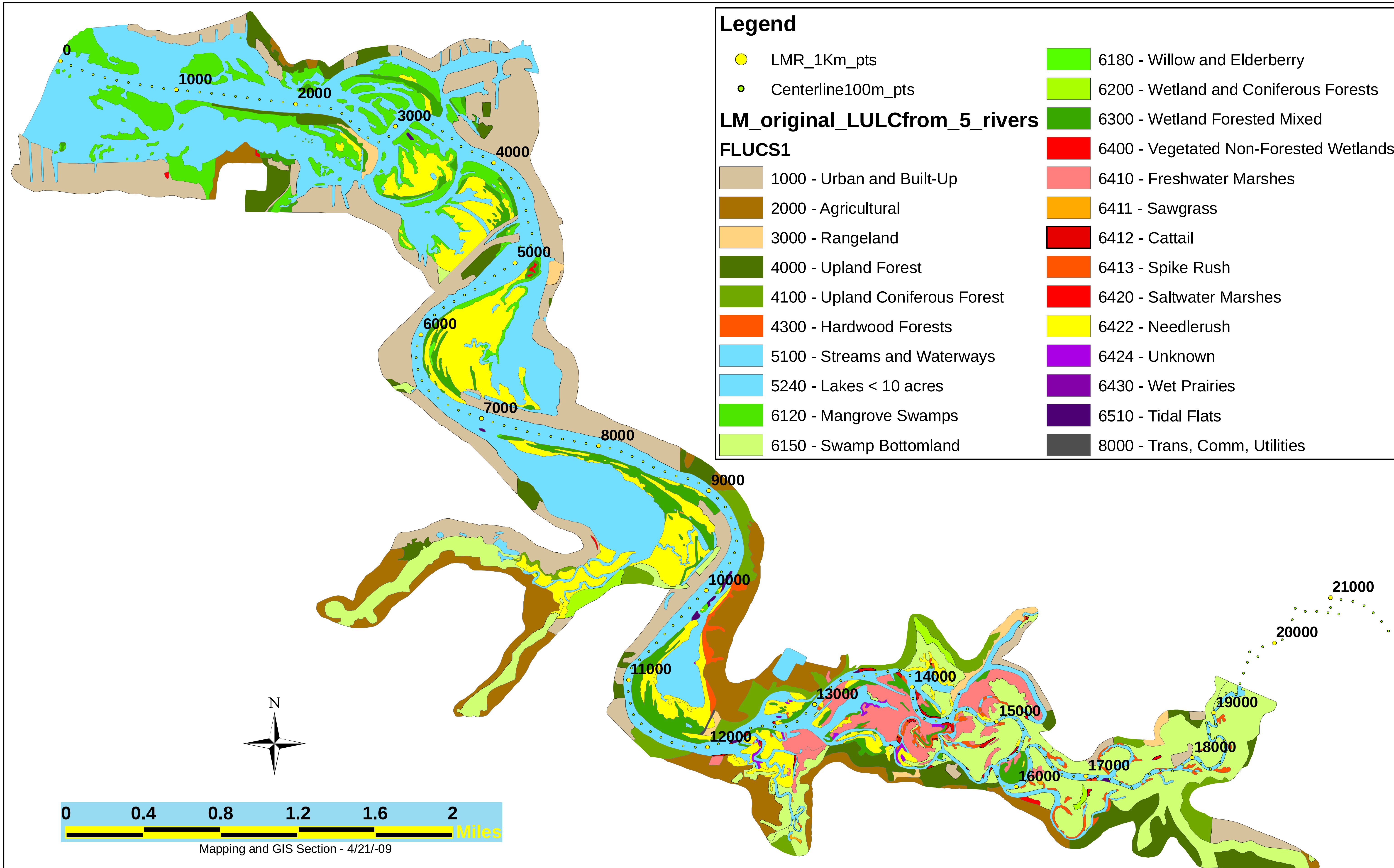
Figure 4-23. Specific conductance values at the Little Manatee River near Wimauma gage recorded by four different agencies (U. S. Geological Survey, Environmental Protection Commission of Hillsborough County, Southwest Florida Water Management District, and the Florida Department of Environmental Protection).

Specific conductance measures the ability of water to conduct an electrical current, which increases with the mineral content of the water. Under natural conditions, ground water in the Little Manatee River basin has greater mineral content than river water. Prior to the 1970s, specific conductance value in the river were typically below 100 microsiemens/cm, reflecting the mineral poor content of rainwater and the sandy soils that comprise the surficial aquifer, from which most of the groundwater baseflow originates. In contrast, the specific conductance values of water in the Floridan aquifer range typically range from 350 to 1,000 microsiemens/cm, depending on proximity to the coast and depth within the aquifer, although much higher concentrations can occur in deeper zones near Tampa Bay.

The increases in the river's low flow characteristics and specific conductance values in the mid-1970s correspond to when there began a pronounced increase agricultural water use in the southern part of the District. Much of the irrigation water that was pumped from the Floridan aquifer that was not used by the crops or lost by non-crop evapotranspiration made its way to the streams. Under high irrigation rates, actual surface runoff of excess irrigation water to the streams was observed. Even when runoff does not occur, excess irrigation water can supplement the surficial aquifer, resulting in increased groundwater baseflow to the river.

Baseflow supplementation and the increased mineralization of river water due to increased agricultural land and water use has been reported for several other

Major Vegetation Communities along the Lower Little Manatee River



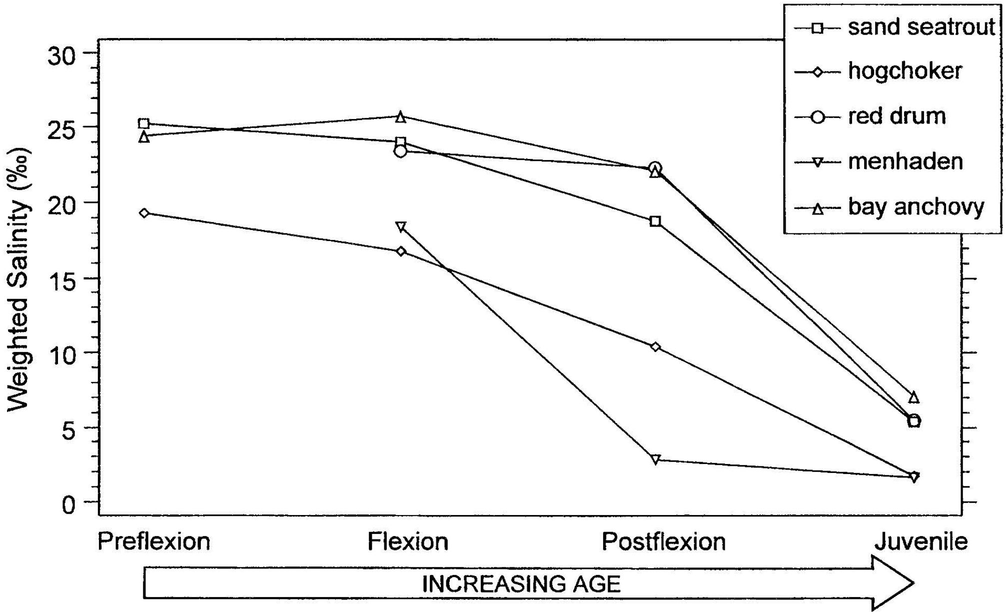


Fig. 5. Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages (Peebles and Flannery 1992).

Means, number of observations (N) and periods of data collection for chlorophyll *a* concentrations at four moving salinity-based stations in the tidal reaches of the Little Manatee, Peace, and Alafia Rivers.

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From:	Sid Flannery
To:	Kym Holzwart
Cc:	Doug Leeper; Gabe I. Herrick; Lei Yang; Xinjian Chen; Chris Zajac; Ron Basso; Kristina Deak; Jordan D. Miller; Randy Smith; Adrienne E. Vining; Eric DeHaven
Subject:	Re: Little Manatee MFLs Peer Review Panel Kick-Off Meeting
Date:	Monday, October 4, 2021 12:04:44 PM
Attachments:	1. Lower Little Manatee vegetation map.pdf 4. Ichthyoplankton figure.pdf 2. Chlorophyll a table.pdf 3. Phytoplankton bar graph.pdf 5. FFWCC Red Drum figures.pdf 7. Appendendix A figure.pdf 6. FFWCC Sand Seatrout distribution flow response.pdf

Hello District Staff,

I would like to address the Little Manatee peer review panel as part of the public comment period during tomorrow's meeting. If possible, I would like to speak for 12 to 15 minutes or so and have provided a brief overview of my comments below. It might be helpful, but not critical, if I could show several slides and I have attached some in that regard.

I would like for my time to address the panel to cover the following three areas.

1. Introduce myself and describe my time with the District's minimum flows program and with other studies of the Little Manatee River (1 minute or less).

2. The second topic I have is related to the slides. I think this is very safe ground that can efficiently improve the District's minimum flows report without too much trouble. The District conducted or sponsored a number of studies of the ecology of the Little Manatee River that are not cited in the report. Each of these studies could be described with one or two paragraphs in the report (probably one), and possibly include a figure or table. One of the figures (#1 attached) is a map that should replace a map currently in the District report. These studies are clearly related to the freshwater flow relationships of the Little Manatee, but briefly describing them would not call for any new minimum flow analyses or reanalysis of existing findings.

3. The most substantive point I have is that from my first reading of the report, it seems the flow based blocks were based strictly on ecological relationships in the freshwater reach of the river. I commend the District for going to flow based blocks rather than seasonal based blocks, and a good hydrologic case is made for that. However, the best flow thresholds for blocks in the estuarine reach of the river might be different than in the freshwater reach, and flow based blocks specific to the tidal reach of the river should possibly be examined separately.

That's it for now. Please let me know if I can speak for 12 to 15 minutes or so. If I can show some slides, I would ask the District moderator to pull them up.

Sid

On Mon, Oct 4, 2021 at 7:42 AM Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us> wrote:

> Agenda is attached
>
> ---
>
> # Microsoft Teams meeting
>
> **Join on your computer or mobile app**
> **Click here to join the meeting**
>
> **Or call in (audio only)**
> +1 786-749-6127,,342540737# United States, Miami
> Phone Conference ID: 342 540 737#
> Find a local number | Reset PIN
>
> INTERNAL USERS: Please use headset and microphone to join meeting audio. EXTERNAL USERS: Please dial toll # or use headset and microphone to join meeting audio.
>
> Learn More | Meeting options
>
> ---

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Doug Leeper; Gabe I. Herrick; Lei Yang; Xinjian Chen; Chris Zajac; Ron Basso; Kristina Deak; Jordan D. Miller; Randy Smith; Adrienne E. Vining; Eric DeHaven
Subject:	Re: Little Manatee MFLs Peer Review Panel Kick-Off Meeting
Date:	Monday, October 4, 2021 5:02:52 PM
Attachments:	A. Lower Little Manatee vegetation map.pdf B. Ichthyoplankton figure.pdf C. Chlorophyll a table.pdf

[EXTERNAL SENDER] Use caution before opening.

Hello Kym,

I will stick with five minutes. I will go through my comments tonight and think I could show three slides comfortably in the five minutes. If that is too much, I will limit it to 1 or 2.
The three slides I could potentially use are attached and listed as A, B, and C in order of priority.

Sid

On Mon, Oct 4, 2021 at 4:39 PM Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us> wrote:

> Good afternoon Sid,
>
> Thanks for providing comments. Please limit your comments to 5 minutes during the public comment period at the end of tomorrow's meeting. If there is a slide or two you wish to be shown while you are speaking, please send it/them to me by email. As a reminder, there are five additional meetings scheduled for the peer review panel to do their work, so there will be plenty of opportunities for you to provide comments.
>
> Best regards,
>
> Kym
>
> ---
>
> **From:** Sid Flannery <sidflannery22@gmail.com>
> **Sent:** Monday, October 4, 2021 12:03 PM
> **To:** Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
> **Cc:** Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Lei Yang <Lei.Yang@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Ron Basso <Ron.Basso@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>; Randy Smith <Randy.Smith@swfwmd.state.fl.us>; Adrienne E. Vining <Adrienne.Vining@swfwmd.state.fl.us>; Eric DeHaven <Eric.Dehaven@swfwmd.state.fl.us>
> **Subject:** Re: Little Manatee MFLs Peer Review Panel Kick-Off Meeting
>
> [EXTERNAL SENDER] Use caution before opening.
>
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1. Introduce myself and describe my time with the District's minimum flows program and with other studies of the Little Manatee River (1 minute or less).

2. The second topic I have is related to the slides. I think this is very safe ground that can efficiently improve the District's minimum flows report without too much trouble. The District conducted or sponsored a number of studies of the ecology of the Little Manatee River that are not cited in the report.   Each of these studies could be described with one or two paragraphs in the report (probably one), and possibly include a figure or table. One of the figures (#1 attached) is a map that should replace a map currently in the District report. These studies are clearly related to the freshwater flow relationships of the Little Manatee, but briefly describing them would not call for any new minimum flow analyses or reanalysis of existing findings.

3. The most substantive point I have is that from my first reading of the report, it seems the flow based blocks were based strictly on ecological relationships in the freshwater reach of the river. I commend the District for going to flow based blocks rather than seasonal based blocks, and a good hydrologic case is made for that. However, the best flow thresholds for blocks in the estuarine reach of the river might be different than in the freshwater reach, and flow based blocks specific to the tidal reach of the river should possibly be examined separately.

That's it for now. Please let me know if I can speak for 12 to 15 minutes or so. If I can show some slides, I would ask the District moderator to pull them up.

Sid

On Mon, Oct 4, 2021 at 7:42 AM Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us> wrote:

Agenda is attached

Microsoft Teams meeting

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Public comments by Sid Flannery at the Little Manatee River minimum flows peer review meeting on 10/5/21 **(not completed at the meeting due to time constraints)**

Below is a transcript of the complete comments I had hoped to give at the peer review panel meeting on October 5, 2021, but ran short on time. I have added two paragraphs about the work by Dr. Gabriel Vargo and have supplied one additional slide I would like sent to the peer review panel with this document. The other two slides that were shown at the meeting are also submitted and all three slides are shown at the end of this document.

I encourage readers to review the information about Dr. Vargo's work and the important topic of separate flow thresholds for freshwater and estuarine sections of the river that starts on page 3, which I did not have time to cover in my public comments at the meeting.

My name is Sid Flannery, and as I introduced myself earlier, I am a retired Chief Environmental Scientist with the District's minimum flows program, where I worked many years on the hydrobiological flow relationships of the Little Manatee River. I managed nine different consultant research or analysis projects for the river and have probably spent 50 plus field days on the lower portions of the Little Manatee.

I want to first acknowledge how hard and conscientiously District staff works on the minimum flows reports, for they are under a very challenging schedule for the adoption of the minimum flow rules.

I quickly read through the minimum flows report for the Little Manatee, and based on further review, I will submit a series of questions and comments to the District. I will request that these questions and comments be provided to the peer review panel via the minimum flows web-board.

Today, I want to briefly discuss two aspects of the minimum flows report, the first of which I think is pretty easy to address, and the second which may require some new analyses.

The first topic is the report does not cite nor describe some important earlier technical reports that were prepared for the District about the Little Manatee River which provide very useful information regarding its ecological relationships with freshwater flows. I think these reports need to be cited and briefly summarized in the District report. Importantly, I don't think that concise summaries of these reports will change the recommended minimum flows and it should be fairly easy to incorporate them in the format of the District report. Inclusion of this material will improve the public and the technical community's understanding of the freshwater flow relationships of the Little Manatee River, and therefore better support the recommended minimum flows.

I have got two slides I want to show you in this regard *(a third slide has been added since I spoke).*

On page 70, the District report shows a land cover map for the lower, tidal reach of the Little Manatee River using the Florida Land Use, Cover, and Forms Classification System, also known as FLUCCS. However, there is much better information available for the river, for in the 1990's the District contracted the State of Florida Marine Research Institute to do detailed mapping of vegetation communities in five tidal rivers, including the Little Manatee.

This slide (at end of this document) shows the vegetation communities that were mapped as part of that project. Note that compared to the FLUCCS codes shown in the District report, the low salinity plant communities are identified with much greater resolution, including *Typha*, *Cladium*, *Acrostichum*, freshwater marshes and other communities. It is worth noting that on the Little Manatee and other tidal rivers, the District has rightly emphasized the protection of low salinity zones, such a < 2 psu salinity. This is particularly relevant on the Little Manatee for it has a highly braided zone above kilometer 12, which has a very high degree of shoreline length per river kilometer. This zone of the river is one of the real unique areas in southwest Florida and its health is closely linked to the minimum flows. This is the map that needs to be used in the District report and work that produced it needs to be cited.

Also, in 1988 and 1989, the District received grants from the Florida Department of Environmental Protection to examine the linkages between the Little Manatee River watershed and its receiving estuary. That project included a two-year study of ichthyoplankton communities in the tidal reach of the river, which involved the early life stages of estuarine fishes. This was conducted by Dr. Ernst Peebles of the University of South Florida College of Marine Science and it is briefly described on page 99 in the District report, followed by a table of the 30 most abundant fish life stages captured during the study. It should be noted this study also quantified the abundance of many invertebrates caught in the plankton net that are important fish food organisms.

There are other valuable findings from this project that could also be briefly summarized in the District report. The next slide is from that project. I think If there is one slide that best supports the District's minimum flows program for tidal rivers, this is it. It shows mean salinity at capture for the immature life stages for five species of fish in the Little Manatee, with age increasing toward the right. The first three are larval stages, as many important estuarine dependent species spawn in the bay or gulf or near the mouths of rivers.

As these fishes grow to juveniles and develop stronger swimming ability, they move into low salinity waters. This, about as effectively as anything, justifies the use of the low salinity habitats as a parameter for establishing minimum flows. There are some other aspects of the ichthyoplankton report for the Little Manatee that are valuable, but at a minimum this graphic needs to go into the District report.

There are four other papers or reports (one a group of three related reports) that need to be cited and summarized in the District report. Of particular significance is important primary production work done by Dr. Gabriel Vargo of the University of South Florida College of Marine Science.

On page 56, the District report shows yearly mean chlorophyll *a* concentrations at five stations in the Little Manatee monitored by the Environmental Protection Commission of Hillsborough

County, including four in the estuarine reach of the river. The report states the spatial pattern shown between these stations is typical of tidal rivers. Well not exactly, the Little Manatee is unusual in that regard and there are reasons for it. The table below, which is also submitted as a slide, is adapted from a report that Dr. Vargo prepared for the District that compares chlorophyll and phytoplankton relationships in the Little Manatee, Alafia, and Peace Rivers.

Means, number of observations (N) and periods of data collection for chlorophyll *a* concentrations at four moving salinity-based stations in the tidal reaches of the Little Manatee, Peace, and Alafia Rivers.

		Salinity-based stations			
	N	0.5 psu	6 psu	12 psu	18 psu or 20 psu (Peace only)
		Chlorophyll a (µg/l)			
Little Manatee (12/87 - 01/90)	36	20.5	13.7	8.5	4.0
Peace - same time period as Little Manatee	24	8.9	22.1	31.5	7.9
Peace - same time period as Alafia	36	6.3	23.4	22.6	15.2
Alafia (01/99 - 12/01)	36	15.3	63.4	95.7	43.7

The Alafia and Peace have the more typical pattern of high chlorophyll *a* concentrations at the 6 and 12 psu zones, while the Little Manatee frequently has its highest values near the freshwater/brackish water interface. This is likely due to comparatively longer residence times in the braided reach of the river which allows phytoplankton blooms to develop. The effects of changes on freshwater inflows on excessive phytoplankton blooms can be an important factor to consider in minimum flows analyses, as was done for the Lower Alafia. I think we are okay on the Little Manatee in that regard, but the three reports that Dr. Vargo prepared for the District need to be cited and briefly summarized in the minimum flows report.*

The citation and summaries of these and a few other reports can be very brief, one or two paragraphs with a figure or table. These concise and informative summaries will improve the public and technical community's understanding of the freshwater inflow relationships of the Little Manatee River and better support the technical justification of the minimum flows.

Assessment of separate thresholds for flow-based blocks for the freshwater and estuarine sections of the Little Manatee River

I want to change topics now and discuss the use of flow-based blocks in the District report. I strongly support the use of flow-based blocks, but they probably should be identified separately for the freshwater and estuarine reaches of the river. For most rivers, the District has previously produced separate reports for the freshwater and estuarine reaches of each river using different analytical methods, such as for the Alafia, Peace and Myakka Rivers. For many

* **The District report cites a paper by Vargo et al. (1991) in the Proceedings of the BASIS 2 Symposium, but the reports for the District provide other valuable findings with the third report completed after BASIS 2.**

years the District used a seasonal block approach for the freshwater rivers, with three seasonal blocks corresponding to low, medium, and high flows. For example, if it was February, you assumed flows were in the medium range and you applied the minimum flow percentages for that time of year.

On page 103 the District report makes a good case that this method has serious limitations, for flows in any season can be above or below the expected seasonal flow range for prolonged periods of time. A much simpler and more direct way to avoid this is to use flow-based blocks, in which minimum flow percentages are defined for different flow ranges, an approach which the District has recommended for the Little Manatee, which I strongly support.

Flow based minimum flows have previously been determined by the District for estuarine rivers, such as the Lower Pithlachascotee and the Lower Peace. In these rivers, the relationships of variables to freshwater inflow within the estuary were examined to determine ranges of flows where different percent withdrawal limits should be applied. Combined with a low flow cutoff, this is a very effective way to largely preserve natural flow characteristics, protect the estuary from significant harm, and make water proportionately more available as flows increase.

The problem with the Little Manatee River report is that flow thresholds of 35 and 72 cfs were based solely on environmental analyses of the freshwater reach of the river. These flow thresholds are then applied to the estuarine reach of lower river as well. This is a first, as the District has never done this before, and it is probably not the best approach.

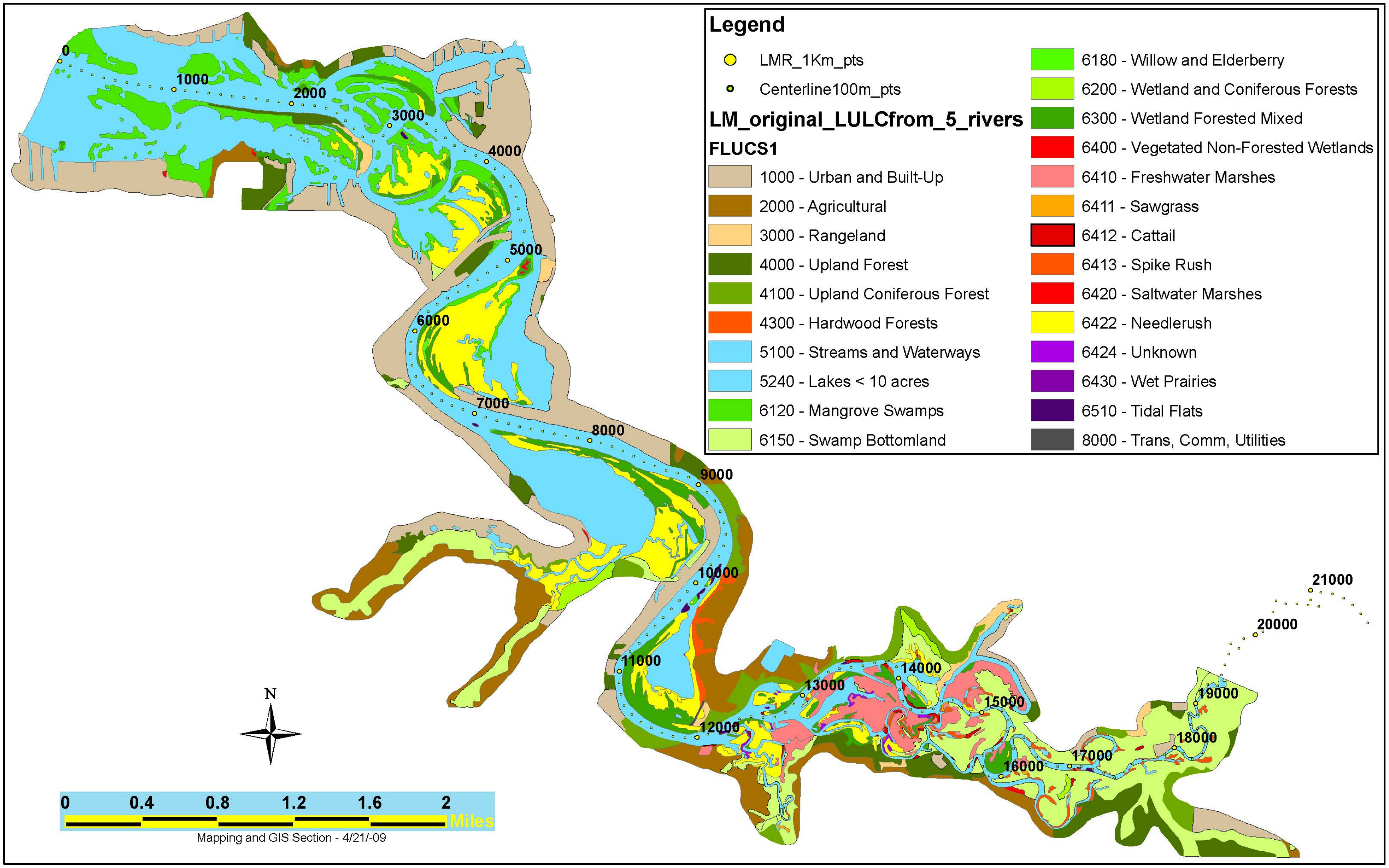
As was done for the Lower Pithlachascotee and Lower Peace Rivers, the response of key variables in the estuary to freshwater inflows should be examined separately for a series of flow ranges. Flow thresholds can then be identified to switch percent allowable flow reductions. Practical and ecologically effective flow thresholds for the estuarine portion of the Little Manatee might be similar to the flow thresholds identified for the freshwater reach, but you don't know until you analyze the data in that manner.

If necessary, the application of separate thresholds for flow-based blocks for the freshwater and estuarine reaches of a rivers is very feasible from a management perspective and can easily be applied, especially on a small river like the Little Manatee.

I recommend the District conduct further analyses to examine the response of low salinity zones and the environmental favorability functions for fishes in the lower river to freshwater inflow, and determine if separate thresholds for flow-based blocks in the estuarine section of the Little Manatee River are needed. The Lower Little Manatee River is an Outstanding Florida Water, an Aquatic Preserve, and is the jewel of tidal rivers flowing to Tampa Bay. It warrants a high degree of protection and the best analyses possible.

Three slides begin on the following page

Major Vegetation Communities along the Lower Little Manatee River



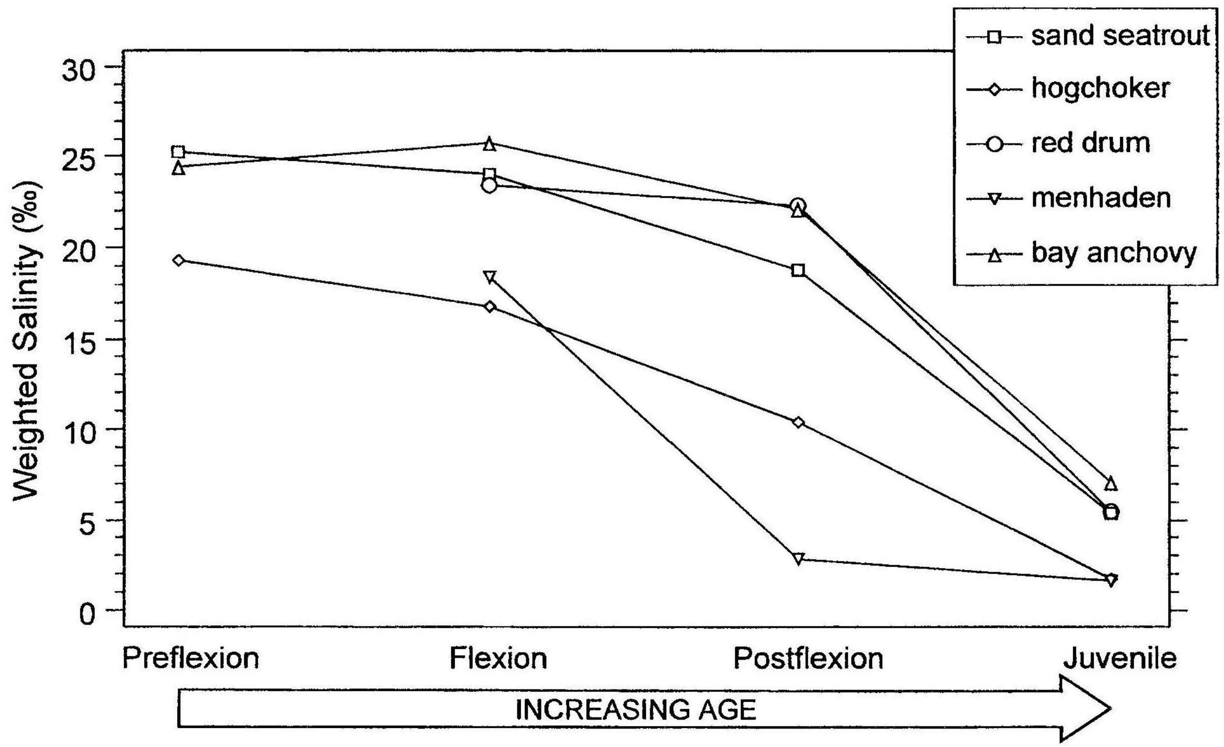


Fig. 5. Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages (Peebles and Flannery 1992).

Means, number of observations (N) and periods of data collection for chlorophyll *a* concentrations at four moving salinity-based stations in the tidal reaches of the Little Manatee, Peace, and Alafia Rivers.					
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Alafia (01/99 - 12/01)	36	15.3	63.4	95.7	43.7

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Doug Leeper; Eric DeHaven; Adrienne E. Vining; Xinjian Chen; Jordan D. Miller; Chris Zajac; Kristina Deak; Gabe I. Herrick; Lei Yang; mburke; esherwood; Ernst Peebles; Karlen, David; Dougherty, Janet; ash; MIke Wessel (MWessel@janickienvironmental.com); Tony Janicki (tjanicki@janickienvironmental.com)
Subject:	Comments for submittal to Little Manatee River minimum flows peer review panel
Date:	Wednesday, October 6, 2021 9:52:59 AM
Attachments:	Comments to Little Manatee River peer review panel from Sid Flannery, #1.pdf Slide 2. Ichthyoplankton figure.pdf Slide 1 - Lower Little Manatee vegetation map.pdf Slide 3. Chlorophyll a table.pdf

Hello Kym,

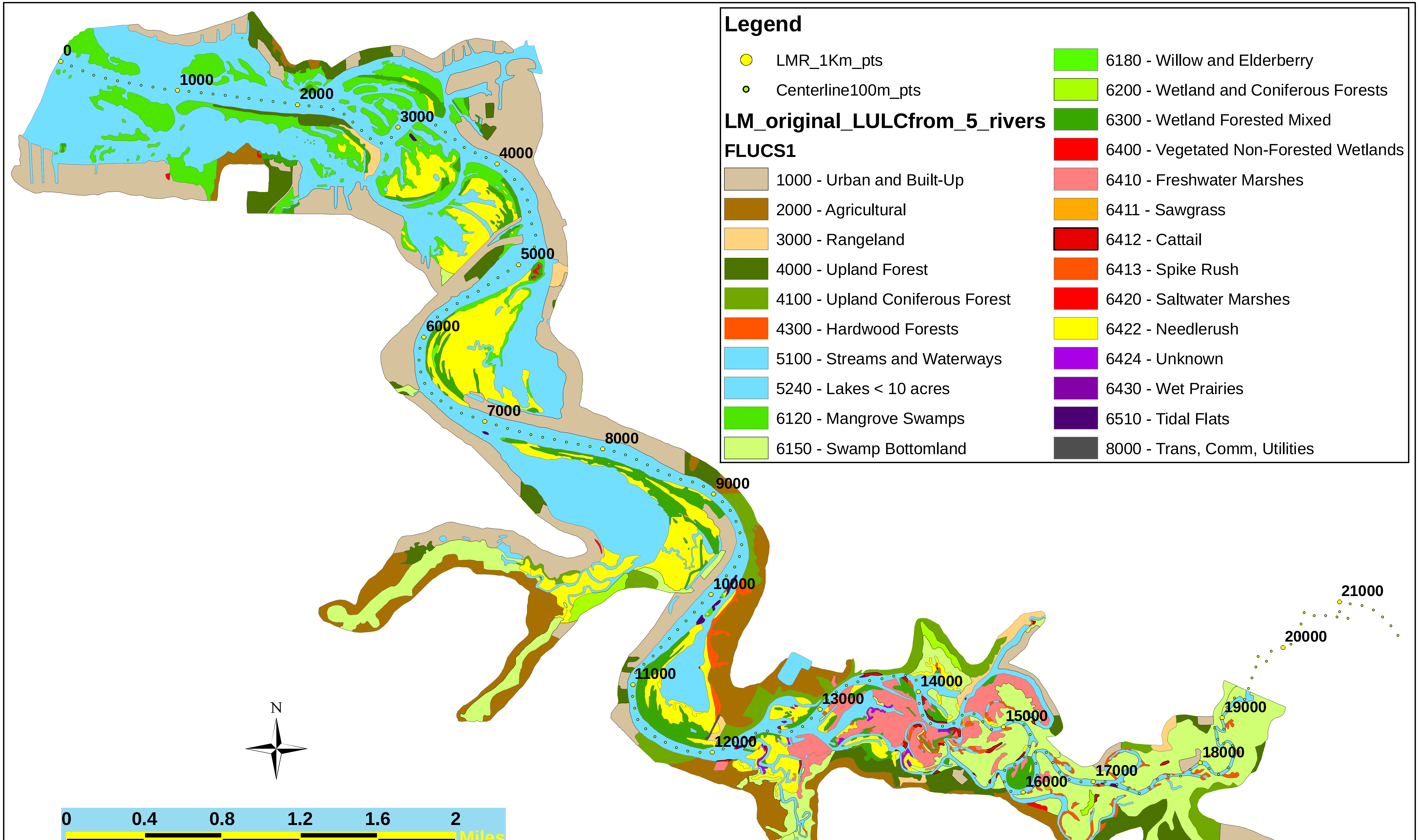
Kudos to you and the District for facilitating an excellent kick-off meeting of the Little Manatee River minimum flows peer review panel. Attached is a pdf of the complete comments I had hoped to present to the panel yesterday, but time ran out before I could finish them.

As described in the italicized preface to the comments, I added two paragraphs and one slide based on work conducted by Dr. Gabriel Vargo of the University of South Florida College of Marine Science (retired). I also encourage readers to review the important section about separate flow-based thresholds for the freshwater and estuarine sections of the river, which begins on page 3.

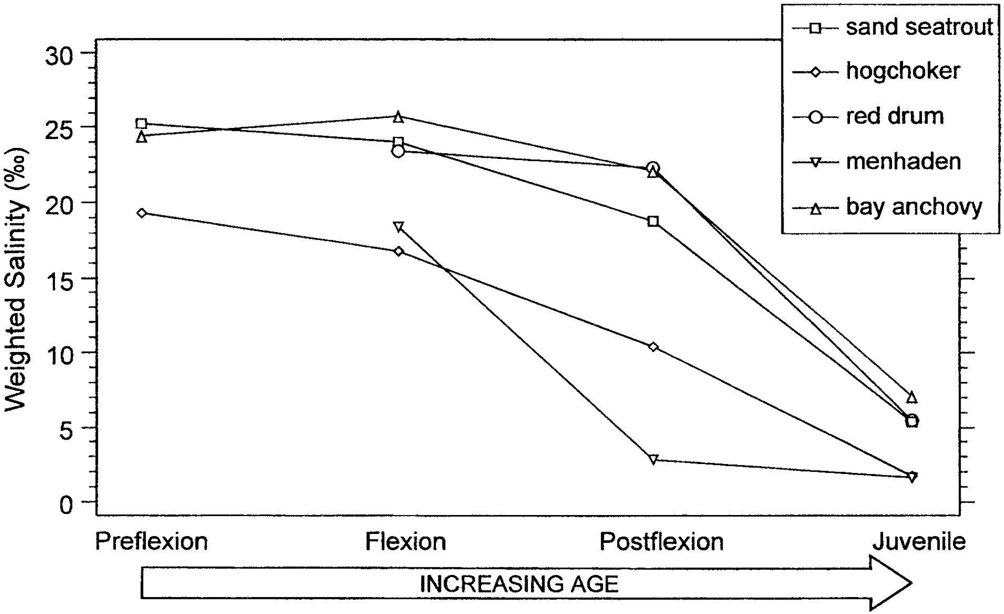
The three slides that are referenced in my comments are also attached. Please provide this email and the attached documents to the minimum flows peer review panel for the Little Manatee River. Thanks to the District for conducting the peer review and considering public comment. I anticipate submitting additional comments to the panel, so please keep me apprised of the dates of future panel meetings.

Thanks again,
Sid

Major Vegetation Communities along the Lower Little Manatee River



Mapping and GIS Section - 4/21/-09



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ENVIRONMENTAL ADVISORY COMMITTEE MEETING

TUESDAY, JULY 13, 2021 – 10:00 AM

2379 BROAD STREET, BROOKSVILLE, FLORIDA 34604

MINUTES

Committee Members Present
Jennifer Hecker, Coastal and Heartland National Estuary Partnership
Allain Hale, Environmental Confederation of Southwest Florida
Gordon Colvin, Save the Homosassa River Alliance
Sid Flannery, Sierra Club Tampa Bay
Alan Bailey, Florida Trail Association
Dave Tomasko, Sarasota Bay Estuary Program
Dwayne Carlton, Ocala/Marion County Chamber & Economic Partnership
Ed Sherwood, Tampa Bay Estuary Program
Paul Crowell, Keystone Civic Association

Governing Board Liaison
John Mitten

Staff Members
Michelle Hopkins
Robyn Felix
Randy Smith
Mohamed Hersi
John Campbell
Eric DeHaven
Doug Leeper
Dave Kramer
Chris Anastasiou
April Brenton
Adrienne Vining
Barbara Garrett

Board Administrative Support
Virginia Singer
Lauren Vossler

1. **Call to Order and Introductions**
The Environmental Advisory Committee of the Southwest Florida Water Management District (District) met for its regular meeting at 10:00 a.m., on July 13, 2021, via Microsoft Teams.

Chair Jennifer Hecker called the meeting to order, and attendance was called.

Mr. John Mitten was introduced as the Liaison for Environmental Advisory Committee.

2. **Additions and Deletions to the Agenda**
None

3. **Approval of April 13, 2021, Meeting Minutes**
A motion was made for approval of the April 13, 2021 minutes. The motion was seconded and passed unanimously.

4. **Public Comments**
None

5. **Elections of Chair and Vice Chair**
A motion as made to nominate Ms. Jennifer Hecker as the Chair and Dave Tomasko as Vice Chair of the Environmental Advisory Committee. The motion was seconded and passed unanimously.

6. **<u>2021 MFL Priority List and Schedule – Doug Leeper, MFLs Program Lead</u>**

Mr. Leeper provided committee members with information on the timeline and process for the annual update of the District's Minimum Flows and Levels (MFLs) priority list and schedule. He discussed statutory timeline requirements and the activities to be completed prior to submission of the list to the Department of Environmental Protection (DEP) for approval. Mr. Leeper noted the draft priority list meets all statutory and rule requirements. He summarized the status of and accomplishments for water bodies included on the current priority list and also discussed the status and accomplishments for a number of unscheduled MFLs.

Mr. Leeper provided members with details on the draft 2021 MFLs priority list. He noted the addition of three Southern Water Use Caution Area (SWUCA) lakes for MFLs reevaluation in 2023 and five SWUCA lakes for reevaluation in 2024. He also noted the addition of MFLs establishment for the Withlacoochee River that is planned for 2024. A detailed timeline was provided for the upcoming steps being taken to support finalization of the 2021 priority list.

Ms. Hecker asked how the District determines when it is appropriate to develop a water reservation in addition to an MFL. Mr. Leeper explained MFLs identify significant harm associated with water use. He further noted that water reservations identify the quantity and the timing of water that is reserved from use by permit applicants for the protection of fish and wildlife or public health and safety.

Ms. Hecker inquired about how much an MFL would have to be exceeded before the need to establish a water reservation would be identified. Mr. Leeper explained if an MFL is not being met then the Governing Board and staff will have to adopt and develop a recovery strategy to ensure compliance with the MFL.

Mr. Flannery inquired about the District's reevaluation of MFLs established for the Upper Peace River. Mr. Leeper noted this reevaluation is not currently on the priority list, but it is planned for completion in 2025.

Mr. Tomasko asked what role hydrologic restoration and water quality will have in terms of MFL development for lakes. Mr. Leeper explained the District is guided by the State Water Resource Implementation Rule which identifies environmental values that are to be considered when developing MFLs, and water quality is one of the values.

7. **<u>ERP Stormwater Rulemaking Update – Dave Kramer, Environmental Resource Permit Bureau Chief</u>**

Mr. Kramer provided an update on the SB712 – Statewide Stormwater Rulemaking Update. He explained stormwater-related pollution is one of the largest potential contributors of nutrients throughout the state, increasing number of water bodies are not meeting state water quality standards, and algae blooms and the red tide events are part of the contributing issues. He discussed part of the solution including: the Blue-Green Algae Task Force, passage of the Senate Bill 712 – Clean Waterways Act, and the Stormwater Technical Advisory Committee (TAC) and agency workgroups.

Mr. Kramer explained that the legislation directed DEP to enter rulemaking by January 1, 2021, to improve the existing regulations pertaining to stormwater. He discussed the goal of the Stormwater TAC is to provide recommendations to the DEP and water management districts related to anticipated rule development, updating stormwater design and operation regulations.

Mr. Kramer explained the expected outcome will consist of recognition of non-traditional stormwater solutions, consideration of most recent scientific stormwater information available, consistent statewide water quality design criteria, improved guidance, updates to Applicants Handbook Volume II (AHVII) or new sections of AHVII, and reductions in stormwater related nutrient pollutant loading.

Ms. Hecker asked how much the current TAC has looked at what the previous TAC crafted regarding the rule language and topics of concern. Mr. Kramer explained the draft 2010 applicant handbook is being used as a baseline for the rulemaking effort.

Ms. Hecker inquired about a possible discussion by the TAC on moving predevelopment to natural land use loading rates based on the predevelopment land coverage types. Mr. Kramer responded in the affirmative.

Discussion ensued about considering wetland areas appropriately in water quality loading and efficiency calculations.

Ms. Hecker also inquired about the TAC timeframe, remaining meetings and what needs to be done to stay engaged. Mr. Kramer responded the TAC meetings began in January, there are two to three additional meetings, and within the next three months the rulemaking process will be initiated.

8. <u>2020 Seagrass Mapping Results – Chris Anastasiou, Chief Water Quality Scientist</u>

Dr. Anastasiou provided members with the 2020 Seagrass mapping results. He explained the three phases that go into creating the maps are acquisition, photointerpretation, and field verification. He provided members with the 2020 mapping results finalized by estuary. Dr. Anastasiou discussed the independent accuracy assessment and its ability to provide 90% accuracy acceptance of the final map product.

Dr. Anastasiou explained the mapped seagrass acreage in Tampa Bay dropped to a 10-year low of 34,297 acres. Sarasota Bay mapped seagrass acreage dropped to a 12-year low of 10,540 acres. However, in Blackburn Bay there was a 4% increase in seagrass acreage. He mentioned the greatest loss occurred along the northern section of Charlotte Harbor's east wall, losing 1,770 acres compared to the previous mapping cycle in 2018. Dr. Anastasiou provided members with the open data portal to view the seagrass mapping: http://data-swfwmd.opendata.arcgis.com/.

Discussion ensued regarding seagrass loss, cause, and effect.

9. <u>Development of agenda topics for the next Environmental Advisory Committee Meeting Tentatively at 10:00 a.m. on Tuesday, October 12, 2021.</u>

Mr. Flannery suggested a future presentation on Lake Hancock and the Upper Peace River recovery strategy. For the upcoming meeting he recommended a presentation on the approach taken on the Little Manatee River MFLs.

Mr. Bailey suggested an update on statewide stormwater rulemaking and low-impact development design and treatment trains into stormwater treatment standards

Mr. Carlton asked for an update on how Piney Point has impacted the Tampa Bay area.

10. <u>Announcements and Other Business</u>

None

11. <u>Adjournment</u>

The meeting adjourned at 12:03 p.m.

From:	Sid Flannery
To:	Virginia Singer
Cc:	Michael Molligan; Jennifer Hecker; Doug Leeper; Kym Holzwart; Chris Zajac; Kristina Deak; Jordan D. Miller
Subject:	Follow up to today"s EAC meeting
Date:	Tuesday, October 12, 2021 2:56:57 PM
Attachments:	EAC 7-13-2021 Draft Minutes .pdf

[EXTERNAL SENDER] Use caution before opening.

Hello Ms. Singer and Mr. Molligan,

Thanks as always to the District for putting on another informative Environmental Advisory Committee meeting. I believe you can let the EAC know when pdfs of the powerpoint presentations are available. Also, can you forward a link where interested parties can view a video of the meeting?

Also, when you convey my question as to why the District chose not to give a presentation to the EAC about the Little Manatee River minimum flows, please note that in Item 9 in the attached EAC meeting minutes from July 13th, I requested that a presentation be given on the approach that was being taken for the minimum flows. In posing that question, I was clear this did not need to include the proposed minimum flows, for I can understand why the District would not want to present those findings until the minimum flows report is approved by the Governing Board for submittal to the peer review panel.

For future reference, when requested, I think it would be valuable to give a general presentation to the EAC about the approach being taken for the minimum flows for a specific river before the report is released for peer review. Having such a presentation about the Little Manatee at today's meeting, which would have been two weeks after the report was approved for peer review, would have been very timely and valuable.

Thanks again,
Sid Flannery

INCREASED NUTRIENT LOADING AND BASEFLOW SUPPLEMENTATION IN THE LITTLE MANATEE RIVER WATERSHED

M. S. Flannery
H. C. Downing, Jr.
G. A. McGarry
M. O. Walters

ABSTRACT

The Little Manatee River has been the site of an interdisciplinary study of the ecological linkages between a watershed and its receiving estuary. This paper examines spatial and temporal trends in the quantity and quality of streamflow in the basin. Analyses of long-term rainfall-runoff relationships show that dry season streamflow in April and May has significantly increased since the mid-1970s while rainfall for those months has decreased or risen only slightly. Streamflow records for six sites gaged during 1988 showed that the highest rates of yearly runoff were from subbasins with the highest rates of agricultural water use. Increased basin outflows are attributed to the direct contribution of irrigation waters or land and water use practices that increase runoff potential. Water quality was measured biweekly for one year at the six streamflow stations and at a seventh station where flows were estimated. The site with the least intensive land use had concentrations of sulfate, nitrate-nitrite, total suspended solids, particulate nutrients and specific conductance that were significantly less than for most other stations. High specific conductance and sulfate concentrations in certain tributaries in the watershed were attributed to mineralized ground water from the Floridan aquifer entering those streams as a result of irrigation runoff. Nitrate-nitrite concentrations were negatively correlated with flow in less impacted, upstream areas, but comparatively high concentrations were observed during high flows at more impacted sites. Turbidity and suspended solids showed a much stronger response to flow increases at the more impacted sites. Areal flux rates for dissolved inorganic and particulate nitrogen differed by an order of magnitude between the least and most impacted subbasins. Long-term data at the Highway 301 bridge show that marked increases of specific conductance, nitrate-nitrite and sulfate concentrations have occurred in the river since the mid-1970s. Average midafternoon dissolved oxygen concentrations during the summer were relatively low (3.4 to 4.2 mg/l) throughout much of the estuary, and further perturbations to water quality of the river and estuary could result in the decreased biological diversity and productivity of this system.

INTRODUCTION

Among the principal creeks and rivers flowing to Tampa Bay, the Little Manatee River (Figure 1) is considered to be the stream that is in the best hydrobiological condition. For this reason, the Little Manatee was selected as the site for an interdisciplinary study of the ecological linkages between a watershed and its receiving estuary. The upstream, freshwater component of the project has emphasized natural and anthropogenic influences on hydrology and water quality, utilizing physical (soils, topography) and land use/cover data available from a Geographic Information System assembled for the project. The downstream portion of the study has examined estuarine water chemistry plus phytoplankton, zooplankton, and larval and juvenile fish communities in the tidal regions of the river and adjacent areas of Tampa Bay (Peebles et al.; Vargo et al., this volume). The goals of the project are two-fold. First, biological data from this study serves as valuable basic information on how tidal creek and river habitats are utilized by the biota of Tampa Bay. Second, the findings of the study will be used to formulate a series of management recommendations specific to the Little Manatee River watershed so that the qualities of this system can be maintained in the wake of expected population growth.

This paper discusses spatial and temporal trends in the quantity and quality of streamflow in the river and its tributaries and compares these trends to the distribution of land and water uses in the basin. These findings are presented as preliminary since we are in the early stages of analysis, and a final report will be available in early 1992 from the Southwest Florida Water Management District (SWFWMD) with contributions by Dames & Moore and the Florida Department of Natural Resources Marine Research Institute. That report will expand the use of GIS data to examine relationships of physical and land-use factors to the delivery of fresh water and nutrients from the basin. At this time, however, several trends are apparent which have important implications for the ecology of the river and Tampa Bay. Dry season flows in the Little Manatee River are supplemented by irrigation waters, and nitrogen loading from the basin appears to have increased significantly in recent years. Recognition of these trends and the development of appropriate management strategies are of immediate concern if the effects of these factors on estuarine productivity and eutrophication are to be controlled.

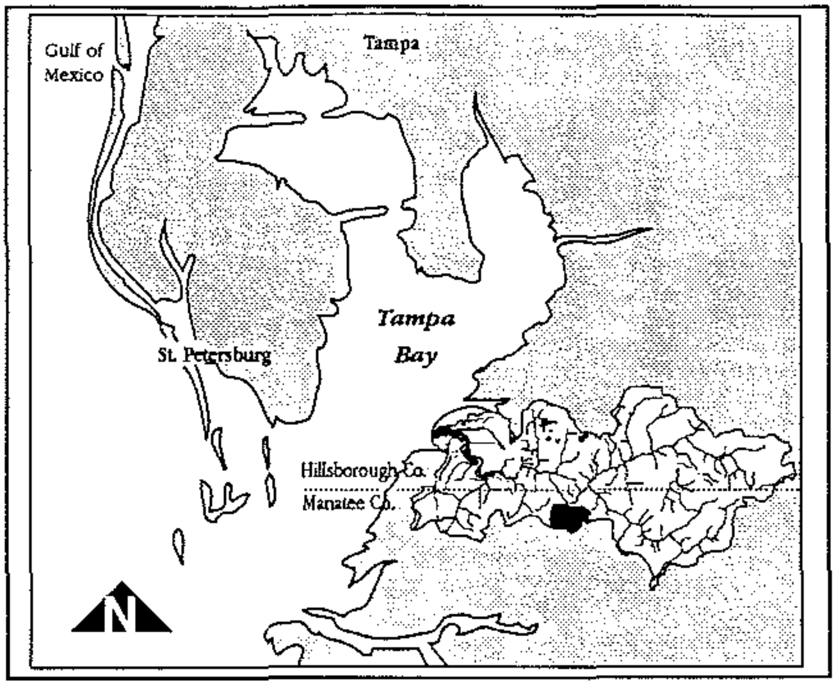

Figure 1. Location of the Little Manatee River watershed.

METHODS AND DATA SOURCES

Seven rainfall stations with daily records are available within or near the Little Manatee River watershed (Figure 2). The periods of record for these stations are of short to intermediate length, ranging from three to twenty years. A thiessen polygon network was constructed from five of these stations to estimate average rainfall in the basin during the period of this study (1988 and 1989). Long-term rainfall in the basin must be estimated from several long-term (77 to 89 years) stations in the Tampa Bay region (e.g., Tampa, Bradenton, Bartow). For the period of record for each intermediate-term station, stepwise multiple linear regression analysis was used to develop a predictive equation for monthly rainfall at the intermediate station as a function of monthly rainfall at a combination of long-term sites. These equations were then used to generate synthetic records for the intermediate stations prior to data collection at those sites. Long-term trends in rainfall for the basin were then evaluated based on the combined synthetic and measured data for the intermediate-term stations.

The U.S. Geological Survey (USGS) maintains and reports daily streamflow records for three gaging stations in the Little Manatee River (LMR) watershed (LMR near Wimauma, LMR near Ft. Lonesome, and Cypress Creek). For this study, three additional gaging stations were established by the USGS and operated from October 1987 to January 1989 (Figure 2). Daily streamflow values for this period were estimated for a seventh station (LMR North Fork) based on differences between nearby stations and adjustment factors for subbasin area. Using reported daily streamflow values from the six gages and estimated values for North Fork, runoff and nutrient loading per unit area were calculated for a total of seven subbasins in the watershed (Figure 2).

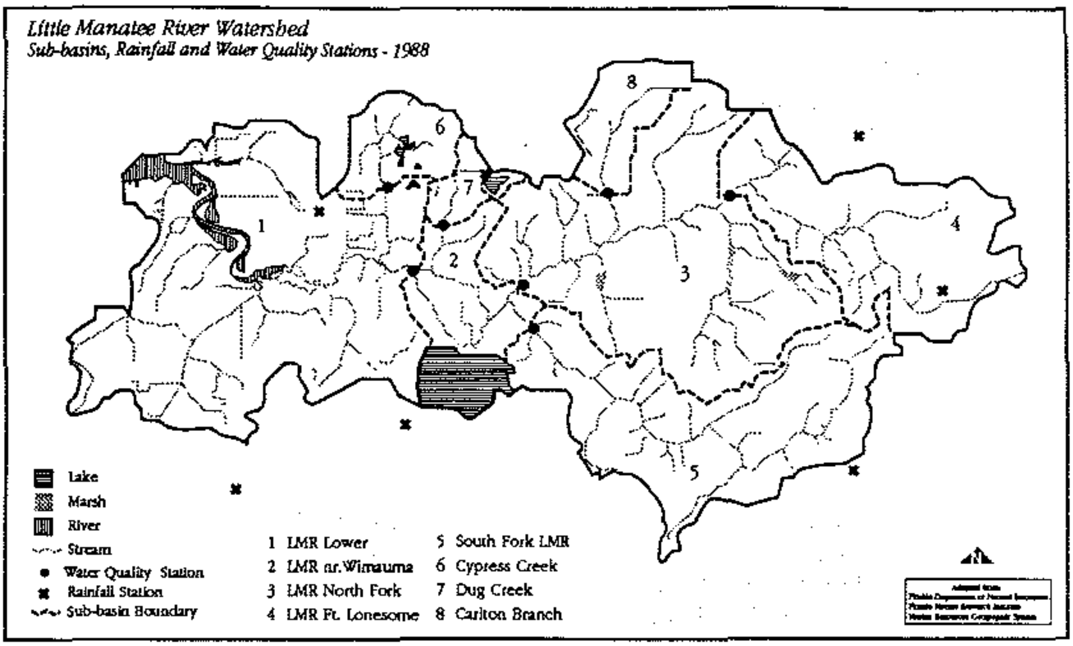

Figure 2. Subbasins, rainfall and water quality stations monitored during the first year of study.

Water quality was monitored by the SWFWMD at biweekly intervals during the first year of study (January 26, 1988 to January 24, 1989) at the seven streamflow sites shown in Figure 2. Measurements of temperature, specific conductance, pH and dissolved oxygen were taken in the field using a Hydro-Lab water quality meter. Duplicate water samples for chemical analysis were collected from a depth of 0.25 meters, or shallower if necessary, placed on ice and returned to the SWFWMD laboratory where analyses were performed according to methods described in EPA (1983), APHA (1983), and the Perkin-Elmer Corporation (1987). Duplicate water samples for chlorophyll *a* determination were collected from three sites and transported in water baths at ambient river temperature to the Department of Natural Resources Laboratory in St. Petersburg where filtrations were performed early that afternoon. Chlorophyll *a* values expressed in this report were calculated using the equations of Jeffrey and Humphrey (1975). Water chemistry, Hydro-Lab, and chlorophyll measurements were continued on a monthly basis for the second year of study (January 1989 to January 1990) at the LMR near Wimauma station. Concurrent with the freshwater sampling regime, water quality monitoring was conducted for both study years at seven stations in the estuarine portion of the river and adjacent areas of Tampa Bay. Details regarding station locations and methods for the estuarine sampling are provided elsewhere in these proceedings (Peebles et al., Vargo et al.). Water quality values reported in this paper also include data collected for the river by the USGS and the Hillsborough County Environmental Protection Commission (HCEPC).

Nutrient loading rates for the seven subbasins were calculated as follows. For each station, total daily loads (kg/day) were calculated separately for the 26 biweekly sampling events by multiplying the constituent concentrations * average flow on that day. These daily loads were then log-transformed and regressed against the logarithm of same day flow for each sample date to yield predictive equations for daily loadings as a function of same-day flow. Using daily streamflow records, these equations were then used to predict daily loadings for each day of the study year. Values for total monthly or yearly loads were then summed from the predicted daily loadings, and flux rates (kilograms/hectare/year) were calculated by dividing the yearly load by the subbasin area.

All spatial geographic data were stored and analyzed using the Marine Resources Geographic Information System (MRGIS) at the Florida Department of Natural Resources Marine Research Institute. MRGIS applications software include the commercially available ERDAS, Inc. raster-based package and ESRI's ARC/INFO vector-based package. The MRGIS also uses ELAS, a nonproprietary image processing software developed by NASA. Numerous data layers are being implemented on the MRGIS and represent a variety of sources (Haddad and McGarry 1989). Land cover data were interpreted from the SPOT satellite base map (imaged April 1988) and aerial photography. Watershed subbasins were digitized based on United States Geological Survey delineations.

THE STUDY AREA

Physiographic and Hydrogeologic Setting

The Little Manatee River watershed drains approximately 222 mi^2 (576 km^2) in southern Hillsborough and northern Manatee Counties, discharging to Middle Tampa Bay on its eastern shore. The headwaters of the river lie in the Polk Uplands physiographic province (White 1970), where land elevations are in excess of 100′ above sea level (NGVD). Immediately to the west, much of the drainage system crosses a small northern lobe of the DeSoto Plain, and the lower third of the watershed lies in the Gulf Coast Lowlands, where elevations range from sea level to 50′ NGVD.

The maximum length of the river is about 40 miles. The two principal tributaries to the river are the North and South Forks, which join about 22 miles above the river mouth at Tampa Bay (the North Fork is generally labeled as the Little Manatee River on maps). In most areas, the channels of the two forks are narrow and well incised. Channel-slope gradients for both forks are comparatively high for peninsular Florida, reported at about 0.13% for the North Fork near the Ft. Lonesome gage (Dames and Moore 1975). Near the USGS stream gage at Highway 301, the channel gradient of the river becomes gentler and minor tidal water level fluctuations are observed during low flow periods. In its lower 10 mile (16 km) reach, the river channel and floodplain become much wider and numerous tidal features such as tidal creeks, bayous, and mangrove-dominated islands become prevalent.

Hydrogeologically the Little Manatee River area is characterized by three distinct groundwater systems: the surficial, intermediate, and Floridan aquifers. The surficial aquifer system is an unconfined system which consists of marine and nonmarine quartz sands, clayey sand, shell and phosphorite. The water table in the surficial aquifer generally follows the topographic relief, with local flow patterns that lead to surface water drainage or depressional features. Below the surficial aquifer is the intermediate system which consists of water-bearing and confining units. The confining beds of the intermediate aquifer impede the vertical exchange of water between all three systems. Estimated recharge rates from the surficial to the intermediate and Floridan aquifers are very low (<2"). This low rate of recharge can partially explain the high runoff potential of the watershed. Below the intermediate system is the Floridan aquifer, which is the principal ground water supply source used within the basin. The Floridan aquifer is a series of limestone formations that begins 200-300′ below land surface and is 1200-1400′ thick. Water quality in the Floridan aquifer is generally good, but deteriorates with depth and proximity to the coast.

Land Use/Cover

The distribution of major land use and cover types are shown in Figure 3. This information is also presented in Table 1, where land use/cover types are expressed as percentages of area for the subbasins shown in Figure 2. Compared to most basins draining to Tampa Bay, the Little Manatee River watershed is lightly urbanized. The combined urban-suburban coverage comprises only 6.6% of the entire watershed. The two principal urban centers, Ruskin and Sun City Center, are located in the western half of the watershed; residential development is minor in the eastern areas. Domestic wastewater facilities in the watershed include a number of small, privately owned plants near Ruskin, which discharge to percolation ponds or drain fields, and the South Hillsborough County wastewater treatment plant which discharges via spray irrigation and industrial reuse.

Industrial land uses in the watershed are primarily for two purposes, phosphate mining and electrical power generation. Most conspicuous is the Florida Power and Light Corporation's power generation facility located near the southern edge of the watershed. A 1,616-hectare offstream reservoir, shown as a lake in Figure 2, is used to store waters for power plant cooling purposes. Phosphate mines, which comprise 0.9% of the total area, are located in the easternmost portions of the watershed where there is a permitted discharge to the river from the Four Corners Mine. At present, the IMC Fertilizer Corporation is in the Development of Regional Impact review process to gain regulatory approval to mine substantially more of their land holdings in the watershed, which lie primarily in the Ft. Lonesome subbasin (Figure 2).

The most notable characteristic of the Little Manatee River watershed is its large amount of agricultural land use. Lands used for row crops and citrus total 27.3% of the watershed while pasture comprises another 26.3%. Vegetable row crops are distributed throughout the basin, but are particularly concentrated in the central and southwestern regions. Citrus, which comprises 8.8% of the watershed, is widely distributed with one area of concentration in the north central region near Carlton and Pierce Branches. Pasture, which includes both improved and unimproved classifications, is concentrated near the I-75 corridor and in the eastern portions of the watershed. Tropical fish farms comprise 0.6% of the watershed and are located in the eastern and central regions.

Apart from agriculture, vegetative land covers comprise approximately 35% of the watershed. The largest vegetation category is wetlands forest (12.6%), which is primarily associated with the stream channels of the river network. Herbaceous wetlands (3.9%) are scattered throughout the basin and estuarine wetlands are located near the river mouth. Upland communities are comprised of hardwoods, pine flatwoods, and range (shrub and brush) which combined total 17.7% of the watershed.

Water Use

A total of 100.4 million gallons per day (mgd) average pumpage is permitted from the Little Manatee River watershed, predominantly from groundwater sources. Total permitted quantities for four major water use categories (agricultural, industrial, recreational and domestic supply) are listed in Table 1 for the entire watershed and the subbasins shown in Figure 2. Industrial water use represents 23.1% of the permitted use in the watershed, with IMC Fertilizer, Inc. and Florida Power and Light Corporation comprising most of this amount. Under an agreement with the SWFWMD, Florida Power and Light Corporation diverts water from the Little Manatee River to maintain their cooling-water reservoir. Water can be diverted when streamflow in the river is over a monthly minimum flow level, and the diversions have averaged 10.6 cfs per day since reservoir filling was completed in 1977. Domestic water supply use in the watershed is very low (0.6 mgd), consisting of small, private water supply systems. There is also a small amount (0.5 mgd) of recreational water use (golf course irrigation) in the watershed.

Agricultural water use comprises about three-fourths (76%) of the total water use in the basin. This use is almost entirely from ground water, using deep wells that tap the Floridan aquifer. Of the subbasins shown in Figure 2, agricultural water use is highest in the lower LMR and North Fork subbasins. Based on a ratio of water use to subbasin size, however, agricultural water use rates are highest in the Carlton

Branch, Cypress and Dug Creek subbasins (0.22 to 0.24 mgd/km^2) and lowest in the Ft. Lonesome and South Fork subbasins (0.07 to 0.10 mgd/km^2).

Supplemental irrigation is typically provided for citrus and vegetable production while little to no irrigation is provided for pastures. Crop irrigation primarily occurs throughout the dry season (October to June). Although irrigation rates can be high in the fall for strawberries and fall vegetables, the highest seasonal pumpage rates typically occur in the spring when crop water demands are the greatest. For citrus and strawberries, short-term periods of high pumpage can occur during the winter for frost-freeze protection.

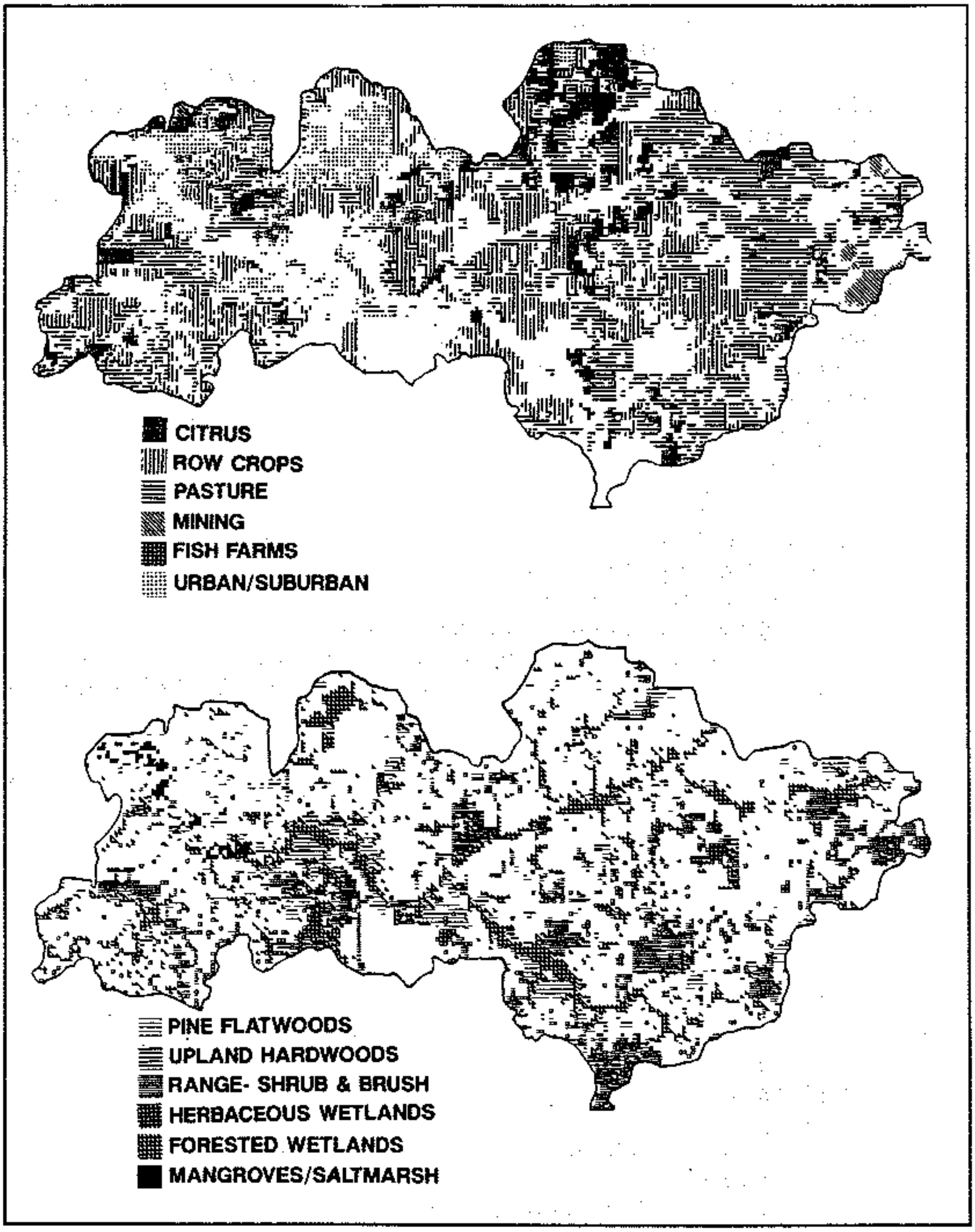

Figure 3. Distribution of major land use and land cover types in the Little Manatee River watershed during 1988.

Table 1. Area, percent coverage of major land use/cover types, and permitted water use for the subbasins shown in Figure 2. The FP&L offstream reservoir is not included in the area and percent coverage data for the LMR-Wimauma subbasin, but the permitted water use associated with the power plant is listed for that subbasin. Water use data were retrieved from the SWFWMD Regulatory Data Base for permits active in May 1991.

	TOTAL	1. LMR LOWER	2. LMR NEAR WIMAUMA	3. LMR NORTH FORK	4. LMR FT. LONESOME	5. SOUTH FORK	6. CYPRESS CREEK	7. DUG CREEK	8. CARLTON BRANCH
Area-(Km^2)	575.9	170.6	28.3	132.8	79.8	100.4	20.5	8.4	21.8
PERCENT COVERAGE									
Urban-Suburban	6.6	12.6	7.6	1.2	0.3	0.2	43.4	15.1	5.3
Citrus	8.8	6.4	6.0	10.5	7.8	7.4	0.7	10.2	41.5
Row Crops	18.5	20.2	25.0	27.7	1.4	16.9	18.0	28.5	15.5
Pasture	26.3	19.3	15.9	26.4	52.1	29.9	3.8	4.0	26.4
Fish Farms	0.6	1.14	2.9	0.3	0.0	0.1	0.0	0.0	0.3
Mining	0.9	0.2	0	0	5.8	0.1	0.0	0.0	0.0
Uplands-Hardwoods	2.4	2.9	1.6	2.5	2.1	3.2	0.3	0.3	0.4
Uplands-Pinelands	6.6	7.7	15.7	4.2	3.1	9.6	4.0	17.7	1.5
Uplands-Shrub and Brush	8.7	5.8	7.3	11.2	11.0	13.3	0.8	8.9	0.2
Wetlands-Herbaceous	3.9	4.9	1.2	3.7	3.6	4.9	1.0	2.0	1.5
Wetlands-Forest	12.6	12.3	16.0	12.0	12.2	14.3	21.4	12.2	7.0
Mangroves & Saltmarsh	0.6	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water	3.7	4.5	0.6	0.4	0.6	0.2	6.6	1.1	0.4
WATER USE (MGD)									
Domestic Supply	0.6	0.5	0.04	0.02	0.01	0	0	0	0
Industrial	23.2	0.3	10.45	1.6	10.8	0	0	0	0
Agricultural	76.1	21.2	3.67	23.9	5.9	10.2	4.4	1.9	5.0
Recreational	0.5	0.001	0	0	0	0	0.5	0	0

The two primary irrigation methods employed in the watershed are micro-irrigation and seepage. Micro-irrigation uses drip or miniature sprinkler systems to apply water directly or in proximity to the soil root zone, resulting in high irrigation efficiencies. Seepage or subirrigation uses lateral ditches and the soil to transport water to the plants. Essentially, an artificial water table is created in close proximity to the root zone which provides a constant supply of water by capillary rise. Irrigation efficiencies for seepage irrigation systems are usually low, and the potential for runoff is high under all weather conditions due to the saturated soil conditions.

RESULTS AND DISCUSSION

Rainfall

The typical seasonal rainfall pattern for the Little Manatee River watershed is shown in Figure 4, where average monthly rainfall totals are shown for the Bradenton and Bartow weather stations. These stations are not in the Little Manatee watershed, but along with the Tampa station, represent the nearest long-term sites. Average rainfall for the 1933 to 1989 period was about 54" for both the Bradenton and Bartow sites. Rainfall at these stations is highest during the summer months of June through September, representing about 60% of the annual rainfall. The summer rainy season is caused by the frequent occurrence of convective thunderstorms in the region and the periodic influence of tropical depressions and storms. A fall to spring dry season extends from October to May, with a minor rainfall peak in February and March due to an increase in rains resulting from cold fronts.

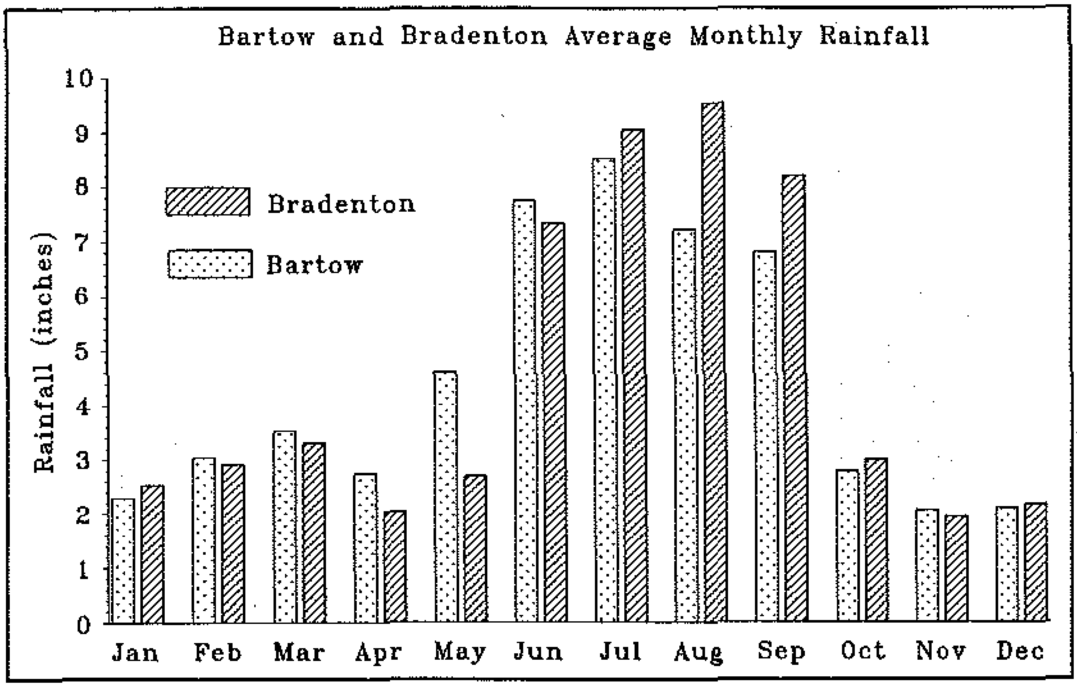

Figure 4. Average monthly precipitation at the Bartow and Bradenton rainfall stations.

Analyses of yearly rainfall records for the Bradenton, Bartow and Tampa stations indicate that portions of the Tampa Bay watershed have experienced a prolonged dry period since 1960. All the stations experienced an extreme wet period around 1960 that was well above the long-term average, but Bartow and Tampa exhibited a significant decrease in the long-term average rainfall after 1960 while the Bradenton station did not. Bradenton's average annual rainfall decreased approximately an inch between the pre-1961 and post-1960 time periods whereas the Bartow and Tampa average rainfalls decreased between 5 and 6 inches. Most of the decreases at Bartow and Tampa occurred between the months of April through October, whereas Bradenton exhibited only a minor redistribution of the monthly rainfall totals (Table 2). As described, stepwise multiple linear regression analysis was used to generate predictive equations for monthly rainfall at stations within or near the LMR watershed as a function of records at the long-term sites. Based on these statistical relationships, the predicted average annual rainfall since January 1961 ranged from 51" in the southern portion of the LMR watershed to 49" in the northern regions. This is in comparison to predicted average annual rainfalls of 56" and 54", respectively, for these regions during the pre-1961 time period.

Table 2. Changes in average monthly and yearly rainfalls from the pre-1961 to the post-1960 period. Values in the top row for each station are differences in inches, whereas the values in parentheses are expressed as percent change.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
BARTOW	0.02	0.46	-0.06	-1.39	-0.43	-1.48	-0.79	-0.89	-0.94	-1.10	0.50	0.29	-5.81
	(0.8)	(17)	(-1.8)	(-45)	(-8.8)	(-17)	(-9.1)	(-11)	(-13)	(-32)	(29)	(14)	(-10.4)
BRADENTON	0.04	0.13	0.43	-1.33	-0.34	0.85	-0.23	0.03	0.27	-1.05	0.17	0.10	-1.01
	(-1.5)	(4.6)	(15)	(-52)	(-11)	(12)	(-2.5)	(0.3)	(3.4)	(-31)	(9.0)	(4.6)	(-1.8)
TAMPA	-0.18	0.46	-0.03	-1.24	0	-1.53	-1.67	-0.02	-0.42	-0.78	0.27	0.20	-5.12
	(-8.1)	(17.9)	(-0.1)	(-52)	0	(-21.8)	(-20.5)	(-2.5)	(-6.4)	(-28.1)	(17.5)	(9.9)	(-10.4)

Spatially averaged rainfall for the watershed during the first study year (January 1988 to January 1989) totaled 54.6", a near normal amount. The seasonal distribution of rainfall was somewhat exaggerated, however, with an unusually dry spring and a wet late summer. Basin-average rainfall from mid-March to early June totaled only 3.4", providing an excellent opportunity to study low-flow conditions in the river. Early the following September, tropical air masses brought over nine inches of rain to the basin during a four-day period, resulting in flooding conditions on the river and a basin-average rainfall of 12.2" for the month of September.

Streamflow — Runoff

The U.S. Geological Survey has reported daily streamflow records for the Little Manatee River near Wimauma gaging station since 1939. This station is located about 15 miles upstream from the river mouth, and measures flow from approximately 67% of the river's watershed. Average yearly flows at the LMR near Wimauma station are plotted versus time in Figure 5A. A trend line derived from a linear regression of flow against year indicates there may be a slight decreasing trend in average yearly flows, but this relationship was not statistically significant. On the other hand, a plot of yearly minimum flows, or the lowest daily flow during a year, shows a definite increasing trend (Figure 5B), which was found to be statistically significant (α=.05, Kendall tau-b test, line plotted using linear regression). The figure also shows that yearly minimum flows typically occur during the months of April through June. Thus, although there has been no significant trend for yearly flows in the basin, baseflow levels in the spring appear to be increasing.

Double-mass curves of accumulated rainfall in the basin and streamflow at the LMR near Wimauma site were examined to see if there has been a change in rainfall-runoff relationships for the basin. The resultant straight line relationship shown in Figure 5C indicates there has been no significant change in the overall rainfall-runoff relationship over the period of record. However, since it was expected that baseflow increases are a seasonal phenomenon, double-mass curves of rainfall and runoff were plotted for individual months. This approach contains a large potential source of error, since average streamflow levels for a month can be strongly affected by antecedent conditions (high flows at the end of a preceding month). The double-mass curve for May shows a similar slope for the periods of 1940 to 1954 and 1960 to 1979. However, there are distinct changes in slope between 1954 and 1960 and from 1979 to 1989. The 1954 to 1960 rise in slope appeared related to antecedent conditions, since there were a number of relatively wet Aprils during that period. For the 1979 to 1989 period, however, April rainfall was below normal while May rainfall showed a small positive net change. Therefore, it appears that during the last decade, greater amounts of streamflow are generated during the spring for given amounts of rain, indicating flow supplementation and/or a change in factors controlling storm-generated runoff.

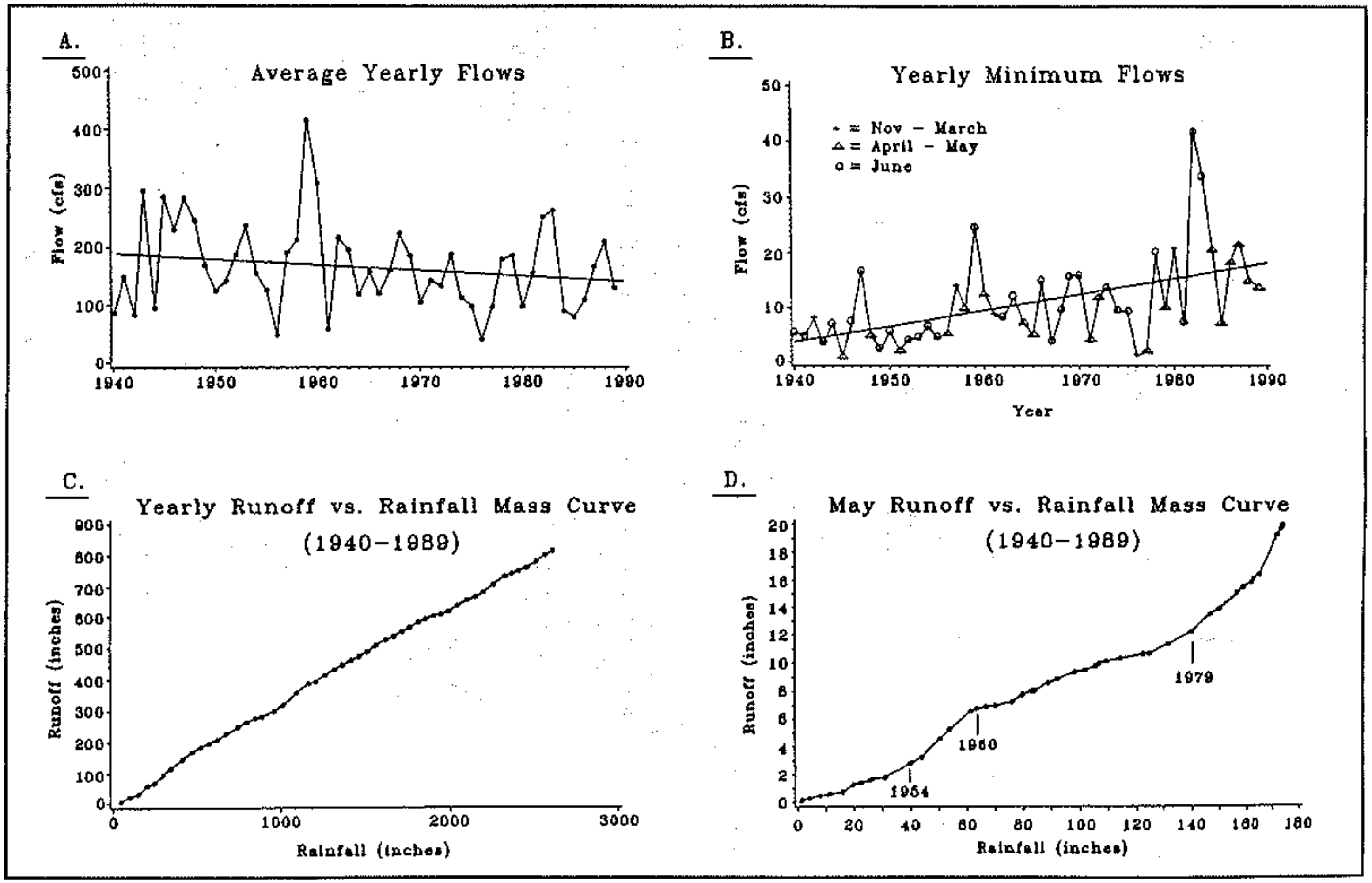

Figure 5. Plots of average yearly flows (A) and yearly minimum flows (B) versus year and double mass curves of cumulative rainfall versus cumulative runoff for yearly totals (C) and totals for May (D) for the period 1940 to 1989.

To further examine possible changes in seasonal levels of streamflow, average monthly flows for the pre-1976 and post-1976 periods were compared (Figure 6). The year 1976 was chosen as a division point since yearly minimum flows indicated a significant increase in values around that time. 1976 was not included in either of these two periods because large non-metered withdrawals from the river by Florida Power and Light Corporation occurred during that year. A comparison of the average monthly flows for the pre-1976 and post-1976 periods (Figures 6A and 6B) shows that flows in April and May increased while flows in the summer and fall (June through October) decreased between the two periods. The decreases in summer and fall streamflow were attributable to corresponding decreases in rainfall (Figure 6C). Increases in streamflow for April and May, however, were not accompanied by similar increases in rainfall. April flows increased by 23% between the two periods despite a 33% decrease in rainfall. In May, streamflow increased by 170% while rainfall increased by only 24%. Other months which showed opposite trends for rainfall and streamflow between the two periods were December and February.

From field observations made during the study it appears that much of the streamflow supplementation of the river comes from agricultural irrigation runoff. These observations are supported by a comparison of net runoff from the seven subbasins monitored during the study. In Figure 7, a smoothed daily hydrograph is shown for runoff from the Carlton Branch and Ft. Lonesome subbasins. The Carlton Branch subbasin contained 57% of its area in citrus and row crops while these land uses comprised only 9.2% of the land in the Ft. Lonesome subbasin. Figure 7 compares the runoff from each gaged area in units of inches to adjust for differences in basin areas. Runoff from the two subbasins exhibited similar temporal patterns, but during the drier months of April through June and October through December, Carlton Branch exhibited higher runoff than Ft. Lonesome. These months correspond to periods of significant irrigation for citrus and vegetable crops. Consequently, the higher runoff rates for Carlton Branch are attributed to either direct irrigation contributions to baseflow or indirect effects which increase the runoff potential of the area.

Yearly runoff rates for the six subbasins from which streamflow was directly monitored during 1988 are listed along with average yearly flows (cfs) in Table 3. The highest runoff rates were observed for the Carlton Branch, Cypress and Dug Creek subbasins (23.2" to 27.0" per year), which have the highest permitted agricultural water use per unit area. The yearly runoff rates for the remaining stations ranged from 21.2" to 21.6". Yearly precipitation totals for the seven rainfall stations monitored during 1988 did not show any spatial pattern that would explain these differences in runoff. The average rate of basin runoff for fifty years of record at the Little Manatee River near Wimauma gage is 15.4" per year. The high rates of runoff observed for all the stations during 1988 were due to the effects of a flood in September 1988, which corresponded to between a one-in-10 and one-in-25 year event.

Water Quality

The water quality results presented below are largely restricted to the biweekly monitoring data collected by the SWFWMD during the first year of study. This is done because of the balanced sampling design and consistency of analytical techniques employed for the seven subbasin sites. For some parameters, however, data available from other sources (USGS, HCEPC) are used to support observed trends. The following discussion characterizes water quality in the Little Manatee River watershed by first examining differences in mean concentrations for the seven monitored stations, and then contrasting water quality at these sites during periods of low flow and storm runoff. Mean values for water quality parameters at each station are listed in Table 4.

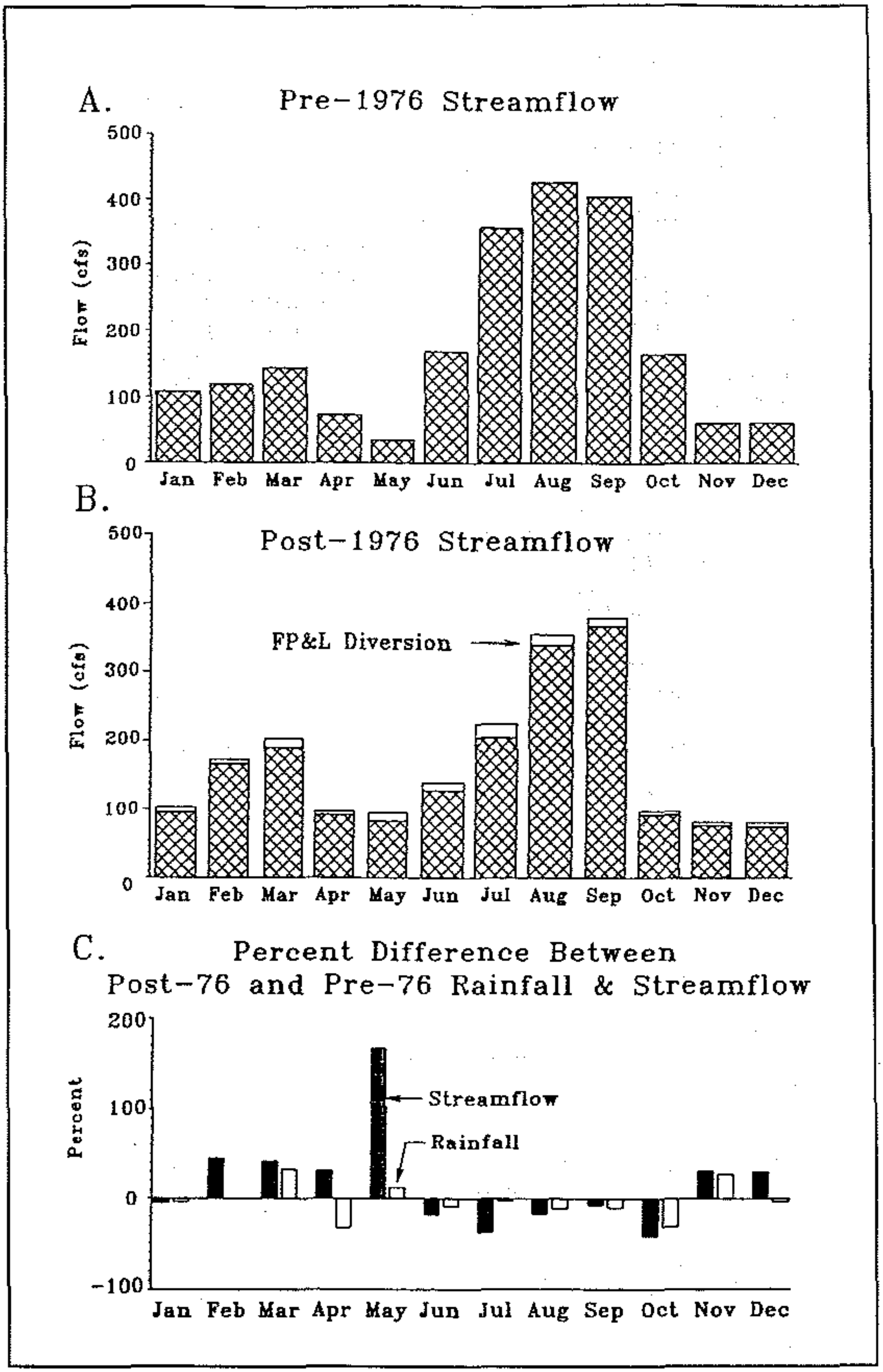

Figure 6. Pre-1976 and post-1976 average monthly flows for the Little Manatee River near Wimauma and percentage changes in monthly rainfall and streamflow between these two periods.

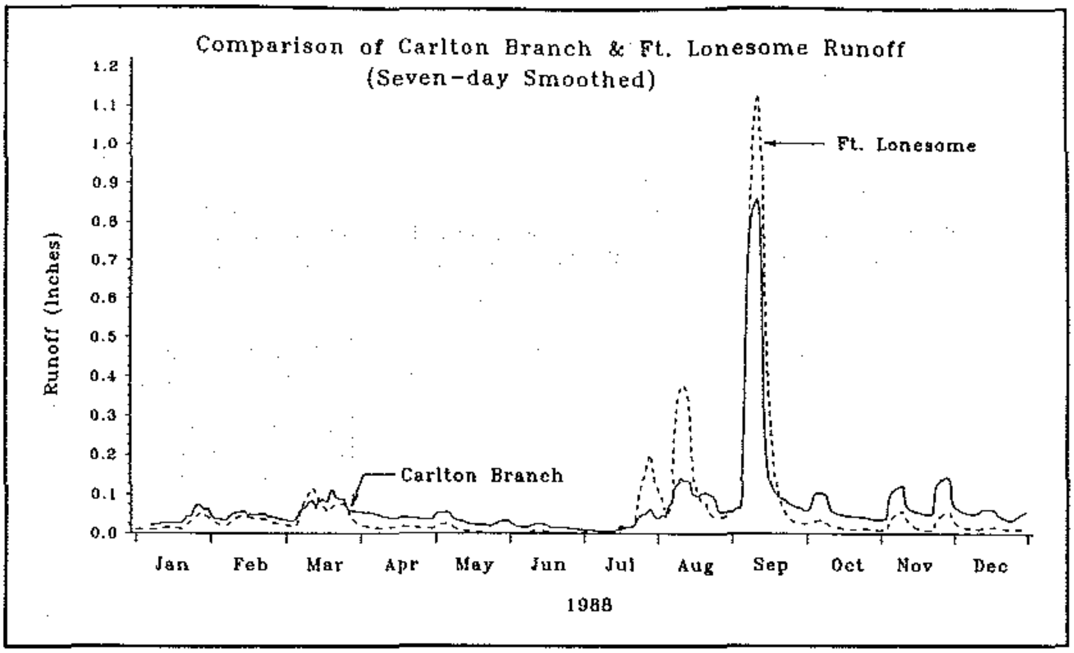

Figure 7. Smoothed hydrograph (seven-day moving average) for runoff in inches for the Carlton Branch and Ft. Lonesome subbasins during 1988.

Table 3. Yearly runoff and average streamflow rates for six subbasins monitored during 1988.

	LMR* NEAR WIMAUMA	FT. LONESOME	SOUTH FORK	CYPRESS CREEK	DUG CREEK	CARLTON BRANCH
Runoff (inches/year)	21.2	21.6	21.5	27.0	23.2	24.8
Streamflow (cfs)	220.9	46.6	61.4	15.7	5.5	15.3

*FP&L withdrawals included.

In order to compare the similarities of water quality at the seven monitored sites, cluster analysis (average linkage method, SAS 1989) was performed on mean values for nine of the parameters listed in Table 4. A dendrogram illustrating the results of this analysis is shown in Figure 8. The horizontal axis of the figure represents the degree of similarity between clusters, with groupings toward the right having increased similarity. To better illustrate spatial trends in the watershed, mean water quality values for the seven stations are discussed in groupings corresponding to the results of the cluster analysis.

Ft. Lonesome and South Fork

Of particular interest are the data for the LMR near Ft. Lonesome station. Mean values for sulfate, total suspended solids, and particulate phosphorus were all significantly less for this station compared to all other sites (Tukey's studentized range test, α=.05). The lowest mean values for specific conductance, nitrate-nitrite, turbidity, pH, and particulate carbon and nitrogen were also observed for the Ft. Lonesome station, with all but pH and turbidity being significantly different from four or five of the other sites. Conversely, mean concentrations of color and dissolved organic carbon were highest at this station.

Table 4. Water quality values for the first study year at the seven stations shown in Figure 2. Value on the first row for each station is the mean for 26 biweekly samples. On the second row from left to right are the averages for five low-flow and five high-flow events among the biweekly samples. Value on the bottom row for four stations is the average from three high-flow and two additional storm samples. Positive or negative sign indicates that parameter concentrations were significantly (α=.05) correlated with flow, with an r value either less than or greater than zero. All values expressed as mg/l except pH or as noted.

	LMR NEAR WIMAUMA	LMR NORTH FORK	LMR FT. LONESOME	SOUTH FORK	CYPRESS CREEK	DUG CREEK	CARLTON BRANCH
pH	6.5 (-) 7.1 6.1 6.4	6.4 (-) 7.3 5.8	6.2 (-) 7.3 5.7 5.8	6.3 (-) 6.8 5.8	6.4 6.5 6.2 6.4	6.8 6.9 6.6	6.7 (-) 7.2 6.2 6.2
Turbidity (NTU)	4.5 (+) 1.3 9.9 43.2	4.3 (+) 1.7 7.2	2.3 (+) 1.3 4.4 9.3	3.2 (+) 1.9 6.9	7.1 6.3 7.5 13.9	5.6 (+) 2.1 14.2	3.7 (+) 2.8 7.4 14.8
Color (PCU)	113 (+) 35 253 189	120 (+) 39 270	142 (+) 69 293 250	117 (+) 37 281	78 (+) 41 92 75	39 (+) 16 71	38 (+) 14.1 83 99
Specific Conductance (umhos/cm)	271 (-) 369 156 267	287 (-) 410 143	154 (-) 198 117 128	204 (-) 297 145	430 (-) 499 386 393	528 (-) 699 400	322 (-) 324 288 299
Ammonia-N	.08 .06 .12 .18	.07 .05 .14	.06 .02 .17 .12	.07 .06 .15	.24 (-) .40 .14 .19	.10 .05 .15	.08 .04 .25 .20
Nitrate/ Nitrite-N	.55 .32 .41 .70	.60 .27 .37	.19 (-) .24 .11 .23	.53 (-) .49 .17	.39 (-) .74 .12 .14	1.1 1.4 .86	1.7 1.2 1.8 2.1
Particulate Nitrogen	.05 (+) .01 .12 .60	.08 (+) .10 .09	.03 .04 .08 .10	.04 (+) .02 .09	.11 (+) .06 .16 .27	.11 (+) .05 .22	.08 (+) .07 .17 .16
Ortho-phosphorus	.34 (+) .24 .52 .53	.37 (+) .27 .55	.37 (+) .30 .53 .42	.27 (+) .20 .42	.04 (+) .02 .03 .03	.10 (+) .07 .24	.27 (+) .18 .38 .49
Particulate phosphorus	.03 .02 .05 .29	.04 .02 .04	.01 .01 .02 .10	.03 (+) .02 .05	.07 .02 .06 .25	.04 (+) .03 .07	.03 (+) .03 .05 .10
Total Suspended Solids	5.2 (+) 1.6 9.9 44.3	7.0 (+) 2.6 8.6	2.0 (+) 1.6 2.8 5.2	4.1 (+) 2.1 8.3	8.6 (+) 5.1 11.2 23	6.2 (+) 3.4 13.1	5.8 (+) 5.1 8.6 10.7
Dissolved organic carbon	15.3 (+) 11.8 21.2 16.4	14.4 (+) 11.4 21.3	18.2 (+) 14.9 23.0 19.0	13.6 (+) 9.0 18.4	16.2 (+) 18.0 16.2 13.8	10.5 (+) 11.6 13.4	8.7 (+) 8.2 12.0 13.8
Particulate carbon	.80 (+) .24 1.8 8.7	.93 (+) .43 1.32	.45 (+) .28 .88 1.4	.74 (+) .43 1.4	1.13 (+) .62 1.6 2.9	1.23 (+) .61 3.0	1.15 (+) 1.3 1.8 2.6
Sulfate	60 (-) 99 18 29	64 (-) 105 12	16 (-) 33 9.6 14	38 (-) 91 5	93 (-) 124 76 57	168 233 146	56 64 47 28
Silicon	6.0 (-) 9.0 3.7 3.3	6.4 (-) 10.5 3.4	4.5 (-) 6.6 3.3 2.7	6.4 (-) 10.6 3.8	3.9 (-) 6.0 2.6 1.9	7.4 (-) 13.6 3.9	7.0 (-) 10.5 4.9 3.7
Chlorophyll a (mg/m³)	2.6 2.9 6.0	2.9 4.8 2.7		1.3 2.1 1.6			

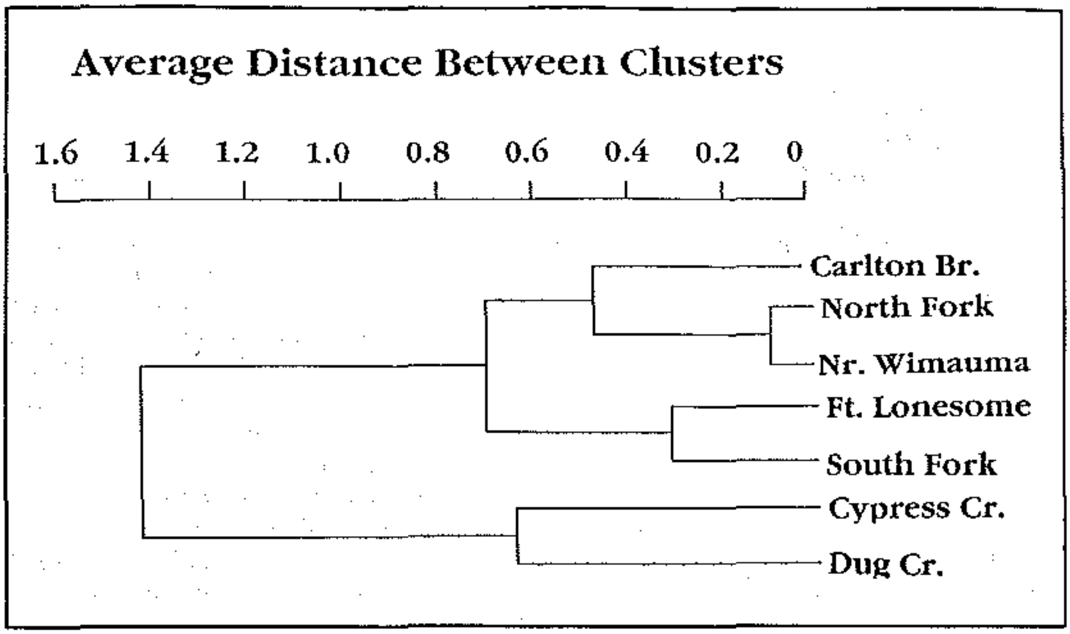

Figure 8. Cluster dendrogram for the seven stations based on mean values of nine water quality parameters. Clusters joined toward the right have greater similarity.

Although water quality at the Ft. Lonesome station has been impacted to some degree, during our study this site best represented the water quality of a natural stream in the basin and can be viewed somewhat as a control site. Over 50% of the land use in the subbasin is improved or unimproved pasture. There is virtually no urban development in the subbasin and citrus and row crops combined are only about 9% of the land area. Much of the land in this subbasin is owned by IMC Fertilizer Inc., and by 1988 approximately 5.8% of the subbasin had been mined for phosphate. This mine was inactive from 1986 through 1988, and average monthly discharges from the one permitted NPDES site were generally small (0.5 to 2.2 cfs) during the study. Larger wet season releases occurred in August and September 1988, when average monthly discharges were 4.8 and 11.3 cfs, respectively. Mining resumed in the subbasin in 1989, and it is emphasized the data presented in this report for the Ft. Lonesome station do not represent any potential influences of recent discharges. The IMC Corporation is currently in the Development of Regional Impact review process for plans to mine substantially more of their land holdings in the Ft. Lonesome area in the next thirty years.

The station that exhibited the greatest similarity to the Ft. Lonesome was the South Fork. Next to Ft. Lonesome, this station had the second lowest mean values for turbidity, specific conductance, sulfate, suspended solids, and particulate nitrogen and carbon. For most land use categories, this subbasin had similar percentage breakdowns as the Ft. Lonesome subbasin, except that it has very little mining and substantially more row crops (16.9% vs. 1.4%).

Cypress and Dug Creeks

Two other stations, Cypress and Dug Creeks, showed similarities distinctly apart from the other five monitored sites (Figure 8). These stations had significantly greater concentrations of specific conductance (430 and 528 µmhos/cm) and sulfate (93 and 168 mg/l) compared to other sites. As elaborated later, high concentrations of these parameters are indicative of pumped ground water entering the streams, primarily as irrigation runoff. The Cypress and Dug Creek stations also shared the characteristic of having significantly lower mean ortho-phosphorus values than the other sites. This was particularly the case for the Cypress Creek, where the mean value (0.04 mg/l) was less than the means of the five highest ranked stations by factors of about 7 to 9, and individual observations showed much reduced variation about the mean compared to other stations.

The Cypress and Dug Creek stations were also similar in that they had comparatively high values for turbidity, total suspended solids, and particulate nutrients. This was especially true for Cypress Creek, which had relatively high turbidity and suspended solids values even during periods of low flow (see low-flow averages in Table 4). The Cypress Creek station represented the only substantially urbanized subbasin in the study, with a combined urban-suburban coverage of 43.4%. During the study, extensive construction work was performed on State Road 674 upstream of the Cypress Creek station and this may have been related to the high turbidity and suspended solids observed at this site. Row crops also comprise a significant proportion (18.7%) of this subbasin, and combined agricultural and golf course irrigation caused this subbasin to have one of the highest rates of groundwater use per unit area (Table 1). The Dug Creek subbasin also contains a significant proportion (15%) of combined urban development, mostly as clustered houses and 34 hectares of golf course, but contains substantially more row crops (28.5%) and citrus (10.2%), which are probably the principal sources of groundwater inputs to this stream.

LMR Near Wimauma, North Fork and Carlton Branch

The remaining three stations were all in the central part of the watershed. The LMR near Wimauma and North Fork sites, along with Ft. Lonesome, are "in-line" stations along the main channel of the river. The Wimauma site represents drainage from 67% of the entire watershed and is the site most often referenced to describe net water quality in the Little Manatee River. The North Fork site, in turn, contributes 35% of the drainage measured at the Wimauma gage. Not surprisingly, water quality at these two stations showed a high degree of similarity and mean concentrations for most parameters were very close.

It is interesting to note that the Ft. Lonesome station was more closely allied to the South Fork than to the immediately downstream North Fork station, and mean values for all parameters except color, ammonia and ortho-phosphorus were significantly different between the Ft. Lonesome and the North Fork sites. These differences were particularly large for nitrate-nitrite, sulfate and particulate nutrients, for which mean values were about 2 to 4 times higher at the North Fork site. This dramatic change in water quality between these two stations reflects the intense agricultural land use in the drainage area between them, much of which occurs in close proximity to natural or man-made drainage channels. An exception to this pattern was ortho-phosphorus, which had similar mean values for the Ft. Lonesome, North Fork and Wimauma sites.

The remaining station, Carlton Branch, was also located upstream of the North Fork site. Mean water quality values indicate that Carlton Branch receives substantial amounts of pumped ground water, as evidenced by high concentrations of specific conductance and sulfate and low concentrations of color. The most distinctive result from Carlton Branch is the high mean nitrate-nitrite concentration (1.7 mg/l), which was significantly greater than for all other stations except Dug Creek. Along with Dug Creek and the North Fork subbasins, Carlton Branch has high percentages of land use in croplands, and by far the highest percentage in citrus production.

Dry Season Characteristics

In addition to mean water quality values (n=26), Table 4 lists average values calculated from five low-flow and five high-flow events at the seven monitored stations. Also shown is a symbol indicating whether the concentration of each parameter was significantly positively or negatively correlated with flow. In general, water quality during low-flow periods was characterized by reduced concentrations of turbidity, ortho-phosphorus and particulate materials, slightly higher pH, and increased concentrations of sulfate, silicon and specific conductance. Color and dissolved organic carbon concentrations were generally near minimum values in the low-flow samples, presumably due to reduced drainage through humus containing soils and vegetation.

It is interesting to note that at the three stations where it was measured, average chlorophyll *a* concentrations were relatively low (2.1 to 4.8 mg/m^3) for the low-flow samples. The 4.8 mg/m^3 average for the North Fork site was influenced by one reading of 10.2 mg/m^3, as values from the other four dates ranged from 2.0 to 4.9 mg/m^3. Based on the one year of data, it appears that algal blooms are uncommon in the nontidal portions of the Little Manatee River, despite the occurrence of abundant nutrients. This is probably due in part to short residence times in the river, for even during low flows the elevational gradient of the channel maintains significant downstream currents. Using average channel velocity data available from USGS streamflow rating measurements, we estimate that transport times from the headwaters to the estuary are no more than three to four days during low flows.

In order to more widely characterize dry season water quality in the watershed, two additional sampling trips were performed in May 1988 and May 1990, during which a total of 21 stations were sampled (Figure 9). For most parameters, concentrations at the stations were similar between the two dates, verifying the spatial trends observed. Average specific conductance values calculated for these two dates showed large variation between tributaries to the North Fork of the river. Values upstream of Carlton Branch were comparatively low, ranging from 190 to 306 µmhos/cm. Four stations in Carlton Branch showed progressively increasing values along the length of the Branch, increasing from 185 µmhos/cm in the upstream reaches to 411 µmhos/cm near the confluence with the river. Highly mineralized waters were observed on three downstream tributaries to the North Fork, with average conductance values exceeding 800 µmhos/cm at these sites. Correspondingly, average conductance values in the North Fork progressively increased downstream, from 222 µmhos/cm at the Ft. Lonesome station to 595 µmhos/cm near the confluence with the South Fork. The South Fork of the river, which had only two accessible sampling sites, similarly showed increased concentrations progressing downstream, but was generally less mineralized than the North Fork as shown by its lower average value (380 µmhos/cm) near the confluence.

Sulfate concentrations for the two May sampling trips showed the same spatial pattern observed for specific conductance, and concentrations of these two parameters were highly correlated (r=.93) throughout the study. Data from headwater reaches in this study and historic values from the USGS indicate that specific conductance values for natural surface waters in the region during the dry season are well under 200 µmhos/cm. Conversely, specific conductance values for wells tapping the Floridan aquifer in the region are typically in the range of 300 to 1,300 µmhos/cm, with sulfate values ranging from less than 20 to over 400 mg/l (USGS 1990). Because of the heavy agricultural water use in the region, it is reasonable to conclude that high instream concentrations of these parameters are indicative of mineralized water from the Floridan aquifer reaching these streams via groundwater pumping. Mineralization of the aquifer increases with depth and proximity to the coast; therefore, the spatial patterns shown in Figure 9 are not entirely indicative of relative amounts of groundwater supplementation since the contributing well waters may have very different mineral concentrations.

Response of Water Quality to Increased Streamflow

The response of various water quality parameters to increased flow was examined through Pearson product-moment correlation analysis of instream concentrations and same-day average flows at the seven sites (Table 4). Additional water samples were taken at four stations (LMR near Wimauma, Ft. Lonesome, Cypress Creek and Carlton Branch) during two storm events during the study. Along with three dates from the regular biweekly sampling, a total of five sampling trips occurred on the rising limb of storm hydrographs at these four stations. Average values calculated for these five storm events at the four stations are listed separately in Table 4, along with averages calculated from a total of five high-flow events for the regular biweekly sampling at all stations (three dates are shared between the high flow and storm averages).

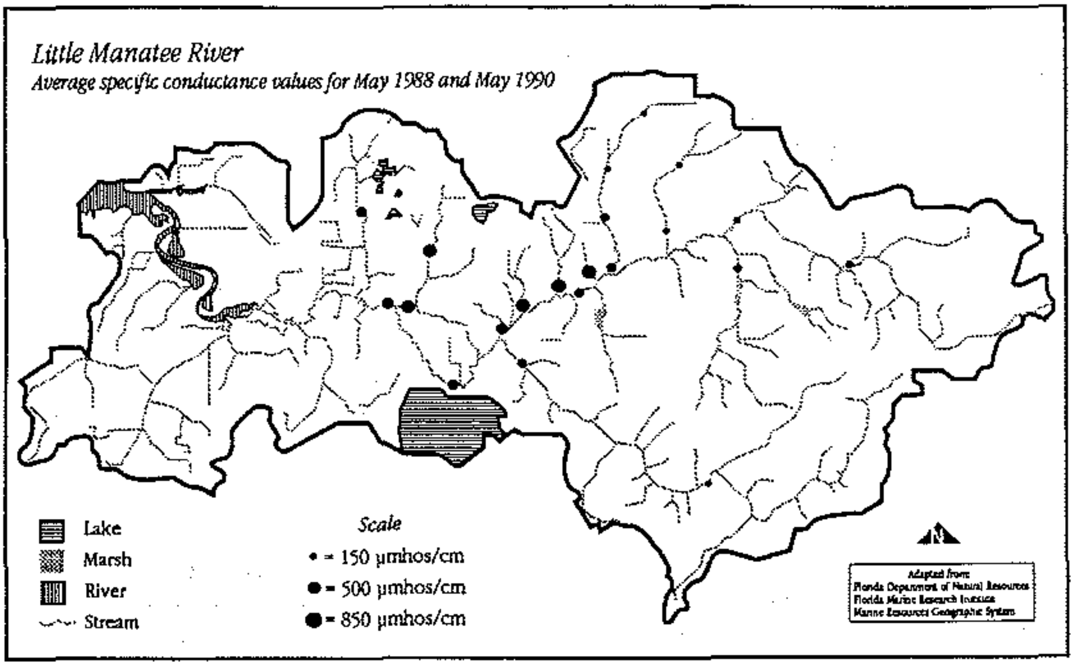

Figure 9. Average specific conductance values for 21 stations sampled during May 1988 and May 1990.

As expected, concentrations of turbidity and particulate materials were positively correlated (α=.05) with flow at most stations. Turbidity was highly correlated with flow at all sites except Cypress Creek, where the relationship was not significant, and average turbidity values were relatively high (6.3 NTU) during low-flow periods. Total suspended solids and particulate carbon and nitrogen were positively correlated with flow at all sites, with the exception of particulate nitrogen at Ft. Lonesome. Interestingly, particulate phosphorus was significantly correlated with flow at only three of the sites, where the corresponding correlation coefficients were less than for the other particulate nutrients.

Although turbidity, suspended solids, and particulate carbon and nitrogen were positively related to flow at most sites, the magnitude of the response of these variables to flow showed large variation throughout the watershed. Average concentrations of suspended solids at Ft. Lonesome for five regular high-flow events were less than the high-flow averages for the other stations by factors of 3.0 to 4.7. Averages for turbidity and particulate nutrients were also lowest at this station. The highest concentrations of turbidity and suspended materials were observed for Dug Creek, followed by Cypress Creek or the LMR near Wimauma site. Dug Creek was not sampled on the extra storm sampling trips, but the storm sample averages listed in Table 4 for Cypress Creek and LMR-Wimauma show very high turbidity and particulate concentrations, especially for the LMR-Wimauma station. Storm averages for turbidity and suspended solids at LMR-Wimauma were 43 NTU and 44 mg/l, respectively, or about 2 to 4 times the averages for Cypress Creek and Carlton Branch, and more than 4 and 8 times the storm averages for turbidity and suspended solids, respectively, at Ft. Lonesome. Comparison of the data from the Ft. Lonesome and LMR-Wimauma sites indicates that land use alterations between these locations have had substantial impact on the loadings of particulate materials to the river system.

Compared to particulate materials, the response of dissolved constituents to streamflow was more varied. Significant negative correlations with flow were observed for sulfate, silicon and specific conductance at all sites, with the exception of sulfate at Dug Creek and Carlton Branch. The reduction of these parameters with increasing flow reflects the reduced proportion of ground water in these streams during periods of increased storm runoff. Ammonia concentrations showed no general pattern, being unrelated to flow at four of the stations, negatively correlated with flow at Cypress Creek, and demonstrating a positive trend at Carlton Branch (α=.06). Ortho-phosphorus did show a consistent trend being positively correlated with flow at all stations.

Nitrate-nitrite concentrations were negatively correlated with flow at three stations and a nonsignificant negative trend with a lower confidence level (α=.08) was observed at Dug Creek. One exception to this pattern was Carlton Branch, where nitrate-nitrite concentrations showed little relationship to flow (r=.02) and high concentrations (>2.0 mg/l) occurred during both high and low flows. For the other stations, plots of nitrate-nitrite concentrations versus flow showed two general types of patterns. For better illustration, and because the 1988 and the combined data sets show consistent relationships, nitrate-nitrite values from the combined SWFWMD-USGS-HCEPC data for the LMR-Wimauma and Ft. Lonesome stations are plotted versus flow in Figure 10. The flow ranges shown for the stations are those flows which were exceeded 10% of the time for the period of the data shown (1982 to 1990). Older nitrate-nitrite values were not used because there has been a significant increase in this parameter over time at the LMR-Wimauma station.

The first thing apparent from Figure 10 is that nitrate-nitrite concentrations at the Wimauma station fluctuate over a much wider range, as only one value from the Ft. Lonesome site exceeded 0.5 mg/l, whereas 56% of the observations from the LMR-Wimauma site exceeded that amount. Second, the basic shapes of the two curves are different; nitrate-nitrite concentrations decreased rapidly with flow below 20 cfs at Ft. Lonesome and remained below 0.2 mg/l at higher flows. There was much more scatter in this relationship at the LMR-Wimauma site, with concentrations above 0.5 mg/l continuing to occur at higher flows and a significant negative correlation was not found with flow. The difference in these two plots indicates that storm runoff in the Ft. Lonesome catchment carries much less nitrate-nitrite than does runoff from areas farther downstream. It is possible that this downstream enrichment occurs in both the surface drainage and the interflow components of the storm hydrograph, but the relative magnitude of these components is not known. It does seem likely that crop fertilization in the basin could enrich nutrient concentrations in the surficial aquifer, potentially increasing instream concentrations via ground-water interflow where agricultural lands are near water table gradients toward stream channels.

Nutrient Loading Rates

The collection of streamflow and water quality data allowed for the computation of nutrient loading rates for the seven subbasins. Yearly flux rates (kilograms per hectare per year) for seven dissolved and particulate constituents from the monitored subbasins during the first study year are listed in Table 5. The flux rates listed for the LMR-Wimauma and the North Fork stations include all areas upstream of those gages. The total areas used for computation of flux rates from those subbasins are as follows from Table 1: North Fork = subbasins 3+4+8; LMR-Wimauma = subbasins 2+3+4+5+7+8. As such, the LMR-Wimauma gage integrates loadings from 67% of the watershed. Cypress Creek represents loading from another 3.6%, so loading from 30.4% of lower river basin was not measured by this study.

Similar to the results for instream concentrations, flux rates for all constituents except dissolved organic carbon and ortho-phosphorus were lowest from the Ft. Lonesome subbasin. The ratio of yearly fluxes of dissolved inorganic nitrogen (ammonia plus nitrate-nitrite) to ortho-phosphorus from the Ft. Lonesome subbasin was 0.34, which is unusually low. This was due to the high ortho-phosphorus concentrations in the stream and the opposite correlative relationship of nitrate-nitrite (negative) and phosphorus concentrations (positive) to flow. Ortho-phosphorus flux rates were similar (2.36 to 2.63 kg/ha/yr) to Ft. Lonesome at three other stations (LMR-Wimauma, North Fork, Carlton Branch), but markedly lower at Cypress and Dug Creeks (0.31 and 0.82 kg/ha/yr).

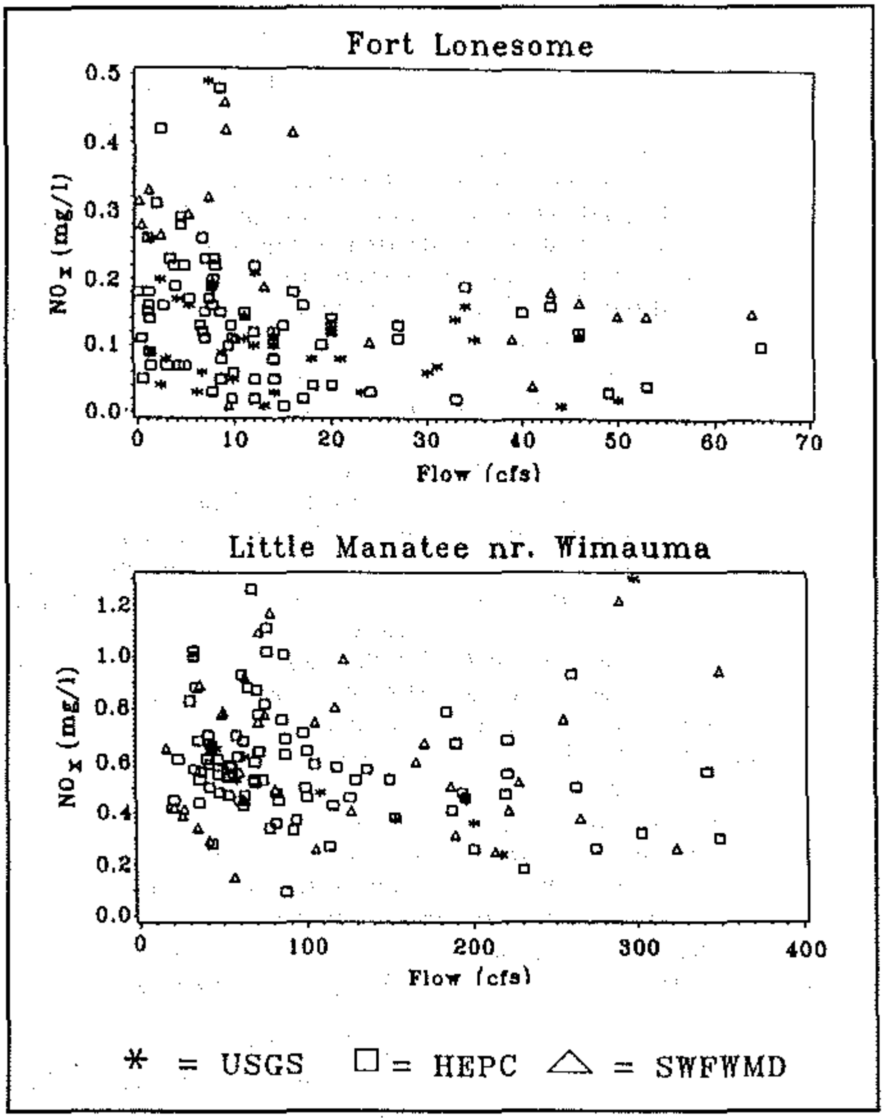

Figure 10. Concentrations of nitrate-nitrite versus streamflow for the Ft. Lonesome and Little Manatee River near Wimauma monitoring stations for 1982 to 1990. Maximum flows shown correspond to the 10% exceedance flow at each station for that period. One outlier for Ft. Lonesome not shown (flow=5.7 cfs, NO_x=0.78 mg/l).

Dissolved inorganic nitrogen (DIN) fluxes were more than twice as high for Carlton Branch than for all other subbasins, and an order of magnitude higher than at Ft. Lonesome. The Dug Creek subbasin, which like Carlton Branch has a high percentage of agricultural land use, had the second highest flux rate for DIN (3.51 kg/ha/yr). The DIN flux for the downstream LMR-Wimauma site was 2.56 kg/ha/yr, and the ratio of DIN and ortho-phosphorus fluxes at this station was approximately one. Readers are reminded these N/P flux ratios do not include particulate nutrients or dissolved organic nitrogen. Dissolved organic nitrogen is less available for plant growth and was not measured in our study. Inclusion of this constituent would increase reported N/P concentration and flux ratios.

Table 5. Yearly material fluxes (kilograms per hectare per year) for the seven monitored subbasins shown in Figure 2. Values expressed for the LMR-Wimauma and North Fork were calculated using the entire drainage areas upstream of those gages.

	LMR NEAR WIMAUMA	LMR NORTH FORK	LMR FT. LONESOME	SOUTH FORK	CYPRESS CREEK	DUG CREEK	CARLTON BRANCH
Dissolved inorganic nitrogen (NH_4+NO_x)	2.56	2.47	0.81	1.78	1.72	3.51	8.96
Particulate nitrogen	0.76	0.53	0.11	0.46	1.10	1.12	0.58
Ortho-phosphorus	2.43	2.63	2.38	2.23	0.31	0.82	2.36
Particulate phosphorus	0.17	0.18	0.08	0.18	0.33	0.39	0.43
Total suspended solids	60.91	62.55	12.82	40.78	79.80	67.40	55.66
Dissolved organic carbon	114.1	118.3	128.9	106.4	124.3	77.6	66.6
Particulate carbon	10.48	8.54	2.95	7.22	10.79	12.63	9.16

The flux rates for particulate materials were highest at the Cypress and Dug Creek stations. In general, differences in particulate flux rates for the seven subbasins were generally less than the range of fluxes observed for dissolved constituents. With the exception of Ft. Lonesome, the highest and lowest flux rates for total suspended solids and particulate nitrogen differed by factors of 1.9 and 2.4, respectively, while the high and low fluxes for DIN and ortho-phosphorus differed by factors of 5.0 and 8.5. Again, the Ft. Lonesome subbasin had flux rates for particulate materials that were markedly lower than the other stations. This was particularly true for total suspended solids and particulate nitrogen, for which fluxes at Ft. Lonesome were about three to four times less than the next lowest subbasin (South Fork), and about five to seven times lower than the net basin flux expressed at the LMR-Wimauma site.

In addition to yearly nutrient flux rates, a few points regarding seasonal nutrient loadings are noteworthy. First, the supplementation of flows by irrigation runoff resulted in very large differences in nutrient loadings between subbasins in the dry season. For example, the computed DIN flux from the Carlton Branch during May 1988 was 35 times higher than the same monthly flux from the Ft. Lonesome subbasin. Second, loading to the estuary is very seasonal, and can be strongly influenced by large storms. In Figure 11, the monthly loadings of DIN and ortho-phosphorus during 1988 are plotted for the sum of the Cypress Creek and the LMR-Wimauma subbasins, or about 70% of the entire watershed. The vertical bar representing the loadings in September has a broken scale to show the effect of a flood event which occurred that month. That flood, which was caused by an average of 9.6" of rain in the basin over four days, raised the peak-day flow to 9,720 cfs at the LMR-Wimauma site, corresponding to between a one-in-10 and one-in-25 year event. Due in large part to this flood, September loadings represented 39% and 58% of the yearly loads of DIN and ortho-phosphorus, respectively.

To indicate seasonal nutrient loading in a more typical year, we adjusted the streamflow records by holding the maximum daily flows observed in September to the maximum daily levels observed in August. This involved changing flows for six days at the LMR-Wimauma and Cypress Creek stations, reducing the peak flow in September to a level that on the average is exceeded about three days in that month. The adjusted September load is indicated by the tops of the shaded bars in Figure 11. This adjustment probably better represents the typical seasonal pattern of loading for these constituents. Although the majority of nutrients continue to be delivered in the late summer, a secondary peak occurs in March, which might have an important role in stimulating primary productivity in the estuary during the spring.

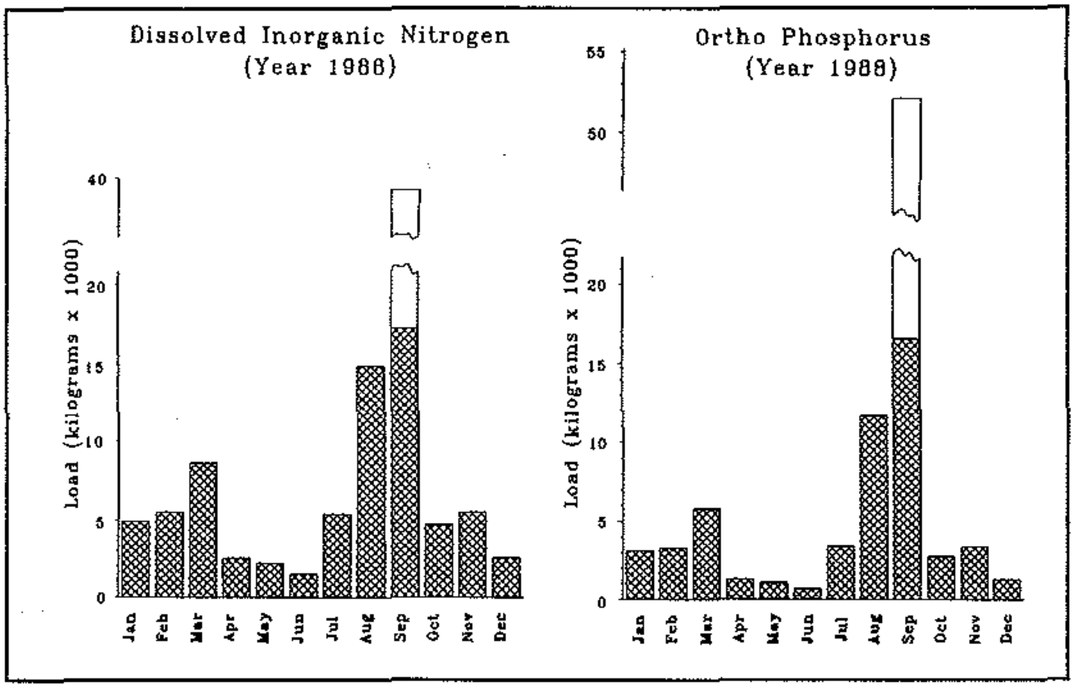

Figure 11. Monthly loadings of dissolved inorganic nitrogen and ortho-phosphorus for the sum of the Cypress Creek and LMR-Wimauma subbasins during 1988. Top of clear bar for September indicates actual load, whereas top of shaded bar indicates loading if combined peak September flows held to peak flows observed in August (1166 cfs).

Finally, it is apparent from Figure 11 that the occurrence of the September flood strongly affected the yearly nutrient fluxes expressed in Table 5. We recalculated total yearly loadings using the adjusted streamflow data and found that the four day flood event accounted for 39%, 22%, and 54% of the total yearly loadings for ortho-phosphorus, DIN, and dissolved organic carbon, respectively. The reason for the high percentage reduction of dissolved organic carbon was that concentrations were highly correlated with flow, so calculated loadings were especially high during the flood. Therefore, it is emphasized that the yearly flux rates listed in Table 5 be used primarily to compare stations within the watershed, and be used with caution if compared to values from other basins.

Long-Term Trends: Other Data Sources

Long-term water quality data from other sources were reviewed to see if temporal trends in water quality mimic the spatial variations we observed between subbasins during 1988. Water quality data for a few parameters are available back to the 1950s from the USGS, and fairly extensive data sets are available back to the mid-1970s when the Hillsborough County Environmental Protection Commission began sampling programs in the region. Data were retrieved from these two sources and merged with the SWFWMD data to create a combined data set for the basin. For constituents that were measured by different labs and expressed in the same units, these values were combined as a single variable. We have not as yet closely checked the methods used by the different labs, but intend to do so to the degree possible. For some parameters, such as specific conductance, there is good confidence that the data are comparable. For some nutrient parameters, such as nitrate-nitrite, very old data may be of questionable resolution, but data for the last 10 to 15 years should be comparable. Kendall tau-b nonparametric correlation analysis was performed to test for significant relationships of constituent concentrations with time (date). Where trends are reported in the following discussion, at least 150 observations were analyzed over periods of ten years or greater. Since the simple Kendall tau-b test does not account for possible seasonality or serial correlation within the data, reported trends are presented as preliminary, and we are currently developing programs to perform the more rigorous seasonal Kendall test (Hirsh and Slack 1984).

The two stations with the most long-term water quality data are the LMR-Wimauma and Ft. Lonesome, which currently have very different water quality characteristics. At the Ft. Lonesome site, Kendall tau-b tests indicated there were significant (α=.05) increasing trends for specific conductance, pH, turbidity and sulfate. For conductance and sulfate, plots of the data versus time showed a rise in the values around 1985 and a stable trend thereafter. Means calculated for the pre-1985 and post-1984 periods for specific conductance rose from 125 to 191 µmhos/cm, for sulfate from 18.3 to 44.0 mg/l, and for pH from 6.5 to 6.9 units. Based on a considerable number of observations, there were no significant trends for total suspended solids or nitrate-nitrite.

Much stronger trends were observed for the LMR near Wimauma station. Specific conductance showed an increasing trend over time with sharp increases in concentrations since the mid-1970s (Figure 12A). Because specific conductance is a very easy and reliable measurement to perform, there should be good confidence in these data. The degree of enrichment since the early 1970s is substantial; the average value for the last three years (n=70) is 320 µmhos/cm compared to average value of 83 µmhos/cm for the period 1955 to 1972 (n=131). Although not shown here, the plot for sulfate showed a similar trend with mean values of 7.8 and 124 mg/l for the pre-1973 and post-1987 periods, respectively. We expect the barium chloride turbidimetric technique was used for the early sulfate measurements and have little reason to doubt those data are reliable. The data indicate that the Little Manatee River has become much more mineralized in the last two decades. As previously discussed, we expect that increased groundwater pumping and irrigation runoff are the primary reasons for the increased mineralization of the river.

Significant trends for increasing concentrations were also observed for turbidity, pH, and nitrate-nitrite. The Kendall tau-b coefficients for turbidity and pH were relatively low (.25 and .22), but plots showed a rise in pH values in the mid-1970s, similar to the pattern observed for conductance and sulfate. The average pH value for dates between 1955 and 1972 was 6.5 (n=104), whereas the average for dates after 1972 was 7.1. A very strong trend was observed for nitrate-nitrite (Figure 12B). The plot of nitrate-nitrite concentrations versus time shows an increasing trend began in the middle to late 1960s and has continued upward in a steady manner. There was no significant trend for ortho-phosphorus concentrations dating back to the 1960s, indicating that the basin is naturally high in phosphorus compounds.

Overall, observations of the long-term data at the LMR-Wimauma station are very striking. Assuming the data from the 1950s and early 1960s are reliable, the Little Manatee was a slightly acid stream with low specific conductance and inorganic nitrogen concentrations. Average values for specific conductance, sulfate, and nitrate-nitrite from the LMR-Wimauma station during early 1970s indicate that water quality there was similar to what is now observed at the Ft. Lonesome site. Independent measurements (pH, sulfate, nitrate-nitrite) show major changes in water quality began occurring in the basin in the 1970s. We have not examined old aerial photographs or other records to examine if dramatic changes in land or water use have occurred since that time. However, the temporal trends at the LMR-Wimauma station correspond to the spatial differences currently observed between highly developed and less impacted subbasins, indicating that intensifying land and water use have been the principal causative factors.

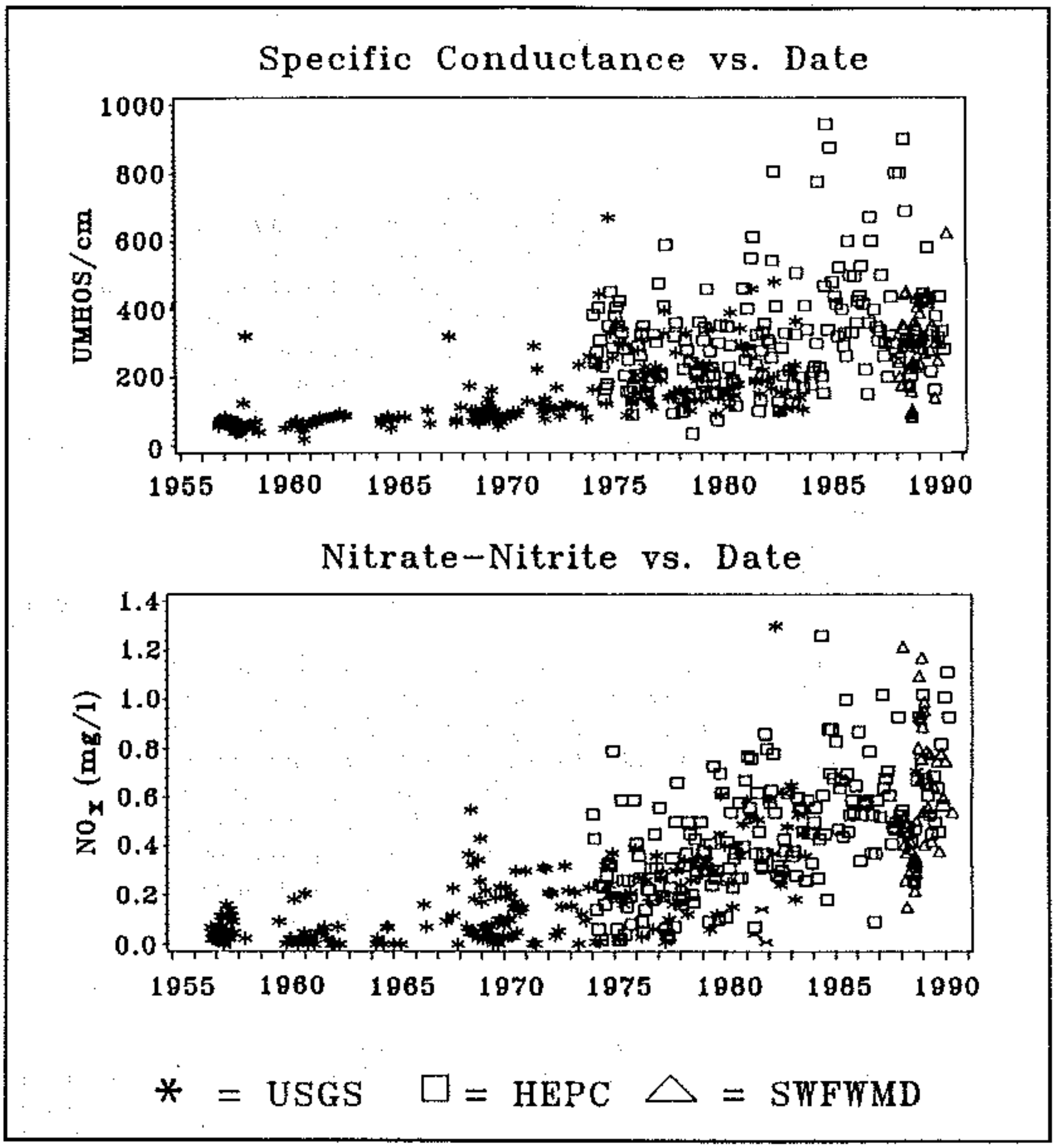

Figure 12. Specific conductance and nitrate-nitrite concentrations versus date for the Little Manatee River near Wimauma station. Symbol indicates source of the data.

Overview — Estuarine Considerations

The focus of this paper has been the freshwater reaches of the Little Manatee River, for much of our estuarine analyses are now in progress and will be published in early 1992 (SWFWMD and Dames & Moore, in prep.). At this time, however, some considerations regarding potential impacts to the estuary are apparent and are discussed below.

The popular perception that the Little Manatee River represents the healthiest river flowing to Tampa Bay is probably correct, but our study indicates there have been significant changes in the streamflow and water quality characteristics of the river in the last 20 years. The nitrate enrichment of the river has particular relevance to Tampa Bay, because phytoplankton production in the bay is nitrogen limited (Fanning and Bell 1985, Palmer and McClelland 1988). The relationships of nitrate-nitrite concentrations to streamflow shown in Figure 10 and the plot of nitrate-nitrite vs. time in Figure 12 indicate that nitrate concentrations in storm runoff have significantly increased due to changes in land use. The Little Manatee River represents approximately 10% of the entire drainage basin for Tampa Bay and contributes approximately the same percentage of tributary flow (Hutchinson, 1983; Flannery, 1989). Obviously, the observed increases for nitrate-nitrite concentrations in the river have important implications for the overall nitrogen budget of Tampa Bay.

The second general conclusion of this report pertains not to the open waters of Tampa Bay, but to the tidal river habitats upstream of the river mouth. Data from companion biological studies of the Little Manatee River (Peebles et al., Vargo et al., this volume) indicate that various estuarine zones along the freshwater to bay gradient differ significantly in their response and sensitivity to eutrophication. One interesting finding was the relative stability of chlorophyll concentrations and phytoplankton numbers near the mouth of the river compared to higher and more variable levels in the upper estuary. The reasons for these spatial patterns are unclear, but may involve differences in biological factors (zooplankton grazing or benthic filter feeding) or physical factors (tidal exchange near the mouth of the river) affecting phytoplankton abundance in these two environments. Algal blooms in the upper estuary were common in the spring and fall during times of low streamflow. Like Tampa Bay, phosphorus is present in excess throughout the riverine estuary and nitrogen appears to be the macronutrient controlling phytoplankton growth (Vargo et al., this volume). Although the effects of nitrogen enrichment in the river during times of low streamflow might be of minor importance to the yearly loading of nutrients to Tampa Bay, increased dry season loading could have important implications for maintaining high algal biomass in the upper estuary.

Field observations and water quality data indicate the upper estuary is rich in organic material in both dissolved and particulate forms (Peebles et al., this volume). Estuaries, because of rapidly changing water chemistry and occurrence of estuarine circulation, are known to accumulate fine-grained and organic materials in upper estuarine mixing zones (Postma 1967, Pritchard and Schubel 1981). Although historical data are scarce, comparison of the recent data from the seven monitored subbasins indicates that land use changes have increased the loading of particulate carbon and nitrogen to the estuary. Particulate organic materials serve as food sources in detrital food webs (Knox 1986), but in excess can lead to low dissolved oxygen concentrations depending on the oxidizable nature of the materials and the potential for high microbial respiration (Aston 1980, Kennish 1986).

Dissolved oxygen concentrations were measured throughout the length of Little Manatee River estuary during the two year estuarine study. During the summer months of July through September, mean water column dissolved oxygen concentrations averaged about 5.2 mg/l for stations near the mouth of the river, with percent saturation values averaging about 77%. Dissolved oxygen concentrations at stations in the middle and upper reaches (above mile 4) were considerably lower, with average concentrations between 3.4 and 4.2 mg/l and percent saturation values in the range of 47% to 56%. These values were all midafternoon readings, and dissolved oxygen concentrations may have been lower during late night or early morning hours. In highly colored Florida waters, and estuaries in general, naturally occurring processes or hydrographic factors can contribute to low dissolved oxygen concentrations

(Belanger et al. 1985, Tyler 1986). It is difficult to discern to what degree the relatively low dissolved oxygen concentrations in the Little Manatee estuary are the result of natural processes versus anthropogenic effects. It can be concluded, however, that summertime dissolved oxygen conditions are marginal with regard to a healthy aquatic system (Friedemann and Hand 1989, F.A.C. 1990), and any perturbations which further lower these concentrations could result in diminished biological diversity and productivity of the system.

In summation, this study emphasizes that estuarine relationships to the quantity and quality of freshwater flows should be examined not only in the open waters of the bay but also in the gradient of ecological zones upstream of tidal creek and river mouths. Because of the important role these areas play with regard to fisheries production, their proper management is of obvious importance. Potentially, these tidal creek/river habitats can be impacted by either point or nonpoint sources. Seasonal nutrient loadings that seem small compared to the overall nutrient budget of the bay may exert important effects in low salinity areas. Fortunately, the total drainage area of Tampa Bay is relatively small, about 2,184 mi^2 (5,650 km^2), and most of the tributary flow originates in one of three counties. Hopefully, the localized nature of tributary flows to Tampa Bay can allow for the development of effective nonpoint source control strategies through the cooperation of the public and private entities involved.

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A Percent-of-flow Approach for Managing Reductions of Freshwater Inflows from Unimpounded Rivers to Southwest Florida Estuaries

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ABSTRACT: The Southwest Florida Water Management District has implemented a management approach for unimpounded rivers that limits withdrawals to a percentage of streamflow at the time of withdrawal. The natural flow regime of the contributing river is considered to be the baseline for assessing the effects of withdrawals. Development of the percent-of-flow approach has emphasized the interaction of freshwater inflow with the overlap of stationary and dynamic habitat components in tidal river zones of larger estuarine systems. Since the responses of key estuarine characteristics (e.g., isohaline locations, residence times) to freshwater inflow are frequently nonlinear, the approach is designed to prevent impacts to estuarine resources during sensitive low-inflow periods and to allow water supplies to become gradually more available as inflow increases. A high sensitivity to variation at low inflow extends to many invertebrates and fishes that move upstream and downstream in synchrony with inflow. Total numbers of estuarine-resident and estuarine-dependent organisms have been found to decrease during low-inflow periods, including mysids, grass shrimp, and juveniles of the bay anchovy and sand seatrout. The interaction of freshwater inflow with seasonal processes, such as phytoplankton production and the recruitment of fishes to the tidal-river nursery, indicates that withdrawal percentages during the springtime should be most restrictive. Ongoing efforts are oriented toward refining percentage withdrawal limits among seasons and flow ranges to account for shifts in the responsiveness of estuarine processes to reductions in freshwater inflow.

Introduction

Stream ecologists have emphasized the importance of natural flow regimes for maintaining the geomorphological and ecological characteristics of rivers (Hill et al. 1991; Poff et al. 1997; Richter et al. 1997). There is also evidence that naturally occurring patterns of freshwater inflow are important for maintaining the structure and productivity of estuarine ecosystems. Suspended sediments transported by periodic pulses of high river discharge are a major factor controlling the geomorphological structure of river deltas and bays (Kennish 1986; Jay and Simenstad 1996; Day et al. 1997). The productivity of coastal fisheries is positively related to freshwater inflow (Browder 1985; Drinkwater 1986; Day et al. 1989), and alterations to inflow regimes have caused dramatic declines and recoveries in fish stocks (Moyle and Leidy 1992; Mann and Lazier 1996; Sinha et al. 1996). Significant relationships have been found between fishery yields of estuarine-dependent species and preceding freshwater inflow terms calculated over 2-mo or 3-mo intervals, indicating that the seasonality of inflow can have a significant effect on fish abundance (Browder 1985; Longley 1994). Wilber and Bass (1998) also found that oyster harvests were negatively correlated with the number of low-flow days that occurred 2 yr prior, indicating that alteration of one component of a flow regime can have an effect on a specific stage of an organism's life history.

As groundwater sources reach their sustainable limits in southwest Florida, there is growing emphasis on using rivers for water supply. Many major rivers in Florida are not impounded and have not been used for water supplies in the past (Jue 1989; Fernald and Purdum 1998). Based on a series of studies of the freshwater inflow relationships of estuaries in the region, the Southwest Florida Water Management District (SWFWMD) has implemented a management approach for unimpounded rivers that limits withdrawals to a percentage of streamflow at the time of withdrawal. This approach considers the natural flow regime of a river to be the baseline for assessing the effects of withdrawals. Trends in various streamflow parameters

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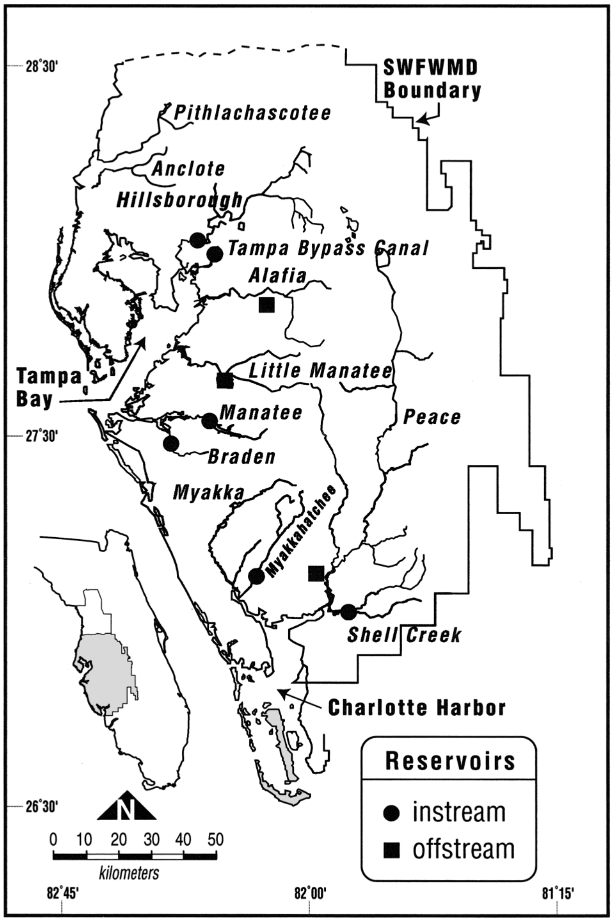

Fig. 1. Location of rivers in the Southwest Florida Water Management District extending from the Tampa Bay area to Charlotte Harbor, including the location of instream and offstream reservoirs used for water supply.

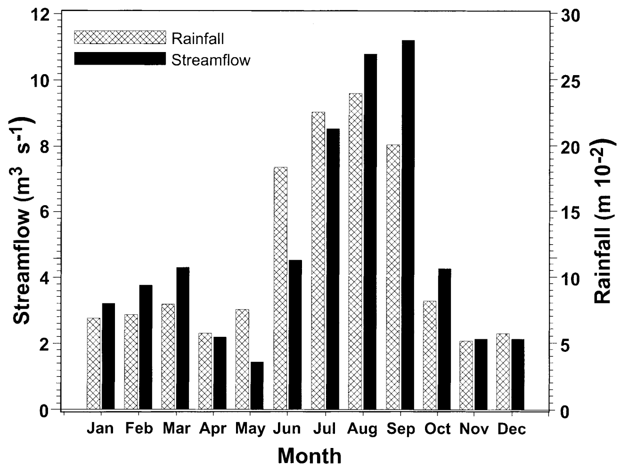

Fig. 2. Mean monthly rainfall at Bradenton, Florida and streamflow (U.S. Geological Survey gauge 02300500) for the Little Manatee River basin for the period 1940–2000.

are evaluated to determine if any components of a river's flow regime have changed. Estuarine relationships with freshwater inflow are then examined within seasons and flow ranges in order to determine percentage withdrawal limits that do not result in adverse environmental impacts. We review the theoretical and empirical framework on which the percent-of-flow approach is based and describe how it is applied in the water management setting. Analyses supporting this approach have emphasized hydrobiological relationships within tidal-river zones of larger estuarine systems in southwest Florida. Representative findings from these tidal rivers are reviewed to illustrate key ecological relationships and applications to the management of freshwater inflow.

Hydrologic Setting of the Region

West-central Florida contains 14 named rivers and numerous small streams that flow to the Gulf of Mexico. The flow regimes of several rivers north of Tampa Bay are dominated by groundwater discharges from large artesian springs, whereas flows in rivers from just north of Tampa Bay southward (Fig. 1) are dominated by surface runoff (Estevez et al. 1991). The region receives an average rainfall of about 1.35 m yr^{-1} with about 60% occurring from June through September. The temporal variability of streamflow in spring-fed rivers is typically more subdued than seasonal variations in rainfall, while average monthly flows in rivers dominated by surface runoff exhibit greater seasonal variability than monthly rainfall (Fig. 2). In rivers dominated by surface runoff, low flows occur in April and May when rainfall is low and potential evapotranspiration rates are increasing (Bidlake and Boetcher 1997; Lee and Swancar 1997); peak flows typically occur in August or September when depressional storage is full and water tables are high. The interaction of this seasonal streamflow pattern with estuarine processes forms the hydrobiological setting for managing freshwater inflows in these systems.

Detecting Changes in Inflow from Unimpounded Rivers

The water supply planning and regulation programs administered by the SWFWMD are designed to maintain the physical structure and ecological characteristics of the region's unimpounded rivers. Municipal water supplies are obtained from five instream impoundments in southwest Florida (Fig. 1), including major reservoirs on the Hillsborough and Manatee Rivers and small, low-head structures that serve as salinity barriers on three smaller streams (Braden River and Shell and Myakkahatchee Creeks). Water supplies are also obtained from the Tampa Bypass Canal, which is a regulated flood control waterway that was constructed in the channel of the Palm River. With the exception of the Tampa Bypass Canal, all of these impoundments were constructed before 1965. Since the mid-1970s, the SWFWMD (1992, 2001b) has emphasized the use of alternative water storage methods for the development of water supplies from unimpounded rivers in order to avoid impacts to riverine systems that can result from impoundment (Petts 1984; Ligon et al. 1995; Collier et al. 1996). Water supply storage from unimpounded rivers has been achieved using offstream reservoirs, which are diked or excavated areas located away from the river channel, and aquifer storage and recovery facilities, in which treated surface waters are pumped into underground aquifers for storage and subsequent retrieval.

The initial step for evaluating potential withdrawals (and resulting reductions in freshwater inflow) from an unimpounded river involves the assessment of historical changes in the river's flow regime. Many factors, such as changes in land use or surface water-groundwater relations in a river basin, can affect flow regimes in the absence of impoundment or direct withdrawals (Newson 1994; FISRWG 1998). Richter et al. (1996) developed a series of quantifiable indicators of hydrologic alteration that can be used to evaluate trends in different components of a flow regime over time. Another useful technique for evaluating changes in low or high flows is trend analysis of daily flow percentiles within each year (Lins and Slack 1999). Using one or more of these hydrologic indicators, historical streamflow records are evaluated to identify trends in different components of a flow regime or changes in seasonal flows. If changes have occurred, analytical effort is directed toward distinguishing the relative effects of climatic variability and anthropogenic influences, which can occur either as distinct events or as gradual changes through time. A series of hydrologic studies have been conducted on the three unimpounded rivers in southwest Florida that are currently allocated for water supply (Peace, Alafia, and Little Manatee; see Fig. 1) in order to assess trends in long-term flows (Hammett 1990; Flannery et al. 1991; Flannery and Barcelo 1998; SDI Environmental Services 1998), seasonal flows (Flannery et al. 1991; Coastal Environmental 1996a), low and high flows (Flannery et al. 1991; Stoker et al. 1996; Flannery and Barcelo 1998), and to compare the effects of anthropogenic influences and climatic variability on streamflow (Hammett 1990; Coastal Environmental 1996b; Flannery and Barcelo 1998; SDI Environmental Services 1998). The findings of these studies have been used to help define the baseline flow regime against which projected withdrawals and potential ecological effects are evaluated.

Defining Interactions Between Stationary and Dynamic Features in Tidal Rivers

The SWFWMD's approach to evaluating estuarine responses to freshwater inflow has been based on a series of literature reviews, workshops, and field studies that have been conducted since the mid-1970s. Two years after being delegated the authority to manage consumptive water use, the SWFWMD sponsored a literature review of the role of freshwater inflow in estuarine systems (Snedaker et al. 1977) and a workshop on the relationships of freshwater inflow to the resources of the Florida coast (Seaman and McLean 1977). A few years later, the proceedings of a national symposium on freshwater inflow to estuaries (Cross and Williams 1981) produced many valuable papers, including one by Browder and Moore (1981), who suggested that fishery recruitment is maximized when there is optimal overlap between stationary and dynamic habitats (i.e., salinity). Stationary components of estuarine habitat include features associated with the geomorphological structure of an estuary plus biological features, such as oyster reefs and tidal wetlands, that change relatively slowly over periods of years. Dynamic components of estuarine habitat include characteristics that can change rapidly as a function of freshwater inflow, such as circulation patterns, turbidity maxima, salinity distributions, and dissolved oxygen concentrations. Biological processes that move within the estuary in response to freshwater inflow can also be considered part of the dynamic component of estuarine systems. The management strategies employed by the SWFWMD are oriented to the conceptual model of Browder and Moore (1981), as the withdrawal of freshwater can move dynamic components away from what are structurally the most productive regions of an estuary.

The stationary components of estuarine habitats have been characterized by mapping and quantifying the distribution of important physical features in tidal rivers such as estuarine volume, the area of deep and shallow habitats, shoreline length, and the area of contiguous wetlands. Salinity distributions are then superimposed over these features to derive the area or volume of habitats within various salinity zones (Peebles and Flannery 1992; Estevez and Marshall 1997; PBS&J 2001). The distribution and salinity relations of tidal wetlands have been emphasized due to the important functions these communities have with regard to habitat structure and the abundance of fish and wildlife associated with estuaries (Odum et al.

1984; Lewis et al. 1985; Coultas and Hsieh 1997). The Florida Marine Research Institute (1997, 1999) used aerial imagery to map the distribution of major wetland communities within tidal freshwater, brackish marsh, salt marsh, and mangrove zones in seven rivers for which salinity data were available. Clewell et al. (2002) investigated the relationships of salinity distributions to plant species composition at 462 shoreline sites in these tidal rivers.

Other investigations of relationships between largely stationary ecological features and freshwater inflow have involved the distribution of mollusk populations and macroinvertebrate communities associated with oyster reefs. Mote Marine Laboratory (2001a) compared the distribution of live and dead mollusk shells in the Peace River and found that as a severe drought progressed, living shells aligned with relict shell footprints, reflecting the effect of periodic droughts on mollusk distributions. Sprinkel (1986) sampled oyster reefs extending off the mouths of four spring-fed rivers and found that the largest oysters were at inshore reefs where mean salinity values were in the range of 11 to 16 psu. On these same rivers, Gorzelany (1986) found there was greater similarity (Morisita's index) among macroinvertebrate communities associated with inshore oyster reefs from different rivers than among communities from inshore, middle, and offshore reefs from the same river.

To address the dynamic component of estuarine systems, a series of studies of the salinity characteristics of tidal rivers in west-central Florida was initiated in the late 1970s, including several that developed regression models to predict the locations of various isohalines as a function of freshwater inflow. These studies indicated that isohalines respond to freshwater inflow in a largely linear manner in five spring-dominated rivers north of Tampa Bay (Yobbi and Knochemus 1989a,b), but respond in a curvilinear manner in seven rivers dominated by surface runoff located farther south (Giovannelli 1981; Stoker et al. 1989; Fernandez 1990; Hammett 1992; Peebles and Flannery 1992; Coastal Environmental 1996b; Estevez and Marshall 1997; Janicki Environmental 2001). The shape of the relationship between isohaline location and freshwater inflow for the Peace and Little Manatee Rivers is typical of this southern region, in that relatively small reductions in freshwater inflow during the dry season can result in dramatic upstream movement of isohalines (Fig. 3). This characteristic response is due to the funnel shape of these tidal rivers, in which the cross-sectional area and volume of the estuary increase rapidly with distance downstream.

The curvilinear response of isohaline locations

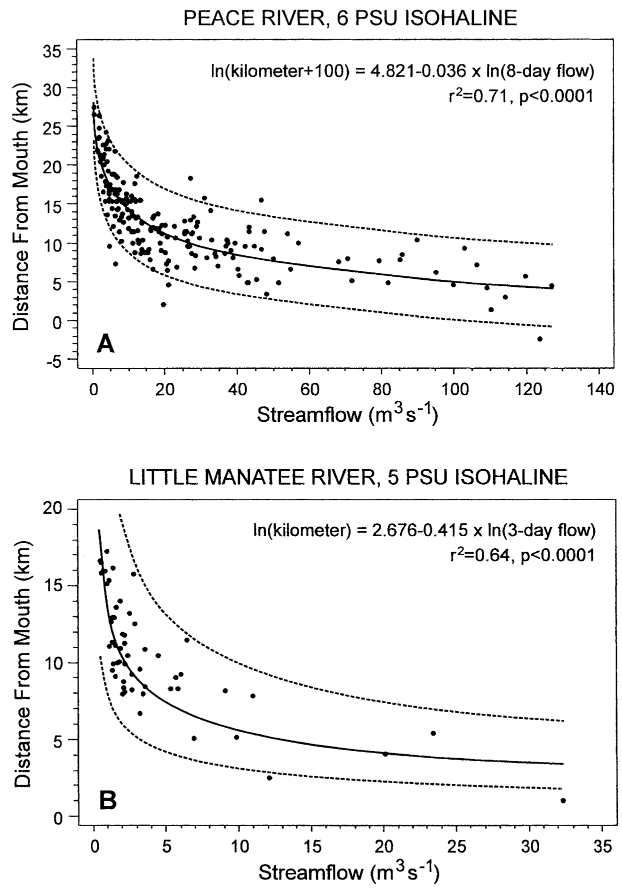

Fig. 3. Regressions of freshwater inflow with (A) the location of the 6 psu surface isohaline in the Peace River (adapted from Janicki Environmental 2001) and (B) the location of the 5 psu surface isohaline in the Little Manatee River (adapted from Peebles and Flannery 1992), with the 95% confidence limits for the predicted values. Regressions are plotted using non-transformed data.

to freshwater inflow was a principal finding used by SWFWMD to develop the percent-of-flow approach for managing withdrawals. Limiting withdrawals to a fixed percentage of streamflow results in relatively small isohaline movements (< 0.8 km) at low, medium, and high inflows (Table 1), preventing major changes to salinity distributions throughout the year. Although isohaline movements for a given percentage flow reduction may be slightly greater at low inflows, the reduction in water volume within a given salinity zone (e.g., < 5 psu) may be greater at higher inflows due to the isohalines being located in a broader region of the estuary. Since the percent-of-flow approach was first implemented, the SWFWMD has emphasized the development of hydrodynamic models to simulate salinity distributions in tidal river estuaries, including the Manatee (Camp, Dresser and McKee, Inc. 1995), Hillsborough (Chen et al. 2000),

TABLE 1. The locations and upstream movements of low-salinity surface isohalines in four rivers in response to 10% reductions of streamflow at flows equal to the 10th, 50th, and 90th percentile flows in the long-term streamflow records. Locations were predicted using regressions developed for the Peace (Janicki Environmental 2001), Myakka (Hammett 1992), Little Manatee (Peebles and Flannery 1992), and Anclote Rivers (Fernandez 1990).

River	Isohaline (psu)	Location + Upstream Movement (km from River Mouth)		
		10th Percentile	50th Percentile	90th Percentile
Peace	6	18.39 + 0.45	12.76 + 0.43	5.69 + 0.41
Myakka	0.5	33.95 + 0.55	21.64 + 0.35	16.18 + 0.26
Little Manatee	5	17.67 + 0.79	11.35 + 0.51	5.57 + 0.25
Anclote	5	14.37 + 0.18	12.47 + 0.18	7.54 + 0.18

Alafia (Chen 2001), and Palm (Myers et al. 2002) Rivers.

Primary Production as a Management Criterion

Phytoplankton populations are among a suite of parameters than can be considered to be dynamic habitat components, as their abundance and distribution can respond quickly to changes in freshwater inflow. To investigate the influence of freshwater inflow on abundance and distribution of phytoplankton, a suite of parameters including chlorophyll *a* (chl *a*) and phytoplankton species counts has been collected at four surface isohalines (0.2 or 0.5, 6, 12, and 18 or 20 psu) in the Peace, Little Manatee, and Alafia Rivers (Vargo et al. 1991; PBS&J 1999a; SWFWMD 2002b). With the exception of the Little Manatee, where chl *a* concentrations were highest near the boundary with tidal freshwater (0.5 psu), mean chlorophyll values were greatest and concentrations most variable at the 6 and 12 psu isohalines, whereas lower values typically occurred in higher salinity waters (Table 2).

The most extensive data for examining phytoplankton response to freshwater inflow are from the Peace River, where phytoplankton production (^{14}C uptake) and chl *a* have been monitored monthly since 1984, with taxonomic cell counts conducted since 1988 (PBS&J 1999a). McPherson et al. (1990) concluded that maximum phytoplankton production and biomass in the Peace River and Charlotte Harbor estuarine system occurs in mid-salinity zones, where freshwater inflow increases the availability of nutrients, but organic color of riverine origin is diluted, allowing for increased light penetration. There is also a positive response to water temperature and presumably photoperiod, as the highest monthly mean values for chl *a* tend to occur in warm waters with moderate amounts of color (PBS&J 1999a). Monthly mean chl *a* concentrations generally increase with water temperature from February through April, but decline or are relatively stable during May and June (Fig. 4). Freshwater inflow typically declines from April through mid-June, reducing nutrient delivery from the watershed. As inflow and nutrient loads increase during the summer rainy season, chl *a* values increase at the 6, 12, and 20 psu isohalines.

These data indicate that reductions of inflow and nutrient loading during the spring dry season could act to limit phytoplankton biomass in the tidal river. Because isohaline locations are sensitive to movement during periods of low inflow, reductions in freshwater inflow during the springtime could move areas of maximum phytoplankton abundance farther upstream with implications for secondary production. Depending on dry-season nutrient loads, increased residence times resulting from reductions in freshwater inflow could act to increase phytoplankton biomass in zones of a tidal river (Ingram et al. 1985; Vallino and Hopkinson 1998). Current SWFWMD efforts are directed toward better defining the roles of light penetration, nutrient loading, and residence time in controlling phytoplankton abundance in tidal rivers in the region, including the highly eutrophic Alafia.

Fish Nursery Use as a Management Criterion

An important component of the SWFWMD's management approach to tidal rivers has involved the response of zooplankton, benthic macroinver-

TABLE 2. Mean (± standard deviation) and number of surveys (n) for chlorophyll *a* concentrations (μg L^{-1}) at four surface isohalines in the Peace, Alafia, and Little Manatee Rivers. Values for the 0.2 and 20 psu isohalines in the Peace River are listed with the 0.5 and 18 psu isohalines, respectively (data from Vargo et al. 1991; PBS&J 2001; SWFWMD 2002b).

River	n	Isohaline (psu)			
		0.5	6	12	18
Peace	208	9.6 (11.2)	23.7 (27.4)	23.3 (32.5)	12.7 (18.8)
Alafia	24	13.1 (15.7)	78.7 (135.2)	106.0 (163.6)	47.2 (41.1)
Little Manatee	28	22.1 (14.9)	15.9 (8.6)	10.7 (8.4)	5.6 (2.0)

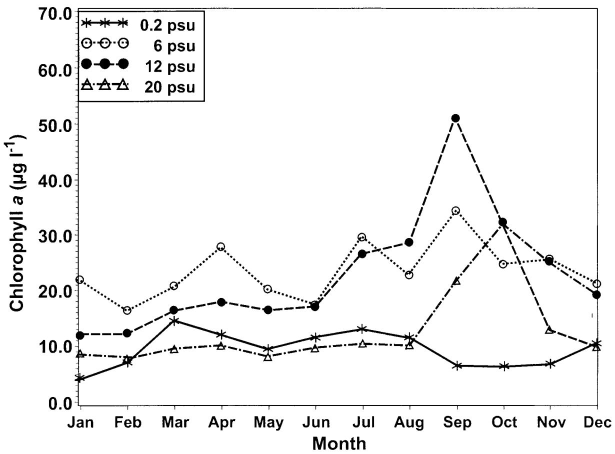

Fig. 4. Monthly mean concentrations of chlorophyll *a* at four surface isohalines in the lower Peace River for the period 1984–2000 (data from PBS&J 2001).

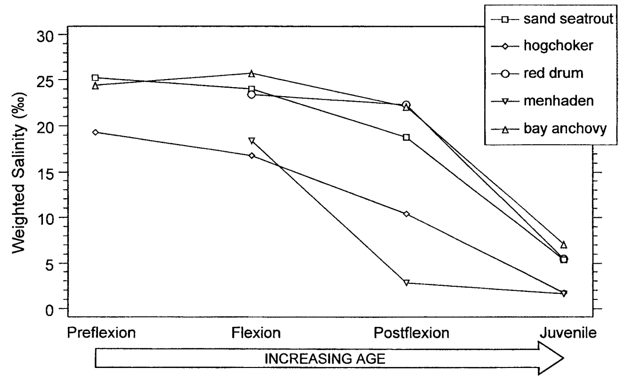

Fig. 5. Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages (Peebles and Flannery 1992).

tebrates, and fishes to freshwater inflow. These studies have been primarily directed toward young or short-lived organisms, particularly the estuarine-dependent fishes that use tidal rivers as juvenile nursery habitat and the prey organisms that these fishes depend on while occupying such habitats. Because tidal-river habitats are small and are directly affected by watershed runoff, the potential for an inflow-related influence on fish recruitment success would appear to be strong. Juvenile estuarine-dependent fishes are generally described as being seasonal migrants (Merriner et al. 1976; Peters and McMichael 1987; McMichael et al. 1989; Barry et al. 1996; Livingston 1997), which is a status that subjects them to inflow variations at subannual time scales.

Rast et al. (1991) found that most zooplankters have peak densities in the downstream, higher-salinity reaches of the Little Manatee River, making them abundantly available as prey for the early life stages of fishes that are spawned near the mouth of the river or migrate there from more seaward locations. Within the tidal river, larval fishes tend to be most abundant near this downstream zooplankton maximum (Peebles and Flannery 1992). As the larvae develop into juveniles, a number of species move into areas of reduced salinity in the interiors of the tidal rivers (Fig. 5). This estuarine-dependent life history pattern is associated with growth-related diet shifts, such as the shift from copepods and other zooplankton to bottom-dwelling organisms, notably mysids, amphipods, and deposit-feeding invertebrates in general (Peters and McMichael 1987; McMichael and Peters 1989; McMichael et al. 1989; Barry et al. 1996; Peebles 1996). Deposit-feeding invertebrates have been observed to be abundant within organically enriched regions of the upper estuary, both locally (Mote Marine Laboratory 2001a,b; Grabe et al. 2002) and elsewhere (McBee and Brehm 1982; Holland et al. 1987; Gaston and Nasci 1988).

Phytoplankton biomass is often maximal either within or immediately upstream of the organically enriched oligohaline and mesohaline areas that are used as juvenile fish nursery habitat (Table 2; Fig. 4). Some species, such as menhaden, appear to associate directly with the chlorophyll maximum in other estuaries (Hughes and Sherr 1983; Friedland et al. 1996). Although the estuarine-dependent pattern of habitat use would appear to increase food availability in many cases (Barry et al. 1996; Peebles 1996; Livingston 1997), various alternative explanations have also been proposed to explain this phenomenon, including benefits associated with reduced predator diversity, reduced predator access to shallow water, and increased structural complexity (Reis and Dean 1981; Weinstein and Brooks 1983; Miller et al. 1985; Day et al. 1989; Hoss and Thayer 1993). Regardless of the cause, the estuarine-dependent life history places the juvenile fishes and their prey within relatively small, semi-confined areas of tidal rivers that constitute focal points for watershed runoff.

The locations occupied by both the fishes and their prey shift upstream and downstream in apparent response to changes in freshwater inflow (Table 3; Fig. 6). This response has been observed in both planktonic forms and active swimmers. For estuarine-resident and estuarine-dependent organisms, movement upstream during low-inflow periods usually involves movement into river reaches that have reduced volumes (Peebles and Flannery 1992; Peebles 2002a,b), which raises the possibility that carrying capacities could also be reduced by low inflow.

The abundances of many estuarine-resident and

TABLE 3. Organism distribution (mean km weighted by CPUE) responses to same-day freshwater inflow (ln $m^3 s^{-1}$) into the tidal Alafia River, ranked by linear regression slope (b). Other regression statistics are the number of monthly transects in which each taxon was encountered (n), intercept (a), slope probability (p), and fit (r^2, as %). DW identifies possible serial correlation (x indicates $p < 0.05$ for Durbin-Watson statistic). Gear codes: P = 500-μm mesh, 0.5-m mouth plankton net deployed surface to bottom over about 400 m of channel length during nighttime flood tide, S = 21.3-m center-bag seine with 3.2-mm mesh deployed at shoreline during day under variable tide stage, T = 6.1-m otter trawl, 38-mm stretched mesh and 3.2-mm liner, deployed over about 180 m of channel bottom during day under variable tide stage (adapted from Peebles 2002a).

Gear	Taxon	Common Name	n	a	b	p	r^2	DW
S	*Gobiosoma bosc*	naked goby	18	5.22	1.57	0.0275	27	
P	calanoids	copepods	21	−0.05	−0.31	0.0224	25	x
P	all dipteran larvae	flies, mosquitoes	26	11.33	−0.45	0.0384	17	
P	*Anchoa* spp. flexion larvae	anchovies	20	1.36	−0.62	0.0333	23	
P	dipterans, chironomid larvae	midges	26	11.56	−0.64	0.0060	27	
P	odonates, zygopteran larvae	damselflies	12	13.11	−0.64	0.0438	35	
P	*Anchoa* spp. preflexion larvae	anchovies	19	1.42	−0.65	0.0440	22	
S	*Achirus lineatus*	lined sole	20	2.95	−0.67	0.0333	23	
S	*Fundulus seminolis*	Seminole killifish	21	12.58	−0.68	0.0020	40	
P	trichopteran larvae	caddisflies	17	13.71	−0.69	0.0389	25	
T	*Farfantepenaeus duorarum*	pink shrimp	21	3.97	−0.76	0.0245	24	
P	*Lucifer faxoni*	shrimp	25	1.81	−0.80	0.0121	24	x
T	*Callinectes sapidus*	blue crab	23	4.70	−0.84	0.0146	25	x
S	*Oligoplites saurus*	leather jack	15	4.78	−0.89	0.0501	26	
S	*Eucinostomus gula*	silver jenny	20	2.57	−0.92	0.0104	31	
S	*Cynoscion nebulosus*	spotted seatrout	16	3.34	−0.93	0.0189	33	x
T	*Menticirrhus americanus*	southern kingfish	19	3.64	−0.96	0.0028	42	
P	*Erichsonella attenuata*	isopod	12	2.91	−1.01	0.0092	51	
P	copepods, freshwater cyclopoids	copepods	14	13.65	−1.02	0.0122	42	
P	cumaceans	cumaceans	26	2.94	−1.05	0.0002	44	x
P	*Anchoa mitchilli* adults	bay anchovy	26	5.36	−1.07	0.0050	28	x
P	cladocerans, daphniid	water fleas	11	14.14	−1.09	0.0071	57	
T	*Cynoscion arenarius*	sand seatrout	20	6.07	−1.10	0.0190	27	
P	*Anchoa mitchilli* juveniles	bay anchovy	26	8.00	−1.13	0.0005	40	
S	*Farfantepenaeus duorarum*	pink shrimp	23	4.38	−1.14	0.0091	28	x
P	coleopterans, elmid adults	riffle beetles	18	13.47	−1.18	0.0469	22	x
P	gobiid preflexion larvae	gobies	16	5.44	−1.21	0.0243	31	
P	*Anchoa mitchilli* postflexion larvae	bay anchovy	18	3.78	−1.21	0.0103	35	
P	decapod zoeae	crab larvae	26	3.91	−1.23	0.0261	19	x
P	mysids	opossum shrimp	26	5.85	−1.23	0.0120	24	
P	polychaetes	worms	26	7.93	−1.25	0.0006	39	
P	hydracarina	water mites	20	13.98	−1.26	0.0002	54	
S	*Cynoscion arenarius*	sand seatrout	14	5.45	−1.33	0.0082	45	x
S	*Symphurus plagiusa*	blackcheek tonguefish	14	4.42	−1.34	0.0408	30	
S	*Callinectes sapidus*	blue crab	20	5.29	−1.36	0.0012	45	
P	branchiurans, *Argulus* spp.	fish lice	18	10.55	−1.41	0.0065	38	
S	*Synodus foetens*	inshore lizardfish	12	3.36	−1.52	0.0036	59	
P	*Limulus polyphemus* larvae	horseshoe crab	13	3.93	−1.52	0.0260	38	
P	*Cynoscion arenarius* juveniles	sand seatrout	14	7.04	−1.56	0.0036	52	
S	*Membras martinica*	rough silverside	12	4.75	−1.57	0.0040	58	
P	*Microgobius* spp. postflexion larvae	gobies	18	4.70	−1.60	0.0098	35	
S	*Menidia* spp.	silversides	23	9.36	−1.65	0.0031	35	
S	*Menticirrhus americanus*	southern kingfish	17	5.01	−1.70	0.0025	47	
P	*Edotea triloba*	isopod	25	8.08	−1.75	0.0000	59	
P	isopods (grouped)	isopods	26	7.92	−1.76	0.0000	57	
P	cymothoid sp. a (*Lironeca*)	isopod	26	7.79	−1.80	0.0000	53	
P	*Gobiosoma* spp. postflexion larvae	gobies	20	6.72	−1.87	0.0234	25	
S	*Cyprinodon variegatus*	sheepshead minnow	14	7.26	−1.94	0.0129	41	x
P	*Trinectes maculatus* juveniles	hogchoker	19	9.89	−2.04	0.0024	43	
P	*Trinectes maculatus* postflexion	hogchoker	18	8.66	−2.11	0.0002	60	
P	*Syngnathus louisianae* juveniles	chain pipefish	10	5.76	−2.16	0.0235	49	x
P	*Trinectes maculatus* flexion larvae	hogchoker	12	6.85	−2.36	0.0141	47	
S	*Brevoortia* spp.	menhaden	10	10.42	−3.49	0.0034	68	

young estuarine-dependent species appear to decline during low-inflow periods (Figs. 7 and 8; Table 4). This trend could raise concern over calculation artifacts because river-segment volume is strongly influential in the calculation of total number and organisms typically move downstream into regions with larger volume-weighting factors during high inflow periods. For many taxa in Table 4,

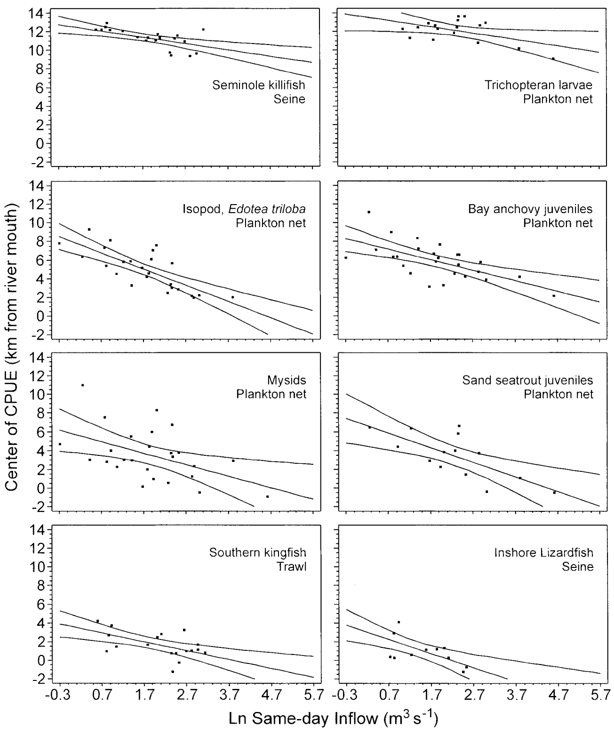

Fig. 6. Regressions of organism distribution against freshwater inflow into the tidal Alafia River, with 95% confidence limits for predicted means. Center of catch per unit effort (CPUE) is the mean location of capture during monthly transects, with the mean being weighted by CPUE. During each transect, the seine and plankton net were deployed at 12 stations and trawls were deployed at four stations. CPUE is either the number per deployment for seines and trawls or the number per volume filtered by the plankton net. Regression statistics are presented in Table 3 (adapted from Peebles 2002a).

the positive inflow relationship also exists when total catch is used (no volume-weighting factor), suggesting that the response is not merely a calculation artifact. For other taxa, the relationship is also likely to be real, as the approach for estimating total number is conceptually robust. It should be kept in mind that the number estimated is actually the number of individuals that are vulnerable to the collection gear within the channel's water column, and this number may be affected by influx from the shoreline, bottom, or downstream directions. The relationships in Fig. 7 represent the ascending limb of a broader response curve; very high flows could decrease abundance in the tidal river.

Other studies (e.g., Jassby et al. 1995; Kimmerer et al. 2001) have documented abundance responses to inflow-related variables by comparing annual averages, which would tend to eliminate the influence of recruitment seasonality and would strongly reduce the effects of short-term time lags in the response. Figures 7 and 8 indicate that abundance

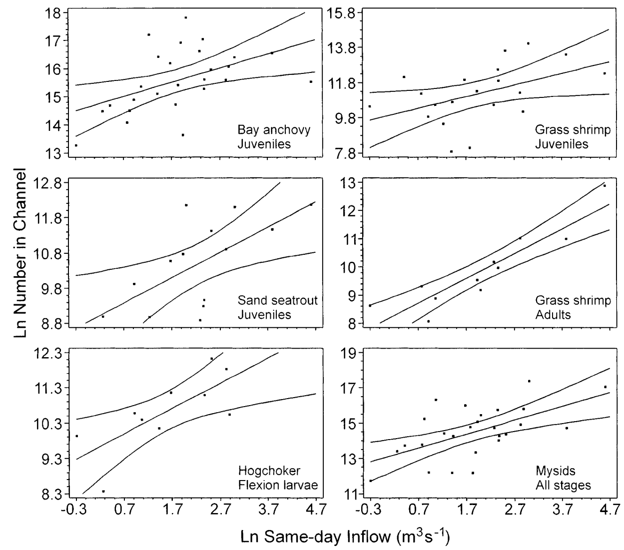

Fig. 7. Regressions of organism number against freshwater inflow into the tidal Alafia River, with 95% confidence limits for predicted means. Number was calculated for each monthly transect by summing the products of mean organism density (ind m^{-3}) and a volume weighting factor (m^3) for six contiguous river segments. All data are from plankton net deployments, which were made at 12 stations per transect. Regression statistics are presented in Table 4 (adapted from Peebles 2002a).

responses can also be identified within sub-annual time intervals for a variety of organisms, and often without any indication of serial correlation (Table 4). Several factors encourage synchrony between the inflow and abundance observations. Because the regressions are based on plankton-net data, most of the animals in the analysis are short-lived species. Longer-lived fish and crustacean species

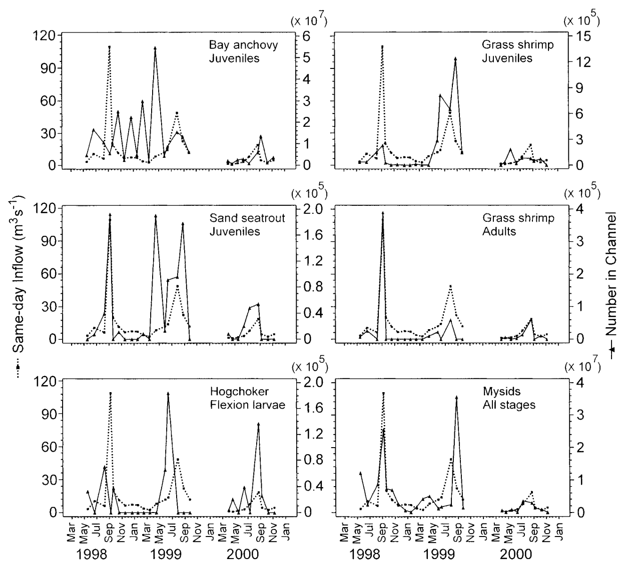

Fig. 8. Time series of the data in Fig. 7.

TABLE 4. Response of total estimated number (ln number of individuals) to same-day freshwater inflow (ln $m^3 s^{-1}$) into the tidal Alafia River, ranked by linear regression slope (b). Other regression statistics are the number of monthly transects in which each taxon was encountered (n), intercept (a), slope probability (p), and fit (r^2, as %). DW identifies possible serial correlation (x indicates $p < 0.05$ for Durbin-Watson statistic). Total number was estimated by summing the products of mean plankton-net density (individuals m^{-3}) and water-level-corrected volume across 6 contiguous river segments (adapted from Peebles 2002a).

Taxon	Common Name	n	a	b	p	r^2	DW
dipteran, *Chaoborus punctipennis*	phantom midge	16	7.47	1.43	0.0058	43	
pinnotherid juveniles	pea crabs	18	11.50	1.40	0.0035	42	
crabs (grouped)	crabs	24	10.90	1.32	0.0049	31	
freshwater cyclopoids	copepods	14	7.50	1.31	0.0000	78	
ephemeropterans	mayflies	22	7.94	1.10	0.0001	56	
Palaemonetes pugio adults	daggerblade grass shrimp	11	8.06	0.88	0.0001	83	
coleopterans, dytiscid adults	predaceous diving beetles	13	7.30	0.88	0.0064	51	
mysids	opossum shrimps	26	13.01	0.79	0.0016	35	
Cynoscion arenarius juveniles	sand seatrout	14	8.85	0.72	0.0131	41	
Trinectes maculatus flexion	hogchoker	10	9.46	0.72	0.0139	55	
Palaemonetes pugio juveniles	daggerblade grass shrimp	20	9.84	0.66	0.0375	22	x
dipterans, pupae	flies, mosquitoes	25	10.07	0.63	0.0092	26	x
coleopterans (grouped)	beetles	21	8.72	0.57	0.0053	34	
Anchoa mitchilli juveniles	bay anchovy	26	14.63	0.51	0.0114	24	
dipterans (grouped)	flies, mosquitoes	26	10.98	0.42	0.0064	27	x
alphaeid postlarvae	snapping shrimps	14	13.35	−0.41	0.0386	31	x
Lolliguncula brevis juveniles	bay squid	13	11.49	−0.49	0.0458	32	
cymothoid sp. a (*Lironeca*)	isopods	26	16.03	−0.53	0.0079	26	x
isopods (grouped)	isopods	26	15.73	−0.58	0.0069	27	x
gobiid preflexion larvae	gobies	15	13.00	−0.66	0.0051	46	
gobiid flexion larvae	gobies	17	11.90	−0.91	0.0129	35	
calanoids	copepods	21	19.47	−1.15	0.0219	25	

were partitioned into shorter developmental stages before analysis and abundance was assessed independently for each stage. For such species, the rate of passage though various larval stages is fast relative to the monthly sampling frequency. Even for the potentially long-lived juvenile stages of larger species (e.g., *Cynoscion arenarius*), a combination of gear avoidance and natural mortality (larger individuals becoming rare) dramatically abbreviated the age range observed in the plankton-net data.

Most of the abundance regressions remained significant when inflows from the previous month's collection dates were used, indicating that the response is not as spontaneous as Figs. 7 and 8 might imply. In the relationships illustrated by these figures, significance was generally lost when a 2-mo lag was used, which suggests that the relationships with inflow had durations of less than 2 mo. Explanations for the decreased abundance include reductions in reproductive effort (Peebles 2002c) and survival rates during low-inflow periods.

From a management perspective, the shape of the abundance response curves can be used to identify inflow ranges that have proportionately large influences on abundance. The non-transformed data represented by the regression statistics in Table 4 are described by the power function $y = ax^b$, which is differentiated as $dy/dx = abx^{(b-1)}$. The value of the slope determines the shape of the non-transformed abundance response to variations in inflow. Organisms with slopes < 0 undergo proportionately large decreases in number as low-end inflows increase. This is characteristic of animals that often occupy the higher salinities near the river mouth. Members of the second group, which includes freshwater, estuarine-resident, and estuarine-dependent taxa, have slopes between 0 and 1 and undergo proportionately large increases in number as low-end inflows increase, although the abundance increase becomes more constant for organisms with slopes near 1. Members of the third group, which is primarily composed of freshwater organisms, are characterized by slopes > 1. Freshwater taxa may either wash into the tidal river at a fairly constant rate (e.g., ephemeropteran larvae in Table 4) or, at even larger slopes, increase dramatically in number during floods (freshwater cyclopoids and *Chaoborus punctipennis*). Floods may also cause burrowing marine-derived animals (e.g., the pinnotherid crab *Pinnixa sayana*) to emerge from their burrows in large numbers, producing a very similar pattern.

Because most estuarine-resident and estuarine-dependent taxa tend to have a group-2 response (proportionately large increases in number at the low end of the inflow range), protection of low inflows becomes important. By scaling withdrawals to the concurrent rate of streamflow, the percent-of-flow approach provides a general safeguard against dramatic changes in organism abundance that could result from large withdrawals during periods of low freshwater inflow.

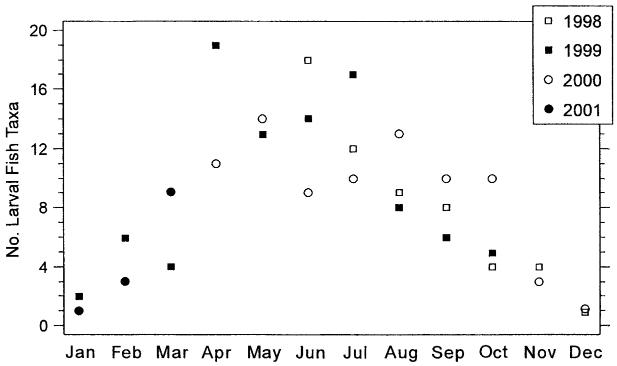

Fig. 9. The seasonal distribution of approximate larval richness in the tidal Alafia River (data from Peebles 2002a).

Most estuarine-dependent fishes have been found to exhibit very regular seasonality in their use of low-salinity habitats, further emphasizing the importance of a seasonal component to inflow management. The spawning-season durations of individual species range from a few months to year-round. Those with shorter seasons generally demonstrate regular seasonality in their spawning. It is interesting that spawning seasons and overall trends in larval taxonomic richness do not conform to the local seasonal rainfall pattern, which can be very different from the pattern in other parts of these species' ranges. Richness is very high during April and May (Fig. 9), which are among the driest months of the year (Fig. 2), and does not change appreciably during the transition to the summer wet season. Richness starts to decline in August and gradually reaches its minimum during December and January. This pattern has been observed repeatedly at various locations since 1988.

The potential for a strong influx of juvenile estuarine-dependent fishes into low-salinity nursery habitats is very high during the spring dry season, making management of freshwater inflow particularly sensitive during that time of year. Although the seasonal pattern of larval richness in Fig. 9 suggests that this sensitivity may diminish during winter, many of the spring and summer larval migrants are still present during winter as older juveniles. There is no season when inflow management becomes less relevant to low-salinity nursery use, although spring appears to be a particularly sensitive season. Any limiting effects associated with the naturally low springtime inflows could be amplified by relatively small freshwater withdrawals.

Applications to the Management of Freshwater Withdrawals

In the late 1980s, the SWFWMD first began to implement a management approach of limiting withdrawals from rivers to a percentage of streamflow at the time of withdrawal. The goals of this approach were to make withdrawals mimic the temporal characteristics of the flow regimes of the streams used for water supply and to protect the estuaries from the effects of large freshwater withdrawals during the ecologically vulnerable dry season. Findings initially used to support the approach included the curvilinear response of isohaline locations to freshwater inflow (Flannery 1989) and the influence of inflow on the location of the center of catch per unit effort (CPUE) for a number of key organisms, a relationship that was first documented in the Little Manatee River (Peebles and Flannery 1992). Studies of the Lower Peace River and Charlotte Harbor estuarine system also demonstrated that the response of residence time to freshwater inflow in that system is strongly curvilinear (Stoker et al. 1989; Miller and McPherson 1991). Reduction of freshwater inflow of a fixed quantity would result in a much greater increase in residence time during periods of low inflow, with possible negative effects on water quality.

The percent-of-flow approach was first applied to the Peace River, where withdrawals for public water supplies began in 1980. The Peace River is not impounded and withdrawals from the river are either pumped directly to the customers after treatment or are stored in an offstream reservoir or the groundwater system using aquifer storage and recovery facilities. Prior to 1989, withdrawals from the Peace River were regulated by the SWFWMD in a manner similar to a groundwater withdrawal, with limitations on maximum-daily and yearly average withdrawal rates. Maximum-daily withdrawals could be taken when flows in the river were above minimum flow rates that were specified for each month. Given this regulatory schedule, withdrawals could take up to 25% of streamflow on low-flow days during the dry season. Based on recommendations of ecologists from both the water supply utility and SWFWMD, the withdrawal schedule was changed in 1989 so that withdrawals could not exceed 10% of the average streamflow from the preceding day as measured at an upstream gauge.

The percent-of-flow approach was also recently applied to allocated withdrawals from the Alafia River, from which withdrawals are scheduled to begin in 2003. These withdrawals by the water supply utility cannot exceed 10% of the streamflow from the preceding day as measured at the intake site, and withdrawals in excess of immediate customer needs will be stored in an offstream reservoir. Withdrawals for cooling water for an electrical power plant have been diverted to an offstream reservoir from the Little Manatee River since 1975. These withdrawals have been regulated as a percentage of streamflow at the time of withdrawal, but at higher percentage rates than allowed for the

Peace or Alafia Rivers (up to 47% on some days during high flows). This power plant has been operating at approximately one-third of capacity since its construction and withdrawals from the Little Manatee River have been relatively infrequent (28% of days) and well below the allocated percentage quantities. In a recent application to convert the power plant from fuel oil to natural gas and increase power production, the utility has requested that the diversion limit be reduced to 10% of the daily flow at the intake site in anticipation of more frequent, but smaller, withdrawals (Florida Power and Light 2002). Findings to support this change in the diversion limit included simulations of changes in salinity distributions and movements of the locations of the center of CPUE for key organisms in the Little Manatee River.

Application of the percent-of-flow approach to these unimpounded rivers has included the use of low-flow cutoffs, or rates of streamflow below which no withdrawals are allowed. These low-flow cutoffs correspond to the long-term 13th percentile flow on the Peace, the 21st percentile flow on the Alafia, and the 36th percentile flow on the Little Manatee. Criteria for determining these low-flow cutoffs have varied, but are generally based on inflections in the response of key variables to freshwater inflow. Data for the Peace River indicate that salinity distributions in the upper estuary are especially sensitive to reductions in freshwater inflow below the low-flow cutoff of 3.7 $m^3 s^{-1}$. During droughts, streamflow in these rivers can be below their low-flow cutoffs for several consecutive months, during which time water supplies must come entirely from storage.

During high flows, the capacities of the diversion structures on these rivers do not allow the utilities to take their full percentage quantities. The effect of regulated percentage withdrawals, including the range of flows over which a full 10% of flow can be diverted, is shown for the Peace River during a typical year (Fig. 10). Due to these regulatory and physical constraints, seasonal and annual reductions in streamflow that result from the percent-of-flow approach are often considerably less than the percent daily limit. Since the streamflow gauges used to calculate the percentage withdrawals do not account for freshwater inflow below the gauging sites, percent reductions of total inflows to the tidal rivers are even less. The drainage areas for the gauges used to calculate percent daily withdrawal limits on the three rivers range from 58% of the total river basin for the Peace River to 91% of the total river basin for the Alafia. Current efforts are directed to modeling the ungauged streamflow in these river basins, so that the actual percentage flow reductions to the tidal rivers can be more closely quantified (Tara et al. 2001).

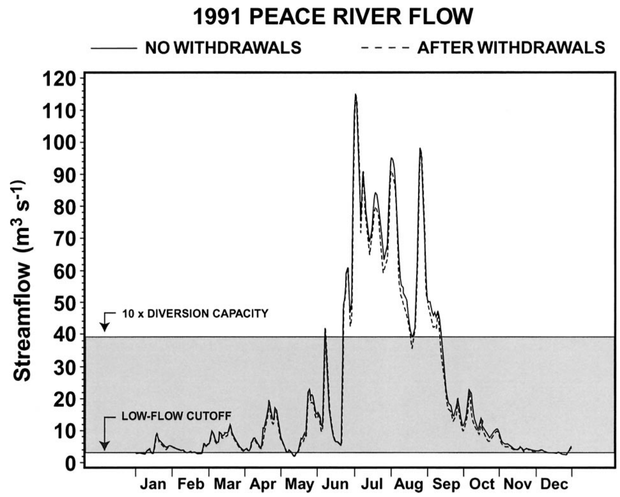

Fig. 10. Daily streamflow values for the Peace River during 1991 (U.S. Geological Survey gauge 02296750), with and without maximum possible withdrawals calculated using the 10% of flow daily limit, combined with a low-flow cutoff of 3.7 $m^3 s^{-1}$ and a diversion capacity of 3.9 $m^3 s^{-1}$. The shaded area represents the range of flows over which a full 10% of streamflow can be diverted.

Ongoing Refinements to the Percent-of-flow Approach

The natural flow regimes of unimpounded rivers and their documented ecological responses provide important information on when estuarine resources are most vulnerable to the effects of reductions in freshwater inflow. Withdrawal quantities that can result in ecological impacts may be markedly smaller during some seasons than others. The findings from southwest Florida estuaries indicate that reductions of freshwater inflow should be most limited during the spring. Historically, the withdrawal of water from rivers has not accounted for the seasonal needs of downstream ecosystems. Rozengurt and Hedgpeth (1989) reported a 12% reduction in the estimated mean annual runoff to the Lower Volga-Caspian Sea ecosystem, but reductions in springtime flows had decreased by as much as 37%. Similarly, water use in southwest Florida also typically peaks during the spring dry season due to increased domestic and agricultural irrigation (SWFWMD 2001a), and percent flow reductions in the region's impounded rivers are greatest during that time of year. The adoption of minimum flow releases that can account for seasonal variations have been scheduled for these impounded rivers (SWFWMD 2002a). It is expected that all new surface water withdrawals in the region will come from unimpounded rivers, for which the

SWFWMD has endorsed the percent-of-flow approach (SWFWMD 1992, 2001b). With the exception of the Little Manatee River, applications of the percent-of-flow approach have used the same percentage rate throughout the year. Current SWFWMD efforts are directed toward evaluating percentage withdrawal limits on a seasonal basis to better account for seasonality in the life histories of various organisms.

The evaluation of potential freshwater withdrawals should also account for the frequent nonlinear response of key estuarine characteristics to freshwater inflow. Changes in residence times, isohaline locations, and salinity at different locations in an estuary can be much greater for a given volume of freshwater withdrawal if it occurs during periods of low freshwater inflow (Miller and McPherson 1991; Uncles and Stephens 1993; Sklar and Browder 1998; Vallino and Hopkinson 1998). The relationships presented herein indicate there can often be a larger decrease in organism numbers if withdrawals of a given quantity are made during low freshwater inflows. A goal of the percent-of-flow approach is to adjust for such nonlinear relationships by scaling withdrawals to the rate of freshwater inflow. The SWFWMD is investigating sliding withdrawal percentages that differ among flow ranges based on changes in the responsiveness of the estuarine variables of concern. In cases where increasing freshwater inflows exacerbate a problem condition such as hypoxia (e.g., Breitburg 2002), percentage withdrawal limits can be adjusted to account for such processes. If high flows cause dispersion of estuarine-dependent organisms away from productive zones of an estuary (e.g., Peebles et al. 1996; Peebles 2002c), this can be factored into the withdrawal management strategy.

Although the percent-of-flow approach uses the flow regime of the contributing river as the basis for determining withdrawals, it is the inflow relationships of the living resources in the estuary that are the final determinant of percentage withdrawal limits. The ambient flow record (without any withdrawals) is used to assess the spatial and seasonal variation of physico-chemical and biological variables within the estuary that are related to freshwater inflow. Percentage withdrawals can then be applied to evaluate responses in the estuary under a range of inflow conditions. For those variables in the estuary that can be modeled, values can be simulated in order to compare the effects of different withdrawal scenarios to the ambient flow record (PBS&J 1998, 2001; Janicki Environmental 2001).

Development of the percent-of flow approach has largely emphasized tidal rivers because most oligohaline and mesohaline zones and nursery habitats in southwest Florida estuaries are located upstream of the tributary mouths. The withdrawal quantities that have been evaluated for unimpounded rivers using the percent-of-flow approach have been relatively small. We have assumed that the physico-chemical effects of these withdrawals and their related biological responses are most strongly manifest within the tidal rivers, due to their small water volumes relative to the open bays. This assumption is periodically reviewed and as the pressure for larger withdrawals increases, the strategy of examining more far-field effects will be increasingly employed.

The percent-of-flow approach lends itself to the process of adaptive management, in which continued data collection can be used to refine management strategies as the body of information expands over time. The SWFWMD requires the monitoring of hydrologic and ecological variables for permits for large surface-water or groundwater withdrawals. At present, extensive monitoring programs are required for withdrawals from both the Peace and Alafia Rivers (PBS&J 1999b, 2001). The findings of these programs can be used to modify percentage withdrawal schedules to better manage the resource, as the findings from the Peace River monitoring program were used to develop the percent-of-flow concept in 1989.

In addition to issuing individual water use permits, the SWFWMD must also establish minimum flow and level rules for flowing water courses which are defined in Florida Statutes (Chapter 373.042) as "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." Minimum flows and levels address not only existing withdrawals, but also the potential effects of future withdrawals and are important for water supply planning. The adoption of minimum flows and levels for the Peace and Alafia rivers could develop percentage withdrawal limits that differ from the 10% regulations currently in effect. The determination of significant harm in the minimum flow and level process rests with Governing Board of the SWFWMD, who are appointed by the Governor of the State of Florida. The role of ecologists is to identify those ecological features, processes, and organisms that can be affected by reductions in freshwater inflow and to develop quantifiable relationships among these variables so that policy makers can determine how much ecological change is to be allowed. The SWFWMD is applying the percent-of-flow approach to evaluate alterations of natural streamflow regimes and to determine how much water may be available for supply without causing adverse impacts to estuarine resources.

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SOURCE OF UNPUBLISHED MATERIALS

CHEN, X. C. 2001. Studying hydrodynamics in a riverine estuary by a combination of 2-D and 3-D simulations (abstract). Poster presented at the 16th biennial conference of the Estuarine Research Federation, November 4–8, 2001. St. Petersburg Beach, Florida.

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From:	Sid Flannery
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Subject:	Technical review of the freshwater flow characteritics presented in the Little Manatee River minimum flows report
Date:	Thursday, October 14, 2021 12:31:26 PM
Attachments:	Technical review of Little Manatee River flow characterization from Sid Flannery.pdf Flannery et al. BASIS 2, 1991.pdf Flannery, Peebles and Montgomery (2002) Percent of flow method.pdf

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and District staff,

Attached is my technical review of the material in the minimum flows report for the Little Manatee River that pertains to the freshwater flow characteristics of the river and how they are related to application of the flow-based minimum flows.   I also attached two articles that are referenced in the review.

Would please forward this email and the attached review and articles to the peer review panel for the Little Manatee River minimum flows report via the minimum flows web-board or however.

In a week or so, I plan to submit comments pertaining to the analyses of the estuarine section of the river contained in the minimum flows report. Would you please keep me apprised of all upcoming meetings of the peer review panel.

Thanks very much,
Sid Flannery

Technical review of the description and analysis of the freshwater flow regime of the Little Manatee River presented in the 2021 SWFWMD minimum flows report

Submitted by Sid Flannery, October 14, 2021

The comments contained in this document pertain to the characterization of the freshwater flow regime of the Little Manatee River presented in the current draft minimum flows report for the river. Some of the comments pertain to the discussion of factors that can affect those flows such as land and water use, climate, and permitted surface water withdrawals and discharges. In a week or two, I will submit additional comments related to the response of various biological and water quality variables in the estuarine portion of the river to freshwater inflow.

In the meantime, the comments below are intended to clarify and enhance the material presented in the District's draft minimum flows report so that readers have a better understanding of the flow regime of the Little Manatee River and how it is related to the ecological characteristics of the river and the potential effects of the proposed minimum flows.

The primary consultant, Janicki Environmental Inc. (JEI), has a done a very good job in justifying the use of flow-based blocks, which I strongly support. Also, the method they developed to adjust the gaged flows to develop a baseline flow record is very good and better than the method presented in the first minimum flow report (Hood et al. 2011).

I realize the District wants to produce minimum flows reports that are concise, but for some topics (e.g., the Florida Power and Light withdrawals), I think the hydrologic characterizations presented in the first minimum flows report are more informative than the material presented in the current report. I suggest the review panel read pages 4-1 and 4-6 to 4-32 to in the first minimum flows report. That report is provided as Appendix A with the current minimum flow report, and possibly in some cases the current report could say something like "See Appendix A for further details on …..". In that regard, I preface some my suggested edits with "At a minimum" and suggest the current report make reference to material presented in the first report. I don't think that is the best solution, but the District could go that route on some items to direct readers to the first minimum flows report for more information on a certain topic.

Organization

In several other minimum flows reports including the Lower Alafia, the Pithlachascotee and the Lower Myakka, the section on the baseline flow adjustment was in the same chapter as the hydrologic characterization, which flowed nicely as the baseline adjustment was described after the presentation of historic trends in rainfall, flows, and anthropogenic factors.

On the other hand, in the current report rainfall and flows are discussed in Chapter 2, while the flow blocks and generation of the baseline flow record are in Chapter 5, as was done for the Lower Peace River minimum flows report. I found this a bit hard to follow, but it is workable and suitable the District did it that way. However, for understanding the potential ecological changes that can result from applying the percent-of-flow method, it is helpful to see some other basic hydrologic data reductions such as a bar graph of average monthly flows and a flow duration curve of baseline and observed flows.   Some suggestions in that regard are presented below, along with other edits to the parts of the report that deal the freshwater flow regime of the river.   Another day I will submit comments pertaining to the estuarine results presented in the report.

<u>Suggested edits</u>

Page (P) 18, Lines (L) 4 to 5.   This sentence could shortened and slightly revised to read "Compared to other rivers in the region, flow in the Little Manatee watershed has a relatively high mean runoff rate normalized by contributing area. See page 4-10 in the previous minimum flows report (Apppendix A), where average areal based runoff rates for the Little Manatee are listed along with values for five other rivers."

Regarding the second half of this same sentence on page 18, I don't think the Little Manatee has a moderate to high baseflow fraction compared to other rivers such as the Hillsborough, Alafia and Withlacoochee, which all receive some springflow and other flow from the upper Floridan aquifer.

For example, from the minimum flows report for the Lower Alafia River, which is located about 14 miles north of the Little Manatee, the 10th percentile flow of the Alafia is 16.2% of its mean flow. If flows from Lithia and Buckhorn Springs are added to the gaged flows, the 10th percentile flow for the Alafia is 21.9% of its mean flow. In contrast, the 10th percentile flow for gaged flows on Little Manatee for 1996 to 2019 period (24 cfs) listed on page 144 in the current report is 14.4% of the mean flow (167 cfs) for that period.

Keep in mind the baseflow in the gaged record of the Little Manatee has been supplemented by excess agriculture irrigation water and the mean flow I just cited was not corrected for withdrawals from Florida Power and Light. So, the baseflow fraction for natural flows corrected for agricultural flows and FP&L withdrawals would be even lower. Therefore, I would not characterize the Little Manatee has having a moderate to high baseflow fraction. Simply drop that part of the sentence, which will agree better with the statement two sentences later about flows in the river having spiky behavior and low relatively low surface storage, which is accurate.

P28 – 30. I have reservations about over postulating about the effects of the Atlantic Multidecadal Oscillation (AMO).   In the more recent warm AMO period (Figure 2-12), which is supposed to result in more rainfall, some of the worst multi-year droughts in the region occurred, including the year 2000 and early 2001 and an eight-year period from 2006 to 2013 when yearly rainfall was below normal for seven years (Figure 2-14).   The report says there is not a lot of surface or surficial aquifer storage in the Little Manatee River basin and it responds quickly to rainfall events. In that regard, the time series graph of moving 20 -year average rainfall does not have as much to do with variations in flows the Little Manatee River as it might with rivers with more surface and groundwater storage like Pithlachascotee or the Withlacoochee. A moving average yearly rainfall hydrograph of shorter length would be more appropriate for comparison to flow trends in the Little Manatee.   The previous minimum flows report used a moving three-year average rainfall hydrograph (Figure 4-4 on page 4-6).

P38 Section 2.5 (Little Manatee River Flow History) This section of the current report starts off describing the effect of agriculture on past flows, then follows with two short paragraphs and four hydrographs about the gaged flow record, then turns to a discussion of groundwater flow modeling. I suggest it would be better to start of with a description of the flow record and present the hydrographs and discuss the temporal patterns shown in them, then switch to possible causative factors including the groundwater modeling discussion.

P39. Figure 2-24. This figure plots average yearly flows on a semi-log scale with a fitted polynomial trend line. The range of yearly flows appears to be from about 40 to 400 cfs, which should plot fine on an arithmetic scale and would give the readers a better sense of the natural variation in yearly flows. If the polynomial trend was fitted to log transformed data, the current hydrograph could also be shown, but I think would be helpful to also show the flows on an arithmetic scale (see page 4-1 in the previous minimum flow report).

Monthly flows are plotted on a semi-log scale in Figure 2-25, which is helpful as there is much greater range in values. The report says there appears to be no significant long-term trend in monthly flows, but the occurrence of low monthly flows prior to the mid-1970s seems apparent, which is supported by other findings presented in the report. The report does suggest there appears to be a slight increasing trend in dry season flows (October to May), but not wet season flows. As with Figure 2-24, the time series plots of yearly average dry and set season flows on an arithmetic scale would be valuable.

Though the data end in the year 2010, there are very informative hydrographs and trend tests presented in previous minimum flows report by Hood et al. 2011. Having worked in estuarine ecology, I think the eight-month October to May dry season discussed in the current report is too broad for some ecological applications, and examining trends in other flow parameters can be meaningful from a resource management perspective. On pages 4-22 to 4-29, the previous minimum flows report showed some interesting results for trend tests and hydrographs for various yearly percentile flows, which clearly show a rise in values for the yearly 10th, 25th, and 50th percentile flows starting in the mid-1970s. As concluded in the current report, the previous report found no significant change in the higher flows. However, trend tests on monthly flows showed an increase for the dry season months of November, December, April and May. The previous report also showed hydrographs and trend results for moving average flows for various durations from 3 to 120 days, which clearly showed significant increases in their yearly minimum values (e.g, the lowest 60-day moving average flow within each year).

Frankly, I think it would be valuable to repeat such graphical and trend analyses for key flow parameters in the current report and see what the updated results look like, but will defer to the District. However, at a minimum, the current report should at least refer to some of the findings in the previous report, acknowledging the flow data end in 2010.

In the discussion of the effects of agriculture on flows in the river, the current District report should cite and briefly mention the paper by Flannery et al. (1991). I am not saying this to see my name in lights, but rather this was a very large effort that was funded by grants the District received from the Florida Department of Environmental Protection that involved the District, the University of South Florida, the USGS, and land use mapping specialists from the Florida Marine Research Institute. The USGS installed three new streamflow gages in the watershed and baseflow and runoff rates were compared from six sub-basins. Extensive water quality monitoring was conducted and nutrient loading rates were compared from these sub-basins. Water quality sampling of 21 sites was also conducted in May 1988 and May 1990, which showed where mineralized water of groundwater origin was entering the river.

The current report can qualify that these data were collected when the quantities of excess agricultural water entering the river was near maximum. On page 4-31, the previous District report has a very short paragraph about this study, and in a previous section described that since that report was produced there have been improvements in agricultural water use practices and a reduction in excess irrigation water entering the streams. The current District report provides a good summary of changes in land use and water use efficiency and the plot of residuals from the baseline flow analysis (Figure 5-2 on page 105) is very effective. Overall, the findings of the watershed assessment in the late 1980s supports the District's findings and that paper (Flannery et al. 1991) should be cited and quickly summarized in a short paragraph in the current report. A pdf of that paper is submitted along with this review.

Florida Power and Light

Because they utilize an off-stream reservoir and have long used withdrawal schedules linked flow rates, the FP&L facility has been an example of progressive water resource management. Along with the Peace and Alafia Rivers, ecological results and management applications from the Little Manatee River are featured in the 2002 journal article about the percent-of-flow method (Flannery et al, 2002), which is also submitted with this review.

Having said that, the withdrawal schedule that FP&L now uses will have to be revised to comply with the proposed minimum flows, and the description of their withdrawal schedule in the previous minimum flows report is much more informative than the discussion in the current report. In particular, the frequency that the emergency withdrawal schedule has been used and the quantities that were withdrawn from the river is well described in the previous minimum flows report. Again, the District could update and enhance the discussion of the FP&L withdrawals in the current report, or at a minimum, refer to the previous report (Appendix A) which provides a history of the changes in the diversion schedule and the frequency of use for the emergency schedule, acknowledging those data end in 2009.

At a minimum, the District needs to support their statement on page 44 that FP&L withdrawals have been less in recent years. The previous report listed an average water withdrawal by FP&L of 9.1 cfs for the 1976-2009 period, pointing out that includes the initial filling of the reservoir. The previous report also mentioned this average withdrawal rate was largely driven by the diversion of high flows, as no withdrawals occurred on 71 percent of the days during that period. The District could easily characterize diversions by FPL during recent years, and at an absolute minimum, report an average diversion value for 2010 to 2020.

I was very involved in the re-evaluation and the revision of the FP&L withdrawal schedule, and toward the end of this peer review process, will offer some thoughts on further revision of their schedule to comply with the minimum flows. As a sneak preview, I think it would ecologically counter-productive to restrict FP&L to the 13% and 11% allowable freshwater flow reductions at flows in block 3. Reasons will be presented later, but if the final percent allowable reduction for estuarine minimum flows is greater at high flows, that is what FP&L should be regulated on. Tentative for now, but should be the way to go.

Mosaic land use and diversions

On page 44, the current report has a short paragraph about the permitted discharge by Mosaic Company for their phosphate mining operations and cites a report from 2012 (FDEP, 2012) to support the statement that the discharge has been limited for several years. Clearly, any characterization of discharges from the D-001 outfall needs to be updated.

As with FP&L, a good description of Mosaic's land use and hydrographs and characterization of the discharges for 1996 to 2009 is provided in the previous District report (pages 4-18 to 4-22). That report described why it would be difficult to create a baseline flow record adjusted for these discharges, so that was not done as part of that study. On page 4-20, the previous report shows an excellent map that showed the status of various categories of the Mosaic Company's lands (e.g., mined, reclaimed, preserved) and described the status of these land use categories and the percentages of the river watershed they represented.

In Section 2.2, the current District report generally characterizes extractive land covers, but provides no information on the status of those lands, such as what is currently and previously mined, reclaimed, preserved, or other. The land use maps that are shown have Extractive land use included as part of Urban and Built-Up, but Table 2-1 has the acreages of Extractive separately quantified over time. The previous District report states that Mosaic owns 26% of the Little Manatee River watershed. Given that a quarter of the watershed is owned by a phosphate mining company, it would improve the current District report to provide a more comprehensive update on the status of Mosaic's land holdings and the projections for future mining.

The District could cite the section on phosphate mining in the previous minimum flows report, but qualify that those results and projections are out of date and may no longer apply. At a minimum, the District needs to access the discharge records for the D-001 outfall and present an updated hydrograph and statistics for those discharges.

Nitrogen trends

In Section 3.3.2 (pages 54-56) the current report presents information on concentrations and trends for various forms of nitrogen measured by the Environmental Protection Commission of Hillsborough County (EPCHC). With the exception of organic nitrogen at freshwater station 113 at the Highway 301 bridge, concentrations were either decreasing or showed no trend. These results are encouraging, and it is good that the tidal section of the Little Manatee River has very little hypoxia (low dissolved oxygen concentrations). With regard to chlorophyll *a*, concentrations generally do not indicate impairment, but as will be discussed in the next review I submit, there are periodically very high chlorophyll *a* concentrations in the upper reaches of the tidal river and the potential effects of flow reductions need to be examined further. But that is for another day.

For now, I think it would be useful for the minimum flows to very briefly point out while that nitrogen concentrations have generally been either decreasing or non-trending in recent years, water in the Little Manatee River is nitrogen enriched compared to decades prior to the 1970s. Historical data presented as part of the late 1980s watershed assessment (Flannery et al. 1991) found that nitrate-nitrite concentrations have increased greatly since the mid-1970s, which corresponds to the increase in agricultural land use. The previous minimum flows report also reported an increase in nitrate-nitrite concentrations measured by the USGS, but the data ended in 1999 (pages 5-4 and 5-5). Increases in specific conductance, which are shown in Figure 12 in Flannery et al. (1991) and Figure 4-23 in the previous minimum flows report, show this same temporal trend, indicating the effect of agricultural land and water use on the river.

Also, during the 1988-1989 study period, the phosphate mining operations were largely inactive and the Ft. Lonesome station in the river upper river sub-basin served somewhat as a control site. Nitrogen concentrations and loading rates from that sub-basin were much less than from downstream sub-basins where there was much more agriculture. The point of this is the current minimum flows report could have one or two sentences that say that although nitrogen has been non-trending or decreasing in recent years, historical data indicate the the river is nitrogen enriched compared to before the 1970s (Flannery et al. 1991, Hood et al. 2011)

P 103 – **Excess flows and adjustment of the baseline flow record**.

The consultant (JEI) did a very nice job on the method for adjusting the gaged flows to develop a baseline flow record, which was an improvement over the method used in the previous District report. However, it is interesting the previous peer review panel did not criticize the method for adjusting the baseline record in the first minimum flows report, but they waxed at length about the use of benchmark flow periods. Regardless, the current method for adjusting the gaged flow to come up with baseline flows is very useful and the plot of residuals and the LOESS curve plotted in Figure 5-2 (page 105) is very informative. Also, with regard to benchmark flows issue, that is handled well in Section 6.5 in the current report in which the estuarine fish habitat analyses were conducted over four different multi-year periods.

Figure 5-3 on page 106 in the current District report is interesting in that there are large increases in excess flows during July to September, when irrigation rates are small or not occurring. This likely occurs because the excess irrigation raises water levels in the surficial aquifer, which can persist into the wet season and increase runoff potential. Also, the change from more natural land covers to agriculture can result in greater runoff from rainfall events.

In Figure 5-3 (page 106) the current District report cites the Lower Myakka River minimum flows report (Flannery et al. 2007). However, all the work on the excess flows was done by Interflow Engineering, which was presented and cited in the District's Lower Myakka River report. The current Little Manatee report should cite their work, such as Interflow Engineering LLC (2008 or 2009). Panel member Dr. Loper who conducted that work, can review the District's Lower Myakka minimum flows report and conclude which of the three references for Interflow Engineering cited therein should be used.

Also, the caption for the figure should say agricultural excess flows in the Myakka River, because Interflow also simulated total excess flows from all land use changes. In that regard, since it was based on overall rainfall runoff relationships, the baseline corrections done by Janicki Environmental are for total excess flows, though I suspect the predominant source of the excess flows results from agricultural land and water use.

A few basic graphics of a table to describe the flow regime of the Little Manatee River

The current report could benefit from presenting a few simple graphics and a table to describe the basic streamflow characteristics of the Little Manatee River. Such hydrologic information is important for not only understanding the seasonal and flow duration characteristics of the river, but also for understanding how application of the minimum flows will affect the ecology the river.

A plot of average monthly flows needs to be included to characterize the seasonal flow characteristics of the river. Two figures from page 4-12 in the previous minimum flows report are presented on the following page. This should be updated for the current report. Obviously, the yellow line in the second figure mimics the average monthly flows in the top graphic, but it is helpful to demonstrate how flows are lagged with regard to seasonal rainfall during some months of the year.

Also, as previously described, the Little Manatee River has a relatively high rate of basin runoff, a spikey response to rainfall events, and a relatively low rate of baseflow. These flow characteristics are manifested in the graphs on the following page where the difference in average monthly flows between the spring dry season and late summer flows is among the highest in the region. As will be described later in this review, the springtime dry season is especially important to the ecology of the freshwater river and the estuary and flow reductions must be managed very carefully during that time of year.

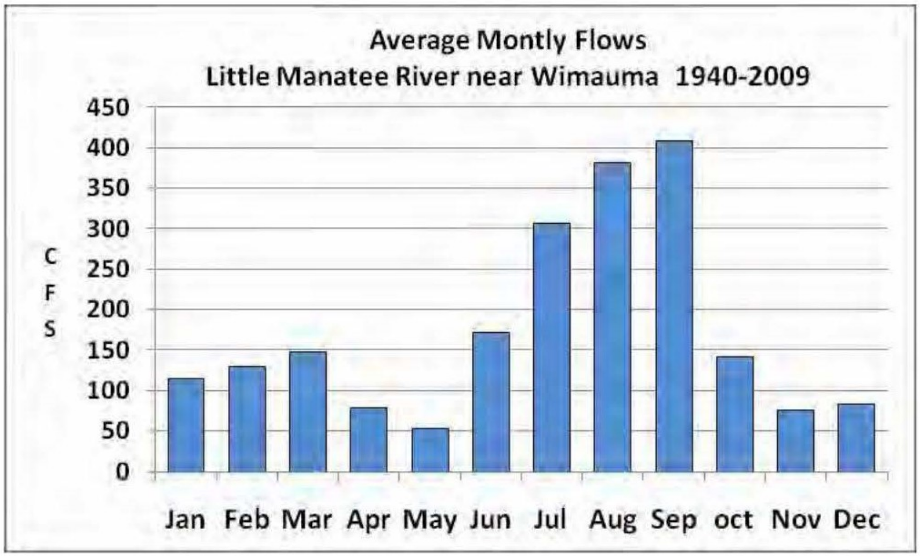


Figure 4-9. Average monthly rates of flow for the Little Manatee River near Wimauma for the years 1940-2009.

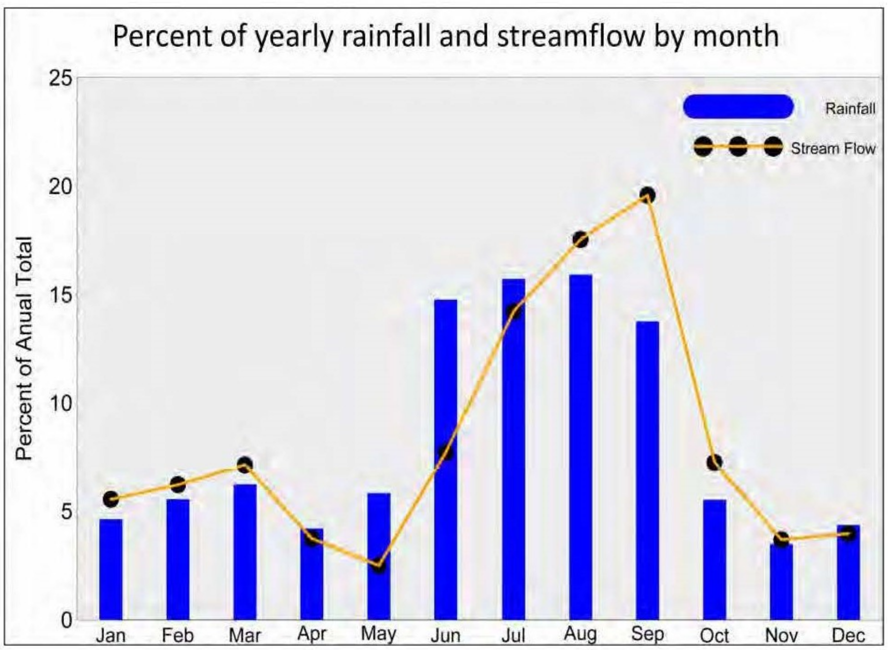


Figure 4-10. The percentage of yearly rainfall and streamflow by month for the Little Manatee River watershed and the LMR Wimauma gage.

4-12

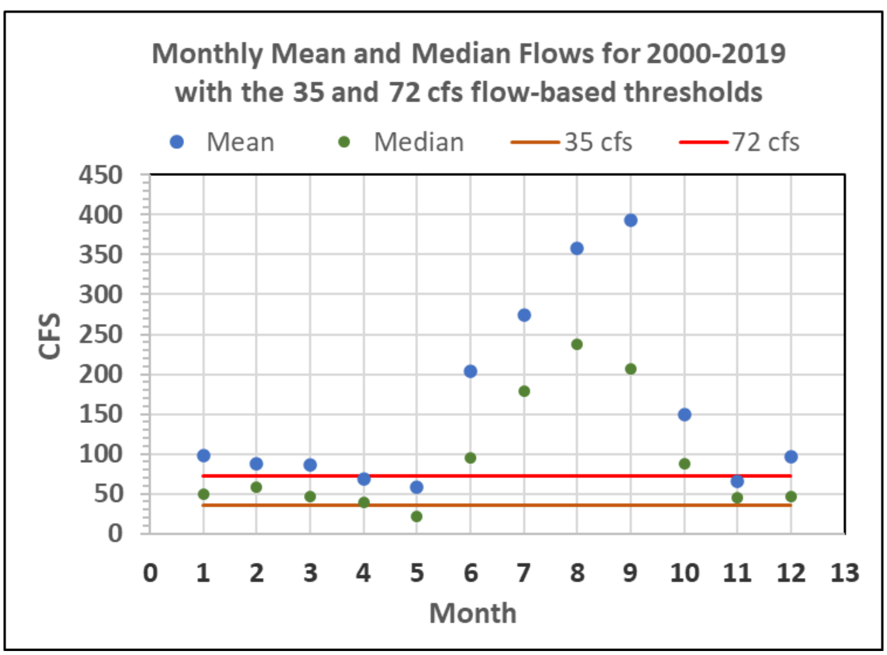
Figures 4-9 and 4-10 from the previous minimum flows report (Hood et al., 2011)

Also, in application of the percent-of-flow method it is very important to understand the seasonal flow duration characteristics of the river, particularly how often the different flow-based blocks will be in effect. In the second paragraph on page 103 the current report states "For reference, 35 cfs is the 34th non-exceedance percentile and 72 cfs is the 60th non-exceedance percentile." This is one of the most important findings in the report, and in general, the amounts of time that flows will be within the various flow-based blocks needs more description and emphasis in the report.

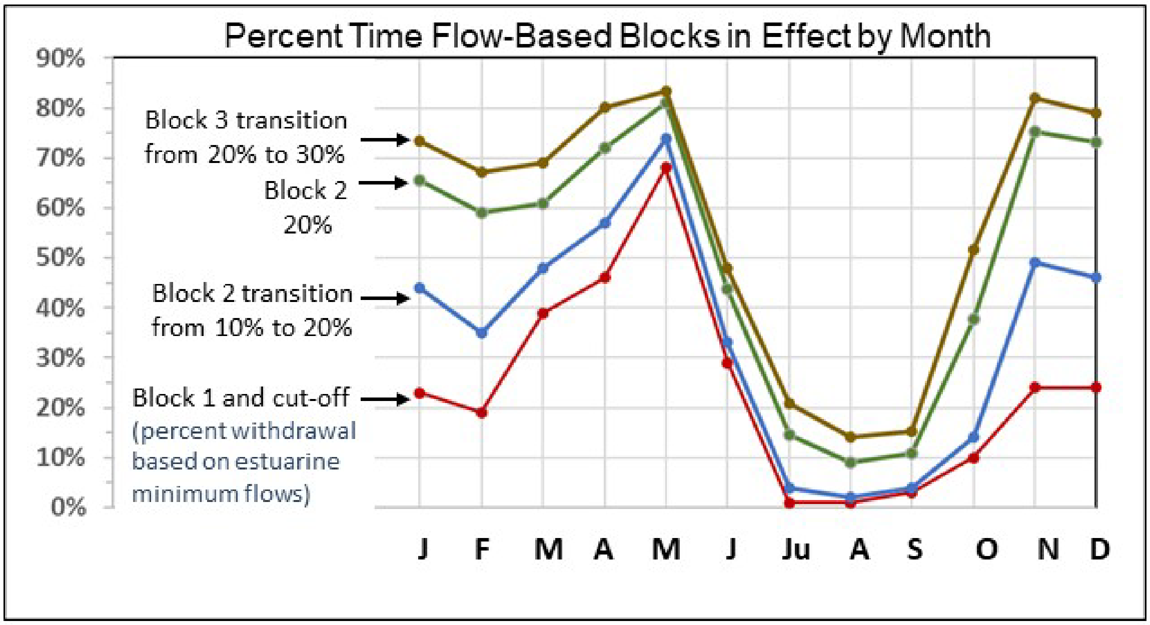
As part of such a description, it would be also helpful to see present a flow duration curve (cumulative distribution function) for the baseline and uncorrected flows for the 1976 to recent period. Both data sets should include corrections for FP&L withdrawals from the river. Also, various percentiles from these two flow records could listed in in a table, as in Table 2 in the first peer review report (Appendix B) or Table 4-2 (page 4-11) in the previous minimum flows report. The current report does show a flow duration curve and some percentile flows for the unadjusted flows at the USGS streamflow gage for four different time periods, but a similar table for baseline and observed flows together would be helpful.

Also, this critical hydrologic information is included in the Sections 5 and 6 of the report. It is probably too late now, but reorganization of the report to put the hydrologic characterization, including the adjustment for baseline flows, in Chapter 2 would be helpful, from where it could be referred to as needed later in the report.

Although flow durations for the entire period of analysis are important, it also useful to see how the flow-based blocks correspond to different seasons in the year. The 35 cfs threshold between blocks 1 and 2 and the 72 cfs threshold between blocks 2 and 3 are show in the figure below along with the average and median flows for each month for a recent 20-year period. It is apparent there are very large differences between months in how frequently flows in the river will be within the different flow-based flows, which has important implications for the ecological effects of the minimum flows.



The figure below shows how often the flow-based blocks would be in effect on a monthly basis. Note that lines are included for the transition between blocks 1 and 2 and between blocks 2 and 3. This is because the full percentage flow reduction for a given block cannot be achieved until flows get to a certain flow rate. For example, using the proposed minimum flows for the estuarine lower river, a 30% flow reduction at 77 cfs in block 3 would result in less flow than a 20% flow reduction at 70 cfs in block 2. Therefore, minimum flows rules typically provide for a transition range between blocks. This operations plan is feasible and is how water user permits for withdrawals from rivers using the percent-of-flow method are currently managed, as the utilities know for each rate of daily flow the amount they can withdraw.



The region below each line is the percent of time that flow reduction, or a lesser flow reduction, will be in effect. For example, in January flows are less than the block 1 cutoff 35 cfs threshold 23 percent of the time. Flows are in the block 2 transition 21 percent of the time, which is the difference between the blue and red lines (44% and 23%, respectively). Full block 2 flow reductions for January will be in effect of 22 percent of the time (66% minus 44%). Flows are fully in block three above the brown line, or 100 percent minus the value of the brown line, which would be 27% of the time (100% – 73%) for January.

Given the large differences in seasonal flows, it is striking how often the different flow blocks will be in effect in the various months. On average, flows are below the 35 cfs low flow cutoff 68% of the time in May, but only 3% of the time in September. Conversely, flows are in block 3 for 85% of the time in September. However, it is emphasized that these are average conditions over 20 years, and flows can be above or below a given threshold for longer periods of time in a specific year.

Seasons are still relevant

As previously described in this review and the document I submitted on October 6th, the District has gone to flow-based blocks for both the freshwater and estuarine reaches of the river. This is a first, for the District has previously used seasonal blocks for freshwater systems.

I support this approach, but emphasize the District continue to consider seasonal factors in their minimum flows analyses. I was not involved in the earlier PHABSIM evaluations of for freshwater systems, but apparently some freshwater fish species have a strong seasonal component to their reproductive cycles and habitat use patterns.

There are also strong seasonal factors in estuaries, with two figures shown below as examples. It has been repeatedly shown in tidal rivers, with and example shown for the Lower Alafia, that the number of larval fish taxa increases rapidly in the spring due to seasonal fish spawning. Based on estuarine considerations, the journal article by Flannery et al. (2002) suggested that flow reductions should be most restrictive in the spring (article submitted with this review). On the other hand, as shown below, the migration of red drum juveniles into the Little Manatee River occurs in the fall and winter (from MacDonald et al. 2007 cited in the current minimum flows report).

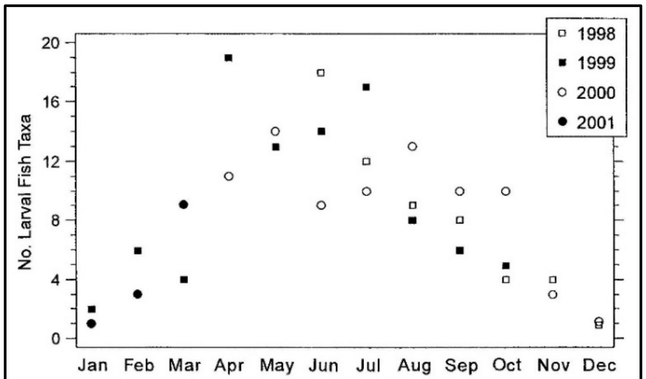
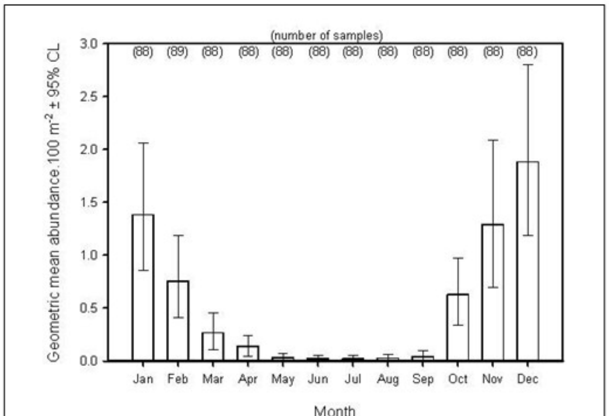


Fig. 9. The seasonal distribution of approximate larval richness in the tidal Alafia River (data from Peebles 2002a).



Red drum, all size classes (primarily juveniles)

Seasonal factors are also important for water quality in estuaries, as hypoxia is often most frequent in the summer during times of high water temperatures. Similarly, low flows and increasing water temperatures often contribute to large phytoplankton blooms in the spring.

All things considered, I think the flow-based approach proposed for the Little Manatee River is appropriate for the tidal portion of the river, in part because using the percent-of-flow method withdrawals in the springtime will be very low. However, as I recommended in the review submitted on October 6th, I strongly recommend that flow-based blocks be evaluated separately for the freshwater and estuarine sections of the river.

I also think the flow-based approach has important advantages for the freshwater section of the river, but I have not worked on the freshwater biological communities in the river and I defer to the District and the review panel. However, for both freshwater and estuarine systems, I suggest the District continue to evaluate seasonal factors and incorporate them in the minimum flows as needed.

Summary Points

- For some topics, the previous minimum flows report is very informative and the current report should refer to it, although it would be better to repeat those analyses or presentations
- It is probably too late, but the report could be reorganized to put the method for baseline flow creation and flow duration characteristics in Chapter 2 with the other hydrologic information
- The differences between seasonal low and high flows in the Little Manatee are among the highest in the region, so it should not be characterized as having moderate to high baseflow
- The discussion of the AMO has less relevance to the Little Manatee than some other rivers
- Chapter 2 should be slightly reorganized to present the flow hydrographs first, then discuss possible causative factors
- Some time series plots of flows on semi-log scale should be changed to an arithmetic scale
- Some of the trend analyses for flow parameters presented in the first minimum flows report should be repeated or as least referred to
- The report should reference the watershed assessment done by the District in the late 1980s as it was a very large effort that supports the District's current findings regarding flows in the river
- The description of Florida Power and Light's withdrawals from the river should be expanded, or at least refer to the previous District report and list an average withdrawal rate since 2010
- The description of the current status of Mosaic Company's land holdings and rates of outfall discharge should be expanded, or least refer to the previous District report and update the discharge records at the outfall
- The report should acknowledge that while water quality trends in recent years are encouraging, the Little Manatee River is nitrogen enriched compared to decades prior to the 1970s
- The report should cite Interflow Engineering regarding excess flows in the Myakka River
- The report should include some graphs of the basic hydrologic characteristics of the Little Manatee and a flow duration curve and table of percentiles for observed and baseline flows.
- The report should describe how often flows will be within the various flow blocks by month or season
- Seasons are important for biological use of both the freshwater and estuarine sections of rivers. The District should continue to evaluate seasonal relationships in their minimum flows analyses and incorporate seasonal factors in proposed minimum flow rules as necessary
- The flow-based blocks seem to work well for the Little Manatee River, in part because the resulting maximum allowable flow reductions will be small in the springtime.
- The District should establish flow-based blocks separately for the freshwater and estuarine sections of the Little Manatee River

Overview of selected technical reports about the Little Manatee River and suggested text, figures, or tables for the District's minimum flows report

Prepared by Sid Flannery, October 19, 2021

This document provides an overview of technical reports about the Lower Little Manatee River that were prepared for the District by staff from the State University System, the Florida Marine Research Institute, or Mote Marine Laboratory. I have also prepared paragraphs or single pages of text that include a figure or table that can be inserted into the minimum flows report to present findings from these reports that describe important relationships of the lower river to freshwater inflows.

These findings support the technical basis for the recommended minimum flows and provide valuable information on the physical, chemical and biological characteristics of the Little Manatee River. As described in the 2002 paper in the journal *Estuaries*, the Little Manatee was one of the three rivers on which the development of the percent-of-flow approach for minimum flows was initially based (Flannery et al. 2002). Furthermore, the tidal reach of the Little Manatee River is a State of Florida Aquatic Preserve and one of the most valued natural resources in the Tampa Bay region. As such, it would be beneficial for the report to briefly describe its biological characteristics, especially as they relate to freshwater inflows that will be affected by the proposed minimum flow rules.

1.1 Overview of Phytoplankton Reports

Dr. Gabriel Vargo of the USF College of Marine Science published two reports for the District about phytoplankton related parameters in the Little Manatee River based on just over two years of sampling from December 1987 to January 2000 (Vargo, 1989, 1991). In a separate report, he compared these data to phytoplankton related data collected from the Lower Peace and Alafia Rivers that used a similar salinity based sampling design (Vargo et al. 2004). None of these three reports are currently cited in the draft minimum flows report, but it does cite a paper that Dr. Vargo submitted to the proceedings of the BASIS 2 conference (Vargo et al. 1991).

Combined, these three reports are very informative about the relationships of different salinity zones to phytoplankton related parameters in tidal rivers, particularly the unusual characteristic of the Little Manatee in which the highest phytoplankton counts and chlorophyll *a* concentrations typically occur at the interface of fresh and brackish waters (0.5 psu), compared to other rivers where the highest phytoplankton counts and chlorophyll *a* concentrations typically occur in mesohaline waters.

In a week or so, I will present data that indicate that relationships of chlorophyll *a* to the rate of freshwater inflow and residence time in the lower river could be important to determining flow thresholds to switch between low, medium, and high minimum flow blocks for the estuarine section of the Little Manatee.

References for the three phytoplankton reports are below, including brief overviews of that work. This is followed text on page 4 that I suggest be inserted into the minimum flows report regarding the phytoplankton work on the Little Manatee River.

Vargo, G.A. 1989. Phytoplankton Studies in the Little Manatee River: Species Composition, Biomass, and Nutrient Effects on Primary Production. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

> Nutrients, chlorophyll *a*, and primary production were monitored on a bi-weekly basis for one year at four moving salinity based stations in the Little Manatee River and two fixed location stations; one near the mouth of the river in Tampa Bay and one in Ruskin Inlet, an urbanized inlet to the middle reaches of the Little Manatee River estuary. Among the salinity based stations, mean chlorophyll *a* and primary production rates were greatest at the 0.5 psu station and lowest at the 18 psu station. The Little Manatee has very low N:P rations due to high inorganic phosphorus concentrations in the river water.

Vargo, G.A. 1991. Phytoplankton studies in the Little Manatee River and Tampa Bay: Species Composition, Size Fractionated Chlorophyll, Primary Production, and Nitrogen Enrichment Studies. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

> During the second year of a two-year study of phytoplankton populations in the Little Manatee River and adjacent waters of Tampa Bay, nutrients, size fractionated values for chlorophyll *a* and primary production rates were monitored monthly at a moving 12 psu salinity station in the river and a fixed location station in Tampa Bay. Phytoplankton populations were found to be nutrient sufficient or borderline nitrogen limited with respect to short-term photosynthesis, but long-term growth and biomass were clearly nitrogen limited based on bioassays of natural populations.

Vargo, G.A., M.B. McNeely and R. Montgomery. 2004. An Investigation of Relationships Between Phytoplankton Populations, Water Quality Parameters, and Freshwater Inflows in Three Tidal Rivers in West-Central Florida. Report of the University of South Florida College of Marine Science prepared for the Southwest Florida Water Management District.

> Phytoplankton populations, nutrients and chlorophyll *a* concentrations were compared from similar, salinity based sampling designs in the Lower Alafia, Peace, and Little Manatee Rivers. Samples were collected on at least a monthly basis at the locations 0.5, 6, 12, and 18 psu surface salinity values in each river, with exception of the location of 20 psu being sampled in the Peace River. Mean phytoplankton counts were highest at the 12 psu station in the Alafia, the 6 psu station in the Peace, and the 0.5 psu station in the Little Manatee (see figure on next page). Phytoplankton counts were frequently an order of magnitude higher in the Alafia compared to the other rivers, presumably due to high nutrient loading from that watershed. In the figure on the next page, note separate axis for the Alafia River, which is an order of magnitude greater.

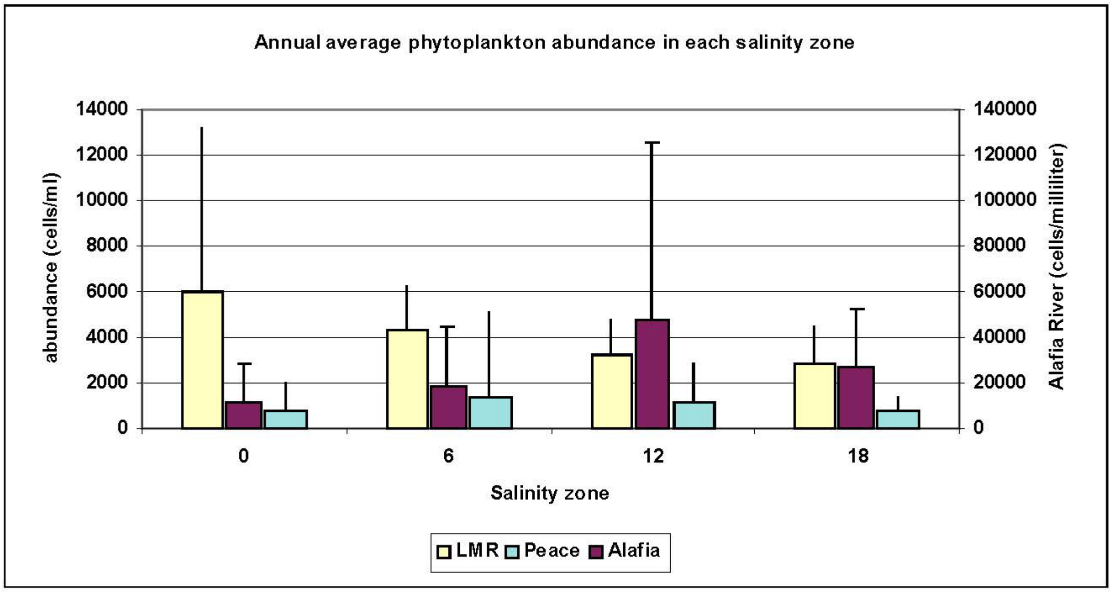


Figure X. Annual average phytoplankton abundance in the Little Manatee, Peace, and Alafia Rivers by salinity zone (20 psu for the Peace grouped with 18 psu). The Alafia is shown on a separate axis since the counts are an order of magnitude greater than the other rivers. From Vargo et al. (2004)

Mean values for chlorophyll *a* concentrations during the phytoplankton sampling periods for these rivers are listed on the following page. The much higher chlorophyll concentrations in the Alafia River are apparent, especially in mesohaline waters. Similar to the phytoplankton count data, the pattern for high chlorophyll *a* in the very low salinity zone (0.5 psu) in the Little Manatee River is again apparent, as are the high concentrations in the mesohaline zones for the Peace and Alafia. Although cell counts are higher in the mesohaline zone in the Little Manatee than in the Peace, chlorophyll *a* concentrations were higher in the Peace due to differences in the species composition of the phytoplankton between the rivers.

Comment - I think that differences in residence time for the Little Manatee contribute to it having its highest phytoplankton abundance and chlorophyll *a* concentrations at the 0.5 psu zone. The upper reaches of the Little Manatee are braided, and given the smaller rates of freshwater inflow, water moves more slowly through the tidal freshwater and oligohaline zones of the Little Manatee compared to the other rivers. All of these rivers (Peace, Alafia and Little Manatee) have residence time values that were generated from hydrodynamic model simulations.

Suggested page for phytoplankton. I think the Little Manatee minimum flows report could contain one page that ties the findings from these reports together. As an example, I have prepared three paragraphs and a table on the following page.

1.2 Phytoplankton (suggested text)

Based on just over two years of sampling spanning 1988 and 1989, the University of South Florida College of Marine Science produced two reports describing phytoplankton related parameters in the tidal reaches of the Little Manatee River and a nearby station in Tampa Bay (Vargo 1989, 1991). Data for nutrients, light penetration, chlorophyll *a*, phytoplankton species composition and primary production rates were measured at four moving salinity-based stations in the river and a fixed location station near the mouth of the river in Tampa Bay (Vargo 1989). Nutrient concentrations in the Little Manatee were characterized by very low nitrogen/phosphorus ratios (generally less than 2) due to high phosphorus concentrations in the inflowing river water. The second of these reports concluded that increased nitrogen loading could result in increased algal biomass and eutrophication in the tidal river (Vargo 1991).

In a subsequent report, (Vargo et al. 2004) compared data from the Little Manatee to phytoplankton related data collected in the Lower Peace and Alafia Rivers that were collected using a similar moving salinity-based design. The highest phytoplankton counts and chlorophyll *a* concentrations typically occurred at the interface of fresh and brackish waters (0.5 psu salinity) in the Little Manatee, whereas the highest cell counts and chlorophyll *a* concentrations typically occurred in mesohaline waters (6 and 12 psu salinity) in the Peace and Alafia (Table x). Using a separate data set for the Alafia, Vargo et al. (1991) compared chlorophyll *a* concentrations and primary production rates for the Little Manatee, the Alafia, and a nearby station in Tampa Bay.

Table X. Means, number of observations (N) and periods of data collection for chlorophyll *a* concentrations at four moving salinity-based stations in the tidal reaches of the Little Manatee, Peace, and Alafia Rivers, adapted from Vargo et al. (2004).

		Salinity-based stations			
	N	**0.5 psu**	**6 psu**	**12 psu**	**18 psu or 20 psu (Peace only)**
		Chlorophyll a (µg/l)			
Little Manatee (12/87 - 01/90)	36	20.5	13.7	8.5	4.0
Peace - same time period as Little Manatee	24	8.9	22.1	31.5	7.9
Peace - same time period as Alafia	36	6.3	23.4	22.6	15.2
Alafia (01/99 - 12/01)	36	15.3	63.4	95.7	43.7

The high chlorophyll *a* concentrations at the freshwater/brackish water interface in the Little Manatee may be related to comparatively long residence times there, which were simulated as part of the development of the hydrodynamic EFDC model for the river (Huang and Liu 2007, Huang et al. 2010, 2011). These comparatively long residence times are related to the braided morphology of the river between kilometers 12 and 16, where the water slows compared to the upstream freshwater reach. These findings and data presented in this report indicate chlorophyll *a* concentrations in the upper reaches of the tidal river could be sensitive to the effects of freshwater flow reductions.

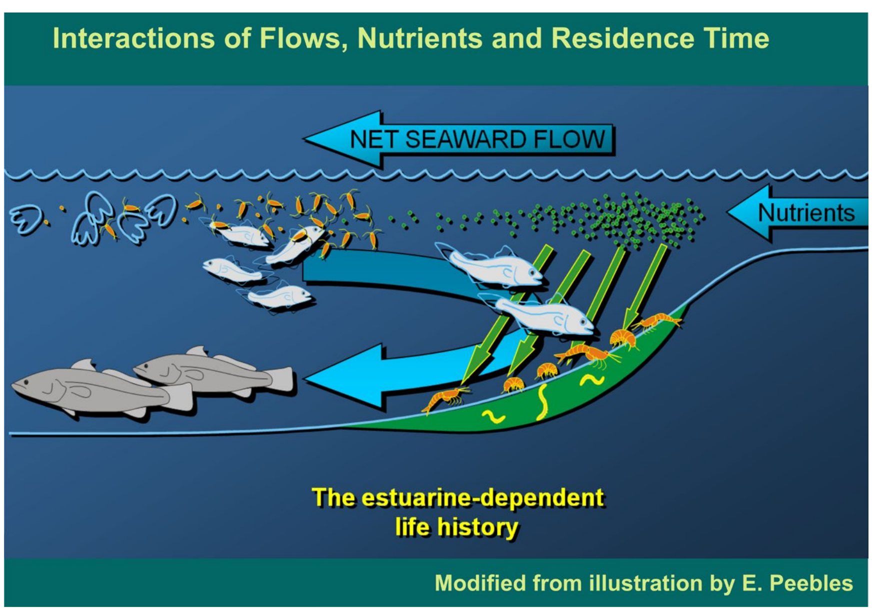
2.1 Overview – Zooplankton Report

Zooplankton were sampled in the estuarine section of the Little Manatee River during 1988 and 1989 concurrently at the same stations as the ichthyoplankton work performed by Dr. Ernst Peebles. Five stations were sampled ranging from the mouth of the river to kilometer 14.2, with another station located at a nearby site in Tampa Bay. The second of these two reports is the more comprehensive of the two and should be briefly described in the District report.

Rast, J.R. and T. L. Hopkins. 1989. The Zooplankton of the Little Manatee River Estuary, Florida. First yearly report. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Rast, J.P., M.E. Flock, T. T. Sutton and T. L. Hopkins. 1991. The Zooplankton of the Little Manatee River Estuary: Species Composition, Distribution, and Relationships with Salinity and Freshwater Discharge. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

In contrast to fish and benthic macroinvertebrate studies, which have been conducted in many rivers, this is the only true zooplankton study in the region's tidal rivers and it is very informative. The second report describes the abundance and distribution of zooplankton, which for many species are more abundant in the lower reaches of the tidal river. Following the tidal river engine concept developed by Peebles (illustration below), this is where the larval stages of many fishes are concentrated early in their life history when they feed on zooplankton. As they grow to juveniles, these fishes migrate to lower salinity waters and feed more on benthic oriented prey. See the illustration below, all evidence I've seen indicates this conceptual model is generally true.



The abundance of zooplankton in higher salinity waters in the lower river probably also results in increased grazing of phytoplankton and contributes to the tendency for chlorophyll *a* concentrations to be lower and more stable near the mouth of the river. Conversely, ungrazed phytoplankton blooms in lower salinity waters probably results in more deposition (see illustration).

The District minimum flows report could briefly summarize the zooplankton study. Along with one table, this would fit on one page and not substantially affect the pagination of the report. Suggested text for a brief discussion of the zooplankton is provided on the following page

Go to next page

2.2 Zooplankton (Suggested text)

Zooplankton in the Lower Little Manatee River were studied during 1988 and 1989 by the University of South Florida College of Marine Science (Rast et al. 1991). These data were collected concurrently with the ichthyoplankton work in the lower river (Peebles and Flannery, 1992), at the same five locations that ranged from kilometers 0 to 14.2, plus a nearby station in Tampa Bay. This project provides valuable information for the abundance and distribution of major zooplankton groups in the lower river, including; holoplankton (entire life cycle in the water column), meroplankton (in the water column for only a portion of their life cycle), tychoplankton (swept off of the river bottom) and hypoplankton (swim off the bottom for a limited amount of time).

Average values for the abundance and estimated biomass of these zooplankton groups are listed in Table X. Holoplankton and meroplankton had their highest values and biomass near the mouth of the river and Tampa Bay, whereas combined tycho-hypoplankton had highest values in the middle and upper parts of the lower river (year 1 only as two stations were discontinued in year 2).

Table X. Average density (numbers/m3) and biomass (in parentheses as mg dry weight/m3) for total holoplankton, meroplankton and tycho-hypoplankton for 25 trips from 1/29/88 – 1/31/89

	Bay or River Kilometer					
	Tampa Bay	**0.0**	**3.8**	**7.1**	**10.3**	**14.3**
Holoplankton	309,000 (147.7)	235,000 (87.6)	177,000 (44.5)	150,000 (34.4)	84,300 (15.1)	29,700 (5.7)
Meroplankton	40,900 (23.8)	12,000 (6.5)	4,350 (3.9)	3,540 (1.7)	4,220 (3.6)	1,490 (1.0)
Tycho-hypoplankton	1,520 (3.7)	1,290 (3.5)	1,390 (22.6)	5,820 (11.3)	4,590 (12.7)	1,530 (3.1)

Zooplankton are very important prey for the early life stages of many fishes, and their abundance in the river is important to the nursery function provided for many estuarine dependent fish species. Based on 48 total samples, the report by Rast et al. (1991) provided informative plots of zooplankton density versus salinity and the rate of freshwater inflow for eleven dominant species or taxonomic groups (e.g., *Acartia tonsa*, *Oithona colcarva,* copepod nauplii, polychaete larvae).

The numbers and biomass of the major zooplankton groups were were also plotted vs. salinity and freshwater inflow at the five stations in the river and Tampa Bay. The response of the different species or groups to inflow and salinity differed, with the abundance of several taxa or groups associated with the lower part of the river increasing upstream with decreased freshwater inflow. On the other hand, benthic harpacticoid copepods maintained relatively high abundance in the upper river stations except for very high flow events. In general, this project provides very useful information on how zooplankton species and communities respond to changes in salinity and freshwater inflow, which can affect fish nursery use of the lower river and is related to the establishment of minimum flows.

3.1 Overview – Mollusk Report

Dr. Ernest Estevez of Mote Marine Laboratory performed a field intensive survey of the distribution of mollusks in subtidal and intertidal habitats in the Little Manatee River during August 2006. The draft minimum flows report has one sentence on page 78 that cites Estevez (2006) and states this work was performed, but mentions no findings from the study.

The minimum flows report should provide one table and a brief description of the findings of the Mote study for three reasons. First, the mollusk communities show clear gradients with regard to salinity in the river, which supports the District's use of salinity as a parameter for determining the minimum flows. Secondly, the report describes the distribution of oyster bars in the river, which are important for shoreline stability, improving water quality, and creating habitat for reef associated fauna in the tidal river. Lastly, as previously discussed, the Lower Little Manatee River is an aquatic preserve and the District report should describe the biological communities of the lower river, especially as they relate to freshwater inflows and the determination of minimum flows.

Based on mollusk studies conducted within the District, noted invertebrate biologist Dr. Paul Montagna of Texas A&M University was the senior author of the journal article below that assessed the relationship of salinity to the distribution of mollusk species in tidal creeks and rivers in the region. This study can also be cited along with a discussion of the Mote Marine Study.

> Montagna, P. A., E. D. Estevez, T. A. Palmer and M. S. Flannery. 2008. Meta-analysis of the relationship between salinity and molluscs in tidal river estuaries of southwest Florida, U.S.A. *American Malacological Bulletin* 24:101-115.

Two short paragraphs about the Mote study and Montagna et al. findings are provided on the following page, including one figure. I suggest that this text or something similar, including the figure, be included in minimum flows report to enhance the biological information presented for the river and provide additional support of the recommended minimum flows

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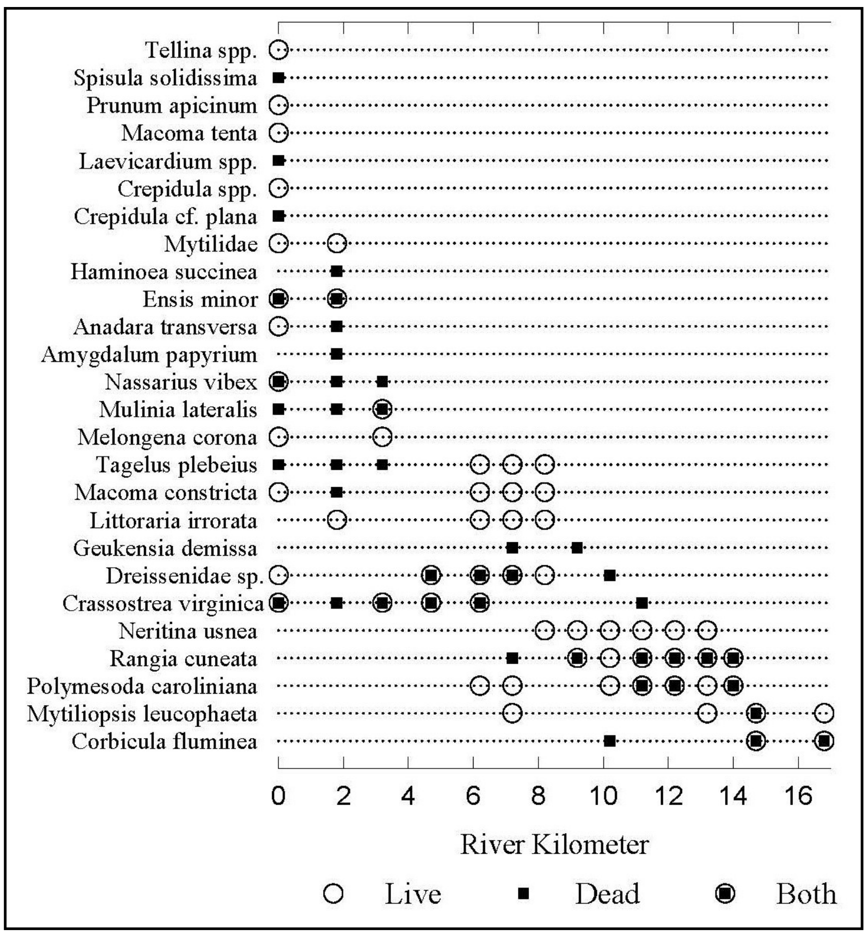
3.2 Mollusks (Suggested Text)

In August of 2006, Dr. Ernest Estevez of Mote Marine Laboratory performed a survey of the distribution of mollusk species in subtidal and intertidal habitats in the Lower Little Manatee River that identified both live mollusks and dead mollusk material (Estevez 2006). Sampling transects were established at 15 locations in the river ranging between river kilometers 0.4 and 16.8 In addition to their presence within the sampling transects, the distribution of oysters in the river was visually described, with large oyster reefs most conspicuous between kilometers 3 and 5 and in the back bays. Smaller oyster reefs with mostly dead material were near the river mouth, with small reefs widely distributed upstream to near kilometer 11, where only dead material was found.

A total of 26 mollusk species or taxa were found (Table x), which is similar to the species richness found using similar methods in other tidal rivers in the District. Mollusk species showed district distributional patterns in relation to salinity gradients in the lower river. In a study of mollusk communities from eleven tidal tributary systems within the District, Montagna et al. (2008) found that salinity was the primary factor affecting the distribution and species composition of mollusk communities.

Table X. Distribution of mollusk species vs. kilometer in the Little Manatee River, including subtidal and intertidal samples with live mollusks and dead mollusk material, from Estevez (2006).



4.1 Overview – Vegetation in the lower river floodplain.

Section 4.1.2 in the draft minimum flows report describes vegetation communities along the tidal reach of the Lower Little Manatee River. The first sentence in the section says that estuarine conditions extend 15 miles (24 kilometers) upstream from the river mouth, but that is incorrect. Based on extensive field work, Peebles and Flannery (1992) report that brackish waters (>1 psu) typically do not extend farther than 16 to 18 kilometers upstream. Also, as described on page 17 in the minimum flows report, minor tidal fluctuations in water levels can sometimes occur about 1 kilometer upstream of the US 301 bridge, but brackish water does not extend nearly that far.

The description of vegetation communities in the river on pages 69 and 70 in the draft report is pretty good and it references the previous minimum flows report from 2011 (Hood et al. Appendix A). Such a description may be in Hood et al., but I ran out of time and could not find such a discussion in that report which focuses on the freshwater section of the river. However, other reports that can be cited that describe vegetation along the lower river (Peebles and Flannery 1992, Clewell et al. 2002).

Most importantly, vegetation communities along the tidal reach of the Little Manatee River were mapped by the Florida Marine Research Institute (FMRI 1997), with reference the given below. This study focused on five tidal rivers including the Little Manatee. Ground truthing was conducted on the Little Manatee and the report contains a very detailed map of vegetation communities along the river and a discussion of the distribution of plant species and communities.

> Florida Marine Research Institute. 1997. Development of GIS-based vegetation maps for the tidal reaches of five gulf coast rivers. Report prepared by the Florida Department of Environmental Protection Florida Marine Research Institute for the Southwest Florida Water Management District.

I showed a slide of the vegetation map from this project at the kick-off meeting of the peer review panel on October 5th. I strongly recommend the minimum flows report include the FMRI map and the cite the report that produced it, at it is much more detailed than the FLUCCS vegetation map shown in the draft report. In that regard, it better supports the District's recommended minimum flows that are based on the maintenance of low salinity habitats. The aerial photography on which the FMRI map is based was taken in 1990, but from my frequent trips on the river it does not appear that vegetation in this part of the river had changed or been altered significantly since that time.

If the District prefers, it could still include the FLUUCS map shown on page 70, but also present the more detailed FMRI map. The report could qualify that map was based on photography from 1990, but it is unlikely that vegetation in this section of the river has changed significantly since that time. This map is impressive and I suggest it be displayed full page with landscape orientation as shown on the following page. This would follow nicely the discussion on pages 69 to 71 in the draft minimum flows report. That discussion could possibly be slightly improved in a second round of edits, but getting the FMRI map and citation in the minimum flows report is very important, in no small part because he District should highlight the excellent work it has funded.

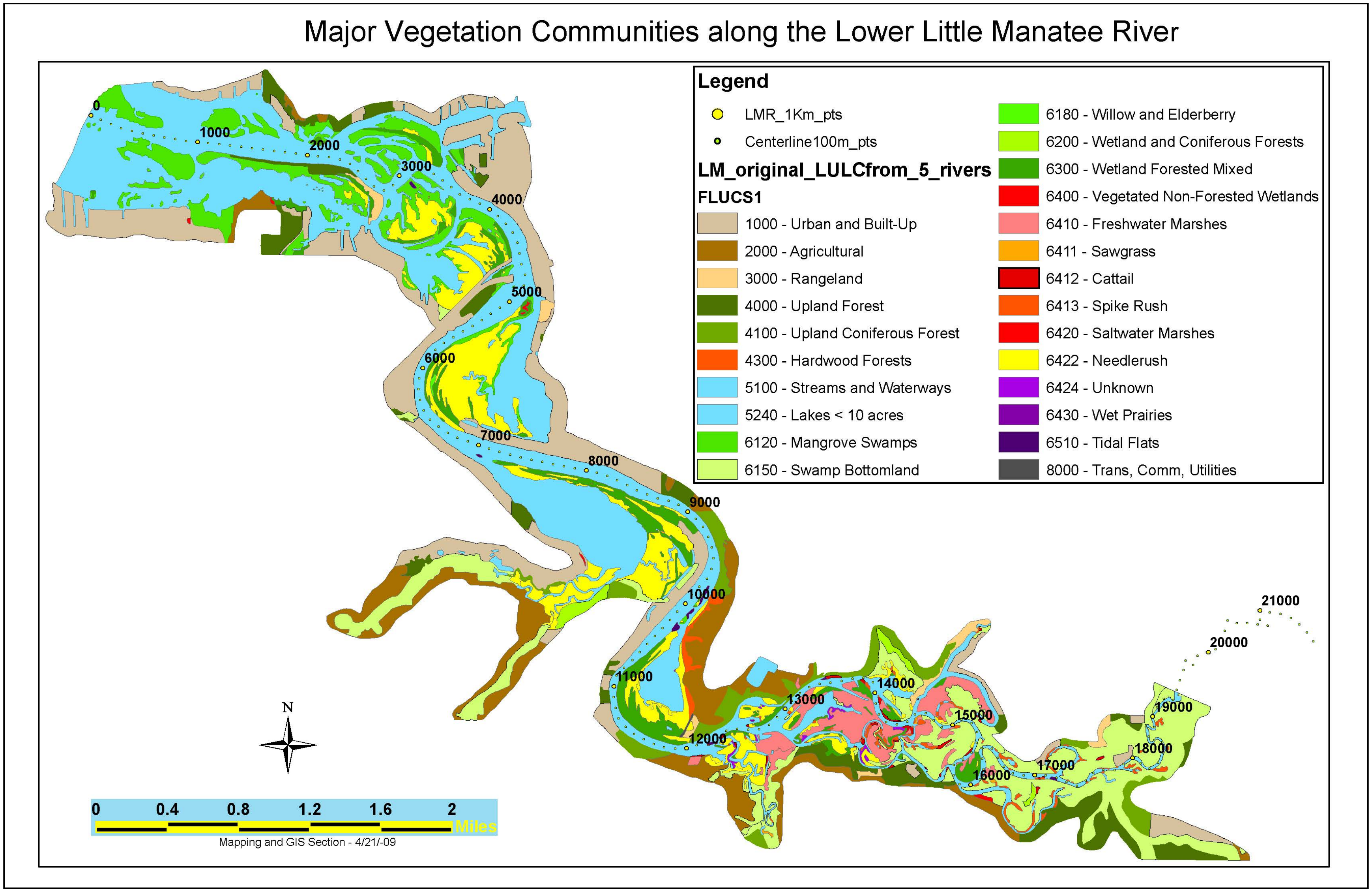


Figure X. Major vegetation communities along the Little Manatee Rive from FMRI (1997), with channel distances in meters.

5.1 Overview - Residence time analyses

In Section 5.4.5 the draft minimum flows report has a good description of EFDC hydrodynamic model for the Lower Little Manatee River that was developed by faculty and staff from FSU (Huang and Liu 2007). As in other tidal rivers (Alafia, Myakka, Lower Peace), model simulations of changes in salinity were a key analytical approach used to determine the minimum flows.

What the minimum flows report does not describe is that this project also included residence time simulations for the lower that were described in the project report (Huang and Liu 2007). This was pursued because the earlier minimum flows analyses for the Lower Alafia River found relationships between residence time (as water age) and very high chlorophyll *a* concentrations in sections of that tidal river. Since then, the District has made a point of having residence time simulations performed for tidal rivers, including the Lower Peace and the Little Manatee.

The project by Huang and Liu simulated residence time as Estuarine Residence Time (ERT) and Pulse Residence Time (PRT), with values of water age at ten locations in the tidal river used to calculate PRT at those locations. Two journal articles concerning residence time in the Little Manatee were also produced from this work (Huang et al. 2020, 2011), for which references are listed below.

Huang, W., X. Liu, X. Chen and M. S. Flannery. 2010. Estimating river flow effects on water ages by hydrodynamic modeling in the Little Manatee River estuary. *Journal of Environmental Fluid Mechanics* 10(1-2):197-211.

Huang, W., X. Liu, X. Chen and M. S. Flannery. 2011. Critical flow for water management in a shallow tidal river based on estuarine residence time. *Water Resources Management* 25(10): 2367-2385.

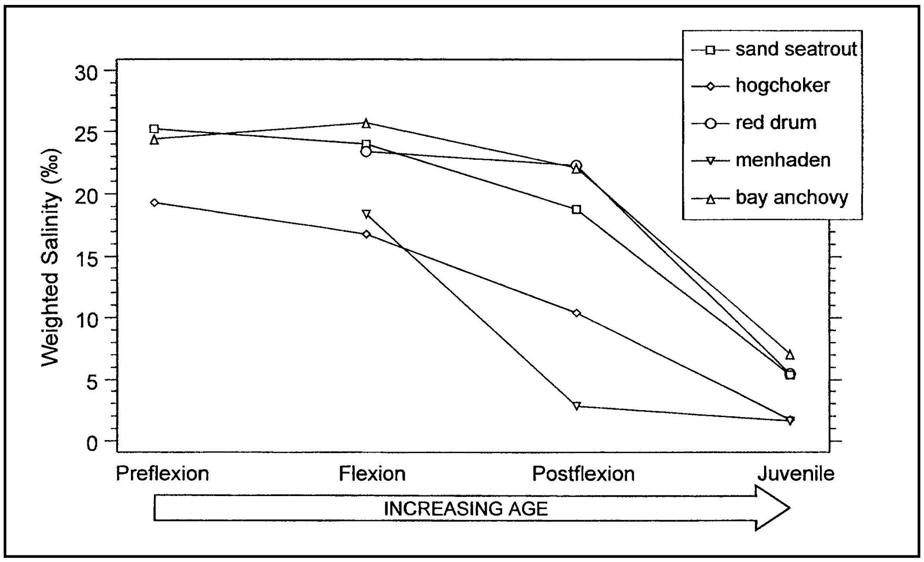
In comments I will submit in a week or so, I will recommend that further analyses be performed to evaluate flow thresholds for switching between low, medium, and high flow blocks specific to the lower river. At present, the thresholds for the flow blocks for the estuarine section of the river were based solely on freshwater analyses, which the District has never done before. This is probably not the best approach and needs to be addressed with additional analyses specific to the lower river.

In that regard, I think that examination of residence time as a function of freshwater inflow needs to be conducted, including evaluating the effects of various flow reductions on residence time. Next week, I will present some information concerning residence time (as water age) and the occurrence of high chlorophyll *a* concentrations in some segments of the tidal Little Manatee River.

But that is for another day. At this time, I recommend that the minimum flows report reference the residence time work performed by Huang and others, possibly showing the results of some residence time simulations in the minimum flows report.

6.1 Overview and suggested text for ichthyoplankton reports

On page 4.3.3 the report has one paragraph that summarizes the Ichthyoplankton work performed by Dr. Ernst Peebles of the University of South Florida College of Marine Science. This summary is good and well written, but I recommend two additions. First, the figure from Peebles and Flannery (1992) below be shown in the minimum flows report. As I mentioned at the peer review kick-off meeting, I think if there is one figure that best justifies the District's minimum flows program for tidal river estuaries, this is it.



Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages, from Peebles and Flannery (1992)

To reference this figure, the text could be added to say something like "Based on detailed microscopic work that identified early life stages as eggs, larvae, or juveniles, density weighted mean salinity values for different life stages were calculated. For a number of species, this showed a movement from higher salinity to lower salinity waters located further upstream as the species matured from larval to juvenile stages (Figure x). This occurs as these fish develop stronger swimming ability and have a change in food habits, switching from diets rich in zooplankton near the mouth of the river to more benthic food resources further upstream (Peebles 2005)." A reference for this second report is below.

Peebles, E. 2005. Review of feeding habits of juvenile estuarine dependent fishes and blue crabs: Identification of important prey. Report prepared by the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

The second addition I suggest pertains to the report by Peebles (2008). At present the draft minimum flows report has one sentence that says "These data were re-evaluated in 2008 using newly developed analytical methods (Peebles 2008)." Some of these findings in the 2008 report are very interesting and are relevant to freshwater inflow management. I suggest the District and JEI review the summary section for this report and select two or three findings to briefly mention in the minimum flows report.   I suggest “These data were re-evaluated in 2008 using new analytical methods that included analyses of organism dispersion as a function of freshwater inflow and organism associations with water masses of varying water age. The study also assessed community heterogeneity as a function of freshwater inflow and mean salinity at the sampling stations in the river.”

6.2 Overview and suggested text for Nekton sampling conducted as part of the Fisheries Independent Monitoring Program of the Florida Fish and Wildlife Conservation Commission

The consultant has done a very good job of accessing and analyzing the extensive data for nekton (fishes and free swimming macroinvertebrates) in the estuarine section of the Little Manatee River collected by the Fisheries Independent Monitoring Program (FIM) of the Florida Fish and Wildlife Conservation Commission (FFWCC or FWC). On page 93 the draft minimum flows report provides a one sentence summary of a report produced by the FFWCC for the District based on these same data collected between 1996 and 2006 (MacDonald et al. 2007).   That sentence mentions this study “demonstrated the importance of the Little Manatee River estuary for providing habitat throughout the year, as peaks in juvenile abundance of offshore spawners, juvenile nearshore spawners, estuarine spawners, and tidal-river residents occurred in different seasons (MacDdonald et al. 2007).”

Though this characterization is helpful, I suggest the minimum flows report could mention a couple other analyses or data presentations from the MacDonald et al. (2007) report. Also, it is not critical, but one page of figures from that report could be shown to highlight the types of information that are presented in it.   I suggest something like below, including the figures for Red drum shown on the following page.

“This report also provides useful analyses and tabular and graphical presentations of the abundance and distribution response of various species in relation to freshwater inflow, plus the size classes, salinity at capture, and abundance of species in different sections and habitats in the lower river.   As an example, a series of graphics for the seine catch of Red drum (*Sciaenops ocellatus*) from MacDonald et al. (2007) are shown on the following page.”   (see figure on the following page).

Sciaenops ocellatus (Red drum), Seines

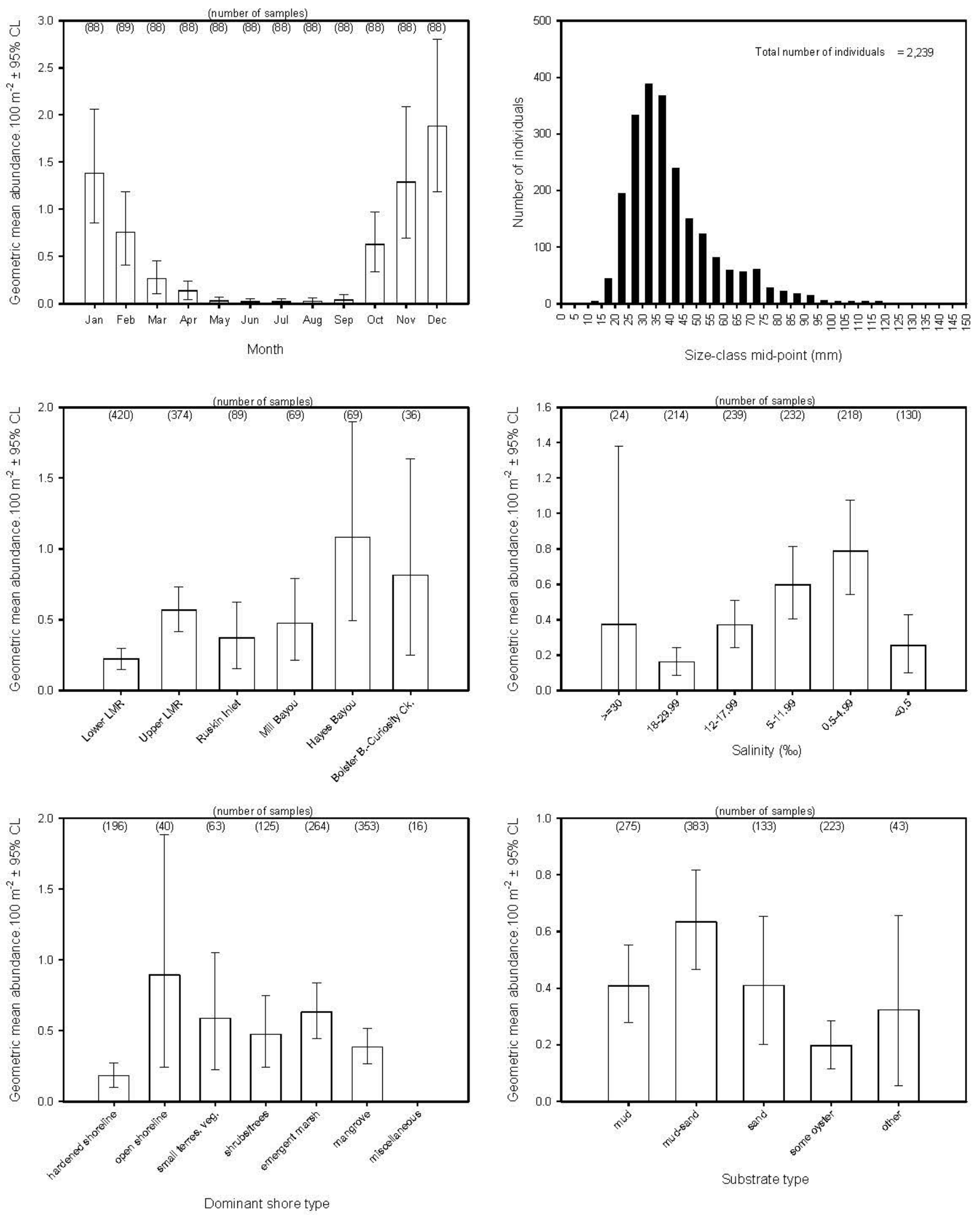


Figure 71. Abundance of *Sciaenops ocellatus* (red drum) in shoreline habitats of the Little Manatee River watershed (FIM SRS survey, January 1996–December 2006).

Figure X. Graphics for the seine catch of Red drum (*Sciaenops ocellatus*) in the Lower Little Manatee River reprinted from MacDonald et al. (2007).

6.3 Multi-River Fish Reports

Both FFWCC and USF prepared reports for the District that analyzed data pooled for the 18 or so rivers they studied for the District. The consultant might find some useful results in these reports that are relevant to the findings presented in the Little Manatee minimum flows report. References for these reports are below.

Hollander, D. and E.B. Peebles. 2004. Estuarine Nursery Function of Tidal Rivers in West-Central Florida: Ecosystem Analyses Using Multiple Stable Isotopes. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Peebles, E.B. 2005. Review of Feeding Habits of Juvenile Estuarine-Dependent Fishes and Blue Crabs: Identification of Important Prey. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Burghart, S.E. and E.B. Peebles. 2011. A Comparison of Spring-Fed and Surface-Fed Estuaries: Zooplankton, Ichthyoplankton, and Hyperbenthos. Report of the University of South Florida College of Marine Science for the Southwest Florida Water Management District.

Gunther, C.B., T.C. MacDonald and R.H. McMichael. 2011. Comparison of Nekton Community Structure Among Spring- and Surface-Fed Estuarine Rivers of Florida's West Coast. Report prepared by the Florida Fish and Wildlife Conservation Commission for the Southwest Florida Water Management District.

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Doug Leeper; Eric DeHaven; Adrienne E. Vining; Xinjian Chen; Jordan D. Miller; Chris Zajac; Kristina Deak; Gabe I. Herrick; Lei Yang; Danielle Rogers; Philip Rhinesmith; mburke; esherwood; Karlen, David; Ernst Peebles; ash; Dougherty, Janet; Wessel MIke; Tony Janicki (tjanicki@janickienvironmental.com)
Subject:	Overview of reports about the Little Manatee River and suggested material for the minimum flows report
Date:	Tuesday, October 19, 2021 3:24:28 PM
Attachments:	Overview and suggested text to describe technical reports about the Litte Manatee River.pdf

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and District staff,

Attached is a document I prepared that provides an overview of several technical reports about the Little Manatee River and provides text the District could include in the minimum flows report to briefly summarize their relevant findings. Would you please upload this email and the attached document to the minimum flows WebForum and inform the Little Manatee minimum flows peer review panel that they are there.

As the attached document describes, I think the District report would benefit greatly from citing and briefly describing the referenced reports for they contain findings that describe the biological communities in the river, including their relationships with salinity gradients and freshwater inflows. In that regard, I think they provide important information that supports the establishment of minimum flows.

Also, the Little Manatee River is part of a State of Florida Aquatic Preserve and is a very highly valued resource in the Tampa Bay region. It therefore benefits the District to summarize information about its biological communities, especially as they are related to salinity gradients and freshwater inflows.

Five of these reports are currently not cited in the draft minimum flows report, while some others are mentioned only very briefly. In addition to biological communities, Section 5.1 in my document pertains to residence time analyses that were performed as part of the development of the EFDC model for the Little Manatee River, which is described in the final report for that project (Huang and Liu, 2007).

I plan to virtually attend tomorrow's meeting of the Little Manatee peer review panel and would like to address them for several minutes to briefly describe the contents of the three documents I have submitted.

Thanks very much,
Sid Flannery

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Doug Leeper; Eric DeHaven; Adrienne E. Vining; Xinjian Chen; Jordan D. Miller; Chris Zajac; Kristina Deak; Gabe I. Herrick; Lei Yang
Subject:	Document to sent to the District tonight, hopefully can be uploaded tomorrow
Date:	Tuesday, October 26, 2021 3:33:05 PM

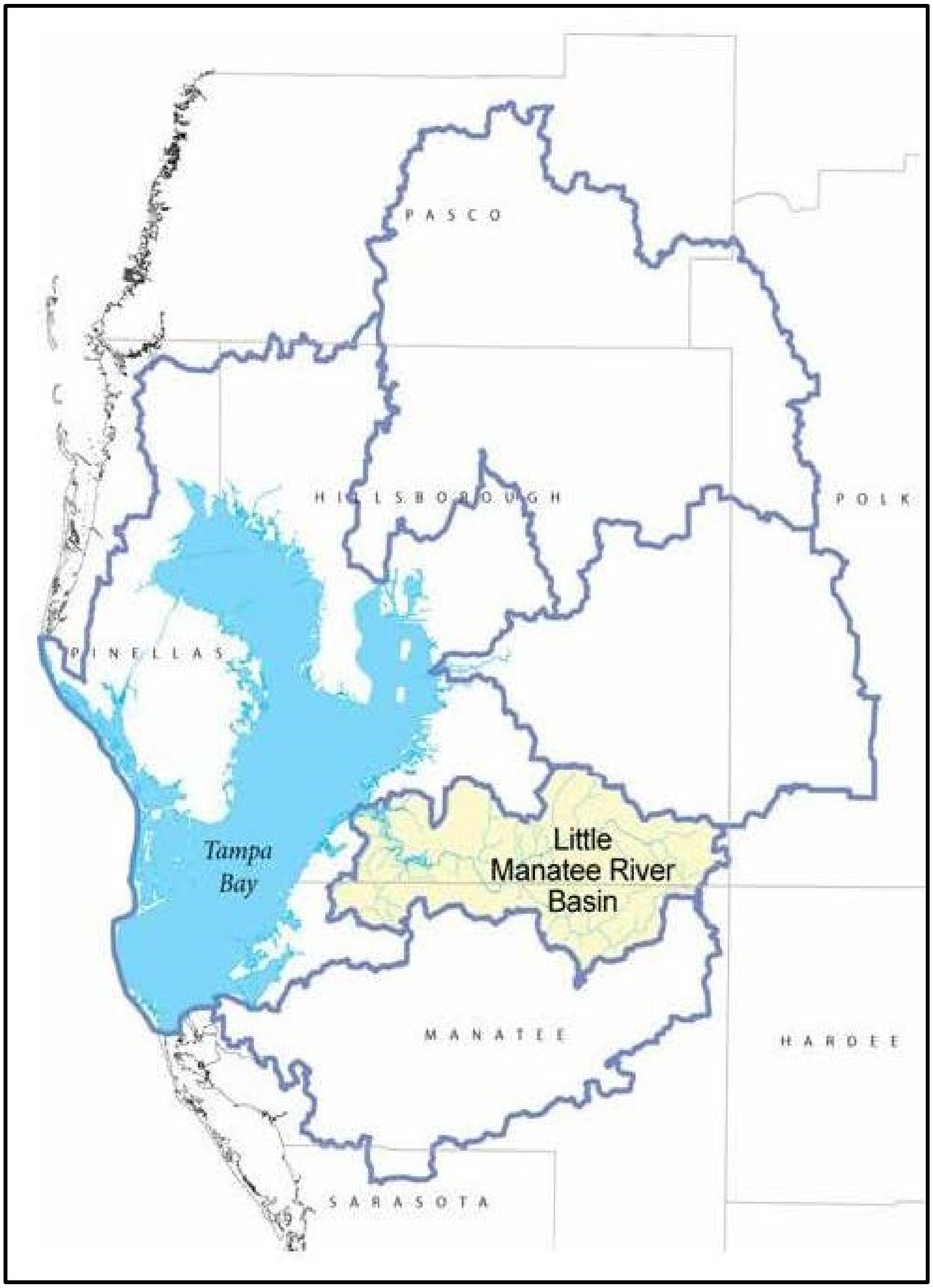
Hello Kym and District staff,

Tonight I will send to the District a pdf file that contains graphics I created related to the determination of flow thresholds to identify low, medium, and high minimum flow flow blocks for the estuarine section of the Little Manatee River.

That email and attached document will be your email inbox first thing tomorrow morning. If you could upload it to the minimum flows WebForum tomorrow morning that would be very helpful, as I could tell the review panel during the public comment period that the document is up and available for their review.

Thanks,
Sid

Graphics related to the evaluation of flow thresholds for flow-based blocks for minimum flows for the estuarine section of the Little Manatee River



Submitted by Sid Flannery, October 27, 2021

Overview and organization of this document

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The draft minimum flows report for the Little Manatee identifies flow rates of 35 and 72 cfs to serve as thresholds to identify low, medium, and high flow blocks for the minimum flows. These flow rates were based solely on analyses of the freshwater reach of the river, but they are being applied to the estuarine reach of the river as well. As my comments in the Appendix state, the District has never done that before, and I strongly recommend that thresholds to identify flow-based blocks be evaluated separately for the freshwater and estuarine sections of the river. Those comments also describe a type of analysis that was done for the first determination of minimum flows for the Lower Peace River that I think should be performed for the Little Manatee to assess appropriate flow blocks for the estuarine reach of the river.

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Many of the graphics have a reference line for 72 cfs, which was visually approximated using power point. As the Appendix states, I think the 72 cfs is clearly too low to serve as a threshold to identify the high flow block for the estuarine section of the Little Manatee. Some brief text is included with some of the graphics, particularly for chlorophyll *a*. All text was also was prepared quickly and is not a through treatment of these relationships.

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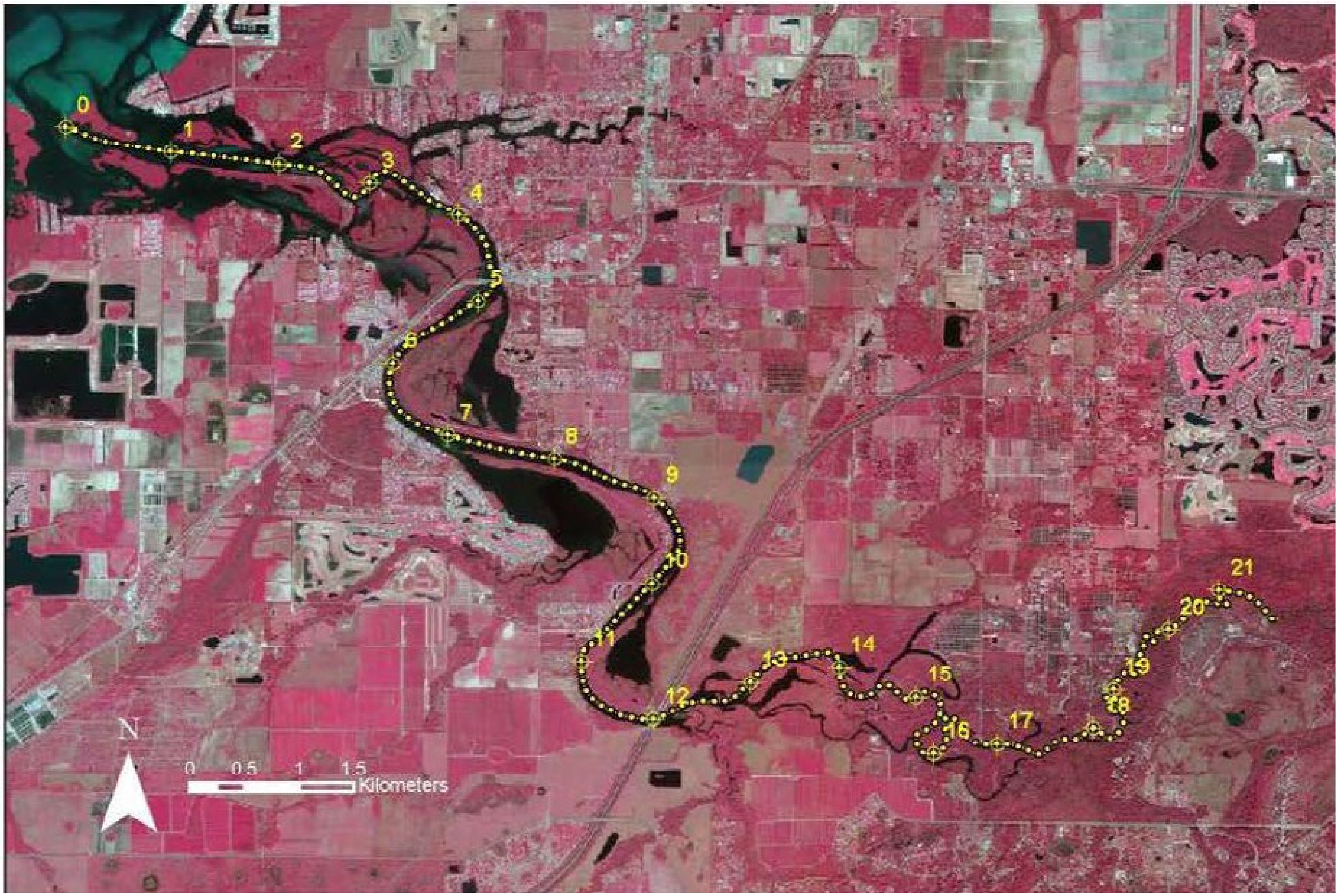

Centerline map of the Lower Little Manatee River with distances in kilometers

Chlorophyll *a*

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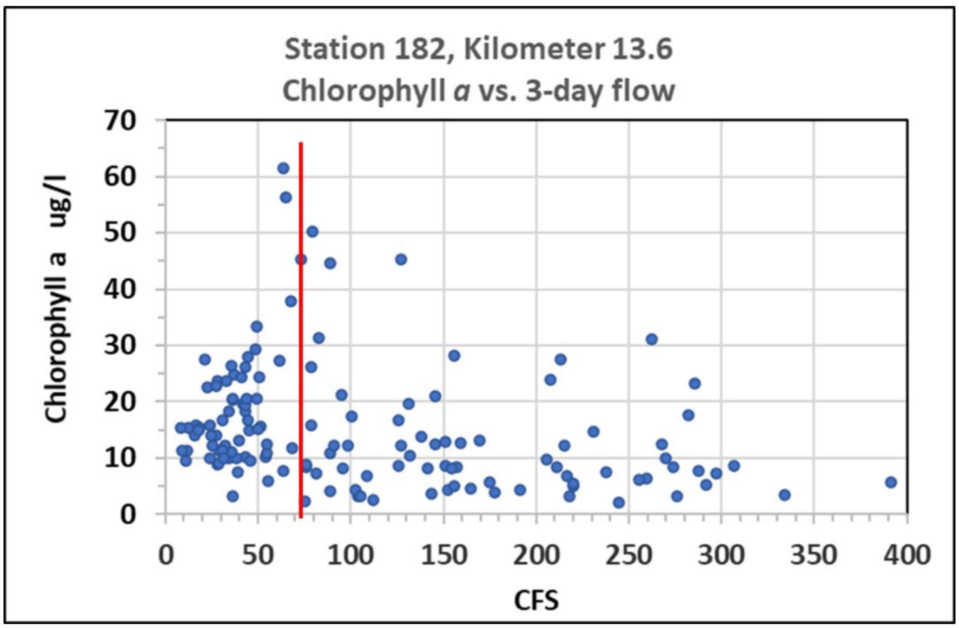
The figure below is from station 182, located in the braided oligohaline section of the river near kilometer 13.6. The pattern that is shown is typical of the upstream reaches of tidal rivers, in that high chlorophyll concentrations are not frequently observed at very low flows (20 to 30 cfs below) probably due to low nutrient loading. However, when flows increase, high chlorophyll concentrations can occur due to greater nutrient loading, with residence times that are still fairly long allowing phytoplankton blooms to develop.

However, at higher flows, high chlorophyll *a* concentrations are not frequently observed as water is moving through these upper reaches of the tidal river fairly rapidly with low residence times. Water color also increases at high flows, which limits light penetration. This tendency would be shown more clearly if the horizontal axis below was expanded to include higher flows, but the emphasis on this graphic is on lower flows. Three-day flow is the average flow for the day of sampling and the preceding two days.

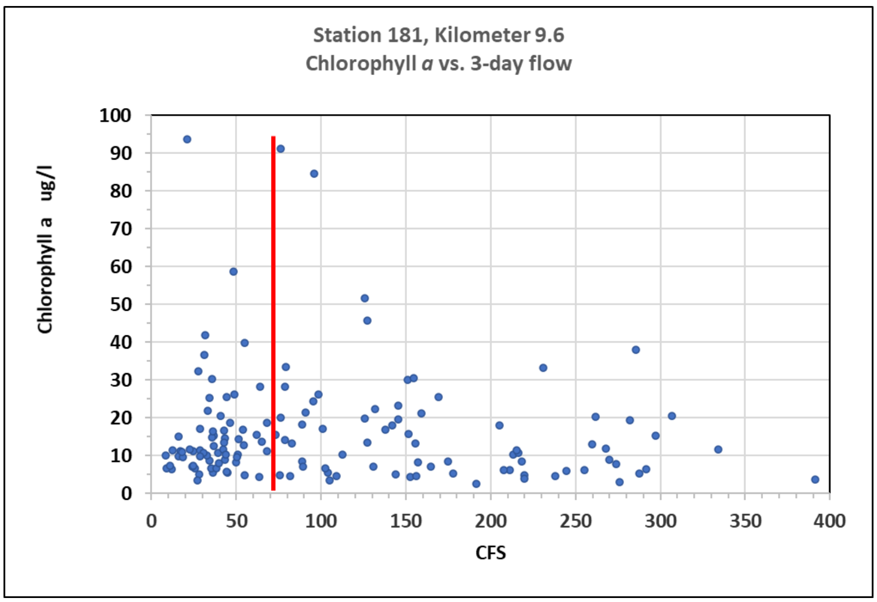


A red reference line is shown in the figure above at approximately 72 cfs, which is the threshold to switch from the medium to high flow block in the proposed minimum flows, which will allow a change in percent withdrawals from 20 percent to 30 percent. Again, this threshold was based solely on analyses of the freshwater reach of the river upstream of US highway 301. As shown in the figure above, 72 cfs is right in the middle of the flow range of when very high chlorophyll *a* concentrations can occur at this location.

What is interesting about the Little Manatee is that peak chlorophyll *a* concentrations often occur in very low salinity waters, even close to the tidal interface between fresh and brackish waters. As described in the *Overview and suggested text* document, peak chlorophyll *a* concentrations often occur in mesohaline waters in the tidal reaches of the Peace and Alafia Rivers. It appears this difference in the Little Manatee is that water slows down considerably in the braided section of the river upstream of I-75, with longer residence times there compared to the upper reaches of other tidal rivers.

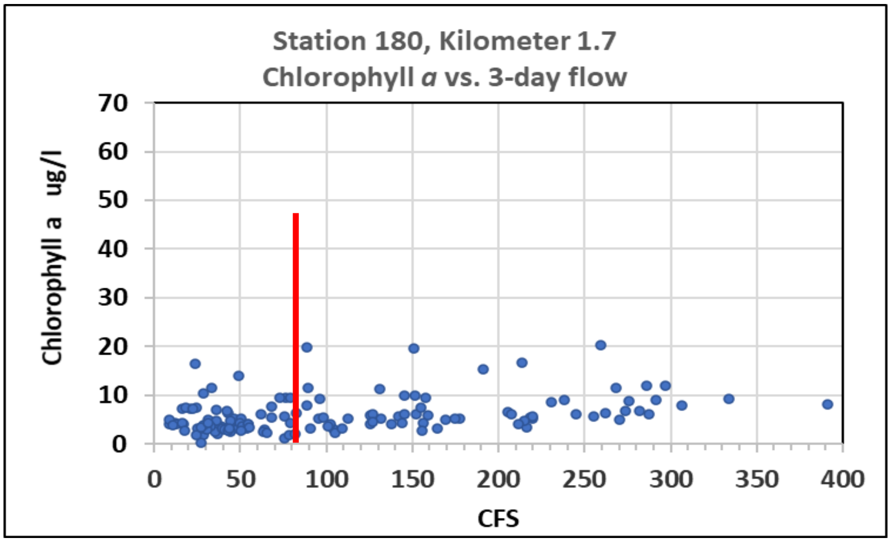
As part of the development of the EFDC hydrodynamic model for the Little Manatee, Drs. Huang and Liu of Florida State University did residence time simulations for the river that are summarized in the *Overview* document that was previously submitted. The District has also done residence time analyses in the Lower Peace and Alafia Rivers, with the minimum flows report for the Lower Alafia presenting a good discussion of the relationships of residence time to chlorophyll *a* in that river.

The relationship of flow to chlorophyll *a* will change at different locations in a tidal river due to changes in the volume of the estuary, residence time, available nutrients, light penetration and tidal exchange with the bay. Plots are presented for EPC stations 181 and 180 in the following discussion, with data shown below for station 181, which is located near kilometer 9.6.



The highest peak chlorophyl *a* concentrations in the Little Manatee recorded by the EPC are at Station 181. High concentrations above 80 µg/l were limited to when three-day average flows were less than 100 cfs, with two concentrations above 90 µg/l at flows below 77 cfs. The minimum flows report has a time series plot of yearly geometric means for chlorophyll *a* that shows that during some years, the FDEP impairment threshold of an annual geometric mean of 11 µg/l is exceeded at this station. I agree with some review panel comments that this threshold is probably too low for productive tidal rivers. However, individual chlorophyll *a* concentrations can be strongly affected by the rate of freshwater inflow, and the occurrence of problematic very high chlorophyll concentrations from large phytoplankton blooms can be exacerbated by flow reductions in sensitive flow ranges in various sections of a tidal river.

The graph below is for station 180, which is located near 1.7 kilometers upstream of the mouth of the river. For easier comparison to the other figures, the Y axis is taken up to 70 µg/l. It is obvious that chlorophyll *a* concentrations are much lower at this location and have a very different relationship with freshwater inflow, due likely to the volume of the estuary, tidal flushing from the bay, and limited available nutrients at low flows. However, at this location there is a tendency for slightly higher chlorophyll *a* concentrations at higher flows, as nutrient delivery from the watershed is increased.



It should be noted that the Little Manatee River has been enriched with nitrogen due to human activities in the watershed. The draft minimum flows report found that with the exception of organic nitrogen at one site, trends for various forms of nitrogen have either been showing no trend or decreasing at EPC stations in the lower river in recent years. However, as described in the document I submitted titled *Technical review of the Little Manatee River flow characterization,* as part of a large study of the Little Manatee River watershed that was conducted by the District and other agencies in the late 1980s, long-term nitrogen data indicated that agriculture activities have increased nitrate concentrations in the river considerably compared to decades prior to the mid-1970s. Given that the river is nitrogen enriched, it is important to carefully manage the effects of flow reductions on excessive phytoplankton blooms and high chlorophyll *a* concentrations in the river.

Again, I have not had time to review the appendices to the minimum flows report that deal with water quality, but the data for stations 181 and 182 in the mid to upper reaches of the tidal river indicate the 72 cfs threshold to switch to 30 percent withdrawals is too low, as it could exacerbate excessive phytoplankton blooms in that part of the river. New analyses should be conducted to develop a threshold for a high flow block for the estuary based on relationships in the lower river, rather than from the freshwater reach where the 72 cfs flow threshold was derived.

SALINTY

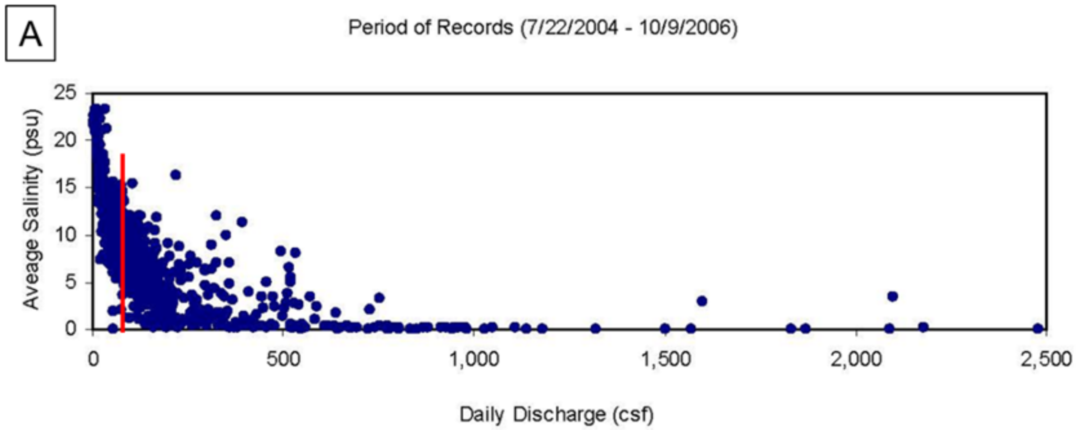
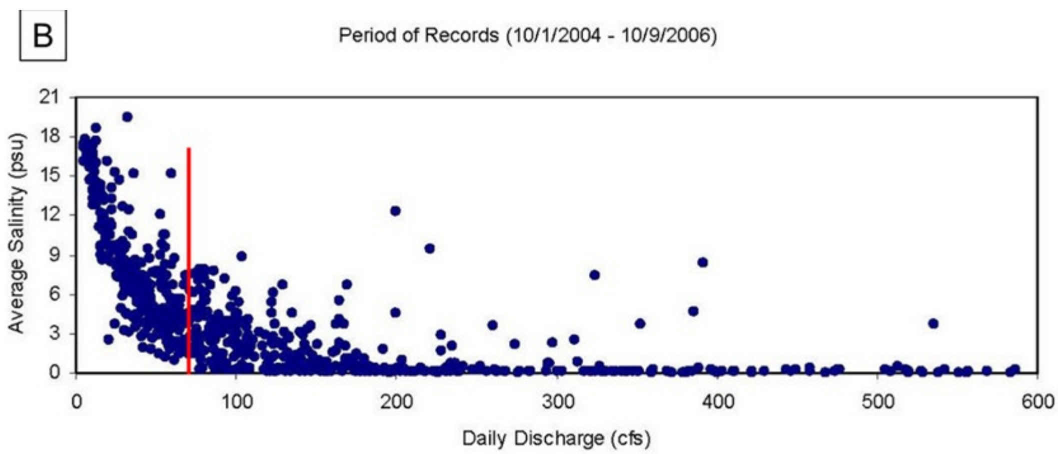


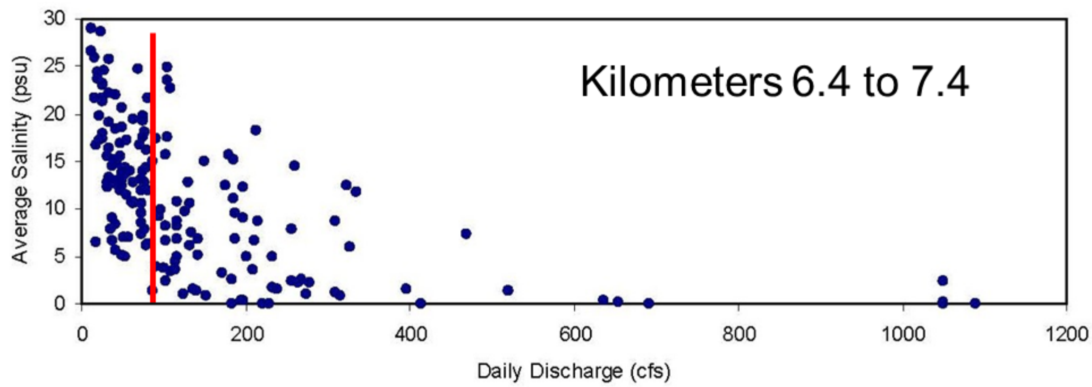
Figure 15. Salinity versus daily discharge for the USGS 02300546 gage, Little Manatee Rive at Ruskin, FL (RKM = 8.3)

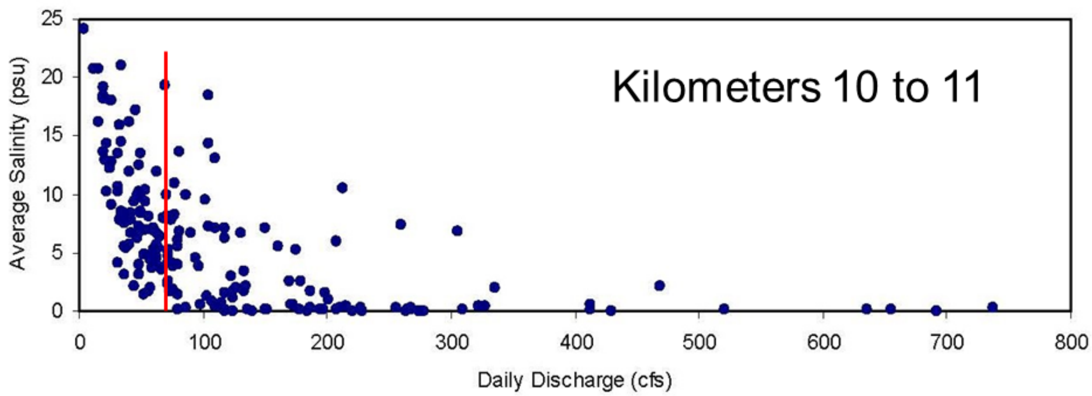


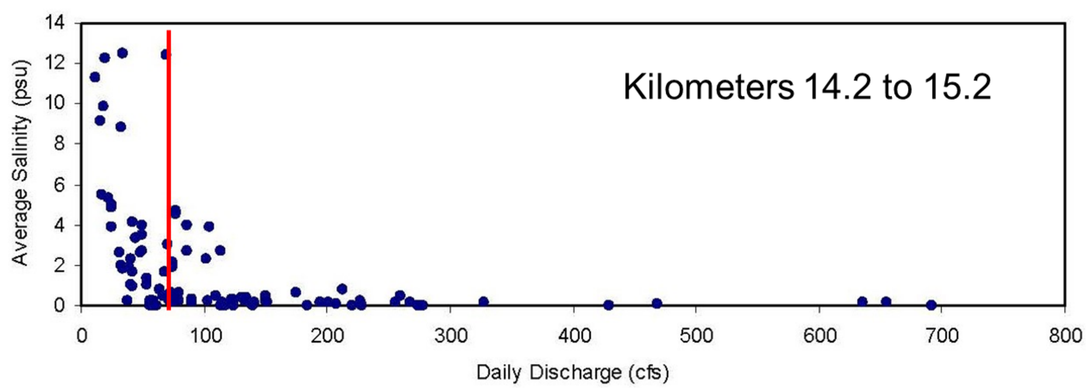
'igure 16. Salinity versus daily discharge for the USGS 02300542 gage, Little Manatee River at I 75 near Ruskin, FL (RKM = 12.1)

Red reference lines inserted at approximately 72 cfs

The USGS operated a series of continuous salinity recorders in the river to support the development of the EFDC hydrodynamic model for the river during 2004 to 2006. Plots of average daily salinity from the top and bottom sensors at each location are shown above for two recorders located at kilometers 8.3 and 12.1. The recorder at 12.1 is at the I-75 bridge, which is just downstream of the braided zone of the river that contains abundant oligohaline marshes that grade upstream to tidal freshwater marshes and forest. Salinity is very responsive to flow in the range of 72 cfs at this location, with the response dampening at higher flows.

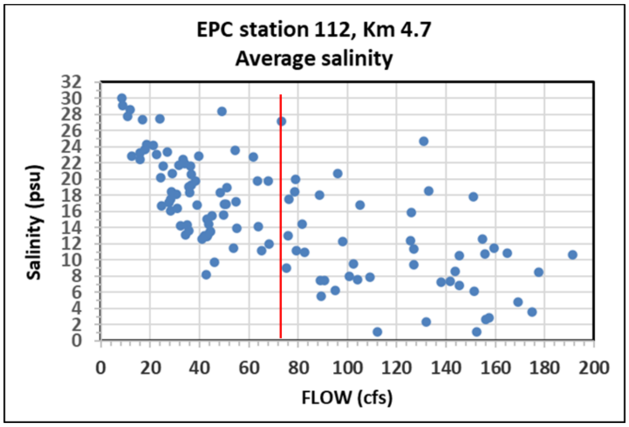


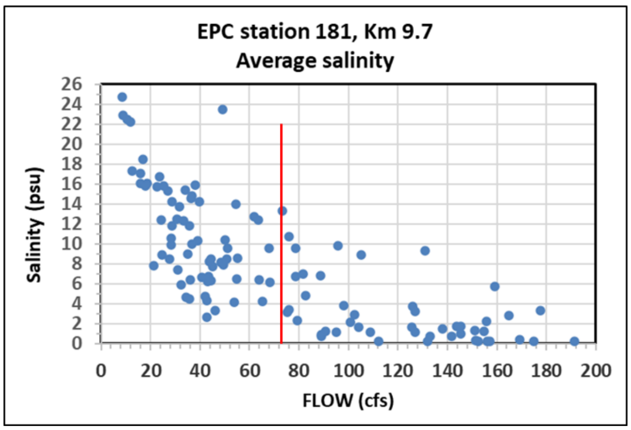


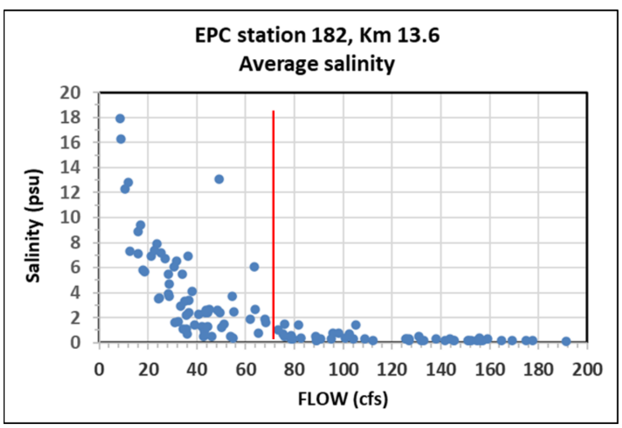


Red Line reference lines inserted at approximately 72 cfs

These graphics on this page are average salinity values from vertical profiles taken by the District and other parties between March 1985 and October 2006. I don't think that 72 cfs represents a good high flow threshold to increase withdrawals, as salinity is very responsive to flow reductions at these sites near that flow value, with a dampened and flatter response at higher flows. Considering that for the most recent twenty year period, 72 cfs has been exceeded 52 percent of the time, a higher threshold to identify high flows would be more appropriate for this estuarine system.







The graphics above are from the Hillsborough County EPC's water quality stations in the tidal river that have been monitored since 2009. At these stations, EPC measures salinity at top, middle and bottom depths, with the average of these values shown above. For station 181 (middle graph), 72 cfs again appears to be too low to serve as a high flow threshold compared to a higher flow rates. The data at station 182 seem more supportive of the 72 cfs threshold, but these salinity values are lower than some average values for kilometers 14.2 to 15.2 reported by the District shown on the previous page. This might be because the District frequently sampled near high tide, or possibly because the District took salinity profiles at surface and 1 meter intervals.

Management Approach for Unimpounded Rivers **1321**

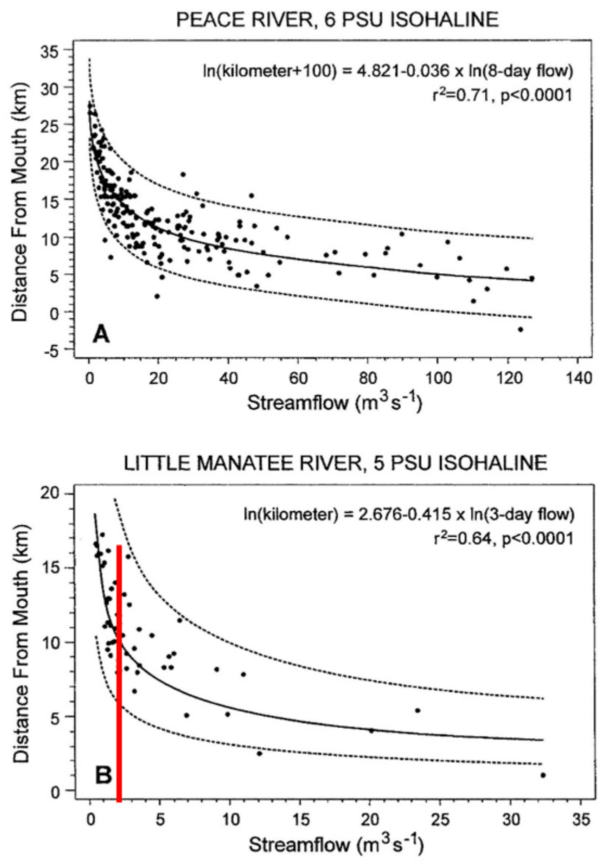


Fig. 3. Regressions of freshwater inflow with (A) the location of the 6 psu surface isohaline in the Peace River (adapted from Janicki Environmental 2001) and (B) the location of the 5 psu surface isohaline in the Little Manatee River (adapted from Peebles and Flannery 1992), with the 95% confidence limits for the predicted values. Regressions are plotted using non-transformed data.

The Figure above shows the strong nonlinear response that salinity isohalines can have with regard to changes in freshwater inflow. The red reference line for the Little Manatee River is near 2 m3/sec, which is equivalent to a flow of 72 cfs. Note there are three occurrences of the surface 5 psu isohaline between kilometers 13 and 16 near a flow rate of 72 cfs and others just below that flow rate. This graphic was taken from an article by Flannery et al (2002) in the journal *Estuaries* that dealt with the percent of flow method, which is referenced in the District's draft minimum flows report.

It should be noted the Little Manatee was one of the three estuarine rivers that provided data and findings that were very important to the initial development of the percent-of-flow method for regulating withdrawals and determining minimum flows for tidal rivers.

208 Environ Fluid Mech (2010) 10:197–211

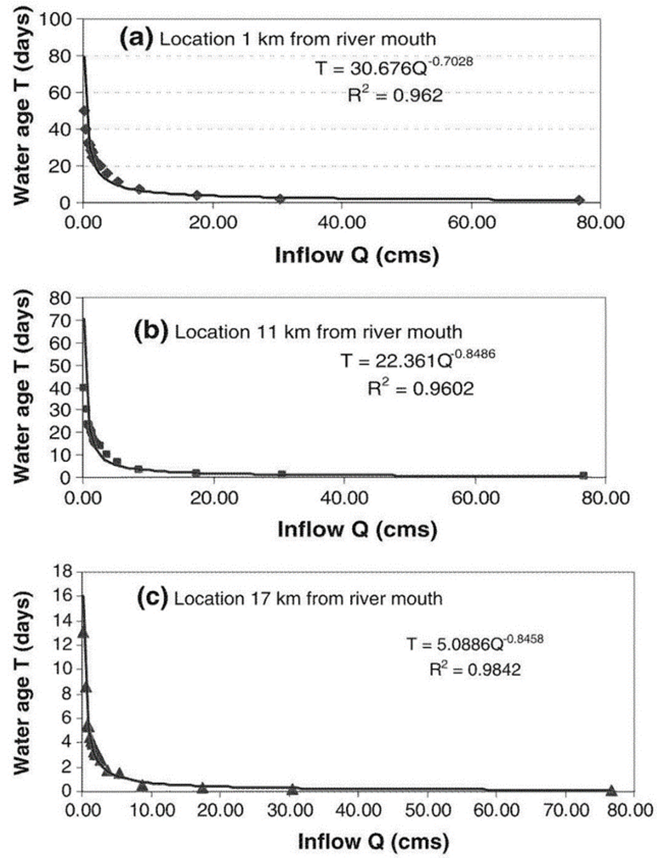


Fig. 9 Tidally-averaged water ages T (days) in responses to river inflows $Q(m^3/s)$ at different locations along the river main channel. Least-square regressions were done by using power law. Data were obtained from hydrodynamic model simulations

The graphic above was taken from a journal article about water age simulations in the Little Manatee River by Huang et al. (2010) that is cited in the *Overview* document. Water age is a form of residence time, that is the travel time of fresh water from the head of the estuary to a given location, with three sites shown above. The horizontal axes in these figures cover a very high range of flows in m3/sec (for reference 72 cfs is equal to about 2 m3/sec and 4 m3/sec equal to about 141 cfs). Even so, the strong nonlinear response of water age at low flows river is clearly apparent at these locations. The Lower Alafia minimum flows report found that water age can be an important factor affecting very high chlorophyll concentrations.

I did not have time to analyze relationships between chlorophyll *a* and water age in the Little Manatee, but the relationships of chlorophyll *a* with flow shown on pages 5 and 6 are probably due in part to differences in water age at low, medium, and high flows. As such, the nonlinear response of residence time and water age to freshwater inflow should be considered in determining what are truly high flows for the estuarine section of the river. In my opinion, 72 cfs is too low a value for identifying high flows in that regard.

Finally, it interesting to note that the peer review panel for the previous minimum flows report included a graphic that indicated that simulations of residence time and water age can be important for assessing phytoplankton abundance in estuarine rivers. The graphic below was taken from page 9 in that report, with red arrows inserted to highlight the suggested work for hydrodynamic modeling for salinity and water age analysis.

I believe that in fairly short order, the data for the estuarine reach of the Little Manatee River can be reassessed to come up with a threshold to identify high flows that much better protects the lower river from significant harm, compared to the proposed 72 cfs threshold which is clearly too low.

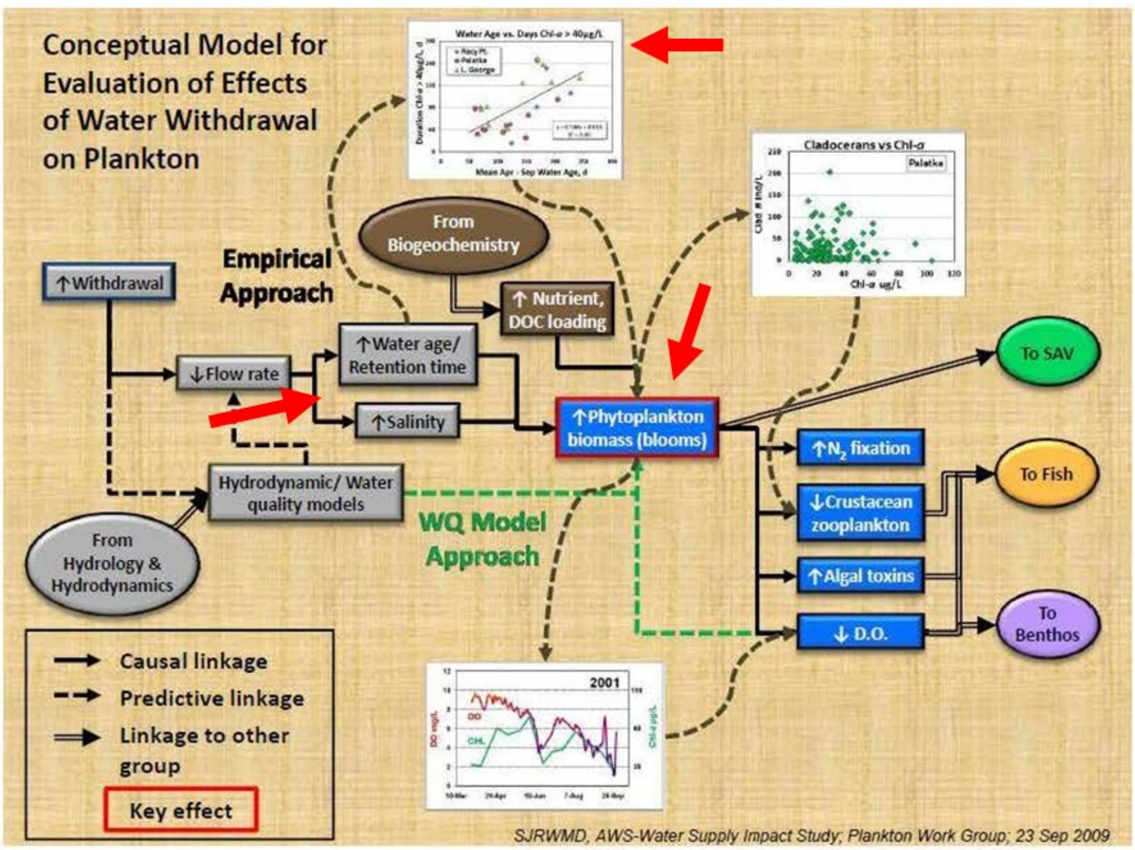


Figure 2. Multidisciplinary studies for assessing water withdrawal impacts on plankton. (SJRWMD 2009)

Figure adapted from Figure 2 in the peer review report for the previous minimum flows report for the Little Manatee River

APPENDIX

Verbal comments to be given at the Little Manatee River minimum flows peer review meeting, October 27, 2021

By Sid Flannery

Good afternoon. Today I would like to talk about the need to establish flow based, minimum flow blocks separately for the freshwater and estuarine sections of the Little Manatee River. I support the use of flow-based blocks, but on the Little Manatee the District based the thresholds for identifying low, medium, and two high flow blocks strictly on analyses of the freshwater section of the river, and then applied three of those same flow blocks to the estuary. Well this is a first, as the District has never done that before, and it is a serious misstep for the Little Manatee River and sets a bad precedent.

The District has previously used flow-based blocks to establish minimum flows for a number of estuarine rivers in the region. For example, last year, the District adopted minimum flows for the Lower Peace River for the second time, using three flow-based blocks that were based on salinity relationships in the estuarine section of the river.

The important thing is for these other tidal rivers, low flow cutoffs and flow-based blocks for the estuarine sections of the rivers were based on relationships of freshwater inflow to variables and parameters within the estuary.

An important factor to consider is that the response of many variables in estuarine rivers to freshwater inflow is nonlinear. Even if you take a fixed percentage of daily flow, say 20 percent, the relative effects of those withdrawals on habitats and other factors can be much greater at low flows than at high flows. Therefore, when applying the percent of flow method in a tidal river, you have to see if there are sensitive flow ranges for the response of different variables to freshwater inflow.

In that regard, I prepared a series of graphs of different variables vs. flow in the Lower Little Manatee that the District uploaded to the minimum flows WebForum this morning. I think the low flow cutoff of 35 cfs for the lower river is suitable, and similar to the 40 cfs cutoff currently in effect for the Florida Power Light withdrawals, which I was involved in evaluating years ago based on estuarine relationships.

However, the 72 cfs threshold for switching from medium to high flow blocks clearly looks to be too low for the lower river, as 72 cfs is in a very sensitive flow range for some important variables, particularly in the low salinity reaches of the river.

Also, based on gaged flows at US 301 for the last twenty years, flows would have been above 72 cfs fifty-two percent of the time. The estuarine section of the Little Manatee has a surface area of 2.2 square miles, and for the ecological functions, 72 cfs is not a high rate of inflow for an estuary of this size.

I strongly suggest the review panel recommend that flow rates to identify low, medium, and high flow blocks be evaluated separately for the fresh and estuarine sections of the Little Manatee. Given the modeling tools that have been developed, I think this could be done fairly quickly.

There is an interesting parallel to this. When minimum flows for the Lower Peace River were evaluated for the first time in 2010, the Section Manager wanted the minimum flows for the lower river to use seasonal blocks. As a check, we examined how the percent withdrawals for seasonal blocks 2 and 3 would perform if they were applied during low flows, which would have happened fairly frequently. We found that at low flows, the percentage withdrawals for seasonal blocks 2 and 3 would cause greater than a 15 percent change in salinity based habitats, but at higher flows they did not. Based on those findings, the first adopted rule for the Lower Peace River had a flow threshold that seasonal blocks 2 and 3 could not be applied until flows in the river went above 625 cfs.

That type of analysis could to done for the Little Manatee. For example, for a 30% withdrawal, for each day calculate the percent reduction in low salinity habitats relative to baseline, then plot these results vs. the corresponding rates of baseline flow. You will find that at some rate of increased flow, these withdrawals will not cause more than a 15 percent change in habitat, while at lower flows they will. You could examine these results to determine a threshold for identifying high flows. I expect that a similar approach could be taken the estuarine fish habitat analysis as well.

Also, From the water management perspective, it entirely practical to implement minimum flows rules that differ between the fresh and estuarine reaches of rivers, in fact that has been the standard District practice for years.

I hope the panel can review the documents that I have prepared for today and previous meetings, which can be found under the public comments section of the Webforum, as I think they provide very useful information pertaining to review of the draft report and the proposed minimum flows.

Finally, the Little Manatee River below Highway 301 is a State of Florida Aquatic Preserve and the crown jewel of the rivers flowing to Tampa Bay. If you are going to protect this valuable estuarine resource from significant harm, you need examine flow-based blocks that are analyzed specifically for this estuarine system.

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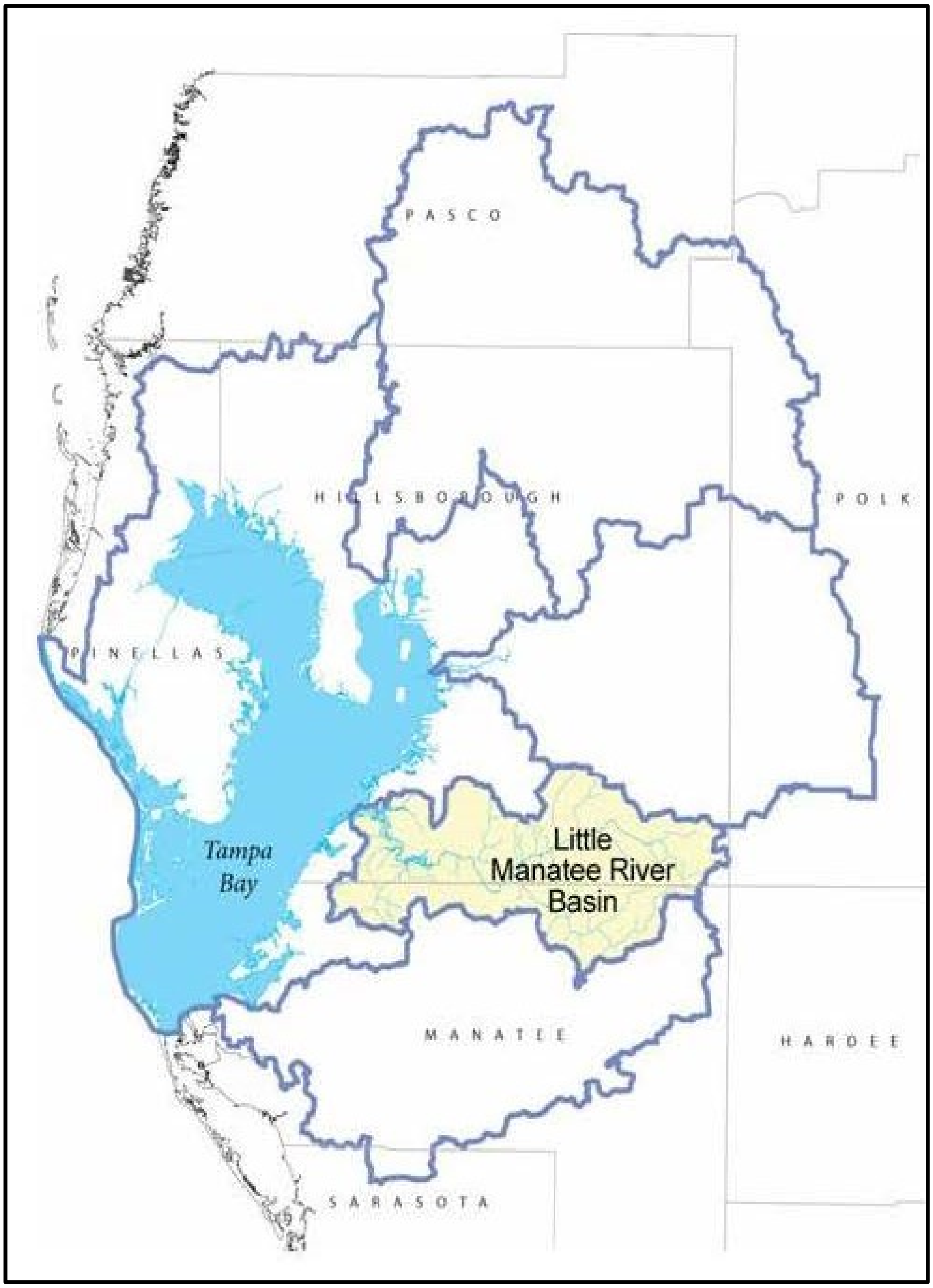

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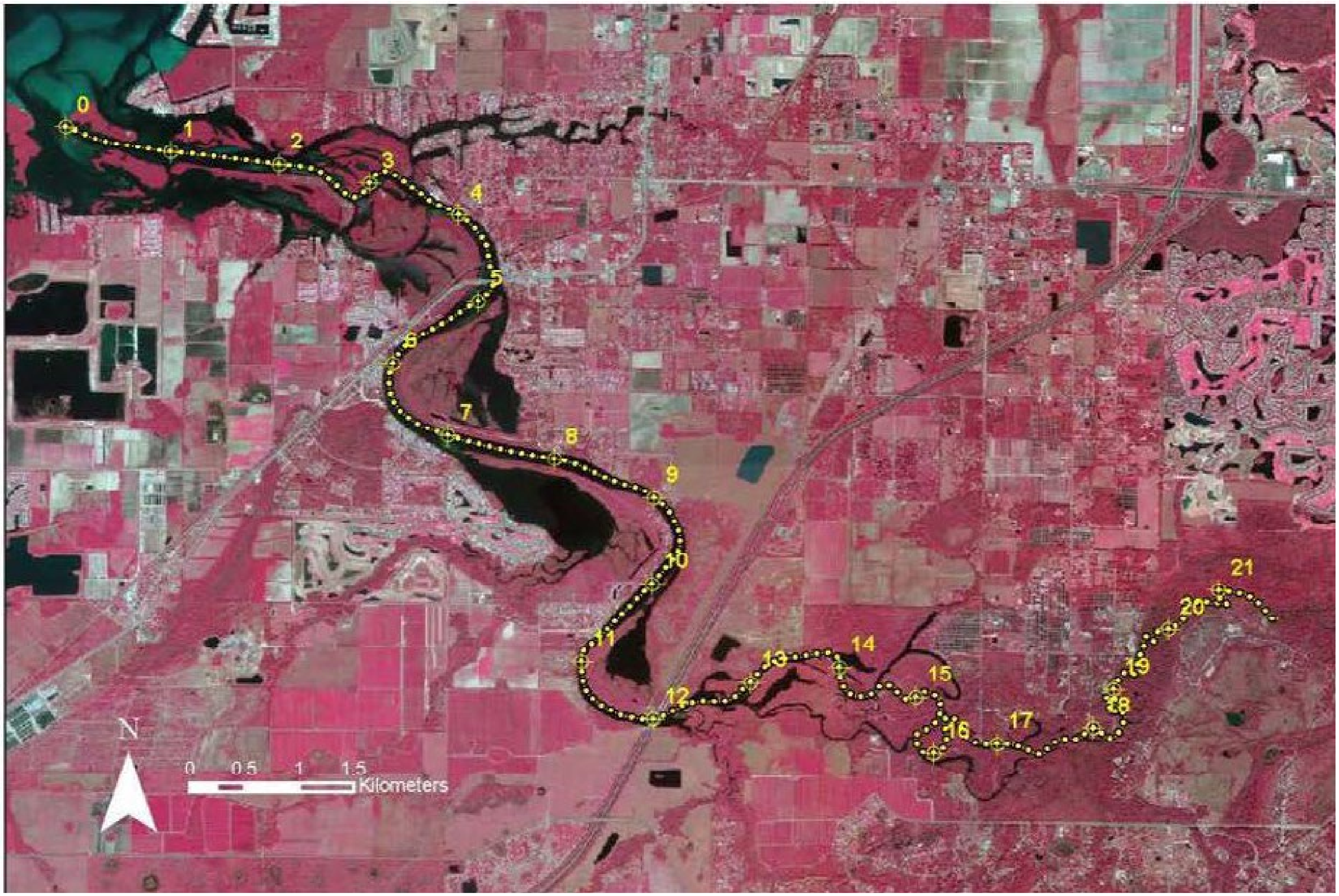

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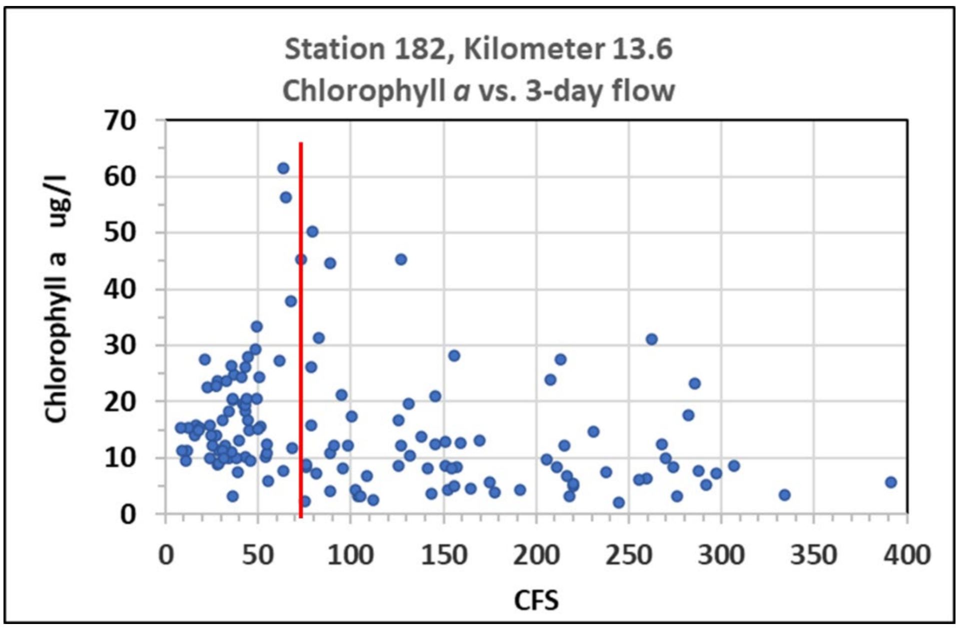
However, at higher flows, high chlorophyll *a* concentrations are not frequently observed as water is moving through these upper reaches of the tidal river fairly rapidly with low residence times. Water color also increases at high flows, which limits light penetration. This tendency would be shown more clearly if the horizontal axis below was expanded to include higher flows, but the emphasis on this graphic is on lower flows. Three-day flow is the average flow for the day of sampling and the preceding two days.

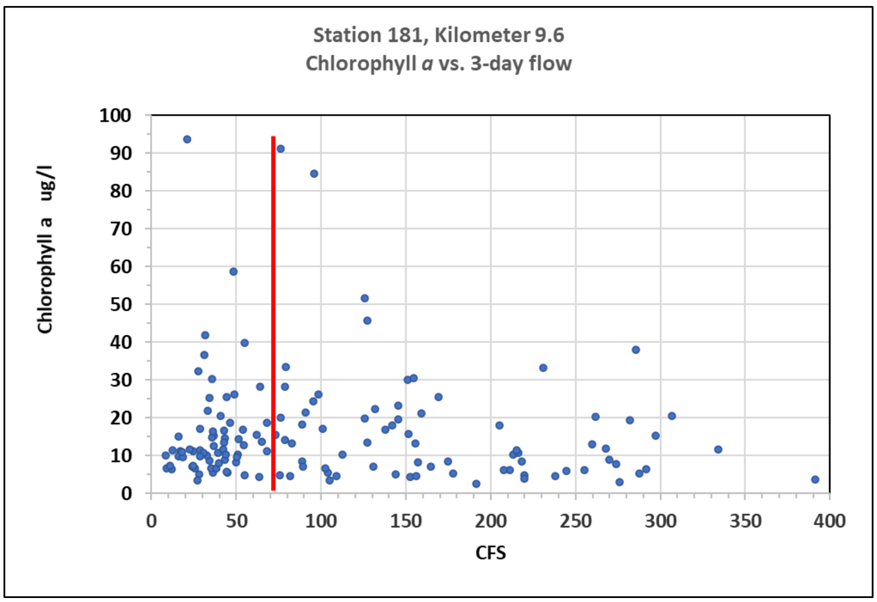


A red reference line is shown in the figure above at approximately 72 cfs, which is the threshold to switch from the medium to high flow block in the proposed minimum flows, which will allow a change in percent withdrawals from 20 percent to 30 percent. Again, this threshold was based solely on analyses of the freshwater reach of the river upstream of US highway 301. As shown in the figure above, 72 cfs is right in the middle of the flow range of when very high chlorophyll *a* concentrations can occur at this location.

What is interesting about the Little Manatee is that peak chlorophyll *a* concentrations often occur in very low salinity waters, even close to the tidal interface between fresh and brackish waters. As described in the *Overview and suggested text* document, peak chlorophyll *a* concentrations often occur in mesohaline waters in the tidal reaches of the Peace and Alafia Rivers. It appears this difference in the Little Manatee is that water slows down considerably in the braided section of the river upstream of I-75, with longer residence times there compared to the upper reaches of other tidal rivers.

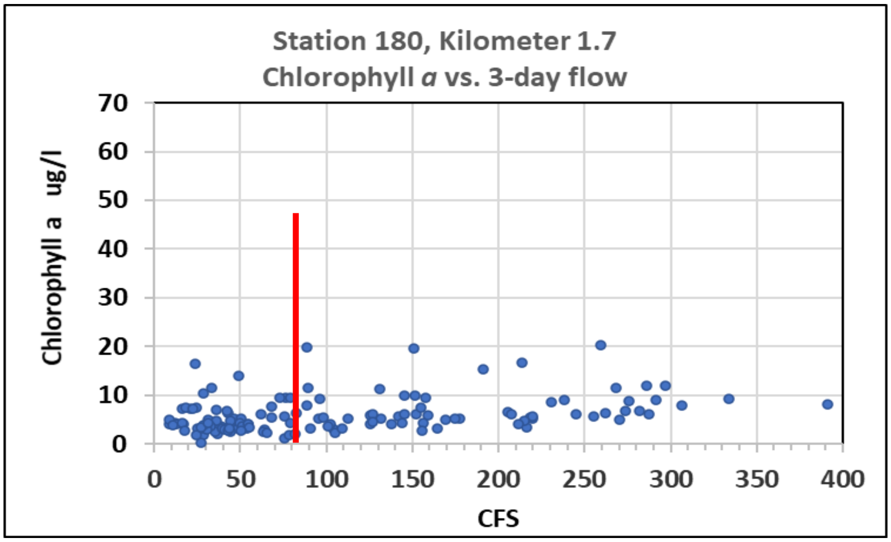
As part of the development of the EFDC hydrodynamic model for the Little Manatee, Drs. Huang and Liu of Florida State University did residence time simulations for the river that are summarized in the *Overview* document that was previously submitted. The District has also done residence time analyses in the Lower Peace and Alafia Rivers, with the minimum flows report for the Lower Alafia presenting a good discussion of the relationships of residence time to chlorophyll *a* in that river.

The relationship of flow to chlorophyll *a* will change at different locations in a tidal river due to changes in the volume of the estuary, residence time, available nutrients, light penetration and tidal exchange with the bay. Plots are presented for EPC stations 181 and 180 in the following discussion, with data shown below for station 181, which is located near kilometer 9.6.



The highest peak chlorophyl *a* concentrations in the Little Manatee recorded by the EPC are at Station 181. High concentrations above 80 µg/l were limited to when three-day average flows were less than 100 cfs, with two concentrations above 90 µg/l at flows below 77 cfs. The minimum flows report has a time series plot of yearly geometric means for chlorophyll *a* that shows that during some years, the FDEP impairment threshold of an annual geometric mean of 11 µg/l is exceeded at this station. I agree with some review panel comments that this threshold is probably too low for productive tidal rivers. However, individual chlorophyll *a* concentrations can be strongly affected by the rate of freshwater inflow, and the occurrence of problematic very high chlorophyll concentrations from large phytoplankton blooms can be exacerbated by flow reductions in sensitive flow ranges in various sections of a tidal river.

The graph below is for station 180, which is located near 1.7 kilometers upstream of the mouth of the river. For easier comparison to the other figures, the Y axis is taken up to 70 µg/l. It is obvious that chlorophyll *a* concentrations are much lower at this location and have a very different relationship with freshwater inflow, due likely to the volume of the estuary, tidal flushing from the bay, and limited available nutrients at low flows. However, at this location there is a tendency for slightly higher chlorophyll *a* concentrations at higher flows, as nutrient delivery from the watershed is increased.



It should be noted that the Little Manatee River has been enriched with nitrogen due to human activities in the watershed. The draft minimum flows report found that with the exception of organic nitrogen at one site, trends for various forms of nitrogen have either been showing no trend or decreasing at EPC stations in the lower river in recent years. However, as described in the document I submitted titled *Technical review of the Little Manatee River flow characterization,* as part of a large study of the Little Manatee River watershed that was conducted by the District and other agencies in the late 1980s, long-term nitrogen data indicated that agriculture activities have increased nitrate concentrations in the river considerably compared to decades prior to the mid-1970s. Given that the river is nitrogen enriched, it is important to carefully manage the effects of flow reductions on excessive phytoplankton blooms and high chlorophyll *a* concentrations in the river.

Again, I have not had time to review the appendices to the minimum flows report that deal with water quality, but the data for stations 181 and 182 in the mid to upper reaches of the tidal river indicate the 72 cfs threshold to switch to 30 percent withdrawals is too low, as it could exacerbate excessive phytoplankton blooms in that part of the river. New analyses should be conducted to develop a threshold for a high flow block for the estuary based on relationships in the lower river, rather than from the freshwater reach where the 72 cfs flow threshold was derived.

SALINTY

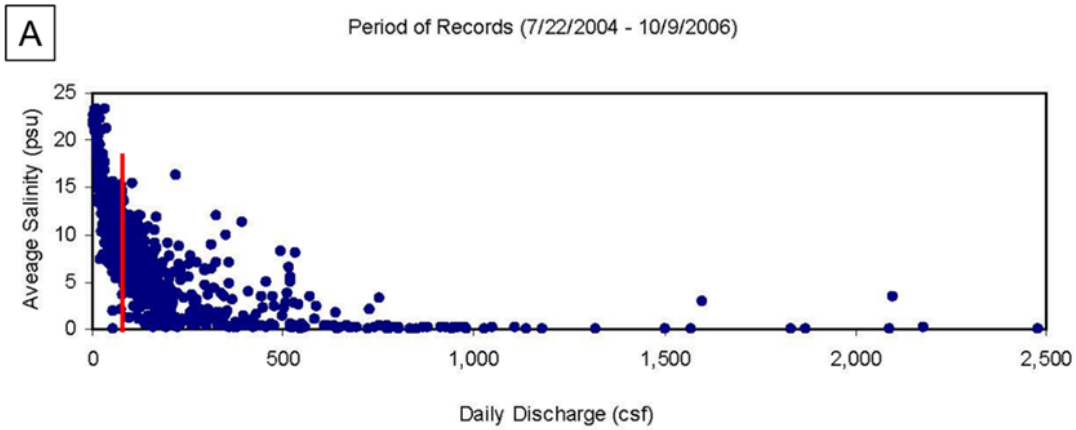
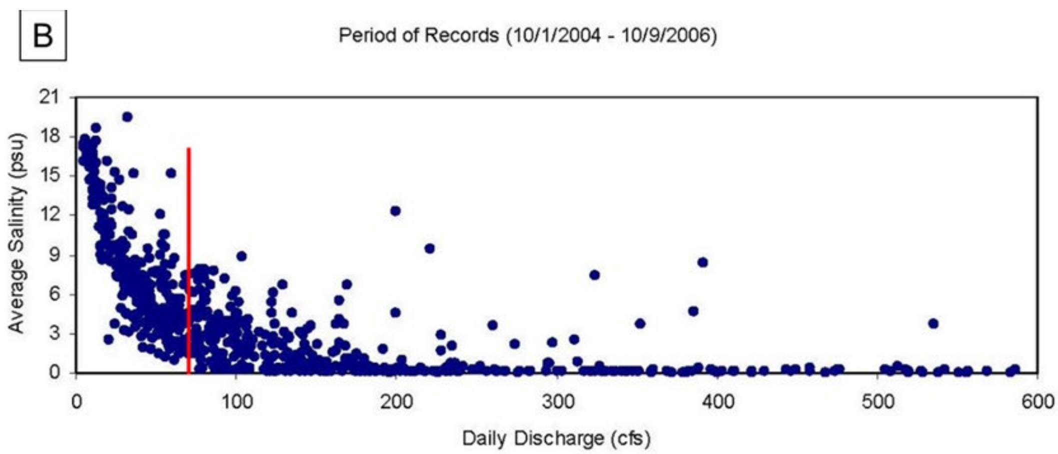


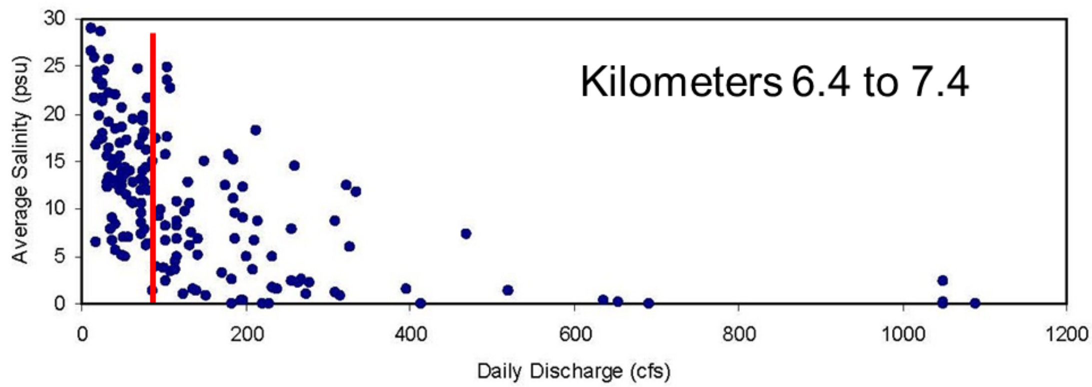
Figure 15. Salinity versus daily discharge for the USGS 02300546 gage, Little Manatee Rive at Ruskin, FL (RKM = 8.3)

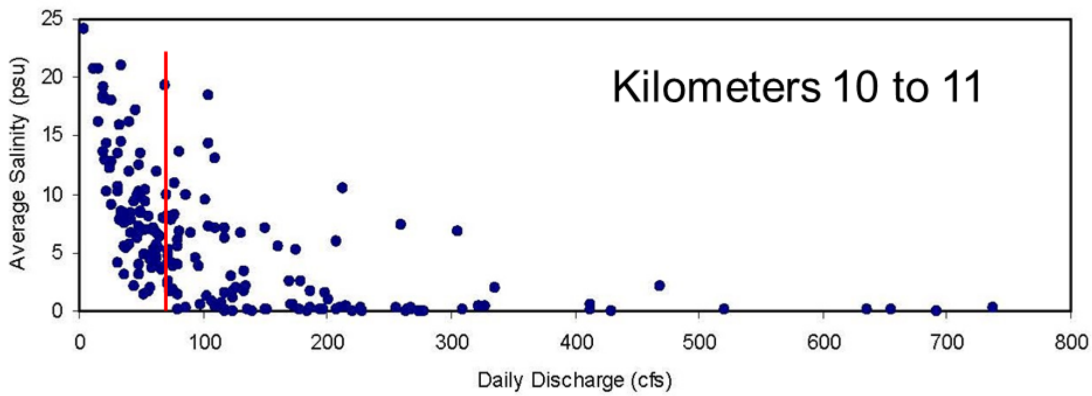


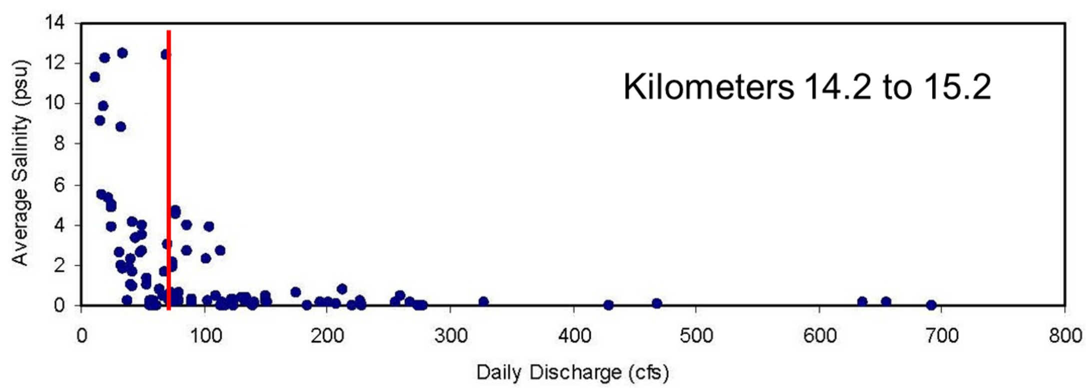
'igure 16. Salinity versus daily discharge for the USGS 02300542 gage, Little Manatee River at I 75 near Ruskin, FL (RKM = 12.1)

Red reference lines inserted at approximately 72 cfs

The USGS operated a series of continuous salinity recorders in the river to support the development of the EFDC hydrodynamic model for the river during 2004 to 2006. Plots of average daily salinity from the top and bottom sensors at each location are shown above for two recorders located at kilometers 8.3 and 12.1. The recorder at 12.1 is at the I-75 bridge, which is just downstream of the braided zone of the river that contains abundant oligohaline marshes that grade upstream to tidal freshwater marshes and forest. Salinity is very responsive to flow in the range of 72 cfs at this location, with the response dampening at higher flows.

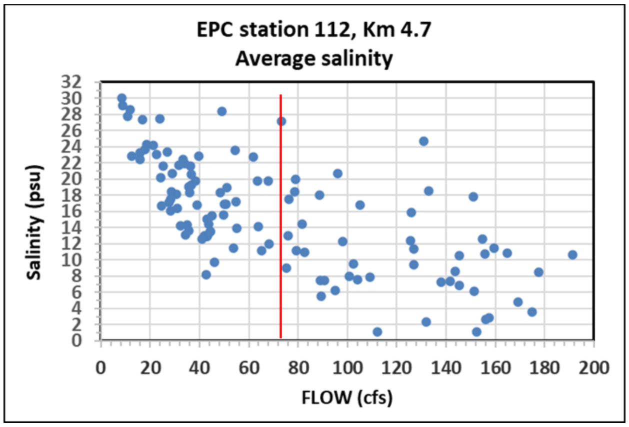


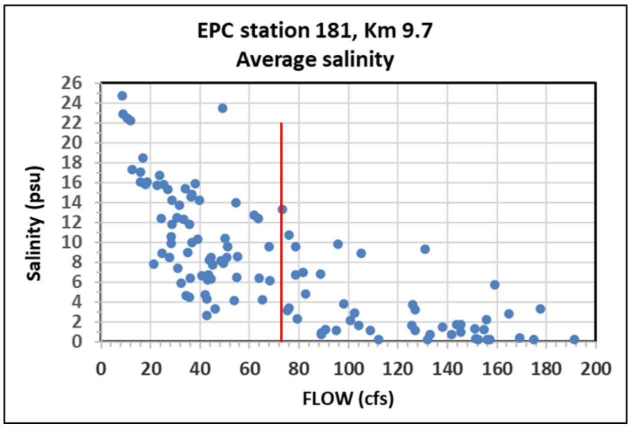


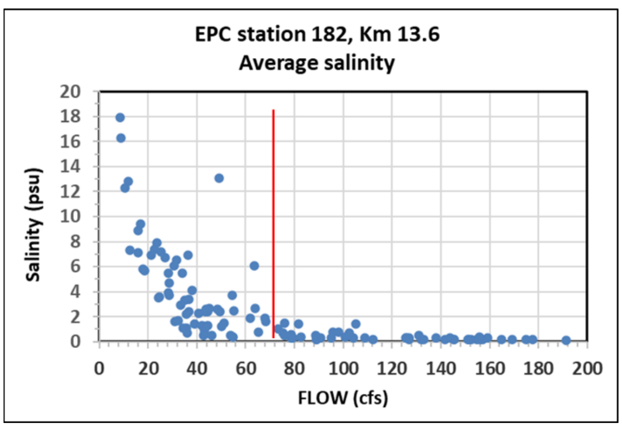


Red Line reference lines inserted at approximately 72 cfs

These graphics on this page are average salinity values from vertical profiles taken by the District and other parties between March 1985 and October 2006. I don't think that 72 cfs represents a good high flow threshold to increase withdrawals, as salinity is very responsive to flow reductions at these sites near that flow value, with a dampened and flatter response at higher flows. Considering that for the most recent twenty year period, 72 cfs has been exceeded 52 percent of the time, a higher threshold to identify high flows would be more appropriate for this estuarine system.







The graphics above are from the Hillsborough County EPC's water quality stations in the tidal river that have been monitored since 2009. At these stations, EPC measures salinity at top, middle and bottom depths, with the average of these values shown above. For station 181 (middle graph), 72 cfs again appears to be too low to serve as a high flow threshold compared to a higher flow rates. The data at station 182 seem more supportive of the 72 cfs threshold, but these salinity values are lower than some average values for kilometers 14.2 to 15.2 reported by the District shown on the previous page. This might be because the District frequently sampled near high tide, or possibly because the District took salinity profiles at surface and 1 meter intervals.

Management Approach for Unimpounded Rivers 1321

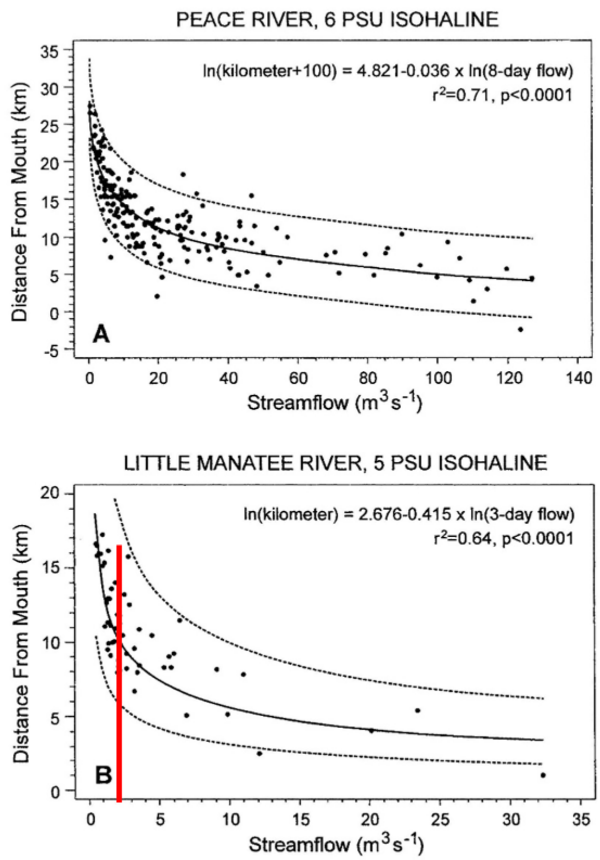


Fig. 3. Regressions of freshwater inflow with (A) the location of the 6 psu surface isohaline in the Peace River (adapted from Janicki Environmental 2001) and (B) the location of the 5 psu surface isohaline in the Little Manatee River (adapted from Peebles and Flannery 1992), with the 95% confidence limits for the predicted values. Regressions are plotted using non-transformed data.

The Figure above shows the strong nonlinear response that salinity isohalines can have with regard to changes in freshwater inflow. The red reference line for the Little Manatee River is near 2 m3/sec, which is equivalent to a flow of 72 cfs. Note there are three occurrences of the surface 5 psu isohaline between kilometers 13 and 16 near a flow rate of 72 cfs and others just below that flow rate. This graphic was taken from an article by Flannery et al (2002) in the journal *Estuaries* that dealt with the percent of flow method, which is referenced in the District's draft minimum flows report.

It should be noted the Little Manatee was one of the three estuarine rivers that provided data and findings that were very important to the initial development of the percent-of-flow method for regulating withdrawals and determining minimum flows for tidal rivers.

208 Environ Fluid Mech (2010) 10:197–211

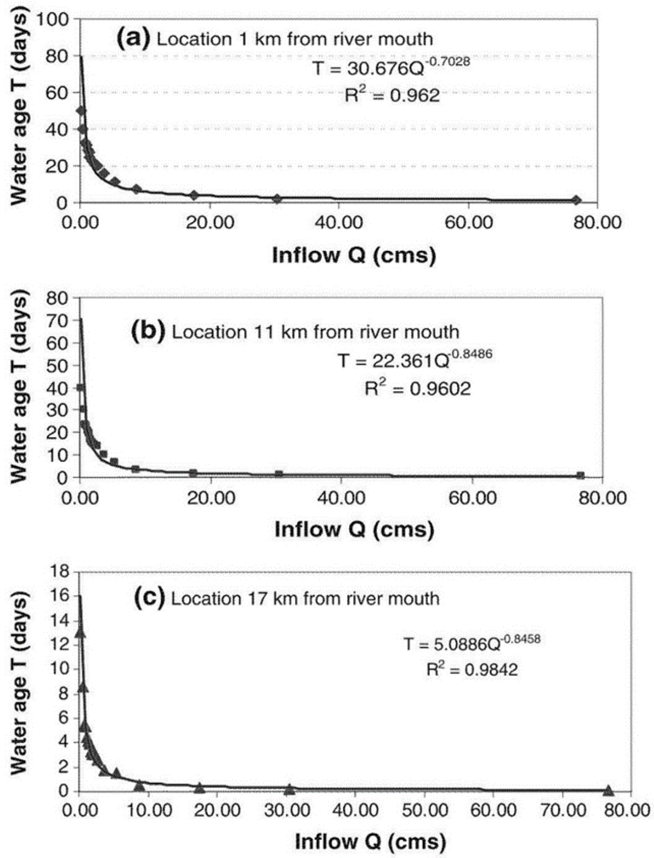


Fig. 9 Tidally-averaged water ages T (days) in responses to river inflows $Q(\mathrm{m}^3/\mathrm{s})$ at different locations along the river main channel. Least-square regressions were done by using power law. Data were obtained from hydrodynamic model simulations

The graphic above was taken from a journal article about water age simulations in the Little Manatee River by Huang et al. (2010) that is cited in the *Overview* document. Water age is a form of residence time, that is the travel time of fresh water from the head of the estuary to a given location, with three sites shown above. The horizontal axes in these figures cover a very high range of flows in m3/sec (for reference 72 cfs is equal to about 2 m3/sec and 4 m3/sec equal to about 141 cfs). Even so, the strong nonlinear response of water age at low flows river is clearly apparent at these locations. The Lower Alafia minimum flows report found that water age can be an important factor affecting very high chlorophyll concentrations.

I did not have time to analyze relationships between chlorophyll *a* and water age in the Little Manatee, but the relationships of chlorophyll *a* with flow shown on pages 5 and 6 are probably due in part to differences in water age at low, medium, and high flows. As such, the nonlinear response of residence time and water age to freshwater inflow should be considered in determining what are truly high flows for the estuarine section of the river. In my opinion, 72 cfs is too low a value for identifying high flows in that regard.

Finally, it interesting to note that the peer review panel for the previous minimum flows report included a graphic that indicated that simulations of residence time and water age can be important for assessing phytoplankton abundance in estuarine rivers. The graphic below was taken from page 9 in that report, with red arrows inserted to highlight the suggested work for hydrodynamic modeling for salinity and water age analysis.

I believe that in fairly short order, the data for the estuarine reach of the Little Manatee River can be reassessed to come up with a threshold to identify high flows that much better protects the lower river from significant harm, compared to the proposed 72 cfs threshold which is clearly too low.

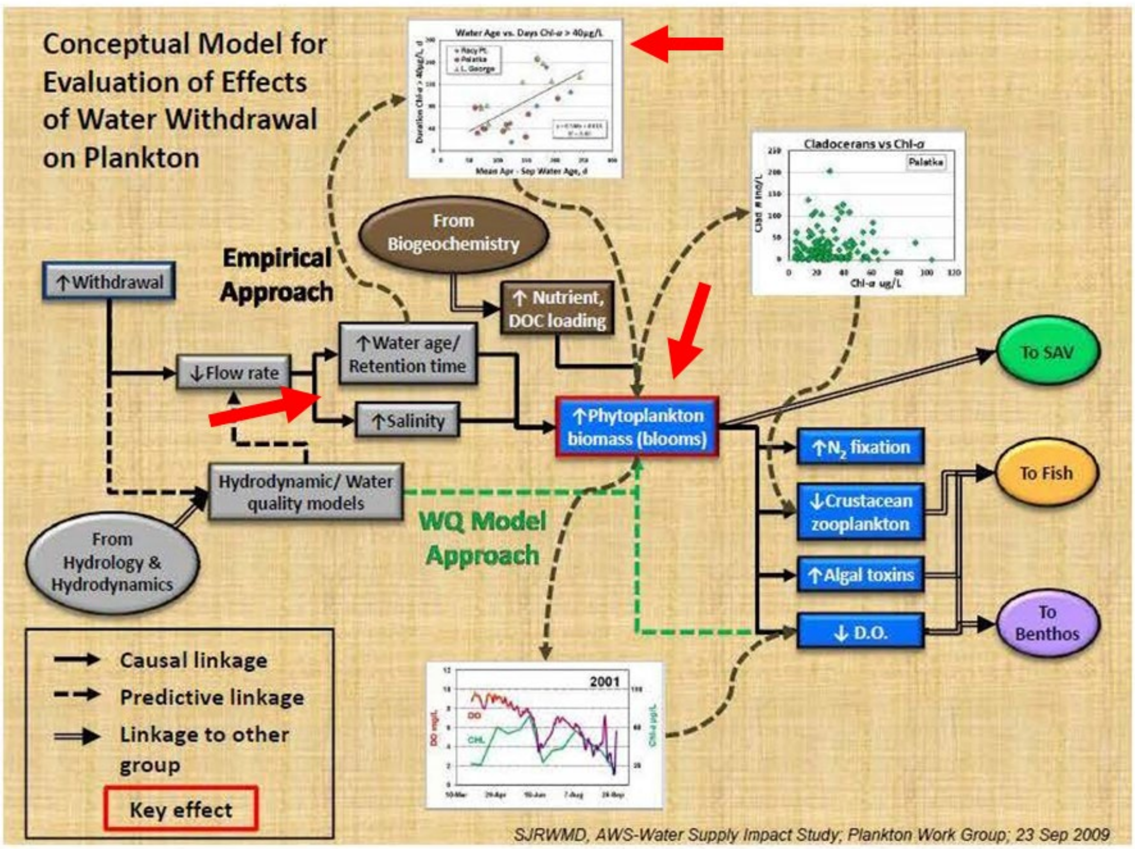


Figure 2. Multidisciplinary studies for assessing water withdrawal impacts on plankton. (SJRWMD 2009)

Figure adapted from Figure 2 in the peer review report for the previous minimum flows report for the Little Manatee River

APPENDIX

Verbal comments to be given at Little Manatee River minimum flows peer review meeting, Oct. 27, 2021
By Sid Flannery

Today I want to talk about the need to establish flow based, minimum flow blocks separately for the freshwater and estuarine sections of the Little Manatee River. I support the use of flow-based blocks, but on the Little Manatee the District has based the flow thresholds for identifying low, medium, and high flows strictly on analyses of the freshwater section of the river, and then applied those same flow thresholds to the estuary. Well this is a first, as the District has never done that before, and it is a serious misstep for the Little Manatee River and sets a bad precedent.

The District has previously used flow-based thresholds to establish minimum flows for a number of estuarine rivers in the region. For example, last year, the District adopted minimum flows for the Lower Peace River for the second time, using three flow-based blocks that were based on salinity relationships in the estuarine section of the river.

The important thing is in all these other rivers, low flow cutoffs and flow-based blocks for the tidal sections of the rivers were based relationships of freshwater inflow to variables and parameters within the estuary.

An important factor to consider is that the response of many important variables in estuarine rivers is nonlinear. Even if you take a fixed percentage of daily flow, say 20 percent, the relative effects of those withdrawals on habitats and other factors can be much greater at low flows than at high flows. Therefore, when applying the percent of flow method in a tidal river, you have to see if there are sensitive flow ranges for the response of different variables to freshwater inflow.

In that regard, I prepared a series of graphs of different variables vs. flow in the Little Manatee that the District uploaded to the minimum flows WebForum this morning. I think the low flow cutoff of 35 cfs for the Little Manatee is adequate, and similar to the 40 cfs cutoff currently in effect for the Florida Power Light withdrawals, which I was involved in evaluating years ago based on estuarine relationships.

However, the 72 cfs threshold for switching from medium to high flow blocks clearly looks to be too low. Based on the graphs that were uploaded today and other analyses, 72 cfs is in a very sensitive flow range for some important variables, particularly in the low salinity reaches of the river.

Also, based on gaged flows at US 301 for the last twenty years, flows would have been above 72 cfs fifty-two percent of the time. The estuarine section of the Little Manatee has a surface area of 2.2 square miles, and for the ecological functions, 72 cfs is not a high rate of inflow for an estuary of this size.

I strongly suggest the review panel recommend that flow rates to identify low, medium, and high flow blocks for minimum flows be evaluated separately for the fresh and estuarine sections of the Little Manatee. Given the modeling tools that have been developed, I think this could be done fairly quickly and the District could issue a purchase order or contract with Janicki Environmental to do this work.

There is an interesting parallel to this. When minimum flows for the Lower Peace River were evaluated for the first time in 2010, the Section Manager wanted the minimum flows for the lower river to use seasonal blocks. As a check, we examined how the percent withdrawals for seasonal blocks 2 and 3 would perform if they were applied during low flows, which would have happened fairly frequently. We found that at low flows, the percentage withdrawals specified for seasonal blocks 2 and 3 would cause greater than a 15 percent change in salinity based habitats, but at higher flows they did not. Based on those findings, the first adopted rule for the Lower Peace River had a flow threshold that seasonal blocks 2 and 3 could not be applied until flows went above a flow rate of 625 cfs.

That type of analysis could to done for the Little Manatee. For example, for a 30% withdrawal, for each day calculate the percent reduction in low salinity habitat relative to baseline, then plot these results vs. the corresponding rates of baseline flow. You will find that at some rate of increased flow, these withdrawals will not cause more than a 15 percent change in habitat, while at lower flows they will. You could examine these results to determine a threshold for identifying high flows, just like we did for the Lower Peace. I expect that a similar approach could be taken the estuarine fish habitat analysis as well.

Also, From the water management perspective, it entirely practical to implement minimum flows rules that differ between the fresh and estuarine reaches of rivers, in fact that has been the standard District practice for years.

Finally, the Lower Little Manatee River below Highway 301 is a State of Florida Aquatic Preserve and the crown jewel of the rivers flowing to Tampa jewel. If you are going to protect this valuable estuarine resource from significant harm, you need examine flow-based blocks that were analyzed specifically for this estuarine system.

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Doug Leeper; Eric DeHaven; Adrienne E. Vining; Xinjian Chen; Jordan D. Miller; Chris Zajac; Kristina Deak; Gabe I. Herrick; Lei Yang; Danielle Rogers; Philip Rhinesmith; mburke; esherwood; Karlen, David; Ernst Peebles; ash; Dougherty, Janet; Wessel MIke; Tony Janicki (tjanicki@janickienvironmental.com); Nancy Stevens; Ernie Estevez
Subject:	Graphics and comments for Little Manatee River peer review
Date:	Wednesday, October 27, 2021 7:31:40 AM
Attachments:	Graphics and comments for Little Manatee River peer review from Sid Flannery, 10_27_2021.pdf

Hello Kym and District staff,

Attached is a set of graphics I prepared related to the ongoing peer review of the minimum flows for the Little Manatee River. The document also includes the verbal comments I plan to give at today's peer review meeting. Would you please upload this email and the attached file to the minimum flows WebForum.

These graphics and comments concern the need to evaluate flow-based thresholds that identify low, medium, and high flow blocks separately for the freshwater and estuarine sections of the Little Manatee. As described in the attached document, I think the 72 cfs threshold for identifying high flows, which was based on the freshwater section of the river, is clearly too low for the estuarine section of the Little Manatee.

Thanks,
Sid

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Doug Leeper; Xinjian Chen; Jordan D. Miller; Chris Zajac; Kristina Deak; Gabe I. Herrick; Lei Yang; mburke; esherwood; Karlen, David; Ernst Peebles; ash; Wessel MIke; Tony Janicki (tjanicki@janickienvironmental.com); Nancy Stevens
Subject:	Re: Graphics and comments for Little Manatee River peer review
Date:	Wednesday, October 27, 2021 4:03:35 PM
Attachments:	Graphics and comments for Little Manatee River peer review from Sid Flannery, 10_27_2021, 4 PM.pdf

Hello Kym,

In going through my presentation, I noticed that a couple of clarifications were needed in the Appendix of the document I submitted earlier today, which were my verbal comments at today's peer review meeting. I made those changes prior to speaking, so they are reflected in the attached document. Could you replace on the WebForum my document titled *Graphics and comments for Little Manatee River peer review from Sid Flannery, 10_27_21*. The attached replacement file ends with *4 PM* in the title.

I would like to point out that none of the material in the Graphics section of the document changed, only some small wording changes in the Appendix.

Thanks,
Sid

Comments for the November 3, 2021 Little Manatee River minimum flows peer review meeting

Prepared by Sid Flannery

Note – Four paragraphs that will not be verbally presented on 11/3/21 due to time constraints are shown in blue font

Today I would like to speak about how minimum flows are implemented using flow-based blocks. The review panel is considering whether the flow blocks should, or should not be, the same for the fresh and estuarine sections of the Little Manatee.

Well, they are not entirely the same in the currently proposed rule, which is shown in the table below. Note than in Block 3 the freshwater minimum flows have a second high flow threshold of 174 cfs that is highlighted in yellow, which is not assigned to the estuarine minimum flows. You can subtract the numbers shown in red to calculate the percent withdrawals in each block. So, for block 3 in the freshwater section, flows cannot be reduced by more than 13 or 11 percent depending on the rate of flow. Further downstream, flows to the lower river cannot be reduced by more than 30 percent at flows above 72 cfs.

Table 6-9. Proposed minimum flows for the Little Manatee River.

	Block 1 (≤ 35 cfs)	Block 2 (> 35 cfs and ≤ 72 cfs)	Block 3 (> 72 cfs)
Upper Little Manatee River (Headwaters to Highway 301)	90% of the flow on the previous day	80% of the flow on the previous day	**87%** of the flow on the previous day when the previous day's flow was > 72 cfs and ≤ 174 cfs, or **89%** of the flow on the previous day when the previous day's flow was > 174 cfs
Lower Little Manatee River (Highway 301 to Tampa Bay)	90% of the flow on the previous day	80% of the flow on the previous day	**70%** of the flow on the previous day
Upper and Lower Little Manatee River	No surface water withdrawals are permitted when flows are ≤ 35 cfs		

So, lets hypothetically change the threshold to switch from block 2 to block 3 for the lower river from 72 cfs to 120 cfs. We still have the 13 and 11 percent limits to withdrawals in block 3 in the freshwater section, but flow reductions to the lower river cannot exceed 20 percent until flows go above 120 cfs, when percent withdrawals can increase to 30 percent. This is very simple and straightforward and poses no water management complications whatsoever.

There are two factors that typically make the percent-of-flow method very practical within the District. Estuaries in the region are generally not as sensitive to ecological impacts from flow reductions as are freshwater rivers, and minimum flows adopted for estuarine rivers usually allow for the same, or more often, greater percent withdrawals than for the corresponding freshwater sections. And, it is an obvious point, but the estuary is always downstream. If these two types of ecosystems were interspersed along the river channel it could be complicated, but that is not the case.

If we are to protect both the freshwater and estuarine sections of our rivers, it is critical to first evaluate the most effective flow blocks separately for these two very different ecosystems, then write the rules accordingly. Based on years of experience applying the percent-of-flow method, that has not been a problem yet and I don't foresee it being a problem in the future.

For years the District has included flow-based blocks in estuarine minimum flow rules based on analyses of relationships within those tidal rivers. However, with the Little Manatee, the District for the first time has developed blocks based solely on the freshwater section of the river and then assigned three of those same blocks to the estuarine section as well.

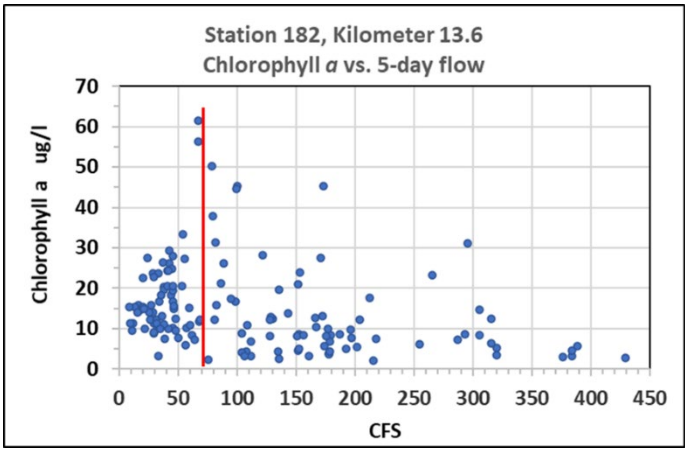
Assigning 72 cfs as the high flow block for the estuary does not allow for the evaluation of important ecological relationships in the lower river above that flow rate, which by the way, was near the median flow for the river for the last 20 years. Many of these relationships at higher flows are important to the ecological functions of the estuarine section of the river.

Last week, Dr. Ernst Peebles of USF said that the combined zooplankton/ichthyoplankton catch in the lower river showed a shift around 100 cfs. Also last week, I discussed that many variables in estuaries respond to freshwater inflow in a nonlinear manner and submitted a document to the WebForum that contained plots for salinity and other parameters in the lower river vs. freshwater inflow. Those plots showed these parameters respond strongly to flow reductions near 72 cfs, but more gradually at higher flow rates, where the relative ecological effects of flow reductions would be smaller. Such relationships could be evaluated to develop a revised block 3 for the lower river.

For example, upstream of I-75 there are widespread oligohaline marshes dominated by freshwater species that have some salt tolerance, such as sawgrass and cattails. The inundation of these marshes with fresh water in the wet season is important to their health and productivity. Plots of salinity versus flow in the graphics document show that salinity is very sensitive to flow reductions at 72 cfs in this reach of the river, but not so much at flows above 100 to 150 cfs.

Go to next page

The graph below is a plot of chlorophyll *a* vs. five-day average flow at the EPC station located about one and a half kilometers upstream of the I-75 bridge. The red reference line is the block 3 threshold at 72 cfs. It is clear that chlorophyll concentrations are near maximum in this flow range. Although trends in nutrients have been encouraging in recent years, longer term data have shown the Little Manatee has been significantly enriched with nutrients from human activities in the watershed. Given that, 72 cfs does not look to be a good place to switch from block 2 to block 3 and increase the withdrawal rate from 20 to 30 percent, slowing the water down in this sensitive flow range. But again, estuarine relationships were not evaluated in the determination of the flow blocks.



A very useful analysis is to examine daily output from the EFDC model to see in what flow range does a specific percent withdrawal rate cause reductions in low salinity habitats greater than 15 percent, similar to what was done for the Lower Peace River. I suspect the fish habitat analysis could be used in a similar manner.

In closing, over the last 30 years the District had spent considerable time, effort, and money to conduct detailed technical investigations of the relationships of streamflow to the ecology of freshwater and estuarine rivers. In doing so, it has developed the very progressive percent-of-flow method, which has been successfully applied to many rivers.

However, the percent-of-flow method is at a critical juncture right now. The topic of whether the flow blocks have to be the same for fresh and estuarine sections of rivers is extremely important and the Little Manatee could be viewed a precedent. Based on a number of ecological factors and practical water management considerations, I strongly believe that flow blocks for fresh and estuarine sections of rivers need to be evaluated separately. Again, the District has evaluated flow blocks for tidal rivers based on relationships within those estuaries in the past, and there is no real practical water management reason to discontinue that now.

It looks like the review of the Little Manatee River minimum flows report is on a very fast track. I suggest the panel take additional time to consider further the flow blocks issue. The panel could get input from other parties, continue discussions with District staff, and consider some other analyses. There is no real need to hurry on the minimum flows for this truly outstanding river, and the flow blocks issue is a critical factor that needs to be thoroughly assessed.

RE: Comments for submittal to Little Manatee River minimum flows peer review panel

Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Wed 10/6/2021 12:53 PM

To: Sid Flannery <sidflannery22@gmail.com>
Cc: Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Eric DeHaven <Eric.Dehaven@swfwmd.state.fl.us>; Adrienne E. Vining <Adrienne.Vining@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Lei Yang <Lei.Yang@swfwmd.state.fl.us>; mburke <mburke@tbep.org>; esherwood <esherwood@tbep.org>; Ernst Peebles <epeebles@usf.edu>; Karlen, David <Karlen@epchc.org>; Dougherty, Janet <doughertyj@epchc.org>; ash <ash@epchc.org>; MIke Wessel (MWessel@janickienvironmental.com) <MWessel@janickienvironmental.com>; Tony Janicki (tjanicki@janickienvironmental.com) <tjanicki@janickienvironmental.com>

Thanks Sid. I will upload the email and files to the WebForum.
Kym

From: Sid Flannery <sidflannery22@gmail.com>
Sent: Wednesday, October 6, 2021 9:52 AM
To: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Cc: Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Eric DeHaven <Eric.Dehaven@swfwmd.state.fl.us>; Adrienne E. Vining <Adrienne.Vining@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Lei Yang <Lei.Yang@swfwmd.state.fl.us>; mburke <mburke@tbep.org>; esherwood <esherwood@tbep.org>; Ernst Peebles <epeebles@usf.edu>; Karlen, David <Karlen@epchc.org>; Dougherty, Janet <doughertyj@epchc.org>; ash <ash@epchc.org>; MIke Wessel (MWessel@janickienvironmental.com) <MWessel@janickienvironmental.com>; Tony Janicki (tjanicki@janickienvironmental.com) <tjanicki@janickienvironmental.com>
Subject: Comments for submittal to Little Manatee River minimum flows peer review panel

[EXTERNAL SENDER] Use caution before opening.

Hello Kym,

Kudos to you and the District for facilitating an excellent kick-off meeting of the Little Manatee River minimum flows peer review panel. Attached is a pdf of the complete comments I had hoped to present to the panel yesterday, but time ran out before I could finish them.

As described in the italicized preface to the comments, I added two paragraphs and one slide based on work conducted by Dr. Gabriel Vargo of the University of South Florida College of Marine Science (retired). I also encourage readers to review the important section about separate flow-based thresholds for the freshwater and estuarine sections of the river, which begins on page 3.

The three slides that are referenced in my comments are also attached. Please provide this email and the attached documents to the minimum flows peer review panel for the Little Manatee River. Thanks to the District for conducting the peer review and considering public comment. I anticipate submitting additional comments to the panel, so please keep me apprised of the dates of future panel meetings.

Thanks again,
Sid

Table 6-9. Proposed minimum flows for the Little Manatee River.

	Block 1 (< 35 cfs)	Block 2 (> 35 cfs and < 72 cfs)	Block 3 (> 72 cfs)
Upper Little Manatee River (Headwaters to Highway 301)	90% of the flow on the previous day	80% of the flow on the previous day	**87%** of the flow on the previous day when the previous day's flow was > 72 cfs and < 174 cfs, or **89%** of the flow on the previous day when the previous day's flow was > 174 cfs
Lower Little Manatee River (Highway 301 to Tampa Bay)	90% of the flow on the previous day	80% of the flow on the previous day	**70%** of the flow on the previous day
Upper and Lower Little Manatee River	No surface water withdrawals are permitted when flows are < 35 cfs		

Verbal comments for November 3 Little Manatee River minimum flows peer review meeting.

Prepared by Sid Flannery

Today I would like to speak about how minimum flows are implemented using flow-based blocks. The review panel is considering whether the flow blocks should, or should not be, the same for the fresh and estuarine sections of the Little Manatee.

Well, they are not entirely the same in the currently proposed rule, which is shown in the table on your screen (below). Note than in Block 3 the freshwater minimum flows have a second high flow threshold of 174 cfs that is highlighted in yellow, which is not assigned to the estuarine minimum flows. You can subtract the numbers shown in red to calculate the percent withdrawals in each block. So, for block 3 in the freshwater section, flows cannot be reduced by 13 or 11 percent depending on the rate of flow Further downstream, flows to the lower river cannot be reduced by more than 30 percent at flows above 72 cfs.

Table 6-9. Proposed minimum flows for the Little Manatee River.

	Block 1 (≤ 35 cfs)	Block 2 (> 35 cfs and ≤ 72 cfs)	Block 3 (> 72 cfs)
Upper Little Manatee River (Headwaters to Highway 301)	90% of the flow on the previous day	80% of the flow on the previous day	**87%** of the flow on the previous day when the previous day's flow was > 72 cfs and ≤ 174 cfs, or **89%** of the flow on the previous day when the previous day's flow was > 174 cfs
Lower Little Manatee River (Highway 301 to Tampa Bay)	90% of the flow on the previous day	80% of the flow on the previous day	**70%** of the flow on the previous day
Upper and Lower Little Manatee River	No surface water withdrawals are permitted when flows are ≤ 35 cfs		

So, lets hypothetically change the threshold to switch from block 2 to block 3 for the lower river to 120 cfs. We still have the 13 and 11 percent limits to withdrawals in block 3 in the freshwater section, but flow reductions to the lower river cannot exceed 20 percent until flows go above 120 cfs, when percent withdrawals can increase to 30 percent. This is very simple and straightforward and poses no water management complications whatsoever.

If we are to protect both the freshwater and estuarine sections of our rivers, it is critical to first evaluate the most effective flow blocks separately for these two very different ecosystems, then write the rules accordingly. Based on years of experience applying the percent of flow method to existing water use permits, I don't think that having separate flow blocks for the fresh and estuarine sections of a river would cause complications for water management, and changing the block 3 threshold for the lower Little Manatee certainly would not.

For years the District has included flow-based blocks in estuarine minimum flow rules based on analyses of relationships within those tidal rivers. However, with the Little Manatee, the District for the first time has assigned flow blocks developed for the freshwater section of the river to the estuarine section as well.

Assigning 72 cfs as the high flow block for the estuary does not allow for the evaluation of important ecological relationships in the lower river above that flow rate, which by the way, was near the median flow for the river for the last 20 years. Many of these relationships at higher flows are important to the ecological functions of the lower river, which could be evaluated to come up with a revised block 3.

For example, last week Dr. Peebles said that combined zooplankton/ichthyoplankton catch in the lower river showed a shift in community heterogeneity around 100 cfs. Last week, I submitted to the WebForum a series of plots of salinity, residence time, isohaline position, and chlorophyll *a* versus freshwater inflow that showed these parameters respond strongly to freshwater inflow near 72 cfs, but less acutely at slightly higher flow rates, which could be evaluated to develop a revised block 3. Given some the discussions the panel has been having, the plots of chlorophyll *a* versus freshwater inflow are particularly interesting in that regard.

Also, a very useful analysis is to examine daily output from the EFDC model see in what flow range does a specific percent withdrawal rate cause reductions in low salinity habitats greater than 15 percent, similar to what was done for the Lower Peace River. I suspect the fish habitat analysis could be used in a similar manner.

In closing, over the last 30 years the District had spent considerable time, effort, and money to conduct detailed technical investigations of the relationships of streamflow to the ecology of freshwater and estuarine rivers. In doing so, it has developed the very progressive percent of flow method, which has been successfully applied to many rivers.

However, the percent of flow method is at a critical juncture right now. The topic of whether the flow blocks have to be the same for fresh and estuarine sections of rivers is extremely important and the Little Manatee could be viewed a precedent. Based on a number of ecological factors and practical water management considerations, I strongly believe that flow blocks for fresh and estuarine sections of rivers need to be evaluated separately. At a minimum, you don't want to simply apply the blocks that were developed for the freshwater section of a river to the estuary, as was done for the Little Manatee.

It looks like the review of the Little Manatee River minimum flows report is on a very fast track. I suggest the panel take additional time to consider further the flow blocks issue. The panel could get input from other parties, continue discussions with District staff, and consider some other analyses. There is no real need to hurry on this minimum flow on this very valuable river, and this is a critical factor that needs to be thoroughly assessed.

Verbal comments for November 3 Little Manatee River minimum flows peer review meeting.

Prepared by Sid Flannery (ADDED PARAGRAPHS IN BLUE)

Today I would like to speak about how minimum flows are implemented using flow-based blocks. The review panel is considering whether the flow blocks should, or should not be, the same for the fresh and estuarine sections of the Little Manatee.

Well, they are not entirely the same in the currently proposed rule, which is shown in the table on your screen (below). Note than in Block 3 the freshwater minimum flows have a second high flow threshold of 174 cfs that is highlighted in yellow, which is not assigned to the estuarine minimum flows. You can subtract the numbers shown in red to calculate the percent withdrawals in each block. So, for block 3 in the freshwater section, flows cannot be reduced by 13 or 11 percent depending on the rate of flow Further downstream, flows to the lower river cannot be reduced by more than 30 percent at flows above 72 cfs.

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There are two factors that typically make the percent of flow method very workable within the District. Estuaries in the region are generally not as sensitive to ecological impacts from flow reductions as are freshwater rivers, and minimum flows adopted for estuarine rivers usually allow for the same, or more often, greater percent withdrawals than for the corresponding freshwater sections. And, it is an obvious point, but the estuary is always downstream. If these two types of ecosystems were interspersed along the river channel it could be complicated, but that is not the case.

If we are to protect both the freshwater and estuarine sections of our rivers, it is critical to first evaluate the most effective flow blocks separately for these two very different ecosystems, then write the rules accordingly. Based on years of experience applying the percent of flow method to existing water use permits, I don't think that having separate flow blocks for the fresh and estuarine sections of a river would cause complications for water management, and changing the block 3 threshold for the lower Little Manatee certainly would not.

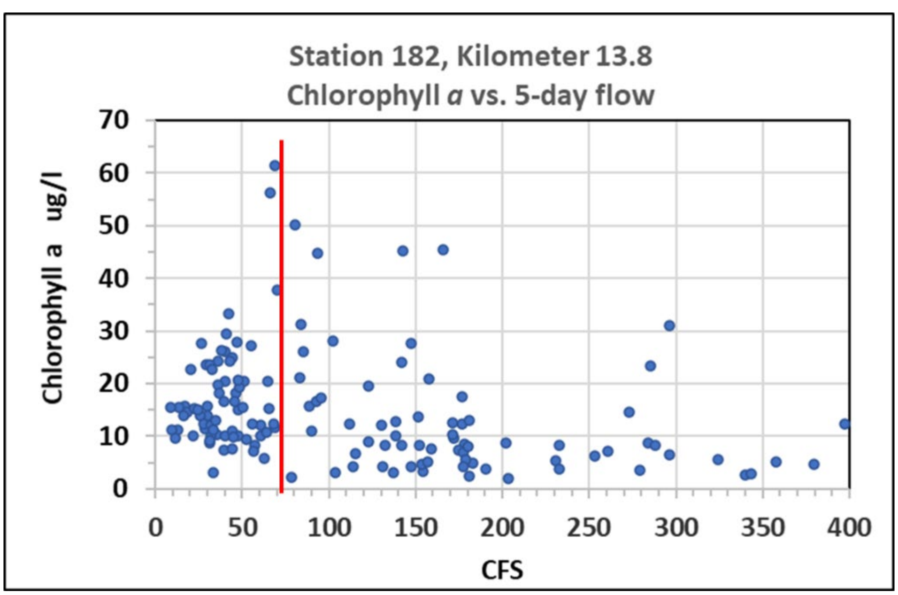
For years the District has included flow-based blocks in estuarine minimum flow rules based on analyses of relationships within those tidal rivers. However, with the Little Manatee, the District for the first time has assigned flow blocks developed for the freshwater section of the river to the estuarine section as well.

Assigning 72 cfs as the high flow block for the estuary does not allow for the evaluation of important ecological relationships in the lower river above that flow rate, which by the way, was near the median flow for the river for the last 20 years. Many of these relationships at higher flows are important to the ecological functions of the lower river, which could be evaluated to come up with a revised block 3.

For example, last week Dr. Ernst Peebles said that the combined zooplankton/ichthyoplankton catch in the lower river showed a shift in community heterogeneity around 100 cfs. Last week I also submitted to the WebForum a series of plots of salinity and other parameters vs freshwater inflow that showed these parameters respond strongly to freshwater inflow near 72 cfs, but less acutely at slightly higher flow rates, which could be evaluated to develop a revised block 3.

For example, upstream of I-75 there are widespread oligohaline marshes dominated by freshwater plants that have some salt tolerance such as sawgrass and cattails. The inundation of these marshes with fresh water in the wet season is important to their health and productivity. Plots of salinity versus flow in the graphics document show that salinity is very sensitive to flow reductions at 72 cfs in this reach of the river, but not so much at flows above 100 to 150 cfs.

The graphics document also includes plots of chlorophyll *a* concentrations versus flow at three locations in the river. Due to a combination of factors, the response of chlorophyll *a* vs. flow differs greatly between the lower and upper sections of the tidal river. At the two uppermost stations, 72 cfs is in the flow range where chlorophyll *a* is reaches peak values in the range of 40 to 90 ug/l (data from kilometer 13.8 shown below, some higher values observed at kilometer 9.6). It could be argued whether that represents an ecological imbalance or not, but in my opinion, 72 cfs is not a flow rate where there should be an increase in the percent withdrawal.



Also, a very useful analysis is to examine daily output from the EFDC model see in what flow range does a specific percent withdrawal rate cause usually reductions in low salinity habitats greater than 15 percent, similar to what was done for the Lower Peace River. I suspect the fish habitat analysis could be used in a similar manner.

In closing, over the last 30 years the District had spent considerable time, effort, and money to conduct detailed technical investigations of the relationships of streamflow to the ecology of freshwater and estuarine rivers. In doing so, it has developed the very progressive percent of flow method, which has been successfully applied to many rivers.

However, the percent of flow method is at a critical juncture right now. The topic of whether the flow blocks have to be the same for fresh and estuarine sections of rivers is extremely important and the Little Manatee could be viewed a precedent. Based on a number of ecological factors and practical water management considerations, I strongly believe that flow blocks for fresh and estuarine sections of rivers need to be evaluated separately. At a minimum, you don't want to simply apply the blocks that were developed for the freshwater section of a river to the estuary, as was done for the Little Manatee.

It looks like the review of the Little Manatee River minimum flows report is on a very fast track. I suggest the panel take additional time to consider further the flow blocks issue. The panel could get input from other parties, continue discussions with District staff, and consider some other analyses. There is no real need to hurry on this minimum flow on this very valuable river, and this is a critical factor that needs to be thoroughly assessed.

From: Sid Flannery
To: Kym Holzwart
Cc: Doug Leeper; Gabe I. Herrick; Xinjian Chen; Lei Yang; Kristina Deak; Chris Zajac
Subject: DRAFT presentations for Little Manatee peer review meeting tomorrow
Date: Tuesday, November 2, 2021 7:59:49 AM
Attachments: Nov. 3 presentation - 6.5 minutes DRAFT.pdf
Nov. 3 presentation - 5 minutes DRAFT.pdf

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and District staff,

Attached are two draft versions of the comments I would like to give as part of the public comments period at the Little Manatee River minimum flows peer review meeting tomorrow. One version is 5 minutes long while the other is 6.5 minutes long.

The 6.5 minute version has three short paragraphs that are shown in blue font. Given the importance of flow blocks issue and its very timely nature, I think it would be better to give the 6.5 minute version, in part because it addresses two topics that have been mentioned by the panel with either incomplete or misleading information (chlorophyll *a* concentrations and marsh vegetation upstream of I-75).

I will give whichever presentation the District allows, but prefer the 6.5 minute version. Please let me know today which version I can give and I will resubmit a document later today for posting to the minimum flows WebForum. The graph(s) in the presentations will be submitted as separate files for showing at the meeting.

Thanks,
Sid

From: Sid Flannery
To: Kym Holzwart
Cc: Doug Leeper; Gabe I. Herrick; Xinjian Chen; Lei Yang; Kristina Deak; Chris Zajac; Adrienne E. Vining; Jordan D. Miller; Randy Smith; phillip.rhinesmith@swfwmd.state.fl.us; Danielle Rogers
Subject: Re: DRAFT presentations for Little Manatee peer review meeting tomorrow
Date: Tuesday, November 2, 2021 11:47:27 AM
Attachments: Email from Sid Flannery 100621.pdf
Sid Flannery Comments 100621.pdf

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and District staff,

I will restrict my comments to 5 minutes tomorrow. However, this afternoon I will send you my final 6.5 minute version and request that is be posted to the WebForum prior to tomrorrow's meeting.

In the mean time, I noticed that my email and comments that were submitted on October 6th are found in the WebForum under the category of *Peer review panel teams kickoff meeting, October 5, 2021.* It might be better to move or copy that email and comments to the Public Comments category. Pdfs of the email and comments that you posted 25 days ago are attached.

Thanks again,
Sid

On Tue, Nov 2, 2021 at 10:10 AM Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us> wrote:

> Good Morning Sid,
>
> Thanks for providing comments. Please limit your comments to no more than 5 minutes during the public comment period at the end of tomorrow's meeting.
>
> Best regards,
>
> Kym
>
> ---
>
> **From:** Sid Flannery <sidflannery22@gmail.com>
> **Sent:** Tuesday, November 2, 2021 7:59 AM
> **To:** Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
> **Cc:** Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Lei Yang <Lei.Yang@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>
> **Subject:** DRAFT presentations for Little Manatee peer review meeting tomorrow

[EXTERNAL SENDER] Use caution before opening.

Hello Kym and District staff,

Attached are two draft versions of the comments I would like to give as part of the public comments period at the Little Manatee River minimum flows peer review meeting tomorrow. One version is 5 minutes long while the other is 6.5 minutes long.

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I will give whichever presentation the District allows, but prefer the 6.5 minute version. Please let me know today which version I can give and I will resubmit a document later today for posting to the minimum flows WebForum.   The graph(s) in the presentations will be submitted as separate files for showing at the meeting.

Thanks,
Sid

From: Sid Flannery
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Cc: Doug Leeper; Adrienne E. Vining; Xinjian Chen; Jordan D. Miller; Chris Zajac; Kristina Deak; Gabe I. Herrick; Lei Yang; Danielle Rogers; Philip Rhinesmith; mburke; esherwood; Karlen, David; Ernst Peebles; ash; Dougherty, Janet; Wessel MIke; Tony Janicki (tjanicki@janickienvironmental.com)
Subject: Comments for Little Manatee River minimum flows peer review meeting on November 3, 2021
Date: Tuesday, November 2, 2021 3:24:45 PM
Attachments: Minimum flows table.pdf
Comments from Sid Flannery for the Little Manatee River peer review meeting, Nov. 3, 2021.pdf

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Hello Kym and District staff,

Tomorrow I plan to address the peer review panel for the Little Manatee River minimum flows during the public comments portion of the meeting. Attached is a written version of my comments. However, in this written version I have included three paragraphs and one figure that I won't be showing tomorrow due to time constraints.

As described in the note at the top of the document, these paragraphs are shown in blue font in the document. I think those paragraphs provide very valuable information and encourage those interested in the minimum flows for the Little Manatee to read them as part of my complete comments.

Also attached is a pdf of a table I would like shown as part of my presentation tomorrow. I think it would be best to first call it up on screen, then I will begin my comments.

Would you please post this email and the attached document and table to the minimum flows WebForum prior to tomorrow's meeting. It is possible I might slightly modify my verbal comments tomorrow, but they will be taken from the attached document.

Thanks as always,
Sid

Public comments by Sid Flannery at the Little Manatee River minimum flows peer review meeting on 10/5/21 (not completed at the meeting due to time constraints)

Below is a transcript of the complete comments I had hoped to give at the peer review panel meeting on October 5, 2021, but ran short on time. I have added two paragraphs about the work by Dr. Gabriel Vargo and have supplied one additional slide I would like sent to the peer review panel with this document. The other two slides that were shown at the meeting are also submitted and all three slides are shown at the end of this document.

I encourage readers to review the information about Dr. Vargo's work and the important topic of separate flow thresholds for freshwater and estuarine sections of the river that starts on page 3, which I did not have time to cover in my public comments at the meeting.

My name is Sid Flannery, and as I introduced myself earlier, I am a retired Chief Environmental Scientist with the District's minimum flows program, where I worked many years on the hydrobiological flow relationships of the Little Manatee River. I managed nine different consultant research or analysis projects for the river and have probably spent 50 plus field days on the lower portions of the Little Manatee.

I want to first acknowledge how hard and conscientiously District staff works on the minimum flows reports, for they are under a very challenging schedule for the adoption of the minimum flow rules.

I quickly read through the minimum flows report for the Little Manatee, and based on further review, I will submit a series of questions and comments to the District. I will request that these questions and comments be provided to the peer review panel via the minimum flows web-board.

Today, I want to briefly discuss two aspects of the minimum flows report, the first of which I think is pretty easy to address, and the second which may require some new analyses.

The first topic is the report does not cite nor describe some important earlier technical reports that were prepared for the District about the Little Manatee River which provide very useful information regarding its ecological relationships with freshwater flows. I think these reports need to be cited and briefly summarized in the District report. Importantly, I don't think that concise summaries of these reports will change the recommended minimum flows and it should be fairly easy to incorporate them in the format of the District report. Inclusion of this material will improve the public and the technical community's understanding of the freshwater flow relationships of the Little Manatee River, and therefore better support the recommended minimum flows.

I have got two slides I want to show you in this regard *(a third slide has been added since I spoke).*

On page 70, the District report shows a land cover map for the lower, tidal reach of the Little Manatee River using the Florida Land Use, Cover, and Forms Classification System, also known as FLUCCS. However, there is much better information available for the river, for in the 1990's the District contracted the State of Florida Marine Research Institute to do detailed mapping of vegetation communities in five tidal rivers, including the Little Manatee.

This slide (at end of this document) shows the vegetation communities that were mapped as part of that project. Note that compared to the FLUCCS codes shown in the District report, the low salinity plant communities are identified with much greater resolution, including *Typha*, *Cladium*, *Acrostichum*, freshwater marshes and other communities. It is worth noting that on the Little Manatee and other tidal rivers, the District has rightly emphasized the protection of low salinity zones, such a < 2 psu salinity. This is particularly relevant on the Little Manatee for it has a highly braided zone above kilometer 12, which has a very high degree of shoreline length per river kilometer. This zone of the river is one of the real unique areas in southwest Florida and its health is closely linked to the minimum flows. This is the map that needs to be used in the District report and work that produced it needs to be cited.

Also, in 1988 and 1989, the District received grants from the Florida Department of Environmental Protection to examine the linkages between the Little Manatee River watershed and its receiving estuary. That project included a two-year study of ichthyoplankton communities in the tidal reach of the river, which involved the early life stages of estuarine fishes. This was conducted by Dr. Ernst Peebles of the University of South Florida College of Marine Science and it is briefly described on page 99 in the District report, followed by a table of the 30 most abundant fish life stages captured during the study. It should be noted this study also quantified the abundance of many invertebrates caught in the plankton net that are important fish food organisms.

There are other valuable findings from this project that could also be briefly summarized in the District report. The next slide is from that project. I think If there is one slide that best supports the District's minimum flows program for tidal rivers, this is it. It shows mean salinity at capture for the immature life stages for five species of fish in the Little Manatee, with age increasing toward the right. The first three are larval stages, as many important estuarine dependent species spawn in the bay or gulf or near the mouths of rivers.

As these fishes grow to juveniles and develop stronger swimming ability, they move into low salinity waters. This, about as effectively as anything, justifies the use of the low salinity habitats as a parameter for establishing minimum flows. There are some other aspects of the ichthyoplankton report for the Little Manatee that are valuable, but at a minimum this graphic needs to go into the District report.

There are four other papers or reports (one a group of three related reports) that need to be cited and summarized in the District report. Of particular significance is important primary production work done by Dr. Gabriel Vargo of the University of South Florida College of Marine Science.

On page 56, the District report shows yearly mean chlorophyll *a* concentrations at five stations in the Little Manatee monitored by the Environmental Protection Commission of Hillsborough

County, including four in the estuarine reach of the river. The report states the spatial pattern shown between these stations is typical of tidal rivers. Well not exactly, the Little Manatee is unusual in that regard and there are reasons for it. The table below, which is also submitted as a slide, is adapted from a report that Dr. Vargo prepared for the District that compares chlorophyll and phytoplankton relationships in the Little Manatee, Alafia, and Peace Rivers.

Means, number of observations (N) and periods of data collection for chlorophyll *a* concentrations at four moving salinity-based stations in the tidal reaches of the Little Manatee, Peace, and Alafia Rivers.					
		Salinity-based stations			
	N	**0.5 psu**	**6 psu**	**12 psu**	**18 psu or 20 psu (Peace only)**
		Chlorophyll a (µg/l)			
Little Manatee (12/87 - 01/90)	36	20.5	13.7	8.5	4.0
Peace - same time period as Little Manatee	24	8.9	22.1	31.5	7.9
Peace - same time period as Alafia	36	6.3	23.4	22.6	15.2
Alafia (01/99 - 12/01)	36	15.3	63.4	95.7	43.7

The Alafia and Peace have the more typical pattern of high chlorophyll *a* concentrations at the 6 and 12 psu zones, while the Little Manatee frequently has its highest values near the freshwater/brackish water interface. This is likely due to comparatively longer residence times in the braided reach of the river which allows phytoplankton blooms to develop. The effects of changes on freshwater inflows on excessive phytoplankton blooms can be an important factor to consider in minimum flows analyses, as was done for the Lower Alafia. I think we are okay on the Little Manatee in that regard, but the three reports that Dr. Vargo prepared for the District need to be cited and briefly summarized in the minimum flows report.*

The citation and summaries of these and a few other reports can be very brief, one or two paragraphs with a figure or table. These concise and informative summaries will improve the public and technical community's understanding of the freshwater inflow relationships of the Little Manatee River and better support the technical justification of the minimum flows.

Assessment of separate thresholds for flow-based blocks for the freshwater and estuarine sections of the Little Manatee River

I want to change topics now and discuss the use of flow-based blocks in the District report. I strongly support the use of flow-based blocks, but they probably should be identified separately for the freshwater and estuarine reaches of the river. For most rivers, the District has previously produced separate reports for the freshwater and estuarine reaches of each river using different analytical methods, such as for the Alafia, Peace and Myakka Rivers. For many

* **The District report cites a paper by Vargo et al. (1991) in the Proceedings of the BASIS 2 Symposium, but the reports for the District provide other valuable findings with the third report completed after BASIS 2.**

years the District used a seasonal block approach for the freshwater rivers, with three seasonal blocks corresponding to low, medium, and high flows. For example, if it was February, you assumed flows were in the medium range and you applied the minimum flow percentages for that time of year.

On page 103 the District report makes a good case that this method has serious limitations, for flows in any season can be above or below the expected seasonal flow range for prolonged periods of time. A much simpler and more direct way to avoid this is to use flow-based blocks, in which minimum flow percentages are defined for different flow ranges, an approach which the District has recommended for the Little Manatee, which I strongly support.

Flow based minimum flows have previously been determined by the District for estuarine rivers, such as the Lower Pithlachascotee and the Lower Peace. In these rivers, the relationships of variables to freshwater inflow within the estuary were examined to determine ranges of flows where different percent withdrawal limits should be applied. Combined with a low flow cutoff, this is a very effective way to largely preserve natural flow characteristics, protect the estuary from significant harm, and make water proportionately more available as flows increase.

The problem with the Little Manatee River report is that flow thresholds of 35 and 72 cfs were based solely on environmental analyses of the freshwater reach of the river. These flow thresholds are then applied to the estuarine reach of lower river as well. This is a first, as the District has never done this before, and it is probably not the best approach.

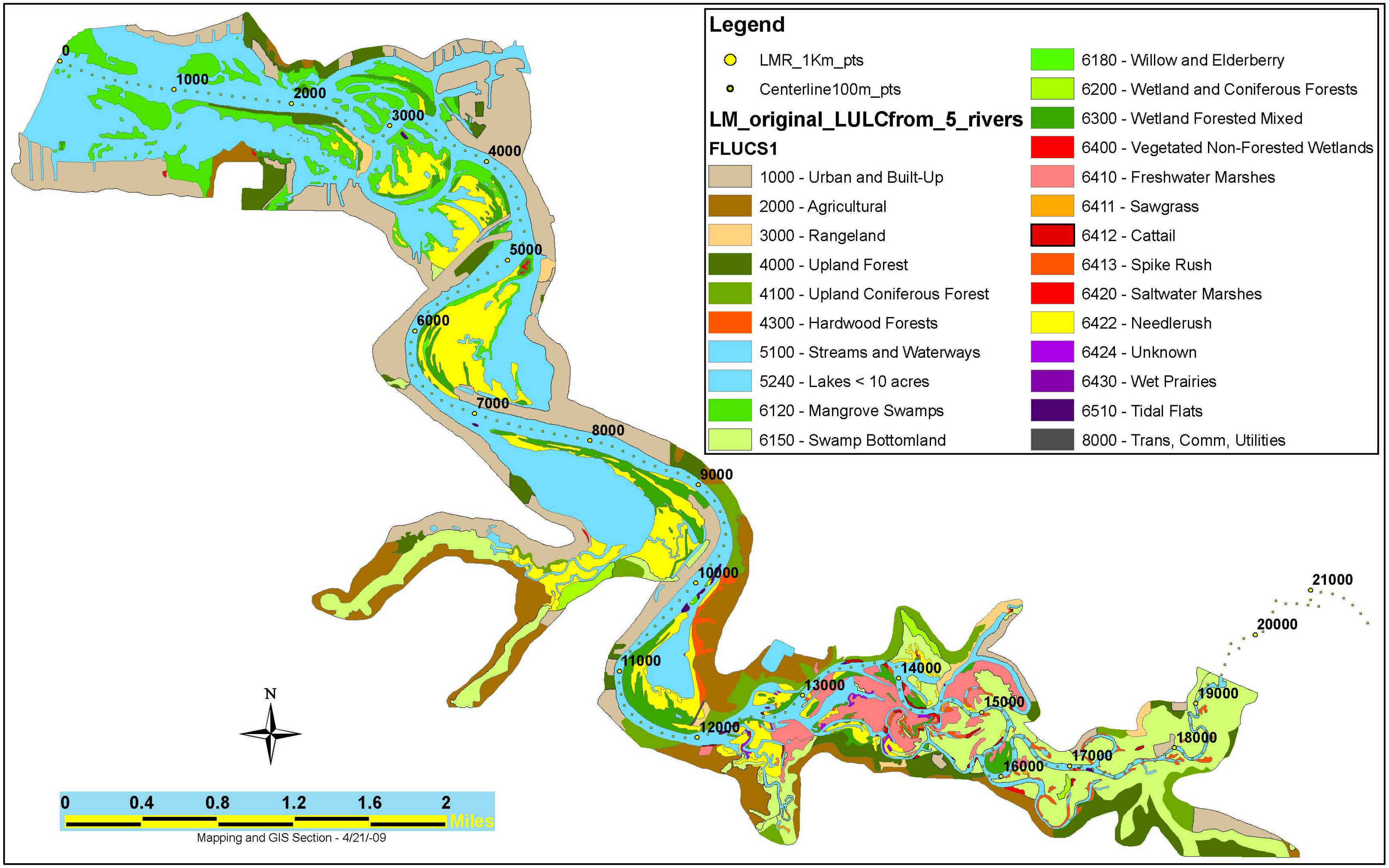
As was done for the Lower Pithlachascotee and Lower Peace Rivers, the response of key variables in the estuary to freshwater inflows should be examined separately for a series of flow ranges. Flow thresholds can then be identified to switch percent allowable flow reductions. Practical and ecologically effective flow thresholds for the estuarine portion of the Little Manatee might be similar to the flow thresholds identified for the freshwater reach, but you don’t know until you analyze the data in that manner.

If necessary, the application of separate thresholds for flow-based blocks for the freshwater and estuarine reaches of a rivers is very feasible from a management perspective and can easily be applied, especially on a small river like the Little Manatee.

I recommend the District conduct further analyses to examine the response of low salinity zones and the environmental favorability functions for fishes in the lower river to freshwater inflow, and determine if separate thresholds for flow-based blocks in the estuarine section of the Little Manatee River are needed. The Lower Little Manatee River is an Outstanding Florida Water, an Aquatic Preserve, and is the jewel of tidal rivers flowing to Tampa Bay. It warrants a high degree of protection and the best analyses possible.

Three slides begin on the following page

Major Vegetation Communities along the Lower Little Manatee River



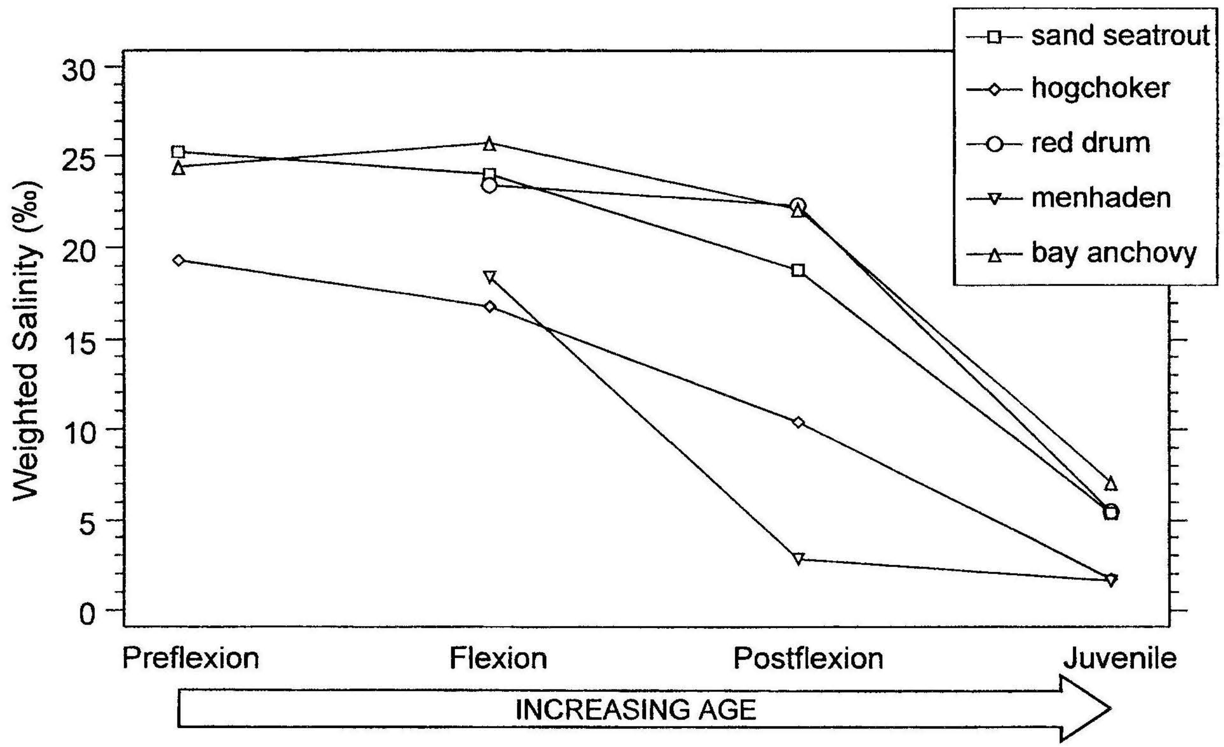
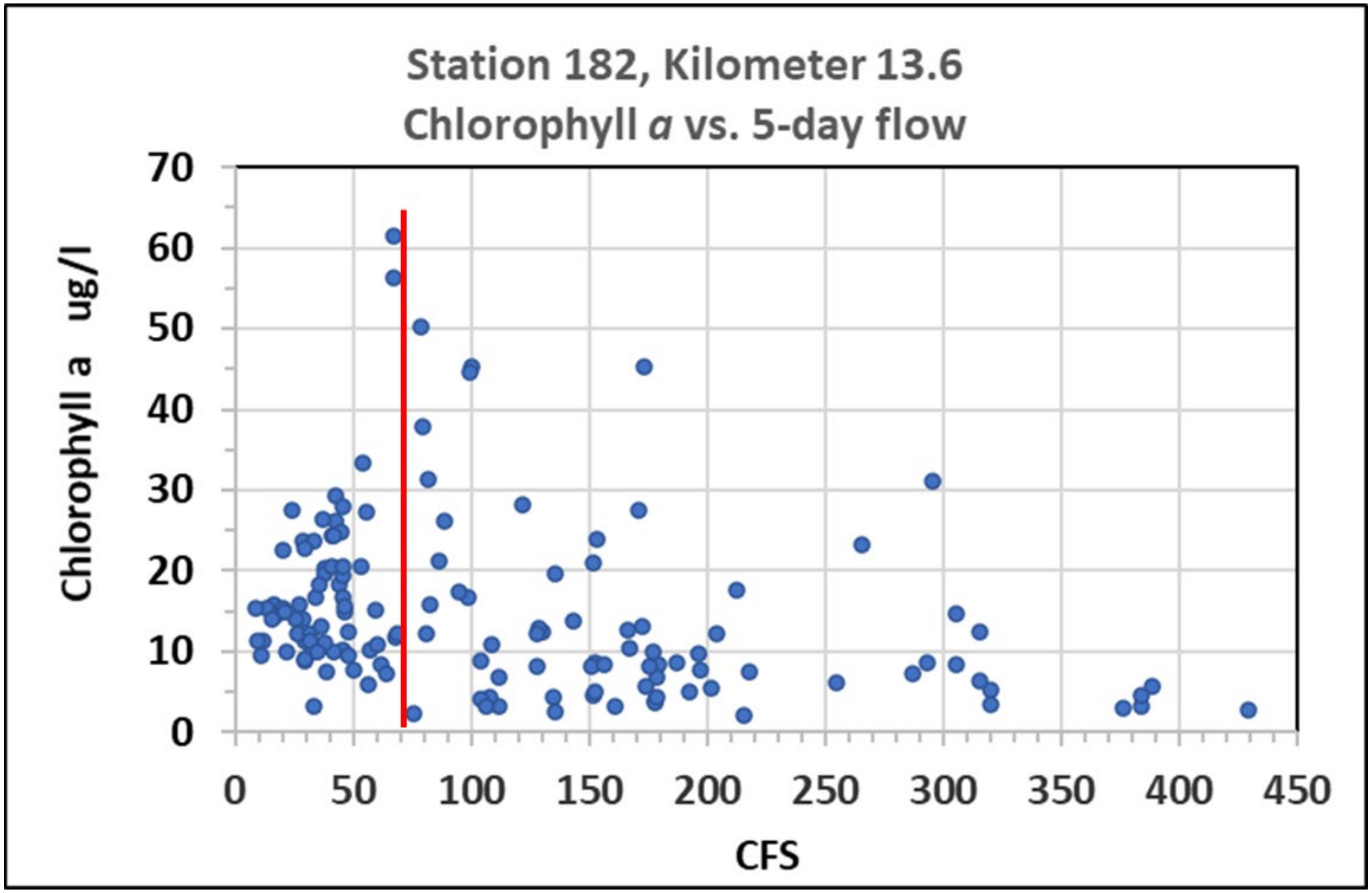


Fig. 5. Decreasing mean salinity at capture during fish development in the Little Manatee River. Preflexion, flexion, and postflexion are successive larval stages (Peebles and Flannery 1992).

Means, number of observations (N) and periods of data collection for chlorophyll *a* concentrations at four moving salinity-based stations in the tidal reaches of the Little Manatee, Peace, and Alafia Rivers.					
		Salinity-based stations			
	N	0.5 psu	6 psu	12 psu	18 psu or 20 psu (Peace only)
		Chlorophyll a (µg/l)			
Little Manatee (12/87 - 01/90)	36	20.5	13.7	8.5	4.0
Peace - same time period as Little Manatee	24	8.9	22.1	31.5	7.9
Peace - same time period as Alafia	36	6.3	23.4	22.6	15.2
Alafia (01/99 - 12/01)	36	15.3	63.4	95.7	43.7



Station 182, Kilometer 13.6
Chlorophyll *a* vs. 5-day flow
Chlorophyll a ug/l
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
400
450
CFS

Comments for the November 3, 2021 Little Manatee River minimum flows peer review meeting

Prepared by Sid Flannery

Note – Four paragraphs that will not be verbally presented on 11/3/21 due to time constraints are shown in blue font

Today I would like to speak about how minimum flows are implemented using flow-based blocks. The review panel is considering whether the flow blocks should, or should not be, the same for the fresh and estuarine sections of the Little Manatee.

Well, they are not entirely the same in the currently proposed rule, which is shown in the table below. Note than in Block 3 the freshwater minimum flows have a second high flow threshold of 174 cfs that is highlighted in yellow, which is not assigned to the estuarine minimum flows. You can subtract the numbers shown in red to calculate the percent withdrawals in each block. So, for block 3 in the freshwater section, flows cannot be reduced by more than 13 or 11 percent depending on the rate of flow. Further downstream, flows to the lower river cannot be reduced by more than 30 percent at flows above 72 cfs.

Table 6-9. Proposed minimum flows for the Little Manatee River.

	Block 1 (≤ 35 cfs)	Block 2 (> 35 cfs and ≤ 72 cfs)	Block 3 (> 72 cfs)
Upper Little Manatee River (Headwaters to Highway 301)	90% of the flow on the previous day	80% of the flow on the previous day	**87%** of the flow on the previous day when the previous day's flow was > 72 cfs and ≤ 174 cfs, or **89%** of the flow on the previous day when the previous day's flow was > 174 cfs
Lower Little Manatee River (Highway 301 to Tampa Bay)	90% of the flow on the previous day	80% of the flow on the previous day	**70%** of the flow on the previous day
Upper and Lower Little Manatee River	No surface water withdrawals are permitted when flows are ≤ 35 cfs		

So, lets hypothetically change the threshold to switch from block 2 to block 3 for the lower river from 72 cfs to 120 cfs. We still have the 13 and 11 percent limits to withdrawals in block 3 in the freshwater section, but flow reductions to the lower river cannot exceed 20 percent until flows go above 120 cfs, when percent withdrawals can increase to 30 percent. This is very simple and straightforward and poses no water management complications whatsoever.

There are two factors that typically make the percent-of-flow method very practical within the District. Estuaries in the region are generally not as sensitive to ecological impacts from flow reductions as are freshwater rivers, and minimum flows adopted for estuarine rivers usually allow for the same, or more often, greater percent withdrawals than for the corresponding freshwater sections. And, it is an obvious point, but the estuary is always downstream. If these two types of ecosystems were interspersed along the river channel it could be complicated, but that is not the case.

If we are to protect both the freshwater and estuarine sections of our rivers, it is critical to first evaluate the most effective flow blocks separately for these two very different ecosystems, then write the rules accordingly. Based on years of experience applying the percent-of-flow method, that has not been a problem yet and I don't foresee it being a problem in the future.

For years the District has included flow-based blocks in estuarine minimum flow rules based on analyses of relationships within those tidal rivers. However, with the Little Manatee, the District for the first time has developed blocks based solely on the freshwater section of the river and then assigned three of those same blocks to the estuarine section as well.

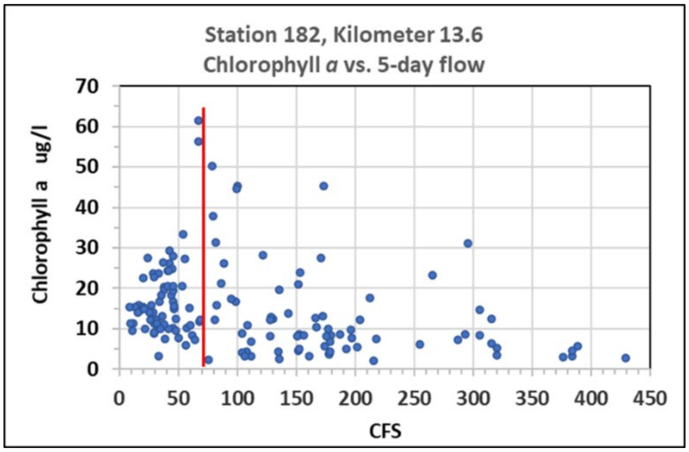
Assigning 72 cfs as the high flow block for the estuary does not allow for the evaluation of important ecological relationships in the lower river above that flow rate, which by the way, was near the median flow for the river for the last 20 years. Many of these relationships at higher flows are important to the ecological functions of the estuarine section of the river.

Last week, Dr. Ernst Peebles of USF said that the combined zooplankton/ichthyoplankton catch in the lower river showed a shift around 100 cfs. Also last week, I discussed that many variables in estuaries respond to freshwater inflow in a nonlinear manner and submitted a document to the WebForum that contained plots for salinity and other parameters in the lower river vs. freshwater inflow. Those plots showed these parameters respond strongly to flow reductions near 72 cfs, but more gradually at higher flow rates, where the relative ecological effects of flow reductions would be smaller. Such relationships could be evaluated to develop a revised block 3 for the lower river.

For example, upstream of I-75 there are widespread oligohaline marshes dominated by freshwater species that have some salt tolerance, such as sawgrass and cattails. The inundation of these marshes with fresh water in the wet season is important to their health and productivity. Plots of salinity versus flow in the graphics document show that salinity is very sensitive to flow reductions at 72 cfs in this reach of the river, but not so much at flows above 100 to 150 cfs.

Go to next page

The graph below is a plot of chlorophyll *a* vs. five-day average flow at the EPC station located about one and a half kilometers upstream of the I-75 bridge. The red reference line is the block 3 threshold at 72 cfs. It is clear that chlorophyll concentrations are near maximum in this flow range. Although trends in nutrients have been encouraging in recent years, longer term data have shown the Little Manatee has been significantly enriched with nutrients from human activities in the watershed. Given that, 72 cfs does not look to be a good place to switch from block 2 to block 3 and increase the withdrawal rate from 20 to 30 percent, slowing the water down in this sensitive flow range. But again, estuarine relationships were not evaluated in the determination of the flow blocks.



A very useful analysis is to examine daily output from the EFDC model to see in what flow range does a specific percent withdrawal rate cause reductions in low salinity habitats greater than 15 percent, similar to what was done for the Lower Peace River. I suspect the fish habitat analysis could be used in a similar manner.

In closing, over the last 30 years the District had spent considerable time, effort, and money to conduct detailed technical investigations of the relationships of streamflow to the ecology of freshwater and estuarine rivers. In doing so, it has developed the very progressive percent-of-flow method, which has been successfully applied to many rivers.

However, the percent-of-flow method is at a critical juncture right now. The topic of whether the flow blocks have to be the same for fresh and estuarine sections of rivers is extremely important and the Little Manatee could be viewed a precedent. Based on a number of ecological factors and practical water management considerations, I strongly believe that flow blocks for fresh and estuarine sections of rivers need to be evaluated separately. Again, the District has evaluated flow blocks for tidal rivers based on relationships within those estuaries in the past, and there is no real practical water management reason to discontinue that now.

It looks like the review of the Little Manatee River minimum flows report is on a very fast track. I suggest the panel take additional time to consider further the flow blocks issue. The panel could get input from other parties, continue discussions with District staff, and consider some other analyses. There is no real need to hurry on the minimum flows for this truly outstanding river, and the flow blocks issue is a critical factor that needs to be thoroughly assessed.

Table 6-9. Proposed minimum flows for the Little Manatee River.

	Block 1 (≤ 35 cfs)	Block 2 (> 35 cfs and ≤ 72 cfs)	Block 3 (> 72 cfs)
Upper Little Manatee River (Headwaters to Highway 301)	90% of the flow on the previous day	80% of the flow on the previous day	**87%** of the flow on the previous day when the previous day's flow was > 72 cfs and ≤ 174 cfs, or **89%** of the flow on the previous day when the previous day's flow was > 174 cfs
Lower Little Manatee River (Highway 301 to Tampa Bay)	90% of the flow on the previous day	80% of the flow on the previous day	**70%** of the flow on the previous day
Upper and Lower Little Manatee River	No surface water withdrawals are permitted when flows are ≤ 35 cfs		

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Doug Leeper; Lei Yang; Xinjian Chen; Gabe I. Herrick; Jordan D. Miller; Danielle Rogers; Philip Rhinesmith
Subject:	Second slide for my presentation
Date:	Wednesday, November 3, 2021 6:33:32 AM
Attachments:	Chlorophyll a graph.pdf Minimum flows table.pdf

Hello Kym,

Attached is a graph I would like to be shown as part of my comments to the Little Manatee peer review panel today. It will be about half-way through my comments and I will say "second slide please." As I emailed yesterday, I also submitted a table I would like shown at the beginning of my comments, which is attached again.

Please confirm that these two slides can be used as part of my comments today. It might be useful to also post these two files to the minimum flows WebForum along with the longer written version of my comments I sent yesterday. I plan to stay within the five minute limit today.

Thanks again,
Sid

From:	Sid Flannery
To:	Kym Holzwart; Gabe I. Herrick
Cc:	Doug Leeper; Chris Zajac; Xinjian Chen; Lei Yang; Jordan D. Miller; Danielle Rogers; Philip Rhinesmith
Subject:	Revised version of complete comments
Date:	Wednesday, November 3, 2021 7:50:38 AM
Attachments:	Comments from Sid Flannery for the Little Manatee peer review meeting, Nov. 3, 2021 new.pdf

Hello Kym,

In going over my comments for today's meeting, I made some revisions to my complete set of comments that I sent yesterday.   Please upload the attached version of my complete comments, in which the file name ends with the word "new." The same email from yesterday would still apply.

If you have already uploaded the complete comments from yesterday, simply replace it with this one.

Thanks again,
Sid

This is print screen of the folder *Received from HSW* which should be under that back then was known as the D Drive, under the folders *Rivers/LMR/HSW* under a large folder of my stuff that was left on the D drive.

I created a new folder at home you will not see there, which is *New Shell Point regression stuff*. I copied files that look relevant to the regression stuff to that folder for convenience. The next page has a print screen of the contents of that folder.

Three pages total

ts › District From D › Rivers › LMR › HSW › Received from HSW ›

Name	Date modified	Type	Size
April DO chlor	3/4/2021 3:53 PM	File folder	
Jan 18 2008 CD	3/4/2021 3:53 PM	File folder	
June 2008 CD	11/4/2021 5:43 AM	File folder	
New Shell Point regression stuff	11/4/2021 6:06 AM	File folder	
Shell point from Feb 1, 08 ftp	3/4/2021 3:54 PM	File folder	
corrected shell stage from wenrui	3/27/2008 11:49 AM	Microsoft Word 9...	4,136 KB
corrected shell stage from wenrui	3/27/2008 11:51 AM	Text Document	1,634 KB
Corrected_shell_tide	3/27/2008 1:20 PM	Microsoft Excel 97...	2,710 KB
Little manatee Summary of Isohaline Regression Models	6/11/2008 1:40 PM	Adobe Acrobat D...	12 KB
LMR Task 8 WQ Database_DO and ChlorA_041608	4/16/2008 10:22 AM	WinRAR ZIP archive	465 KB
meter_profile_database.sas7bdat	11/12/2007 10:27 AM	SAS7BDAT File	3,873 KB
meter_profile_database	11/9/2007 3:33 PM	WinRAR ZIP archive	723 KB
Salinity prediction using synthetic tides at Shell Point - 03312008 update	3/31/2008 2:44 PM	Microsoft Excel 97...	23,730 KB
Salinity_predictions_using_synthetic_tides_at_ShellPoint_03312008	3/31/2008 5:36 PM	WinRAR ZIP archive	7,129 KB
Synthetic tides at Shell Point with Dec 1999	1/21/2008 10:45 PM	Text Document	1,671 KB
Uncorrected tides Dec 1999	3/27/2008 1:01 PM	Text Document	1,671 KB
uncorrected_Shell_tide	3/27/2008 1:13 PM	Microsoft Excel 97...	3,853 KB
Vertical Profile Meter Database - for Sid	10/12/2007 10:50 AM	Microsoft Excel 97...	3,611 KB

Print screen of folder called *New Shell Point regression stuff* I created at home from files under the folder described on the previous page. There is probably plenty of files here that are not relevant to the question of how the model boundary condition for additional years was created, which is basically described in my email of Nov. 4, 2021 and will be discussed with a follow up phone call

Name	Date modified	Type	Size
HSW correspondence	11/4/2021 5:49 AM	File folder	
Shell point from Feb 1, 08 ftp	11/4/2021 5:29 AM	File folder	
corrected shell stage from wenrui	3/27/2008 11:49 AM	Microsoft Word 9...	4,136 KB
corrected shell stage from wenrui	3/27/2008 11:51 AM	Text Document	1,634 KB
Corrected_shell_tide	3/27/2008 1:20 PM	Microsoft Excel 97...	2,710 KB
Draft Report_06-10-2008	9/13/2010 10:19 AM	Adobe Acrobat D...	119 KB
FSU_PO_FLOW	2/20/2008 2:45 PM	Microsoft Excel 97...	181 KB
FSU_PO_FLOW_SECOND	12/10/2008 10:54 AM	Microsoft Excel 97...	189 KB
FSUMODELFLOWS	12/4/2006 1:08 PM	Microsoft Excel 97...	55 KB
Salinity prediction using synthetic tides at Shell Point - 03312008 update	3/31/2008 2:44 PM	Microsoft Excel 97...	23,730 KB
Salinity_predictions_using_synthetic_tides_at_ShellPoint_03312008	3/31/2008 5:36 PM	WinRAR ZIP archive	7,129 KB
Shell Point Synthetic tides_new	1/3/2008 12:00 AM	Text Document	1,639 KB
Synthetic tides at Shell Point with Dec 1999	1/21/2008 10:45 PM	Text Document	1,671 KB
Table 3. Summary of Isohaline Regression Models	6/11/2008 1:40 PM	Adobe Acrobat D...	12 KB
Table 4. Summary of Fixed Loaction Salinity Models	6/11/2008 1:40 PM	Adobe Acrobat D...	49 KB
Tables 1 & 2	6/11/2008 1:40 PM	Adobe Acrobat D...	59 KB
Uncorrected tides Dec 1999	3/27/2008 1:01 PM	Text Document	1,671 KB
uncorrected_Shell_tide	3/27/2008 1:13 PM	Microsoft Excel 97...	3,853 KB

This is a print screen of the folder *Model runs* under the *Rivers/LMR fold*er that was on the D drive. I think the Huang_PO scope is useful

Name	Date modified	Type	Size
2011 runs	11/4/2021 9:39 AM	File folder	
2012 water levels	3/4/2021 3:54 PM	File folder	
2014 delivery	11/4/2021 10:18 AM	File folder	
Copies of 2011 runs	3/4/2021 3:54 PM	File folder	
Flows for model scenarios	11/4/2021 10:17 AM	File folder	
sal output 2000 - 2005 runs	3/4/2021 3:54 PM	File folder	
AA Log of 2011 Wenrui model runs	10/28/2013 3:10 PM	Microsoft Word D...	13 KB
EL8KM00_05.dat	5/12/2008 11:01 AM	DAT File	1,271 KB
FSU P-2 Purchase Order Payment 1	1/28/2014 2:54 PM	Microsoft Excel 97...	45 KB
FSU P-2 Purchase Order Payment 2 DRAFT	9/29/2013 8:33 AM	Microsoft Excel 97...	45 KB
Huang_PO_scope	10/8/2010 1:59 PM	Microsoft Word 9...	30 KB
invoice2012-8-15	8/15/2012 9:10 AM	Adobe Acrobat D...	9 KB
PO_scope_Huang_salinity_modeling	3/1/2011 4:04 PM	Microsoft Word 9...	33 KB
sallinity-area scenarios from FSU	8/10/2007 2:32 PM	Microsoft Excel 97...	658 KB
salvolume scenarios from FSU	5/18/2007 4:11 AM	Microsoft Excel 97...	749 KB
Synthetic tides at Ruskin.dat	5/12/2008 11:01 AM	DAT File	1,271 KB
Synthetic tides at Shell Point _ no 1999	1/17/2008 9:13 AM	Text Document	1,639 KB
Synthetic tides at Shell Point with Dec 1999	1/21/2008 11:45 PM	Text Document	1,671 KB

From:	Sid Flannery
To:	Xinjian Chen; Lei Yang
Cc:	Doug Leeper; Kym Holzwart
Subject:	Little Manatee boundary condtion analysis
Date:	Thursday, November 4, 2021 11:43:03 AM
Attachments:	Print screen of possible boundaray conditon regression related files (way too inclusive).docx

Hello Xinjian and Lei,

In response to the panel question regarding the boundary condition for the extended model runs for the EFDC model, I have attached a WORD file that is a print screen of files I left behind on what was D drive back then where the relevant information can be found. I am 90% certain of what the relevant files are, and give the short version below. I don't have time to double check them today, but can look again tomorrow. The print screen contains lots of other files, but I did have time to isolate the relevant files out.

Or, since Lei was HSW and worked on this project back then, I'll just leave it to her to figure it all out......................Just kidding!!!

The short version is that Wenrui Huang provided synthetic tides for Shell Point for 2000 forward that were based on a harmonic analysis he did. There are two files for a PO scope of work to Dr. Huang that appear to be largely duplicates. They describe the overall approach including generation of the synthetic tides. Files of the tide values are also included. Those files are on page 3 of the attached file.

The next files are shown on the first two pages of the attached WORD file. The second page shows files copied from other folders, so you will also see them listed elsewhere.

From measured data at the Shell Point USGS recorder between 2004 and 2006, HSW used tide (water levels), salinity, freshwater inflow and monthly salinity data for Tampa Bay, which they interpolated to get daily values, to develop a regression to predict 15 minute values for salinity at that location. Starting at the bottom of page 10, the file *Draft report _06_10_2008* has a description of modeling to predict salinity at Shell Point while the file *Table 4* looks to be a summary of the fixed location salinity models.

HSW then used that regression with the synthetic tides and the same explanatory variables (freshwater inflow, interpolated bay salinity) to predict salinity at Shell point for 2000 forward. The file *Salinity prediction using synthetic.........update* file looks to have the final salinity predictions, which look to be hourly. Those values were then used to run the EFDC model for 2000 forward.

That is it for me today - I will look in more detail again tomorrow.   Lei may actually have some recollection of this work.

Have a fine weekend.

Sid

From:	Sid Flannery
To:	Doug Leeper
Cc:	Kym Holzwart; Chris Zajac; Xinjian Chen; Gabe I. Herrick; Jordan D. Miller; Kristina Deak
Subject:	Output files for Little Manatee EFDC model runs
Date:	Tuesday, November 9, 2021 5:53:40 AM

[EXTERNAL SENDER] Use caution before opening.

Hello Doug and District staff,

If possible, I would like to receive selected output files from the EFDC model runs for the Little Manatee River minimum flows project. I expect these are for model runs that have already been conducted and no additional model runs will be needed.

The information I would like to receive is described below. It would be nice to get the different flow scenarios and salinity zone values as separate files, but I expect the original files may have values for salinity zones in addition to the ones I am asking for. Or, the output files may contain flow scenarios in addition to the ones I am asking for. Receiving such large files would be fine as long as I can identify and query out the values for the salinity zones and flow scenarios I am interested in.

I would like to receive daily values for bottom area and water volume from the EFDC model runs from January 2000 to June 2005. The salinity zones I am interested in are < 2psu, < 5 psu, <10 psu, and <15 psu. If the values are in increments smaller than daily, that is okay as I can calculate daily average values from those values.

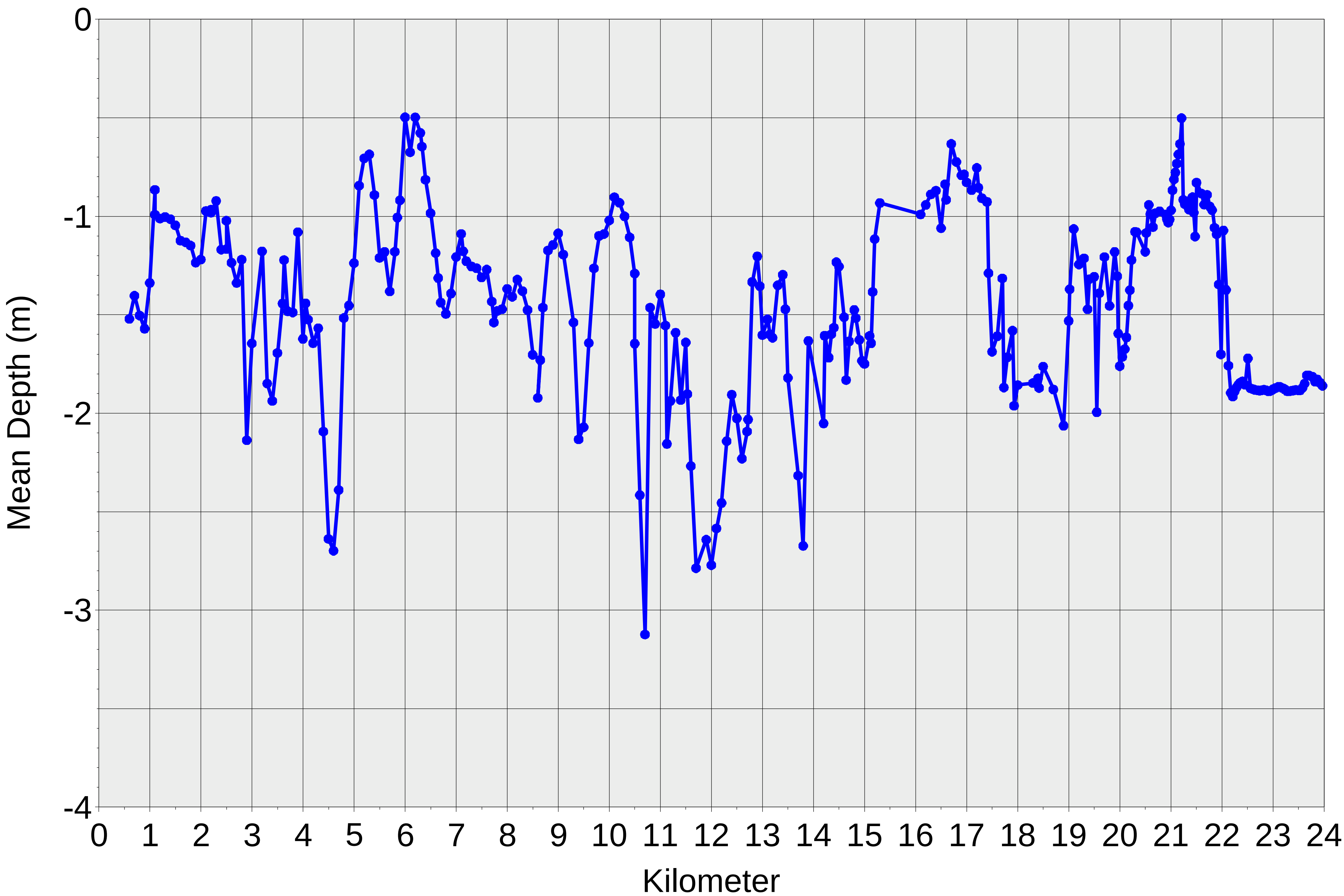
The flow scenarios I would like to receive are baselline, and the 15 percent, 20 percent, 25 percent, 30 percent, and 35 percent flow reductions not including the 35 cfs low-flow cutoff.
I would also like to receive the output for any of these same percentage flow reductions that included the 35 cfs low-flow cutoff.

I will also need to flow values on which these values were based, at least for the baseline scenario, with the flows for the other scenarios being helpful as well. The ungaged flows should be the same for all the scenarios, so I believe the flows that I need for the baseline and the flow reduction scenarios will be the flows at the USGS gage at the US 301 bridge.

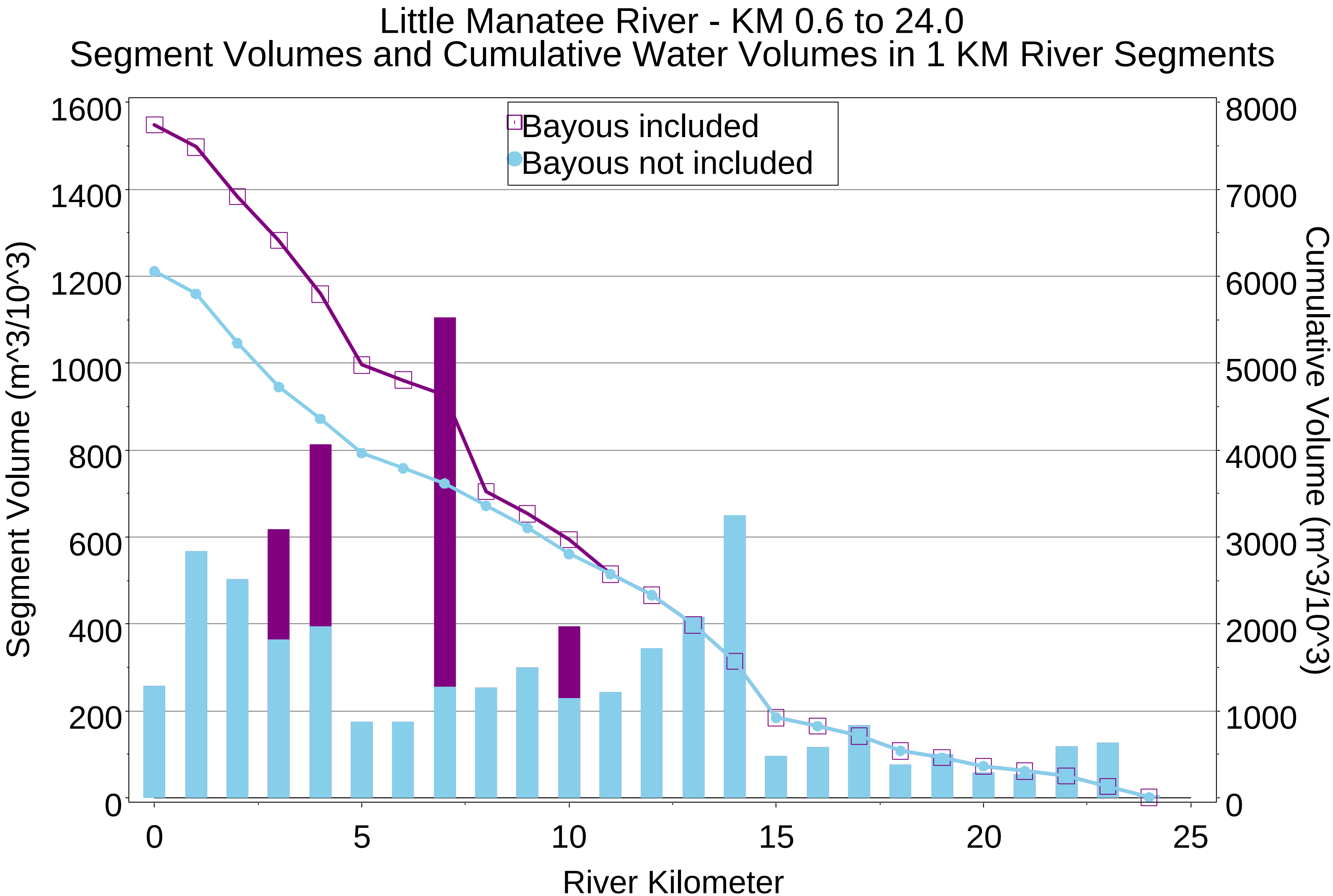
If possible, SAS files would be very helpful, but I can work with EXCEL files or tab or comma delimited text files. Please contact me if I can provide any clarification for this request.

Thanks very much for your time and whatever the District can provide.

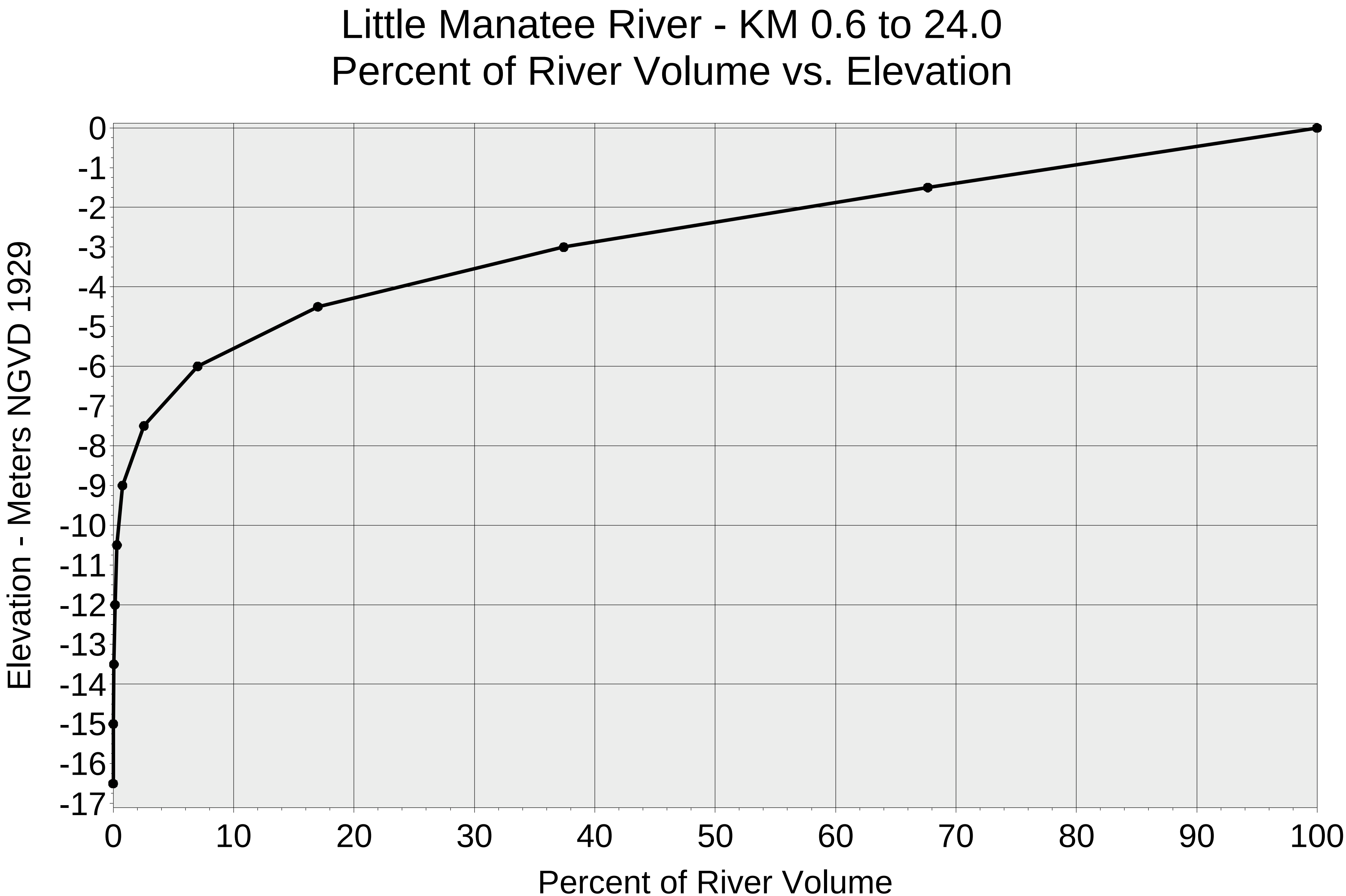
Sid
813-245-0331

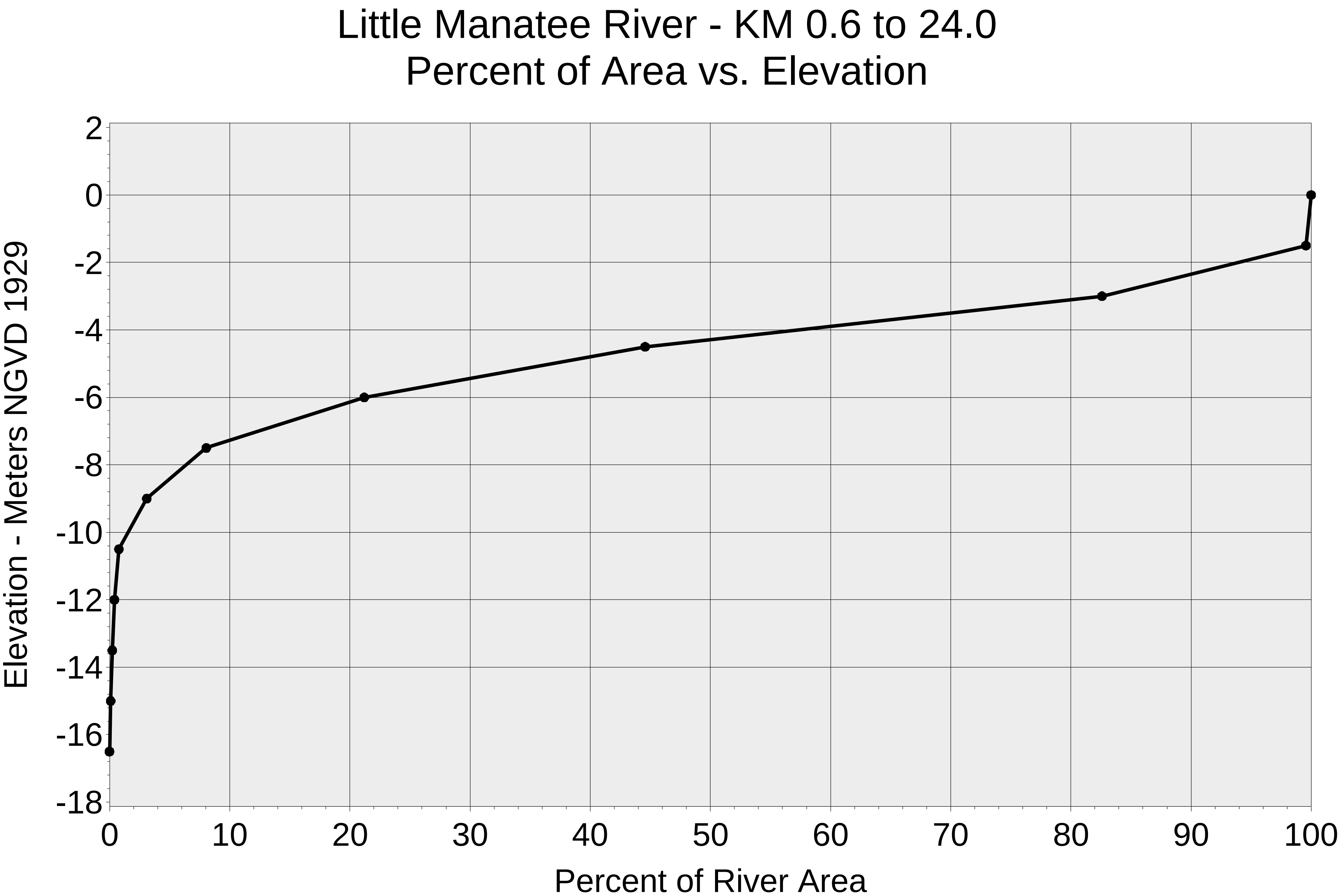


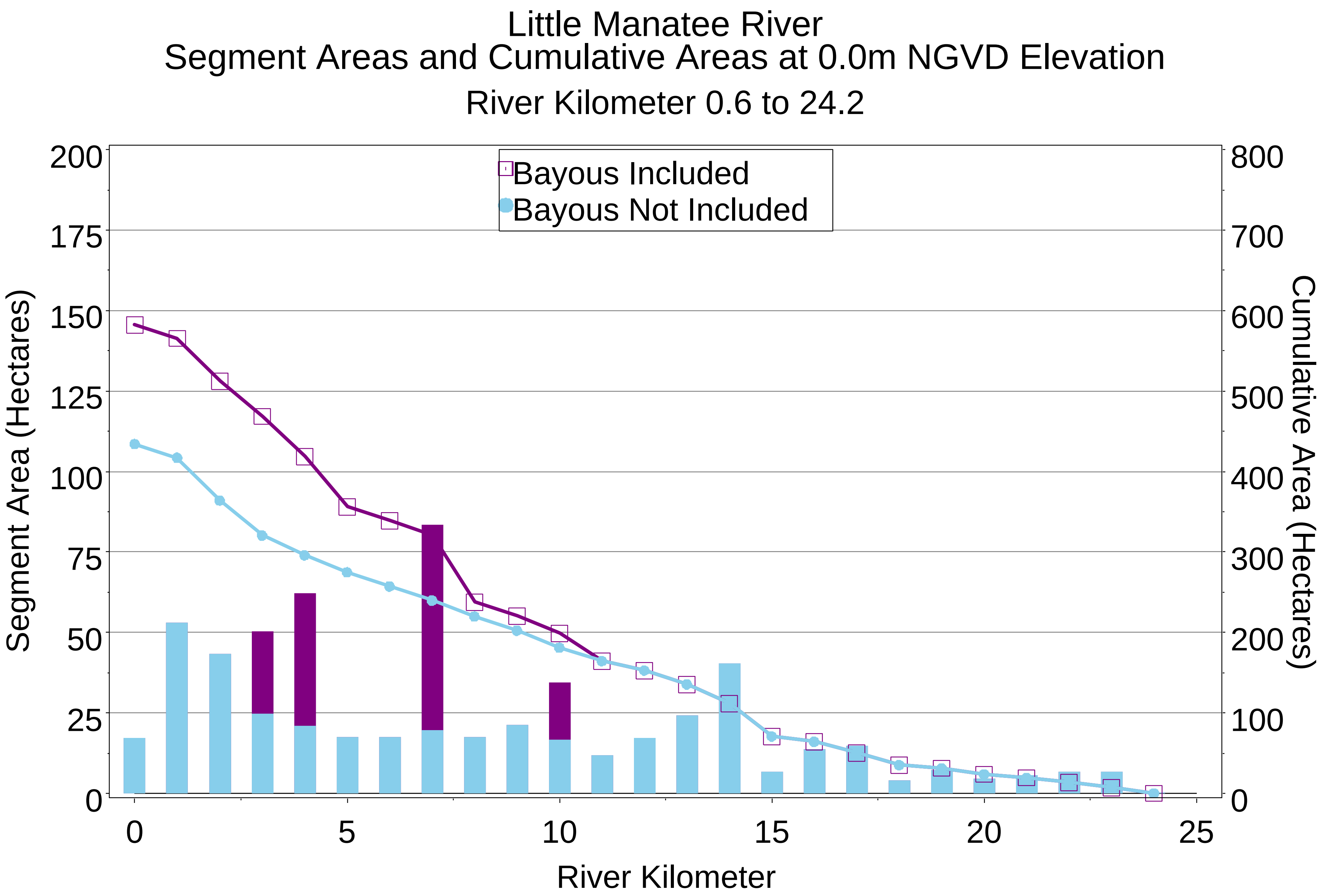
0
-1
-2
-3
-4
Mean Depth (m)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Kilometer



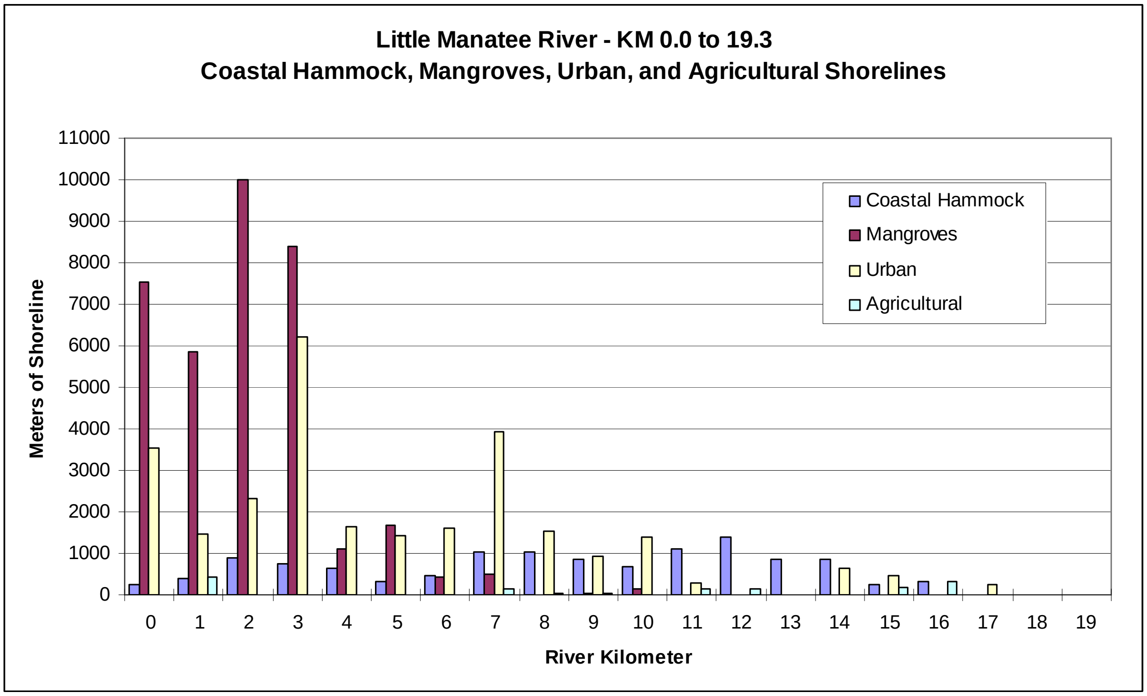
Little Manatee River - KM 0.6 to 24.0
Segment Volumes and Cumulative Water Volumes in 1 KM River Segments
Bayous included
Bayous not included
Segment Volume (m^3/10^3)
Cumulative Volume (m^3/10^3)
River Kilometer
0
200
400
600
800
1000
1200
1400
1600
0
1000
2000
3000
4000
5000
6000
7000
8000
0
5
10
15
20
25

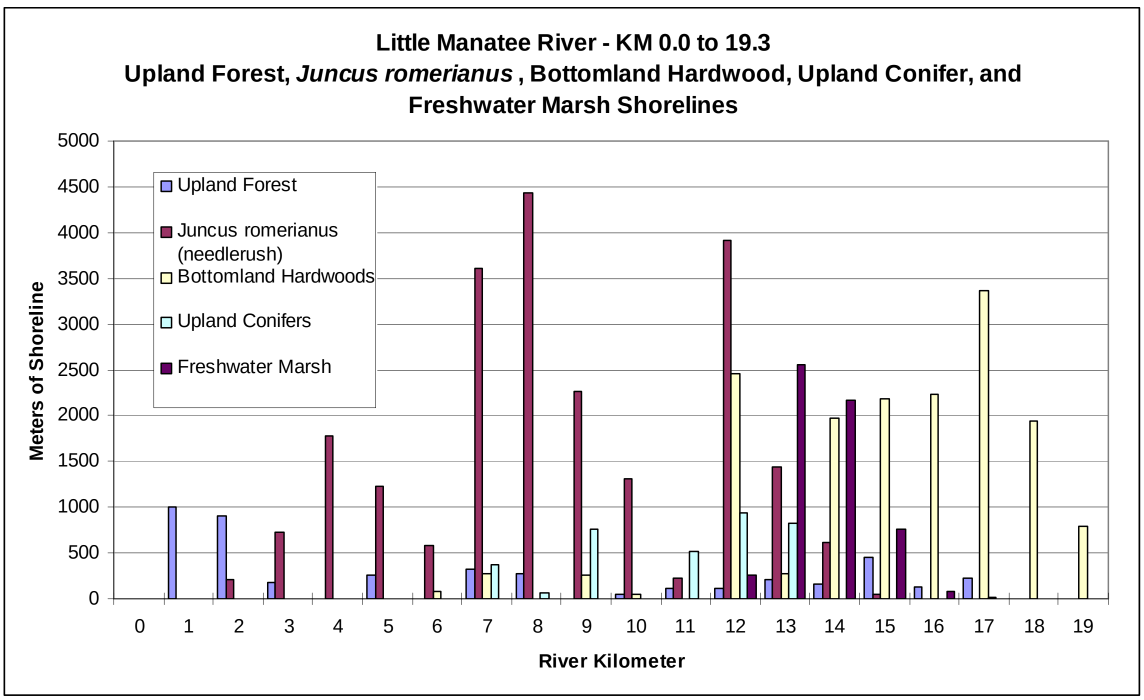

Little Manatee River - KM 0.6 to 24.0
Percent of River Volume vs. Elevation
Elevation - Meters NGVD 1929
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
0
10
20
30
40
50
60
70
80
90
100
Percent of River Volume

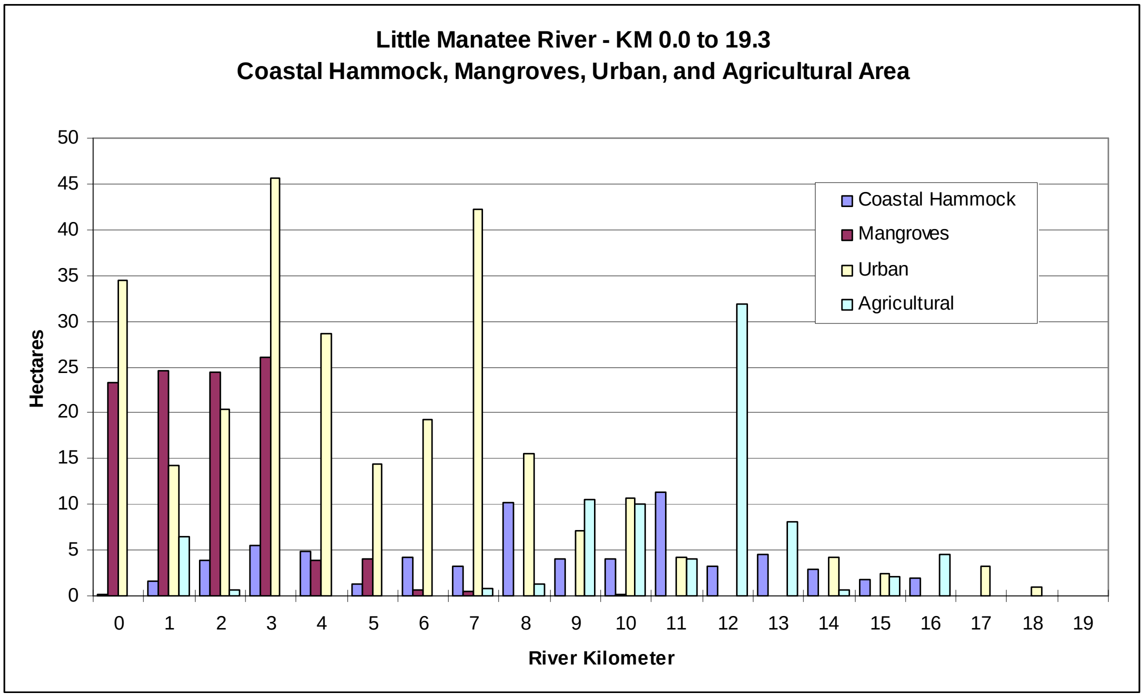

Little Manatee River - KM 0.6 to 24.0
Percent of Area vs. Elevation
Elevation - Meters NGVD 1929
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
10
20
30
40
50
60
70
80
90
100
Percent of River Area



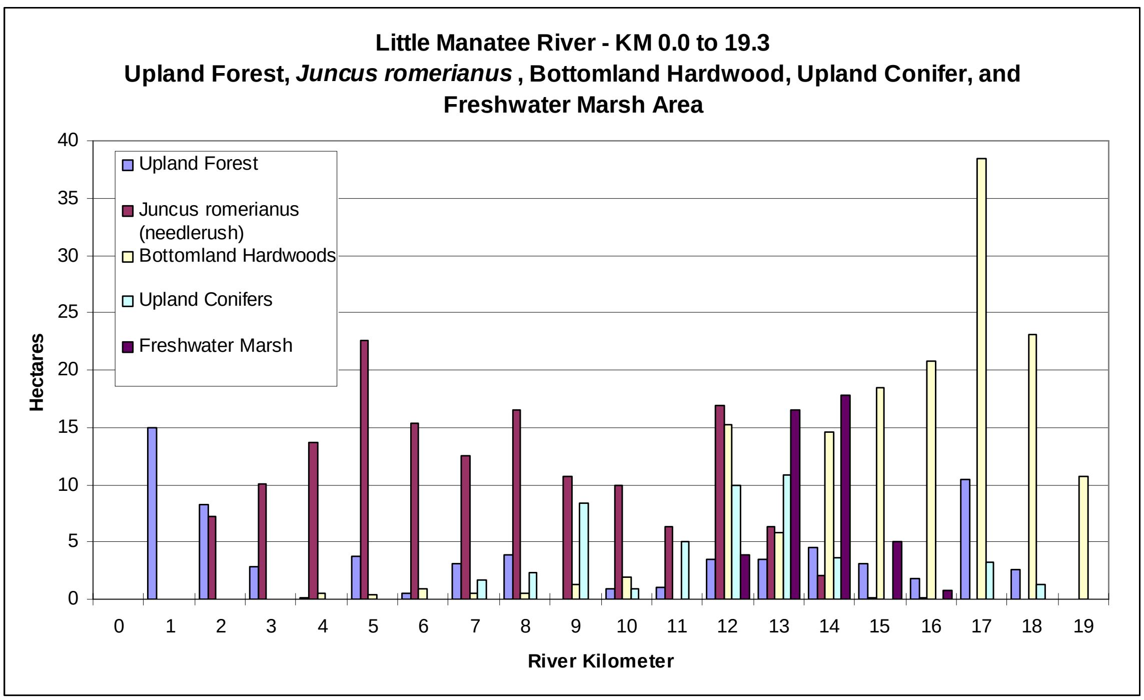
Little Manatee River
Segment Areas and Cumulative Areas at 0.0m NGVD Elevation
River Kilometer 0.6 to 24.2
Bayous Included
Bayous Not Included
Segment Area (Hectares)
Cumulative Area (Hectares)
River Kilometer
0
25
50
75
100
125
150
175
200
100
200
300
400
500
600
700
800
5
10
15
20
25


Little Manatee River - KM 0.0 to 19.3
Coastal Hammock, Mangroves, Urban, and Agricultural Shorelines
Meters of Shoreline
River Kilometer
Coastal Hammock
Mangroves
Urban
Agricultural
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

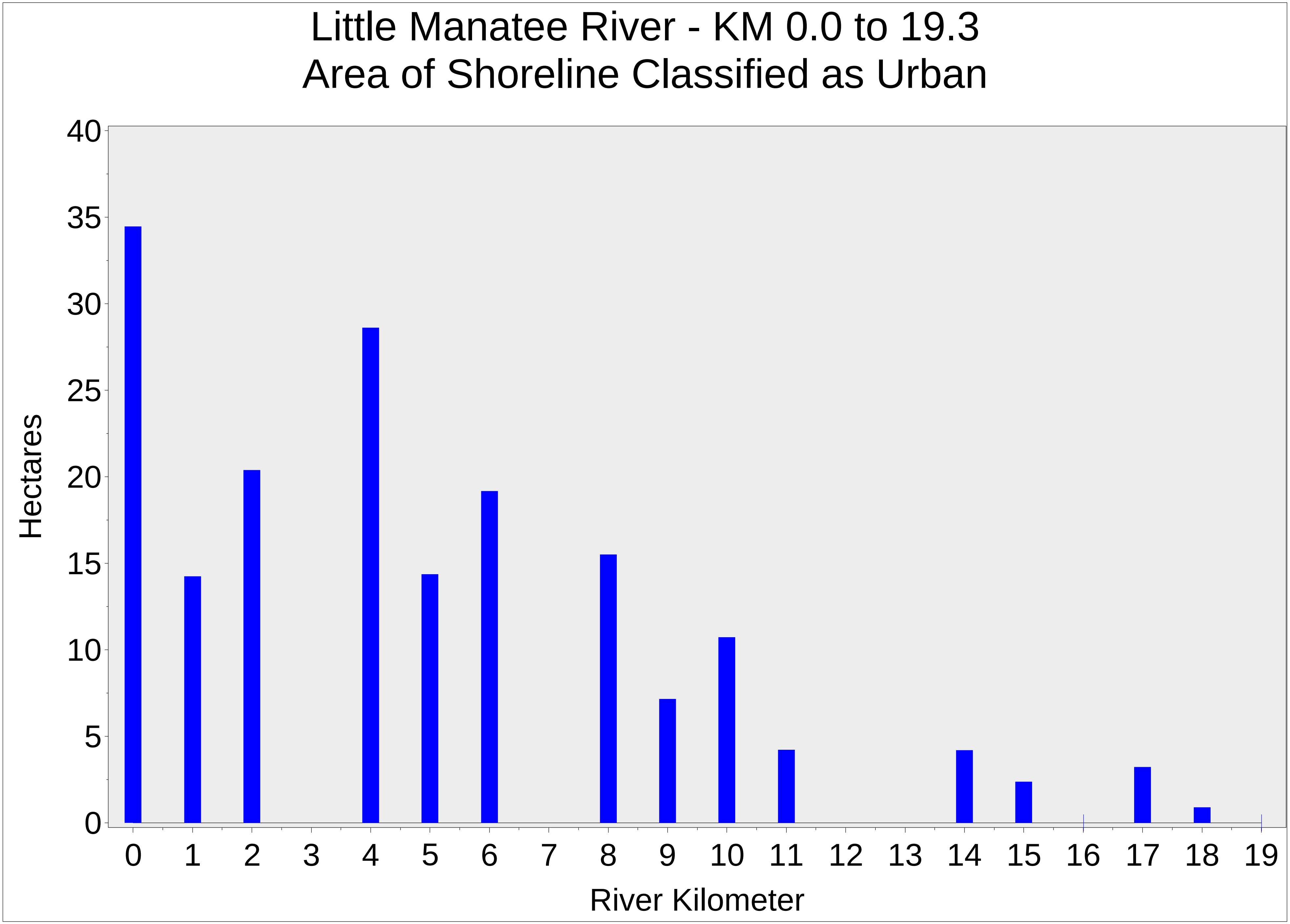

Little Manatee River - KM 0.0 to 19.3
Upland Forest, *Juncus romerianus* , Bottomland Hardwood, Upland Conifer, and Freshwater Marsh Shorelines
Meters of Shoreline
River Kilometer
Upland Forest
Juncus romerianus (needlerush)
Bottomland Hardwoods
Upland Conifers
Freshwater Marsh
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

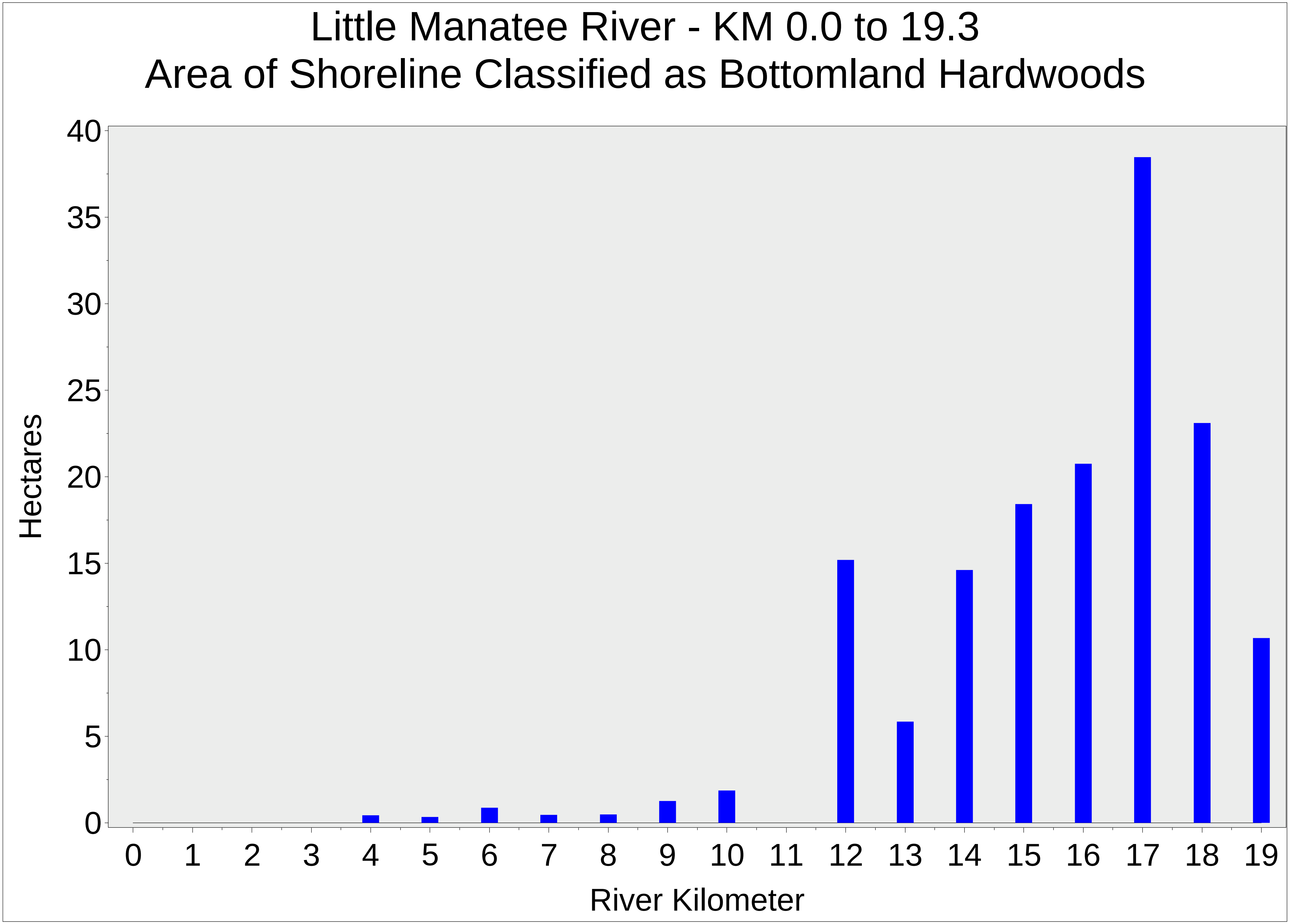


Little Manatee River - KM 0.0 to 19.3
Coastal Hammock, Mangroves, Urban, and Agricultural Area
Hectares
River Kilometer
Coastal Hammock
Mangroves
Urban
Agricultural
0
5
10
15
20
25
30
35
40
45
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

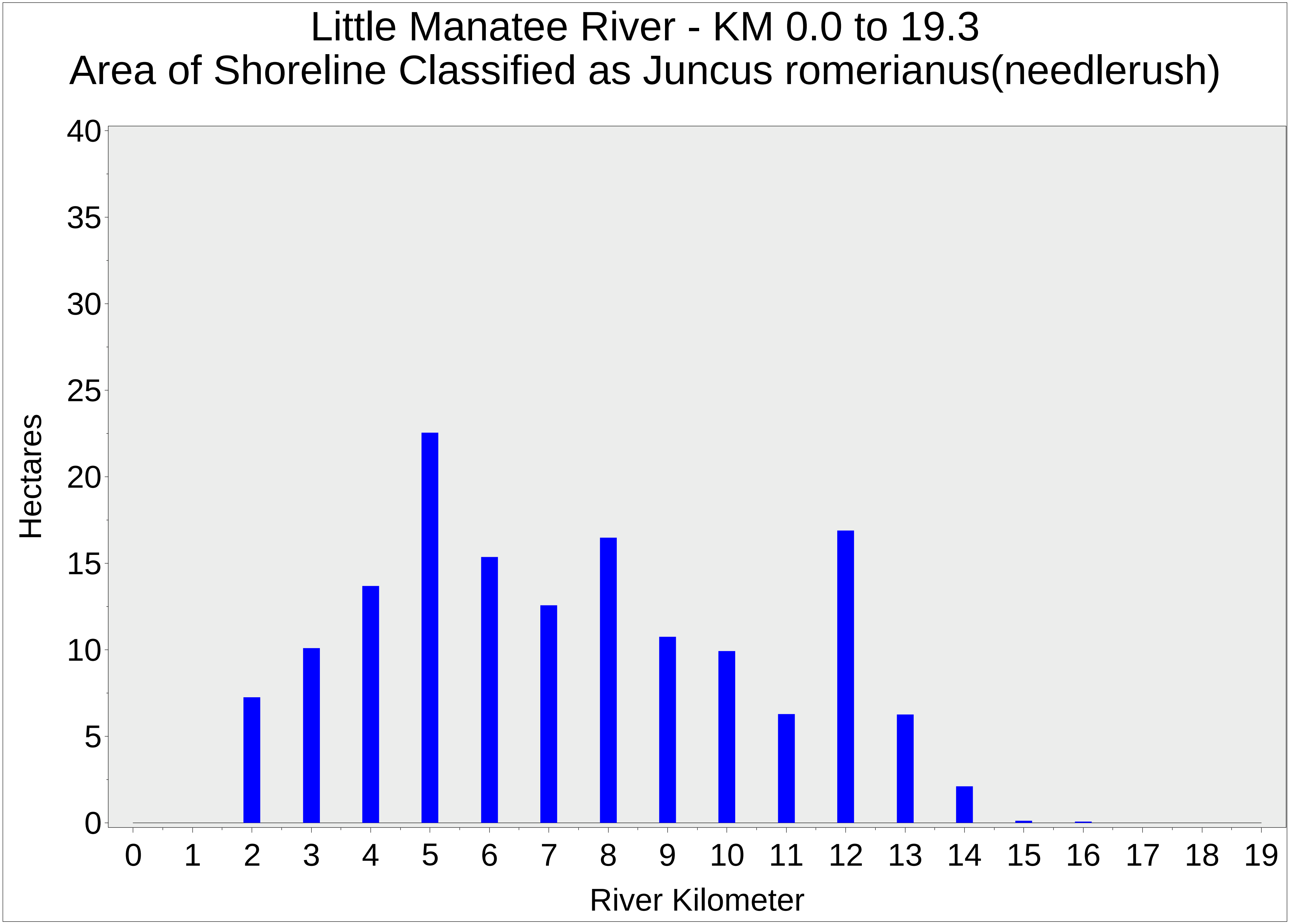


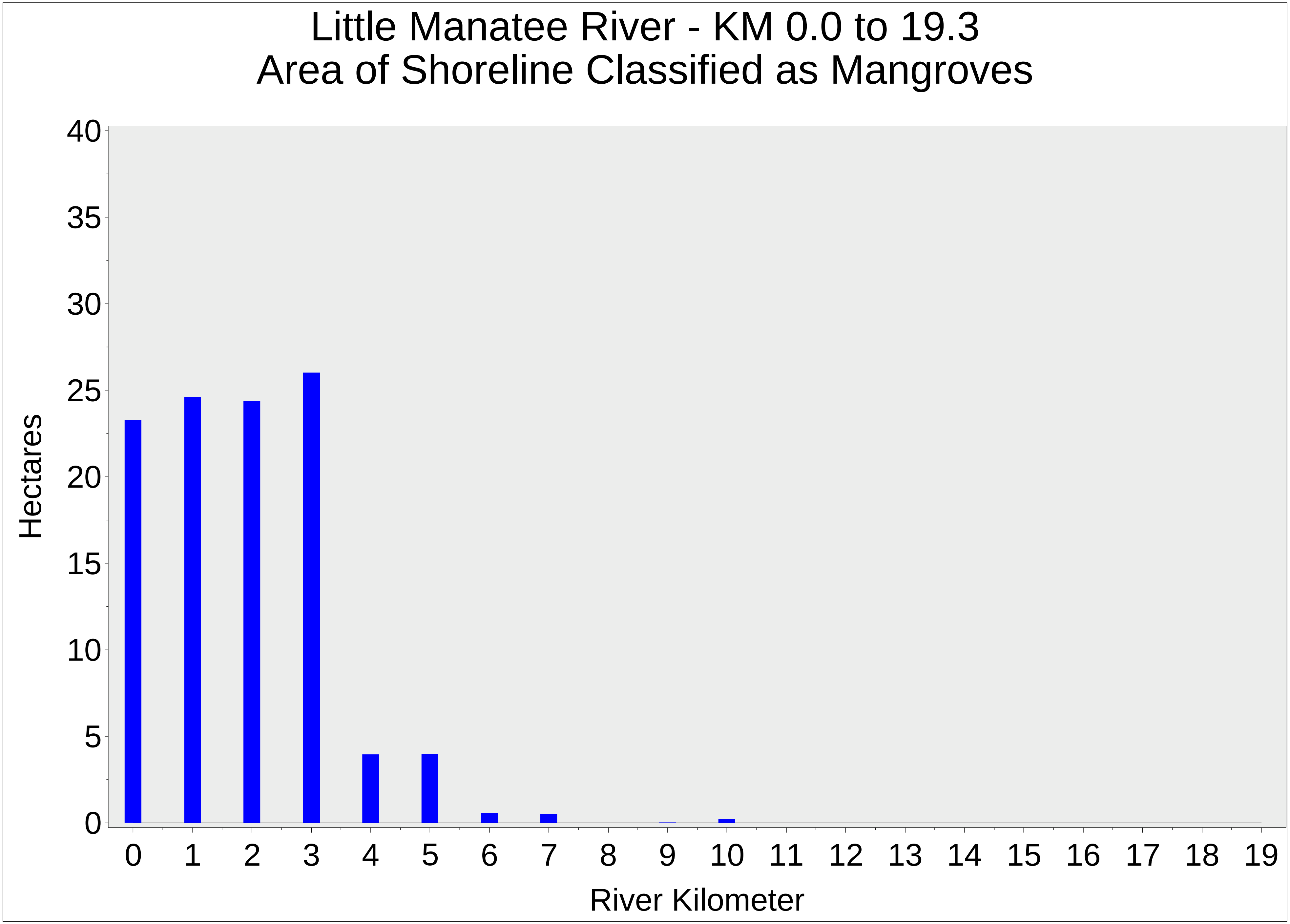
Little Manatee River - KM 0.0 to 19.3
Upland Forest, *Juncus romerianus* , Bottomland Hardwood, Upland Conifer, and Freshwater Marsh Area
Hectares
River Kilometer
Upland Forest
Juncus romerianus (needlerush)
Bottomland Hardwoods
Upland Conifers
Freshwater Marsh
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

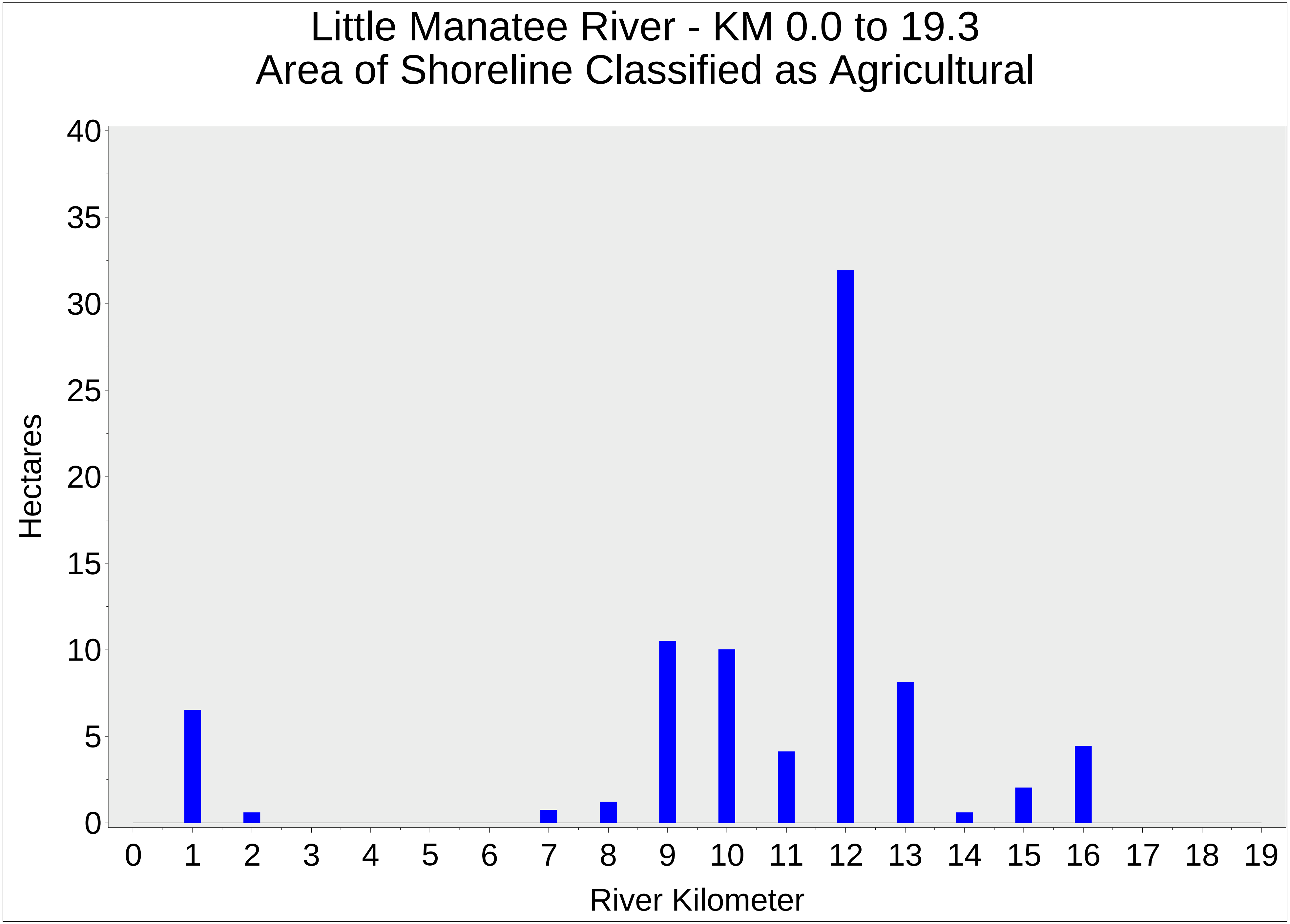

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Urban
Hectares
40
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

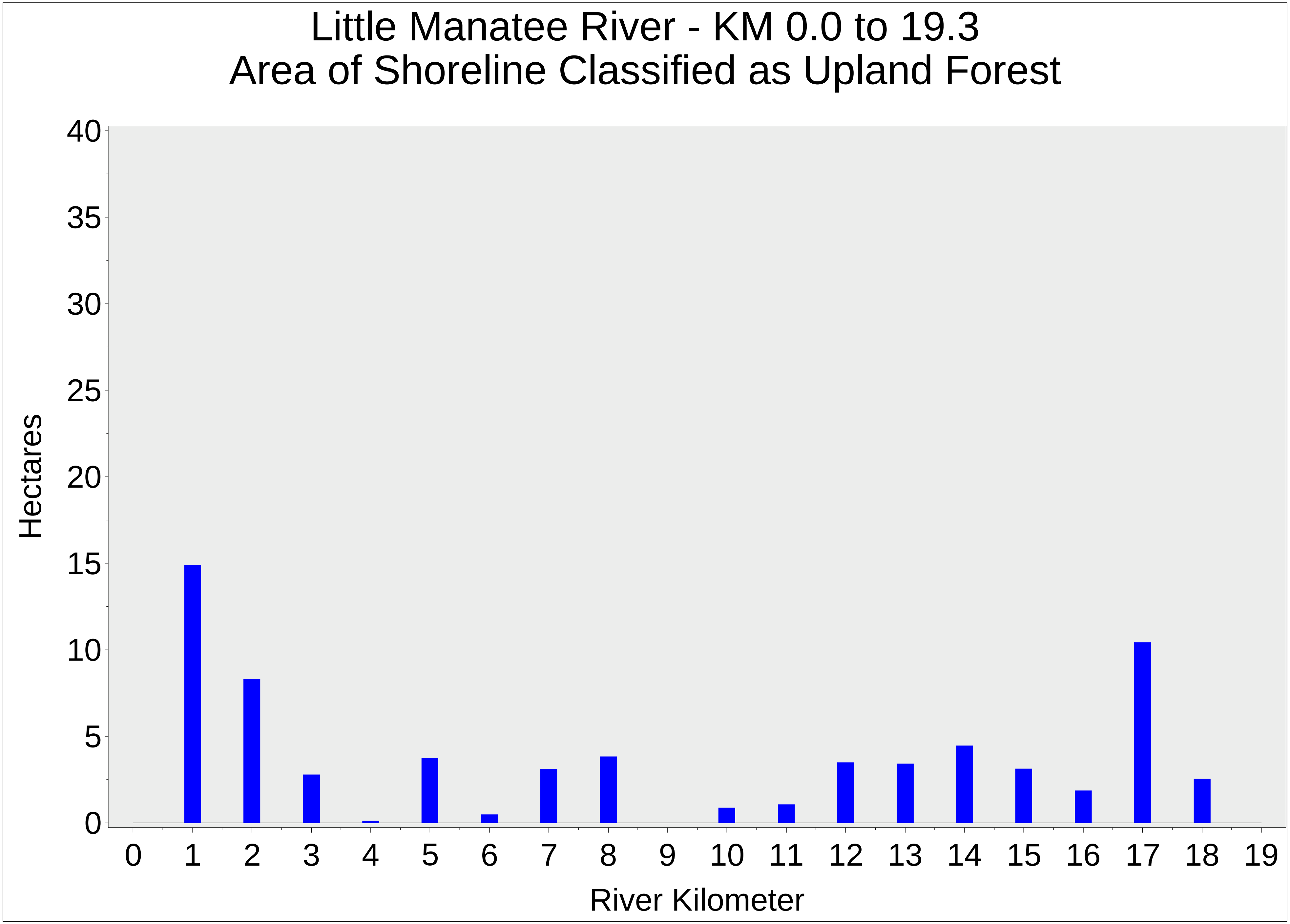


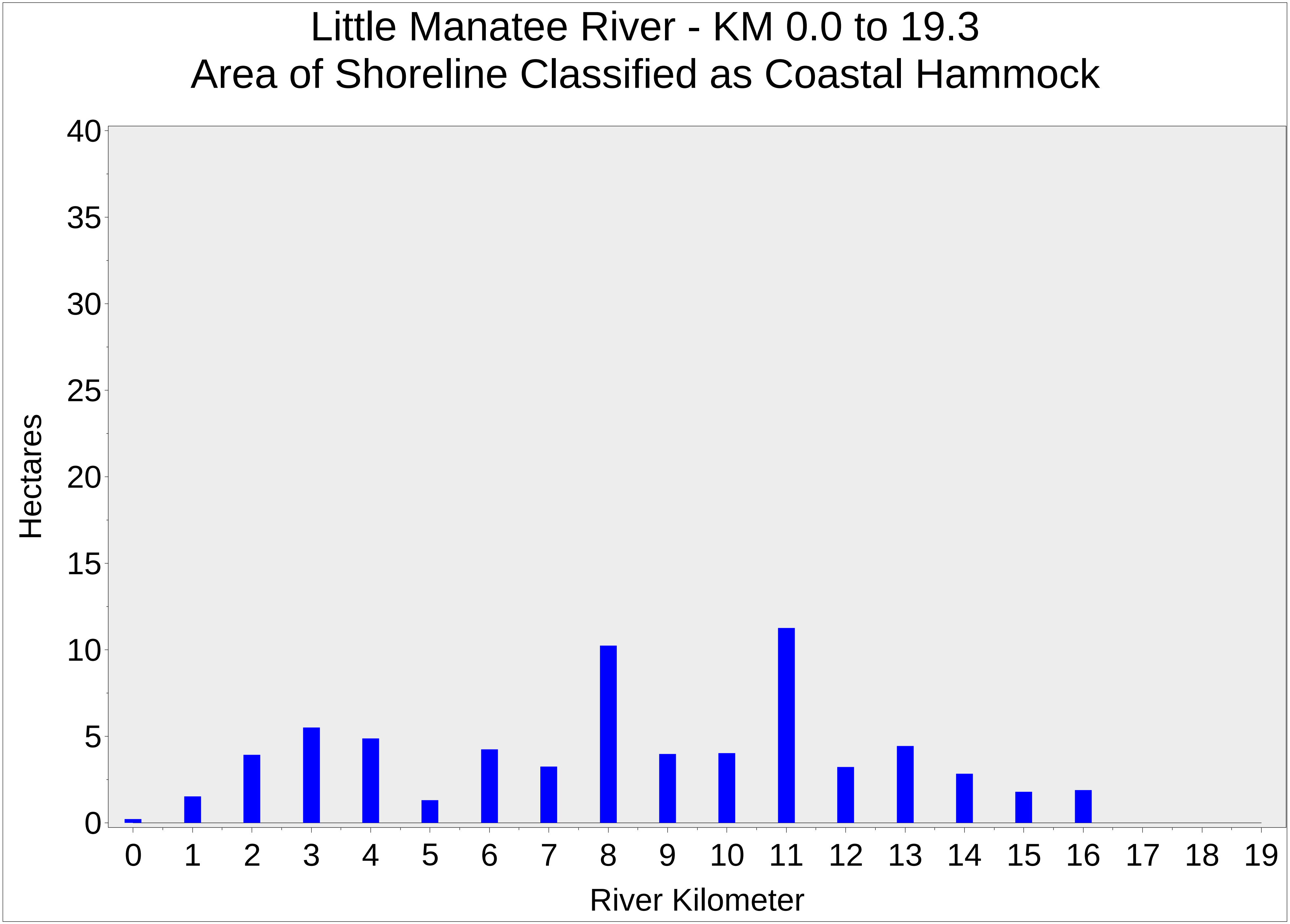
Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Bottomland Hardwoods
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Juncus romerianus(needlerush)
Hectares
0
5
10
15
20
25
30
35
40
River Kilometer
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

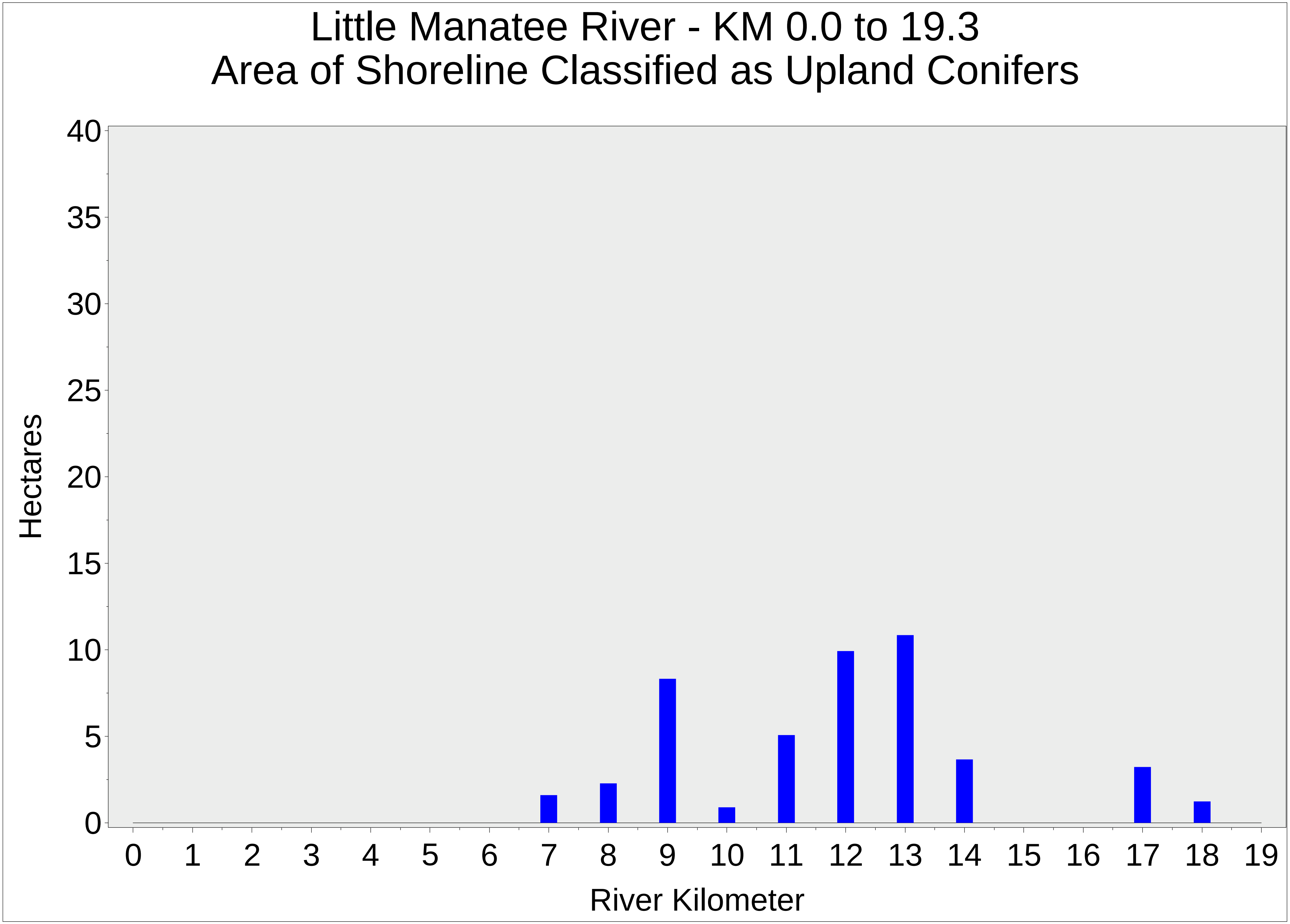

Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Mangroves
Hectares
0
5
10
15
20
25
30
35
40
River Kilometer
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19


Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Agricultural
Hectares
0
5
10
15
20
25
30
35
40
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Upland Forest
Hectares
0
5
10
15
20
25
30
35
40
River Kilometer
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19



Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Coastal Hammock
Hectares
40
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer



Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as Upland Conifers
Hectares
0
5
10
15
20
25
30
35
40
River Kilometer
0
1
2
3
4
5
6
7
8
9
10
11
12
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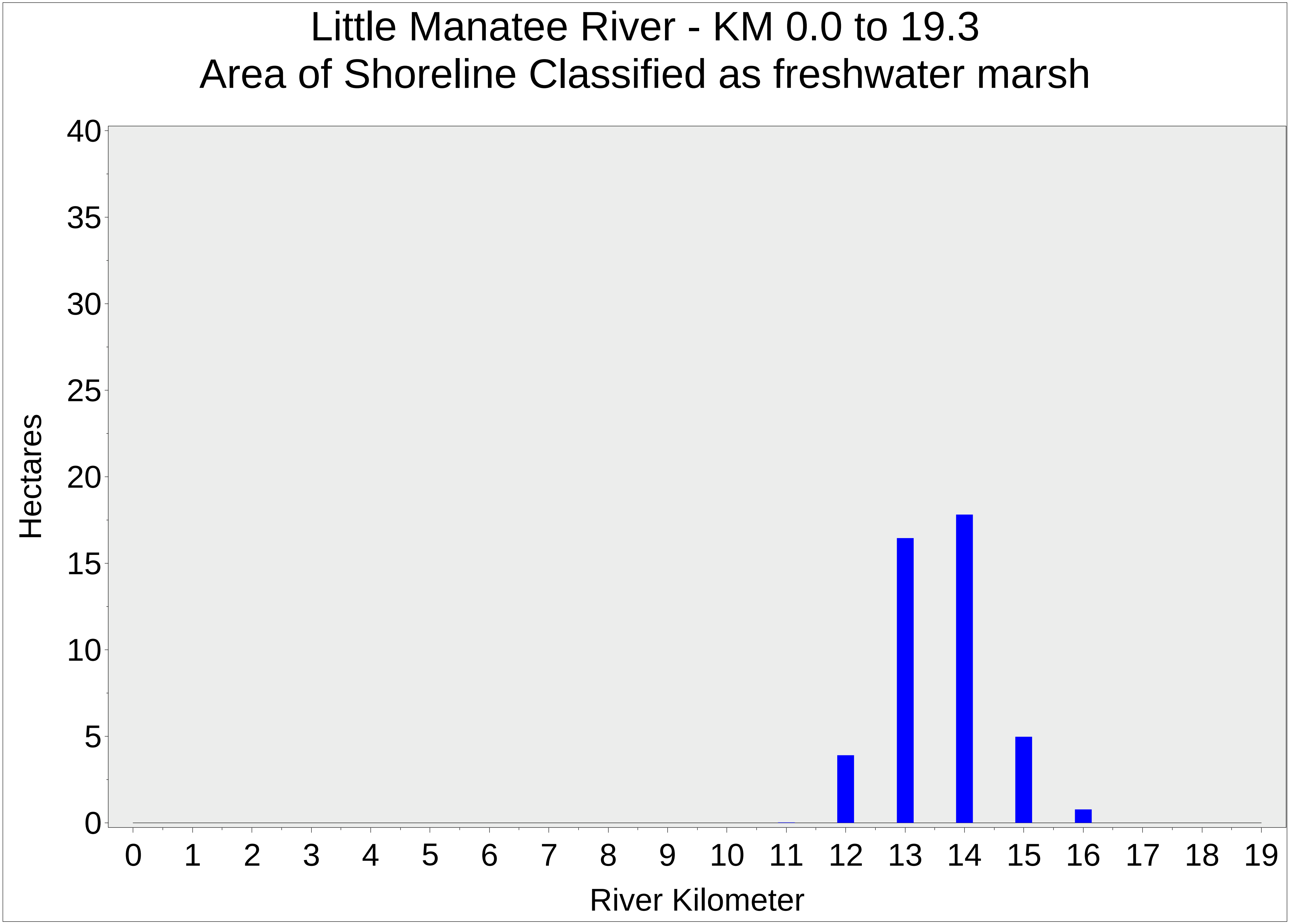
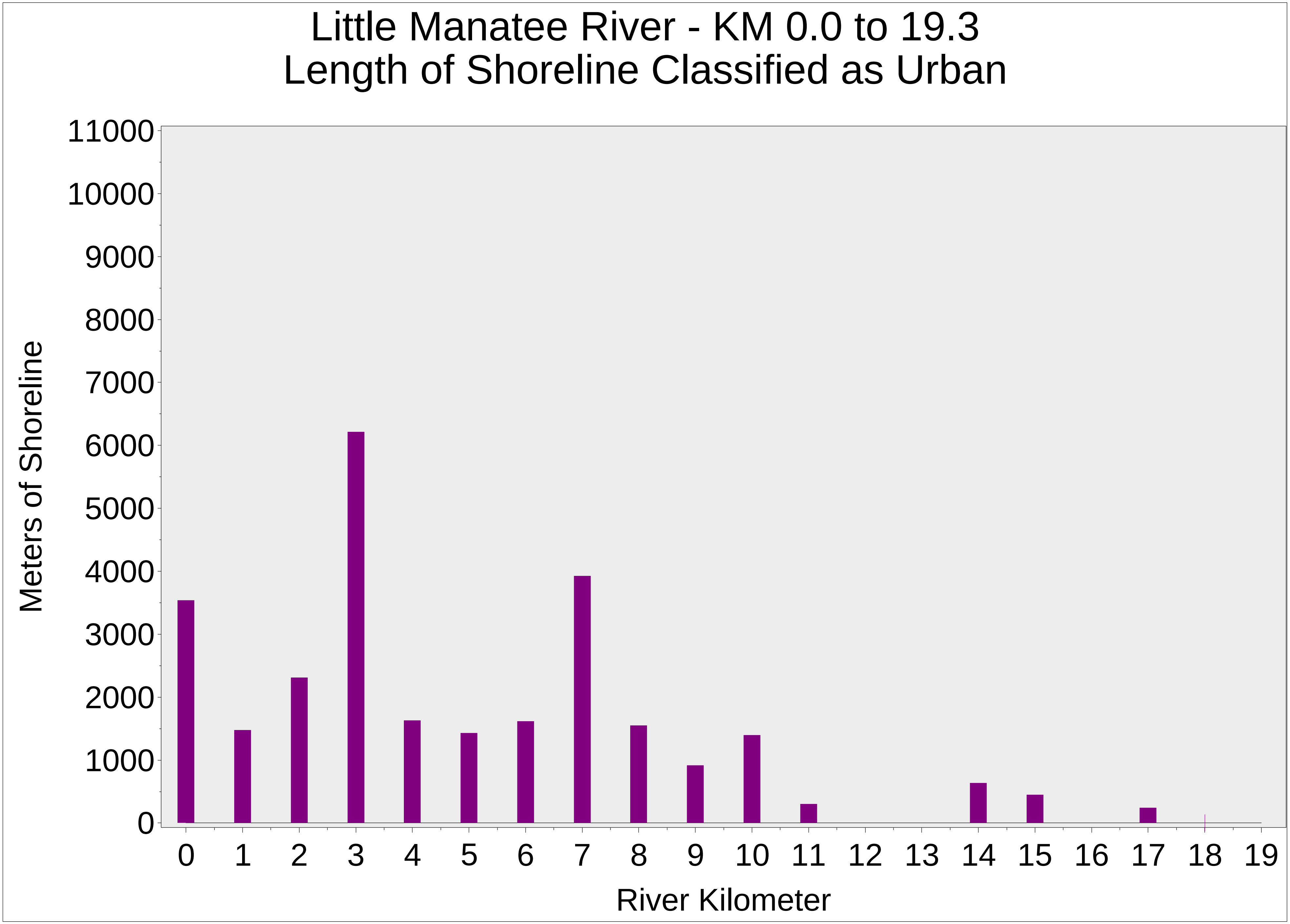
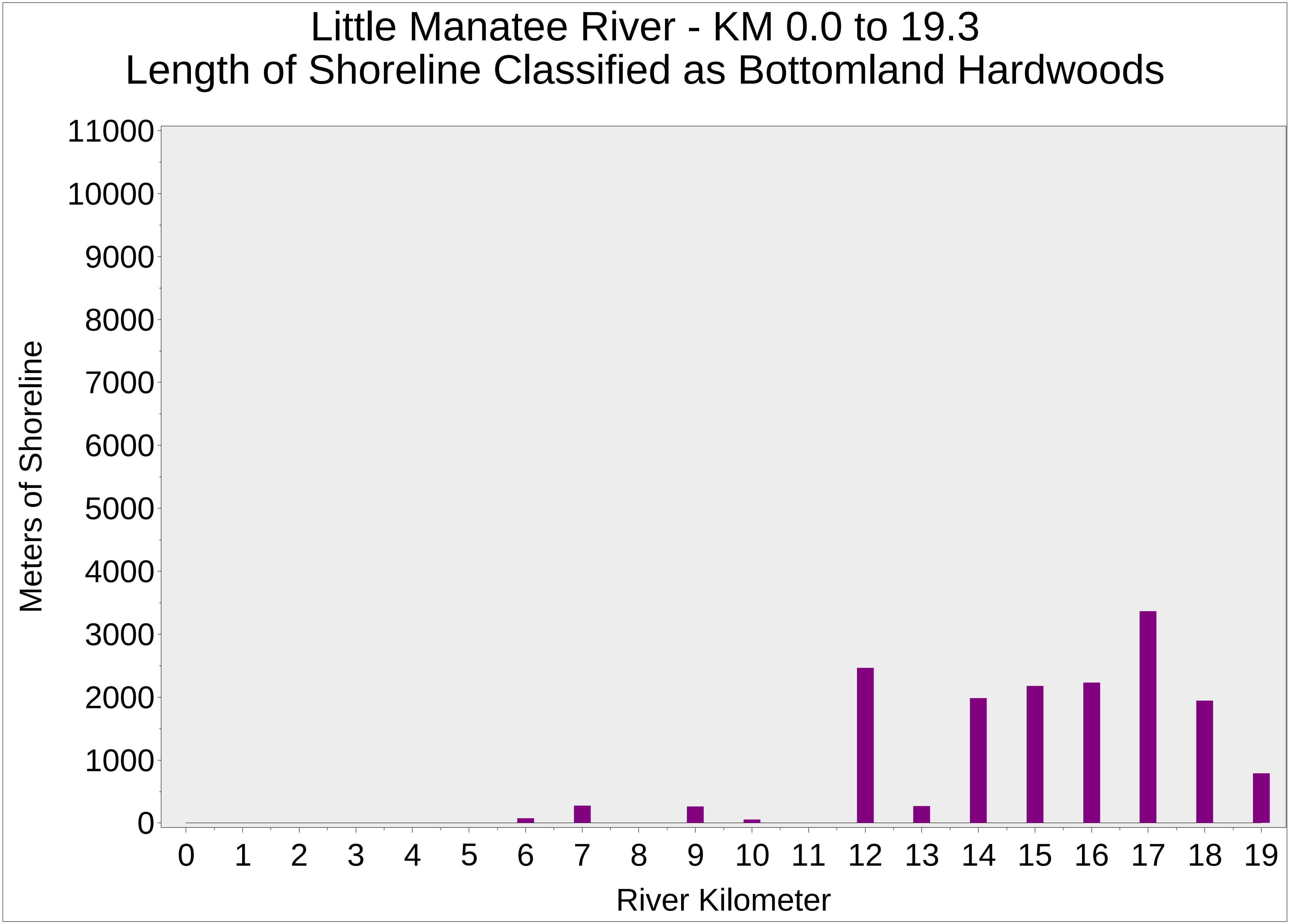
14
15
16
17
18
19

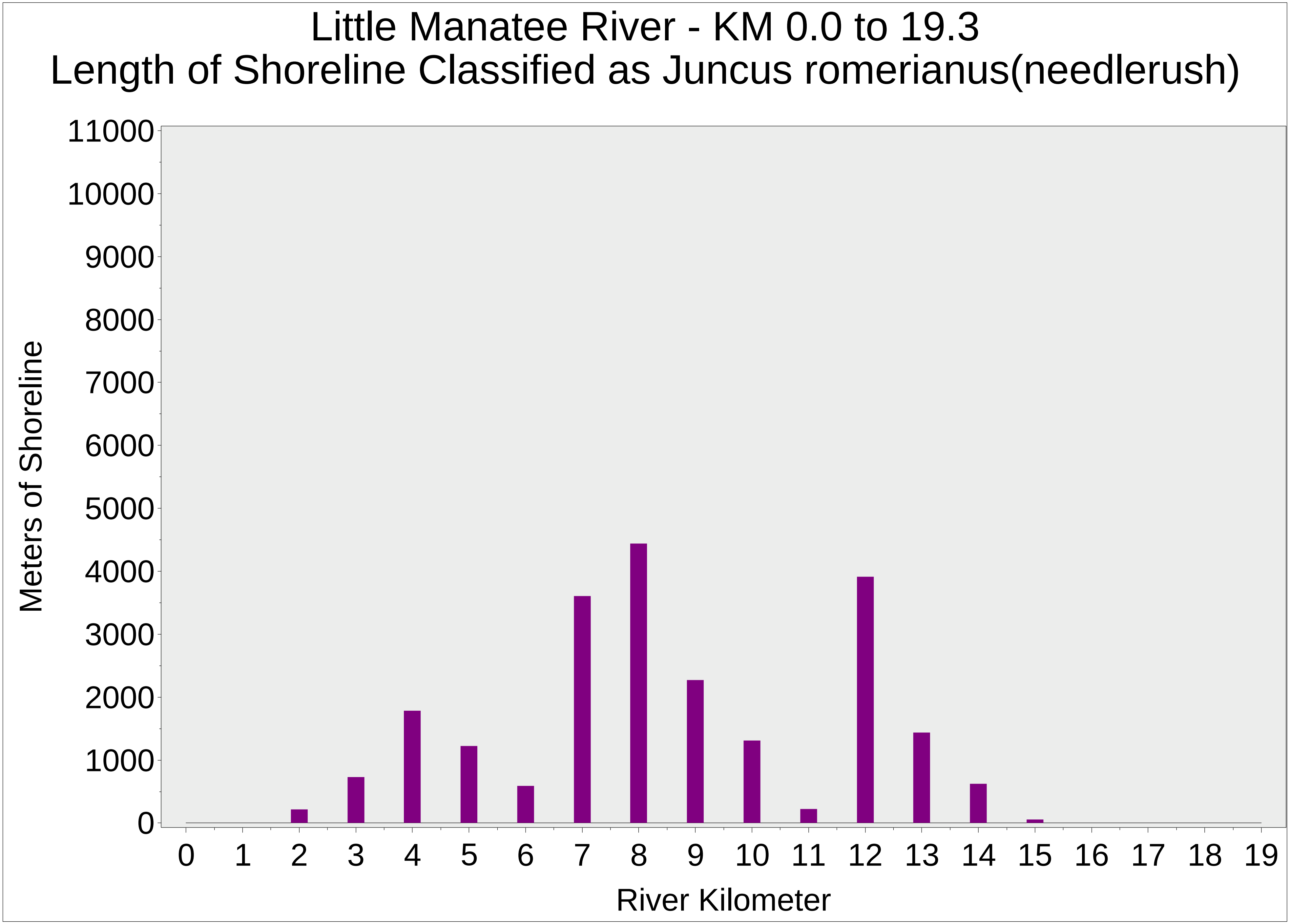


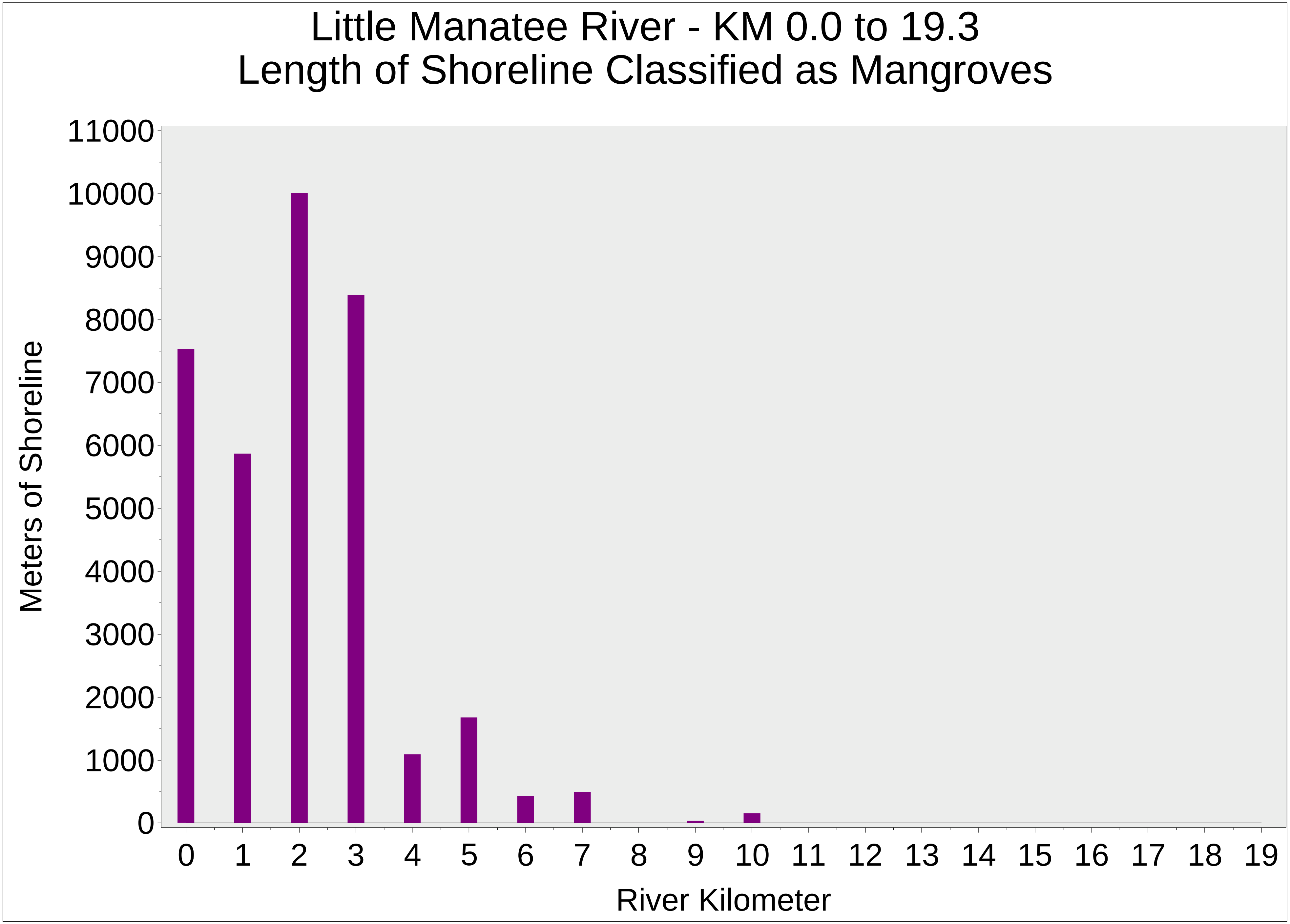
Little Manatee River - KM 0.0 to 19.3
Area of Shoreline Classified as freshwater marsh
Hectares
40
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

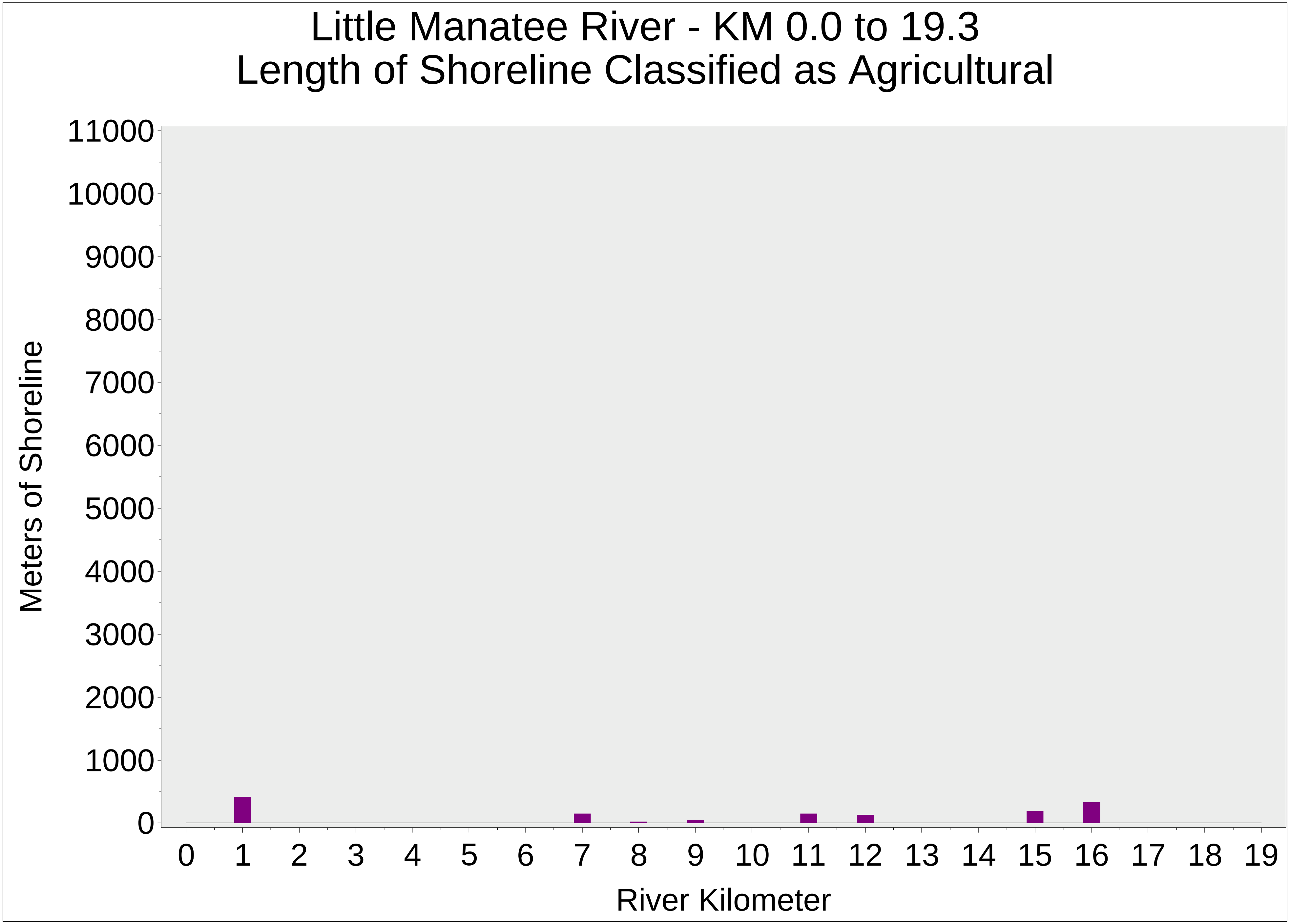


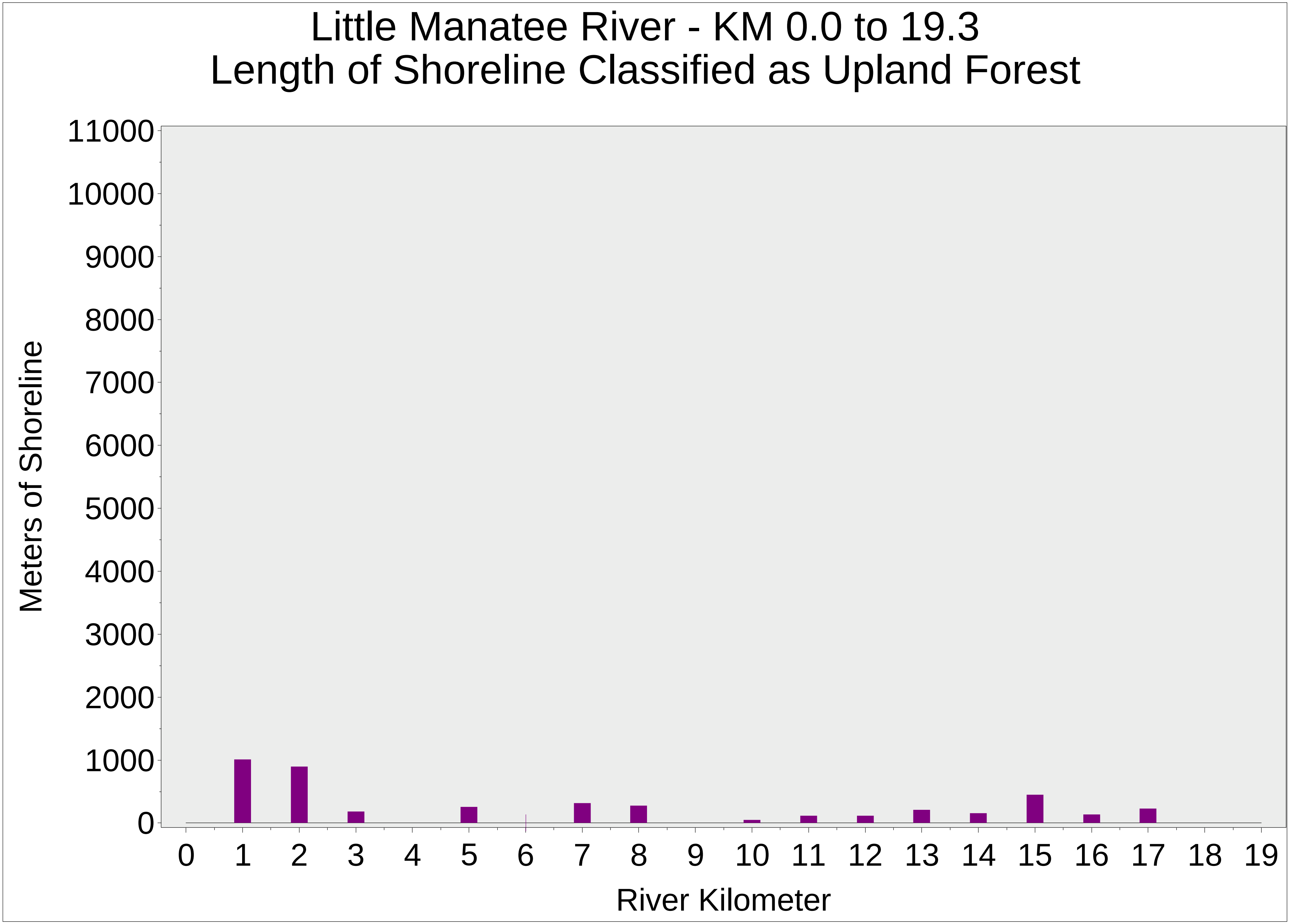
Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Urban
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Bottomland Hardwoods
Meters of Shoreline
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

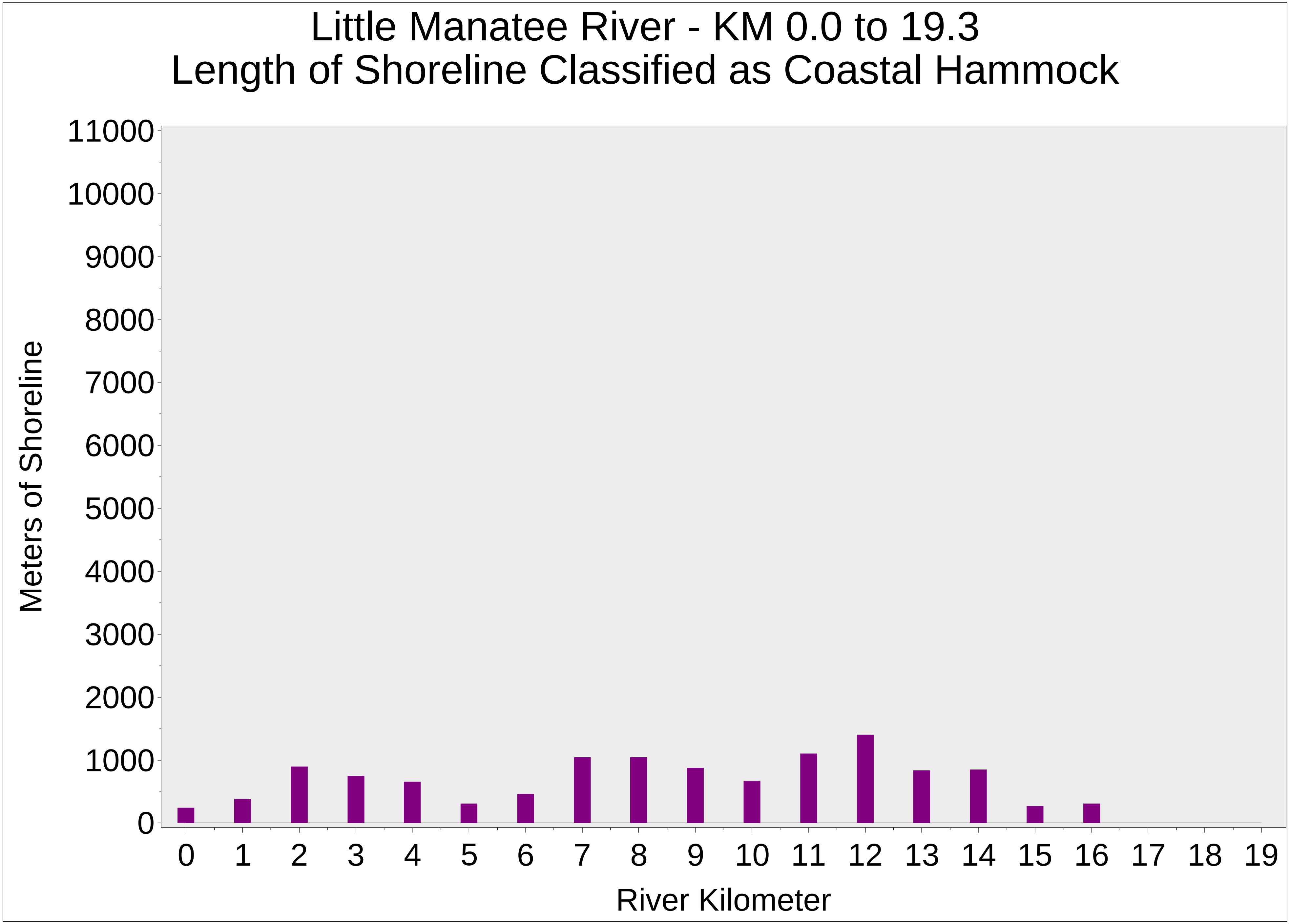

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Juncus romerianus(needlerush)
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Mangroves
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
River Kilometer

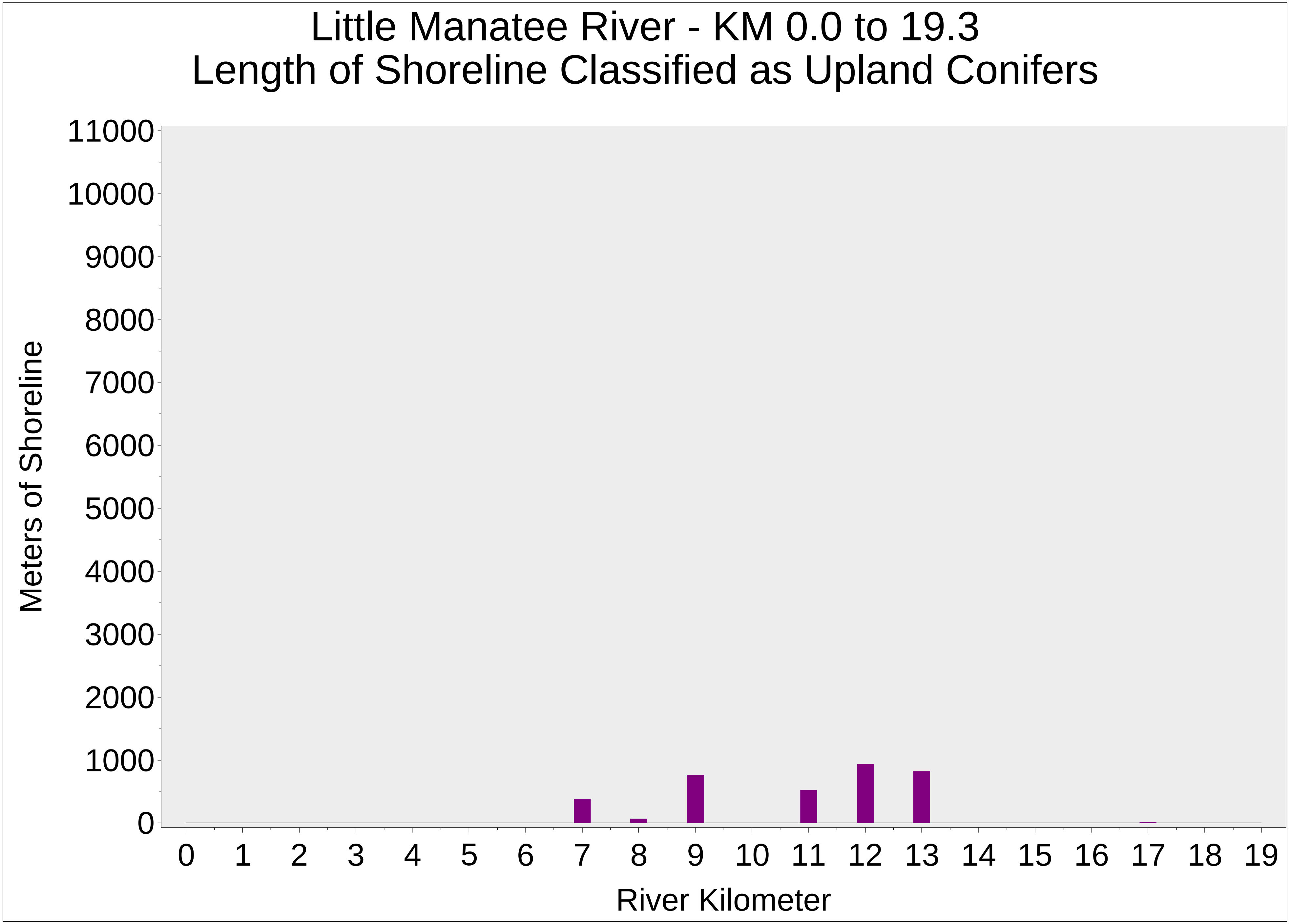

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Agricultural
Meters of Shoreline
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
River Kilometer



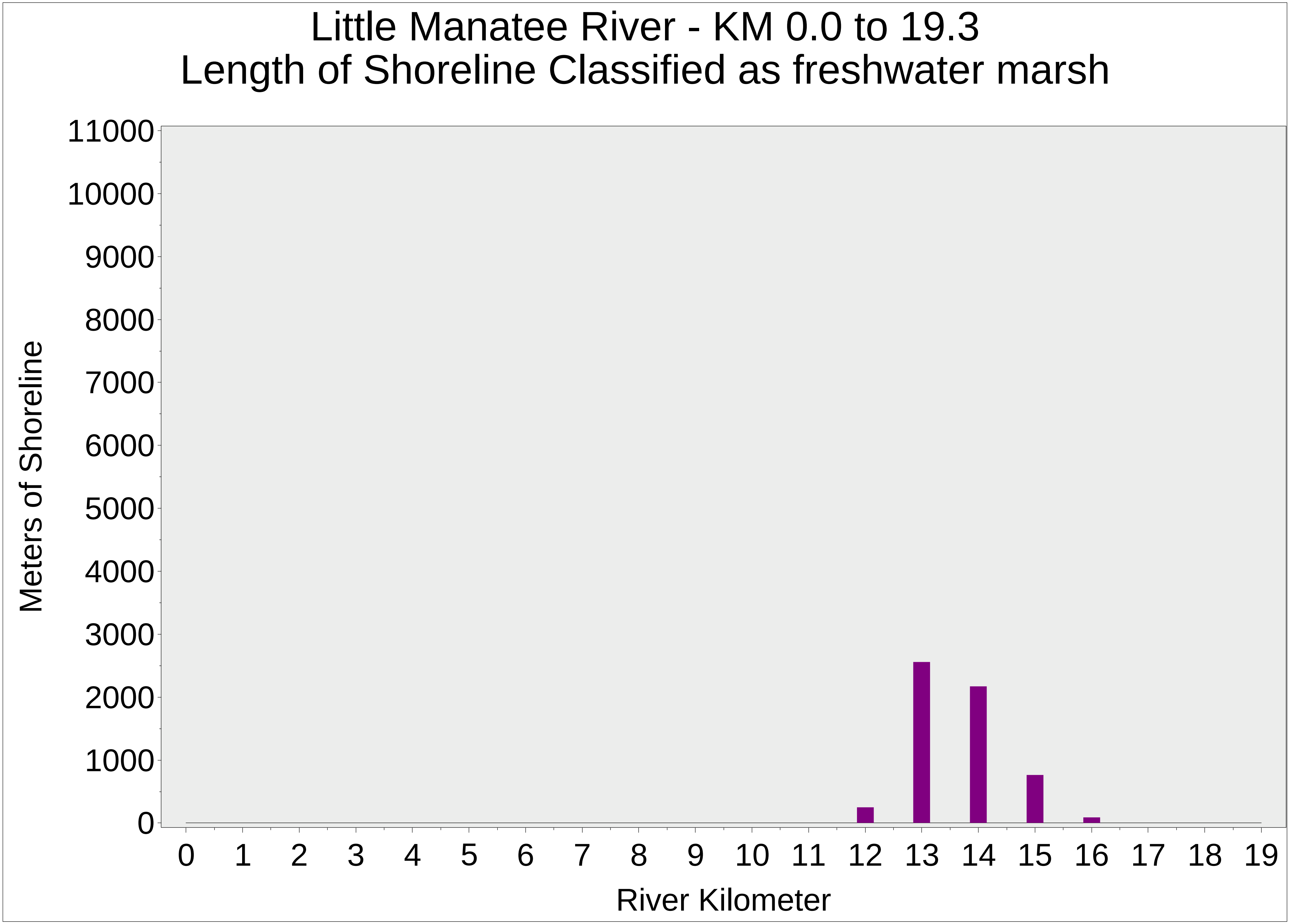
Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Upland Forest
Meters of Shoreline
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

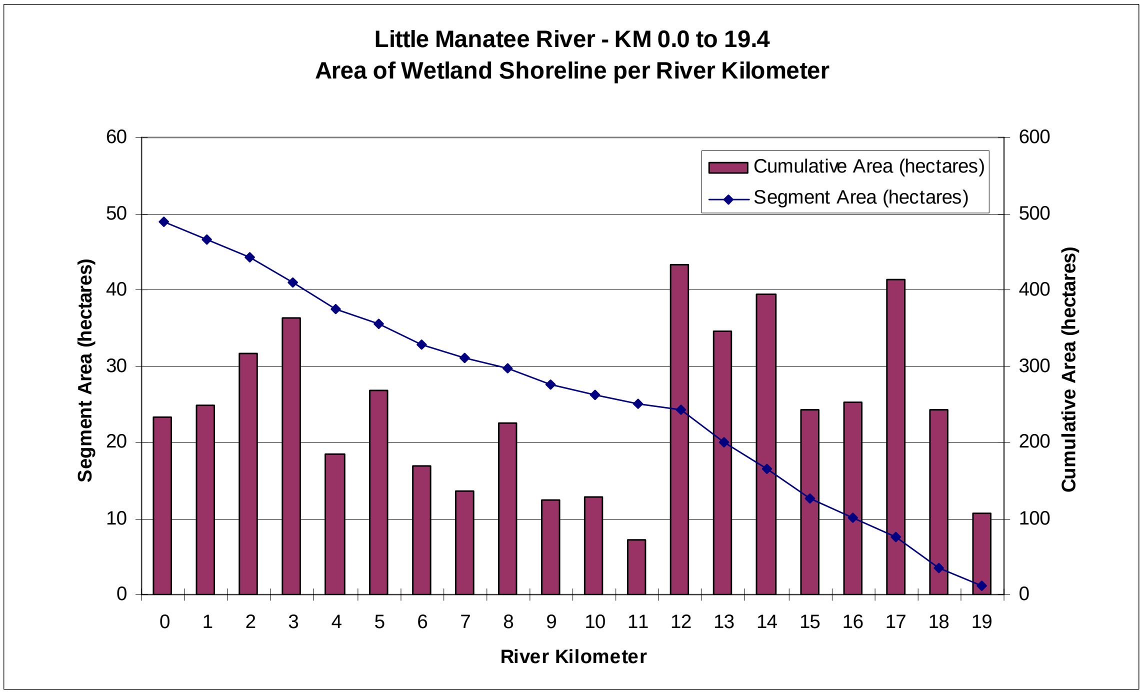


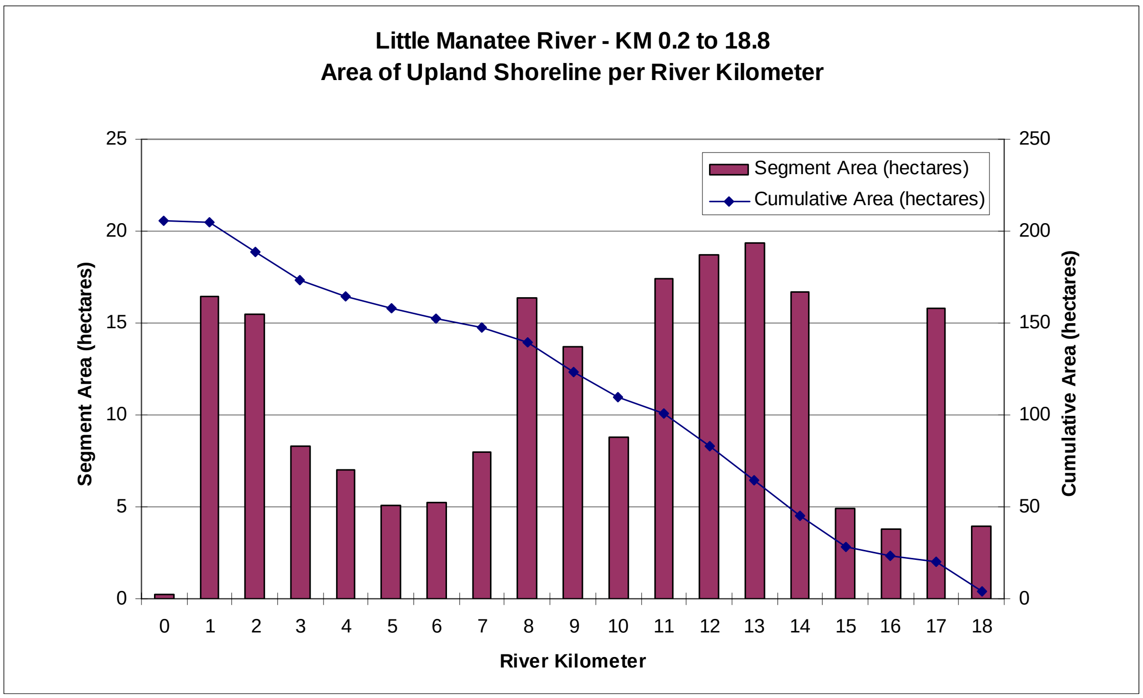
Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Coastal Hammock
Meters of Shoreline
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

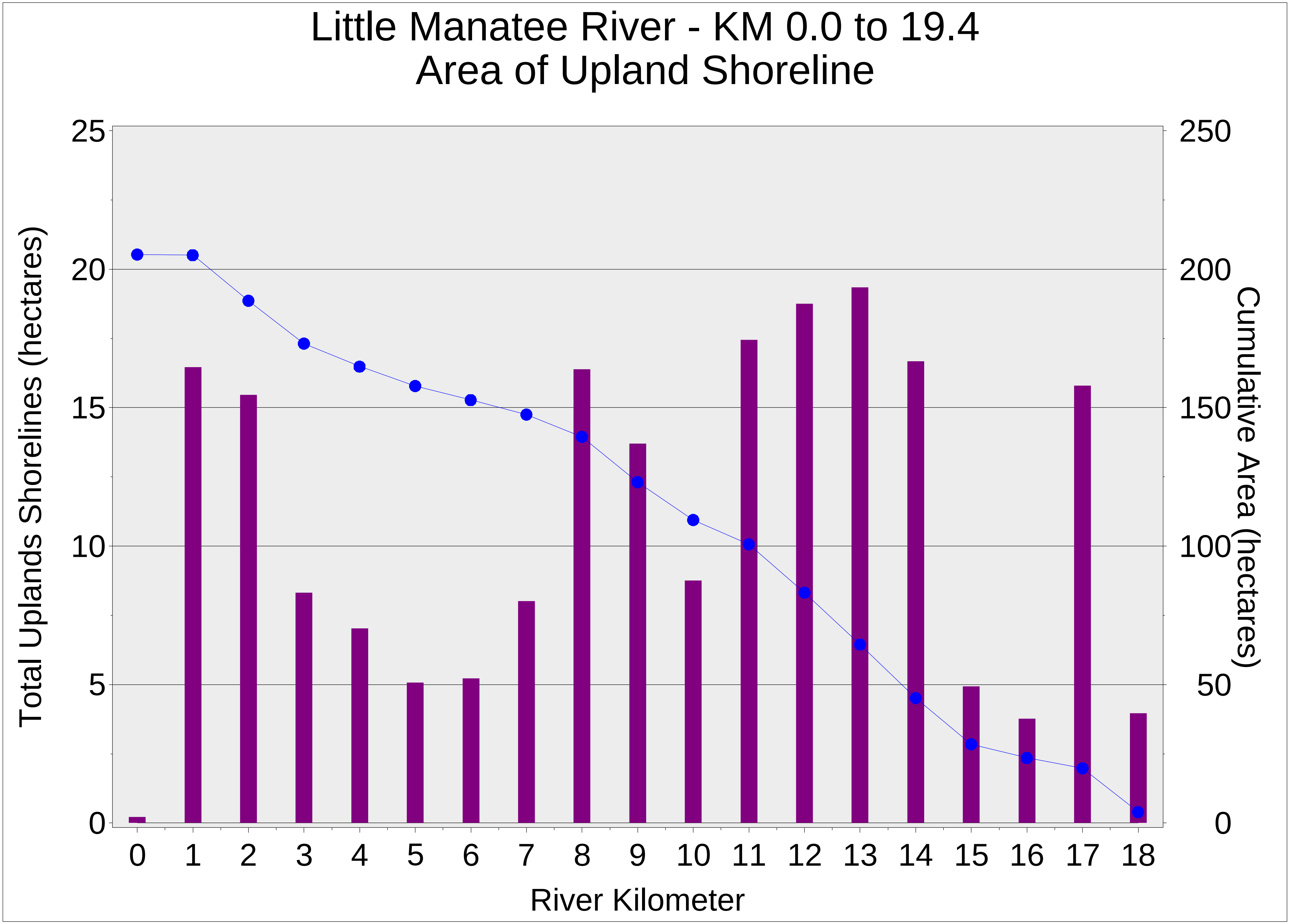


Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as Upland Conifers
Meters of Shoreline
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
River Kilometer

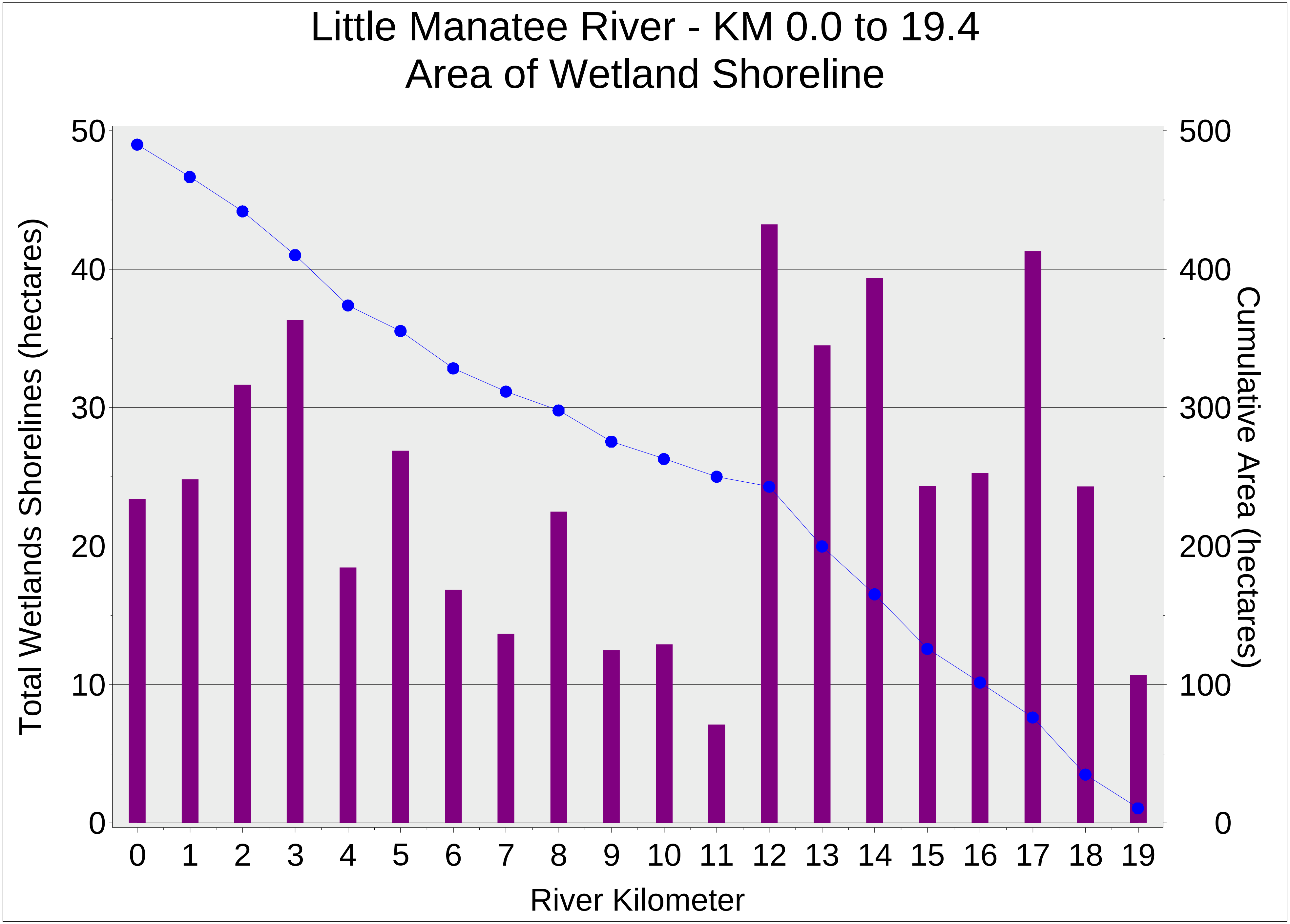

Little Manatee River - KM 0.0 to 19.3
Length of Shoreline Classified as freshwater marsh
Meters of Shoreline
River Kilometer
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19


Little Manatee River - KM 0.0 to 19.4
Area of Wetland Shoreline per River Kilometer
Cumulative Area (hectares)
Segment Area (hectares)
Segment Area (hectares)
Cumulative Area (hectares)
River Kilometer
0
10
20
30
40
50
60
0
100
200
300
400
500
600
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19


Little Manatee River - KM 0.2 to 18.8
Area of Upland Shoreline per River Kilometer
Segment Area (hectares)
Cumulative Area (hectares)
Segment Area (hectares)
Cumulative Area (hectares)
River Kilometer
0
5
10
15
20
25
0
50
100
150
200
250
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18



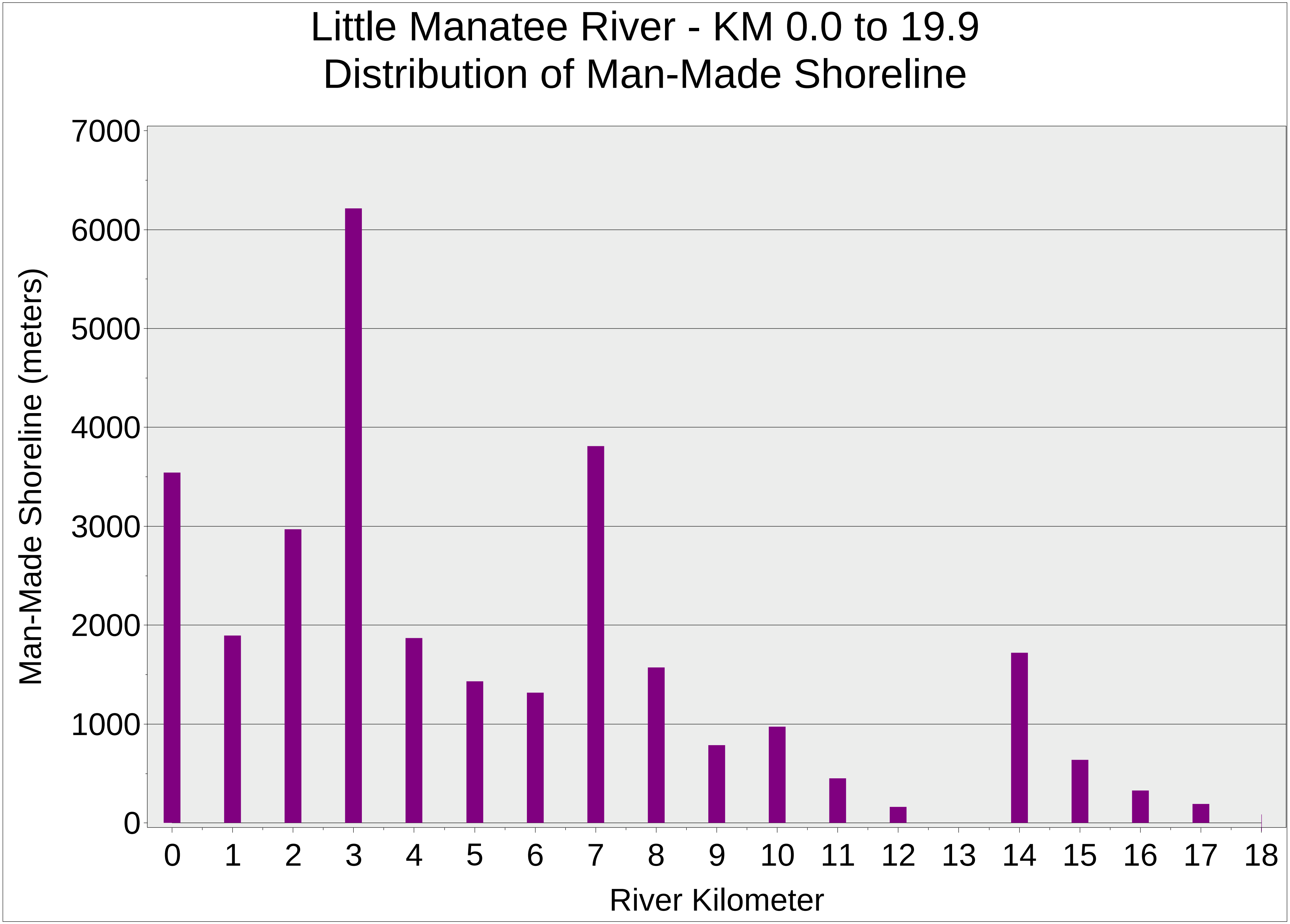
Little Manatee River - KM 0.0 to 19.4
Area of Upland Shoreline
Total Uplands Shorelines (hectares)
Cumulative Area (hectares)
River Kilometer
0
5
10
15
20
25
0
50
100
150
200
250
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18



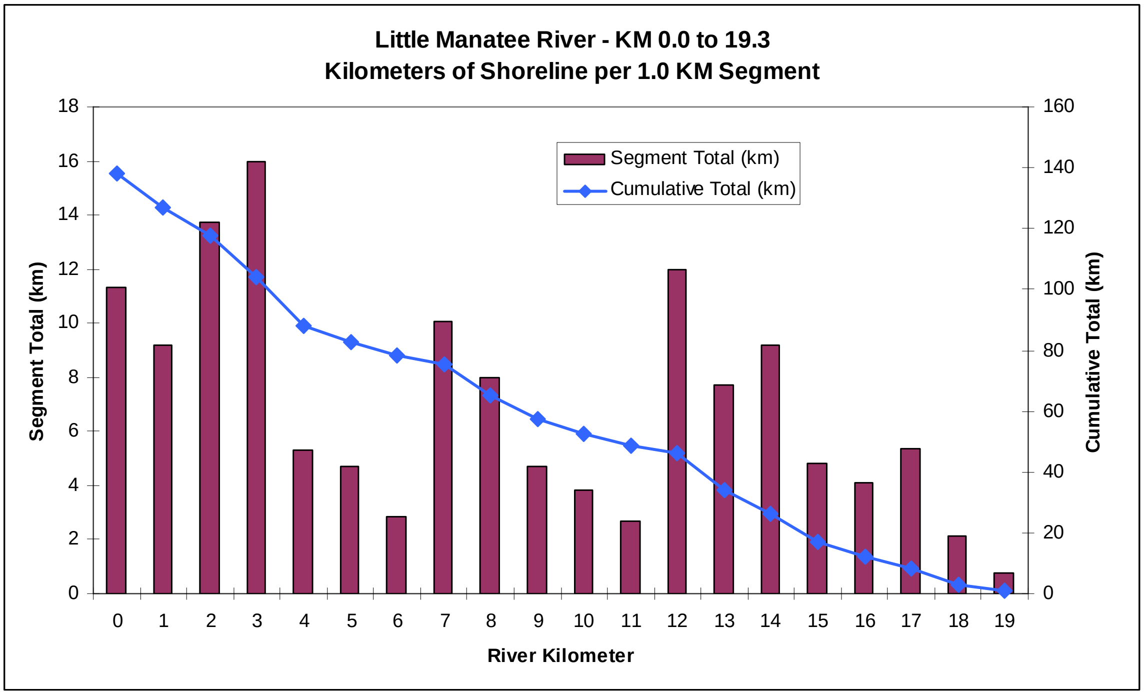
Little Manatee River - KM 0.0 to 19.4
Area of Wetland Shoreline
Total Wetlands Shorelines (hectares)
Cumulative Area (hectares)
River Kilometer
0
10
20
30
40
50
100
200
300
400
500
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

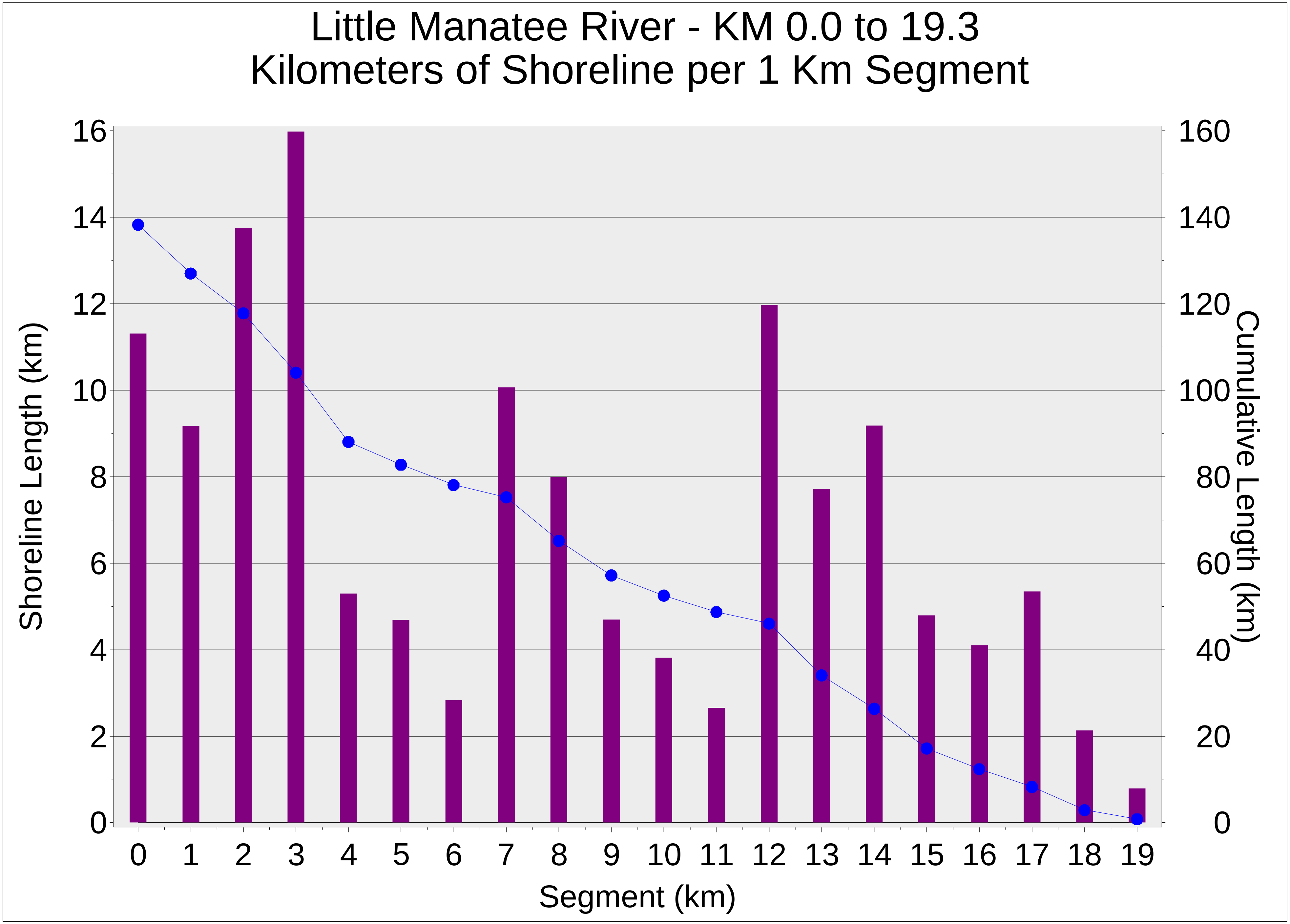
Area of Major Shoreline Plant Communities Along the Little Manatee River Shoreline

Species or Group	Area (hectares)	Percent of Total
Urban	267.63	25.6%
Bottomland Hardwoods	152.91	14.6%
Juncus romerianus(needlerush)	150.54	14.4%
Mangroves	107.64	10.3%
Agricultural	81.02	7.8%
Upland Forest	68.80	6.6%
Coastal Hammock	68.78	6.6%
Upland Conifers	47.21	4.5%
Freshwater Marsh	44.01	4.2%
Range	14.76	1.4%
Echinochloa	9.97	1.0%
Wetland Conifers	8.93	0.9%
Upland Hardwoods	5.29	0.5%
Marsh with Cladium (sawgrass)	4.56	0.4%
Typha (cattail)	3.38	0.3%
Leatherfern	2.35	0.2%
Juncus and Leatherfern	1.91	0.2%
Tidal Flat	1.65	0.2%
Wetland Marsh	0.88	0.1%
Cladium (sawgrass)	0.72	0.1%
Saltmarsh	0.48	0.0%
Sabal Palmetto	0.47	0.0%
Utilities	0.39	0.0%
Wet Prairie	0.06	0.0%



Little Manatee River - KM 0.0 to 19.9
Distribution of Man-Made Shoreline
Man-Made Shoreline (meters)
0
1000
2000
3000
4000
5000
6000
7000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
River Kilometer


Little Manatee River - KM 0.0 to 19.3
Kilometers of Shoreline per 1.0 KM Segment
Segment Total (km)
Cumulative Total (km)
Segment Total (km)
Cumulative Total (km)
River Kilometer
0
2
4
6
8
10
12
14
16
18
20
40
60
80
100
120
140
160
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19


Little Manatee River - KM 0.0 to 19.3
Kilometers of Shoreline per 1 Km Segment
Shoreline Length (km)
Cumulative Length (km)
Segment (km)
0
2
4
6
8
10
12
14
16
20
40
60
80
100
120
140
160
1
3
5
7
9
11
13
15
17
18
19

Bathymetric Survey at Anclote River System and Little Manatee River System

Final Report

Submitted by

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February 3, 2006

INTRODUCTION

This bathymetric survey project included two river systems: the Anclote River system and the Little Manatee River system. The Anclote River system includes 1) the Anclote River and all the side creeks, 2) the Anclote estuary, and 3) the nearly all the navigable tidal creeks in the estuary. The Little Manatee River system includes 1) the Little Manatee River and all the side creeks, 2) the Little Manatee River estuary, and 3) the nearly all the navigable tidal creeks in the estuary. 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 Anclote River, extending roughly 15 river miles, is shown in Figure 1. The project area along Little Manatee River, extending to Highway 301, is shown in Figure 2. All the navigable side creeks were included in the survey. The project was composed of two consecutive portions: shoreline mapping and bathymetry survey. The bathymetry measurements included cross-section surveys spaced at 500 ft or less and one centerline survey. To cover the entire stretch of the river, the GPS base station was established at four locations. Nearly all the navigable side creeks and tidal creeks in the down stream of the river were included in the survey.

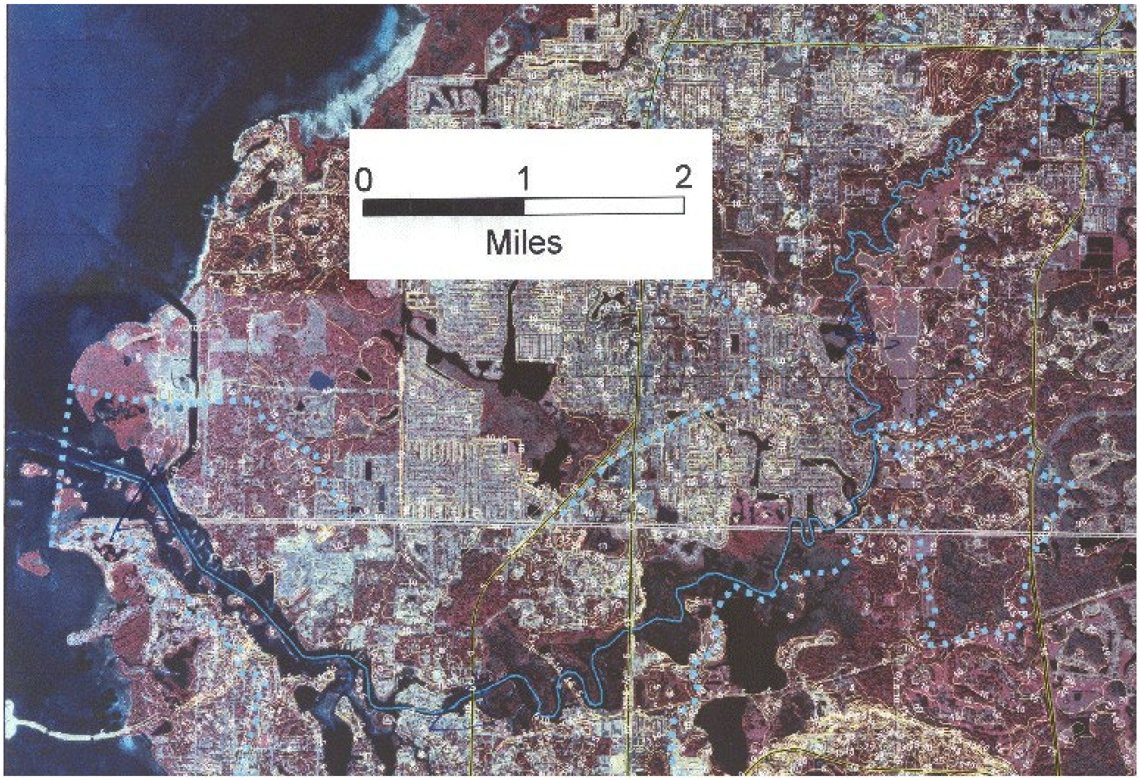


Figure 1. Anclote River project area.

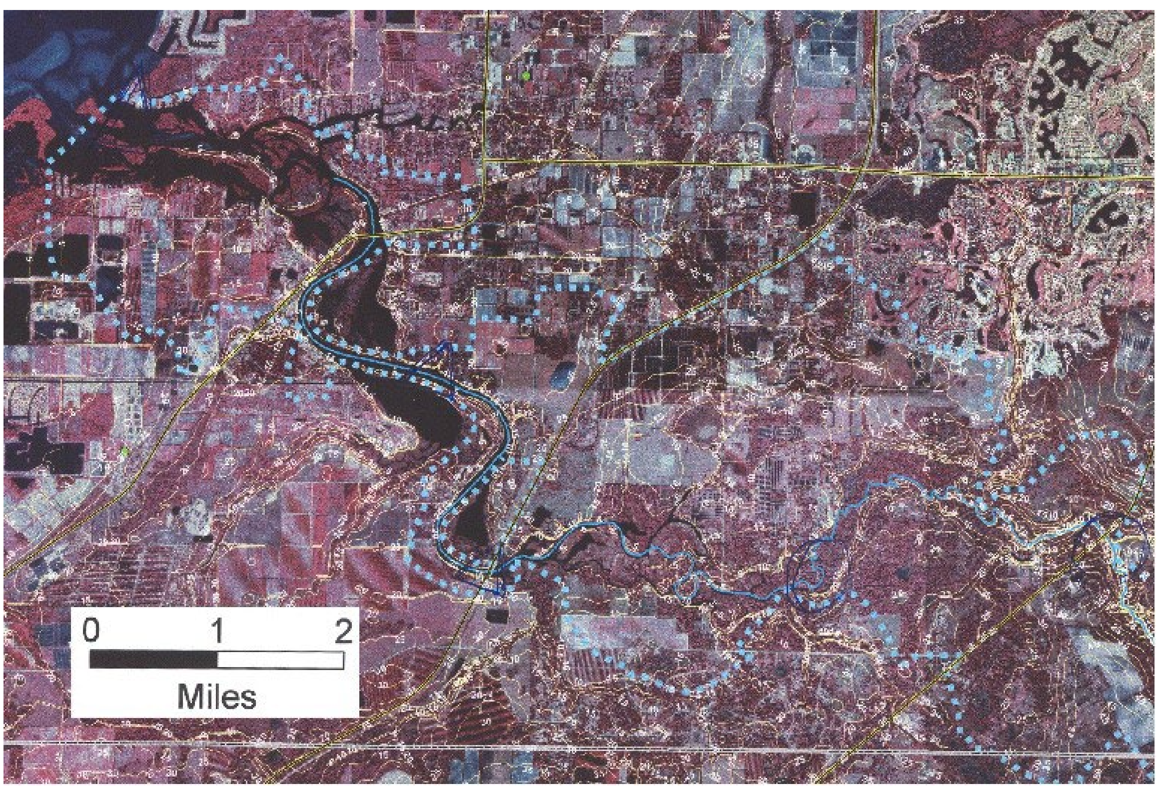


Figure 2. Little Manatee River project area.

FIELD METHODOLOGY

A 24-ft pontoon boat and a 14-ft aluminum boat were used for the shoreline and bathymetry survey (Figure 3). 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 3. The survey vessels, upper: the pontoon boat; lower: the 14-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 14-ft boat (Figure 3 lower). The shoreline mapped here is typically 3 to 6 ft from the actual vegetation line along the riverbank (Figure 3). 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.

A portion of the upper stretch of the Little Manatee River is very heavily vegetated with tall trees. The dense overhanging trees caused some problem for the GPS to receive adequate satellite information. Therefore, the survey could not be conducted at a few locations although shoreline and bathymetry were obtained along most of this stretch. Due to these gaps in the data, this stretch of the river is not completely continuous (some small gaps) on the GIS map.

The positions of the shoreline 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. 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 GPS system was sampled at 1 Hz, or roughly 4 to 6 ft (1.2 to 2.0 m) per point along the shoreline. This 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 4). 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, especially those "horizontally-growing" palm trees (Figure 5). 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.

Figure 4. Protruding boat docks caused some problem in shoreline mapping.

Figure 5. Protruding palm trees caused some problem in the shoreline mapping.

These obstacles, both artificial and natural, did not have significant influence on the overall shoreline mapping. 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.

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 0.59 ft (18 cm) below the water surface on the pontoon boat and 0.52 ft (16 cm) below on the aluminum boat (Figure 6). The sensor has a minimum range of approximately 1 ft (30 cm). Therefore, the minimum measurable water depth for the present system is roughly 1.6 ft (50 cm).

Under most circumstances, the survey lines are roughly perpendicular to the shoreline (Figure 7). The 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. Some of the creeks are too narrow, e.g., less than 80 ft (25 m) wide. A large portion of the creek could not be covered by the survey vessel simply because the sensor was mounted in the middle of the vessel. In this case, in addition to cross sections, a survey line following a zigzag pattern along the creek was added. A centerline was surveyed over the entire project area.

Figure 6. The survey echo sounder was mounted at 18 cm below water surface.

The echo sounder was sampled at 1 Hz, i.e., one measurement every second, or roughly one measurement every 3 to 8 ft (1.0 to 2.4 m). This close sampling interval was adopted to ensure detailed spatial coverage, especially in the river channel. 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. Although the system is capable of faster-than-1-Hz sampling, it was not adopted to avoid excessive data, which may add unnecessary work during data processing.

Figure 7. Surveying cross sections.

Several sources may induce errors in the survey. The echo sounder sometimes became unstable in shallower water, mostly when water depth became shallower than 2 ft (0.6 m) in combination with relatively rough conditions. Occasionally, the echo sounder will return a reading of zero. These erroneous readings were removed during the data processing. The reason for the zero reading is not clear.

Occasionally, the echo sounder returned a reading that was apparently twice the water depth (Figure 8). 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 multiple reflections by two. A computer routine was developed 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 (or three or four under rare occasions). Figure 8 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.

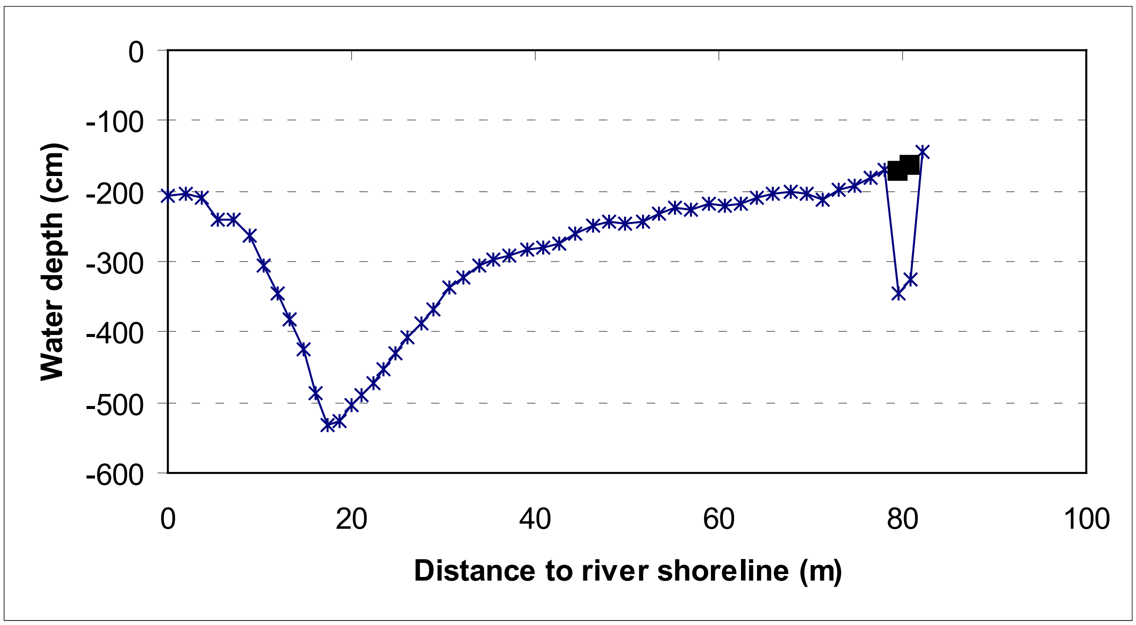


Figure 8. Multiple reflections in the echo sounder record. The solid squares are corrected water depth. An example of a cross section at Peace River (from an earlier SWFWMD project).

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., in the estuaries, 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.

Another uncertainty associated with the floating platform survey was caused by the tidal water-level variations. Nearly the entire 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. This is conducted using simultaneous tide measurements. The USGS maintains a suit of tide gages throughout the entire study area. The tide measurements from the closest USGS tide gages were used to remove the tide influence and to refer the measured water depth to NGVD29.

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 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 (NGVD29 – cm);
b) Surveyed centerline positions in Florida State Plane and UTM 17 coordinates in meters and elevations in centimeters (NGVD29 – cm);
c) Surveyed cross-sections in State Plane and UTM17 Northing in meters, State Plane and UTM17 Easting in meters, and elevation in centimeters (NGVD29-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 (NGVD29 – 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 (NGVD29-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.

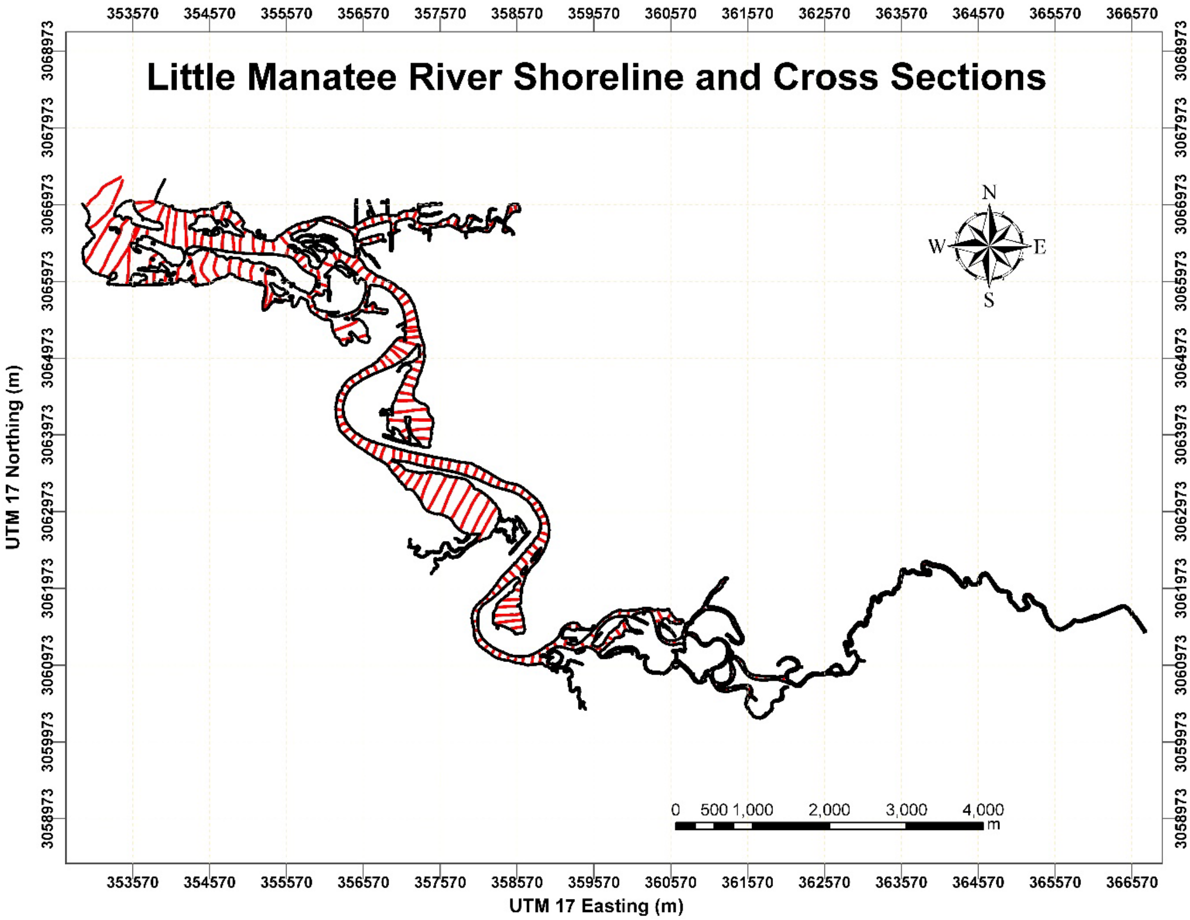
Set IV: JPG format of the GIS maps including the bathymetry contour and shoreline maps of the entire project area.

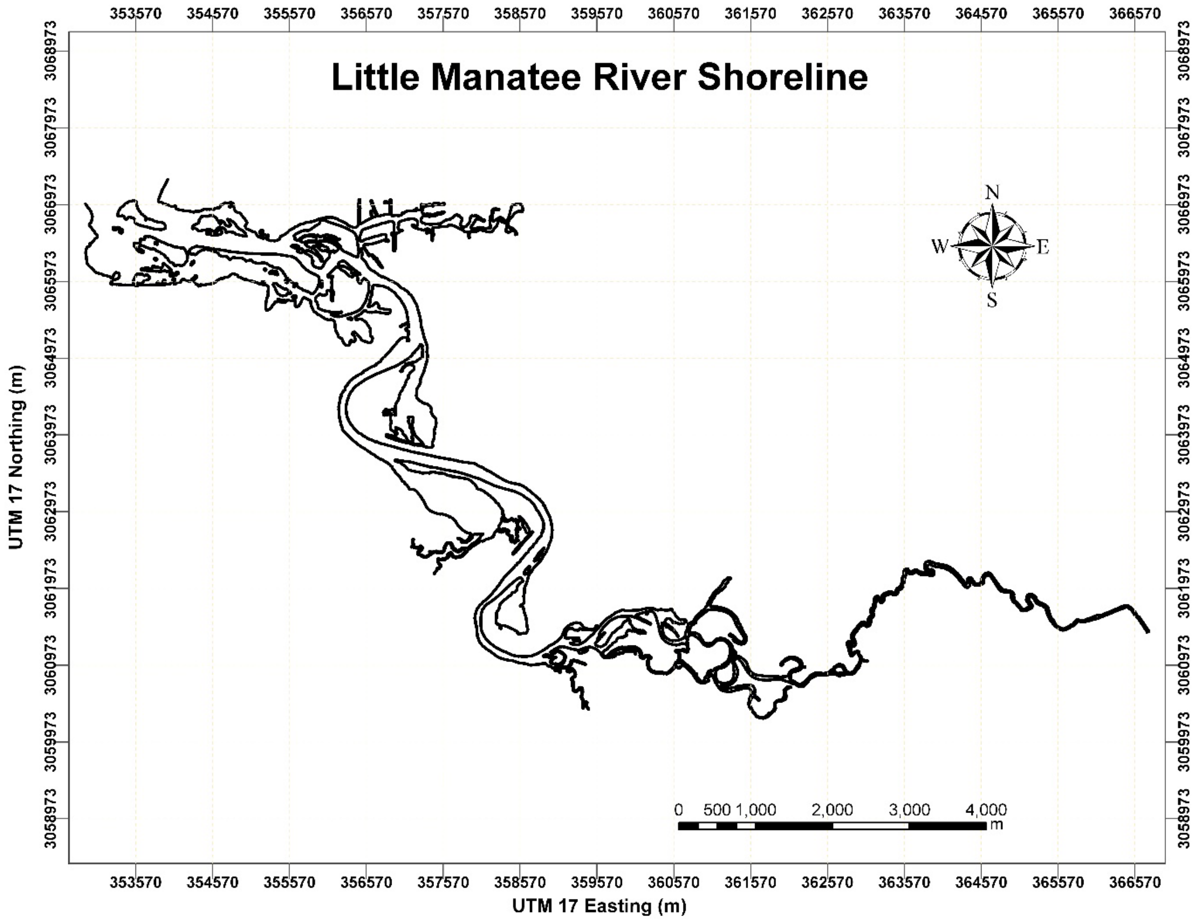
The GIS maps are preliminary in the sense that detailed work to improve the map presentation was not conducted. However, the data processing was completed (except the possibility of USGS revising the tide data, the data can be revised relatively easily). The details of the contour maps can also be improved 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.

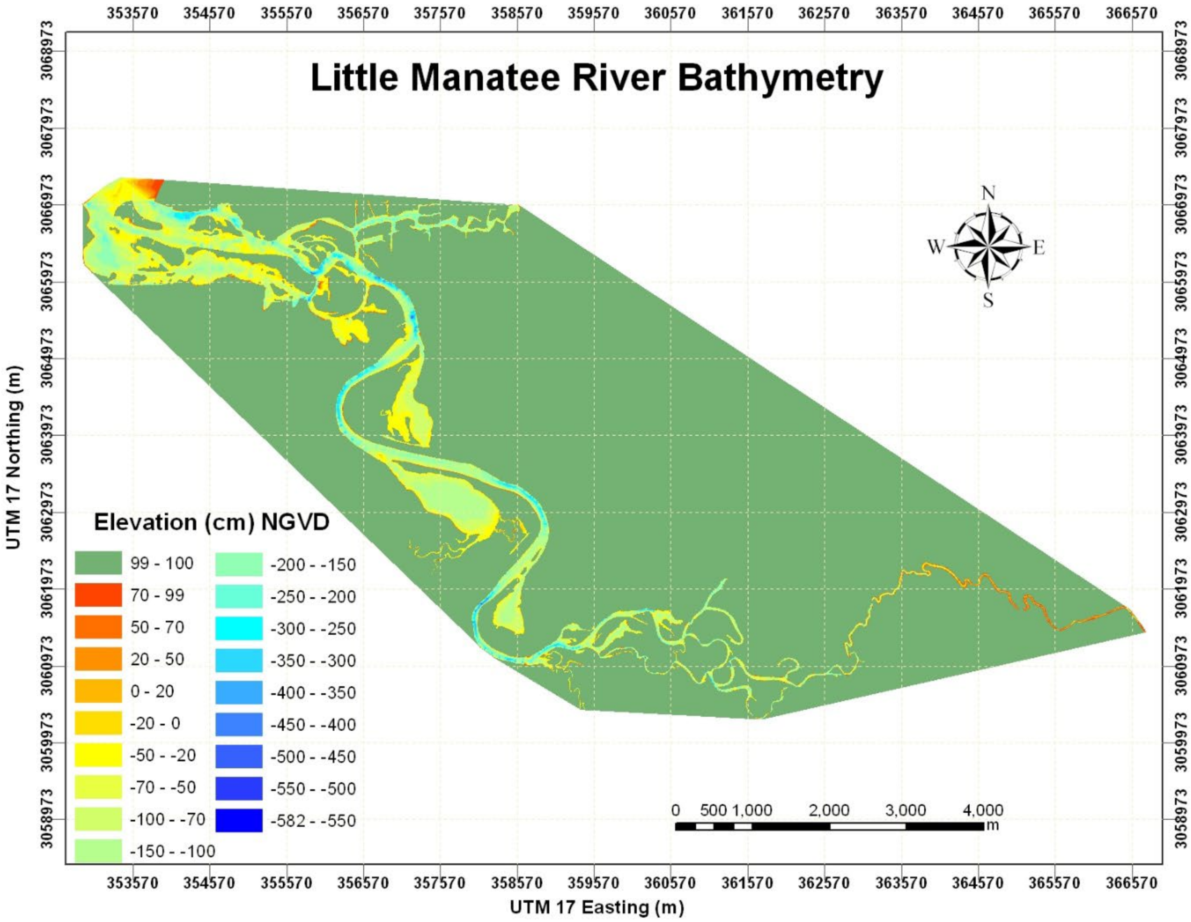
Deliverables

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) printed on large papers.

All the processed data are delivered on one CD with each set as one folder.


Little Manatee River Shoreline and Cross Sections
353570
354570
355570
356570
357570
358570
359570
360570
361570
362570
363570
364570
365570
366570
3068973
3067973
3066973
3065973
3064973
3063973
3062973
3061973
3060973
3059973
3058973
UTM 17 Northing (m)
UTM 17 Easting (m)
N
E
S
W
0
500
1,000
2,000
3,000
4,000
m


Little Manatee River Shoreline
UTM 17 Easting (m)
UTM 17 Northing (m)
353570
354570
355570
356570
357570
358570
359570
360570
361570
362570
363570
364570
365570
366570
3068973
3067973
3066973
3065973
3064973
3063973
3062973
3061973
3060973
3059973
3058973
N
W
E
S
0
500
1,000
2,000
3,000
4,000
m



Little Manatee River Bathymetry
Elevation (cm) NGVD
99 - 100
70 - 99
50 - 70
20 - 50
0 - 20
-20 - 0
-50 - -20
-70 - -50
-100 - -70
-150 - -100
-200 - -150
-250 - -200
-300 - -250
-350 - -300
-400 - -350
-450 - -400
-500 - -450
-550 - -500
-582 - -550
N
S
E
W
0 500 1,000 2,000 3,000 4,000 m
353570 354570 355570 356570 357570 358570 359570 360570 361570 362570 363570 364570 365570 366570
3068973 3067973 3066973 3065973 3064973 3063973 3062973 3061973 3060973 3059973 3058973
UTM 17 Easting (m)
UTM 17 Northing (m)

From:	Sid Flannery
To:	Doug Leeper; Kym Holzwart; Xinjian Chen; MIke Wessel (MWessel@janickienvironmental.com)
Subject:	Bathymetry and shoreline stuff
Date:	Thursday, November 18, 2021 3:01:47 PM
Attachments:	Little Manatee and Anclote final bathymetry report.doc LIttle Manatee morphology and vegetation plots.pdf

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Hello all,

I just talked with Doug about EFDC model output files and will reply about that tomorrow morning. In short, I can wait for the revised model runs.

In the meantime, Doug and I were talking about the bathymetry data for the Little Manatee and I brought up the bathymetry report and data sets that Ping Wang of USF did for the District. I am sure that you all, especially Xinjian, are aware of that. This is the bathymetry data from USF that were provided to FSU for construction of the EFDC model. Again, I expect you have those files, and if not, Xinjian can find them in the files I left behind.

I have attached three jpgs from the USF bathymetry work plus the WORD file of the final USF report. It looks like USF did go into the side channels quite a bit.

I have also attached a pdf of some combined graphs taken from the bathymetry data that Allan Willis generated for the District when he was Atkins. I think the area and volume plots could be helpful.

There are also shoreline plots, but I am thinking they must have come from the vegetation work that FWRI did for the District as the vegetation is classified into different groups. The vegetation plots are more than you need, but it was easier than sorting them out.

As I told Doug, I will submit to the District a document by the Monday after Thanksgiving that lists data and graphics I think would be useful, including some of these graphics.

Sid

From:	Sid Flannery
To:	Doug Leeper
Cc:	Kym Holzwart; Chris Zajac; Xinjian Chen; Gabe I. Herrick; Jordan D. Miller; Kristina Deak; MIke Wessel (MWessel@janickienvironmental.com)
Subject:	Re: Output files for Little Manatee EFDC model runs
Date:	Friday, November 19, 2021 11:08:12 AM

[EXTERNAL SENDER] Use caution before opening.

Hello Doug,

It was good talking with you yesterday. Regarding my request for EFDC model output files that is described in the email stream below, I would be happy to wait until the revised model runs are completed for the Little Manatee River. When convenient after that, I would like to receive the revised output files for the model runs described below. As I also mentioned below, I would like to get the gaged flow records that correspond with each model run.

On another note, if you have files handy for the Florida Power and Light daily withdrawals from the river from 2010 forward, could you please send them to me. If staff do not have these files readily available, there is no need to generate them, as I will not request such files if they are not already at hand.

Thanks again,
Sid

> On Tue, Nov 9, 2021 at 3:56 PM Doug Leeper <Doug.Leeper@swfwmd.state.fl.us> wrote:
>
> > Got it, Sid. I'll be in touch with you regarding this data request.
> >
> > Doug Leeper
> >
> > MFLs Program Lead
> >
> > Southwest Florida Water Management District
> >
> > 2379 Broad Street
> >
> > Brooksville, FL 34604
> >
> > 1-800-423-1476 or 352-796-7211, ext. 4272
> >
> > doug.leeper@watermatters.org or doug.leeper@swfwmd.state.fl.us
> >
> > ---
> >
> > **From:** Sid Flannery <sidflannery22@gmail.com>

Sent: Tuesday, November 9, 2021 5:53 AM
To: Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>
Cc: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>
Subject: Output files for Little Manatee EFDC model runs

Hello Doug and District staff,

If possible, I would like to receive selected output files from the EFDC model runs for the Little Manatee River minimum flows project. I expect these are for model runs that have already been conducted and no additional model runs will be needed.

The information I would like to receive is described below. It would be nice to get the different flow scenarios and salinity zone values as separate files, but I expect the original files may have values for salinity zones in addition to the ones I am asking for. Or, the output files may contain flow scenarios in addition to the ones I am asking for. Receiving such large files would be fine as long as I can identify and query out the values for the salinity zones and flow scenarios I am interested in.

I would like to receive daily values for bottom area and water volume from the EFDC model runs from January 2000 to June 2005. The salinity zones I am interested in are < 2psu, < 5 psu, <10 psu, and <15 psu. If the values are in increments smaller than daily, that is okay as I can calculate daily average values from those values.

The flow scenarios I would like to receive are basselline, and the 15 percent, 20 percent, 25 percent, 30 percent, and 35 percent flow reductions not including the 35 cfs low-flow cutoff.

I would also like to receive the output for any of these same percentage flow reductions that included the 35 cfs low-flow cutoff.

I will also need to flow values on which these values were based, at least for the baseline scenario, with the flows for the other scenarios being helpful as well. The ungaged flows should be the same for all the scenarios, so I believe the flows that I need for the baseline and the flow reduction scenarios will be the flows at the USGS gage at the US 301 bridge.

If possible, SAS files would be very helpful, but I can work with EXCEL files or tab or comma delimited text files. Please contact me if I can provide any clarification for this request.

Thanks very much for your time and whatever the District can provide.

Sid

813-245-0331

From: Sid Flannery
To: Doug Leeper
Cc: Kym Holzwart; Chris Zajac; Xinjian Chen; Gabe I. Herrick; Jordan D. Miller; Kristina Deak; MIke Wessel (MWessel@janickienvironmental.com); Amanda J. Siff; Valerie Jordan; Shellie Ferreira-Lee; Adrienne E. Vining
Subject: Re: Output files for Little Manatee EFDC model runs
Date: Friday, November 19, 2021 2:32:13 PM

[EXTERNAL SENDER] Use caution before opening.

Doug,
Yes, this file looks great.
Thanks very much and have a good weekend.
Sid

On Fri, Nov 19, 2021 at 2:15 PM Doug Leeper <Doug.Leeper@swfwmd.state.fl.us> wrote:

> Hey Sid: Hopefully, the attached file is what you are looking for.
>
> Doug Leeper
>
> MFLs Program Lead
>
> Southwest Florida Water Management District
>
> 2379 Broad Street
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> Brooksville, FL 34604
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> 1-800-423-1476 or 352-796-7211, ext. 4272
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>
> ---
>
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> **Sent:** Friday, November 19, 2021 11:08 AM
> **To:** Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>
> **Cc:** Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>; MIke Wessel (MWessel@janickienvironmental.com) <MWessel@janickienvironmental.com>
> **Subject:** Re: Output files for Little Manatee EFDC model runs

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Sent: Tuesday, November 9, 2021 5:53 AM
To: Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>
Cc: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Chris Zajac <Chris.Zajac@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; Gabe I. Herrick <Gabe.Herrick@swfwmd.state.fl.us>; Jordan D. Miller <Jordan.Miller@swfwmd.state.fl.us>; Kristina Deak <Kristina.Deak@swfwmd.state.fl.us>
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If possible, SAS files would be very helpful, but I can work with EXCEL files or tab or comma delimited text files. Please contact me if I can provide any clarification for this request.

Thanks very much for your time and whatever the District can provide.

Sid

813-245-0331

From:	Sid Flannery
To:	Kym Holzwart; Doug Leeper; Xinjian Chen; MIke Wessel (MWessel@janickienvironmental.com); Lei Yang
Cc:	Chris Zajac; Randy Smith; Gabe I. Herrick; Danielle Rogers; Kristina Deak; Jordan D. Miller
Subject:	EFDC model output and fish EFF modeling
Date:	Tuesday, November 23, 2021 1:29:21 PM

[EXTERNAL SENDER] Use caution before opening.

Hello Kym, Doug, Xinjian, Mike and Lei,

It is good to know that some revised EFDC model runs will be made for the Little Manatee River (LMR), I believe to include boundary conditions that are calculated separately for baseline flows and various flow reduction scenarios. In that regard, I have been thinking about the EFDC modeling output and the following points occurred to me. Topic #4 is not EFDC modeling per se, but is related.

1. It is not surprising that the low salinity zones (e.g., < 2 psu) are the most sensitive to flow reductions, as the newly-named Law of Proportionality is taking effect. For example, there will always be less volume upstream of the 2 psu zone than the 10 psu zone. Therefore, when a percent change in area or volume is calculated for a flow reduction scenario, the percent change will be typically greater for the 2 psu zone simply because the net change in area or volume is being divided by a smaller baseline value.

For example, the same 20 hectare change in area for both zones will result in a greater percent habitat reduction for the < 2 psu zone than for the <10 psu zone. In that regard, it could also be useful to consider the absolute changes in area or volume between flow scenarios. Possibly, this is somewhat indirectly alleviated by the EFF fish analyses described in topic 4, but absolute changes in salinity zone habitats should possibly be presented somewhere.

2. Also, on other rivers, I recall that the District evaluated changes in shoreline habitat for given salinity zones. It never seemed to be as limiting as area or volume, but it could be important for the Little Manatee. The LMR is unusual in that it has the braided zone that runs between I-75 and kilometer 17.3. This zone has abundant sensitive, oligohaline marshes dominated by freshwater plants such as sawgrass and cattail that have some salt tolerance, which upstream grade into freshwater marshes. These communities were identified by the FWRI vegetation mapping project (1997) and by the Clewell et al. (2002) field vegetation survey.

These truly are biological communities that would be related to the movement of the 2 psu isohaline. In a separate piece of correspondence I will submit before the next panel meeting, I will make the case that these oligohaline and tidal freshwater plant communities should be considered in the determination of flow blocks for the lower river and could be considered in the determination of allowable flow reductions.

I believe the District is going to be generating additional elevation data in shoreline areas. This could be a good time in the post-processing of model output to calculate the percent change in the length of total shorelines or wetland shorelines that are upstream of various isohalines. I don't know that it needs to be done for the entire river, and possibly could be done just upstream of I-75 to a determined location.

3. This involves what is considered the head of the estuary for change in habitat calculations. I believe the EFDC model goes up to the US 301 bridge, which I recall is located approximately 25 kilometers upstream of the mouth of the river. If there are truly tidal water level fluctuations that far upstream, they are very small and likely restricted to low flows. I am not asking the District to look at it, but I wonder what the model input files show for tidal water level fluctuations at that location, as I assume FSU used 15 minute values from the USGS recorder at US 301 for model calibration. I may look at the data myself.

As I will describe in a separate piece of correspondence, there is very extensive data for salinity gradients in the lower river measured by both the District and the EPC, that total 101 sampling trips in which salinity and other meter parameters were measured at numerous stations along the length of the brackish river.

These data show that salinity rarely goes upstream of kilometer 17, and with only one observation of 1.3 psu at kilometer 18.6. The channel upstream of kilometer 18 is narrow and has the morphology of a freshwater river, although it does have some tidal water level fluctuations that diminish upstream. The panel seems to have no understanding of this as the report says that "estuarine conditions" occur below US 301 and that should be clarified.

Including area and volume data for the river up to highway 301 increases the baseline values for the river, therefore making the percent changes in habitat due to flow reductions smaller than they would be if a more downstream location was used. In that regard, in terms of calculating percent changes in area and volume of what are truly estuarine waters, including at very low flows, it might be more meaningful in the model post-processing to calculate the head of the estuary at a different location, say kilometer 20.

I realize the area and volume of the river upstream between kilometer 20 and 25 is very small. However, if shoreline habitat is used, including the reach between kilometers 20 and 25, that would inflate the shoreline values of the river that are not really affected by the flow reductions.

Limiting the upstream extent of the length of the river that is used for changes in habitat should be considered, especially for shoreline habitat. which I recommend pursuing.

4. This last topic pertains to the fish habitat modeling simulations. I have not yet gone over that closely nor the related appendices, but it looks like a very useful technique and kudos to Mike for that work. However, since the <2 psu zone has been declared the most sensitive to change, it appears the review panel seems to think it is the most critical zone for fish habitat. No, I will work up the data and submit it with another piece of correspondence, but data from the ichthyoplankton, seine, and trawl collections show that many abundant and important species have mean salinity at capture values in mesohaline waters.

On page 130 the minimum flows report says that "Only those taxa with negative responses to salinity (i.e. a negative linear coefficient) were considered for the analysis. These species, which exhibit a higher probability of occurrence at lower or mid-range salinities than at higher salinities, were considered most useful ...." I would think that would include taxa that are centered in mesohaline waters (e.g. snook, sheepshead) - is that correct? Also, hopefully, the change in fish EFF values would not be affected by the proportionality issue as described for topic 1 above. Would that be correct? Do the EFF values look at total habitat less than a certain salinity value, or instead calculate changes in preferred habitat that have downstream and upstream limits or salinity values. Just thinking aloud, as I will look at the fish appendices over another day.

In a week or so I plan to submit a document that provides some clarification on a few topics and also shows some salinity data from the upstream part of the study area. Then a couple of weeks later I will submit a document related to the determination of appropriate flow blocks for the lower river, which will be related in part to the distribution of the oligohaline marshes and salinity/flow relationships upstream of I-75. The response of chlorophyll *a* to flow will also be evaluated in that regard.

In the meantime, I hope the District can consider the topics in this email related to analyses of the output files from the EFDC model and the EFF fish simulations. Please let me know if you have any questions or comments about the material presented above.

Thanks for your time and have a fine Thanksgiving!!

Sid

From:	Sid Flannery
To:	Kym Holzwart
Cc:	Chris Zajac; Randy Smith; Doug Leeper; Adrienne E. Vining; esherwood; Dave Tomasko; Jennifer Hecker
Subject:	Re: Extending Little Manatee River Proposed Minimum Flows Peer Review period and January EAC meeting change
Date:	Wednesday, December 1, 2021 10:16:57 AM

Hello Kym and District staff (cc's to three EAC members),

Thanks for filling me in on the delay in the Little Manatee River (LMR) minimum flows peer review panel meetings. It is good the District is revisiting the EFDC hydrodynamic salinity modeling given the comments of the panel. I expect the panel and the interested parties in the region (EPCHC, Tampa Bay Estuary Program) will appreciate that this work is being done and not mind the delay. Also, later this month I will be submitting some technical materials for the District and the panel to review and this gives me more time.

I can go with whatever the District decides on moving the Little Manatee minimum flows presentation to the EAC, but think it makes perfect sense to give the presentation at the January meeting and clearly prefer that. Last July, when I proposed the LMR minimum flows be presented at the October meeting, I suggested it could be valuable for the EAC to hear about the District's general approach without specific minimum flows recommendations, but that presentation did not occur. Since that time, the District has published a draft minimum flows report, has had four peer review panel meetings, and received comments about the minimum flows report from interested technical parties.

This seems like an opportune time to appraise the EAC of the progress on the LMR minimum flows. The District could summarize their technical approach, the proposed (but tentative) flow thresholds and minimum flows, and the status of the peer review panel process and an overview of the key panel comments. As a member of the EAC, I would quickly summarize my comments on the draft report and my technical concerns and recommendations (e.g., changing the high flow threshold for the lower river and assessing shoreline habitats in the lower river as part of the EFDC modeling).

I recall that at the last EAC meeting, a few members commented that they would like to hear about District projects while they are ongoing, rather than after the fact. This seems like the perfect opportunity to address that objective on a river in the District where there is great public interest and ongoing technical discussions and assessments.

Again, I am okay with whatever the District chooses on the date of the

LMR presentation to the EAC, but think that January is much better than April. Please let me know what you think of that suggestion.

Best wishes and Happy Holidays coming up.

Sid

On Tue, Nov 30, 2021 at 3:27 PM Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us> wrote:

> Good Afternoon Sid,
> Because the District needs more time to respond to the Little Manatee River Proposed Minimum Flows Peer Review Panel comments, which includes conducting additional modeling work, the length of the peer review period is being extended. This will result in the cancellation of the Dec. 15th and Jan. 5th public meetings of the Peer Review Panel, which will be rescheduled for some time early next year. In addition, the presentation planned for the Jan. 11, 2022 Environmental Advisory Committee meeting will be rescheduled for the next EAC meeting in April 2022. Are you OK with moving the Little Manatee presentation from the Jan. EAC meeting to the April EAC meeting?
> Best regards,
> Kym
>
> Kym Rouse Holzwart, M.S.
> Certified Senior Ecologist
> Senior Environmental Scientist
> Environmental Flows and Levels Section
> Natural Systems & Restoration Bureau
> Southwest Florida Water Management District
> 2379 Broad Street
> Brooksville, FL 34604
> 1-800-423-1476, ext. 4295
> 352-796-7211, ext. 4295
> kym.holzwart@swfwmd.state.fl.us

Bolster Bayou area & volume below certain elevation Z (in ft, NGVD29) for each segment

	Z (	0		-1.5		-3	
Segment No.	Se	Area (m^2)	Vol (m^3)	Area (m^2)	Vol (m^3)	Area (m^2)	Vol (m^3)
1	#	5376.31	6121.94	5376.31	3663.89	3971.61	1450.82
2	#	6715.85	7227.65	6699.58	4158.40	4518.50	1503.81
3	#	23483.18	23380.01	23455.55	12645.61	16185.13	2837.82
4	#	22970.80	22635.18	22970.80	12132.93	17085.55	2237.11
5	#	30429.91	29418.60	30162.07	15526.45	23830.42	2702.31
6	#	33641.90	30817.27	32666.19	15510.55	22691.76	2102.21
7	#	36962.02	30792.21	35761.36	13984.66	13780.03	1050.04
8	#	18260.00	13585.70	18023.00	5255.29	0.00	0.00
		177839.97	163978.55	175114.86	82877.77	102062.99	13884.11
		177840.0	163978.5	175114.9	82877.8	102063.0	13884.1

-4.5		-6	
Area (m^2)	Vol (m^3)	Area (m^2)	Vol (m^3)
1419.77	226.66	0.00	0.00
1368.65	210.75	0.00	0.00
889.71	79.49	0.00	0.00
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00
3678.13	516.91		

3678.1 516.9

Little Manatee River Area-Volume file

All values are total area and volume less than an elevation (not interval total)

Hayes, Mill, and Bolster Bayous in separate worksheet, cells where they join the rive

No data for kilometer < .6

Reference elevation is NGVD 1929

Connect to Bayous	cell	Long*	Lat*	Dx (m)	Centerline (Kilometer)
	2	-82.4817	27.7165	93.21	0.60
	3	-82.4808	27.71627	87.65	0.70
	4	-82.4799	27.71604	83.79	0.80
	5	-82.4791	27.71583	81.49	0.90
	6	-82.4783	27.71562	80.61	1.00
	7	-82.4776	27.71541	82.01	1.10
	8	-82.4767	27.71521	83.84	1.10
	9	-82.4759	27.71499	87.64	1.20
	10	-82.475	27.71477	90.45	1.30
	11	-82.4741	27.71455	92.66	1.40
	12	-82.4732	27.71431	94.21	1.50
	13	-82.4723	27.71409	94.44	1.60
	14	-82.4711	27.71464	94.53	1.70
	15	-82.47	27.71516	93.05	1.80
	16	-82.4691	27.71493	91.19	1.90
	17	-82.4682	27.71471	87.42	2.00
	18	-82.4674	27.71449	83.99	2.10
	19	-82.4666	27.71427	80.73	2.20
	20	-82.4658	27.71406	76.76	2.20
	21	-82.4651	27.71385	74.63	2.30
	22	-82.4644	27.71364	72.25	2.40
	23	-82.4637	27.71342	69.5	2.50
	24	-82.463	27.71321	68.74	2.50
	25	-82.4624	27.71299	66.58	2.60
	26	-82.4618	27.71278	63.62	2.70
	27	-82.4612	27.71255	63.23	2.80
	28	-82.4606	27.71232	66.4	2.90
	29	-82.4595	27.7129	72.04	3.00
	30	-82.4584	27.71332	78.83	3.20
	31	-82.4577	27.71297	87.06	3.30
	32	-82.4569	27.71257	91.22	3.40
connect to Ruskin Inlet Bayou	33	-82.4561	27.71215	84.24	3.50
	34	-82.4554	27.71176	74.69	3.60
	35	-82.4548	27.71138	73.84	3.63
	36	-82.4542	27.71097	75.87	3.70
	37	-82.4536	27.71054	80.32	3.80
	38	-82.4529	27.71005	88.82	3.90
	39	-82.4519	27.70986	86.64	4.00
	40	-82.451	27.70961	73.41	4.05
	41	-82.4506	27.70915	65.86	4.10

	42	-82.4501	27.70867	79.04	4.20
	43	-82.4495	27.70803	105.33	4.30
	44	-82.4485	27.70743	112.82	4.40
	45	-82.4482	27.70656	105.8	4.50
	46	-82.4481	27.70565	100.31	4.60
	47	-82.4481	27.70473	105.87	4.70
connect to Mills Bayou	**48**	-82.4484	27.70375	121.68	4.80
	49	-82.4489	27.70285	104.22	4.90
	50	-82.4496	27.7021	103.96	5.00
	51	-82.4503	27.70145	99.56	5.10
	52	-82.4511	27.70085	103.21	5.20
	53	-82.4519	27.70035	94.79	5.30
	54	-82.4527	27.69995	94.79	5.40
	55	-82.4536	27.6996	85.53	5.50
	56	-82.4544	27.69928	87.99	5.60
	57	-82.4551	27.6989	77.98	5.70
	58	-82.4557	27.6985	73.94	5.80
	59	-82.4563	27.69803	78.58	5.85
	60	-82.4567	27.69745	75.21	5.90
	61	-82.457	27.69683	74.92	6.00
	62	-82.4571	27.69615	78.45	6.10
	63	-82.4572	27.69545	77.83	6.20
	64	-82.4571	27.69478	72.63	6.30
	65	-82.457	27.69415	69.56	6.33
	66	-82.4568	27.69357	67.95	6.40
	67	-82.4564	27.69303	75.52	6.50
	68	-82.4559	27.69253	70.3	6.60
	69	-82.4553	27.69207	81.24	6.65
	70	-82.4547	27.69165	82.02	6.70
	71	-82.454	27.6913	76.56	6.80
	72	-82.4532	27.69095	90.45	6.90
	73	-82.4524	27.6906	81.05	7.00
	74	-82.4517	27.69033	79.2	7.10
	75	-82.4509	27.6901	77.13	7.14
connect to Hayes Bayou	**76**	-82.4501	27.68993	90.33	7.20
	77	-82.4493	27.68978	80.69	7.30
	78	-82.4484	27.68965	89.3	7.40
	79	-82.4475	27.68953	85.57	7.50
	80	-82.4467	27.6894	89.3	7.60
	81	-82.4458	27.6893	89.3	7.70
	82	-82.4449	27.68917	90.33	7.74
	83	-82.444	27.68903	85.57	7.80
	84	-82.4431	27.68885	91.36	7.90
	85	-82.4422	27.68865	91.36	8.00
	86	-82.4413	27.68845	91.36	8.10
	87	-82.4404	27.68825	91.36	8.20
	88	-82.4395	27.688	94.68	8.30
	89	-82.4386	27.68765	94.8	8.40
	90	-82.4378	27.6873	85.54	8.50
	91	-82.437	27.68698	88	8.65
	92	-82.4362	27.68662	92.34	8.60
	93	-82.4354	27.6863	85.54	8.70

	94	-82.4345	27.68595	94.8	8.80
	95	-82.4337	27.6855	96.41	8.90
	96	-82.4329	27.68498	99.82	9.00
	97	-82.4322	27.68437	99.94	9.10
	98	-82.4315	27.68368	102.25	9.30
	99	-82.431	27.68285	109.44	9.40
	100	-82.4307	27.6819	112.27	9.50
	101	-82.4307	27.68088	118.4	9.60
	102	-82.431	27.67992	104.4	9.70
	103	-82.4315	27.6791	104.23	9.80
	104	-82.4321	27.67837	96.54	9.90
	105	-82.4328	27.67772	93.41	10.00
	106	-82.4334	27.6771	95.92	10.10
	107	-82.4341	27.67653	85.12	10.20
	108	-82.4347	27.67598	92.24	10.30
	109	-82.4354	27.67543	88.53	10.40
	110	-82.436	27.67488	85.12	10.50
	111	-82.4367	27.67435	88.55	10.50
	112	-82.4373	27.6738	89.11	10.60
	113	-82.4379	27.67323	78.59	10.70
	114	-82.4384	27.67265	82.91	10.80
	115	-82.4388	27.67205	72.96	10.90
	116	-82.4391	27.6714	83.25	11.00
	117	-82.4393	27.67072	72.94	11.10
	118	-82.4393	27.67005	78.45	11.13
	119	-82.4391	27.66938	74.92	11.20
	120	-82.4388	27.66872	80.36	11.30
	121	-82.4384	27.66813	75.87	11.40
	122	-82.4379	27.66763	77.54	11.50
	123	-82.4373	27.66715	88.56	11.53
	124	-82.4364	27.6667	103.61	11.60
	125	-82.4354	27.66635	118.07	11.70
	126	-82.4342	27.66613	119.47	11.90
	127	-82.4331	27.6661	108.89	12.00
	128	-82.432	27.66625	110.58	12.10
	129	-82.4309	27.6665	113.38	12.20
	130	-82.4299	27.66688	101.89	12.30
	131	-82.429	27.66735	104.62	12.40
	132	-82.428	27.66778	101.38	12.50
	133	-82.4271	27.66797	84.09	12.60
	134	-82.4265	27.66793	40.55	12.70
	135	-82.4259	27.66788	84.4	12.72
	136	-82.4251	27.66815	85.24	12.80
	137	-82.4243	27.66842	69.81	12.90
	138	-82.4237	27.66893	72.29	12.95
	139	-82.4238	27.66935	77.55	13.00
	140	-82.4232	27.66996	63.09	13.10
	141	-82.4227	27.67042	78.41	13.15
	142	-82.4221	27.67095	69.13	13.20
	143	-82.4216	27.67154	75.77	13.30
	144	-82.4209	27.67171	85.74	13.40
	145	-82.4201	27.67187	83.57	13.45

	146	-82.4193	27.672	77.14	13.50
	147	-82.4177	27.67211	79.31	13.70
	148	-82.4169	27.67213	69.67	13.80
	149	-82.4162	27.67165	59.58	13.90
	150	-82.4156	27.6694	65.53	14.20
	151	-82.415	27.66904	59.4	14.22
	152	-82.4144	27.66901	54.31	14.30
	153	-82.4139	27.66899	39.27	14.35
	154	-82.4135	27.66898	39.96	14.40
	155	-82.4131	27.66895	50.62	14.45
	156	-82.4125	27.66893	60.77	14.50
	157	-82.4119	27.66925	55.07	14.60
	158	-82.4114	27.66923	41.29	14.64
	159	-82.411	27.66921	44.73	14.70
	160	-82.4105	27.66883	57.85	14.80
	161	-82.4099	27.66845	60.62	14.83
	162	-82.4093	27.66842	52.62	14.90
	163	-82.4088	27.66841	44.41	14.95
	164	-82.4084	27.66875	38.6	14.97
	165	-82.408	27.66873	34.99	15.00
	166	-82.4077	27.66872	32.44	15.10
	167	-82.4074	27.66872	30.3	15.13
	168	-82.4071	27.66871	28.84	15.16
	169	-82.4068	27.66835	28.35	15.20
	170	-82.4065	27.66799	28.76	15.30
	171	-82.4061	27.6643	34.01	16.10
	172	-82.4058	27.66465	32.35	16.20
	173	-82.4056	27.66547	27.53	16.30
	174	-82.4053	27.66629	27.11	16.40
	175	-82.405	27.6663	38.98	16.50
	176	-82.4045	27.66592	52.41	16.58
	177	-82.4039	27.66554	62.45	16.60
	178	-82.4032	27.66484	66.02	16.70
	179	-82.4025	27.66466	67.22	16.80
	180	-82.4019	27.6645	61.48	16.90
	181	-82.4013	27.66444	65.64	16.95
	182	-82.4006	27.6644	68.03	17.00
	183	-82.3999	27.66436	70.64	17.10
	184	-82.3992	27.66428	72.05	17.20
	185	-82.3985	27.66414	70.06	17.23
	186	-82.3978	27.66398	63.92	17.30
	187	-82.3972	27.66387	59.35	17.40
	188	-82.3966	27.6639	57.25	17.43
	189	-82.396	27.66406	61.74	17.50
	190	-82.3955	27.66433	68.62	17.60
	191	-82.3948	27.66461	71.62	17.70
	192	-82.3941	27.66483	71.36	17.73
	193	-82.3935	27.665	68.48	17.80
	194	-82.3928	27.66516	66.66	17.90
	195	-82.3922	27.66532	63.65	17.93
	196	-82.3916	27.66551	59.21	18.00
	197	-82.3891	27.66576	55.15	18.30

	198	-82.3891	27.6661	55.72	18.40
	199	-82.3891	27.66652	56.15	18.42
	200	-82.3891	27.66702	58.03	18.50
	201	-82.3902	27.66757	65.6	18.70
	202	-82.3901	27.66818	71.34	18.90
	203	-82.3901	27.66882	71.68	19.00
	204	-82.3899	27.66945	73.84	19.02
	205	-82.3896	27.67009	81.38	19.10
	206	-82.389	27.67057	73.65	19.20
	207	-82.3885	27.67086	58.58	19.30
	208	-82.388	27.67116	51.33	19.37
	209	-82.3878	27.67159	56.32	19.40
	210	-82.3877	27.67214	68.54	19.50
	211	-82.3875	27.67267	54.72	19.55
	212	-82.3873	27.67311	52.84	19.60
	213	-82.3869	27.67348	58.68	19.70
	214	-82.3865	27.67372	48.36	19.80
	215	-82.3861	27.67386	41.77	19.90
	216	-82.3857	27.67398	40.38	19.95
	217	-82.3853	27.67411	38.95	19.97
	218	-82.3849	27.67425	37.41	20.00
	219	-82.3846	27.67441	36.32	20.05
	220	-82.3843	27.6746	35.78	20.10
	221	-82.384	27.67483	35.33	20.13
	222	-82.3838	27.67508	36.18	20.17
	223	-82.3836	27.67536	37.34	20.20
	224	-82.3835	27.67569	40.78	20.23
	225	-82.3833	27.67605	45.9	20.30
	226	-82.383	27.67641	51.99	20.33
	227	-82.3826	27.67668	48.56	20.50
	228	-82.3822	27.67681	44.99	20.52
	229	-82.3817	27.67687	43.12	20.57
	230	-82.3813	27.6769	40.51	20.60
	231	-82.3809	27.67694	41.17	20.65
	232	-82.3805	27.67698	41.59	20.70
	233	-82.3802	27.67699	25.33	20.78
	234	-82.3799	27.67718	27.58	20.90
	235	-82.3796	27.67738	27.09	20.92
	236	-82.3793	27.67769	27.58	20.95
	237	-82.3791	27.67772	27.59	20.98
	238	-82.3788	27.6778	27.58	21.01
	239	-82.3785	27.6778	27.57	21.03
	240	-82.3782	27.67782	28.55	21.06
	241	-82.3779	27.67761	28.07	21.09
	242	-82.3776	27.67739	28.64	21.12
	243	-82.3773	27.67716	29.72	21.15
	244	-82.377	27.67691	31.35	21.18
	245	-82.3767	27.67681	32.09	21.21
	246	-82.3765	27.67665	31.82	21.24
	247	-82.3762	27.67647	30.7	21.27
	248	-82.376	27.67628	28.96	21.30
	249	-82.3758	27.67609	26.1	21.33

	250	-82.3757	27.67591	25.21	21.35
	251	-82.3755	27.67576	24.49	21.38
	252	-82.3753	27.67562	23.86	21.40
	253	-82.3751	27.67552	23.21	21.43
	254	-82.3749	27.67544	24.72	21.45
	255	-82.3746	27.6754	26.19	21.48
	256	-82.3743	27.67538	27.22	21.50
	257	-82.3737	27.67541	99.92	21.60
	258	-82.373	27.67557	49.01	21.65
	259	-82.3725	27.67575	57	21.71
	260	-82.372	27.67572	53.01	21.76
	261	-82.3715	27.67553	46.97	21.81
	262	-82.3711	27.67529	45.18	21.86
	263	-82.3708	27.67505	42.84	21.90
	264	-82.3704	27.67482	41.07	21.94
	265	-82.3701	27.67462	42.64	21.98
	266	-82.3697	27.67442	49.18	22.03
	267	-82.3693	27.67414	52.76	22.08
	268	-82.3689	27.67381	45.94	22.13
	269	-82.3687	27.67348	43.68	22.17
	270	-82.3684	27.67318	41.49	22.21
	271	-82.3681	27.67292	37.67	22.25
	272	-82.3679	27.67271	35.1	22.29
	273	-82.3675	27.67262	34.04	22.32
	274	-82.3672	27.67265	37.31	22.36
	275	-82.3668	27.67278	43.24	22.40
	276	-82.3663	27.6739	53.46	22.46
	277	-82.3658	27.67388	54.96	22.51
	278	-82.3653	27.6732	49.34	22.56
	279	-82.3649	27.67246	46.56	22.61
	280	-82.3646	27.67219	45.34	22.65
	281	-82.3642	27.67192	44.24	22.70
	282	-82.3639	27.67165	44.65	22.74
	283	-82.3636	27.67137	42.82	22.78
	284	-82.3633	27.67112	40.55	22.82
	285	-82.3629	27.6709	37.63	22.86
	286	-82.3626	27.67076	35.18	22.90
	287	-82.3623	27.6707	34.46	22.93
	288	-82.3619	27.67074	37.31	22.97
	289	-82.3616	27.67086	40.52	23.01
	290	-82.3612	27.67102	44.12	23.05
	291	-82.3607	27.67118	45.72	23.10
	292	-82.3603	27.67132	45.81	23.14
	293	-82.3599	27.67142	45.43	23.19
	294	-82.3594	27.67151	44.24	23.23
	295	-82.359	27.67159	42.91	23.28
	296	-82.3586	27.67168	42.69	23.32
	297	-82.3581	27.67178	43.6	23.36
	298	-82.3577	27.67189	43.29	23.41
	299	-82.3573	27.67201	42.52	23.45
	300	-82.3569	27.67213	43.34	23.49
	301	-82.3565	27.67227	43.27	23.54

	302	-82.3561	27.67241	42.56	23.58
	303	-82.3557	27.67257	42.12	23.62
	304	-82.3553	27.67275	45.83	23.67
	305	-82.3548	27.67291	50.54	23.72
	306	-82.3543	27.67298	54.68	23.77
	307	-82.3538	27.67289	53.2	23.83
	308	-82.3533	27.6727	44.27	23.87
	309	-82.3529	27.67242	55.62	23.93
	310	-82.3526	27.67207	47.73	23.97
	311	-82.3523	27.67173	48.28	24.02

note: 1 * Lon and Lat are the longitude and latitude of the g
Elevations are NGVD 1929
2 I is the segment numbering along the river central
3 I numbers connected to bayous are marked

er listed below

A=Area	V=Volume

Z<-0.0 feet		Z<-1.5 feet		Z<- 3 feet		Z<- 4.5 feet		Z<- 6 fee
A (m^2)*	V(m^3)*	A(m^2)*	V(m^3)*	A(m^2)	V(m^3)	A(m^2)	V(m^3)	A(m^2)
46471.2	70658.53	46386.27	49512.04	46301.35	28365.54	26654.56	11380.17	16711.48
43527.74	61061.72	43447.89	41266.73	34614.44	21953.2	17584.19	12048.26	17544.63
41445.56	62309.75	41369.23	43464.12	32959.99	25993.42	16738.75	15144.89	16700.93
40192.42	63121.16	40118.19	44862.25	31971.57	26724.41	23107.36	14559.96	16222.26
39613.17	53004.92	39539.75	35004.37	30794.8	17741.48	8554.65	9711.67	8518.24
50361.76	43584.99	50286.41	20614.25	16925	2912.38	0	0	0
51265.94	50797.46	51188.97	27428.02	42890.65	5826.16	0	0	0
52153.75	52737.65	52073.33	28957.6	35280.61	7913.95	0	0	0
53480.41	53637.28	53397.51	29231.29	37482.17	7726.94	9741.52	267.89	0
64307.19	65191.71	64222.58	35831.32	27822.01	15682.37	18925.56	6801.57	0
46347.9	48452.39	46261.79	27324.87	37457.74	8076.05	9151.56	1624.4	0
46353.5	52062.38	46267.21	30937.19	46180.93	9812	7848.34	58.86	0
46280.87	52364.46	46194.68	31303.12	46108.5	10241.78	8837.23	1829.65	0
45294.72	52005.31	45210.26	31398.94	45125.8	10792.56	8725.07	3193.89	0
35442.72	43774.51	35360.23	27682.77	35277.74	11591.03	8590.78	4591.2	8549.06
33792.31	41199.41	33713.52	25858.21	33634.73	10517.01	8269.71	5154.82	8229.72
32228.12	31345.57	32152.71	16690.44	16284.68	4235.16	0	0	0
39728.02	38385.09	39655.4	20297.17	24502.32	6358.4	0	0	0
54010.68	52995.45	53941.93	28373.14	38970.48	5451.72	6262.27	234.73	0
52153.02	48066.29	52086.33	24264.44	19218.09	7667.56	7092.84	2393.83	0
39386.46	46033.85	39322.44	28067.65	18398.77	13414.06	12825.88	7406.94	12825.88
32369.03	37745.74	32307.41	22988.37	24349.72	9535.78	12327.68	2434.72	0
31850.79	32547.36	31790.01	18030.4	23878.52	4731.98	6235.94	296.21	0
30676.68	37904.3	30617.97	23931.56	24218.19	10244.16	5424.23	4868.25	5424.23
29152.47	39007.59	29096.52	25744.66	29040.57	12481.73	18539.06	2754.26	0
28749.39	35057.99	28693.93	21973.95	28638.46	8889.91	0	0	0
30031.04	64159.65	29972.96	50538.99	29914.88	36918.34	19339.44	25959.33	19308.13
50249.07	82685.17	50186.75	59823.84	43960.79	37178.23	25414.48	24335.17	25380.54
56158.32	66142.35	56091.64	40550.51	30215.64	17505.09	9038.06	7786.92	5469.23
19465.09	35991.26	19385.83	27226.82	19306.57	18462.38	19227.31	9697.94	9898.91
20195.3	39118.11	20116.68	30027.02	20038.06	20935.93	19959.44	11844.83	15880.42
18382.46	31132.06	18306.86	22835.57	18231.26	14539.09	14493.58	6325.33	0
16069.41	23180.73	16001.44	15913.65	15933.48	8646.57	4980.33	2925.94	4980.33
15691.76	19172.75	15624.58	12077.07	8061.32	5468.94	8026.85	1804.85	0
15975.94	23672.52	15906.93	16478.57	15837.91	9284.62	15768.89	2090.67	3195.9
16723.34	24885.75	16650.29	17380.42	8648.63	9914.73	8611.13	6036.91	3425.93
18098.08	19553.54	18017.3	11389.44	9331.19	4733.91	3688.73	2599.99	3647.25
15432.77	25030.78	15353.07	18107.11	10018.03	11578.07	6572.22	7614.94	6531.35
12696.01	18305.38	12629.57	12621.65	5458.7	7684.66	5424.63	5254.6	5390.55
7384.92	11256.66	7324.7	7974.38	7264.49	4692.11	4757.32	2405.22	2085.1

11287.61	18555.53	11214.88	13529.35	11142.15	8503.18	5022.21	3492.12	2550.49
14721.38	23085.63	14624.49	16529.72	14527.59	9973.81	6555.5	4937.72	3332.72
18609.85	38956.41	18506.88	30634.07	18403.91	22311.74	18300.94	13989.41	14764.63
17542.92	46274.67	17443.63	38519.85	17344.34	30765.03	17245.05	23010.21	17145.76
18788.47	50695.38	18697.51	42352.53	18606.55	34009.67	18515.59	25666.82	18424.63
25932.28	61960.26	25831.27	50342.71	25730.25	38725.16	25629.24	27107.61	25528.23
38810.1	58842.73	38705.21	41247.6	38600.31	23652.47	38495.42	6057.34	0
28740.14	41764.3	28637.73	28766.22	28535.32	15768.15	28432.91	2770.08	0
25210.75	31204.56	25120.31	19783.69	25029.87	8362.82	0	0	0
24418.64	20606.4	24324.01	9515.31	0	0	0	0	0
22056.53	15558.64	21964.41	5533.18	0	0	0	0	0
18428.27	12621.71	18338.14	4252.97	0	0	0	0	0
16086.46	14331.28	16003.7	7046.21	0	0	0	0	0
14151.47	17133.15	14068.87	10760.45	13986.26	4387.76	0	0	0
12142.31	14332.55	12066.63	8868.27	11990.94	3403.98	0	0	0
11208.4	15477.38	11133.27	10455.46	11058.15	5433.55	10983.02	411.63	0
10560.87	12455.36	10491.71	7706.75	10422.55	2958.15	0	0	0
10915.51	10978.93	10847.4	6054.56	10779.29	1130.18	0	0	0
10853.64	9967.44	10786.75	5064.1	10719.87	160.77	0	0	0
11595.96	5759.78	11526.05	489.58	0	0	0	0	0
12376.61	8345.7	12306.96	2730.76	0	0	0	0	0
12872.67	6397.25	12801.15	543.77	0	0	0	0	0
12707.24	7320.89	12640.18	1546.22	0	0	0	0	0
14425.41	9313.39	14357.06	2758.2	0	0	0	0	0
13721.04	11163.1	13661.06	4934.91	0	0	0	0	0
16213.34	15952.07	16093.8	8654	15974.27	1355.93	0	0	0
16068	19058.56	15997.14	11792.49	15926.28	4526.41	0	0	0
16064.24	21096.28	15994.62	13839.48	15925.01	6582.67	0	0	0
15767.46	22672.1	15692.68	15567.66	15617.91	8463.21	15543.14	1358.77	0
15362.65	22974.52	15288.06	16059.49	15213.46	9144.46	15138.87	2229.44	0
18125.17	25223.9	18048.63	17039.55	17972.1	8855.2	17895.56	670.85	0
17897.16	21585.69	17820.67	13491.06	17744.18	5396.42	0	0	0
18027.98	19634.18	17953.65	11468.15	17879.31	3302.11	0	0	0
17948.15	21129.75	17874.31	13006.34	17800.48	4882.93	0	0	0
22802.59	27989.34	22728.13	17651.72	22653.67	7314.1	0	0	0
17695.24	22189.79	17614.92	14196.22	17534.6	6202.66	0	0	0
16296.97	20581.79	16219.25	13225.41	16141.53	5869.02	0	0	0
15593.23	20427.83	15512.75	13400.96	15432.27	6374.1	0	0	0
14875.58	18893.44	14794.19	12192.86	14712.79	5492.28	0	0	0
14006.82	20067.03	13924.63	13778.91	13842.45	7490.78	13760.26	1202.65	0
14094.67	21692.52	14013.72	15371.29	13932.78	9050.06	13851.83	2728.84	0
13947.37	20648.61	13864.72	14392.49	13782.07	8136.37	13699.41	1880.25	0
14618.33	21507.68	14532.96	14947.84	14447.6	8388	14362.24	1828.15	0
15574.1	21313.76	15494.96	14298.62	15415.81	7283.48	15336.67	268.34	0
17132.74	24126.18	17049.15	16407.49	16965.55	8688.8	16881.96	970.11	0
18032.84	23818.53	17944.82	15686.46	17856.79	7554.39	0	0	0
17510.07	24155.16	17426.29	16261.6	17342.51	8368.04	17258.73	474.48	0
16613.84	24514.5	16531.23	17037.58	16448.63	9560.65	16366.02	2083.73	0
14895.88	25364.71	14812.14	18695.54	14728.41	12026.37	14644.68	5357.2	0
13574.74	23483.61	13495.35	17413.69	13415.95	11343.78	13336.56	5273.86	0
14314.31	27507.97	14232.83	21119.7	14151.34	14731.42	14069.86	8343.15	13988.37
14809.63	21665.98	14727.13	15013.5	14644.62	8361.03	14562.11	1708.56	0

16170.01	18967.52	16081.23	11675.38	15992.45	4383.25	0	0	0
17021.2	19488.91	16934.27	11802.55	16847.34	4116.19	0	0	0
17298.15	18790.57	17208.39	10975.4	17118.63	3160.23	0	0	0
48459.6	57863.71	48368.16	35803.17	48276.72	13742.63	0	0	0
16264.64	25031.51	16171.1	17737.3	16077.56	10443.08	15984.02	3148.87	0
17807.62	37965.94	17709.1	30034.7	17610.59	22103.46	17512.08	14172.22	17413.56
20903.59	43294.4	20799.64	33951.38	20695.69	24608.37	20591.73	15265.36	20487.78
24141	39669.79	24035.08	28802.17	23929.16	17934.55	23823.24	7066.92	0
22773.29	28791.03	22673.1	18500.49	22572.92	8209.94	0	0	0
22659.06	24902.91	22566.74	14638.87	22474.41	4374.84	0	0	0
21562.52	23487.13	21474.94	13718.62	21387.36	3950.11	0	0	0
21378.17	21814.67	21289.83	12125.15	21201.5	2435.62	0	0	0
20469.28	18474.04	20384.75	9186.27	0	0	0	0	0
18137.26	16888.79	18054.29	8668.98	17971.33	449.17	0	0	0
17351.88	17347.95	17272.3	9489.85	17192.72	1631.74	0	0	0
16378.77	18117.09	16295.93	10716.58	16213.09	3316.07	0	0	0
14806.02	19097.85	14726.56	12428.18	14647.11	5758.51	0	0	0
13888.73	22863.85	13812.67	16637.53	13736.61	10411.22	13660.56	4184.9	0
13468.11	32532.95	13384.86	26579.42	13301.6	20625.89	13218.35	14672.36	13135.1
10792.99	33710.12	10721.09	29008.18	10649.18	24306.23	10577.28	19604.29	10505.37
10432.78	15265.12	10354.69	10609.26	10276.6	5953.4	10198.51	1297.54	0
9264.86	14326.15	9191.57	10204	9118.28	6081.85	9045	1959.71	0
9230.35	12886.04	9160.24	8763.41	9090.13	4640.78	9020.02	518.14	0
8171.13	12698.18	8104	9067.29	8036.87	5436.41	7969.74	1805.52	0
9692.81	20892.87	9618.13	16625.68	9543.45	12358.5	9468.77	8091.32	9394.1
9928.81	19229.78	9857	14830.97	9785.19	10432.16	9713.38	6033.34	9641.57
10174.52	16185.45	10105.81	11642.6	10037.1	7099.75	9968.39	2556.9	0
10397.25	20095.88	10328.55	15475.84	10259.85	10855.81	10191.15	6235.78	10122.46
8732.14	14322.7	8662.52	10445.4	8592.9	6568.1	8523.28	2690.8	0
9869.85	18778.64	9791.46	14417.61	9713.07	10056.58	9634.68	5695.55	9556.29
12447.33	28231.82	12353.37	22758.92	12259.41	17286.01	12165.45	11813.1	12071.49
14598.7	40679.42	14494.14	34305.85	14389.57	27932.27	14285	21558.7	14180.44
15018.28	39673.49	14911.56	33097.18	14804.84	26520.86	14698.11	19944.55	14591.39
13539.87	37521.38	13444.98	31602.06	13350.1	25682.74	13255.21	19763.42	13160.33
12904.27	33352.37	12803.46	27721.85	12702.66	22091.33	12601.85	16460.81	12501.05
19555.21	48014.37	19450.83	39331.93	19346.46	30649.49	19242.08	21967.05	19137.71
17466.12	37408.98	17370.04	29629.61	17273.96	21850.24	17177.87	14070.88	17081.79
17613.42	33564.5	17519.38	25689.75	17425.33	17815	17331.28	9940.26	17237.23
17763.98	35979.49	17643.82	28103.59	17523.67	20227.7	17403.51	12351.81	17283.35
14002.97	31231.42	13918.62	25019.08	13834.26	18806.75	13749.9	12594.41	13665.54
4986.6	10434.09	4949.02	8234.28	4911.44	6034.46	4873.85	3834.65	4836.27
8608.83	17491.26	8531.97	13709.19	8455.11	9927.12	6681.29	6217.32	4907.51
10879.78	14505.42	10802.4	9645.68	10725.03	4785.94	5146.76	1764.52	1424.99
12261.63	14753.09	12198.59	9234.68	10636.52	3738.76	1281.61	325.49	0
21916.66	29680.81	21852.32	19759.53	21787.99	9838.25	8565.89	1253.05	0
17060.97	27348.33	16992.51	19672.89	16924.05	11997.44	14809.61	4593.09	2782.74
22802.9	34727.89	22747.78	24407.13	22692.66	14086.38	17162.03	4853	2697.01
24739	39564.8	24671.22	28390.06	24603.43	17215.33	16030.37	7207.81	3768.13
19226.1	31078.26	19167.05	22397.55	19108	13716.83	11500.06	5455.78	7306.24
22209.23	29976.33	22144.86	19906.72	22080.5	9837.1	8559.1	958.86	0
22761.79	29508.04	22689.13	19186.3	22616.46	8864.56	7638.84	2587.07	0
30649.3	45099.87	30579.03	31185.68	30508.76	17271.49	15818.42	3937.71	1642.61

16364.11	29786.65	16300.56	22423	16237.01	15059.35	16173.46	7695.71	8451.79
17773.86	41165.34	17708.01	33169.22	17642.16	25173.11	17576.3	17176.99	11246.38
28883.33	77213.44	28824.6	64103	28765.86	50992.56	21939.89	38817.8	19894.28
19009.64	31032.54	18957.3	22411.96	18904.96	13791.39	8903.66	6142.68	3967.57
41125.8	84368.13	41066.55	65637.4	41007.29	46906.67	18423.57	31034.03	14493.95
31401.69	50426.35	31345.05	36160.48	31288.42	21894.6	9963.41	13410.46	7661.9
31956.22	54875.31	31904.11	40386.18	31852.01	25897.05	18108.32	15095.04	13194.52
15841.39	25313.24	15804.13	18129.8	15766.86	10946.35	9878.26	5213.72	5344.59
15344.38	24012.59	15306.6	17053.78	15268.83	10094.98	9884.74	4329.48	4291.15
19956.44	24592.23	19909.12	15527.11	19861.8	6462	4050.63	790.91	0
28879.07	36227.46	28822.37	23091.49	24231.54	10235.12	12193.28	1638.51	0
97647.73	147601.88	97572.27	103040.4	97496.82	58478.99	85589.56	15461.29	8635.9
13042.5	23880.68	12991.67	18006.77	12940.85	12132.86	12890.02	6258.95	9365.07
12032.94	19671.25	11978.85	14260.02	11924.76	8848.79	11870.68	3437.56	0
16554.27	24422.08	16494.12	16948.49	16433.96	9474.9	11680.28	3216.1	2324.41
21635.38	32808.16	21573.21	23024.58	19079.34	13447.69	14857.1	5347.15	3518.25
20285.48	33009.06	20219.65	23844.82	20153.82	14680.58	18033.71	5891.25	5618.49
20568.08	35648.15	20499.48	26344.73	20430.88	17041.32	20362.29	7737.9	2219.9
18755.05	32619.63	18697.72	24130.92	18640.38	15642.22	16766.79	7357.85	5046.16
12264.65	21453.19	12228.86	15922	12193.07	10390.82	9138.66	5319.61	5834.01
9922.07	15943.52	9888.63	11471.76	8589.75	7272.06	6864.76	3772.52	5447.08
12634.08	20771.82	12601.13	15056.36	10068.89	9758.17	10035.93	5186.14	5043.41
9877.32	13670.46	9845.73	9210.16	7427.34	5336.92	4585.47	2361.72	3395.37
11277.83	12584.09	11246.88	7476.81	5627.31	3523.84	4490.71	1473.66	0
12311.25	11476.99	12280.15	5883.98	3325.89	2063.3	3307.87	552.96	0
11684.22	11568.76	11652.41	6262.14	6922.54	1803.81	3272.71	57.26	0
11138.64	10490.05	11107.35	5422.42	5941.84	1102.35	0	0	0
9637.34	8559.18	9610.01	4179.29	6007.27	372.33	0	0	0
7096.25	6169.11	7069.07	2954.25	936.98	647.21	924.68	227.21	0
9787.45	10372.87	9749.57	5950.23	6251.71	2428.87	4409.34	243.29	0
10305.22	8624.63	10257.5	3938.87	4732.57	966.78	0	0	0
16529.23	15137.62	16475.53	7614.26	9358.81	1685.93	0	0	0
13722.33	8668.27	13659.48	2430.43	0	0	0	0	0
17135.3	12399.09	17063.24	4612.9	0	0	0	0	0
13712.25	10849.61	13655.09	4624.14	4733.65	307.43	0	0	0
17609.08	13855.18	17536.21	5859.64	5074.3	532.08	0	0	0
19248.61	15923.24	19167.49	7189.04	5242.05	1436.42	0	0	0
18433.76	15978.22	18357.04	7616.58	5710.89	1961.85	0	0	0
19433.3	14646.73	19354.19	5817.64	0	0	0	0	0
18710.73	15983.63	18635.38	7493.52	5565.92	1801.52	0	0	0
18003.88	16346.17	17929.51	8185.43	4745.74	2847.78	4716.5	694.29	0
4504.07	4171.74	4449.77	2162.72	4395.46	153.7	0	0	0
4887.43	6297.75	4835.05	4131.42	4782.67	1965.09	0	0	0
6045.58	10201.61	5989.09	7534.62	5932.6	4867.62	5876.1	2200.63	0
7365.67	11848.83	7302.88	8583.27	7240.1	5317.7	7177.31	2052.13	0
7515.09	9884.31	7449.55	6534.63	7384.02	3184.94	0	0	0
6709.98	12541.77	6644.69	9599.28	6579.39	6656.79	6514.1	3714.29	6448.8
5851.62	10035.56	5788.96	7470.6	5726.3	4905.65	5663.64	2340.7	0
6024.06	9520.89	5963.07	6864.91	5902.08	4208.93	5841.08	1552.95	0
6758.99	13258.58	6700.75	10285.14	6642.51	7311.71	6584.27	4338.28	6526.03
6889.68	12791.63	6835.5	9743.63	6781.32	6695.62	6727.14	3647.61	6672.97
6311.37	11652.32	6260.9	8861.26	6210.44	6070.19	6159.98	3279.12	6109.52

5870.66	10697.47	5819.68	8108	5768.69	5518.54	5717.71	2929.07	5666.72
5426.34	10154.33	5374.96	7771.97	5323.58	5389.61	5272.2	3007.25	5220.83
5484.83	9669.34	5366.77	7389.07	5248.71	5108.8	5130.65	2828.53	5012.58
5596.99	10516.9	5536.97	8074.52	5476.94	5632.15	5416.92	3189.77	5356.9
5801.37	11968.91	5736.09	9457.09	5670.82	6945.26	5605.54	4433.44	5540.26
5292.13	8100.41	5226.55	5784.2	5160.96	3467.99	5095.37	1151.78	0
5033.67	6896.16	4966.11	4689.87	4898.55	2483.58	4830.98	277.29	0
5467.92	5817.77	5393.46	3398.11	5319	978.44	0	0	0
5365.4	6676.25	5298.01	4308.51	5230.62	1940.77	0	0	0
4985.16	6048.39	4931.56	3834.68	4877.96	1620.97	0	0	0
4921.01	7242.75	4874.04	5062.77	4827.07	2882.8	4780.11	702.83	0
5110.48	6741.91	5058.94	4473.95	5007.41	2205.99	0	0	0
5770.38	7540.19	5707.67	4984.9	5644.95	2429.62	0	0	0
4565.84	9105.63	4515.77	7121.9	4465.7	5138.18	4415.63	3154.45	4365.56
4407.91	6128.26	4359.56	4181.26	4311.22	2234.26	4262.87	287.26	0
5425.55	6547.23	5371.86	4131.62	5318.17	1716.01	0	0	0
4777.97	6949.33	4733.72	4829.79	4689.47	2710.24	4645.22	590.69	0
4166.14	4918.72	4127.92	3058.95	4089.7	1199.19	0	0	0
4059	5294.04	4022.05	3486.56	3985.1	1679.08	0	0	0
3860.72	6158.11	3825.08	4450.64	3789.45	2743.16	3753.81	1035.68	0
3622.78	6379.13	3588.55	4784.35	3554.32	3189.57	3520.09	1594.78	3485.86
3436.6	5886.99	3403.37	4373.9	3370.13	2860.81	3336.9	1347.72	0
3295.7	5517.86	3262.96	4067.04	3230.22	2616.22	3197.48	1165.41	0
3057.1	4936.51	3024.78	3592.19	2992.45	2247.87	2960.12	903.56	0
2900.91	4215.39	2867.81	2938.21	2834.7	1661.03	2801.6	383.85	0
2737.4	3761.76	2703.23	2558.26	2669.06	1354.76	2634.9	151.26	0
2694.33	3290.26	2657.02	2104.99	2619.71	919.72	0	0	0
3129.39	3374.49	3016.48	2077.15	2903.57	779.82	0	0	0
3272.25	3534.49	3224.68	2090.71	3177.11	646.94	0	0	0
2479.96	2925.82	2435.53	1846.33	2391.09	766.85	0	0	0
1806.35	1958.3	1765.18	1179.24	1724.02	400.17	0	0	0
1751.97	1649.92	1712.51	887.46	1673.06	124.99	0	0	0
1709.93	1690.69	1672.86	946.95	1635.79	203.21	0	0	0
1818.48	1917.06	1780.81	1126.92	1743.14	336.78	0	0	0
1905.65	1874.58	1867.6	1041.94	1829.54	209.3	0	0	0
1156.31	1126.73	1133.14	621.36	1109.96	115.99	0	0	0
1210.21	1198.96	1184.97	671.53	1159.74	144.11	0	0	0
1098.5	1113.36	1073.71	637.32	1048.92	161.28	0	0	0
1118.09	1153.19	1092.86	669.17	1067.62	185.14	0	0	0
1163.47	1181.74	1138.23	676.46	1112.98	171.19	0	0	0
1114.23	1079.13	1089	595.11	1063.76	111.09	0	0	0
1061.72	920.5	1036.49	457.72	0	0	0	0	0
1096.03	890.37	1069.91	411.14	0	0	0	0	0
1123.64	873.32	1097.96	380.05	0	0	0	0	0
1192.86	873.49	1166.65	347.67	0	0	0	0	0
1247.65	855.86	1220.45	304.37	0	0	0	0	0
1466.24	926.56	1437.55	274.41	0	0	0	0	0
1862.18	933.02	1832.82	96.05	0	0	0	0	0
2284.36	2091.06	2255.24	1073.34	2226.13	55.61	0	0	0
2546.87	2388.41	2518.78	1250.18	2490.69	111.96	0	0	0
2554.56	2399	2528.06	1255.73	2501.56	112.45	0	0	0
2244.86	2128.4	2220.98	1124.54	2197.1	120.68	0	0	0

2005.96	1936.48	1982.89	1041.59	1959.83	146.7	0	0	0
1630.54	1535.54	1608.14	811.3	1585.73	87.07	0	0	0
1181.55	1079.4	1159.72	559.59	1137.88	39.77	0	0	0
873.86	788.27	852.62	408.66	831.38	29.04	0	0	0
788.32	773.23	765.7	436.32	743.08	99.42	0	0	0
772.34	851.38	748.38	526.79	724.42	202.2	0	0	0
821.77	681	796.87	326.96	0	0	0	0	0
4747.2	4198.28	4655.77	2110.55	4564.35	22.82	0	0	0
3102.82	2917.51	3057.98	1541.47	3013.13	165.43	0	0	0
3284.34	2925.1	3232.19	1470.5	3180.03	15.9	0	0	0
2593.78	2463.93	2545.28	1325.3	2496.77	186.66	0	0	0
2291.2	2218.28	2248.22	1213.47	2205.24	208.65	0	0	0
2547.7	2693.13	2506.36	1573.04	2465.02	452.94	0	0	0
2798.74	3053.17	2759.54	1817.04	2720.34	580.91	0	0	0
2964.84	3989.79	2927.26	2685.98	2889.69	1382.18	2852.11	78.37	0
3405.66	5791.87	3366.64	4303.23	3327.63	2814.59	3288.61	1325.95	0
4206.37	4507.99	4161.37	2633.07	4116.37	758.16	0	0	0
4558.99	6261	4510.72	4243.81	4462.44	2226.62	4414.17	209.43	0
3778.56	6641.49	3736.53	4990.14	3694.49	3338.79	3652.46	1687.44	3610.42
3368.6	6387.76	3328.63	4926.56	3288.67	3465.36	3248.7	2004.16	3208.73
2970.27	5687.69	2932.31	4405.86	2894.34	3124.03	2856.38	1842.2	2818.42
2514.47	4749.71	2480	3668.62	2445.54	2587.53	2411.07	1506.44	2376.6
2148.12	4015.44	2116	3096.91	2083.89	2178.38	2051.77	1259.84	2019.65
1892.62	3512.93	1861.48	2709.35	1830.33	1905.76	1799.18	1102.18	1768.04
1922.58	3546.69	1888.45	2735.38	1854.31	1924.08	1820.17	1112.77	1786.03
2135.19	3924.46	2095.63	3026.74	2056.06	2129.02	2016.5	1231.3	1976.93
2954.2	5480.72	2905.28	4227	2856.37	2973.29	2807.45	1719.58	2758.54
3674.24	6324.8	3557.15	4878	3440.07	3431.2	3322.99	1984.4	3205.9
3108.91	5823.11	3063.77	4491.07	3018.62	3159.04	2973.48	1827	2928.33
3027.33	5682.18	2984.73	4382.38	2942.13	3082.58	2899.52	1782.78	2856.92
3055.01	5747.3	3013.52	4432.6	2972.04	3117.91	2930.55	1803.21	2889.06
3025.13	5696.34	2984.65	4393.3	2944.17	3090.27	2903.69	1787.23	2863.21
3099.16	5841.11	3058.3	4504.96	3017.45	3168.8	2976.59	1832.65	2935.74
2929.32	5516.07	2890.14	4254.27	2850.96	2992.47	2811.78	1730.67	2772.59
2705.9	5087.4	2668.8	3923.66	2631.69	2759.92	2594.59	1596.17	2557.49
2572.76	4844.49	2538.33	3736.31	2503.9	2628.13	2469.47	1519.96	2435.04
2487.58	4693.72	2455.39	3620.03	2423.2	2546.34	2391.01	1472.65	2358.82
2459.07	4642.45	2427.53	3580.49	2396	2518.53	2364.47	1456.57	2332.94
2583.34	4868.21	2549.21	3754.61	2515.07	2641	2480.93	1527.4	2446.79
2630.96	4937.77	2593.89	3808.25	2556.81	2678.74	2519.74	1549.22	2482.66
2751.76	5150.57	2711.39	3972.38	2671.02	2794.18	2630.65	1615.99	2590.29
2730.4	5095.04	2688.56	3929.55	2646.73	2764.06	2604.9	1598.57	2563.06
2741.27	5116.06	2699.35	3945.76	2657.44	2775.46	2615.52	1605.16	2573.61
2843.92	5324.4	2802.35	4106.44	2760.78	2888.48	2719.21	1670.53	2677.64
2912.76	5471.6	2872.28	4219.97	2831.8	2968.34	2791.32	1716.72	2750.84
3048.76	5754.23	3009.49	4437.95	2970.23	3121.67	2930.97	1805.39	2891.7
3048.92	5756.32	3009.86	4439.56	2970.8	3122.8	2931.74	1806.05	2892.67
3062.46	5776.13	3022.57	4454.84	2982.68	3133.55	2942.78	1812.26	2902.89
2990.47	5634.63	2950.86	4345.71	2911.25	3056.78	2871.64	1767.86	2832.03
2870.1	5400.04	2831.19	4164.78	2792.29	2929.52	2753.38	1694.26	2714.48
2947.55	5548.39	2907.9	4279.19	2868.24	3010	2828.59	1740.81	2788.93
2964.86	5583.56	2925.27	4306.32	2885.68	3029.08	2846.08	1751.84	2806.49

2849.82	5334.05	2810.88	4107.76	2771.93	2881.46	2732.99	1655.16	2694.05
2715.48	5022.56	2676.94	3856.15	2638.4	2689.75	2599.86	1523.34	2561.32
2783.71	5031.14	2741.78	3838.53	2699.85	2645.91	2657.91	1453.3	2615.98
3096.59	5599.9	3050.34	4272.46	3004.1	2945.02	2957.85	1617.59	2911.61
3811.2	6914.35	3761.16	5266.79	3711.13	3619.23	3661.1	1971.67	3611.07
3990.53	7341.19	3941.85	5609.95	3893.18	3878.72	3844.5	2147.49	3795.82
3550.45	6490.48	3509.95	4943.92	3469.44	3397.36	3428.93	1850.8	3388.43
4450.16	8214.64	4399.26	6277.42	4348.37	4340.21	4297.48	2402.99	4246.59
3673.3	6832.95	3629.63	5238.01	3585.95	3643.08	3542.28	2048.14	3498.61
3876.88	7052.59	3832.71	5363.29	3788.53	3673.99	3744.36	1984.69	3700.18

grids center along the center line A and V are the area and volum of water under certain depth in that cro

line

t	Z<- 7.5 feet		Z<- 9 feet		Z<- 10.5 feet		Z<- 12 feet	
V(m^3)	A(m^2)	V(m^3)	A(m^2)	V(m^3)	A(m^2)	V(m^3)	A(m^2)	V(m^3)
2170.91	0	0	0	0	0	0	0	0
4030.69	0	0	0	0	0	0	0	0
7509.51	7837.88	2684.47	0	0	0	0	0	0
6628.14	8588.25	879.45	0	0	0	0	0	0
5839.7	8481.84	1967.72	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
683.34	0	0	0	0	0	0	0	0
1396.53	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
1539.11	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
2386.66	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
17154.98	19276.82	8350.63	13923.96	1275.79	0	0	0	0
12757.85	13231.46	4961.46	5175.87	491.04	0	0	0	0
3773.77	5469.23	1271.59	0	0	0	0	0	0
3994.91	6000.18	435.01	0	0	0	0	0	0
4163.52	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
647.44	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
287	0	0	0	0	0	0	0	0
3960.79	3388.43	2438.05	3350.93	915.31	0	0	0	0
942.16	0	0	0	0	0	0	0	0
4656.27	6490.49	1697.6	0	0	0	0	0	0
2824.54	2371.63	1401.87	2337.55	337.38	0	0	0	0
782.69	0	0	0	0	0	0	0	0

1427.4	2513.34	281.72	0	0	0	0	0	0
2152.51	3283.27	660.43	0	0	0	0	0	0
6046.14	6603.3	1559.64	0	0	0	0	0	0
15255.39	17046.46	7500.56	0	0	0	0	0	0
17323.96	18333.67	8981.11	18242.71	638.25	0	0	0	0
15490.07	25427.22	3872.52	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
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	0	0	0
0	0	0	0	0	0	0	0	0
1954.88	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
6240.98	0	0	0	0	0	0	0	0
5922.35	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
8718.83	13051.85	2765.3	0	0	0	0	0	0
14902.34	10433.47	10200.4	10361.56	5498.45	10289.66	796.5	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
3824.14	0	0	0	0	0	0	0	0
1634.53	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1615.75	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1334.52	0	0	0	0	0	0	0	0
6340.2	11977.53	867.29	0	0	0	0	0	0
15185.13	14075.87	8811.55	13971.31	2437.98	0	0	0	0
13368.24	14484.67	6791.93	14377.95	215.62	0	0	0	0
13844.1	13065.44	7924.77	12970.55	2005.45	0	0	0	0
10830.29	12400.24	5199.77	0	0	0	0	0	0
13284.61	19033.34	4602.17	0	0	0	0	0	0
6291.51	0	0	0	0	0	0	0	0
2065.51	0	0	0	0	0	0	0	0
4475.92	0	0	0	0	0	0	0	0
6382.07	13581.18	169.74	0	0	0	0	0	0
1634.83	0	0	0	0	0	0	0	0
3282.67	3036.99	1104.69	1339.6	6.7	0	0	0	0
309.43	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
773.08	0	0	0	0	0	0	0	0
1516.54	2667.79	299.32	0	0	0	0	0	0
2415.25	3731.28	715.29	0	0	0	0	0	0
1228.28	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
361.37	0	0	0	0	0	0	0	0

1600.57	0	0	0	0	0	0	0	0
10837.6	8948.35	6344.69	4583.73	3280.43	2228.97	1354.1	2228.97	334.34
28828.41	13959.34	20538.3	11738.51	14696	9599.32	10015.52	7603.21	6522.08
2745.82	2025.63	1139.42	2025.63	212.69	0	0	0	0
23766.01	14493.95	17135.03	12255.27	11231.62	7906.57	6488.69	7906.57	2871.43
9794.32	7634.23	6308.92	6040.16	3131.27	4017.64	494.31	0	0
8316.14	11138.86	3231.76	0	0	0	0	0	0
1851.72	0	0	0	0	0	0	0	0
895.37	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
671.64	0	0	0	0	0	0	0	0
1475.59	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
23.24	0	0	0	0	0	0	0	0
910.18	0	0	0	0	0	0	0	0
929.99	0	0	0	0	0	0	0	0
2575.08	2219.9	1559.48	2219.9	543.88	0	0	0	0
2708.86	3528.3	411.63	0	0	0	0	0	0
1839.36	0	0	0	0	0	0	0	0
1276.49	0	0	0	0	0	0	0	0
1495.77	0	0	0	0	0	0	0	0
406.87	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
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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
771.8	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
1364.85	0	0	0	0	0	0	0	0
599.61	0	0	0	0	0	0	0	0
488.06	0	0	0	0	0	0	0	0

339.6	0	0	0	0	0	0	0	0
624.88	0	0	0	0	0	0	0	0
548.26	0	0	0	0	0	0	0	0
747.39	0	0	0	0	0	0	0	0
1921.61	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
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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
1170.72	0	0	0	0	0	0	0	0
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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
36.1	0	0	0	0	0	0	0	0
542.96	0	0	0	0	0	0	0	0
560.36	0	0	0	0	0	0	0	0
425.35	0	0	0	0	0	0	0	0
341.31	0	0	0	0	0	0	0	0
298.6	0	0	0	0	0	0	0	0
301.47	0	0	0	0	0	0	0	0
333.58	0	0	0	0	0	0	0	0
465.86	0	0	0	0	0	0	0	0
537.61	0	0	0	0	0	0	0	0
494.96	0	0	0	0	0	0	0	0
482.99	0	0	0	0	0	0	0	0
488.52	0	0	0	0	0	0	0	0
484.19	0	0	0	0	0	0	0	0
496.49	0	0	0	0	0	0	0	0
468.87	0	0	0	0	0	0	0	0
432.43	0	0	0	0	0	0	0	0
411.78	0	0	0	0	0	0	0	0
398.97	0	0	0	0	0	0	0	0
394.61	0	0	0	0	0	0	0	0
413.8	0	0	0	0	0	0	0	0
419.71	0	0	0	0	0	0	0	0
437.8	0	0	0	0	0	0	0	0
433.08	0	0	0	0	0	0	0	0
434.87	0	0	0	0	0	0	0	0
452.57	0	0	0	0	0	0	0	0
465.09	0	0	0	0	0	0	0	0
489.11	0	0	0	0	0	0	0	0
489.29	0	0	0	0	0	0	0	0
490.97	0	0	0	0	0	0	0	0
478.94	0	0	0	0	0	0	0	0
459	0	0	0	0	0	0	0	0
471.61	0	0	0	0	0	0	0	0
474.6	0	0	0	0	0	0	0	0

428.87	0	0	0	0	0	0	0	0
356.93	0	0	0	0	0	0	0	0
260.68	0	0	0	0	0	0	0	0
290.15	0	0	0	0	0	0	0	0
324.11	0	0	0	0	0	0	0	0
416.25	0	0	0	0	0	0	0	0
304.24	0	0	0	0	0	0	0	0
465.78	0	0	0	0	0	0	0	0
453.21	0	0	0	0	0	0	0	0
295.4	0	0	0	0	0	0	0	0

ɔss section

Z<- 13.5 feet		Z<- 15 feet		Z<- 16.5 feet	
A(m^2)	V(m^3)	A(m^2)	V(m^3)	A(m^2)	V(m^3)
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
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5994.36	3522.24	4295.93	1128	0	0
0	0	0	0	0	0
4072.47	335.98	0	0	0	0
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	A=Area	V=Volumn			Centerline Distance
Connect to Bayous	I*	Lon*	Lat*	Dx (m)	(Kilometer)
	2	-82.4817	27.7165	93.21	0.60
	3	-82.4808	27.71627	87.65	0.70
	4	-82.4799	27.71604	83.79	0.80
	5	-82.4791	27.71583	81.49	0.90
	6	-82.4783	27.71562	80.61	1.00
	7	-82.4776	27.71541	82.01	1.10
	8	-82.4767	27.71521	83.84	1.10
	9	-82.4759	27.71499	87.64	1.20
	10	-82.475	27.71477	90.45	1.30
	11	-82.4741	27.71455	92.66	1.40
	12	-82.4732	27.71431	94.21	1.50
	13	-82.4723	27.71409	94.44	1.60
	14	-82.4711	27.71464	94.53	1.70
	15	-82.47	27.71516	93.05	1.80
	16	-82.4691	27.71493	91.19	1.90
	17	-82.4682	27.71471	87.42	2.00
	18	-82.4674	27.71449	83.99	2.10
	19	-82.4666	27.71427	80.73	2.20
	20	-82.4658	27.71406	76.76	2.20
	21	-82.4651	27.71385	74.63	2.30
	22	-82.4644	27.71364	72.25	2.40
	23	-82.4637	27.71342	69.5	2.50
	24	-82.463	27.71321	68.74	2.50
	25	-82.4624	27.71299	66.58	2.60
	26	-82.4618	27.71278	63.62	2.70
	27	-82.4612	27.71255	63.23	2.80
	28	-82.4606	27.71232	66.4	2.90
	29	-82.4595	27.7129	72.04	3.00
	30	-82.4584	27.71332	78.83	3.20
	31	-82.4577	27.71297	87.06	3.30
	32	-82.4569	27.71257	91.22	3.40
connect to Ruskin Inlet Bayou	33	-82.4561	27.71215	84.24	3.50
	34	-82.4554	27.71176	74.69	3.60
	35	-82.4548	27.71138	73.84	3.63
	36	-82.4542	27.71097	75.87	3.70
	37	-82.4536	27.71054	80.32	3.80
	38	-82.4529	27.71005	88.82	3.90
	39	-82.4519	27.70986	86.64	4.00
	40	-82.451	27.70961	73.41	4.05
	41	-82.4506	27.70915	65.86	4.10
	42	-82.4501	27.70867	79.04	4.20
	43	-82.4495	27.70803	105.33	4.30
	44	-82.4485	27.70743	112.82	4.40
	45	-82.4482	27.70656	105.8	4.50
	46	-82.4481	27.70565	100.31	4.60
	47	-82.4481	27.70473	105.87	4.70
connect to Mills Bayou	48	-82.4484	27.70375	121.68	4.80
	49	-82.4489	27.70285	104.22	4.90
	50	-82.4496	27.7021	103.96	5.00

	51	-82.4503	27.70145	99.56	5.10
	52	-82.4511	27.70085	103.21	5.20
	53	-82.4519	27.70035	94.79	5.30
	54	-82.4527	27.69995	94.79	5.40
	55	-82.4536	27.6996	85.53	5.50
	56	-82.4544	27.69928	87.99	5.60
	57	-82.4551	27.6989	77.98	5.70
	58	-82.4557	27.6985	73.94	5.80
	59	-82.4563	27.69803	78.58	5.85
	60	-82.4567	27.69745	75.21	5.90
	61	-82.457	27.69683	74.92	6.00
	62	-82.4571	27.69615	78.45	6.10
	63	-82.4572	27.69545	77.83	6.20
	64	-82.4571	27.69478	72.63	6.30
	65	-82.457	27.69415	69.56	6.33
	66	-82.4568	27.69357	67.95	6.40
	67	-82.4564	27.69303	75.52	6.50
	68	-82.4559	27.69253	70.3	6.60
	69	-82.4553	27.69207	81.24	6.65
	70	-82.4547	27.69165	82.02	6.70
	71	-82.454	27.6913	76.56	6.80
	72	-82.4532	27.69095	90.45	6.90
	73	-82.4524	27.6906	81.05	7.00
	74	-82.4517	27.69033	79.2	7.10
	75	-82.4509	27.6901	77.13	7.14
connect to Hayes Bayou	**76**	-82.4501	27.68993	90.33	7.20
	77	-82.4493	27.68978	80.69	7.30
	78	-82.4484	27.68965	89.3	7.40
	79	-82.4475	27.68953	85.57	7.50
	80	-82.4467	27.6894	89.3	7.60
	81	-82.4458	27.6893	89.3	7.70
	82	-82.4449	27.68917	90.33	7.74
	83	-82.444	27.68903	85.57	7.80
	84	-82.4431	27.68885	91.36	7.90
	85	-82.4422	27.68865	91.36	8.00
	86	-82.4413	27.68845	91.36	8.10
	87	-82.4404	27.68825	91.36	8.20
	88	-82.4395	27.688	94.68	8.30
	89	-82.4386	27.68765	94.8	8.40
	90	-82.4378	27.6873	85.54	8.50
	91	-82.437	27.68698	88	8.65
	92	-82.4362	27.68662	92.34	8.60
	93	-82.4354	27.6863	85.54	8.70
	94	-82.4345	27.68595	94.8	8.80
	95	-82.4337	27.6855	96.41	8.90
	96	-82.4329	27.68498	99.82	9.00
	97	-82.4322	27.68437	99.94	9.10
	98	-82.4315	27.68368	102.25	9.30
	99	-82.431	27.68285	109.44	9.40
	100	-82.4307	27.6819	112.27	9.50
	101	-82.4307	27.68088	118.4	9.60
	102	-82.431	27.67992	104.4	9.70

	103	-82.4315	27.6791	104.23	9.80
	104	-82.4321	27.67837	96.54	9.90
	105	-82.4328	27.67772	93.41	10.00
	106	-82.4334	27.6771	95.92	10.10
	107	-82.4341	27.67653	85.12	10.20
	108	-82.4347	27.67598	92.24	10.30
	109	-82.4354	27.67543	88.53	10.40
	110	-82.436	27.67488	85.12	10.50
	111	-82.4367	27.67435	88.55	10.50
	112	-82.4373	27.6738	89.11	10.60
	113	-82.4379	27.67323	78.59	10.70
	114	-82.4384	27.67265	82.91	10.80
	115	-82.4388	27.67205	72.96	10.90
	116	-82.4391	27.6714	83.25	11.00
	117	-82.4393	27.67072	72.94	11.10
	118	-82.4393	27.67005	78.45	11.13
	119	-82.4391	27.66938	74.92	11.20
	120	-82.4388	27.66872	80.36	11.30
	121	-82.4384	27.66813	75.87	11.40
	122	-82.4379	27.66763	77.54	11.50
	123	-82.4373	27.66715	88.56	11.53
	124	-82.4364	27.6667	103.61	11.60
	125	-82.4354	27.66635	118.07	11.70
	126	-82.4342	27.66613	119.47	11.90
	127	-82.4331	27.6661	108.89	12.00
	128	-82.432	27.66625	110.58	12.10
	129	-82.4309	27.6665	113.38	12.20
	130	-82.4299	27.66688	101.89	12.30
	131	-82.429	27.66735	104.62	12.40
	132	-82.428	27.66778	101.38	12.50
	133	-82.4271	27.66797	84.09	12.60
	134	-82.4265	27.66793	40.55	12.70
	135	-82.4259	27.66788	84.4	12.72
	136	-82.4251	27.66815	85.24	12.80
	137	-82.4243	27.66842	69.81	12.90
	138	-82.4237	27.66893	72.29	12.95
	139	-82.4238	27.66935	77.55	13.00
	140	-82.4232	27.66996	63.09	13.10
	141	-82.4227	27.67042	78.41	13.15
	142	-82.4221	27.67095	69.13	13.20
	143	-82.4216	27.67154	75.77	13.30
	144	-82.4209	27.67171	85.74	13.40
	145	-82.4201	27.67187	83.57	13.45
	146	-82.4193	27.672	77.14	13.50
	147	-82.4177	27.67211	79.31	13.70
	148	-82.4169	27.67213	69.67	13.80
	149	-82.4162	27.67165	59.58	13.90
	150	-82.4156	27.6694	65.53	14.20
	151	-82.415	27.66904	59.4	14.22
	152	-82.4144	27.66901	54.31	14.30
	153	-82.4139	27.66899	39.27	14.35
	154	-82.4135	27.66898	39.96	14.40

	155	-82.4131	27.66895	50.62	14.45
	156	-82.4125	27.66893	60.77	14.50
	157	-82.4119	27.66925	55.07	14.60
	158	-82.4114	27.66923	41.29	14.64
	159	-82.411	27.66921	44.73	14.70
	160	-82.4105	27.66883	57.85	14.80
	161	-82.4099	27.66845	60.62	14.83
	162	-82.4093	27.66842	52.62	14.90
	163	-82.4088	27.66841	44.41	14.95
	164	-82.4084	27.66875	38.6	14.97
	165	-82.408	27.66873	34.99	15.00
	166	-82.4077	27.66872	32.44	15.10
	167	-82.4074	27.66872	30.3	15.13
	168	-82.4071	27.66871	28.84	15.16
	169	-82.4068	27.66835	28.35	15.20
	170	-82.4065	27.66799	28.76	15.30
	171	-82.4061	27.6643	34.01	16.10
	172	-82.4058	27.66465	32.35	16.20
	173	-82.4056	27.66547	27.53	16.30
	174	-82.4053	27.66629	27.11	16.40
	175	-82.405	27.6663	38.98	16.50
	176	-82.4045	27.66592	52.41	16.58
	177	-82.4039	27.66554	62.45	16.60
	178	-82.4032	27.66484	66.02	16.70
	179	-82.4025	27.66466	67.22	16.80
	180	-82.4019	27.6645	61.48	16.90
	181	-82.4013	27.66444	65.64	16.95
	182	-82.4006	27.6644	68.03	17.00
	183	-82.3999	27.66436	70.64	17.10
	184	-82.3992	27.66428	72.05	17.20
	185	-82.3985	27.66414	70.06	17.23
	186	-82.3978	27.66398	63.92	17.30
	187	-82.3972	27.66387	59.35	17.40
	188	-82.3966	27.6639	57.25	17.43
	189	-82.396	27.66406	61.74	17.50
	190	-82.3955	27.66433	68.62	17.60
	191	-82.3948	27.66461	71.62	17.70
	192	-82.3941	27.66483	71.36	17.73
	193	-82.3935	27.665	68.48	17.80
	194	-82.3928	27.66516	66.66	17.90
	195	-82.3922	27.66532	63.65	17.93
	196	-82.3916	27.66551	59.21	18.00
	197	-82.3891	27.66576	55.15	18.30
	198	-82.3891	27.6661	55.72	18.40
	199	-82.3891	27.66652	56.15	18.42
	200	-82.3891	27.66702	58.03	18.50
	201	-82.3902	27.66757	65.6	18.70
	202	-82.3901	27.66818	71.34	18.90
	203	-82.3901	27.66882	71.68	19.00
	204	-82.3899	27.66945	73.84	19.02
	205	-82.3896	27.67009	81.38	19.10
	206	-82.389	27.67057	73.65	19.20

	207	-82.3885	27.67086	58.58	19.30
	208	-82.388	27.67116	51.33	19.37
	209	-82.3878	27.67159	56.32	19.40
	210	-82.3877	27.67214	68.54	19.50
	211	-82.3875	27.67267	54.72	19.55
	212	-82.3873	27.67311	52.84	19.60
	213	-82.3869	27.67348	58.68	19.70
	214	-82.3865	27.67372	48.36	19.80
	215	-82.3861	27.67386	41.77	19.90
	216	-82.3857	27.67398	40.38	19.95
	217	-82.3853	27.67411	38.95	19.97
	218	-82.3849	27.67425	37.41	20.00
	219	-82.3846	27.67441	36.32	20.05
	220	-82.3843	27.6746	35.78	20.10
	221	-82.384	27.67483	35.33	20.13
	222	-82.3838	27.67508	36.18	20.17
	223	-82.3836	27.67536	37.34	20.20
	224	-82.3835	27.67569	40.78	20.23
	225	-82.3833	27.67605	45.9	20.30
	226	-82.383	27.67641	51.99	20.33
	227	-82.3826	27.67668	48.56	20.50
	228	-82.3822	27.67681	44.99	20.52
	229	-82.3817	27.67687	43.12	20.57
	230	-82.3813	27.6769	40.51	20.60
	231	-82.3809	27.67694	41.17	20.65
	232	-82.3805	27.67698	41.59	20.70
	233	-82.3802	27.67699	25.33	20.78
	234	-82.3799	27.67718	27.58	20.90
	235	-82.3796	27.67738	27.09	20.92
	236	-82.3793	27.67769	27.58	20.95
	237	-82.3791	27.67772	27.59	20.98
	238	-82.3788	27.6778	27.58	21.01
	239	-82.3785	27.6778	27.57	21.03
	240	-82.3782	27.67782	28.55	21.06
	241	-82.3779	27.67761	28.07	21.09
	242	-82.3776	27.67739	28.64	21.12
	243	-82.3773	27.67716	29.72	21.15
	244	-82.377	27.67691	31.35	21.18
	245	-82.3767	27.67681	32.09	21.21
	246	-82.3765	27.67665	31.82	21.24
	247	-82.3762	27.67647	30.7	21.27
	248	-82.376	27.67628	28.96	21.30
	249	-82.3758	27.67609	26.1	21.33
	250	-82.3757	27.67591	25.21	21.35
	251	-82.3755	27.67576	24.49	21.38
	252	-82.3753	27.67562	23.86	21.40
	253	-82.3751	27.67552	23.21	21.43
	254	-82.3749	27.67544	24.72	21.45
	255	-82.3746	27.6754	26.19	21.48
	256	-82.3743	27.67538	27.22	21.50
	257	-82.3737	27.67541	99.92	21.60
	258	-82.373	27.67557	49.01	21.65

	259	-82.3725	27.67575	57	21.71
	260	-82.372	27.67572	53.01	21.76
	261	-82.3715	27.67553	46.97	21.81
	262	-82.3711	27.67529	45.18	21.86
	263	-82.3708	27.67505	42.84	21.90
	264	-82.3704	27.67482	41.07	21.94
	265	-82.3701	27.67462	42.64	21.98
	266	-82.3697	27.67442	49.18	22.03
	267	-82.3693	27.67414	52.76	22.08
	268	-82.3689	27.67381	45.94	22.13
	269	-82.3687	27.67348	43.68	22.17
	270	-82.3684	27.67318	41.49	22.21
	271	-82.3681	27.67292	37.67	22.25
	272	-82.3679	27.67271	35.1	22.29
	273	-82.3675	27.67262	34.04	22.32
	274	-82.3672	27.67265	37.31	22.36
	275	-82.3668	27.67278	43.24	22.40
	276	-82.3663	27.6739	53.46	22.46
	277	-82.3658	27.67388	54.96	22.51
	278	-82.3653	27.6732	49.34	22.56
	279	-82.3649	27.67246	46.56	22.61
	280	-82.3646	27.67219	45.34	22.65
	281	-82.3642	27.67192	44.24	22.70
	282	-82.3639	27.67165	44.65	22.74
	283	-82.3636	27.67137	42.82	22.78
	284	-82.3633	27.67112	40.55	22.82
	285	-82.3629	27.6709	37.63	22.86
	286	-82.3626	27.67076	35.18	22.90
	287	-82.3623	27.6707	34.46	22.93
	288	-82.3619	27.67074	37.31	22.97
	289	-82.3616	27.67086	40.52	23.01
	290	-82.3612	27.67102	44.12	23.05
	291	-82.3607	27.67118	45.72	23.10
	292	-82.3603	27.67132	45.81	23.14
	293	-82.3599	27.67142	45.43	23.19
	294	-82.3594	27.67151	44.24	23.23
	295	-82.359	27.67159	42.91	23.28
	296	-82.3586	27.67168	42.69	23.32
	297	-82.3581	27.67178	43.6	23.36
	298	-82.3577	27.67189	43.29	23.41
	299	-82.3573	27.67201	42.52	23.45
	300	-82.3569	27.67213	43.34	23.49
	301	-82.3565	27.67227	43.27	23.54
	302	-82.3561	27.67241	42.56	23.58
	303	-82.3557	27.67257	42.12	23.62
	304	-82.3553	27.67275	45.83	23.67
	305	-82.3548	27.67291	50.54	23.72
	306	-82.3543	27.67298	54.68	23.77
	307	-82.3538	27.67289	53.2	23.83
	308	-82.3533	27.6727	44.27	23.87
	309	-82.3529	27.67242	55.62	23.93
	310	-82.3526	27.67207	47.73	23.97

	311	-82.3523	27.67173	48.28	24.02

note: 1 * Lon and Lat are the longitude and latitude of the grids cent
Z=0 is mean sea level,
2 I is the segment numbering along the river central line
3 I numbers connected to bayous are marked

Z<-0.0 feet		Z<-1.5 feet		Z<- 3 feet		Z<- 4.5 feet		Z<- 6 fee
A (m^2)*	V(m^3)*	A(m^2)*	V(m^3)*	A(m^2)	V(m^3)	A(m^2)	V(m^3)	A(m^2)
46471.2	70658.53	46386.27	49512.04	46301.35	28365.54	26654.56	11380.17	16711.48
43527.74	61061.72	43447.89	41266.73	34614.44	21953.2	17584.19	12048.26	17544.63
41445.56	62309.75	41369.23	43464.12	32959.99	25993.42	16738.75	15144.89	16700.93
40192.42	63121.16	40118.19	44862.25	31971.57	26724.41	23107.36	14559.96	16222.26
39613.17	53004.92	39539.75	35004.37	30794.8	17741.48	8554.65	9711.67	8518.24
50361.76	43584.99	50286.41	20614.25	16925	2912.38	0	0	0
51265.94	50797.46	51188.97	27428.02	42890.65	5826.16	0	0	0
52153.75	52737.65	52073.33	28957.6	35280.61	7913.95	0	0	0
53480.41	53637.28	53397.51	29231.29	37482.17	7726.94	9741.52	267.89	0
64307.19	65191.71	64222.58	35831.32	27822.01	15682.37	18925.56	6801.57	0
46347.9	48452.39	46261.79	27324.87	37457.74	8076.05	9151.56	1624.4	0
46353.5	52062.38	46267.21	30937.19	46180.93	9812	7848.34	58.86	0
46280.87	52364.46	46194.68	31303.12	46108.5	10241.78	8837.23	1829.65	0
45294.72	52005.31	45210.26	31398.94	45125.8	10792.56	8725.07	3193.89	0
35442.72	43774.51	35360.23	27682.77	35277.74	11591.03	8590.78	4591.2	8549.06
33792.31	41199.41	33713.52	25858.21	33634.73	10517.01	8269.71	5154.82	8229.72
32228.12	31345.57	32152.71	16690.44	16284.68	4235.16	0	0	0
39728.02	38385.09	39655.4	20297.17	24502.32	6358.4	0	0	0
54010.68	52995.45	53941.93	28373.14	38970.48	5451.72	6262.27	234.73	0
52153.02	48066.29	52086.33	24264.44	19218.09	7667.56	7092.84	2393.83	0
39386.46	46033.85	39322.44	28067.65	18398.77	13414.06	12825.88	7406.94	12825.88
32369.03	37745.74	32307.41	22988.37	24349.72	9535.78	12327.68	2434.72	0
31850.79	32547.36	31790.01	18030.4	23878.52	4731.98	6235.94	296.21	0
30676.68	37904.3	30617.97	23931.56	24218.19	10244.16	5424.23	4868.25	5424.23
29152.47	39007.59	29096.52	25744.66	29040.57	12481.73	18539.06	2754.26	0
28749.39	35057.99	28693.93	21973.95	28638.46	8889.91	0	0	0
30031.04	64159.65	29972.96	50538.99	29914.88	36918.34	19339.44	25959.33	19308.13
50249.07	82685.17	50186.75	59823.84	43960.79	37178.23	25414.48	24335.17	25380.54
56158.32	66142.35	56091.64	40550.51	30215.64	17505.09	9038.06	7786.92	5469.23
19465.09	35991.26	19385.83	27226.82	19306.57	18462.38	19227.31	9697.94	9898.91
20195.3	39118.11	20116.68	30027.02	20038.06	20935.93	19959.44	11844.83	15880.42
18382.46	31132.06	18306.86	22835.57	18231.26	14539.09	14493.58	6325.33	0
16069.41	23180.73	16001.44	15913.65	15933.48	8646.57	4980.33	2925.94	4980.33
15691.76	19172.75	15624.58	12077.07	8061.32	5468.94	8026.85	1804.85	0
15975.94	23672.52	15906.93	16478.57	15837.91	9284.62	15768.89	2090.67	3195.9
16723.34	24885.75	16650.29	17380.42	8648.63	9914.73	8611.13	6036.91	3425.93
18098.08	19553.54	18017.3	11389.44	9331.19	4733.91	3688.73	2599.99	3647.25
15432.77	25030.78	15353.07	18107.11	10018.03	11578.07	6572.22	7614.94	6531.35
12696.01	18305.38	12629.57	12621.65	5458.7	7684.66	5424.63	5254.6	5390.55
7384.92	11256.66	7324.7	7974.38	7264.49	4692.11	4757.32	2405.22	2085.1
11287.61	18555.53	11214.88	13529.35	11142.15	8503.18	5022.21	3492.12	2550.49
14721.38	23085.63	14624.49	16529.72	14527.59	9973.81	6555.5	4937.72	3332.72
18609.85	38956.41	18506.88	30634.07	18403.91	22311.74	18300.94	13989.41	14764.63
17542.92	46274.67	17443.63	38519.85	17344.34	30765.03	17245.05	23010.21	17145.76
18788.47	50695.38	18697.51	42352.53	18606.55	34009.67	18515.59	25666.82	18424.63
25932.28	61960.26	25831.27	50342.71	25730.25	38725.16	25629.24	27107.61	25528.23
38810.1	58842.73	38705.21	41247.6	38600.31	23652.47	38495.42	6057.34	0
28740.14	41764.3	28637.73	28766.22	28535.32	15768.15	28432.91	2770.08	0
25210.75	31204.56	25120.31	19783.69	25029.87	8362.82	0	0	0

24418.64	20606.4	24324.01	9515.31	0	0	0	0	0
22056.53	15558.64	21964.41	5533.18	0	0	0	0	0
18428.27	12621.71	18338.14	4252.97	0	0	0	0	0
16086.46	14331.28	16003.7	7046.21	0	0	0	0	0
14151.47	17133.15	14068.87	10760.45	13986.26	4387.76	0	0	0
12142.31	14332.55	12066.63	8868.27	11990.94	3403.98	0	0	0
11208.4	15477.38	11133.27	10455.46	11058.15	5433.55	10983.02	411.63	0
10560.87	12455.36	10491.71	7706.75	10422.55	2958.15	0	0	0
10915.51	10978.93	10847.4	6054.56	10779.29	1130.18	0	0	0
10853.64	9967.44	10786.75	5064.1	10719.87	160.77	0	0	0
11595.96	5759.78	11526.05	489.58	0	0	0	0	0
12376.61	8345.7	12306.96	2730.76	0	0	0	0	0
12872.67	6397.25	12801.15	543.77	0	0	0	0	0
12707.24	7320.89	12640.18	1546.22	0	0	0	0	0
14425.41	9313.39	14357.06	2758.2	0	0	0	0	0
13721.04	11163.1	13661.06	4934.91	0	0	0	0	0
16213.34	15952.07	16093.8	8654	15974.27	1355.93	0	0	0
16068	19058.56	15997.14	11792.49	15926.28	4526.41	0	0	0
16064.24	21096.28	15994.62	13839.48	15925.01	6582.67	0	0	0
15767.46	22672.1	15692.68	15567.66	15617.91	8463.21	15543.14	1358.77	0
15362.65	22974.52	15288.06	16059.49	15213.46	9144.46	15138.87	2229.44	0
18125.17	25223.9	18048.63	17039.55	17972.1	8855.2	17895.56	670.85	0
17897.16	21585.69	17820.67	13491.06	17744.18	5396.42	0	0	0
18027.98	19634.18	17953.65	11468.15	17879.31	3302.11	0	0	0
17948.15	21129.75	17874.31	13006.34	17800.48	4882.93	0	0	0
22802.59	27989.34	22728.13	17651.72	22653.67	7314.1	0	0	0
17695.24	22189.79	17614.92	14196.22	17534.6	6202.66	0	0	0
16296.97	20581.79	16219.25	13225.41	16141.53	5869.02	0	0	0
15593.23	20427.83	15512.75	13400.96	15432.27	6374.1	0	0	0
14875.58	18893.44	14794.19	12192.86	14712.79	5492.28	0	0	0
14006.82	20067.03	13924.63	13778.91	13842.45	7490.78	13760.26	1202.65	0
14094.67	21692.52	14013.72	15371.29	13932.78	9050.06	13851.83	2728.84	0
13947.37	20648.61	13864.72	14392.49	13782.07	8136.37	13699.41	1880.25	0
14618.33	21507.68	14532.96	14947.84	14447.6	8388	14362.24	1828.15	0
15574.1	21313.76	15494.96	14298.62	15415.81	7283.48	15336.67	268.34	0
17132.74	24126.18	17049.15	16407.49	16965.55	8688.8	16881.96	970.11	0
18032.84	23818.53	17944.82	15686.46	17856.79	7554.39	0	0	0
17510.07	24155.16	17426.29	16261.6	17342.51	8368.04	17258.73	474.48	0
16613.84	24514.5	16531.23	17037.58	16448.63	9560.65	16366.02	2083.73	0
14895.88	25364.71	14812.14	18695.54	14728.41	12026.37	14644.68	5357.2	0
13574.74	23483.61	13495.35	17413.69	13415.95	11343.78	13336.56	5273.86	0
14314.31	27507.97	14232.83	21119.7	14151.34	14731.42	14069.86	8343.15	13988.37
14809.63	21665.98	14727.13	15013.5	14644.62	8361.03	14562.11	1708.56	0
16170.01	18967.52	16081.23	11675.38	15992.45	4383.25	0	0	0
17021.2	19488.91	16934.27	11802.55	16847.34	4116.19	0	0	0
17298.15	18790.57	17208.39	10975.4	17118.63	3160.23	0	0	0
48459.6	57863.71	48368.16	35803.17	48276.72	13742.63	0	0	0
16264.64	25031.51	16171.1	17737.3	16077.56	10443.08	15984.02	3148.87	0
17807.62	37965.94	17709.1	30034.7	17610.59	22103.46	17512.08	14172.22	17413.56
20903.59	43294.4	20799.64	33951.38	20695.69	24608.37	20591.73	15265.36	20487.78
24141	39669.79	24035.08	28802.17	23929.16	17934.55	23823.24	7066.92	0
22773.29	28791.03	22673.1	18500.49	22572.92	8209.94	0	0	0

22659.06	24902.91	22566.74	14638.87	22474.41	4374.84	0	0	0
21562.52	23487.13	21474.94	13718.62	21387.36	3950.11	0	0	0
21378.17	21814.67	21289.83	12125.15	21201.5	2435.62	0	0	0
20469.28	18474.04	20384.75	9186.27	0	0	0	0	0
18137.26	16888.79	18054.29	8668.98	17971.33	449.17	0	0	0
17351.88	17347.95	17272.3	9489.85	17192.72	1631.74	0	0	0
16378.77	18117.09	16295.93	10716.58	16213.09	3316.07	0	0	0
14806.02	19097.85	14726.56	12428.18	14647.11	5758.51	0	0	0
13888.73	22863.85	13812.67	16637.53	13736.61	10411.22	13660.56	4184.9	0
13468.11	32532.95	13384.86	26579.42	13301.6	20625.89	13218.35	14672.36	13135.1
10792.99	33710.12	10721.09	29008.18	10649.18	24306.23	10577.28	19604.29	10505.37
10432.78	15265.12	10354.69	10609.26	10276.6	5953.4	10198.51	1297.54	0
9264.86	14326.15	9191.57	10204	9118.28	6081.85	9045	1959.71	0
9230.35	12886.04	9160.24	8763.41	9090.13	4640.78	9020.02	518.14	0
8171.13	12698.18	8104	9067.29	8036.87	5436.41	7969.74	1805.52	0
9692.81	20892.87	9618.13	16625.68	9543.45	12358.5	9468.77	8091.32	9394.1
9928.81	19229.78	9857	14830.97	9785.19	10432.16	9713.38	6033.34	9641.57
10174.52	16185.45	10105.81	11642.6	10037.1	7099.75	9968.39	2556.9	0
10397.25	20095.88	10328.55	15475.84	10259.85	10855.81	10191.15	6235.78	10122.46
8732.14	14322.7	8662.52	10445.4	8592.9	6568.1	8523.28	2690.8	0
9869.85	18778.64	9791.46	14417.61	9713.07	10056.58	9634.68	5695.55	9556.29
12447.33	28231.82	12353.37	22758.92	12259.41	17286.01	12165.45	11813.1	12071.49
14598.7	40679.42	14494.14	34305.85	14389.57	27932.27	14285	21558.7	14180.44
15018.28	39673.49	14911.56	33097.18	14804.84	26520.86	14698.11	19944.55	14591.39
13539.87	37521.38	13444.98	31602.06	13350.1	25682.74	13255.21	19763.42	13160.33
12904.27	33352.37	12803.46	27721.85	12702.66	22091.33	12601.85	16460.81	12501.05
19555.21	48014.37	19450.83	39331.93	19346.46	30649.49	19242.08	21967.05	19137.71
17466.12	37408.98	17370.04	29629.61	17273.96	21850.24	17177.87	14070.88	17081.79
17613.42	33564.5	17519.38	25689.75	17425.33	17815	17331.28	9940.26	17237.23
17763.98	35979.49	17643.82	28103.59	17523.67	20227.7	17403.51	12351.81	17283.35
14002.97	31231.42	13918.62	25019.08	13834.26	18806.75	13749.9	12594.41	13665.54
4986.6	10434.09	4949.02	8234.28	4911.44	6034.46	4873.85	3834.65	4836.27
8608.83	17491.26	8531.97	13709.19	8455.11	9927.12	6681.29	6217.32	4907.51
10879.78	14505.42	10802.4	9645.68	10725.03	4785.94	5146.76	1764.52	1424.99
12261.63	14753.09	12198.59	9234.68	10636.52	3738.76	1281.61	325.49	0
21916.66	29680.81	21852.32	19759.53	21787.99	9838.25	8565.89	1253.05	0
17060.97	27348.33	16992.51	19672.89	16924.05	11997.44	14809.61	4593.09	2782.74
22802.9	34727.89	22747.78	24407.13	22692.66	14086.38	17162.03	4853	2697.01
24739	39564.8	24671.22	28390.06	24603.43	17215.33	16030.37	7207.81	3768.13
19226.1	31078.26	19167.05	22397.55	19108	13716.83	11500.06	5455.78	7306.24
22209.23	29976.33	22144.86	19906.72	22080.5	9837.1	8559.1	958.86	0
22761.79	29508.04	22689.13	19186.3	22616.46	8864.56	7638.84	2587.07	0
30649.3	45099.87	30579.03	31185.68	30508.76	17271.49	15818.42	3937.71	1642.61
16364.11	29786.65	16300.56	22423	16237.01	15059.35	16173.46	7695.71	8451.79
17773.86	41165.34	17708.01	33169.22	17642.16	25173.11	17576.3	17176.99	11246.38
28883.33	77213.44	28824.6	64103	28765.86	50992.56	21939.89	38817.8	19894.28
19009.64	31032.54	18957.3	22411.96	18904.96	13791.39	8903.66	6142.68	3967.57
41125.8	84368.13	41066.55	65637.4	41007.29	46906.67	18423.57	31034.03	14493.95
31401.69	50426.35	31345.05	36160.48	31288.42	21894.6	9963.41	13410.46	7661.9
31956.22	54875.31	31904.11	40386.18	31852.01	25897.05	18108.32	15095.04	13194.52
15841.39	25313.24	15804.13	18129.8	15766.86	10946.35	9878.26	5213.72	5344.59
15344.38	24012.59	15306.6	17053.78	15268.83	10094.98	9884.74	4329.48	4291.15

19956.44	24592.23	19909.12	15527.11	19861.8	6462	4050.63	790.91	0
28879.07	36227.46	28822.37	23091.49	24231.54	10235.12	12193.28	1638.51	0
97647.73	147601.88	97572.27	103040.4	97496.82	58478.99	85589.56	15461.29	8635.9
13042.5	23880.68	12991.67	18006.77	12940.85	12132.86	12890.02	6258.95	9365.07
12032.94	19671.25	11978.85	14260.02	11924.76	8848.79	11870.68	3437.56	0
16554.27	24422.08	16494.12	16948.49	16433.96	9474.9	11680.28	3216.1	2324.41
21635.38	32808.16	21573.21	23024.58	19079.34	13447.69	14857.1	5347.15	3518.25
20285.48	33009.06	20219.65	23844.82	20153.82	14680.58	18033.71	5891.25	5618.49
20568.08	35648.15	20499.48	26344.73	20430.88	17041.32	20362.29	7737.9	2219.9
18755.05	32619.63	18697.72	24130.92	18640.38	15642.22	16766.79	7357.85	5046.16
12264.65	21453.19	12228.86	15922	12193.07	10390.82	9138.66	5319.61	5834.01
9922.07	15943.52	9888.63	11471.76	8589.75	7272.06	6864.76	3772.52	5447.08
12634.08	20771.82	12601.13	15056.36	10068.89	9758.17	10035.93	5186.14	5043.41
9877.32	13670.46	9845.73	9210.16	7427.34	5336.92	4585.47	2361.72	3395.37
11277.83	12584.09	11246.88	7476.81	5627.31	3523.84	4490.71	1473.66	0
12311.25	11476.99	12280.15	5883.98	3325.89	2063.3	3307.87	552.96	0
11684.22	11568.76	11652.41	6262.14	6922.54	1803.81	3272.71	57.26	0
11138.64	10490.05	11107.35	5422.42	5941.84	1102.35	0	0	0
9637.34	8559.18	9610.01	4179.29	6007.27	372.33	0	0	0
7096.25	6169.11	7069.07	2954.25	936.98	647.21	924.68	227.21	0
9787.45	10372.87	9749.57	5950.23	6251.71	2428.87	4409.34	243.29	0
10305.22	8624.63	10257.5	3938.87	4732.57	966.78	0	0	0
16529.23	15137.62	16475.53	7614.26	9358.81	1685.93	0	0	0
13722.33	8668.27	13659.48	2430.43	0	0	0	0	0
17135.3	12399.09	17063.24	4612.9	0	0	0	0	0
13712.25	10849.61	13655.09	4624.14	4733.65	307.43	0	0	0
17609.08	13855.18	17536.21	5859.64	5074.3	532.08	0	0	0
19248.61	15923.24	19167.49	7189.04	5242.05	1436.42	0	0	0
18433.76	15978.22	18357.04	7616.58	5710.89	1961.85	0	0	0
19433.3	14646.73	19354.19	5817.64	0	0	0	0	0
18710.73	15983.63	18635.38	7493.52	5565.92	1801.52	0	0	0
18003.88	16346.17	17929.51	8185.43	4745.74	2847.78	4716.5	694.29	0
4504.07	4171.74	4449.77	2162.72	4395.46	153.7	0	0	0
4887.43	6297.75	4835.05	4131.42	4782.67	1965.09	0	0	0
6045.58	10201.61	5989.09	7534.62	5932.6	4867.62	5876.1	2200.63	0
7365.67	11848.83	7302.88	8583.27	7240.1	5317.7	7177.31	2052.13	0
7515.09	9884.31	7449.55	6534.63	7384.02	3184.94	0	0	0
6709.98	12541.77	6644.69	9599.28	6579.39	6656.79	6514.1	3714.29	6448.8
5851.62	10035.56	5788.96	7470.6	5726.3	4905.65	5663.64	2340.7	0
6024.06	9520.89	5963.07	6864.91	5902.08	4208.93	5841.08	1552.95	0
6758.99	13258.58	6700.75	10285.14	6642.51	7311.71	6584.27	4338.28	6526.03
6889.68	12791.63	6835.5	9743.63	6781.32	6695.62	6727.14	3647.61	6672.97
6311.37	11652.32	6260.9	8861.26	6210.44	6070.19	6159.98	3279.12	6109.52
5870.66	10697.47	5819.68	8108	5768.69	5518.54	5717.71	2929.07	5666.72
5426.34	10154.33	5374.96	7771.97	5323.58	5389.61	5272.2	3007.25	5220.83
5484.83	9669.34	5366.77	7389.07	5248.71	5108.8	5130.65	2828.53	5012.58
5596.99	10516.9	5536.97	8074.52	5476.94	5632.15	5416.92	3189.77	5356.9
5801.37	11968.91	5736.09	9457.09	5670.82	6945.26	5605.54	4433.44	5540.26
5292.13	8100.41	5226.55	5784.2	5160.96	3467.99	5095.37	1151.78	0
5033.67	6896.16	4966.11	4689.87	4898.55	2483.58	4830.98	277.29	0
5467.92	5817.77	5393.46	3398.11	5319	978.44	0	0	0
5365.4	6676.25	5298.01	4308.51	5230.62	1940.77	0	0	0

4985.16	6048.39	4931.56	3834.68	4877.96	1620.97	0	0	0
4921.01	7242.75	4874.04	5062.77	4827.07	2882.8	4780.11	702.83	0
5110.48	6741.91	5058.94	4473.95	5007.41	2205.99	0	0	0
5770.38	7540.19	5707.67	4984.9	5644.95	2429.62	0	0	0
4565.84	9105.63	4515.77	7121.9	4465.7	5138.18	4415.63	3154.45	4365.56
4407.91	6128.26	4359.56	4181.26	4311.22	2234.26	4262.87	287.26	0
5425.55	6547.23	5371.86	4131.62	5318.17	1716.01	0	0	0
4777.97	6949.33	4733.72	4829.79	4689.47	2710.24	4645.22	590.69	0
4166.14	4918.72	4127.92	3058.95	4089.7	1199.19	0	0	0
4059	5294.04	4022.05	3486.56	3985.1	1679.08	0	0	0
3860.72	6158.11	3825.08	4450.64	3789.45	2743.16	3753.81	1035.68	0
3622.78	6379.13	3588.55	4784.35	3554.32	3189.57	3520.09	1594.78	3485.86
3436.6	5886.99	3403.37	4373.9	3370.13	2860.81	3336.9	1347.72	0
3295.7	5517.86	3262.96	4067.04	3230.22	2616.22	3197.48	1165.41	0
3057.1	4936.51	3024.78	3592.19	2992.45	2247.87	2960.12	903.56	0
2900.91	4215.39	2867.81	2938.21	2834.7	1661.03	2801.6	383.85	0
2737.4	3761.76	2703.23	2558.26	2669.06	1354.76	2634.9	151.26	0
2694.33	3290.26	2657.02	2104.99	2619.71	919.72	0	0	0
3129.39	3374.49	3016.48	2077.15	2903.57	779.82	0	0	0
3272.25	3534.49	3224.68	2090.71	3177.11	646.94	0	0	0
2479.96	2925.82	2435.53	1846.33	2391.09	766.85	0	0	0
1806.35	1958.3	1765.18	1179.24	1724.02	400.17	0	0	0
1751.97	1649.92	1712.51	887.46	1673.06	124.99	0	0	0
1709.93	1690.69	1672.86	946.95	1635.79	203.21	0	0	0
1818.48	1917.06	1780.81	1126.92	1743.14	336.78	0	0	0
1905.65	1874.58	1867.6	1041.94	1829.54	209.3	0	0	0
1156.31	1126.73	1133.14	621.36	1109.96	115.99	0	0	0
1210.21	1198.96	1184.97	671.53	1159.74	144.11	0	0	0
1098.5	1113.36	1073.71	637.32	1048.92	161.28	0	0	0
1118.09	1153.19	1092.86	669.17	1067.62	185.14	0	0	0
1163.47	1181.74	1138.23	676.46	1112.98	171.19	0	0	0
1114.23	1079.13	1089	595.11	1063.76	111.09	0	0	0
1061.72	920.5	1036.49	457.72	0	0	0	0	0
1096.03	890.37	1069.91	411.14	0	0	0	0	0
1123.64	873.32	1097.96	380.05	0	0	0	0	0
1192.86	873.49	1166.65	347.67	0	0	0	0	0
1247.65	855.86	1220.45	304.37	0	0	0	0	0
1466.24	926.56	1437.55	274.41	0	0	0	0	0
1862.18	933.02	1832.82	96.05	0	0	0	0	0
2284.36	2091.06	2255.24	1073.34	2226.13	55.61	0	0	0
2546.87	2388.41	2518.78	1250.18	2490.69	111.96	0	0	0
2554.56	2399	2528.06	1255.73	2501.56	112.45	0	0	0
2244.86	2128.4	2220.98	1124.54	2197.1	120.68	0	0	0
2005.96	1936.48	1982.89	1041.59	1959.83	146.7	0	0	0
1630.54	1535.54	1608.14	811.3	1585.73	87.07	0	0	0
1181.55	1079.4	1159.72	559.59	1137.88	39.77	0	0	0
873.86	788.27	852.62	408.66	831.38	29.04	0	0	0
788.32	773.23	765.7	436.32	743.08	99.42	0	0	0
772.34	851.38	748.38	526.79	724.42	202.2	0	0	0
821.77	681	796.87	326.96	0	0	0	0	0
4747.2	4198.28	4655.77	2110.55	4564.35	22.82	0	0	0
3102.82	2917.51	3057.98	1541.47	3013.13	165.43	0	0	0

3284.34	2925.1	3232.19	1470.5	3180.03	15.9	0	0	0
2593.78	2463.93	2545.28	1325.3	2496.77	186.66	0	0	0
2291.2	2218.28	2248.22	1213.47	2205.24	208.65	0	0	0
2547.7	2693.13	2506.36	1573.04	2465.02	452.94	0	0	0
2798.74	3053.17	2759.54	1817.04	2720.34	580.91	0	0	0
2964.84	3989.79	2927.26	2685.98	2889.69	1382.18	2852.11	78.37	0
3405.66	5791.87	3366.64	4303.23	3327.63	2814.59	3288.61	1325.95	0
4206.37	4507.99	4161.37	2633.07	4116.37	758.16	0	0	0
4558.99	6261	4510.72	4243.81	4462.44	2226.62	4414.17	209.43	0
3778.56	6641.49	3736.53	4990.14	3694.49	3338.79	3652.46	1687.44	3610.42
3368.6	6387.76	3328.63	4926.56	3288.67	3465.36	3248.7	2004.16	3208.73
2970.27	5687.69	2932.31	4405.86	2894.34	3124.03	2856.38	1842.2	2818.42
2514.47	4749.71	2480	3668.62	2445.54	2587.53	2411.07	1506.44	2376.6
2148.12	4015.44	2116	3096.91	2083.89	2178.38	2051.77	1259.84	2019.65
1892.62	3512.93	1861.48	2709.35	1830.33	1905.76	1799.18	1102.18	1768.04
1922.58	3546.69	1888.45	2735.38	1854.31	1924.08	1820.17	1112.77	1786.03
2135.19	3924.46	2095.63	3026.74	2056.06	2129.02	2016.5	1231.3	1976.93
2954.2	5480.72	2905.28	4227	2856.37	2973.29	2807.45	1719.58	2758.54
3674.24	6324.8	3557.15	4878	3440.07	3431.2	3322.99	1984.4	3205.9
3108.91	5823.11	3063.77	4491.07	3018.62	3159.04	2973.48	1827	2928.33
3027.33	5682.18	2984.73	4382.38	2942.13	3082.58	2899.52	1782.78	2856.92
3055.01	5747.3	3013.52	4432.6	2972.04	3117.91	2930.55	1803.21	2889.06
3025.13	5696.34	2984.65	4393.3	2944.17	3090.27	2903.69	1787.23	2863.21
3099.16	5841.11	3058.3	4504.96	3017.45	3168.8	2976.59	1832.65	2935.74
2929.32	5516.07	2890.14	4254.27	2850.96	2992.47	2811.78	1730.67	2772.59
2705.9	5087.4	2668.8	3923.66	2631.69	2759.92	2594.59	1596.17	2557.49
2572.76	4844.49	2538.33	3736.31	2503.9	2628.13	2469.47	1519.96	2435.04
2487.58	4693.72	2455.39	3620.03	2423.2	2546.34	2391.01	1472.65	2358.82
2459.07	4642.45	2427.53	3580.49	2396	2518.53	2364.47	1456.57	2332.94
2583.34	4868.21	2549.21	3754.61	2515.07	2641	2480.93	1527.4	2446.79
2630.96	4937.77	2593.89	3808.25	2556.81	2678.74	2519.74	1549.22	2482.66
2751.76	5150.57	2711.39	3972.38	2671.02	2794.18	2630.65	1615.99	2590.29
2730.4	5095.04	2688.56	3929.55	2646.73	2764.06	2604.9	1598.57	2563.06
2741.27	5116.06	2699.35	3945.76	2657.44	2775.46	2615.52	1605.16	2573.61
2843.92	5324.4	2802.35	4106.44	2760.78	2888.48	2719.21	1670.53	2677.64
2912.76	5471.6	2872.28	4219.97	2831.8	2968.34	2791.32	1716.72	2750.84
3048.76	5754.23	3009.49	4437.95	2970.23	3121.67	2930.97	1805.39	2891.7
3048.92	5756.32	3009.86	4439.56	2970.8	3122.8	2931.74	1806.05	2892.67
3062.46	5776.13	3022.57	4454.84	2982.68	3133.55	2942.78	1812.26	2902.89
2990.47	5634.63	2950.86	4345.71	2911.25	3056.78	2871.64	1767.86	2832.03
2870.1	5400.04	2831.19	4164.78	2792.29	2929.52	2753.38	1694.26	2714.48
2947.55	5548.39	2907.9	4279.19	2868.24	3010	2828.59	1740.81	2788.93
2964.86	5583.56	2925.27	4306.32	2885.68	3029.08	2846.08	1751.84	2806.49
2849.82	5334.05	2810.88	4107.76	2771.93	2881.46	2732.99	1655.16	2694.05
2715.48	5022.56	2676.94	3856.15	2638.4	2689.75	2599.86	1523.34	2561.32
2783.71	5031.14	2741.78	3838.53	2699.85	2645.91	2657.91	1453.3	2615.98
3096.59	5599.9	3050.34	4272.46	3004.1	2945.02	2957.85	1617.59	2911.61
3811.2	6914.35	3761.16	5266.79	3711.13	3619.23	3661.1	1971.67	3611.07
3990.53	7341.19	3941.85	5609.95	3893.18	3878.72	3844.5	2147.49	3795.82
3550.45	6490.48	3509.95	4943.92	3469.44	3397.36	3428.93	1850.8	3388.43
4450.16	8214.64	4399.26	6277.42	4348.37	4340.21	4297.48	2402.99	4246.59
3673.3	6832.95	3629.63	5238.01	3585.95	3643.08	3542.28	2048.14	3498.61

3876.88	7052.59	3832.71	5363.29	3788.53	3673.99	3744.36	1984.69	3700.18

:er along the center line A and V are the area and volum of water under certain depth in that cross sectio

t	Z<- 7.5 feet		Z<- 9 feet		Z<- 10.5 feet		Z<- 12 feet	
V(m^3)	A(m^2)	V(m^3)	A(m^2)	V(m^3)	A(m^2)	V(m^3)	A(m^2)	V(m^3)
2170.91	0	0	0	0	0	0	0	0
4030.69	0	0	0	0	0	0	0	0
7509.51	7837.88	2684.47	0	0	0	0	0	0
6628.14	8588.25	879.45	0	0	0	0	0	0
5839.7	8481.84	1967.72	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
683.34	0	0	0	0	0	0	0	0
1396.53	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
1539.11	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
2386.66	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
17154.98	19276.82	8350.63	13923.96	1275.79	0	0	0	0
12757.85	13231.46	4961.46	5175.87	491.04	0	0	0	0
3773.77	5469.23	1271.59	0	0	0	0	0	0
3994.91	6000.18	435.01	0	0	0	0	0	0
4163.52	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
647.44	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
287	0	0	0	0	0	0	0	0
3960.79	3388.43	2438.05	3350.93	915.31	0	0	0	0
942.16	0	0	0	0	0	0	0	0
4656.27	6490.49	1697.6	0	0	0	0	0	0
2824.54	2371.63	1401.87	2337.55	337.38	0	0	0	0
782.69	0	0	0	0	0	0	0	0
1427.4	2513.34	281.72	0	0	0	0	0	0
2152.51	3283.27	660.43	0	0	0	0	0	0
6046.14	6603.3	1559.64	0	0	0	0	0	0
15255.39	17046.46	7500.56	0	0	0	0	0	0
17323.96	18333.67	8981.11	18242.71	638.25	0	0	0	0
15490.07	25427.22	3872.52	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
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	0	0	0
0	0	0	0	0	0	0	0	0
1954.88	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
6240.98	0	0	0	0	0	0	0	0
5922.35	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
8718.83	13051.85	2765.3	0	0	0	0	0	0
14902.34	10433.47	10200.4	10361.56	5498.45	10289.66	796.5	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
3824.14	0	0	0	0	0	0	0	0
1634.53	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1615.75	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1334.52	0	0	0	0	0	0	0	0
6340.2	11977.53	867.29	0	0	0	0	0	0
15185.13	14075.87	8811.55	13971.31	2437.98	0	0	0	0
13368.24	14484.67	6791.93	14377.95	215.62	0	0	0	0
13844.1	13065.44	7924.77	12970.55	2005.45	0	0	0	0
10830.29	12400.24	5199.77	0	0	0	0	0	0
13284.61	19033.34	4602.17	0	0	0	0	0	0
6291.51	0	0	0	0	0	0	0	0
2065.51	0	0	0	0	0	0	0	0
4475.92	0	0	0	0	0	0	0	0
6382.07	13581.18	169.74	0	0	0	0	0	0
1634.83	0	0	0	0	0	0	0	0
3282.67	3036.99	1104.69	1339.6	6.7	0	0	0	0
309.43	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
773.08	0	0	0	0	0	0	0	0
1516.54	2667.79	299.32	0	0	0	0	0	0
2415.25	3731.28	715.29	0	0	0	0	0	0
1228.28	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
361.37	0	0	0	0	0	0	0	0
1600.57	0	0	0	0	0	0	0	0
10837.6	8948.35	6344.69	4583.73	3280.43	2228.97	1354.1	2228.97	334.34
28828.41	13959.34	20538.3	11738.51	14696	9599.32	10015.52	7603.21	6522.08
2745.82	2025.63	1139.42	2025.63	212.69	0	0	0	0
23766.01	14493.95	17135.03	12255.27	11231.62	7906.57	6488.69	7906.57	2871.43
9794.32	7634.23	6308.92	6040.16	3131.27	4017.64	494.31	0	0
8316.14	11138.86	3231.76	0	0	0	0	0	0
1851.72	0	0	0	0	0	0	0	0
895.37	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
671.64	0	0	0	0	0	0	0	0
1475.59	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
23.24	0	0	0	0	0	0	0	0
910.18	0	0	0	0	0	0	0	0
929.99	0	0	0	0	0	0	0	0
2575.08	2219.9	1559.48	2219.9	543.88	0	0	0	0
2708.86	3528.3	411.63	0	0	0	0	0	0
1839.36	0	0	0	0	0	0	0	0
1276.49	0	0	0	0	0	0	0	0
1495.77	0	0	0	0	0	0	0	0
406.87	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
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0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0
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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
771.8	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
1364.85	0	0	0	0	0	0	0	0
599.61	0	0	0	0	0	0	0	0
488.06	0	0	0	0	0	0	0	0
339.6	0	0	0	0	0	0	0	0
624.88	0	0	0	0	0	0	0	0
548.26	0	0	0	0	0	0	0	0
747.39	0	0	0	0	0	0	0	0
1921.61	0	0	0	0	0	0	0	0
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1170.72	0	0	0	0	0	0	0	0
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542.96	0	0	0	0	0	0	0	0
560.36	0	0	0	0	0	0	0	0
425.35	0	0	0	0	0	0	0	0
341.31	0	0	0	0	0	0	0	0
298.6	0	0	0	0	0	0	0	0
301.47	0	0	0	0	0	0	0	0
333.58	0	0	0	0	0	0	0	0
465.86	0	0	0	0	0	0	0	0
537.61	0	0	0	0	0	0	0	0
494.96	0	0	0	0	0	0	0	0
482.99	0	0	0	0	0	0	0	0
488.52	0	0	0	0	0	0	0	0
484.19	0	0	0	0	0	0	0	0
496.49	0	0	0	0	0	0	0	0
468.87	0	0	0	0	0	0	0	0
432.43	0	0	0	0	0	0	0	0
411.78	0	0	0	0	0	0	0	0
398.97	0	0	0	0	0	0	0	0
394.61	0	0	0	0	0	0	0	0
413.8	0	0	0	0	0	0	0	0
419.71	0	0	0	0	0	0	0	0
437.8	0	0	0	0	0	0	0	0
433.08	0	0	0	0	0	0	0	0
434.87	0	0	0	0	0	0	0	0
452.57	0	0	0	0	0	0	0	0
465.09	0	0	0	0	0	0	0	0
489.11	0	0	0	0	0	0	0	0
489.29	0	0	0	0	0	0	0	0
490.97	0	0	0	0	0	0	0	0
478.94	0	0	0	0	0	0	0	0
459	0	0	0	0	0	0	0	0
471.61	0	0	0	0	0	0	0	0
474.6	0	0	0	0	0	0	0	0
428.87	0	0	0	0	0	0	0	0
356.93	0	0	0	0	0	0	0	0
260.68	0	0	0	0	0	0	0	0
290.15	0	0	0	0	0	0	0	0
324.11	0	0	0	0	0	0	0	0
416.25	0	0	0	0	0	0	0	0
304.24	0	0	0	0	0	0	0	0
465.78	0	0	0	0	0	0	0	0
453.21	0	0	0	0	0	0	0	0

295.4	0	0	0	0	0	0	0	0

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From:	Sid Flannery
To:	Xinjian Chen
Cc:	Kym Holzwart; Doug Leeper
Subject:	Re: Bathymetry and shoreline stuff
Date:	Friday, December 3, 2021 2:30:24 PM
Attachments:	BolsterBayou_Area&Volume_with totals for Alan.xls LMR_Area_volume_file__from FSU new.xls LIttle Manatee Area_volume_final_withnotes.xls SWFWMD_FSU_SOW_Final_revise.doc

[EXTERNAL SENDER] Use caution before opening.

Hello Xinjian,

First things first. For several philosophical reasons, I am so disgusted with the Gators firing their football coach before the year was over. I guess Doug and I did not have our annual Dawgs/Gators lunch bet, or he is being kind and not cashing in.

Back to bidness. Attached is EXCEL file that I am 99% sure that Allan used for the area and volume plots, plus a version with notes. See the folder called *area volume* in my Rivers/LMR folder that was on the D drive. We received the precursor of this from FSU, as one version of the spreadsheet says from FSU (also attached). Note that version does not have data for Bolster Bayou, as the FSU EFDC model does not have that bayou as well. But, there is a sub-folder for Bolster Bayou under LMR which contains area volume results I think the District generated and added to the spreadsheet Allan used.

Also attached is the scope of work for FSU, which calls for the area/volume spreadsheet. However, I wonder if this spreadsheet is more exact than the cells used in their EFDC model. The data for the spreadsheet might have come first, then those same data grouped for the model grid (which might not have the same vertical resolution as the spreadsheet). Do you know what I mean - what do you think?

Have a good weekend,
Sid

On Fri, Dec 3, 2021 at 9:29 AM Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us> wrote:

> Thanks Sid!
>
> XinJian

From: Sid Flannery <sidflannery22@gmail.com>
Sent: Friday, December 3, 2021 9:26 AM
To: Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>
Cc: Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
Subject: Re: Bathymetry and shoreline stuff

[EXTERNAL SENDER] Use caution before opening.

Hi Xinjian,

I have a meeting coming up, but can look this afternoon.

This could be a case of "let's go fishin" and you will have access to the same files I have. It was a long time ago, and I assume I submitted Ping Wang files to Allan.

BUT - there is a general volume/area spreadsheet that was created that Allan may have used. I am pretty sure I can find that after lunch and it may match up with those plots, maybe not.

Sid

On Fri, Dec 3, 2021 at 9:18 AM Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us> wrote:

> Good morning Sid,
>
> In your 11/18/2021 email, you attached four files. One of them is called "Little Manatee morphology and vegetation plots.pdf". You mentioned that Allan Willis of Atkins generated those area and volume plots in the file from the bathymetry data. I assume that these were the bathymetry data surveyed by Ping Wang of USF. I am trying to find electric files containing data points for generating these Atkins plots but failed. Do you have these files by any chance? If you have, would you please email them to me?
>
> Thanks,

XinJian

From: Sid Flannery <sidflannery22@gmail.com>
Sent: Thursday, November 18, 2021 2:59 PM
To: Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; MIke Wessel (MWessel@janickienvironmental.com) <MWessel@janickienvironmental.com>
Subject: Bathymetry and shoreline stuff

[EXTERNAL SENDER] Use caution before opening.

Hello all,

I just talked with Doug about EFDC model output files and will reply about that tomorrow morning. In short, I can wait for the revised model runs.

In the meantime, Doug and I were talking about the bathymetry data for the Little Manatee and I brought up the bathymetry report and data sets that Ping Wang of USF did for the District. I am sure that you all, especially Xinjian, are aware of that. This is the bathymetry data from USF that were provided to FSU for construction of the EFDC model. Again, I expect you have those files, and if not, Xinjian can find them in the files I left behind.

I have attached three jpgs from the USF bathymetry work plus the WORD file of the final USF report. It looks like USF did go into the side channels quite a bit.

I have also attached a pdf of some combined graphs taken from the bathymetry data that Allan Willis generated for the District when he was Atkins. I think the area and volume plots could be helpful.

There are also shoreline plots, but I am thinking they must have come from the vegetation work that FWRI did for the District as the vegetation is classified into different groups. The vegetation plots are more than you need, but it was easier than sorting them out.

As I told Doug, I will submit to the District a document by the Monday after Thanksgiving that lists data and graphics I think would be useful, including some of these graphics.

Sid

SCOPE OF WORK
HYDRODYNAMIC MODELING OF LITTLE MANATEE RIVER

BACKGROUND

Sections 373.042 and 373.0421 of the Florida Status require Water Management Districts to establish and implement minimum flows and levels (MFLs) for certain priority water bodies within their respective jurisdictional boundaries. The Florida Status defines an MFL is defined as: *the minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.*

The Little Manatee River (LMR) is one of the priority water bodies for that MFLs are to be adopted by the Southwest Florida Water Management District. This project is to support the adoption of MFLs for the tidal reach of the LMR. The river extends approximately 40 miles from its mouth on the southeast corner of Tampa Bay near Ruskin to its eastward origin in southeastern Hillsborough County. The drainage area is approximately 225 square miles. Tidal effects are discernable up to 15 miles from Tampa Bay. Key elements for adopting minimum flows for the LMR is a sound understanding of salinity transport processes and how freshwater flows affect salinity distributions and mixing times (e.g., residence times) in the riverine estuary. The present project involves the development of a hydrodynamic model for the LMR to simulate salinity transport processes and residence times in the tidal river. ~~and to quantify the effects of freshwater inflows on these characteristics of the river.~~

TASKS

The UNIVERSITY shall complete the following tasks:

Task I: Project Kick-Off Meeting

The UNIVERSITY shall attend an initial project kick-off meeting with DISTRICT staff to review the overall project objectives, the scope of work, project schedules, and other project-related matters. The UNIVERSITY shall take and submit minutes for the project kick-off meeting.

Task II Processing Data

Sub-Task II.1 Processing Bathymetric Data

The UNIVERSITY shall obtain, from the DISITRICT, bathymetric data measured in the LMR. The UNIVERSITY shall process these data using a GIS (Geophysical Information System) software package and/or an appropriate software package. The UNIVERSITY will report to the DISTRICT on the adequacy of bathymetric data for the study area. Pending UNIVERSITY's findings, the DISTRICT will be responsible for gathering new bathymetric data.

The bathymetric cross-sectional survey points shall be extended to include 1'-, 3'-, and 5'-contours above NGVD 1929 wherever these topographic contour lines are available. Based on measured bathymetric and available topographic data, the UNIVERSITY shall generate a grid system for the LMR hydrodynamic model. It is anticipated that the lengths of the cells along the longitudinal dimension of the estuary will range between 100 and 500 meters. The selection of the final model grid will be submitted to and approved by the DISTRICT. Under the DISTRICT's direction, the UNIVERSITY shall also generate an area-volume spreadsheet using processed bathymetric/topographic information of the grid system.

Sub-Task II.2 Processing USGS Data

The United State Geological Survey (USGS) has several data collection sites along the LMR: two above the tidal reach that measure streamflow and three along the tidal reach that measure water level, specific conductance, and temperature. The most downstream streamflow gauge measures approximately 67% of the entire Little Manatee River watershed. The DISTRICT will provide data from these sites for the period from April 2004 through July 2005 to UNIVERSITY by October 1, 2005. The UNIVERSITY shall graph and access the quality of these data. If some problematic data are identified, the UNIVERSITY shall contact the DISTRICT and/or the USGS to resolve these data issues. The USGS data will be used either for boundary conditions of the model or for model calibrations/verifications.

Sub-Task II.3 Processing Meteorological Data

The UNIVERSITY shall obtain, from the DISTRICT, meteorological data, including rainfall, wind, air temperature, air humidity, and solar radiation. The UNIVERSITY shall graph these data to identify any problems with the data. If problems are found in the data, the UNIVERSITY shall contact the DISTRICT to resolve these problems before they are used in the model.

Task III Hydrodynamic Modeling

Under the DISTRICT's direction, the UNIVERSITY will develop an LMR hydrodynamic model based on either the DISTRICT LAMFE model or another proper hydrodynamic model. The UNIVERSITY shall obtain approval from the DISTRICT on the simulation domain. The UNIVERSITY shall perform hydrodynamic simulations for a period of at least 15 months beginning in April 2004. The model will be used to evaluate salinity distributions, water temperature, and residence times in segments of the LMR. It is important that the hydrodynamic model is well calibrated and verified.

The DISTRICT will provide estimates of watershed runoff from the un-gauged 33% of the watershed to the UNIVERSITY for the period April 2004 through July

2005. The DISTRICT will provide preliminary estimates of un-gauged flows to the UNIVERSITY by October 1, 2005. Final values of un-gauged flows for the period April 2004 through July 2005 will be provided to the UNIVERSITY by December 20, 2005.

The DISTRICT will recommend that a baseline freshwater inflow scenario first be run, followed by three scenarios with the freshwater inflows reduced by different amounts. The model will be used to calculate salinity distributions and temperature regimes throughout the estuary. ~~and residence times in different segments of the estuary for the series of freshwater inflow scenarios.~~ It may be necessary to run some simulations for a three to five month period outside the calibration period in order to simulate the effects of low freshwater inflows. If such simulations are done, The DISTRICT will provide boundary conditions, streamflow, ungaged runoff, and meteorlogical data for this other period to the UNIVERSITY.

The output for the model will consist of simulated variables (stage, salinity, temperature, and water velocity) in all cells with a time interval of one hour. The UNIVERSITY will construct databases of model output for the baseline scenario and up to three flow reduction scenarios. The model output for each scenario will be provide to the DISTRICT in a mutually agreed format.

The UNIVERISTY will also required to produce graphic and tabular output for up to six periods in the baseline and three flow reduction scenarios. These outputs may include graphics of salinity distributions in the estuary and tables of volumes of water in different salinity zones.

The UNIVERSITY shall compute residence time as Pulse Residence Time (PRT) for one-kilometer segments and Estuarine Residence Time (ERT) for the entire estuary. Both ERT and PRT will be calculated for up 16 rates of freshwater inflow. The output of this effort will be a spreadsheet of values for PRT in each river segment and ERT for the entire estuary for all rates of flow examined.

Task IV Final Project Report

The UNIVERSITY shall submit a draft project report for the DISTRICT's review. The DISTRICT shall provide written comments on the draft report within two weeks of receipt. The UNIVERSITY shall incorporate the DISTRICT's comments into the final version of the project report that shall include at the minimum the following sections:

1. Executive summary,
2. Introduction,
3. Field Measurements (the location of the measurement, instruments used, plots of measured data, some preliminary analyses, etc.),

4. Hydrodynamic Modeling (brief description of model theory; boundary conditions used to driving the model, etc.),
5. Model Results (graphical and/or tabular output of model results showing comparisons with measured data, results of baseline runs vs. those of flow reductions, salinity distributions at selected time points, residence times for various flow scenarios, discussions, etc.),
6. Conclusions, and
7. References.

Task V General Administration

The UNIVERSITY shall submit a series of brief bi-monthly progress reports to the DISTRICT updating project status.

DELIVERABLES

The UNIVERSITY shall provide the DISTRICT with the following items:

1. Electronic files containing all measured data in the ASCII format,
2. The hydrodynamic model used,
3. Input files for model simulations,
4. Results of model simulations and residence time analyses specified in Task II in either the ASCII format or the MS Excel format,
5. All graphic files for figures included in the final report,
6. The final project report in the MS WORD and pdf formats, and
7. Five (5) hard copies of the final project report.

If the hydrodynamic model is not developed on a Microsoft Windows system (95, 98, 2000, or NT), it shall be adapted to a Microsoft Windows system.

SCHEDULE

The contract shall terminate on December 31, 2006. Starting from the date when Notice To Proceed (NTP) is issued, the UNIVERSITY shall complete each task within the time frame specified in the following table:

Task	From NTP
I. Kick-Off Meeting	1 Week
II. Processing Data	1 Months
III. Hydrodynamic Modeling	7 Months
IV. Final Project Report	8 Months
V. General Administration	Ongoing

BUDGET (Adjust costs as determined by Univeristy, kick off meeting is too much)

Task	Budget

I. Kick-Off Meeting	$1,000
II. Processing Data	$12,000
III. Hydrodynamic Modeling	$75,000
IV. Final Project Report	$9,000
V. General Administration	$3,000
Total	$100,000

		DZ(m)			1.00	1.00	1.00	1.00
		Z_Top		-11.07	-10.07	-9.07	-8.07	-7.07
		Z(m)			-10.57	-9.57	-8.57	-7.57
		Z_Bottom			-11.07	-10.07	-9.07	-8.07
		Volume(Hec-m)			1.4704	3.8569	5.7398	6.2988
		Cul_Vol		0	1.4704	5.3273	11.0671	17.3659
	DX(km)	X_end	RivKM_XJC	RivKM_PBSJ				
1	0.100	0.100	0.050	-0.018	0.0304	0.4770	0.7266	0.8252
2	0.100	0.2000	0.150	0.083	0.0844	0.4967	0.6978	0.8012
3	0.100	0.3000	0.250	0.182	0.1385	0.5165	0.6691	0.7772
4	0.100	0.4000	0.350	0.282	0.2214	0.5777	0.6860	0.7927
5	0.100	0.5000	0.450	0.383	0.4200	0.8053	0.8852	0.9663
6	0.100	0.6000	0.550	0.492	0.5757	0.9837	1.0413	1.1024
7	0.100	0.7000	0.650	0.593	0.0000	0.0000	1.0338	1.0338
8	0.100	0.8000	0.750	0.693	0.0000	0.0000	0.0000	0.0000
9	0.100	0.9000	0.850	0.796	0.0000	0.0000	0.0000	0.0000
10	0.100	1.0000	0.950	0.900	0.0000	0.0000	0.0000	0.0000
11	0.100	1.1000	1.050	1.001	0.0000	0.0000	0.0000	0.0000
12	0.100	1.2000	1.150	1.101	0.0000	0.0000	0.0000	0.0000
13	0.100	1.3000	1.250	1.202	0.0000	0.0000	0.0000	0.0000
14	0.100	1.4000	1.350	1.305	0.0000	0.0000	0.0000	0.0000
15	0.100	1.5000	1.450	1.410	0.0000	0.0000	0.0000	0.0000
16	0.100	1.6000	1.550	1.512	0.0000	0.0000	0.0000	0.0000
17	0.100	1.7000	1.650	1.609	0.0000	0.0000	0.0000	0.0000
18	0.100	1.8000	1.750	1.720	0.0000	0.0000	0.0000	0.0000
19	0.100	1.9000	1.850	1.872	0.0000	0.0000	0.0000	0.0000
20	0.100	2.0000	1.950	2.001	0.0000	0.0000	0.0000	0.0000
21	0.100	2.1000	2.050	2.124	0.0000	0.0000	0.0000	0.0000
22	0.100	2.2000	2.150	2.207	0.0000	0.0000	0.0000	0.0000
23	0.100	2.3000	2.250	2.303	0.0000	0.0000	0.0000	0.0000
24	0.100	2.4000	2.350	2.401	0.0000	0.0000	0.0000	0.0000
25	0.100	2.5000	2.450	2.503	0.0000	0.0000	0.0000	0.0000
26	0.100	2.6000	2.550	2.603	0.0000	0.0000	0.0000	0.0000
27	0.100	2.7000	2.650	2.703	0.0000	0.0000	0.0000	0.0000
28	0.100	2.8000	2.750	2.802	0.0000	0.0000	0.0000	0.0000
29	0.100	2.9000	2.850	2.902	0.0000	0.0000	0.0000	0.0000
30	0.100	3.0000	2.950	3.003	0.0000	0.0000	0.0000	0.0000
31	0.100	3.1000	3.050	3.105	0.0000	0.0000	0.0000	0.0000
32	0.100	3.2000	3.150	3.205	0.0000	0.0000	0.0000	0.0000
33	0.100	3.3000	3.250	3.306	0.0000	0.0000	0.0000	0.0000
34	0.100	3.4000	3.350	3.406	0.0000	0.0000	0.0000	0.0000
35	0.100	3.5000	3.450	3.506	0.0000	0.0000	0.0000	0.0000
36	0.100	3.6000	3.550	3.609	0.0000	0.0000	0.0000	0.0000
37	0.100	3.7000	3.650	3.709	0.0000	0.0000	0.0000	0.0000
38	0.100	3.8000	3.750	3.808	0.0000	0.0000	0.0000	0.0000
39	0.100	3.9000	3.850	3.909	0.0000	0.0000	0.0000	0.0000
40	0.100	4.0000	3.950	4.008	0.0000	0.0000	0.0000	0.0000
41	0.100	4.1000	4.050	4.108	0.0000	0.0000	0.0000	0.0000
42	0.100	4.2000	4.150	4.208	0.0000	0.0000	0.0000	0.0000
43	0.100	4.3000	4.250	4.307	0.0000	0.0000	0.0000	0.0000
44	0.100	4.4000	4.350	4.407	0.0000	0.0000	0.0000	0.0000

45	0.100	4.5000	4.450	4.508	0.0000	0.0000	0.0000	0.0000
46	0.100	4.6000	4.550	4.610	0.0000	0.0000	0.0000	0.0000
47	0.100	4.7000	4.650	4.709	0.0000	0.0000	0.0000	0.0000
48	0.100	4.8000	4.750	4.810	0.0000	0.0000	0.0000	0.0000
49	0.100	4.9000	4.850	4.911	0.0000	0.0000	0.0000	0.0000
50	0.100	5.0000	4.950	5.011	0.0000	0.0000	0.0000	0.0000
51	0.100	5.1000	5.050	5.109	0.0000	0.0000	0.0000	0.0000
52	0.100	5.2000	5.150	5.211	0.0000	0.0000	0.0000	0.0000
53	0.100	5.3000	5.250	5.313	0.0000	0.0000	0.0000	0.0000
54	0.100	5.4000	5.350	5.415	0.0000	0.0000	0.0000	0.0000
55	0.100	5.5000	5.450	5.514	0.0000	0.0000	0.0000	0.0000
56	0.100	5.6000	5.550	5.614	0.0000	0.0000	0.0000	0.0000
57	0.100	5.7000	5.650	5.713	0.0000	0.0000	0.0000	0.0000
58	0.100	5.8000	5.750	5.813	0.0000	0.0000	0.0000	0.0000
59	0.100	5.9000	5.850	5.913	0.0000	0.0000	0.0000	0.0000
60	0.100	6.0000	5.950	6.013	0.0000	0.0000	0.0000	0.0000
61	0.100	6.1000	6.050	6.114	0.0000	0.0000	0.0000	0.0000
62	0.100	6.2000	6.150	6.215	0.0000	0.0000	0.0000	0.0000
63	0.100	6.3000	6.250	6.318	0.0000	0.0000	0.0000	0.0000
64	0.100	6.4000	6.350	6.418	0.0000	0.0000	0.0000	0.0000
65	0.100	6.5000	6.450	6.519	0.0000	0.0000	0.0000	0.0000
66	0.100	6.6000	6.550	6.618	0.0000	0.0000	0.0000	0.0000
67	0.100	6.7000	6.650	6.712	0.0000	0.0000	0.0000	0.0000
68	0.100	6.8000	6.750	6.809	0.0000	0.0000	0.0000	0.0000
69	0.100	6.9000	6.850	6.910	0.0000	0.0000	0.0000	0.0000
70	0.100	7.0000	6.950	7.011	0.0000	0.0000	0.0000	0.0000
71	0.100	7.1000	7.050	7.110	0.0000	0.0000	0.0000	0.0000
72	0.100	7.2000	7.150	7.209	0.0000	0.0000	0.0000	0.0000
73	0.100	7.3000	7.250	7.310	0.0000	0.0000	0.0000	0.0000
74	0.100	7.4000	7.350	7.410	0.0000	0.0000	0.0000	0.0000
75	0.100	7.5000	7.450	7.510	0.0000	0.0000	0.0000	0.0000
76	0.100	7.6000	7.550	7.610	0.0000	0.0000	0.0000	0.0000
77	0.100	7.7000	7.650	7.711	0.0000	0.0000	0.0000	0.0000
78	0.100	7.8000	7.750	7.811	0.0000	0.0000	0.0000	0.0000
79	0.100	7.9000	7.850	7.913	0.0000	0.0000	0.0000	0.0000
80	0.100	8.0000	7.950	8.011	0.0000	0.0000	0.0000	0.0000
81	0.100	8.1000	8.050	8.113	0.0000	0.0000	0.0000	0.0000
82	0.100	8.2000	8.150	8.211	0.0000	0.0000	0.0000	0.0000
83	0.100	8.3000	8.250	8.312	0.0000	0.0000	0.0000	0.0000
84	0.100	8.4000	8.350	8.412	0.0000	0.0000	0.0000	0.0000
85	0.100	8.5000	8.450	8.512	0.0000	0.0000	0.0000	0.0000
86	0.100	8.6000	8.550	8.612	0.0000	0.0000	0.0000	0.0000
87	0.100	8.7000	8.650	8.713	0.0000	0.0000	0.0000	0.0000
88	0.100	8.8000	8.750	8.813	0.0000	0.0000	0.0000	0.0000
89	0.100	8.9000	8.850	8.915	0.0000	0.0000	0.0000	0.0000
90	0.100	9.0000	8.950	9.018	0.0000	0.0000	0.0000	0.0000
91	0.100	9.1000	9.050	9.119	0.0000	0.0000	0.0000	0.0000
92	0.100	9.2000	9.150	9.219	0.0000	0.0000	0.0000	0.0000
93	0.100	9.3000	9.250	9.319	0.0000	0.0000	0.0000	0.0000
94	0.100	9.4000	9.350	9.410	0.0000	0.0000	0.0000	0.0000
95	0.100	9.5000	9.450	9.508	0.0000	0.0000	0.0000	0.0000
96	0.100	9.6000	9.550	9.609	0.0000	0.0000	0.0000	0.0000

97	0.100	9.7000	9.650	9.707	0.0000	0.0000	0.0000	0.0000
98	0.100	9.8000	9.750	9.807	0.0000	0.0000	0.0000	0.0000
99	0.100	9.9000	9.850	9.907	0.0000	0.0000	0.0000	0.0000
100	0.100	10.0000	9.950	10.003	0.0000	0.0000	0.0000	0.0000
101	0.100	10.1000	10.050	10.110	0.0000	0.0000	0.0000	0.0000
102	0.100	10.2000	10.150	10.207	0.0000	0.0000	0.0000	0.0000
103	0.100	10.3000	10.250	10.307	0.0000	0.0000	0.0000	0.0000
104	0.100	10.4000	10.350	10.408	0.0000	0.0000	0.0000	0.0000
105	0.100	10.5000	10.450	10.505	0.0000	0.0000	0.0000	0.0000
106	0.100	10.6000	10.550	10.602	0.0000	0.0000	0.0000	0.0000
107	0.100	10.7000	10.650	10.703	0.0000	0.0000	0.0000	0.0000
108	0.100	10.8000	10.750	10.804	0.0000	0.0000	0.0000	0.0000
109	0.100	10.9000	10.850	10.902	0.0000	0.0000	0.0000	0.0000
110	0.100	11.0000	10.950	11.003	0.0000	0.0000	0.0000	0.0000
111	0.100	11.1000	11.050	11.102	0.0000	0.0000	0.0000	0.0000
112	0.100	11.2000	11.150	11.202	0.0000	0.0000	0.0000	0.0000
113	0.100	11.3000	11.250	11.302	0.0000	0.0000	0.0000	0.0000
114	0.100	11.4000	11.350	11.402	0.0000	0.0000	0.0000	0.0000
115	0.100	11.5000	11.450	11.503	0.0000	0.0000	0.0000	0.0000
116	0.100	11.6000	11.550	11.603	0.0000	0.0000	0.0000	0.0000
117	0.100	11.7000	11.650	11.704	0.0000	0.0000	0.0000	0.0000
118	0.100	11.8000	11.750	11.803	0.0000	0.0000	0.0000	0.0000
119	0.100	11.9000	11.850	11.904	0.0000	0.0000	0.0000	0.0000
120	0.100	12.0000	11.950	12.005	0.0000	0.0000	0.0000	0.0000
121	0.100	12.1000	12.050	12.106	0.0000	0.0000	0.0000	0.0000
122	0.100	12.2000	12.150	12.213	0.0000	0.0000	0.0000	0.0000
123	0.100	12.3000	12.250	12.296	0.0000	0.0000	0.0000	0.0000
124	0.100	12.4000	12.350	12.400	0.0000	0.0000	0.0000	0.0000
125	0.100	12.5000	12.450	12.490	0.0000	0.0000	0.0000	0.0000
126	0.100	12.6000	12.550	12.582	0.0000	0.0000	0.0000	0.0000
127	0.100	12.7000	12.650	12.683	0.0000	0.0000	0.0000	0.0000
128	0.100	12.8000	12.750	12.789	0.0000	0.0000	0.0000	0.0000
129	0.100	12.9000	12.850	12.892	0.0000	0.0000	0.0000	0.0000
130	0.100	13.0000	12.950	12.992	0.0000	0.0000	0.0000	0.0000
131	0.100	13.1000	13.050	13.091	0.0000	0.0000	0.0000	0.0000
132	0.100	13.2000	13.150	13.191	0.0000	0.0000	0.0000	0.0000
133	0.100	13.3000	13.250	13.296	0.0000	0.0000	0.0000	0.0000
134	0.100	13.4000	13.350	13.426	0.0000	0.0000	0.0000	0.0000
135	0.100	13.5000	13.450	13.493	0.0000	0.0000	0.0000	0.0000
136	0.100	13.6000	13.550	13.600	0.0000	0.0000	0.0000	0.0000
137	0.100	13.7000	13.650	13.700	0.0000	0.0000	0.0000	0.0000
138	0.100	13.8000	13.750	13.800	0.0000	0.0000	0.0000	0.0000
139	0.100	13.9000	13.850	13.899	0.0000	0.0000	0.0000	0.0000
140	0.100	14.0000	13.950	13.996	0.0000	0.0000	0.0000	0.0000
141	0.100	14.1000	14.050	14.094	0.0000	0.0000	0.0000	0.0000
142	0.100	14.2000	14.150	14.185	0.0000	0.0000	0.0000	0.0000
143	0.100	14.3000	14.250	14.285	0.0000	0.0000	0.0000	0.0000
144	0.100	14.4000	14.350	14.391	0.0000	0.0000	0.0000	0.0000
145	0.100	14.5000	14.450	14.495	0.0000	0.0000	0.0000	0.0000
146	0.100	14.6000	14.550	14.591	0.0000	0.0000	0.0000	0.0000
147	0.100	14.7000	14.650	14.689	0.0000	0.0000	0.0000	0.0000
148	0.100	14.8000	14.750	14.781	0.0000	0.0000	0.0000	0.0000

149	0.100	14.9000	14.850	14.879	0.0000	0.0000	0.0000	0.0000
150	0.100	15.0000	14.950	14.977	0.0000	0.0000	0.0000	0.0000
151	0.100	15.1000	15.050	15.074	0.0000	0.0000	0.0000	0.0000
152	0.100	15.2000	15.150	15.171	0.0000	0.0000	0.0000	0.0000
153	0.100	15.3000	15.250	15.269	0.0000	0.0000	0.0000	0.0000
154	0.100	15.4000	15.350	15.366	0.0000	0.0000	0.0000	0.0000
155	0.100	15.5000	15.450	15.465	0.0000	0.0000	0.0000	0.0000
156	0.100	15.6000	15.550	15.565	0.0000	0.0000	0.0000	0.0000
157	0.100	15.7000	15.650	15.662	0.0000	0.0000	0.0000	0.0000
158	0.100	15.8000	15.750	15.762	0.0000	0.0000	0.0000	0.0000
159	0.100	15.9000	15.850	15.855	0.0000	0.0000	0.0000	0.0000
160	0.100	16.0000	15.950	15.941	0.0000	0.0000	0.0000	0.0000
161	0.100	16.1000	16.050	16.041	0.0000	0.0000	0.0000	0.0000
162	0.100	16.2000	16.150	16.151	0.0000	0.0000	0.0000	0.0000
163	0.100	16.3000	16.250	16.250	0.0000	0.0000	0.0000	0.0000
164	0.100	16.4000	16.350	16.348	0.0000	0.0000	0.0000	0.0000
165	0.100	16.5000	16.450	16.448	0.0000	0.0000	0.0000	0.0000
166	0.100	16.6000	16.550	16.548	0.0000	0.0000	0.0000	0.0000
167	0.100	16.7000	16.650	16.646	0.0000	0.0000	0.0000	0.0000
168	0.100	16.8000	16.750	16.747	0.0000	0.0000	0.0000	0.0000
169	0.100	16.9000	16.850	16.843	0.0000	0.0000	0.0000	0.0000
170	0.100	17.0000	16.950	16.946	0.0000	0.0000	0.0000	0.0000
171	0.100	17.1000	17.050	17.046	0.0000	0.0000	0.0000	0.0000
172	0.100	17.2000	17.150	17.143	0.0000	0.0000	0.0000	0.0000
173	0.100	17.3000	17.250	17.241	0.0000	0.0000	0.0000	0.0000
174	0.100	17.4000	17.350	17.334	0.0000	0.0000	0.0000	0.0000
175	0.100	17.5000	17.450	17.433	0.0000	0.0000	0.0000	0.0000
176	0.100	17.6000	17.550	17.528	0.0000	0.0000	0.0000	0.0000
177	0.100	17.7000	17.650	17.629	0.0000	0.0000	0.0000	0.0000
178	0.069	17.7690	17.735	17.705	0.0000	0.0000	0.0000	0.0000

1.60	1.00	0.60	0.50	0.40	0.40	0.40	0.40	0.40
-5.47	-4.47	-3.87	-3.37	-2.97	-2.57	-2.17	-1.77	-1.37
-6.27	-4.97	-4.17	-3.62	-3.17	-2.77	-2.37	-1.97	-1.57
-7.07	-5.47	-4.47	-3.87	-3.37	-2.97	-2.57	-2.17	-1.77
12.1888	8.8133	5.9104	5.7450	6.3565	10.7449	16.1985	24.3509	38.8004
29.5547	38.3680	44.2784	50.0233	56.3798	67.1248	83.3233	107.6742	146.4746

1.4304	0.9528	0.5921	0.5112	0.4225	0.4347	0.4496	0.4655	0.4846
1.4112	0.9564	0.5968	0.5146	0.4244	0.4361	0.4500	0.4648	0.4819
1.3920	0.9599	0.6016	0.5180	0.4262	0.4374	0.4504	0.4640	0.4792
1.4298	0.9951	0.6250	0.5373	0.4411	0.4522	0.4648	0.4782	0.4917
1.6958	1.1571	0.7230	0.6201	0.5084	0.5204	0.5354	0.5515	0.5652
1.9043	1.2840	0.7999	0.6686	0.5349	0.5608	0.5810	0.6030	0.6292
1.6541	1.0338	0.6203	0.5169	0.4135	0.5003	0.5359	0.5751	0.6594
1.1685	0.7303	0.4382	0.3652	0.2921	0.4398	0.4908	0.5472	0.6896
0.0000	0.4269	0.2561	0.2135	0.1708	0.3793	0.4457	0.5194	0.7197
0.0000	0.0000	0.0000	0.0617	0.0494	0.3188	0.4006	0.4916	0.7498
0.0000	0.0000	0.0000	0.0000	0.0260	0.2841	0.3822	0.4823	0.7003
0.0000	0.0000	0.0000	0.0000	0.0000	0.2555	0.3700	0.4775	0.6318
0.0000	0.0000	0.0000	0.0000	0.0000	0.2270	0.3578	0.4727	0.5633
0.0000	0.0000	0.0000	0.0000	0.1178	0.2536	0.3739	0.4714	0.5930
0.0000	0.0000	0.0000	0.0000	0.1178	0.2808	0.3902	0.4702	0.6235
0.0000	0.0000	0.0000	0.0124	0.1178	0.3079	0.4066	0.4690	0.6540
0.0000	0.0000	0.0000	0.0000	0.0959	0.2932	0.4234	0.4932	0.6772
0.0000	0.0000	0.0000	0.0000	0.0615	0.2548	0.4405	0.5318	0.6963
0.0000	0.0000	0.0000	0.0000	0.0504	0.2170	0.4017	0.4974	0.6497
0.0000	0.0000	0.0000	0.0000	0.0000	0.1794	0.3358	0.4275	0.5714
0.0000	0.0000	0.0000	0.0000	0.0000	0.1418	0.2699	0.3576	0.4931
0.0000	0.0000	0.0000	0.0000	0.0000	0.1212	0.2337	0.3058	0.4694
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2337	0.2760	0.5122
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2337	0.2462	0.5551
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2164	0.5979
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1781	0.5615
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1372	0.5008
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0964	0.4401
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0555	0.3794
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0665	0.3347
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0871	0.2929
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0400	0.1077	0.2510
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0400	0.1215	0.2243
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0400	0.1215	0.2280
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1215	0.2318
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1215	0.2356
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1215	0.2394
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2431
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2469
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2483
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0743	0.2486
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0748	0.2478
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0781	0.2402
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0814	0.2327

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0846	0.2253
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2190
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2142
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0434
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1318
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2180
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1325	0.2822
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1325	0.2794
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0460	0.1230	0.2289
0.0000	0.0000	0.0000	0.0000	0.0000	0.0427	0.0665	0.1271	0.2502
0.0000	0.0000	0.0000	0.0000	0.0000	0.0427	0.0826	0.1373	0.2598
0.0000	0.0000	0.0000	0.0000	0.0000	0.0427	0.0897	0.1595	0.2464
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0908	0.1504	0.2504
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1385	0.2344
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1374
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0588
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0692
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0796
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0846
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0840
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2429
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3193
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1124	0.2925
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1252	0.2646
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0815	0.1495	0.2356
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0492	0.1536	0.2190
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0263	0.1506	0.2060
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0635	0.1337	0.1988
0.0000	0.0000	0.0000	0.0000	0.0000	0.0403	0.0941	0.1521	0.2082
0.0000	0.0000	0.0000	0.0000	0.0000	0.0403	0.0856	0.1603	0.2120
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0550	0.1557	0.2276
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1430	0.3277
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1335	0.3202
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1258	0.2545
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1169	0.2148
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1053	0.2300
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0992	0.1155	0.2140
0.0000	0.0000	0.0000	0.0000	0.0000	0.0468	0.0979	0.1389	0.1807
0.0000	0.0000	0.0000	0.0000	0.0000	0.0348	0.0868	0.1439	0.1866
0.0000	0.0000	0.0000	0.0000	0.0000	0.0228	0.0756	0.1488	0.1926
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1488	0.2348
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0975	0.2602
0.0000	0.0000	0.0000	0.0000	0.0000	0.0343	0.0534	0.0975	0.2446
0.0000	0.0000	0.0000	0.0000	0.0164	0.0407	0.0724	0.1089	0.2128
0.0000	0.0000	0.0000	0.0000	0.0297	0.0534	0.1098	0.1313	0.1654
0.0000	0.0000	0.0000	0.0000	0.0000	0.0534	0.0858	0.1319	0.1823
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0813	0.1364	0.1958

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0938	0.1444	0.2060
0.0000	0.0000	0.0405	0.0589	0.0630	0.0778	0.0997	0.1271	0.1530
0.0000	0.0000	0.0000	0.0520	0.0416	0.0416	0.1082	0.1555	0.1928
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1162	0.1791	0.2333
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0894	0.0894	0.1455
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0728	0.0890	0.1378
0.0000	0.0000	0.0000	0.0000	0.0000	0.0086	0.0728	0.1267	0.1644
0.0000	0.0000	0.0000	0.0000	0.0562	0.0562	0.0926	0.1306	0.1540
0.0000	0.0000	0.0000	0.0000	0.0817	0.0817	0.0988	0.1282	0.1465
0.0000	0.0000	0.0000	0.0000	0.0540	0.0664	0.0890	0.1331	0.1547
0.0000	0.0000	0.0000	0.0232	0.0540	0.0929	0.1081	0.1314	0.1420
0.0000	0.0000	0.0000	0.0232	0.0521	0.0759	0.1021	0.1155	0.1236
0.0000	0.0000	0.0000	0.0000	0.0507	0.0640	0.0974	0.1073	0.1183
0.0000	0.0000	0.0000	0.0000	0.0000	0.0656	0.0963	0.1194	0.1476
0.0000	0.0000	0.0000	0.0000	0.0000	0.0600	0.0870	0.1131	0.1467
0.0000	0.0000	0.0000	0.0000	0.0186	0.0433	0.0652	0.0826	0.1032
0.0000	0.0000	0.0000	0.0000	0.0000	0.0296	0.0554	0.1265	0.1456
0.0000	0.0000	0.0000	0.0000	0.0000	0.0175	0.0458	0.1632	0.1820
0.0000	0.0000	0.0000	0.0000	0.0000	0.0175	0.0372	0.1459	0.1753
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0287	0.1286	0.1686
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0202	0.1112	0.1619
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0117	0.0940	0.1552
0.0000	0.0000	0.0000	0.0000	0.0278	0.0738	0.0764	0.1050	0.1247
0.0000	0.0000	0.0000	0.0000	0.0278	0.0655	0.0930	0.1141	0.1242
0.0000	0.0000	0.0000	0.0000	0.0278	0.0536	0.0886	0.1223	0.1368
0.0000	0.0000	0.0000	0.0000	0.0000	0.0536	0.0598	0.0942	0.1368
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0310	0.0662	0.1368
0.0000	0.0000	0.0000	0.0924	0.0739	0.0739	0.0739	0.0956	0.1304
0.0000	0.0448	0.0895	0.1066	0.0885	0.0966	0.1054	0.1195	0.1253
0.0000	0.0000	0.0685	0.0571	0.0457	0.0559	0.0707	0.1088	0.1272
0.0000	0.0000	0.0000	0.0000	0.0028	0.0152	0.0360	0.0980	0.1291
0.0000	0.0000	0.0000	0.0000	0.0106	0.0236	0.0395	0.0793	0.1042
0.0000	0.0000	0.0000	0.0000	0.0178	0.0313	0.0432	0.0638	0.0838
0.0000	0.0000	0.0000	0.0000	0.0178	0.0301	0.0472	0.0718	0.0976
0.0000	0.0000	0.0959	0.0800	0.0640	0.0640	0.0803	0.1024	0.1222
0.1027	0.1361	0.1264	0.1358	0.1296	0.1296	0.1400	0.1534	0.1566
0.0000	0.1361	0.1264	0.1060	0.0848	0.0848	0.1100	0.1247	0.1302
0.0000	0.0000	0.0000	0.0000	0.0000	0.0298	0.0708	0.0876	0.0976
0.0000	0.0000	0.0000	0.0697	0.0647	0.0647	0.0942	0.1036	0.1091
0.0000	0.0000	0.0195	0.0697	0.0953	0.0996	0.1177	0.1198	0.1206
0.0000	0.0000	0.0000	0.0361	0.0784	0.0960	0.1072	0.1101	0.1109
0.0000	0.0000	0.0000	0.0129	0.0607	0.0846	0.0953	0.1002	0.1020
0.0000	0.0000	0.0000	0.0000	0.0425	0.0602	0.0833	0.0918	0.0961
0.0000	0.0000	0.0000	0.0000	0.0372	0.0448	0.0791	0.0880	0.0928
0.0000	0.0000	0.0000	0.0000	0.0000	0.0330	0.0780	0.0862	0.0906
0.0000	0.0000	0.0000	0.0000	0.0506	0.0506	0.0823	0.0882	0.0919
0.0000	0.0000	0.0000	0.0931	0.0792	0.0792	0.0888	0.0916	0.0945
0.0000	0.0000	0.0000	0.0000	0.0843	0.0844	0.0844	0.0989	0.1044
0.0000	0.0000	0.0000	0.0000	0.0000	0.0668	0.0767	0.1016	0.1095
0.0000	0.0000	0.0000	0.0513	0.0565	0.0668	0.0754	0.0870	0.0913
0.0000	0.0000	0.0469	0.0402	0.0560	0.0654	0.0727	0.0781	0.0820
0.0000	0.0000	0.0000	0.0160	0.0551	0.0623	0.0683	0.0762	0.0830

0.0000	0.0000	0.0000	0.0070	0.0374	0.0467	0.0654	0.0808	0.0909
0.0000	0.0000	0.0000	0.0014	0.0184	0.0303	0.0623	0.0852	0.0982
0.0000	0.0000	0.0219	0.0192	0.0265	0.0360	0.0492	0.0618	0.0744
0.0000	0.0000	0.0219	0.0263	0.0274	0.0423	0.0482	0.0557	0.0698
0.0000	0.0000	0.0000	0.0263	0.0233	0.0490	0.0552	0.0612	0.0780
0.0000	0.0000	0.0000	0.0019	0.0262	0.0390	0.0496	0.0591	0.0733
0.0000	0.0000	0.0000	0.0000	0.0257	0.0257	0.0438	0.0572	0.0705
0.0000	0.0000	0.0000	0.0000	0.0000	0.0114	0.0384	0.0555	0.0690
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0309	0.0542	0.0684
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0188	0.0538	0.0700
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0068	0.0534	0.0717
0.0000	0.0000	0.0000	0.0000	0.0000	0.0122	0.0296	0.0547	0.0665
0.0000	0.0000	0.0000	0.0000	0.0037	0.0114	0.0481	0.0562	0.0626
0.0000	0.0000	0.0000	0.0000	0.0000	0.0078	0.0524	0.0584	0.0631
0.0000	0.0000	0.0000	0.0000	0.0000	0.0042	0.0567	0.0606	0.0636
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0463	0.0569	0.0629
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0334	0.0522	0.0621
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0206	0.0476	0.0612
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0078	0.0429	0.0604
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0072	0.0316	0.0542
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0201	0.0478
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0184	0.0460
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0450
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0352
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.0172
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0081
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0040
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

0.40	0.40	0.30	0.30	0.30	0.40	0.50
-0.97	-0.57	-0.27	0.03	0.33	0.73	1.23
-1.17	-0.77	-0.42	-0.12	0.18	0.53	0.98
-1.37	-0.97	-0.57	-0.27	0.03	0.33	0.73
63.0381	81.3678	70.1384	71.5331	71.7200	95.8908	120.2495
209.5127	290.8805	361.0189	432.5520	504.2721	600.1629	720.4124
0.5089	0.5580	0.4823	0.4832	0.4840	0.6466	0.8107
0.5046	0.5428	0.4538	0.4545	0.4553	0.6084	0.7626
0.5003	0.5277	0.4253	0.4259	0.4267	0.5702	0.7145
0.5108	0.5289	0.4137	0.4141	0.4149	0.5545	0.6945
0.5809	0.5956	0.4694	0.4697	0.4705	0.6284	0.7871
0.6474	0.6634	0.5284	0.5286	0.5294	0.7070	0.8854
0.7013	0.7351	0.5994	0.5998	0.6006	0.8020	1.0042
0.7551	0.8068	0.6704	0.6710	0.6718	0.8971	1.1229
0.8090	0.8786	0.7415	0.7422	0.7430	0.9922	1.2417
0.8628	0.9503	0.8126	0.8134	0.8142	1.0872	1.3604
0.8199	0.9496	0.8494	0.8554	0.8563	1.1434	1.4310
0.7540	0.9317	0.8780	0.8906	0.8915	1.1904	1.4900
0.6881	0.9138	0.9067	0.9257	0.9267	1.2374	1.5491
0.6996	0.9133	0.8460	0.8600	0.8610	1.1497	1.4391
0.7117	0.9130	0.7846	0.7934	0.7944	1.0608	1.3276
0.7238	0.9126	0.7231	0.7268	0.7278	0.9718	1.2161
0.9623	1.3717	1.0431	1.0446	1.0453	1.3954	1.7451
1.3280	2.0891	1.5777	1.5787	1.5789	2.1073	2.6344
1.2871	2.2294	1.7114	1.7243	1.7246	2.3018	2.8779
1.0496	2.0904	1.6513	1.6820	1.6829	2.2461	2.8091
0.8121	1.9514	1.5911	1.6398	1.6411	2.1904	2.7402
0.7118	1.7681	1.5227	1.5795	1.5810	2.1101	2.6403
0.7784	1.5308	1.4443	1.4974	1.4986	2.0001	2.5027
0.8450	1.2934	1.3658	1.4152	1.4162	1.8901	2.3650
0.9116	1.0561	1.2873	1.3330	1.3337	1.7801	2.2274
0.9181	0.9934	1.1692	1.2093	1.2100	1.6151	2.0212
0.9061	0.9843	1.0389	1.0727	1.0735	1.4332	1.7939
0.8940	0.9753	0.9086	0.9362	0.9369	1.2512	1.5666
0.8820	0.9662	0.7783	0.7997	0.8004	1.0693	1.3393
0.8869	1.0129	0.8495	0.8778	0.8791	1.1741	1.4701
0.8948	1.0698	0.9576	0.9953	0.9972	1.3314	1.6666
0.9028	1.1267	1.0657	1.1128	1.1153	1.4888	1.8631
0.8963	1.1484	1.1154	1.1662	1.1691	1.5604	1.9526
0.8606	1.0990	1.0470	1.0903	1.0929	1.4588	1.8256
0.8248	1.0496	0.9787	1.0143	1.0166	1.3572	1.6986
0.7890	1.0003	0.9104	0.9384	0.9404	1.2556	1.5717
0.7533	0.9509	0.8420	0.8624	0.8642	1.1540	1.4447
0.7175	0.9015	0.7737	0.7865	0.7879	1.0524	1.3177
0.6818	0.8521	0.7054	0.7106	0.7117	0.9507	1.1907
0.6442	0.8180	0.6599	0.6643	0.6653	0.8888	1.1134
0.6058	0.7911	0.6251	0.6319	0.6329	0.8453	1.0591
0.5675	0.7584	0.6216	0.6309	0.6320	0.8440	1.0575
0.5296	0.6948	0.7889	0.8008	0.8037	1.0729	1.3438
0.4917	0.6312	0.9561	0.9707	0.9753	1.3018	1.6301

0.4584	0.5716	1.0966	1.1137	1.1198	1.4946	1.8712
0.5102	0.5875	0.7501	0.7667	0.7698	1.0278	1.2872
0.5402	0.6371	0.5031	0.5183	0.5191	0.6934	0.8689
0.4883	0.8135	0.6302	0.6412	0.6419	0.8572	1.0738
0.4379	0.8949	0.7151	0.7223	0.7231	0.9655	1.2090
0.3884	0.9154	0.7728	0.7767	0.7775	1.0382	1.2994
0.3475	0.9312	0.8187	0.8201	0.8209	1.0962	1.3717
0.3865	0.9038	0.7547	0.7617	0.7625	1.0184	1.2750
0.4255	0.8765	0.6906	0.7034	0.7041	0.9407	1.1782
0.5251	0.7972	0.5988	0.5998	0.6005	0.8022	1.0049
0.5415	0.6774	0.5090	0.5099	0.5107	0.6823	0.8546
0.5426	0.5844	0.4392	0.4401	0.4411	0.5892	0.7383
0.4969	0.5726	0.4307	0.4316	0.4327	0.5781	0.7252
0.3552	0.4593	0.4482	0.4715	0.4725	0.6316	0.7915
0.3514	0.4641	0.4292	0.4454	0.4463	0.5966	0.7479
0.3374	0.4413	0.3906	0.4042	0.4051	0.5416	0.6791
0.3036	0.3642	0.3132	0.3332	0.3340	0.4468	0.5605
0.3561	0.4535	0.3803	0.3985	0.3995	0.5343	0.6700
0.4174	0.5499	0.4559	0.4712	0.4723	0.6314	0.7917
0.4501	0.5574	0.4626	0.4759	0.4769	0.6375	0.7996
0.4838	0.5662	0.4672	0.4782	0.4792	0.6405	0.8035
0.5222	0.5810	0.4619	0.4690	0.4700	0.6283	0.7884
0.5606	0.5960	0.4567	0.4598	0.4607	0.6161	0.7732
0.5556	0.5802	0.4366	0.4377	0.4386	0.5866	0.7363
0.5058	0.5332	0.4013	0.4024	0.4034	0.5394	0.6771
0.4660	0.4792	0.3608	0.3616	0.3626	0.4853	0.6091
0.4183	0.4442	0.3346	0.3353	0.3364	0.4503	0.5653
0.3608	0.4327	0.3259	0.3268	0.3279	0.4388	0.5512
0.3243	0.4032	0.3036	0.3046	0.3057	0.4090	0.5138
0.3067	0.3573	0.2691	0.2700	0.2710	0.3624	0.4554
0.2844	0.3368	0.2537	0.2546	0.2555	0.3417	0.4289
0.2680	0.3237	0.2439	0.2447	0.2455	0.3283	0.4117
0.2777	0.3211	0.2420	0.2428	0.2435	0.3257	0.4088
0.2878	0.3261	0.2457	0.2468	0.2477	0.3315	0.4165
0.2763	0.3280	0.2551	0.2649	0.2658	0.3558	0.4473
0.2714	0.3405	0.2757	0.2955	0.2963	0.3965	0.4985
0.3764	0.4190	0.3332	0.3390	0.3398	0.4546	0.5703
0.3839	0.4523	0.3632	0.3661	0.3670	0.4909	0.6157
0.3386	0.4611	0.3783	0.3844	0.3855	0.5154	0.6467
0.3173	0.4577	0.3809	0.3878	0.3889	0.5199	0.6525
0.3466	0.4284	0.3569	0.3596	0.3605	0.4821	0.6051
0.3056	0.3848	0.3207	0.3285	0.3294	0.4406	0.5533
0.2243	0.3318	0.2766	0.2941	0.2950	0.3947	0.4962
0.2220	0.2873	0.2402	0.2493	0.2502	0.3349	0.4209
0.2198	0.2429	0.2039	0.2047	0.2055	0.2752	0.3458
0.2770	0.3118	0.2492	0.2500	0.2508	0.3357	0.4218
0.3067	0.3442	0.2732	0.2801	0.2809	0.3759	0.4722
0.2693	0.2872	0.2452	0.2729	0.2738	0.3664	0.4598
0.2344	0.2698	0.2334	0.2588	0.2598	0.3478	0.4369
0.2020	0.2904	0.2371	0.2382	0.2391	0.3205	0.4037
0.2374	0.2869	0.2410	0.2442	0.2453	0.3284	0.4135
0.2443	0.2682	0.2232	0.2288	0.2297	0.3077	0.3872

0.2260	0.2365	0.1867	0.1945	0.1954	0.2620	0.3294
0.1730	0.1921	0.1551	0.1628	0.1637	0.2196	0.2764
0.2164	0.2335	0.1911	0.1955	0.1964	0.2629	0.3309
0.2668	0.2850	0.2338	0.2346	0.2354	0.3148	0.3961
0.2471	0.3108	0.2448	0.2454	0.2460	0.3288	0.4128
0.2322	0.2950	0.2333	0.2348	0.2354	0.3149	0.3955
0.2195	0.2613	0.2123	0.2151	0.2158	0.2891	0.3638
0.1787	0.1988	0.1604	0.1708	0.1715	0.2302	0.2900
0.1597	0.1698	0.1347	0.1505	0.1514	0.2034	0.2563
0.1739	0.1888	0.1569	0.1672	0.1681	0.2255	0.2840
0.1531	0.1635	0.1498	0.1506	0.1514	0.2033	0.2558
0.1328	0.1426	0.1260	0.1268	0.1275	0.1713	0.2157
0.1273	0.1365	0.1150	0.1163	0.1170	0.1571	0.1980
0.1610	0.1696	0.1376	0.1409	0.1417	0.1901	0.2392
0.1753	0.1862	0.1514	0.1548	0.1556	0.2087	0.2626
0.1606	0.1782	0.1514	0.1522	0.1529	0.2051	0.2582
0.1779	0.1933	0.1542	0.1550	0.1557	0.2088	0.2630
0.1926	0.2061	0.1562	0.1571	0.1578	0.2115	0.2664
0.1881	0.2016	0.1531	0.1538	0.1545	0.2070	0.2606
0.1835	0.1971	0.1500	0.1507	0.1513	0.2026	0.2548
0.1790	0.1926	0.1469	0.1475	0.1480	0.1981	0.2490
0.1744	0.1881	0.1438	0.1442	0.1447	0.1936	0.2432
0.1311	0.1357	0.1031	0.1037	0.1044	0.1400	0.1761
0.1282	0.1302	0.0986	0.0994	0.1002	0.1347	0.1701
0.1429	0.1454	0.1102	0.1111	0.1120	0.1508	0.1911
0.1609	0.1632	0.1235	0.1244	0.1253	0.1684	0.2127
0.1788	0.1811	0.1368	0.1377	0.1386	0.1859	0.2344
0.1528	0.1564	0.1184	0.1193	0.1203	0.1618	0.2046
0.1310	0.1358	0.1031	0.1040	0.1050	0.1416	0.1796
0.1358	0.1413	0.1071	0.1079	0.1088	0.1465	0.1853
0.1406	0.1468	0.1111	0.1118	0.1126	0.1514	0.1910
0.1259	0.1333	0.1033	0.1041	0.1049	0.1413	0.1791
0.1132	0.1216	0.0962	0.0971	0.0979	0.1322	0.1682
0.1166	0.1238	0.0952	0.0961	0.0969	0.1307	0.1658
0.1321	0.1370	0.1036	0.1043	0.1051	0.1412	0.1784
0.1586	0.1599	0.1205	0.1210	0.1215	0.1627	0.2047
0.1377	0.1454	0.1103	0.1110	0.1118	0.1502	0.1897
0.1118	0.1261	0.0967	0.0976	0.0986	0.1331	0.1691
0.1166	0.1242	0.0944	0.0950	0.0958	0.1287	0.1627
0.1214	0.1222	0.0921	0.0925	0.0929	0.1243	0.1563
0.1116	0.1124	0.0848	0.0851	0.0856	0.1148	0.1445
0.1030	0.1038	0.0784	0.0788	0.0793	0.1065	0.1345
0.0977	0.0985	0.0744	0.0749	0.0754	0.1014	0.1282
0.0950	0.0959	0.0725	0.0729	0.0734	0.0986	0.1246
0.0933	0.0944	0.0713	0.0717	0.0722	0.0969	0.1221
0.0954	0.0976	0.0738	0.0743	0.0748	0.1006	0.1271
0.0989	0.1027	0.0777	0.0783	0.0789	0.1063	0.1350
0.1096	0.1144	0.0866	0.0874	0.0881	0.1187	0.1506
0.1147	0.1194	0.0905	0.0914	0.0922	0.1241	0.1570
0.0947	0.0976	0.0740	0.0747	0.0754	0.1014	0.1281
0.0860	0.0884	0.0670	0.0677	0.0683	0.0919	0.1159
0.0905	0.0942	0.0714	0.0720	0.0727	0.0978	0.1234

0.0961	0.0986	0.0746	0.0752	0.0758	0.1019	0.1286
0.1006	0.1018	0.0770	0.0775	0.0780	0.1048	0.1324
0.0775	0.0855	0.0649	0.0656	0.0662	0.0894	0.1137
0.0736	0.0820	0.0626	0.0633	0.0641	0.0866	0.1101
0.0826	0.0871	0.0668	0.0676	0.0683	0.0922	0.1168
0.0799	0.0836	0.0636	0.0643	0.0649	0.0875	0.1104
0.0783	0.0818	0.0621	0.0627	0.0633	0.0853	0.1078
0.0777	0.0809	0.0615	0.0621	0.0628	0.0847	0.1072
0.0780	0.0816	0.0620	0.0626	0.0633	0.0855	0.1085
0.0803	0.0853	0.0648	0.0655	0.0662	0.0894	0.1136
0.0827	0.0890	0.0676	0.0683	0.0691	0.0933	0.1187
0.0729	0.0762	0.0579	0.0585	0.0592	0.0800	0.1018
0.0654	0.0666	0.0507	0.0513	0.0519	0.0702	0.0892
0.0660	0.0680	0.0520	0.0527	0.0533	0.0720	0.0913
0.0666	0.0694	0.0533	0.0540	0.0547	0.0739	0.0935
0.0686	0.0748	0.0573	0.0580	0.0587	0.0793	0.1005
0.0707	0.0809	0.0617	0.0624	0.0632	0.0853	0.1082
0.0728	0.0870	0.0662	0.0669	0.0676	0.0912	0.1160
0.0750	0.0930	0.0706	0.0713	0.0721	0.0972	0.1237
0.0648	0.0768	0.0619	0.0626	0.0634	0.0857	0.1089
0.0542	0.0595	0.0525	0.0533	0.0541	0.0733	0.0930
0.0513	0.0544	0.0464	0.0471	0.0478	0.0648	0.0824
0.0497	0.0514	0.0408	0.0414	0.0420	0.0570	0.0726
0.0477	0.0487	0.0372	0.0378	0.0383	0.0520	0.0665
0.0454	0.0465	0.0355	0.0361	0.0367	0.0499	0.0640
0.0367	0.0429	0.0362	0.0396	0.0413	0.0571	0.0749
0.0246	0.0386	0.0383	0.0459	0.0492	0.0695	0.0932
0.0162	0.0282	0.0293	0.0362	0.0411	0.0613	0.0871
0.0088	0.0162	0.0174	0.0224	0.0288	0.0477	0.0745
0.0018	0.0042	0.0051	0.0074	0.0127	0.0250	0.0441

Volume for each individual layer - cell combination.
Total volume for each cell is in column AA. Total volume of river is in 10Y

		DZ(m)			**1.00**	**1.00**	**1.00**
		Z_Top		**-11.07**	**-10.07**	**-9.07**	**-8.07**
		Z(m)			**-10.57**	**-9.57**	**-8.57**
		Z_Bottom			**-11.07**	**-10.07**	**-9.07**
		Volume(Hec-m)			**1.4704**	**3.8569**	**5.7398**
		Cul_Vol (Hec-m)		**0**	**1.4704**	**5.3273**	**11.0671**
cell #	**cell length km**	**cell end km**	**km-mid cell**	**km mid -HBMP**			
1	0.100	0.100	0.050	-0.018	0.0304	0.4770	0.7266
2	0.100	0.2000	0.150	0.083	0.0844	0.4967	0.6978
3	0.100	0.3000	0.250	0.182	0.1385	0.5165	0.6691
4	0.100	0.4000	0.350	0.282	0.2214	0.5777	0.6860
5	0.100	0.5000	0.450	0.383	0.4200	0.8053	0.8852
6	0.100	0.6000	0.550	0.492	0.5757	0.9837	1.0413
7	0.100	0.7000	0.650	0.593	0.0000	0.0000	1.0338
8	0.100	0.8000	0.750	0.693	0.0000	0.0000	0.0000
9	0.100	0.9000	0.850	0.796	0.0000	0.0000	0.0000
10	0.100	1.0000	0.950	0.900	0.0000	0.0000	0.0000
11	0.100	1.1000	1.050	1.001	0.0000	0.0000	0.0000
12	0.100	1.2000	1.150	1.101	0.0000	0.0000	0.0000
13	0.100	1.3000	1.250	1.202	0.0000	0.0000	0.0000
14	0.100	1.4000	1.350	1.305	0.0000	0.0000	0.0000
15	0.100	1.5000	1.450	1.410	0.0000	0.0000	0.0000
16	0.100	1.6000	1.550	1.512	0.0000	0.0000	0.0000
17	0.100	1.7000	1.650	1.609	0.0000	0.0000	0.0000
18	0.100	1.8000	1.750	1.720	0.0000	0.0000	0.0000
19	0.100	1.9000	1.850	1.872	0.0000	0.0000	0.0000
20	0.100	2.0000	1.950	2.001	0.0000	0.0000	0.0000
21	0.100	2.1000	2.050	2.124	0.0000	0.0000	0.0000
22	0.100	2.2000	2.150	2.207	0.0000	0.0000	0.0000
23	0.100	2.3000	2.250	2.303	0.0000	0.0000	0.0000
24	0.100	2.4000	2.350	2.401	0.0000	0.0000	0.0000
25	0.100	2.5000	2.450	2.503	0.0000	0.0000	0.0000
26	0.100	2.6000	2.550	2.603	0.0000	0.0000	0.0000
27	0.100	2.7000	2.650	2.703	0.0000	0.0000	0.0000
28	0.100	2.8000	2.750	2.802	0.0000	0.0000	0.0000
29	0.100	2.9000	2.850	2.902	0.0000	0.0000	0.0000
30	0.100	3.0000	2.950	3.003	0.0000	0.0000	0.0000
31	0.100	3.1000	3.050	3.105	0.0000	0.0000	0.0000
32	0.100	3.2000	3.150	3.205	0.0000	0.0000	0.0000
33	0.100	3.3000	3.250	3.306	0.0000	0.0000	0.0000
34	0.100	3.4000	3.350	3.406	0.0000	0.0000	0.0000
35	0.100	3.5000	3.450	3.506	0.0000	0.0000	0.0000
36	0.100	3.6000	3.550	3.609	0.0000	0.0000	0.0000
37	0.100	3.7000	3.650	3.709	0.0000	0.0000	0.0000
38	0.100	3.8000	3.750	3.808	0.0000	0.0000	0.0000
39	0.100	3.9000	3.850	3.909	0.0000	0.0000	0.0000

40	0.100	4.0000	3.950	4.008	0.0000	0.0000	0.0000
41	0.100	4.1000	4.050	4.108	0.0000	0.0000	0.0000
42	0.100	4.2000	4.150	4.208	0.0000	0.0000	0.0000
43	0.100	4.3000	4.250	4.307	0.0000	0.0000	0.0000
44	0.100	4.4000	4.350	4.407	0.0000	0.0000	0.0000
45	0.100	4.5000	4.450	4.508	0.0000	0.0000	0.0000
46	0.100	4.6000	4.550	4.610	0.0000	0.0000	0.0000
47	0.100	4.7000	4.650	4.709	0.0000	0.0000	0.0000
48	0.100	4.8000	4.750	4.810	0.0000	0.0000	0.0000
49	0.100	4.9000	4.850	4.911	0.0000	0.0000	0.0000
50	0.100	5.0000	4.950	5.011	0.0000	0.0000	0.0000
51	0.100	5.1000	5.050	5.109	0.0000	0.0000	0.0000
52	0.100	5.2000	5.150	5.211	0.0000	0.0000	0.0000
53	0.100	5.3000	5.250	5.313	0.0000	0.0000	0.0000
54	0.100	5.4000	5.350	5.415	0.0000	0.0000	0.0000
55	0.100	5.5000	5.450	5.514	0.0000	0.0000	0.0000
56	0.100	5.6000	5.550	5.614	0.0000	0.0000	0.0000
57	0.100	5.7000	5.650	5.713	0.0000	0.0000	0.0000
58	0.100	5.8000	5.750	5.813	0.0000	0.0000	0.0000
59	0.100	5.9000	5.850	5.913	0.0000	0.0000	0.0000
60	0.100	6.0000	5.950	6.013	0.0000	0.0000	0.0000
61	0.100	6.1000	6.050	6.114	0.0000	0.0000	0.0000
62	0.100	6.2000	6.150	6.215	0.0000	0.0000	0.0000
63	0.100	6.3000	6.250	6.318	0.0000	0.0000	0.0000
64	0.100	6.4000	6.350	6.418	0.0000	0.0000	0.0000
65	0.100	6.5000	6.450	6.519	0.0000	0.0000	0.0000
66	0.100	6.6000	6.550	6.618	0.0000	0.0000	0.0000
67	0.100	6.7000	6.650	6.712	0.0000	0.0000	0.0000
68	0.100	6.8000	6.750	6.809	0.0000	0.0000	0.0000
69	0.100	6.9000	6.850	6.910	0.0000	0.0000	0.0000
70	0.100	7.0000	6.950	7.011	0.0000	0.0000	0.0000
71	0.100	7.1000	7.050	7.110	0.0000	0.0000	0.0000
72	0.100	7.2000	7.150	7.209	0.0000	0.0000	0.0000
73	0.100	7.3000	7.250	7.310	0.0000	0.0000	0.0000
74	0.100	7.4000	7.350	7.410	0.0000	0.0000	0.0000
75	0.100	7.5000	7.450	7.510	0.0000	0.0000	0.0000
76	0.100	7.6000	7.550	7.610	0.0000	0.0000	0.0000
77	0.100	7.7000	7.650	7.711	0.0000	0.0000	0.0000
78	0.100	7.8000	7.750	7.811	0.0000	0.0000	0.0000
79	0.100	7.9000	7.850	7.913	0.0000	0.0000	0.0000
80	0.100	8.0000	7.950	8.011	0.0000	0.0000	0.0000
81	0.100	8.1000	8.050	8.113	0.0000	0.0000	0.0000
82	0.100	8.2000	8.150	8.211	0.0000	0.0000	0.0000
83	0.100	8.3000	8.250	8.312	0.0000	0.0000	0.0000
84	0.100	8.4000	8.350	8.412	0.0000	0.0000	0.0000
85	0.100	8.5000	8.450	8.512	0.0000	0.0000	0.0000
86	0.100	8.6000	8.550	8.612	0.0000	0.0000	0.0000
87	0.100	8.7000	8.650	8.713	0.0000	0.0000	0.0000
88	0.100	8.8000	8.750	8.813	0.0000	0.0000	0.0000
89	0.100	8.9000	8.850	8.915	0.0000	0.0000	0.0000
90	0.100	9.0000	8.950	9.018	0.0000	0.0000	0.0000
91	0.100	9.1000	9.050	9.119	0.0000	0.0000	0.0000

92	0.100	9.2000	9.150	9.219	0.0000	0.0000	0.0000
93	0.100	9.3000	9.250	9.319	0.0000	0.0000	0.0000
94	0.100	9.4000	9.350	9.410	0.0000	0.0000	0.0000
95	0.100	9.5000	9.450	9.508	0.0000	0.0000	0.0000
96	0.100	9.6000	9.550	9.609	0.0000	0.0000	0.0000
97	0.100	9.7000	9.650	9.707	0.0000	0.0000	0.0000
98	0.100	9.8000	9.750	9.807	0.0000	0.0000	0.0000
99	0.100	9.9000	9.850	9.907	0.0000	0.0000	0.0000
100	0.100	10.0000	9.950	10.003	0.0000	0.0000	0.0000
101	0.100	10.1000	10.050	10.110	0.0000	0.0000	0.0000
102	0.100	10.2000	10.150	10.207	0.0000	0.0000	0.0000
103	0.100	10.3000	10.250	10.307	0.0000	0.0000	0.0000
104	0.100	10.4000	10.350	10.408	0.0000	0.0000	0.0000
105	0.100	10.5000	10.450	10.505	0.0000	0.0000	0.0000
106	0.100	10.6000	10.550	10.602	0.0000	0.0000	0.0000
107	0.100	10.7000	10.650	10.703	0.0000	0.0000	0.0000
108	0.100	10.8000	10.750	10.804	0.0000	0.0000	0.0000
109	0.100	10.9000	10.850	10.902	0.0000	0.0000	0.0000
110	0.100	11.0000	10.950	11.003	0.0000	0.0000	0.0000
111	0.100	11.1000	11.050	11.102	0.0000	0.0000	0.0000
112	0.100	11.2000	11.150	11.202	0.0000	0.0000	0.0000
113	0.100	11.3000	11.250	11.302	0.0000	0.0000	0.0000
114	0.100	11.4000	11.350	11.402	0.0000	0.0000	0.0000
115	0.100	11.5000	11.450	11.503	0.0000	0.0000	0.0000
116	0.100	11.6000	11.550	11.603	0.0000	0.0000	0.0000
117	0.100	11.7000	11.650	11.704	0.0000	0.0000	0.0000
118	0.100	11.8000	11.750	11.803	0.0000	0.0000	0.0000
119	0.100	11.9000	11.850	11.904	0.0000	0.0000	0.0000
120	0.100	12.0000	11.950	12.005	0.0000	0.0000	0.0000
121	0.100	12.1000	12.050	12.106	0.0000	0.0000	0.0000
122	0.100	12.2000	12.150	12.213	0.0000	0.0000	0.0000
123	0.100	12.3000	12.250	12.296	0.0000	0.0000	0.0000
124	0.100	12.4000	12.350	12.400	0.0000	0.0000	0.0000
125	0.100	12.5000	12.450	12.490	0.0000	0.0000	0.0000
126	0.100	12.6000	12.550	12.582	0.0000	0.0000	0.0000
127	0.100	12.7000	12.650	12.683	0.0000	0.0000	0.0000
128	0.100	12.8000	12.750	12.789	0.0000	0.0000	0.0000
129	0.100	12.9000	12.850	12.892	0.0000	0.0000	0.0000
130	0.100	13.0000	12.950	12.992	0.0000	0.0000	0.0000
131	0.100	13.1000	13.050	13.091	0.0000	0.0000	0.0000
132	0.100	13.2000	13.150	13.191	0.0000	0.0000	0.0000
133	0.100	13.3000	13.250	13.296	0.0000	0.0000	0.0000
134	0.100	13.4000	13.350	13.426	0.0000	0.0000	0.0000
135	0.100	13.5000	13.450	13.493	0.0000	0.0000	0.0000
136	0.100	13.6000	13.550	13.600	0.0000	0.0000	0.0000
137	0.100	13.7000	13.650	13.700	0.0000	0.0000	0.0000
138	0.100	13.8000	13.750	13.800	0.0000	0.0000	0.0000
139	0.100	13.9000	13.850	13.899	0.0000	0.0000	0.0000
140	0.100	14.0000	13.950	13.996	0.0000	0.0000	0.0000
141	0.100	14.1000	14.050	14.094	0.0000	0.0000	0.0000
142	0.100	14.2000	14.150	14.185	0.0000	0.0000	0.0000
143	0.100	14.3000	14.250	14.285	0.0000	0.0000	0.0000

144	0.100	14.4000	14.350	14.391	0.0000	0.0000	0.0000
145	0.100	14.5000	14.450	14.495	0.0000	0.0000	0.0000
146	0.100	14.6000	14.550	14.591	0.0000	0.0000	0.0000
147	0.100	14.7000	14.650	14.689	0.0000	0.0000	0.0000
148	0.100	14.8000	14.750	14.781	0.0000	0.0000	0.0000
149	0.100	14.9000	14.850	14.879	0.0000	0.0000	0.0000
150	0.100	15.0000	14.950	14.977	0.0000	0.0000	0.0000
151	0.100	15.1000	15.050	15.074	0.0000	0.0000	0.0000
152	0.100	15.2000	15.150	15.171	0.0000	0.0000	0.0000
153	0.100	15.3000	15.250	15.269	0.0000	0.0000	0.0000
154	0.100	15.4000	15.350	15.366	0.0000	0.0000	0.0000
155	0.100	15.5000	15.450	15.465	0.0000	0.0000	0.0000
156	0.100	15.6000	15.550	15.565	0.0000	0.0000	0.0000
157	0.100	15.7000	15.650	15.662	0.0000	0.0000	0.0000
158	0.100	15.8000	15.750	15.762	0.0000	0.0000	0.0000
159	0.100	15.9000	15.850	15.855	0.0000	0.0000	0.0000
160	0.100	16.0000	15.950	15.941	0.0000	0.0000	0.0000
161	0.100	16.1000	16.050	16.041	0.0000	0.0000	0.0000
162	0.100	16.2000	16.150	16.151	0.0000	0.0000	0.0000
163	0.100	16.3000	16.250	16.250	0.0000	0.0000	0.0000
164	0.100	16.4000	16.350	16.348	0.0000	0.0000	0.0000
165	0.100	16.5000	16.450	16.448	0.0000	0.0000	0.0000
166	0.100	16.6000	16.550	16.548	0.0000	0.0000	0.0000
167	0.100	16.7000	16.650	16.646	0.0000	0.0000	0.0000
168	0.100	16.8000	16.750	16.747	0.0000	0.0000	0.0000
169	0.100	16.9000	16.850	16.843	0.0000	0.0000	0.0000
170	0.100	17.0000	16.950	16.946	0.0000	0.0000	0.0000
171	0.100	17.1000	17.050	17.046	0.0000	0.0000	0.0000
172	0.100	17.2000	17.150	17.143	0.0000	0.0000	0.0000
173	0.100	17.3000	17.250	17.241	0.0000	0.0000	0.0000
174	0.100	17.4000	17.350	17.334	0.0000	0.0000	0.0000
175	0.100	17.5000	17.450	17.433	0.0000	0.0000	0.0000
176	0.100	17.6000	17.550	17.528	0.0000	0.0000	0.0000
177	0.100	17.7000	17.650	17.629	0.0000	0.0000	0.0000
178	0.069	17.7690	17.735	17.705	0.0000	0.0000	0.0000

1.00	**1.60**	**1.00**	**0.60**	**0.50**	**0.40**	**0.40**	**0.40**	**0.40**
-7.07	**-5.47**	**-4.47**	**-3.87**	**-3.37**	**-2.97**	**-2.57**	**-2.17**	**-1.77**
-7.57	**-6.27**	**-4.97**	**-4.17**	**-3.62**	**-3.17**	**-2.77**	**-2.37**	**-1.97**
-8.07	**-7.07**	**-5.47**	**-4.47**	**-3.87**	**-3.37**	**-2.97**	**-2.57**	**-2.17**
6.2988	**12.1888**	**8.8133**	**5.9104**	**5.7450**	**6.3565**	**10.7449**	**16.1985**	**24.3509**
17.3659	**29.5547**	**38.3680**	**44.2784**	**50.0233**	**56.3798**	**67.1248**	**83.3233**	**107.6742**
0.8252	1.4304	0.9528	0.5921	0.5112	0.4225	0.4347	0.4496	0.4655
0.8012	1.4112	0.9564	0.5968	0.5146	0.4244	0.4361	0.4500	0.4648
0.7772	1.3920	0.9599	0.6016	0.5180	0.4262	0.4374	0.4504	0.4640
0.7927	1.4298	0.9951	0.6250	0.5373	0.4411	0.4522	0.4648	0.4782
0.9663	1.6958	1.1571	0.7230	0.6201	0.5084	0.5204	0.5354	0.5515
1.1024	1.9043	1.2840	0.7999	0.6686	0.5349	0.5608	0.5810	0.6030
1.0338	1.6541	1.0338	0.6203	0.5169	0.4135	0.5003	0.5359	0.5751
0.0000	1.1685	0.7303	0.4382	0.3652	0.2921	0.4398	0.4908	0.5472
0.0000	0.0000	0.4269	0.2561	0.2135	0.1708	0.3793	0.4457	0.5194
0.0000	0.0000	0.0000	0.0000	0.0617	0.0494	0.3188	0.4006	0.4916
0.0000	0.0000	0.0000	0.0000	0.0000	0.0260	0.2841	0.3822	0.4823
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2555	0.3700	0.4775
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2270	0.3578	0.4727
0.0000	0.0000	0.0000	0.0000	0.0000	0.1178	0.2536	0.3739	0.4714
0.0000	0.0000	0.0000	0.0000	0.0000	0.1178	0.2808	0.3902	0.4702
0.0000	0.0000	0.0000	0.0000	0.0124	0.1178	0.3079	0.4066	0.4690
0.0000	0.0000	0.0000	0.0000	0.0000	0.0959	0.2932	0.4234	0.4932
0.0000	0.0000	0.0000	0.0000	0.0000	0.0615	0.2548	0.4405	0.5318
0.0000	0.0000	0.0000	0.0000	0.0000	0.0504	0.2170	0.4017	0.4974
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1794	0.3358	0.4275
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1418	0.2699	0.3576
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1212	0.2337	0.3058
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2337	0.2760
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2337	0.2462
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2164
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1781
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1372
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0964
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0555
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0665
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0871
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0400	0.1077
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0400	0.1215
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0400	0.1215
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1215
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1215
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1215
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0743
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0748
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0781
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0814
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0846
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
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0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1325
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1325
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0460	0.1230
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0427	0.0665	0.1271
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0427	0.0826	0.1373
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0427	0.0897	0.1595
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0908	0.1504
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1385
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1124
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1252
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0815	0.1495
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0492	0.1536
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0263	0.1506
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0635	0.1337
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0403	0.0941	0.1521
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0403	0.0856	0.1603
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0550	0.1557
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1430
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1335
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1258
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1169
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1053
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0992	0.1155
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0468	0.0979	0.1389
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0348	0.0868	0.1439
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0228	0.0756	0.1488
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1488
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0975

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0343	0.0534	0.0975
0.0000	0.0000	0.0000	0.0000	0.0000	0.0164	0.0407	0.0724	0.1089
0.0000	0.0000	0.0000	0.0000	0.0000	0.0297	0.0534	0.1098	0.1313
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0534	0.0858	0.1319
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0813	0.1364
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0938	0.1444
0.0000	0.0000	0.0000	0.0405	0.0589	0.0630	0.0778	0.0997	0.1271
0.0000	0.0000	0.0000	0.0000	0.0520	0.0416	0.0416	0.1082	0.1555
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1162	0.1791
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0894	0.0894
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0728	0.0890
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0086	0.0728	0.1267
0.0000	0.0000	0.0000	0.0000	0.0000	0.0562	0.0562	0.0926	0.1306
0.0000	0.0000	0.0000	0.0000	0.0000	0.0817	0.0817	0.0988	0.1282
0.0000	0.0000	0.0000	0.0000	0.0000	0.0540	0.0664	0.0890	0.1331
0.0000	0.0000	0.0000	0.0000	0.0232	0.0540	0.0929	0.1081	0.1314
0.0000	0.0000	0.0000	0.0000	0.0232	0.0521	0.0759	0.1021	0.1155
0.0000	0.0000	0.0000	0.0000	0.0000	0.0507	0.0640	0.0974	0.1073
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0656	0.0963	0.1194
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0600	0.0870	0.1131
0.0000	0.0000	0.0000	0.0000	0.0000	0.0186	0.0433	0.0652	0.0826
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0296	0.0554	0.1265
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0175	0.0458	0.1632
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0175	0.0372	0.1459
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0287	0.1286
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0202	0.1112
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0117	0.0940
0.0000	0.0000	0.0000	0.0000	0.0000	0.0278	0.0738	0.0764	0.1050
0.0000	0.0000	0.0000	0.0000	0.0000	0.0278	0.0655	0.0930	0.1141
0.0000	0.0000	0.0000	0.0000	0.0000	0.0278	0.0536	0.0886	0.1223
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0536	0.0598	0.0942
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0310	0.0662
0.0000	0.0000	0.0000	0.0000	0.0924	0.0739	0.0739	0.0739	0.0956
0.0000	0.0000	0.0448	0.0895	0.1066	0.0885	0.0966	0.1054	0.1195
0.0000	0.0000	0.0000	0.0685	0.0571	0.0457	0.0559	0.0707	0.1088
0.0000	0.0000	0.0000	0.0000	0.0000	0.0028	0.0152	0.0360	0.0980
0.0000	0.0000	0.0000	0.0000	0.0000	0.0106	0.0236	0.0395	0.0793
0.0000	0.0000	0.0000	0.0000	0.0000	0.0178	0.0313	0.0432	0.0638
0.0000	0.0000	0.0000	0.0000	0.0000	0.0178	0.0301	0.0472	0.0718
0.0000	0.0000	0.0000	0.0959	0.0800	0.0640	0.0640	0.0803	0.1024
0.0000	0.1027	0.1361	0.1264	0.1358	0.1296	0.1296	0.1400	0.1534
0.0000	0.0000	0.1361	0.1264	0.1060	0.0848	0.0848	0.1100	0.1247
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0298	0.0708	0.0876
0.0000	0.0000	0.0000	0.0000	0.0697	0.0647	0.0647	0.0942	0.1036
0.0000	0.0000	0.0000	0.0195	0.0697	0.0953	0.0996	0.1177	0.1198
0.0000	0.0000	0.0000	0.0000	0.0361	0.0784	0.0960	0.1072	0.1101
0.0000	0.0000	0.0000	0.0000	0.0129	0.0607	0.0846	0.0953	0.1002
0.0000	0.0000	0.0000	0.0000	0.0000	0.0425	0.0602	0.0833	0.0918
0.0000	0.0000	0.0000	0.0000	0.0000	0.0372	0.0448	0.0791	0.0880
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0330	0.0780	0.0862
0.0000	0.0000	0.0000	0.0000	0.0000	0.0506	0.0506	0.0823	0.0882
0.0000	0.0000	0.0000	0.0000	0.0931	0.0792	0.0792	0.0888	0.0916

0.0000	0.0000	0.0000	0.0000	0.0000	0.0843	0.0844	0.0844	0.0989
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0668	0.0767	0.1016
0.0000	0.0000	0.0000	0.0000	0.0513	0.0565	0.0668	0.0754	0.0870
0.0000	0.0000	0.0000	0.0469	0.0402	0.0560	0.0654	0.0727	0.0781
0.0000	0.0000	0.0000	0.0000	0.0160	0.0551	0.0623	0.0683	0.0762
0.0000	0.0000	0.0000	0.0000	0.0070	0.0374	0.0467	0.0654	0.0808
0.0000	0.0000	0.0000	0.0000	0.0014	0.0184	0.0303	0.0623	0.0852
0.0000	0.0000	0.0000	0.0219	0.0192	0.0265	0.0360	0.0492	0.0618
0.0000	0.0000	0.0000	0.0219	0.0263	0.0274	0.0423	0.0482	0.0557
0.0000	0.0000	0.0000	0.0000	0.0263	0.0233	0.0490	0.0552	0.0612
0.0000	0.0000	0.0000	0.0000	0.0019	0.0262	0.0390	0.0496	0.0591
0.0000	0.0000	0.0000	0.0000	0.0000	0.0257	0.0257	0.0438	0.0572
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0114	0.0384	0.0555
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0309	0.0542
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0188	0.0538
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0068	0.0534
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0122	0.0296	0.0547
0.0000	0.0000	0.0000	0.0000	0.0000	0.0037	0.0114	0.0481	0.0562
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0078	0.0524	0.0584
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0042	0.0567	0.0606
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0463	0.0569
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0334	0.0522
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0206	0.0476
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0078	0.0429
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0072	0.0316
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0201
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0184
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

0.40	**0.40**	**0.40**	**0.30**	**0.30**	**0.30**	**0.40**	**0.50**
-1.37	**-0.97**	**-0.57**	**-0.27**	**0.03**	**0.33**	**0.73**	**1.23**
-1.57	**-1.17**	**-0.77**	**-0.42**	**-0.12**	**0.18**	**0.53**	**0.98**
-1.77	**-1.37**	**-0.97**	**-0.57**	**-0.27**	**0.03**	**0.33**	**0.73**
38.8004	**63.0381**	**81.3678**	**70.1384**	**71.5331**	**71.7200**	**95.8908**	**120.2495**
146.4746	**209.5127**	**290.8805**	**361.0189**	**432.5520**	**504.2721**	**600.1629**	**720.4124**
0.4846	0.5089	0.5580	0.4823	0.4832	0.4840	0.6466	0.8107
0.4819	0.5046	0.5428	0.4538	0.4545	0.4553	0.6084	0.7626
0.4792	0.5003	0.5277	0.4253	0.4259	0.4267	0.5702	0.7145
0.4917	0.5108	0.5289	0.4137	0.4141	0.4149	0.5545	0.6945
0.5652	0.5809	0.5956	0.4694	0.4697	0.4705	0.6284	0.7871
0.6292	0.6474	0.6634	0.5284	0.5286	0.5294	0.7070	0.8854
0.6594	0.7013	0.7351	0.5994	0.5998	0.6006	0.8020	1.0042
0.6896	0.7551	0.8068	0.6704	0.6710	0.6718	0.8971	1.1229
0.7197	0.8090	0.8786	0.7415	0.7422	0.7430	0.9922	1.2417
0.7498	0.8628	0.9503	0.8126	0.8134	0.8142	1.0872	1.3604
0.7003	0.8199	0.9496	0.8494	0.8554	0.8563	1.1434	1.4310
0.6318	0.7540	0.9317	0.8780	0.8906	0.8915	1.1904	1.4900
0.5633	0.6881	0.9138	0.9067	0.9257	0.9267	1.2374	1.5491
0.5930	0.6996	0.9133	0.8460	0.8600	0.8610	1.1497	1.4391
0.6235	0.7117	0.9130	0.7846	0.7934	0.7944	1.0608	1.3276
0.6540	0.7238	0.9126	0.7231	0.7268	0.7278	0.9718	1.2161
0.6772	0.9623	1.3717	1.0431	1.0446	1.0453	1.3954	1.7451
0.6963	1.3280	2.0891	1.5777	1.5787	1.5789	2.1073	2.6344
0.6497	1.2871	2.2294	1.7114	1.7243	1.7246	2.3018	2.8779
0.5714	1.0496	2.0904	1.6513	1.6820	1.6829	2.2461	2.8091
0.4931	0.8121	1.9514	1.5911	1.6398	1.6411	2.1904	2.7402
0.4694	0.7118	1.7681	1.5227	1.5795	1.5810	2.1101	2.6403
0.5122	0.7784	1.5308	1.4443	1.4974	1.4986	2.0001	2.5027
0.5551	0.8450	1.2934	1.3658	1.4152	1.4162	1.8901	2.3650
0.5979	0.9116	1.0561	1.2873	1.3330	1.3337	1.7801	2.2274
0.5615	0.9181	0.9934	1.1692	1.2093	1.2100	1.6151	2.0212
0.5008	0.9061	0.9843	1.0389	1.0727	1.0735	1.4332	1.7939
0.4401	0.8940	0.9753	0.9086	0.9362	0.9369	1.2512	1.5666
0.3794	0.8820	0.9662	0.7783	0.7997	0.8004	1.0693	1.3393
0.3347	0.8869	1.0129	0.8495	0.8778	0.8791	1.1741	1.4701
0.2929	0.8948	1.0698	0.9576	0.9953	0.9972	1.3314	1.6666
0.2510	0.9028	1.1267	1.0657	1.1128	1.1153	1.4888	1.8631
0.2243	0.8963	1.1484	1.1154	1.1662	1.1691	1.5604	1.9526
0.2280	0.8606	1.0990	1.0470	1.0903	1.0929	1.4588	1.8256
0.2318	0.8248	1.0496	0.9787	1.0143	1.0166	1.3572	1.6986
0.2356	0.7890	1.0003	0.9104	0.9384	0.9404	1.2556	1.5717
0.2394	0.7533	0.9509	0.8420	0.8624	0.8642	1.1540	1.4447
0.2431	0.7175	0.9015	0.7737	0.7865	0.7879	1.0524	1.3177
0.2469	0.6818	0.8521	0.7054	0.7106	0.7117	0.9507	1.1907

0.2483	0.6442	0.8180	0.6599	0.6643	0.6653	0.8888	1.1134
0.2486	0.6058	0.7911	0.6251	0.6319	0.6329	0.8453	1.0591
0.2478	0.5675	0.7584	0.6216	0.6309	0.6320	0.8440	1.0575
0.2402	0.5296	0.6948	0.7889	0.8008	0.8037	1.0729	1.3438
0.2327	0.4917	0.6312	0.9561	0.9707	0.9753	1.3018	1.6301
0.2253	0.4584	0.5716	1.0966	1.1137	1.1198	1.4946	1.8712
0.2190	0.5102	0.5875	0.7501	0.7667	0.7698	1.0278	1.2872
0.2142	0.5402	0.6371	0.5031	0.5183	0.5191	0.6934	0.8689
0.0000	0.4883	0.8135	0.6302	0.6412	0.6419	0.8572	1.0738
0.0000	0.4379	0.8949	0.7151	0.7223	0.7231	0.9655	1.2090
0.0000	0.3884	0.9154	0.7728	0.7767	0.7775	1.0382	1.2994
0.0000	0.3475	0.9312	0.8187	0.8201	0.8209	1.0962	1.3717
0.0000	0.3865	0.9038	0.7547	0.7617	0.7625	1.0184	1.2750
0.0434	0.4255	0.8765	0.6906	0.7034	0.7041	0.9407	1.1782
0.1318	0.5251	0.7972	0.5988	0.5998	0.6005	0.8022	1.0049
0.2180	0.5415	0.6774	0.5090	0.5099	0.5107	0.6823	0.8546
0.2822	0.5426	0.5844	0.4392	0.4401	0.4411	0.5892	0.7383
0.2794	0.4969	0.5726	0.4307	0.4316	0.4327	0.5781	0.7252
0.2289	0.3552	0.4593	0.4482	0.4715	0.4725	0.6316	0.7915
0.2502	0.3514	0.4641	0.4292	0.4454	0.4463	0.5966	0.7479
0.2598	0.3374	0.4413	0.3906	0.4042	0.4051	0.5416	0.6791
0.2464	0.3036	0.3642	0.3132	0.3332	0.3340	0.4468	0.5605
0.2504	0.3561	0.4535	0.3803	0.3985	0.3995	0.5343	0.6700
0.2344	0.4174	0.5499	0.4559	0.4712	0.4723	0.6314	0.7917
0.1374	0.4501	0.5574	0.4626	0.4759	0.4769	0.6375	0.7996
0.0588	0.4838	0.5662	0.4672	0.4782	0.4792	0.6405	0.8035
0.0692	0.5222	0.5810	0.4619	0.4690	0.4700	0.6283	0.7884
0.0796	0.5606	0.5960	0.4567	0.4598	0.4607	0.6161	0.7732
0.0846	0.5556	0.5802	0.4366	0.4377	0.4386	0.5866	0.7363
0.0840	0.5058	0.5332	0.4013	0.4024	0.4034	0.5394	0.6771
0.2429	0.4660	0.4792	0.3608	0.3616	0.3626	0.4853	0.6091
0.3193	0.4183	0.4442	0.3346	0.3353	0.3364	0.4503	0.5653
0.2925	0.3608	0.4327	0.3259	0.3268	0.3279	0.4388	0.5512
0.2646	0.3243	0.4032	0.3036	0.3046	0.3057	0.4090	0.5138
0.2356	0.3067	0.3573	0.2691	0.2700	0.2710	0.3624	0.4554
0.2190	0.2844	0.3368	0.2537	0.2546	0.2555	0.3417	0.4289
0.2060	0.2680	0.3237	0.2439	0.2447	0.2455	0.3283	0.4117
0.1988	0.2777	0.3211	0.2420	0.2428	0.2435	0.3257	0.4088
0.2082	0.2878	0.3261	0.2457	0.2468	0.2477	0.3315	0.4165
0.2120	0.2763	0.3280	0.2551	0.2649	0.2658	0.3558	0.4473
0.2276	0.2714	0.3405	0.2757	0.2955	0.2963	0.3965	0.4985
0.3277	0.3764	0.4190	0.3332	0.3390	0.3398	0.4546	0.5703
0.3202	0.3839	0.4523	0.3632	0.3661	0.3670	0.4909	0.6157
0.2545	0.3386	0.4611	0.3783	0.3844	0.3855	0.5154	0.6467
0.2148	0.3173	0.4577	0.3809	0.3878	0.3889	0.5199	0.6525
0.2300	0.3466	0.4284	0.3569	0.3596	0.3605	0.4821	0.6051
0.2140	0.3056	0.3848	0.3207	0.3285	0.3294	0.4406	0.5533
0.1807	0.2243	0.3318	0.2766	0.2941	0.2950	0.3947	0.4962
0.1866	0.2220	0.2873	0.2402	0.2493	0.2502	0.3349	0.4209
0.1926	0.2198	0.2429	0.2039	0.2047	0.2055	0.2752	0.3458
0.2348	0.2770	0.3118	0.2492	0.2500	0.2508	0.3357	0.4218
0.2602	0.3067	0.3442	0.2732	0.2801	0.2809	0.3759	0.4722

0.2446	0.2693	0.2872	0.2452	0.2729	0.2738	0.3664	0.4598
0.2128	0.2344	0.2698	0.2334	0.2588	0.2598	0.3478	0.4369
0.1654	0.2020	0.2904	0.2371	0.2382	0.2391	0.3205	0.4037
0.1823	0.2374	0.2869	0.2410	0.2442	0.2453	0.3284	0.4135
0.1958	0.2443	0.2682	0.2232	0.2288	0.2297	0.3077	0.3872
0.2060	0.2260	0.2365	0.1867	0.1945	0.1954	0.2620	0.3294
0.1530	0.1730	0.1921	0.1551	0.1628	0.1637	0.2196	0.2764
0.1928	0.2164	0.2335	0.1911	0.1955	0.1964	0.2629	0.3309
0.2333	0.2668	0.2850	0.2338	0.2346	0.2354	0.3148	0.3961
0.1455	0.2471	0.3108	0.2448	0.2454	0.2460	0.3288	0.4128
0.1378	0.2322	0.2950	0.2333	0.2348	0.2354	0.3149	0.3955
0.1644	0.2195	0.2613	0.2123	0.2151	0.2158	0.2891	0.3638
0.1540	0.1787	0.1988	0.1604	0.1708	0.1715	0.2302	0.2900
0.1465	0.1597	0.1698	0.1347	0.1505	0.1514	0.2034	0.2563
0.1547	0.1739	0.1888	0.1569	0.1672	0.1681	0.2255	0.2840
0.1420	0.1531	0.1635	0.1498	0.1506	0.1514	0.2033	0.2558
0.1236	0.1328	0.1426	0.1260	0.1268	0.1275	0.1713	0.2157
0.1183	0.1273	0.1365	0.1150	0.1163	0.1170	0.1571	0.1980
0.1476	0.1610	0.1696	0.1376	0.1409	0.1417	0.1901	0.2392
0.1467	0.1753	0.1862	0.1514	0.1548	0.1556	0.2087	0.2626
0.1032	0.1606	0.1782	0.1514	0.1522	0.1529	0.2051	0.2582
0.1456	0.1779	0.1933	0.1542	0.1550	0.1557	0.2088	0.2630
0.1820	0.1926	0.2061	0.1562	0.1571	0.1578	0.2115	0.2664
0.1753	0.1881	0.2016	0.1531	0.1538	0.1545	0.2070	0.2606
0.1686	0.1835	0.1971	0.1500	0.1507	0.1513	0.2026	0.2548
0.1619	0.1790	0.1926	0.1469	0.1475	0.1480	0.1981	0.2490
0.1552	0.1744	0.1881	0.1438	0.1442	0.1447	0.1936	0.2432
0.1247	0.1311	0.1357	0.1031	0.1037	0.1044	0.1400	0.1761
0.1242	0.1282	0.1302	0.0986	0.0994	0.1002	0.1347	0.1701
0.1368	0.1429	0.1454	0.1102	0.1111	0.1120	0.1508	0.1911
0.1368	0.1609	0.1632	0.1235	0.1244	0.1253	0.1684	0.2127
0.1368	0.1788	0.1811	0.1368	0.1377	0.1386	0.1859	0.2344
0.1304	0.1528	0.1564	0.1184	0.1193	0.1203	0.1618	0.2046
0.1253	0.1310	0.1358	0.1031	0.1040	0.1050	0.1416	0.1796
0.1272	0.1358	0.1413	0.1071	0.1079	0.1088	0.1465	0.1853
0.1291	0.1406	0.1468	0.1111	0.1118	0.1126	0.1514	0.1910
0.1042	0.1259	0.1333	0.1033	0.1041	0.1049	0.1413	0.1791
0.0838	0.1132	0.1216	0.0962	0.0971	0.0979	0.1322	0.1682
0.0976	0.1166	0.1238	0.0952	0.0961	0.0969	0.1307	0.1658
0.1222	0.1321	0.1370	0.1036	0.1043	0.1051	0.1412	0.1784
0.1566	0.1586	0.1599	0.1205	0.1210	0.1215	0.1627	0.2047
0.1302	0.1377	0.1454	0.1103	0.1110	0.1118	0.1502	0.1897
0.0976	0.1118	0.1261	0.0967	0.0976	0.0986	0.1331	0.1691
0.1091	0.1166	0.1242	0.0944	0.0950	0.0958	0.1287	0.1627
0.1206	0.1214	0.1222	0.0921	0.0925	0.0929	0.1243	0.1563
0.1109	0.1116	0.1124	0.0848	0.0851	0.0856	0.1148	0.1445
0.1020	0.1030	0.1038	0.0784	0.0788	0.0793	0.1065	0.1345
0.0961	0.0977	0.0985	0.0744	0.0749	0.0754	0.1014	0.1282
0.0928	0.0950	0.0959	0.0725	0.0729	0.0734	0.0986	0.1246
0.0906	0.0933	0.0944	0.0713	0.0717	0.0722	0.0969	0.1221
0.0919	0.0954	0.0976	0.0738	0.0743	0.0748	0.1006	0.1271
0.0945	0.0989	0.1027	0.0777	0.0783	0.0789	0.1063	0.1350

0.1044	0.1096	0.1144	0.0866	0.0874	0.0881	0.1187	0.1506
0.1095	0.1147	0.1194	0.0905	0.0914	0.0922	0.1241	0.1570
0.0913	0.0947	0.0976	0.0740	0.0747	0.0754	0.1014	0.1281
0.0820	0.0860	0.0884	0.0670	0.0677	0.0683	0.0919	0.1159
0.0830	0.0905	0.0942	0.0714	0.0720	0.0727	0.0978	0.1234
0.0909	0.0961	0.0986	0.0746	0.0752	0.0758	0.1019	0.1286
0.0982	0.1006	0.1018	0.0770	0.0775	0.0780	0.1048	0.1324
0.0744	0.0775	0.0855	0.0649	0.0656	0.0662	0.0894	0.1137
0.0698	0.0736	0.0820	0.0626	0.0633	0.0641	0.0866	0.1101
0.0780	0.0826	0.0871	0.0668	0.0676	0.0683	0.0922	0.1168
0.0733	0.0799	0.0836	0.0636	0.0643	0.0649	0.0875	0.1104
0.0705	0.0783	0.0818	0.0621	0.0627	0.0633	0.0853	0.1078
0.0690	0.0777	0.0809	0.0615	0.0621	0.0628	0.0847	0.1072
0.0684	0.0780	0.0816	0.0620	0.0626	0.0633	0.0855	0.1085
0.0700	0.0803	0.0853	0.0648	0.0655	0.0662	0.0894	0.1136
0.0717	0.0827	0.0890	0.0676	0.0683	0.0691	0.0933	0.1187
0.0665	0.0729	0.0762	0.0579	0.0585	0.0592	0.0800	0.1018
0.0626	0.0654	0.0666	0.0507	0.0513	0.0519	0.0702	0.0892
0.0631	0.0660	0.0680	0.0520	0.0527	0.0533	0.0720	0.0913
0.0636	0.0666	0.0694	0.0533	0.0540	0.0547	0.0739	0.0935
0.0629	0.0686	0.0748	0.0573	0.0580	0.0587	0.0793	0.1005
0.0621	0.0707	0.0809	0.0617	0.0624	0.0632	0.0853	0.1082
0.0612	0.0728	0.0870	0.0662	0.0669	0.0676	0.0912	0.1160
0.0604	0.0750	0.0930	0.0706	0.0713	0.0721	0.0972	0.1237
0.0542	0.0648	0.0768	0.0619	0.0626	0.0634	0.0857	0.1089
0.0478	0.0542	0.0595	0.0525	0.0533	0.0541	0.0733	0.0930
0.0460	0.0513	0.0544	0.0464	0.0471	0.0478	0.0648	0.0824
0.0450	0.0497	0.0514	0.0408	0.0414	0.0420	0.0570	0.0726
0.0352	0.0477	0.0487	0.0372	0.0378	0.0383	0.0520	0.0665
0.0172	0.0454	0.0465	0.0355	0.0361	0.0367	0.0499	0.0640
0.0081	0.0367	0.0429	0.0362	0.0396	0.0413	0.0571	0.0749
0.0040	0.0246	0.0386	0.0383	0.0459	0.0492	0.0695	0.0932
0.0000	0.0162	0.0282	0.0293	0.0362	0.0411	0.0613	0.0871
0.0000	0.0088	0.0162	0.0174	0.0224	0.0288	0.0477	0.0745
0.0000	0.0018	0.0042	0.0051	0.0074	0.0127	0.0250	0.0441

Volume for all depths in each cell (Hec-m)
11.77619
11.59822
11.42049
11.72417
13.95511
15.75824
13.61915
10.75677
9.2794
8.7727
8.7799
8.76111
8.76832
8.57843
8.26791
7.96972
10.59038
14.87902
15.67269
14.72547
13.82855
13.04369
12.27402
11.62571
10.74353
9.8757
8.94059
8.00531
7.07013
7.55149
8.2927
9.0739
9.39423
8.86368
8.29322
7.76285
7.23228
6.58028
6.04978

5.70231
5.51408
5.43448
6.35276
7.27102
8.03587
5.91828
4.49417
5.14612
5.66781
5.96825
6.20614
5.86253
5.56239
5.06019
4.50341
4.18949
4.07958
4.02759
3.96743
3.72149
3.19383
3.68382
4.16259
3.99735
3.97728
3.98995
4.00264
3.85617
3.54653
3.36743
3.20356
3.16898
2.95399
2.75851
2.57743
2.44868
2.45762
2.59684
2.69152
2.81265
3.30283
3.4927
3.49033
3.43658
3.27455
3.09151
2.77701
2.45696
2.13766
2.47978
2.69082

2.60441
2.49221
2.42041
2.45013
2.30261
2.07471
1.96282
2.21825
2.49501
2.36007
2.24086
2.14928
1.89009
1.76269
1.86156
1.77904
1.5348
1.40476
1.60884
1.70134
1.57148
1.66488
1.75626
1.69474
1.61587
1.55438
1.49272
1.30162
1.28607
1.3925
1.42288
1.42733
1.57373
1.67628
1.46663
1.24641
1.14905
1.06622
1.08966
1.51034
2.25899
1.85905
1.11858
1.32329
1.44391
1.27739
1.14006
1.02442
0.97488
0.90942
1.00701
1.20412

1.21194
1.144
1.07401
1.02638
0.98303
0.97893
0.96766
0.85178
0.83378
0.87429
0.80327
0.76418
0.71111
0.69489
0.7077
0.72062
0.66944
0.62734
0.63705
0.65052
0.66324
0.68012
0.69703
0.71385
0.61697
0.50761
0.45844
0.39972
0.36344
0.33232
0.33667
0.36304
0.29932
0.21587
0.100229

From:	Sid Flannery
To:	Xinjian Chen
Cc:	Kym Holzwart; Doug Leeper
Subject:	Re: Bathymetry and shoreline stuff
Date:	Monday, December 6, 2021 7:30:10 AM
Attachments:	Alafia_Area_Volume.xls Alafia_Area_Volume_Xsectional_final.xls

---

[EXTERNAL SENDER] Use caution before opening.

Hello Xinjan,

With regard to the files I sent you on Friday, I have a few follow-up questions/observations, but first things first for Doug's benefit. Too bad about the UGA Dawgs losing to Alabama yet again. The good news is the Dawgs made it to the playoffs, but the bad news is they might have to play Bama again. I am not a football nut, but like to see teams that are long overdue have some success. In that regard, I would like to see Michigan do well.

As I asked on Friday, do you think that FSU developed the area-volume spreadsheet that I sent you directly from the bathymetric data that USF generated, then FSU generated the model grid separately? That seems to be the case, but I could be wrong. Below are some questions about models and bathymetry based on my experience using data from your models (the gold standard) and the EFDC model for the Little Manatee. Can you elaborate on below. I am just trying to understand this stuff better.

On page 16, the FSU report for the Little Manatee EFDC model says "In the river main stem, multiple grids were employed to account for the variations of river bathymetry. In the vertical direction, three sigma layers were adopted to resolve vertical mixing in this shallow water system." Does this mean that three vertical layers were used throughout the entire lower river? If so, did the depths or thicknesses of these layers stay consistent or did they vary from one river segment to another. Also, does the thickness of the layers vary with tide or water level?

Whatever the answers are, it seems to me like FSU generated the area-volume spreadsheet based on the bathymetry data that USF generated, as it had much more than three layers. Then, FSU used the USF data to independently generate the layers for the EFDC model. Is that your understanding or did they do something else? I am thinking the raw USF information is in the Bathymetry sub-folder in the LMR folder I left on the D drive.

I was always amazed with the models you created in that output values could be segregated out on really fine distance and depth scales. That was in part because your models have vertical layers in fairly small increments that seemed to reflect fairly well the bathymetry of the river. Attached are two versions of the area-volume spreadsheet you created for the Alafia, one is which I grouped the data a bit. I am wondering, did you create the area-volume spreadsheet for the Alafia from your model grids, which seems fine as your model grids were of fairly good resolution. Or, did you do what I suggested for FSU and generated the area-volume spreadsheet from the raw bathymetry data, which I seem to recall that Mote Marine generated.

None of this Alafia stuff matters now, but I am just wondering how area-volume spreadsheets are generated. I don't know much about hydrodynamic models, but always thought your models had some advantages over the EFDC model and am wondering how bathymetry is handled.

Go Wolverines!
Sid

On Fri, Dec 3, 2021 at 2:28 PM Sid Flannery <sidflannery22@gmail.com> wrote:

> Hello Xinjian,
>
> First things first. For several philosophical reasons, I am so disgusted with the Gators firing their football coach before the year was over. I guess Doug and I did not have our annual Dawgs/Gators lunch bet, or he is being kind and not cashing in.
>
> Back to bidness. Attached is EXCEL file that I am 99% sure that Allan used for the area and volume plots, plus a version with notes. See the folder called *area volume* in my Rivers/LMR folder that was on the D drive. We received the precursor of this from FSU, as one version of the spreadsheet says from FSU (also attached). Note that version does not have data for Bolster Bayou, as the FSU EFDC model does not have that bayou as well. But, there is a sub-folder for Bolster Bayou under LMR which contains area volume results I think the District generated and added to the spreadsheet Allan used.
>
> Also attached is the scope of work for FSU, which calls for the area/volume spreadsheet. However, I wonder if this spreadsheet is more exact than the cells used in their EFDC model. The data for the spreadsheet might have come first, then those same data grouped for the model grid (which might not have the same vertical resolution as the spreadsheet). Do you know what I mean - what do you think?
>
> Have a good weekend,
> Sid

On Fri, Dec 3, 2021 at 9:29 AM Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us> wrote:

> Thanks Sid!
>
> XinJian
>
> ---
>
> **From:** Sid Flannery <sidflannery22@gmail.com>
> **Sent:** Friday, December 3, 2021 9:26 AM
> **To:** Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>
> **Cc:** Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>
> **Subject:** Re: Bathymetry and shoreline stuff
>
> [EXTERNAL SENDER] Use caution before opening.
>
> Hi Xinjian,
>
> I have a meeting coming up, but can look this afternoon.
>
> This could be a case of "let's go fishin" and you will have access to the same files I have. It was a long time ago, and I assume I submitted Ping Wang files to Allan.
>
> BUT - there is a general volume/area spreadsheet that was created that Allan may have used. I am pretty sure I can find that after lunch and it may match up with those plots, maybe not.
>
> Sid
>
> On Fri, Dec 3, 2021 at 9:18 AM Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us> wrote:
>
>> Good morning Sid,

In your 11/18/2021 email, you attached four files. One of them is called "Little Manatee morphology and vegetation plots.pdf". You mentioned that Allan Willis of Atkins generated those area and volume plots in the file from the bathymetry data. I assume that these were the bathymetry data surveyed by Ping Wang of USF. I am trying to find electric files containing data points for generating these Atkins plots but failed. Do you have these files by any chance? If you have, would you please email them to me?

Thanks,

XinJian

From: Sid Flannery <sidflannery22@gmail.com>
Sent: Thursday, November 18, 2021 2:59 PM
To: Doug Leeper <Doug.Leeper@swfwmd.state.fl.us>; Kym Holzwart <Kym.Holzwart@swfwmd.state.fl.us>; Xinjian Chen <Xinjian.Chen@swfwmd.state.fl.us>; MIke Wessel (MWessel@janickienvironmental.com) <MWessel@janickienvironmental.com>
Subject: Bathymetry and shoreline stuff

[EXTERNAL SENDER] Use caution before opening.

Hello all,

I just talked with Doug about EFDC model output files and will reply about that tomorrow morning.   In short, I can wait for the revised model runs.

In the meantime, Doug and I were talking about the bathymetry data for the Little Manatee and I brought up the bathymetry report and data sets that Ping Wang of USF did for the District. I am sure that you all, especially Xinjian, are aware of that.   This is the bathymetry data from USF that were provided to FSU for construction of the EFDC model. Again, I expect you have those files, and if not, Xinjian can find them in the files I left behind.

I have attached three jpgs from the USF bathymetry work plus the

WORD file of the final USF report. It looks like USF did go into the side channels quite a bit.

I have also attached a pdf of some combined graphs taken from the bathymetry data that Allan Willis generated for the District when he was Atkins. I think the area and volume plots could be helpful.

There are also shoreline plots, but I am thinking they must have come from the vegetation work that FWRI did for the District as the vegetation is classified into different groups. The vegetation plots are more than you need, but it was easier than sorting them out.

As I told Doug, I will submit to the District a document by the Monday after Thanksgiving that lists data and graphics I think would be useful, including some of these graphics.

Sid

December 13, 2021

Request and questions about Little Manatee River EFF modeling

Hello Kym and Doug,

I have request for a report, selected model output, and have a few questions about the Environmental Favorability Function (EFF) modeling results presented in the minimum flows report for the Little Manatee River. If the District could address these requests when it is convenient, it would be greatly appreciated.

The references for report I am asking for is below, taken from page 186 in the minimum flows report.

Wessel, M. 2011. Defining the Fish-Flow Relationship in Support of Establishing Minimum Flows and Levels for Southwest Florida Tidal Rivers: Building on the Toolbox of Analytical Techniques. Report prepared by Janicki Environmental Inc. for the Southwest Florida Management District

I would also like to receive output from the Environmental Favorability Function modeling that was done for fish species in the lower river. In particular, I am requesting daily output for the amount of favorable habitat for the fish species listed on pages 146 to 149 of the minimum flows report, except for Sheepshead, for the baseline and the 15, 20, 25 and 30% flow reduction scenarios. If it saves time, my request could be limited to the Sailfin Molly, Naked and Clown Gobies, Eastern Mosquitofish, Rainwater Killifish, small gobies and Common Snook. I would also like to receive the flows at the USGS streamflow gage near Wimauma for these flow scenarios for the years 2015 to 2019, the results for which are presented on pages 146 to 149.

The questions I have are about the EFF analyses are listed below.

1. Figure 6-11 on page 147 in the minimum flow report shows average percent reductions in favorable habitat for 10 species. How were the average percent change values calculated for each flow reduction scenario. Were simple arithmetic averages of favorable habitat calculated from all days for the baseline scenario and each flow reduction scenario, then the average for the flow reduction scenario divided by the baseline average value, or was some other method used?

Similarly, in Tables 6-5 to 6-7, were the percent reduction in favorable habitat values calculated as averages for each flow reduction scenario as described above, within flow blocks, or was some other method used to calculate the percent reduction values?

2. The report about nekton in the river collected by the FFWCC that was prepared for the District (MacDonald et al., 2007) divided the stages of many species into size classes for certain analyses. For the species that were assessed for the EFF modeling, were all size classes combined for the modeling of flow reduction effects?

The following questions pertain to the habitat factor that is included in the logistic regression equation that is shown on page 129 of the minimum flows report with the intercept adjustment on page 130. Information on the EFF model is also presented in the report included as Appendix E the minimum flows report, which is draft minimum flows analysis submitted by Janicki Environmental (JEI) in June 2018. The questions below pertain to Appendix E. If these factors are no longer applicable or have been updated, please let me know.

3. On page 4-21, Appendix E says that for the refined model, the habitat levels were collapsed to the following categories: mangroves, emergent (marshes), structure and freshwater habitats, with tree,

terrestrial grasses, and bare sand group as a single category. Are these the categories that remained in the final EFF model used to determine the minimum flows?

Also, this page shows a map of the dominant shore types assigned by FFWCC as part of their seine collections. Were the shoreline classifications assigned by FFWCC categories used as the source data to create the collapsed shore habitat types used in the EFF modeling, or was some other source used to determine the shore habitat types?

The map of page 4-21 of Appendix E shows the distribution of dominant shore types identified FFWCC as part of their sampling. It is interesting to note that the map shows 'freshwater" shore types that are located fairly far downstream, sometimes in the mesohaline reach of the river. I wonder what the FFWCC was using to classify the shore type. Were they looking at the vegetation on the upland next to the shoreline? For fish sampling, I would suggest that the shore type should be classified based on habitats and vegetation within the inter-tidal range of the river, but I don't really know what FFWCC used to classify shore types. Does the District or JEI have any information on that?

Also, the FFWCC sampling generally did not extend upstream of approximately kilometer 14. Again, what source data was used to assign habitat types, was something other that data for FFWCC data used? What was applied upstream of kilometer 14?

In general, how was favorable shore habitat determined and applied in the EFF model? I am assuming that shore type was what used to determine shore habitat. Is that correct? Was a separate analysis conducted on the frequency of occurrence of fish species in various shore habitats conducted to determine favorable shore habitats, then the quantity of those shore habitats in various river reaches applied in the EFF modeling? Or, did the EFF modeling itself derive what the favorable shore habitats were for each species? More explanation of how favorable shore habitats were determined and applied in the model would be helpful.

For example, could a species have more than one favorable shore habitat? From looking at the map on page 4-21, I would think that combined emergent marsh and freshwater would make sense.

The figure on page 4-25 for favorable habitat predictions for the striped mojarra (*Eugerre plumieiri*) using the EFDC and the LOESS model is interesting. Does it incorporate both the salinity predictions and favorable habitat factors or is it just based on salinity? On this date (December 6, 2003), it appears that salinity distribution had much to do with favorable habitat being upstream of approximately kilometer 10, as the flow at the gage on that date was 53 cfs.

I would assume on a day with higher flow, the favorable habitat would extend farther downstream. If that were the case, does the EFF analysis also incorporate data from within the bayous and Ruskin Inlet? Page 169 in MacDonald et al. (2007) shows that the striped mojarra had higher geometric mean abundance values in the bayous than in the river channel during that period of data collection (1996-2006).

Thanks for whatever information you can provide to these questions. I expect you are very busy with the holidays approaching, so whenever you can address these if fine, with after Christmas or sometime thereafter being fine.

Thanks again and Happy Holidays!

Sid

From:	Sid Flannery
To:	Doug Leeper; Kym Holzwart; Gabe I. Herrick; Lei Yang; Xinjian Chen; Jordan D. Miller; Chris Zajac; Randy Smith; Kristina Deak
Subject:	Request for material pertaining to EFF modeling in the Little Manatee River
Date:	Monday, December 13, 2021 12:27:10 PM
Attachments:	Requests and questions related to Little Manatee River EFF modeling.docx

Hello Kym, Doug, and other District staff,

Attached is a WORD document that includes requests I have for a report and selected model output related to the Environmental Favorability Function modeling results that were presented in the minimum flows report for the Little Manatee River. I also have a few questions related to the EFF modeling.

As the document says, whenever the District can accommodate these requests and questions will be fine.

Thanks very much for what you can do and have a fine holiday season.

Go Dawgs!
Sid

DEPARTMENT OF ENVIRONMENTAL PROTECTION DISCHARGE MONITORING REPORT - PART A

PERMITTEE NAME:	Mosaic Fertilizer, L.L.C.	PERMIT NUMBER:	FL0036412		
ADDRESS:	13830 Circa Crossing Dr Lithia, FL 33547	LIMIT:	FINAL	REPORT:	Monthly
		FACILITY TYPE:	IW	GROUP:	Industrial
		MONITORING GROUP:	D-001		
FACILITY:	Mosaic Fertilizer, LLC - Four Corners Mine				
LOCATION:	11200 SR 37 S Bradley, FL 33835	DESCRIPTION:	OUTFALL 001 - DISCHARGE TO ALDERMAN CREEK, LITTLE MANATTEE RIVER		
COUNTY:	MANATEE				
		MONITORING PERIOD:	From: 05/01/2021 To: 05/31/2021		

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Flow	**Sample Measurement**	**NOD**	**NOD**						**0**	**NOD**	**NOD**
PARM Code 50050 1 Mon. Site: EFF-001	**Permit Requirement**	**Report (Daily Mx)**	**Report (Mo Avg)**	**MGD**						**(1 Continuous)**	**(Meter)**
Stream Flow	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00060 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**		**Report (Daily Mx)**	**MGD**						**(1 Monthly)**	**(Calculated)**
Stream Flow	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00060 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**		**Report (Daily Mx)**	**MGD**						**(1 Monthly)**	**(Calculated)**
pH	**Sample Measurement**				**NOD**		**NOD**		**0**	**NOD**	**NOD**
PARM Code 00400 1 Mon. Site: EFF-001	**Permit Requirement**				**6.0 (Daily Mn)**		**8.5 (Daily Mx)**	**s.u.**		**(1 Weekly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
pH	**Sample Measurement**				**NOD**		**NOD**		**0**	**NOD**	**NOD**
PARM Code 00400 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**				**Report (Daily Mn)**		**Report (Daily Mx)**	**s.u.**		**(1 Monthly, when discharging)**	**(Grab)**
pH	**Sample Measurement**				**NOD**		**NOD**		**0**	**NOD**	**NOD**
PARM Code 00400 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**				**Report (Daily Mn)**		**Report (Daily Mx)**	**s.u.**		**(1 Monthly, when discharging)**	**(Grab)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 1 Add. Desc: effluent Mon. Site: EFF-001	**Permit Requirement**						**Report (Maximum)**	**NTU**		**(1 Weekly)**	**(Grab)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**						**Report (Maximum)**	**NTU**		**(1 Weekly, when discharging)**	**(Grab)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 P Add. Desc: calculated limit Mon. Site: SWB-001	**Permit Requirement**						**Report (Maximum)**	**NTU**		**(1 Weekly)**	**(Calculated)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-001	**Permit Requirement**						**0.0 (Maximum)**	**NTU**		**(1 Weekly)**	**(Calculated)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**					**NOD**	**NOD**		**0**	**NOD**	**NOD**
PARM Code 00530 1 Mon. Site: EFF-001	**Permit Requirement**					**60.0 (Daily Mx)**	**30.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00530 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00530 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Solids, Fixed Suspended	**Sample Measurement**					**NOD**	**NOD**		**0**	**NOD**	**NOD**
PARM Code 00540 1 Mon. Site: EFF-001	**Permit Requirement**					**25.0 (Daily Mx)**	**12.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**					**NOD**	**NOD**		**0**	**NOD**	**NOD**
PARM Code 00665 1 Mon. Site: EFF-001	**Permit Requirement**					**5.0 (Daily Mx)**	**3.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00665 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00665 P Mon. Site: EFF-001	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 1 Add. Desc: effluent Mon. Site: EFF-001	**Permit Requirement**						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 P Add. Desc: calculated limit Mon. Site: SWB-001	**Permit Requirement**						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-001	**Permit Requirement**						**0.0 (Daily Mx)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**NOD**				**0**	**NOD**	**NOD**
PARM Code 00301 1 Mon. Site: EFF-001	**Permit Requirement**				**38.0 (Daily Mn)**			**percent**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**NOD**				**0**	**NOD**	**NOD**
PARM Code 00301 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**				**Report (Dlyavmin)**			**percent**		**(1 Monthly, when discharging)**	**(Grab)**
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**NOD**				**0**	**NOD**	**NOD**
PARM Code 00301 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**				**Report (Dlyavmin)**			**percent**		**(1 Monthly, when discharging)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00010 1 Mon. Site: EFF-001	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00010 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly, when discharging)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00010 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly, when discharging)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Nitrogen, Total	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00600 1 Mon. Site: EFF-001	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00600 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00600 P Mon. Site: EFF-001	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	I CERTIFY UNDER PENALTY OF LAW THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM, OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING THE INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR KNOWING VIOLATIONS.	SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	TELEPHONE	SUBMITTED ON
Bethany Niec		Electronically Signed	(863) 661-0315	06/18/2021

DEPARTMENT OF ENVIRONMENTAL PROTECTION DISCHARGE MONITORING REPORT - PART A

PERMITTEE NAME:	Mosaic Fertilizer, L.L.C.	PERMIT NUMBER:	FL0036412				
ADDRESS:	13830 Circa Crossing Dr Lithia, FL 33547	LIMIT:	FINAL	REPORT:	Monthly		
		FACILITY TYPE:	IW	GROUP:	Industrial		
		MONITORING GROUP:	D-002				
FACILITY:	Mosaic Fertilizer, LLC - Four Corners Mine						
LOCATION:	11200 SR 37 S Bradley, FL 33835	DESCRIPTION:	OUTFALL 002 - DISCHARGE TO PAYNE CREEK, PEACE RIVER				
COUNTY:	MANATEE	MONITORING PERIOD:	From: 05/01/2021 To: 05/31/2021				

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Flow	**Sample Measurement**	**NOD**	**NOD**						**0**	**NOD**	**NOD**
PARM Code 50050 1 Mon. Site: EFF-002	**Permit Requirement**	**Report (Daily Mx)**	**Report (Mo Avg)**	**MGD**						**(1 Continuous)**	**(Meter)**
Stream Flow	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00060 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**		**Report (Daily Mx)**	**MGD**						**(1 Monthly)**	**(Calculated)**
Stream Flow	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00060 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**		**Report (Daily Mx)**	**MGD**						**(1 Monthly)**	**(Calculated)**
pH	**Sample Measurement**				**NOD**		**NOD**		**0**	**NOD**	**NOD**
PARM Code 00400 1 Mon. Site: EFF-002	**Permit Requirement**				**6.0 (Daily Mn)**		**8.5 (Daily Mx)**	**s.u.**		**(1 Weekly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
pH	**Sample Measurement**				**NOD**		**NOD**		**0**	**NOD**	**NOD**
PARM Code 00400 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**				**Report (Daily Mn)**		**Report (Daily Mx)**	**s.u.**		**(1 Monthly, when discharging)**	**(Grab)**
pH	**Sample Measurement**				**NOD**		**NOD**		**0**	**NOD**	**NOD**
PARM Code 00400 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**				**Report (Daily Mn)**		**Report (Daily Mx)**	**s.u.**		**(1 Monthly, when discharging)**	**(Grab)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 1 Add. Desc: effluent Mon. Site: EFF-002	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Weekly)**	**(Grab)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Weekly, when discharging)**	**(Grab)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 P Add. Desc: calculated limit Mon. Site: SWB-002	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Weekly)**	**(Calculated)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-002	**Permit Requirement**						**0.0 (Daily Mx)**	**NTU**		**(1 Weekly)**	**(Calculated)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**					**NOD**	**NOD**		**0**	**NOD**	**NOD**
PARM Code 00530 1 Mon. Site: EFF-002	**Permit Requirement**					**60.0 (Daily Mx)**	**30.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00530 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00530 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Solids, Fixed Suspended	**Sample Measurement**					**NOD**	**NOD**		**0**	**NOD**	**NOD**
PARM Code 00540 1 Mon. Site: EFF-002	**Permit Requirement**					**25.0 (Daily Mx)**	**12.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**					**NOD**	**NOD**		**0**	**NOD**	**NOD**
PARM Code 00665 1 Mon. Site: EFF-002	**Permit Requirement**					**5.0 (Daily Mx)**	**3.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00665 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00665 P Mon. Site: EFF-002	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 1 Add. Desc: effluent Mon. Site: EFF-002	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 P Add. Desc: calculated limit Mon. Site: SWB-002	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-002	**Permit Requirement**						**0.0 (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**NOD**				**0**	**NOD**	**NOD**
PARM Code 00301 1 Mon. Site: EFF-002	**Permit Requirement**				**38.0 (Dlyavmin)**			**percent**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**NOD**				**0**	**NOD**	**NOD**
PARM Code 00301 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**				**Report (Dlyavmin)**			**percent**		**(1 Monthly, when discharging)**	**(Grab)**
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**NOD**				**0**	**NOD**	**NOD**
PARM Code 00301 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**				**Report (Dlyavmin)**			**percent**		**(1 Monthly, when discharging)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00010 1 Mon. Site: EFF-002	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00010 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly, when discharging)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00010 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly, when discharging)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Nitrogen, Total	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00600 1 Mon. Site: EFF-002	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00600 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00600 P Mon. Site: EFF-002	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	I CERTIFY UNDER PENALTY OF LAW THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM, OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING THE INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR KNOWING VIOLATIONS.	SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	TELEPHONE	SUBMITTED ON
Bethany Niec		Electronically Signed	(863) 661-0315	06/18/2021

DEPARTMENT OF ENVIRONMENTAL PROTECTION DISCHARGE MONITORING REPORT - PART A

PERMITTEE NAME:	Mosaic Fertilizer, L.L.C.	PERMIT NUMBER:	FL0036412
ADDRESS:	13830 Circa Crossing Dr Lithia, FL 33547	LIMIT:	FINAL REPORT: Monthly
		FACILITY TYPE:	IW GROUP: Industrial
		MONITORING GROUP:	D-003
FACILITY:	Mosaic Fertilizer, LLC - Four Corners Mine		
LOCATION:	11200 SR 37 S Bradley, FL 33835	DESCRIPTION:	Outfall D-003
COUNTY:	MANATEE	MONITORING PERIOD:	From: 05/01/2021 To: 05/31/2021

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Flow	**Sample Measurement**	**NOD**	**NOD**						**0**	**NOD**	**NOD**
PARM Code 50050 1 Mon. Site: EFF-003	**Permit Requirement**	**Report (Daily Mx)**	**Report (Mo Avg)**	**MGD**						**(1 Continuous)**	**(Meter)**
Stream Flow	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00060 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**		**Report (Daily Mx)**	**MGD**						**(1 Monthly)**	**(Calculated)**
Stream Flow	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00060 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**		**Report (Daily Mx)**	**MGD**						**(1 Monthly)**	**(Calculated)**
pH	**Sample Measurement**				**NOD**		**NOD**		**0**	**NOD**	**NOD**
PARM Code 00400 1 Mon. Site: EFF-003	**Permit Requirement**				**6.0 (Daily Mn)**		**8.5 (Daily Mx)**	**s.u.**		**(1 Weekly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
pH	**Sample Measurement**				**NOD**		**NOD**		**0**	**NOD**	**NOD**
PARM Code 00400 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**				**Report (Daily Mn)**		**Report (Daily Mx)**	**s.u.**		**(1 Monthly, when discharging)**	**(Grab)**
pH	**Sample Measurement**				**NOD**		**NOD**		**0**	**NOD**	**NOD**
PARM Code 00400 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**				**Report (Daily Mn)**		**Report (Daily Mx)**	**s.u.**		**(1 Monthly)**	**(Grab)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 1 Add. Desc: effluent Mon. Site: EFF-003	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Weekly)**	**(Grab)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Weekly, when discharging)**	**(Grab)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 P Add. Desc: calculated limit Mon. Site: SWB-003	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Weekly)**	**(Calculated)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-003	**Permit Requirement**						**0.0 (Daily Mx)**	**NTU**		**(1 Weekly)**	**(Calculated)**
Turbidity	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00070 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**					**NOD**	**NOD**		**0**	**NOD**	**NOD**
PARM Code 00530 1 Mon. Site: EFF-003	**Permit Requirement**					**60.0 (Daily Mx)**	**30.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00530 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00530 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Solids, Fixed Suspended	**Sample Measurement**					**NOD**	**NOD**		**0**	**NOD**	**NOD**
PARM Code 00540 1 Mon. Site: EFF-003	**Permit Requirement**					**25.0 (Daily Mx)**	**12.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**					**NOD**	**NOD**		**0**	**NOD**	**NOD**
PARM Code 00665 1 Mon. Site: EFF-003	**Permit Requirement**					**5.0 (Daily Mx)**	**3.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00665 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00665 P Mon. Site: EFF-003	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 1 Add. Desc: effluent Mon. Site: EFF-003	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 P Add. Desc: calculated limit Mon. Site: SWB-003	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-003	**Permit Requirement**						**0.0 (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00095 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**NOD**				**0**	**NOD**	**NOD**
PARM Code 00301 1 Mon. Site: EFF-003	**Permit Requirement**				**38.0 (Dlyavmin)**			**percent**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**NOD**				**0**	**NOD**	**NOD**
PARM Code 00301 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**				**Report (Dlyavmin)**			**percent**		**(1 Monthly, when discharging)**	**(Grab)**
Oxygen, Dissolved Percent Saturation	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00301 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**						**Report (Daily Av)**	**percent**		**(1 Monthly, when discharging)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00010 1 Mon. Site: EFF-003	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00010 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly, when discharging)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00010 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly, when discharging)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Nitrogen, Total	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00600 1 Mon. Site: EFF-003	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**						**NOD**		**0**	**NOD**	**NOD**
PARM Code 00600 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**		**NOD**						**0**	**NOD**	**NOD**
PARM Code 00600 P Mon. Site: EFF-003	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	I CERTIFY UNDER PENALTY OF LAW THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM, OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING THE INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR KNOWING VIOLATIONS.	SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	TELEPHONE	SUBMITTED ON
Bethany Niec		Electronically Signed	(863) 661-0315	06/18/2021

DEPARTMENT OF ENVIRONMENTAL PROTECTION DISCHARGE MONITORING REPORT - PART A

PERMITTEE NAME:	Mosaic Fertilizer, L.L.C.	PERMIT NUMBER:	FL0036412			
ADDRESS:	13830 Circa Crossing Dr Lithia, FL 33547	LIMIT:	FINAL	REPORT:	Monthly	
		FACILITY TYPE:	IW	GROUP:	Industrial	
		MONITORING GROUP:	D-001			
FACILITY:	Mosaic Fertilizer, LLC - Four Corners Mine					
LOCATION:	11200 SR 37 S Bradley, FL 33835	DESCRIPTION:	OUTFALL 001 - DISCHARGE TO ALDERMAN CREEK, LITTLE MANATTEE RIVER			
COUNTY:	MANATEE					
		MONITORING PERIOD:	From: 08/01/2021 To: 08/31/2021			

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Flow	**Sample Measurement**	**77.33**	**39.78**						**0**	**1 Continuous**	**Meter**
PARM Code 50050 1 Mon. Site: EFF-001	**Permit Requirement**	**Report (Daily Mx)**	**Report (Mo Avg)**	**MGD**						**(1 Continuous)**	**(Meter)**
Stream Flow	**Sample Measurement**		**16.80**						**0**	**1 Monthly**	**Calculated**
PARM Code 00060 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**		**Report (Daily Mx)**	**MGD**						**(1 Monthly)**	**(Calculated)**
Stream Flow	**Sample Measurement**		**58.20**						**0**	**1 Monthly**	**Calculated**
PARM Code 00060 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**		**Report (Daily Mx)**	**MGD**						**(1 Monthly)**	**(Calculated)**
pH	**Sample Measurement**				**7.12**		**7.40**		**0**	**1 Weekly**	**Grab**
PARM Code 00400 1 Mon. Site: EFF-001	**Permit Requirement**				**6.0 (Daily Mn)**		**8.5 (Daily Mx)**	**s.u.**		**(1 Weekly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
pH	**Sample Measurement**				7.03		7.22		0	1 Monthly, when discharging	Grab
PARM Code 00400 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**				Report (Daily Mn)		Report (Daily Mx)	s.u.		(1 Monthly, when discharging)	(Grab)
pH	**Sample Measurement**				7.15		7.43		0	1 Monthly, when discharging	Grab
PARM Code 00400 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**				Report (Daily Mn)		Report (Daily Mx)	s.u.		(1 Monthly, when discharging)	(Grab)
Turbidity	**Sample Measurement**						8.27		0	1 Weekly	Grab
PARM Code 00070 1 Add. Desc: effluent Mon. Site: EFF-001	**Permit Requirement**						Report (Maximum)	NTU		(1 Weekly)	(Grab)
Turbidity	**Sample Measurement**						6.01		0	1 Weekly, when discharging	Grab
PARM Code 00070 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**						Report (Maximum)	NTU		(1 Weekly, when discharging)	(Grab)
Turbidity	**Sample Measurement**						35.01		0	1 Weekly	Calculated
PARM Code 00070 P Add. Desc: calculated limit Mon. Site: SWB-001	**Permit Requirement**						Report (Maximum)	NTU		(1 Weekly)	(Calculated)

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Turbidity	**Sample Measurement**						**-26.74**		**0**	**1 Weekly**	**Calculated**
PARM Code 00070 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-001	**Permit Requirement**						**0.0 (Maximum)**	**NTU**		**(1 Weekly)**	**(Calculated)**
Turbidity	**Sample Measurement**						**7.45**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00070 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**					**7.20**	**5.95**		**0**	**1 Weekly**	**Grab**
PARM Code 00530 1 Mon. Site: EFF-001	**Permit Requirement**					**60.0 (Daily Mx)**	**30.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**4.2**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00530 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**9.2**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00530 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Solids, Fixed Suspended	**Sample Measurement**					**5.7**	**4.1**		**0**	**1 Weekly**	**Grab**
PARM Code 00540 1 Mon. Site: EFF-001	**Permit Requirement**					**25.0 (Daily Mx)**	**12.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**					**0.43**	**0.38**		**0**	**1 Weekly**	**Grab**
PARM Code 00665 1 Mon. Site: EFF-001	**Permit Requirement**					**5.0 (Daily Mx)**	**3.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**						**0.7**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00665 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**		**215.54**						**0**	**1 Monthly**	**Calculated**
PARM Code 00665 P Mon. Site: EFF-001	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**445**		**0**	**1 Monthly**	**Grab**
PARM Code 00095 1 Add. Desc: effluent Mon. Site: EFF-001	**Permit Requirement**						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Specific Conductance PARM Code 00095 5 Add. Desc: background Mon. Site: SWB-001	**Sample Measurement**						**241**		**0**	**1 Monthly, when discharging**	**Grab**
	Permit Requirement						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Specific Conductance PARM Code 00095 P Add. Desc: calculated limit Mon. Site: SWB-001	**Sample Measurement**						**1275**		**0**	**1 Monthly**	**Calculated**
	Permit Requirement						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance PARM Code 00095 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-001	**Sample Measurement**						**-830**		**0**	**1 Monthly**	**Calculated**
	Permit Requirement						**0.0 (Daily Mx)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance PARM Code 00095 6 Add. Desc: downstream Mon. Site: SWD-001	**Sample Measurement**						**426**		**0**	**1 Monthly, when discharging**	**Grab**
	Permit Requirement						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Oxygen, Dissolved Percent Saturation PARM Code 00301 1 Mon. Site: EFF-001	**Sample Measurement**				**39.9**				**0**	**1 Monthly**	**Grab**
	Permit Requirement				**38.0 (Daily Mn)**			**percent**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				80				0	1 Monthly, when discharging	Grab
PARM Code 00301 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**				Report (Dlyavmin)			percent		(1 Monthly, when discharging)	(Grab)
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				84.5				0	1 Monthly, when discharging	Grab
PARM Code 00301 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**				Report (Dlyavmin)			percent		(1 Monthly, when discharging)	(Grab)
Temperature (C), Water	**Sample Measurement**						31.3		0	1 Monthly	Grab
PARM Code 00010 1 Mon. Site: EFF-001	**Permit Requirement**						Report (Daily Mx)	Deg C		(1 Monthly)	(Grab)
Temperature (C), Water	**Sample Measurement**						27.5		0	1 Monthly, when discharging	Grab
PARM Code 00010 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**						Report (Daily Mx)	Deg C		(1 Monthly, when discharging)	(Grab)
Temperature (C), Water	**Sample Measurement**						29.5		0	1 Monthly, when discharging	Grab
PARM Code 00010 6 Add. Desc: downstream Mon. Site: SWD-001	**Permit Requirement**						Report (Daily Mx)	Deg C		(1 Monthly, when discharging)	(Grab)

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Nitrogen, Total	**Sample Measurement**						**1.0**		**0**	**1 Monthly**	**Grab**
PARM Code 00600 1 Mon. Site: EFF-001	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**						**1.2**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00600 5 Add. Desc: background Mon. Site: SWB-001	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**		**508.91**						**0**	**1 Monthly**	**Calculated**
PARM Code 00600 P Mon. Site: EFF-001	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	I CERTIFY UNDER PENALTY OF LAW THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM, OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING THE INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR KNOWING VIOLATIONS.	SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	TELEPHONE	SUBMITTED ON
Bethany Niec		Electronically Signed	(863) 661-0315	09/22/2021

DEPARTMENT OF ENVIRONMENTAL PROTECTION DISCHARGE MONITORING REPORT - PART A

PERMITTEE NAME:	Mosaic Fertilizer, L.L.C.	PERMIT NUMBER:	FL0036412			
ADDRESS:	13830 Circa Crossing Dr Lithia, FL 33547	LIMIT:	FINAL	REPORT:	Monthly	
		FACILITY TYPE:	IW	GROUP:	Industrial	
		MONITORING GROUP:	D-002			
FACILITY:	Mosaic Fertilizer, LLC - Four Corners Mine					
LOCATION:	11200 SR 37 S Bradley, FL 33835	DESCRIPTION:	OUTFALL 002 - DISCHARGE TO PAYNE CREEK, PEACE RIVER			
COUNTY:	MANATEE	MONITORING PERIOD:	From: 08/01/2021 To: 08/31/2021			

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Flow	Sample Measurement	26.51	16.13						0	1 Continuous	Meter
PARM Code 50050 1 Mon. Site: EFF-002	Permit Requirement	Report (Daily Mx)	Report (Mo Avg)	MGD						(1 Continuous)	(Meter)
Stream Flow	Sample Measurement		OTH						0	1 Monthly	Calculated
PARM Code 00060 5 Add. Desc: background Mon. Site: SWB-002	Permit Requirement		Report (Daily Mx)	MGD						(1 Monthly)	(Calculated)
Stream Flow	Sample Measurement		43.50						0	1 Monthly	Calculated
PARM Code 00060 6 Add. Desc: downstream Mon. Site: SWD-002	Permit Requirement		Report (Daily Mx)	MGD						(1 Monthly)	(Calculated)
pH	Sample Measurement				7.17		7.8		0	1 Weekly	Grab
PARM Code 00400 1 Mon. Site: EFF-002	Permit Requirement				6.0 (Daily Mn)		8.5 (Daily Mx)	s.u.		(1 Weekly)	(Grab)

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
pH	**Sample Measurement**				6.97		6.97		0	1 Monthly, when discharging	Grab
PARM Code 00400 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**				Report (Daily Mn)		Report (Daily Mx)	s.u.		(1 Monthly, when discharging)	(Grab)
pH	**Sample Measurement**				7.18		7.18		0	1 Monthly, when discharging	Grab
PARM Code 00400 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**				Report (Daily Mn)		Report (Daily Mx)	s.u.		(1 Monthly, when discharging)	(Grab)
Turbidity	**Sample Measurement**						6.6		0	1 Weekly	Grab
PARM Code 00070 1 Add. Desc: effluent Mon. Site: EFF-002	**Permit Requirement**						Report (Daily Mx)	NTU		(1 Weekly)	(Grab)
Turbidity	**Sample Measurement**						8.8		0	1 Weekly, when discharging	Grab
PARM Code 00070 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						Report (Daily Mx)	NTU		(1 Weekly, when discharging)	(Grab)
Turbidity	**Sample Measurement**						37.8		0	1 Weekly	Calculated
PARM Code 00070 P Add. Desc: calculated limit Mon. Site: SWB-002	**Permit Requirement**						Report (Daily Mx)	NTU		(1 Weekly)	(Calculated)

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Turbidity	**Sample Measurement**						**-31.2**		**0**	**1 Weekly**	**Calculated**
PARM Code 00070 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-002	**Permit Requirement**						**0.0 (Daily Mx)**	**NTU**		**(1 Weekly)**	**(Calculated)**
Turbidity	**Sample Measurement**						**3.5**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00070 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**					**6.1**	**5.3**		**0**	**1 Weekly**	**Grab**
PARM Code 00530 1 Mon. Site: EFF-002	**Permit Requirement**					**60.0 (Daily Mx)**	**30.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**5**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00530 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**5**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00530 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Solids, Fixed Suspended	**Sample Measurement**					**4.0**	**3.0**		**0**	**1 Weekly**	**Grab**
PARM Code 00540 1 Mon. Site: EFF-002	**Permit Requirement**					**25.0 (Daily Mx)**	**12.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**					**0.7**	**0.6**		**0**	**1 Weekly**	**Grab**
PARM Code 00665 1 Mon. Site: EFF-002	**Permit Requirement**					**5.0 (Daily Mx)**	**3.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**						**0.7**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00665 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**		**139.77**						**0**	**1 Monthly**	**Calculated**
PARM Code 00665 P Mon. Site: EFF-002	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**534**		**0**	**1 Monthly**	**Grab**
PARM Code 00095 1 Add. Desc: effluent Mon. Site: EFF-002	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Specific Conductance	**Sample Measurement**						**195**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00095 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Specific Conductance	**Sample Measurement**						**1275**		**0**	**1 Monthly**	**Calculated**
PARM Code 00095 P Add. Desc: calculated limit Mon. Site: SWB-002	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**-741**		**0**	**1 Monthly**	**Calculated**
PARM Code 00095 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-002	**Permit Requirement**						**0.0 (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**410**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00095 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**86.5**				**0**	**1 Monthly**	**Grab**
PARM Code 00301 1 Mon. Site: EFF-002	**Permit Requirement**				**38.0 (Dlyavmin)**			**percent**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**27.1**				**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00301 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**				**Report (Dlyavmin)**			**percent**		**(1 Monthly, when discharging)**	**(Grab)**
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**42.0**				**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00301 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**				**Report (Dlyavmin)**			**percent**		**(1 Monthly, when discharging)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**31.9**		**0**	**1 Monthly**	**Grab**
PARM Code 00010 1 Mon. Site: EFF-002	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**28.3**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00010 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly, when discharging)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**30.5**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00010 6 Add. Desc: downstream Mon. Site: SWD-002	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly, when discharging)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Nitrogen, Total	**Sample Measurement**						**0.9**		**0**	**1 Monthly**	**Grab**
PARM Code 00600 1 Mon. Site: EFF-002	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**						**1.5**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00600 5 Add. Desc: background Mon. Site: SWB-002	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**		**196.53**						**0**	**1 Monthly**	**Calculated**
PARM Code 00600 P Mon. Site: EFF-002	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT		SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	TELEPHONE	SUBMITTED ON
Bethany Niec	I CERTIFY UNDER PENALTY OF LAW THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM, OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING THE INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR KNOWING VIOLATIONS.	Electronically Signed	(863) 661-0315	09/22/2021

Parameter	Monitoring Site	Comments for Monitoring Group - D-002
00060 5	SWB-002	The maximum flow for SWB-002 was out of banks and unable to be safely measured.

DEPARTMENT OF ENVIRONMENTAL PROTECTION DISCHARGE MONITORING REPORT - PART A

PERMITTEE NAME: Mosaic Fertilizer, L.L.C.
ADDRESS: 13830 Circa Crossing Dr
Lithia, FL 33547

FACILITY: Mosaic Fertilizer, LLC - Four Corners Mine
LOCATION: 11200 SR 37 S
Bradley, FL 33835

COUNTY: MANATEE

PERMIT NUMBER: FL0036412
LIMIT: FINAL REPORT: Monthly
FACILITY TYPE: IW GROUP: Industrial
MONITORING GROUP: D-003

DESCRIPTION: Outfall D-003

MONITORING PERIOD: From: 08/01/2021 To: 08/31/2021

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Flow	**Sample Measurement**	**19.99**	**17.93**						**0**	**1 Continuous**	**Meter**
PARM Code 50050 1 Mon. Site: EFF-003	**Permit Requirement**	**Report (Daily Mx)**	**Report (Mo Avg)**	**MGD**						**(1 Continuous)**	**(Meter)**
Stream Flow	**Sample Measurement**		**5.82**						**0**	**1 Monthly**	**Calculated**
PARM Code 00060 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**		**Report (Daily Mx)**	**MGD**						**(1 Monthly)**	**(Calculated)**
Stream Flow	**Sample Measurement**		**OTH**						**0**	**1 Monthly**	**Calculated**
PARM Code 00060 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**		**Report (Daily Mx)**	**MGD**						**(1 Monthly)**	**(Calculated)**
pH	**Sample Measurement**				**7.30**		**7.79**		**0**	**1 Weekly**	**Grab**
PARM Code 00400 1 Mon. Site: EFF-003	**Permit Requirement**				**6.0 (Daily Mn)**		**8.5 (Daily Mx)**	**s.u.**		**(1 Weekly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
pH	**Sample Measurement**				6.75		6.75		0	1 Monthly, when discharging	Grab
PARM Code 00400 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**				Report (Daily Mn)		Report (Daily Mx)	s.u.		(1 Monthly, when discharging)	(Grab)
pH	**Sample Measurement**				7.19		7.49		0	1 Monthly	Grab
PARM Code 00400 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**				Report (Daily Mn)		Report (Daily Mx)	s.u.		(1 Monthly)	(Grab)
Turbidity	**Sample Measurement**						9.9		0	1 Weekly	Grab
PARM Code 00070 1 Add. Desc: effluent Mon. Site: EFF-003	**Permit Requirement**						Report (Daily Mx)	NTU		(1 Weekly)	(Grab)
Turbidity	**Sample Measurement**						9.8		0	1 Weekly, when discharging	Grab
PARM Code 00070 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						Report (Daily Mx)	NTU		(1 Weekly, when discharging)	(Grab)
Turbidity	**Sample Measurement**						38.8		0	1 Weekly	Calculated
PARM Code 00070 P Add. Desc: calculated limit Mon. Site: SWB-003	**Permit Requirement**						Report (Daily Mx)	NTU		(1 Weekly)	(Calculated)

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Turbidity	**Sample Measurement**						**-28.9**		**0**	**1 Weekly**	**Calculated**
PARM Code 00070 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-003	**Permit Requirement**						**0.0 (Daily Mx)**	**NTU**		**(1 Weekly)**	**(Calculated)**
Turbidity	**Sample Measurement**						**2.6**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00070 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**						**Report (Daily Mx)**	**NTU**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**					**6.4**	**4.6**		**0**	**1 Weekly**	**Grab**
PARM Code 00530 1 Mon. Site: EFF-003	**Permit Requirement**					**60.0 (Daily Mx)**	**30.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**1.6**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00530 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Solids, Total Suspended	**Sample Measurement**						**1.6**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00530 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Solids, Fixed Suspended	**Sample Measurement**					**4.2**	**2.4**		**0**	**1 Weekly**	**Grab**
PARM Code 00540 1 Mon. Site: EFF-003	**Permit Requirement**					**25.0 (Daily Mx)**	**12.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**					**0.5**	**0.3**		**0**	**1 Weekly**	**Grab**
PARM Code 00665 1 Mon. Site: EFF-003	**Permit Requirement**					**5.0 (Daily Mx)**	**3.0 (30Da Avg)**	**mg/L**		**(1 Weekly)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**						**0.2**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00665 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Phosphorus, Total (as P)	**Sample Measurement**		**75.74**						**0**	**1 Monthly**	**Calculated**
PARM Code 00665 P Mon. Site: EFF-003	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**533**		**0**	**1 Monthly**	**Grab**
PARM Code 00095 1 Add. Desc: effluent Mon. Site: EFF-003	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Specific Conductance	**Sample Measurement**						**251**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00095 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Specific Conductance	**Sample Measurement**						**1275**		**0**	**1 Monthly**	**Calculated**
PARM Code 00095 P Add. Desc: calculated limit Mon. Site: SWB-003	**Permit Requirement**						**Report (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**-742**		**0**	**1 Monthly**	**Calculated**
PARM Code 00095 Q Add. Desc: effluent minus calculated limit Mon. Site: SWB-003	**Permit Requirement**						**0.0 (Maximum)**	**umhos/cm**		**(1 Monthly)**	**(Calculated)**
Specific Conductance	**Sample Measurement**						**522**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00095 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**						**Report (Daily Mx)**	**umhos/cm**		**(1 Monthly, when discharging)**	**(Grab)**
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**41.2**				**0**	**1 Monthly**	**Grab**
PARM Code 00301 1 Mon. Site: EFF-003	**Permit Requirement**				**38.0 (Dlyavmin)**			**percent**		**(1 Monthly)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Oxygen, Dissolved Percent Saturation	**Sample Measurement**				**76.1**				**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00301 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**				**Report (Dlyavmin)**			**percent**		**(1 Monthly, when discharging)**	**(Grab)**
Oxygen, Dissolved Percent Saturation	**Sample Measurement**						**31.8**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00301 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**						**Report (Daily Av)**	**percent**		**(1 Monthly, when discharging)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**29.9**		**0**	**1 Monthly**	**Grab**
PARM Code 00010 1 Mon. Site: EFF-003	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**28.1**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00010 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly, when discharging)**	**(Grab)**
Temperature (C), Water	**Sample Measurement**						**30.4**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00010 6 Add. Desc: downstream Mon. Site: SWD-003	**Permit Requirement**						**Report (Daily Mx)**	**Deg C**		**(1 Monthly, when discharging)**	**(Grab)**

Parameter		Quantity or Loading		Units	Quality or Concentration			Units	No. Ex.	Frequency of Analysis	Sample Type
Nitrogen, Total	**Sample Measurement**						**1.3**		**0**	**1 Monthly**	**Grab**
PARM Code 00600 1 Mon. Site: EFF-003	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**						**1.1**		**0**	**1 Monthly, when discharging**	**Grab**
PARM Code 00600 5 Add. Desc: background Mon. Site: SWB-003	**Permit Requirement**						**Report (Daily Mx)**	**mg/L**		**(1 Monthly, when discharging)**	**(Grab)**
Nitrogen, Total	**Sample Measurement**		**215.2**						**0**	**1 Monthly**	**Calculated**
PARM Code 00600 P Mon. Site: EFF-003	**Permit Requirement**		**Report (Daily Mx)**	**lb/day**						**(1 Monthly)**	**(Calculated)**

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	I CERTIFY UNDER PENALTY OF LAW THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHERED AND EVALUATED THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM, OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING THE INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION, INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR KNOWING VIOLATIONS.	SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT	TELEPHONE	SUBMITTED ON
Bethany Niec		Electronically Signed	(863) 661-0315	09/22/2021

Parameter	Monitoring Site	Comments for Monitoring Group - D-003
00060 6	SWD-003	The maximum flow for SWD-003 was out of banks and unable to be safely measured.