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ENVIRONMENTAL EVALUATIONS FOR THE DEVELOPMENT OF MINIMUM FLOWS AND LEVELS FOR THE ST. JOHNS RIVER NEAR DELAND AT STATE ROAD 44, VOLUSIA COUNTY

REVISED SEPTEMBER 2008

ENVIRONMENTAL EVALUATIONS FOR THE DEVELOPMENT OF MINIMUM FLOWS AND LEVELS FOR THE ST. JOHNS RIVER NEAR DELAND AT STATE ROAD 44, VOLUSIA COUNTY

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Revisions

The following are the revisions to the May 2003 report:

Page No.	Line No.	Was	Changed to
5-34	24	RM 14.8	RM 14.3
5-34	24	11.0	11.1
5-34	24	RM 19.8	RM 19.2
5-34	24	6.7	7.2
5-34	25	RM 24.9	RM 23.7
5-34	25	2.8	2.7
5-34	25	RM 34.1	RM 33.9
5-34	25	1.0	0.9
5-34	26	RM 48.4	RM 47.9
5-38	4	RM 9.0	RM 8.8
5-38	4	5.0	5.5
5-38	6	RM 31.6	RM 30.8
5-38	6	1.2	1.1
5-38	7	RM 34.1	RM 33.9
5-38	18	3-year salinity	3-year average salinity
5-38	18-19	0.21 0.33 0.52	0.20 0.33 0.51
5-38	20	no measurable changes	less than 0.01 ppt change
5-38	21	RM 67.8	RM 67.1
5-41	9	RM 19.8	RM 19.2
5-41	13	34.4	32
5-41	13	RM 24.9	RM 23.7
5-41	14	5.0	5.5
5-41	15	0.46	0.47
5-41	16	27.5	26
5-41	16	RM 34.1	RM 33.9
5-41	18	The historic maximum	The maximum
5-41	19	RM 48.4	RM 49.9

Page No.	Line No.	Was	Changed to
5-41	27-28	about 1 to 2 miles downstream from JU	between JU and Trout River
5-45	6	RM 45.6	RM 45.2
5-45	10	RM 31.6	RM 30.8
5-45	11	RM 42.5	RM 42.3
5-45	13	0.97	0.98
5-45	13	Piney Point (RM 31.6)	Venetia (RM 27.8)
5-45	15	near RM 22.7 between JU and Acosta Bridge	between JU and Piney Point
5-45	16	1.49	1.5
5-63	16	2.4	2.5
5-63	17	0.8	0.3
5-63	18	3,880 2,230 1,130	4,188 2,161 430
5-64		Replace Figure 5-27	
5-65	4	46.50 33.54 28.39	46.0 32.7 27.4
5-65	5	48.02 34.27 28.89	47.5 33.4 27.6
5-65	6	48.94 37.70 29.15	48.6 33.9 27.7
5-65	7	50.08 35.28 29.59	49.6 34.5 28.1
5-65	12	1.52 0.73 0.50 2,720 1,260 740	1.5 0.7 0.2 2,617 1,277 282
5-65	13	2.44 1.16 0.76 3,880 2,230 1,130	2.5 1.2 0.3 4,188 2,161 430
5-65	14	3.58 1.74 1.20 5,140 3,310 1,760	3.6 1.8 0.7 5,831 3,321 1,041
5-66	25	less than 0.02	less than or equal to 0.02
5-67	6	9.0	8.8
5-67	7	19.8	19.2
5-67	8	34.1	33.9
5-67	8	3.01	3.00
5-67	9	50.3	49.9
5-69	7	9.0	8.8
5-69	8	11.0 20.37 12.20 0.22 0.35 0.53	10.6 21.52 12.22 0.22 0.32 0.49
5-69	9	14.8	14.3
5-69	10	19.8	19.2
5-69	11	24.9 6.74 5.00 0.31 0.46 0.70	23.7 7.15 5.52 0.32 0.47 0.71

Page No.	Line No.	Was	Changed to
5-69	12	34.1	33.9
5-69	13	42.9	42.3
5-69	14	48.4	47.9
5-69	15	50.3	49.9
5-69	16	60.9	60.2
5-69	17	67.8 0.49 0.02 0.00 0.00	67.1 0.49 0.02 <0.01 <0.01

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EXECUTIVE SUMMARY

The St. Johns River near DeLand (SJRND), Volusia County, has been identified as a potential alternative surface water supply source for east-central Florida (Vergara, 2000). Development of alternative water supply sources is required to avoid projected environmental impacts to regional water resource features, such as springs, isolated wetlands, and lakes, resulting from increased ground water withdrawals. To protect water resource values and quantify safe yields from this reach of the St. Johns River, the St. Johns River Water Management District (SJRWMD or the District) is currently establishing minimum flows and levels (MFL), as mandated by state water policy (Section 373.042, Florida Statutes[F.S.]). The MFL designate the minimum hydrologic/hydraulic conditions that must be maintained in the river to prevent significant harm to the ecology or water resources of the area resulting from permitted water withdrawals (Section 373.042, F.S.).

The District's MFL determination efforts for this river section included extensive evaluation of topographic, soil, and vegetation data collected within the plant communities associated with the river (Mace, 2002), in conjunction with an intensive hydrologic modeling effort (Robison, 2001). The ecosystems that exist in the SJRND were categorized by District biologists based on topography, soil, and vegetation characteristics observed on eight transects through the wetland communities along the subject reach of the St. Johns River. Hydrologic models were developed by Robison (2001) to implement the MFL, and to provide the District a basis for decision making as to how best to manage surface water withdrawals.

Based on the evaluation of hydric soils, wetland communities, and the results of hydrological modeling, SJRWMD recommended three preliminary minimum surface water flows and levels for the SJRND: minimum frequent high level, minimum average level, and minimum frequent low level. The technical evaluation is included in the report *Preliminary Minimum Levels Determination: St. Johns River near DeLand, Volusia County* (Mace, 2002).

According to Section 62-40.473, F.A.C., the MFL should be evaluated to ensure the protection of the following natural resources and environmental values:

1. Recreation in and on the water (Rule 62-40.473[1][a], F.A.C.).
2. Fish and wildlife habitats and the passage of fish (Rule 62-40.473[1][b], F.A.C.).
3. Estuarine resources (Rule 62-40.473[1][c], F.A.C.).
4. Transfer of detrital material (Rule 62-40.473[1][d], F.A.C.).
5. Maintenance of freshwater storage and supply (Rule 62-40.473[1][e], F.A.C.).
6. Aesthetic and scenic attributes (Rule 62-40.473[1][f], F.A.C.).
7. Filtration and absorption of nutrients and other pollutants (Rule 62-40.473[1][g], F.A.C.).
8. Sediment loads (Rule 62-40.473[1][h], F.A.C.).
9. Water quality (Rule 62-40.473[1][i], F.A.C.).
10. Navigation (Rule 62-40.473[1][j], F.A.C.).

Environmental Consulting & Technology, Inc. (ECT), was contracted by the District to conduct an environmental assessment and to determine whether the preliminary SJRND MFL protect these 10 natural resource and environmental values.

District documents containing information about the hydrologic and ecological criteria that were used to develop preliminary MFL for the SJRND were used by ECT, along with field reconnaissance and information in the scientific literature, to evaluate whether the MFL protect water and ecological resources. The results of this assessment are summarized in Table ES-1.

In summary, it is ECT's opinion that the preliminary MFL for the SJRND will protect the 10 natural resource and environmental values listed in Section 62-40.473, F.A.C. These conclusions are made with varied degrees of certainty ranging from high to medium certainty. Recommendations for further study have been made.

Table ES-1. Environmental Assessment Summary for SJRND MFL Regime

Resource or Value	MFL Protects the Resource from Significant Harm		Certainty			Further Study/Monitoring		
	Yes (1)	No (2)	High	Medium	Low	Necessary (3)	Recommended (4)	Not Needed (5)
a. Recreation in and on the water	X		X					X
b. Fish and wildlife habitats and the passage of fish	X			X			X	
c. Estuarine resources	X			X			X	
d. Transfer of detrital material	X		X					X
e. Maintenance of freshwater storage and supply	X		X					X
f. Aesthetic and scenic attributes	X		X					X
g. Filtration and absorption of nutrients and other pollutants	X		X					X
h. Sediment loads	X			X			X	
i. Water quality	X			X			X	
j. Navigation	X		X					X

Notes:

(1) Proposed MFLs allow for decline in water levels and flows, but the resource value should be protected.
(2) Proposed MFLs would allow water levels and flows to decline such that significant harm will occur.
(3) ECT recommends further study to support or verify.
(4) ECT recommends further study may be beneficial to ensure protection of the resource.
(5) ECT recommends no further study required.

Source: ECT, 2003.

1.0 INTRODUCTION

The St. Johns River near DeLand (SJRND), Volusia County, has been identified as a potential alternative surface water supply source for east-central Florida (Vergara, 2000). Development of alternative water supply sources is required to avoid projected environmental impacts to regional water resource features, such as springs, isolated wetlands, and lakes, resulting from increased ground water withdrawals. To protect water resource values and quantify safe yields from this reach of the St. Johns River, the St. Johns River Water Management District (District or SJRWMD) is currently establishing minimum flows and levels (MFL), as mandated by state water policy (Section 373.042, Florida Statutes [F.S.]). The MFL designate the minimum hydrologic/hydraulic conditions that must be maintained in the river to prevent significant harm to the water resources or ecology of the area resulting from permitted water withdrawals (Section 373.042, F. S.).

Section 62-40.473, Florida Administrative Code (F.A.C.), states that protection of water resources, natural seasonal variations in water flows and levels, and environmental values associated with the local ecology must be considered when establishing MFL. Relevant factors that relate to specific elements of water resources and ecology must be considered in any MFL development. The establishment of MFL determines whether or not water may be available for other reasonable beneficial uses. Once the MFL have been established, they are used to regulate future water supply development and other water management activities. Rule 40C-8.011(5), F.A.C., states that MFL "are used as a basis for limitations on withdrawals of ground water and surface water, for reviewing proposed surface water management and storage systems and stormwater management systems, and for imposing water shortage restrictions."

The District's MFL determination efforts for this section of the river included extensive evaluation of topographic, soil, and vegetation data collected within the plant communities associated with the river floodplain (Mace, 2002), in conjunction with an intensive hydrologic modeling effort (Robison, 2001). The ecosystems that exist in the SJRND were categorized by District biologists based on topography, soil, and vegetation characteristics observed along eight transects through the wetland communities. Hydrologic models were developed by Robison (2001) to implement the MFL, and to provide the District a basis for decision making as to how best to manage surface water withdrawals.

Based on the evaluation of hydric soils, wetland communities, and the results of hydrological modeling, SJRWMD recommended three minimum surface water flows and levels for the SJRND: minimum frequent high level, minimum average level, and minimum frequent low level. The technical evaluation is included in the report *Preliminary Minimum Levels Determination: St. Johns River near DeLand, Volusia County* (Mace, 2002). The flow rates and elevations of these recommended MFL and their associated hydroperiod categories, approximate frequencies, and approximate durations at State Road (SR) 44 are listed in Table 1-1.

Table 1-1. Preliminary Minimum Surface Water Levels and Flows for the SJRND at SR 44

	Minimum Frequent High Level	Minimum Average Level	Minimum Frequent Low Level
Elevation (ft-NGVD)	1.9	0.8	0.3
Flow (cfs)	4,600	2,000	1,100
Hydroperiod category	Seasonally flooded	Typically saturated	Semipermanently flooded
Frequency	Once every 2-year high	Once every 2-year low	Once every 5- to 10-year low
Duration	30 days or more	~ 6 months	Several months

Source: Mace, 2002.

Robison (2001) used an interactive hydrological modeling approach and found that the MFL regime will be exceeded (violated) when more than a maximum surface water withdrawal of 320 cubic feet per second (cfs) occurs from the river. The following withdrawal schedule was applied to the hydrologic model to simulate the 320 cfs withdrawal:

- Existing flow condition subject to withdrawal limit of 320 cfs.

- Water withdrawal may occur only when water level at DeLand is above 0.1 foot National Geodetic Vertical Datum (ft-NGVD; 1929 datum).
- The amount of allowable water withdrawal will gradually increase to the maximum amount (320 cfs) when the water level at DeLand reaches 0.25 ft-NGVD.

This withdrawal schedule is just one of many possible scenarios. Depending on the stage parameters used to regulate withdrawals, the maximum withdrawal limit might change.

According to Section 62-40.473, F.A.C., the MFL should be evaluated to ensure the protection of the following natural resource and environmental values:

1. Recreation in and on the water (Rule 62-40.473[1][a], F.A.C.).
2. Fish and wildlife habitats and the passage of fish (Rule 62-40.473[1][b], F.A.C.).
3. Estuarine resources (Rule 62-40.473[1][c], F.A.C.).
4. Transfer of detrital material (Rule 62-40.473[1][d], F.A.C.).
5. Maintenance of freshwater storage and supply (Rule 62-40.473[1][e], F.A.C.).
6. Aesthetic and scenic attributes (Rule 62-40.473[1][f], F.A.C.).
7. Filtration and absorption of nutrients and other pollutants (Rule 62-40.473[1][g], F.A.C.).
8. Sediment loads (Rule 62-40.473[1][h], F.A.C.).
9. Water quality (Rule 62-40.473[1][i], F.A.C.).
10. Navigation (Rule 62-40.473[1][j], F.A.C.).

Environmental Consulting & Technology, Inc. (ECT), was contracted by the District to conduct an environmental assessment and to determine whether the SJRND MFL recommended by the District protects each of these 10 natural resources and environmental values.

SJRWMD has prepared two documents associated with the MFL determination:

- *Middle St. Johns River Minimum Flows and Levels Hydrologic Methods Report*, by C. Price Robison, P.E. (2001; 10/18/2001 draft report).
- *Preliminary Minimum Levels Determination: St. Johns River near DeLand, Volusia County*, by Jane Mace (2002).

These documents contain information about the hydrologic and ecological considerations that were used by the District to develop preliminary MFL for the SJRND. This information was used by ECT, along with field reconnaissance and information in the scientific literature, to evaluate whether the preliminary SJRND MFL set by the District protect the human use and water resource values listed in Section 62-40.473, F.A.C.

2.0 STUDY AREA

The St. Johns River is a north-flowing river with a very low hydraulic gradient. The River has its source near Blue Cypress Lake in Indian River County along the east coast of Florida (Figure 2-1). The St. Johns River is the longest north-flowing river in the United States, with an overall drainage basin area of about 9,430 square miles (mi^2). The direct watershed of the River, not including any tributaries, is about 2,625 mi^2. The St. Johns River discharges into the Atlantic Ocean east of Jacksonville, more than 300 miles from the source. It has an average discharge of approximately 6,500 cfs at its mouth and is classified as a major river (Morris, 1995).

The District has divided the St. Johns River watershed into four hydrologic basins: Upper St. Johns River (USJR), Middle St. Johns River (MSJR), Lake George, and Lower St. John River (LSJR) basins (Adamus *et al*., 1997). The SJRND reach of the River is in the Lake George basin, from river mile (RM) 127 near SR 40 just south of Lake George, to RM 157 just north of the confluence of the Wekiva and St. Johns Rivers. Figure 2-2 shows that the drainage basin of the SJRND is comprised of two Planning Units—the Lake Woodruff Unit (5A) and the Alexander Spring Creek Unit (5B).

A stage and flow gauge has been maintained by the U.S. Geological Survey (USGS) at SR 44 west of DeLand (RM 144) since 1933. There are also stage recorders at SR 40 at the northern limit of the study area, and at Lake Monroe, just south of the study area. All three of the springs that discharge into the SJRND (Blue, DeLeon, and Alexander springs) are gauged.

The influence of the tide can be seen in downstream water level records from the river mouth to Lake George, approximately 110 miles from the ocean. Tidal influence has been documented in the SJRND study area and in Lake Monroe, just south of the southern study area limit. Negative (south) river flow in the SJRND occurs on a relatively frequent basis (Morris, 1995). Hydrodynamically, the SJRND reach is affected by both upstream headwater and downstream backwater conditions of stage and flow.

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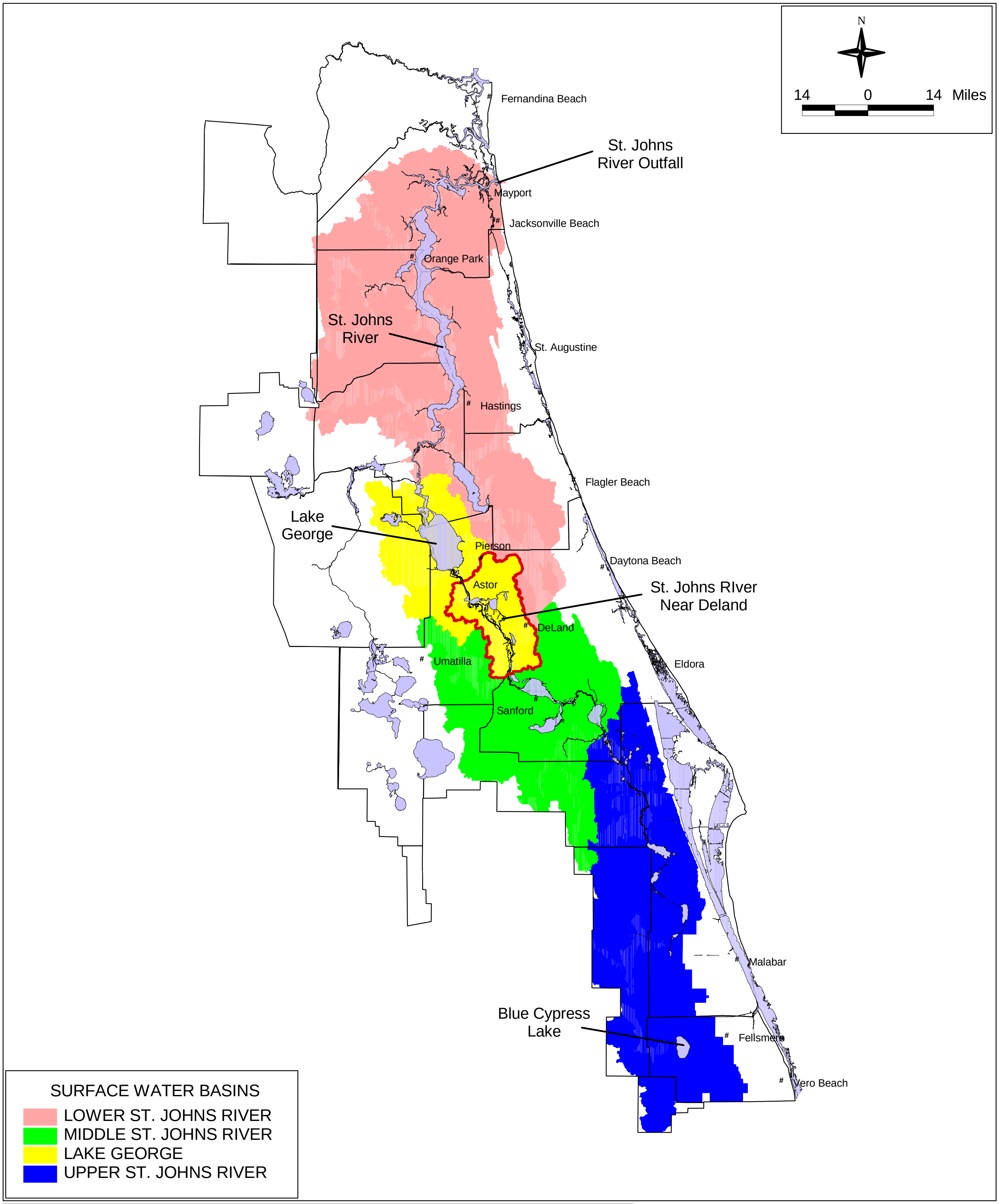

FIGURE 2-1.

ST. JOHNS RIVER NEAR DELAND LOCATION MAP

Sources: SJRWMD, 2002; ECT, 2002.

ECT
Environmental Consulting & Technology, Inc.

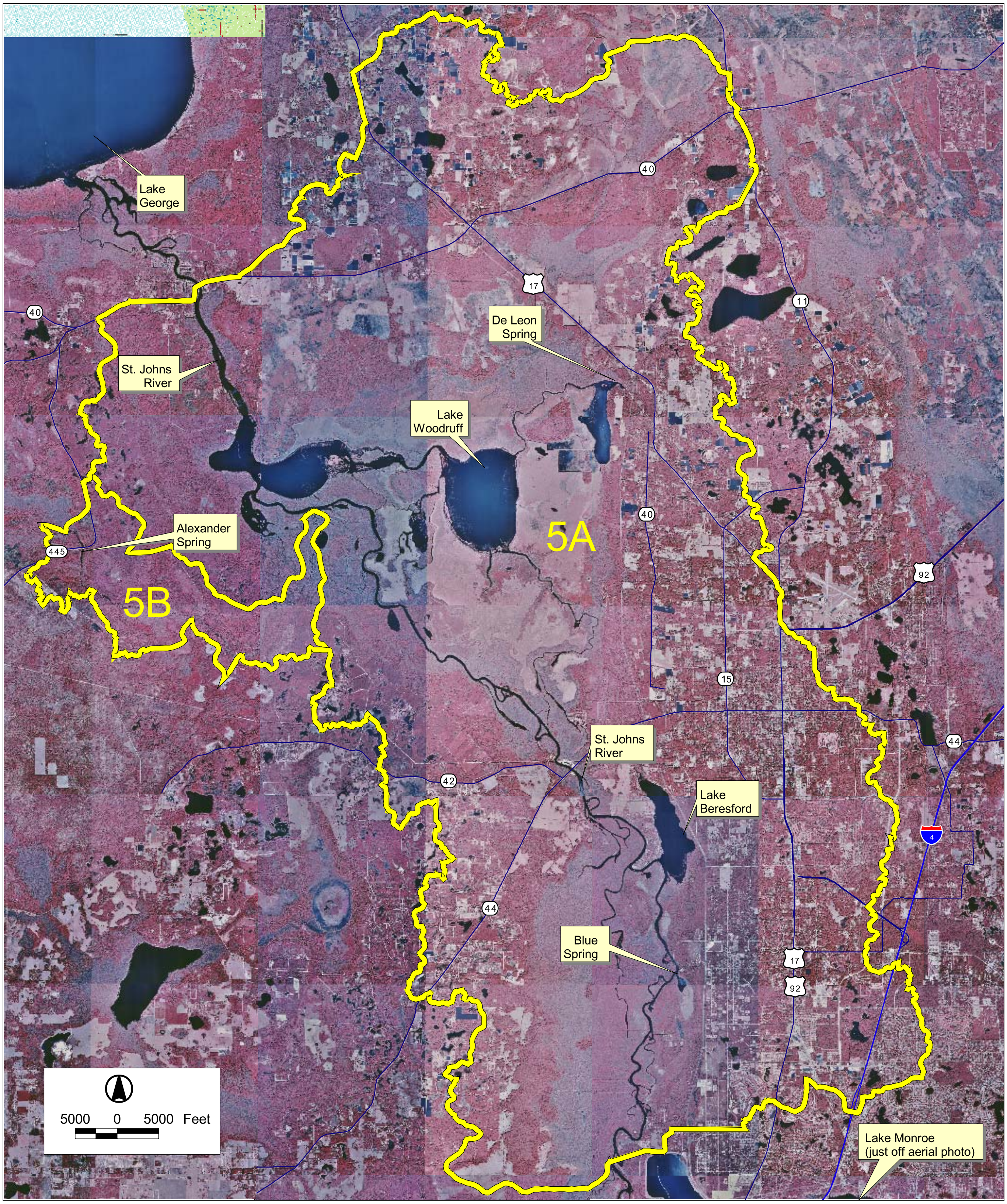

FIGURE 2-2.
ST. JOHNS RIVER NEAR DELAND STUDY AREA
DRAINAGE SUB-BASINS - LAKE GEORGE BASIN
PLANNING UNITS: LAKE WOODRUFF (5A)
ALEXANDER SPRING (5B)

Sources: SJRWMD, 2000; ECT, 2002.

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In general, the SJRND reach of the St. Johns River is characterized by river flow channels, lakes, and seasonally inundated floodplains. The combination of these three features creates a complex hydrologic system. The diversity of the hydrologic conditions in the area contributes to the richness of the ecological setting of the SJRND.

The main stem of the SJRND is defined in this report as the channel segment that has been dredged by the U.S. Army Corps of Engineers (USACE) to a project depth of 12 feet (ft) in the SJRND since 1910. In addition to the main stem, there are numerous branching flowways in the SJRND. The channels in the SJRND are flanked by forested swamp floodplain. South of SR 44, the floodplain is broad, approximately 1 mile wide. There are several defined channels through most of this segment. The channels outside of the main stem are relatively narrow and shallow in the river segment south of SR 44, and some of them are dead-end reaches. South of SR 44 there is one lake within the reach, Lake Beresford, and it is directly connected to the main stem of the SJRND. Blue Spring Run discharges into the SJRND near the southern limit of the study area.

At SR 44, the width of the floodplain narrows significantly. However it widens again north of SR 44, with several defined flowways. Though the main stem is the primary channel north of SR 44 flowing directly to Lake Dexter, there is also a significant secondary eastern channel that flows from the main stem into Lake Woodruff, that rejoins the main stem in Lake Dexter. DeLeon Spring also discharges into Lake Woodruff through Spring Garden Run. Alexander Spring discharges into Alexander Spring Creek that in turn discharges into the main stem just south of Lake Dexter. The overall floodplain width from SR 44 to Lake Dexter is much wider than the segment south of SR 44, with a maximum width of approximately 3.5 miles.

There is a single channel from north of Lake Dexter to SR 40. Farther north, this main stem channel connects with Lake George. The floodplain in this section is about 0.5 mile wide.

The surface water inputs to the SJRND include the main stem river flow from Lake Monroe, Blue Spring, Alexander Spring, DeLeon Spring, and the Wekiva River (combined with Blackwater Creek) which discharges into the SJRND at the southern limit of the reach. Ground water inputs to the river and floodplain include seepage from the surficial aquifer in the adjacent uplands which helps maintain the seasonal soil moisture conditions in the floodplain, particularly at the edge of the floodplain adjacent to the high elevation uplands.

South of SR 44, there is an intermittent berm along the bank of the river directly adjacent to the main stem channel that is higher in elevation than the remaining floodplain. This feature is present in all transects south of SR 44 (Mace, 2002), though it is more pronounced in some transects than in others. By examination of the aerial photograph of the project area, many small channels were found that cut through the berm, allowing hydraulic connection between the main stem river and the floodplain when the river level is below the top of the berm. Most of the area behind the floodplain berm is likely to be inundated first by flood water through these hydraulic connections.

Water can be introduced into the floodplain by several methods:

- Flow through direct hydraulic connections (channels or berm breaches).
- Ground water seepage.
- Rainfall.

The persistence of puddles and small ponded areas depends on the peak flood water elevation in the wet season, the extent of the ground water influence that keeps the substrate saturated, the length of time it takes for the floodplain to drain, and other factors including evaporation, rainfall, and soil permeability.

Because the topography of the floodplain may differ only by inches of elevation, the resultant landscape during the initial part of the dry season is a mosaic of small ponded areas that contain food for wading birds and other wildlife, a food source that concentrates further with each day of drying.

Worldwide, floodplains support some of the most productive inland fisheries (Welcomme, 1979), as well as provide habitat for important populations of wildlife. Climatic factors, particularly the annual cycle of wet and dry seasons, affect the development and longevity of floodplains along river systems.

Florida has a humid, subtropical climate with seasonal rainfall patterns that are controlled by the Bermuda high-pressure cell. During late fall, early winter, and early spring, subsidence from this high suppresses thunderstorms resulting in a dry season. As the Bermuda high weakens in late spring and summer, afternoon thunderstorms occur over the land and at night over the Gulf of Mexico and the Atlantic Ocean (Chen and Gerber, 1990). Most of Florida's annual rainfall occurs during the summer.

The alternation of rainy and dry seasons creates a cycle of flood and drought over much of the floodplain, although a core of permanent water persists within the main river channels and the low-lying depressions of the floodplain itself. Although floodplains appear flat and relatively featureless, slight variations in the elevation and slope of the terrain lead to great differences in the flooding duration at any locality and in flow patterns (Welcomme, 1979).

During the rainy season, river levels rise and overflow their banks. Some species time their spawning so that the young find refuge and food in the marshes and swamps of the floodplain (Graff and Middleton, 2002). As a result, the populations of some small fishes increase during this period. Flood events also deposit river sediments on the floodplain and wash detritus that has accumulated during the dry season into the main river channels as flood waters recede. As water levels drop during the dry season, floodplain fish populations seek refuge in the main stem channel or become concentrated in shrinking floodplain pools.

In addition to seasonal patterns, Florida is also subjected to variations in rainfall that recur on a longer cycle. *El Niño* and *La Niña* are examples of climatic phenomena that recur at irregular intervals and may result in severe drought or flooding. In Florida, El Niño results in wetter and cooler than normal winters, but also causes a reduction in hurricanes and tropical storms; thus may result in drier summers. La Niña causes warmer, but drier winters and springs, and an increase in the number of hurricanes and tropical storms, thus wetter summers (Green *et al*., 1997; Bove *et al*., 1998).

3.0 EXISTING DATA

3.1 STAGE

Daily water levels have been recorded at the SR 44 gauge by the USGS from January 1, 1934, to January 30, 2002, and are presented in Figure 3-1.

The minimum daily stage (water level) during the period 1934-2002 was -0.54 ft-NGVD and the maximum daily stage was 6.06 ft-NGVD (Figure 3-1). The average stage was 1.29 ft-NGVD, and the median stage was 1.09 ft-NGVD. For comparison with other river reaches, the maximum and minimum daily stage values for Palatka for data through 1991 were 3.90 and -1.46 ft-NGVD, respectively; at Jacksonville, these values were 6.0 and -2.09 ft-NGVD, respectively. At the headwaters, the typical water level at Blue Cypress Lake (RM 311) in Indian River County ranges from 23 to 24 ft-NGVD. Levels in this area are managed by the District to meet the goals of the Upper St. Johns River Basin (USJRB) project which include environmental protection and flood control. The Lake Washington weir at RM 254 is set at elevation 14 ft-NGVD. A frequency plot of recorded water levels at SR 44 (Figure 3-2) indicated that 90 percent of the time the water level equals or exceeds 0.26 ft-NGVD, 50 percent of the time it equals or exceeds 1.1 ft-NGVD, and 10 percent of the time it equals or exceeds 2.6 ft-NGVD.

A number of patterns can be discerned upon review of Figure 3-1. For example, seasonal cycles of high and low runoff can be observed. Also, patterns of high and low flows having multi-year periodicities, possibly associated with the El Ninó/Southern Oscillation (ENSO) effects can be observed. Over the longer term, the annual range of the water level fluctuation appears to decrease after the late 1960s. This observed reduction in the annual range of water level fluctuation is likely due to changes in water management philosophy, particular in the USJRB, although climate may certainly play a role. In short, the system, formerly managed for flood control purposes only, includes goals of environmental protection and floodplain restoration. According to Hall and Borah (1998), the stages at upstream Lake Washington declined in the early 1950s, perhaps caused by channelization north of the lake and the development of major drainage canals in the

G-DP02/SJRWMD/MFL/FIG3.XLS—7/18/02

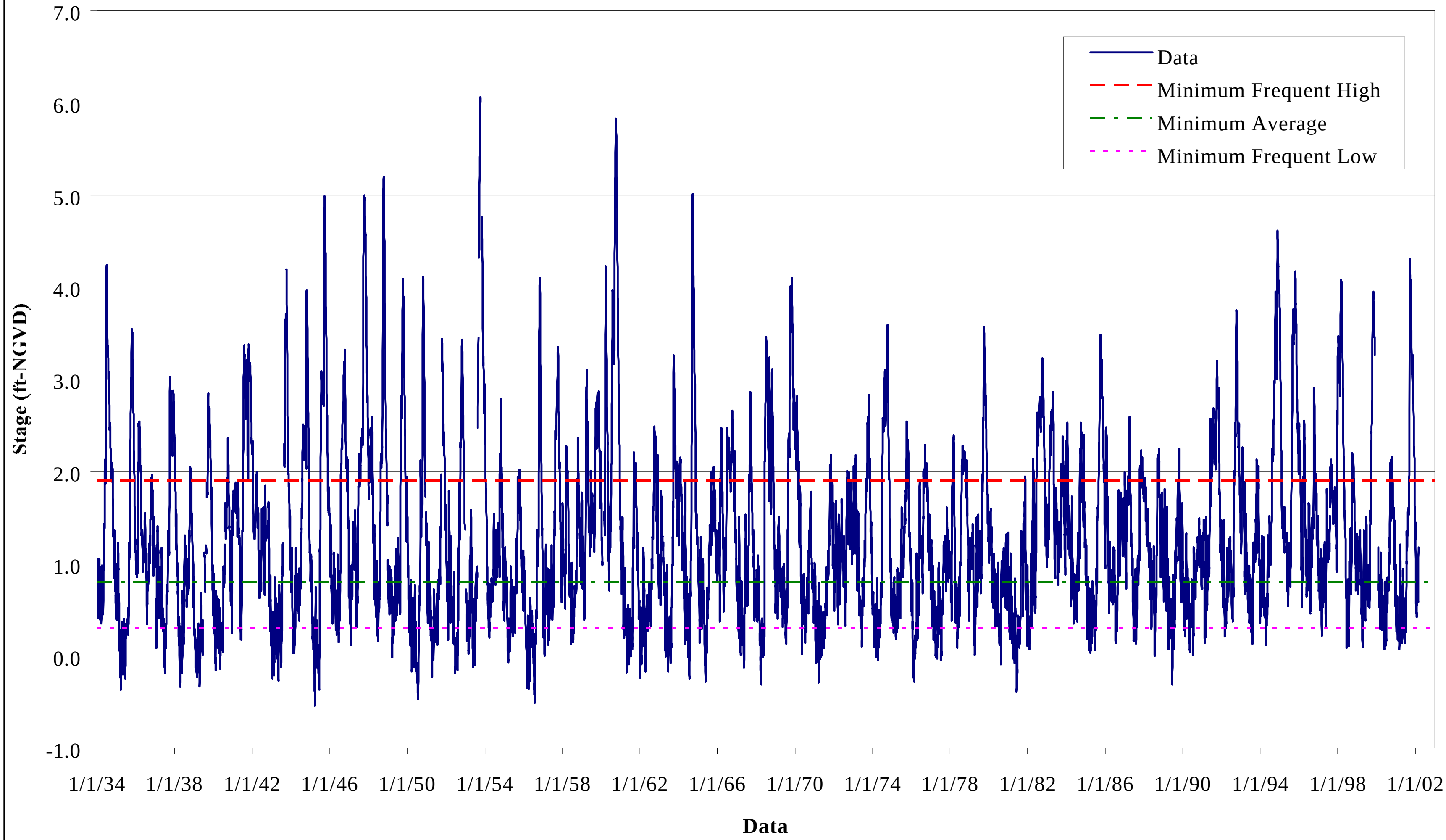

FIGURE 3-1.

ST. JOHNS RIVER WATER LEVEL NEAR DELAND (1934-2002)

Source: ECT, 2002.

ECT
Environmental Consulting & Technology, Inc.

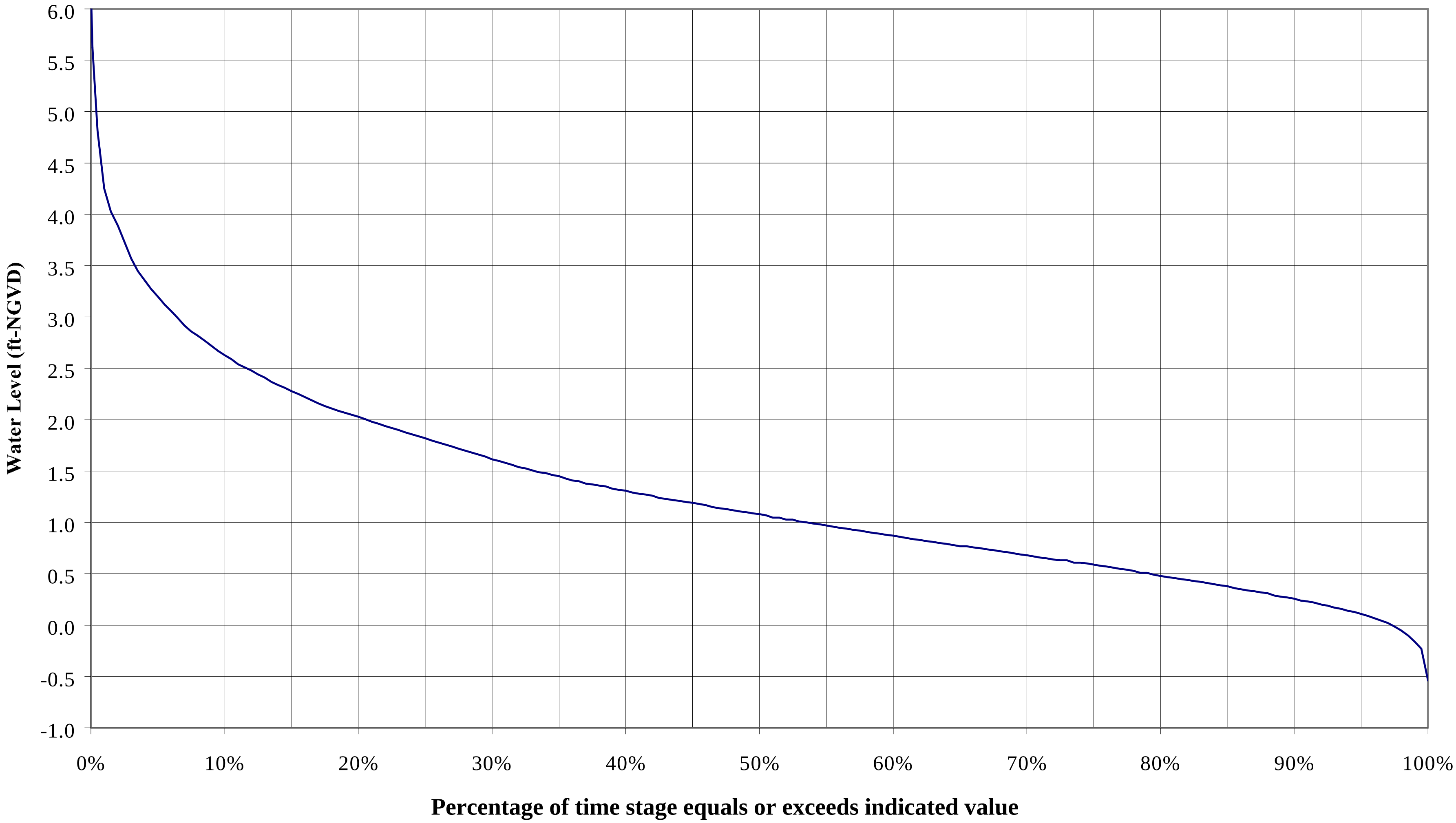

FIGURE 3-2.

STAGE DURATION CURVE OF ST. JOHNS RIVER WATER LEVEL AT THE USGS GAUGE NEAR DELAND (1934-2002)

Source: ECT, 2002.

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headwaters of the St. Johns River, which diverted flow to the Indian River Lagoon. The operation of the C-54 Canal is also thought to have an influence on this observed change.

Morris (1995) indicated that the variability in the water level in the LSJR downstream (north) of the SJRND can be attributed to the elevation of the tide, the volume of fresh-water flowing into and out of the reach, wind, and barometric pressure. For the SJRND, these factors are also important, though the influence of the tide is greatly reduced. For the SJRND, the elevation of the water surface upstream may also be important, though the relatively large storage volume of Lake Monroe may dampen the influence.

3.2 FLOW

The USGS has been monitoring flow since 1934. The mean average daily flow rate at the SR 44 gauge through February 2002 was 3,041 cfs for the period of record. The maximum positive (downstream) average daily flow for this period was 17,100 cfs. The maximum negative (upstream) average daily flow at the SR 44 gauge was -3,260 cfs. However, negative flow does not usually last longer than a few days, except in times of drought when it may last for weeks. A plot of flow for the period 1934-2002 is presented as Figure 3-3.

USGS data presents a minimum average daily flow at the SR 44 gauge of 62 cfs, which occurred for May 1962 and is a value that includes both positive and negative flow directions. Maximum average daily flow at the SR 44 gauge is 15,800 cfs, occurring in October 1953. Figure 3-4 presents the monthly average flow for the SR 44 gauge. The lowest average daily flow occurs in May, and the highest average daily flow occurs in October. Average daily flows for January, February, March, and April are similar in value—approximately 2,500 cfs.

G-DP02/SJRWMD/MFL/FIG3.XLS—7/19/02

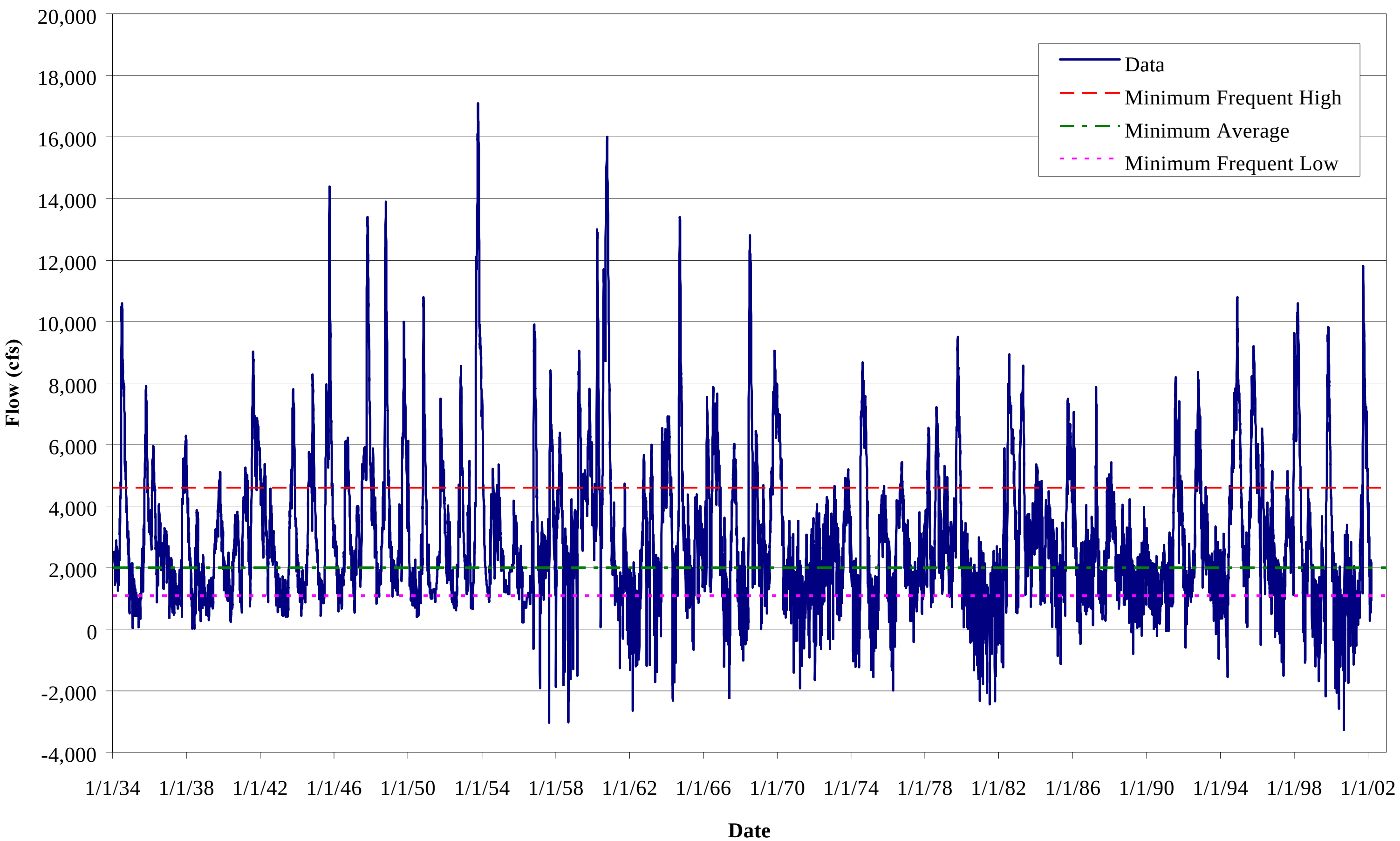

FIGURE 3-3.

DAILY AVERAGE FLOW OF SJRND (1934-2002)

Source: ECT, 2002.

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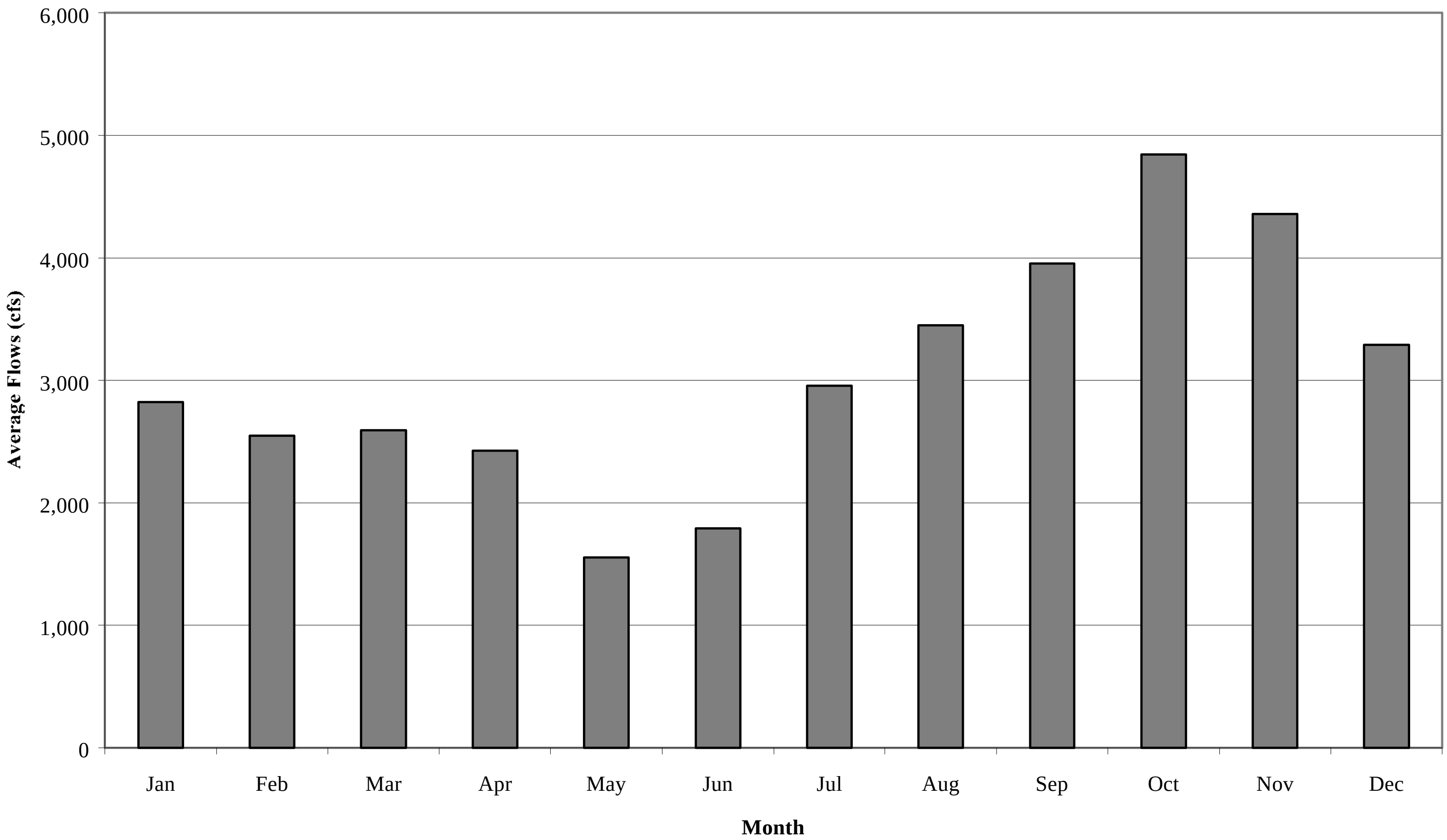

FIGURE 3-4.

MONTHLY AVERAGE FLOWS AT SJRND (1934-2000)

Source: ECT, 2002.

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4.0 PRELIMINARY MFL FOR THE SJRND

Mace (2002) described the methodology that was used to determine the preliminary MFL in the SJRND. Eight transects of various length through the SJRND floodplain were surveyed for vegetation, soil characteristics, and ground surface elevation. These transects were located in four different areas of the floodplain:

- Pine Island.
- North Emmanuel Bend.
- Lower Wekiva.
- Lake Woodruff National Wildlife Refuge.

From this information, preliminary MFL were established for each area:

- Minimum frequent high level.
- Minimum frequent average level.
- Minimum frequent low level.

The MFL were then transferred to water level values for the SR 44 gauge using linear interpolation of the water surface. For each minimum level category, the four transferred values were then averaged. This created the recommended MFL for the SJRND, as follows:

- Minimum frequent high = 1.9 ft-NGVD, seasonally flooded.
- Minimum average = 0.8 ft-NGVD, typically saturated.
- Minimum frequent low = 0.3 ft-NGVD, semipermanently flooded.

For comparative purposes, the SR 44 MFL were then transferred back to the four areas using linear interpolation of water surface and found to protect onsite criteria (± 1-2 inches).

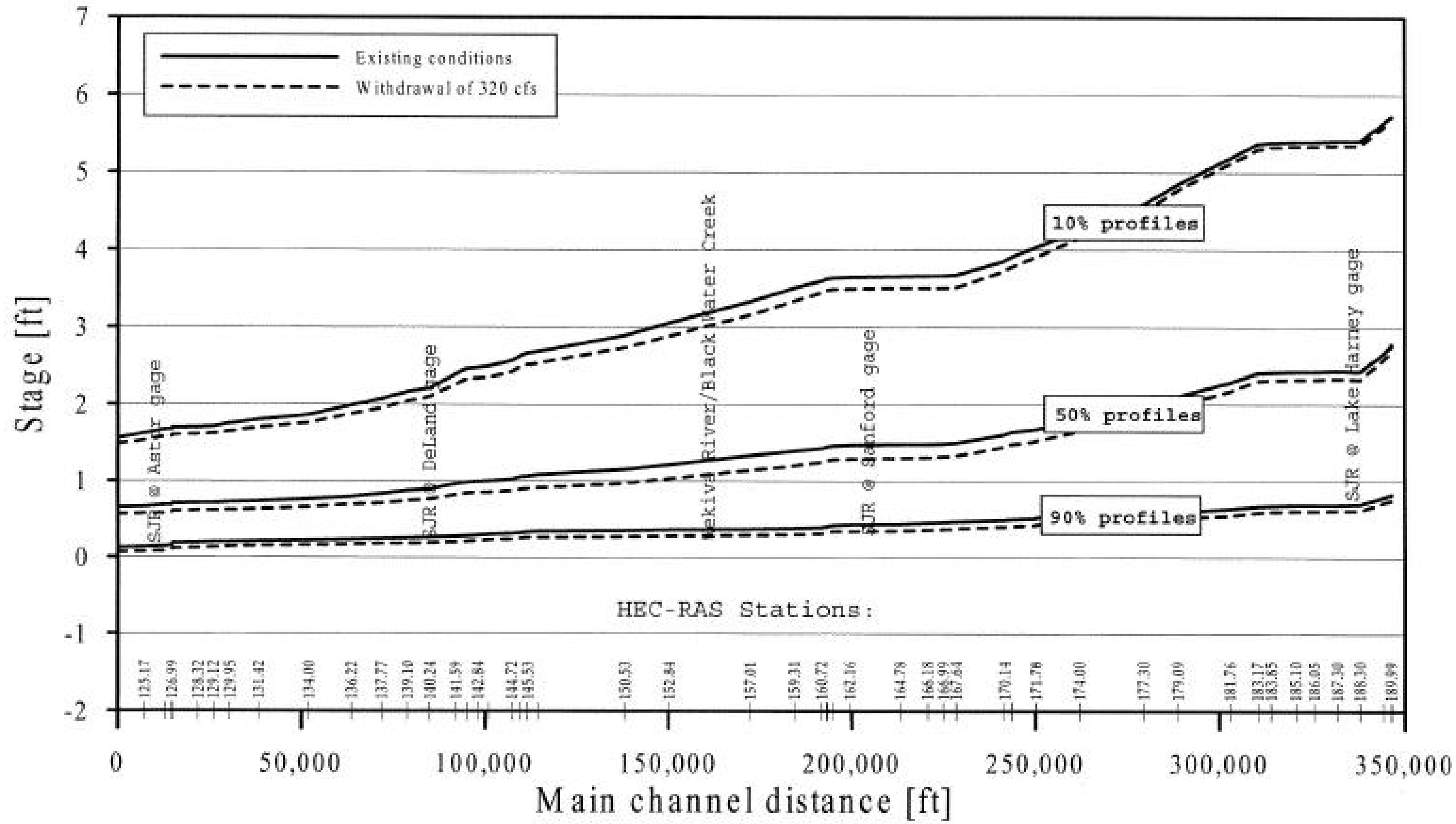
Mace (2002) presented the results of an analysis in which flows are subject to the same statistical analyses as levels. By pairing levels and flows of similar statistical characteristics, a minimum flow was determined for each of the final three levels for the SJRND at SR 44 as follows:

- Minimum frequent high flow —4,600 cfs, seasonally flooded.
- Minimum average flow —2,000 cfs, typically saturated.
- Minimum frequent low flow —1,100 cfs, semipermanently flooded.

Robison (2001) presented information on the hydrologic modeling effort that was conducted as part of the work to establish preliminary MFL for the SJRND. Analysis of the model output can assist in decision making regarding surface water withdrawals from the St. Johns River. Robison (2001) describes two models that were developed. A hydrologic model and a hydraulic model were separately created. The hydrologic model is the Streamflow Synthesis and Reservoir Regulation (SSARR) (USACE, 1986) model and the hydraulic model is the USACE's Hydrologic Engineering Center River Analysis System (HEC-RAS) (USACE, 1997).

Calibration of the SSARR model was completed using the period 1952 to 1998. In analyzing the SSARR model calibration, Robison (2001) indicated that the model provides some underestimation and overestimation of annual water volumes, though overall simulated water volumes are similar to values computed from the measured data. Robison (2001) indicated that modeled stage duration replicate existing conditions to ± 0.2 ft (~ 2.5 inches). Maximum and minimum stages were simulated within 0.5 ft of observed values. With respect to flows, SSARR flows had a lower range of values than the observed flow values (Robison, 2001).

For SSARR modeling purposes, the SJRND was modeled as a series of interconnected lakes. Simulated water levels at the SR 44 gauge site from SSARR output needed to be translated to the transect locations. To interpolate levels between the SSARR lakes, HEC-RAS was first used to develop water surface profiles from the gauge at Astor (SR 40) to the gauge at Lake Harney. The results of these simulated water surface and velocity profiles are presented in Figures 4-1 and 4-2. According to Robison (2001), the simulated water surface profiles between Lake Monroe and the SR 44 gauge site constitute more or



Note: Percentiles refer to discharge exceedances.

FIGURE 4-1.

WATER SURFACE PROFILES FOR THE SJRND FROM HEC-RAS SIMULATIONS

Source: Robison, 2002.

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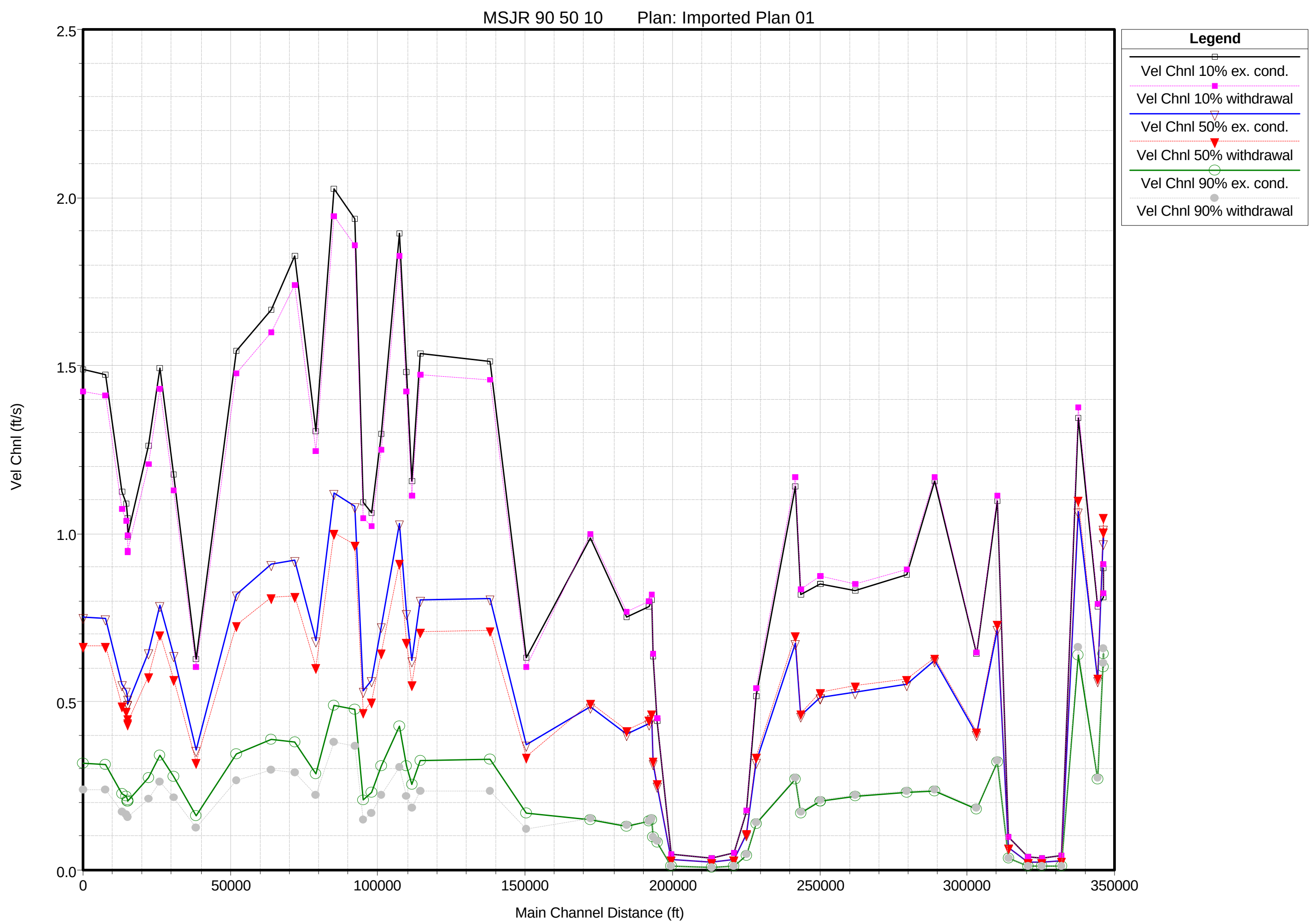

FIGURE 4-2.

CHANNEL VELOCITY PROFILES FOR THE SJRND AS DETERMINED FROM HEC-RAS SIMULATIONS

Source: Robison, 2002.

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less straight lines. Therefore, modeled stages from SSARR for the SR 44 gauge site could be transferred to the transect sites between Lake Monroe and the SR 44 gauge site with linear interpolation instead of HEC-RAS. Levels were transferred between Lake Woodruff and the SR 44 gauge site (and vice versa) assuming the level at one location corresponded to a level with the same percent chance of exceedance at the other location.

Robison (2001) performed frequency analyses of the simulated results for stage and flow of various durations. Beyond the 1-day maximums (or minimums), the frequency analysis encompassed four types of events: maximum average stages or flows, minimum average stages or flows, maximum stages or flows continuously exceeded, and minimum stages or flows continuously not exceeded. Graphical results from Robison (2001, 2002) are presented in Appendix A. An example of such a graph is presented in Figure 4-3. Table 4-1 presents a summary of the results at DeLand.

Robison (2001) presented an operating schedule for a potential maximum withdrawal from the SJRND of 320 cfs. The operating schedule specifies no withdrawal from the river when the water level is below 0.1 ft-NGVD. When the river level rises above 0.1 ft-NGVD, withdrawal may occur on a linearly increasing basis, until the water level reaches 0.25 ft-NGVD, at which time the withdrawal rate is maximized at 320 cfs. These values were specified using exceedance frequency analysis of simulated data for the 95 and 90 percent exceedance levels at DeLand, respectively. The hydrologic modeling results determined that a withdrawal beyond this maximum would exceed (violate) the minimum average level.

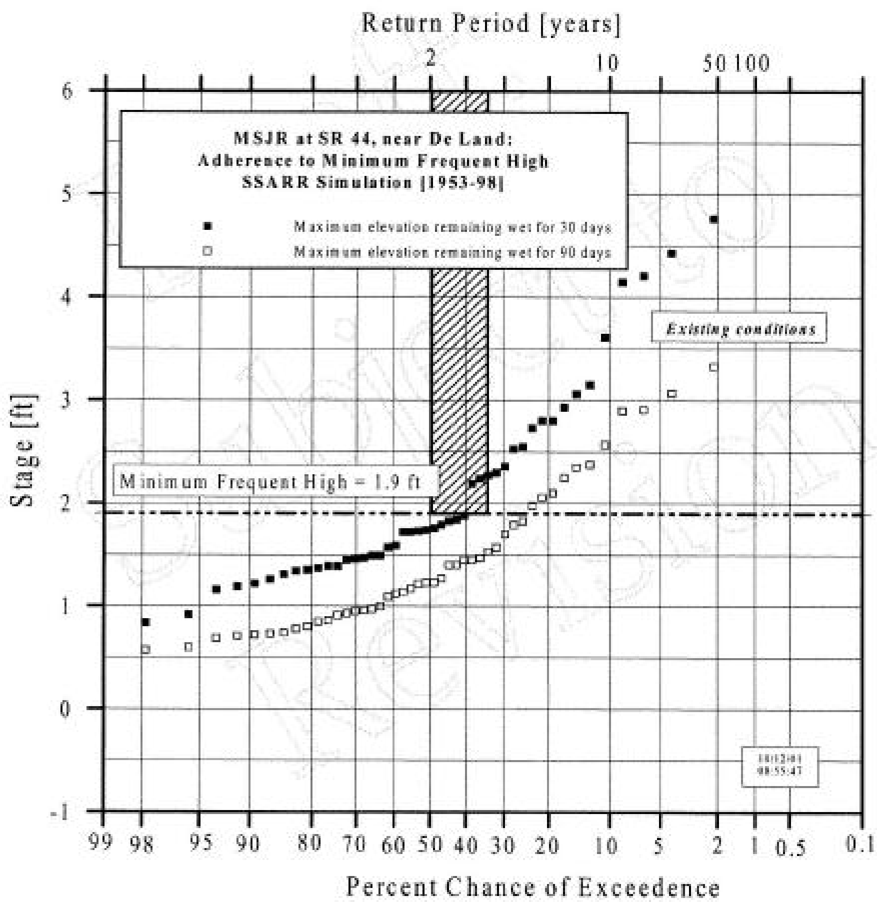

FIGURE 4-3.

EXAMPLE FREQUENCY ANALYSIS

Source: Robison, 2001.

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Table 4-1. Water Level Frequency-Duration Table at DeLand

Return Period (years)	Minimum Frequent Low Water Level (ft-NGVD)					Minimum Average Water Level (ft-NGVD)					Minimum Frequent High Water Level (ft-NGVD)				
	Duration (months)					Duration (months)					Duration (months)				
	1	2	3	4	6	1	2	3	4	6	1	2	3	4	6
Existing															
1.5	0.70	0.83	0.95	1.19	1.60	0.60	0.65	0.70	0.77	0.93	1.46	1.23	0.96	0.84	0.60
2	0.56	0.69	0.81	1.08	1.28	0.44	0.53	0.58	0.66	0.77	1.74	1.46	1.22	1.06	0.80
3	0.33	0.53	0.68	0.82	1.09	0.28	0.34	0.43	0.51	0.61	2.27	1.74	1.53	1.28	0.97
5	0.22	0.28	0.47	0.50	0.84	0.13	0.16	0.21	0.26	0.36	2.80	2.38	2.07	1.85	1.30
10	0.11	0.24	0.34	0.42	0.66	0.03	0.11	0.16	0.18	0.28	3.77	2.98	2.67	2.40	1.44
320-cfs Withdrawal															
1.5	0.57	0.7	0.82	1.06	1.48	0.47	0.52	0.57	0.65	0.8	1.34	1.1	0.83	0.72	0.47
2	0.43	0.57	0.68	0.95	1.16	0.31	0.4	0.45	0.53	0.65	1.62	1.34	1.09	0.93	0.67
3	0.24	0.43	0.57	0.7	0.96	0.19	0.23	0.31	0.39	0.5	2.15	1.62	1.41	1.16	0.84
5	0.17	0.22	0.38	0.41	0.73	0.09	0.12	0.15	0.18	0.27	2.67	2.25	1.95	1.72	1.18
10	0.07	0.18	0.28	0.33	0.55	0	0.07	0.11	0.13	0.21	3.63	2.83	2.52	2.27	1.32
Difference															
1.5	-0.13	-0.13	-0.13	-0.13	-0.12	-0.13	-0.13	-0.13	-0.12	-0.13	-0.12	-0.13	-0.13	-0.12	-0.13
2	-0.13	-0.12	-0.13	-0.13	-0.12	-0.13	-0.13	-0.13	-0.13	-0.12	-0.12	-0.12	-0.13	-0.13	-0.13
3	-0.09	-0.10	-0.11	-0.12	-0.13	-0.09	-0.11	-0.12	-0.12	-0.11	-0.12	-0.12	-0.12	-0.12	-0.13
5	-0.05	-0.06	-0.09	-0.09	-0.11	-0.04	-0.04	-0.06	-0.08	-0.09	-0.13	-0.13	-0.12	-0.13	-0.12
10	-0.04	-0.06	-0.06	-0.09	-0.11	-0.03	-0.04	-0.05	-0.05	-0.07	-0.14	-0.15	-0.15	-0.13	-0.12

Note: The enclosed boxes represent the approximate frequency-duration ranges for the respective hydroperiod category.

Source: Robison, 2002; ECT, 2002.

G-DP02/SJRWMD/MFL/TB41.xls—8/23/02

5.0 ENVIRONMENTAL AND RESOURCE EVALUATION

5.1 RECREATION IN AND ON THE WATER

5.1.1 INTRODUCTION

Recreational boating, fishing, swimming, and tourism on the St. Johns River provide the surrounding communities with important economic resources. In 1997 there were more than 24,000 recreational boats registered in Volusia County, and there were 16,056 freshwater fishing licenses sold in Volusia and Lake counties during 2001. Lake George is known as one of the best bass fishing lakes in the southern United States and is the second largest freshwater lake in Florida. The St. Johns River is not only a resource to the surrounding communities but also to Florida's recreational boaters and out-of-state tourists. Many of the businesses along the river rely on and cater to these tourists providing daily and weekly boat rentals, canoe rentals, river tours, and fishing guides.

To ensure that the preliminary MFL for the SJRND will provide protection to recreation, ECT surveyed various local businesses and communities that use the river (Appendix B), and reviewed a Volusia County boating activity study conducted from July 1994 to May 1995 (Volusia County, 1996).

Lower water levels in the St. Johns River occur regularly, with May being the typical period of lowest water. Recreational boating and waterfront businesses may be affected by lowered water levels. Low water levels may prevent use of some docks, slips, and boat ramps, and can impede river access. Low-water accessibility is an existing problem for some residential properties and parks that have short launching ramps, according to local sources (personal communication with boat operators at Ed Foster Park). Additionally, shallow banks near piers and ramps make it dangerous during low water times for boaters without local knowledge of the St. Johns River. Not only is damage to boats more prevalent during low water levels, according to local marine businesses, but also to docks. This results in increased cost of operation for the riverside business owners when levels are low.

5.1.2 DISCUSSION

Volusia County conducted a boating activity study of the St. Johns River and the Intercoastal Waterway of Volusia County and selected bordering counties from July 1994, to May 1995 (Volusia County, 1996). The purpose of this study was to collect data that described and quantified the boating activities, patterns, and composition of boat types utilizing Volusia County's two main waterways, the St. Johns River and the Intercoastal Waterway. Data were collected to depict the summer and winter boating patterns within the County. The data were collected using several methodologies: ramp intercept interviews, aerial surveys, boat ramp trailer census, shoreline dock surveys, marina surveys, and a mail survey to 2,050 registered Volusia County boaters. The following information was taken from the study.

The results of the Volusia County boating activity study indicated that the main use of the St. Johns River was for recreational purposes, with traveling and fishing being the two major boating activities, accounting for 86 percent of all activities. The data indicated that there were 50 percent more boats on the St. Johns River during the summer than the winter. However, there was a marked increase in the number of recreational fishermen during the winter compared to the summer period.

Most of the boats on the river were outboard engine powerboats, with an average of 100 horsepower. The size class most observed was the Class 1 boat (16 to 25 ft), followed by the Class A boat (less than 16 ft). These two class sizes accounted for 88 percent of the boats observed. The majority of boaters stored their boats at home on a trailer. For those who stored their boats at marinas in wet slips, the primary type of boat was a Class 2 powerboat (26 to 39 ft).

The survey found that the most common destination for boaters on the St. Johns River was the Silver Glen Spring area, located on Lake George, commonly referred to as *The Glen*. The primary sphere of influence for The Glen is as far south as the Ed Stone Park boat ramp in DeLand. Boaters have indicated that prior to the advent of the manatee speed zones, boaters from as far away as Lake Monroe would travel to The Glen. The speed zones now make the trip too time consuming. The two public boat ramps in Astor

(Lake County), Butler Street and Pearl Street (at Midway Marine), are the primary launch points for boaters going to The Glen. In addition to these ramps, there are several remote ramps that serve the area, but the survey data did not indicate that these ramps contributed a significant amount of boat traffic to this location.

The area is also served by several fish camps in the Astor area in Volusia County and several in the Georgetown area of Putnam County (on the east shore of Lake George). The data did not indicate whether these ramps added significantly to use of The Glen. In fact, the data indicated that these fish camps cater more to winter recreational fishermen traveling to Lakes George, Dexter, and Woodruff.

The boating activity study indicated that lakes Dexter and Woodruff were popular fishing lakes, especially during the winter, when the area experiences an influx of out-of-state visitors. The Norris Dead River is also a popular fishing and boating area, as this is one of the primary access rivers to these two lakes.

During aerial surveys conducted in January and February 1995, more than 100 boats were counted in the lakes Dexter and Woodruff area on each of the 8:00 am flights conducted over five weekends. While the winter population of boats on the entire St. Johns River system was 50 percent less than the summer population, the observed number of boats on lakes Dexter and Woodruff were similar during the winter and the summer. The majority of the boats observed were powerboats less than 20 ft in length. Due to the shallow depth of the two lakes, no boats greater than 26 ft in length were observed during either the summer or winter surveys. This was also true of the Norris Dead River, since the river is narrow and winding in certain areas.

The sphere of influence for the lakes Dexter and Woodruff area stretches from Georgetown on Lake George to Ed Stone Park at SR 44. There are five fish camps in Putnam County, eight in Volusia County, and six in Lake County that provide direct access to this area. These fish camps have wet storage for boats on a year-round or seasonal basis, as well as boat ramps that are open to the general public. In addition, there are five public boat ramps, three commercial marinas, and one recreational marina servicing this area.

Hontoon Island State Park is also a popular boating destination. The park has approximately 40 boat slips for park access. There are also two commercial marinas, Holly Bluff Marina and Hontoon Landing Marina, that have a large houseboat rental business.

East of Hontoon Island, is Lake Beresford. This is a popular area for water sports such as water skiing and riding personal watercraft. In addition, Lake Beresford is a popular fishing location, especially in the winter when the fish are bedding. There are three private ramps on the lake, two of which allow public access. In addition, there is a private yacht club located on the west shore of the lake. This facility has a boat ramp but does not allow public access.

South of Lake Beresford, is Blue Spring State Park, which is a popular boating destination for picnicking and swimming in the summer and for observing manatees in the winter. There is an unimproved ramp to the north of the park, but survey data indicated that this ramp does not attract much boat launching usage. It does attract swimmers and overflow from the beach at the park.

To assess the current conditions along the St. Johns River, ECT conducted a limited survey of riverside businesses and recreational areas that provide river access north of SR 44. The list of surveyed entities included:

- The Boat Show Marina.
- Monroe Harbor Marina.
- Hontoon Landing Resort & Marina.
- DeLeon Springs State Recreation Area.
- Holly Bluff Marine.
- Tow Boat US.
- Hidden Harbor Marina.
- Highbanks Marina and Camp Resort.
- Ed Stone Park.
- Sunstate Towing.

The survey (see survey notes in Appendix B) addressed issues such as limitations to service, overall operation, and recreational value to river users during low river levels. Additionally, the survey provided reconnaissance for common-knowledge issues such as signs of stressed wildlife (fish kills, algae overgrowth, changes in vegetation); shorelines that provide access which become unusable; restrictions to recreational activities (canoeing, fishing, swimming, skiing); and impassable/unusable channels. Those that were interviewed were asked if they observed a noticeable difference in the river level last year as compared to their previous knowledge. This question assessed whether they could perceive high and low water levels because the SJRND experiences a seasonal period of low water during most years.

It was apparent from the ECT survey that the commercial businesses noticed that the fluctuation in water levels impacted their daily operations. However, there was no consensus as to how much the low water levels impaired their operation. Some businesses indicated that they were equipping their rental boats with depth finders, while others would forego use of certain slips or docks. Although there was a perceived change in water levels, many businesses reported that higher water levels caused by floods were a greater concern. All reported an ability to provide service during low water level, with minor limitations.

Many businesses along the St. Johns River have adapted to the fluctuating water levels. These adaptations include installation of depth finders on rental boats, selectively docking boats with higher drafts in deeper slips, and supervised use of docks and ramps by knowledgeable persons. Only one business surveyed made reference to decreases in boat use during low water periods and a decrease in revenue for the riverside business. There were several references to increased operation costs due to repairs and extra supervision of customers. This scenario may lead to increased costs that are typically passed on to the customers.

The common-knowledge section of the ECT survey focused more on environmental changes on the river, which may affect some recreational activities. Most reported better fishing and increased algae growth during low river levels. There was mention of fish kills immediately following herbicide spraying for aquatic plant management. They did not mention any changes in vegetation or wildlife abundance. Overall the information gathered demonstrated that the local businesses had some knowledge of the dynamics of the St. Johns River system, but were not acutely aware of extreme low water conditions. Additionally the local businesses lacked awareness of summer 2001 extreme low levels along the SJRND. This may be due to common knowledge of the frequent seasonal river level fluctuations, since most of the persons interviewed had ten or more years of local knowledge.

5.1.3 SUMMARY

The segment of the St. Johns River system between the confluence of the Wekiva River, south of DeLand, and SR 40 at Astor to the north, has significant main stem flowways with depths of 8 to 12 ft to accommodate recreational and commercial interests in the area. The most significant recreational use appears to occur on these main flowways. Interviews with boaters and marine-related businesses in the area did not reveal MFL issues to be a serious concern.

In the 1995 Volusia County boating activity study (Volusia County, 1996), the greatest boater concerns expressed during ramp interviews and a mail survey centered around speed zones and boater education. Second to these issues were concerns regarding the adequacy and/or conditions of existing facilities. This may have been related to the ramps/launch facilities, since the majority of boaters trailer their boats. During recent ramp interviews for the purpose of this MFL evaluation, those interviewed expressed some concern about short ramps during low water levels. They indicated, however, that most of the problem ramps were privately owned and public ramps were adequate during low water levels.

During most typical years, some of the shallow lake areas that are frequented by shallow draft boaters, primarily fishermen, can become inaccessible at water elevations of 0.25 ft-NGVD or less. For example, during a site reconnaissance on May 3, 2002, some portions of Lakes Woodruff, Dexter, and Tick Island Mud Lake were not accessible by shallow draft boat. At that time, river elevations were reported at SR 44 and SR 40 as 0.32 and 0.14 ft, respectively. It is assumed that the corresponding lake elevation around Tick Island was 0.25 ft.

Based upon stage-duration curves for the MSJR (Figure H IV-5 in Appendix A) hydrologic conditions at SR 44 near DeLand, these low conditions which were observed on the May 3rd site reconnaissance, exist for about 12 percent duration during a typical year. A comparison with predicted hydrologic conditions after a withdrawal of 320 cfs near DeLand (Figure H IV-9 in Appendix A) shows the number of days that the lakes will reach these level increases. The duration increases to about 17 percent during a typical year.

The significance of this increased low-stage duration appears to be small and would only impact recreation in specific, remote areas of the lakes. Therefore, it appears that the preliminary MFL for the SJRND will provide protection to recreational use in and on the water.

5.2 FISH AND WILDLIFE HABITATS AND THE PASSAGE OF FISH

5.2.1 FISHERIES

The St. Johns River system is unusual because of the extent to which marine forms penetrate the strictly fresh waters of the river's upper reaches. This is due to the abundance of calcium chloride in the water and the presence of salt springs that drain into the river. Salinity could increase with distance upstream between Palatka and Lake George (Beck, 1965; Tagatz, 1967). This situation results in an unusual mixture of marine and freshwater species.

The composition of the fish fauna of the St. Johns River is well known from studies by McLane (1955), Tagatz (1967), and the Florida Fish and Wildlife Conservation Commission (FFWCC) (undated) (see Table 5-1). The fishes of the St. Johns River were divided into four groups based on their preferred habitats (see Table 5-2) and expected responses to potential impacts from water withdrawals. These groups, which are discussed in the following paragraphs, are primarily marine and estuarine species, anadromous species, main channel species, and floodplain species.

Table 5-1. Fishes of the Middle St. Johns River

Dasyatis sabina, Atlantic stingray
Acipenser brevirostrum, Shortnose sturgeon
Lepisosteus osseus, Longnose gar
Lepisosteus platyrhincus, Florida gar
Amia calva, Bowfin
Elops saurus, Ladyfish
Megalops atlanticus, Tarpon
Anguilla rostrata, American eel
Alosa aestivalis, Blueback herring
Alosa mediocris, Hickory shad
Alosa sapidissima, American shad
Brevoortia tyrannus, Atlantic menhaden
Dorosoma cepedianum, Gizzard shad
Dorosoma petenense, Threadfin shad
Anchoa mitchilli, Bay anchovy
Esox americanus, Redfin pickerel
Esox niger, Chain pickerel
Umbra pygmaea, Eastern mudminnow
Cyprinus carpio, Common carp
Notemigonus crysoleucas, Golden shiner
Notropis chalybaeus, Ironcolor shiner
Notropis cummingsae, Dusky shiner
Notropis harperi, Redeye chub
Notropis maculatus, Taillight shiner
Notropis petersoni, Coastal shiner
Opsopoeodus emillae, Pugnose minnow
Pteronotropis hypselopterus, Sailfin shiner
Pteronotropis welaka, Bluenose shiner
Erimyzon sucetta, Lake chubsucker
Ameiurus brunneus, Snail bullhead
Ameiurus catus, White catfish
Ameiurus natalis, Yellow bullhead
Ameiurus nebulosus, Brown bullhead
Ictalurus punctatus, Channel catfish
Noturus gyrinus, Tadpole madtom
Noturus leptacanthus, Speckled madtom
Bagre marinus, Gafftopsail catfish
Hypostomus plecostomus, Suckermouth catfish
Aphredoderus sayanus, Pirate perch
Strongulura marina, Atlantic needlefish
Cyprinodon variegatus, Sheepshead minnow
Fundulus chrysotus, Golden topminnow
Fundulus confluentus, Marsh killifish
Fundulus escambiae, Eastern starhead minnow
Fundulus lineolatus, Lined topminnow
Fundulus rubifrons, Redface topminnow
Fundulus seminolis, Seminole killifish
Jordanella floridae, Flagfish
Leptolucania ommata, Pygmy killifish
Lucania goodei, Bluefin killifish
Lucania parva, Rainwater killifish
Belonesox belizanus, Pike killifish
Gambusia holbrooki, Mosquitofish
Heterandria formosa, Least killifish
Poecilia latipinna, Sailfin molly
Labidesthes sicculus, Brook silverside
Menidia beryllina, Inland silverside
Menidia menidia, Atlantic silverside
Syngnathus scovelli, Gulf pipefish
Centropomus undecimalis, Snook
M. saxatilis x M. chrysops, Striped bass hybrid
Morone saxatilis, Striped bass
Acantharchus pomotis, Mud sunfish
Centrarchus macropterus, Flier
Elassoma evergladei, Everglades pygmy sunfish
Elassoma okefenokee, Okefenokee pygmy sunfish
Elassoma zonatum, Banded pygmy sunfish
Enneachanthus gloriosus, Bluespotted sunfish
Enneachanthus obesus, Banded sunfish
Lepomis auritus, Redbreast sunfish
Lepomis gulosus, Warmouth
Lepomis macrochirus, Bluegill
Lepomis marginatus, Dollar sunfish
Lepomis microlophus, Redear sunfish
Lepomis punctatus, Spotted sunfish
Micropterus salmoides, Largemouth bass
Pomoxis nigromarginatus, Black crappie
Etheostoma edwini, Brown darter
Etheostoma fusiforme, Swamp darter
Etheostoma olmstedi, Tessellated darter
Percina nigrofasciata, Blackbanded darter
Lutjanus griseus, Gray snapper
Eucinostomus argenteus, Spotfin mojarra
Gerres cinereus, Yellowfin mojarra
Micropogonias undulatus, Atlantic croaker
Sciaenops ocellatus, Red drum
Oreochromis aurea, Blue tilapia
Mugil cephalus, Striped mullet
Mugil curema, White mullet
Dormitator maculatus, Fat sleeper
Gobiosoma bosci, Naked goby
Microgobius gulosus, Clown goby
Paralichthys lethostigma, Southern flounder
Trinectes maculatus, Hogchoker

Sources: Adapted from Tagatz (1967), Burgess *et al*., (1977), Trexler (1995), and FFWCC (undated)].

Table 5-2. Habitat Preferences and/or Salinity Ranges at Time of Capture for Selected Fish Species Occurring in the St. Johns River near DeLand

Scientific Name	Common Name	Salinity Range (ppt)	Habitat	References
Dasyatis sabina	Atlantic stingray	0.09 - 41	Usually marine, close to shore	Bigelow and Schroeder, 1953; Gunter and Hall, 1965; Mountain, 1972; Snelson and Williams, 1981
Acipenser brevirostrum	Shortnose sturgeon	—	Predominently marine, ascends river to spawn in spring (anadromous)	Vladykov and Greeley, 1963; Gilbert, 1978
Lepisosteus osseus	Longnose gar	1.2 - 26.9	Adults in large rivers, juveniles in small streams, occasionally enter brackish water	Springer and Woodburn, 1960; Suttkus, 1963; Swingle and Bland, 1974
Lepisosteus platyrhincus	Florida gar	0 - 26.0	Main river channels, pools in small creeks, lakes and ponds, occasionally enter brackish water	Barnett, 1972; Gunter and Hall, 1965; Mountain, 1972; Suttkus, 1963; Tabb and Manning, 1962
Amia calva	Bowfin	—	Sluggish, weedy waters	Barnett, 1972
Elops saurus	Ladyfish	0 - 35	Marine and estuarine, shallow water	Hildebrand *et al*., 1963; Gunter and Hall, 1965; Swingle and Bland, 1974; Tabb and Manning, 1962
Megalops atlanticus	Tarpon	0 - 35	Marine and estuarine, entering fresh water; young in brackish and fresh pools and lagoons	Hilbebrand *et al*., 1963; Tabb and Manning, 1962
Anguilla rostrata	American eel	0.3 - 29.9	Adults in fresh water, undercut banks of rivers, ponds; spawn in Sargasso Sea	Smith, 1968; Springer and Woodburn, 1960; Swingle and Bland, 1974; Graff and Middleton, 2002
Alosa sapidissima	American shad	—	Enter St. Johns River when temperature falls below 20ºC	Leggett, 1973
Dorosoma cepedianum	Gizzard shad	0.0 - 24.7	Large, mud bottom, highly eutrophic lakes	Barnett, 1972; Swingle and Bland, 1974
Dorosoma petenense	Threadfin shad	0.0 - 21.7	Open water in lakes	Barnett, 1972; Gunter and Hall, 1965; Swingle and Bland, 1974

Table 5-2. Habitat Preferences and/or Salinity Ranges at Time of Capture for Selected Fish Species Occurring in the St. Johns River near DeLand (Continued, Page 2 of 7)

Scientific Name	Common Name	Salinity Range (ppt)	Habitat	References
Anchoa mitchilli	Bay anchovy	0 - 36	Marine and estuarine; abundant in brackish waters with muddy bottoms	Futch and Dwinell, 1977; Gallaway and Strawn, 1974; Gunter and Hall, 1965; Mountain, 1972; Springer and Woodburn, 1960; Swingle and Bland, 1974; Tabb and Manning, 1962
Notemigonus crysoleucas	Golden shiner	1.3 - 10.7	Permanent open water with a depth of 0.5m or more, most common along outer edge of vegetation; fry and juveniles in shallow weedy areas	Barnett, 1972; Swingle and Bland, 1974
Notropis chalybaeus	Ironcolor shiner	—	Swamp streams, spring runs, rivers and bayou ponds in moving water	Barnett, 1972; Marshall, 1946
Notropis maculatus	Taillight shiner	0.09 - 1.0	Ponds and lakes on or near the bottom at a depth of 2-3 m	Barnett, 1972; Beach, 1974; Gunter and Hall, 1965
Notropis petersoni	Coastal shiner	0.12 - 0.65	Found in nearly all flowing water and occasionally in stagnant pools.	Barnett, 1972; Cowell and Resico, 1975; Gunter and Hall, 1965
Pteronotropis hypselopterus	Sailfin shiner	—	Streams of moderate to swift currents with a sand or gravel bottom	Barnett, 1972
Pteronotropis welaka	Bluenose shiner	—	Deeper holes and quiet, weedy water	Gilbert, 1978
Erimyzon sucetta	Lake chubsucker	0.6 - 14.4	Nearly every available aquatic habitat; young school in moderate current but adults prefer quiet, vegetated backwaters	Barnett, 1972; Swingle and Bland, 1974
Ameiurus brunneus	Snail bullhead	—	Streams with rock bottoms and moderate to swift current	Gilbert, 1978
Ameiurus catus	White catfish	0.09 - 0.26	Deep portions of rivers and large connecting lakes	Barnett, 1972; Gunter and Hall, 1965
Ameiurus natalis	Yellow bullhead	0 - 12	Quiet heavily vegetated areas in streams and ponds	Barnett, 1972; Tabb and Manning, 1962

Table 5-2. Habitat Preferences and/or Salinity Ranges at Time of Capture for Selected Fish Species Occurring in the St. Johns River near DeLand (Continued, Page 3 of 7)

Scientific Name	Common Name	Salinity Range (ppt)	Habitat	References
Ameiurus nebulosus	Brown bullhead	0.4 - 3.5	Common in ponds, less common in flowing water	Barnett, 1972; Swingle and Bland, 1974
Ictalurus punctatus	Channel catfish	0 - 12.6	Deep portions of river channel and in large connecting lakes	Barnett, 1972; Gunter and Hall, 1965; McMahon and Terrell, 1982; Swingle and Bland, 1974
Noturus gyrinus	Tadpole madtom	—	Sand or silt bottom eddies near vegetation or under leaves and other rubble	Barnett, 1972
Noturus leptacanthus	Speckled madtom	0.22		Gunter and Hall, 1965
Bagre marinus	Gafftopsail catfish	0.17 - 35	--	Gunter and Hall, 1965; Mountain, 1972; Springer and Woodburn, 1960; Swingle and Bland, 1974; Tabb and Manning, 1962
Esox americanus	Redfin pickerel	—	Quiet, weedy areas of rivers, sluggish swamp streams, and pond margins	Barnett, 1972; Graff and Middleton, 2002
Esox niger	Chain pickerel	0 – 7.5	Common in rivers and large lakes in heavily vegetated areas or where fallen logs are present	Barnett, 1972; Swingle and Bland, 1974; Graff and Middleton, 2002
Aphredoderus sayanus	Pirate perch	0.6 - 19.7	Sluggish fish which swim infrequently, occupy dense vegetation	Parker and Simpco, 1975; Swingle and Bland, 1974; Graff and Middleton, 2002
Strongulura marina	Atlantic needlefish	0 - 23.0	—	Mountain, 1972; Swingle and Bland, 1974
Cyprinodon variegatus	Sheepshead minnow	0 - 31.8	Shallow areas next to shoreline which are without vegetation	Gunter and Hall, 1965; Mountain, 1972; Springer and Woodburn, 1960; Swingle and Bland, 1974; Tabb and Manning, 1962
Fundulus chrysotus	Golden topminnow	0 - 5	Common in shallow, current-free areas with dense vegetation	Barnett, 1972; Gunter and Hall, 1965; Swingle and Bland, 1974; Tabb and Manning, 1962
Fundulus confluentus	Marsh killifish	0.0 - 20.4	—	Gunter and Hall, 1965; Springer and Woodburn, 1960; Swingle and Bland, 1974; Tabb and Manning, 1962

Table 5-2. Habitat Preferences and/or Salinity Ranges at Time of Capture for Selected Fish Species Occurring in the St. Johns River near DeLand (Continued, Page 4 of 7)

Scientific Name	Common Name	Salinity Range (ppt)	Habitat	References
Fundulus lineolatus	Lined topminnow	—	Vegetated margins of lakes, ponds, and swamp stream pools, at outer edge of vegetation	Barnett, 1972
Fundulus seminolis	Seminole killifish	0 - 7.3	On bottom of lakes from near shore to depths of 2 meters	Barnett, 1972; Gunter and Hall, 1965; Tabb and Manning, 1962
Jordanella floridae	Flagfish	0 - 9	Shallow areas of ponds and streams, usually near vegetation	Barnett, 1972; Gunter and Hall, 1965; Tabb and Manning, 1962
Lucania goodei	Bluefin killifish	0 - 12	Vegetated areas in springs, swamp streams, rivers, ponds and lakes, usually in dense vedgetation	Barnett, 1972; Gunter and Hall, 1965; Tabb and Manning, 1962
Lucania parva	Rainwater killifish	0 - 28	Heavily vegetated areas, usually at salinity greater than 25 ppt	Gunter and Hall, 1965; Mountain, 1972; Springer and Woodburn, 1960; Swingle and Bland, 1974; Tabb and Manning, 1962
Gambusia holbrooki	Mosquitofish	0 - 30	Almost any fresh water body, usually in shallow water near vegetation	Barnett, 1972; Gunter and Hall, 1965; Swingle and Bland, 1974; Tabb and Manning, 1962
Heterandria formosa	Least killifish	0 - 30.2	Usually near surface in heavy vegetation	Barnett, 1972; Gunter and Hall, 1965; Tabb and Manning, 1962
Poecilia latipinna	Sailfin molly	0 - 33	Shallow, densely vegetated shorelines	Barnett, 1972; Gunter and Hall, 1965; Mountain, 1972; Swingle and Bland, 1974; Tabb and Manning, 1962
Labidesthes sicculus	Brook silverside	0.12	Open water of lakes, streams, river channels	Barnett, 1972; Gunter and Hall, 1965
Menidia beryllina	Inland silverside	0 - 33	—	Gallaway and Strawn, 1974; Gunter and Hall, 1965; Mountain, 1972; Swingle and Bland, 1974; Tabb and Manning, 1962
Syngnathus scovelli	Gulf pipefish	0 - 35	Marine and estuarine grass flats	Gunter and Hall, 1965; Springer and Woodburn, 1960; Swingle and Bland, 1974; Tabb and Manning, 1962

Table 5-2. Habitat Preferences and/or Salinity Ranges at Time of Capture for Selected Fish Species Occurring in the St. Johns River near DeLand (Continued, Page 5 of 7)

Scientific Name	Common Name	Salinity Range (ppt)	Habitat	References
Centropomus undecimalis	Common snook	0 - 35	—	Gunter and Hall, 1965; Tabb and Manning, 1962
Morone saxatilis	Striped bass	—	Inshore coastal waters, ascending rivers; some populations landlocked; spawns in fresh or nearly freshwater at head of estuaries or in rivers.	Fischer, 1978
Acantharchus pomotis	Mud sunfish	—	Low gradient streams and ponds with dense vegetation	Gilbert, 1978
Elassoma evergladei	Everglades pygmy sunfish	0 - 14.4	Shallow margins of ponds, streams, and rivers; as water rises in spring, moves into extremely shallow areas with or without cover	Barnett, 1972; Swingle and Bland, 1974; Rubenstein, 1981; Tabb and Manning, 1962
Elassoma okefenokee	Okefenokee pygmy sunfish	—	Margins of rivers	Barnett, 1972
Enneachanthus gloriosus	Bluespotted sunfish	0 – 3.8	Lakes and rivers wherever dense vegetation in present	Barnett, 1972; Gunter and Hall, 1965; Swingle and Bland, 1974
Lepomis auritus	Redbreast sunfish	0	Flowing water and connecting lakes	Barnett, 1972; Tabb and Manning, 1962
Lepomis gulosus	Warmouth	0.5 - 14.4	Sluggish swamp streams and ponds in dense cover	Barnett, 1972; Swingle and Bland, 1974; Graff and Middleton, 2002
Lepomis macrochirus	Bluegill	0 - 13.8	Ponds, lakes, low velocity streams; prefers velocity <10 cm/sec	Barnett, 1972; Gunter and Hall, 1965; Stuber *et al*., 1982a; Swingle and Bland, 1974; Graff and Middleton, 2002
Lepomis marginatus	Dollar sunfish	5	Pond margins, eddies along margins of swift streams; rarely numerous	Barnett, 1972; Swingle and Bland, 1974
Lepomis microlophus	Redear sunfish	0 - 14.4	Lakes and sluggish currents in streams, usually in deep areas	Barnett, 1972; Gunter and Hall, 1965; Swingle and Bland, 1974; Tabb and Manning, 1962
Lepomis punctatus	Spotted sunfish	0 - 17.5	Common in streams, usually in areas less than 1 m deep with dense cover	Barnett, 1972; Swingle and Bland, 1974; Tabb and Manning, 1962

Table 5-2. Habitat Preferences and/or Salinity Ranges at Time of Capture for Selected Fish Species Occurring in the St. Johns River near DeLand (Continued, Page 6 of 7)

Scientific Name	Common Name	Salinity Range (ppt)	Habitat	References
Micropterus salmoides	Largemouth bass	0 - 17.5	All permanent bodies of water; adults near cover; fry and fingerlings in shallow, current-free, vegetated areas	Barnett, 1972; Chew, 1974; Stuber, *et al*., 1982b; Swingle and Bland, 1974; Tabb and Manning, 1962
Pomoxis nigromarginatus	Black crappie	0 - 2.4	Open water of lakes and ponds; prefers clear water	Barnett, 1972; Edwards, *et al*., 1982; Swingle and Bland, 1974
Etheostoma fusiforme	Swamp darter	—	Sand and mud bottomed lakes, swamp stream, and rivers	Barnett, 1972
Etheostoma olmstedi	Tessellated darter	2.23	Small to medium-sized streams, out of main current	Gilbert, 1978
Lutjanus griseus	Gray snapper	0 - 37	Primarily marine and estuarine	Gunter and Hall, 1965; Springer and Woodburn, 1960; Swingle and Bland, 1974; Tabb and Manning, 1962
Eucinostomus argenteus	Spotfin mojarra	0 - 35	Primarily marine and estuarine	Futch and Dwinell, 1977; Gunter and Hall, 1965; Mountain, 1972; Springer and Woodburn, 1960; Swingle and Bland, 1974
Gerres cinereus	Yellowfin mojarra	12 - 35	Primarily marine and estuarine	Tabb and Manning, 1962
Micropogonias undulatus	Atlantic croaker	0 - 29.8	Primarily marine and estuarine	Gallaway and Strawn, 1974; Gunter and Hall, 1965; Mountain, 1972; Springer and Woodburn, 1960; Swingle and Bland, 1974
Sciaenops ocellatus	Red drum	0.14 - 34.5	Primarily marine and estuarine	Gunter and Hall, 1965; Mountain, 1972; Springer and Woodburn, 1960; Tabb and Manning, 1962
Mugil cephalus	Striped mullet	0 - 39.0	Primarily marine and estuarine, often entering freshwater to the heads of streams	Fischer, 1978; Futch and Dwinell, 1977; Gunter and Hall, 1965; Moore, 1974; Mountain, 1972; Springer and Woodburn, 1960; Swingle and Bland, 1974; Tabb and Manning, 1962
Mugil curema	White mullet	11.0 - 37.5	Primarily marine and estuarine	Futch and Dwinell, 1977; Gunter and Hall, 1965; Moore, 1974; Mountain, 1972; Springer and Woodburn, 1960

Table 5-2. Habitat Preferences and/or Salinity Ranges at Time of Capture for Selected Fish Species Occurring in the St. Johns River near DeLand (Continued, Page 7 of 7)

Scientific Name	Common Name	Salinity Range (ppt)	Habitat	References
Dormitator maculatus	Fat sleeper	0.1 - 3.4	Low salinity streams	Springer and Woodburn, 1960; Swingle and Bland, 1974
Gobiosoma bosci	Naked goby	0 - 33.0	—	Gunter and Hall, 1965; Springer and Woodburn, 1960; Swingle and Bland, 1974
Microgobius gulosus	Clown goby	0.18 - 33.0	Primarily marine and estuarine	Gunter and Hall, 1965; Mountain, 1972; Swingle and Bland, 1974; Tabb and Manning, 1962
Paralichthys lethostigma	Southern flounder	0 - 30.8	Primarily marine and estuarine	Gunter and Hall, 1965; Swingle and Bland, 1974
Trinectes maculatus	Hogchoker	0 - 35	—	Gunter and Hall, 1965; Mountain, 1972; Swingle and Bland, 1974; Tabb and Manning, 1962

Source: ECT, 2002.

Atlantic stingray, ladyfish, tarpon, Atlantic menhaden, bay anchovy, gafftopsail catfish, Atlantic needlefish, Atlantic silverside, gulf pipefish, snook, gray snapper, spotfin mojarra, yellowfin mojarra, Atlantic croaker, red drum, striped mullet, white mullet, naked goby, and southern flounder are primarily marine and estuarine species which occur at least as far upstream as Lake George; many of these species occur much further upstream. Withdrawal of water from the river could allow salinity to increase, which would permit these species to penetrate further upstream. According to hydrodynamic models of potential withdrawals (320 cfs), salinity will not change at the SJRND reach (ECT, 2002). Therefore, no changes in fish species (i.e., more estuarine species) are anticipated due to the proposed maximum water withdrawal.

Shortnose sturgeon, blueback herring, hickory shad, American shad, and striped bass are anadromous species. These species ascend the river and streams to spawn, but return to the sea as adults. These species primarily use the main channel, and proposed MFL in the SJRND should protect these species.

Longnose gar, gizzard shad, threadfin shad, golden shiner, ironcolor shiner, redeye chub, coastal shiner, pugnose minnow, lake chubsucker, snail bullhead, white catfish, channel catfish, brook silverside, redbreast sunfish, largemouth bass, black crappie, and blue tilapia utilize the main channel of the river (Table 5-2). Florida gar also use the main channel, but are as likely to use the floodplain and backwater pools and oxbows (Table 5-2). The young of many of these species utilize the flooded swamps and marshes as a nursery during the rainy season (Graff and Middleton, 2002). The main channel of the river is quite deep; dredged to a depth of 12 ft to accommodate barge traffic. Potential water withdrawals as limited by the MFL would leave adequate water in the main channel to support these species.

Bowfin, American eel, redfin pickerel, chain pickerel, eastern mudminnow, common carp, bluenose shiner, yellow bullhead, brown bullhead, tadpole madtom, pirate perch, golden topminnow, marsh killifish, flagfish, pygmy killifish, bluefin killifish, mosquitofish, least killifish, sailfin molly, mud sunfish, everglades pygmy sunfish, bluespotted sunfish, warmouth, dollar sunfish, spotted sunfish, and swamp darter occupy backwaters and streams where a remnant population survives the dry season in deeper holes (Table 5-2). Many of these species (especially the killifish, mosquitofish, and pygmy sunfish) mature rapidly and reproduce throughout the wet season so that their populations expand rapidly. Lower dry season water levels due to withdrawals may dry out shallow pools and ponded floodplain areas. However, sufficient refuges should remain in deeper holes in the floodplain, such as alligator holes (Kushlan, 1974), and vegetated areas of the main channel and in tributaries to the St. Johns River to allow repopulation of floodplain sloughs during the rainy season.

5.2.2 PASSAGE OF FISH

Thompson (1972) developed minimum depth criteria for passage of fish in a stream based on the body dimensions of large salmonids. He determined that a depth of 0.8 ft over at least 25 percent of the stream width was required for Chinook salmon. No salmonid species are found in the St. Johns River and most of the larger fishes of the St. Johns River are smaller than Chinook salmon. In any case, as stated previously, the St. Johns River from Palatka to Lake Monroe was dredged to a depth of 12 ft to accommodate barge traffic. This depth is more than sufficient for any species inhabiting the river.

Fish also move onto the floodplain during periods of high water. Juvenile mosquitofish and mollies have been observed to occupy the shorelines of streams in water only a couple of millimeters deep. They exhibit a positive rheotaxis and will force their way upstream against any trickle of water entering their pond or stream (L.J. Swanson, personal observation). In this way, they colonize floodplains at the very beginning to the rainy season.

If it is assumed that the floodplains begin to flood when the river stage equals 1.0 to 1.5 ft, the proposed water withdrawal would reduce the duration of flooding by 14 to 29 days per year (calculated from Appendix A, Figure H IV-9). The resulting period of flooding should be sufficient to protect the passage of fish onto the floodplain.

Number of Days River Stage is Exceeded

River Stage		Location	
		SR44	Lake Monroe
1.0 ft	Existing conditions	171 days	248 days
	@ 320 cfs withdrawal	146 days	219 days
1.5 ft	Existing conditions	88 days	164 days
	@ 320 cfs withdrawal	73 days	150 days

5.2.3 AQUATIC INVERTEBRATES

Aquatic invertebrates have several adaptations to enable them to survive drying of their environment. Many species, such as clams and crayfish, burrow into the substrate to maintain contact with water. Crayfish (*Procambarus* spp.) burrow to reach subsurface water during the dry season and emerge to feed during floods (Graff and Middleton, 2002). Crayfish burrows, in turn, may be refugia for small fish and macroinvertebrates (Redmer, 2000).

Crayfish are aquatic invertebrates that breathe with gills requiring at least some degree of contact with water. They are abundant in many aquatic/wetland habitats and can have important direct effects on benthic communities (Yoon, 2001). They consume invertebrates, filamentous green algae, and detritus (Momot, 1978). Researchers believe that crayfish act as a keystone predator, interact at all levels in the trophic structure, and can exert a considerable influence on surrounding habitats (ibid.).

Burrowing species of crayfish may be found at considerable distances from surface water and inhabit burrows which usually extend deep enough so the crayfish can retreat to or below the ground water level (Redmer, 2000). In areas, such as Florida, where the water table depth can be unpredictable, deep burrows are important retreats for crayfish to await wetter conditions (rainy season) allowing overland movements. In addition, these burrows can serve as refugia during dry periods for a number of invertebrate and vertebrate species until the rainy season returns and surface waters flood the wetland. Salamanders, odonate larvae, tadpole madtoms, amphipods, copepods, bluefin killifish, pirate perch, banded pygmy sunfish, and cricket frogs have been reported from crayfish burrows (ibid.). In addition, a study of crayfish burrows in dry sloughs in Missouri documented up to 6,000 organisms per liter of burrow water including ostracods, copepods and amphibians (Creaser, 1931). Neill (1951) in a study of a dry cypress pond in flatwoods documented the presence of four fish species, and suspected that three additional species used the burrows as refugia. In turn, crayfish are frequent prey for raccoons, otters, wading birds, large fish, turtles, frogs, and snakes (Redmer, 2000). In summary, crayfish can be considered a keystone or indicator taxa to monitor the health of wetland ecosystems, particularly that attributable to hydrology.

Other invertebrates, particularly insects, only inhabit aquatic habitats as larvae; the adults are terrestrial and lay eggs in newly flooded waters to recolonize the floodplains after drought. Others survive in deeper pools and tributaries, or in the main channel of the river, and migrate into newly flooded areas during the rainy season. In a study of the invertebrates of the flooded floodplain of Reedy Creek in central Florida (L.J. Swanson, unpublished data), the density of invertebrates in the substrate (infauna) was very low. The most common species were tubificid worms and chironomids of the genus *Chironomus*. Other common species included isopods (*Caecidotea* sp.), amphipods (*Hyalella azteca*, and *Crangonyx* sp.) and sphaeriid clams. Invertebrates of the St. Johns River are not as well known as fishes. However, some information is available in Heard (1979) and Water & Air Research, Inc. (2000) (see Table 5-3). Two of the species listed in Table 5-3 are noteworthy. *Cyathura polita* is an estuarine isopod that is not usually found in fresh waters. Apparently the same mechanism that enables marine fishes to penetrate the river (i.e., high calcium chloride content) allows this species to exist in nominally fresh water. The other species is mud crab (*Rhithropanopeus harrisii).* This is a small crab of upper estuaries and tributaries that is known to tolerate fresh water (salinity range of <1 to 27.5 parts per thousand [ppt]) (Williams, 1965; Odum, 1971). There is no evidence that the potential water withdrawals as limited by the recommended MFL will significantly affect macroinvertebrate guilds in either the channel of the river or the associated floodplain.

Table 5-3. Invertebrates of the Middle St. Johns River

Arcteonais lomondi	*Caecidotea racovitzai australis*
Aulodrilus pigueti	*Cyathura polita*
Ilyodrilus templetoni	*Gammarus cf tigrinus*
Limnodrilus hoffmeisteri	*Hyalella azteca*
Helobdella triserialis	*Procambarus* spp.
Helobdella xz	*Rhithropanopeus harrisii*
Helobdella stagnalis	*Libellulidae*
Nematoda	*Limnephilidae (pupa)*
Amnicola dalli	*Chaoborus punctipennis*
Viviparus georgianus	*Chironominae*
Corbicula manilensis	*Chironomus* sp.
Byssanodonta cubensis	*Chironomus crassicaudatus*
Musculium securis	*Cladotanytarsus* sp.
Musculium partumeium	*Clinotanypus* sp.
Musculium transversum	*Coelotanypus* sp. *im.*
Musculium lacustre	*Coelotanypus tircolor*
Pisidium casertanum	*Cryptochironomus fulvus group*
Pisidium dubium	*Dicrotendipes neomodestus*
Pisidium adamsi	*Dicrotendipes modestus*
Pisidium compressum	*Djalmabatista pulchra*
Pisidium punctiferum	*Einfeldia natchitochaea*
Anodonta couperiana	*Glyptotendipes* sp. *im.*
Carunculina parva	*Glyptotendipes paripes*
Elliptio icterina	*Goeldichironomus amazonicus*
Elliptio buckleyi	*Goeldichironomus holoprasinus*
Elliptio jayensis	*Paralauterborniella nigrohalteralis*
Uniomerus carolinianus	*Polypedilum halterae group*
Villosa vibex	*Procladius (Holotanypus)* sp.
Villosa amygdala	*Tanytarsus limneticus*
Villosa villosa	*Tanytarsus* sp. *G*

Sources: Adapted from Heard (1979) and Water & Air Research, Inc. (2000).

5.2.4 WILDLIFE

Wildlife are dependent on particular vegetation communities to provide food, cover, and/or nesting sites. Therefore, in order to protect wildlife, it is necessary to protect the associated vegetation and soils. District biologists conducted an intensive survey of vegetation and soils in areas of the floodplain of the SJRND (Mace, 2002). They sampled 14,465 ft of transects along the river. These transects ranged from approximately 1,100 ft in length (North Emmanuel Bend 1 Transect) to 5,040 ft in length (Lower Wekiva Transect) from the river edge across the adjacent floodplain to uplands. Based upon vegetation maps, the ten most abundant wetland communities within 2 miles of the river (in decreasing order of coverage) are hardwood swamp, hydric hammock, shallow marsh, shrub swamp, wet prairie, forested depression, free floating, bayhead, cypress, and deep marsh. The proposed MFL were determined based on elevations of plant communities and soils, and are assumed to allow a sufficient frequency and duration of flooding to prevent an unacceptable level of change from occurring to these ecological features.

Most wetlands in central Florida have adapted to a late fall, winter, and spring dry season and an approximately 4-month-long rainy season. Nonetheless, shallow-rooted wetland plants, especially herbaceous species, are sensitive to alterations in wetland hydroperiods particularly during the normal dry season or extended droughts. Reductions in wetland hydroperiods can result in changes to species composition and structure of wetland communities particularly during the dry season. Short- or long-term changes to normal depth, duration, and frequency of flooding events can result in the increase of transitional or upland species at the expense of hydrophytic species. In addition, invasive, undesirable plants such as cattails or primrose willow can proliferate at the expense of species considered more *desirable*, especially in herbaceous dominated communities such as shallow marsh, wet prairie, and deep marsh. The replacement of low growing, native plants with tall weedy plants could result in changes to wildlife diversity. Opportunistic species, such as bladder pod and dog fennel, are already present along the edges of hammocks and marshes within the floodplain of the St. Johns River (Mace, 2002), but apparently not at problematical levels. During drought periods, these upland/transitional species can outcompete desirable wetland plants and, thereby, alter the structure and composition of wetland systems. The hydrologic alterations, which lead to species shifts in wetlands, are not well documented. However, potential water withdrawals as limited by the MFL could result in a short-term increase in transitional or upland plant species throughout the higher elevations within the floodplain. Even though a short-term change in plant species composition (i.e., invasion by upland/transitional plant species) could occur, it is ECT's professional judgment that it most probably would be minor, reversible, and, therefore, inconsequential (i.e., even under normal hydrologic conditions opportunistic, nonwetland plants can invade the drier portions of wetlands during dry spring months, but these ephemeral populations are largely eliminated by rising water levels in the summer of the same year).

For the most part, wetland trees will not be affected by small-scale lowering of the water level. The only potential long-term change may be the migration of transitional trees such as laurel oaks into areas presently dominated by maples and pop ash, for example. If the organic soils are dried for sufficiently prolonged periods, oxidation/subsidence could occur. Soil subsidence could affect the roots of wetland trees, resulting in tree mortality (Reynolds, Smith and Hills, Inc., [RS&H] 1985). Fallen trees form gaps in the forest canopy, allowing pioneer wetland species to invade and become established. This occurrence would also result in a change to the wetland ecosystem and cause a concomitant shift in wildlife species populations. Any changes due to alteration of hydrology are more likely to be manifested in the herbaceous community in the short term (RS&H, 1986). It is unlikely, based on ECT's professional judgment, that the existing canopy structure or composition will be changed by the proposed MFL.

The wetland communities of the St. Johns River provide food, cover, and nesting sites for a variety of animals. Most of these animals only spend part of their lives in the swamps, hammocks, and marshes, and move to higher ground or to other water bodies/wetlands as water levels rise and fall (Ewel, 1990; Kushlan, 1990). During inspections of the vegetation/soil transects and other areas along the SJRND, ECT ecologists observed a diversity of wildlife species, including, alligator, mud turtle, black racer, great blue heron, little blue heron, common egret, tricolored heron, limpkin, anhinga, wood duck, double-crested cormorant, moorhen, brown pelican, boat-tailed grackle, common crow, cardinal, red-shouldered hawk, osprey, pileated woodpecker, red-winged blackbird, and grey squirrel.

Ecotones and the interior floodplain forests are particularly important to birds and mammals due to abundant food resources (insects, foliage, fruits and seeds, crayfish, snails, clams, etc.), nesting sites (canopy, tree cavities, shrubs, etc.), and protection (dense vegetation, evergreen trees and shrubs providing cover in the winter, etc.). Wading birds are perhaps the most conspicuous component of marsh and swamp animal communities. Wading birds feed on the fishes and amphibians that become abundant during the rainy season and become concentrated in the shallow floodplain pools as waters recede during the dry season. Wading birds are particularly conspicuous along river edges and are often year-round residents. The majority of wading birds should be found along the northern reaches of the SJRND (i.e., the greatest area of open marsh, wet prairie, and lake littoral zones occurs in this area). Among waterfowl, only wood ducks are common in Florida swamps (Ewel, 1990). Migratory birds utilize the floodplain forests during spring and fall migrations.

A variety of amphibians and reptiles can be found in floodplain communities. However, these herpetofauna are not common and arboreal species out number ground-dwelling species in river swamps (Ewel, 1990). Many common amphibians and reptiles depend on swamps for reproduction, but are also found in other aquatic and terrestrial ecosystems (ibid.). However, some herpetofauna species such as dwarf siren, mud snake and rainbow snake are seldom found outside swamps (ibid).

Mammals such as southeastern shrew, cotton mouse, rice rat, opossum, raccoon, river otter, mink, weasel, and white-tailed deer are commonly found in the floodplain communities. These animals utilize the floodplain plant communities for cover and abundant food resources. River otter, mink, and raccoon feed on crayfish that are often found in floodplain communities as well as in the river channel.

Based on ECT's professional judgment, the recommended MFL will protect wildlife populations. This conclusion is based upon the premise that floodplain plant communities will not be significantly impacted by the hydrologic conditions resulting from the proposed MFL regime.

5.2.5 THREATENED AND ENDANGERED SPECIES

Another concern of changes to the hydrologic conditions (duration and frequency of flooding/dewatering events) in the St. Johns River floodplains is the possible adverse effects to listed species. Listed species are important for our natural heritage, and some species also play a key role in the ecological function and health of Florida ecosystems. Invertebrates, fish, amphibians, reptiles, birds, mammals, and plants exhibiting significant declines from historic population levels have been placed into specific categories of protection by both federal and state agencies.

The Endangered Species Act of 1973 (7 U.S.C. 136; 16 U.S.C., 460 *et seq.*) provides for a program for the conservation of threatened and endangered plants and animals and the habitats in which these species are found. The U.S. Fish and Wildlife Service (USFWS) administers these federally listed plants and animals and provides protection of these species. The State of Florida has state-listed endangered, threatened, or species of special concern animals that are protected by FFWCC via Sections 39-27.003, 39-27.004 and 39-27.005, F.A.C., respectively. The state lists of plants are categorized into endangered, threatened, and commercially exploited, and are administered and maintained by the Florida Department of Agriculture and Consumer Services via Chapter 5B-40, F.A.C.

Based upon a likelihood of occurrence assessment, Table 5-4 provides a listing of 35 species (fish [3], reptiles [2], birds [10], mammals [2], and vascular plants [18]) listed as endangered, threatened, or species of special concern by state and/or federal agencies which could occur within the St. Johns River and associated floodplain (adapted from Florida National Areas Inventory [FNAI], 2001) based upon floodplain ecosystems. Potential effects of the proposed MFL on some of these species are discussed below and are based on the professional judgment of ECT biologists.

Short-nose sturgeon, a state/federally endangered fish, is an anadromous species which typically inhabits the lower reaches of rivers and the near-shore ocean environment from Canada to Florida. It ascends streams to spawn in fresh water (Gilbert, 1978; Vladykov and Greeley, 1963). Since it mostly utilizes the main channel of the river, proposed MFL are unlikely to cause harm to this species.

Table 5-4. State and Federally Listed Species, Listed as Endangered (E), Threatened (T), and Species of Special Concern (SSC), Expected to Occur in the Middle St. Johns River and Associated Floodplains

		Status	
Common Name	Scientific Name	State	Federal
FISH			
Short-nose sturgeon	*Acipenser brevirostrum*	E	E
Snook	*Centropomis undecimalis*	SSC	
Bluenose shiner	*Pteronotropis welaka*	SSC	
REPTILES			
American alligator	*Alligator mississippiensis*	SSC	T(S/A)
Eastern indigo snake	*Drymarchon corais couperi*	T	T
BIRDS			
Roseate spoonbill	*Ajaia ajaja*	SSC	
Limpkin	*Aramus guarauna*	SSC	
Little blue heron	*Egretta caerulea*	SSC	
Snowy egret	*Egretta thula*	SSC	
Tricolored heron	*Egretta tricolor*	SSC	
White ibis	*Eudocimus albus*	SSC	
Peregrine falcon	*Falco peregrinus*	E	
Florida sandhill crane	*Grus canadensis pratensis*	T	
Bald eagle	*Haliaeetus leucocephalus*	T	T
Wood stork	*Mycteria americana*	E	E
MAMMALS			
Manatee	*Trichechus manatus*	E	E
Florida black bear	*Ursus americanus floridanus*	T	
VASCULAR PLANTS			
Auricled spleenwort	*Asplenium erosum*	E	
American bird's nest fern	*Asplenium serratum*	E	
Hand fern	*Cheiroglossa palmata*	E	
Okeechobee gourd	*Cucurbita okeechobeensis*	E	E
Spoon-leaved sundew	*Drosera intermedia*	T	
Hartwrightia	*Hartwrightia floridana*	T	
Florida hasteola	*Hasteola robertiorum*	E	
Lake-side sunflower	*Helianthus carnosus*	E	
Star anise	*Illicium parviflorum*	E	
Narrowleaf naiad	*Najas filifolia*	T	
Fall-flowering ixia	*Nemastylis floridana*	E	
Plume polypody	*Pecluma plumula*	E	
Swamp plume polypody	*Pecluma ptilodon*	E	
Terrestrial peperomia	*Peperomia humilis*	E	
Florida willow	*Salix floridana*	E	
Chaffseed	*Schwalbea americana*	E	E
Ocala vetch	*Vicia ocalensis*	E	
Rain lily	*Zephyranthes simpsonii*	T	

Source: FNAI, 2001.

Snook, a state species of special concern, is a marine species whose young use low salinity marshes as nurseries. Adults tolerate fresh water and at times can be found fairly far upstream. In the St. Johns River, this species is primarily found downstream of Lake George (Gilbert, 1978) and should not be adversely affected by potential withdrawals of water from the SJRND.

Bluenose shiners, another state species of special concern, inhabit deeper, weedy pools of backwater areas (Gilbert, 1978). These deeper pools should remain under the preliminary recommended MFL hydrologic regime.

Alligators, a state species of special concern, are an important component of marshes and swamps since they excavate *gator holes* which usually retain water during the dry season (Kushlan, 1974). They are also common in the main river channel where they would not be affected by the potential water withdrawals.

Eastern indigo snakes, a state/federally threatened snake, utilize a wide range of habitats from sand pine scrub to floodplain forests. However, they are primarily associated with upland areas and should not be impacted by the potential water withdrawals.

The state/federally endangered wood stork feeds in freshwater swamps and marshes, tidal creeks, or tidal pools, usually in water 6 to 10 inches deep (USFWS) (undated). They nest in large colonies, using the upper branches of large cypress trees. Nesting in north Florida takes place from March to late May with the young fledging in July and August; however, the largest rookeries are found in south Florida (USFWS) (undated). The proposed MFL should not adversely impact wood storks.

Other wading birds utilizing the St. Johns River and its floodplain include roseate spoonbill, little blue heron, snowy egret, tricolored heron, and white ibis (all state species of special concern). These species depend on the cycle of flooding and drying of the river’s floodplain marshes and swamps, but also can feed along the shores of the main river channel. White ibis, in particular, feed extensively on crayfish, which is abundant along river floodplains. The proposed MFL should not affect these species.

Limpkins, another state species of special concern, occur in floodplain forests and feed on apple snails (abundant apple snail casings were observed on tree trunks along the river's edge during field surveys). Its well-being is also dependent on the continued functioning of the floodplains, but should not be impacted by proposed MFL.

Florida sandhill cranes, a state threatened species, build their nests in marshes with specific water levels. They feed in open marshes and pastures. The St. Johns River and its floodplain do not contain the typical nesting or feeding habitat for sandhill cranes; therefore, the proposed MFL should not impact this species.

Bald eagles, a state/federally threatened species, are fish-eating birds which can find ample feeding habitat in the main channel of the river. Tall trees in the floodplain forests could provide suitable nest sites. Peregrine falcons, a state endangered species, are winter residents in Florida. Typically, they feed on other birds in more open areas such as beaches and garbage dumps. The listed species of birds for the SJRND should be protected by the hydrologic conditions caused by the MFL regime.

The forested floodplains are also important to rare and endangered large mammals such as the Florida black bear (state threatened mammal), which requires a large home range and whose upland habitats have been largely lost to development. SJRWMD staff sited a young black bear along the Lower Wekiva River transect in October 2000 (Jane Mace, 2002 – personal communication). Florida black bears are found mainly in seven more-or-less separate populations, one of which is the Ocala National Forest (USFWS, 1998). There are estimated to be several hundred bears in the Ocala National Forest, which is contiguous to the northern reach of the SJRND (ibid.). No impacts to black bears are anticipated as a result of the hydrologic conditions produced by the recommended MFL regime.

Manatees, a state/federally endangered species, utilize much of the St. Johns River, especially the springs flowing into the river. Blue Spring from its point of origin to its confluence with the St. Johns River (Blue Spring Run) was designated as a critical manatee warm water habitat by the USFWS (Rouhani *et al*., 2002). Blue Spring and its run is one of only three large natural warm water winter refuges for manatees in the State of Florida (Rouhani *et al*., 2002). As many as 103 manatees have been reported for Blue Spring (Rouhani *et al*., 2002). Smaller groups of manatees have also been reported in Spring Garden Run, downstream from DeLeon Spring, in the Lake Woodruff National Wildlife Preserve.

The stage of Blue Spring Run is mainly controlled by water levels in the St. Johns River and not by spring discharge (Rouhani *et al*., 2002). Rouhani *et al.* (2002) conducted an extensive study to evaluate the effects of reduced Blue Spring discharges on manatee habitat in Blue Spring. Based on the combined effects of intrusion of cold St. Johns River water into Blue Spring Run and manatee depth limitations, Rouhani *et al*. (2002) defined useable warm-water manatee habitat as a function of St. Johns River water level, water temperature, and spring discharge.

During the winter months (November through March) when access to warm water refuges is critical to manatee survival, water levels and flows in the St. Johns River near Blue Spring approximate the minimum average level and flow regime as presented in Mace (2002). According to Table 4-1, the estimated reduction in water level for the minimum average condition is up to 0.13 ft or 1.5 inches. The access channel depth of the Blue Spring Run is more than 5 ft, therefore, the reduction in water level of 1.5 inches should not limit manatee ingress/ egress to Blue Spring Run.

The location and growth of most listed species of plants is restricted by specific habitat requirements associated with such environmental factors as soil chemistry, light, humidity, wind, fire, water, etc. Their growth is also limited by competition with other species, predation from insects, fish and mammals, and disease. Some listed plant species grow only in discrete, isolated populations and can be easily affected by minor environmental changes such as microclimate alteration. More adaptable listed plant species populations can vary from year to year due to fluctuations in water levels, natural community succession and disturbance by man. However, some of the more fragile plant species populations could be impacted by alterations to wetland hydroperiods. For example, the hand fern (*Cheiroglossa palmata)*, which could potentially occur in the floodplain forests of the SJRND (no records currently available for SJRND; species at the northern extent of historic State distribution based upon herbarium records), is a state endangered tropical fern that was once locally common in the southern part of the peninsula, but now is quite rare. Hand ferns have diminished in numbers in Florida primarily due to drainage, fire, development, and over collection. If water levels are lowered for prolonged periods where hand ferns grow, the resultant reduction in available moisture/humidity and/or opportunity for the advent of fire due to dry conditions could result in the loss of local populations. However, it is unlikely any listed species occurring within the portion of the floodplain with a river overflow-based hydrology, as well as in the river channel, will be impacted by the potential water withdrawals as limited by the MFL.

5.2.6 SUMMARY

It is concluded that, with the information that is available, there is no direct evidence that the recommended MFL regime will have unacceptable impacts to the fish and wildlife habitats and fish passage in this riverine ecosystem. The hydrologic conditions created by the recommended MFL should result in an acceptable level of shift in the duration and frequency of flooding events (i.e., the MFL are considered to be within acceptable levels of ecological tolerance). The study by Mace (2002) was extensive and considerable fieldwork was completed.

5.3 ESTUARINE RESOURCES

5.3.1 INTRODUCTION

An estuary is a dynamic ecoregion where saltwater from the ocean meets the freshwater from the watershed. The mixing/transport of the estuarine water is driven by the forces of tides, freshwater flows, and meteorologic phenomena. The LSJR receives approximately 60 percent of its total freshwater flow from sources upstream of Buffalo Bluff (Upper and Middle St. Johns River basins and the Lake George basin). Therefore, the salinity distribution in the LSJR may be significantly influenced by the freshwater inflow from the Lake George and MSJR basins.

The estuarine resources such as fish and wildlife, aquatic vegetation, and water quality are significantly influenced by instream salinity concentrations. It is important to ensure that the MFL regime in the study area will protect the salinity regime of any part of the LSJR from significant alteration. The LSJR is defined as the 101-mile river segment of the river from the confluence of the Ocklawaha River and the St. Johns River to the river mouth at the Atlantic Ocean. Prominent features in the LSJR and river mile designations are presented in Figures 5-1 through 5-3.

ECT conducted a salinity assessment study for the LSJR in 2002 to quantify the effects of the freshwater withdrawal on the LSJR salinity distribution and to evaluate whether the preliminary SJRND MFL established by SJRWMD will provide adequate protection of the estuarine resources. The results of that study were presented in *Lower St. Johns River Salinity Regime Assessment: Effects of Upstream Flow Reduction near DeLand* (ECT, 2002). The following sections summarize the methods, results, and conclusion of the salinity assessment study.

5.3.2 METHODOLOGY

Salinity conditions within the LSJR basin under various reductions in freshwater inflow regimes were simulated with the three-dimensional EFDC computer model. To isolate the effects of the freshwater flow regimes alone, the model simulations for the various flow scenarios used the same tidal and meteorological conditions, while only freshwater inflow rates were varied. The change in salinity regimes was quantified by comparing the daily maximum, daily average, and daily minimum isohaline shifts and the cumulative frequency of average daily salinity among four different freshwater inflow conditions for various locations along the river.

The EFDC model was developed by Dr. John Hamrick (Hamrick, 1992a; 1992b). It is a three-dimensional finite difference model using orthogonal curvilinear grid in the horizontal dimension. It uses a stretched sigma grid in the vertical dimension. The model

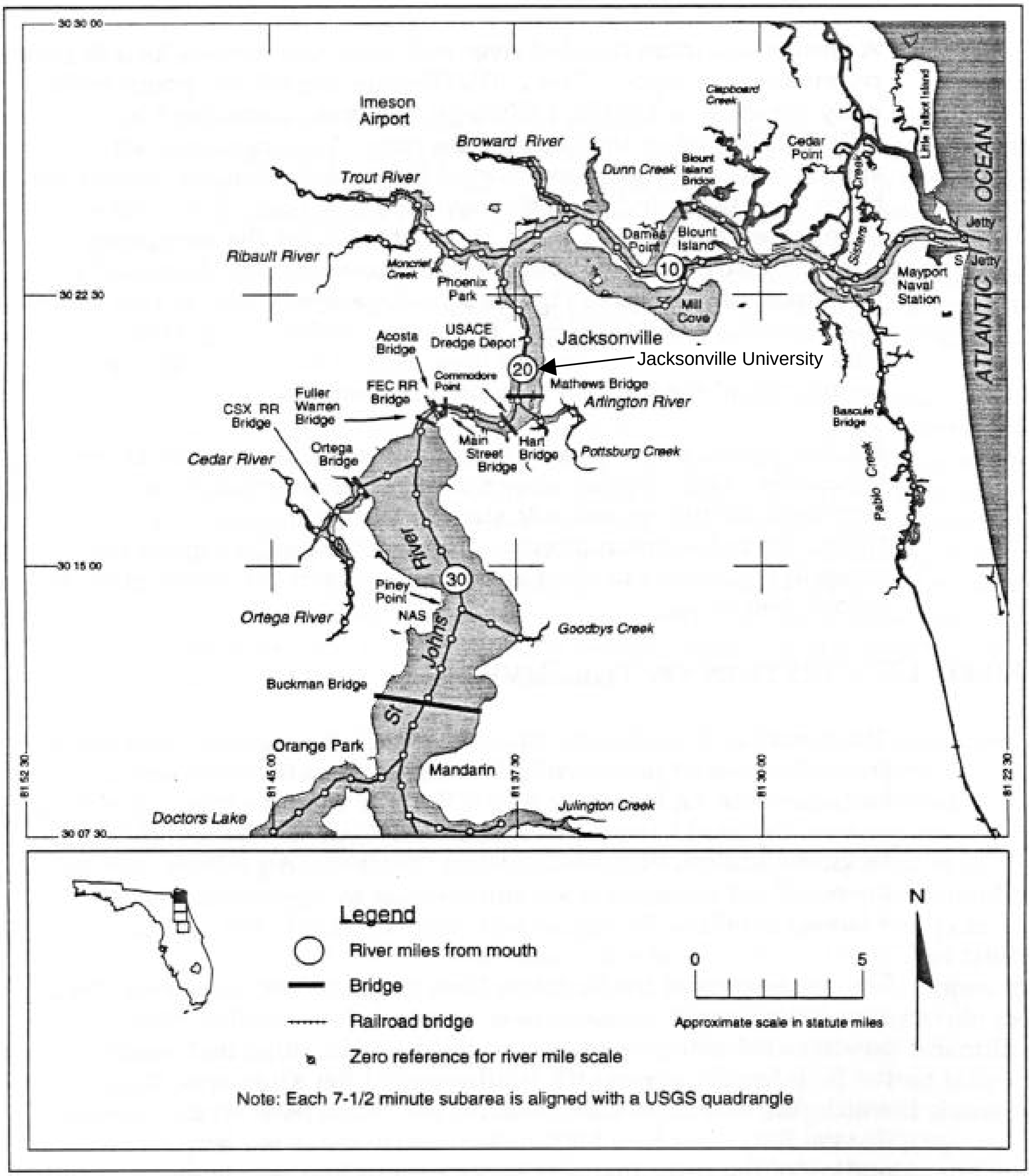

FIGURE 5-1.
LOCATION MAP, BY RIVER MILE, FOR SIGNIFICANT LOCATIONS ON THE ST. JOHNS RIVER BETWEEN THE RIVER MOUTH AND JULINGTON CREEK

Source: Morris, 1995.

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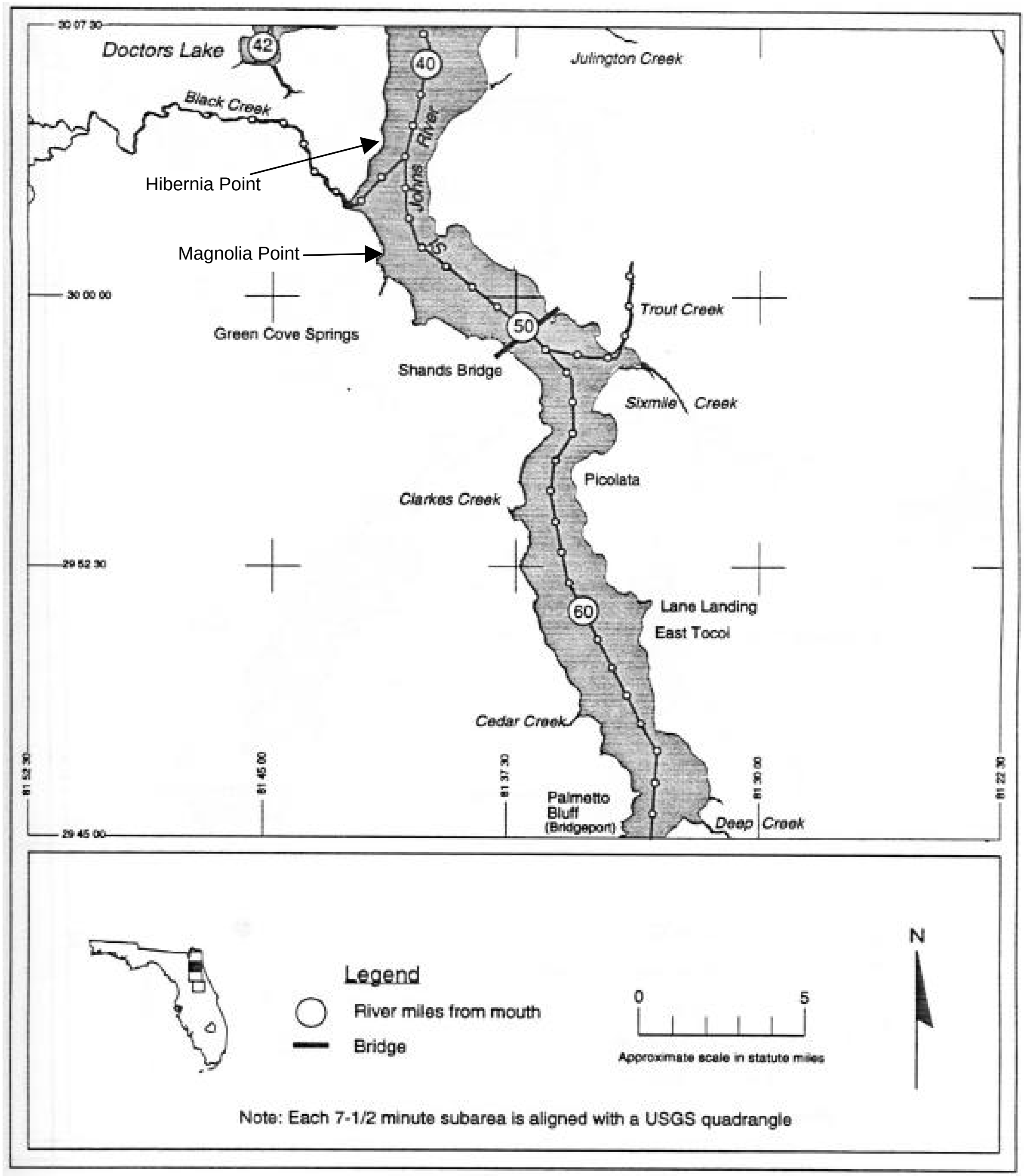

FIGURE 5-2.
LOCATION MAP, BY RIVER MILE, FOR SIGNIFICANT LOCATIONS ON THE ST. JOHNS RIVER BETWEEN JULINGTON CREEK AND DEEP CREEK

Source: Morris, 1995.

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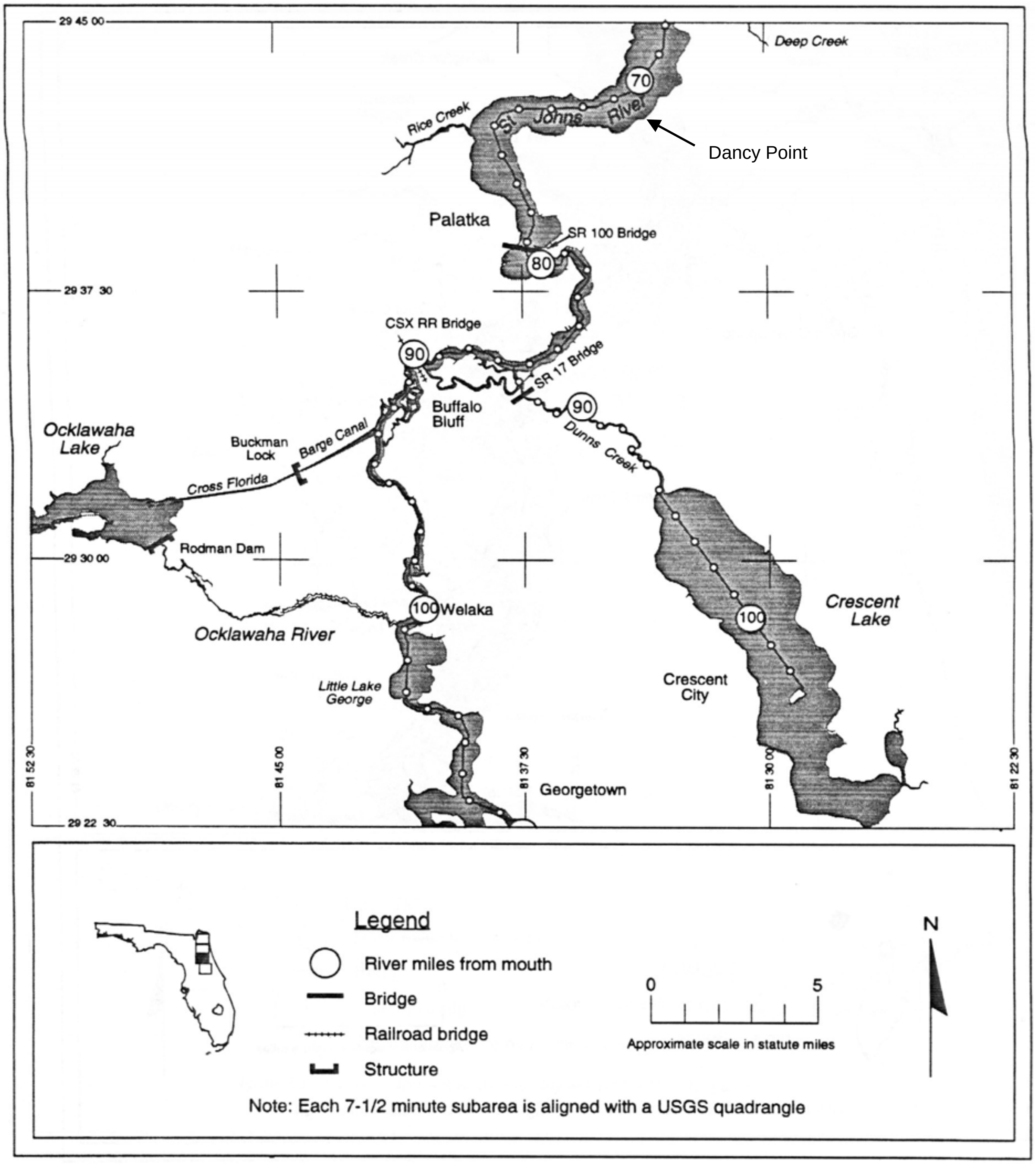

FIGURE 5-3.
LOCATION MAP, BY RIVER MILE, FOR SIGNIFICANT LOCATIONS ON THE ST. JOHNS RIVER BETWEEN A LOCATION NORTH OF RICE CREEK AND GEORGETOWN

Source: Morris, 1995.

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solves the momentum equation, continuity equation, equation of state, and turbulent kinetic energy.

SJRWMD has previously applied the EFDC model in the LSJR basin for the purpose of establishing total maximum daily load (TMDL) of nutrients and other pollutants in the watershed. The model was calibrated by SJRWMD (Sucsy and Morris, 2002) using tide and salinity data collected in the river. The model grid configuration is shown in Figure 5-4.

A total of four freshwater-flow scenarios were evaluated using the EFDC model as part of the salinity assessment in the LSJR:

- Baseline (existing) freshwater flow conditions.
- Maximum withdrawal limit of 320 cfs (as limited as the MFL regime).
- Withdrawal limit of 160 cfs (50 percent less than the maximum withdrawal rate defined by the MFL regime).
- Withdrawal limit of 480 cfs (50 percent more than the maximum withdrawal rate defined by the MFL regime).

The recommended MFL regime (maximum withdrawal limit of 320 cfs) will limit the freshwater withdrawal to 9.8 percent of the historic average flow at DeLand.

5.3.3 BASELINE SALINITY CHARACTERIZATION

Maximum, average, and minimum salinities for each day within the 3-year simulation period were computed at all 60 time-series output locations. Averages of the daily maximum, daily average, and daily minimum salinities for the 3-year simulation period were computed and are presented in Figure 5-5. The results indicate that the average salinity near the river mouth is about 32.1 ppt, and is reduced to 14.8 ppt at Drummond Point (RM 14.3), 11.1 ppt at the Jacksonville University (JU) (RM 19.2), 7.2 ppt at the Acosta Bridge (RM 23.7), 2.7 ppt at the Buckman Bridge (RM 33.9), and 0.9 ppt at Green Cove Springs (RM 47.9). The daily salinity fluctuations were computed at each location by taking the difference between daily maximum and daily minimum salinity. The 3-year average of the daily salinity fluctuations was then computed for each location. Figure 5-6

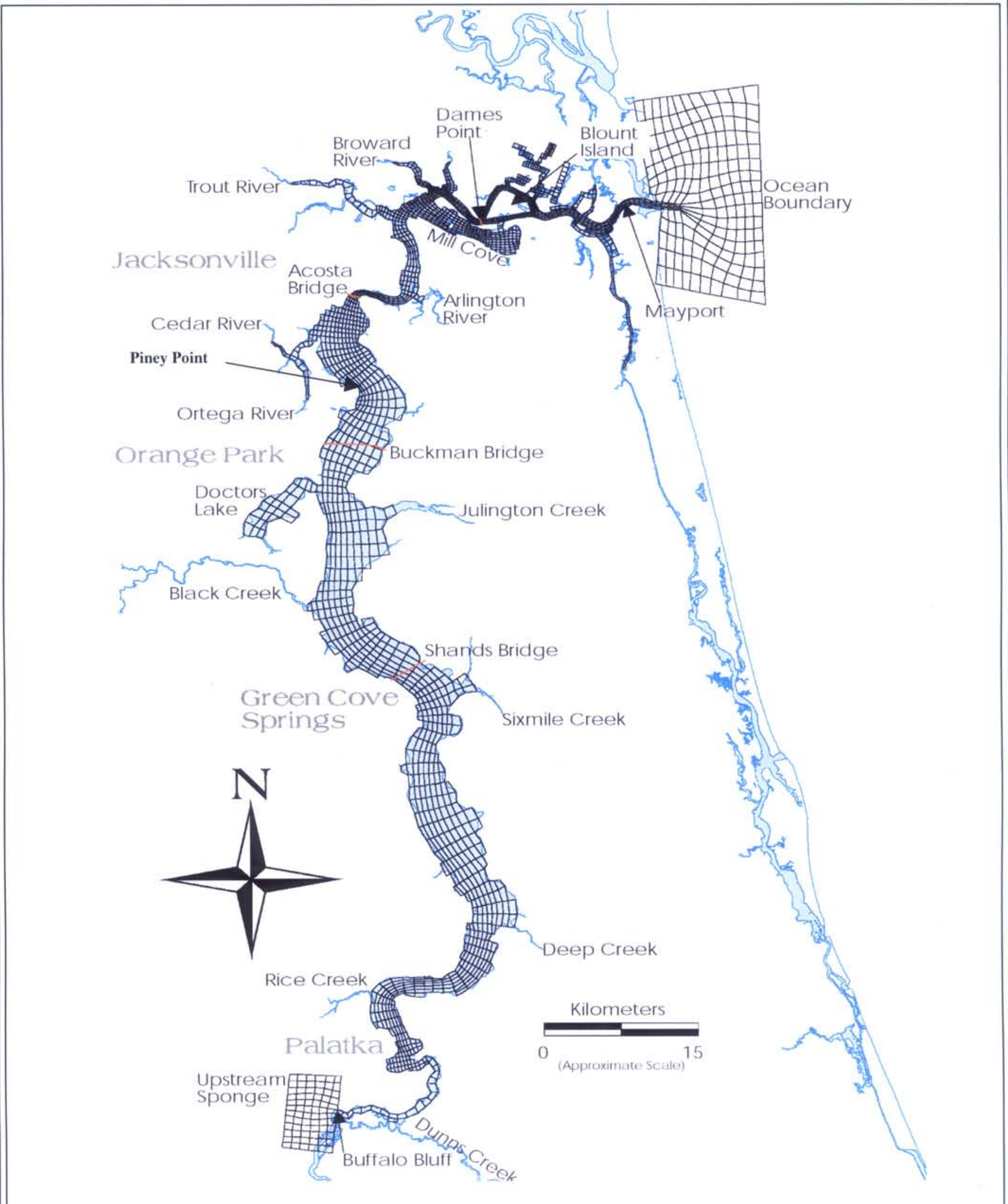

FIGURE 5-4.

BOUNDARY-FITTED MODEL GRID OF THE LOWER ST. JOHNS RIVER

Source: SJRWMD, 2002.

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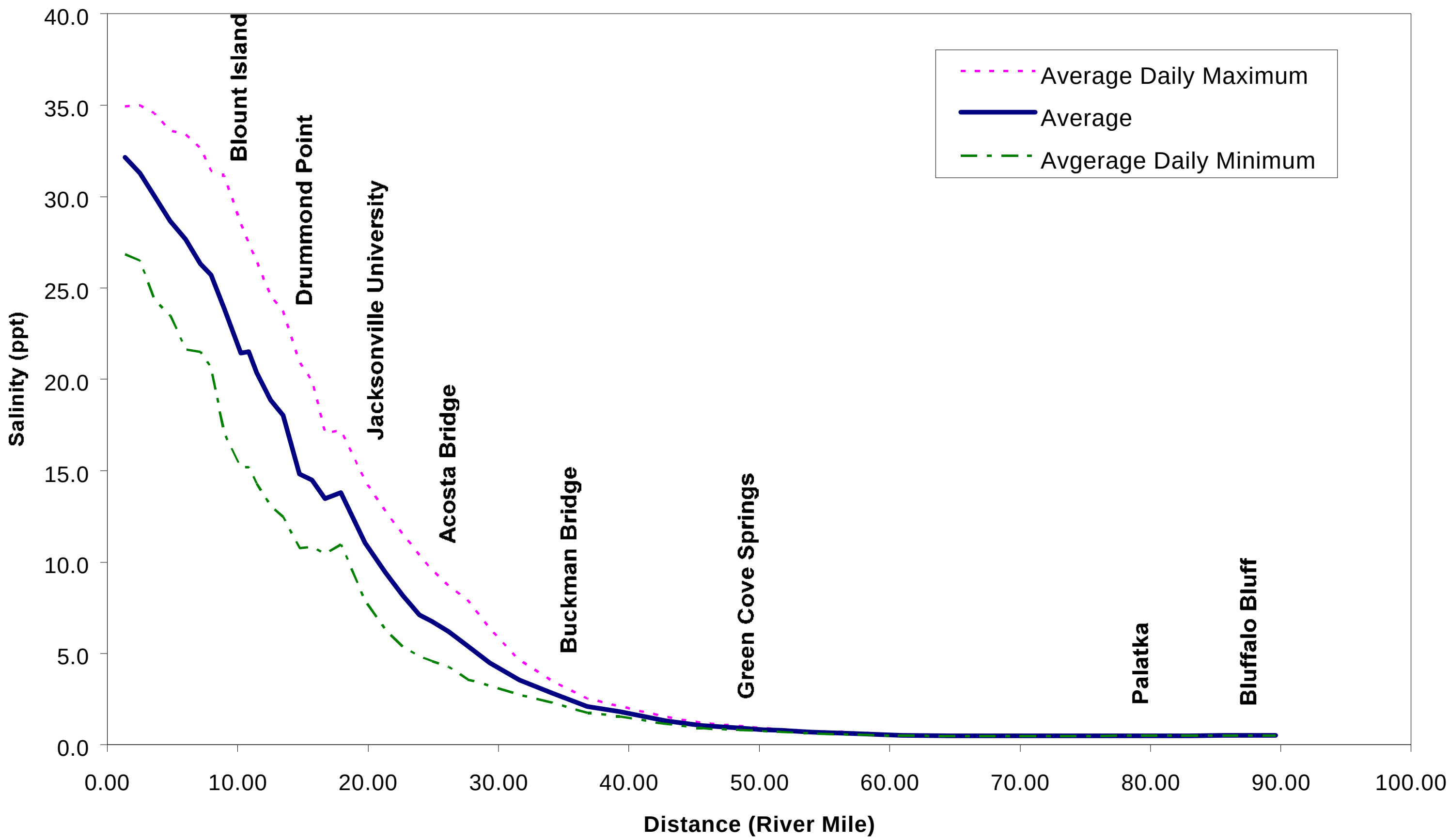

Note: All salinity values are vertically averaged.

FIGURE 5-5.

MODEL-SIMULATED LONGITUDINAL SALINITY PROFILES IN THE ST. JOHNS RIVER—BASELINE CONDITIONS (1997-1999)

Source: ECT, 2002.

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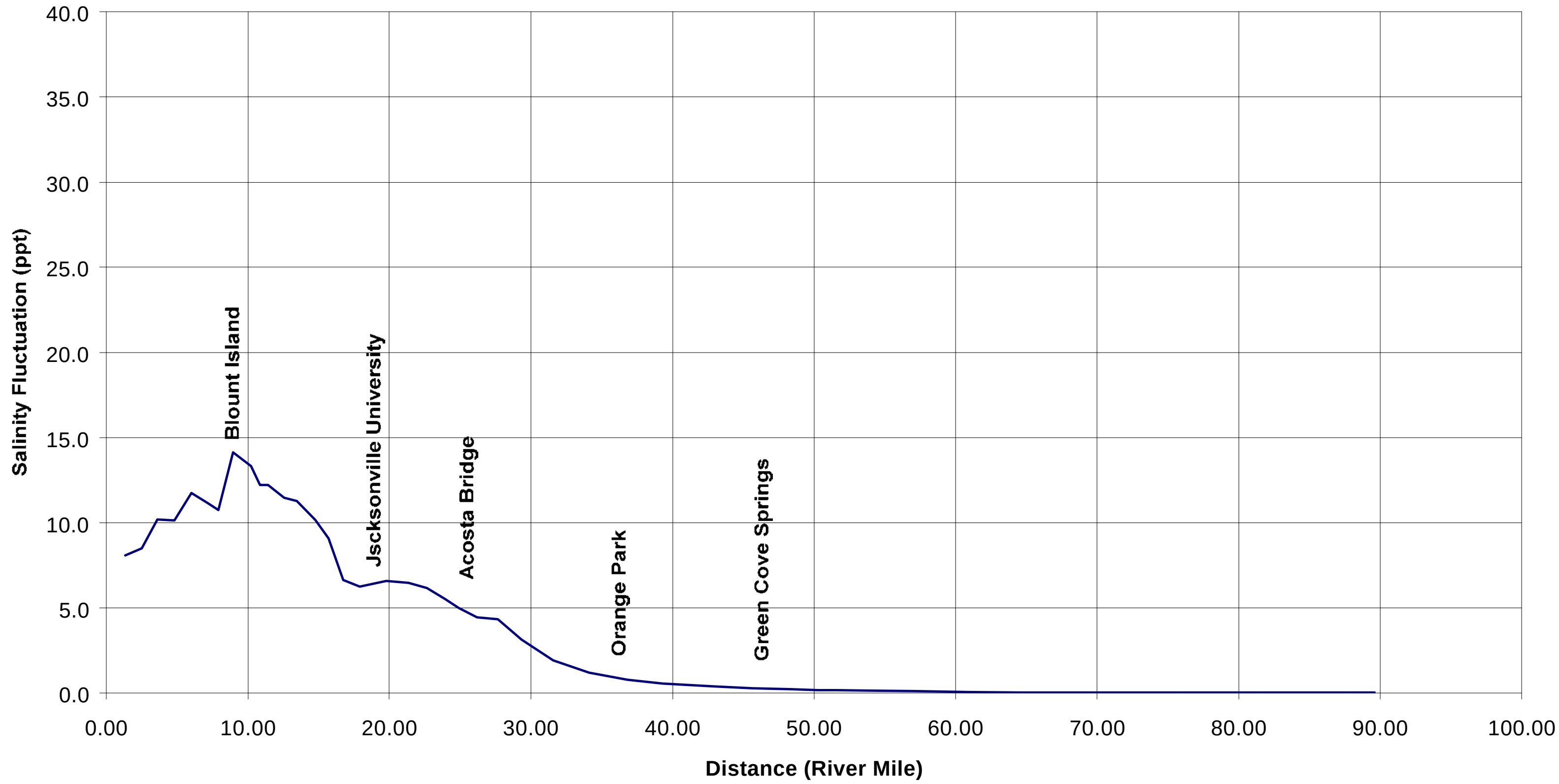

FIGURE 5-6.

AVERAGE DAILY FLUCTUATIONS OF SALINITY IN THE ST. JOHNS RIVER

Source: ECT, 2002.

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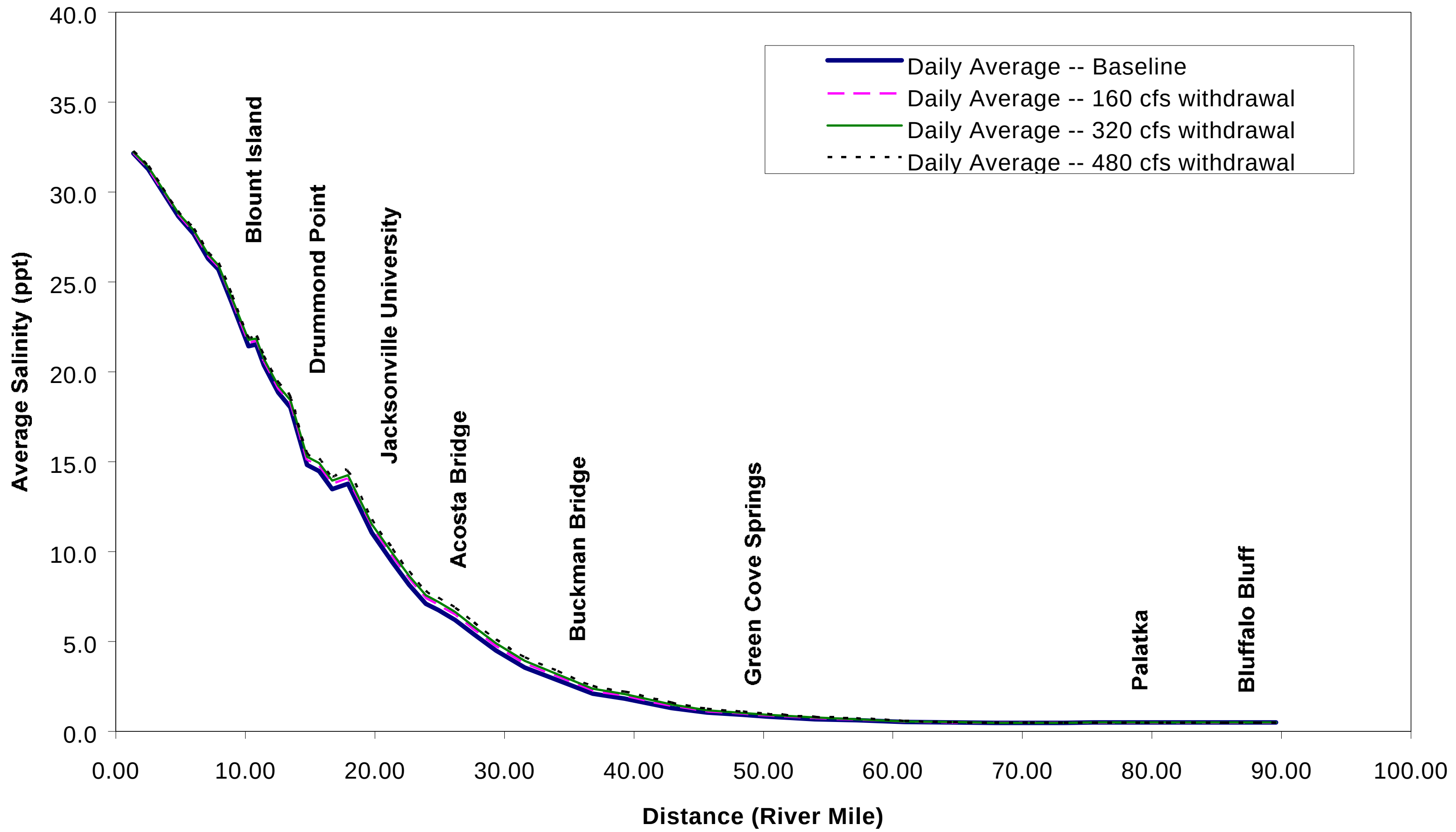
shows the averages of daily salinity fluctuations at various locations along the main stem of the river. The results show that the average daily salinity fluctuation is about 8.1 ppt near the river entrance, and the greatest salinity fluctuation occurs near Blount Island (RM 8.8) with an average daily fluctuation range of 14.1 ppt. Further upstream from this point, the diminishing salt exchange with the ocean gradually reduces salinity fluctuation to 6.6 ppt at JU, 5.5 ppt at Acosta Bridge, 1.9 ppt at Piney Point (RM 30.8)**,** and 1.1 ppt at Buckman Bridge (RM 33.9).

5.3.4 SALINITY INCREASE DUE TO FRESHWATER FLOW REDUCTION

Similar to the baseline case, the 3-year average salinity was computed at various locations along the river for each surface water withdrawal scenario and was compared to the baseline case. Figure 5-7 presents the longitudinal profiles of the 3-year average simulated salinity for the baseline and 160-, 320-, and 480-cfs withdrawal scenarios. The results show that the average salinity increase caused by the withdrawal scenarios will not be large (less than 0.5 ppt at 320-cfs withdrawal limit). Figure 5-8 presents the 3-year average salinity increase along the river for each withdrawal scenario. The results indicate that the greatest average salinity increase occurs near JU. The 3-year average increases of salinity at JU are 0.33, 0.49, and 0.74 ppt for the withdrawal limits of 160, 320, and 480 cfs, respectively. The 3-year average salinity increases at the Buckman Bridge are 0.20, 0.33, and 0.51 ppt for 160, 320, and 480 cfs withdrawal limits, respectively. There will be less than 0.01 ppt change in average salinity in the river upstream from the Federal Point (RM 67.1) at the given withdrawal rates.

The salinity distribution in an estuary is influenced primarily by the freshwater inflows from upstream and tributaries and by the ocean saltwater transported upstream by tidal currents. At one extreme, the salinity near the mouth of the river is dominated by the ocean background salinity and it is not likely to increase appreciably by the MFL limited freshwater reduction. At the other extreme, the upstream end of a river is dominated by the freshwater inflow and its salinity is near zero and it is not subject to appreciable salinity increase due to moderate freshwater reduction. The river segments between these two extremes will exhibit varying degrees of salinity increases according to bathymetry, tributaries, and width of the river. The model projection shows a maximum salinity increase



Note: All salinity values are vertically averaged.

FIGURE 5-7.

MODEL SIMULATED LONGITUDINAL AVERAGE SALINITY PROFILES (1997-1999)

Source: ECT, 2002.

Environmental Consulting & Technology, Inc.

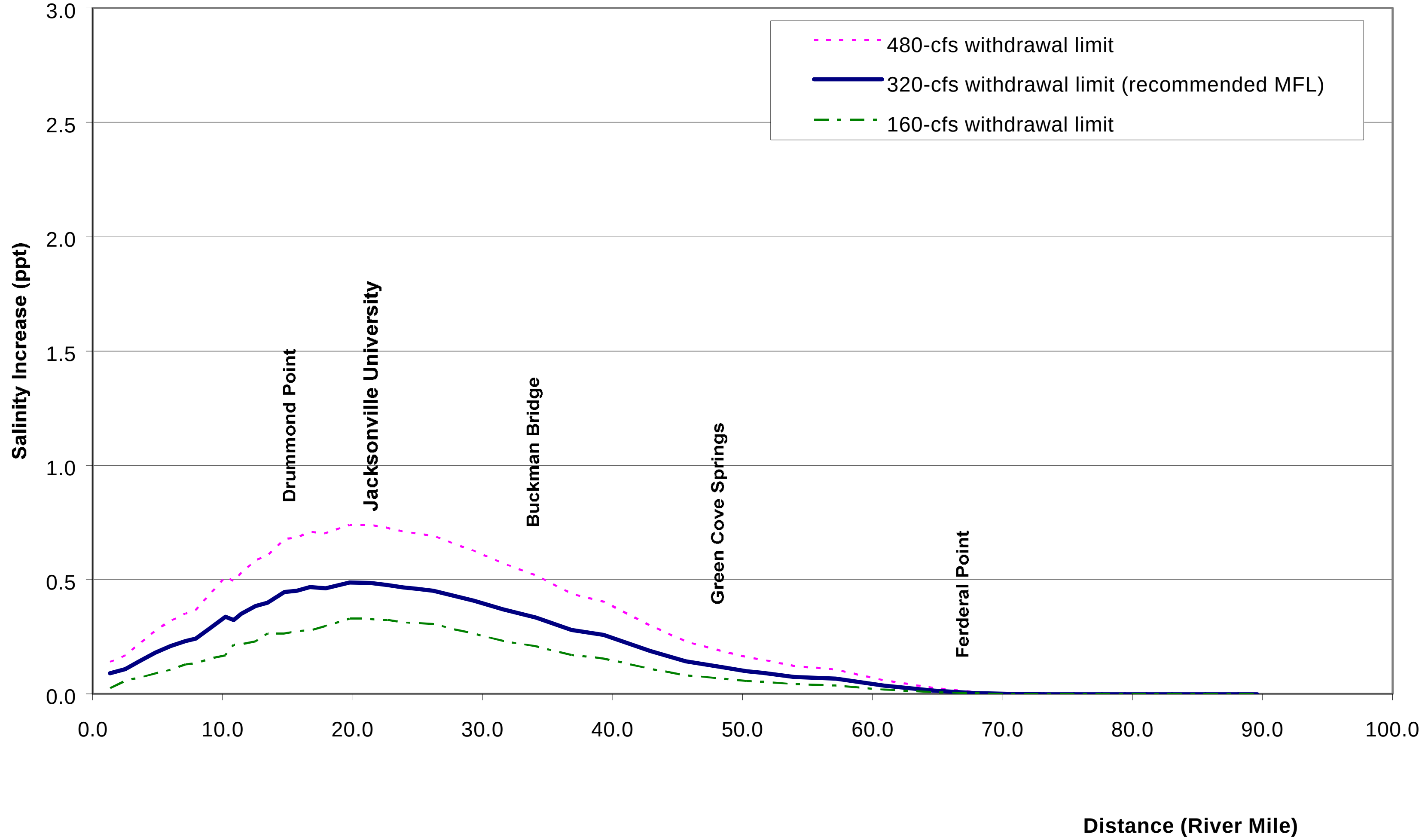


FIGURE 5-8.

AVERAGE SALINITY INCREASE DUE TO FRESHWATER WITHDRAWAL

Source: ECT, 2002.

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near JU due to flow reduction ranging from 160 to 480 cfs (Figure 5-8). It could be an indication that the relative influences from the ocean and freshwater inflow may reach a balance in this stretch of the river.

Figure 5-9 presents the average salinity increase resulting from the recommended MFL regime (withdrawal limit of 320 cfs), compared with the average salinity in the river and the naturally-occurring daily salinity fluctuations. It shows that the average salinity increase resulting from the MFL regime is quite small compared to the daily variability of the salinity caused by tidal transport. For example, the average salinity increase at JU (RM 19.2) is 0.49 ppt, while the average salinity is 11.1 ppt and the average daily salinity fluctuation is 6.6 ppt.

In addition to daily tidal variation in salinity, the salinity in LSJR is subject to large seasonal changes according to historic data collected by USGS. For example, the seasonal salinity changes can be as high as 32 ppt at the Acosta Bridge (RM 23.7) where the projected average daily salinity variation is 5.5 ppt and the projected average salinity increase due to the proposed MFL regime is only 0.47 ppt. Similarly, the historic seasonal salinity changes is up to 26 ppt at the Buckman Bridge (RM 33.9) where the average daily salinity variation is 1.09 ppt and the average salinity increase due to proposed MFL regime is 0.33 ppt. The maximum seasonal salinity change is 9.6 ppt at the Shands Bridge (RM 49.9) where the daily salinity variation is 0.16 ppt and the salinity increase due to the proposed MFL regime is only 0.10 ppt.

Similarly, Figure 5-10 presents the longitudinal profiles of the 3-year average of the daily maximum salinity for various flow scenarios. Figure 5-11 presents the 3-year average of the daily minimum salinities. The results also indicate that the changes of the daily maximum and minimum salinities will be relatively small at the given withdrawal scenarios. The greatest change of average daily maximum salinity occurs near the Acosta Bridge. It is increased by 0.35, 0.49, and 0.75 ppt for 160, 320, and 480 cfs withdrawal limits, respectively. The greatest change of average daily minimum salinity occurs between JU and Trout River. It is increased by 0.33, 0.49, and 0.75 ppt for 160, 320, and 480 cfs withdrawal limits, respectively.

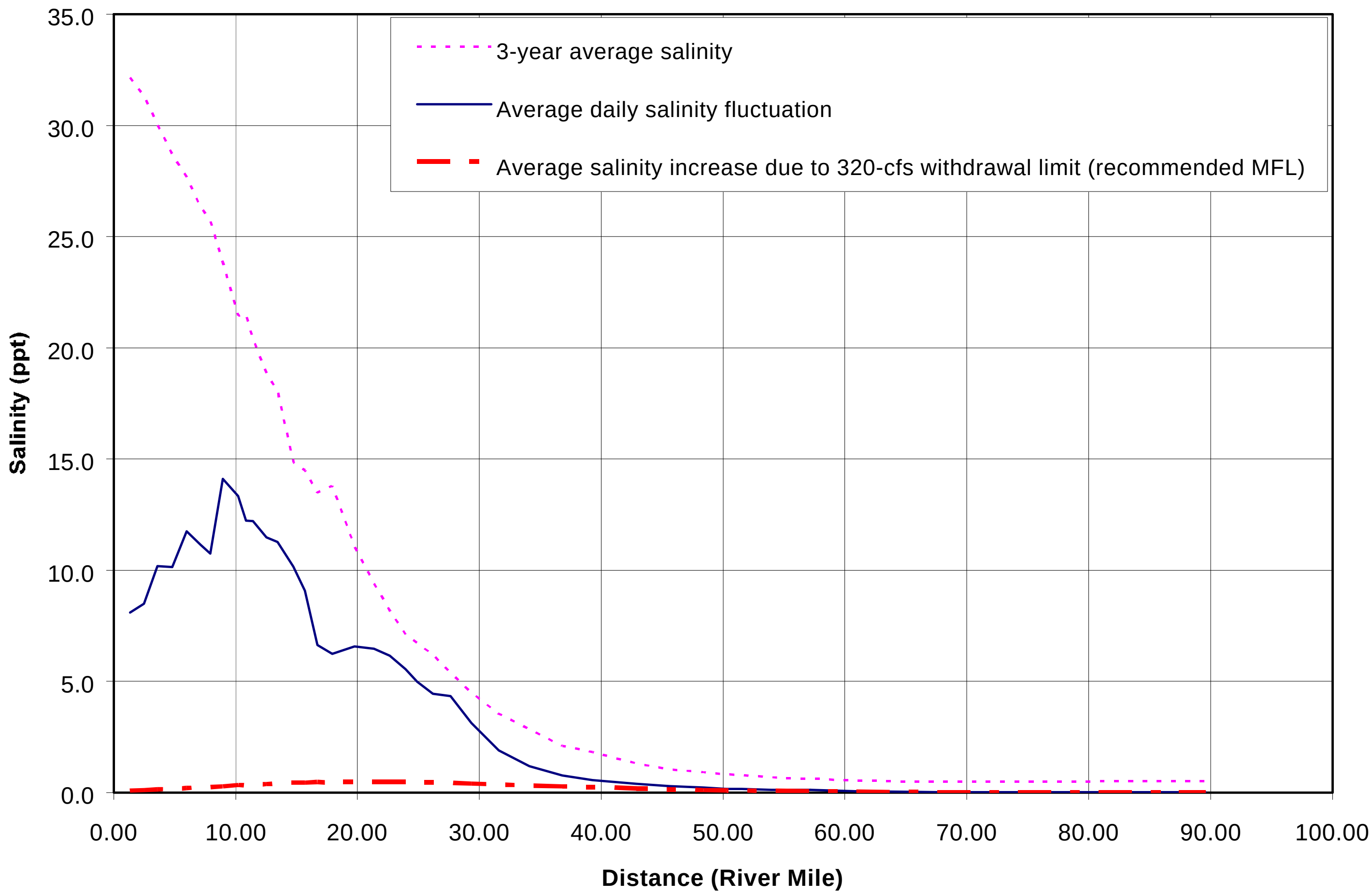

FIGURE 5-9.

AVERAGE SALINITY CHANGES RELATIVE TO DAILY FLUCTUATIONS IN THE ST. JOHNS RIVER

Source: ECT, 2002.

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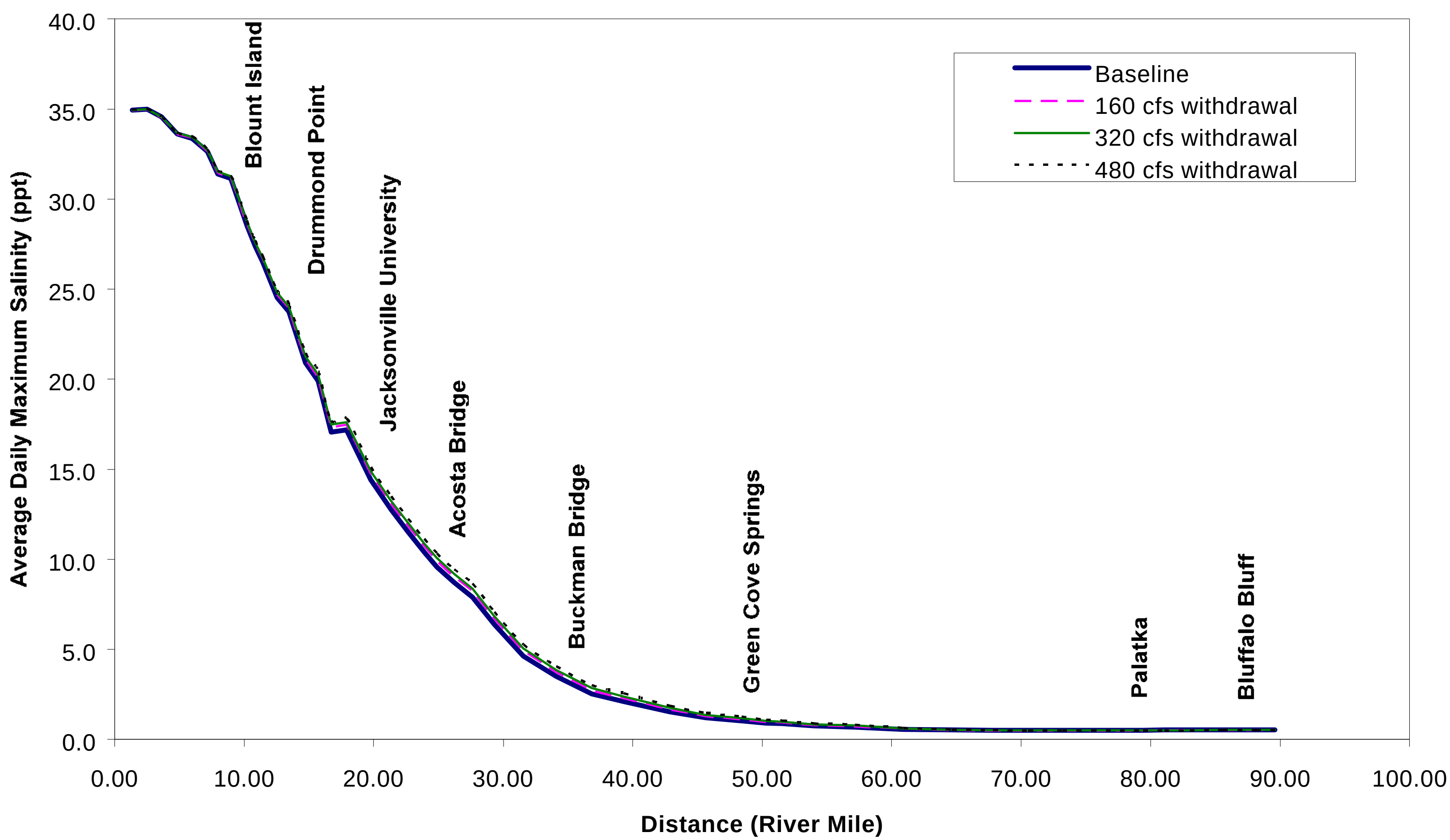


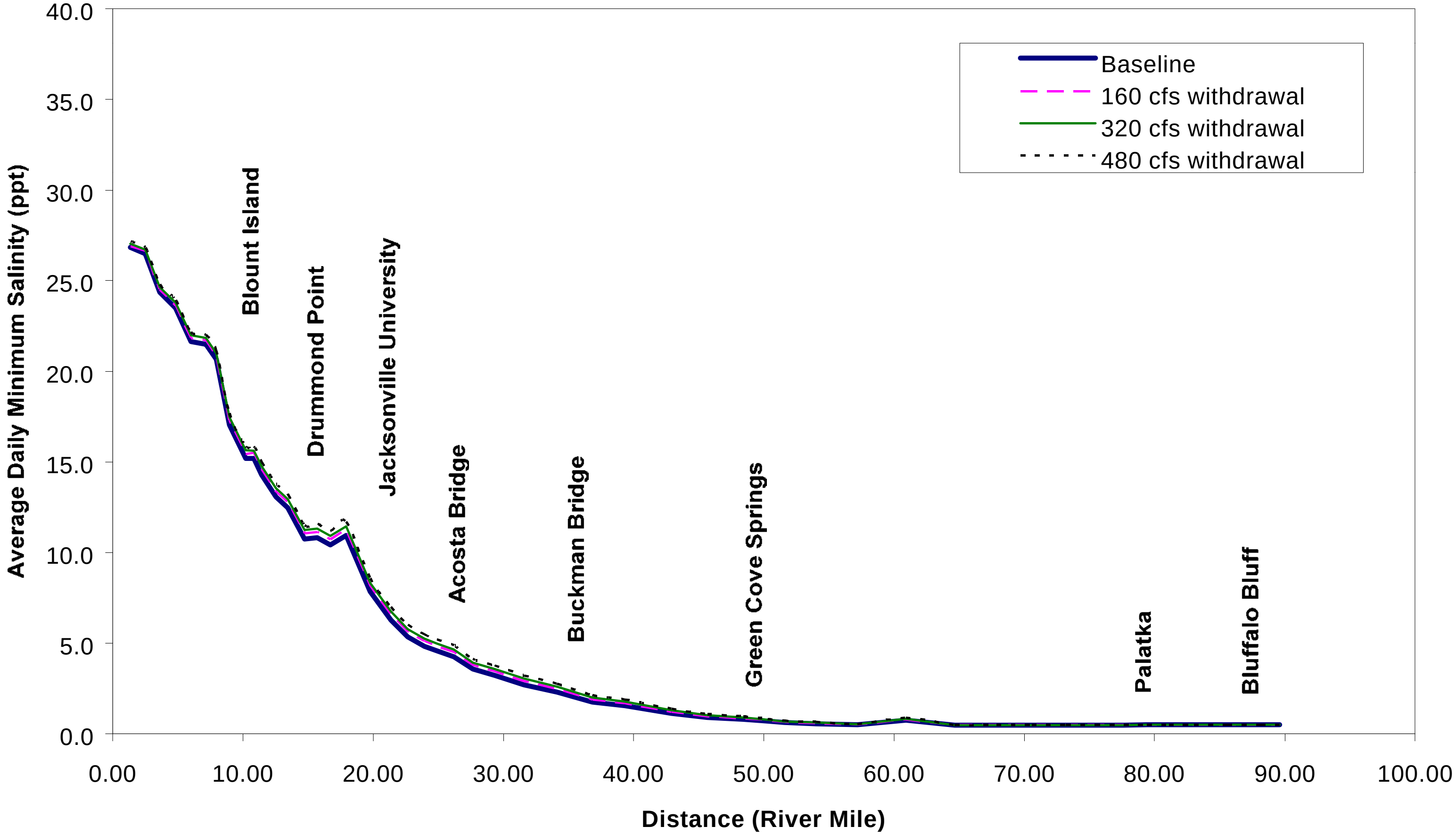
Note: All salinity values are vertically averaged.

FIGURE 5-10.

MODEL SIMULATED LONGITUDINAL AVERAGE DAILY MAXIMUM SALINITY PROFILES (1997-1999)

Source: ECT, 2002.

Environmental Consulting & Technology, Inc.



Note: All salinity values are vertically averaged.

FIGURE 5-11.

MODEL SIMULATED LONGITUDINAL AVERAGE DAILY MINIMUM SALINITY PROFILES (1997-1999)

Source: ECT, 2002.

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To quantify the short-term salinity increase due to freshwater withdrawals near DeLand, frequency analyses were conducted for the daily salinity time-series. Figures 5-12 through 5-26 present the cumulative frequency analyses results for the daily average salinity at 15 selected locations (11 in the main river and 4 in the tributaries) for various flow scenarios. The analyses indicate the maximum increase of daily salinity due to 320 cfs withdrawal is about 1.2 ppt between JU and Magnolia Point (RM 45.2). This short-term increase near JU represents about an 8 percent increase of the daily average salinity, and is about 19 percent of the average daily salinity fluctuation due to tidal transport.

The maximum daily salinity increase by 160 cfs withdrawal is 0.9 ppt, occurring between JU and Piney Point (RM 30.8). The maximum daily salinity increase by 480 cfs withdrawal limit is about 1.8 ppt, occurring between JU and Hibernia Point (RM 42.3). According to the frequency analysis, the greatest 95th percentile daily salinity increase by the 320 cfs withdrawal limit is 0.98 ppt, occurring near Venetia (RM 27.8). The greatest 95th percentile salinity increase by 160 cfs withdrawal limit is 0.70 ppt, occurring between JU and Piney Point. The greatest 95th percentile salinity increase by 480 cfs withdrawal limit is 1.5 ppt, occurring near Piney Point.

5.3.5 POTENTIAL EFFECTS OF PREDICTED SALINITY CHANGE ON AQUATIC LIFE

Salinity changes within the LSJR basin due to the MFL regime hydrologic conditions may result in changes in the distribution of fishes and invertebrates. Table 5-5 lists the observed salinity ranges at which selected species have been collected. As described in Section 5.2, many of the species inhabiting the LSJR are of marine or estuarine origin. These species are euyhaline, that is they are adapted to a wide range of salinities. For these species, the increase in salinity may result in changes in the areas or the upstream/downstream limits of where they can survive, although many of these species already occur throughout the river. On the other hand, the primary freshwater species (for example, fishes of the families Cyprinidae, Ictaluridae, and Centrarchidae, as well as most insect larvae) are restricted to narrower ranges of salinities (stenohaline), often less

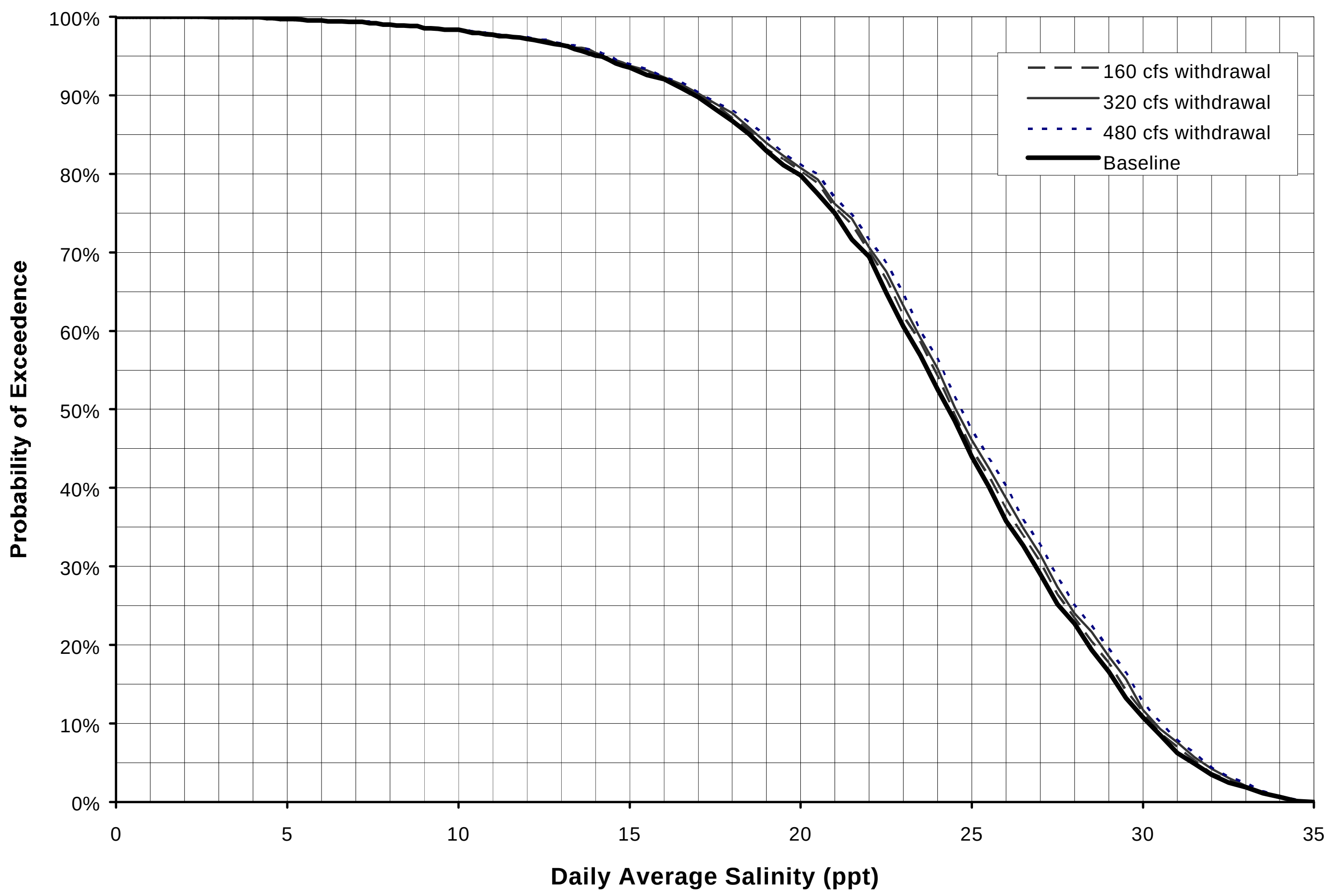

FIGURE 5-12.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
NEAR BLOUNT ISLAND

Source: ECT, 2002.

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Environmental Consulting & Technology, Inc.

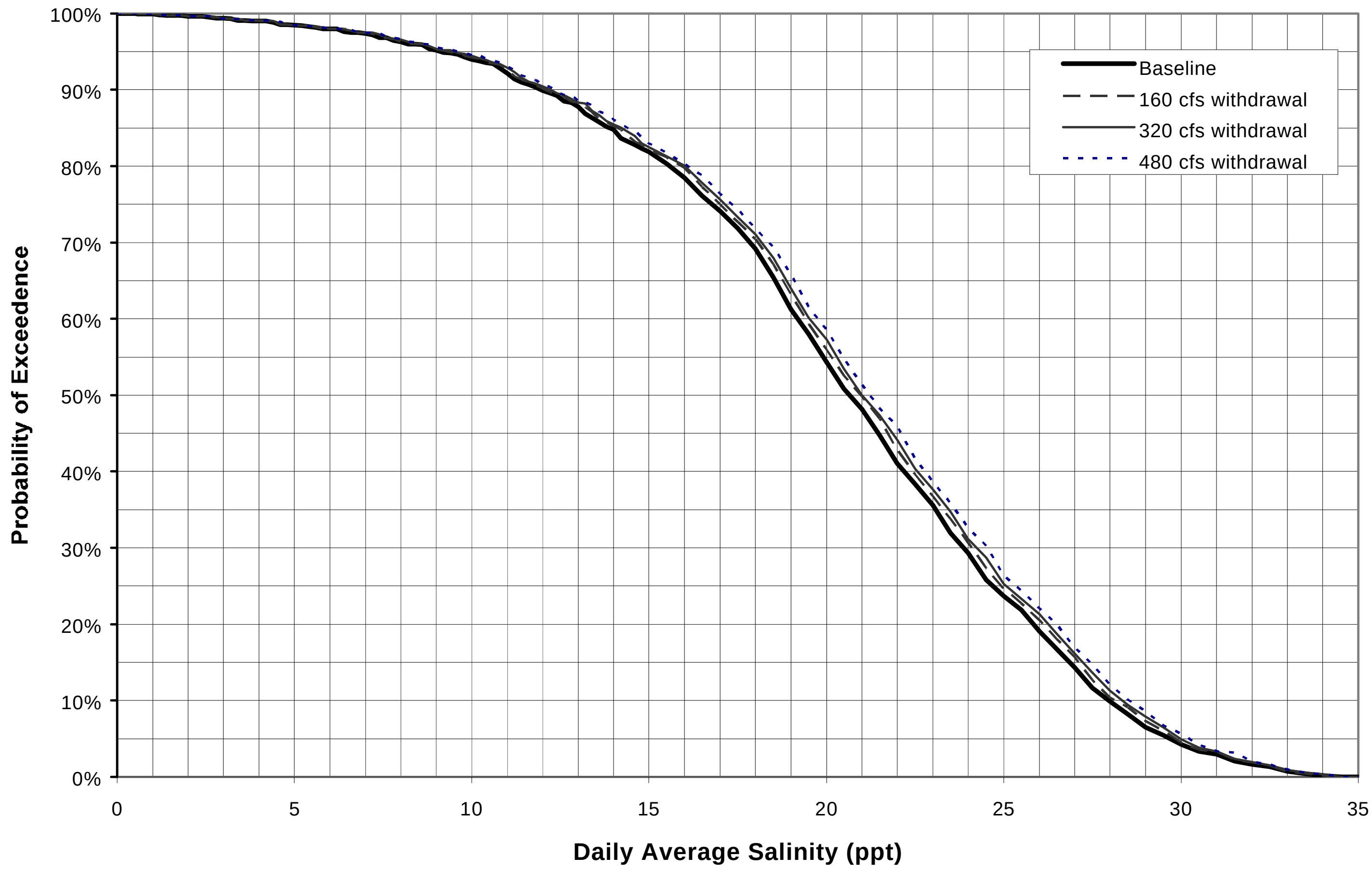

FIGURE 5-13.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
NEAR DAMES POINT

Source: ECT, 2002.

Environmental Consulting & Technology, Inc.

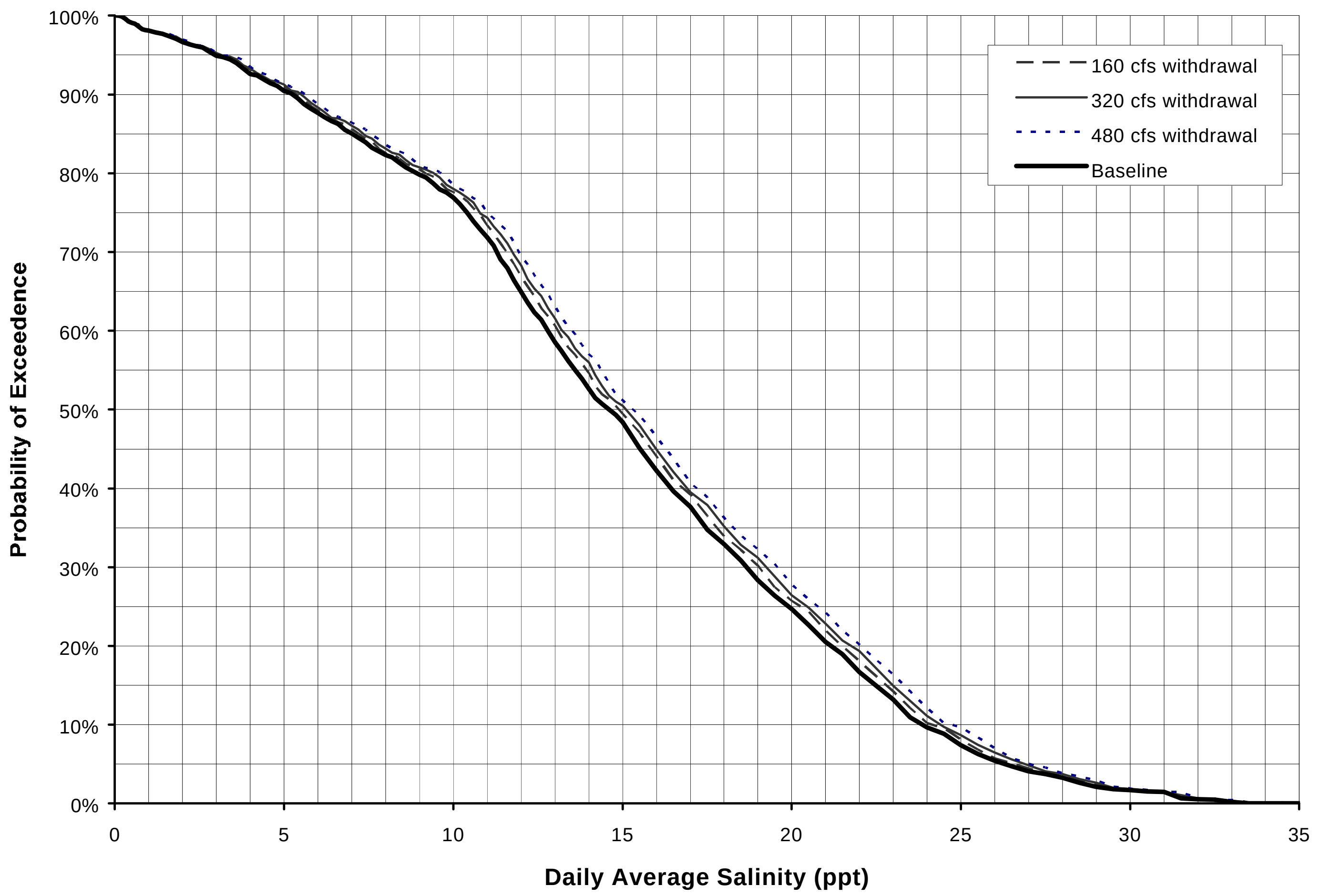

FIGURE 5-14.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
NEAR DRUMMOND POINT

Source: ECT, 2002.

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Environmental Consulting & Technology, Inc.

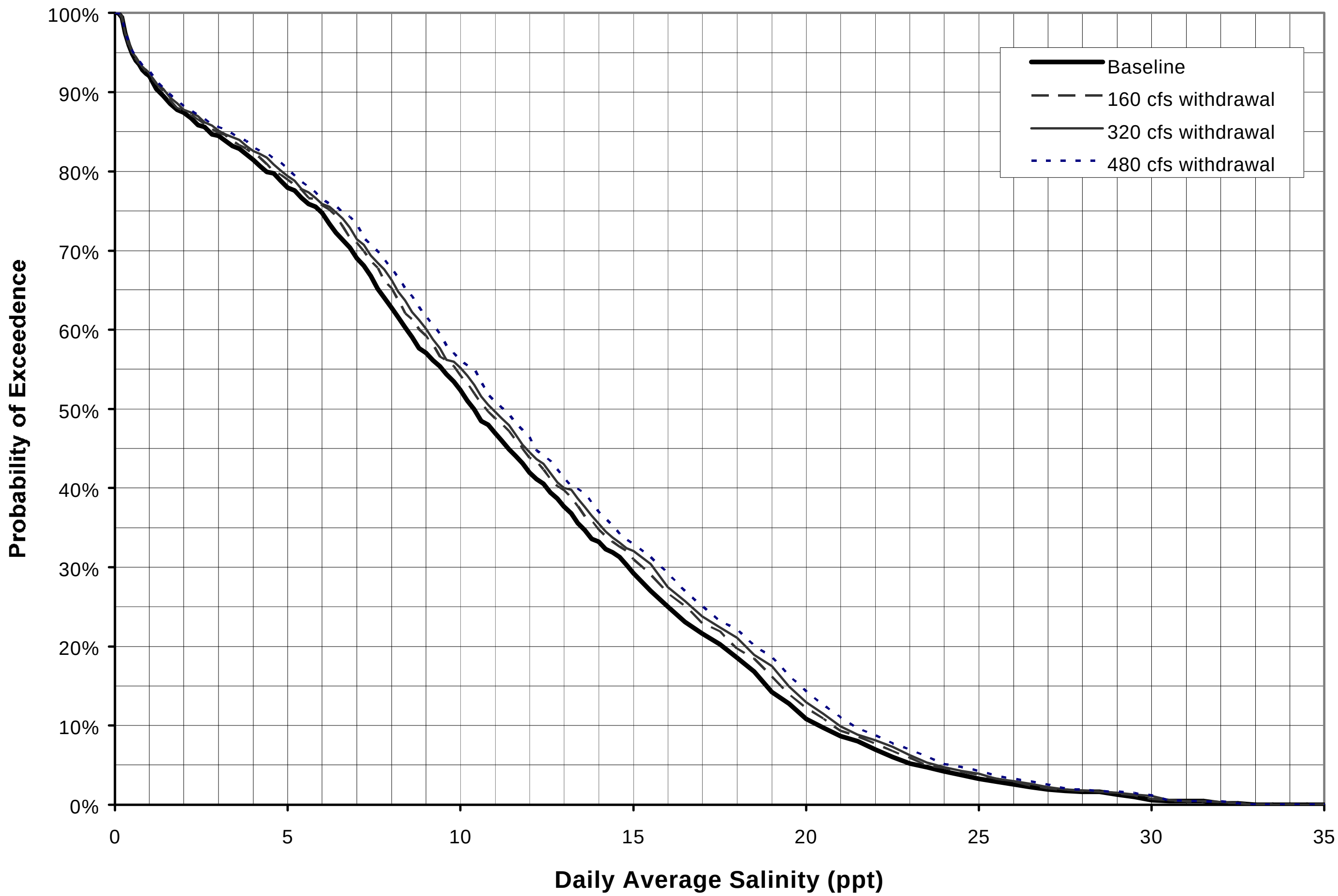

FIGURE 5-15.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
NEAR JACKSONVILLE UNIVERSITY

Source: ECT, 2002.

Environmental Consulting & Technology, Inc.

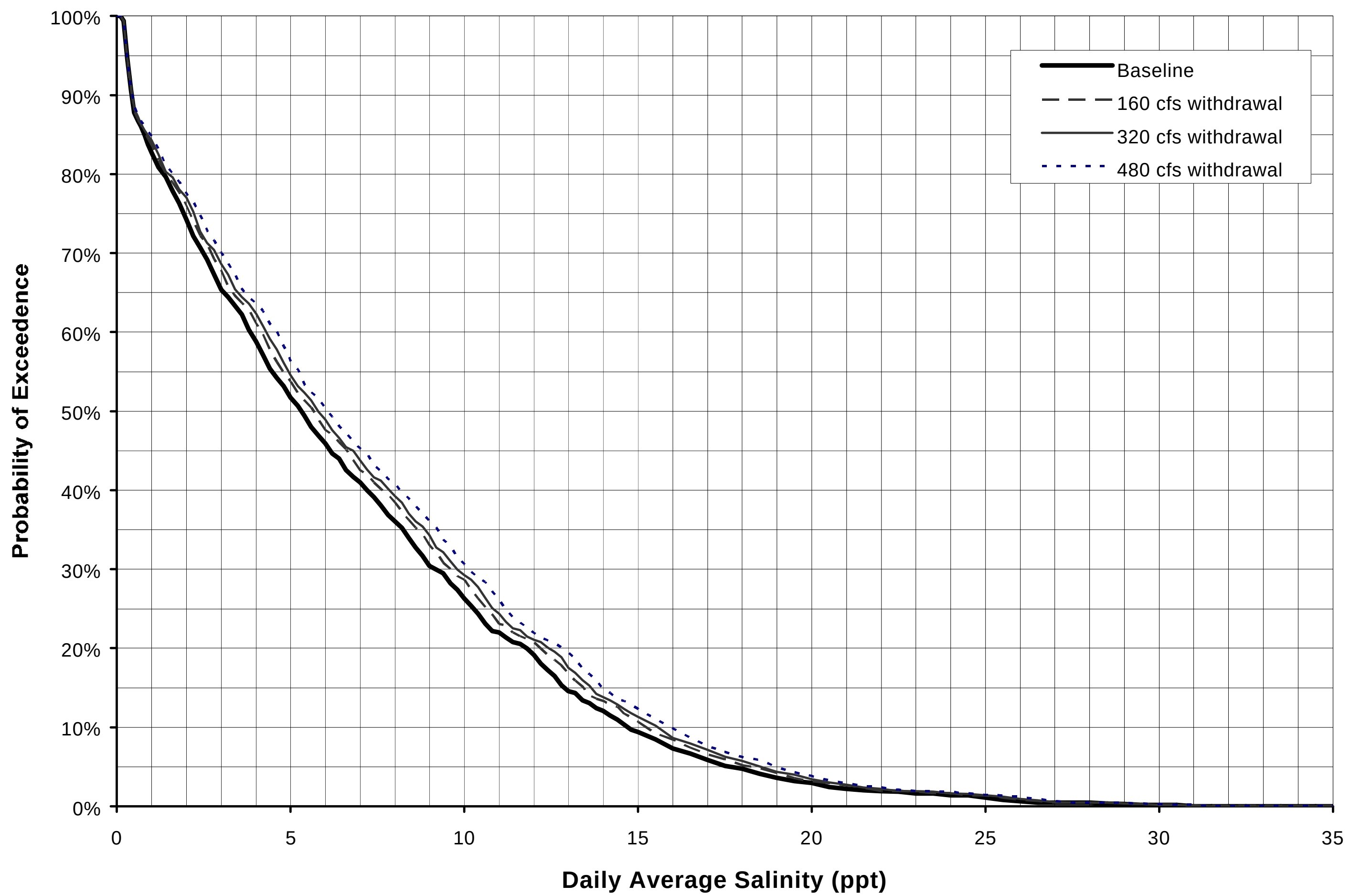

FIGURE 5-16.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
AT ACOSTA BRIDGE

Source: ECT, 2002.

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Environmental Consulting & Technology, Inc.

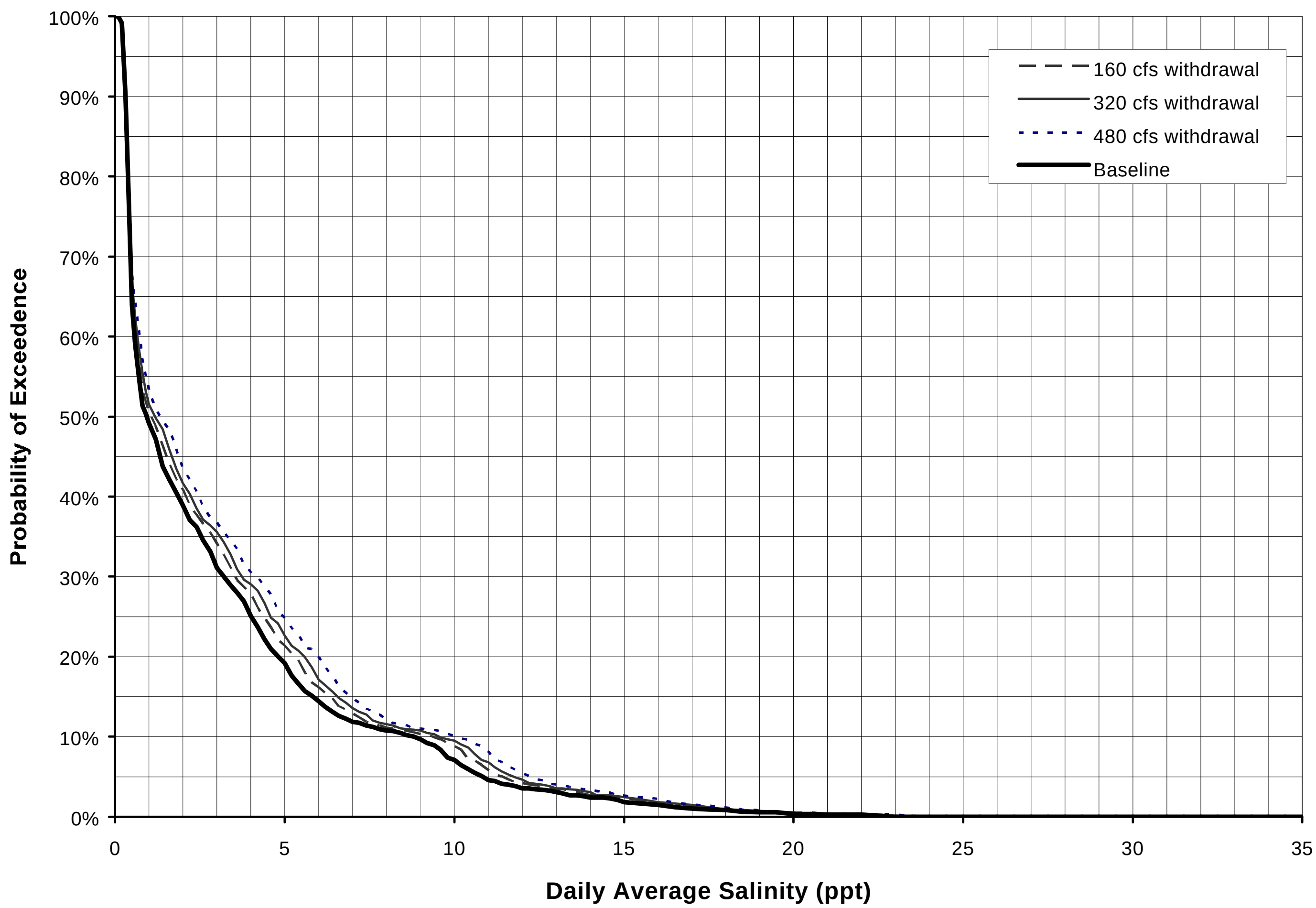

FIGURE 5-17.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
AT BUCKMAN BRIDGE
Source: ECT, 2002.

ECT
Environmental Consulting & Technology, Inc.

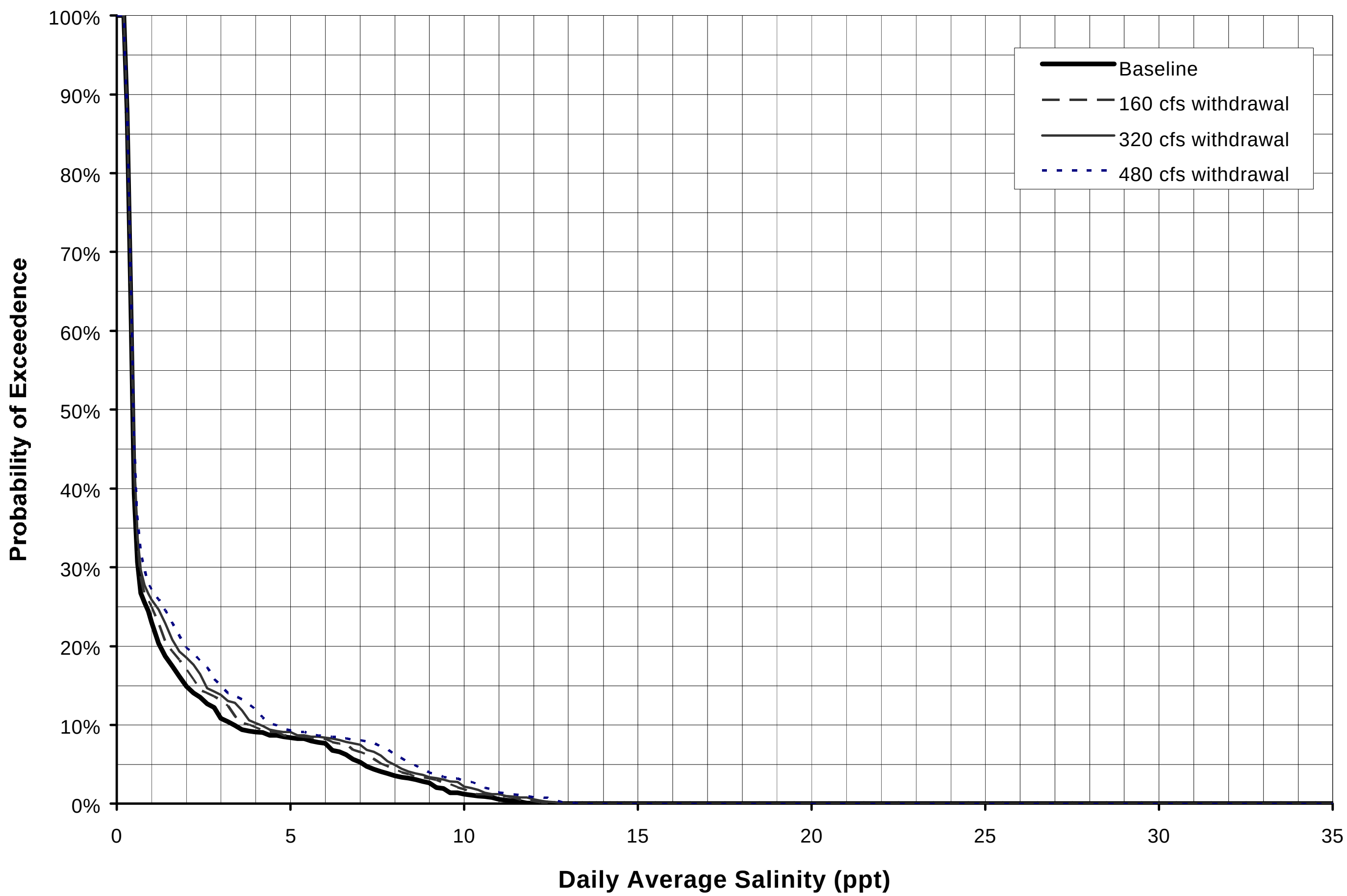

FIGURE 5-18.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
AT HIBERNIA POINT

Source: ECT, 2002.

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Environmental Consulting & Technology, Inc.

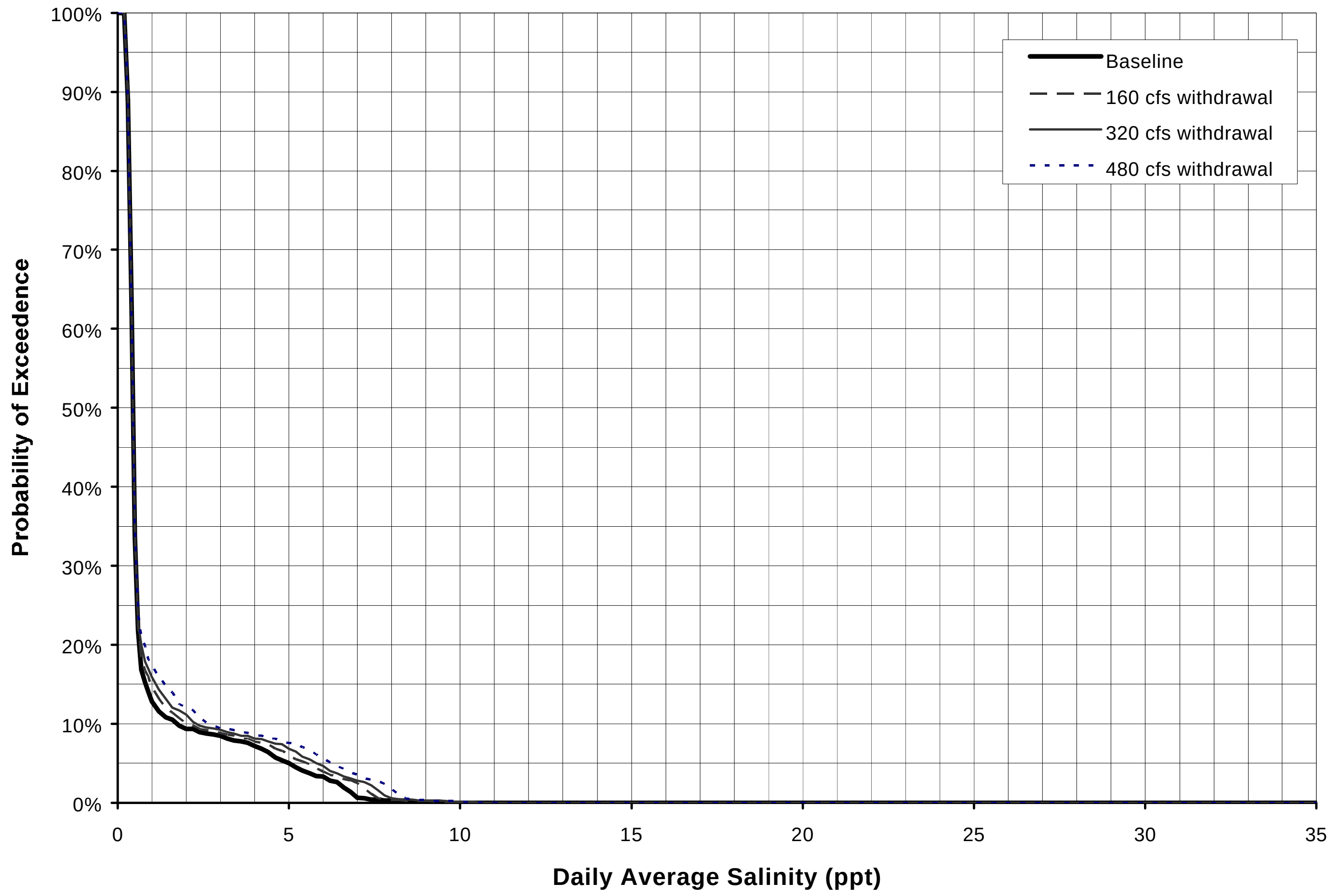

FIGURE 5-19.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
NEAR GREEN COVE SPRINGS

Source: ECT, 2002.

Environmental Consulting & Technology, Inc.

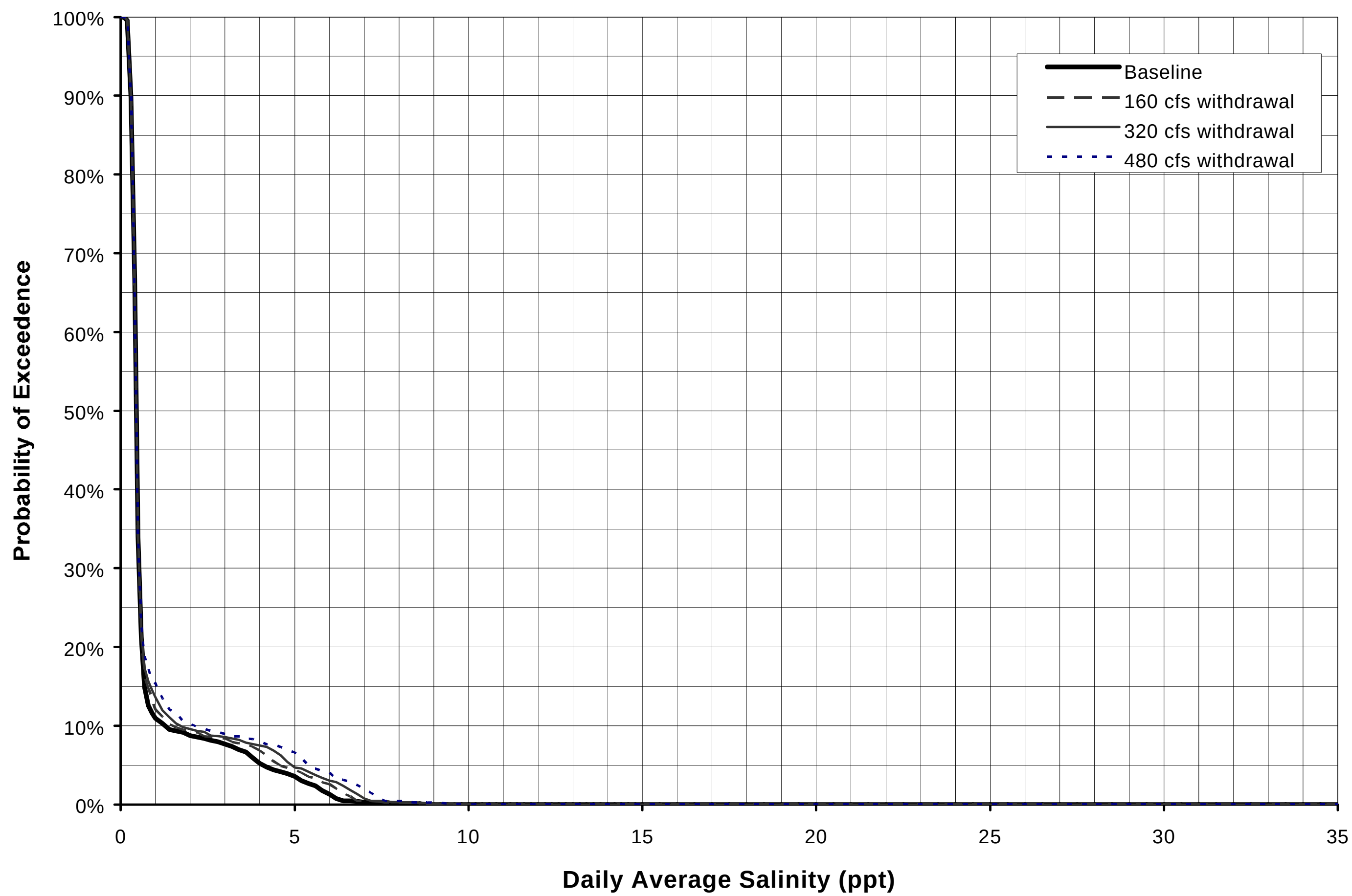

FIGURE 5-20.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY AT SHANDS BRIDGE

Source: ECT, 2002.

Environmental Consulting & Technology, Inc.

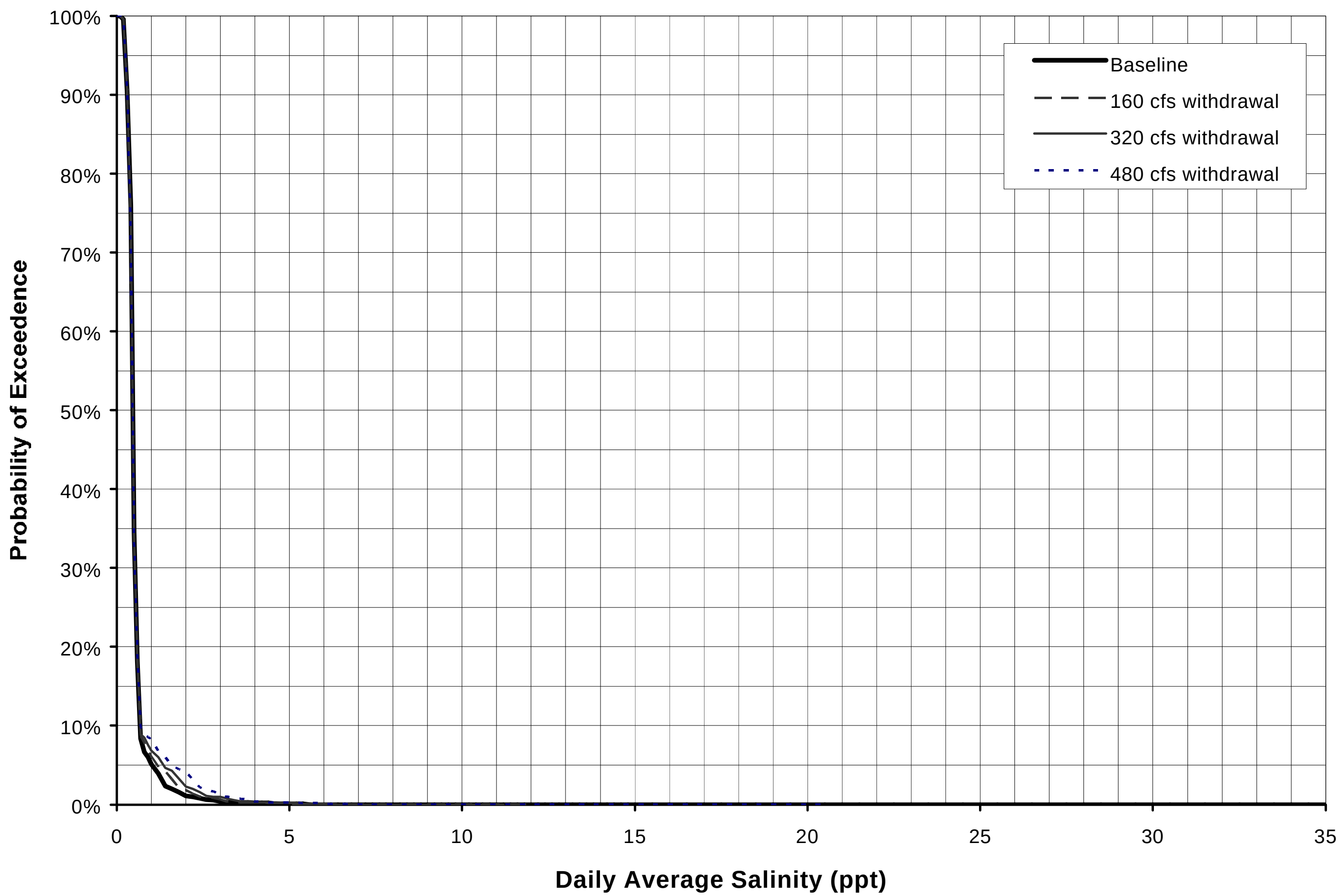

FIGURE 5-21.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
NEAR WEST TOCOI

Source: ECT, 2002.

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Environmental Consulting & Technology, Inc.

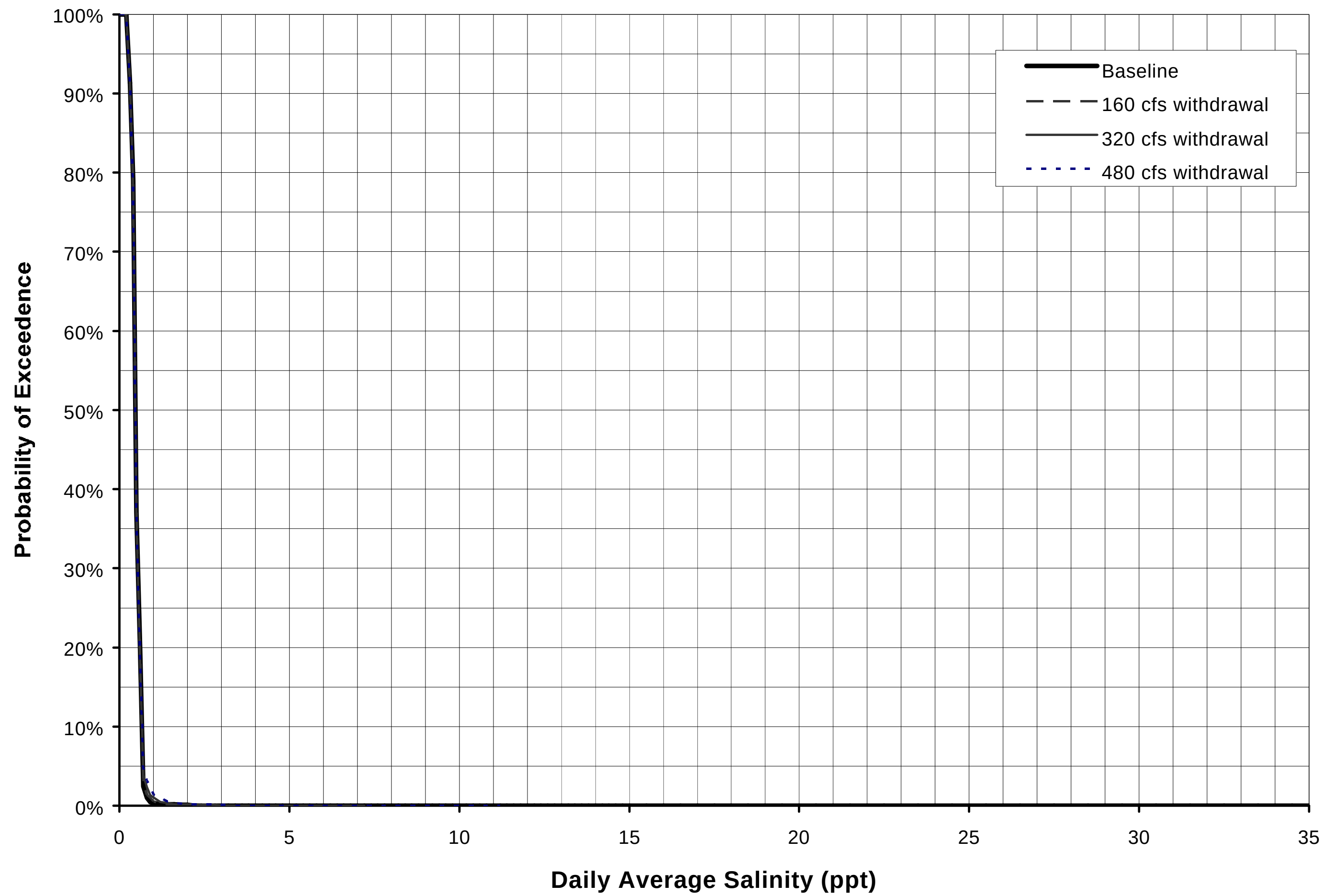

FIGURE 5-22.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
NEAR FEDERAL POINT

Source: ECT, 2002.

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Environmental Consulting & Technology, Inc.

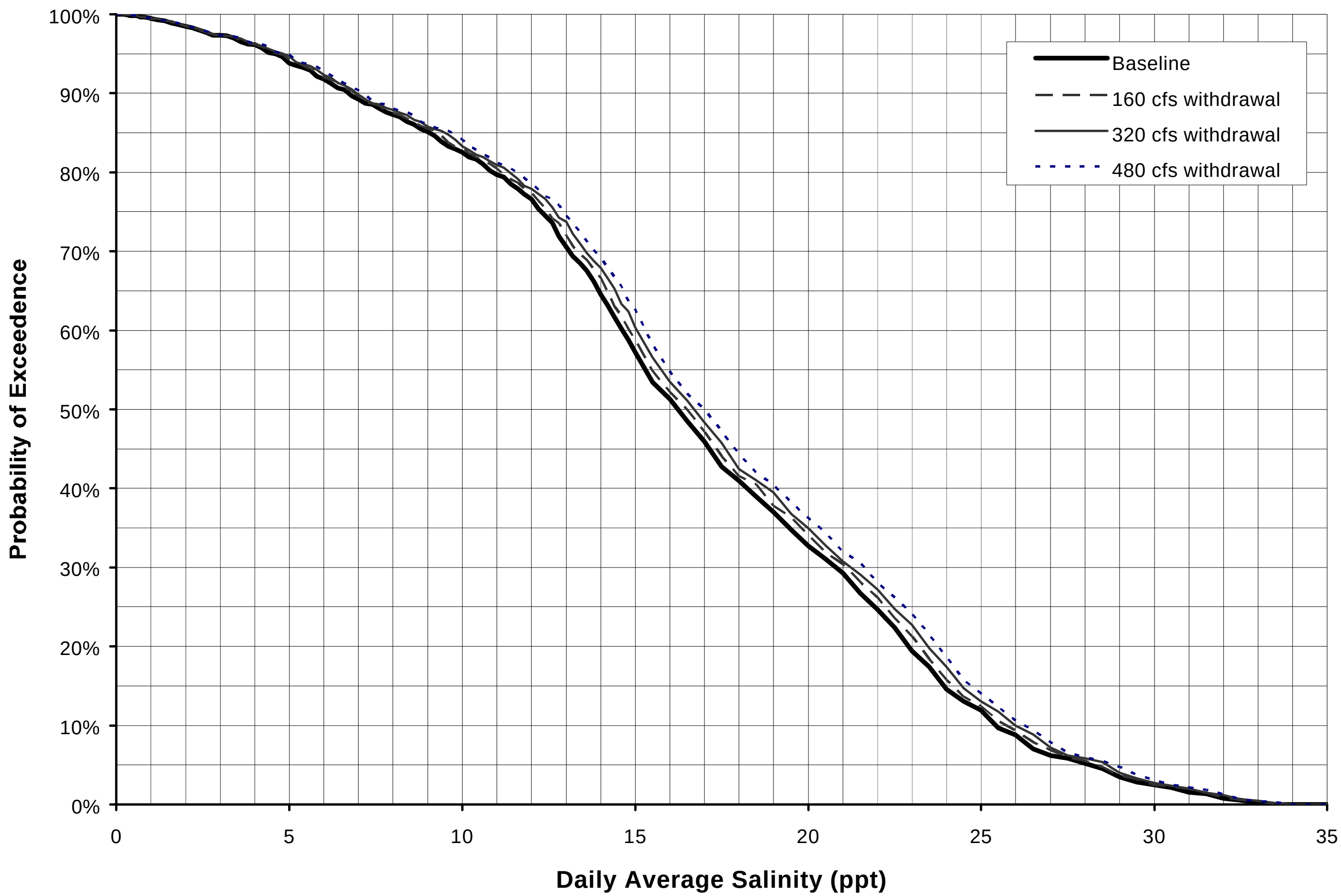

FIGURE 5-23.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
AT MILL COVE

Source: ECT, 2002.

Environmental Consulting & Technology, Inc.

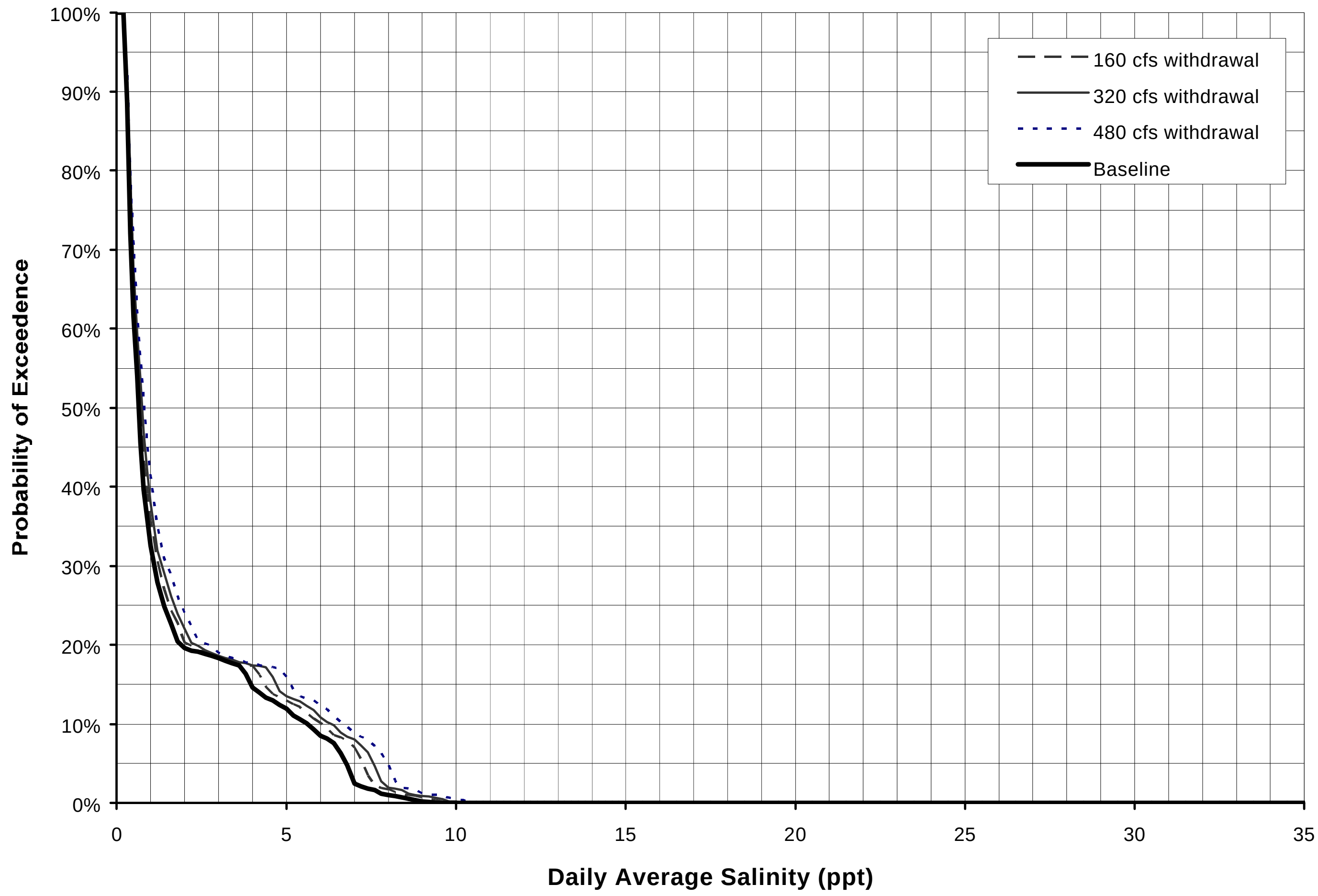

FIGURE 5-24.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
AT DOCTORS LAKE

Source: ECT, 2002.

Environmental Consulting & Technology, Inc.

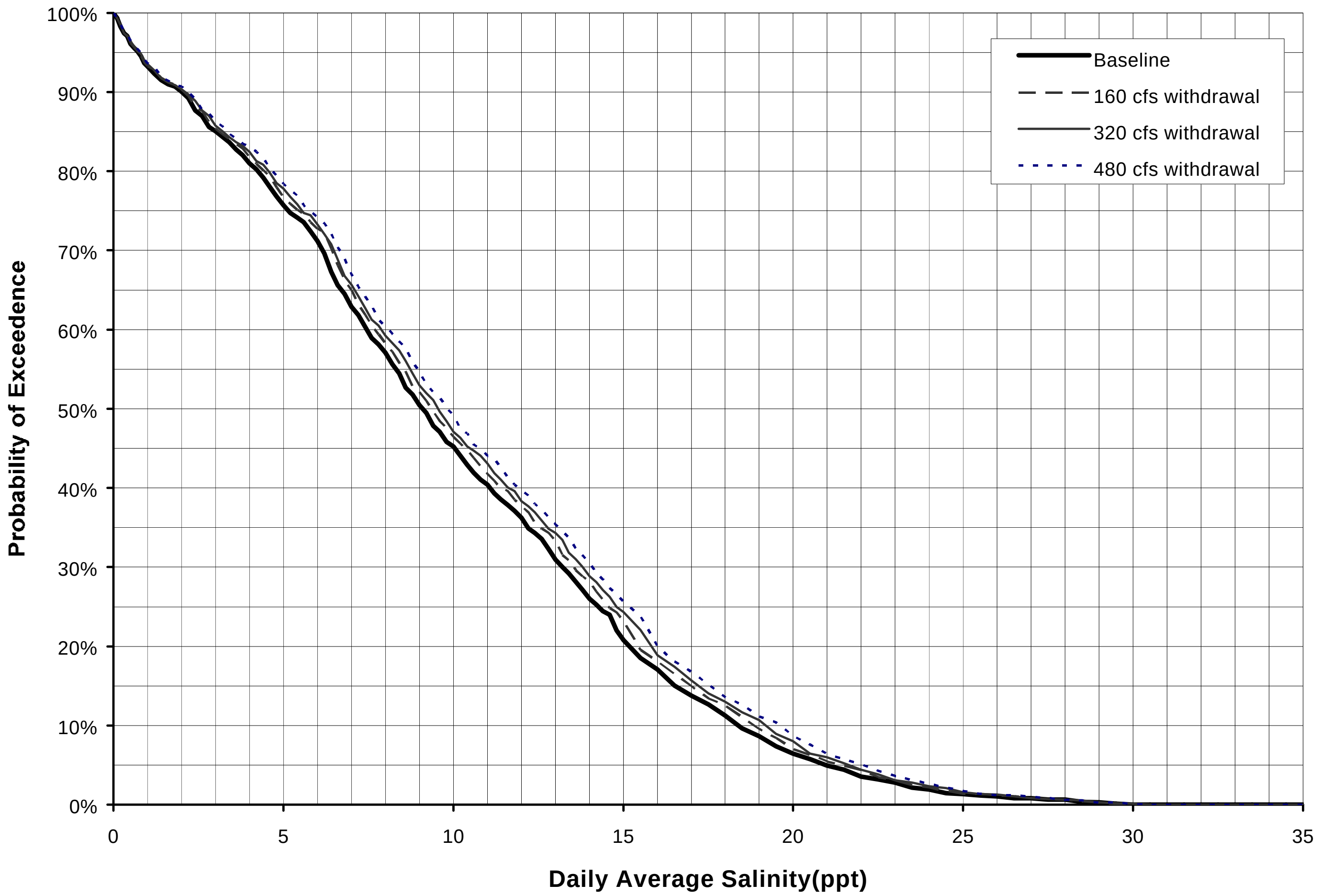

FIGURE 5-25.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY AT TROUT RIVER

Source: ECT, 2002.

ECT Environmental Consulting & Technology, Inc.

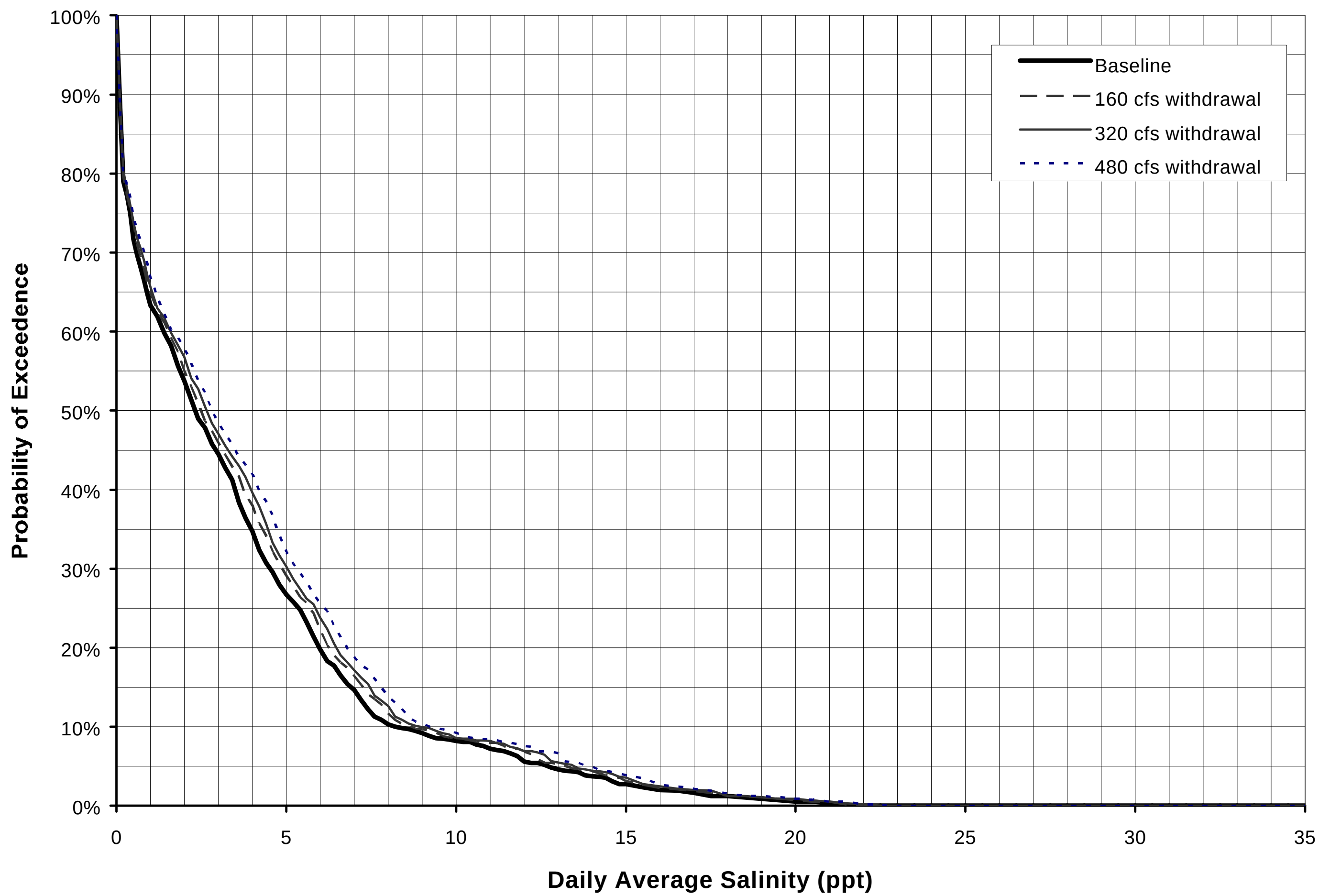

FIGURE 5-26.

CUMULATIVE FREQUENCY OF DAILY AVERAGE SALINITY
AT ORTEGA RIVER

Source: ECT, 2002.

ECT
Environmental Consulting & Technology, Inc.

Table 5-5. Salinity Ranges for Selected Species

Scientific name	Common name	Salinity Range (ppt)	References
Dasyatis sabina	Atlantic stingray	0.09 - 41	4, 6, 8
Lepisosteus osseus	Longnose gar	1.2 - 26.9	9, 10
Lepisosteus platyrhincus	Florida gar	0 - 26.0	4, 6, 11
Elops saurus	Ladyfish	0 - 35	4, 10, 11
Megalops atlanticus	Tarpon	0 - 35	11
Anguilla rostrata	American eel	0.3 - 29.9	9, 10
Brevoortia tyrannus	Atlantic menhaden	36	1
Dorosoma cepedianum	Gizzard shad	0.0 - 24.7	10
Dorosoma petenense	Threadfin shad	0.0 - 21.7	4, 10
Anchoa mitchilli	Bay anchovy	0 - 36	1, 2, 4, 6, 9, 10, 11
Esox niger	Chain pickerel	0 - 7.5	10
Notemigonus crysoleucas	Golden shiner	1.3 - 10.7	10
Notropis maculatus	Taillight shiner	0.09 - 1.0	4
Notropis petersoni	Coastal shiner	0.12 - 0.65	4
Erimyzon sucetta	Lake chubsucker	0.6 - 14.4	10
Ameiurus catus	White catfish	0.09 - 0.26	4
Ameiurus natalis	Yellow bullhead	0 - 12	11
Ameiurus nebulosus	Brown bullhead	0.4 - 3.5	10
Ictalurus punctatus	Channel catfish	0 - 12.6	4, 10
Noturus leptacanthus	Speckled madtom	0.22	4
Bagre marinus	Gafftopsail catfish	0.17 - 35	4, 6, 9, 10, 11
Aphredoderus sayanus	Pirate perch	0.6 - 19.7	10
Strongulura marina	Atlantic needlefish	0 - 23.0	6, 10
Cyprinodon variegatus	Sheepshead minnow	0 - 31.8	4, 6, 10, 11
Fundulus chrysotus	Golden topminnow	0 - 5	4, 10, 11
Fundulus confluentus	Marsh killifish	0.0 - 20.4	4, 9, 10, 11
Fundulus seminolis	Seminole killifish	0 - 7.3	4, 11
Jordanella floridae	Flagfish	0 - 9	4, 11
Lucania goodei	Bluefin killifish	0 - 12	4, 11
Lucania parva	Rainwater killifish	0 - 28	4, 6, 10, 11
Gambusia holbrooki	Mosquitofish	0 - 30	4, 10, 11
Heterandria formosa	Least killifish	0 - 30.2	4, 11
Poecilia latipinna	Sailfin molly	0 - 33	4, 6, 10, 11
Labidesthes sicculus	Brook silverside	0.12	4
Menidia beryllina	Inland silverside	0 - 33	2, 4, 6, 10, 11
Syngnathus scovelli	Gulf pipefish	0 - 35	4, 9, 10, 11
Centropomus undecimalis	Snook	0 - 35	4, 11
Elassoma evergladei	Everglades pygmy sunfish	0 - 14.4	10, 11
Enneachanthus gloriosus	Bluespotted sunfish	0 - 3.8	4, 10
Lepomis auritus	Redbreast sunfish	0	11
Lepomis gulosus	Warmouth	0.5 - 14.4	10

Table 5-5. Salinity Ranges for Selected Species

Scientific name	Common name	Salinity Range (ppt)	References
Lepomis macrochirus	Bluegill	0 - 13.8	4, 10
Lepomis marginatus	Dollar sunfish	5	10
Lepomis microlophus	Redear sunfish	0 - 14.4	4, 10, 11
Lepomis punctatus	Spotted sunfish	0 - 17.5	10, 11
Micropterus salmoides	Largemouth bass	0 - 17.5	10, 11
Pomoxis nigromarginatus	Black crappie	0 - 2.4	10
Etheostoma olmstedi	Tessellated darter	2.23	3
Lutjanus griseus	Gray snapper	0 - 37	4, 9, 10, 11
Eucinostomus argenteus	Spotfin mojarra	0 - 35	1, 4, 6, 9, 10
Gerres cinereus	Yellowfin mojarra	12 - 35	11
Micropogonias undulatus	Atlantic croaker	0 - 29.8	2, 4, 6, 9, 10
Sciaenops ocellatus	Red drum	0.14 - 34.5	4, 6, 9, 11
Mugil cephalus	Striped mullet	0 - 39.0	1, 4, 5, 6, 9, 10, 11
Mugil curema	White mullet	11.0 - 37.5	1, 4, 5, 6, 9
Dormitator maculatus	Fat sleeper	0.1 - 3.4	10
Gobiosoma bosci	Naked goby	0 - 33.0	4, 9, 10
Microgobius gulosus	Clown goby	0.18 - 33.0	4, 6, 10, 11
Paralichthys lethostigma	Southern flounder	0 - 30.8	4, 10
Trinectes maculatus	Hogchoker	0 - 35	4, 6, 10, 11
Rhithropanopeus harrisii	Mud crab	<1 - 27.5	7
Vallisneria americana	Eel grass	0 - 7	12

1 Futch and Dwinell, 1977.
2 Gallaway and Strawn, 1974.
3 Gilbert, 1978.
4 Gunter and Hall, 1965.
5 Moore, 1974.
6 Mountain, 1972.
7 Odum, 1971.
8 Snelson and Williams, 1981.
9 Springer and Woodburn, 1960.
10 Swingle and Bland, 1974.
11 Tabb and Manning, 1962.
12 Korschgen and Green. 1988.

than 3 to 5 ppt (although different species may be able to tolerate higher salinity for varying periods of time). In addition, salinity at any point in the river is subject to seasonal changes due to variation in rainfall, and daily/hourly changes due to tidal transport. These natural salinity variations can be seen in Figures 5-9 through 5-14. Most animals are able to move in response to preferred salinity. Plants, however, are fixed in position and are, therefore, subject to ambient conditions.

To quantity the spatial shifts of the fish habitats and the potential loss of freshwater plants habitats due to freshwater withdrawal, the 1-, 3-, and 5- ppt isohalines positions are determined for various flow scenarios based on the model simulation results and are shown in Figure 5-27. Table 5-6 presents the average salinity isohaline positions for 1, 3, and 5 ppt under the baseline condition as well as the 160-, 320-, and 480- cfs withdrawal limit scenarios. Table 5-7 presents the longitudinal translation of the 1-, 3-, and 5-ppt isohaline due to freshwater withdrawals. The results show that the 1-ppt isohalines occur near Green Cove Springs, the 3-ppt isohalines occur near the Buckman Bridge, and the 5-ppt isohalines occur between Piney Point and the Ortega River mouth. The 320-cfs freshwater withdrawal scenario will shift the 1-, 3-, and 5-ppt isohalines upstream by 2.5, 1.2, and 0.3 mile, respectively. The potential impacted area of freshwater habitats due to 320-cfs withdrawal for 1-, 3-, and 5-ppt area are 4,188; 2,161; and 430 acres, respectively.

Assuming the 5-ppt isohaline being the upper salinity boundary for freshwater species, the withdrawal of water at the rate of 320 cfs would shift the 5-ppt isohaline 0.8 mile upstream. This could result in the corresponding potential impact on 1,130 acres of habitat for freshwater plants such as *Vallisneria americana* (eel grass), which only thrives at salinity less than 6 ppt (Korschgen and Green, 1988). Eel grass is a predominant submerged aquatic vegetation (SAV) in the LSJR, which makes up about 40 to 60 percent of the total SAV in the river (Dobberfuhl, pers. comm., 2002). Currently, Dr. Dean Dobberfuhl of the SJRWMD is conducting field experiments in conjunction with USGS to determine the response of SAV to salinity changes. The study is expected to be complete in 2003. According to preliminary information from Dr. Dobberfuhl, the SAV responds to salinity changes in a rather complex manner. The SAV does not just perish when salinity exceeds

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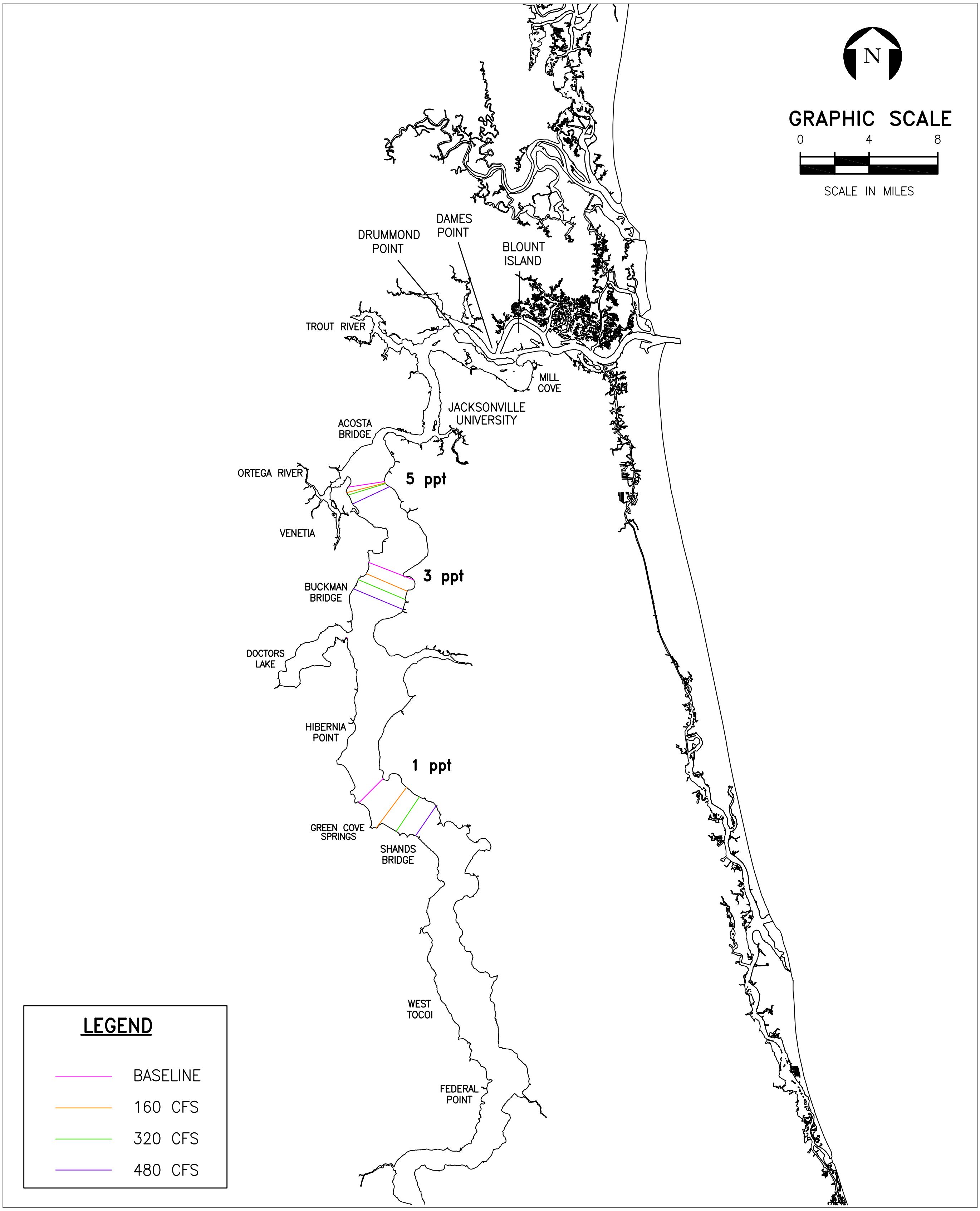

FIGURE 5-27.

AVERAGE SALINITY ISOHALINE SHIFTS DUE TO FRESHWATER WITHDRAWAL

Source: ECT, 2008.

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Table 5-6. Isohaline Positions for Various Flow Scenarios

Flow Scenarios	Isohaline Position (RM) 1 ppt	3 ppt	5 ppt
Baseline	46.0	32.7	27.4
160-cfs withdrawal	47.5	33.4	27.6
320-cfs withdrawal	48.6	33.9	27.7
480-cfs withdrawal	49.6	34.5	28.1

Source: ECT, 2008.

Table 5-7. Isohaline Shifts and Change of Freshwater Habitat Areas

Withdrawal Scenario	Isohaline Shift (miles)			Area Changes (acres)		
	1 ppt	3 ppt	5 ppt	1 ppt	3 ppt	5 ppt
160 cfs	1.5	0.7	0.2	2,6,17	1,277	282
320 cfs	2.5	1.2	0.3	4,188	2,161	430
480 cfs	3.6	1.8	0.7	5,831	3,321	1,041

Source: ECT, 2008.

a certain threshold value. Instead, it may tolerate a salinity level of varying ranges depending on many factors, including the toxicity level and the duration of exposure (Dobberfuhl, pers. comm., 2002). It should be pointed out that the isohaline shifts and acreage changes presented in this section are based on certain assumed fixed thresholds. Although the 5-ppt isohaline may be shifted upstream by 0.8 mile at 320-cfs withdrawal limit, the absolute change in mean salinity within the impacted area is only about 0.4 ppt.

Due to the minor changes in salinity level in the LSJR resulting from the 320-cfs withdrawal, the overall composition of plant and animal species inhabiting the river should not change. The only changes that may occur are minor shifts in the boundary between fresh water and estuarine habitats and their associated faunas. Although it is possible that the minor salinity increases due to surface water withdrawals from the river near DeLand could affect distribution of some aquatic species, the effect would be minor.

5.3.6 EFFECTS OF SALINITY CHANGES ON DISSOLVED OXYGEN

When salinity is increased in the water column, the dissolved oxygen (DO) may decrease because the DO saturation level decreases with increasing salinity. To quantify the changes in DO saturation concentration due to salinity increase resulting from freshwater withdrawal, the saturation DO concentrations at several locations are computed for the baseline and 320-cfs withdrawal condition at average salinity. The saturation DO was computed by a computer program developed by Ivan B. Chou (Chou, 1982), based on the data presented in Clark *et al*. (1971). A water temperature of 30 degrees Celsius (ºC) (86 degrees Fahrenheit [ºF]) is used for the calculations. Table 5-8 shows the baseline average saturation DO concentration at Blount Island, JU, Buckman Bridge, and Shands Bridge. The average saturation DO concentrations for the 320 cfs withdrawal limit are also presented in Table 5-8. The results show that the change in saturation DO concentration is less than or equal to 0.02 mg/L at all locations. Therefore, it is concluded that the decrease in DO concentration due to freshwater water withdrawal will be negligible.

Table 5-8. Dissolved Oxygen Impact Due to Freshwater Withdrawal (at 30ºC)

Location	River Miles	Baseline Conditions Average Salinity (ppt)	Baseline Conditions Saturation DO (mg/L)	320 cfs Withdrawal Average Salinity (ppt)	320 cfs Withdrawal Saturation DO (mg/L)	320 cfs Withdrawal Saturation DO Reduction (mg/L)
Blount Island	8.8	23.83	6.63	24.12	6.61	0.02
Jacksonville University	19.2	11.05	7.17	11.54	7.15	0.02
Buckman Bridge	33.9	2.68	7.53	3.00	7.52	0.01
Shands Bridge	49.9	0.83	7.61	0.93	7.61	<0.01

Source: ECT, 2008.

5.3.7 SUMMARY

Simulations were provided by SJRWMD using the EFDC model to project changes in the salinity regime of the LSJR which may occur as a result of increased surface water withdrawals in the SJRND. An assessment of the effect the projected salinity changes would have on aquatic life in the LSJR was also performed.

The EFDC model was run for the baseline, or existing, flow conditions and for three other flow regimes. These three flow regimes reflect the withdrawal of surface water from the SJRND at the maximum rate of 160, 320, and 480 cfs. Statistical analyses for the four simulated scenarios were performed and comparisons were made to quantify the changes in average salinity regime. The results of these analyses are summarized in Table 5-9. For the withdrawal limit of 320 cfs, the results show that the projected increase in salinity in the LSJR over the 3-year period is small, when compared with the daily variability in salinity presently observed in the LSJR caused by tidal transport.

With respect to aquatic life in the LSJR, the projected average increase in salinity as a result of the surface water withdrawals may have a minor effect on the distribution of some aquatic species. The salinity simulation results indicate the average 5-ppt isohaline will be shifted upstream by 0.8 mile. This upstream translation of the saline water may impose stress or cause impacts on freshwater plant habitat in a 1,130-acre area. Although the 5-ppt isohaline may be shifted upstream by 0.8 mile at 320-cfs withdrawal limit, the absolute change in mean salinity within the impacted area is only 0.4 ppt. The species composition of the river, however, is not expected to change.

The potential DO decrease due to the recommended MFL regime is determined to be insignificant.

Based on the results of the salinity assessment in the LSJR, it is ECT's opinion that the MFL regime recommended by SJRWMD will provide protection of the estuarine resources. However, this conclusion should be re-evaluated when the results of the ongoing eel grass study by SJRWMD and USGS become available.

Table 5-9. Summary of Salinity Changes in the LSJR Due to Freshwater Withdrawal

Location	River Miles	Baseline Conditions: Average Salinity (ppt)	Baseline Conditions: Average Daily Fluctuations (ppt)	Daily Average Salinity Increase: 160 cfs withdrawal (ppt)	Daily Average Salinity Increase: 320 withdrawal (ppt)	Daily Average Salinity Increase: 480 withdrawal (ppt)
Blount Island	8.8	23.83	14.11	0.15	0.29	0.43
Dames Point	10.6	21.52	12.22	0.22	0.32	0.49
Drummond Pt.	14.3	14.83	10.16	0.26	0.45	0.68
Jacksonville University	19.2	11.05	6.58	0.33	0.49	0.74
Acosta Bridge	23.7	7.15	5.52	0.32	0.47	0.71
Buckman Bridge	33.9	2.68	1.09	0.20	0.33	0.51
Hibernia Point	42.3	1.31	0.39	0.11	0.19	0.30
Green Cove Springs	47.9	0.91	0.22	0.07	0.12	0.19
Shands Bridge	49.9	0.83	0.16	0.06	0.10	0.16
West Tocoi	60.2	0.53	0.06	0.02	0.03	0.06
Federal Point	67.1	0.49	0.02	<0.01	<0.01	0.01
Mill Cove		16.56	2.01	0.22	0.44	0.67
Doctors Lake		1.59	0.06	0.13	0.22	0.35
Trout River		9.90	1.37	0.26	0.44	0.66
Ortega River		3.58	0.83	0.20	0.32	0.50

Source: ECT, 2008.

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5.4 TRANSFER OF DETRITAL MATERIAL

Detrital material is an important component of the food web in aquatic ecosystems (Mitch and Gosselink, 1993) It is derived from plants via the decomposition of leaves, stems, roots, etc., often of terrestrial origin. As the plant matter decomposes, it is rendered into smaller particles that may be transported by currents. The particles increase in nutritional value as bacteria and fungi accumulate.

Detritus is deposited on the upland and the floodplain by stormwater surface runoff or during periods of high water. As the detritus decomposes, it releases inorganic nutrients that stimulates primary productivity of the floodplain vegetation. The small particles are fed on by many worms, mollusks, insect larvae, microcrustaceans, and small fishes. These, in turn, are the food of larger crustaceans, fishes, birds, and mammals, including important recreational and commercially-harvested species.

Therefore, detritus is an important component to the food chain and primary productivity of the SJRND and its associated floodplain. The ecology of the floodplain and aquatic communities is dependent to some extent on the events that deliver detritus to the system. Although surface runoff can transfer the detrital material from upland to the floodplain or the river, it is not the most effective means of transport because of the filtering effects of vegetation. Most of the detritus transport occurs during periods of high water level when the accumulated materials are detached from land surface by flood water and moved by flow currents. Therefore, maintaining the hydroperiod characteristics in the SJRND floodplain, especially the minimum frequent high water level, is essential to the supply and transport of detrital material.

Existing data on detritus transport is generally not available; therefore, the literature can not be used to quantify the impact of the hydroperiod changes on detritus transport in the SJRND. However, because of the generally large size of the detrital material, it is known that the higher flow and level at which the detrital material is distributed will be more important for detrital transport processes than the lower levels at which detrital material is not transported by the water. HEC-RAS simulation results as presented in Figures 4-1 and 4-2 (Robison, pers. comm., 2002) indicated that at the higher levels of flow, represented by the 10 percent exceedance condition, channel velocities are reduced by 0.1 foot per second (fps) or less and stages are reduced by 0.2 ft or less as a result of the 320-cfs withdrawal rate. It would appear that the velocity profiles for the existing condition are essentially maintained under the MFL hydrologic regime.

According to the frequency-duration information provided by SJRWMD (Appendix A) and Table 4-1, the minimum frequent high water level at 320-cfs freshwater withdrawal limit (as limited by the MFL regime) is about 0.10-0.13 ft lower than the existing minimum frequent high water level, depending on the location. Based on the minimum frequent high water levels established by SJRWMD and the floodplain transects presented by Mace (2002), the change of hydroperiod due to the 320-cfs withdrawal limit may cause a 60-ft reduction of the wetted floodplain width at Pine Island transect where the total width of the wetted floodplain is about 1,700 ft. This reduction represents about 3.5 percent of the length of transect subject to detritus transfer. Similarly, the reduction of the wetted floodplain width at minimum frequent high water level are 10, 50, and 20 ft at the North Emanuel Bend, Lower Wekiva, and Dexter Point East transects, respectively. The surveyed transects at Dexter Point South and Lake Woodruff are lower than the minimum frequent high water level; therefore, the detritus transport in these areas will not be affected significantly with a 0.13-ft reduction of the water level. Based on the available transect data and observation of aerial photography, it was conservatively estimated (over-estimate) that the reduction of the total wetted floodplain due to the recommended minimum frequent high hydroperiod would be less than 1.5 percent of the total flooded area. Review of the frequency-duration information contained in Appendix A indicated that this reduction in the area of innundation is expected to occur on average approximately 3 out of 100 years less under the MFL hydrologic regime than under the existing hydrologic regime. Based on this small change, it is ECT's opinion that the recommended MFL regime at SJRND can protect the transfer of detrital material.

5.5 MAINTENANCE OF FRESHWATER STORAGE AND SUPPLY

5.5.1 INTRODUCTION

District and USGS water resource publications addressing the SJRND study area were reviewed. Characteristics of the surficial and Upper Floridan aquifers were investigated.

This included the recharge characteristics of the aquifers and how water levels and flows in the SJRND might affect the potentiometric levels in these aquifers.

The District's consumptive use permit (CUP) records were obtained and evaluated to determine which CUPs designated the St. Johns River as the water source. Locations of the CUPs were overlaid on GIS information obtained from the District to determine those which were located near the SJRND study area. Those CUPs which identified the St. Johns River as their source were inventoried and total pump capacity calculated. This capacity was compared to the minimum flow conditions associated with the preliminary MFL developed for the SJRND (Mace, 2002).

5.5.2 AQUIFER CHARACTERISTICS

Three hydrogeologic units are present in the study area; they are the surficial aquifer, the intermediate confining unit, and the Floridan aquifer system. Recharge to the surficial aquifer occurs primarily through rainfall. Recharge to the Floridan aquifer occurs in areas where the elevation of the water table of the surficial aquifer is higher than the elevation of the potentiometric surface of the Floridan aquifer. In areas where the elevation of the potentiometric surface is higher than the surficial aquifer water table elevation, no recharge occurs. Instead, a potential for upward movement of water from the Floridan aquifer is created that may, at times, provide recharge to the surficial aquifer from the Floridan aquifer. Where the elevation of the potentiometric surface is higher than land surface elevation, artesian conditions will occur. Evidence of this condition in the study area is the presence of springs (Blue Spring, Ponce De Leon Spring, and Alexander Spring) which discharge to the SJRND.

Boniol *et al*. (1993) developed a recharge map of the District using a GIS (Figure 5-28). While the developed recharge map is regional in scale, the results are consistent with more detailed local studies of the area conducted by the USGS (Phelps, 1990; Vecchioli *et al*., 1990). In the area of the SJRND, the river and its associated floodplain are shown to be areas of no recharge to the Upper Floridan aquifer, with areas of discharge from the Upper Floridan aquifer being the aforementioned springs. McKenzie-Arenburg and Szell

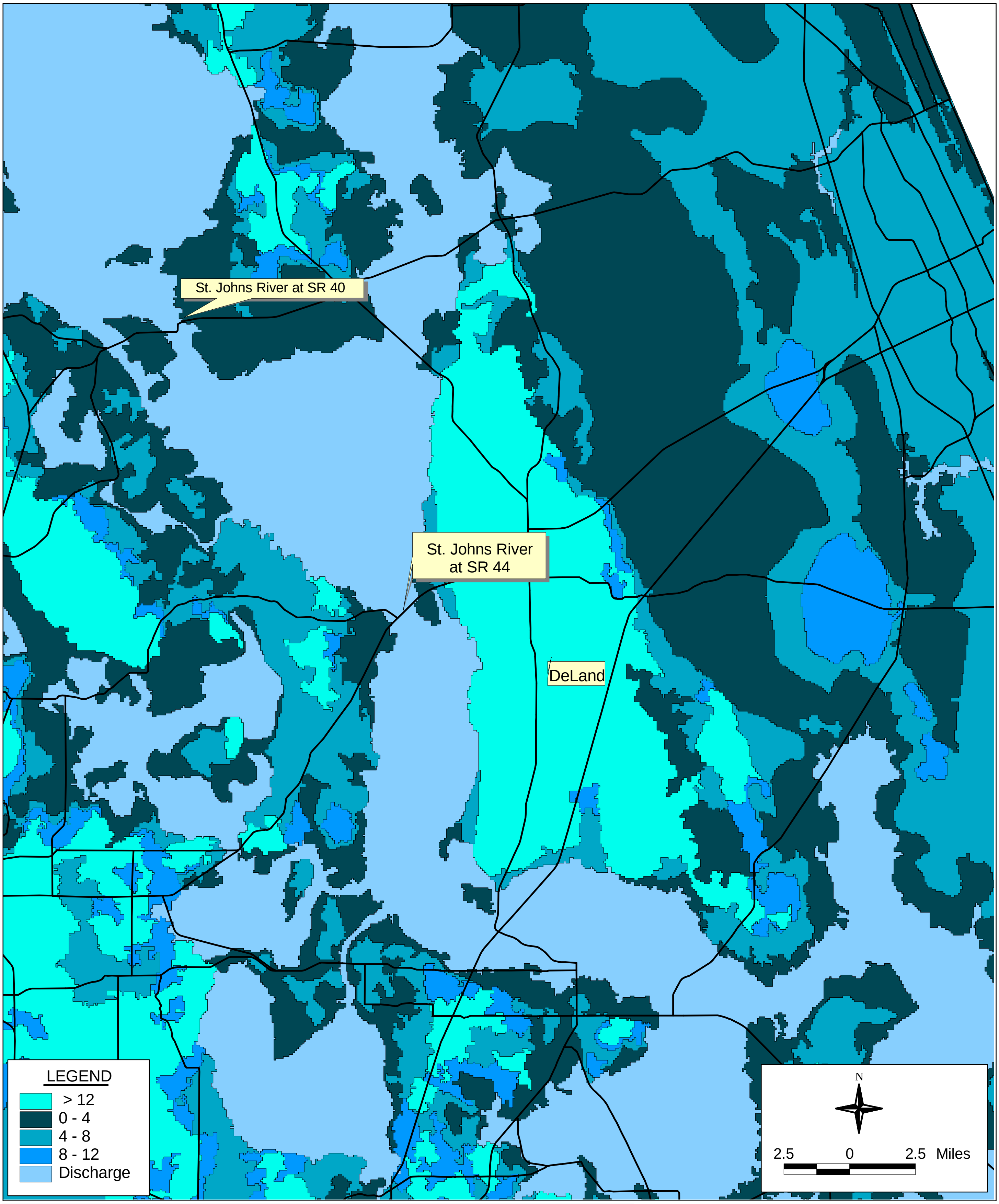

FIGURE 5-28.
AQUIFER RECHARGE IN THE VICINITY OF THE
ST. JOHNS RIVER NEAR DELAND

Sources: SJRWMD, 1995; ECT, 2002.

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(1990) and McKenzie-Arenburg (1989) also indicated that the river and floodplain provided no recharge to the Floridan aquifer. Recharge areas to the Upper Floridan aquifer are located in the upland areas adjacent to the floodplain and at higher elevations. Because the river and its associated floodplain is a discharge area supplying little or no recharge, the changing water levels under the MFL regime should have no effect on ground water recharge.

5.5.3 SPRINGS

Springs contribute a significant percentage of the river flow in some portions of the St. Johns River, during times of low flow (Robison, 2001). This is particularly true for the SJRND, in which three large springs discharge an average of 296 cfs to the river. The three springs and their mean flows are presented in Table 5-10.

Table 5-10. Springs Located in the SJRND Study Area

Spring	Mean Flow[1] (cfs)
Alexander	110
Blue	158
Ponce de Leon	28

[1]Average of annual mean spring discharges (from Rao and Clapp, 1996)

Robison (2001) described a method of accounting for spring discharges in the MSJR SSARR model which includes the SJRND reach. The spring discharge rate is a function of the head difference between the elevations of the potentiometric surface of the Upper Floridan aquifer and the spring pool. Some were modeled using Darcian flow, while others were modeled using a power formula relating discharge to aquifer potentiometric surface elevations. Based on the elevations of the spring pools, Robison (2001) modeled the three spring flows to the SJRND using power relationships.

Rao and Clapp (1996) evaluated the potential impacts of spring discharge reductions on the flows of receiving water bodies within the SJRWMD. The projected reductions in spring discharges were the result of projected declines in hydraulic pressure in the Upper

Floridan aquifer which result from increases in ground water withdrawals between 1988 and 2010. Median spring discharges were projected to decrease flow in the SJRND by 85.7 cfs by 2010; a projected reduction of 3.6 percent. The reduction in median spring discharge for the Blue, DeLeon, and Alexander Springs was projected to be 29.6 cfs in 2010, or 1.3 percent of the median flow of the St. Johns River at SR 44. This issue is being addressed by other SJRWMD studies.

5.5.4 SURFACE WATER

Figure 5-29 presents the locations of surface water withdrawals in the study area. No direct St. Johns River withdrawals were identified in the SJRND. However, there are permitted surface water users in the vicinity of the SJRND located approximately 0.50 mile south of the study area near Konomac Lake (Figure 5-30). The total pumping capacity of these four pumps is 3940 gpm, or 8.8 cfs. This represents 0.8 percent of the flow component of the minimum frequent low flow for the SJRND at SR 44.

The other identified surface water pumps are located out of the SJRND floodplain and utilize ponds, pits, and lakes as water sources. In reality, it is the surficial aquifer which is being utilized for supply.

5.5.5 SUMMARY

Upon review of the existing information, it is concluded that the proposed MFL will protect freshwater storage and supplies. This conclusion is based on the following premises:

1. A review of District CUP records showed that there are currently no users of water directly from the SJRND. There are four surface water pumps identified in the CUP records that are located nearby. The total pump capacity of these users is 3,940 gpm, which represents 0.8 percent of the estimated flow at the preliminary minimum frequent low level of 0.3 ft-NGVD.
2. Based on the literature reviewed, the SJRND does not provide recharge to either the surficial aquifer or the Upper Floridan aquifer. The proposed MFL for the SJRND should not affect recharge to ground water aquifers and, therefore, would not reduce available ground water supplies.

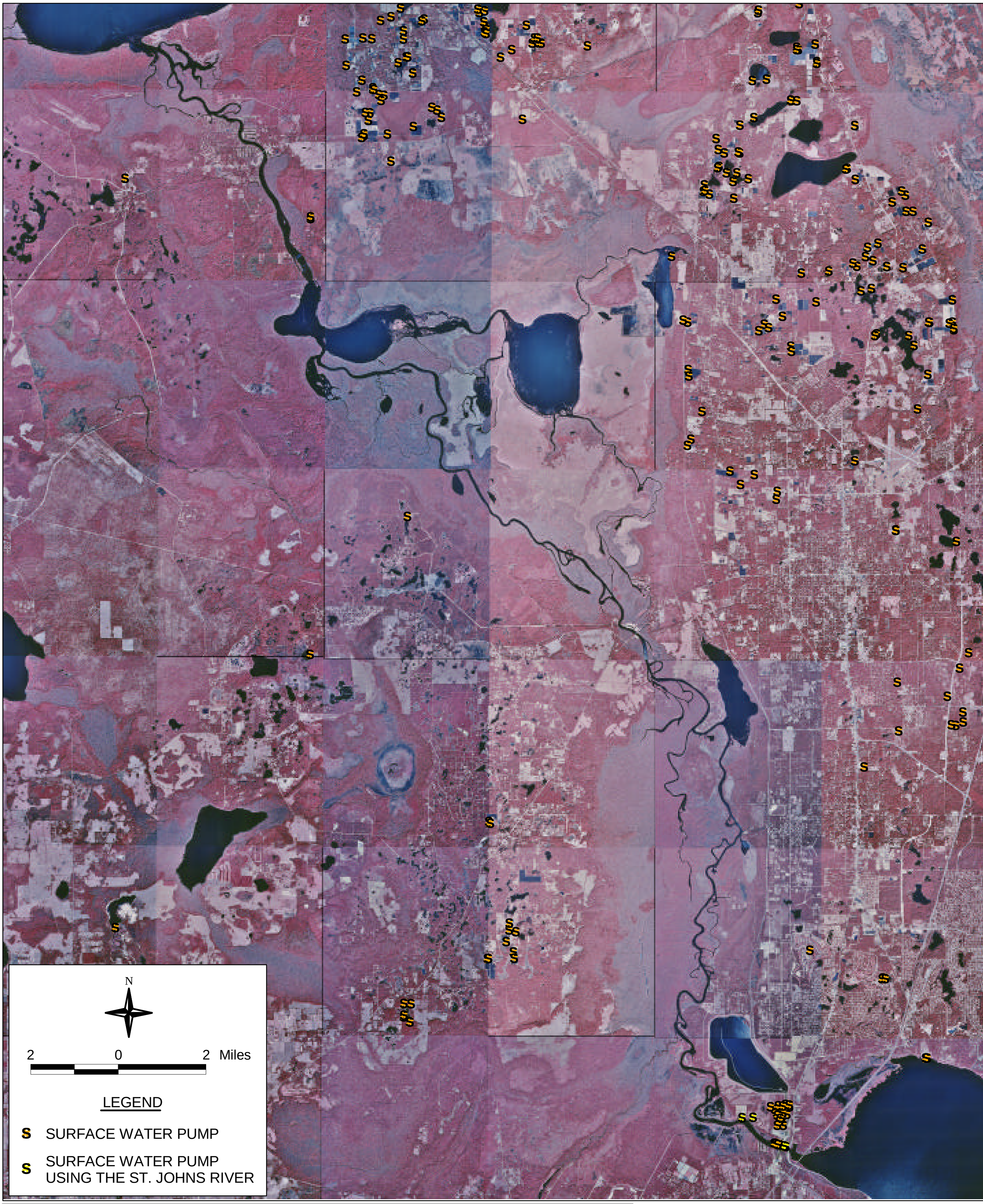

FIGURE 5-29.
SURFACE WATER PUMPS NEAR THE SJRND AS IDENTIFIED IN CONSUMPTIVE USE PERMITTING RECORDS

Sources: SJRWMD, 1995; ECT, 2002.

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FIGURE 5-30.
CLOSE-UP VIEW OF THE SURFACE WATER PUMPS USING THE ST. JOHNS RIVER

Sources: SJRWMD, 1995; ECT, 2002.

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5.6 AESTHETIC AND SCENIC ATTRIBUTES

5.6.1 INTRODUCTION

Extreme low water levels may adversely impact the aesthetic appearance of residential or commercial establishments and public use areas. Extreme low water levels may also expose discharge/intake pipes or pipe crossings that may detract from the scenic value of a river reach. In addition, extreme low water levels may contribute to fallen shoreline timber due to bank instability and increased turbidity due to sediment resuspension from boat traffic in shallow water. ECT evaluated the proposed MFL for the SJRND with respect to the potential impacts to aesthetic and scenic attributes according to the amount of bottom exposure, the material exposed, duration of exposure, public perception, and related impacts.

5.6.2 DISCUSSION

There is usually a strong connection between aesthetic and scenic attributes of a water body, and fish and wildlife habitats and recreational uses. Riparian habitats are ecologically diverse and productive environments. When these areas are managed to conserve natural conditions, riparian habitats can support many wildlife species of interest to the general public. ECT conducted limited public interviews to assess perceptions and also performed a field reconnaissance of the area.

The SJRND is characterized by a deep (12 to 20 ft) main stem channel, numerous side channels (3 to 8 ft) and an extensive forested swamp floodplain. Most of the area remains in a natural state, although most of the floodplain was subjected to logging operations just after the turn of the century. The northern reach of the study area (DeLand to Astor) contains the Ocala National Forest, Lake Woodruff National Wildlife Refuge, Lake George State Forest, and the Alexander Spring Wilderness Area as important scenic attributes. Lakes Woodruff and Dexter are the main water features in this area, flanked by several miles of floodplain. The southern reach of the study area contains Wekiva River State Preserve, Blue Springs State Park, and Hontoon Island State Park. This relatively natural area is characterized by fluctuations in water level ranging from low water levels near sea level to flood stages up to 6 ft above sea level. During extreme low levels, channel banks are exposed revealing snags, stumps and eroded bank slopes. This natural variation in water levels is a common occurrence and seems to be anticipated by local residents and users of the resource. Due to the age of the riverine system, the wetland and aquatic habitats that contribute to the aesthetic and scenic value have adapted to the extreme seasonal highs and lows.

The extreme low river levels (100-year drought) of 2001 were a benchmark to assess the public's perception of scenic quality. When marina operators and the general public were asked about the extreme low levels in 2001, they did not recall that a problem existed. Most individuals surveyed did not think that scenic or aesthetic quality was impacted by the low river levels (Appendix B).

Stage-duration curves (Figure H IV-9 in Appendix A) for the SJRND indicate that elevations may only decrease by as much as 2.4 inches as a result of the MFL hydrologic regime. This change will have little affect on aesthetic and scenic attributes.

5.6.3 SUMMARY

Based on observations and interviews, and considering the natural variability of the SJRND, it appears that the recommended MFL will protect the aesthetic and scenic attributes of the SJRND.

5.7 FILTRATION AND ABSORPTION OF NUTRIENTS AND OTHER POLLUTANTS

Natural wetland ecosystems filter nutrients and other pollutants from the surrounding water through physical, chemical, and biological processes. The filtration mechanisms are dependent on flowing water. For filtration and absorption to take place, the water must reach the biological system through transport and deposition mechanisms.

No site-specific data on filtration and absorption could be found to determine the level of protection of MFL on existing processes. Downstream water quality, which is consistent with the water quality throughout the undeveloped portions of the system, suggests that the SJRND water quality is maintained through efficient filtering of the water by in-stream and floodplain processes.

The deeper main stem of the River filtration capability is less than that of the floodplain. However, some dissolved pollutants in the deeper main stem may be broken down by photodecomposition or volatilization by the ultraviolet rays of the sun (WEF, 2001). This would occur as the water flows through the reach.

Therefore, in the case of the SJRND, the potential filtration and absorption capability for nutrients and pollutants of the existing floodplain is great. The mechanism by which this occurs takes place along many paths and is therefore difficult to evaluate in a quantitative manner, but the benefit of the floodplain, in general, for filtration and absorption is widely accepted. For the floodplain of the SJRND to continue to function for that purpose, the existing variation in water flows and levels must not be markedly altered.

A review of floodplain transects presented by Mace (2002) indicated that floodplain inundation begins to occur at elevations ranging from 1.0 ft-NGVD in the Lake Woodruff transect to 1.8 ft-NGVD in the Lower Wekiva transect. A review of the stage-frequency curves for the existing and the MFL hydrologic regimes for elevations in this range indicate that flooding of these elevations will occur approximately 5 percent of the time less under the MFL hydrologic regime than occurs under the existing hydrologic regime. This implies that those floodplain areas which provide filtration and absorption functions will see water approximately 5 percent of the time less under the MFL regime. Therefore, long-term effectiveness of filtration and absorption functions may be reduced. This reduced effectiveness would be offset by pollutant load reductions which would occur during withdrawals occurring under the MFL regime.

It is ECT's opinion that the estimated flow reduction caused by the MFL regime will not adversely impact filtration and absorption functions. River water quality is the measure of whether these functions are being maintained. Therefore, it is ECT's opinion that the preliminary MFL will protect filtration and absorption processes, but that ambient water quality monitoring and assessment programs be continued to evaluate river water quality trends.

5.8 SEDIMENT LOADS

Sediments consist of either organic particles (detritus) or inorganic particles. It can also be categorized into cohesive (muck and clay) and noncohesive sediment (pebble, sand, silt, etc.).

Sediments can be deposited or carried to the St. Johns River by wind, stormwater surface runoff, or river flow. Larger sediment particles are usually deposited rather quickly to the floodplain and the river bed, while smaller sediment particles are transported by river flow in two modes: suspended load and bed load. The suspended load is supported by turbulence and transported by the river current. When water velocity decreases, the turbulent intensity also decreases, causing larger particles of sand and silt to be deposited to the river bottom and become part of the bed load. The bed load material is transported by shear stress at the water/sediment interface or by turbulence at the boundary layer. When the river flow velocity increases, the turbulence may cause some smaller bed load particles to be suspended in the water column and become suspended load; thus bottom erosion occurs. Because the river flow changes seasonally, the river bed constantly adjusts to a state of equilibrium by erosion and deposition cycles. A mature river usually reaches a quasi-equilibrium state and does not exhibit long-term erosion or deposition, although short-term seasonal changes of river bed may occur.

Long-term physical alteration of a river (e.g., dredging, flow augmentation, or water withdrawal) will change the river bed and sediment transport regime accordingly, in order to reach a new equilibrium state. The alteration of the sediment loads and sediment transport regime may subsequently influence the sediment composition at the river bottom because more fine material may be deposited due to flow reduction. The following discussion evaluates how a 320-cfs withdrawal, as limited by the recommended SJRND MFL, would change the sediment loads and transport in the river.

As described previously, a reduction in river flow may cause some suspended sediment to be settled out of the water column and be deposited to the river bed. This new or increased accumulation of bed load material, when introduced in a short duration, may adversely affect benthic processes by smothering organisms. It may also affect navigation if marked deposition occurs. The change of sediment loads to the floodplain can also potentially affect the biota in that part of the ecosystem. Therefore, maintenance of natural sedimentation processes is important in protecting the existing ecosystems in the SJRND and the floodplain.

River sediments may be formed by the soils of the upstream drainage basin, and be transported downstream by the river flow. The distance of travel from the point of origin depends on the flow rate, velocity, and sediment characteristics. Additionally, when the river flows through an area of past or present industrial or agriculture development, pollutants such as toxic compounds and metals can enter the sediments. These contaminated sediments can be transported downstream by sufficient flows. When biogenic organic particles make up a significant fraction of the sediments, there is an opportunity for absorption of toxic materials on the surface of the biogenic particle.

Sediment particles can be resuspended, transported and redistributed by wind, tide, river flow, and motorboat propeller-induced turbulence. If the sediment particles contain toxics or metals, this contaminated material may be resuspended and transported from the point of origin to other segments of the river. Since some of these materials are resistant to biological breakdown, they can remain in the aquatic, marine, or estuarine systems for long periods of time. The alteration of the sediment quality in the river bed may also affect the water quality.

According to Keller and Schell (1993), as sediments bind nutrients from the watershed, the sediment nutrient content has an effect on the quality of sediments. Benthic algae and bacteria are stimulated by the presence of nutrients. The growth activities can reduce DO concentrations and alter the sediment/water interface redox potential. Metals that are adsorbed to organic particles can be released into the water column when the sediments become anoxic, which can have a water quality and biological impact.

Very little data exists in the scientific literature regarding sediment chemical properties of Florida surface waters. Though a lot of sediment has been removed and transported through dredging, relatively limited sediment sample analyses were conducted to determine the chemical, physical, and biological characteristics of the sediment material.

A study of the sediment quality throughout the District that was done by Battelle was the subject of a report by Durrell and Fredriksson (2000). Several sampling sites were located on Lake George and Lake Monroe, though no samples were taken from the SJRND reach. The quality of the sediments in the fresh water bodies of the SJRWMD is said to be varied according to this study. Lake Disston and Lake George are said to have the lowest contaminant concentrations among the locations that were studied. Analytical results showed that DDT concentrations in Lake George were less than 20 µg/kg dry weight, with four of eight stations having less than 2 µg/kg dry weight. For Lake Monroe, one station was in the 20-120 µg/kg DDT dry weight category, three stations were less than 20 µg/kg DDT dry weight, and three stations were between 0 and 2 µg/kg DDT dry weight.

No chemistry data were found for sediments in the SJRND study area. It is not known where sediments have been accumulated, and the quality of the sediment is unknown. From the two studies on the adjacent upstream and downstream reaches of the River, it can be surmised that the sediments are of relatively good quality, though the transport of some contaminants from Lake Monroe into the SJRND is possible. Because of the relatively high level of boat traffic in the main stem, the potential for resuspension and reentrainment of sediments is high. Accumulated sediments are likely high in TOC, which could provide sites for attachment of certain contaminants, if they have been introduced to the river reach.

Information regarding sediment particle characteristics in the SJRND was not found. Without such a study the exact changes in sediment loads and sediment transport due to alteration of the hydroperiod is difficult to determine. Although a detailed sediment transport study is outside the scope of this environmental assessment based on existing channel morphological information, hydroperiod simulation results by Robison (2001), and river flow and currents information, an opinion can be rendered as described in the following paragraphs.

It is safe to say that a maximum freshwater withdrawal of 320-cfs, as limited by the recommended MFL regime, will not change the watershed condition; therefore, the total sediment loads to the river (in both quantity and quality) will not change. A water withdrawal may actually reduce the suspended load because of the physical removal of suspended sediment from the river system. However, additional bed load may be introduced due to potential deposition of the suspended load caused by velocity reduction.

Qualitatively, it appears that equilibrium for sediment transport has been reached in this river reach as evidenced by the absence of maintenance dredging required for navigation in the past 5 years (Brodehl, pers. comm., 2002). The HEC-RAS simulation results as presented in Figure 4-1 (Robison, pers. comm., 2002) indicate that a reduction of 0.05 to 0.1 fps in channel velocity is expected as a result of a 320-cfs withdrawal. This represents a 10 to 13 percent decrease in channel velocities as simulated for the 50 percent exceedance flow condition, which approximates the recommended MFL minimum average condition. It would be anticipated that some additional deposition would occur as a result of the lowered velocities occurring under the MFL regime. The river reach would begin to establish a new equilibrium where sediment deposition and transport are balanced. Assuming the characteristics of the sediments deposited and transported do not change, velocities would need to increase by approximately 10 percent to achieve the deposition-transport balance that occurred under the existing hydrologic regime. A reduction in flow area of 10 percent would be required to increase velocities to their former magnitude. For relatively wide cross-sections as exist in the SJRND, this would be approximated by a reduction in depth of approximately 10 percent based on a simple and very conservative estimate (over-estimate). For a minimum channel depth of 8 ft as currently exists, depth would be reduced by 0.8 ft, or approximately 10 inches. This depth reduction should not affect navigation. According to the frequency-duration analysis of the existing and MFL regime, a 320-cfs withdrawal limit may cause a reduction of the water surface by approximately 0.1 ft. This small water depth reduction due to sediment deposition may cause a small amount of additional suspended load due to re-suspension caused by boat traffic in shallow portions of the river.

Based on the available information, a maximum 320-cfs freshwater withdrawal, as limited by the recommended MFL, will not increase the net sediment loads (suspended and bed loads) to SJRND. Part of the suspended load, however, may be deposited to the river channel, causing a potential long-term depth reduction of 10 inches and a reduction of the total suspended sediment in the water column. Therefore, it is ECT's opinion that the recommended MFL hydrologic regime will protect SJRND sediment loads.

5.9 WATER QUALITY

The water quality data were provided by the District for locations in the SJRND. Summary statistics for the data collected at three locations on the St. Johns River were developed and are presented in Tables 5-11 through 5-13.

The water quality of the SJRND is typical of freshwater streams in the non-coastal areas of Florida. These flowing waters contain color and are somewhat turbid. Oxygen levels are typically low and the water is somewhat hard, but low in alkalinity.

MFL must be set so that water quality is not impacted by consumptive uses of water.

Direct withdrawals from a surface water would not be expected to increase the concentration of a substance. The magnitude of the pollutant mass reduction depends on localized pumping rates and pollutant concentrations in the source water. For example, a large withdrawal at a location of lower concentration will reduce mass loading, but this may be offset by a reduction in dilution. Conversely, if a large withdrawal occurs at a location of relatively high concentration, a beneficial mass load reduction would occur.

Biological processes that depend on the transport of materials from the channels into the floodplain may be impacted by a reduction in water level or flow that could also alter water quality. Depending on a number of factors, a change in transport processes could decrease or increase the concentration of a particular substance.

Table 5-11. Summary Statistics for Water Quality Data in St. Johns River near Deland (1995 through 2001)

Parameter	Mean	Standard Deviation	Maximum	Minimum	Median	95th Per-centile	Number of Values
Temperature (Celsius)	23.8	8.5	31.2	11.6	23.5	30.3	30
Secchi disc (meter)	0.7	0.3	1.4	0.3	0.7	1.2	28
Color (PCU)	133	95	500	20	120	270	33
Specific Conductance (umhos/cm)	950	354	1530	409	850	1504	32
Dissolved Oxygen (mg/L)	5.71	1.63	8.87	2.83	5.60	8.29	32
pH (su)	7.07	0.55	8.72	6.25	6.93	7.92	32
Alkalinity (mg/L as $CaCO_3$)	64.8	19.3	110.1	38.5	58.9	98.3	33
Salinity (ppt)	0.5	0.3	0.8	0.0	0.6	0.8	15
Total Suspended Solids (mg/L)	8	2	22	4	6	16	33
Ammonia-N (mg/L)	0.050	0.033	0.120	0.001	0.058	0.099	39
Kjehldahl Nitrogen (mg/L)	1.30	0.32	2.15	0.70	1.29	1.85	39
Nitrite+Nitrate (mg/L)	0.100	0.088	0.376	0	0.074	0.227	40
Total Phosphorus (mg/L)	0.082	0.020	0.155	0.041	0.082	0.109	38
Total Organic Carbon (mg/L)	16.2	5.0	29.6	5.6	16.3	24.3	38
Total Calcium (mg/L)	47.4	18.2	83.7	19.7	47.5	76.8	39
Total Magnesium (mg/L)	17.9	6.9	30.4	6.8	17.2	28.1	39
Total Sodium (mg/L)	118.1	46.1	195.8	45.8	113.1	185.8	39
Total Potassium (mg/L)	5.6	1.9	9.8	2.7	5.3	8.6	39
Total Chloride (mg/L)	218	83	382	91	191	351	39
Total Sulfate (mg/L)	65	37	175	7	54	123	39
Total Arsenic (ug/L)	3.151	4.275	16.300	0.001	1.740	13.835	18
Total Barium (µg/L)	25.7	4.8	37.2	16.0	25.0	34.0	19
Total Cadium (µg/L)	0.251	0.430	1.712	0.007	0.060	0.990	19
Total Chromium (µg/L)	1.162	2.067	9.100	0.001	0.470	4.370	21
Total Copper (µg/L)	1.470	1.374	7.000	0.001	1.07	3.838	39
Total Iron (µg/L)	227	175	793	17	167	466	39
Total Lead (µg/L)	0.92	1.04	5.41	0	0.59	2.75	39
Total Manganese (µg/L)	15.28	8.00	36.34	6.50	13.88	27.94	21
Total Nickel (µg/L)	3.48	4.27	13.40	0.15	1.16	12.10	21
Total Zinc (µg/L)	8.1	12.4	68.0	0.1	4.5	26.4	38
Total Aluminum (µg/L)	97.6	27.9	165.5	58.9	97.3	141.4	21
Total Selenium (µg/L)	0.556	1.158	4.300	0.001	0.065	3.160	20
Fecal Coliform (MF)	43	88	320	2	19	167	12
Chlorophyll a (µg/L)	18.46	18.22	80.89	0.01	13.15	51.02	37
Total Dissolved Solids (mg/L)	565	197	910	234	534	837	38
Total Orthophosphate (mg/L)	0.040	0.015	0.066	0.010	0.041	0.059	39
Turbidity (NTU)	3.5	2.0	9.6	0.9	3.1	7.9	39

Source: ECT, 2002.

Table 5-12. Summary Statistics for Water Quality Data in St. Johns River at SR40 near Astor (1996 through 2001)

Parameter	Mean	Standard Deviation	Maximum	Minimum	Median	95th Per-centile	Number of Values
Temperature (Celsius)	24.0	7.5	31.5	12.1	24.2	30.3	46
Secchi disc (meter)	0.8	0.2	1.5	0.4	0.8	1.1	46
Color (PCU)	148	98	540	25	120	310	39
Specific Conductance (umhos/cm)	1031	332	1560	411	1084	1477	45
Dissolved Oxygen (mg/L)	6.35	1.71	9.33	2.01	6.46	8.84	44
pH (su)	7.2	0.6	9.0	6.1	7.2	8.1	45
Alkalinity (mg/L as $CaCO_3$)	66.9	365.7	97.5	37.2	66.0	90.3	40
Salinity (ppt)	0.6	0.2	0.8	0.2	0.6	0.7	32
Total Suspended Solids (mg/L)	8.2	4.5	23.0	0	7.0	14.9	35
Ammonia-N (mg/L)	0.071	0.047	0.249	0.024	0.064	0.157	33
Kjehldahl Nitrogen (mg/L)	1.3	0.3	2.0	0.7	1.2	1.7	40
Nitrite+Nitrate (mg/L)	0.082	0.075	0.313	0.001	0.063	0.206	34
Total Phosphorus (mg/L)	0.072	0.017	0.109	0.040	0.069	0.102	34
Total Organic Carbon (mg/L)	17	5	29	7	16	25	37
Total Calcium (mg/L)	45.2	13.5	66.3	21.8	47.4	63.2	37
Total Magnesium (mg/L)	17.5	5.9	27.3	7.4	17.0	25.3	40
Total Sodium (mg/L)	119	41	192	52	112	177	40
Total Potassium (mg/L)	5.4	1.9	14.7	3.0	5.1	7.6	40
Total Chloride (mg/L)	229	74	340	86	220	331	40
Total Sulfate (mg/L)	65	30	130	23	61	111	40
Total Fluoride (mg/L)	0.13	0.05	0.35	0.10	0.17	0.21	23
Total Copper (µg/L)	2.6	2.2	9.0	0.5	2.0	5.6	16
Total Iron (µg/L)	265	217	983	21	273	496	16
Total Lead (µg/L)	0.904	0.702	3.000	0.000	0.870	2.003	16
Total Zinc (µg/L)	4.98	4.48	17.00	0	5.00	12.50	16
Fecal Coliform (MF)	46	100	360	2	15	190	12
Chlorophyll a (ug/L)	19.2	20.0	63.9	0.010	9.0	58.8	16
Total Dissolved Solids (mg/L)	561	167	1026	263	547	808	36
Total Orthophosphate (mg/L)	0.035	0.021	0.080	0.009	0.033	0.069	16
Hardness (mg/L)	192	95	271	90	205	269	35
Turbidity (NTU)	3.2	1.9	9.3	0.9	2.8	7.1	39

Source: ECT, 2002.

Table 5-13. Summary Statistics for Water Quality Data in St. Johns River at US 17 and US 92 (1995 through 2001)

Parameter	Mean	Standard Deviation	Maximum	Minimum	Median	95th Per-centile	Number of Values
Temperature (Celsius)	24.5	5.1	31.3	16.0	24.3	31.0	30
Secchi disc (meter)	0.6	0.2	1.4	0.4	0.5	0.9	27
Color (PCU)	128	81	400	20	120	295	43
Specific Conductance (umhos/cm)	1016	450	1820	435	905	1751	30
Dissolved Oxygen (mg/L)	7.47	1.58	10.23	4.33	7.39	9.59	30
pH (su)	7.71	0.70	9.30	6.37	7.71	8.62	30
Alkalinity (mg/L as $CaCO_3$)	59	19	101	26	52	88	44
Salinity (ppt)	0.6	0.2	0.9	0.2	0.6	0.9	15
Total Suspended Solids (mg/L)	13	9	32	2	8	28	42
Ammonia-N (mg/L)	0.041	0.050	0.301	0.001	0.022	0.101	44
Kjehldahl Nitrogen (mg/L)	1.70	0.47	2.97	0.86	1.74	2.55	43
Nitrite+Nitrate (mg/L)	0.049	0.054	0.171	0.000	0.024	0.160	44
Total Phosphorus (mg/L)	0.093	0.052	0.375	0.037	0.086	0.141	43
Total Organic Carbon (mg/L)	20.5	5.7	31.8	10.8	20.8	786.0	42
Total Calcium (mg/L)	46.4	20.0	86.5	17.1	39.7	75.6	42
Total Magnesium (mg/L)	18.5	8.6	35.9	7.1	16.0	32.1	42
Total Sodium (mg/L)	134.9	63.8	259.0	49.7	119.0	228.4	42
Total Potassium (mg/L)	6.3	2.5	12.4	3.1	5.7	10.2	42
Total Chloride (mg/L)	252	113	464	85	222	429	44
Total Sulfate (mg/L)	70	43	149	16	56	148	44
Total Arsenic (µg/L)	5.45	10.88	36.50	0.13	2.28	36.05	19
Total Barium (µg/L)	32.5	8.9	46.5	17.1	33.7	46.0	21
Total Cadium (mg/L)	0.220	0.656	3.000	0.002	0.027	0.693	21
Total Chromium (µg/L)	2.887	7.358	27.100	0.160	0.460	22.600	21
Total Copper (µg/L)	2.415	2.956	16.000	0.001	1.290	6.934	42
Total Iron (µg/L)	271	190	875	15	202	617	42
Total Lead (µg/L)	0.91	0.95	4.21	0.00	0.61	2.90	42
Total Manganese (µg/L)	21.69	13.60	54.89	4.19	17.59	53.88	21
Total Nickel (µg/L)	4.95	6.35	18.90	0.02	1.45	17.30	21
Total Zinc (µg/L)	4.4	3.4	16.0	0.0	4.0	11.0	42
Total Aluminum (µg/L)	141.2	54.9	267.6	65.7	134.0	235.4	18
Total Selenium (µg/L)	0.663	0.911	3.510	0.001	0.335	2.570	20
Fecal Coliform (MF)	273	372	1300	20	160	900	11
Chlorophyll a (µg/L)	1.39	2.31	11.70	0.01	0.51	6.04	44
Total Dissolved Solids (mg/L)	577	254	1020	108	529	1000	41
Total Orthophosphate (mg/L)	0.034	0.021	0.084	0.013	0.026	0.075	38
Hardness (mg/L)	207	85	359	81	218	333	34
Turbidity (NTU)	5.8	3.9	18.0	0.9	5.3	10.8	44

Source: ECT, 2002.

It appears that the recommended MFL will protect water quality. There will be effects from proposed withdrawals, but the overall impact on the SJRND should not be significant, given the volume of water in the SJRND at any given point compared to the proposed maximum withdrawal rate. Current ambient water quality monitoring efforts should be continued to evaluate water quality trends.

5.10 NAVIGATION

5.10.1 INTRODUCTION

The primary navigational use of the St. Johns River between Lake Monroe and Astor at SR 40 is recreational boating (Volusia County, 1996). There is some commercial/ industrial use of the waterway with the transport of building materials, marine products and fuel oil for the Sanford Power Plant. ECT evaluated the existing navigation channels, according to bathymetric maps and field reconnaissance, to determine if the recommended MFL regime will provide adequate protection of the navigation system. ECT also conducted an informal survey of marine-related businesses and recreational users in the area, as well as a review of the 1995 Volusia County (Volusia County, 1996) boating activity study, to aid in the evaluation of the navigation issue.

5.10.2 DISCUSSION

The Volusia County boating study provided insight to the type of boating use in the area and as to whether there are navigation issues of concern for this section of the St. Johns River. The study revealed that recreational use (traveling and fishing) is the primary activity in the area and the majority of boats (88 percent) are less than 25 ft in length.

Lakes Dexter and Woodruff were identified as popular fishing lakes, especially during the winter, when the area experiences an influx of out-of-state fishermen. Aerial surveys revealed that the majority of boats in these lake areas were less than 20 ft in length. No boats over 26 ft in length were observed during either the summer or winter surveys, most likely due to the shallow depths. The same was true of the Norris Dead River, probably because the river is narrow and winding in certain areas. This river, however, does provide good navigational depth (6 to 8 ft) for the smaller vessels.

The boating study did not reference navigation issues as being a concern of the boating public in 1995. The greatest boater concerns expressed during ramp interviews and a mail survey centered around speed zones and boater education.

ECT conducted its own survey of the study area which focused on marine-related businesses and recreational areas that provide river access. The survey addressed recreational aspects, as well as navigational issues (see Appendix B). None of the ten marine related business respondents identified navigation as a concern. Most of the marine-related businesses have made compensations for seasonal fluctuations in water levels. For example, boat rental operations have equipped their boats with depth finders and provide significant instruction to their customers. All the businesses reported the ability to provide service during low water levels with minor limitations.

Some of the survey respondents indicated that the side-channel areas south of DeLand, known as the logging channels, were difficult to navigate during low water levels. However, more problems with navigation occurred during flood stages when the channels were less defined and submerged brush and snags become a hazard.

The primary commercial use of the main river channel is for the transit of fuel oil to the Florida Power and Light (FPL) Sanford Power Plant on the St. Johns River at Highway 17-92. Sunstate Towing provides the barge transport service for FPL. Discussions with their agent indicated that navigation of the main river channel has not been a problem, even at low water levels. Their problems occur during flood stages when bridge clearances are reduced and increased currents affect steering of barges. They do not believe that the recommended MFL will affect navigation.

In addition, a comparison of stage duration curves (Figure H IV-9 in Appendix A) for simulations of existing hydrologic conditions, with predicted hydrologic conditions following a withdrawal of 320 cfs near DeLand, indicate that navigable depths will potentially decrease by only 2.4 inches. This is an insignificant change related to navigation. Therefore, navigation should be protected by the recommended MFL.

5.10.3 SUMMARY

Based on survey information obtained by the Volusia County boating survey in 1995 (Volusia County, 1996) and the ECT survey conducted in March-May 2002 field reconnaissance, and review of river bathymetry data, navigation should be protected by the recommended MFL.

6.0 SUMMARY AND CONCLUSIONS

The conclusions of the assessment are presented in Table 6-1. In summary, it is ECT's opinion that the recommended MFL for the SJRND will protect the 10 natural resource and environmental values listed in Section 62-40.473, F.A.C. These conclusions are made with varied degrees of certainty ranging from high certainty to medium certainty. Recommendations for further study have been made where some uncertainty exists.

The District's MFL determination efforts for this section of the river included extensive evaluation of topographic, soil, and vegetation data collected within the plant communities associated with the river (Mace, 2002), in conjunction with an intensive hydrologic modeling effort (Robison, 2001). The study by Mace (2002) was extensive and considerable fieldwork was completed. The ecosystems that exist in the SJRND were categorized by District biologists based on topography, soil, and vegetation characteristics observed on eight transects through the wetland communities along the subject reach of the St. Johns River. Hydrologic models were developed by Robison (2001) to implement the MFL, and to provide the District a basis for decision making as to how best to manage surface water withdrawals.

Based on the evaluation of hydric soils, wetland communities, and the results of hydrological modeling, SJRWMD recommended three preliminary minimum surface water flows and levels for the SJRND: minimum frequent high level, minimum average level, and minimum frequent low level. The technical evaluation is included in the report *Preliminary Minimum Levels Determination: St. Johns River near DeLand, Volusia County* (Mace, 2002). The flow rates and elevations of the recommended MFL and their associated hydroperiod categories, frequencies, and durations at SR 44 are presented in Table 1-1.

Robison (2001) used an interactive hydrological modeling approach and found that the MFL regime may be exceeded (violated) when more than a maximum surface water withdrawal of 320 cfs occurs in the river. The following withdrawal schedule was applied to regulate the amount of water withdrawn from the river:

- Existing flow condition subject to withdrawal limit of 320 cfs.
- Water withdrawal may occur only when water level at DeLand is above 0.1 ft-NGVD.
- The amount of allowable water withdrawal will gradually increase to the maximum amount (320 cfs) when the water level at DeLand reaches 0.25 ft-NGVD.

This withdrawal rule is just one of many possibilities. Depending on the stage parameters used to regulate withdrawals, the maximum withdrawal limit might change.

According to Section 62-40.473, F.A.C., the MFL should be evaluated to ensure the protection of the following natural resource and environmental values:

1. Recreation in and on the water (Rule 62-40.473[1][a], F.A.C.).
2. Fish and wildlife habitats and the passage of fish (Rule 62-40.473[1][b], F.A.C.).
3. Estuarine resources (Rule 62-40.473[1][c], F.A.C.).
4. Transfer of detrital material (Rule 62-40.473[1][d], F.A.C.).
5. Maintenance of freshwater storage and supply (Rule 62-40.473[1][e], F.A.C.).
6. Aesthetic and scenic attributes (Rule 62-40.473[1][f], F.A.C.).
7. Filtration and absorption of nutrients and other pollutants (Rule 62-40.473[1][g], F.A.C.).
8. Sediment loads (Rule 62-40.473[1][h], F.A.C.).
9. Water quality (Rule 62-40.473[1][i], F.A.C.).
10. Navigation (Rule 62-40.473[1][j], F.A.C.).

ECT was contracted by the District to conduct an environmental assessment and to determine whether the preliminary SJRND MFL recommended by the District protects each of these 10 natural resource and environmental values.

District documents containing information about the hydrologic and ecological considerations that were used by the District to develop preliminary MFL for the SJRND were used by ECT, along with field reconnaissance and information in the scientific literature, to evaluate whether the preliminary SJRND MFL set by the District protects water and ecological resources. The results of this assessment are summarized in the following sections.

6.1 RECREATION IN AND ON THE WATER

The segment of the St. Johns River system between the confluence of the Wekiva River, south of DeLand, and SR 40 at Astor to the north, has significant main stem flowways with depths of 8 to 12 ft to accommodate recreational interests in the area. The most significant recreational use appears to occur on these main flowways. Interviews with boaters and marine-related businesses in the area did not reveal MFL issues to be a serious concern.

Some of the shallow lake areas that are frequented by shallow draft boaters, primarily fishermen, can become inaccessible, during most typical years, at water elevations of 0.25 ft-NGVD or less. For example, during a site reconnaissance on May 3, 2002, some portions of lakes Woodruff, Dexter, and Tick Island Mud Lake were not accessible by shallow draft boat. At that time, river elevations were reported at SR 44 and SR 40 as 0.32 and 0.14 ft, respectively. It is assumed that the corresponding lake elevation around Tick Island was 0.25 ft on the reconnaissance trip. Based upon stage-duration curves for the MSJR hydrologic conditions at SR 44 near DeLand, these low stages exist for over 50 days during a typical year. A comparison with the predicted MFL hydrologic conditions (withdrawal of 320 cfs) near DeLand shows an increase in the number of days that these low stages would be experienced (3 percent or 11 days in a typical year).

The significance of this increased low-stage duration appears to be small and would only impact recreation in specific, remote areas of the lakes. Therefore, it appears that the preliminary MFL for the SJRND will provide protection to recreational use in and on the water.

6.2 FISH AND WILDLIFE HABITATS AND THE PASSAGE OF FISH

It is concluded that, with the information that is available, there is no direct evidence that the potential water withdrawals as limited by the MFL established for the part of the floodplain studied will have unacceptable impacts to the riverine ecosystem. The potential water withdrawals as limited by the recommended MFL should result in an acceptable level of shift in the duration and frequency of flooding events (i.e., the MFL are considered to be within acceptable levels of ecological tolerance).

6.3 ESTUARINE RESOURCES

Simulations were provided by SJRWMD using the EFDC model to project changes in the salinity regime of the LSJR which may occur as a result of increased surface water withdrawals in the SJRND. An assessment of the effect the projected salinity changes would have on aquatic life in the LSJR was also performed.

The EFDC model was run for the baseline, or existing, flow conditions and for three other flow regimes. These three flow regimes reflect the withdrawal of surface water from the SJRND at the maximum rate of 160, 320, and 480 cfs, respectively. Statistical summaries for the four simulated scenarios were performed and comparisons were made to quantify the changes in average salinity regime. The results of these analyses are summarized in Table 5-9. For the withdrawal limit of 320 cfs, the results show that the projected increase in salinity in the LSJR over the 3-year period is small, (less than 0.5 ppt at 320 cfs withdrawal limit) when compared with the daily variability in salinity presently observed in the LSJR caused by tidal transport.

With respect to aquatic life in the LSJR, the projected average increase in salinity as a result of the surface water withdrawals may have a minor effect on the distribution of some aquatic species. The salinity simulation results indicate the average 5-ppt isohaline will be shifted upstream by 0.8 mile. This upstream translation of the saline water may impose stress or cause impacts on freshwater plant habitat in a 1,130-acre area. Although the 5-ppt isohaline may be shifted upstream by 0.8 mile at 320-cfs withdrawal limit, the absolute change in mean salinity within the impacted area is only 0.4 ppt. The species composition of the river, however, is not expected to change.

The potential DO decrease due to 320 cfs withdrawal is determined to be insignificant.

Based on the results of the salinity assessment in the LSJR, it is ECT's opinion that the MFL regime recommended by SJRWMD will provide protection of the estuarine resources. However, this conclusion should be re-evaluated when the results of the ongoing eel grass study by SJRWMD and USGS become available.

6.4 TRANSFER OF DETRITAL MATERIAL

Detritus is the principal component of the particulate organic carbon in aquatic systems. It is derived from vascular plants via the decomposition of leaves, stems, roots, etc., often of terrestrial origin. As the plant matter decomposes, it is rendered into smaller particles that may be transported by currents. The particles increase in nutritional value as they accumulate bacteria and fungi that bring about their decomposition while also releasing inorganic nutrients.

Most of the detritus transport occurs during periods of high water level when the accumulated materials are flushed from land surface by flood water. Therefore, maintaining the hydroperiod characteristics in the SJRND floodplain, especially the minimum frequent high water level, is essential to the supply and transport of detrital material. HEC-RAS simulation results as presented in Figures 4-1 and 4-2 (Robison, pers. comm.,2002) indicated that at the higher levels of flow, represented by the 10 percent exceedance condition, channel velocities are reduced by 0.1 fps or less and stages are reduced by 0.2 ft or less as a result of the 320-cfs withdrawal rate. It would appear that the velocity profiles for the existing condition are essentially maintained under the MFL hydrologic regime.

According to the frequency-duration information provided by SJRWMD (Appendix A) and Table 4-1, the minimum frequent high water level at 320-cfs freshwater withdrawal limit (as limited by the MFL regime) is about 0.10-0.13 ft lower than the existing minimum frequent high water level, depending on the location. Based on the minimum frequent high water levels established by SJRWMD and the floodplain transects presented by Mace (2002), the change of hydroperiod due to the 320-cfs withdrawal limit may cause a total reduction of 140 ft. of the wetted floodplain width at all surveyed transect where the total width of the wetted floodplain is about 1,700 ft. This reduction represents about 3.5 percent of the area. Based on the available transect data and observation of aerial photo, it was conservatively estimated (over-estimate) that the reduction of the total wetted floodplain due to a 320-cfs withdrawal at minimum frequent high water hydroperiod would be less than 1.5 percent of the total flooded area. Review of the frequency-duration information contained in Appendix A indicated that this reduction in the area of innundation is expected to occur on average approximately 3 out of 100 years less under the MFL hydrologic regime than under the existing hydrologic regime. Based on this small change, it is ECT's opinion that the recommended MFL regime at SJRND can protect the transfer of detrital material.

6.5 MAINTENANCE OF FRESHWATER SUPPLY AND STORAGE

It is concluded that the proposed MFL will protect freshwater storage and supplies. This conclusion is based on a review of District CUP records showed that there are currently no users of water directly from the SJRND and is based on the literature reviewed that indicated that the SJRND does not provide recharge to either the surficial aquifer or the Upper Floridan aquifer.

In determining the appropriate limit for surface water withdrawals in the SJRND (modeled by Robison [2001] at 320 cfs), it is important to consider the projected reductions in spring flow contributions to the St. Johns River. A previous study (Rao and Clapp, 1996) estimated this reduction to decrease the median flow in the St. Johns River at SR 44 by 85.7 cfs, which is 27 percent of the proposed preliminary surface water withdrawal by the year 2010. Further study is warranted to determine the impact of increased ground water withdrawals on spring discharges, and their subsequent effect on MFL and possible water supply withdrawals in the St. Johns River.

6.6 AESTHETIC AND SCENIC ATTRIBUTES

Based on observations and interviews, and considering the natural variability of the SJRND, it appears that the recommended MFL will protect the aesthetic and scenic attributes of the SJRND.

6.7 FILTRATION AND ABSORPTION OF NUTRIENTS AND OTHER POLLUTANTS

A review of floodplain transects presented by Mace (2002) indicated that floodplain inundation begins to occur at elevations ranging from 1.0 to 1.8 ft-NGVD, upstream from Lake Woodruff National Wildlife Refuge to the Wekiva River. A review of the stage-frequency curves for the existing and the MFL hydrologic regimes for elevations in this range indicate that these elevations will occur or be exceeded approximately 5 percent of the time less under the MFL hydrologic regime than occurs under the existing hydrologic regime. This implies that those floodplain areas which provide filtration and absorption functions will be flooded approximately 5 percent of the time less under the MFL regime. Therefore, long-term effectiveness of filtration and absorption functions would be reduced accordingly. This would be offset by pollutant load reductions due to surface water withdrawal as allowed under the MFL regime.

It is ECT's opinion that the MFL hydrologic regime will protect filtration and absorption functions in the river and floodplain. Maintenance of River water quality will be the primary indicator that these functions are being protected. Therefore, ECT recommends that ambient water quality monitoring and assessment programs be continued to evaluate river water quality trends.

6.8 SEDIMENT LOADS

Based on the available information, a maximum 320-cfs freshwater withdrawal, as limited by the recommended MFL, will not increase the net sediment loads (suspended and bed loads) to SJRWND. Part of the suspended load, however, may be deposited to the river channel, causing a potential long-term depth reduction of 10 inches and a reduction of the total suspended sediment in the water column. However, the magnitude of these changes are small, therefore, it is ECT's opinion that the recommended MFL will protect SJRND sediment loads.

6.9 WATER QUALITY

It is concluded that the preliminary MFL will protect water quality. There will be potential changes in some water quality parameters due to the MFL regime. However, it is ECT's opinion that the overall impact to the SJRND will be insignificant, given the volume of water in the SJRND as compared to the proposed maximum withdrawal rate. Current ambient water quality monitoring efforts should be continued so that water quality trends may be continually ascertained in the SJRND.

6.10 NAVIGATION

Based on survey information obtained by the Volusia County boating survey in 1995 (Volusia County, 1996) and the ECT survey conducted in March-May 2002 field reconnaissance, and review of river bathymetry data, navigation should be protected by the recommended MFL. In addition, a comparison of stage duration curves for simulations of existing hydrologic conditions, with predicted hydrologic conditions following a withdrawal of 320 cfs near DeLand, indicate that navigable depths will change only slightly. Stages in navigable channels would potentially decrease by only 2.4 inches. This is an insignificant change related to navigation. Therefore, navigation should be protected by the MFL.

Table 6-1. Environmental Assessment Summary for SJRND MFL Regime

Resource or Value	MFL Protects the Resource from Significant Harm		Certainty			Further Study/Monitoring			Comments
	Yes (1)	No (2)	High	Medium	Low	Necessary (3)	Recommended (4)	Not Needed (5)	
a. Recreation in and on the water	X		X					X	
b. Fish and wildlife habitats and the passage of fish	X			X			X		
c. Estuarine resources	X			X			X		(6)
d. Transfer of detrital material	X		X					X	
e. Maintenance of freshwater storage and supply	X		X					X	
f. Aesthetic and scenic attributes	X		X					X	
g. Filtration and absorption of nutrients and other pollutants	X		X					X	
h. Sediment loads	X			X			X		(7)
i. Water quality	X			X			X		(8)
j. Navigation	X		X					X	

Notes:

(1) Proposed MFLs allow for decline in water levels and flows, but the resource value should be protected.
(2) Proposed MFLs would allow water levels and flows to decline such that significant harm will occur.
(3) ECT recommends further study to support or verify.
(4) ECT recommends further study may be beneficial to ensure protection of the resource.
(5) ECT recommends no further study required.
(6) There is an ongoing study by SJRWMD and USGS to assess the salinity effects on *Vallisneria americana*.
(7) Characterization of sediment physical and chemical properties is recommended.
(8) Ambient water quality monitoring should continue and water quality assessment and modeling is recommended.

Source: ECT, 2003.

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APPENDIX A

HYDROLOGIC MODEL SIMULATION RESULTS

Source: Robison, C.P. 2001. Middle St. Johns River Minimum Flows and Levels Hydrologic Methods Report.

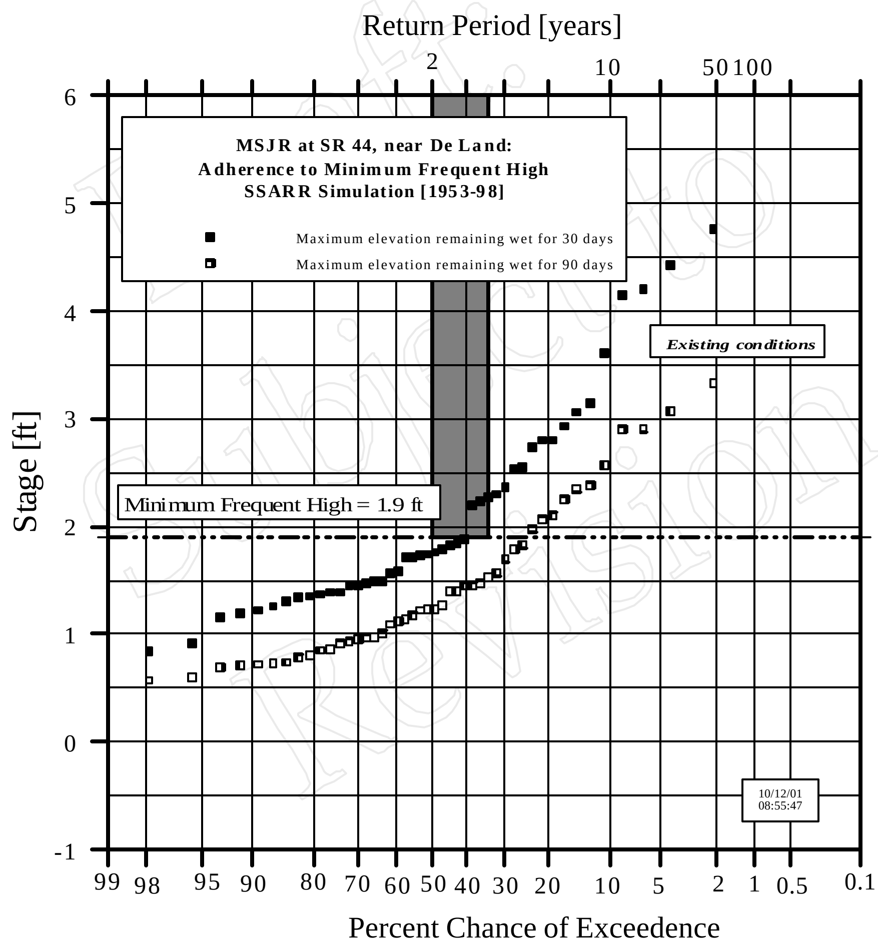


Figure H IV-1 Adherence of the MSJR existing hydrologic conditions simulation to the MFH at SR 44, near De Land

Source: Robison, C.P. 2001. Middle St. Johns River Minimum Flows and Levels Hydrologic Methods Report.

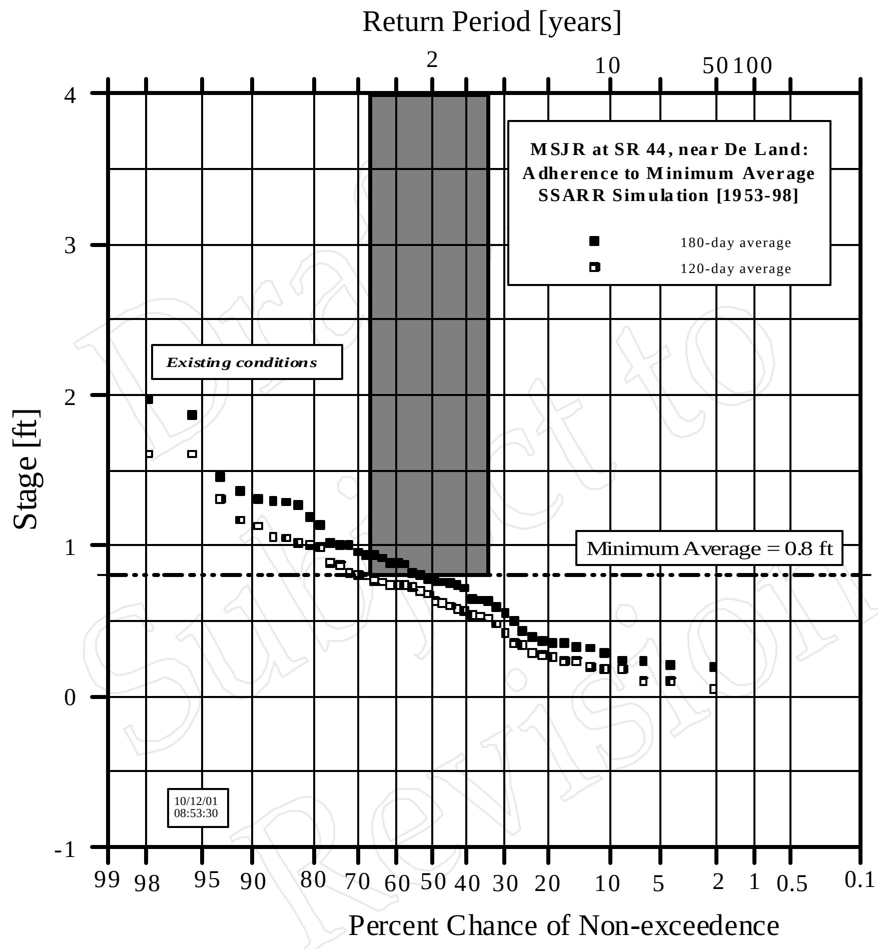


Figure H IV-2 Adherence of the MSJR existing hydrologic conditions simulation to the MA at SR 44, near De Land

Source: Robison, C.P. 2001. Middle St. Johns River Minimum Flows and Levels Hydrologic Methods Report.

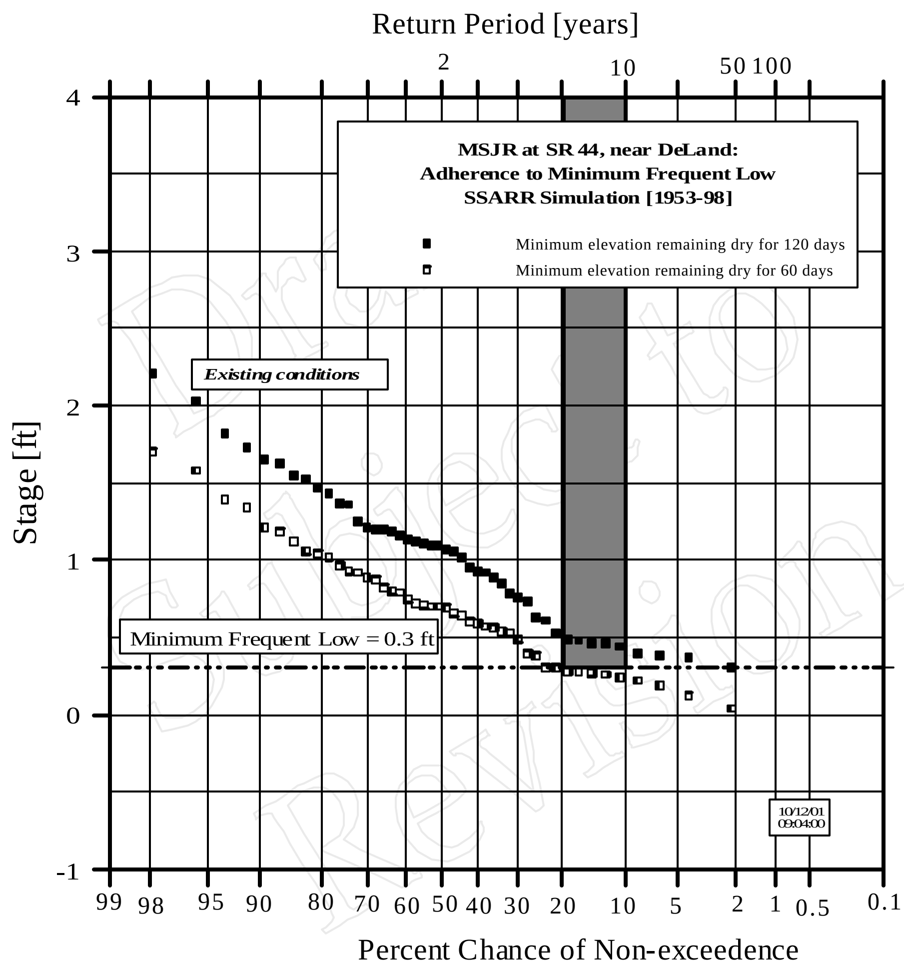


Figure H IV-3 Adherence of the MSJR existing hydrologic conditions simulation to the MFL at SR 44, near De Land

Source: Robison, C.P. 2001. Middle St. Johns River Minimum Flows and Levels Hydrologic Methods Report.

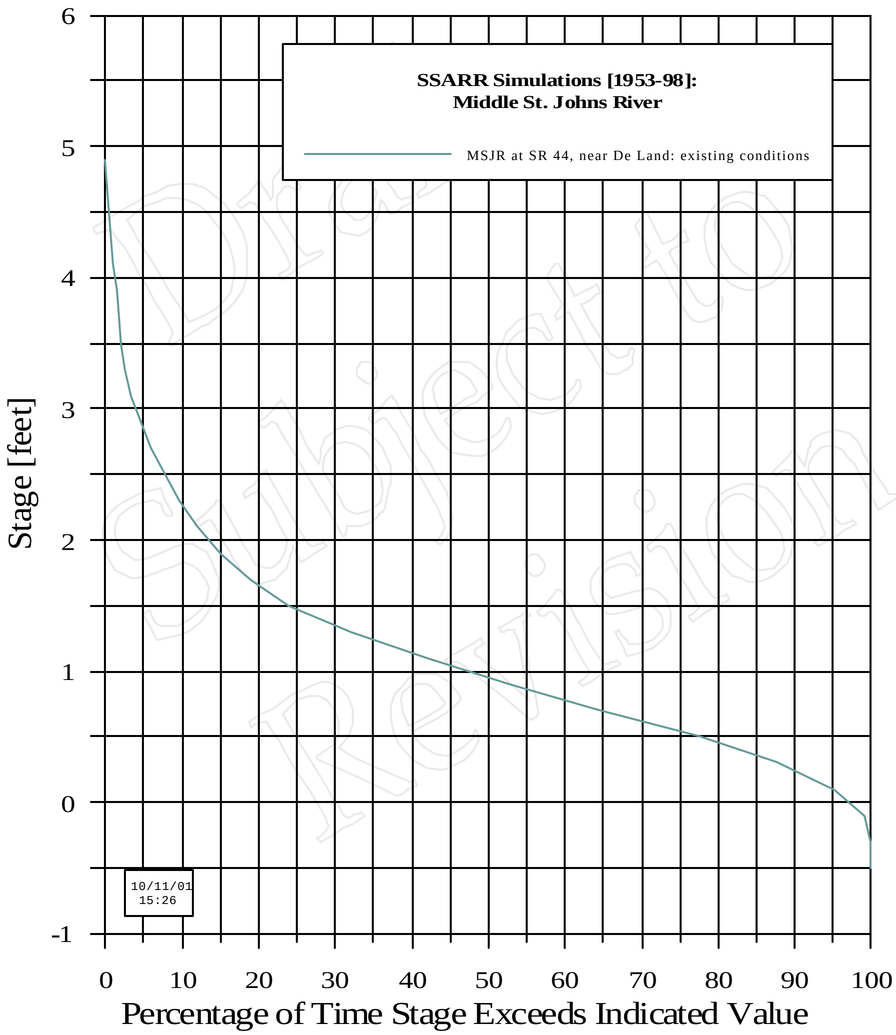


Figure H IV-5 Stage duration curve for MSJR SSARR simulation of existing hydrologic conditions at SR 44, near De Land

Source: Robison, C.P. 2001. Middle St. Johns River Minimum Flows and Levels Hydrologic Methods Report.

Source: Robison, C.P. 2001. Middle St. Johns River Minimum Flows and Levels Hydrologic Methods Report.

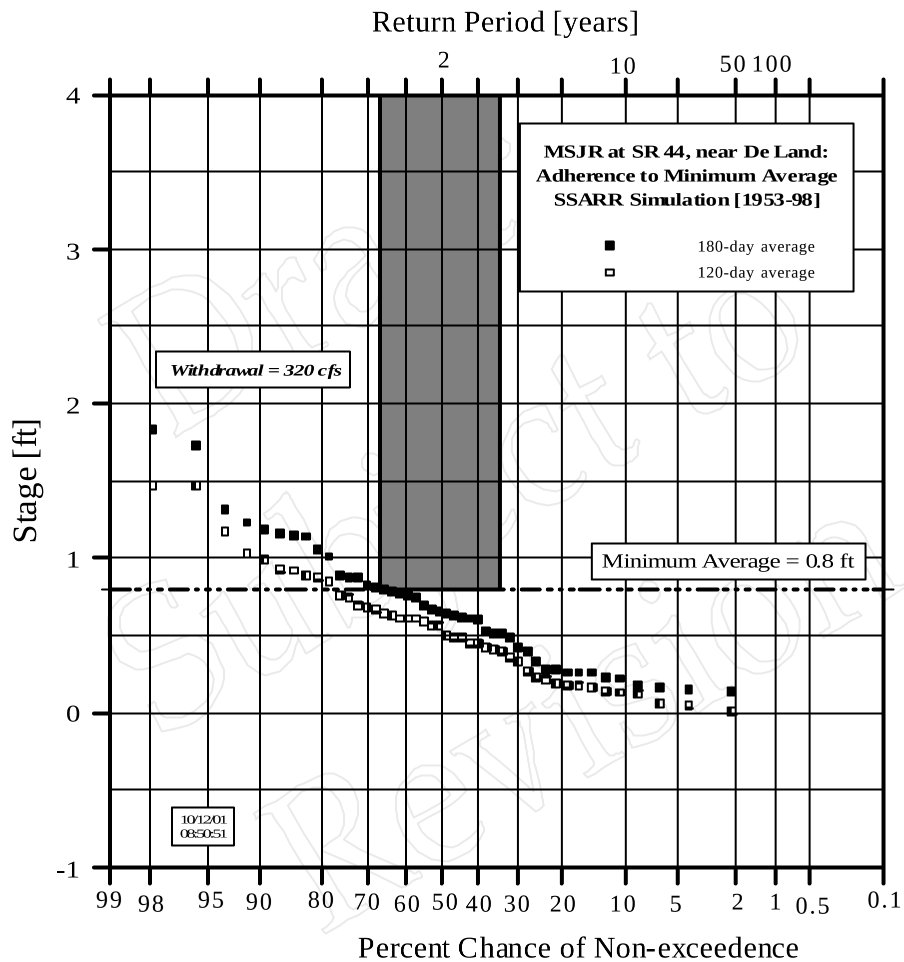


Figure H IV-6 Assessment of the effect on the MA at SR 44, near De Land, of a 320 cfs withdrawal from the MSJR near De Land

Source: Robison, C.P. 2001. Middle St. Johns River Minimum Flows and Levels Hydrologic Methods Report.

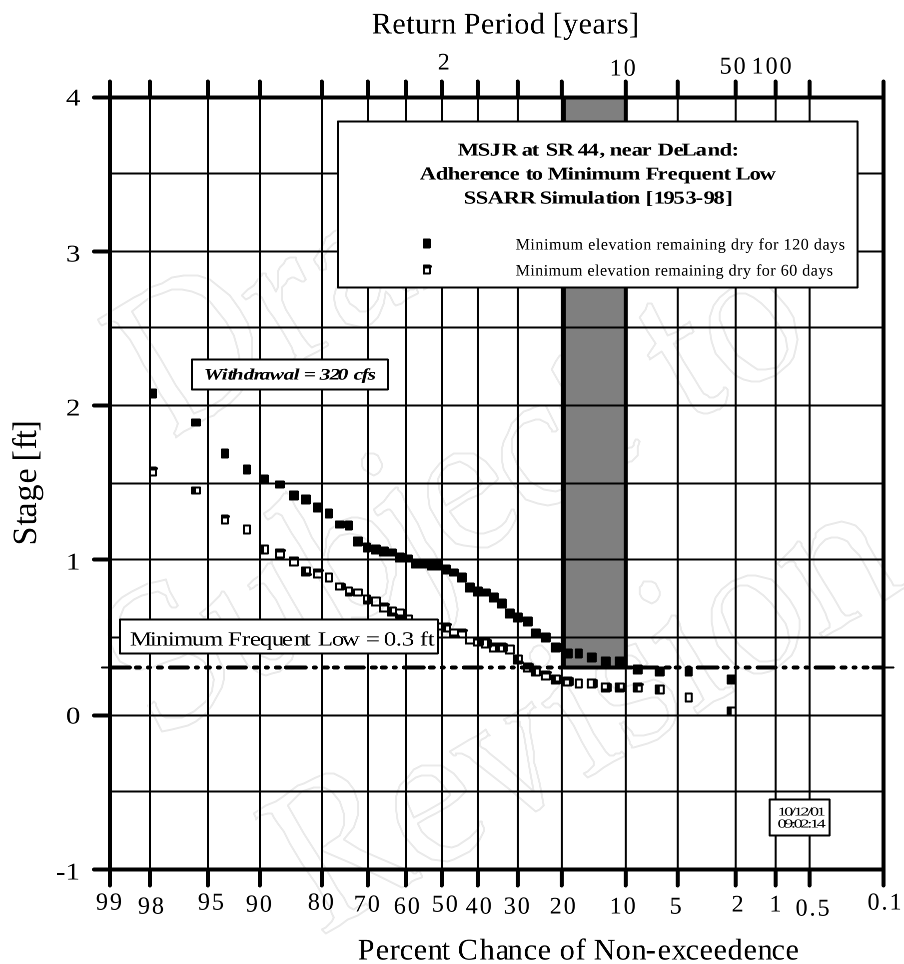


Figure H IV-7 Assessment of the effect on the MFL at SR 44, near De Land, of a withdrawal of 320 cfs from the MSJR near De Land

Source: Robison, C.P. 2001. Middle St. Johns River Minimum Flows and Levels Hydrologic Methods Report.

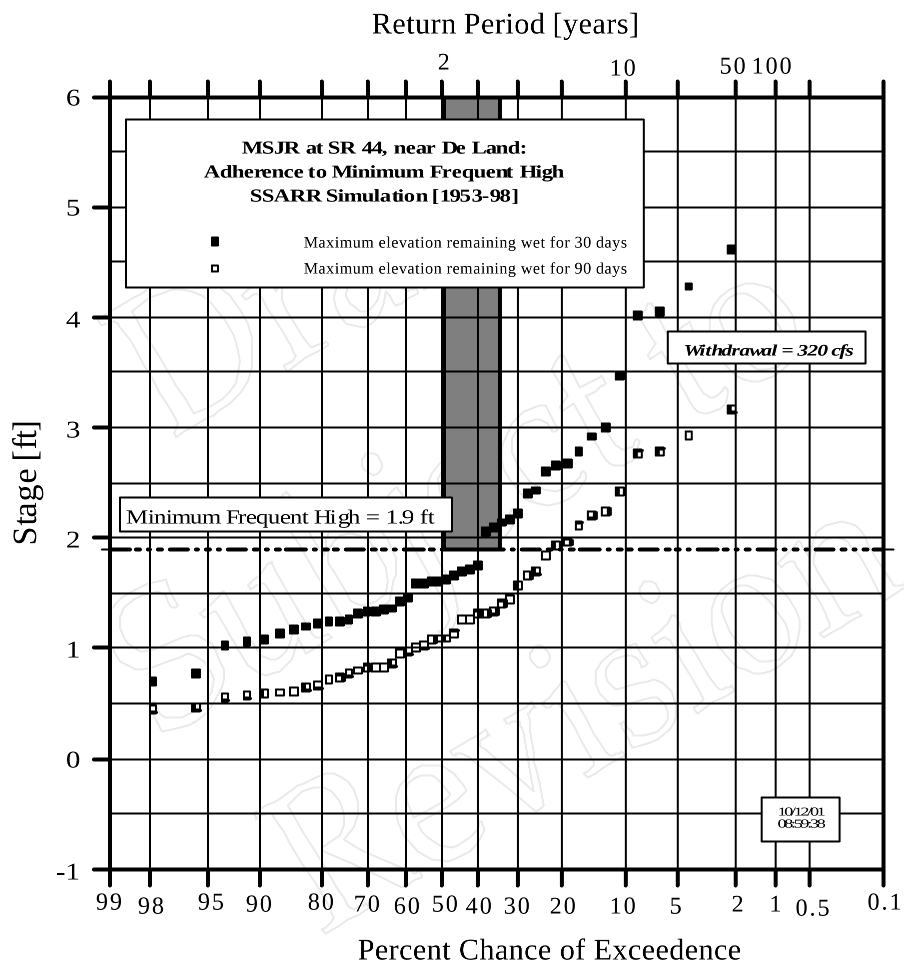


Figure H IV-8 Assessment of the effect on the MFH at SR 44, near De Land, of a withdrawal of 320 cfs from the MSJR near De Land

Source: Robison, C.P. 2001. Middle St. Johns River Minimum Flows and Levels Hydrologic Methods Report.

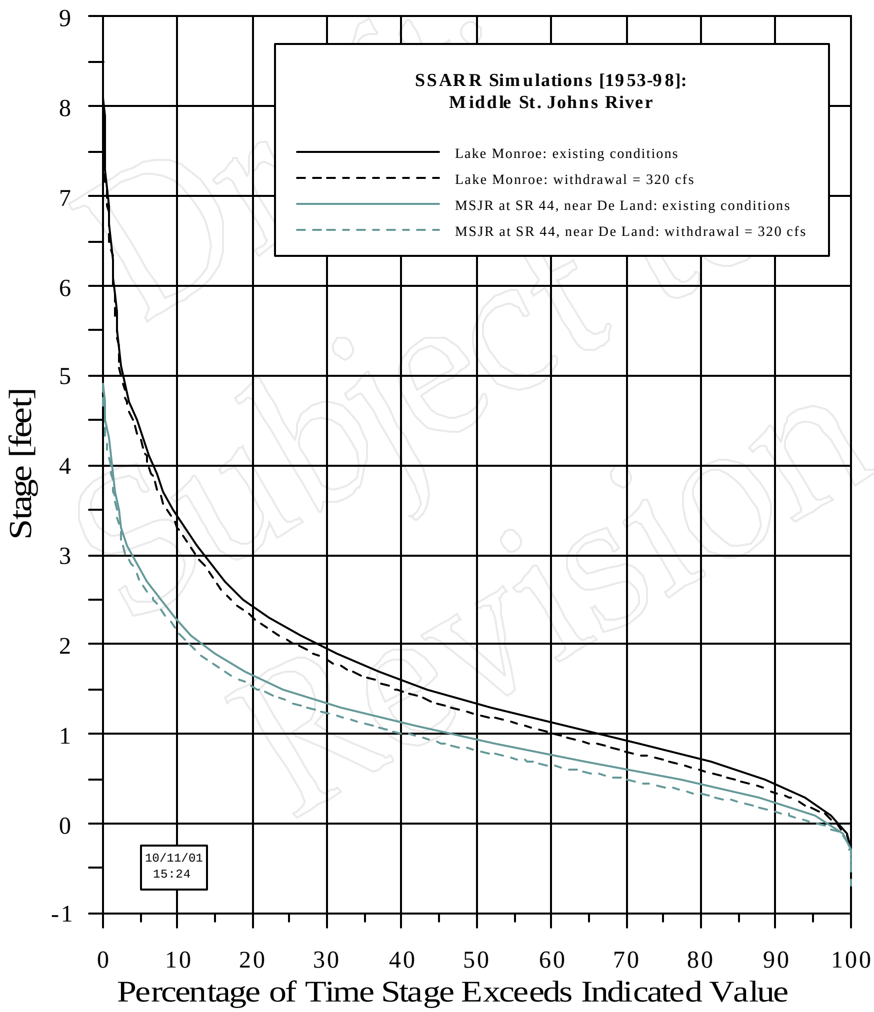
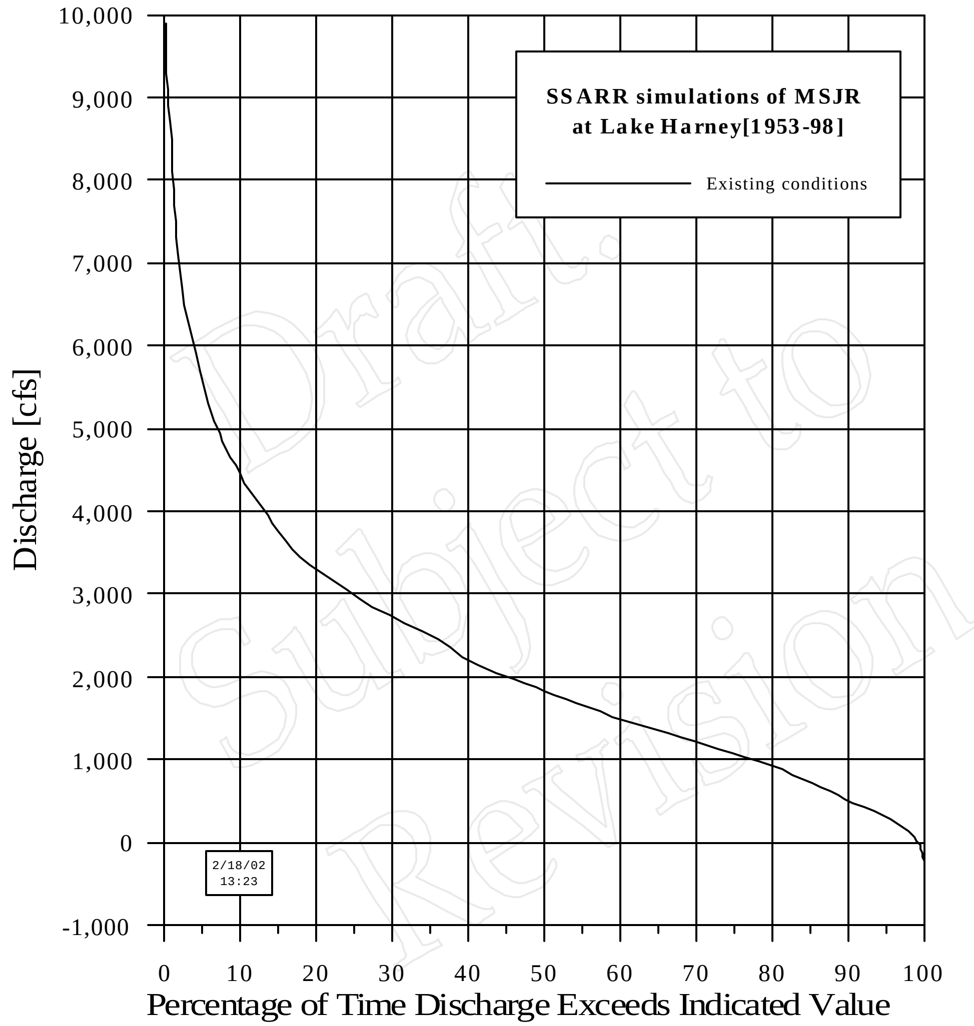
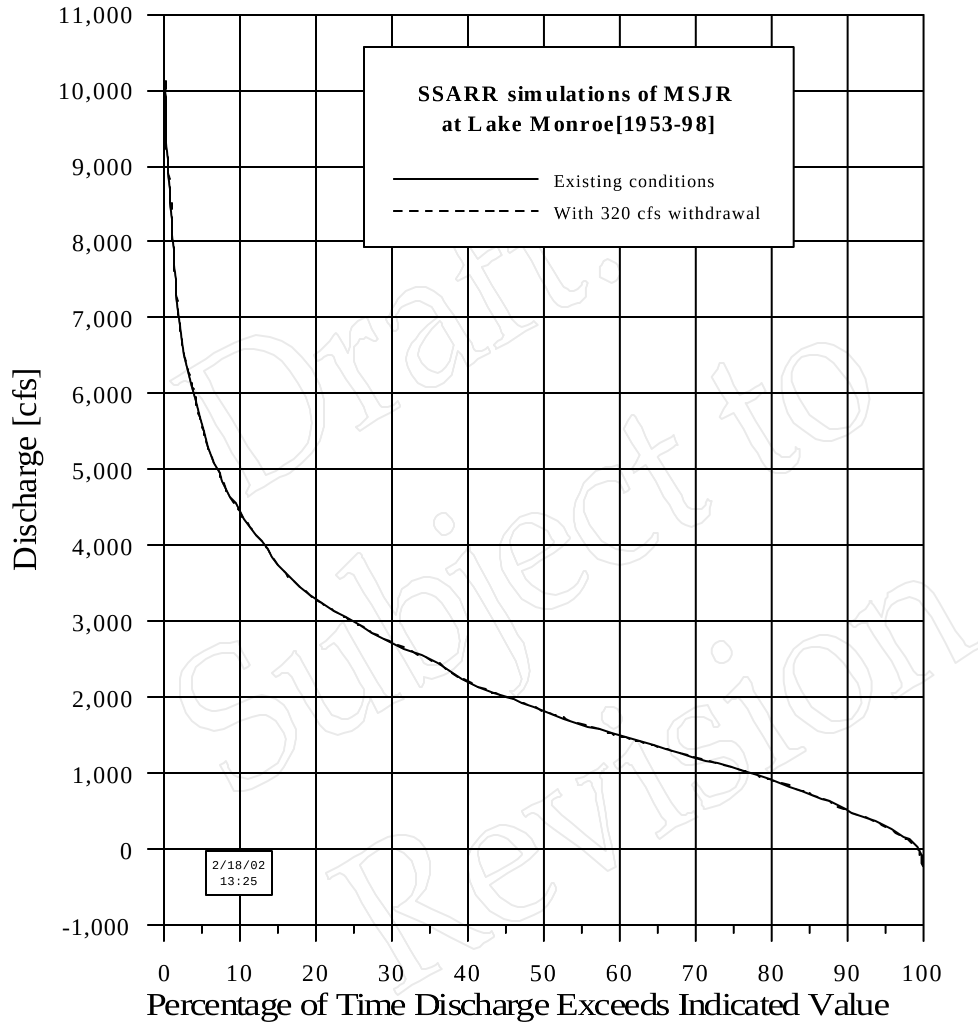


Figure H IV-9 Stage duration curves for MSJR SSARR simulations of existing hydrologic conditions and a withdrawal of 320 cfs near De Land

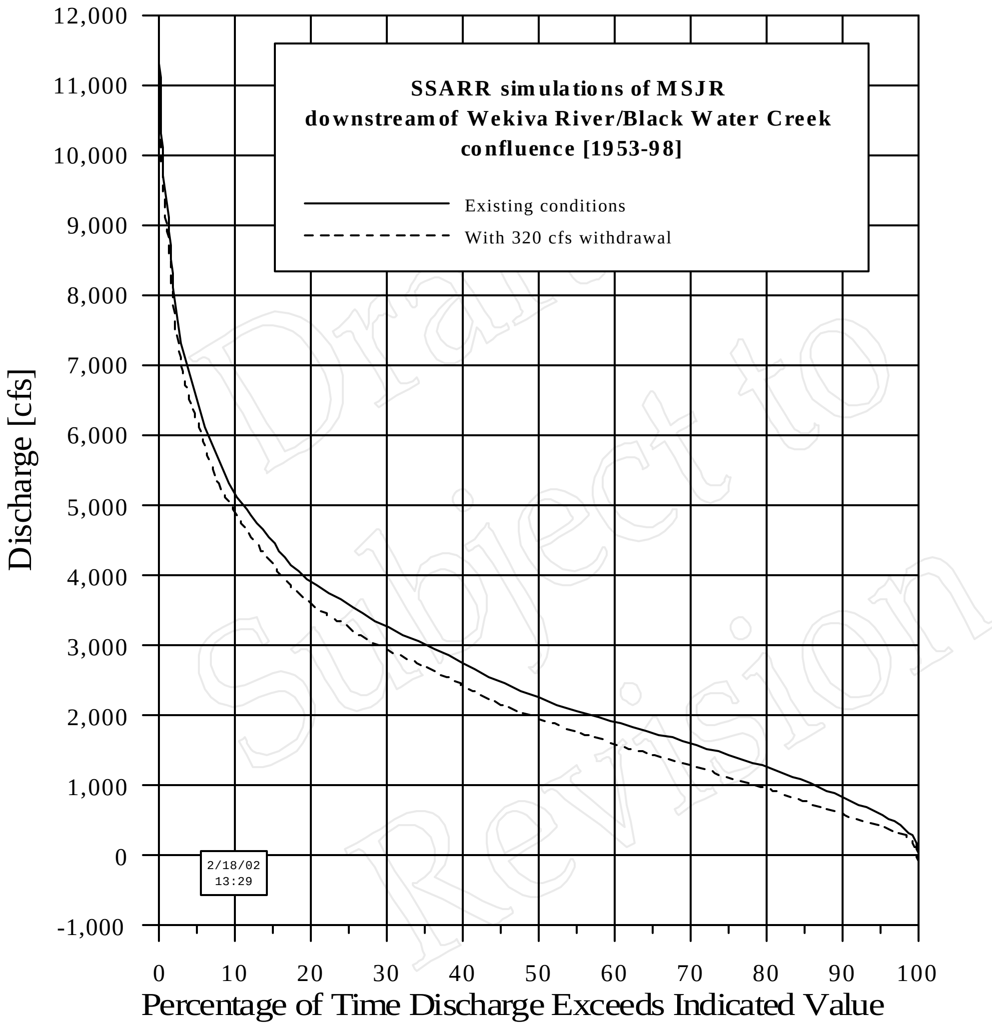
Source: Robison, C.P. 2002. Personal communication. St. Johns River Water Management District.



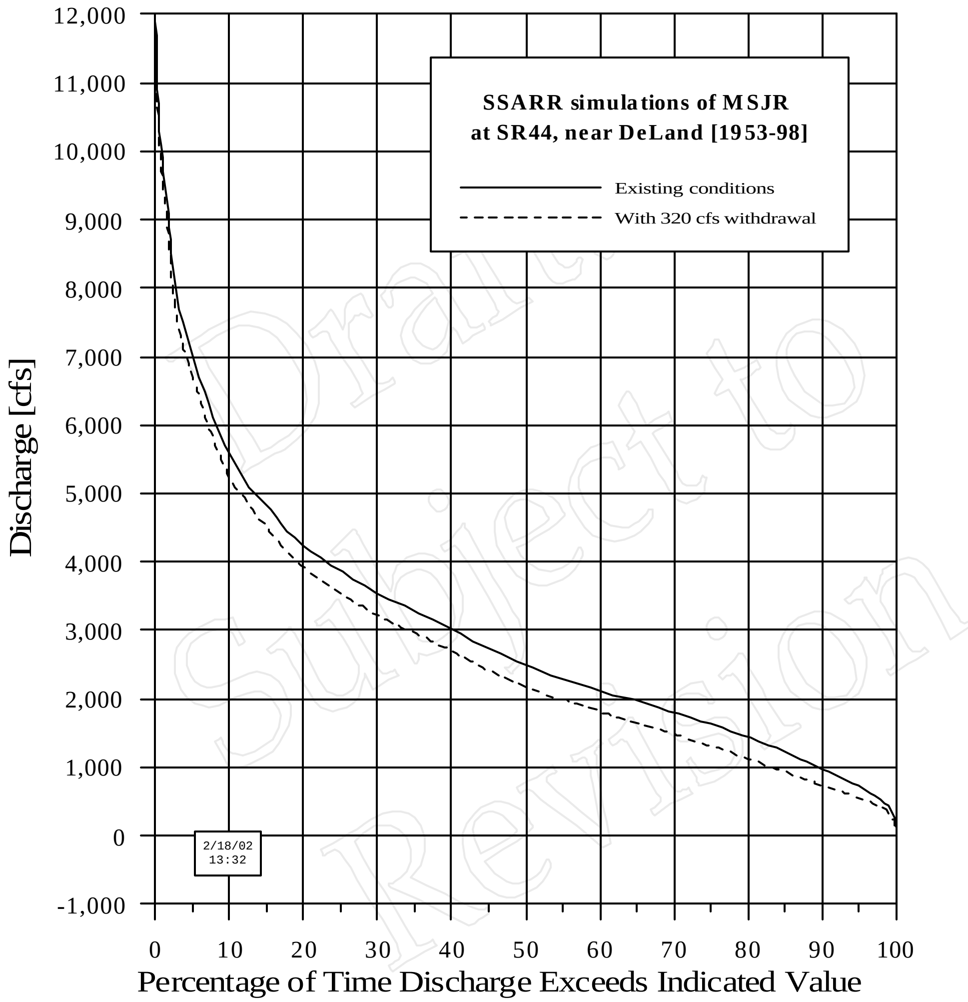
Source: Robison, C.P. 2002. Personal communication. St. Johns River Water Management District.



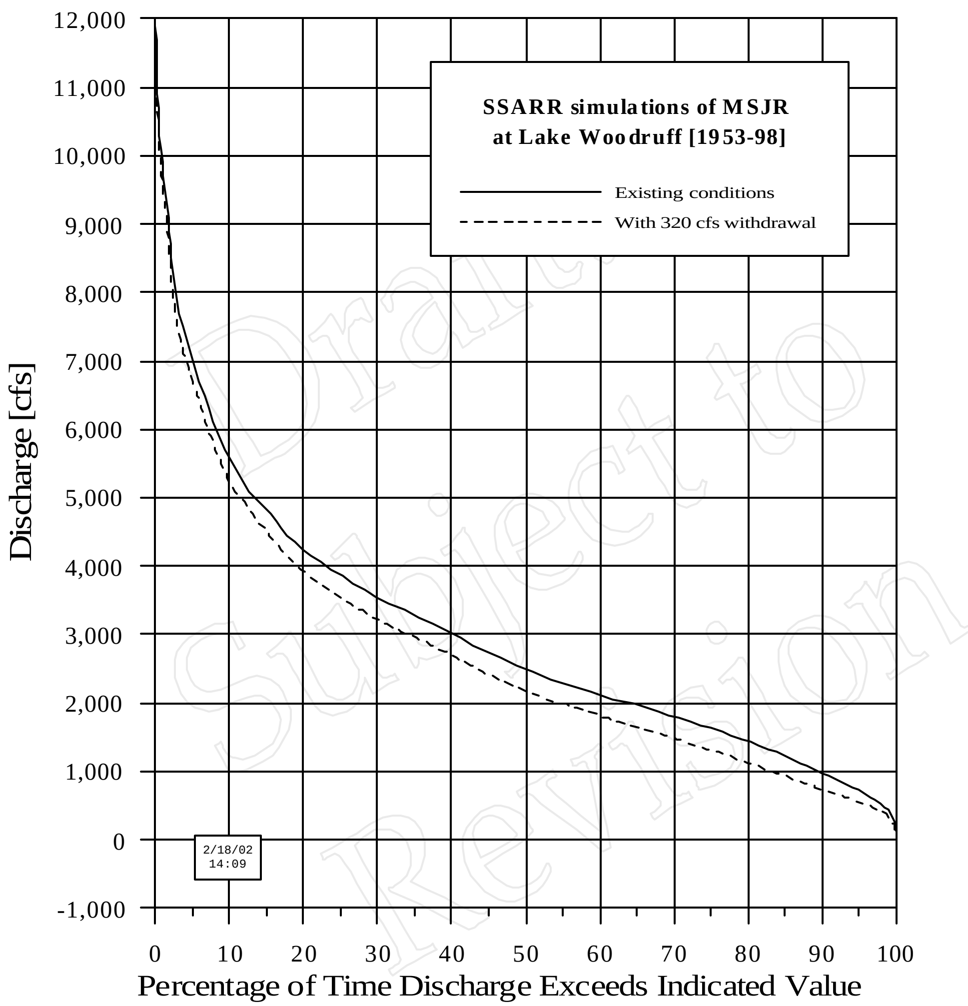
Source: Robison, C.P. 2002. Personal communication. St. Johns River Water Management District.



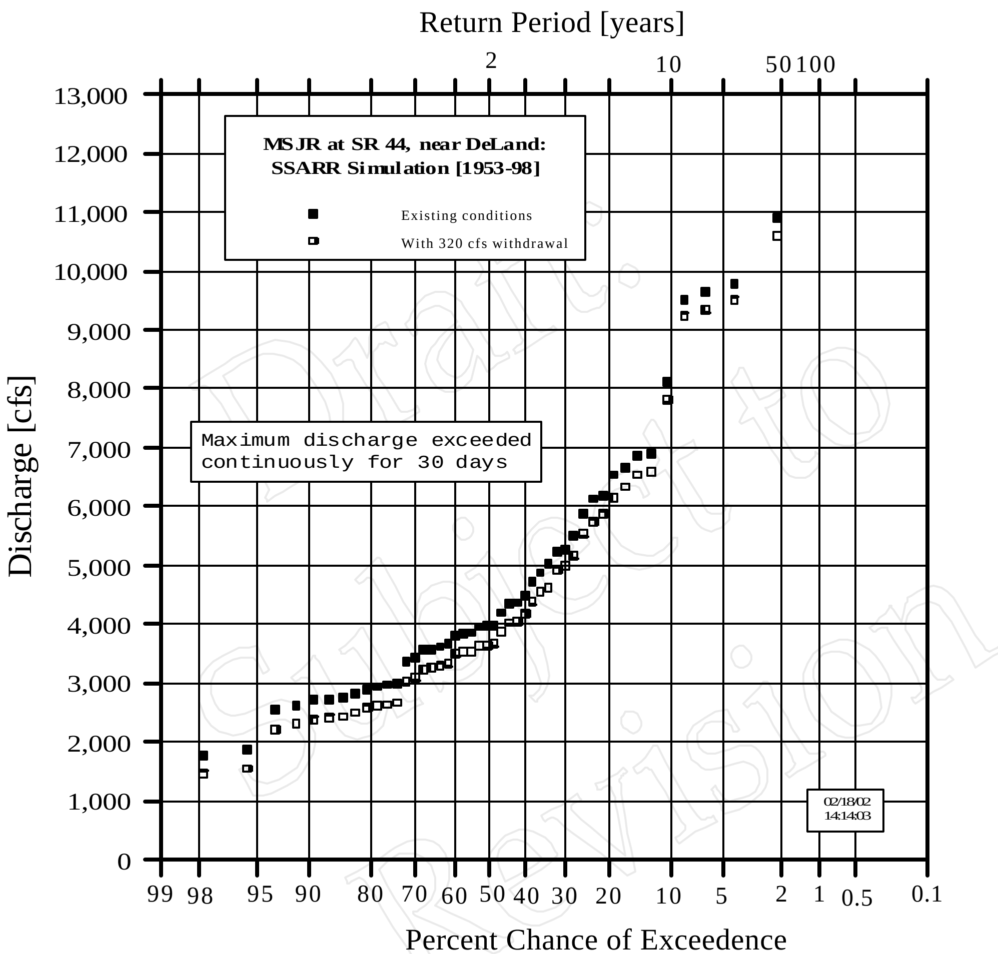
Source: Robison, C.P. 2002. Personal communication. St. Johns River Water Management District.



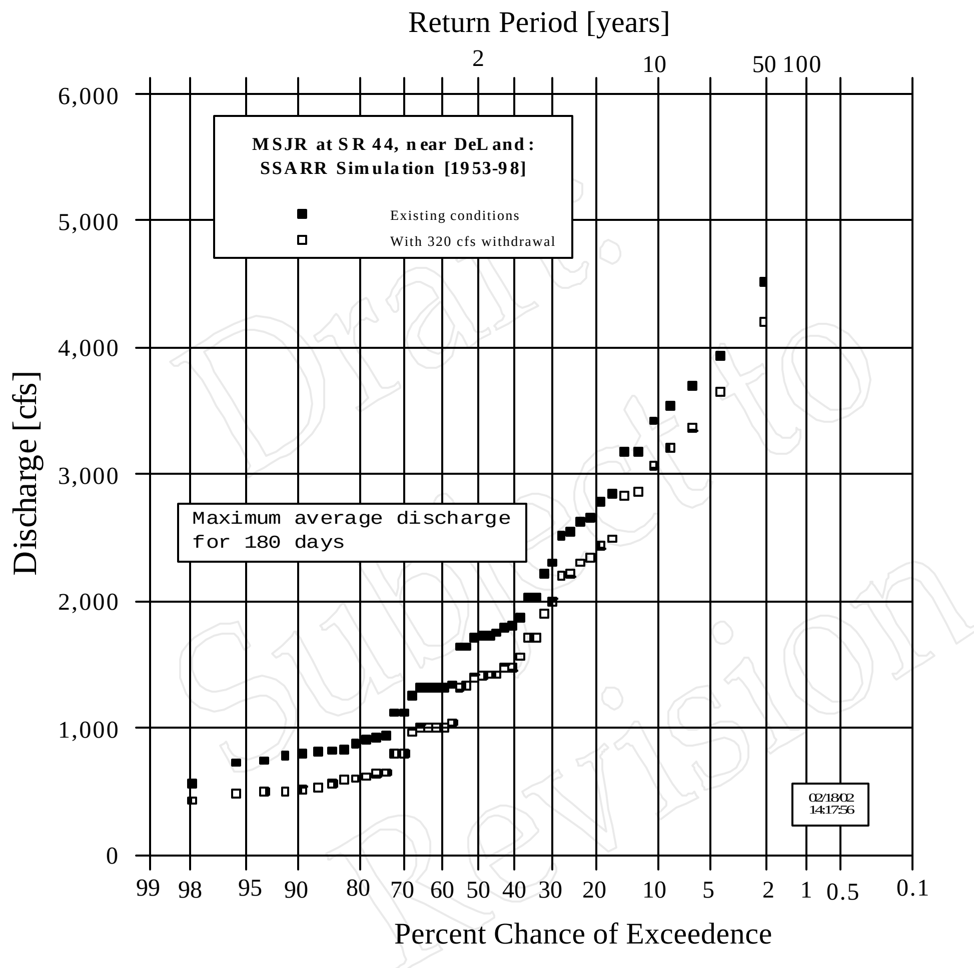
Source: Robison, C.P. 2002. Personal communication. St. Johns River Water Management District.



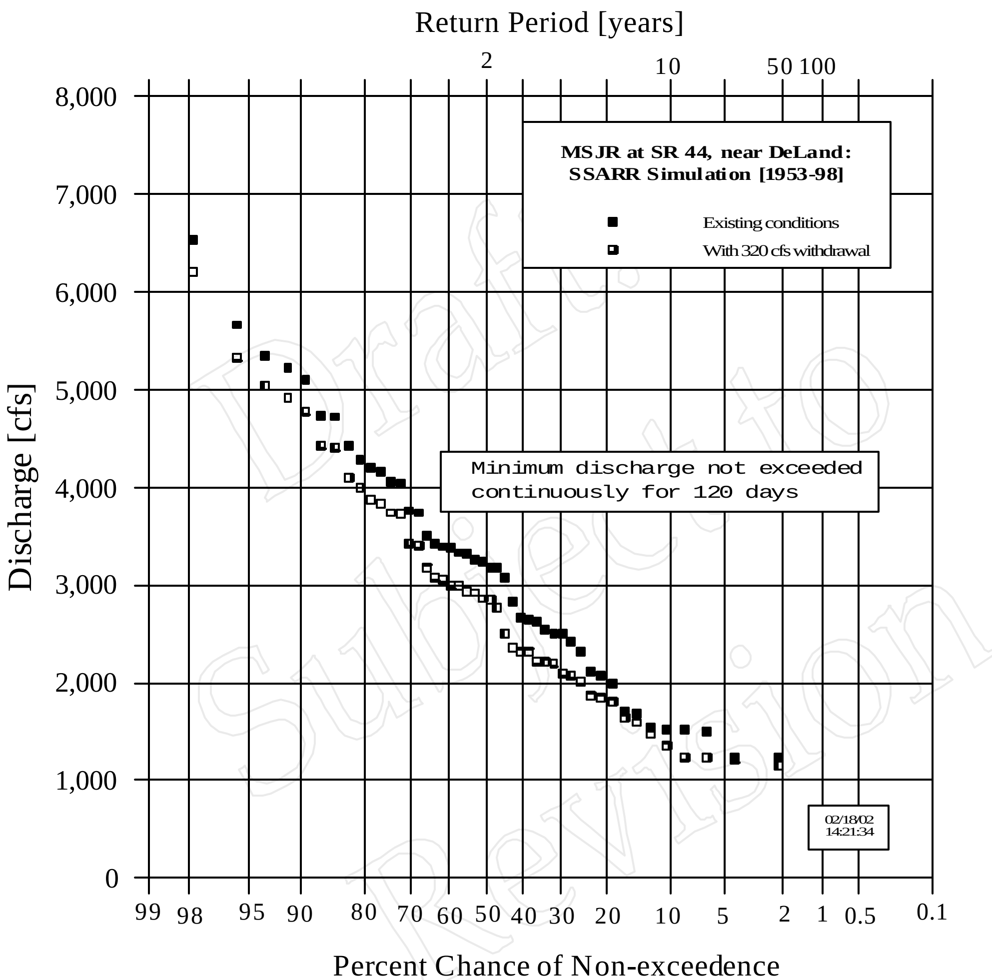
Source: Robison, C.P. 2002. Personal communication. St. Johns River Water Management District.



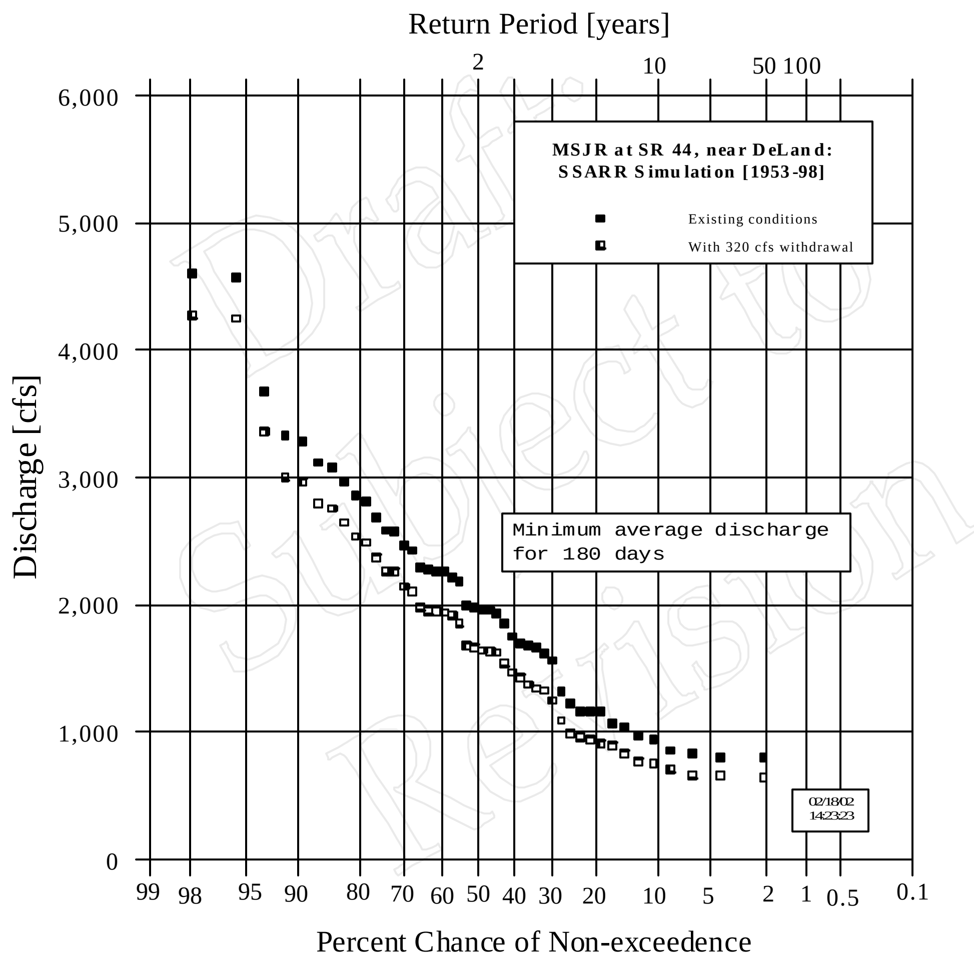
Source: Robison, C.P. 2002. Personal communication. St. Johns River Water Management District.



Source: Robison, C.P. 2002. Personal communication. St. Johns River Water Management District.



Source: Robison, C.P. 2002. Personal communication. St. Johns River Water Management District.



APPENDIX B

BUSINESS/RECREATION/NAVIGATION SURVEY

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

Riverside Business/Recreation/Navigation Survey

In cooperation with the St. John's Water Management District we are interviewing businesses along the river. We are performing this survey to determine if lower water levels have an impact on your business or daily operation. In addition we are gathering any first hand knowledge of the river levels and the effects they have had on the community.

Business:

Location:

► *What effect (in general) does lower water levels have on your business or operation?*

► *In your opinion was there a noticeable difference in the river level last year during the months of __ to __?*

► *Was there any limitations to your operation or ability to provide service due to lower water levels?*

►*In your opinion, what is the lowest water level that does not impact your business?*

►*Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

►*Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

►*Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

►*Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

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Ed (dockmaster) call on thursday 8-5

Business: The Boat Show Marina (~~904~~ 386) 736-6601

Location: Just north of 44 and bridge

▶ *What effect (in general) does lower water levels have on your business or operation?*

Floating docks no sailboats

▶ *In your opinion was there a noticeable difference in the river level last year during the months of __ to __?*

No

▶ *Was there any limitations to your operation or ability to provide service due to lower water levels?*

No

▶ *In your opinion, what is the lowest water level that does not impact your business?*

22 years

no

high water is problem 3 or 4 time had to pull out larger boats that get stuck

▶ *Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

No

▶ *Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

No

▶ *Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

No

▶ *Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

No

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

Riverside Business/Recreation/Navigation Survey

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Luke (dockmaster) 3/27

Business: Monroe Harbor Marina (407)322-2910 boat ramp/rental

Location: on Lake Monroe

► *What effect (in general) does lower water levels have on your business or operation?*

Sailing vessels with draft of greater than 9ft have problems during lower water levels but just along the Lake (Monroe) near the marina and shoreline

► *In your opinion was there a noticeable difference in the river level last year during the months of __ to __?*

No

► *Was there any limitations to your operation or ability to provide service due to lower water levels?*

No, when low some slips can't be used by bigger boats but it doesn't affect business

►*In your opinion, what is the lowest water level that does not impact your business?*

Never see any level too low since at sea level. 30 yrs. Luke has been on St. John's

►*Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

Lots of water hyethins, weeds floating around dock area during high water times

►*Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

Just in Lake Monroe certain areas are shallow but boats do fine in channels.

►*Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

No

►*Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

No

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

Riverside Business/Recreation/Navigation Survey

In cooperation with the St. John's Water Management District we are interviewing businesses along the river. We are performing this survey to determine if lower water levels have an impact on your business or daily operation. In addition we are gathering any first hand knowledge of the river levels and the effects they have had on the community.

Michelle answers Dianat spoke to 3/27

Business: Hontoon ~~Island~~ Landing Resort & Marina (386 ~~904~~) 734-2474 boat ramp/rental

Location: across from Hontoon Island State Park

► *What effect (in general) does lower water levels have on your business or operation?*

make adjustments, depth finders on boats

► *In your opinion was there a noticeable difference in the river level last year during the months of __ to __?*

Yes can see water line on tree, undercut banks
water level fluctuates all the time

► *Was there any limitations to your operation or ability to provide service due to lower water levels?*

no

▶ *In your opinion, what is the lowest water level that does not impact your business?*

Not that has occurred over the years yet, there has always been ability to function with the fluctuating water table

▶ *Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?* never observed Fish Kills

See more wildlife when water is higher

Seasonal changes not water level she sees as having a bigger effect on wildlife, water hytherias

▶ *Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

No, main channel not a problem

Some of the smaller tributaries become unnavigatable but this also happens at high water levels when vegetation overgrows

▶ *Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

No more the opposite during high water times

▶ *Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

No feels comfortable with ability to sustain recreational activities during fluctuating water levels especially since this is what they run the business off.

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

Riverside Business/Recreation/Navigation Survey

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Steve Barton (manager) back around 4 pm today

Business: DeLeon Springs State Rec. Area ~~(904)~~ 386 985-4212 Boat ramp & rental

Location: Spring Garden Lake, Lake off ~~off~~ Lake Woodruff

▶ *What effect (in general) does lower water levels have on your business or operation?*

None

▶ *In your opinion was there a noticeable difference in the river level last year during the months of __ to __?*

Yes noticed, swimming in spring not really affect
spring garden creek ← saw a little drop.

▶ *Was there any limitations to your operation or ability to provide service due to lower water levels?*

NO

►*In your opinion, what is the lowest water level that does not impact your business?*

14yrs. never experienced a level too low. not many boats are launched at this site. Since off river see less fluctuation

►*Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

NO, havenoticed increase algae growth in form of water hyacints

►*Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

NO

►*Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

NO

►*Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

No

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

Riverside Business/Recreation/Navigation Survey

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Nancy Nolel (dock master)

Business: Holly Bluff Marina (~~904~~ 386) 822-9992 boat ramp & rental

Location: channel marker 49, on point before Lake Beresford

▶ *What effect (in general) does lower water levels have on your business or operation?*

Less able to operate boats in all areas of river
drop off in fishing
boat repairs increase

▶ *In your opinion was there a noticeable difference in the river level last year during the months of __ to __?*

Direction flow changed to south
(usually flow north)

▶ *Was there any limitations to your operation or ability to provide service due to lower water levels?*

In ~~your~~ their channel along the marina
north end of property had difficulty bringing in boats
- depth finder on boats

▶ *In your opinion, what is the lowest water level that does not impact your business?*

No thus far have not seen levels that impede business completely but this marina has a lot of problems with low water levels

▶ *Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

Fish Kill

in Orlando Sentinale last year mid to Late summer due to posionnoss algae Lake Beresford

▶ *Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

Tow Boat U.S. Nathan Bush 352 348 8697

Mouth of Lake George south

← speak, may have a lot of informatim on impassible area

Snake creek ← boats get stuck here.

▶ *Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

This marina have seen problems with launching docking during low levels.

▶ *Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

No

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

Riverside Business/Recreation/Navigation Survey

In cooperation with the St. John's Water Management District we are interviewing businesses along the river. We are performing this survey to determine if lower water levels have an impact on your business or daily operation. In addition we are gathering any first hand knowledge of the river levels and the effects they have had on the community.

Nathan Bush

Business: Tow Boat US (352)348-8697

Location:

▶ *What effect (in general) does lower water levels have on your business or operation?*

increases business

▶ *In your opinion was there a noticeable difference in the river level last year during the months of* May *to* August *?*

not particularly, currently have noticed water level is very low

▶ *Was there any limitations to your operation or ability to provide service due to lower water levels?*

no

have noticed when assisting stuck boater that river bottom is not covered with root more a hard sandy bottom as levels have dropped

also when water fluctuates logs + trees float out from shore into channels

►*In your opinion, what is the lowest water level that does not impact your business?*

►*Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

Corp of
Kills weeds hyanths
around Astor fishing very poor

►*Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

I-4
Lake George
No wake zones
channel very navigational

►*Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

ramp Blue Creek Road
Astor are good
lake Monroe

►*Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

Sand fills in during low periods no vegetatim

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

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after 1 pm Don Borum manager wed-sunday

Business: Hidden Harbor Marina (407)322-1610 boat ramp

Location: Mouth to Lake Monroe

► *What effect (in general) does lower water levels have on your business or operation?*

Restaurant business may decrease

Lake County Mt. Dora

Slips & dry storage

► *In your opinion was there a noticeable difference in the river level last year during the months of* may *to* August*?*

Yes

meter

► *Was there any limitations to your operation or ability to provide service due to lower water levels?*

No

► *In your opinion, what is the lowest water level that does not impact your business?*

► *Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

No

► *Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

No

► *Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

No

► *Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

NO

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

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Richard Brown (manager) call tomorrow 9:30

Business: Highbanks Marina and Camp Resort ~~(407)~~ 386 668-4491 boat rental

Location: SwampHouse Grill b/w channel marker 90 & 92

► *What effect (in general) does lower water levels have on your business or operation?*

Water down to 26" at front dock
Usage is limited by patrons
boat size limited
fishing gets better during lower conditions

► *In your opinion was there a noticeable difference in the river level last year during the months of* May *to* August*?*

Yes

► *Was there any limitations to your operation or ability to provide service due to lower water levels?*

Can't anchor boats on lateral docks b/c the Front of the dock is river bottom exposed
Patrons are limited to use of facility must be aware of boats draft levels.

►*In your opinion, what is the lowest water level that does not impact your business?*

16 years experience/Knowledge
In his opinion both high and low water impacts his business been making adjustments

►*Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

After Corp of Engineering sprays for weeds have a fish kills. ← in the past
said to speak with Hontoon Fish Camp

►*Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

Logging Channels have problems
used by tourists/public

►*Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

Boat ramps concreted to a certain level after which the river drops about 12ft. at low levels

►*Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

No

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

Recreation/Navigation Survey

In cooperation with the St. John's Water Management District we are interviewing individuals along the river. We are performing this survey to determine if lower water levels have an impact on your recreational use or navigation. In addition we are gathering any first hand knowledge of the river levels and the effects they have had on the community.

Location: Ed Stone Park - Rt. 44 (Individual #1)
3/26/02

▶ *What effect (in general) does lower water levels have on your river use?*

None, continue to use river.

▶ *In your opinion was there a noticeable difference in the river level last year during the months of May to August?*

Seemed lower. Ramp was steeper, more difficult to launch boat.

▶ *Were there any limitations to your use of the river due to lower water levels?*

Not really.

▶ *In your opinion, what is the lowest water level that does not impact your use?*

Like today's level - 3/26/02

►*Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

No.

►*Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

Some sloughs, but no channels.

►*Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

Some private ramps.

►*Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

No.

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

Recreation/Navigation Survey

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Location: Ed Stone Park Ramp – 3/26/02
people launching boat.

▶ *What effect (in general) does lower water levels have on your river use?*

Continue to use main channel. Plenty of depth.

▶ *In your opinion was there a noticeable difference in the river level last year during the months of May to August?*

Looked the same.

▶ *Were there any limitations to your use of the river due to lower water levels?*

No.

▶ *In your opinion, what is the lowest water level that does not impact your use?*

Not sure

►*Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

aquatic weeds sprayed and dying.

►*Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

Portions of Lake Woodruff.

►*Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

Private ramps

►*Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

No.

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Location: Ed Stone Ramp
3/26/02 (3 people launching new boat)

▶ *What effect (in general) does lower water levels have on your river use?*

Ramps are steeper, but still can launch.

▶ *In your opinion was there a noticeable difference in the river level last year during the months of May to August?*

Ed Stone ramp got real steep.

▶ *Were there any limitations to your use of the river due to lower water levels?*

another park had drop off at ramp.

▶ *In your opinion, what is the lowest water level that does not impact your use?*

Typical summer levels.

►*Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

No.

►*Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

No.

►*Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

No.

►*Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

No.

Minimum Flows and Levels for the St. John's River near Deland at State Road 44, Volusia County

Riverside Business/Recreation/Navigation Survey

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Business: Sunstate Towing
Location: Bob Coppedge 5/10/02

► *What effect (in general) does lower water levels have on your business or operation?*

None. High water and increased flows create more of a problem steering barges through bridges.

► *In your opinion was there a noticeable difference in the river level last year during the months of May to Aug?*

More caution needed around Lake Dexter bend, but still navigable.

► *Was there any limitations to your operation or ability to provide service due to lower water levels?*

No. 20 trips per month.

Sanford plant converting to gas powered – fuel oil transport will diminish

►*In your opinion, what is the lowest water level that does not impact your business?*

Have not seen.

►*Did you notice any signs of stressed wildlife such as fish kills, algae overgrowth, or changes in vegetation during drought conditions?*

No.

►*Are you familiar with any navigable channels in the St. John's River that are susceptible to changes in water level or that become impassible in drought conditions?*

Near Lake Dexter - shoals. Depths ok in channel.

►*Are you familiar with any shorelines used for river access that are shallow and become unusable in drought conditions?*

No.

►*Have you observed any restrictions to recreational/navigational activities, such as swimming, canoeing, boating, and skiing due to low water levels?*

No.