MINIMUM FLOWS AND LEVELS

ECONFINA RIVER, FLORIDA

SUWANNEE RIVER WATER MANAGEMENT DISTRICT
9225 CR 49
LIVE OAK FLORIDA 32060

DECEMBER 2015

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1.0 INTRODUCTION

This report, entitled "Minimum Flows and Levels, Econfina River, Florida" (Report), presents the data and analyses that provide technical support for the establishment and adoption of Minimum Flows and Levels (MFLs) for the Econfina River. The location of the Econfina River and its watershed is shown in Figure 1-1.

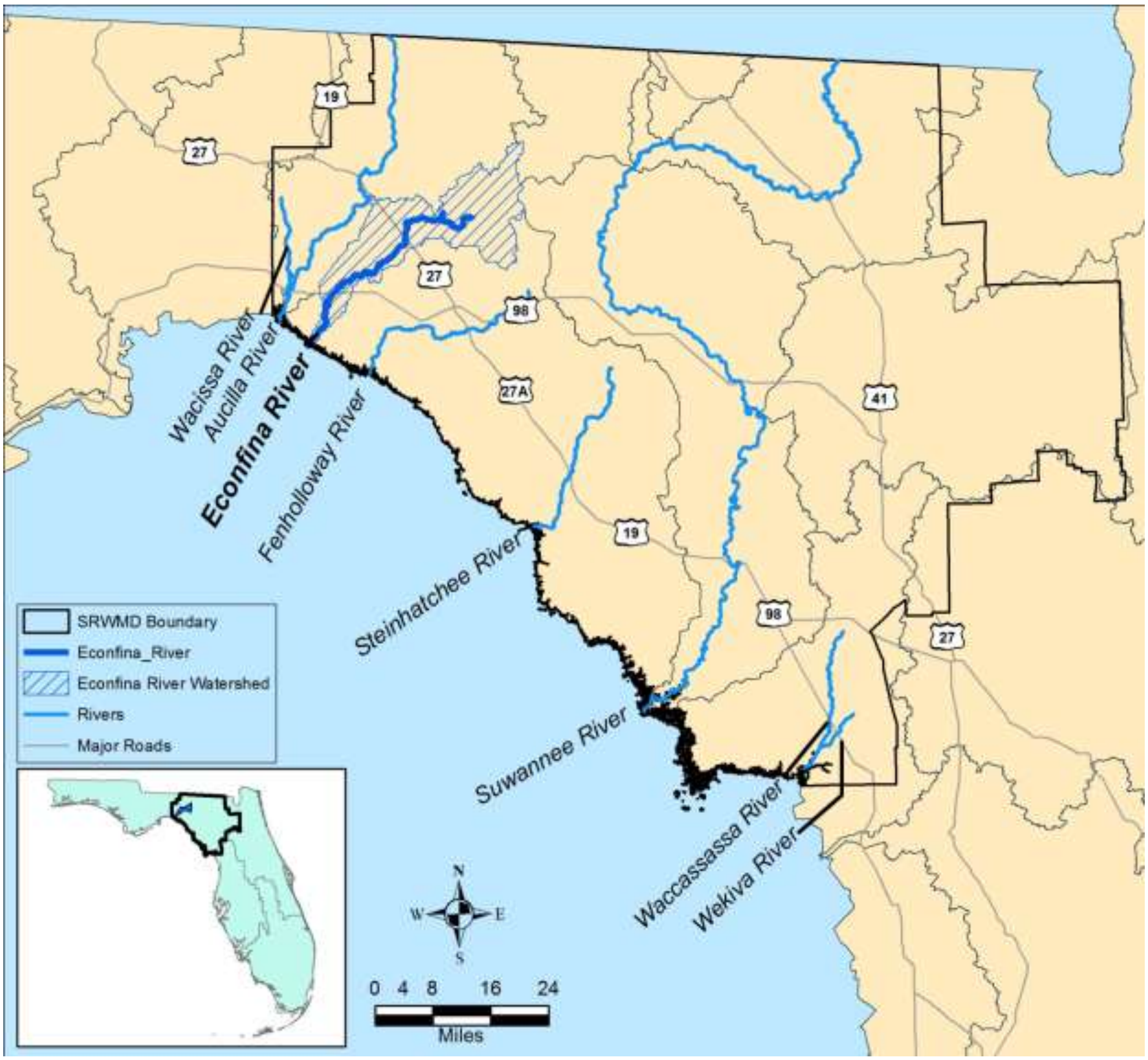

Figure 1-1. Location of the Econfina River watershed.

Section 1.0 of the Report provides an overview of the requirement for establishing MFLs, the water policy framework and scope of the Econfina River and regional context for the MFLs.

1.1 REQUIREMENT TO ESTABLISH MINIMUM FLOWS AND LEVELS

The Florida Legislature has directed the Suwannee River Water Management District (the District) to establish MFLs for streams, springs, rivers, lakes, and other priority water bodies within its boundaries (Chapter 373.042, F.S.). Chapter 373.042, F.S., specifies that:

1) Within each section, or the water management district as a whole, the Department (Florida Department of Environmental Protection) or the (District) Governing Board shall establish the following:
   a) Minimum flows for all surface watercourses in the area. The minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.
   b) Minimum water level. The minimum water level shall be the level of groundwater in an aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area.

The statute provides that MFLs shall be established using the best information available, that where appropriate, may reflect seasonal variations in flows and levels, and may provide for the protection of non-consumptive uses (Chapter 373.042[1], F.S.). In Chapter 373.0421, F.S., factors are provided that the Governing Board may consider when determining the appropriate reference point for MFL establishment. The statute recognizes that use of the historical hydrological condition of a water body may be an appropriate reference point for MFL establishment and allows certain exclusions when returning to those conditions may not be feasible.

Additional policy guidance regarding MFLs is provided in the State Water Resource Implementation Rule (Chapter 62-40.473, Florida Administrative Code [F.A.C.]), indicating that

> "…consideration shall be given natural seasonal fluctuations in water flows or levels, nonconsumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology… These environmental and water resource values may include:
>
> - Recreation in and on the water,
> - Fish and wildlife habitats and the passage of fish,
> - Estuarine resources,

- Transfer of detrital material,
- Maintenance of freshwater storage and supply,
- Aesthetic and scenic attributes,
- Filtration and absorption of nutrients and other pollutants,
- Sediment loads,
- Water quality, and
- Navigation."

A discussion of the environmental and water resource values that are applicable to the Econfina River is provided in Section 3.0.

Prior to the establishment of MFLs, the District may voluntarily subject technical work to independent scientific peer review (Section 373.042, F.S.). The purpose of the peer review is to conduct an independent examination of the scientific or technical data, methodologies, and models, including all scientific and technical assumptions employed in each model, used to establish each minimum flow or level.

Once the MFL has been determined, if the existing flow or level in a water body is below the applicable MFL, the District is required to develop and implement a recovery strategy. If the MFL is currently being met, but the water body is expected to fall below it within 20 years, a prevention strategy must be developed and implemented. Rule 62.40.473(5), F.A.C., requires that when recovery or prevention strategies are needed, they are to be simultaneously approved with the adoption of the MFL.

Once established by rule, MFLs are used in both the District's water supply planning and consumptive use permitting programs. In planning, MFLs are used to evaluate which water sources could be used while protecting the needed flows and levels for the water resource. In permitting, applicants must provide reasonable assurances that the proposed withdrawal will not violate an adopted MFL and is in accordance with any approved recovery or prevention strategy (Rule 62.40B-2.301 F.A.C.).

1.2 WATER POLICY FRAMEWORK

The District completed and accepted the 2010 Water Supply Assessment in December 2010 (SRWMD 2010). The Water Supply Assessment report utilized an interim MFL for the Econfina River that would limit the reduction in river flow to 10-percent.

1.3 SCOPE OF THE ECONFINA RIVER MFL

The Econfina River watershed encompasses 216 square miles from its headwaters in Madison County to its mouth at Apalachee Bay in Taylor County (Figure 1-1). It flows in southwesterly direction to the Big Bend region of Florida. The total length of the river is approximately 40 miles,

1.4 WATER RESOURCES ISSUES IN THE ECONFINA RIVER WATERSHED

There are several existing water use permits that are located within and adjacent to the Econfina River watershed (Figure 1-2). As can be seen, the water use in this area is relatively modest which is not surprising as neither urbanized areas nor agriculture make up a significant portion of the landscape in and around the Econfina River watershed. A more comprehensive presentation and analysis of the nature of the Econfina River and its watershed can be found in Section 2.

Figure 1-2. Study area of the Econfina River watershed.

1.5 CONTENT OF REMAINING SECTIONS

The remaining sections of this report contain the following:

- Section 2.0 – Provides an overview of the study area's geology, surface water hydrology, riverine and wetland habitats, water use, and land use.
- Section 3.0 – Describes the conceptual model used to develop the proposed MFLs, including a discussion of the Water Resource Values (WRVs) of the system and the in-channel and out-of-bank WRVs in each river system.
- Section 4.0 – Provides the basis for the development of minimum flows for the Econfina River. Descriptions of data collection and analysis are included for each WRV.
- Section 5.0 – Summarizes much of the discussion from the previous sections and then uses that information to develop and recommend MFLs for the Econfina River.
- Section 6.0 – Literature Cited

2.0 DESCRIPTION OF THE ECONFINA RIVER AND WATERSHED

This section presents a description of the Econfina River and its watershed. This description includes the:

- Physical setting of the river including geology, geomorphology, soils, and landuse/cover;
- Morphometry and bathymetry;
- Hydrology/rainfall;
- Water use;
- Riparian habitats;
- Aquatic biota; and
- Water quality.

2.1 PHYSICAL SETTING

The Econfina River, as defined for this study, extends from the mouth of the river, where it meets the Gulf of Mexico, upstream beyond the community of Econfina, a distance of approximately 3.6 miles. This limited reach was selected by the District as the primary study area due to the lack of existing information further upriver that would allow a quantitative definition of the relationships need to establish meaningful water resource value links to flow. However, in the following sections a broader description of the watershed is given.

2.1.1 GENERAL DESCRIPTION OF THE ECONFINA RIVER

The Econfina River watershed encompasses 216 square miles from its headwaters in Madison County to its mouth at Apalachee Bay in Taylor County. It is located on the western side of the center of the Big Bend region of Florida. The watershed is sparsely populated with only two communities, Eridu and Shady Grove. The majority of the watershed falls within the Gulf Coast Lowlands; further downstream it crosses into the Coastal Swamp Region.

The study area ranges from the river mouth at RM 0 to RM 3.1 (Figure 2-1). At the mouth, the river is a broad tidal estuary, more than 1,300 feet across. The landforms associated with the area near the mouth are primarily tidal grasslands connected to the main river by numerous tidal creeks extending along both sides of the river, with some connections to the Gulf through these tidal creeks as well. Downstream of RM 0.6, the tidal grasses are the dominant landform along the river. The river bottom is relatively shallow, with few locations deeper than approximately 8 feet.

Between RM 0.6 and 1.2, there are a few isolated stands of higher ground scattered through the grasses, with palms trees indicating the locations of these pockets. The river narrows to approximately 295 feet across at RM 1.2, with smaller tidal creeks extending from both sides of the river upstream of here. Between RM 1.2 and 1.9, the incidence of higher elevation areas along the shore increases, with more numerous and larger areas of tree-covered uplands found. Beginning at RM 1.9, just downstream of the boat landing and Econfina River State Park located about 2 miles upriver from the Gulf; the shoreline becomes dominated by upland vegetation, often with the shoreline undercut beneath rocky outcrops and even tree root systems. A few small tidal creeks still connect to the main river upstream of RM 1.9. The river channel is relatively deep here, with several locations deeper than 9.8 feet.

At RM 1.9, the river is approximately 200 feet across, narrowing to approximately 65 feet by RM 2.5. The boat landing at the State Park is near RM 2.2, and upstream of this point, between RM 2.5 and 3.1, is the community of Econfina, with many homes and associated boat docks along the western shore. The eastern shore of the river is lined with trees, rocky banks, and numerous rocky outcroppings rising from the bottom to near the surface of the river. Between RM 1.9 and 2.5, the river includes three islands separated from the main shore by lower elevation flow areas, although these areas are very shallow, with greatest depths of 5.0 feet or less. Several relatively deep areas exist along the river channel in this section of the river, with some areas deeper than 11.5 feet.

Upstream of RM 3.1, where the river is approximately 65 feet wide, the shores of the river are lined with trees on both sides, and a small bridge crosses the river. Throughout this area, the river bed is sometimes very shallow, with relatively deep (>6.5 feet deep) areas between relatively shallow (<3.5 feet deep) sills.

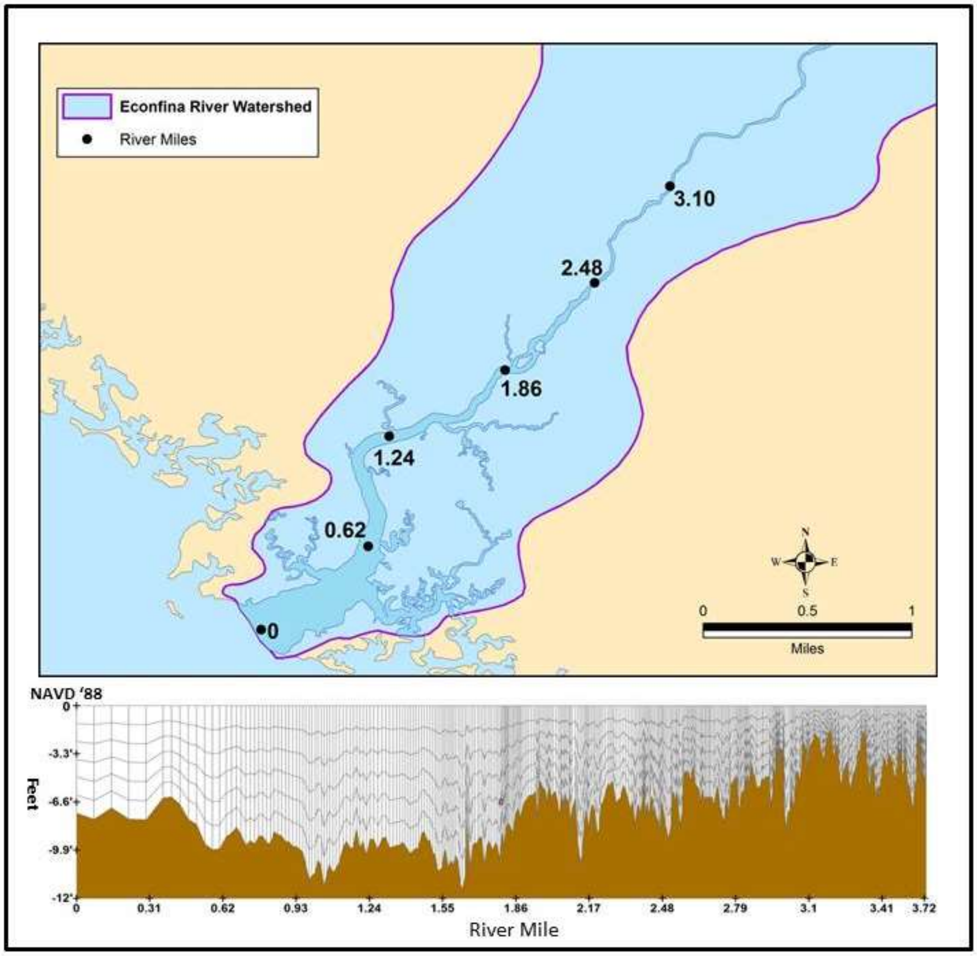

Figure 2-1. Econfina River plan view and profile of the lower portion of the river.

2.1.2 GEOMORPHOLOGY, GEOLOGY, AND SOILS

The watershed is contained within the Ocala Karst Geomorphic Region which is subdivided locally into the Perry Karst/San Pedro Bay and the Woodville Karst Plain (Figure 2-2). The Perry Karst subdivision is a narrow transitional zone between the Woodville Karst Plain to the west and San Pedro Bay on the east. The Perry Karst area is poorly to moderately drained, while San Pedro Bay is extremely poorly drained. The Suwannee Limestone underlies the Perry Karst/San Pedro Bay in this area. In the San Pedro Bay, a clay layer up to five feet thick overlies the limestone, providing confinement to the Floridan aquifer system (FAS) (Copeland 1982). Plio-Pleistocene sediments cover the entire area, and the unit is poorly to very poorly drained. Recharge to the FAS is low to moderate in San Pedro Bay, while recharge to the FAS may be moderate to high along the transition from San Pedro Bay to the Perry Karst. The Woodville Karst Plain has common karst features, springs, disappearing streams (swallets), and resurgent streams. Elevations, in general, range from sea level to approximately 50 feet. Relief is very low over the entire area and drainage is poor, resulting in vast swamps. Tertiary carbonates underlie the entire area beneath a thin siliciclastic cover. The Lower Oligocene Suwannee Limestone underlies the karst plain in Taylor and Jefferson Counties. (Scott et al. 2004). Limiting the watershed's extent is the Cody Scarp.

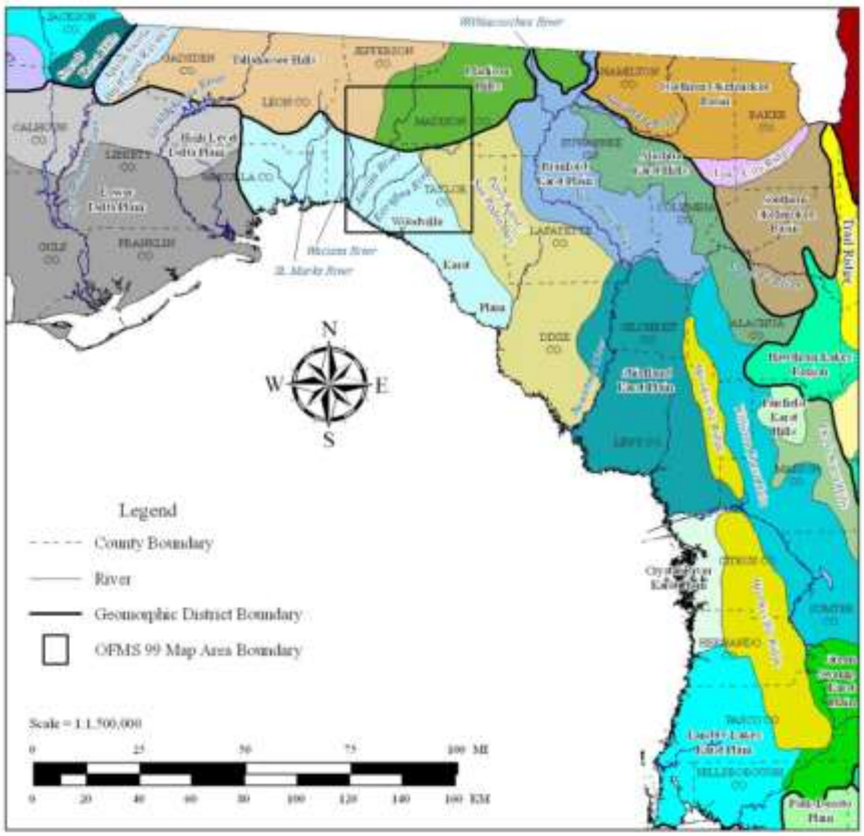

Figure 2-2. Geomorphology of the Florida Big Bend area and the Econfina River watershed in (box). From Paul et al. (2008).

The Florida Geological Survey (FGS), a division of the Florida Department of Environmental Protection, is responsible for conducting geological investigations within the state. The Econfina watershed is contained within the western area covered by the Perry, Florida 30 x 60 minute quadrangle published as FGS Open-File Map Series 99-0 (Table 2-1). Four distinct units comprise the surficial geology within the watershed: Undifferentiated Quaternary sediments, Miccosukee Formation, Torreya Formation of the Hawthorne Group and Suwannee Limestone (Figure 2-3).

At Econfina, the top of the Suwannee Limestone varies in depth from surface outcrop to about 30 feet below the surface. The limestone surface is highly eroded, containing numerous solution pipes, holes, small caves, sinks and pinnacles. Although some of these features may be seen on the Econfina, they are generally masked by in-filling with younger, unconsolidated sands and clayey sands. In shallower spots of the Econfina River, the Suwannee Limestone bed is visible and forms shoals separating deeper pools.

Table 2-1. Lithostratigraphic (rock) nomenclature for the area near and around the Econfina River watershed.

System	Series	Formation	Aquifer System
Quarternary	Holocene/Pleistocene	Undifferentiated Quaternary	Surficial
Tertiary	Pliocene	Miccosukee Formation	Surficial
Tertiary	Miocene	Hawthorn Group - Torreya Formation	Intermediate Aquifer System
Tertiary	Oligocene	Suwannee Limestone	Upper Floridian

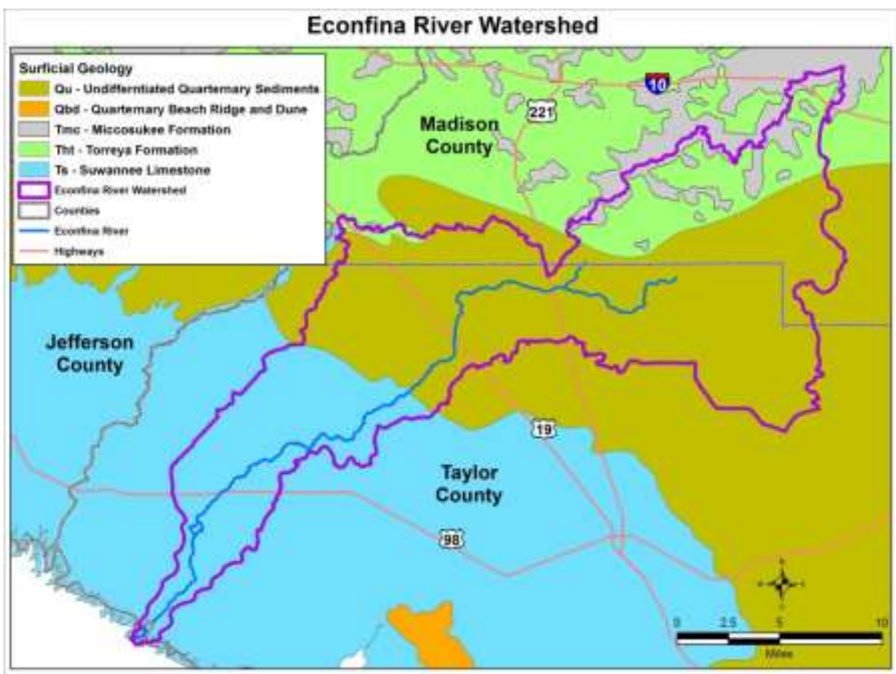

Figure 2-3. Geology of the Florida Big Bend area and the Econfina River watershed. From Paul et al. (2008).

An analysis of soils data obtained from National Resource Conservation Service of the US Department of Agriculture was conducted. The data were downloaded and processed for further analysis with a GIS environment focusing on its hydrologic characteristics (Figure 2-4). Soils of the B/D type made up the largest percentage within the watershed, the majority of which can be found in the headlands. These exhibit a mix of moderate infiltration rates and very slow infiltration rates. These were followed by A/D soils, a mix of high infiltration and low runoff potential soils with low infiltration and high runoff potential soils throughout the middle one-third of the watershed. The lower one-third is made up of primarily C/D soils with slow to very slow infiltration and high runoff potential.

The soils underlying the coastal marsh have been mapped as Bayvi-Isles-Estero soils (FDEP 2006). This marshy area is covered by needlerush (*Juncus roemerianus*), sawgrass (*Cladium* sp.), and cordgrass (*Spartina alterniflora*).

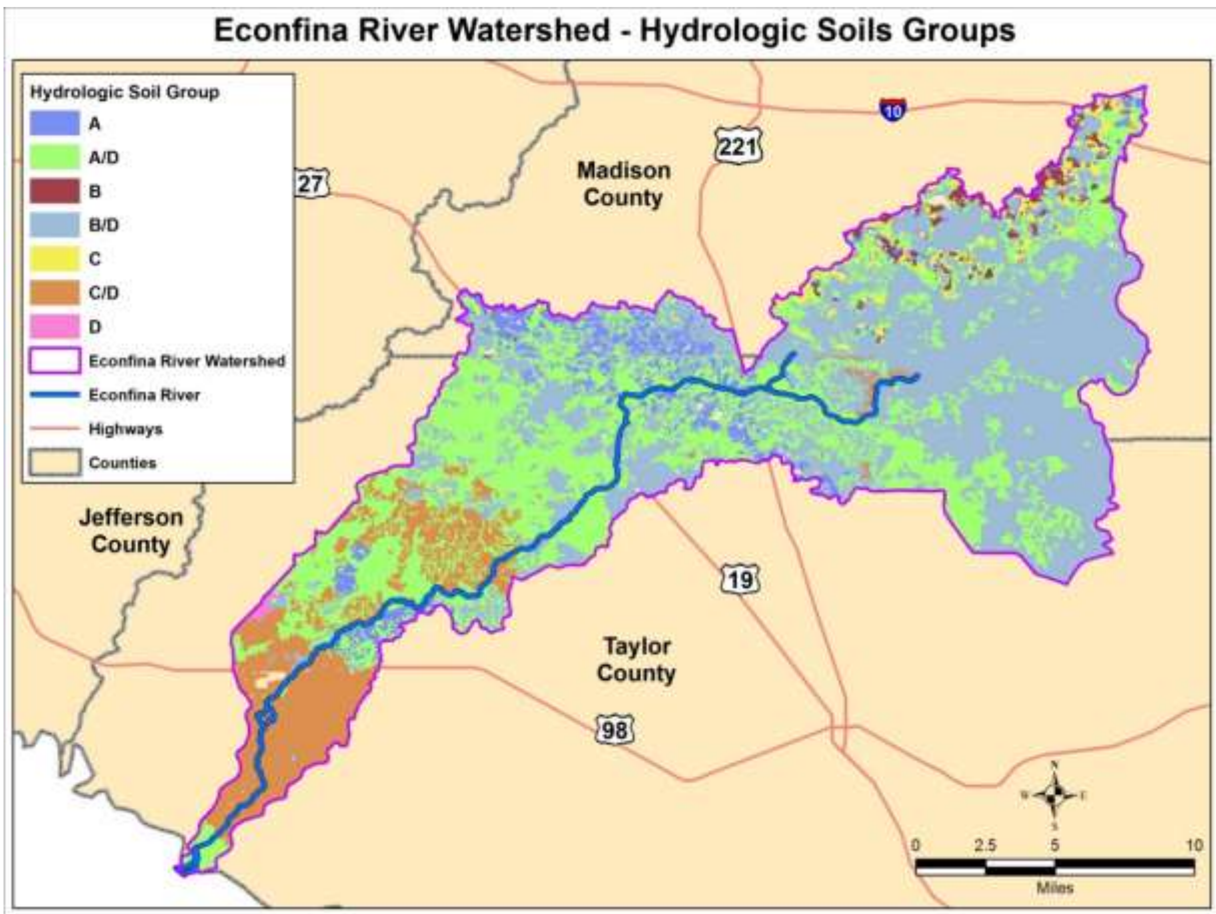

Figure 2-4. Hydrologic Soils in the Econfina River watershed.

An analysis of the landuse/cover characteristics provided by the District (SRWMD 2011) depicts the Econfina River watershed as a lightly disturbed area with the majority (93.7 percent) of the land surface comprised of wetlands (51.7 percent) and forested uplands (41.98 percent) Table 2-2). Agricultural activities comprise 4.26 percent of the watershed primarily in the form of pastures and rangeland with crop farming making up less than 1 percent. Urban activities cover

5.84 percent of the watershed comprised of residential (1.2 percent), commercial/institutional (4.26 percent) and transportation/utilities (0.38 percent).

Table 2-2. Landuse/cover in the Econfina River watershed.

Landuse/Cover	Acres	Percentage Composition
Residential	1362	0.84
Commercial/Institutional	593	0.37
Agriculture/Rangeland	6915	4.26
Forested Uplands	68185	41.98
Open Water	783	0.48
Wetlands	83985	51.70
Transportation, Utilities and other	612	0.38
Total	162435	100

The fact that the Econfina River watershed is minimally disturbed led the FDEP to designate a portion of the freshwater reach as a reference site of freshwater streams in the development of the numeric nutrient criteria (FDEP 2012). This designation also led to the delisting of the freshwater Econfina the river for dissolved oxygen, “Econfina River is a reference site for the bioassessment program and was the control site for the Fenholloway SSAC (Site Specific Alternative Criterion). Low DO is a natural condition, as there are no anthropogenic sources of pollutants.” (FDEP 2014).

2.1.3 MORPHOMETRY AND BATHYMETRY

A plan view of the Econfina River and a profile view of the river’s bathymetry is shown in Figure 2-1. Figures 2-5 through 2-7 present the river volume, shoreline length, and bottom area, respectively, over the study area. In terms of river volume, much of the water in the river is found below RM 1.9. The cumulative river volumes provided in Figure 2-5 are based on the average modeled conditions during the 2-year period selected as the baseline period for MFL modeling (Oct. 1, 2001 - Sep. 30, 2003, as described in Section 4.3). The shoreline length and bottom area are estimated based on the dimensions of the hydrodynamic model grid cells. The EFDC model does not allow horizontal cell dimensions to change over time, and requires all vertical cells at a single horizontal location to have the same horizontal dimensions, so that the shoreline length and bottom area for each grid cell are fixed regardless of the water level. There is only a modest increase in the river volume from RM 2.5 to RM 3.7. Similarly, the majority of the river bottom area occurs below RM 1.2 and a relatively small increase above RM

1.9. The shoreline length increases linearly from the mouth upstream to RM 3.1. These physical river characteristics are of particular importance in how the river responds to changes in freshwater inflows.

The bottom of the river is primarily rocky, with elevated rocky areas extending throughout the lower river, often visible breaking the water surface. The river channel is incised, with the lower river connected via tidal creeks to large grassy tidal regions extending up-river almost two miles and along the Gulf of Mexico shoreline in both direction.

A bathymetric survey was recently completed (Land & Sea Surveying 2014) for the lower portion of the river (Figure 2-8). Water depths within this area ranged from 1 to 10 feet (bottom elevations were -1 to -10 feet NAVD88; for reference, MLLW is 1.28 feet below NAVD88 here), with the majority of the area between 2.5 and 4 feet in depth.

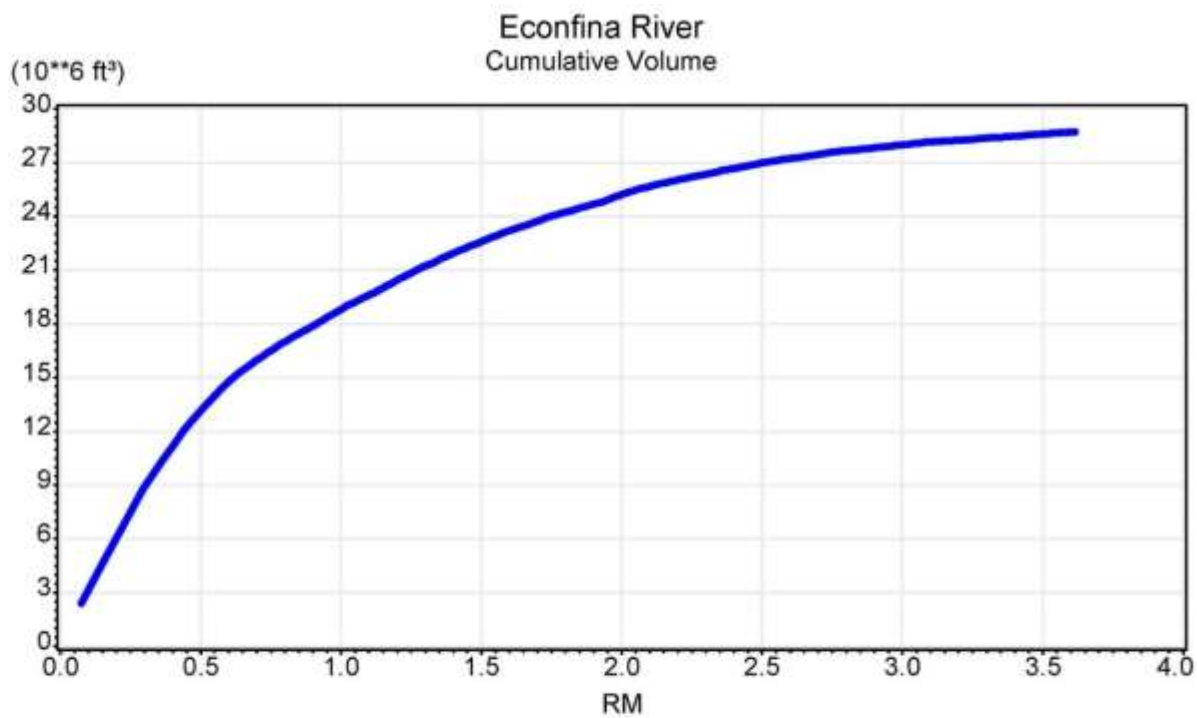

Figure 2-5. Econfina River cumulative volume from the mouth at RM 0 to RM 3.6.

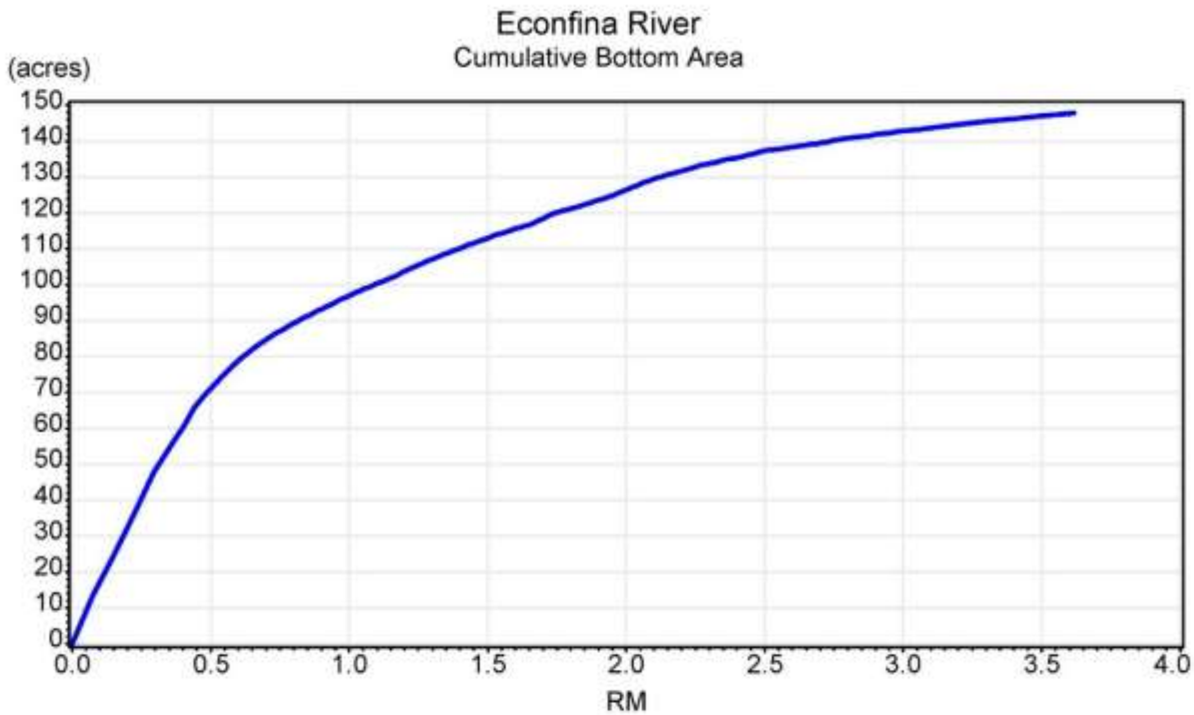

Figure 2-6. Econfina River cumulative bottom area from the mouth at RM 0 to RM 3.6.

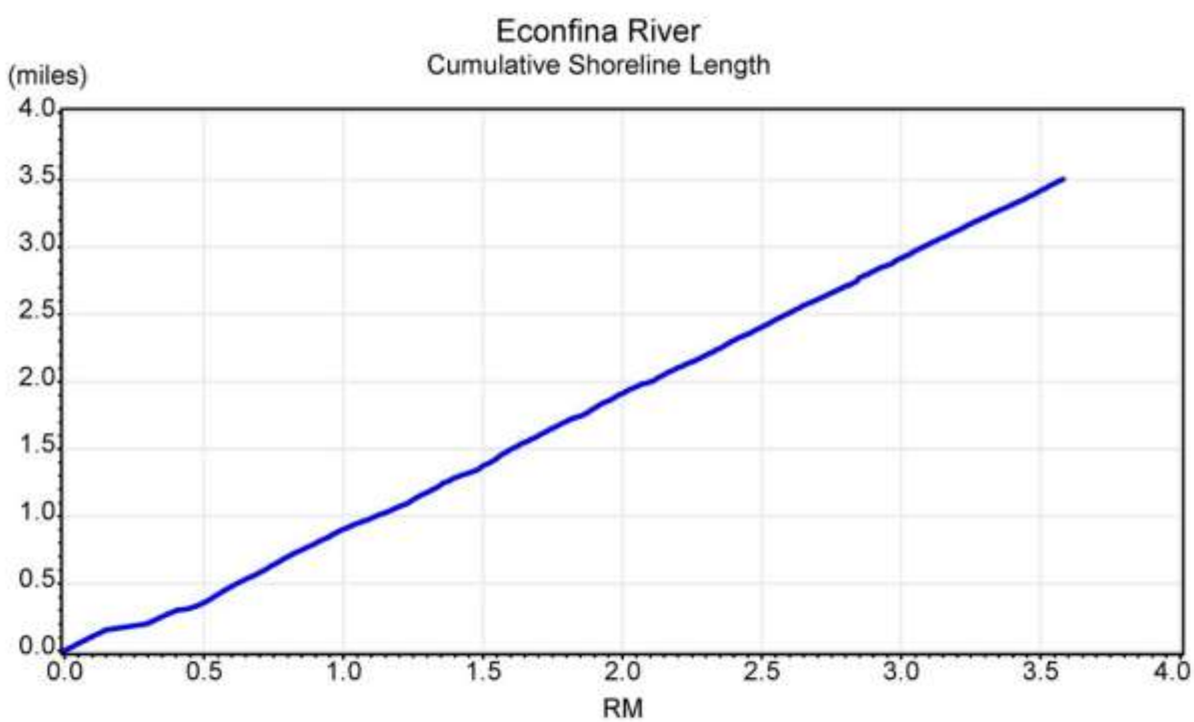

Figure 2-7. Econfina River cumulative shoreline length from the mouth at RM 0 to RM 3.6.

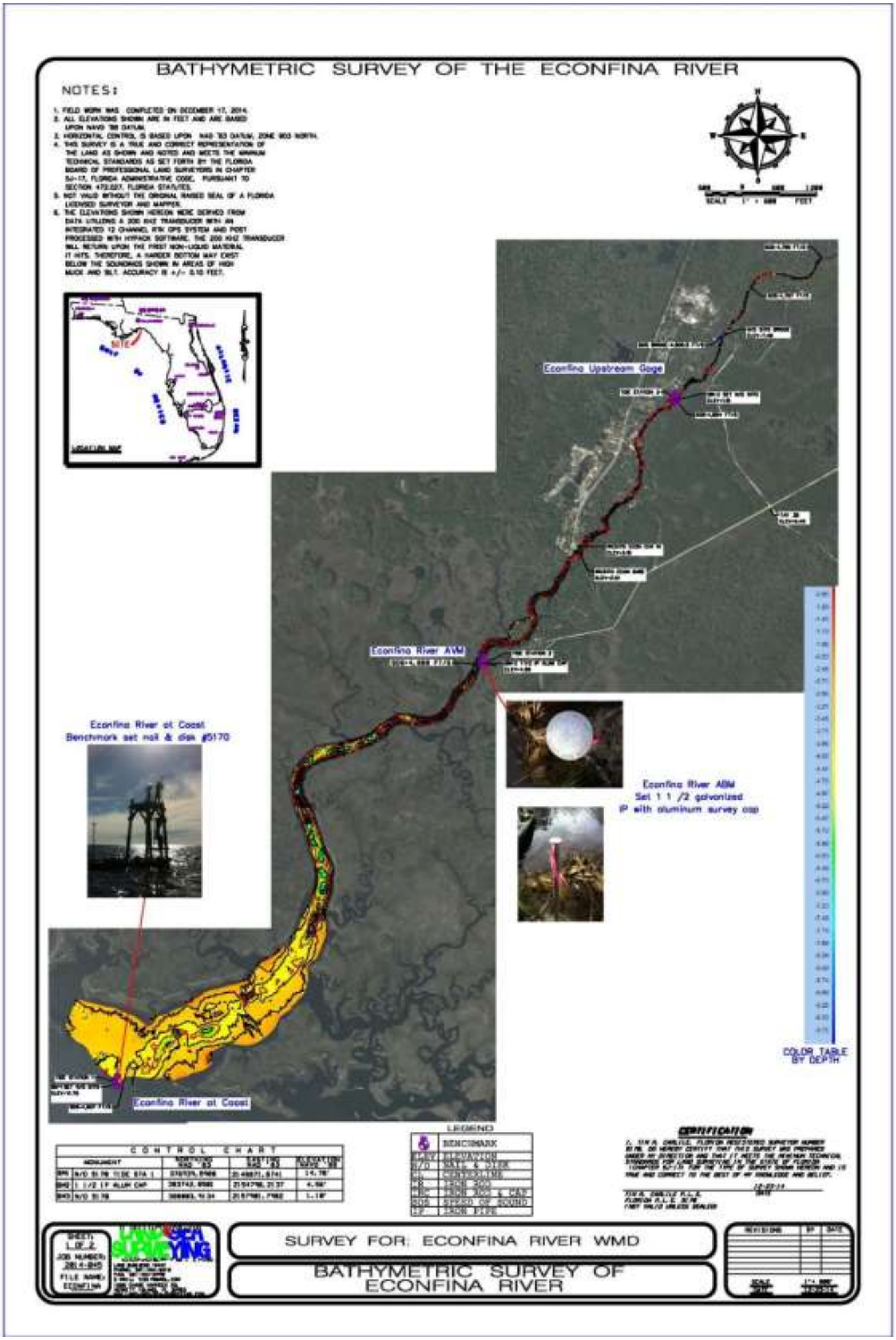

Figure 2-8. Econfina River bathymetric survey results (Land & Sea Surveying 2014).

2.1.4 RAINFALL AND HYDROLOGY

Examination of the temporal variation in rainfall is important to understanding the Econfina River hydrology on several temporal scales ranging from daily through annual. Rainfall has been monitored at a gage near Perry (Figure 2-9) since 1960. Figure 2-10 presents the total monthly (upper panel) and annual (lower panel) rainfall for that gage.

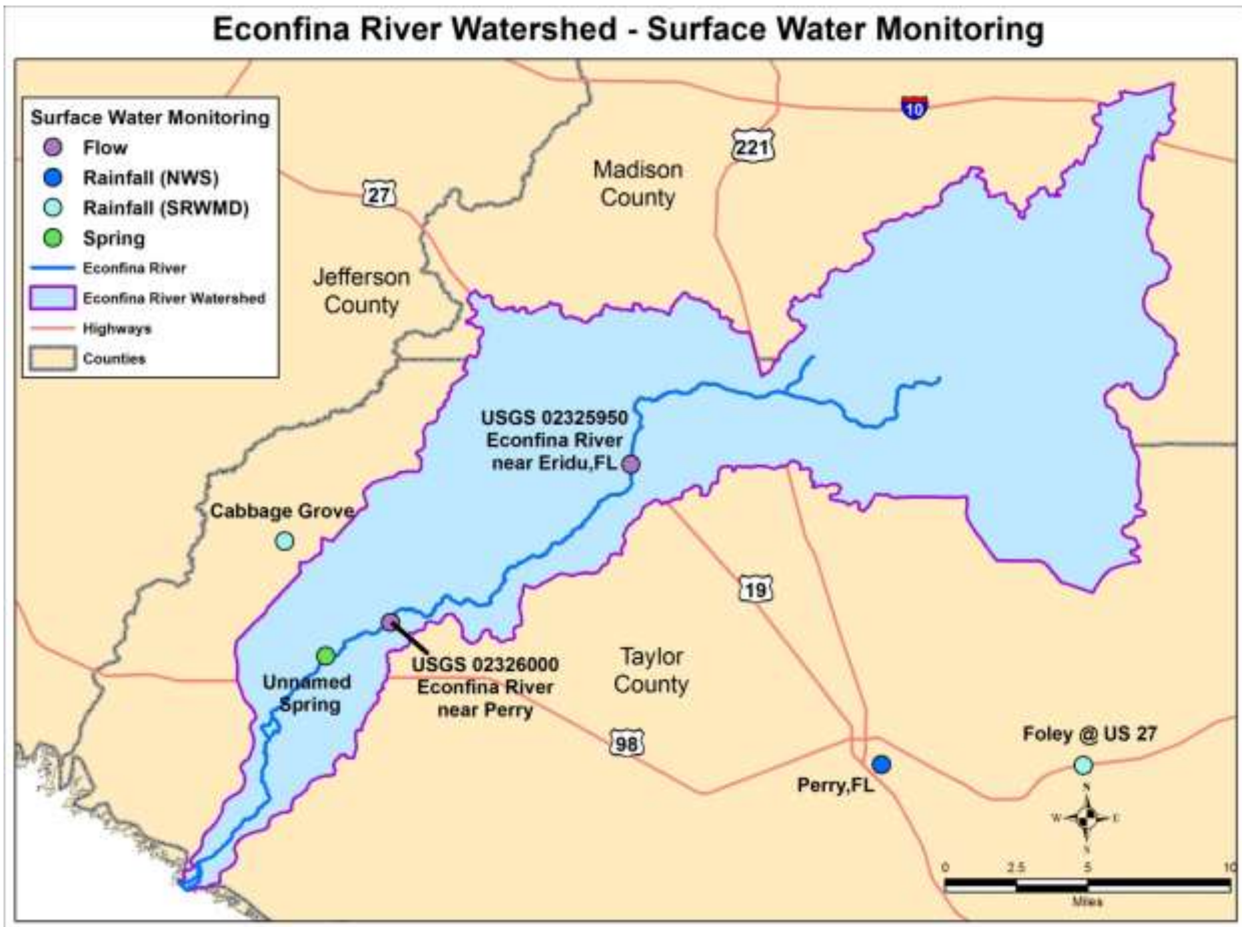

Figure 2-9. Surface water hydrology and rainfall monitoring locations.

The total annual rainfall at Perry has ranged from approximately 40 inches to more than 70 inches with a median of 56 inches. Over the period of record, the total annual rainfall has not exceeded 40 inches in 10-percent of the years, including the recent years of 2000, 2006, 2007, and 2011.

The overall mean monthly rainfall for the period of record was 4.8 inches (Figure 2-10). Maximum monthly rainfalls have exceeded 10 inches approximately 10-percent of the time.

Typical monthly rainfall has ranged between 0 and 10 inches. Figure 2-11 shows the typical monthly rainfall pattern at Perry with a clear seasonal pattern emerging with two wet seasons, one in the summer and the second during the winter. The pronounced wet season that occurs in the summer months (June through September) is associated with localized, convectional thunderstorms or periodic tropical weather systems (hurricanes, tropical storms). Winter (January through March) precipitation events are due to mid-latitude frontal weather systems with individual rainfall events that are usually more widespread.

The primary gage where Econfina River flows are monitored is operated by USGS (02326000) and located near Perry (Figure 2-9). The period of record used in this report is from 1950 through 2014. The selection of this baseline period is discussed more thoroughly in Section 4. Much of the Econfina River flow is provided by surface runoff. Baseflow is provided through small springs and seeps in the eroded Suwannee Limestone.

Figure 2-12 presents the mean daily flows for the Econfina River near Perry for the period of record. The median flow for this period is 56 cfs and the P90 and P10 are 16 cfs and 365 cfs, respectively. There are several recent periods during which the mean daily flows were particularly low including 2000-2001, 2008, and 2011. Similar flows were observed earlier in the mid-1950s and late 1960s.

Figure 2-13 presents the mean annual flows for the Econfina River near Perry for the period of record. The median flow for this period is 142 cfs and the P90 and P10 are 32 cfs and 230 cfs, respectively.

Figure 2-14 presents the mean monthly flows for the Econfina River near Perry for the period of record. The median flow for this period is 69 cfs and the P90 and P10 are 17 cfs and 358 cfs, respectively. Interestingly, the P10 and P90 flows are quite similar for both the daily and monthly flows. The low flow periods are even more apparent in the mean monthly flow data.

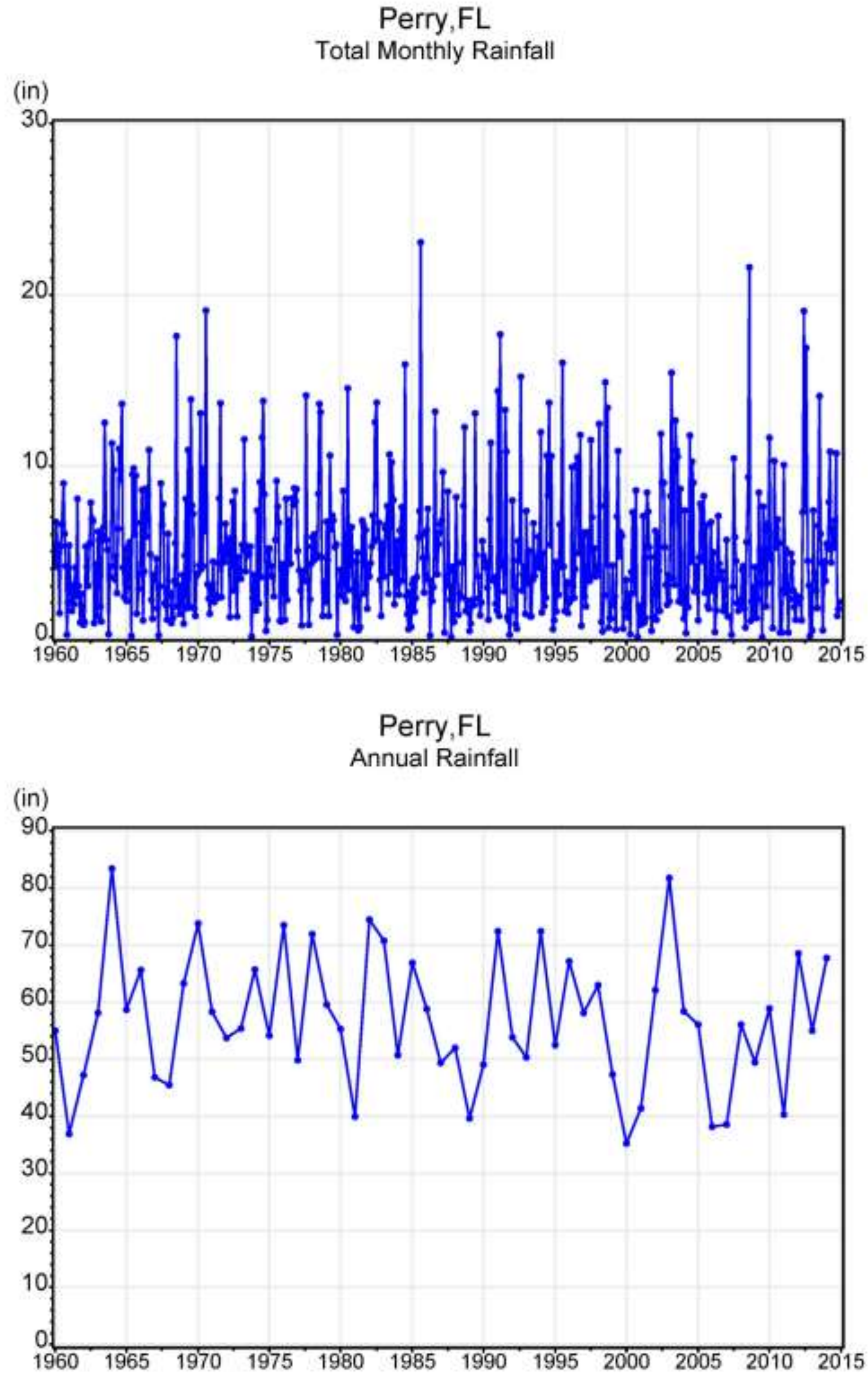

Figure 2-10. Monthly rainfall (inches) (upper panel) and annual rainfall (lower panel) from the NWS gage at Perry.

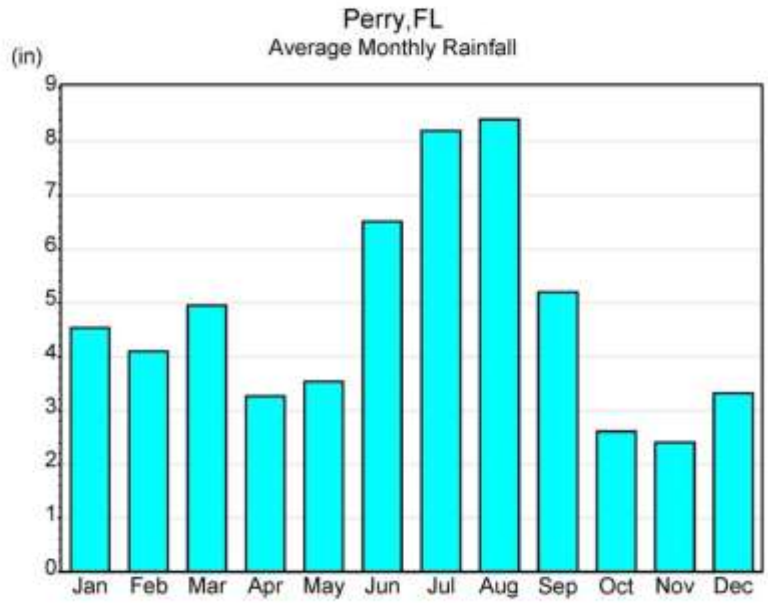

Figure 2-11. Mean monthly rainfall (inches) by calendar month for the period 1960 through 2014.

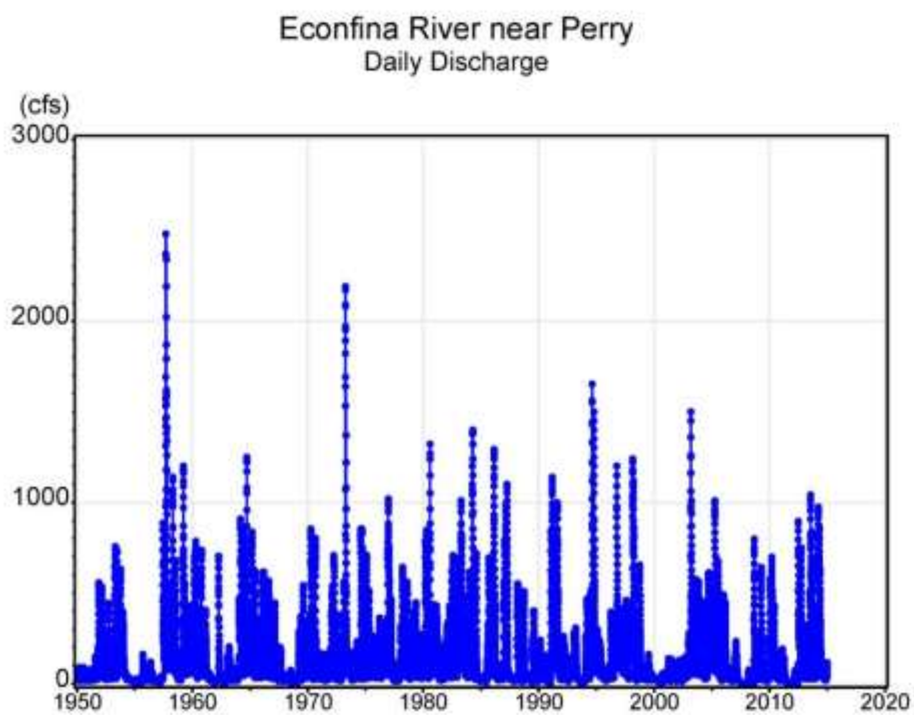

Figure 2-12. Mean daily discharge (cfs) for the Econfina River near Perry (USGS 02326000) for the period of record 1950 through 2014.

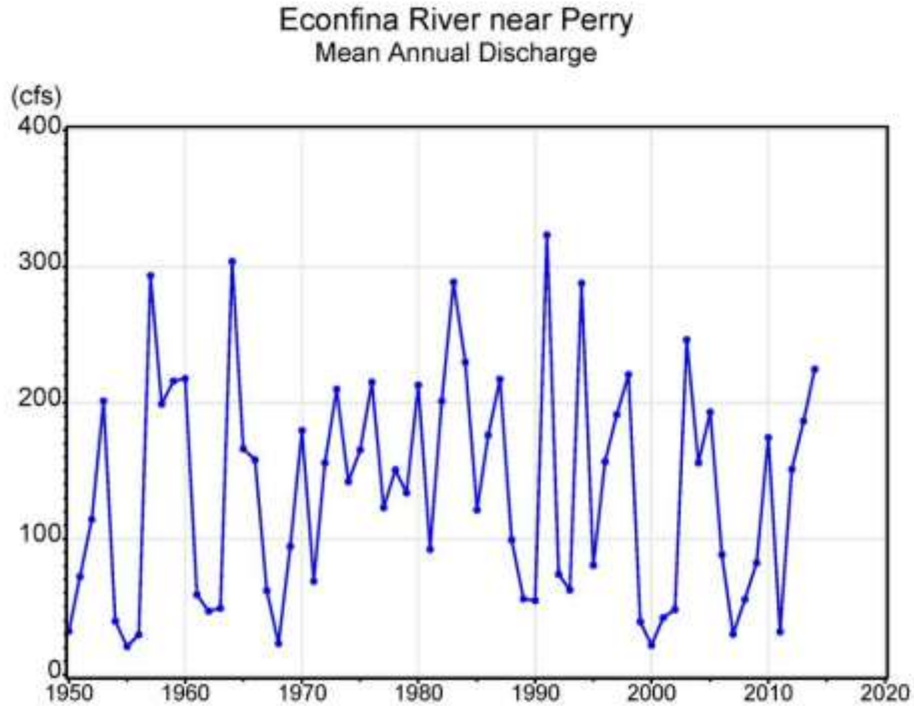

Figure 2-13. Mean annual discharge (cfs) for the Econfina River near Perry (USGS 02326000) for the period of record 1950 through 2014.

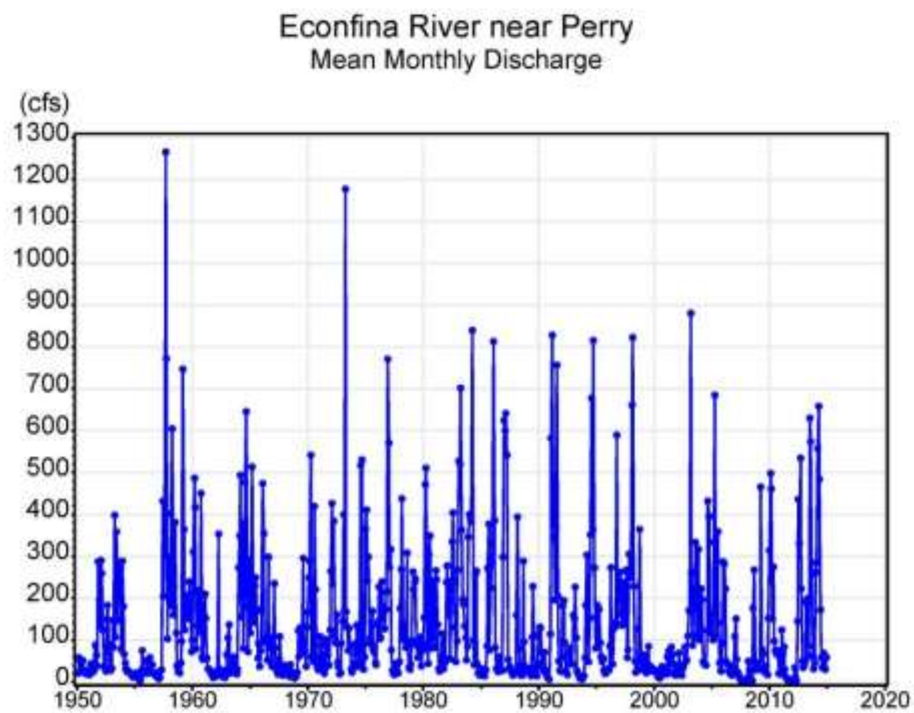

Figure 2-14. Mean monthly discharge (cfs) for the Econfina River near Perry (USGS 02326000) for the period of record 1950 through 2014.

2.1.5 SEASONAL FLOW PATTERNS

Heath and Conover (1981) recognized the existence of a “climatic river basin divide” in Florida that approximates a portion of the eastern Suwannee River basin boundary (Figure 2-15). Streams north and west of the climatic divide exhibit high flows in the late winter/early spring, with low flows in the late Spring and Fall. Streams south of the climatic divide exhibit high flows in the late Summer/Fall, with low flows in the Spring. Streams lying along the climatic divide tend to exhibit a mix of both of these patterns (a “bimodal” pattern of floods in the Spring and Fall). More recently, Kelly (2004) reconfirmed these hydrologic patterns in streams in Florida, which he termed the “northern river” pattern (spring flooding), the “southern river” pattern (fall flooding), and the “bimodal” pattern (both Spring and Fall flooding).

These temporal flow patterns are driven in part by climatic characteristics. The Econfina watershed lies in the transitional climatic area between the warm, temperate climate of the southeastern U.S. and the subtropical climate of the Florida peninsula. Higher, late winter/early spring rainfall and lower evapotranspiration (ET) in the northern part of the state drives the spring flooding. In contrast, high summer rainfall in combination with tropical weather events creates the southern river flooding pattern in peninsular Florida (Kelly 2004). Rivers that fall in the transitional area often reflect a bimodal pattern with characteristics of both the warm, temperate climate of the southeastern U.S. and the subtropical climate of the Florida peninsula.

Figure 2-16 presents the mean monthly flows for the Econfina River near Perry (USGS 02326000) for the period of record 1950 through 2014.

2.1.6 WATER USE

The bulk of Taylor County’s consumptive water is drawn from near-surface limestone of the Floridan aquifer. The top of this aquifer locally corresponds to the top of the Suwannee Limestone that is 0 to 30 feet below the surface. Numerous shallow domestic wells draw freshwater from this component (FDEP 2006). The shallow sands and clayey sands commonly contain freshwater which is in hydrologic continuity with the underlying limestone of the Floridan aquifer. Domestic wells near the coast are typically drilled into the limestone to depths of 10 to 80 feet, though some deeper wells in excess of 100 feet reach the Ocala Limestone. Locally, the portion of the Floridan aquifer containing potable water may attain a thickness in excess of 500 feet.

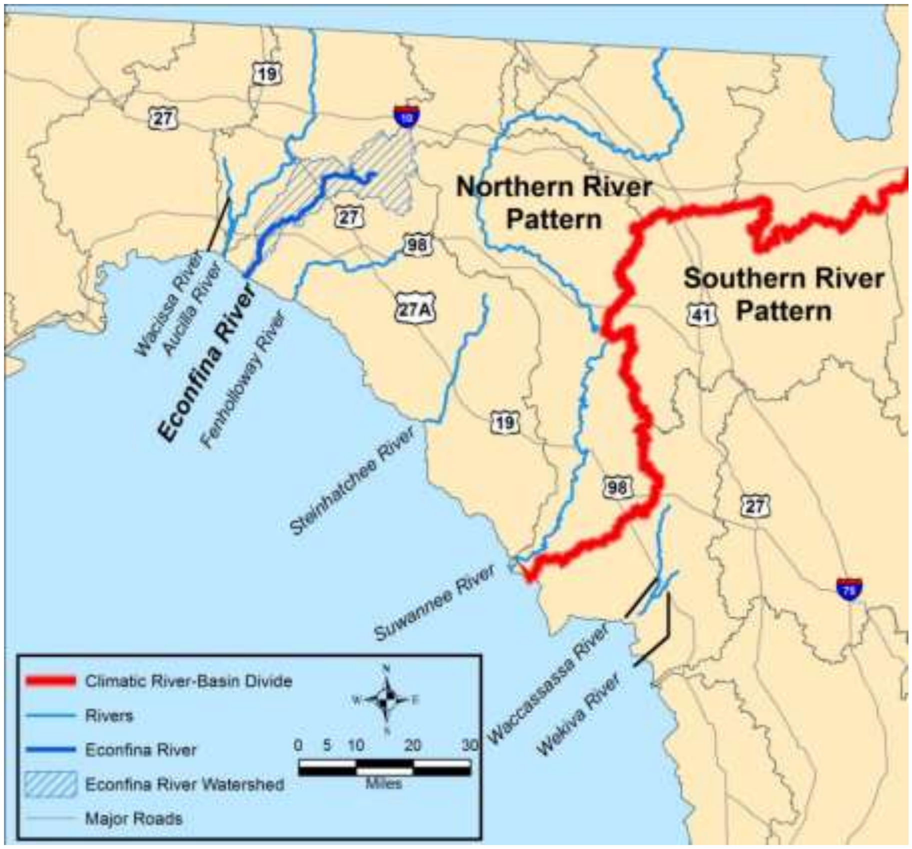

Figure 2-15. Climatic river-basin divide of Heath and Conover (1981). River pattern data from Kelly (2004).

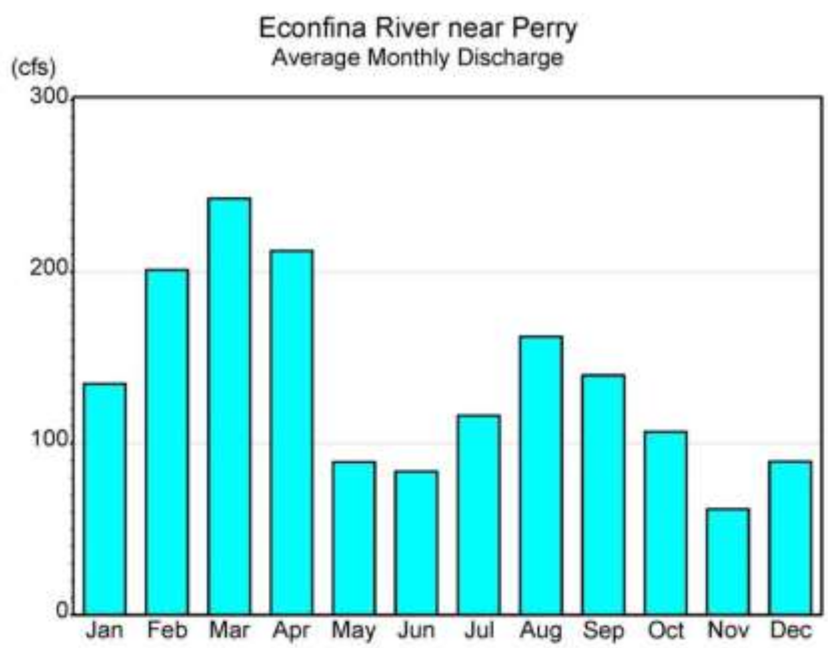

Figure 2-16. Mean monthly flows (cfs) for the Econfina River near Perry (USGS 02326000) for the period of record 1950 through 2014 by calendar month.

Figure 2-17 presents the locations of water use permits by section within the Econfina watershed. The total water use is relatively modest and totals 4.2 MGD.

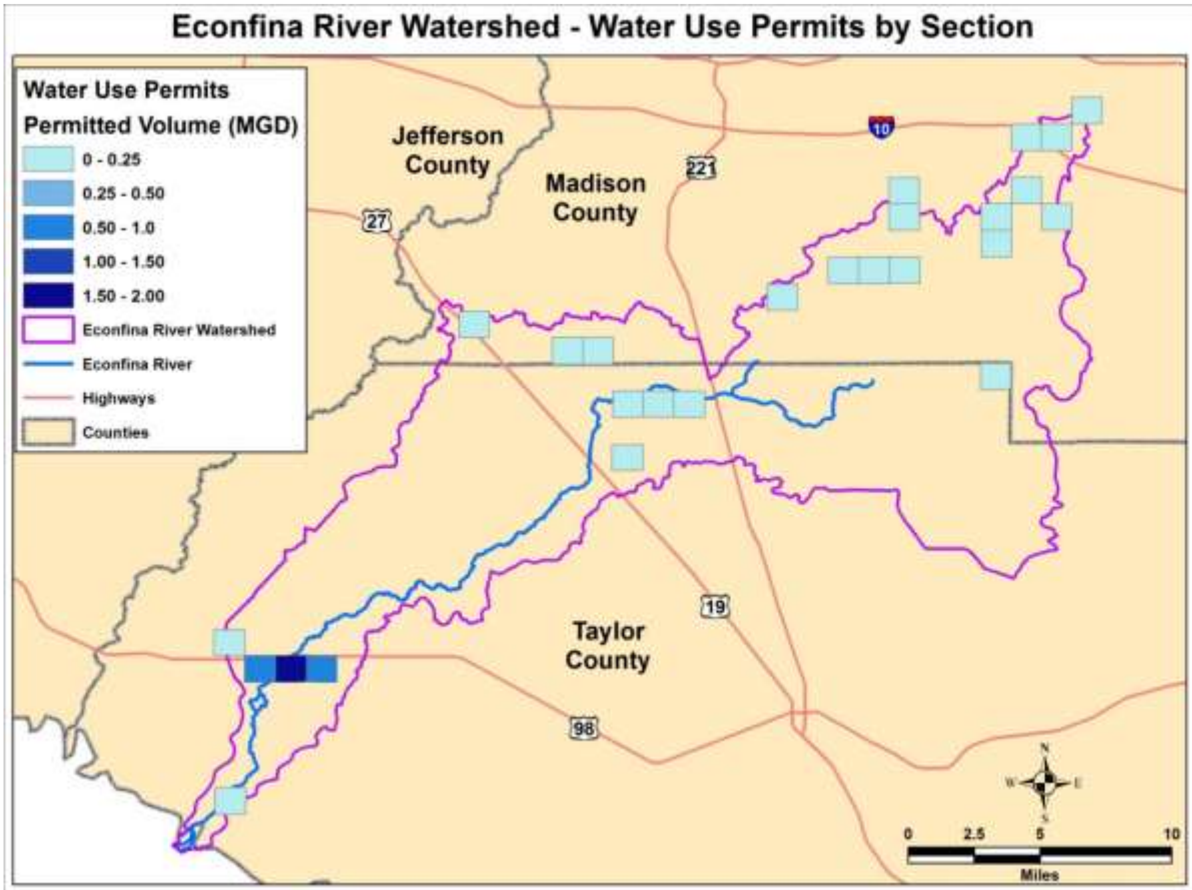

Figure 2-17. Water use permit locations by section within the Econfina River watershed.

2.1.7 ESTUARINE RIPARIAN HABITATS

Shoreline vegetative communities (including wetlands) are important components of riverine and estuarine systems. The river reach investigated for this report is limited by the available data. Much of the lower river is comprised by wetlands or other areas that are at least seasonally inundated (Figure 2-18) (FDEP 2006). An analysis of the land use/cover dataset made available by the SRWMD (SRWMD 2011) was conducted to identify the shoreline vegetation communities present along the Econfina River. Wetland communities are the dominant feature within a 50-ft buffer of the river. These were made up of wetland hardwood forests, vegetated non-forested wetlands, wetland forested mixed, and wetland coniferous forests.

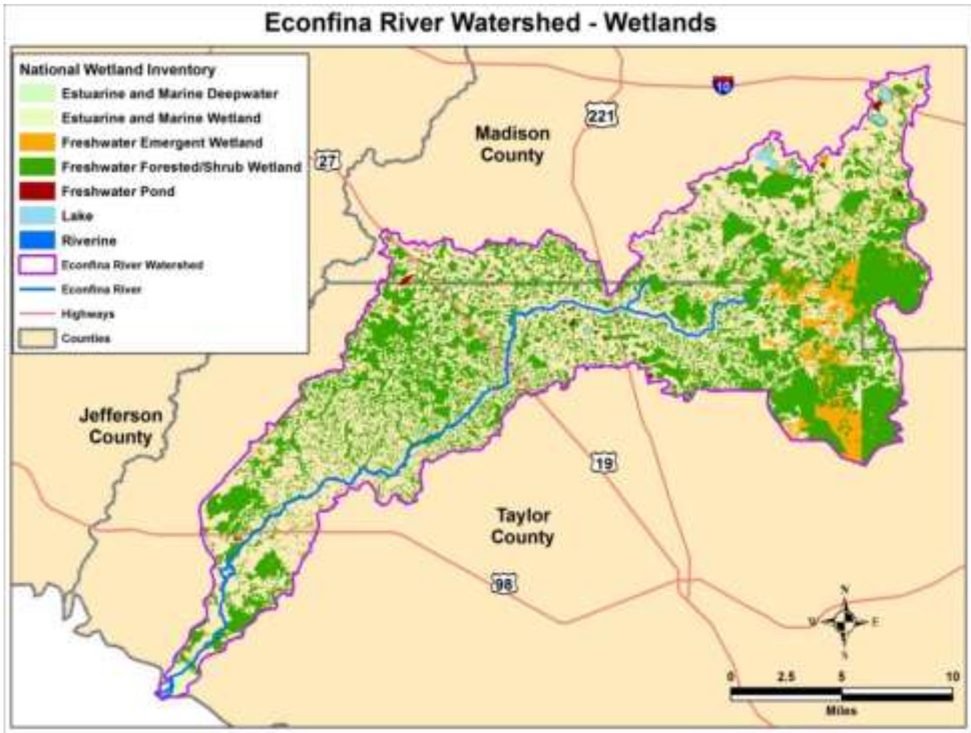

Figure 2-18. Wetlands within the Econfina River watershed. From National Wetland Inventory.

The salt marshes at the mouth of the Econfina River are dissected by numerous tidal creek branches and drainages from interior freshwater seepage areas (FDEP 2006). A coastal hydric hammock sub association has been described in the Unit Management Plan for the Econfina River State Park (FDEP 2006). This sub association can be found on scattered islands within the tidal marsh, and on a low chain of discrete, slightly elevated islands along an ecotone that separates the high salt marsh from interior plant communities. This sub association is regularly influenced by Gulf waters. The coastal islands, within the tidal marsh, generally consist of an outer vegetative ring of cabbage palm (*Sabal palmetto*), red cedar (*Juniperus virginiana*), and Christmas berry (*Lycium carolinianum*) which is the more heavily marine-influenced hammock portion of the islands. The center of an island may consist of wet mesic flatwoods (slash pine-saw palmetto) or an oak-dominated xeric hammock community.

The estuarine tidal marsh at the mouth of the Econfina River (Figure 2-19) is similar to much of the fringing marshes that are found from Wakulla County southward through Pasco County. This community may be one of the most extensive marshes in the United States (FDEP 2006). These areas are extremely important habitat for numerous wildlife. The marsh also acts as a buffer and filter at the land/sea interface, protecting the nearshore area. Some common flora in this area include black needlerush, saltgrass, cordgrass, marsh elder, sea oxeye, marsh fleabane, perennial glasswort, saltbush and Christmas berry (FDEP 2006).

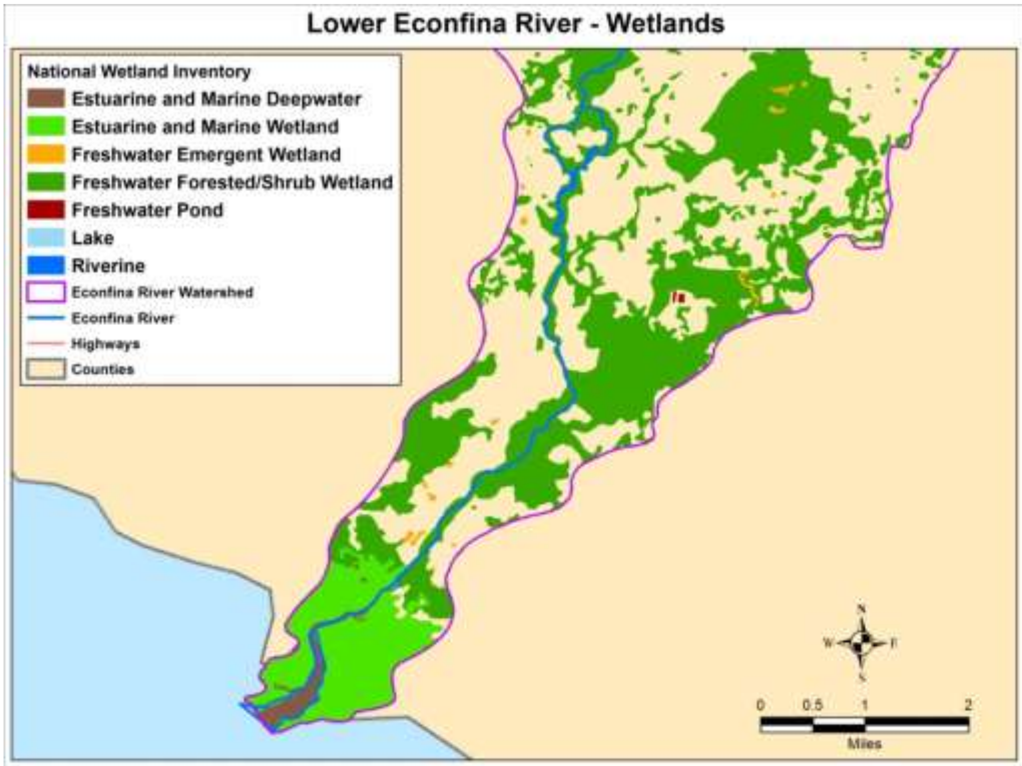

Figure 2-19. Wetlands within the lower Econfina River. From National Wetland Inventory.

2.1.8 COASTAL AQUATIC BIOTA

Flow can affect both the water quality and biology of a river system. For this study, relationships between flow, water quality, fish, and macroinvertebrates were considered. Freshwater flow affects water quality variables, including both concentrations and loadings. The magnitude and timing of freshwater inflows affects the amount of nutrients and organic matter that enters a waterway and the subsequent effects on the productivity of the waterbody.

Freshwater flow can affect aquatic biota either directly (physical factors), or indirectly (by affecting salinity or other environmental parameters). Depending upon flow regime, in terms of both volume and velocity, available habitat for a given species may be altered. In estuarine and coastal habitats, alterations to the salinity regime (e.g., timing and magnitude of change) will also affect the types and numbers of species that occur.

Tsou and Matheson (2002) analyzed four years of juvenile fish data collected in the Florida Marine Research Institute's (FWRI) Fisheries Independent Monitoring (FIM) Program in the Suwannee estuary and found that tidal creeks were an important explanatory variable accounting for the distribution and abundance of several important "FWRI selected taxa". These included important forage species such as spot (*Leiostomus xanthurus*), pinfish (*Lagodon rhomboides*), silversides (*Menidia* spp.) and mojarras (*Eucinostomus* spp.); juvenile sportfish including redfish (*Sciaenops ocellatus*) and spotted seatrout (*Cynoscion nebulosus*); and commercial taxa including blue crab (*Callinectes sapidus*), pink shrimp (*Farfantepenaeus duorarum*), and mullet (*Mugil cephalus*). They attributed one of the main habitat values of tidal creeks to be the associated areas of reduced salinity. Thus, a suitable regime of fresh-water inflows to the Suwannee estuary is necessary to maintain the fishery habitat values of tidal creeks.

Fisheries data have been collected by the Florida Fish and Wildlife Commission (FWC) FIM Program since 2008 and the sampling stations in the area nearest the Econfina River are shown in Figure 2-20. The fisheries data from these stations were analyzed to identify the most abundant (total number of a species in the sample, Table 2-3) and most commonly found number of samples where a fish species occurs (Table 2-4) .

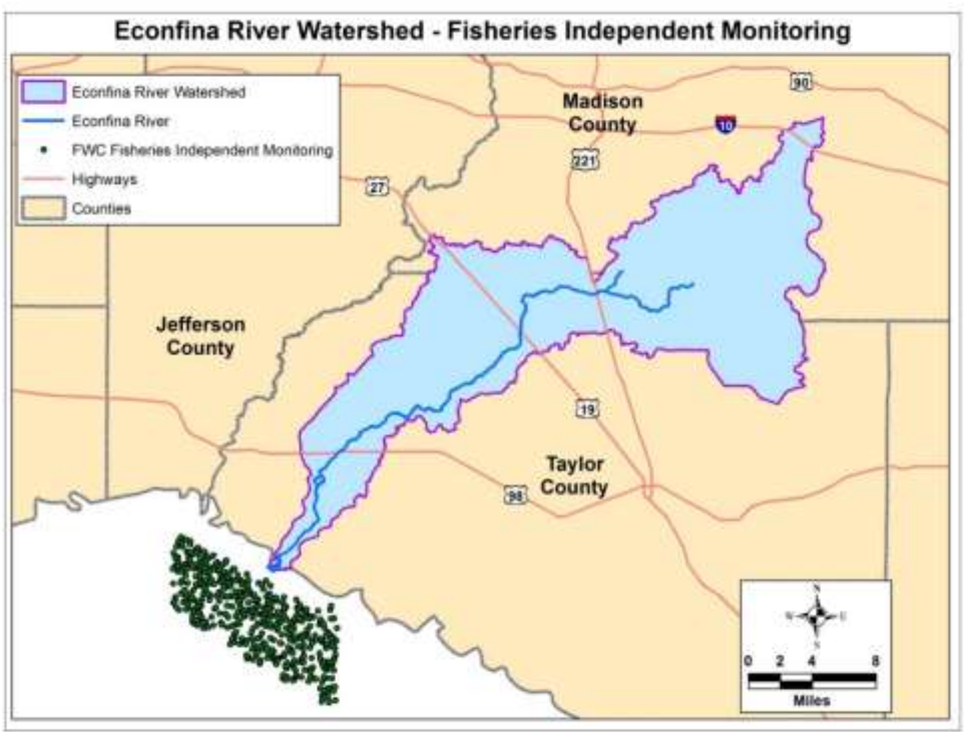

Figure 2-20. Locations of the FIM fish sampling stations near the mouth of the Econfina River.

Pinfish (*Lagodon rhomboides*) was the most abundant (Table 2-3) and commonly found (Table 2-4) species captured by the FIM program. Other abundant and commonly found fish species included Black Sea Bass (*Centropristis striata)*, Pigfish (*Orthopristis chrysoptera)*, and Spottail Pinfish (*Diplodus holbrookii)*,

Table 2-3. Ten most abundant fish species collected by the FIM program from stations identified in Figure 2-20.

Scientific Name	Common Name	Total Number	Rank
Lagodon rhomboides	Pinfish	25016	1
Orthopristis chrysoptera	Pigfish	4044	2
Diplodus holbrookii	Spottail Pinfish	3439	3
Centropristis striata	Black Sea Bass	3114	4
Bairdiella chrysoura	Silver Perch	2418	5
Syngnathus floridae	Dusky Pipefish	2222	6
Monacanthus ciliatus	Fringed Filefish	1458	7
Anchoa mitchilli	Bay Anchovy	1142	8
Stephanolepis hispidus	Planehead Filefish	1041	9
Haemulon plumierii	White Grunt	1031	10

Table 2-4. Ten most commonly found fish species collected by the FIM program from stations identified in Figure 2-20.

Scientific Name	Common Name	# of Samples	Rank
Lagodon rhomboides	Pinfish	435	1
Centropristis striata	Black Sea Bass	386	2
Syngnathus floridae	Dusky Pipefish	347	3
Orthopristis chrysoptera	Pigfish	334	4
Bairdiella chrysoura	Silver Perch	297	5
Monacanthus ciliatus	Fringed Filefish	259	6
Diplodus holbrookii	Spottail Pinfish	255	7
Opsanus beta	Gulf Toadfish	252	8
Stephanolepis hispidus	Planehead Filefish	243	9
Haemulon plumierii	White Grunt	230	10

The only benthic invertebrate data specific to the Econfina River are qualitative in nature. These samples were collected over the 1999 through 2010 period using dipnets (SRWMD data).

In a series of papers and reports produced by Robert Livingston of Florida State University, the area of Apalachee Bay near the mouth of the Econfina River was compared to the area near the mouth of the Fenholloway River. Greening and Livingston (1982) found that crustaceans comprised 63 percent of those species representing at least 1 percent of the total number of individuals collected with mollusks and echinoderms contributing 30-percent and 7 percent, respectively.

Janicki Environmental (2007) examined the benthic invertebrate communities of a series of rivers from the Springs Coast to Charlotte Harbor along the Gulf Coast. Macroinvertebrate communities were described using metrics including taxon distribution, taxon abundance, prey group taxa abundance, community composition, community diversity and community richness. Analysis of benthic community structure was then used to understand the general geographical differences in benthic communities among rivers. The most abundant and commonly found taxa across all rivers included three amphipod crustaceans and a polychaete - *Grandidierella bonnieroides*, *Ampelisca abdita*, *Apocorophium louisianum,* and *Streblospio gynobranchiata.* The Springs Coast rivers had the most unique dominants (16), even though the fewest samples were collected from these rivers. Ten of these 16 were crustaceans, including four amphipods.

Two bivalves, bay scallops and oysters, are major components of the benthic communities along much of the Florida Gulf Coast including near the mouth of the Econfina River. The bay scallop (*Argopecten irradians*) is commonly found throughout much of the Florida Gulf Coast (Figure 2-21). Bay scallops typically are found in seagrass beds and have a peak spawning period in the fall (Arnold 2009). Laboratory studies suggest that either high (> 30 ppt) or low (<20 ppt) salinity can result in mortality with an apparent optimal salinity of approximately 24 ppt (Tettlebach and Rhoads 1981).

Oysters compose a significant component of the estuarine ecosystem near the mouth of the Econfina River. Oysters have often been used as indicator organisms, given their sessile nature and propensity to bio-accumulate toxic substances. Oysters are also recognized for their economic value. Oysters and other estuarine biota can be found in habitats that vary widely in their salinity. Their populations often benefit from the typical seasonal variation in salinity as their spatial distributions also follow these typical salinity patterns.

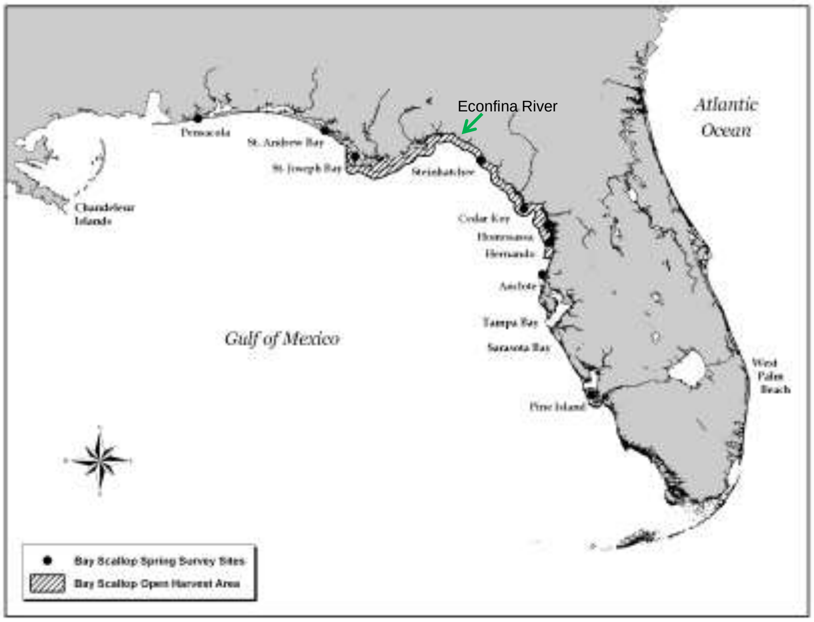

Figure 2-21. Bay scallop open harvest areas on Florida's Gulf Coast. From Arnold (2009).

Perhaps the most extensive oyster beds can be found in the Suwannee Sound and in adjacent tidal creek areas north and south of the river; the principal habitat that provides "structure" is oyster reefs and bars. These are composed primarily of the eastern oyster (*Crassostrea virginica*), with two species of mussels (*Brachidontes* spp. and/or *Ischadium recurvum*) being secondary members of the reefs. The oysters themselves are a harvestable economic resource. Oyster landings from Dixie and Levy counties (which primarily reflect harvest in the Suwannee estuary) in 2001 were 78,000 lbs, and average 50,000-100,000 lbs annually (FWC website; www.florida conservation.org), making the Suwannee estuary the second largest oyster producing area in the state, after Apalachicola Bay.

Oyster habitat suitability has been the subject of many past research projects. Barnes et al., (2007) presented a habitat suitability index model for the Eastern oyster (*Crassostrea virginica*). They conducted a literature review to obtain information regarding salinity tolerances and preferences for the Eastern oyster and reported the following:

- Oyster larvae
  - Salinity limits – 5 ppt to 35 ppt
  - Optimal salinity- 10 ppt to 30 ppt
  - Peak – 20 ppt to 22 ppt; settlement peak - 25 ppt to 29 ppt
- Oyster adult
  - Optimal salinity- 10 ppt to 20 ppt
  - Normal range – 10 ppt to 30 ppt.

In addition to their economic importance, perhaps even more important, is the value of oyster habitats for estuarine invertebrates and fishes (Bahr and Lanier 1981). A recent study (Glancy 2000) found that oyster habitats in the Crystal River area supported significantly higher biomass and density of decapod crustaceans (primarily various crabs) than seagrass or marsh edge habitats. He interpreted this result to indicate that "...oyster makes a potentially important contribution to estuarine systems by supporting large abundances of a distinct assemblage of decapod crustaceans." (Glancy 2000). This contribution constitutes an important food base for highly sought recreational species such as red drum, black drum, and sheepshead (Pattillo et al. 1997). Biodiversity of oyster-associated fauna is relatively high. Mote Marine Laboratory (1986) collected a total of 248 taxa of oyster reef-associated benthic invertebrates in estuaries in the southern Big Bend region of Florida (Levy to Pasco counties). Bass and Guillory (1979) found a distinct assemblage of oyster reef-associated fish in the Withlacoochee River estuary dominated by benthic species, such as gobies, toadfish, and blennies.

2.1.9 WATER QUALITY

Water quality within the Econfina River has been monitored by the District at three stations (Figure 2-22): ECN005C1, ECN010C1, and ECN015C1. The following describes the spatial and temporal variation in a number of water quality constituents that have been monitored.

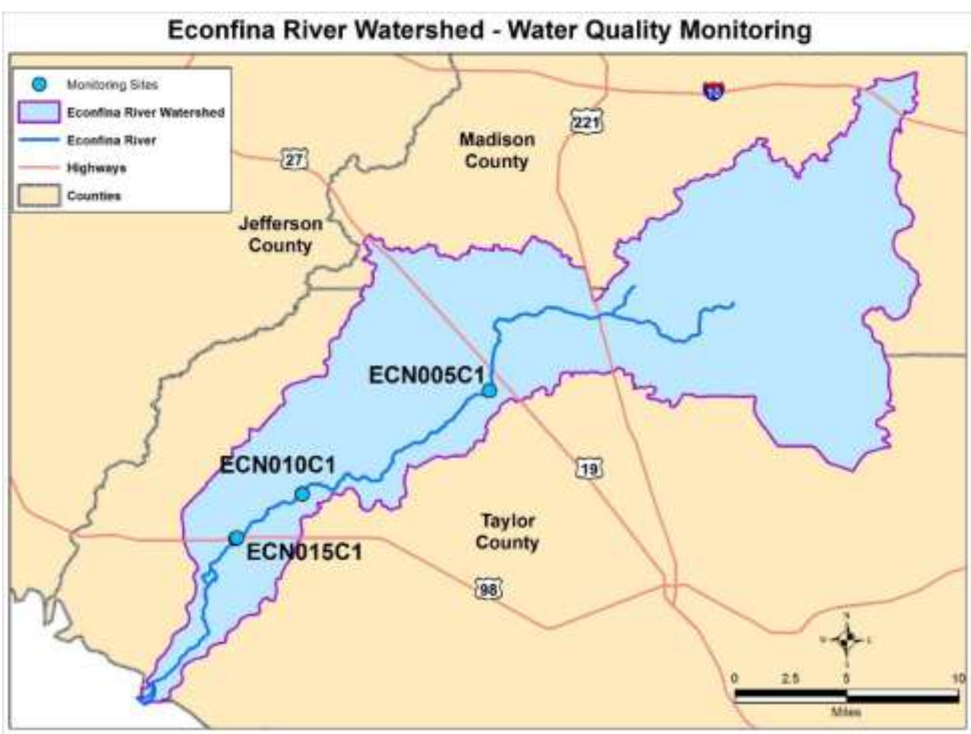

Figure 2-22. Water quality sampling stations on the Econfina River.

- Water Temperature – Figure 2-23 presents the water temperature data for the three District monitoring stations on the Econfina River. The period of record for ECN005C1, and ECN015C1 was October 1994 through July 1999. The period of record for ECN010C1 was February 1989 through September 2010. The median temperature was 20.6°C at the upper two stations and slightly higher at the most downstream station at 21.6°C. A similar pattern was found for the lower (10^{th} percentile) temperatures. There is no apparent temporal trend in the observed water temperatures.
- Conductivity – Figure 2-24 presents the conductivity data for the three District monitoring stations on the Econfina River. The periods of record were the same as for water temperature. The median conductivity of the most upstream station was relatively low (58 µmhos), indicating that tidal influences are minimal this far upstream. The conductivity at the two lower stations was higher and more variable than the upstream station with median values in excess of 200 µmhos as a result of greater tidal influence in this portion of the river. There is no apparent temporal trend in the observed conductivity.
- Water Color – Figure 2-25 presents the color data for the three District monitoring stations on the Econfina River. The periods of record were the same as for water temperature. Color is an indicator of the relative effects of decomposing organic carbon, often of allochthonous origins. Drainage from wetlands can often be detected by increasing color. The observed color at all three stations were relatively high with median values ranging from 375 PtCo units to approximately 330 PtCo units from upstream to downstream on the Econfina River. There is no apparent temporal trend in the observed water color. The observed variability in the color data is likely related to seasonal variation in river flow,
- Dissolved Oxygen – Figure 2-26 presents the dissolved oxygen (DO) data for the three District monitoring stations on the Econfina River. The periods of record were the same as for water temperature. There was very little difference in the DO observed at the three stations. The median values were approximately 5 mg/L with low DO (10^{th} percentile) values of approximately 4.0 mg/L. There is no apparent temporal trend in the observed DO conditions.
- Total Nitrogen – Figure 2-27 presents the total nitrogen (TN) data for the three District monitoring stations on the Econfina River. The periods of record were the

same as for water temperature. The TN concentrations displayed a clear upstream to downstream gradient, The mean (1.24 mg/L) and median (1.12 mg/L) at the upstream station was greater than both the mean and median concentrations at the middle station (mean and median=0.97 mg/L) and in the downstream station (mean and median=0.88 mg/L). This spatial variation is often found in tidal rivers where upstream nutrient loading is diluted as the upstream water mixes with estuarine water that typically has relatively low TN concentrations. There is no apparent temporal trend in the observed TN concentrations.

- Total Phosphorus – Figure 2-28 presents the total phosphorus (TP) data for the three District monitoring stations on the Econfina River. The periods of record were the same as for water temperature. The TP concentrations varied widely over time at both the upstream and downstream stations. The time series of TP concentrations at the middle station suggests an appreciable reduction from the range of 0.06 to 0.27 mg/L observed from 1980-1990 to the range of 0.01 to 0.22 mg/L observed since 1990. Spatially, the TP concentrations tended to be greater at the downstream stations.

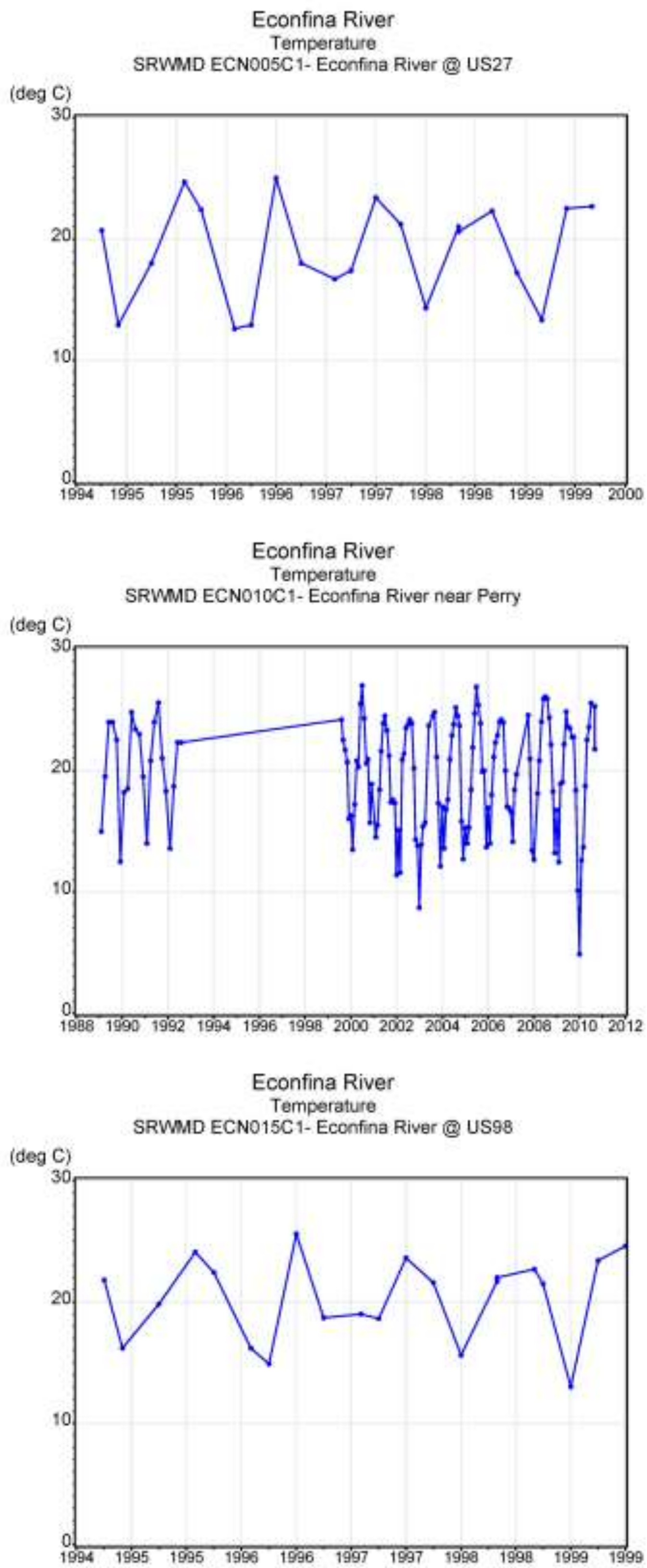

Figure 2-23. Time series of water temperatures from three stations on the Econfina River. There are no data at Station ECN015C1 from 1992 through 1999.

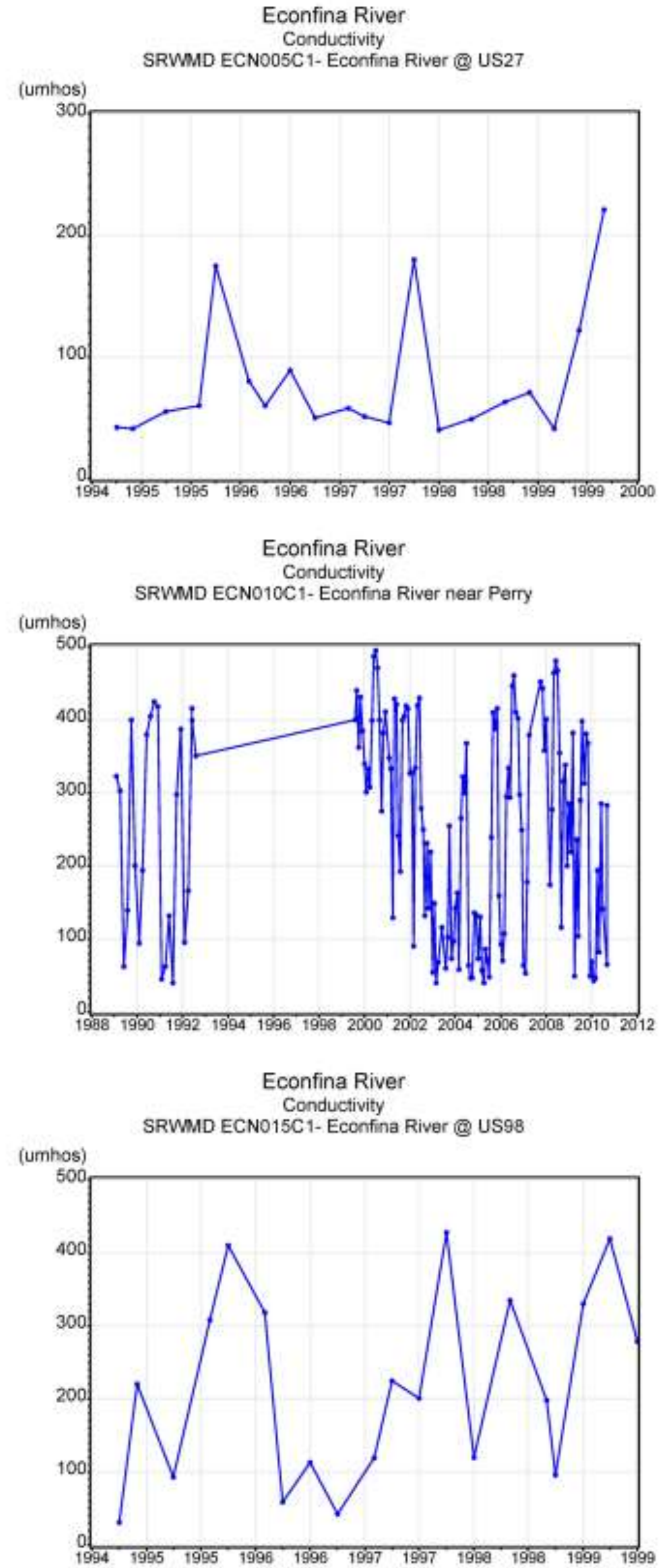

Figure 2-24. Time series of conductivity from three stations on the Econfina River. There are no data at Station ECN015C1 from 1992 through 1999.

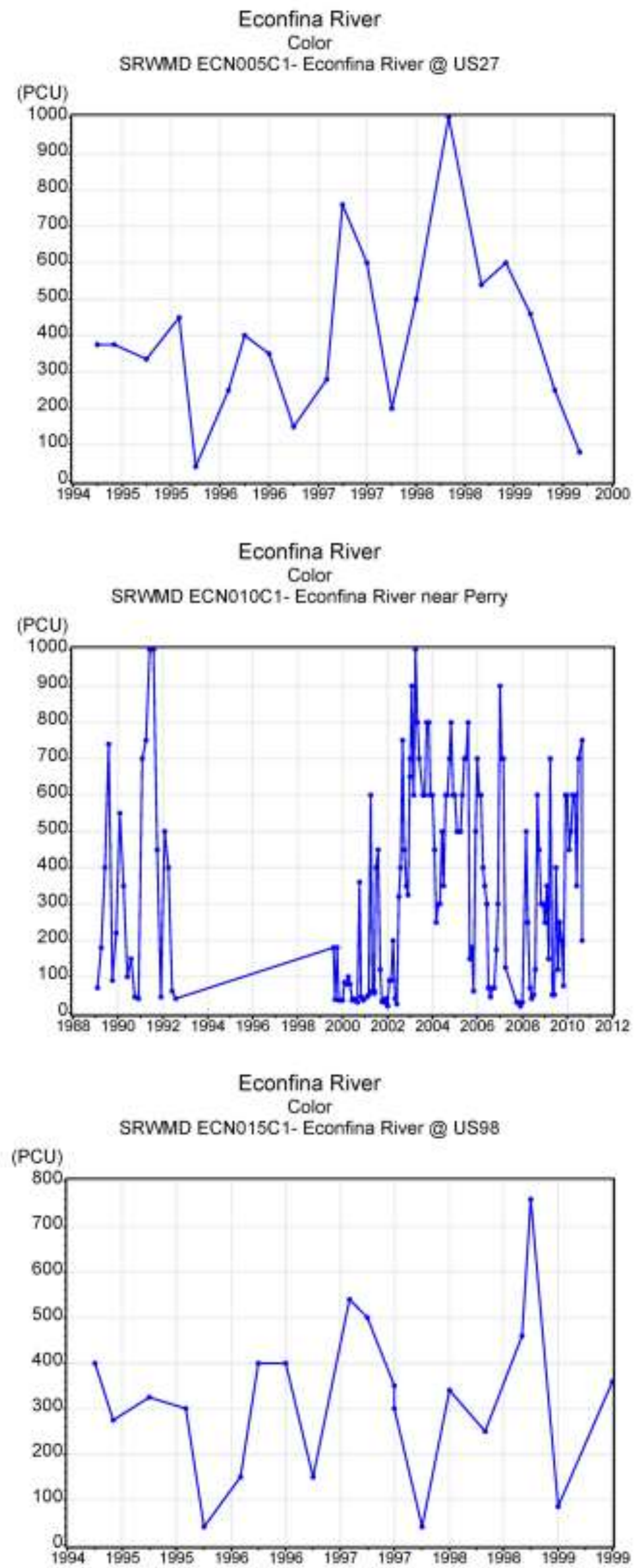

Figure 2-25. Time series of color from three stations on the Econfina River. There are no data at Station ECN015C1 from 1992 through 1999.

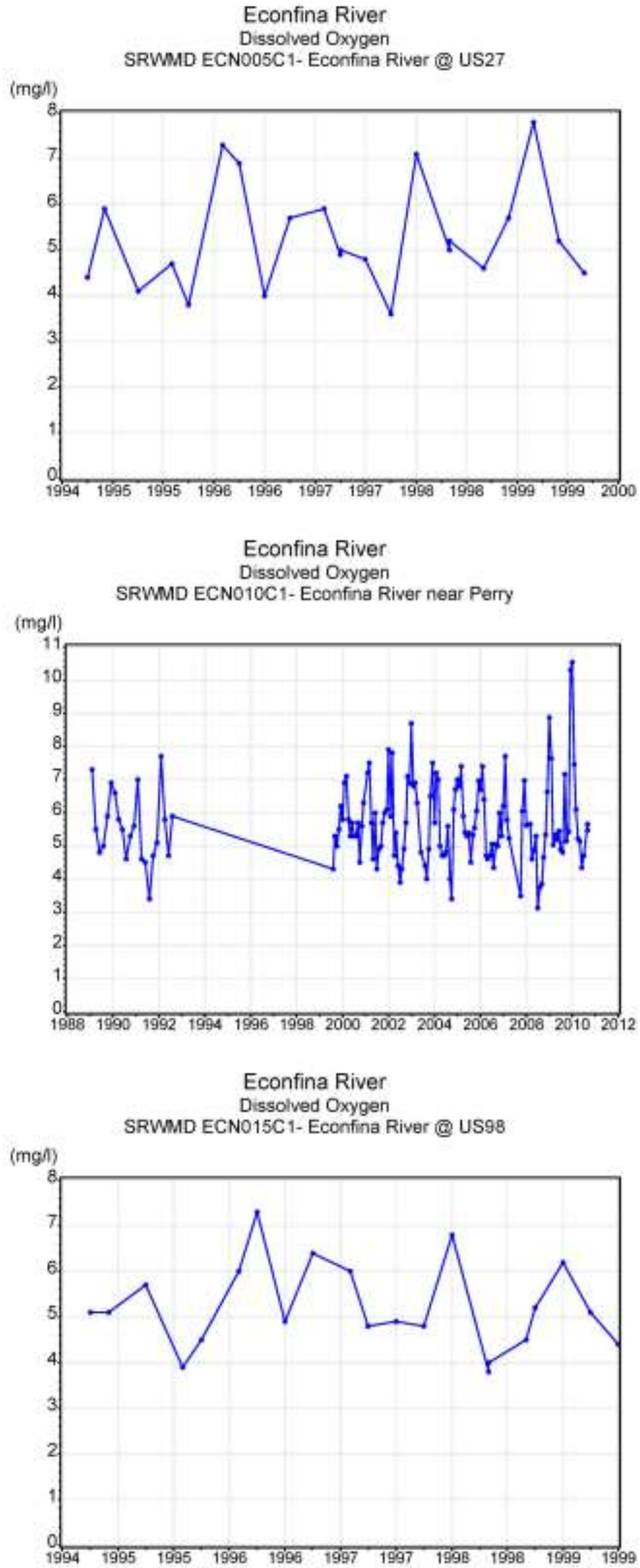

Figure 2-26. Time series of DO from three stations on the Econfina River. There are no data at Station ECN015C1 from 1992 through 1999.

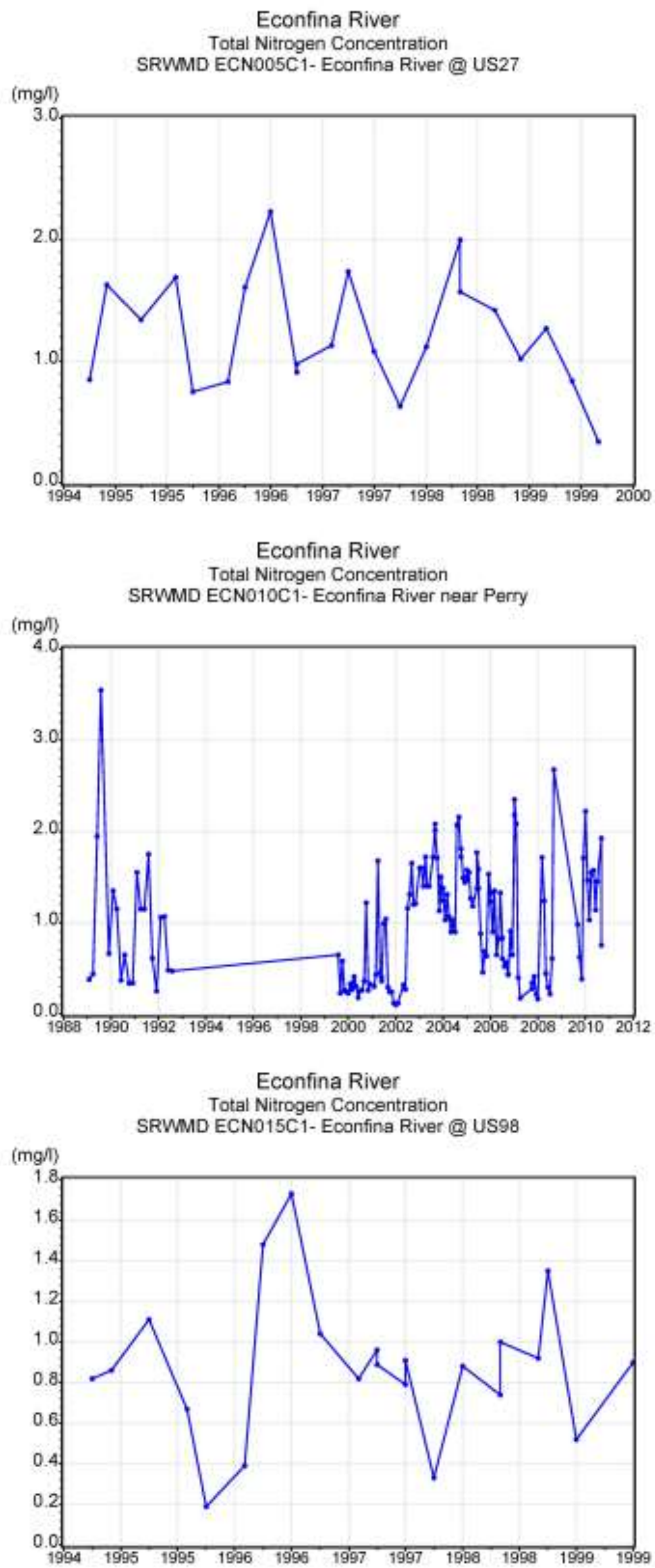

Figure 2-27. Time series of TN from three stations on the Econfina River. There are no data at Station ECN015C1 from 1992 through 1999.

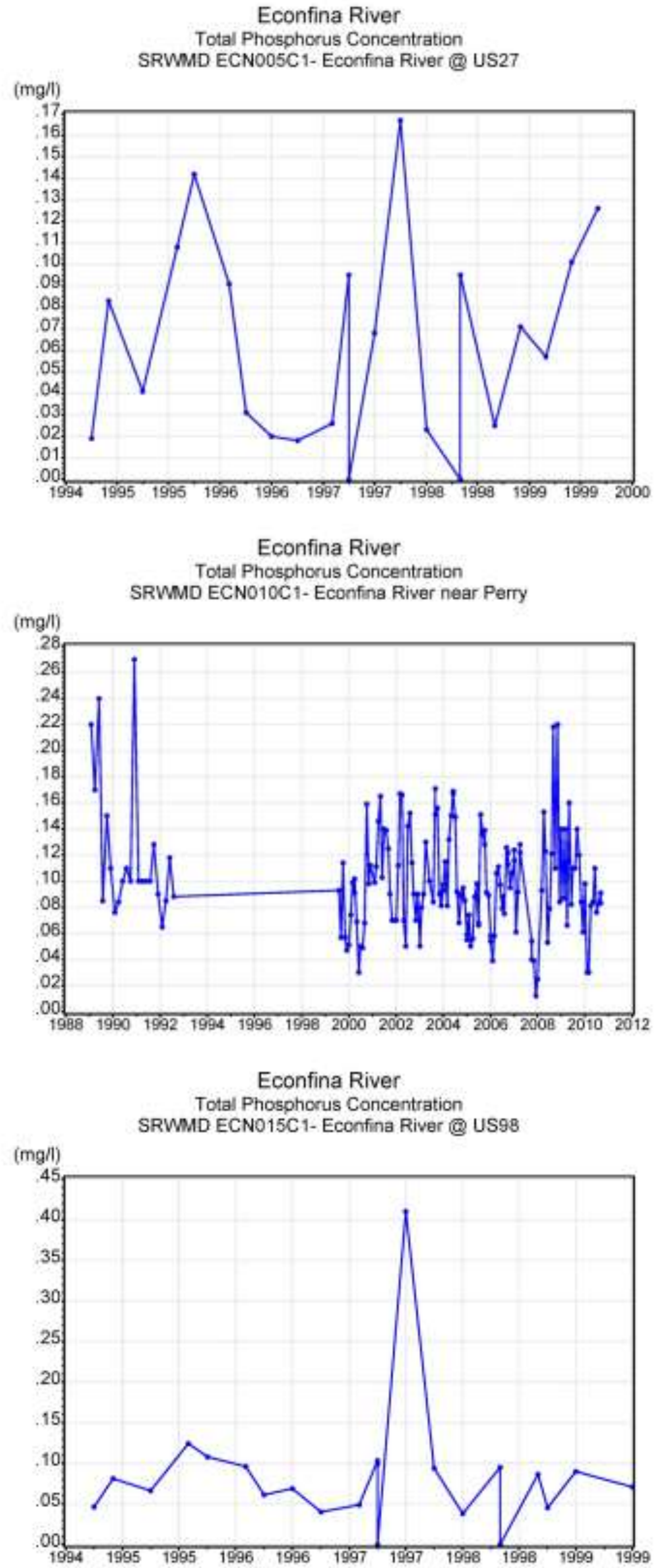

Figure 2-28. Time series of TP from three stations on the Econfina River. There are no data at Station ECN015C1 from 1992 through 1999.

3.0 CONCEPTUAL MODEL AND APPROACH TO MFL ESTABLISHMENT

To be an effective water resource management tool, the establishment of MFLs must consider protection of the entire flow regime and not strictly low flow conditions. Thus, in some ways the term “minimum flow and level” may be a misnomer.

The importance of protecting the full flow regime has been recognized by others and is reflected in multiple MFLs being set for various waterbodies. This became most apparent in cases where inline reservoirs could significantly affect both the low flow and high flow extremes. Richter et al. (1996) concluded that both intra- and inter-annual variations in flow should be protected, thus, mimicking the natural flow regime. Postel and Richter (2003) also emphasized the critical nature of flood events in terms of both frequency and duration.

Stalnaker (1990) discussed the influence of flows on physical processes (e.g., sediment transport, channel formation) which, in turn, affect biological resources. This linkage was also apparent to Hill et al. (1991) who identified four types of flows that should be considered when examining river flow requirements, both for in-stream and out-of-bank floodplain habitat:

- Flood flows that determine the boundaries and shape of floodplain and valley features;
- Overbank flows that maintain riparian habitats;
- In-channel flows that keep immediate streambanks and channels functioning; and
- In-stream flows that meet critical biota requirements.

Therefore, establishment of MFLs considers more than the species-specific needs of any particular taxon. Rather, broad ecological functions are included. As discussed in Section 1.0, the State Water Resources Implementation Rule regarding MFLs (Chapter 62-40.473, F.A.C.) indicates that “...consideration shall be given natural seasonal fluctuations in water flows or levels, non-consumptive uses, and environmental values associated with coastal, estuarine, aquatic, and wetlands ecology...” These environmental and water resource values (WRVs) include:

- Recreation in and on the water,
- Fish and wildlife habitats and the passage of fish,

- Estuarine resources,
- Transfer of detrital material,
- Maintenance of freshwater storage and supply,
- Aesthetic and scenic attributes,
- Filtration and absorption of nutrients and other pollutants,
- Sediment loads,
- Water quality, and
- Navigation.

The following section discusses each of these WRVs.

3.1 CONCEPTUAL MODEL FOR MFLS

The conceptual model utilized in the development of the MFLs for the Econfina River was envisioned by recognizing the physical setting of the river’s in-channel and floodplain habitats and the specific locations of the available river flow data (i.e., USGS 02326000). Therefore, the intersection of these two elements, i.e., the physical setting of the river and the available flow data, became the framework for the conceptual model (Figure 3-1). Thus, the relationships between flows and various aspects of habitat suitability/availability are the basis for the MFL development approach.

In addition to the physical setting of the waterbodies of concern, an understanding of hydrologic characteristics is essential. Thus, there is an apparent need for a tool that allows comparison of different flow regimes. Flow Duration Curves (FDCs) are a convenient tool for visualization, simplification, and comparison of streamflow data. Searcy (1959, pp. 1-2) notes the curves are cumulative frequency curves “combining in one curve the flow characteristics of a stream throughout the range of discharge.” Flow duration curves have had “wide-spread application” and a “long history” in a variety of hydrologic studies including in-stream flow assessments (Vogel & Fennessey 1995, p. 1029). They show the percent of time specified discharges were equaled or exceeded for a continuous record in a given period. For example, during the period 1950 to 2014, the daily mean flow of the Econfina River near Perry (Figure 3-2) was at least 16 cfs, 90 percent of the time. This curve is influenced by the period of record used in their creation (Vogel & Fennessey 1994, p. 495), but for comparison purposes between different scenarios over a fixed time period they are extremely useful.

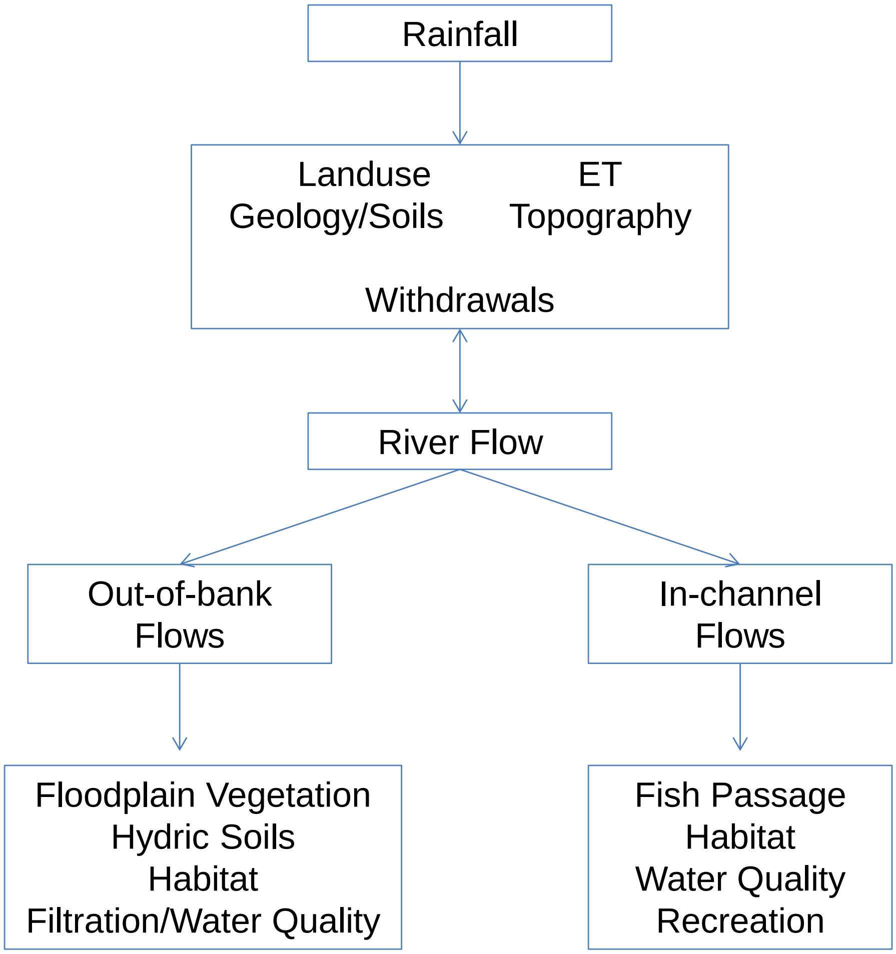

Figure 3-1. Conceptual model of the relationships between river flow with the physical and biological features of rivers.

The vertical axis of an FDC is the streamflow rate in cfs and the horizontal axis is the exceedance probability expressed as a decimal. As can be observed in Figure 3-2, FDCs are constructed by sorting all of the daily data, from highest to lowest and assigning probability. The highest flow in the record corresponds to the lowest exceedance probability flow; the lowest flow in the record corresponds to the highest exceedance probability flow. The exceedance probability commonly used (and used here) is the Weibull plotting position (Jacobs & Ripo, 2001).

Flows and/or exceedance probabilities of interest can be plotted “on top” of the FDC. For example, the magnitude of a spring is of common interest to the public and is used in MFL priority list development. An exceedance probability of 0.5 (the median) is used to determine spring magnitude (Florida Geological Survey 2005).

Given the characteristics of the rivers and the available flow data, the Econfina River MFL has been developed at the USGS gage near Perry (Station Number 02326000). These data are combined with the WRV information described in the next section to arrive at the final MFL specification.

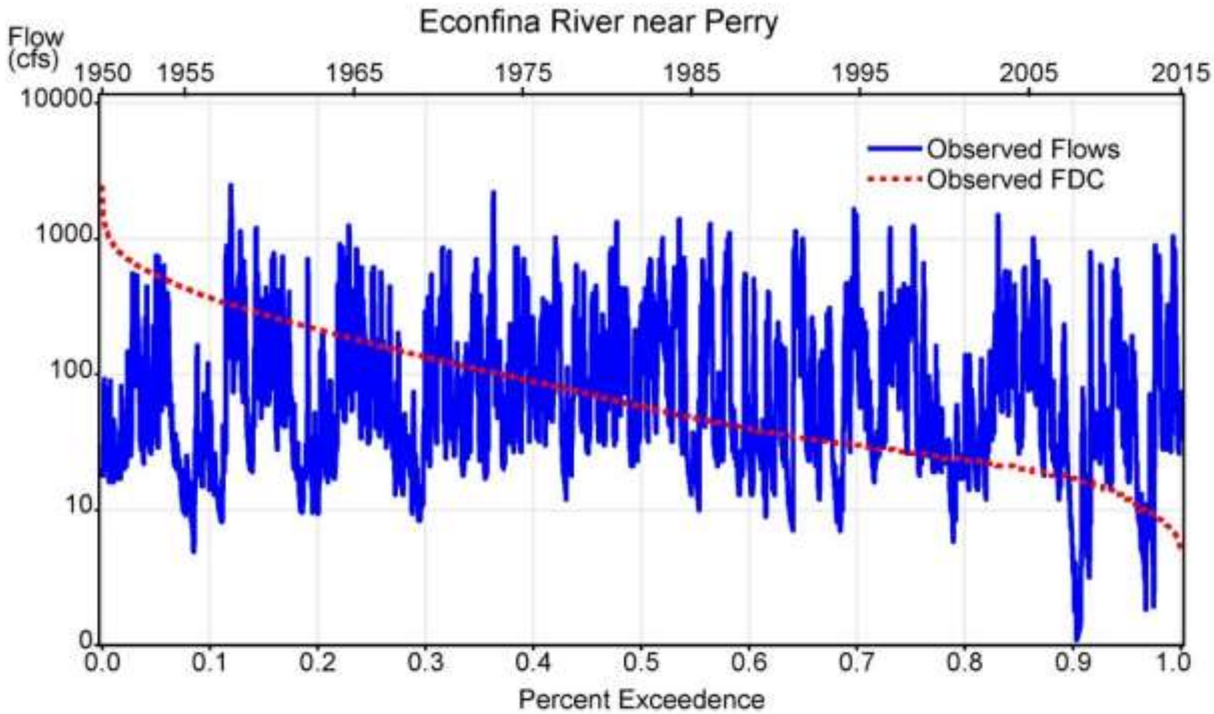

Figure 3-2. Comparison of hydrograph of the Econfina River near Perry with its flow duration curve (FDC).

3.2 WATER RESOURCE VALUES CONSIDERED IN THE ESTABLISHMENT OF MFLS

The following sections discuss the ten WRVs for the Econfina River.

3.2.1 RECREATION IN AND ON THE WATER (WRV 1)

Recreation is an important use of the Econfina River. Econfina River State Park allows users to enjoy a multitude of activities such as boating or kayaking, fishing, hiking, and visiting prehistoric archaeological sites. Recreation is in fact the designed single use of the park, which was acquired in 1998 (FDEP 2006). Also located along the river is the Lower Econfina River Wildlife Management Area (WMA). The WMA allows fishing and paddling, as well as horseback riding and hiking in the floodplain forests, swamps, bottomland forests, pine plantation and mixed hardwood forests that it encompasses. Recreational use of the freshwater portion of the river and associated lands is at greater risk from flow reduction than the tidally-controlled estuary.

3.2.2 FISH AND WILDLIFE HABITATS AND THE PASSAGE OF FISH (WRV 2)

Freshwater fish and wildlife are important factors in the Econfina River's appeal to the public. Instream fish habitat can be characterized by water depth, velocity, and suitable substrate, all three of which may be adversely affected by flow reduction. Freshwater fish passage also can be adversely affected by flow reductions as might occur during low-flow conditions.

While information regarding species that rely specifically on the Econfina River is not readily available, species within the state park include: Florida black bear, white-tailed deer, blue herons, egrets, bald eagle, marsh hawk, otter, bobcat, and manatee (FDEP 2006). Of particular interest is the manatee, which is listed as an endangered species by both the Federal government and the State of Florida. Manatees utilize the coastal rivers to escape from the cold water during winter as well as for foraging (Reid et al. 2011). In support of the development of minimum flows for Blue Springs, Rouhani et al. (2007) noted that prolonged exposure to water at 66-68°F may be extremely detrimental to Florida manatee populations.

The substantial work of Light et.al. (2002) on the lower Suwannee River regarding the hydroperiod and inundation frequencies required to maintain floodplain forests may be transferable to the Econfina River.

3.2.3 ESTUARINE RESOURCES (WRV 3)

Estuarine resources are the flora and fauna that inhabit brackish water with salinity between 0.5 and 30 parts per thousand (ppt). Salinity reflects a blend of freshwater with a saline (>30 ppt) source like the Gulf of Mexico. The salinity regime at a particular location is inversely proportional to freshwater flow such that higher salinity is associated with lower freshwater flow. In terms of spatial distribution, diminished freshwater flows can result in an isohaline movement up-river. This WRV is clearly associated with the use of the Econfina Estuary for recreational scalloping and fishing. In the estuarine portion of the river low salinity fauna may experience habitat loss due to increased salinity as freshwater inflow to the estuary is reduced by withdrawals. The biota typically found in the estuarine portion of the river will have relatively wide salinity tolerances. These can include vegetation, benthic organisms, and fishes. However, if salinity responses to changes in river flows result in salinity conditions outside their tolerances shifts in the distributions of the biota can be expected to occur.

3.2.4 TRANSFER OF DETRITAL MATERIAL (WRV 4)

Detrital material is a food source for detritivores that obtain nutrients by consuming decomposing plant and animal material. These primary consumers are crucial to benthic ecosystems. While flow reduction could reduce the downstream transfer of this organic energy, this WRV is concluded to be of less importance for the Econfina River than the three previously addressed WRVs, in addition there are no data available to assess this WRV.

3.2.5 MAINTENANCE OF FRESHWATER STORAGE AND SUPPLY (WRV 5)

Maintaining freshwater storage is a relevant WRV that involves the protection of an amount of freshwater supply for permitted users at the time of MFLs determination. The direct withdrawal of surface water or an indirect flow reduction associated with groundwater withdrawals will reduce streamflow to one degree or another. The fact that WRV 5 is at risk from flow reductions is evidenced by the State-wide regulation of water use and provisions for reviewing water use applications where MFLs have been established.

Freshwater storage associated with the Econfina is important, because the adjacent wetlands and marshes need water to maintain ecological health. The great majority of the Econfina State Park is a wetland wilderness. The park includes a high-quality salt marsh that is contiguous with the vast salt marsh community that extends as far south as Pasco County (FDEP 2006). The park also contains large expanses of hydric hammock and low lying, closed canopy hardwood forests that harbor a great many plant and animal species. With the reduction of flow, these habitats may be reduced in quality or size, or may no longer exist.

3.2.6 AESTHETIC AND SCENIC ATTRIBUTES (WRV 6)

Aesthetic and scenic attributes refers to features of a natural or modified waterscape usually associated with passive uses, such as sightseeing, hiking, photography, contemplation, and other forms of relaxation. As such it is closely linked to WRV 1. The Econfina River is relatively undisturbed (FDEP 2006) and less well-known than other, larger Florida rivers and therefore maintains much of its natural scenic beauty. Nevertheless, the aesthetic and scenic attributes of the Econfina River are less susceptible to adverse effects from flow reduction than the actual means of accessing the scenic locations, as the Econfina River is relatively shallow and narrow, compared to rivers that are more susceptible to having large shoreline lengths exposed during low flows. Generally, there is little quantitative information linking aesthetics and flow suitable for the establishment of MFL criteria.

3.2.7 FILTRATION AND ABSORPTION OF NUTRIENTS AND OTHER POLLUTANTS (WRV-7)

This WRV refers to the attenuation of nutrients and other pollutants through the process of filtration and absorption (i.e., removal of suspended and dissolved materials) as these substances move through the water column, soil or substrate, and associated organisms. These processes are different than assimilation, a process in which organic matter is integrated into living matter.

The Econfina often is used as a baseline or benchmark for the Fenholloway River (FDEP 2006). The Econfina River relies on the marshes and wetlands to filter out pollutants. The only impairment identified along the Econfina involved lead. This finding of impairment subsequently was delisted as it was concluded that the measured concentrations of lead reflect natural conditions.

3.2.8 SEDIMENT LOADS (WRV 8)

Sediment loads refer to the transport of inorganic material, suspended in water, which may settle or rise. A load, by definition, is the product of discharge and sediment concentration; thus, flow reductions would likely reduce sediment loads. The river bottom is largely composed of limerock and the smaller sediments are relatively less common.

3.2.9 WATER QUALITY (WRV 9)

Water quality refers to the chemical and physical properties of water not included in WRV 7. The Econfina has been used as a benchmark for the Fenholloway River, which has several listed impairments, because of the Econfina's superior water quality. There are no impairments within the Econfina planning unit (FDEP 2015). It is important to maintain the pristine water quality of the Econfina River so that this river can continue to serve as a benchmark for the Fenholloway River and other Florida rivers.

3.2.10 NAVIGATION (WRV 10)

While navigation is directly impacted by changes in flow, it is not a relevant WRV for the Econfina River because no commercial barges or other large commercial vessels utilize the river or estuary.

3.2.11 PRELIMINARY SCREENING AND IDENTIFICATION OF RELEVANT WRVS

A qualitative evaluation of risk and value was performed to identify WRVs most relevant to that system (HSW and Janicki Environmental 2015). This evaluation was based on review of available information and assessment of outcomes that potentially could result under a flow-reduction scenario. The ten WRVs were scored on a nine-point scale for relevance from low (1 point) to high (9 points) by considering the risk of adverse consequences attributable to a flow reduction, the intrinsic value of the WRV, and existence of legislated protection. A WRV that would be adversely impacted by a flow reduction is scored higher than one that would be impacted to a lesser degree or not at all. Intrinsic value is a measure of how essential the WRV is perceived to be to the public and water managers. The legislated protection factor is a measure of a WRV's perceived value as evidenced by special legislation that protects the water resource (§62-302.700, F.A.C.)

Based on a preliminary review of available information and data, three of the ten WRVs with total scores of 7 are deemed potentially relevant to the Econfina River MFL (Table 3-1). These highest-ranked WRVs include Fish/Wildlife Habitat and Fish Passage, Estuarine Resources, and Water Quality (7 points each), followed by Recreation and Freshwater Storage (6 points each). The lowest ranked WRVs scored 5 points or less.

Table 3-1. Econfina River water resource values screening summary. [Scoring factors for relevance are 0 for not applicable, 1 for low, 2 for medium, and 3 for high]. From HSW, Inc. and Janicki Environmental (2015).

		Scoring for Relevance			
WRV#	Water Resource Value	Function Risk to Flow Reduction	Overall Intrinsic Value	Legislated Environmental Protection	Total Score
1	Recreation in/on water	2	2	2	6
2	Fish/wildlife habitat and fish passage	2	3	2	7
3	Estuarine resources	2	3	2	7
4	Transfer of detrital material	2	2	1	5
5	Maintain freshwater storage	2	2	2	6
6	Aesthetic/scenic attributes	1	2	1	4
7	Filtration/absorption of nutrients/other pollutants	2	1	1	4
8	Sediment loads	3	1	1	5
9	Water quality	2	3	2	7
10	Navigation	0	1	1	2

3.2.12 SUMMARY

A collection of human activities, hydrogeomorphic processes, and/or the health and sustainability of flora and fauna characteristic of the Econfina River may be used as WRV indicators for the river. For example, a key indicator used to assess the recreational viability of a river would be access to the river by boaters and paddlers. WRV indicator metrics are surrogate measures of water resource values that are relatable to the discharge of the river. The association between flow and a WRV metric is referred to as a response function.

WRV metrics can be expressed in terms of time, distance, area, or other meaningful characteristics. For instance, kayakers and other recreational users of the river are more likely to relate to a flow reduction and the associated change in the number of days available for river access for paddling or boating than they would to a change in navigable distance that a flow reduction might cause. Likewise, the natural life cycle of a certain animal species (e.g., scallops) may require some minimum hydrologic condition sufficient for spawning that must be maintained frequently enough and for a minimum duration to sustain the population and allow commercial or recreational harvesting.

WRV indicators and associated response functions and metrics, with specific examples, have been identified for the five WRVs for which total scores of 6 or higher were assigned (Table 3-1). These five WRVs can cover a wide range of flow conditions and thus are sufficient for developing MFLs that would be protective of not only these particular WRVs but the remaining five WRVs as well.

3.3 MFL DEVELOPMENT

As discussed in Section 1, the goal of a MFL determination is to protect the resource from significant harm due to water withdrawals, and was broadly defined in the enacting legislation as "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." However, as previously shown, significant harm is rarely depicted as a “bright line,” as habitat loss typically varies monotonically (without a clear inflection or break point) with flow (SWFWMD 2005). Thus, there is a need for an operationally defined threshold that protects the WRVs used to establish the MFL.

Table 3-2. Indicators, response functions, and MFL assessment metrics for WRVs relevant to the Econfina River. From HSW, Inc. and Janicki Environmental (2015).

	WRV	Indicator	Relevance	Response Function	Metric	Key Source	Example
1	Recreation In and On the Water	River access	Many recreational activities involve boat access to the river.	Relationship between freshwater flow and river depth	Depth of the river at access locations and for on-water boating.	Personal communications with local marinas and outfitters	Viable stage for kayaking / canoeing + 1.5 feet (average shaft length of short and long-shaft engines (HSW 2012)
2	Fish Passage / Fish and Wildlife Habitat	Habitat	Different animal species require minimum water depths, velocities, substrate, and temperatures to thrive.	Relationship between freshwater flow and river depth and velocity and floodplain wetland inundation	Extent of time that adequate depth that permits fish passage	SRWMD 2014	Frequency of flows that allow fish passage in Lower Santa Fe and Ichetucknee rivers (SRWMD 2014)
3	Estuarine Resources	Flora and fauna located in water with salinity ranging between 0 and 35 ppt	Many commercial and public interests are associated with sports fishing and scalloping within three miles of the coast.	Relationship between freshwater flow, salinity and isohaline locations	Estuary volume, bottom area and shoreline length.	FDEP 2014.	Relative amount of time that desirable salinities can be found
5	Maintenance of Freshwater Storage and Supply	Available fresh water	Beneficial and reasonable water use (e.g., potable supply, wetland rehydration)	Relationship between freshwater flow and permitted withdrawals (surface water and groundwater)	Freshwater flow remaining after withdrawals for legally permitted uses	Chapters 40B-2 and 40B-8, F.A.C.	Frequency of time that freshwater flow exceeds an established MFL
9	Water Quality	Concentrations of primary water quality parameters	Healthy scallop beds and fish populations depend on sufficient levels of dissolved oxygen and absence of elevated levels of pollutants, including nutrients	Relationship between freshwater flow and water quality	Compliance with state water quality standards		Increase in the number of years of non-compliance with state water quality standards

The proposed threshold for the development of the Econfina River MFL is a 15% reduction in the river volume less than a critical salinity and in the frequency of fish passage and out-of-bank flows. Lacking sufficient data and defined relationships between flow and specific estuarine habitats in their locations, volume is proposed as a surrogate for appropriate estuarine habitat. The following provides justification for the proposed threshold.

The Southwest Florida Water Management District (SWFWMD 2005) has implemented a 15% loss of habitat or resource as a threshold for significant harm that limits the withdrawal of water from the freshwater ecosystems. Instream flow determinations in other areas have been based on percent changes in habitat that ranged from 10-percent to 33 percent (Jones Edmunds and Associates 2012). In their review of a SWFWMD MFL, Cichra et al. (2005), stated:

> "…the peer review panel for the Middle Peace found that use of the 15% threshold is reasonable and prudent (Shaw, Dahm, & Golladay 2005), especially given the absence of clear guidance in statute or in the scientific literature on levels of change that would constitute significant harm. We acknowledge that percentage changes reported in the literature have ranged from 10-33% in other applications designed to prevent significant harm. The present panel affirms the use of the 15% threshold in the Alafia and Myakka rivers for similar reasons."

Jones Edmunds and Associates (2012) conducted a literature review to allow examination of the 15% habitat loss criterion. The literature search resulted in the review and documentation of 366 articles. JEA concluded:

> "In examining the literature, we have drawn several broad conclusions that are consistent with previous observations made by the water management districts of Florida in various MFL documents. Minimum flow recommendations should address a range of processes and the flow events that influence each process. Many programs employ assessment methods that rely heavily on the input of scientific experts to define flow-ecology relationships. To increase transparency and community acceptance, some programs have supplemented scientific expertise with input from local stakeholders through a workshop approach. The coupling of scientific experts and local stakeholders to arrive at a recommended flow regime is commonly referred to as a holistic method or approach."

The general approach taken in the development of the Econfina River MFL includes the following steps:

- Set a goal (for this MFL, protection from significant harm);
- Identify the resources of interest to be protected (WRVs);
- Define a unit of measure (e.g., flow in cubic feet per second, percent reduction in flow);
- Define a baseline flow regime; and
- Define a protection standard statistic (e.g., a prescribed percent reduction).

The following sections of this report present the above approach in greater detail.

4.0 APPROACH AND METHODOLOGY FOR THE ESTABLISHMENT OF THE ECONFINA RIVER MFL

The paradigm upon which the proposed MFLs are based is that a single minimum flow is inadequate for the maintenance of a healthy river ecosystem (Stalnaker 1990; Hill, Platts, and Beschta 1991). Rather, a series of flows or a flow regime are needed to support and protect those physical processes within a river that ultimately affect the biological resources of that river. Richter et al. (1996) noted that maintenance of the full range of natural variation in flows offers the best management approach to sustainable "natural biodiversity." For example, the St. Johns River Water Management District typically develops multiple flow requirements when establishing MFLs. The proposed MFLs, therefore, are intended to mimic, to the extent feasible, the natural flow regime. In other words, both in-stream flows and out-of-bank flows are critical, and within-year variation is also an important component.

The approach for developing MFLs for the Econfina River is a resource-based approach, focusing on meeting the water needs of target habitats in order to protect the resources ecosystem values. USEPA (United States Environmental Protection Agency) and National Marine Fisheries Service note that the primary emphasis for maintaining wildlife biodiversity in Florida (including protection of listed species) should be the conservation of the important habitats upon which indigenous wildlife depend. Thus, basing the development of MFLs for the Econfina River on sustaining target habitats is consistent with a variety of other conservation approaches at national, regional, and state levels.

Another justification for the habitat-based approach is that it is generally acknowledged that impacts to and changes in habitat are relatively straightforward to measure and quantify (Stalnaker et al. 1995). This is in contrast to documenting impacts to or changes in fish and wildlife populations. Quantitative, repeatable measurement of many fish and wildlife populations remains subject to wide error. Thus, by focusing on target habitats, ecological changes due to hydrologic alteration may be detected, or in the present case, predicted.

The development of lotic MFLs in Florida requires a MFL prevent "significant harm" to the state's rivers. Therefore, "significant harm" must be defined so MFL compliance can be assessed. The prevention of significant harm need not require strict agreement (i.e., no change) with an historical hydrologic regime. Rather, a MFL should be based on the establishment of

Critical flows for target habitats from which modifications to the flow regime can be considered. Similar to the approach taken by the Southwest Florida Water Management District, and as put forward by Beecher (1990), the proposed MFL for the Econfina River is based on the following steps:

- Set a goal (for this MFL, protection from significant harm);
- Identify the resources of interest to be protected (WRVs);
- Define a baseline flow regime,
- Define a unit of measure (e.g., flow in cubic feet per second, percent reduction in flow); and
- Define a protection standard statistic (e.g., a prescribed percent reduction).

The establishment of MFLs ultimately depends upon the quantitative relationship between river and spring flows and the WRVs of concern. For a variety of reasons, and despite the availability of generally accepted conceptual models, much of the research that addresses these relationships has not been conducted. Therefore, the following analyses use the best available data to derive the MFLs for the Econfina River.

The proposed MFL for the Econfina River is based on the relationships between river flow and the following:

- Salinity distributions in the tidal portion of the river,
- Out-of-bank flows within the portion of the river that inundate floodplains and provide access to floodplain habitat or food resources for fish and other organisms, and maintain the appropriate geomorphology as indicated by bankfull flows, and
- In-channel flows that provide fish passage within the lower portion of the river.

4.1 STEPS IN THE DEVELOPMENT OF THE ECONFINA RIVER MFL

The general approach taken in the development of the Econfina River MFL includes the steps defined above. The specific results from these steps for the Econfina River include:

- MFL Goal - The goal for the Econfina River MFL is a given – protection from significant harm due to water withdrawals.

- Baseline Flow Regime - the baseline flow regime for the Econfina River MFL comes from the flow data generated by the U.S. Geological Survey at the gage on the Econfina River near Perry (02326000). - The period of record at this gage includes Water Years 1950 through 2014 and is characterized by a wide range of meteorological conditions and the resulting wide range of river flows. Also, there is little water use in the Econfina River watershed and as a result the river flows can be viewed as relatively unaffected by water withdrawals. A presentation of these flow data can be found in Section 2.1.4.
- Resources of Interest – The WRVs associated with the resources of interest include WRV 2 Fish Passage / Fish and Wildlife Habitat and WRV 3 Estuarine Resources. WRV 1 Recreation in and on the Water and WRV 5 Freshwater Supply are not included due to the lack of data. The relevant aspect of WRV 9 Water Quality is implicitly addressed by evaluating the relationship between river flow and salinity.
- MFL Metrics and Unit of Measure - An MFL metric has been identified for each WRV where adequate data exist for the development of a MFL. A critical flow, i.e., the flow that is the threshold for a given MFL metric, has been defined for each metric. The MFL for a given metric is the flow that considers modifications to the baseline flow time series. The unit of measure by which the Econfina River MFL is to be expressed is a percent reduction in flow from the baseline.
- Protection Standard Statistic for Econfina River MFL – The protection standard statistic is 15%, i.e., the critical flow will not allow more than a 15% change in the metric for any MFL WRV (see Section 3.3).

The following discusses the relevance for the WRVs chosen for the establishment of the Econfina River.

4.2 ESTUARINE RESOURCES

Salinity is one of the major determinants of the composition and distribution (both spatial and temporal) of the biotic communities in tidal waters. The general behavior of salinity response to changes in freshwater inflow are well-known. Established MFLs for other similar systems along the Florida Gulf Coast considered how freshwater inflows affected salinity; these include the Lower Hillsborough River (SWFWMD 2006), Lower Peace River (SWFWMD 2007), Lower Alafia River (SWFWMD 2008a), Weeki Wachee River (SWFWMD 2008b), Anclote River

(SWFWMD 2010), Lower Myakka River (SWFWMD 2011), Lower Suwannee River (WRA et al. 2005), and Waccasassa River (WRA et al. 2006).

Salinity varies in the lower reaches of these rivers along the Florida Gulf Coast in response to changing freshwater inflow in an inverse fashion - higher river flow results in lower salinity in the tidal portions of the rivers upriver and lower river flow results in higher salinity in those same portions. Due to higher salinity waters being denser than lower salinity waters, salinity concentrations are often lower near the water surface and higher near the water bottom for any particular location in the lower river. A high degree of variation in salinity is expected due to freshwater inflows and the influences of tide, wind, and vertical stratification. Salinity can vary significantly over the course of each day as the tide moves upstream and downstream. Lateral variation in salinity depends upon the morphometry of the river.

Salinity tolerances have been described for many common fish and invertebrate taxa such as in the Lower Suwannee River (Heard 1982; Gosner 1978). Based on Rogers et al. (1984), salinities of <10 ppt may be critical for recruitment of many fish taxa. Additionally, creeks in very low-salinity areas (< 5 ppt) are important nursery habitat for commercial and recreational fishery species (Rozas and Hackney 1983).

A critical step in establishing the MFL that is protective of estuarine resources is the definition of important salinities and salinity ranges. From the multivariate analysis described in WRA et al. (2005), a critical salinity of <5 ppt was chosen as a salinity limit which may be most sensitive to changes in flow regime and salinity patterns. This category represented the classic "oligohaline" zone for estuarine environments and exhibited a fairly narrow range indicating potential for a high degree of sensitivity to habitat alterations. This critical salinity is also supported by several other lines of evidence. Oligohaline river habitats with salinities less than 5 ppt have been disproportionately lost throughout the Gulf Coast (Beck et al. 2000). Analysis of fish community structure in the several rivers along the Florida Gulf Coast suggests break points for distinct groups of these organisms at approximately 0, 2, and 5 ppt (SWFWMD 2006, 2007, 2008a, 2008b, 2011; WRA et al. 2005, 2006). The MFL for Sulphur Springs (SWFWMD 2004) and Lower Hillsborough River MFL reevaluation (SWFWMD 2006) both had the goal of maintaining low salinity (less than 5 ppt) habitat in the Lower Hillsborough River. There is an opportunity to maintain such habitats in the Econfina River given appropriate minimum flow.

Freshwater is typically viewed as having a salinity of 0 ppt while others have used 0.5 ppt as the criterion. The 0 ppt threshold is protective of the biotic communities that are classified as freshwater. Therefore, for the analyses that support the MFL for the Econfina River, a threshold of 0 ppt is used.

Lastly, a critical salinity ≤2 ppt is supported by several pieces of evidence. Jassby et al*.* (1995) use the 2 ppt isohaline (an area of similar salinities) as an indicator of overall ecosystem productivity in the Sacramento - San Joaquin estuary system; fish studies on the many Florida Gulf Coast rivers showed that many freshwater fish and invertebrates have mean salinity of capture of less than 2 ppt; analysis of fish community structure in the Lower Suwannee River and Lower Peace River reveals break points for distinct groups of these organisms at approximately 2, 5, and 15 ppt; Clewell et al. (1999) and Clewell et al*.* (2002) described glycophytes as having low salinity tolerances with several species being most abundant where median yearly salinities are below 2 ppt; and the Lower Suwannee River MFL was based on "average salinities of high tide waters flooding the swamps should be kept <2 ppt, with briefer periods of higher salinity tolerable." (WRA et al. 2005).

An application of the Environmental Fluid Dynamics Code (EFDC) model was used to simulate salinity and water surface elevations in the Econfina River. A description of the model and its application is presented later in this section and a more comprehensive description of the specific model application to the Econfina River can be found in Appendix A.

In order to estimate the amount of available habitat that meets the biologically-relevant salinities discussed above under various flow conditions, the following metrics that have been used in establishing the MFLs for the Lower Peace River (SWFWMD 2010), Dona Bay (SWFWMD 2009), and Lower Hillsborough River (SWFWMD 2006) were used as surrogates for habitat:

- The volume of water in the system less than a given salinity, since the fishes generally utilize the entire water column;
- The bottom area in the system less than a given salinity, since the benthic macroinvertebrates inhabit the bottom substrate;
- The shoreline length in the system less than a given salinity, since this metric best defines the amount of shoreline vegetation habitat available in the system.

In the application of these three MFL metrics to the Econfina River, the location of the 0, 2, and 5 ppt isohalines during the baseline period was estimated. These isohaline locations were then estimated under altered flow conditions by simulating a series of flow reductions (5-percent, 10-percent, 20-percent and 30-percent).

The potential MFL flows were estimated by comparing the available habitat modeled from the series of percent flow reductions to that to that available according to baseline model results. The critical flow for each MFL metric is defined as that flow reduction that results in a 15% reduction in habitat extent or isohaline location. The most restrictive of the critical flows associated with the habitat extent and isohaline locations was identified as the MFL for the estuarine resource WRV.

4.2.1 FISH PASSAGE / FISH AND WILDLIFE HABITAT

Under low-flow conditions, water depth can be an obstruction to the longitudinal passage of fish up and down a river. The Econfina River is not known to be heavily used by anadromous fishes such as the Gulf sturgeon (*Acipenser oxyrinchus desotoi*) or American shad (*Alosa sapidissima)*. However, the ability to move up and down a river is important for many fish species to escape predation or undesirable conditions, or to find food sources or spawning habitat. MFL development should consider the maintenance of longitudinal connectivity along a river corridor, to the extent that this connectivity has historically occurred.

Information used to examine the potential for limited fish passage under baseline and altered river flow conditions was obtained from the EFDC model described later in this section. The fish passage analysis required that the point of lowest elevation at each model cell along the longitudinal axis of the river be identified. This is often referred to as the thalweg and the elevations along the thalweg can be seen in Figure 4-1. The river water level (stage) at each lateral series of model cells was compared to the thalweg elevation across a range of flow conditions. Flows necessary for fish-passage at each of the lateral series of model cells defining a cross-section were identified using the output from multiple runs of the EFDC model. The flows were determined by using a 0.8-ft depth fish-passage criterion. This depth was added to the lowest spot in the channel and determining the flow necessary to achieve the resultant elevations. The frequency of occurrence of these critical flows during the baseline period was estimated using output from the EFDC model. The reduction in the frequency of the critical flow was estimated by simulating a series of flow reductions (5-percent, 10-percent, 20-percent and 30-percent). The MFL for the fish passage MFL metric was the percent reduction in flow that resulted in a 15% reduction in the frequency of the critical flow.

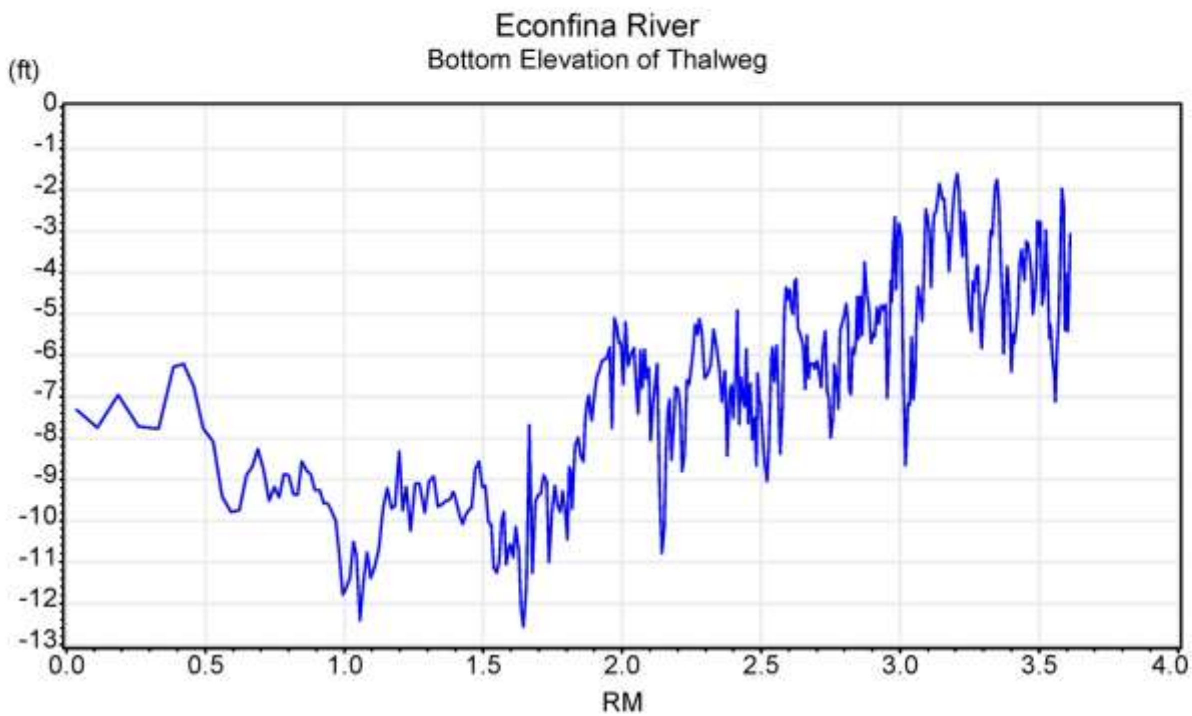

Figure 4-1. Thalweg elevations along the Econfina River (Elevations given in feet, NAVD88).

4.2.2 OUT-OF-BANK FLOWS

Establishing out-of-bank or high flow MFLs on the Econfina River is vital to preserving the ecological health of the entire ecosystem, since high-flows support the extent and integrity of floodplain vegetation and soils necessary to support these communities (Hynes 1970; Allan 1995). Floodplains are known to represent an important riverine habitat that is created on a seasonal basis during higher flows (i.e., out-of-bank flows) (Light et al. 1998; Light et al. 2002; Kelly et al. 2005; Mitsch & Gosselink 1986). The floodplains contain unique wetland communities that are formed in relation to the frequency and duration of inundation. Additionally, it has been shown that the overall biological productivity of river ecosystems is linked to the predictable seasonal inundation of the floodplains (Crance 1988; Junk et al. 1989). Fish and other organisms that inhabit the river channel benefit from the expanded habitat provided by access to inundated floodplains (Wharton et al. 1982; Ainsle et al. 1999; Hill & Cichra 2002). The inundation of the floodplain also provides a nutrient subsidy to the river, by introducing a new source of detrital matter. Thus, the resource of concern identified for selecting a high-flow MFL for the Econfina River is inundation of the floodplain.

The frequency of occurrence of these critical flows during the baseline period was estimated using output from the EFDC model. The reduction in the frequency of the critical flow was estimated by simulating a series of flow reductions (5-percent, 10-percent, 20-percent and 30-percent). The MFL for the “out-of-bank flows” MFL metric was the percent reduction in flow that resulted in a 15% reduction in the frequency of the critical flow.

4.3 EFDC MODEL APPLICATION

The EFDC model used in this project is a general purpose modeling package for simulating two- and three-dimensional flow, transport and biogeochemical processes in surface water systems, including rivers, lakes, estuaries, reservoirs, wetlands, and nearshore to shelf-scale coastal regions. The EFDC model was developed by Dr. John Hamrick at the Virginia Institute of Marine Science and is considered public domain software. EFDC is currently supported by the U.S. Environmental Protection Agency (EPA) Office of Research and Development (ORD), EPA Region 4, and EPA Headquarters. Additionally, the Florida Department of Environmental Protection (FDEP) and the Water Management Districts (WMD) throughout the state have used this model extensively.

The spatial domain of the model includes the nearshore area of the Gulf of Mexico to approximately two miles offshore of the mouth of the river, extends along the Gulf shore for approximately one mile to either side of the river mouth, and extends upstream almost four miles. The upstream limit of the model is above the expected salinity intrusion into the system based upon available salinity data and model simulations of the salinity intrusion. A complete description of the model development and calibration is provided in Appendix A.

The model grid (Figure 4-2) within the river was developed utilizing available LiDAR data for elevations from 0.15 feet and greater referenced to the North American Vertical Datum of 1988 (NAVD88) to develop a river shoreline at the 1 foot level. The LiDAR data were combined with the bathymetric data collected in the river from outside the mouth upstream to the RM 3.6 to develop the river bathymetry. The bathymetry for the model grid in the offshore region was created utilizing the USGS bathymetry coverage developed for the Florida Shelf Habitat (FLaSH) study (Robbins et al. 2007), with adjustments made to the bathymetry to ensure the progression of offshore conditions to the mouth of the river. Boundary conditions necessary to run the model include the offshore water surface elevations, offshore salinity, upstream freshwater inflows, and meteorological data (wind speed and direction).

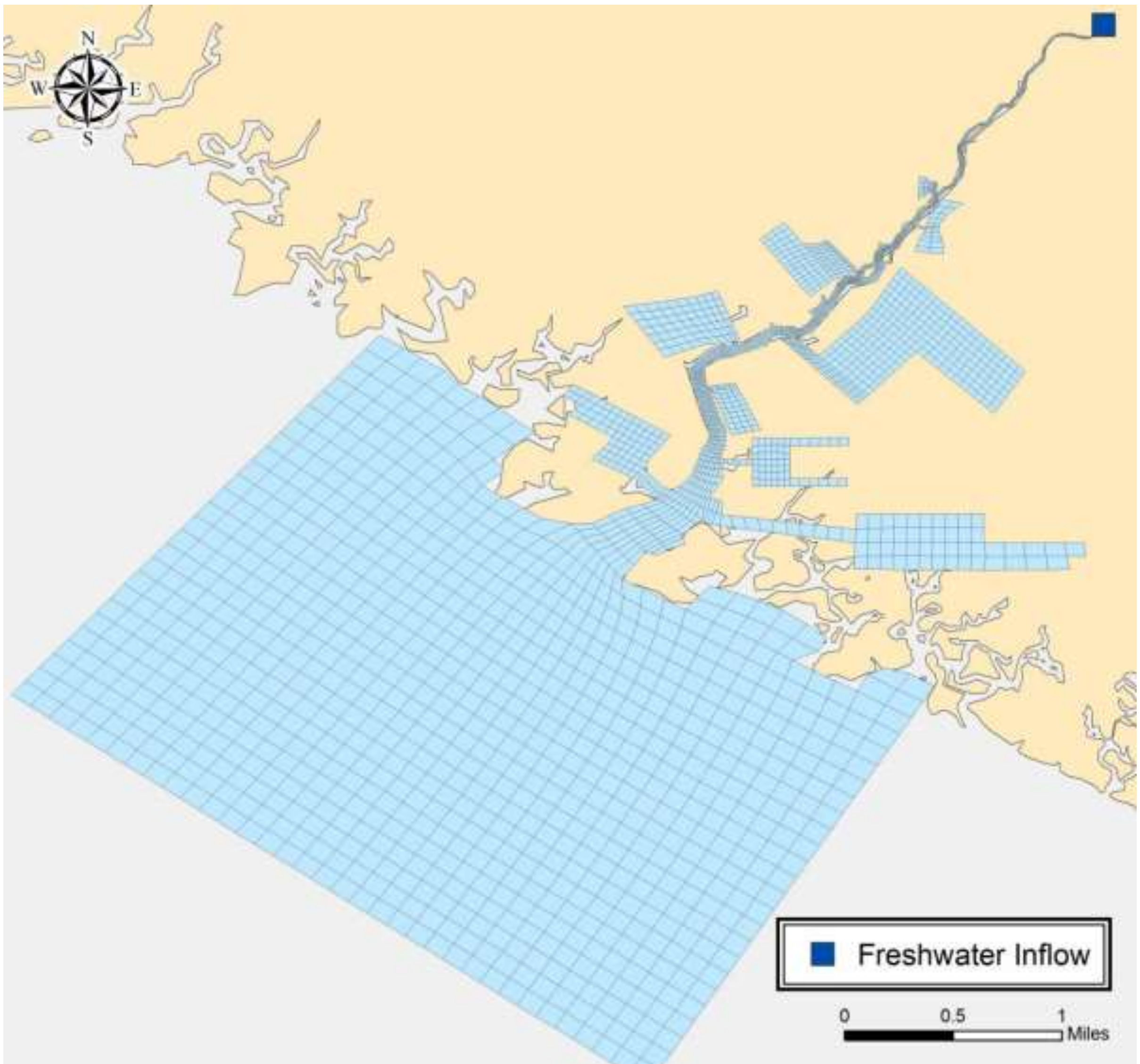

Figure 4-2. Econfina River Model Grid.

It was determined during the model calibration that it was necessary to incorporate representative storage areas along the main stem of the river to accurately simulate the tidal prism moving through the system. These storage areas were roughly based on the area of inundation along tidal creeks tributary to the river, with the volumes of these areas adjusted so that the modeled flows in the system were calibrated to observed flows collected during the calibration period.

To evaluate the likely effects of reductions in freshwater inflows on salinity regimes in the lower Econfina River, it is important to select a period for model application that includes, to the greatest extent possible, a distribution of flows similar to that over the long-term record. This allows the impacts of flow reductions to be evaluated over the entire range of flows experienced in the river utilizing only a relatively small portion of the available flow record.

Constraining the selection of a baseline period were the length of the baseline period to be evaluated in a reasonable time (a function of model run time) and the availability of boundary condition data during the selected baseline period. As the hydrodynamic model developed for the evaluation contains 3500 horizontal cells, six vertical layers, and requires a time step of one second, a baseline period length of two years was determined as an appropriate period for evaluation. Then the set of two-year periods to be examined was further constrained by the availability of offshore water surface elevation and salinity data, which were available from previously completed Gulf Coast Shelf Model (GCSM) runs for the period 1995-2002. If at all possible, a two-year baseline time period some time during the 1995-2002 period was preferred.

A comparison of the distribution of the period of record daily flows (1950-2014) and the distribution of flows during the two-year periods for which GCSM output existed indicated that the flow distribution for the period October 1, 2001 - September 30, 2003 (water years 2002 and 2003) was an appropriate match for the period of record distribution. Figure 4-3 provides a graphic comparison of statistics from 1995 to current and for the set of sequential two-year (water year) periods between 1995 and 2014. Based on this evaluation, the two-year baseline period was selected as October 1, 2001 - September 30, 2003 (indicated on the horizontal axis by 2003). Figure 4-4 provides a graphical display of the distributions of flows for the October 1, 2001 - September 30, 2003 period and flows for the complete period of record, and Table 4-1 provides comparison of the flow distribution statistics for the period of record to those for the two-year baseline period (October 1, 2001 - September 30, 2003).

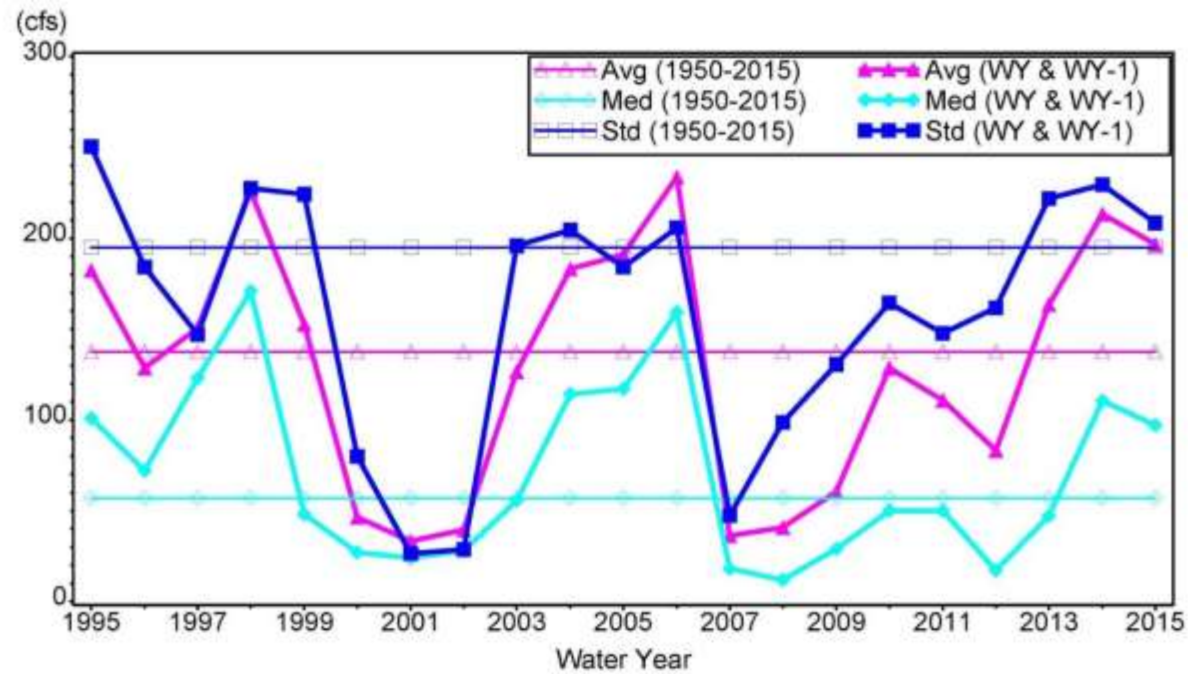

Figure 4-3. Comparison of flow statistics (average, median, and standard deviation) for the period of record and potential two-year baseline periods between 1995 and 2014. WY=Water Year.

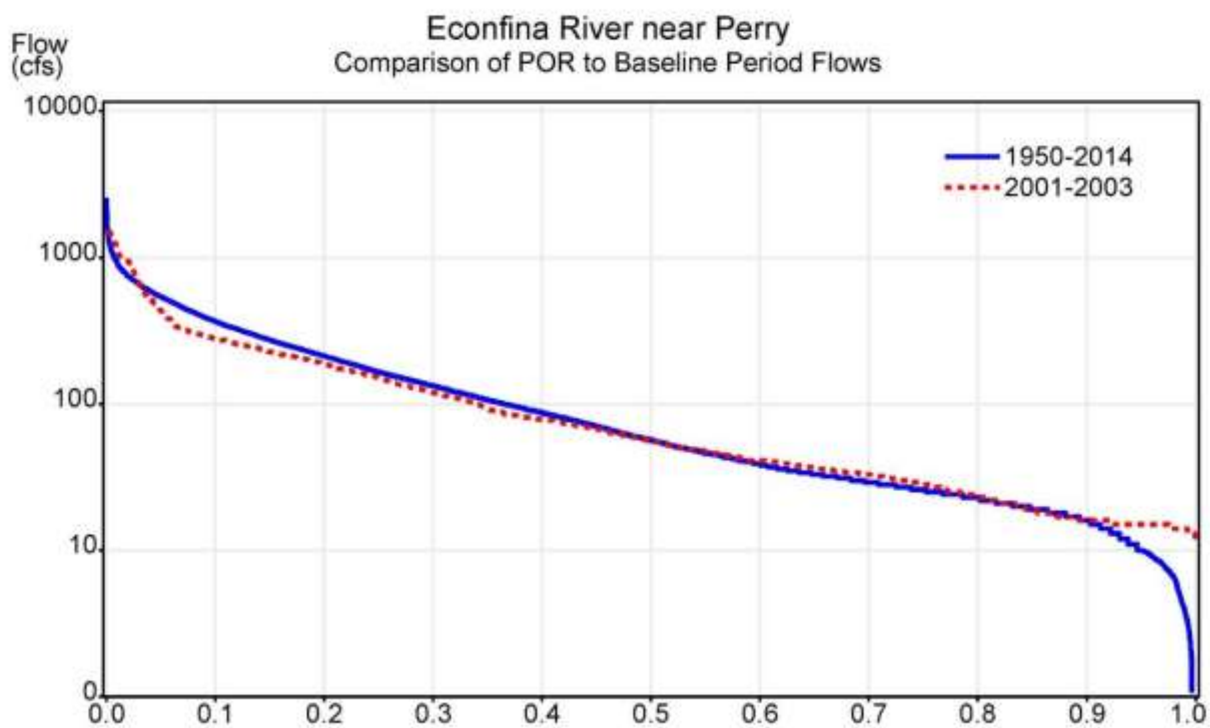

Figure 4-4. Comparison of flow distributions for period of record (1950-2014) and the selected two-year baseline period (October 1, 2001 - September 30, 2003).

Table 4-1. Comparison of flow distribution statistics for the period of record (1950-2014) and two-year baseline period (October 1, 2001 - September 30, 2003).

Flow percentile	Period of Record Flow (cfs)	Baseline Period Flow (cfs)
5^{th}	10	15
25^{th}	26	28
50^{th} (median)	56	55.5
75^{th}	164	149
95^{th}	535	429
Mean	136.3	126.5

Upstream freshwater inflows to the model domain were developed based on the relationship between the measured flow within the tidal river, collected over February 13, 2015 - June 3, 2015, and the flow at the USGS gage 02326000, upstream of the model domain, during the same dates. Time series of the two flows over this almost 4-month period are provided in Figure 4-5. The relationship between flows at the two locations has an R^2 of 0.97, and the equation relating the two is

Lower River Flow (cfs) = -6.656489 + 1.94205*Flow at USGS 02326000 (cfs).

When this equation is used to predict flows during the period when measurements exist at both the mid-river site and the USGS gage, the resultant predicted flows at the mid-river site compare very well to those measured at the mid-river site (Figure 4-6).

The EFDC model runs included the following:

- Baseline – ambient conditions during the period October 2001 - September 2003
- 5-percent flow reduction – daily flows reduced by 5-percent
- 10-percent flow reduction – daily flows reduced by 10-percent
- 20-percent flow reduction – daily flows reduced by 20-percent
- 30-percent flow reduction – daily flows reduced by 30-percent.

An additional model run simulated the effects of a sea level rise of 5.1 inches which is an estimate of the potential sea level rise for 2035. The results of this model run can be found in Appendix B.

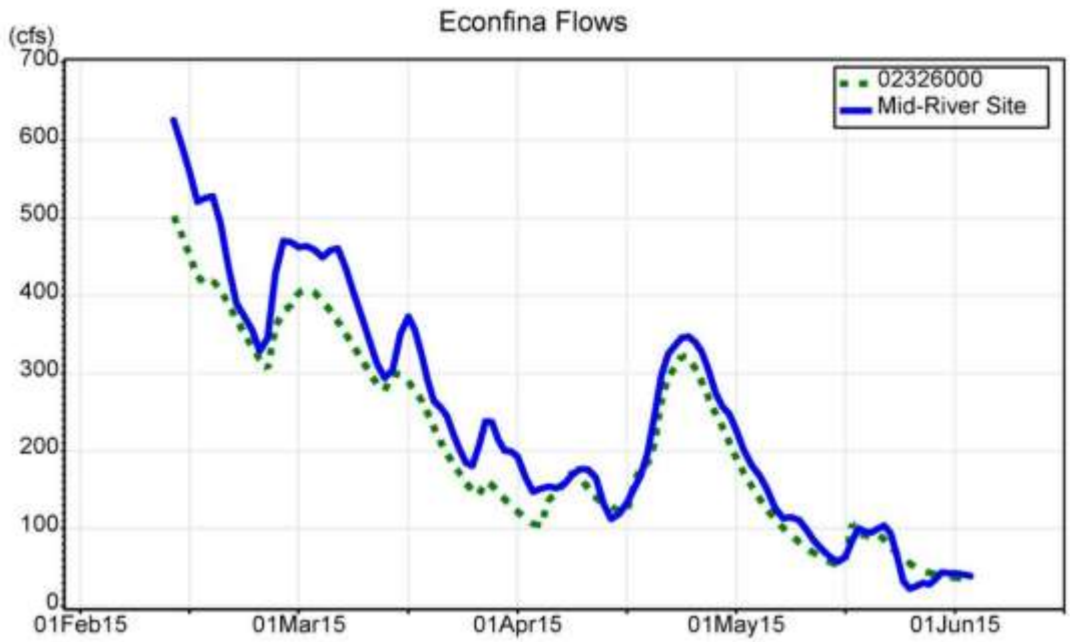

Figure 4-5. Comparison of the time series of flows at the USGS gage 0232600 and measured flows at the mid-river site during the February 13 - June 3, 2015 period.

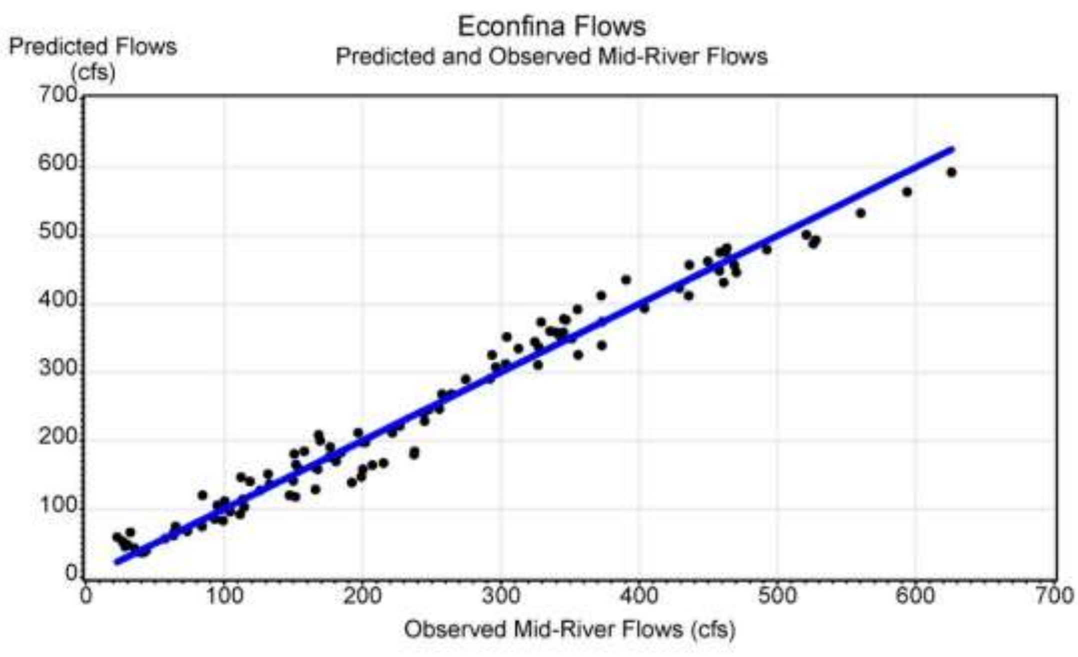

Figure 4-6. Comparison of measured flows at the mid-river site for the February 13 - June 3, 2015 period to those predicted at the mid-river site using the relationship based on USGS gaged flow. The blue line represents the 1:1 line. If the relationship was perfect (R^2=1.00), all black dots would lie on the blue line.

5.0 PROPOSED ECONFINA RIVER MFL

As discussed in Section 4, an application of the EFDC model described in Appendix A was used to examine the relationships between river flow reductions and the responses in three MFL metrics – salinity distributions, fish passage, and frequency of out-of-bank flows. These three metrics relate to the two WRVs – Fish Passage / Fish & Wildlife Habitat and Estuarine resources that have been selected for the establishment of the Econfina River MFL. The model scenarios that were simulated using the EFDC model included a baseline (observed flows over the period October 2001 through September 2003); a 5-percent, 10-percent, 20-percent, and 30-percent reduction in the baseline flows. The following examines the responses in the salinity of the Econfina River to the variation in river flows and estimates the changes in the salinity distributions, river depth, and water surface elevations due to the percent flow reductions that were simulated.

5.1 RESPONSES IN SALINITY TO VARIATIONS IN RIVER FLOWS – BASELINE SCENARIO

To examine the responses in the salinity of the Econfina River to the variation in river flows, time series of river salinity from the various model scenarios were examined. Figures 5-1 through 5-6 present the mean daily salinity time series plots for RM 0 through RM 3.1, respectively. Several key observations can be made. First, except for periods of relatively low salinity, vertical stratification is clear at all locations in the river. Secondly, the range of salinities found over the two-year simulation period decreases from the mouth (RM 0) to the upper reaches of the model domain (RM 2.5 – RM 3.1) where the salinity ranges from 0 to 30 ppt with a median near 27 ppt at the surface. Except for the latter months of 2001 and the dry months of 2003, salinity greater than 0 ppt was rarely found at RM 3.1. The greatest longitudinal difference was found between RM 1.2 and RM 1.9 where the median surface salinity declined from 14.4 ppt to 7.1 ppt.

The relationship between salinity and river flow is the most important relationship that is simulated by the EFDC model. Figures 5-7 through 5-12 present the relationships between mean daily salinity and fiver flow at RM 0 through RM 3.1, respectively. At RM 0, the mean daily salinity is typically greater than 20 ppt at flows less than 100 cfs. The surface salinity has an inflection point at 20 ppt where the decline in salinity becomes less precipitous. At RM 1.2, the decline in salinity is greatest at flows less than 100 cfs where the mean daily salinity declines from approximately 30 ppt to 10 ppt. As flow approaches 200 cfs both the mean daily surface and bottom salinity at RM 1.9 is less than 5 ppt. The mean daily surface and bottom salinity are at or near 0 ppt when flows exceed 400 cfs.

The availability of habitat with the critical salinity (i.e., 0, 0-2, and 0-5 ppt) can be expected to vary with river flow. The three habitat metrics include the river volume, bottom area, and shoreline length from RM 0 to RM 3.6 (the total longitudinal extent of the EFDC model).

Figures 5-13 through 5-15 present the mean monthly volume, bottom area, and shoreline length for the three critical salinities as a function of river flow.

The increase in mean monthly river volume with increasing river flows is approximately linear for all three critical salinities with a slight inflection point at 50 cfs. The response in bottom area to changing river flows was similar to the response in volume but with an inflection point that is more apparent at 50 cfs. The increase in mean monthly shoreline length was greatest with increased flows up to approximately 100 cfs and an infection point at 200 cfs above which the increase in shoreline length was less apparent.

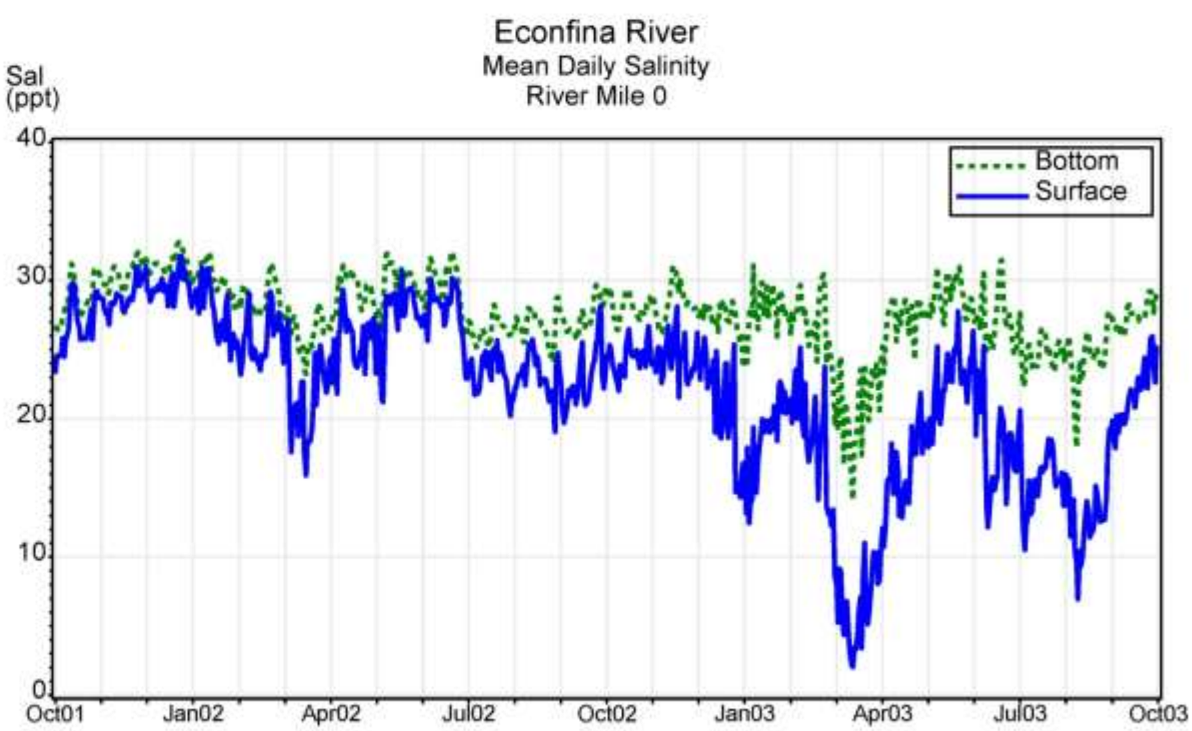

Figure 5-1. Mean daily surface and bottom salinity at RM 0.

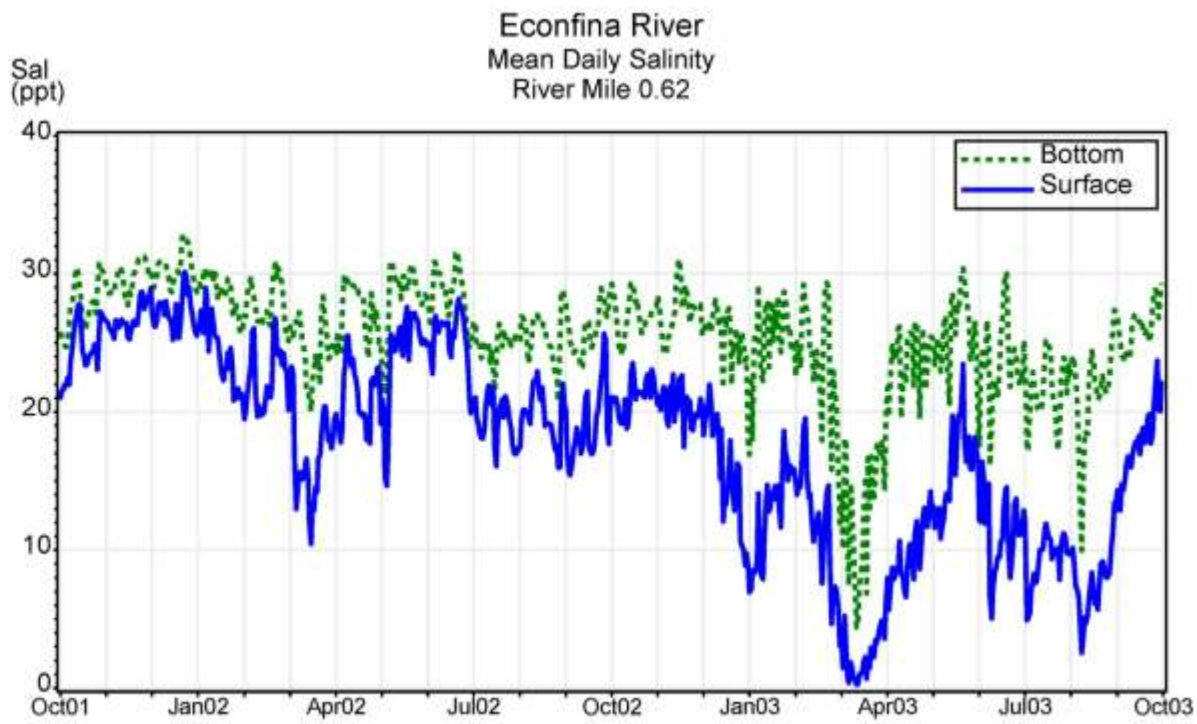

Figure 5-2. Mean daily surface and bottom salinity at RM 0.62.

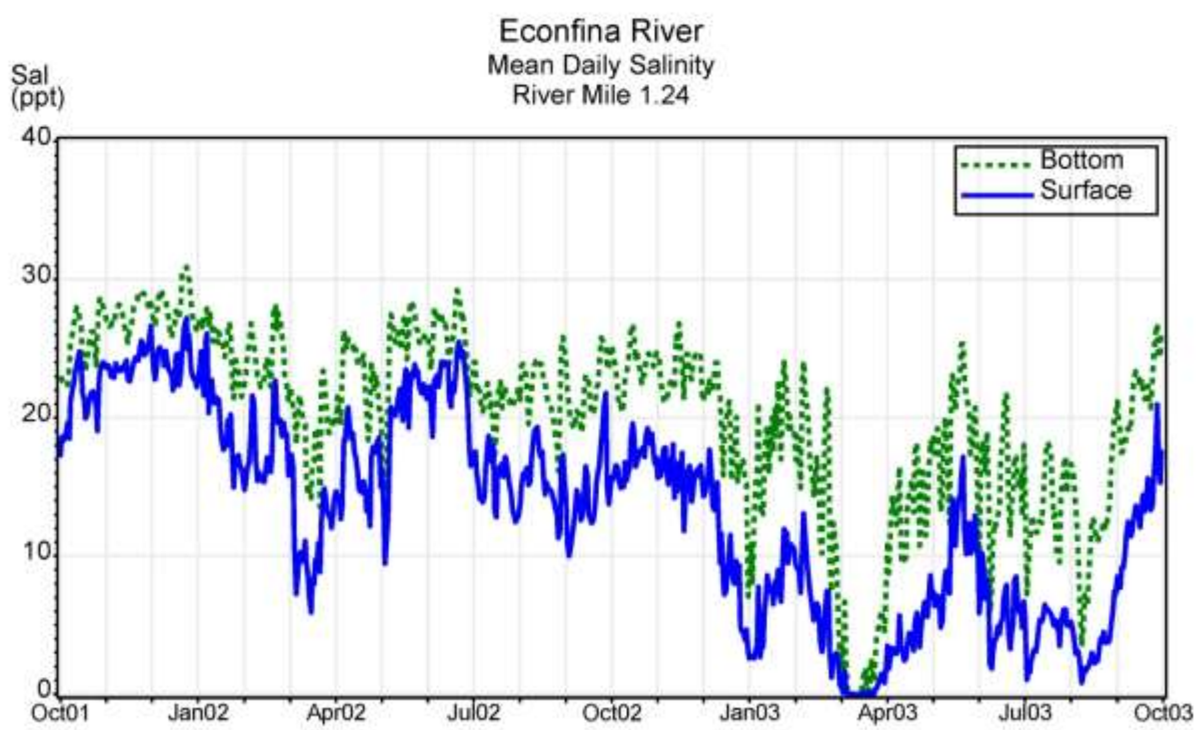

Figure 5-3. Mean daily surface and bottom salinity at RM 1.24.

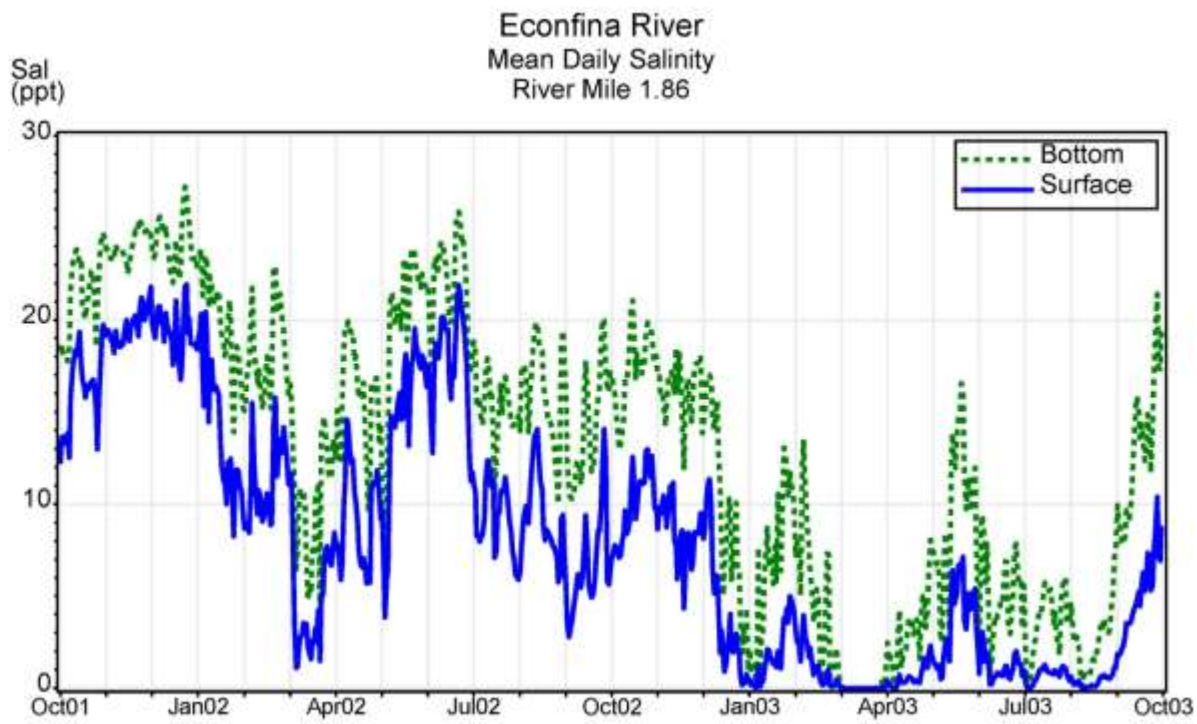

Figure 5-4. Mean daily surface and bottom salinity at RM 1.86.

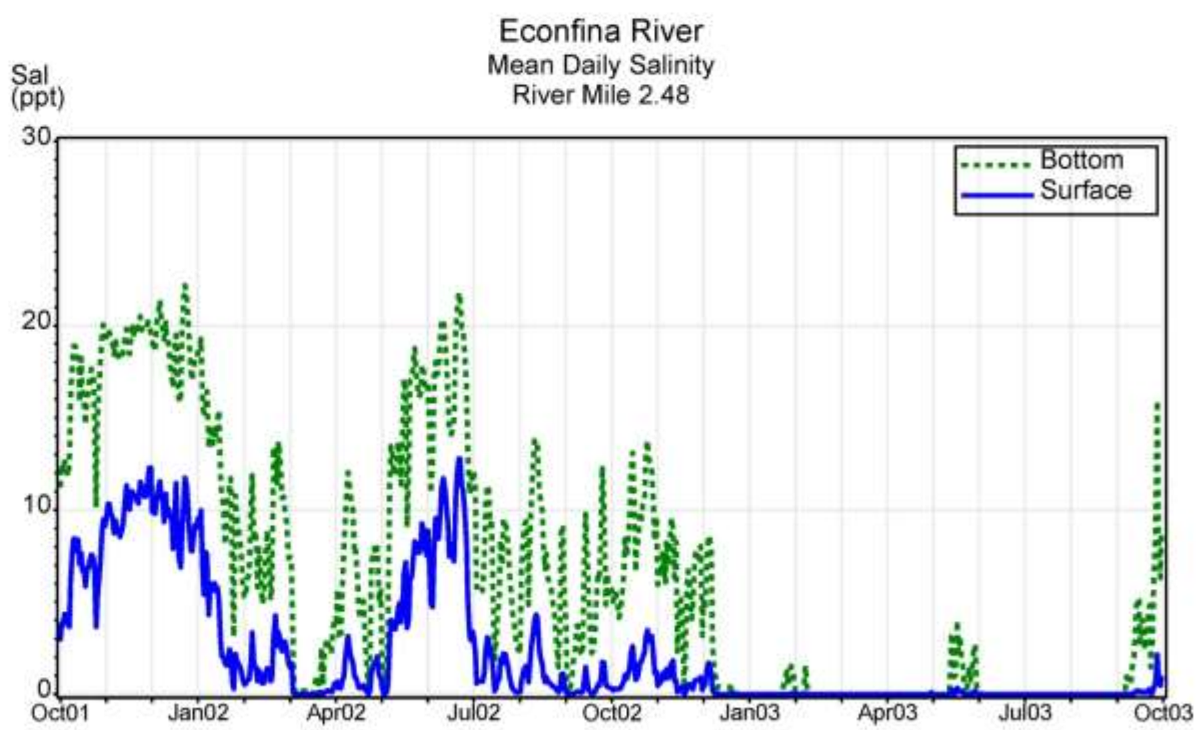

Figure 5-5. Mean daily surface and bottom salinity at RM 2.48.

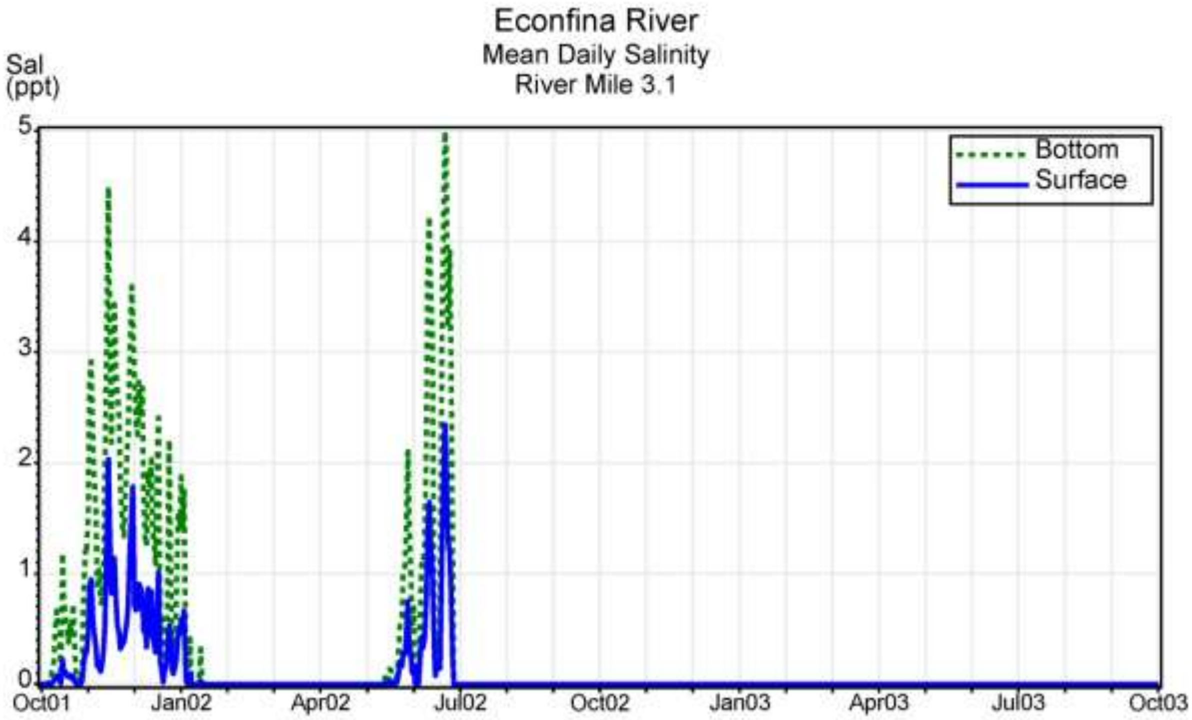

Figure 5-6. Mean daily surface and bottom salinity at RM 3.1.

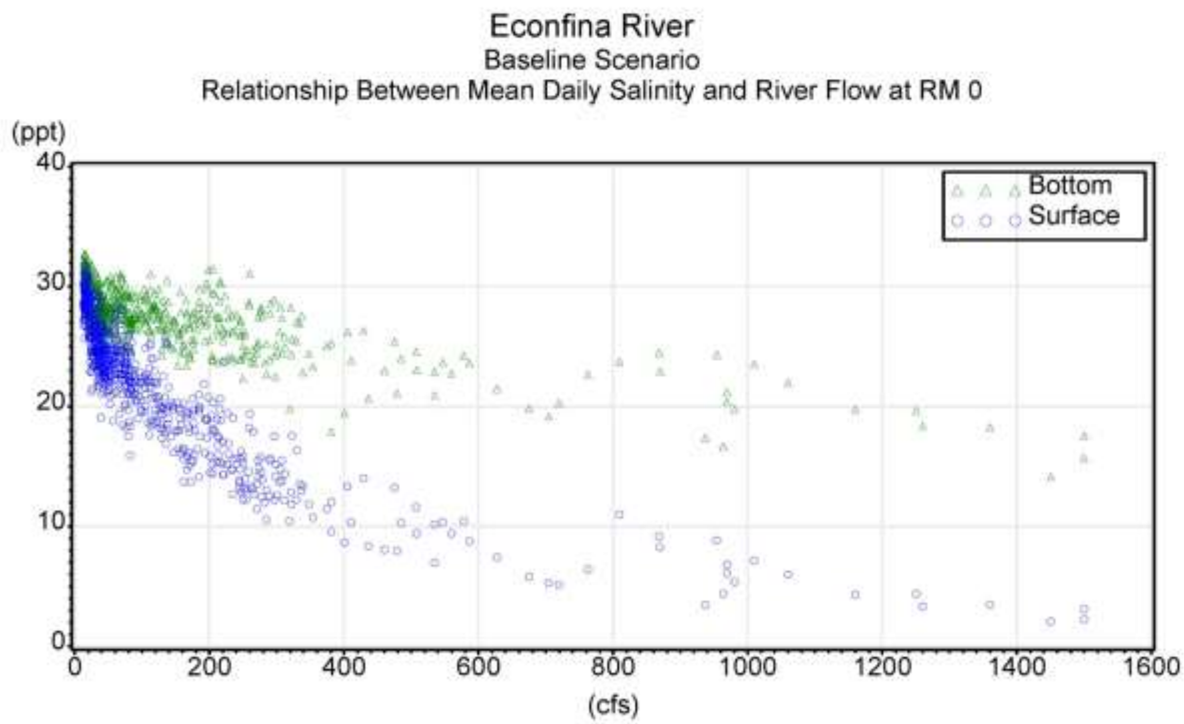

Figure 5-7. Relationship between mean daily surface and bottom salinity with river flow at RM 0.

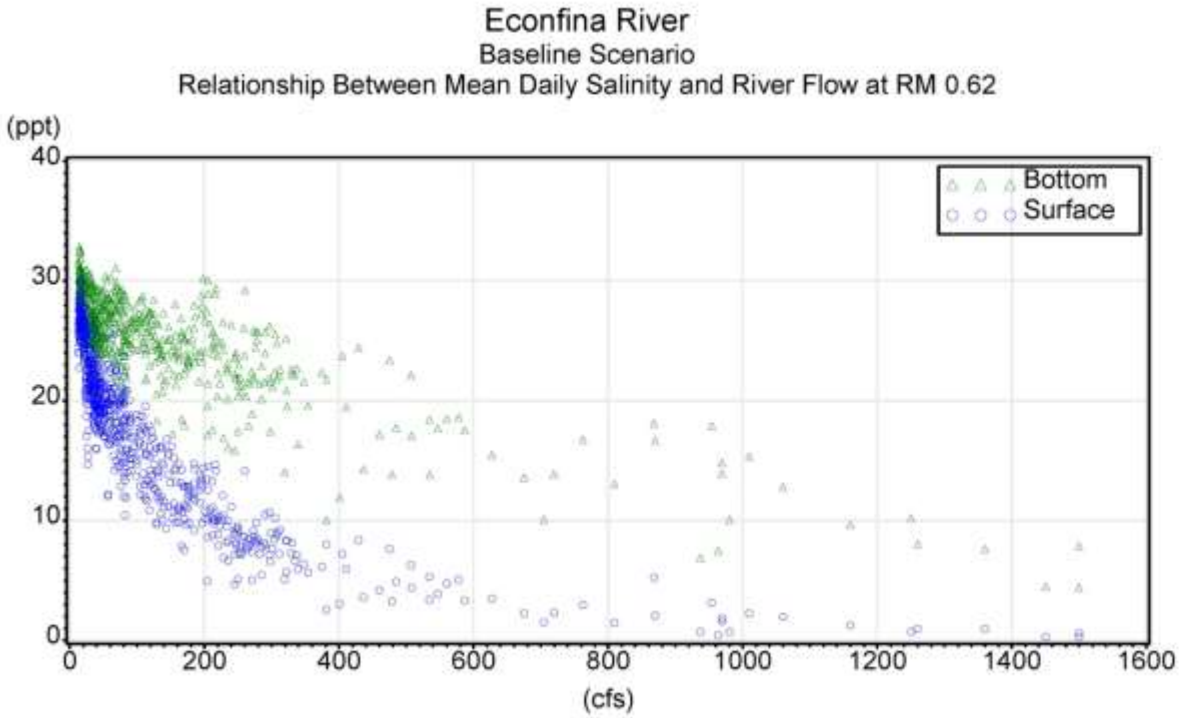

Figure 5-8. Relationship between mean daily surface and bottom salinity with river flow at RM 0.6.

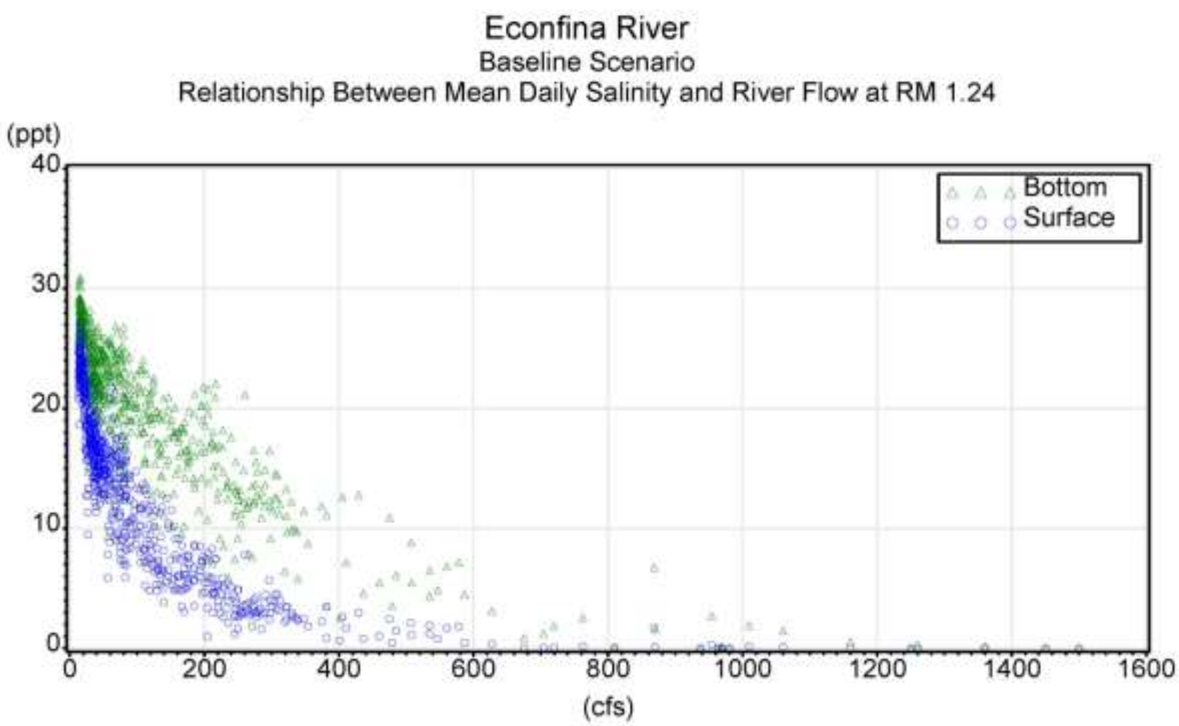

Figure 5-9. Relationship between mean daily surface and bottom salinity with river flow at RM 1.2.

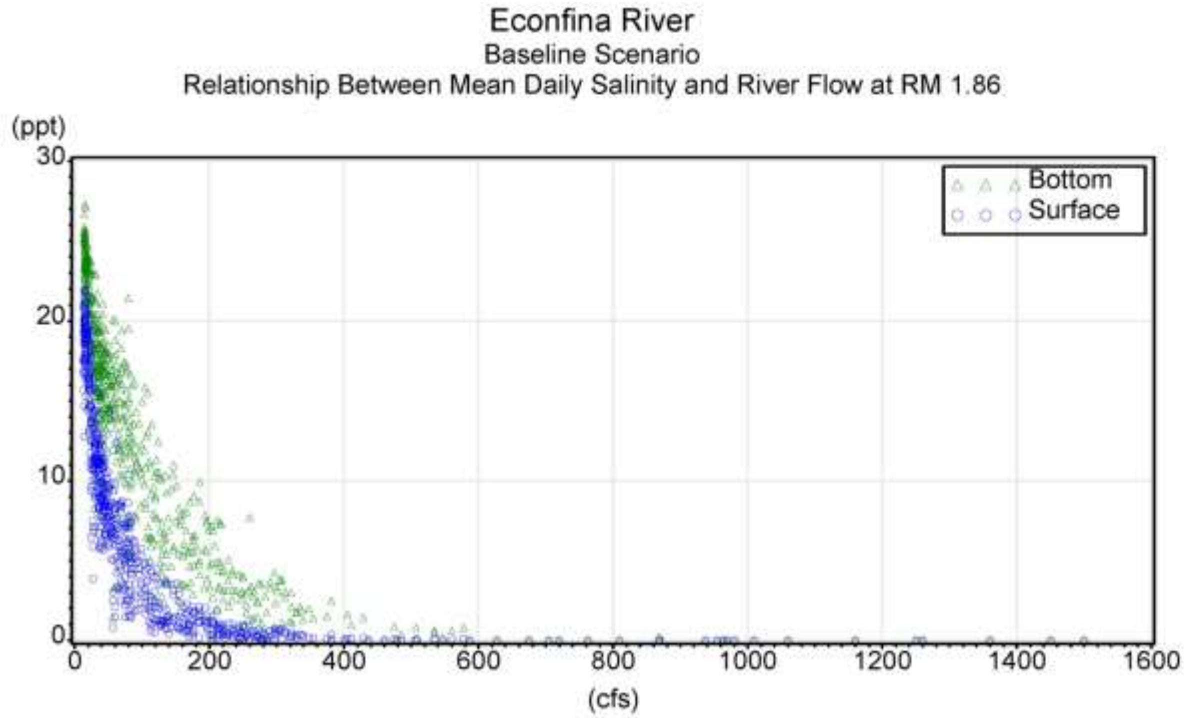

Figure 5-10. Relationship between mean daily surface and bottom salinity with river flow at RM 1.9.

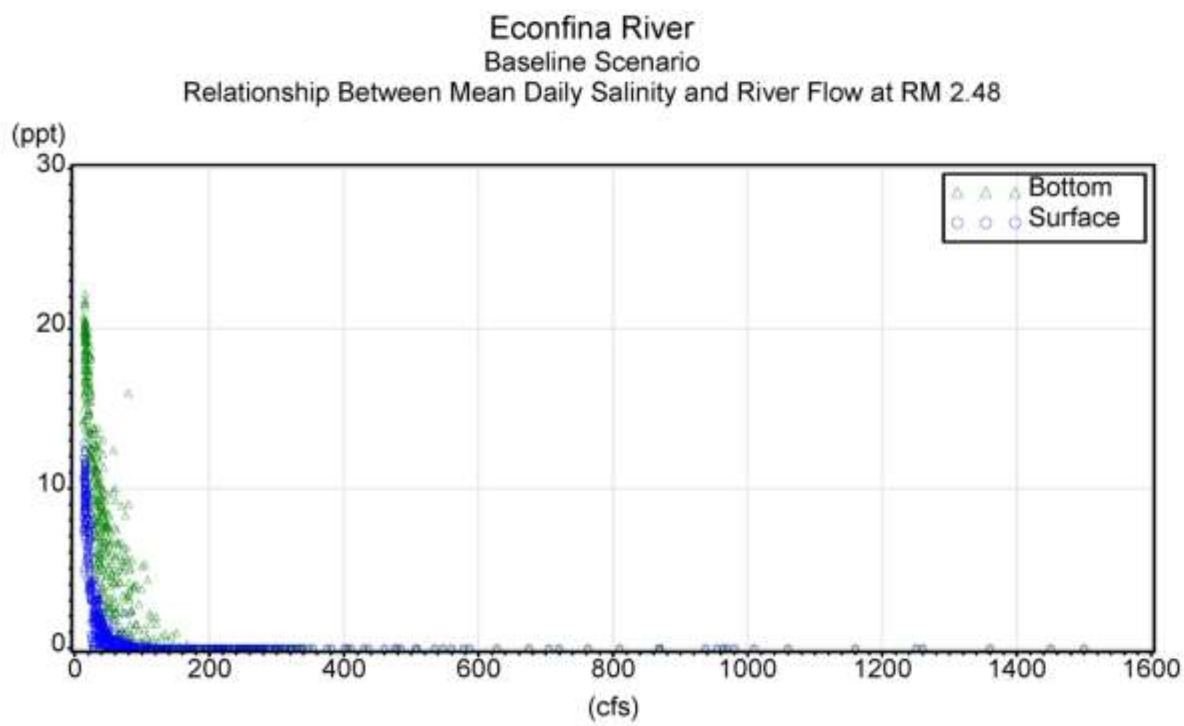

Figure 5-11. Relationship between mean daily surface and bottom salinity with river flow at RM 2.5.

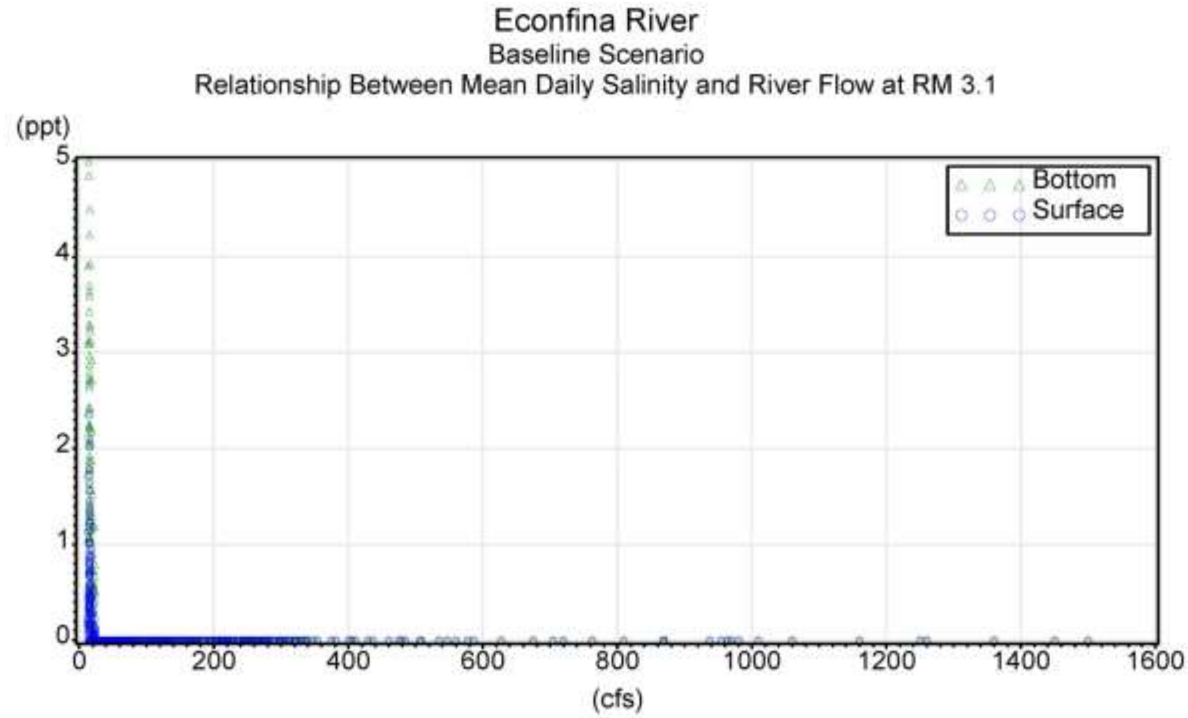

Figure 5-12. Relationship between mean daily surface and bottom salinity with river flow at RM 3.1.

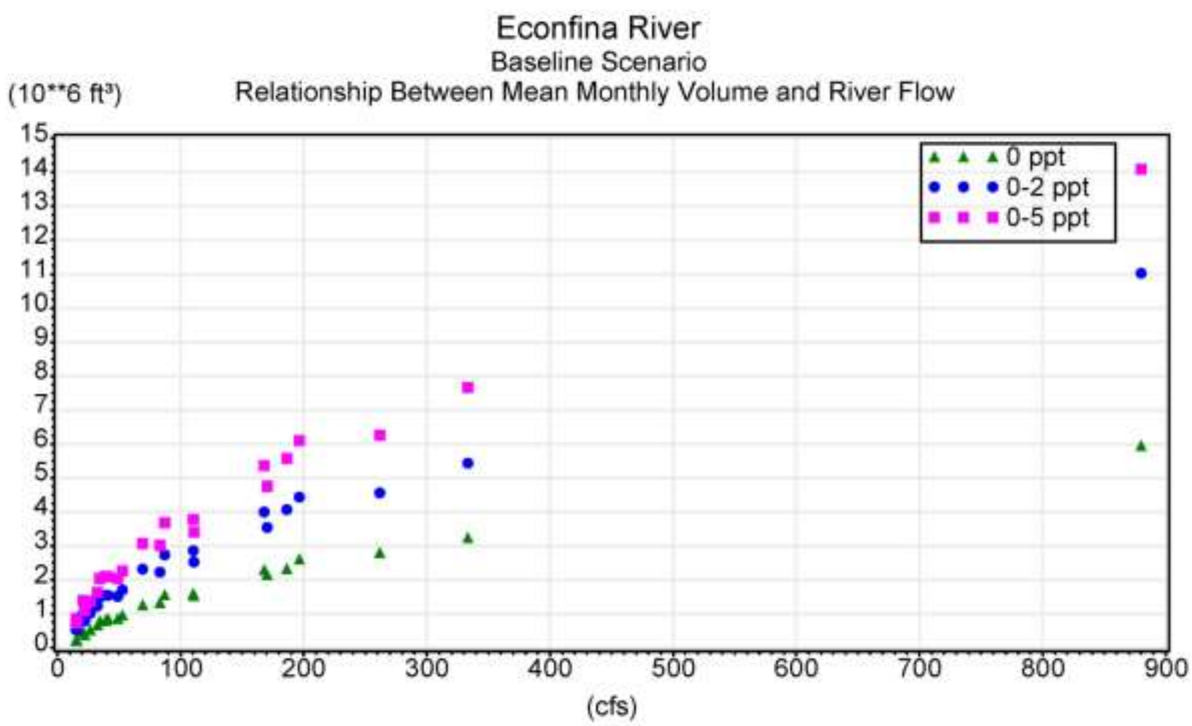

Figure 5-13. Relationship between mean monthly river volume with 0, 0-2, and 0-5 ppt with river flow.

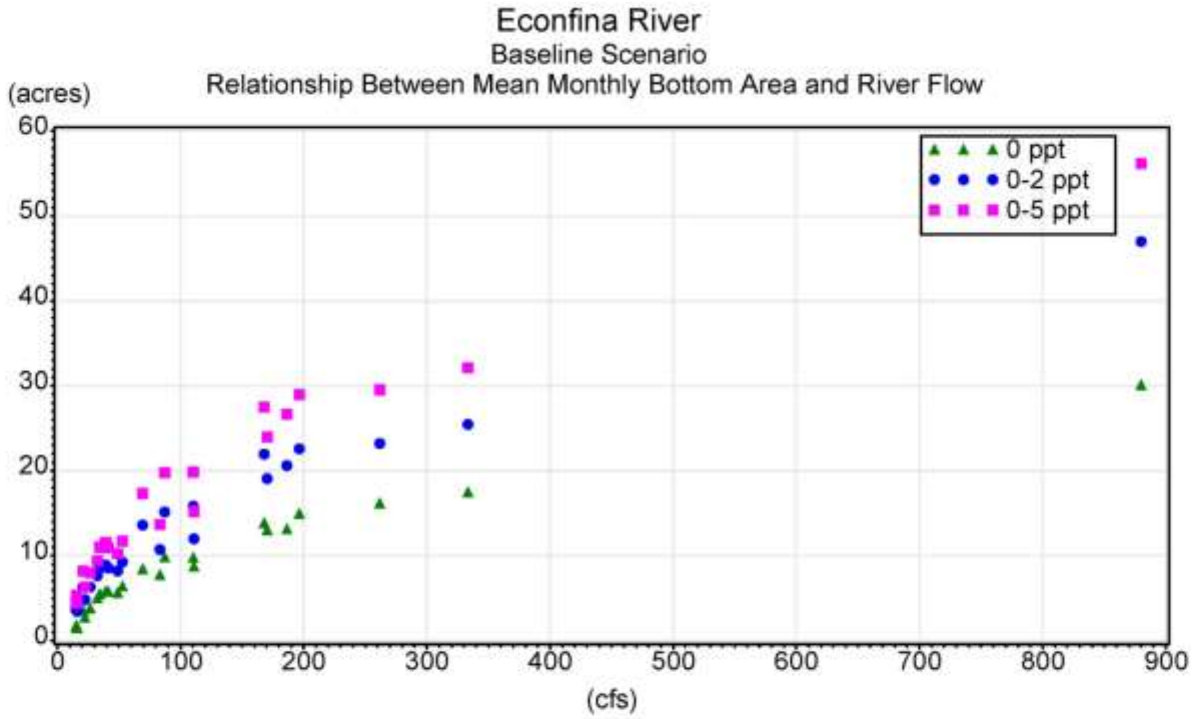

Figure 5-14. Relationship between mean monthly bottom area with 0, 0-2, and 0-5 ppt with river flow.

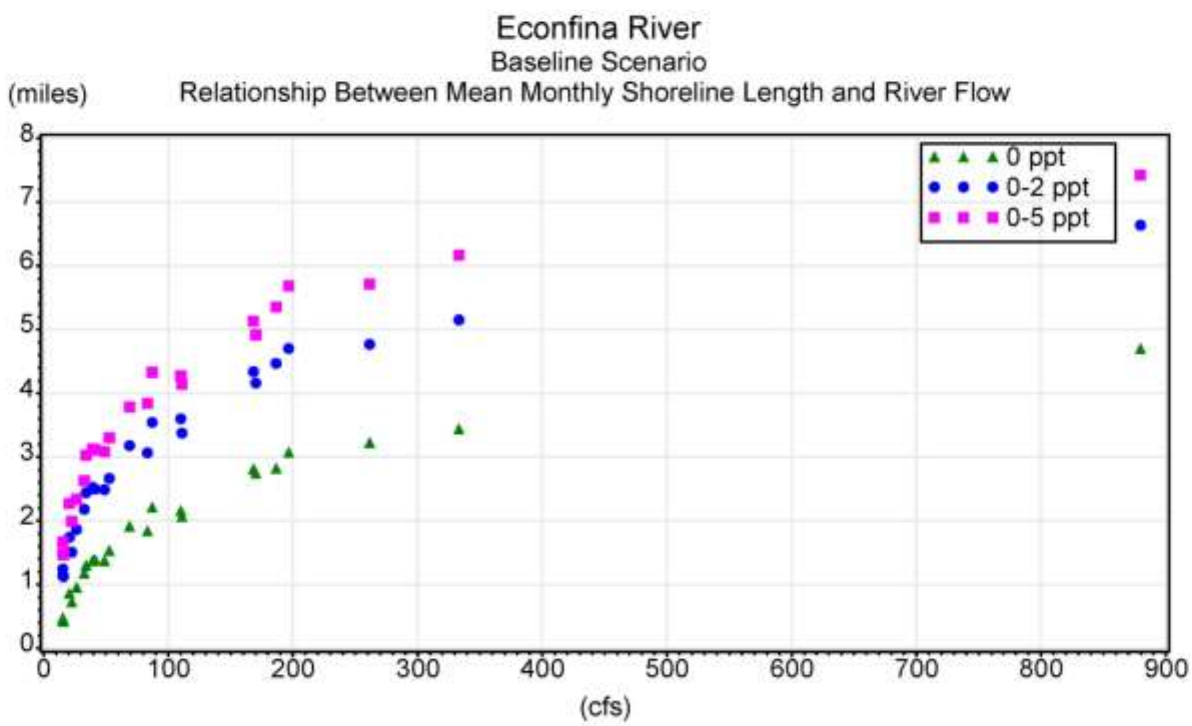

Figure 5-15. Relationship between mean monthly shoreline length with 0, 0-2, and 0-5 ppt with river flow.

5.2 RESPONSES IN SALINITY TO VARIATIONS IN REDUCTIONS IN RIVER FLOWS

The establishment of the Econfina River MFL will be based on the responses in the river as indicated by the output from the model runs for a series of flow reductions (5-percent, 10-percent, 20-percent, and 30-percent) and the estimated differences from the baseline conditions.

A simple comparison of the baseline salinity conditions to those from the four (4) percent reduction scenarios is shown in Figure 5-16. Shown is a longitudinal cross-section of the Econfina River that displays those portions of the river where the difference between the mean daily salinity over the simulation period for the baseline and each of the four (4) percent reduction scenarios exceeded 15% (colored in dark blue). Values presented are differences in the averages for each lateral row of model cells. Several observations are clear. The location and extent of the portions of the river where the difference in mean daily salinity exceeded 15% varies with the degree of flow reductions. With increasing flow reductions the location moved downstream from approximately from RM 3.0 under the 5-percent flow reduction to RM 1.6 under the 30-percent flow reduction. The differences also extended from the surface at the upstream location to throughout the water column at RM 1.6.

Figures 5-17 through 5-19 present mean monthly river volumes at salinities of 0 ppt, 0-2 ppt, and 0-5 ppt, as compared between the baseline condition and the four (4) percent flow reduction scenarios. These results show that the responses to the different flow reductions are simply proportional to the flow reductions with very little difference particularly for the 5-percent flow reduction. The highest river volumes were found for the spring 2003 when the highest river flows during the simulation period were observed.

Figures 5-20 through 5-22 present mean monthly river bottom area with at salinities of 0 ppt, 0-2 ppt, and 0-5 ppt, as compared between the baseline condition and the four (4) percent flow reduction scenarios. As for the river volume, these results show that the responses to the different flow reductions are simply proportional to the flow reductions.

Figures 5-23 through 5-25 present mean monthly shoreline length at salinities of 0 ppt, 0-2 ppt, and 0-5 ppt, as compared between the baseline condition and the four flow reduction scenarios. These results show that the responses to the different flow reductions are simply proportional to the flow reductions.

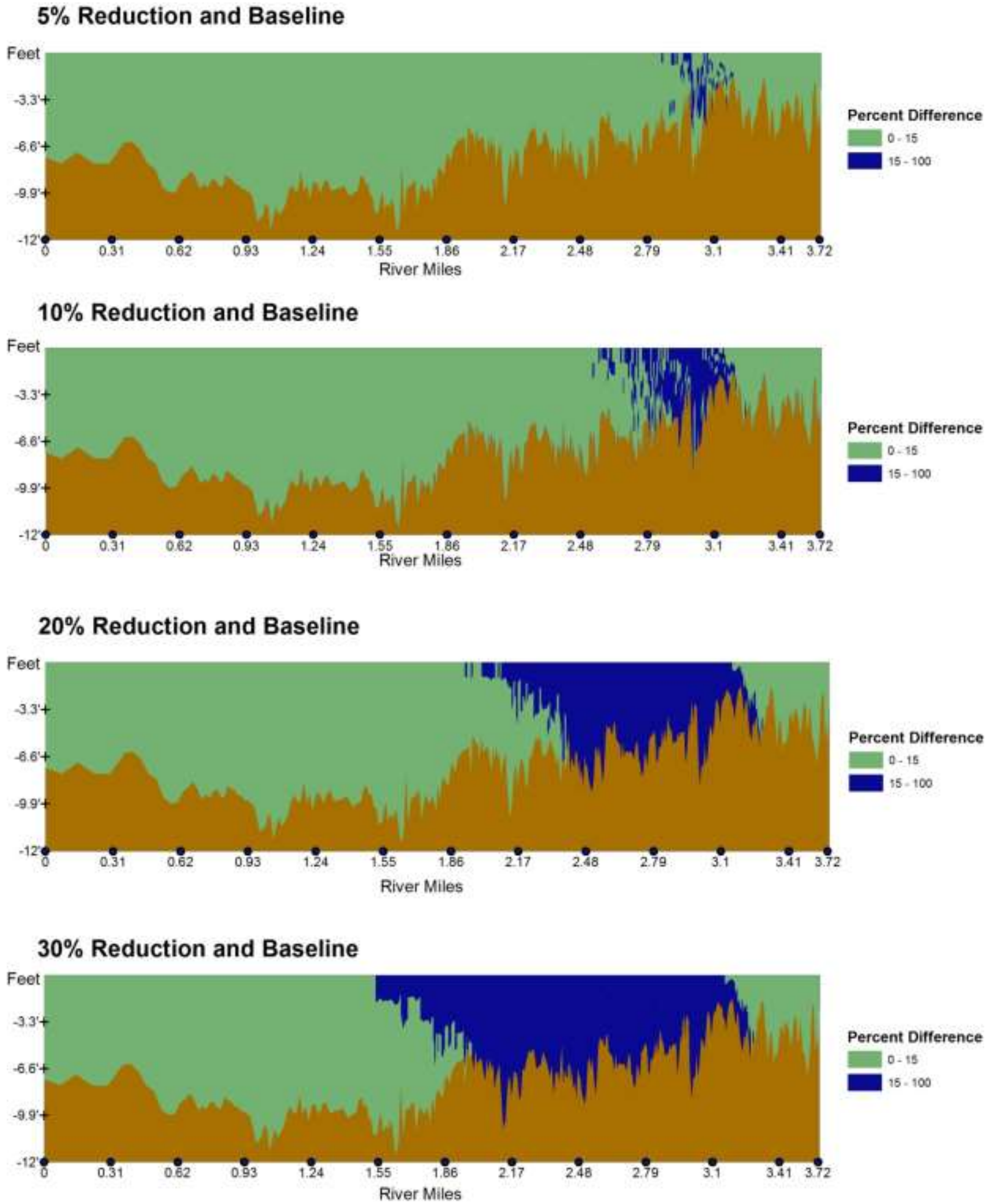

Figure 5-16. Comparison of the mean monthly river volume with 0 ppt salinity for the baseline and four (4) percent flow reduction scenarios. Values presented are differences in the averages for each lateral row of model cells.

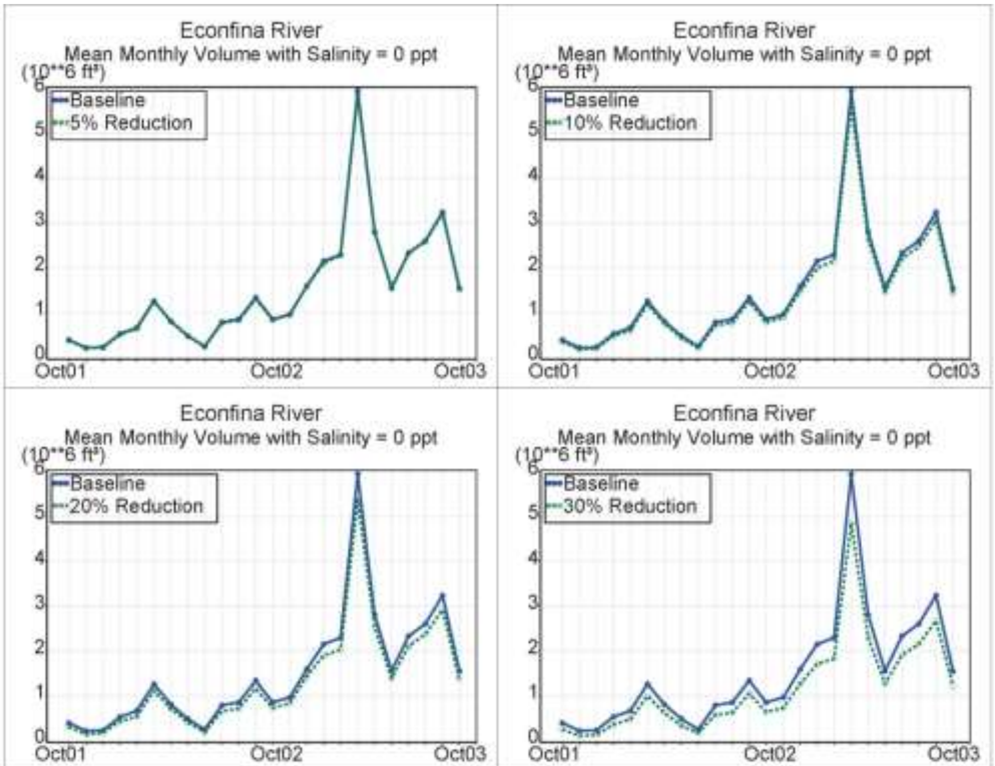

Figure 5-17. Comparison of the mean monthly river volume with 0 ppt salinity for the baseline and four (4) percent flow reduction scenarios.

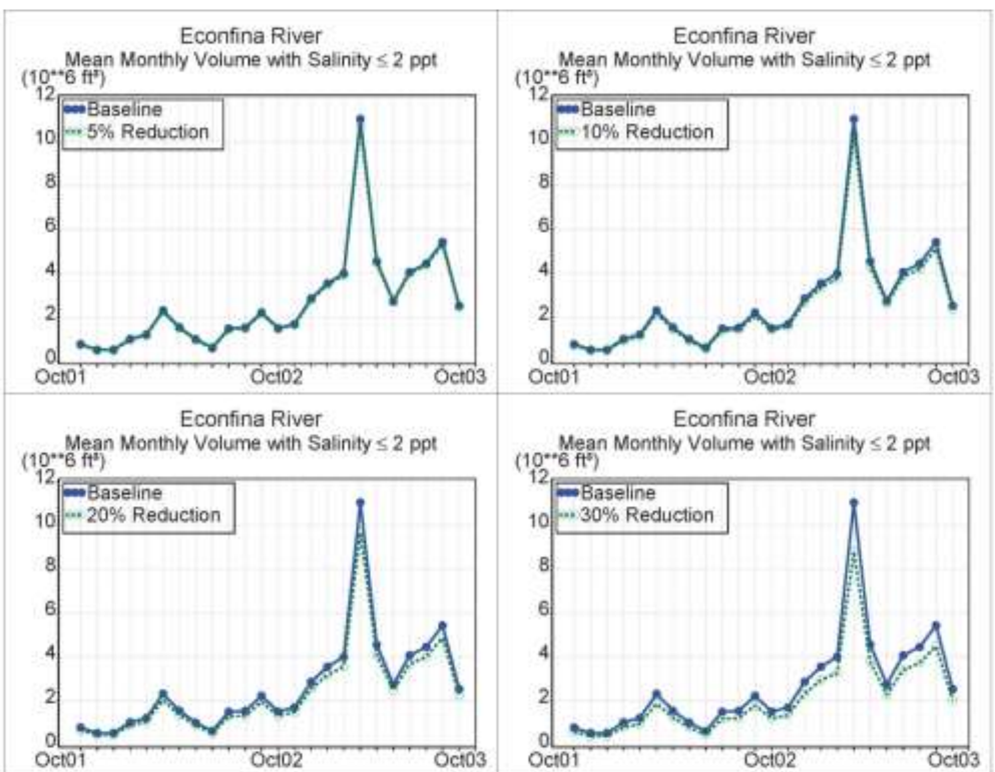

Figure 5-18. Comparison of the mean monthly river volume with 0-2 ppt salinity for the baseline and four (4) percent flow reduction scenarios.

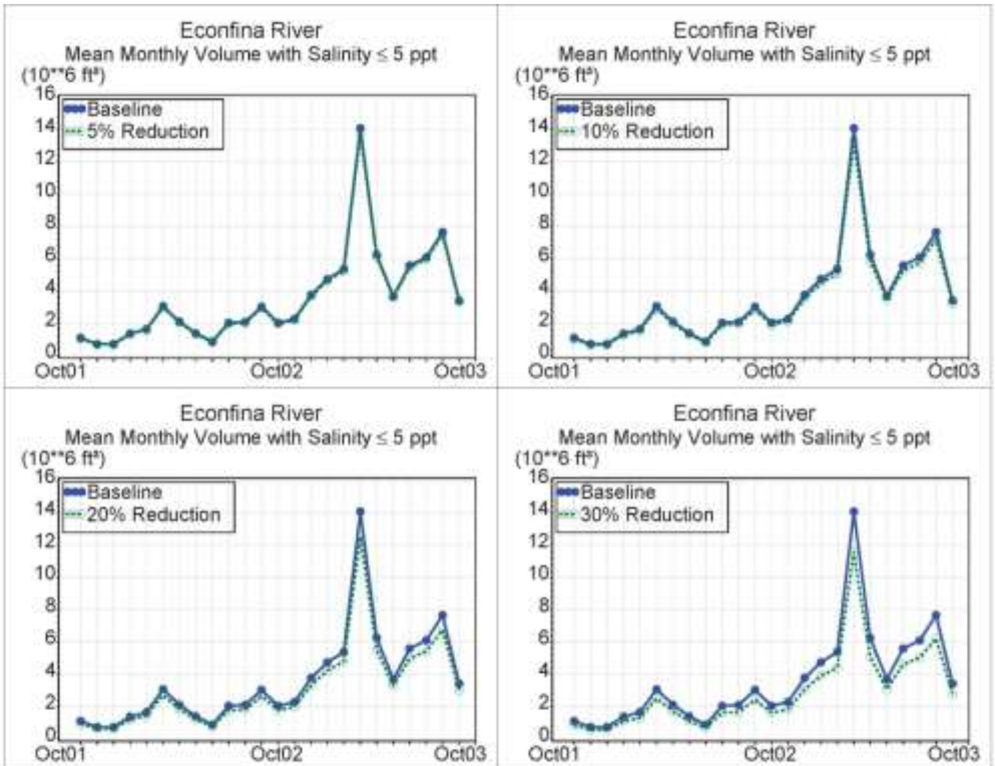

Figure 5-19. Comparison of the mean monthly river volume with 0-5 ppt salinity for the baseline and four (4) percent flow reduction scenarios.

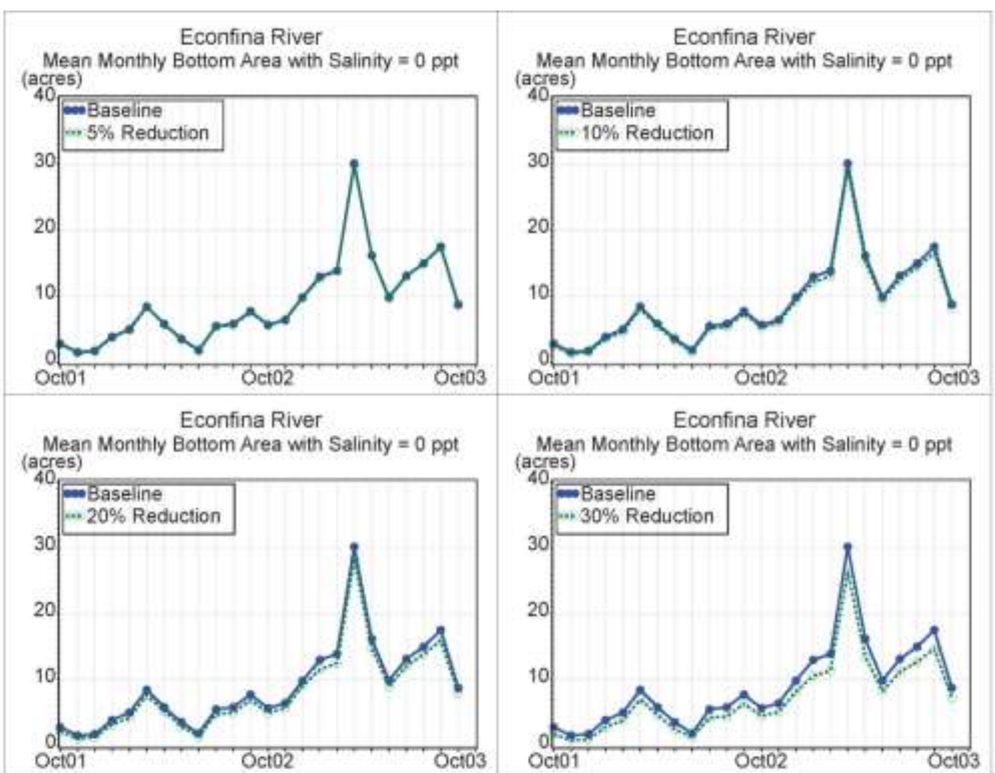

Figure 5-20. Comparison of the mean monthly bottom area with 0 ppt salinity for the baseline and four (4) percent flow reduction scenarios.

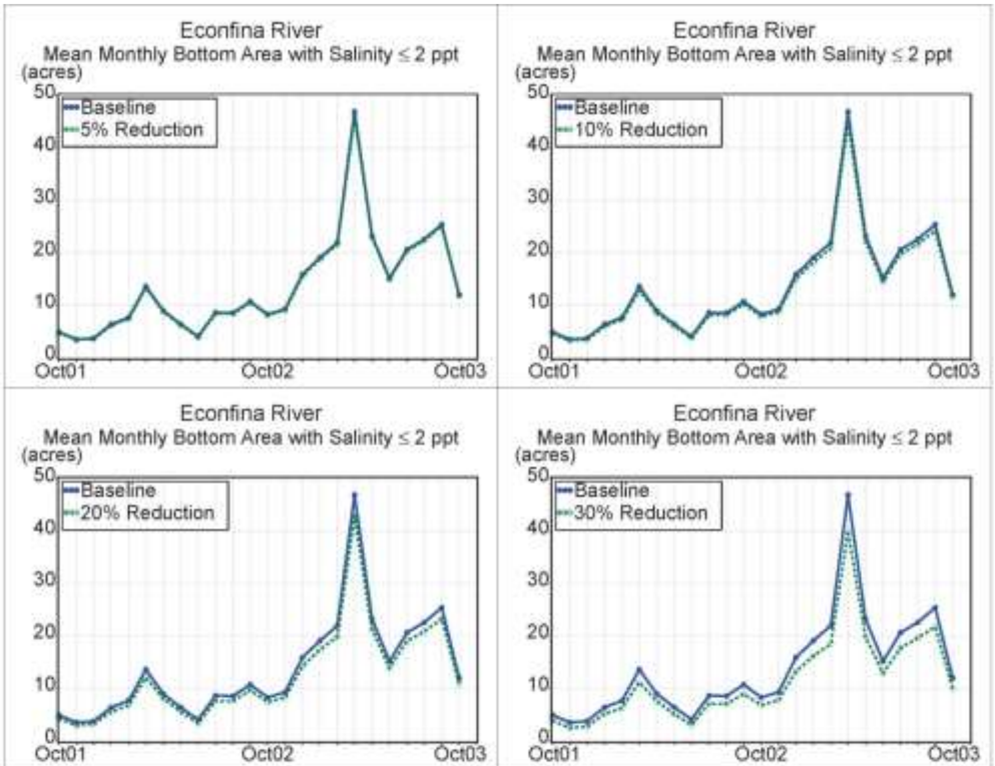

Figure 5-21. Comparison of the mean monthly bottom area with 0-2 ppt salinity for the baseline and four (4) percent flow reduction scenarios.

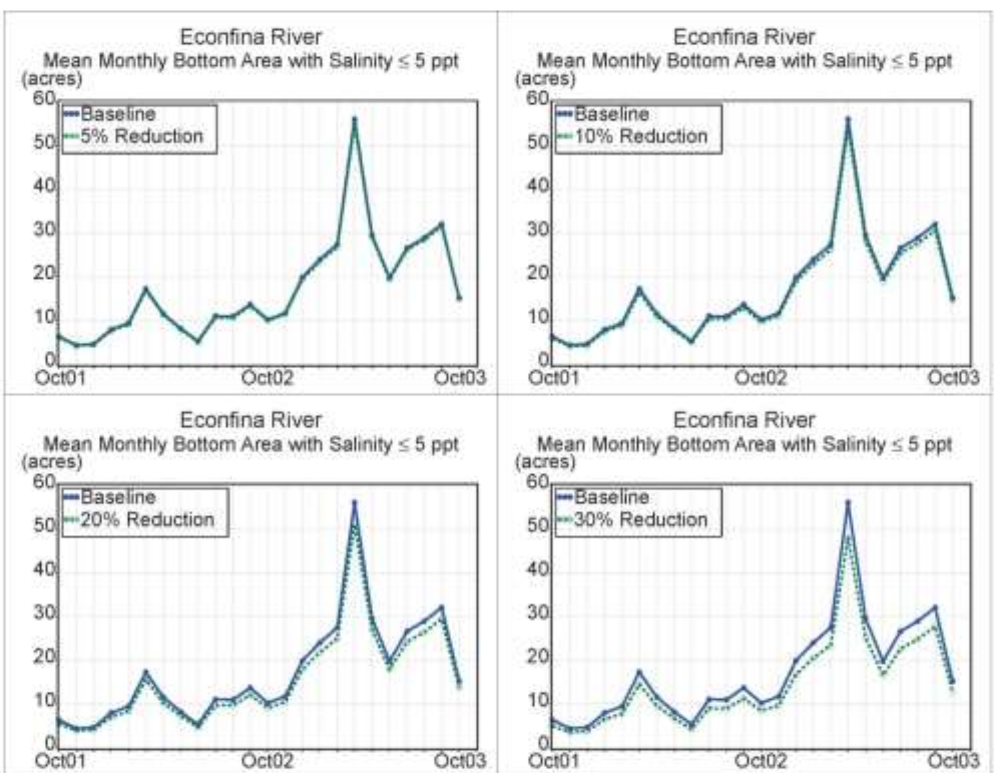

Figure 5-22. Comparison of the mean monthly bottom area with 0-5 ppt salinity for the baseline and four (4) percent flow reduction scenarios.

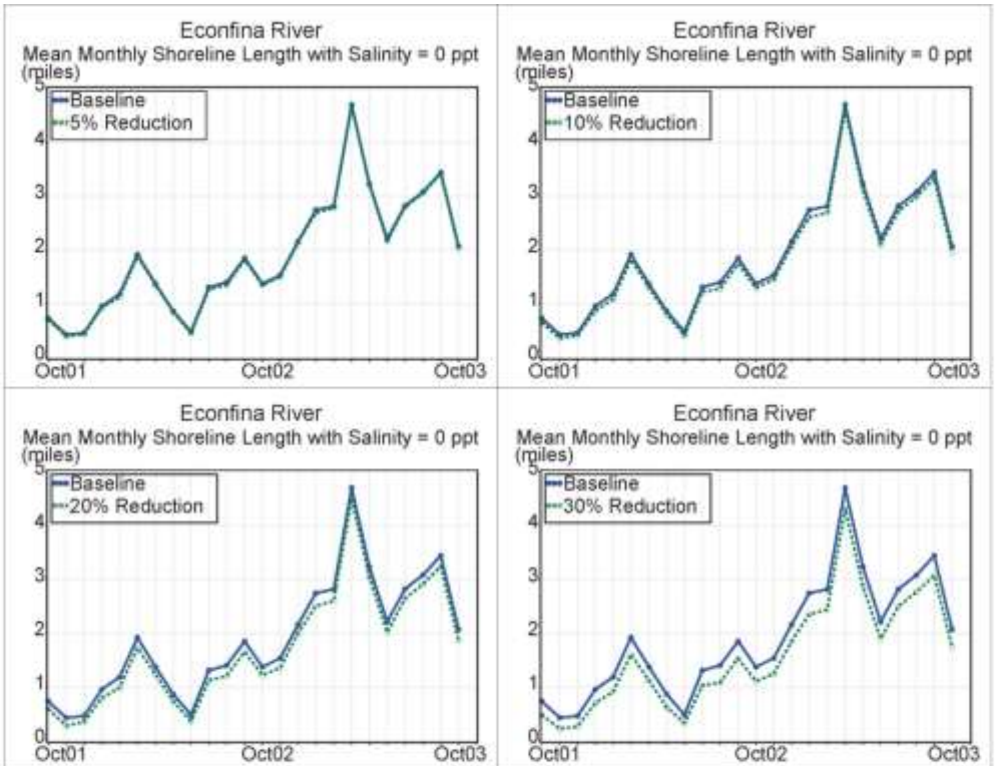

Figure 5-23. Comparison of the mean monthly shoreline length with 0 ppt salinity for the baseline and four (4) percent flow reduction scenarios.

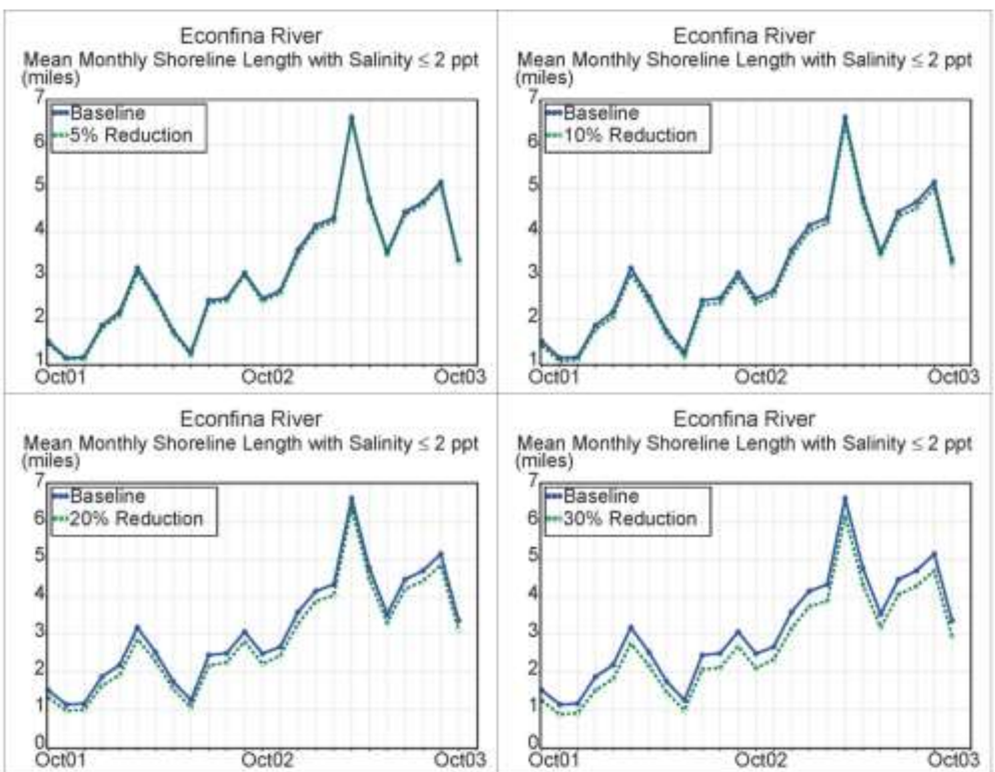

Figure 5-24. Comparison of the mean monthly shoreline length with 0-2 ppt salinity for the baseline and four (4) percent flow reduction scenarios.

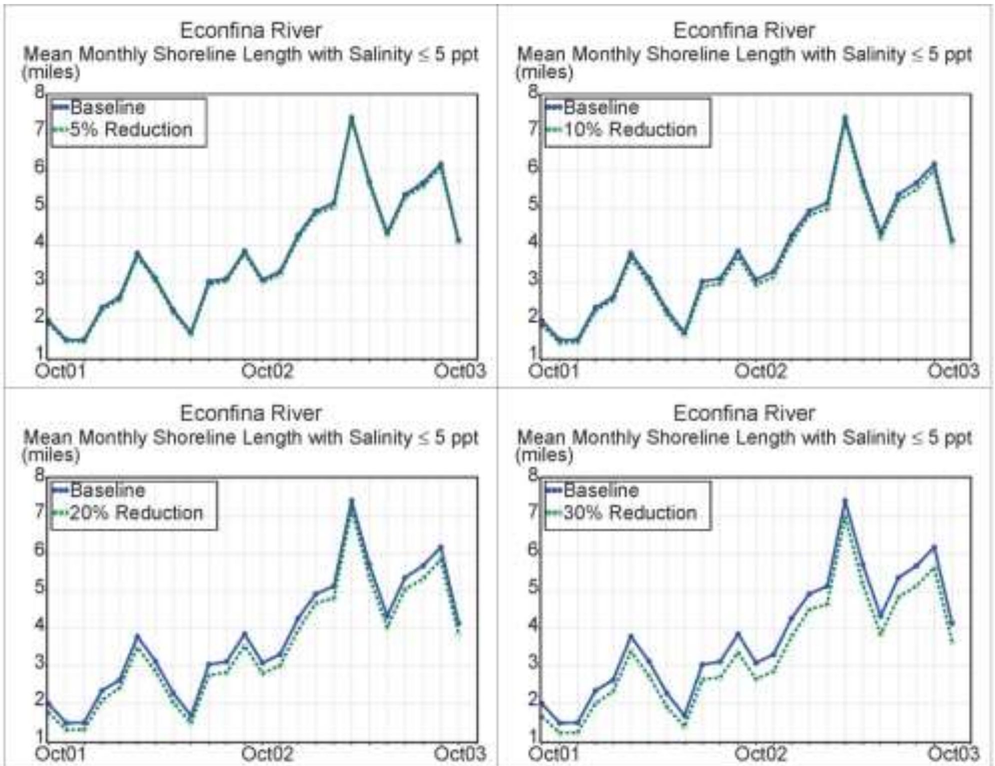

Figure 5-25. Comparison of the mean monthly shoreline length with 0-5 ppt salinity for the baseline and four (4) percent flow reduction scenarios.

The responses in the river volume, bottom area, and shoreline length at the three critical salinities to the simulated reductions in river flow were also examined by plotting the cumulative distribution functions of the baseline results with the results from each of the four (4) percent reductions in river flow. Figures 5-26 through 5-28 present the comparisons of the cumulative distribution functions of the mean monthly river volume with 0 ppt, 0-2 ppt, and 0-5 ppt salinity for the baseline and four (4) percent flow reduction scenarios, respectively. As seen in the comparisons of the time series results, the differences are small for both the 5-percent and 10-percent reductions in flow for three salinities examined. The differences increased with increasing flow reductions but the differences between the baseline and the 20-percent and 30-percent flow reductions were modest with the greatest differences being found at the mid-range of river volumes.

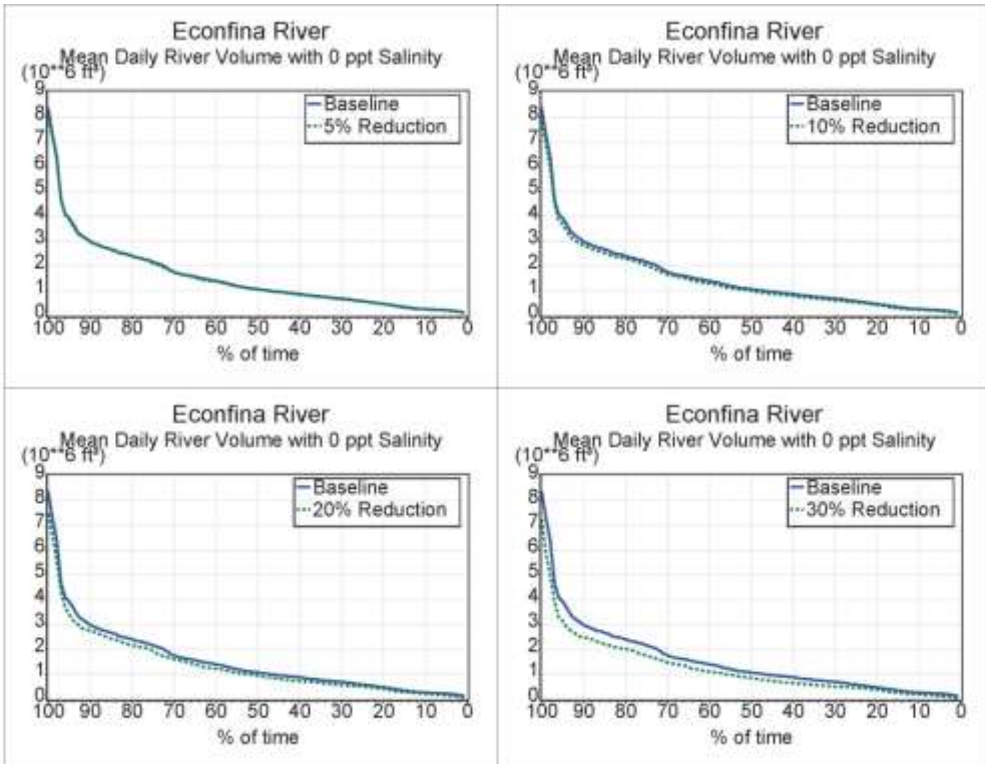

Figure 5-26. Comparison of the cumulative distribution functions of the mean monthly river volume with 0 ppt salinity for baseline and 4 percent flow reduction scenarios.

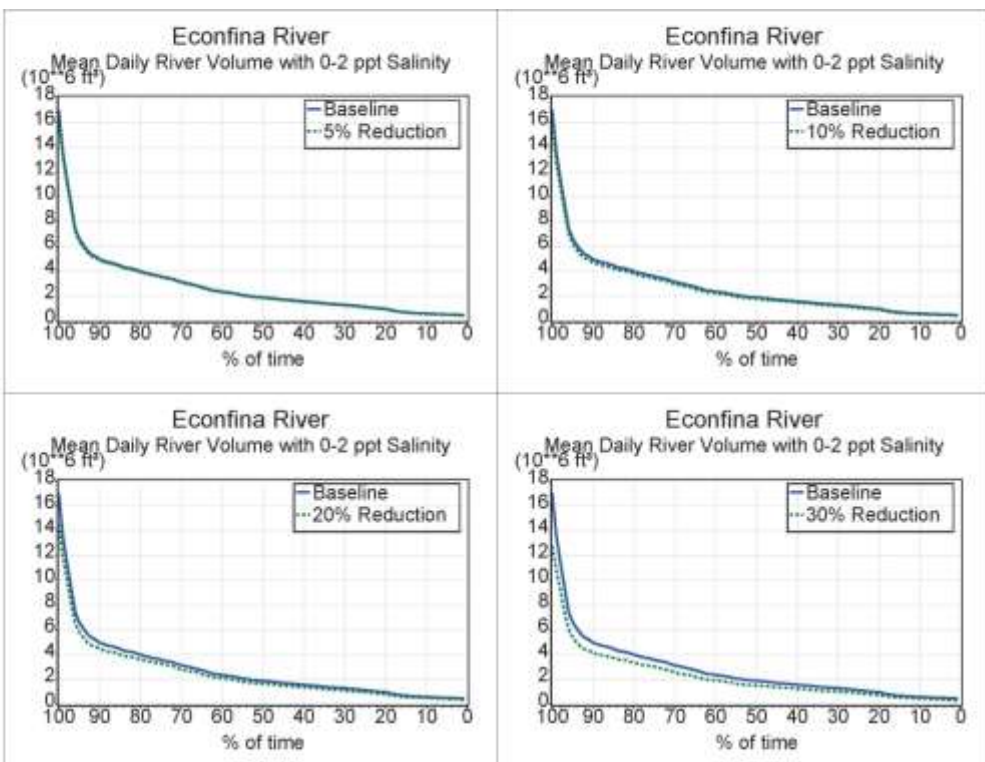

Figure 5-27. Comparison of the cumulative distribution functions of the mean monthly river volume with 0-2 ppt salinity for baseline and 4 percent flow reduction scenarios.

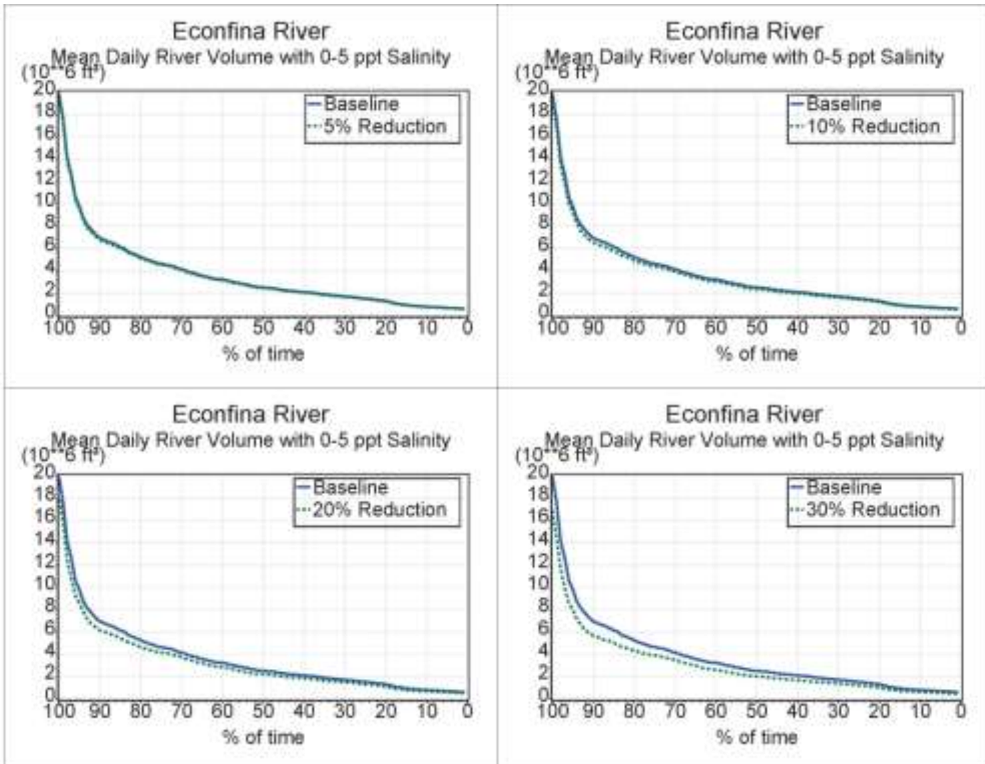

Figure 5-28. Comparison of the cumulative distribution functions of the mean daily river volume with 0-5 ppt salinity for the baseline and 4 percent flow reduction scenarios.

Figures 5-29 through 5-31 present the comparisons of the cumulative distribution functions of the mean monthly bottom area with 0 ppt, 0-2 ppt, and 0-5 ppt salinity for the baseline and four (4) percent flow reduction scenarios, respectively. As seen in the comparisons of the time series results, the differences are small for both the 5-percent and 10-percent reductions in flow for three salinities examined. The differences increased with increasing flow reductions but the differences between the baseline and the 20-percent and 30-percent flow reductions were modest with the greatest differences being found at the mid-range of bottom areas.

Figures 5-32 through 5-34 present the comparisons of the cumulative distribution functions of the mean monthly shoreline length with 0 ppt, 0-2 ppt, and 0-5 ppt salinity for the baseline and four (4) percent flow reduction scenarios, respectively. As seen in the comparisons of the time series results, the differences are small for both the 5-percent and 10-percent reductions in flow for three salinities examined. The differences increased with increasing flow reductions but the differences between the baseline and the 20-percent and 30-percent flow reductions were modest with the greatest differences being found at the mid-range of shoreline lengths.

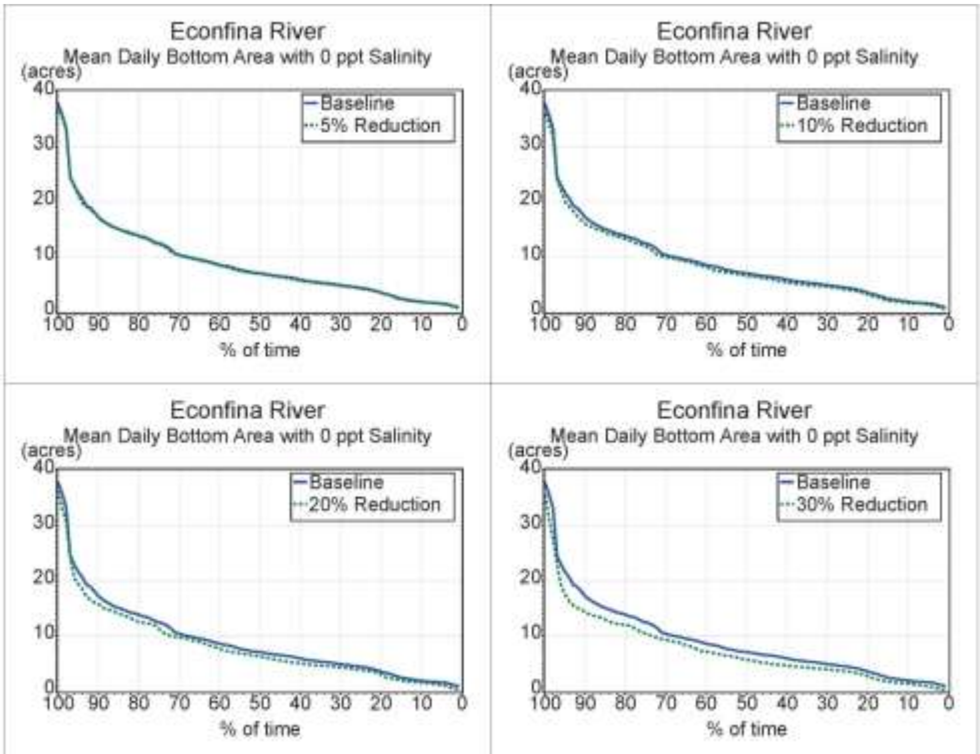

Figure 5-29. Comparison of the cumulative distribution functions of the mean daily bottom area with 0 ppt salinity for the baseline and 4 percent flow reduction scenarios.

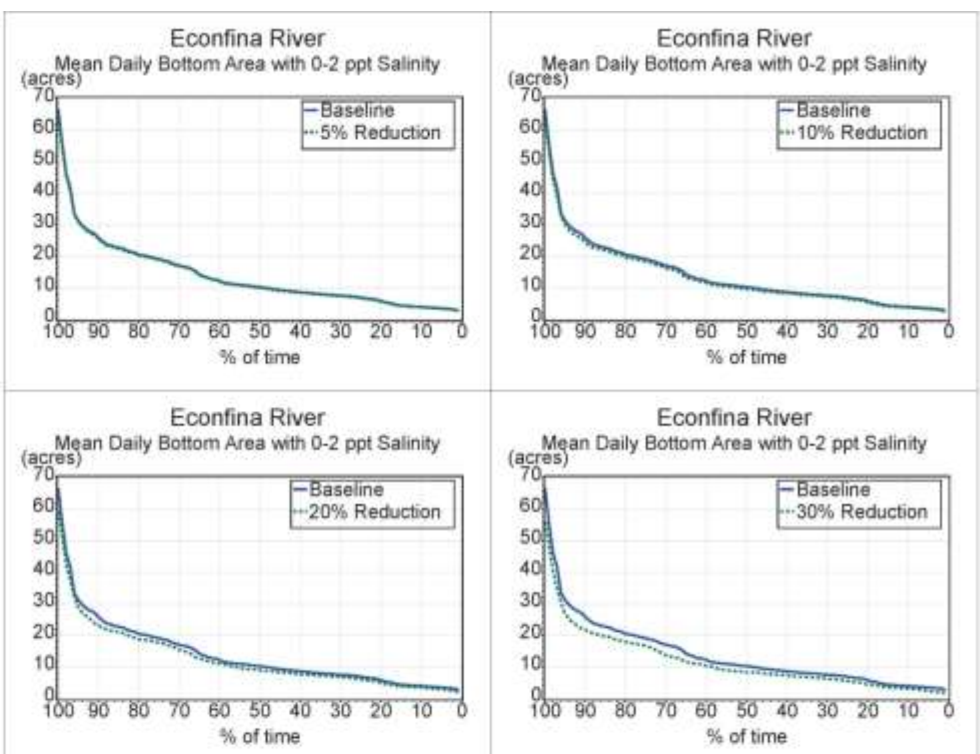

Figure 5-30. Comparison of the cumulative distribution functions of the mean daily bottom area with 0-2 ppt salinity for the baseline and 4 percent flow reduction scenarios.

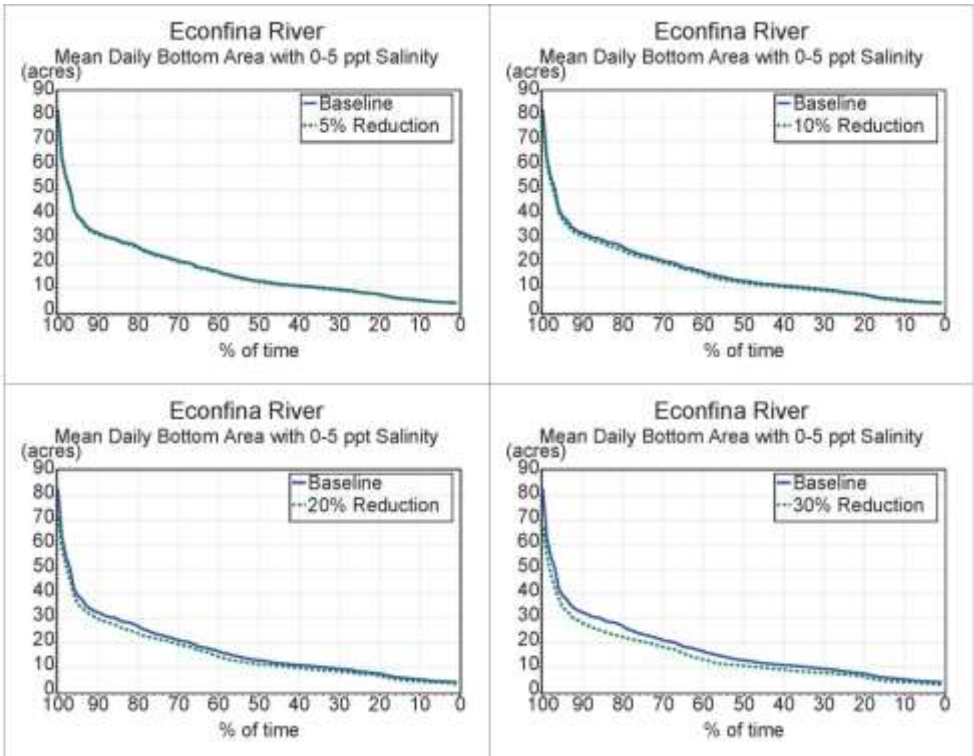

Figure 5-31. Comparison of the cumulative distribution functions of the mean daily bottom area with 0-5 ppt salinity for the baseline and 4 percent flow reduction scenarios.

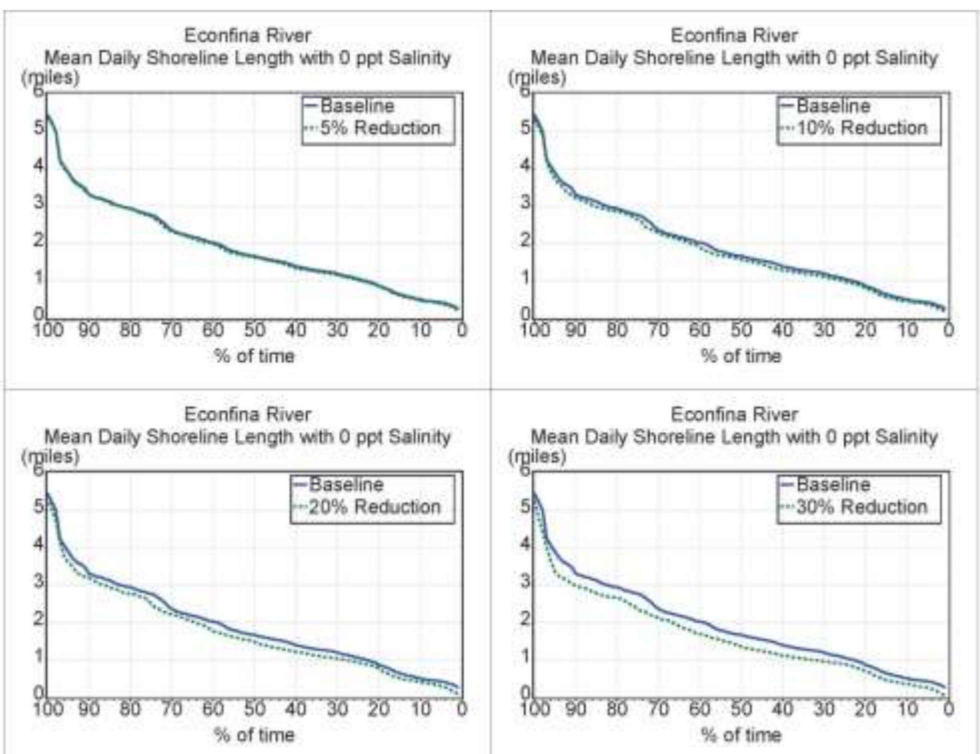

Figure 5-32. Comparison of the cumulative distribution functions of the mean daily shoreline length with 0 ppt salinity for the baseline and 4 percent flow reduction scenarios.

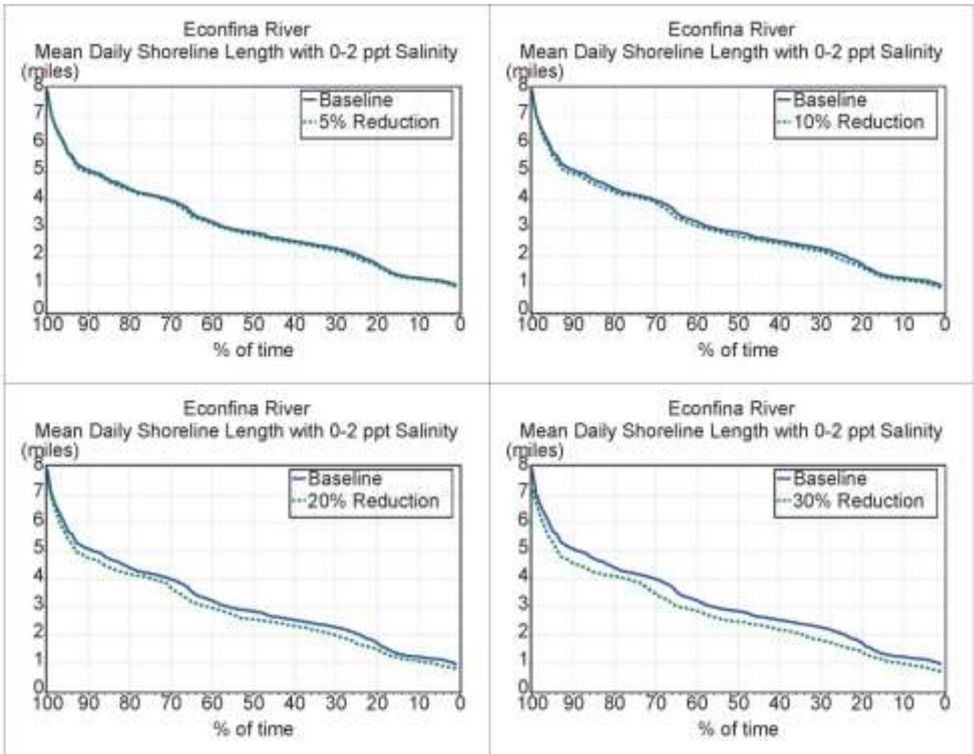

Figure 5-33. Comparison of the cumulative distribution functions of the mean daily shoreline length with 0-2 ppt salinity for the baseline and 4 percent flow reduction scenarios.

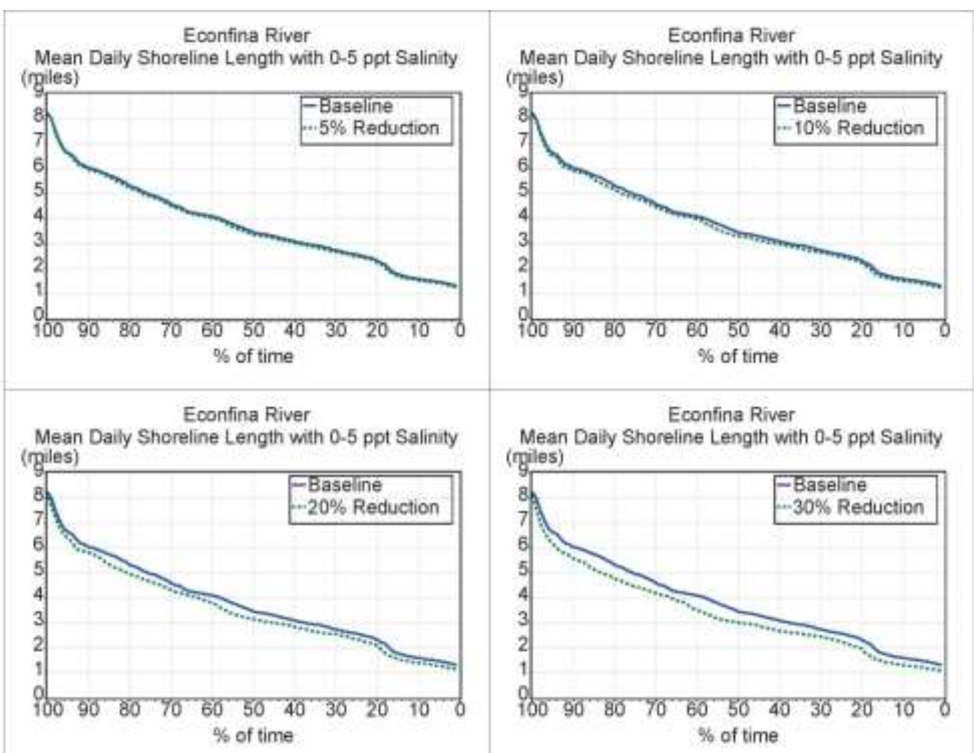

Figure 5-34. Comparison of the cumulative distribution functions of the mean daily shoreline length with 0-5 ppt salinity for the baseline and 4 percent flow reduction scenarios.

The cumulative distribution functions of the baseline results with the results from each of the four (4) percent reductions in river flow for the bottom areas and shoreline lengths showed similar responses as observed in the river volumes. These plots can be found in Appendix C.

In addition to the analysis of the river volume, bottom area, and shoreline length as a function of reductions in river flow, the relationships between the percent flow reductions simulated by the EFDC model and the location of the 0 ppt, 2 ppt, and 5 ppt isohalines in the surface and bottom waters of the Econfina River, a series of time series plots that compare the locations of these isohalines for the baseline and each percent flow reduction are included in Appendix C.

5.2.1 SUMMARY OF THE RESPONSES IN SALINITY TO VARIATIONS IN REDUCTIONS IN RIVER FLOWS

The following presents summaries of the comparisons of the various river habitat metrics (volume, bottom area, and shoreline length) that have the critical salinities of 0 ppt, 0-2 ppt, and 0-5 ppt for the baseline and each of the four (4) percent flow reduction scenarios that were simulated by the EFDC model. Similar comparisons were made for the 0 ppt, 2 ppt, and 5 ppt isohalines in the surface and bottom waters of the Econfina River.

Tables 5-1 through 5-3 present a summary of the comparisons of the median river volume, bottom area, and shoreline length between the baseline and percent reduction scenarios. For example, the statistics compared in these tables were calculated by estimating the daily river volume for a given salinity or salinity range for each day in the simulation period and deriving the median of those values for each model scenario. The differences between the medians for each of the percent reduction scenarios and the median for the baseline condition are calculated as a percent difference from the baseline. The objective is to estimate the percent flow reduction that corresponds to a 15% difference from the baseline.

With respect to river volume, the percent flow reduction that corresponds to a 15% difference is bracketed by the 20-percent and 30-percent flow reductions. In other words, the percent flow reduction that corresponds to a 15% reduction in river volume with a given salinity (0, 0-2, or 0-5 ppt) lies between 20-percent and 30-percent. The estimated percent flow reduction that results in a 15% reduction in river volume was 23% for each of the salinity/salinity ranges of 0 ppt, 0-2 ppt, and 0-5 ppt; the result was insensitive to the selected salinity/salinity range.

Table 5-1. Comparison of median baseline volume to the median volumes by critical salinity for each of the four (4) percent reduction scenarios.

Scenario	Statistic	0 ppt	0-2 ppt	0-5 ppt
Baseline	Volume ($ft^3 * 10^3$)	1,062	1,873	2,508
5% Reduction	Volume ($ft^3 * 10^3$)	1,048	1,838	2,448
	% Difference from Baseline	-1.3%	-1.9%	-2.4%
10% Reduction	Volume ($ft^3 * 10^3$)	9,926	1,758	2,355
	% Difference from Baseline	-6.5%	-6.2%	-6.1%
20% Reduction	Volume ($ft^3 * 10^3$)	927	1,640	2,188
	% Difference from Baseline	-12.7%	-12.5%	-12.8%
30% Reduction	Volume ($ft^3 * 10^3$)	833	1,499	2,014
	% Difference from Baseline	-21.6%	-20.0%	-19.7%

Table 5-2. Comparison of median baseline bottom area to the median bottom areas by critical salinity for each of the four (4) percent reduction scenarios.

Scenario	Statistic	0 ppt	0-2 ppt	0-5 ppt
Baseline	Bottom Area ($ft^2 * 10^3$)	306	444	558
5% Reduction	Bottom Area ($ft^2 * 10^3$)	303	432	541
	% Difference from Baseline	-1.1%	-2.6%	-3.1%
10% Reduction	Bottom Area ($ft^2 * 10^3$)	286	417	522
	% Difference from Baseline	-6.6%	-6.2%	-6.5%
20% Reduction	Bottom Area ($ft^2 * 10^3$)	274	389	493
	% Difference from Baseline	-10.50%	-12.50%	-11.70%
30% Reduction	Bottom Area ($ft^2 * 10^3$)	246	364	465
	% Difference from Baseline	-19.8%	-18.1%	-16.7%

Table 5-3. Comparison of median baseline shoreline length to the median shoreline lengths by critical salinity for each of the four (4) percent reduction scenarios.

Scenario	Statistic	0 ppt	0-2 ppt	0-5 ppt
Baseline	Shoreline Length (ft)	8,791	15,019	18,193
5% Reduction	Shoreline Length (ft)	8,588	14,549	17,692
	% Difference from Baseline	-2.3%	-3.1%	-2.8%
10% Reduction	Shoreline Length (ft)	8,303	14,293	17,425
	% Difference from Baseline	-5.6%	-4.8%	-4.2%
20% Reduction	Shoreline Length (ft)	7,794	13,499	16,609
	% Difference from Baseline	-11.3%	-10.1%	-8.7%
30% Reduction	Shoreline Length (ft)	7,110	13,062	15,893
	% Difference from Baseline	-19.1%	-13.0%	-12.6%

With respect to bottom area (Table 5-2), the percent flow reduction that corresponds to a 15% difference is again bracketed by the 20-percent and 30-percent flow reductions. The estimated percent flow reduction that results in a 15% reduction in bottom area with a salinity of 0 ppt, 0-2 ppt, and 0-5 ppt varied and was 25%, 25%, and 27%, respectively.

With respect to shoreline length (Table 5-3), even a 30-percent reduction in flows did not result in at least a 15% reduction in shoreline lengths with salinity of 0-2 ppt or 0-5 ppt. The percent flow reduction that corresponds to a 15% difference in shoreline length with 0 ppt salinity is bracketed by the 20-percent and 30-percent flow reductions. The estimated percent flow reduction that results in a 15% reduction in shoreline length with a salinity of 0 ppt was 25%.

Table 5-4 presents comparisons of the locations of the 0 ppt, 2 ppt, and 5 ppt isohalines for the surface waters of the Econfina River under the baseline and each of the four (4) percent flow reductions. None of the percent flow reduction scenarios resulted in at least a 15% difference between the baseline isohalines and the isohalines for each of the percent flow reductions. Similar results were obtained for the bottom water isohalines (Table 5-5).

Table 5-4. Comparison of median baseline surface isohaline locations to the median isohaline locations for each of the four (4) percent reduction scenarios.

Scenario	Statistic	0 ppt	2 ppt	5 ppt
Baseline	River Mile	2.73	2.20	1.92
5% Reduction	River Mile	2.74	2.22	1.94
	% Difference from Baseline	0.2%	0.4%	2.3%
10% Reduction	River Mile	2.77	2.24	1.97
	% Difference from Baseline	1.5%	2.3%	3%
20% Reduction	River Mile	2.79	2.29	2.02
	% Difference from Baseline	2.2%	4.3%	5.8%
30% Reduction	River Mile	2.84	2.35	2.09
	% Difference from Baseline	4.7%	6.1%	9.4%

Table 5-5. Comparison of median baseline bottom waters isohaline locations to the median isohaline locations for each of the four (4) percent reduction scenarios.

Scenario	Statistic	0 ppt	2 ppt	5 ppt
Baseline	River Mile	2.73	2.46	2.29
5% Reduction	River Mile	2.74	2.47	2.30
	% Difference from Baseline	0%	0.4%	0%
10% Reduction	River Mile	2.77	2.49	2.32
	% Difference from Baseline	1.3%	1.5%	0.3%
20% Reduction	River Mile	2.79	2.53	2.36
	% Difference from Baseline	2.1%	2.2%	0.6%
30% Reduction	River Mile	2.84	2.58	2.42
	% Difference from Baseline	4.6%	2.7%	5.6%

5.3 RESPONSES IN FISH PASSAGE AND OUT-OF-BANK FLOWS TO REDUCTIONS IN RIVER FLOWS

As discussed in earlier sections, there are two WRVs that are being considered in the establishment of the Econfina River MFL – WRV 2 Fish Passage / Fish and Wildlife Habitat and WRV 3 Estuarine Resources. The Estuarine Resources WRV was examined in Section 5.2. WRV 2 is addressed in the following.

5.3.1 FISH PASSAGE

Fish passage is one of the WRVs that is addressed in the establishment of the Econfina River MFL. As discussed in Section 4, fish passage is assumed to be precluded at water depths less 0.8 ft. The water depths along the thalweg of the river were estimated on a daily basis for the entire simulation period for the baseline and the four (4) percent flow reductions that were simulated.

None of the percent flow reductions simulated resulted in a water depth that precludes fish passage in the Econfina River. Again, the water depths along the thalweg were compared in this analysis. A more conservative measure, the mean water depth across each lateral row of model cells, was also compared between the baseline and the four (4) percent flow reduction scenarios. As with the thalweg water depth, none of the percent flow reductions that were simulated resulted in a water depth that precludes fish passage across any lateral row of model cells in the Econfina River. Thus, any MFL that allows less than a 30-percent reduction in flows will be protective of fish passage in the reach of the Econfina River that is represented in the EFDC model.

5.3.2 OUT-OF-BANK FLOWS

The best available data information that relates river flows to the availability of fish and wildlife habitat can be derived from the EFDC model simulations. As discussed in Section 4, the occurrence of out-of-bank flows allows fish and other wildlife to take advantage of the inundated areas as well as supporting the riparian vegetation and hydric soils.

The frequency of out-of-bank flows was estimated by comparing the daily water surface elevations to the elevation of the topmost model cell along a reach of the river where the most extensive riparian vegetation can be found – near RM 3.4. The bank elevation in this portion of the river is approximately 1.92 feet. To estimate the frequency of out-of-bank flows the daily water surface elevations were compared to 1.92 feet.

The number of days during the simulation period when the water surface elevation in the river near RM 3.4 was at or below 1.92 feet were found as follows:

- Baseline – 104 days
- 5-percent Reduction Scenario – 92 days
- 10-percent Reduction Scenario – 87 days
- 20-percent Reduction Scenario – 68 days
- 30-percent Reduction Scenario – 58 days

A frequency of out-of-bank flows of 88 days is equivalent to a reduction of 15% in the number of days for the baseline (104 days). The percent flow reduction that results in the 15% reduction in the number of days during which out-of-bank flows occurred is 8.6 percent.
That means if the river flow is reduced across the board by 8.6 percent from the baseline there will be only 88 days of out-of-bank flows.

The lowest flow that provided for out-of-bank flows at RM 3.4 during the simulation period was estimated as follows. First, the days during the simulation period when the 1.92 feet at RM 3.4 was exceeded were identified. These were the 104 days identified from the baseline model scenario. There were 2 days in the 104 that had unrealistically low flows (62 and 79 cfs) which were not used in this analysis. Excepting these, the lowest flow during those days that provided for out-of-bank flows at RM 3.4 was 211 cfs at USGS Gage 02326000. Therefore, the 8.6 percent flow reduction is applicable to river flows that are ≥ 211 cfs.

5.4 MFL RECOMMENDATIONS

Based on the analyses discussed above, two recommended MFLs emerge:

- A 23 percent reduction from the baseline flows that is protective of the salinity distributions in the lower Econfina River; and
- A 8.6 percent reduction of flows at river flows ≥ 211 cfs.

Both of these MFLs are also protective of fish passage in the Econfina River. Additionally, the relationships between river flows and water quality parameters, other than salinity, have been examined. The plots that display these relationships are found in Appendix D. Based on an examination of these plots, the proposed MFL for the Econfina River will be protective of the water quality in the river.

Figure 5-35 presents the baseline and proposed MFL FDCs for the Econfina River. Selected exceedances that describe the two FDCs are given in Table 5-6. The differences between the baseline and MFL values show variable flow reductions ranging from 2.3 cfs to 46.4 cfs.

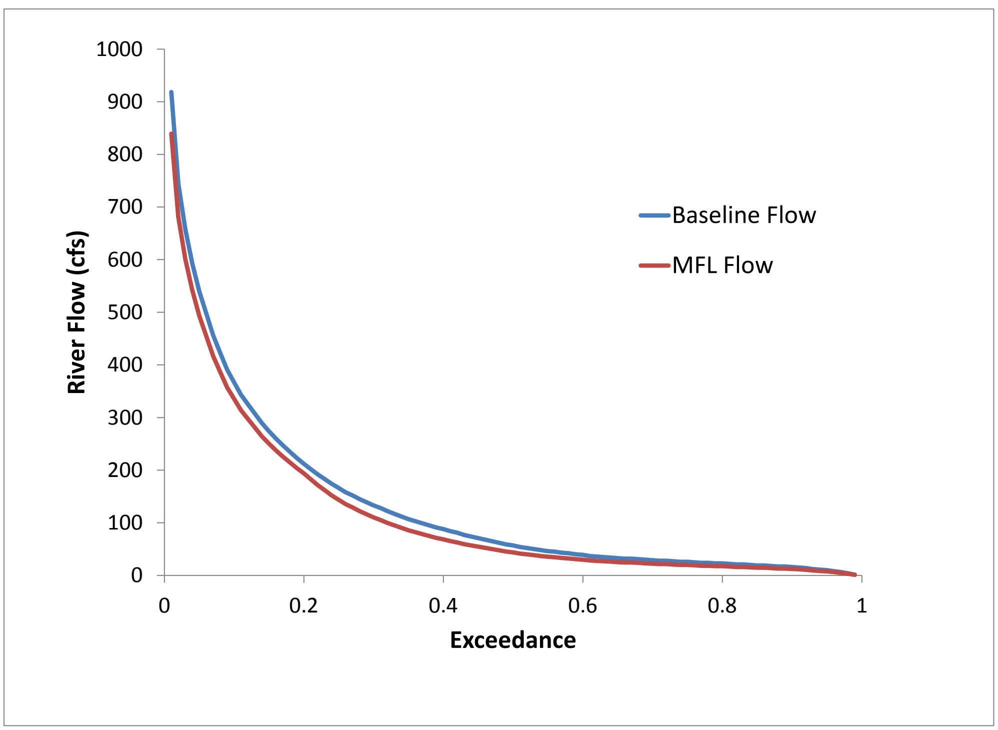

Figure 5-35. Comparison of the baseline and MFL flow duration curves.

Table 5-6. Comparison of baseline and MFL discharge exceedance amounts.

FDC	Discharge Exceedance Amounts (cfs)						
	5%	10%	25%	50%	75%	90%	95%
Baseline	540.0	367.0	166	57.0	26.0	16.0	10.0
MFL	493.6	335.4	143.6	43.9	20.0	12.3	7.7
Difference	46	31.6	22.4	13.1	6	3.7	2.32
%Difference	8.5	8.6	13.5	23	23	23.1	23

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