Effects of the Withdrawal of Water on Protected Species in the Pascagoula River: An Application of the Instream Flow Incremental Methodology

Strategic Petroleum Reserve Richton ■ U.S. Department of Energy ■ March 2009

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Strategic Petroleum Reserve Richton

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Acronyms

BA	Biological Assessment
cfs	cubic feet per second
CSI	composite suitability index
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
EPACT	Energy Policy Act of 2005
ESA	Endangered Species Act
FR	*Federal Register*
FWS	U.S. Fish and Wildlife Service
IFIM	Instream Flow Incremental Methodology
MDEQ	Mississippi Department of Environmental Quality
MDWFP	Mississippi Department of Wildlife, Fisheries and Parks
mgd	million gallons per day
MIF	minimum instream flow
MMNS	Mississippi Museum of Natural Science
NEPA	National Environmental Policy Act
PHABSIM	Physical Habitat Simulation System
ROD	Record of Decision
RWI	raw water intake
SPR	Strategic Petroleum Reserve
USGS	U.S. Geological Survey
VAF	velocity adjustment factor
WUA	weighted usable area
YOY	young-of-the-year

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Chapter 1. Introduction

This report describes the results of an analysis of the impacts of the proposed expansion of the Strategic Petroleum Reserve (SPR) in Richton, MS on fish and reptile species of the Pascagoula River (Figure 1-1). The Instream Flow Incremental Methodology (IFIM) results are used to assess how withdrawal of water from the Pascagoula River associated with the development and operation of the SPR will modify flow in the river and thereby change the quantity and quality of habitat for the species. The background, methodology, and conclusions regarding the potential impact of the SPR on the study species are summarized below. The analysis is supported by detailed model results (Appendix A) and hydrological data (Appendix B).

1.1. Purpose

Expansion of the SPR in the Pascagoula River basin would require the use of fresh water to solution mine a salt dome in Richton, MS to create underground oil storage. The proposed project would remove water from the Pascagoula River via a raw water intake (RWI) (Figure 1-1). The withdrawal has the potential to alter stream flows and affect several rare species, including the Gulf sturgeon (*Acipenser oxyrinchus*), pearl darter (*Percina aurora*), and yellow blotched map turtle (*Graptemys flavimaculata*) (EEE Consulting 2008). The proposed water withdrawal is for a sustained removal above a given minimum instream flow (MIF) to the operational limit of 78 cubic feet per second (cfs).

The SPR expansion project and corresponding installation of a RWI is proposed by DOE, and requires approval from state and federal resource managers responsible for permitting the proposed action. The management agencies and authorities agreed to use IFIM (Bovee *et al*. 1998) to assess the effect of the water withdrawal on species in the Pascagoula River basin relative to laws and regulations protecting aquatic resources in the system.

The following permitting and review agencies, along with DOE and their consultants, make up the IFIM Review Team:

- U.S. Department of Energy (DOE)
- U.S. Fish and Wildlife Service (FWS)
- Mississippi Department of Environmental Quality (MDEQ)
- Mississippi Department of Wildlife, Fisheries and Parks (MDWFP)
- Mississippi Museum of Natural Science (MMNS)
- ICF and ICF Jones & Stokes
- EEE Consulting

1.2. Project Background

The Energy Policy Act of 2005 (EPACT) (P.L. 109-58) required DOE to select the sites necessary to expand the SPR from its current 727-million-barrel capacity to 1 billion barrels. To fulfill the requirements of the National Environmental Policy Act (NEPA) for the expansion project, DOE has prepared a Final Environmental Impact Statement (EIS) regarding site selection.

In the Record of Decision (ROD) (February 22, 2007, 72 *Federal Register* (FR) 7964), DOE announced its selection of Richton, Mississippi, as the location of a new SPR facility as part of the expansion project. The site was selected for its large and undeveloped salt dome, enhanced oil distribution capabilities, and inland location, which is less vulnerable to hurricanes than a Gulf Coast location. The ROD states that the RWI, needed for oil storage cavern development, maintenance, and drawdown at the Richton facility, will be located by the Leaf River at New Augusta, Mississippi (10 miles from the Richton Site). A secondary RWI will be sited at the Gulf of Mexico (88 miles from the Richton Site), and a terminal and tank farm will be located at the former Naval Station Pascagoula, a Base Realignment and Closure site on Singing River Island in the Gulf of Mexico.

Since release of the ROD, DOE has engaged in further consultations with FWS, MDEQ, and other governmental entities. As a result, DOE has agreed to analyze the impacts of the proposed withdrawal at a proposed location with greater water availability than the Leaf River at New Augusta. DOE has identified the Pascagoula River near Merrill as one alternative to be considered, and is preparing a Supplemental Environmental Impact Statement.

In accordance with Section 7 of the Endangered Species Act (ESA), DOE will prepare a Biological Assessment (BA) evaluating the impact of the entire proposed SPR expansion project described in the ROD, including any subsequent changes (such as relocating the withdrawal to the Pascagoula River) on species protected under the ESA. Listed species include the yellow blotched map turtle and the Gulf sturgeon, both listed as threatened under the ESA; and the pearl darter, a candidate for listing under the ESA. FWS requested analysis of the impacts of the project on ESA species using IFIM (Bovee *et al*. 1998). As the applicant, lead agency, and a member of the IFIM Review Team, DOE agreed to engage in an IFIM study to address the potential adverse impacts of the project on these three species.

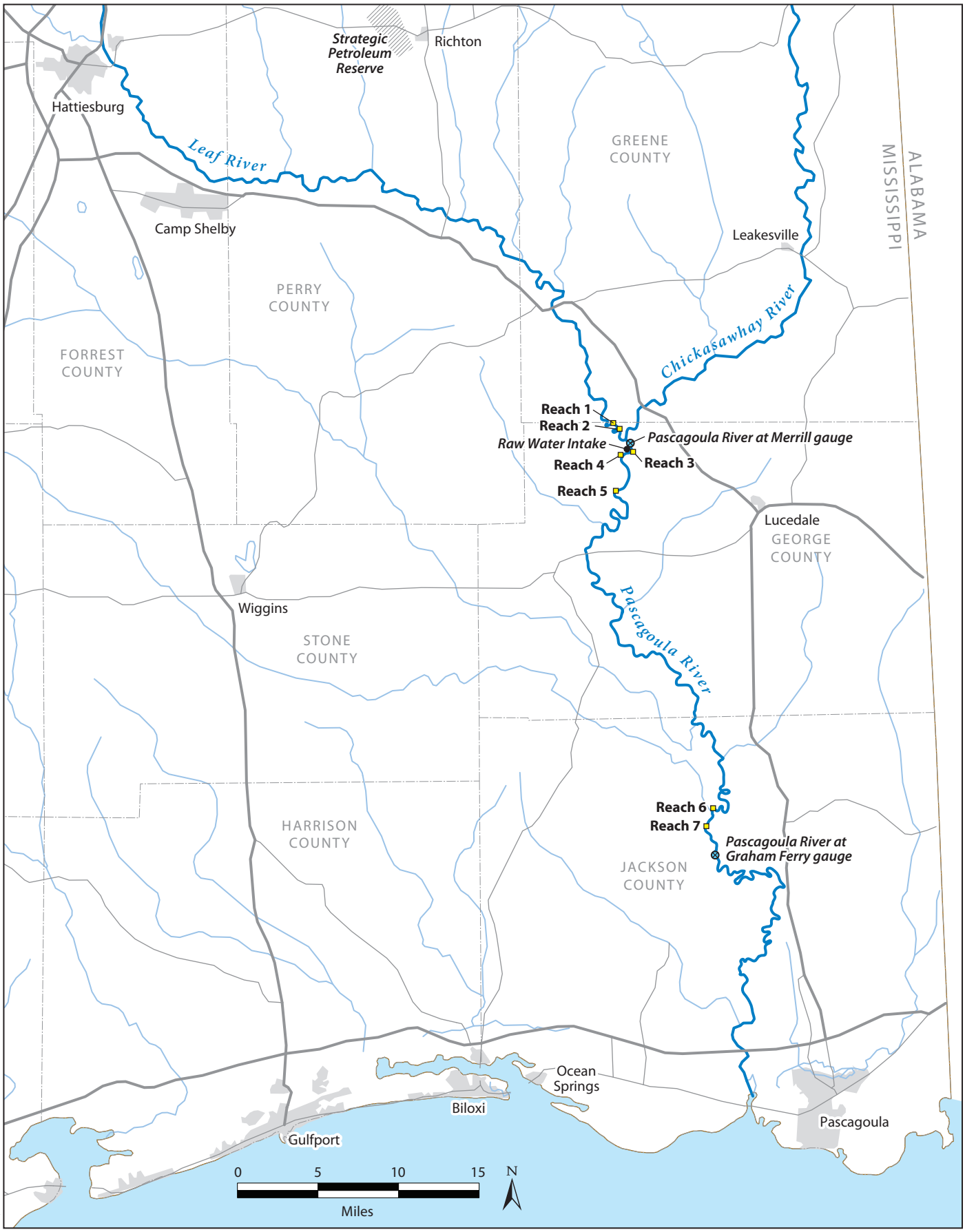

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Figure 1-1
Study Area

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IFIM is a structured decision-support system, originally developed by FWS and U.S. Geological Survey (USGS) to estimate the impacts of water management alternatives on habitat for aquatic species. IFIM is a collection of generalized methodologies and a process that can be adapted to a variety of instream issues. IFIM is generalized in several respects, and must be adapted to any particular water management investigation. IFIM consists of four phases:

1. Scoping
2. Planning
3. Implementation
4. Analysis and Resolution

The scoping and planning phases for this project were completed during spring and summer of 2008 and were presented in the Detailed Implementation Plan approved by the IFIM Review Team in August, 2008 (ICF Jones & Stokes 2008). Those phases, including background information describing the purpose and need for the IFIM, the institutional framework for the analysis, and the rationale for scoping of the analysis, are described in this Introduction. The focus of this report is the implementation of IFIM in accordance with the Detailed Implementation Plan, the results of the IFIM, and the interpretation of those results.

1.3. Institutional Process

Early in 2008, discussions occurred between DOE and FWS concerning the proposed SPR expansion project's potential effects on species protected under, or candidates for protection under, the ESA. Although the SPR expansion project as a whole could affect a variety of species, three listed species occupy aquatic habitat within the Pascagoula River and would be affected by the withdrawal of water. These are the Gulf sturgeon, the pearl darter, and the yellow blotched map turtle. These are hereafter referred to as the study species. In the spring of 2008, DOE and FWS agreed that IFIM was an appropriate methodology for evaluation of potential project effects on these species. An IFIM Review Team was assembled that included relevant state and federal agencies. At that time, the greater part of the IFIM effort was scoped.

The IFIM Review Team members, and their institutional concerns and responsibilities, are as follows:

U.S. Department of Energy: DOE is the project proponent. Under Section 7 of the ESA they are required to consult with FWS regarding the project's potential effects on ESA-protected species. These agencies are responsible for providing project information necessary for formulation and testing of alternatives using IFIM. Their primary concern is to ensure that their project remains viable while meeting its legal obligations under ESA and other laws.

U.S. Fish and Wildlife Service: FWS is charged with implementation and enforcement of the ESA for these species. FWS suggested the use of the IFIM as an appropriate tool for evaluating potential project effects on ESA-protected species. The IFIM was originally developed by FWS. The technique has been widely implemented for a variety of aquatic species. However, it is only one of several information

sources that FWS will use in determining whether to concur with DOE's assessment of project effects on ESA-protected species. The primary concern of FWS in the IFIM process is that it be implemented in a manner that reveals the potential effects of flow changes on ESA-protected species and meets data quality requirements for information supporting a final determination of project effects.

Mississippi Department of Wildlife, Fisheries and Parks: MDWFP is charged with management of Mississippi's wildlife resources, including the study species. They also manage a substantial portion of the river bottom lands potentially affected by flow changes resulting from the proposed SPR expansion project. Their primary concern is that project effects on these resources and lands be minimized. MDWFP is represented on the IFIM Review Team by Dennis Riecke, fisheries biologist.

Mississippi Department of Environmental Quality: MDEQ has authority under regulations pertaining to the diversion and use of water resources in Mississippi. DOE must secure from MDEQ a permit authorizing the proposed withdrawal at Merrill, and MDEQ has authority to limit and condition that permit as necessary to protect state resources. MDEQ's primary concern is that DOE meet permitting requirements for the proposed withdrawal in a manner that minimizes impacts on all state resources.

Mississippi Museum of Natural Science: MMNS is part of MDWFP, and representatives of MMNS are providing technical guidance for the species of concern as part of MDWFP's mission to manage the state's wildlife resources. They are represented on the review team by Dr. Robert Jones, a recognized expert on the yellow-blotched map turtle, and are participating to ensure a biologically accurate implementation of IFIM. Dr. Jones also participated in the field phase of IFIM implementation. They are also represented by Dr. Todd Slack, a recognized expert on the biology of the Gulf sturgeon, pearl darter, and other Mississippi fishes. Dr. Slack contributed greatly to the development of the IFIM. Dr. Slack also participated in the field phase of IFIM implementation.

EEE Consulting: EEE Consulting is a consultant assisting the DOE. They are charged with preparing the BA, and they also participated in the field phase of IFIM implementation.

ICF and ICF Jones & Stokes: ICF is a consultant assisting the DOE. They are charged with implementation of the IFIM and preparation of supporting documents, including this report. ICF is also preparing the Supplemental EIS.

1.4. Scope

The IFIM Review Team assembled on June 9 and 10, 2008, in Jackson, Mississippi. Meeting attendees are listed in Appendix C. At that meeting, the scope of the IFIM analysis was developed. That scope included the following elements:

Geography: The proposed withdrawals for the SPR expansion project would come from the Pascagoula River at Merrill, just below the confluence of the Leaf and Chickasawhay Rivers. Flows would be altered downstream of the proposed withdrawal. It was agreed that the IFIM would be conducted for study reaches that included the Pascagoula River at the proposed withdrawal, and a major sturgeon holding area

located approximately 30 miles downstream from the proposed withdrawal, with the precise locations of transects to be determined in the field by members of the review team.

Hydrology: It was agreed that the primary hydrological data source would be the USGS gauge station on the Pascagoula River at Merrill (USGS 02479000). The IFIM Review Team agreed to focus on the low flow conditions in the Pascagoula, agreeing that the proposed quantity of water to be withdrawn would not likely affect peak or high flows in any discernable manner. Following preparation of the draft IFIM assessment in December 2008, the IFIM Review Team showed interest in studying system response to a greater variation in flows, and the studied flow scenarios were expanded to extend from 0 cfs to 4,000 cfs (0 to 2,000 cfs for the two study reaches on the Leaf River). Evaluation of higher flows was deemed unnecessary because it would require excessive extrapolation from observational data, which were collected at flows of approximately 2,000 cfs (Pascagoula River at Merrill gauge), and because the proposed withdrawal was relatively small compared with moderate and high flows on the Pascagoula.

Study species. The IFIM Review Team recommended that the study address flow impacts on the habitat of adult and juvenile pearl darter, juvenile Gulf sturgeon, and the yellow blotched map turtle. The IFIM Review Team agreed that these species are representative of the hydrological and ecological conditions of the Pascagoula, and would be sufficient for evaluating the impacts of the proposed withdrawal.

Alternatives: DOE is proposing to withdraw water at a rate up to 78 cfs at the withdrawal site to support solution mining and maintenance of the SPR. DOE has agreed that the project should not increase the occurrence of the 7Q10 flow, set by MDEQ at 917 cfs. The "7Q10" flow is the average discharge during the driest 7-day period within a 10-year period. It was also agreed that the hypothetically greatest impact would occur if the withdrawal caused the flow to drop to the 7Q10 flow[1]. To evaluate this scenario the IFIM would evaluate the effects of causing Pascagoula River flows to drop by 78 cfs. We assessed these flow changes across a range of conditions varying from 400 to 4,000 cfs (200 to 2,000 cfs for the two reaches on the Leaf River, which contributes approximately 50% of the Pascagoula flow at Merrill).

Habitat Suitability Relationships: A key element of the Pascagoula IFIM was the development of habitat suitability relationships for the study species. These relationships are the basis for assessing the impacts of flow on the habitat for the study species. Because habitat suitability relationships for the study species have not been published, the collective knowledge of the IFIM Review Team was used to construct habitat suitability relationships for this project. The team considered the life history stages that would be studied, the environmental variables important to those life history stages, and the quantitative importance of those environmental variables. As a follow-up to the scope development stage, a meeting was held in on November 18 and 19, 2008, in Jackson, Mississippi, at which the habitat suitability curves were formulated. Species biology and derivation of the habitat suitability curves are presented in Section 3.3 of this report.

[1] Note that DOE subsequently committed to avoiding any withdrawal at flows of less than 1,000 cfs, so this worst case scenario would never occur in practice. Nonetheless 7Q10 is retained in this analysis as a benchmark minimum flow level that has a legal significance in the context of MDEQ regulation.

Goal and Objectives: The IFIM Review Team identified an overarching goal for the project with objectives relevant to specific institutional roles and objectives. The overarching goal is to develop an instream flow recommendation that will include the following elements:

- *No Net Loss of Habitat:* The recommended instream flow should not result in any net loss of habitat. This will be achieved through either avoidance or mitigation.
- *No Adverse Modification of Habitat:* The recommended flow should not result in any adverse modification to habitat that would preclude recovery of the listed species.
- *Data Gaps:* Where data gaps exist, the study should use the best available science including the professional judgment of the IFIM Review Team. The IFIM Review Team especially noted that an important data gap exists regarding the juvenile sturgeon life history stage.
- *Maintain Water Quality:* The recommended flow should maintain the water quality and designated uses (fishable and swimmable) of the Pascagoula River.
- *Alternatives Analysis (to include flow):* The study should include an alternative analysis that reduces potential impacts. The analysis would address a variety of flows to support alternative flow management decisions.
- *Avoidance or Mitigation:* The study should include appropriate avoidance or mitigation recommendations as necessary, depending on the instream flow findings.
- *Minimize Impact on Listed Species and Habitats:* The IFIM should include sufficient information to support future decisions that would not jeopardize the species of concern and would ensure compliance with the ESA.
- *Public Communication:* Study methodology, results, and recommendations should be appropriately documented so they could be effectively communicated to the public.

This report addresses objectives relevant to the IFIM, which include Data Gaps and Alternatives Analysis using the IFIM methodology. This report does not present a recommendation about minimum instream flows, but it does present information that will allow DOE to make such a recommendation as part of their proposal. Some objectives, such as maintaining water quality, will be addressed in the supplemental EIS for the proposed SPR expansion project or in other permitting documents within the jurisdiction of one or more IFIM Review Team members.

Chapter 2. Overview of the Instream Flow Incremental Methodology

Loss of aquatic habitat as a result of the modification of instream flow is pervasive across the United States and internationally (Dynesius and Nilsson 1994). To address these changes in habitat and their effects on aquatic species, guidelines were developed by many states to protect remaining stream resources. Many assessment methods that rely on hydrologic and empirical habitat information have been developed. These methods usually attempt to establish thresholds for minimum flow below which water may not be withdrawn for consumptive use (Stalnaker *et al*. 1995, cited by Zappia and Hayes 1998).

In the last 30 years, attention has shifted from establishing minimum flows to methods capable of quantifying the effects of incremental changes in streamflow. This shift in emphasis has occurred because single minimum instream flows are commonly inadequate to protect the aquatic resource. This situation arises because multiple values are often attached to natural resources such as fish species of concern or recreational uses, that may vary in their sensitivity to flow over the course of the year. The IFIM that was developed under the guidance of FWS uses various methodologies to evaluate changes in the amount of estimated usable habitat for various species or groups of species as flow changes.

2.1. The Instream Flow Incremental Methodology Process

The IFIM process integrates concepts of water supply planning, analytical hydraulic engineering models, and empirically derived habitat suitability relationships to address questions concerning the effects of flow modification on selected aquatic species. The IFIM process is a water management tool rather than an ecosystem model (Bovee *et al*. 1998). A goal of an IFIM study is the development of a consensus view of the problem amongst agencies and stakeholders. Cooperation and communication enable stakeholders to identify the problems and concerns, determine the effects of various alternatives, and recommend and implement plans and policy to minimize adverse effects of low-flow periods.

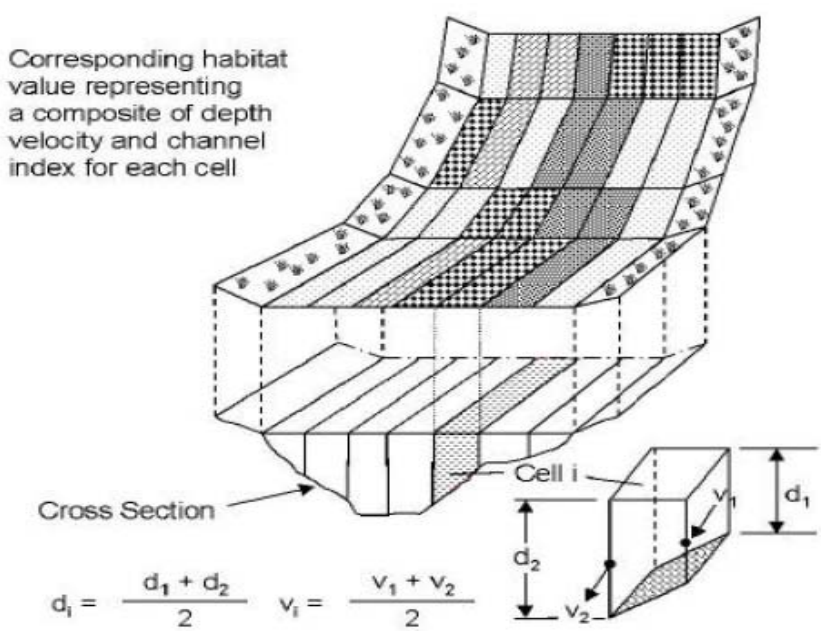
2.2. Instream Flow Technical Methods

This report details implementation of the IFIM technique on the Pascagoula River. The analysis required the use of hydraulic models to represent flow conditions corresponding to the incremental flows, and required a habitat simulation using the Physical Habitat Simulation Model (PHABSIM). PHABSIM is an established component of IFIM that rates the effects of habitat change on the study species within a study reach.

A study reach is a portion of the river within which habitat conditions are relatively uniform, and reflects a habitat condition that is widespread and/or biologically important within the river as a whole. This study, for instance, incorporated reaches that were dominated by point bars, by glide habitat, or by deep pool habitat. As will be shown in Section 3, each of these channel types provides important habitat for one or more of the species of concern. Each study reach is defined by representative cross-sections, called transects. Knowledge of the cross-sectional shape of the channel makes it possible to use PHABSIM to predict the water surface elevation in that reach for any given streamflow.

The result of PHABSIM is an estimate of the weighted usable area (WUA) of habitat for the study species. WUA is an environmental rating for each reach for the study species based on habitat suitability relationships established for each species. Study reaches are divided into cells and characterized with regard to water velocity, depth, or other attributes associated with the species (Figure 2-1). The area of each cell is weighted by its suitability based on the habitat suitability relationships. The area and characteristics of each cell change in response to flow. This results in a change in WUA for the species at different flow levels.

Figure 2-1. Schematic Diagram of a Composite Stream Reach



This schematic diagram of a composite stream reach depicts transects and stream cells. At any given flow, each cell will have a unique combination of hydrologic and stream-channel characteristics (source: Bovee *et al*. 1998).

Stream reaches are characterized by mesohabitat type. Mesohabitat types typically are the same order of magnitude in length as the channel width and are defined by the local channel slope, shape, structure, flow depth, and flow velocity. Riffles, runs, pools, bars, and divided channels are some stream features that are commonly classified as mesohabitat types. PHABSIM is used to model the hydraulics and habitat conditions for selected discharges. Data collected by either method are used to calibrate the model. The calibrated model is then used to simulate hydraulic conditions at selected flows other than those directly measured. If the representative reach method is used, PHABSIM is used to analyze channel geometry, flow, and habitat through transects and stream cells established in the reach and to determine the relation between habitat and discharge for the reach. In the representative reach method, the sequence and spacing of mesohabitat types in the reach represent the sequence and spacing of mesohabitat types in the segment.

PHABSIM is used to analyze channel geometry, flow, and habitat through transects and stream cells established in the individual mesohabitat types. A simulated reach is then developed where transects and stream cells in each mesohabitat type are weighted according to the proportion of that mesohabitat type in the segment. The relation between habitat and discharge for the stream segment is represented by the relation between habitat and discharge of the simulated reach. The simulated reach may represent the sequence of mesohabitat types in the segment, but it does not represent the actual spacing between transects.

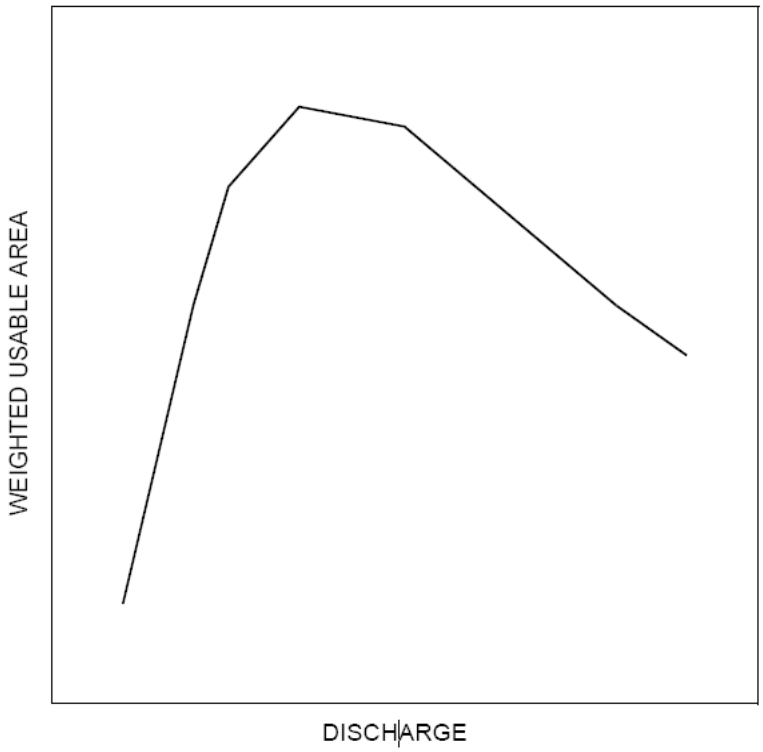
The hydraulic module of PHABSIM requires two types of data for the simulation of flow in the stream (Bovee *et al.* 1998): channel structure and hydraulic variables. Channel structure data include channel geometry and substrate classification and distribution, as well as other structures relevant to the issues being addressed. Hydrologic variables include water surface elevation, width, depth, velocity, wetted perimeter, discharge, and surface area. The hydraulic model simulates hydraulic variables at unmeasured discharges. Simulated variables are used as a substitute for repeated empirical measurements at numerous flows (Bovee *et al.* 1998). Channel structure and hydraulic variables then can be used to generate a computerized “map” of a composite stream reach representing the study stream reach. The composite stream reach is depicted as a mosaic of stream cells (Figure 2-1). At any given discharge, each cell will have a unique combination of hydraulic and stream channel characteristics (Bovee *et al.* 1998).

Hydraulic simulation with PHABSIM assumes that channel geometry does not change with discharge over the range of flows simulated. The results of the hydraulic calculations are water surface elevations and velocities. Water depths used in the habitat programs are calculated from the water surface elevations simulated in the hydraulic programs and the channel geometry. The water surface elevation for a simulated discharge at a specific transect is used for all the cells in that transect. In contrast, velocities vary from cell to cell in the transect. The hydraulic model assumes water-surface elevations are independent of the velocity distribution in the channel (Bovee *et al.* 1998). Three methods are available for calculation of water surface elevations: (1) direct stage-discharge relation or rating curve, (2) use of Manning’s equation, and (3) the step-backwater method. Any single method or combination of methods can be used to determine water surface elevations for simulated discharges through the reach (Bovee *et al.* 1998).

PHABSIM uses an empirically-derived rating curve to predict water surface elevations from the stage-discharge relation. A least-squares regression is fit to three or more pairs of log-transformed stage-discharge data. In reality, the regression is performed on the water surface elevation minus the stage of zero flow. The habitat part of the PHABSIM model requires hydraulic variables simulated in the hydraulic model and habitat suitability curves developed by use of direct field observation or by expert opinion. Habitat suitability curves can be used to relate the adequacy of hydraulic conditions to provide usable habitat for aquatic biota or support the water use of interest. Habitat suitability curves and water use flow requirements are combined with hydraulic conditions to rank the suitability of each stream cell in a computerized map for the aquatic biota or a water use of interest.

This study uses habitat suitability curves developed collaboratively by members of the IFIM Review Team. When the habitat suitability curve indices are multiplied by the surface area of the cell for a specified discharge, WUA is the result (Bovee *et al.* 1998). The WUA for a reach can be determined by summing the WUA of the individual cells at the specified discharge. A functional relation between discharge and habitat availability is produced by calculating the WUA at multiple discharges (Figure 2-2).

Figure 2-2. Generalized Relation of Weighted Usable Area to Discharge



Source: Zappia and Hayes 1998

Chapter 3. Application of the Instream Flow Incremental Methodology to the Pascagoula River

3.1. Watershed Conditions

The Pascagoula River basin covers an area of about 8,800 square miles in southeast Mississippi. The Pascagoula River itself has been described as the largest remaining uncontrolled river in the lower 48 states (Dynesius and Nilsson 1994). The Pascagoula is formed by the convergence of the Leaf and Chickasawhay Rivers, which come together just upstream of the proposed withdrawal, 80.8 river miles upstream from the Gulf of Mexico. Elevations in the basin range from sea level to 650 feet. At its head, the Pascagoula River has an average annual flow of 10,120 cfs. The seasonal pattern of flow reflects winter rains. Average monthly flows range from 3,227 cfs in October to 20,110 cfs in March, with most flow occurring from December through May. The basin is 72% forested and 21% in agricultural land, with the remainder in other land uses. The river generally has good to excellent water quality. Human use of the river includes consumptive and non-consumptive uses amounting to 3.3 million gallons per day (mgd) for irrigation, 4.2 mgd for livestock watering, and 49 mgd for industrial uses (Strom 1998, U.S. Geological Survey 2008).

The USGS gauge station on the Leaf River near McLain is 14.6 miles upstream from the Chickasawhay confluence. The Leaf River basin upstream of this point has an area of 3,495 square miles. The gauge datum is 42.15 feet, and the 1900 flood reached a stage of approximately 32 feet. Gauge heights usually vary from about 3 to 12 feet. Gauge data cover the period from 1939 to the present.

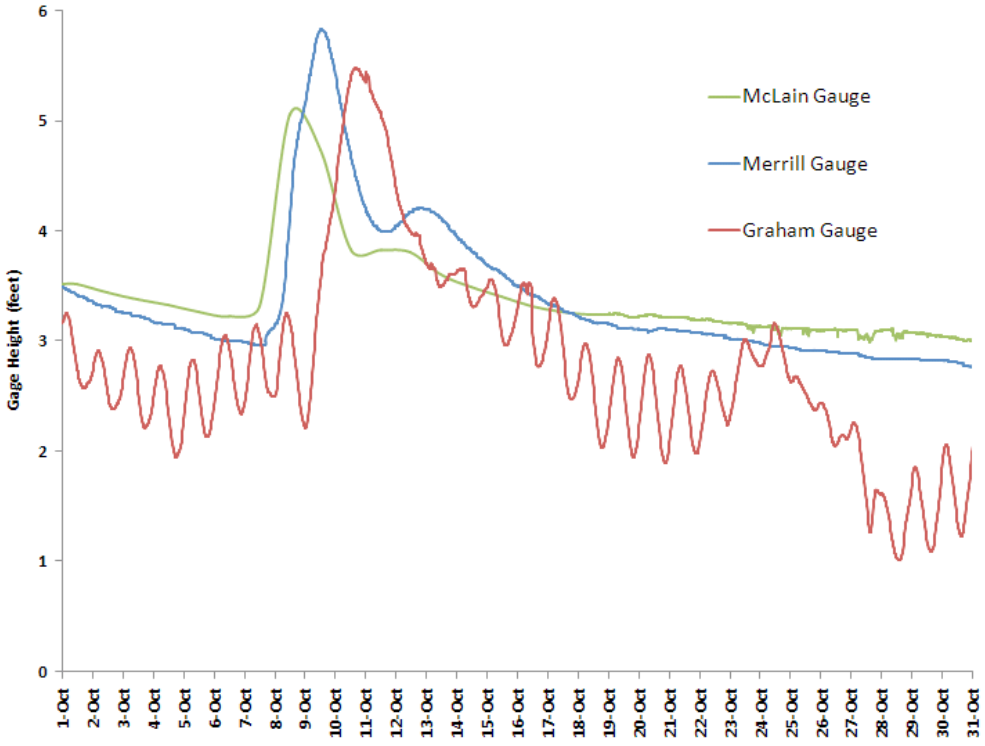
The USGS gauge station at Merrill is at river mile 80.8, 0.5 mile below the Leaf-Chickasawhay confluence and very near the site of the proposed withdrawal. The river basin upstream of this point has an area of 6,590 square miles. The gauge datum is 26.25 feet, and the flood of record, in April 1900, reached a stage of 32.5 feet. Most years, the monthly average gauge heights vary from about 3.5 to 14.5 feet. Gauge data cover the period from 1931 to the present.

The USGS gauge station at Graham Ferry is at river mile 34.4, by the State Highway 614 bridge. The river basin upstream of this point has an area of 8,204 square miles. The gauge datum is 0.00 feet, and this is a tidal reach of the river. The flood of record, in February 1961, reached a stage of 20.5 feet. Most years, the monthly average gauge heights vary from about 2.8 to 10.9 feet. Gauge data cover the period from 1993 to the present.

Stage measurements at the McLain, Merrill, and Graham Ferry gauges, taken during October 2008, are shown in Figure 3-1. Field data were collected during this time, including measurements of reach and transect data and flow velocity. Except during a freshet that peaked on October 10, the Graham Ferry gauge clearly shows tidal stage changes. As shown in Figure 3-2, discharge at Graham Ferry is on average 33% greater than discharge at Merrill, and discharge at McLain is on average half of discharge at Merrill. The flow discrepancy between the Merrill and Graham Ferry gauges is greatest in the low-flow months of September, October, and November, suggesting that baseflow variation is greater at Merrill than at Graham Ferry.

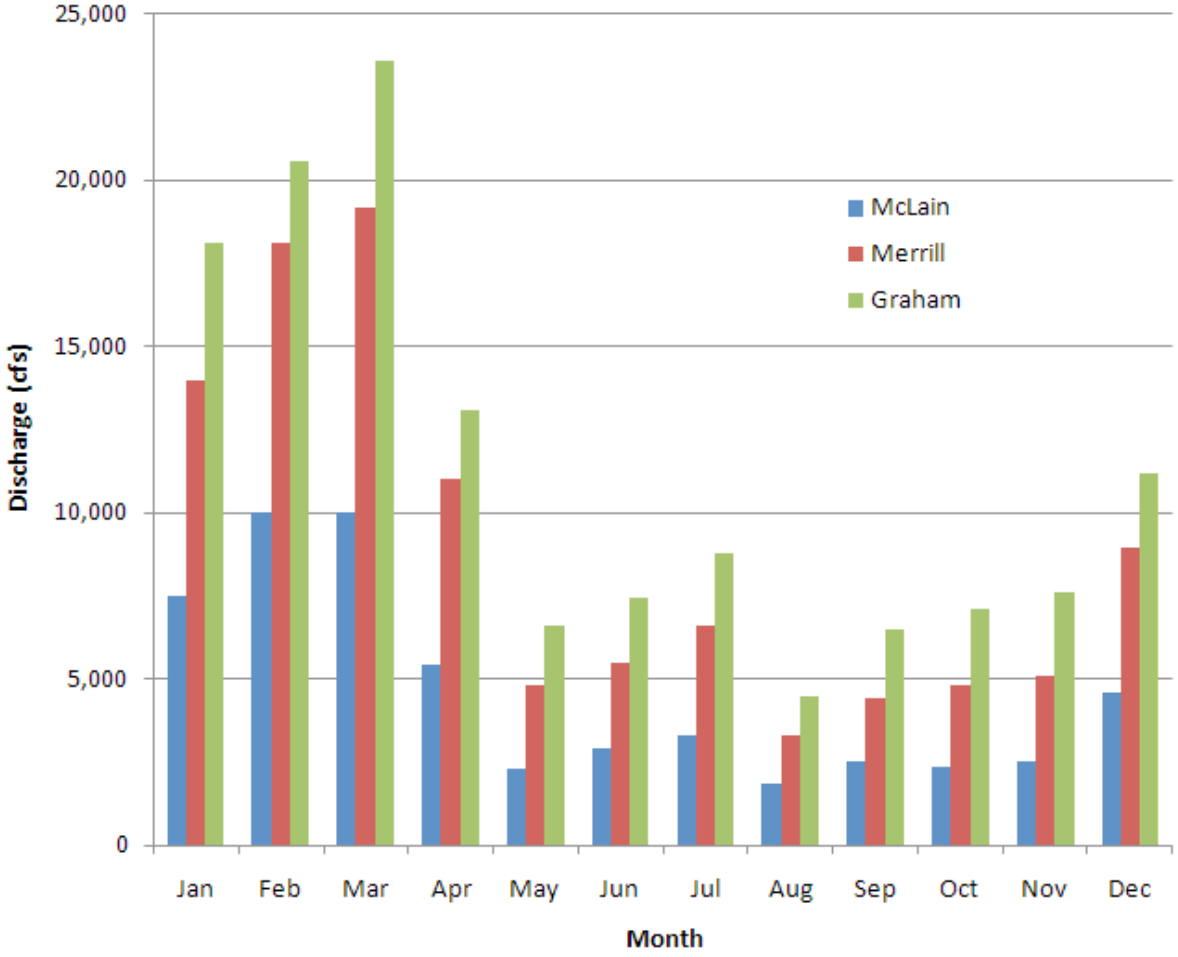
Appendix B includes the average flow exceedences and a description of the variances in flow. Flow increases and decreases occur very quickly in the system where changes in the daily mean stage height are usually far larger than the proposed 78 cfs withdrawal.

Figure 3-1. River Stage Recorded at the McLain, Merrill, and Graham Ferry Gauges (October 2008)



Source: U.S. Geological Survey 2008

Figure 3-2. Monthly Flows at McLain, Merrill, and Graham Ferry



Source: U.S. Geological Survey 2008

3.2. Study Area

IFIM Review Team members defined seven stream reaches for the IFIM study (Table 3-1, Figures 3-3 through 3-9). Reaches were delineated relative to the proposed withdrawal and were selected to sample habitat representative of the study species.

Reaches 1 and 2 are located on the lower Leaf River approximately 2.25 miles and 1.0 miles upstream from the confluence, respectively. These reaches were in a location that would not be affected by the withdrawal and thus constitute reference reaches. They are also distinct from all other reaches in being located on point bars.

Table 3-1. Sampled Reaches

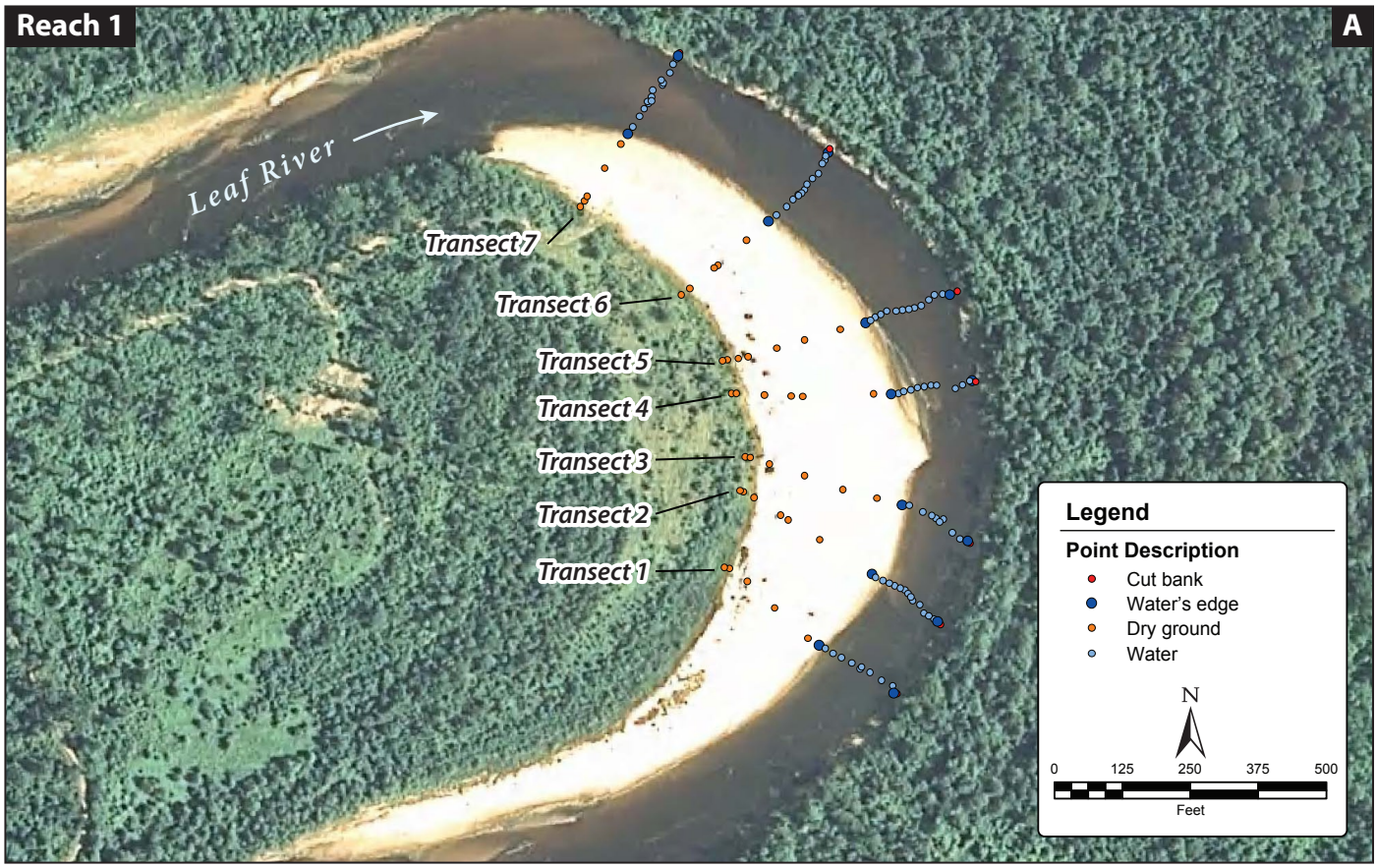
Reach	River Mile	Date sampled	Transects measured	Reach Length (feet)	Species Evaluated
1	82.9*	Oct. 14	7	1412	yellow blotched map turtle, juvenile Gulf sturgeon, pearl darter
2	82.2*	Oct. 15	6	647	yellow blotched map turtle, juvenile Gulf sturgeon, pearl darter
3	80.6	Oct. 16	3	464	yellow blotched map turtle, juvenile Gulf sturgeon, pearl darter
4	79.3	Oct. 20	9	1637	yellow blotched map turtle, juvenile Gulf sturgeon, pearl darter
5	76.7	Oct. 17	7	1156	yellow blotched map turtle, juvenile Gulf sturgeon, pearl darter
6	40.0	Oct. 21	3	489	subadult and adult Gulf sturgeon, pearl darter
7	38.5	Oct. 18	3	398	subadult and adult Gulf sturgeon, pearl darter

*Reach is on the Leaf River, river mile is measured from the mouth of the Pascagoula.
Data collected in October, 2008.

Based on the species data described below (Section 3.4), these reaches are suitable for evaluation of habitat for the pearl darter, juvenile Gulf sturgeon, and the yellow blotched map turtle.

Reaches 3, 4, and 5 are located on the Pascagoula River approximately 0.61, 1.32, and 4.36 miles below the confluence, respectively. Reach 3 is located near the proposed withdrawal. Reaches 3 and 4 are on the main channel in glide reaches, which constitute the principal mesohabitat type on the Pascagoula for many miles downstream from the proposed withdrawal. Reach 5 is on a large (approximately 200 feet wide) side channel and represents a locally common subtype of the glide habitat. These reaches are also suitable for evaluation of habitat for the pearl darter, juvenile Gulf sturgeon, and the yellow blotched map turtle.

Reaches 6 and 7 are on the Pascagoula River approximately 41.50 and 42.85 miles below the confluence, respectively. Both reaches represent pool habitat in a tidally influenced portion of the river. These reaches are in an area that is heavily used by subadult and adult sturgeon for holding.



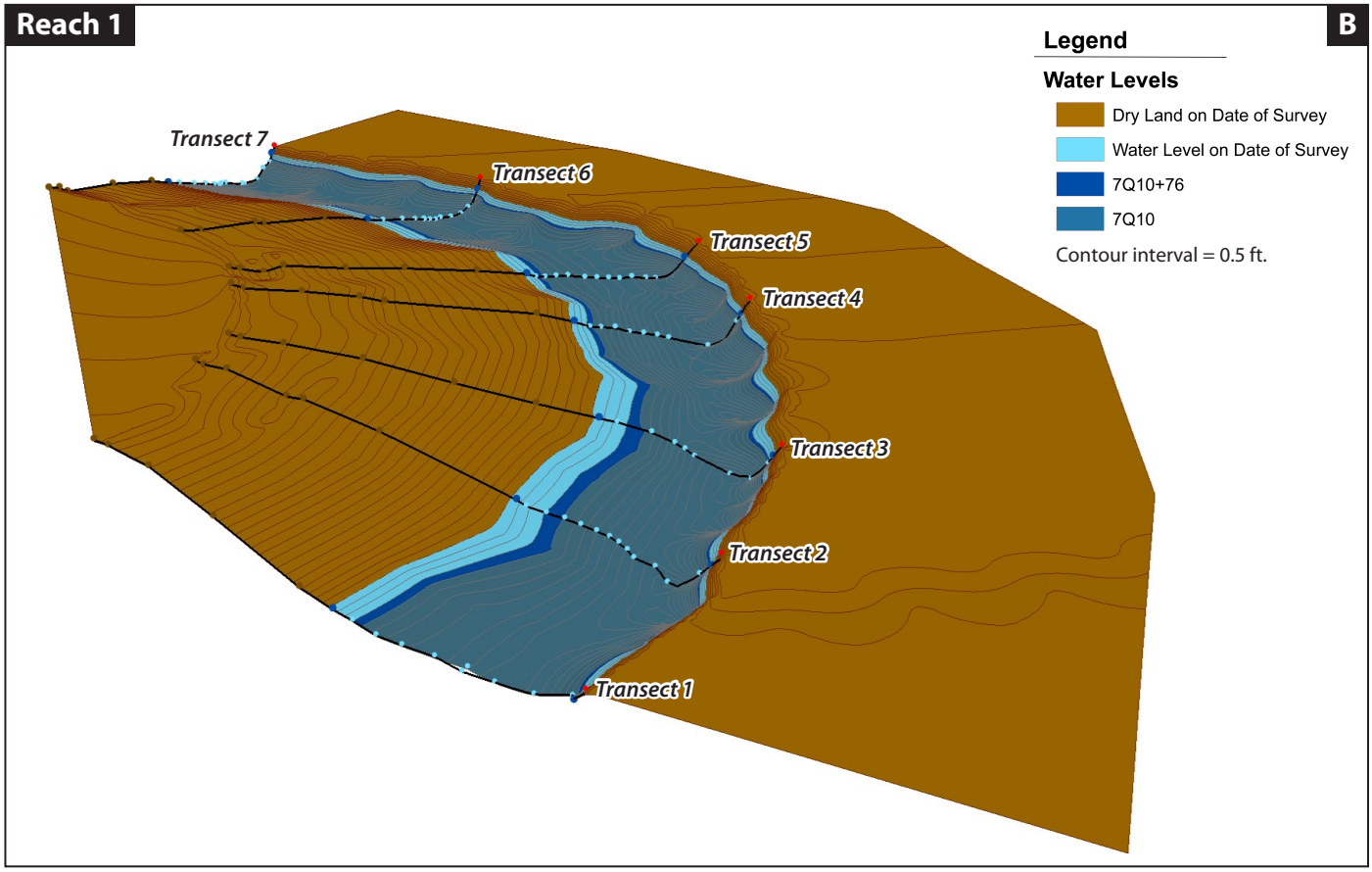


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Figure 3-3
Reach 1

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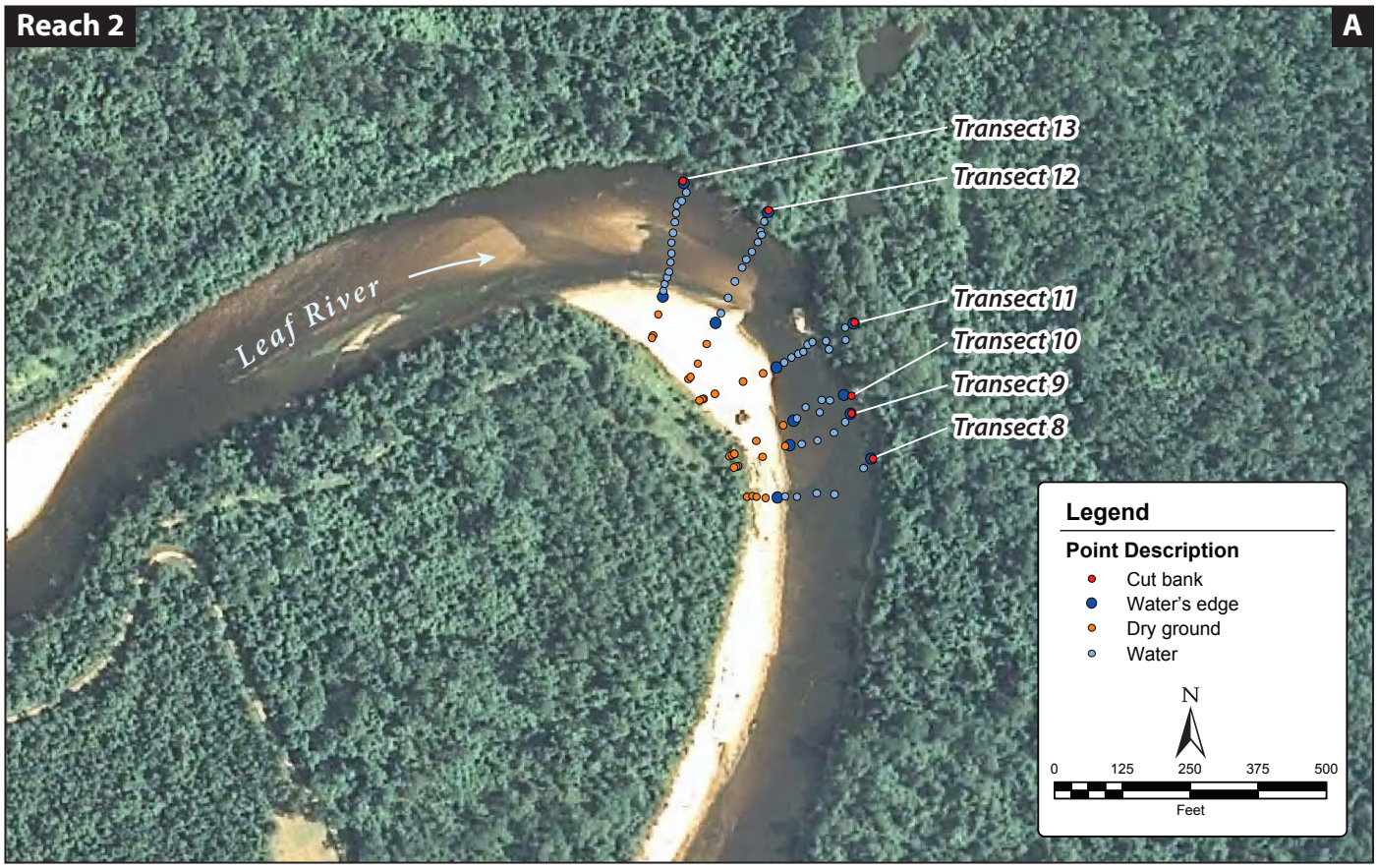

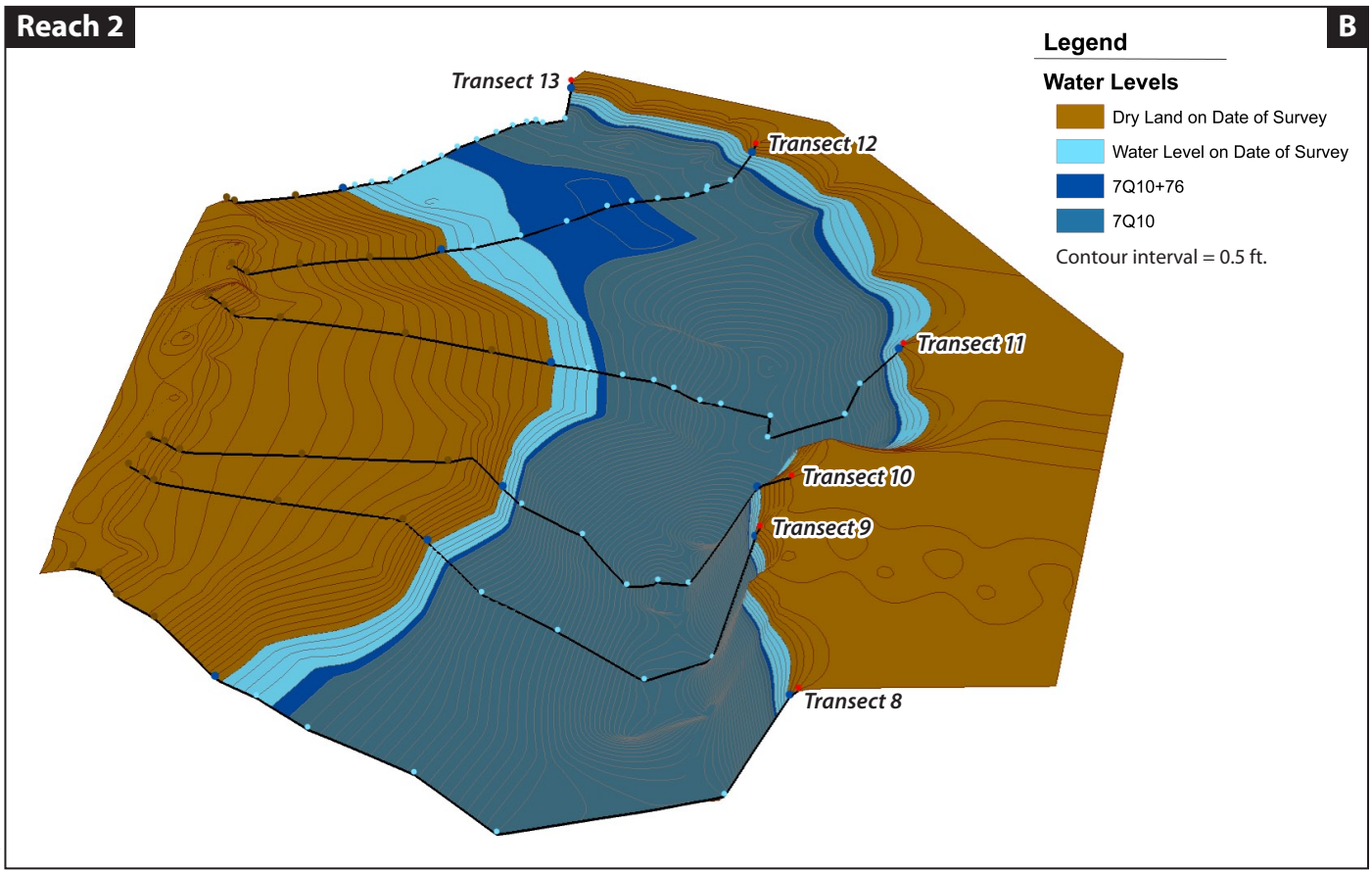

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Figure 3-4
Reach 2

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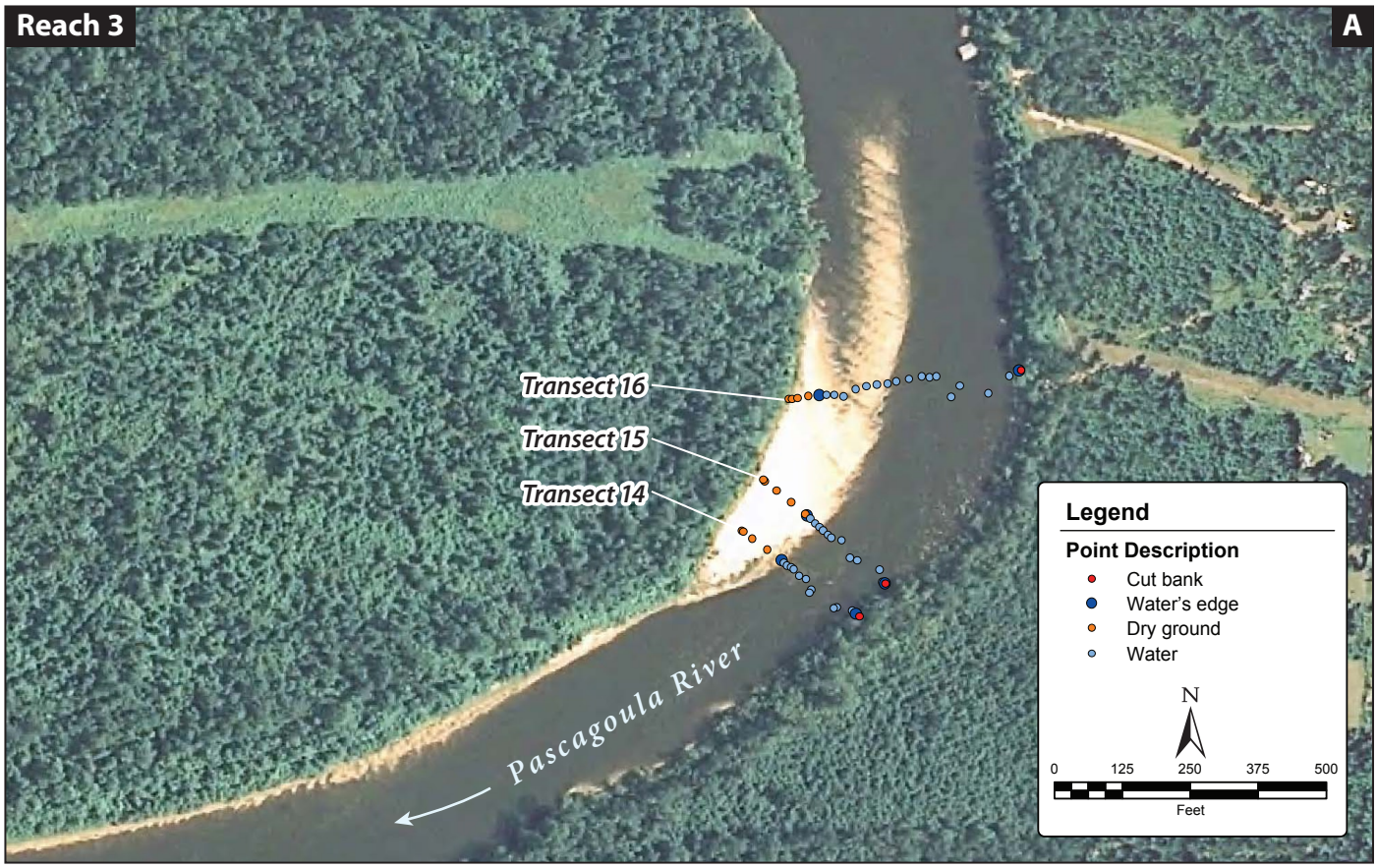

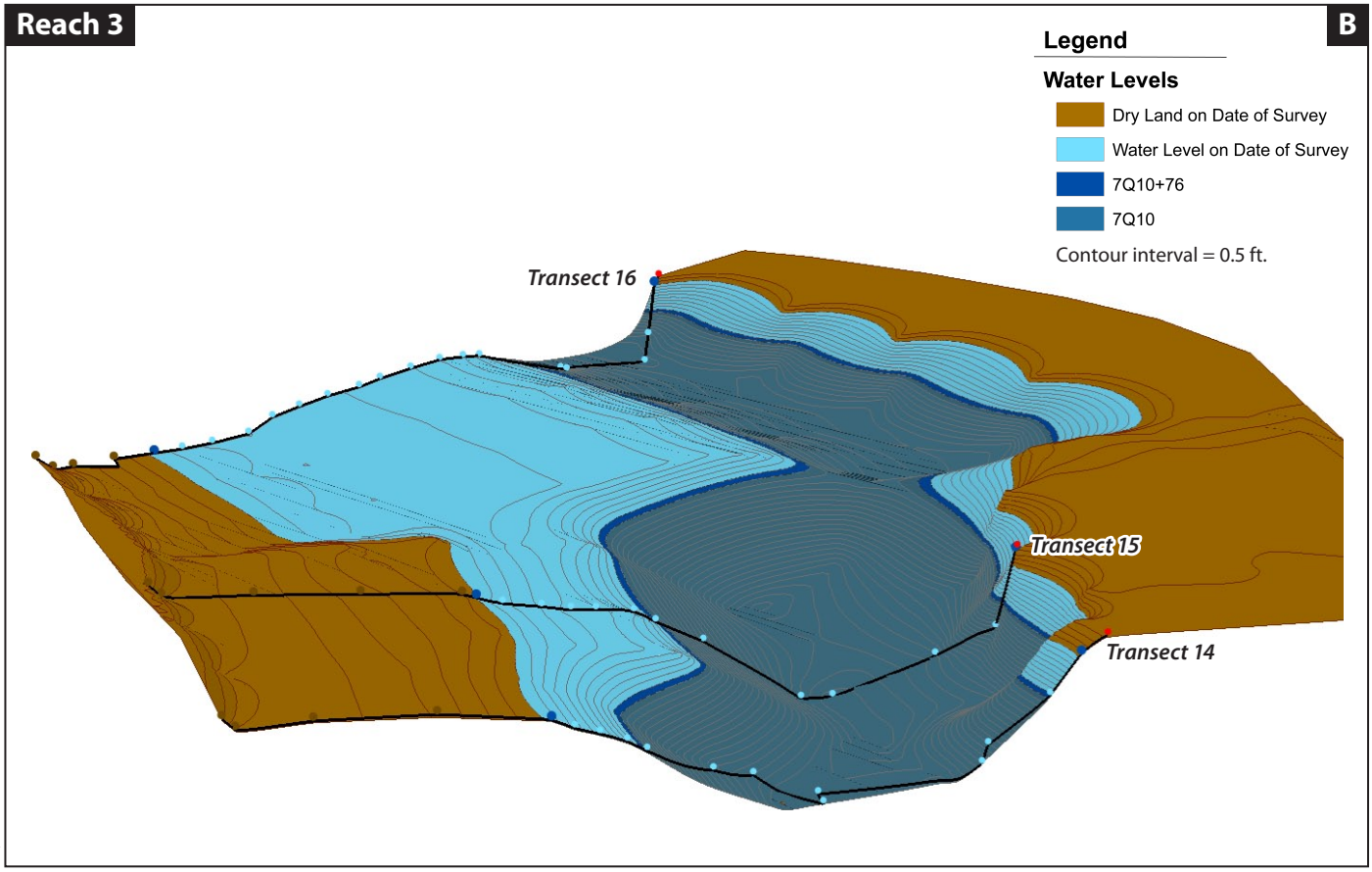

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Figure 3-5
Reach 3

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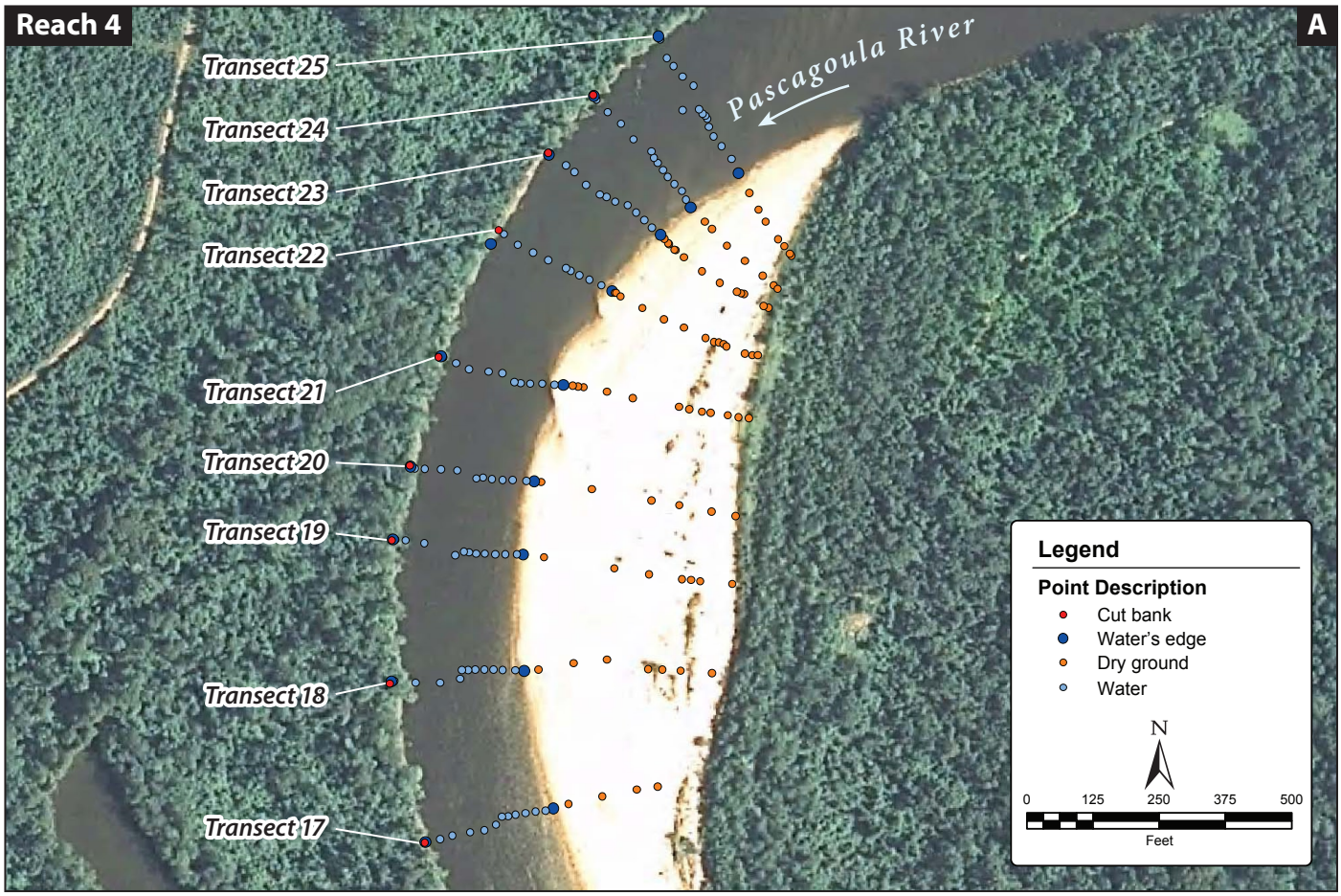

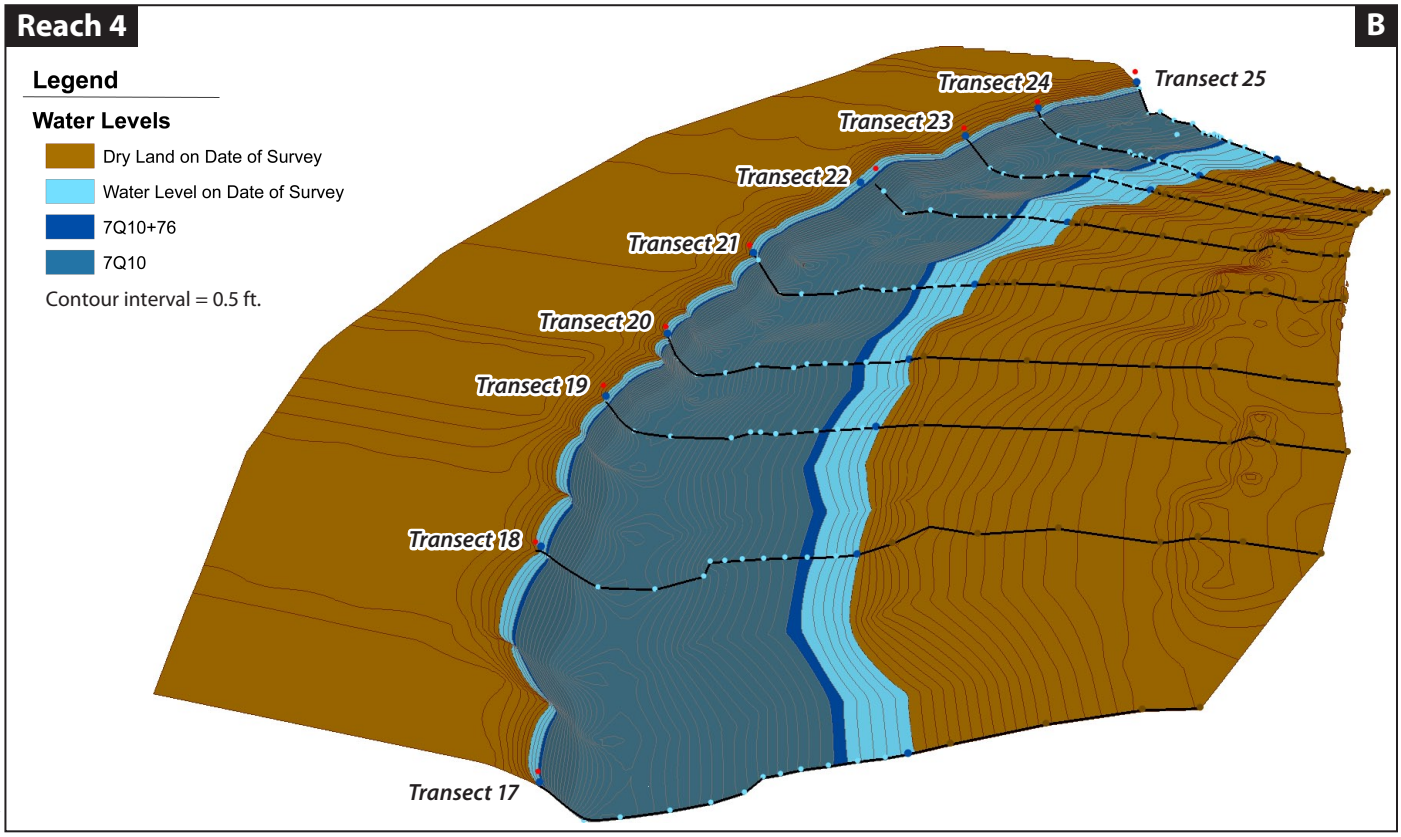

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Figure 3-6
Reach 4

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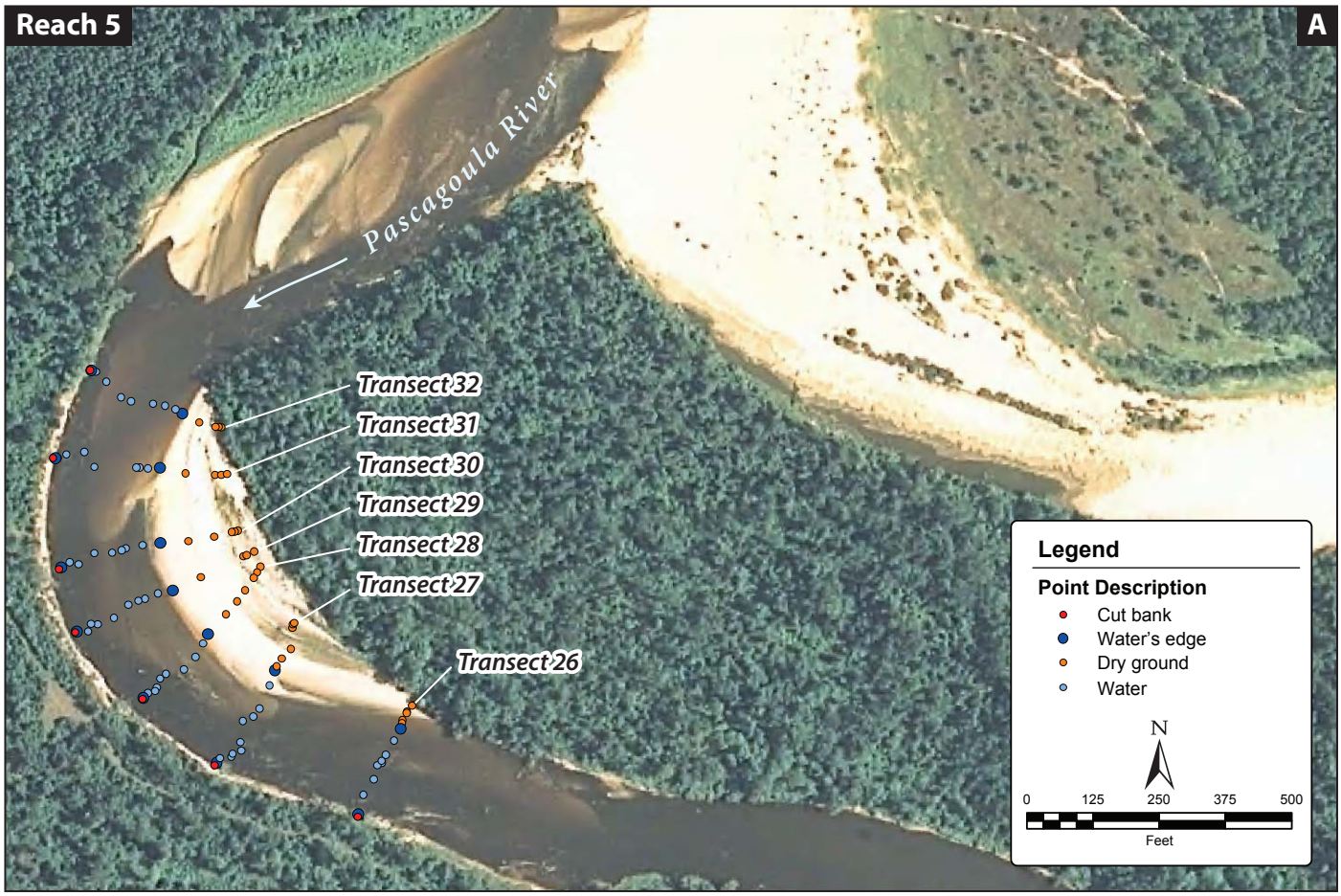

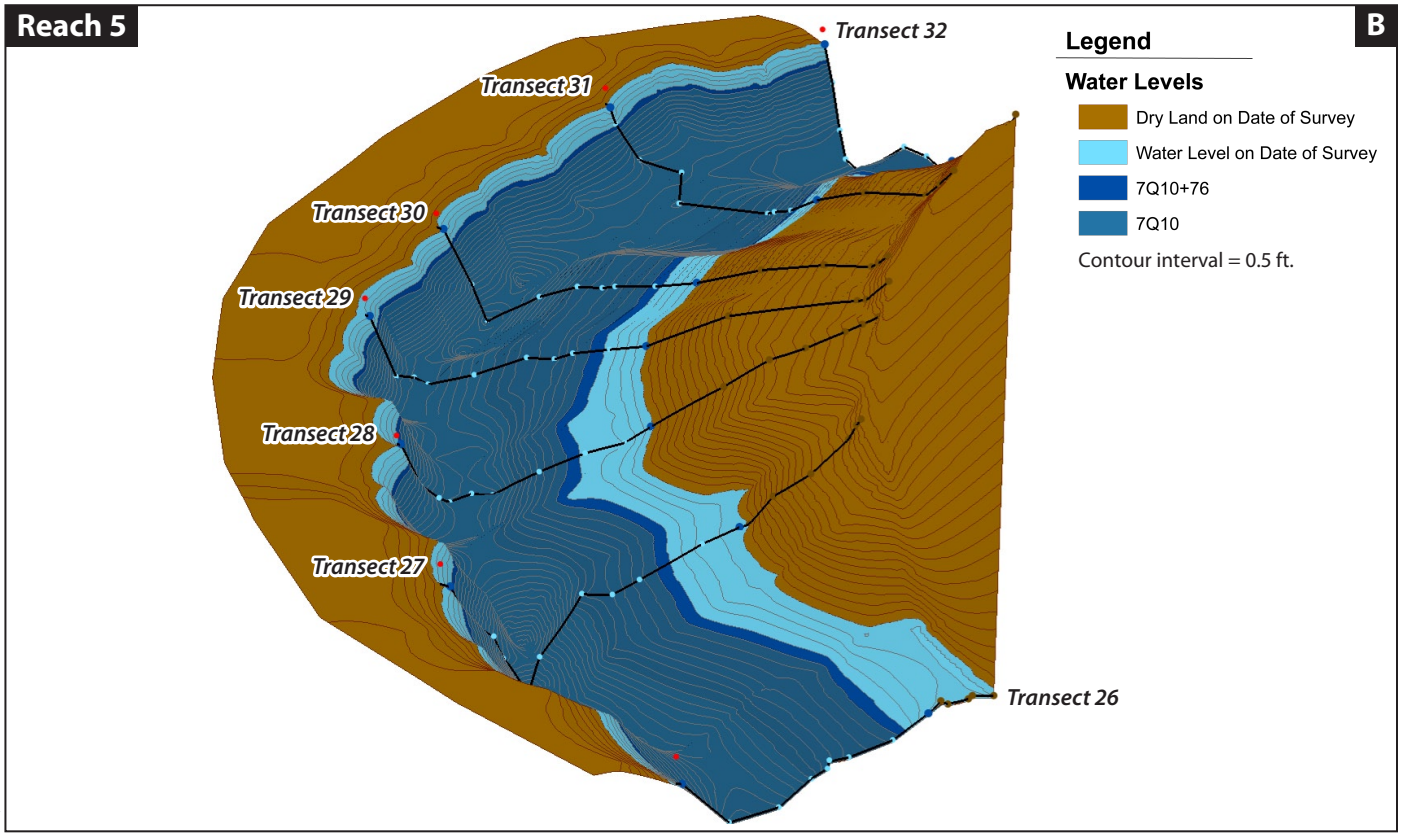

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Figure 3-7
Reach 5

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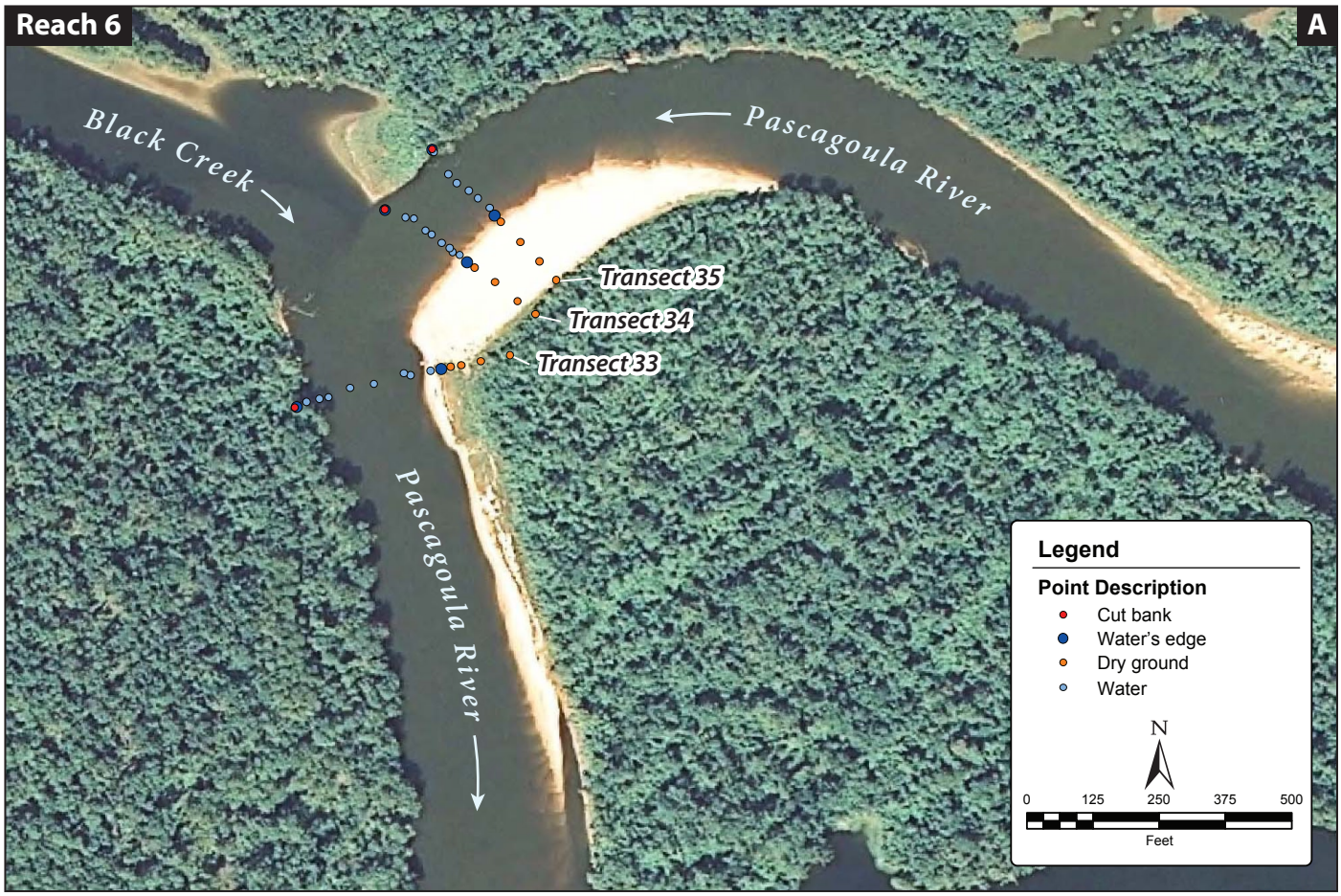

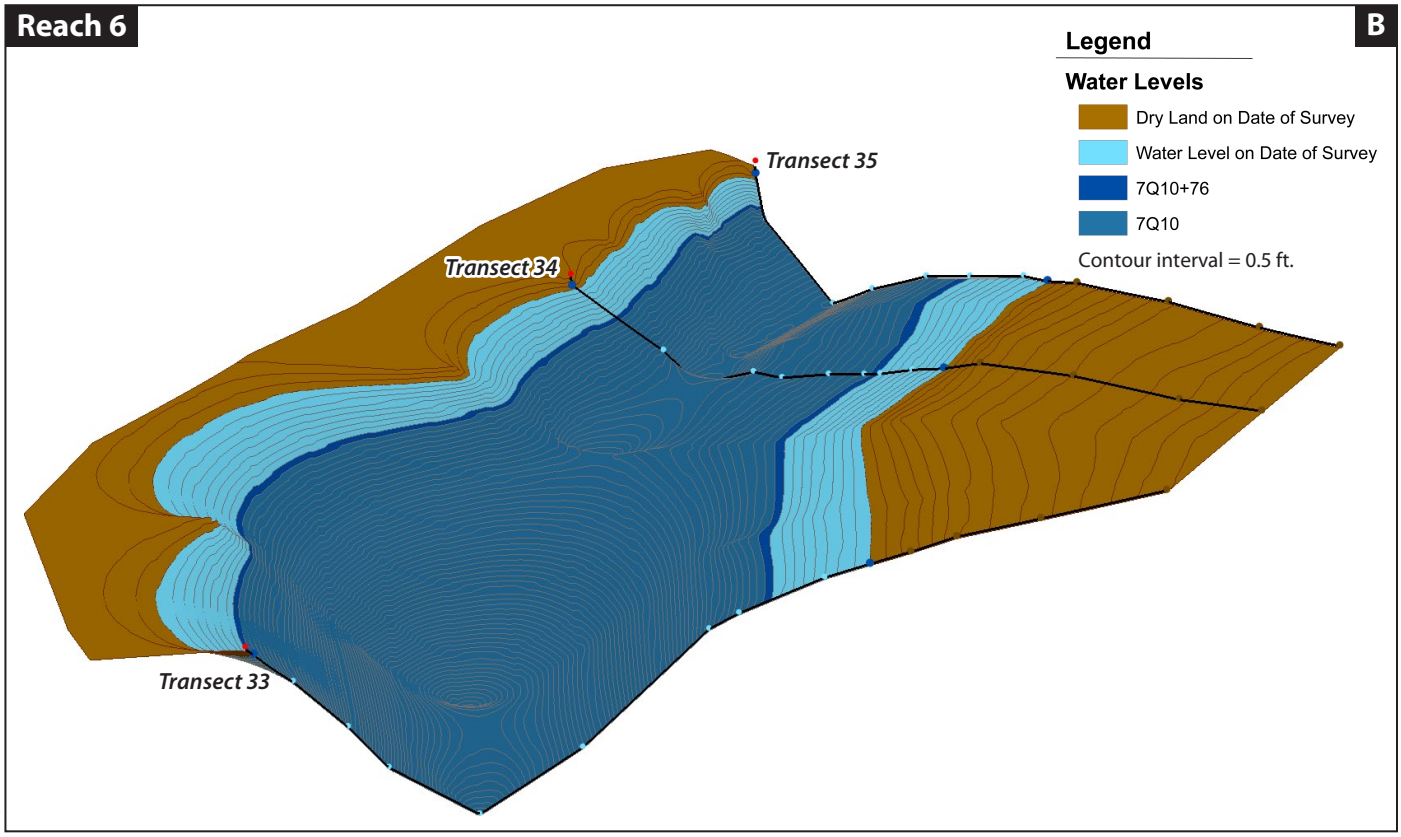

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Figure 3-8
Reach 6

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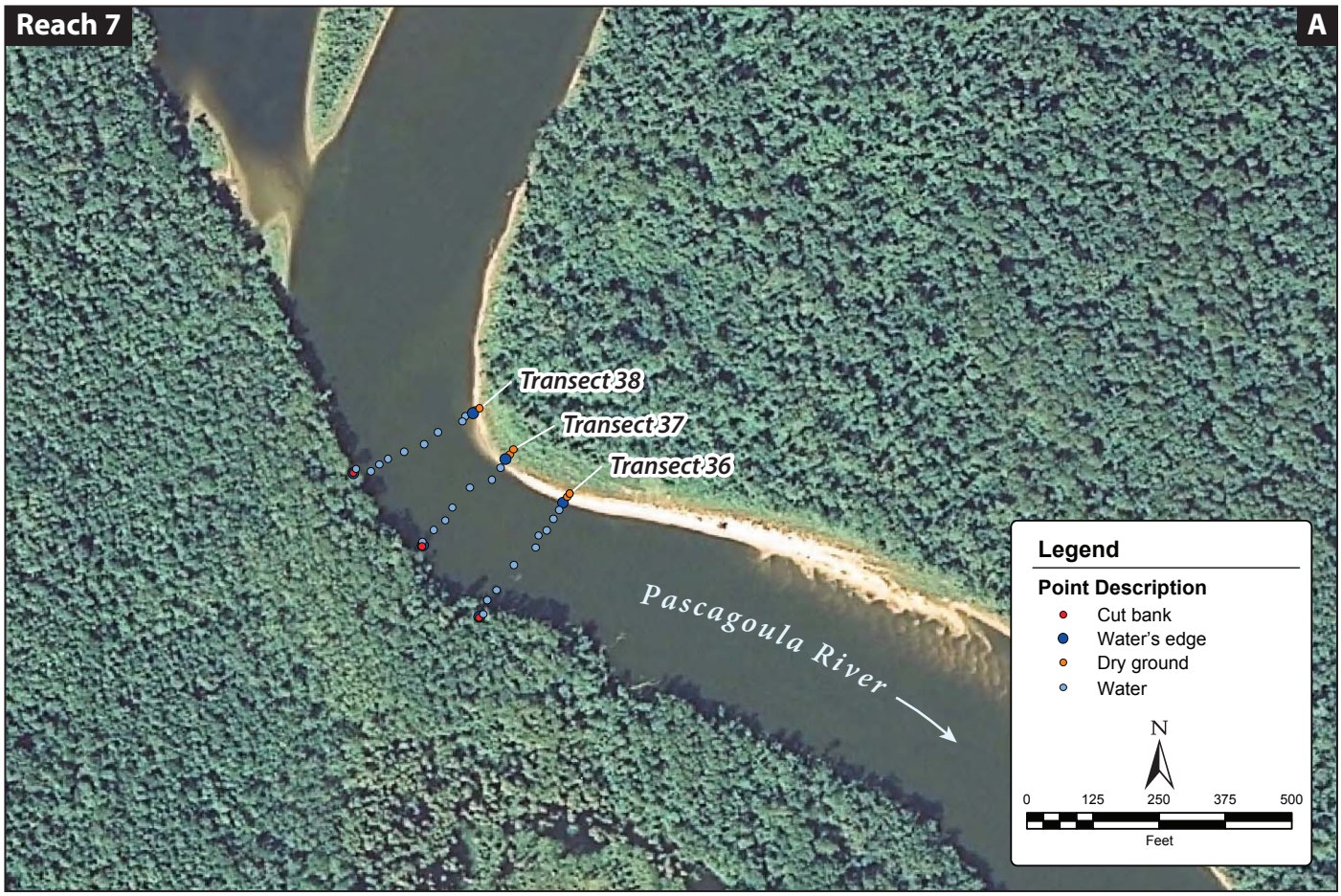

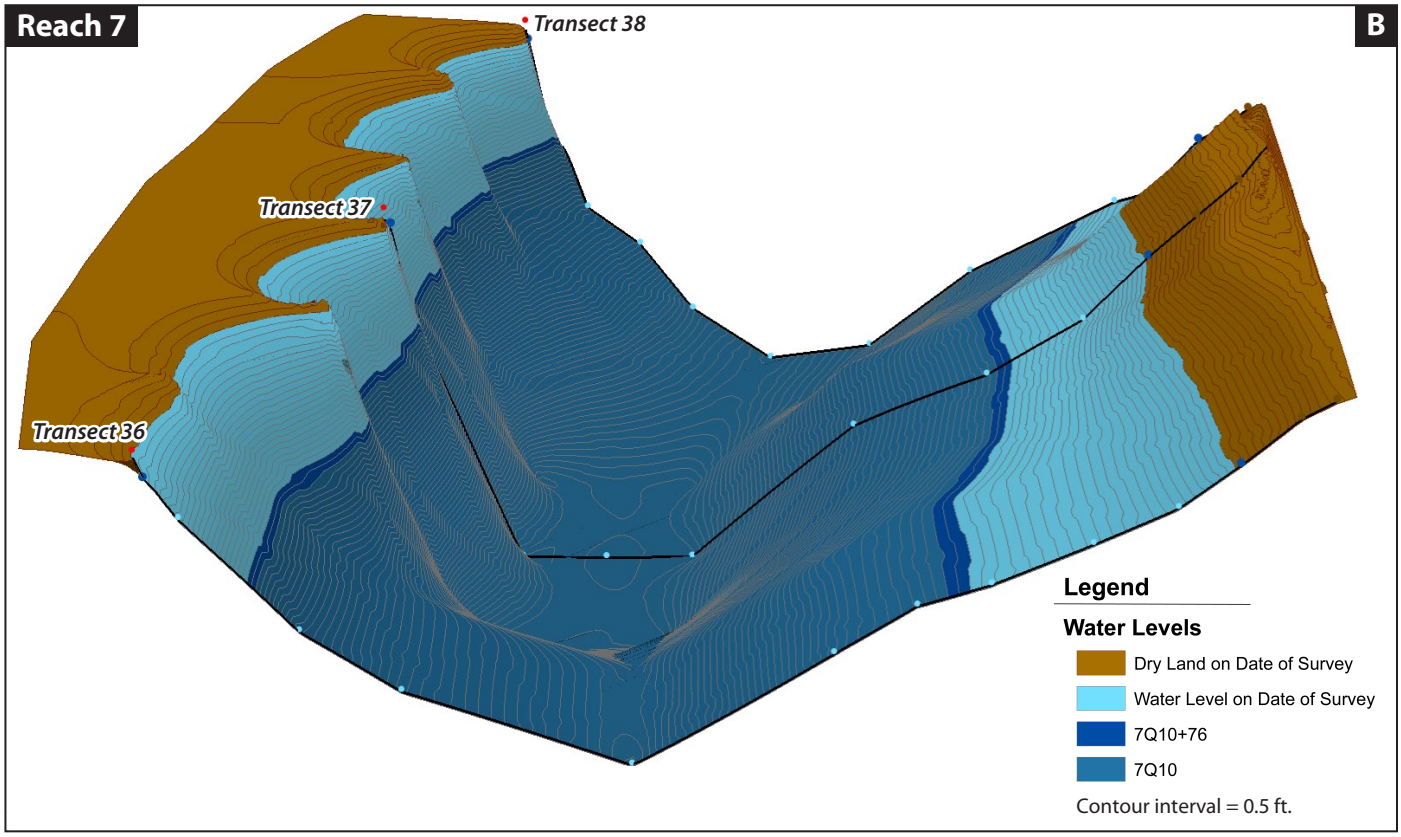

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Figure 3-9
Reach 7

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3.3. Calibration and Simulation of Hydraulic Conditions

Data were collected at verticals along transects to represent hydraulic and geomorphologic conditions for each cell in a reach. Reaches 1 through 5 were sited on river bends or glides with sand bars, habitat considered to be critical to the target species, while Reaches 6 and 7 were sited along long, deep pools, known to be used for summer holding by adult sturgeon. Water surface elevations were determined at each transect for one measured discharge. The discharges for Reaches 1 through 7 were 1,100, 1,060, 2,085, 1,783, 1,941, 2,650, and 2,940 cfs, respectively. Reaches 1 and 2 were in the lower 2 miles of the Leaf River (McLain gauge, USGS site 2475000), above the RWI. Reaches 3 through 5 were in the Pascagoula River just below the confluence of the Leaf and the Chickasawhay Rivers (Merrill gauge, USGS site 2479000), in the general vicinity of the RWI. Reaches 6 and 7 were in the lower Pascagoula River (Graham Ferry gauge, USGS site 2479310), approximately 42 miles downstream of the Merrill gauge.

Depth, velocity, and substrate type were determined at each vertical along a transect, and water surface elevation was estimated at the wetted edge of each transect. Cell width was determined from the spacing of the verticals. Channel structure and hydraulic variables were collected by use of standard USGS discharge measurement procedures. Substrate was quite uniform over all reaches, consisting of silt and sand, rarely including pockets of small gravel. Substrate data were obtained by visual observation or by prodding the bottom with a measuring rod. The Manning's equation method was used exclusively for calibration of water surface elevations because only a single calibration discharge was used. The Manning's equation model was calibrated by following the steps outlined in the manual for the PHABSIM habitat model (U.S. Geological Survey 2001). The beta parameter was initially set at 0.2 for each transect, and revised values were obtained by running the CALC4 procedure. Beta was adjusted manually until simulated water surface elevations fell within 0.1 foot of observed values.

Velocities were calibrated by use of a single velocity data set. A mean velocity was determined for each cell vertical in each transect. Manning's equation was used to calculate a roughness coefficient for each cell. When another discharge was simulated, the PHABSIM habitat model obtained a new water surface elevation corresponding to the new discharge from the Manning's equation model. New depths were determined for each cell, the roughness coefficient was held constant, and a new mean velocity was computed. An estimated discharge was then computed by use of the new widths, depths, and velocities of all cells in the transect and compared to the simulated discharge. A velocity adjustment factor (VAF) was computed from the ratio of the simulated and estimated discharge. Corrected mean velocities were calculated by multiplying the new mean velocities by the VAF. The VAF is plotted against discharge as an indicator of model performance and should range between 0.2 and 5.0. Further information on hydraulic model calibration is provided in Appendix A.

After model calibration, hydraulic conditions were simulated for discharges ranging from 0 to 4,000 cfs (0 to 2,000 cfs for Reaches 1 and 2 on the Leaf River). This particular range of flows was chosen to illustrate the impacts of relatively low flows (the mean annual Pascagoula discharge is approximately 10,000 cfs) on WUA and wetted perimeter. Depths and mean velocities were computed for each cell at all simulated discharges. Substrate data determined in the field remained constant for all simulated discharges. The depth, velocity, and substrate type, as a function of discharge, were then integrated with habitat suitability indices to produce a measure of the relation between habitat and discharge.

3.4. Status of the Species

3.4.1. Yellow Blotched Map Turtle

Species Biology

The yellow blotched map turtle (*Graptemys flavimaculata)* was listed as threatened under the Endangered Species Act on January 14, 1991 (56 FR 1459), and a final recovery plan (Jones 1993) was issued on March 15, 1993. Critical habitat has not been designated.

The map turtle is endemic to the Pascagoula River basin. Its preferred habitat is river stretches with moderate currents, abundant basking sites, and sand bars. Its diet consists largely of insects and snails. The principal threats to its continued existence are habitat and water quality degradation (Jones 1993).

During scoping meetings, it was agreed that the map turtle can be affected by flows and water quality. This effect would arise primarily as a result of changing the distance between the wetted edge of the river and upland nesting sites. Adult and juvenile turtles migrate across these areas where they are vulnerable to predation. Thus, the terrestrial environment is critical for the turtle. The focus of the biological analysis is how river flow affects the characteristics of the shoreline habitat rather than the aquatic habitat itself.

For purposes of the IFIM study there are four major life stages for the turtle:

- adult terrestrial movement up to spawning,
- survival of eggs,
- juvenile movement to water, and
- adult growth and feeding stage.

During discussions, the following life stages and activities were determined to be the most likely affected by the proposed withdrawal:

- increased adult terrestrial movement up to spawning,
- survival of eggs,
- nesting habitat and predation risk,
- increased juvenile movement to water, and
- adult growth and feeding stage.

The discussion identified the critical life stage as the adult female movement during nesting and successful reproduction. The following parameters affect survival of turtles in the terrestrial environment and the probability that the female will successfully reproduce, i.e., that she will lay eggs, the eggs will hatch, and the juveniles will successfully enter the river to swim away.

- Successful reproduction occurs along sandbars.

- The width of the sandbar determines the distance that a turtle must travel to reach a suitable nest site. A long travel distance is undesirable as it exposes both juvenile and adult turtles to predation risk.
- Stress will induce the turtle to nest near the water line, with reduced chance of successful production of young.
- Adult females may travel up to 100 feet over a sand bar to locate a suitable nest site.
- Successful reproduction is greater when the sand bar has a low slope perpendicular to the water line.
- Similarly, successful reproduction occurs when stream banks are stable. Unstable banks are usually too steep for the turtle to climb.
- Successful reproduction occurs from late May through early August.
- Successful reproduction occurs on sites with a functionally intact riparian zone.
- Successful reproduction occurs on sites with good habitat connectivity; i.e., multiple sand bars along the river with continuity of aquatic and riparian habitat.
- Successful reproduction occurs on sandbars with sparse vegetation.

Simulation of Physical Habitat Requirements

The PHABSIM habitat model is not suitable for evaluating the effects of incremental flow changes on map turtles, which respond to habitat in the portion of the channel that is *not* wetted. Instead, the results of the hydraulic model were used to calculate the changes in channel-wetted perimeter resulting from incremental flow changes, and those changes are used to calculate the changes in overall path distance required for turtles to travel from the water's edge to the riparian margin of the sand bar. As such, the habitat changes between study flows are assessed as follows:

Travel distance change = reach average percentage change in wetted perimeter

All transects used to evaluate turtle habitat were located at sites with sand bars suitable for turtle nesting. These sites include Reaches 1 through 5. Transect locations and geometry are presented in Section 3.2. The results of the incremental analysis are presented in Chapter 4.

3.4.2. Gulf Sturgeon

Species Biology

The Gulf sturgeon (*Acipenser oxyrinchus desotoi*) was listed as threatened under the ESA on September 30, 1991 (56 FR 49653). The principal reasons for its decline were cited as habitat loss resulting from dams, overfishing, and water quality deterioration. A recovery plan (Gulf Sturgeon Recovery/Management Task Team 1995) was issued on September 22, 1995. Critical habitat was designated on March 19, 2003 (68 FR 13370), and includes all of the Pascagoula River in the study area.

Gulf sturgeon are anadromous. They spawn in freshwater streams and return to the Gulf to feed and mature as adults. Sturgeon currently range from Lake Pontchartrain and the Pearl River system in Louisiana and Mississippi, east to the Suwannee River in Florida (68 FR 13370). In the Pascagoula

River, sturgeon migrate upstream 155 river miles to spawn in the Bouie River north of Hattiesburg, Mississippi, 75 river miles upstream of the proposed withdrawal. Spawning may also occur, but has not been documented, in the upper reaches of the Chickasawhay and Leaf rivers (Dugo et al. 2004, Heise et al. 2004). The Pascagoula population is a particularly critical one, being genetically quite distinct from more easterly populations and possibly acting as a founder population for remnant Pearl River sturgeon (Dugo et al. 2004). The sturgeon begin their upriver migration in early spring when water temperatures start to rise above 60 degrees Fahrenheit and flows start to increase from winter lows, arriving at Hattiesburg beginning in late March or early April. Spawning occurs soon afterward and most fish migrate downstream in May or June, but some continue their residence in the upper river for as long as a year (Heise *et al.* 2004). Juveniles take much longer to outmigrate, remaining in the river for as long as two years (Gulf Sturgeon Recovery/Management Task Team 1995).

After spawning, the outmigrant adults spend the summer and fall months holding in deep pools in a location 25 to 43 river miles upstream of the mouth, or about 44 to 62 river miles downstream of the proposed withdrawal. Nonspawning subadults also come upstream to this holding area each spring, so that the bulk of the Pascagoula adult sturgeon population apparently congregates in this area during the summer and fall months (Ross *et al.* 2001, cited by Heise *et al.* 2004).

The IFIM Review Team identified 12 major life stages for the sturgeon:

1. Egg and hatchling yolk reabsorption, which occurs upstream of the proposed withdrawal (Hattiesburg area).
2. Larval drift, which also occurs upstream of the proposed withdrawal.
3. Feeding and migration by young-of-the-year (YOY), throughout the river downstream of spawning sites.
4. Estuary transition for out-migrant juveniles.
5. Juvenile growth in the marine environment.
6. Adult growth in the marine environment.
7. Estuary transition for in-migrant adults.
8. Upstream migration by adults and subadults, throughout the river downstream of the summer holding area; and by spawning adults, throughout the river downstream of spawning sites.
9. Spawning by adults near Hattiesburg.
10. Adult migration downstream to the summer holding area.
11. Adult and subadult holding.
12. Estuary transition for out-migrant adults and subadults.

With regard to life stage 3, YOY migration, discussion among IFIM Review Team members identified the following habitat conditions as important to sustain population size and vigor during YOY migration:

- bank stability;
- habitat connectivity;

- drought severity (not qualified);
- water velocity (only at high flows);
- aquatic invertebrates;
- timing (between May and November, which includes the annual minimum flow, typically in October);
- abundance of bare shallow sand flats;
- absence of structures or vegetation;
- presence of the downstream end of point bars;
- magnitude of December and September flows;
- presence of dense algal growth;
- temperature; and
- predation.

Simulation of Physical Habitat Requirements

The IFIM Review Team also determined that sturgeon life stages 3 and 11 were likely to be affected by the proposed withdrawal, with life stage 11, summer holding, particularly dependent on flow discharge and temperature. It was agreed that the PHABSIM habitat model would be an appropriate model for evaluating the effects of incremental flow changes on summer holding. All transects used to evaluate summer holding were in the summer holding reach (Reaches 6 and 7). Transect locations and geometry are presented in Section 3.2. The results of the incremental analysis are presented in Chapter 4.

The IFIM Review Team agreed that the PHABSIM habitat model would also be an appropriate model for evaluating the effects of incremental flow changes on life stage 3, YOY migration. Flow effects on the YOY migration were evaluated in Reaches 1 to 5, located near the proposed withdrawal, as this is the area where incremental flow changes would be most pronounced. Transect locations and geometry are presented in Section 3.2. The results of the incremental analysis are presented in Chapter 4.

Habitat Suitability

Habitat suitability for juvenile Gulf sturgeon was assessed at Reaches 1 through 5, and habitat suitability for adult Gulf sturgeon was assessed only at Reaches 6 and 7. The IFIM Review Team determined that the primary habitat variable influencing juvenile sturgeon in these reaches was water velocity and that water velocity is optimal for juvenile sturgeon at water velocities of 2 to 4 feet per second. The habitat suitability curve representing this information is shown in Figure 3-10.

The IFIM Review Team did not prescribe any habitat suitability criteria for adult Gulf sturgeon. However, based on the known habitat preference of Gulf sturgeon (e.g., Ross *et al*. 2001, Heise *et al*. 2004) and that of other sturgeon species such as the shortnose, white, and green sturgeon, it appears likely that habitat suitability is optimum in waters at least 10 feet deep, and is reduced in shallower waters. A habitat suitability curve representing this information is shown in Figure 3-11.

Figure 3-10. Habitat Suitability Curve, Velocity, for Juvenile Sturgeon

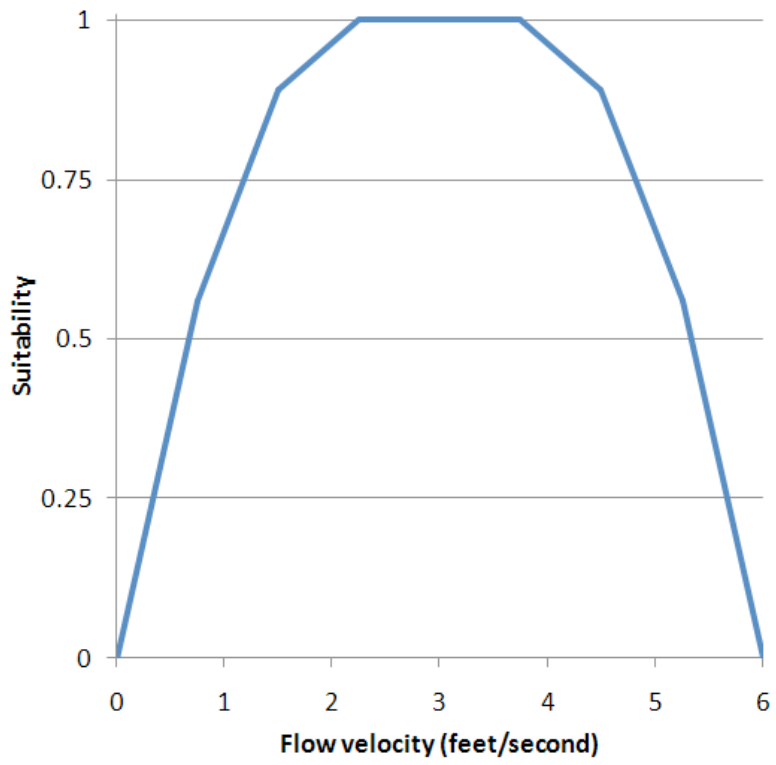
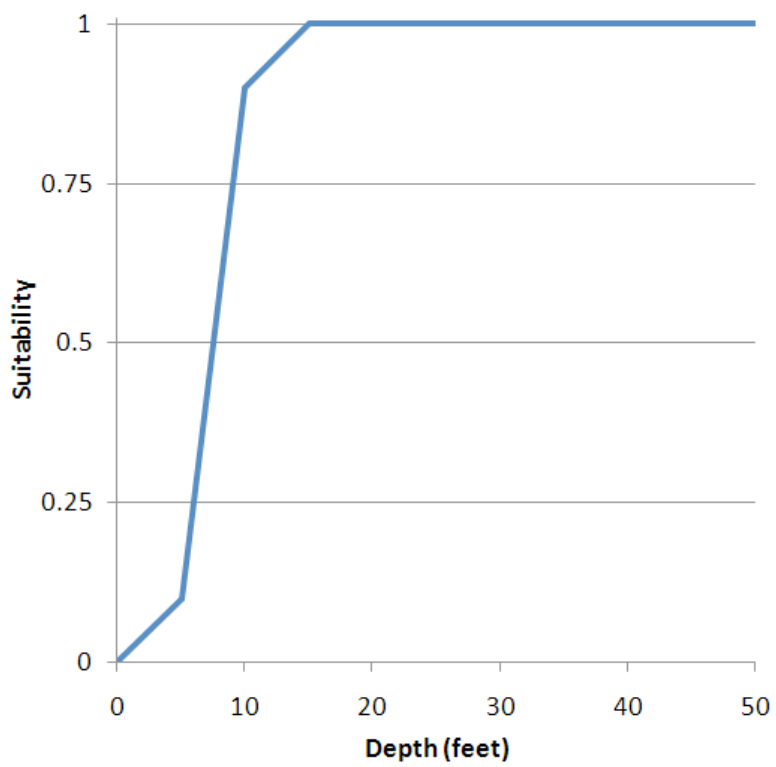


Figure 3-11. Habitat Suitability Curve, Depth, for Adult Sturgeon



3.4.3. Pearl Darter

Species Biology

Since 1999, the pearl darter (*Percina aurora*) has been a candidate for listing under the ESA (72 FR 69066). Historically, the darter was found in the Pascagoula and Pearl River drainages in Mississippi and Louisiana, but the last observation in the Pearl River drainage was in the early 1970s. The species is now considered extirpated from that drainage (Bart and Suttkus 1995, cited by Slack *et al.* 2005). In the Pascagoula River basin, its range is known to extend from far upstream on the Leaf and Chickasawhay Rivers, downstream to approximately River Mile 30 and thus includes the area near and well downstream of the proposed withdrawal.

Slack *et al.* (2002, cited by Slack *et al.* 2005), sampling in the Pascagoula River at and downstream of the site of the proposed withdrawal, found that pearl darters are typically associated with scour holes on the inside bend of the river downstream from a point bar. They also select banks with good slope at a water depth reaching 5 feet at a distance of 13 to 23 feet from shore, and substrata primarily of coarse sand with an accumulation of detritus in troughs perpendicular to the shoreline. In contrast, pearl darters were generally not present at sites with shallow, homogenous sand flats, free of detritus, where compact sand was the dominant substratum. Slack *et al.* (2005) additionally found that pearl darters are more common in depositional areas rather than in the faster waters of the main channel, and that their distribution is relatively continuous along the length of the river where the fish have been found to occur.

Pearl darters are vulnerable to the cumulative impacts of a variety of nonpoint pollution sources, such as sedimentation and chemicals, and also to more localized and concentrated pollution events. The steady yet gradual change in river and tributary geomorphology and hydrology over time is believed to have had an impact on this species. The magnitude of threat to this species is high because of their limited and disjunct populations and threat from sedimentation (72 FR 69066).

During scoping meetings, it was agreed that there are three major life stages for the darter:

- eggs and spawning,
- juveniles, and
- adults.

The IFIM Review Team concluded that each of these life stages could be affected by the proposed withdrawal. The following habitat conditions were identified as suitable for the darter:

- Eggs and spawning life stage requires:
    - shallow, gravelly riffle habitat
    - waters 0.5 to 1.5 feet deep
    - conditions most important in April through May
    - certain velocity conditions, not enumerated
    - complex substrate with logs, cobbles
    - adequate dissolved oxygen (critical levels not established)
    - appropriate temperature (critical levels not established)

- Juvenile and adult life stages require:
  - depositional organic-rich silty substrates that contain:
    - detritus
    - detritivores, for which the darter forages
  - scour holes (approximately 5 feet deep) adjacent to main channel that:
    - taper out into main channel
    - have side slopes of 30%
    - have reduced flow velocities
    - are associated with point bars
  - appropriate velocity (critical levels not established)
  - predation (major predators have not been identified)
  - transitional pools

Simulation of Physical Habitat Requirements

The IFIM Review Team agreed that PHABSIM would be an appropriate habitat model for evaluating the effects of incremental flow changes on all pearl darter life stages. Transects used to evaluate pearl darter life stages were located in Reaches 1 through 7. Transect locations and geometry are presented in Section 3.2. The results of the incremental analysis are presented in Chapter 4.

Habitat Suitability

Habitat suitability for both juvenile and adult pearl darter was assessed at Reaches 1 through 7. The IFIM Review Team concluded that both water velocity and water depth influence pearl darters in these reaches. Habitat suitability for both juveniles and adults is optimum at flow velocities of less than 1 foot per second. Water depth is optimal for both juveniles and adults at depths of approximately 0.5 to 5 feet, and is otherwise unsuitable. These habitat suitability curves are very similar to those that have been published for the slough darter (Edwards *et al*. 1982), but have been modified to reflect species-specific information on pearl darter depth preferences and tolerance for higher velocities. The habitat suitability curves representing this information are shown in Figures 3-12, 3-13, and 3-14.

Figure 3-12. Habitat Suitability Curve, Water Velocity, for Juvenile Pearl Darter

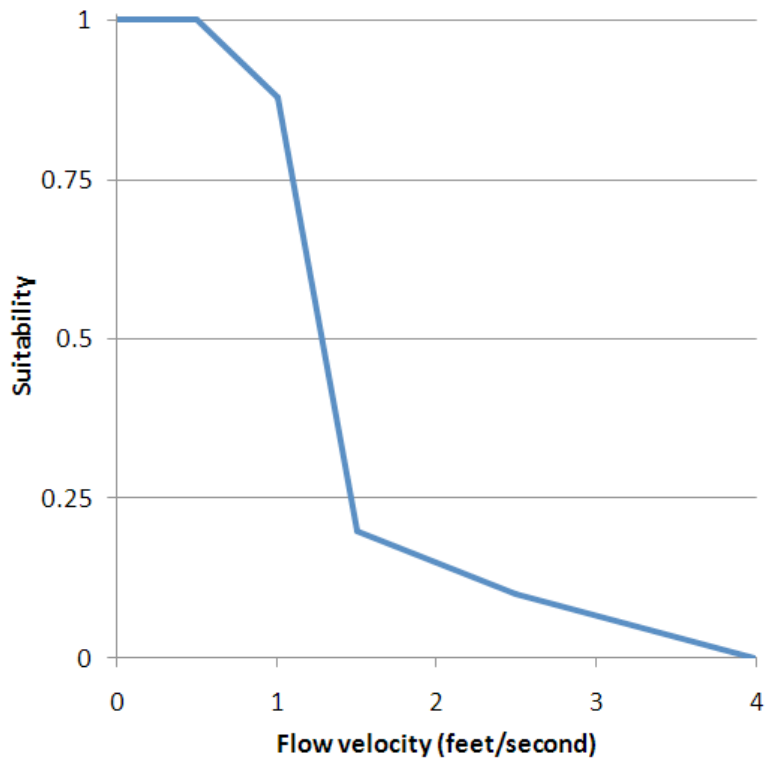


Figure 3-13. Habitat Suitability Curve, Water Velocity, for Adult Pearl Darter

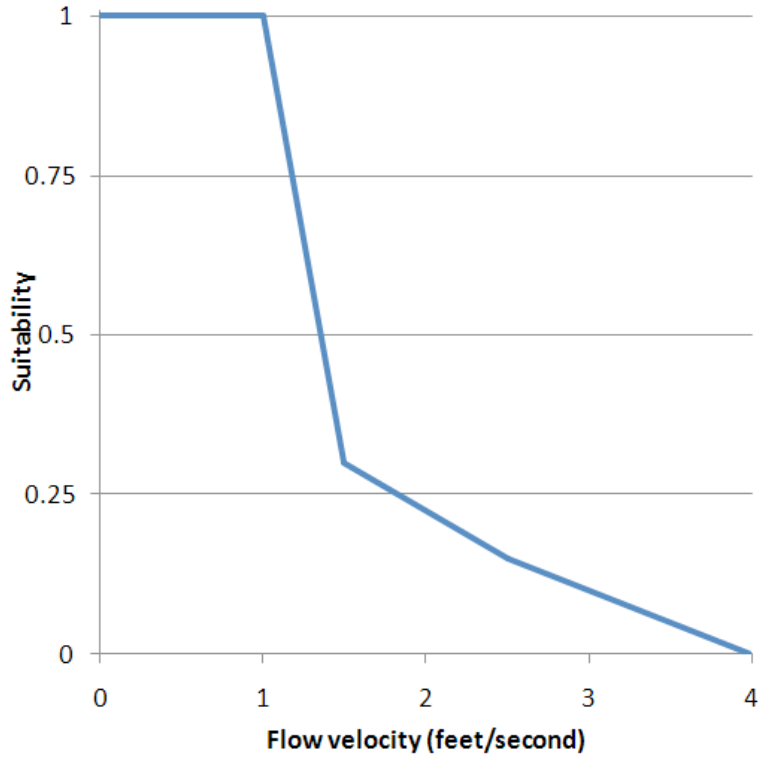
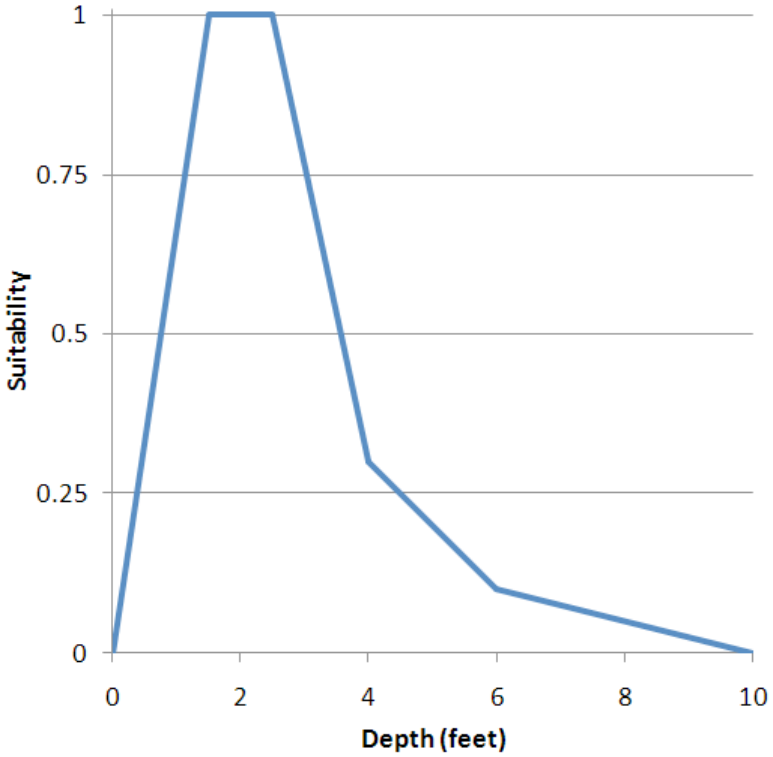


Figure 3-14. Habitat Suitability Curve, Water Depth, for both Juvenile and Adult Pearl Darter



Chapter 4. Results and Analysis

4.1. Yellow Blotched Map Turtle

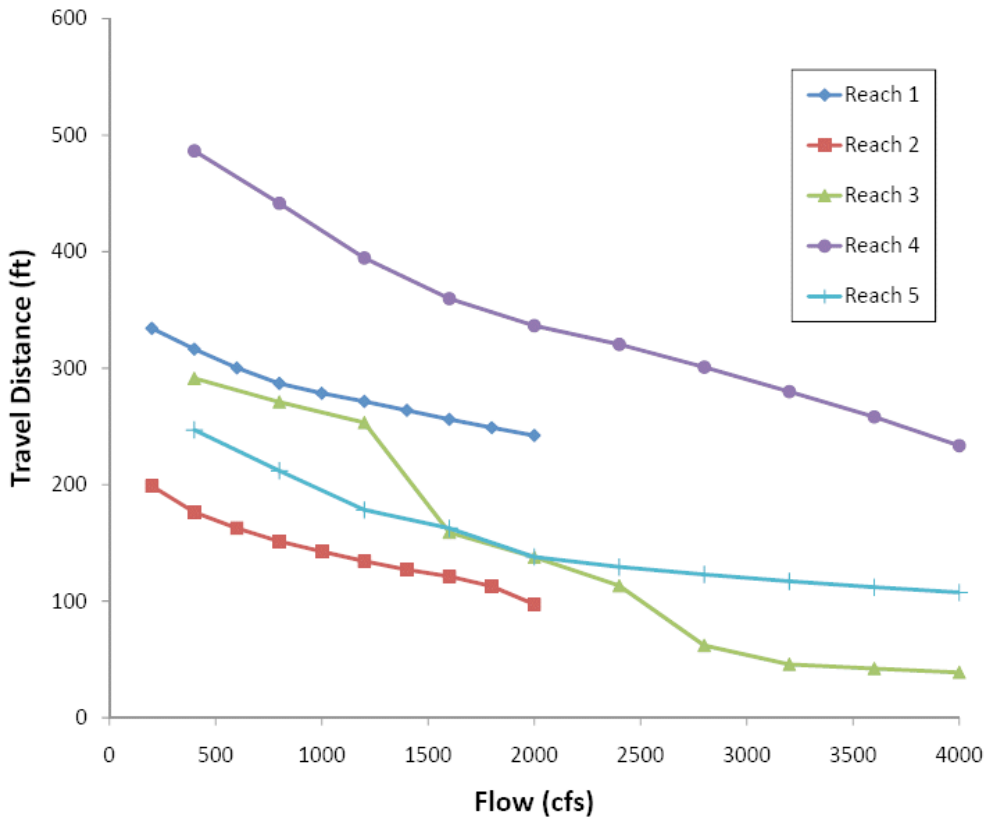
Yellow blotched map turtle habitat was assessed for Reaches 1 through 5. As noted previously, the PHABSIM habitat model was developed to quantify instream habitat, and thus was not used to define changes in WUA of map turtle habitat. However, the hydraulic model within PHABSIM was used to determine changes in water level under the alternative hydraulic regimes, and these changes in water level were used to estimate the changes in the distance between the water's edge and the riparian vegetation. This is presumed to be an index of the distance that gravid female turtles would have to travel to reach a suitable nest site, or alternatively, the distance that hatchlings would have to travel to reach the water. These distances are shown in Figure 4-1.

For Reaches 1 and 2, which are upstream of the withdrawal, the withdrawal would have no effect. However, to illustrate the nature of flow-habitat relationships in these reaches, effects were calculated for a series of flows. For all reaches and all flow increments, travel distance decreases with higher flows, reflecting higher water in the river.

In Reaches 3, 4, and 5, which are at or downstream of the proposed withdrawal, these results show a decrease in travel distance corresponding to increased flows. The magnitude of the change, which corresponds to the slope of the curve in Figure 4-1, is fairly consistent between reaches. For a change corresponding to the 78 cfs withdrawal, travel distance would increase by an average of 2.7% (ranging from 0.8% to 16%, with 90% of the estimates less than 4.3%).

The biological significance of these results is limited. Across the period of record, the average daily change in flows observed on the Pascagoula River at Merrill is 1,041 cfs. This is more than an order of magnitude larger than the proposed 78 cfs withdrawal, so the effects of the withdrawal likely would be immeasurable in comparison. However, that does not mean that no effects would occur. Effects would

Figure 4-1. Travel Distance Changes for Yellow Blotched Map Turtle



be expected to occur predominantly during egg-laying, incubation, and hatching. As noted in Section 3.4.1, the most valuable life stage of the turtle is the adult female, so flows should be protective of adult females. Females lay their eggs from mid-May to mid-August, with peak activity in June (Home et al. 2003; Jones 2006, reporting on the closely related species *G. oculifera*). Most females lay a single clutch (Horne et al. 2003). Normal May to August flows are in the vicinity of 3,000 to 7,000 cfs (Figure 3-2), and much of the time exceed the modeled flows. Actually, peak flows have been found to be a primary cause of nest failure (Horne et al. 2003). The effect of the proposed withdrawal on peak flows was not assessed, but would likely be minimal, as a 78 cfs withdrawal has little potential to alter flow peaks that are well in excess of 10,000 cfs.

The modeled flows may have more relevance for hatchling travel to the water, which occurs after a gestation period of approximately 60 days, depending on temperature. This corresponds to the period from mid-July to mid-October. August to October flows normally vary from about 3,000 to 4,500 cfs (Figure 3-2). At these times, withdrawals could affect habitat quality by increasing the travel distance to the wetted perimeter by 2% to 3%, proportionally increasing hatchling exposure to predation risk.

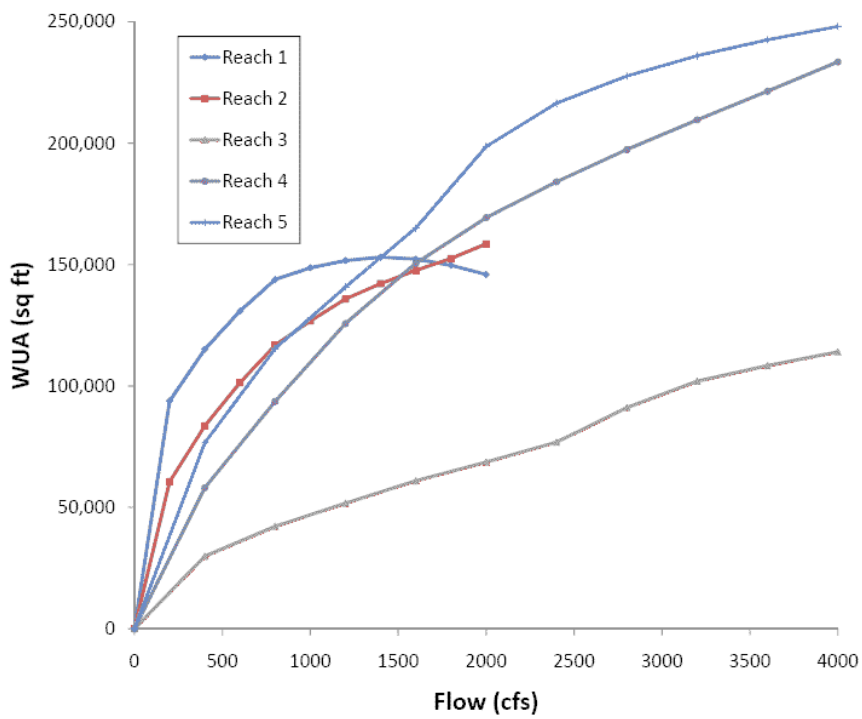
4.2. Gulf Sturgeon

4.2.1. Juvenile Sturgeon

Juvenile sturgeon habitat was assessed for Reaches 1through 5. No habitat suitability curve was established for depth preference, so habitat suitability is determined solely by water velocity.

WUA for the range of modeled flows is shown in Figure 4-2. The incremental change in WUA, which corresponds to the slope of the curve in Figure 4-2, is fairly consistent between Reaches 2, 4, and 5, but is quite different for Reaches 1 and 3. Reaches 2, 4, and 5 show a typical concave-downward curve form indicating that increasing flows result in improved velocity conditions and an increase in inundated area, with optimum velocity conditions likely existing near the upper end of the range of modeled flows. Reach 1, on the lower Leaf River, passes a habitat optimum at about 1,250 cfs and then shows declining habitat value. This probably indicates that at flows higher than 1,250 cfs, water velocities in this reach are above the optimum for juvenile sturgeon. It is possible that suitable conditions would be re-established at higher flows than those modeled. Reach 3, on the other hand, shows a relatively small increase in habitat value with incremental flow increases, but the increase is consistent across a wide range of modeled flows; the curve has a nearly constant slope from 500 cfs to 4,000 cfs. This is a somewhat surprising finding. Review of PHABSIM output data indicate that there is an abrupt change from suboptimum to optimum flow velocities in Reach 3 at about 1,200 cfs, but at that flow level the channel also has a steep-sided bathymetry so that flow increases do not result in proportional increases in wetted area. These effects cancel each other out to result in only a small increase in WUA. At higher flows, velocity conditions remain within the optimum range but a broadening of the channel results in

Figure 4-2. Weighted Usable Area Changes for Juvenile Sturgeon



increased WUA solely as a result of increases in wetted area. Thus, Reach 3 shows how both bathymetry and habitat suitability can interact to produce observed WUA changes.

In each reach, the habitat impact of a 78 cfs withdrawal predictably diminishes with increasing flow. The change is predictable simply because 78 cfs is a large fraction of a low flow, but is a small fraction of a high flow. The predicted changes in WUA (Table 4-1) vary from almost 20% at flows of 400 cfs, to 2% at flows of 4,000 cfs.

Table 4-1. Percent Change in Juvenile Gulf Sturgeon Weighted Usable Area Attributable to a 78 cfs Reduction in Flow

Flow (cfs)	Reach				
	1	2	3	4	5
400	-19.5%	-19.5%	-19.5%	-19.5%	-19.5%
800	-9.8%	-9.8%	-9.8%	-9.8%	-9.8%
1200	-6.5%	-6.5%	-6.5%	-6.5%	-6.5%
1600	-4.9%	-4.9%	-4.9%	-4.9%	-4.9%
2000	-3.9%	-3.9%	-3.9%	-3.9%	-3.9%
2400			-3.3%	-3.3%	-3.3%
2800			-2.8%	-2.8%	-2.8%
3200			-2.4%	-2.4%	-2.4%
3600			-2.2%	-2.2%	-2.2%
4000			-2.0%	-2.0%	-2.0%

These results may be of biological relevance because juvenile sturgeon remain in the river for as long as two years after hatching (Gulf Sturgeon Recovery/Management Task Team 1995) and thus are presumably present during seasonal low flows. It is plausible that the proposed flow reductions would both decrease the area of habitat accessible to sturgeon, and result in flow velocity reductions reducing the suitability of the remaining habitat in Reaches 3, 4, and 5. Given the small change in WUA associated with these reductions, their biological significance is unclear. These in-stream changes should be considered when evaluating the proposed withdrawal at Merrill or the impacts of any flow alterations in the Pascagoula, especially under low flow conditions.

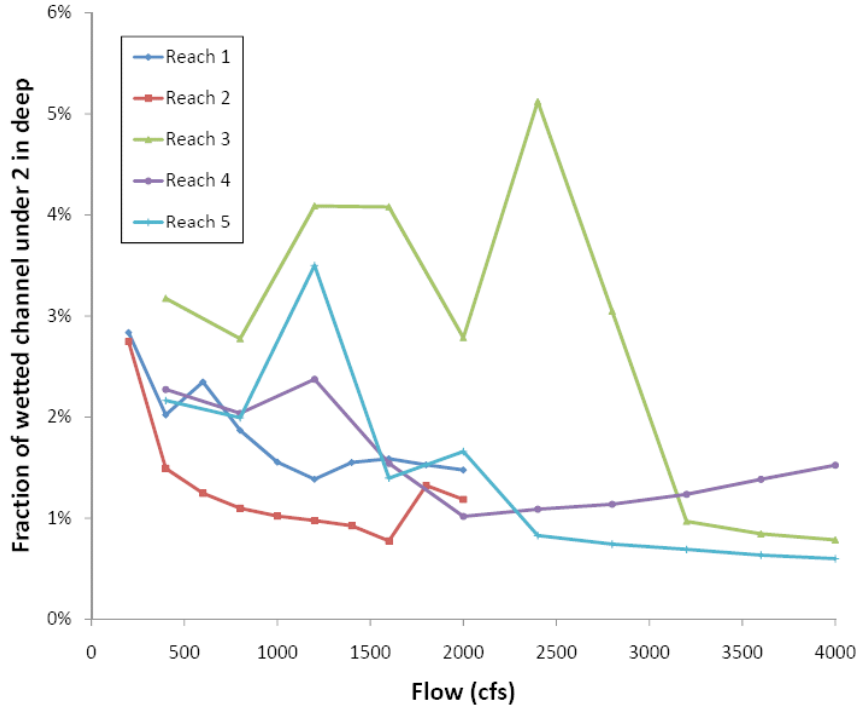
The IFIM Review Team also identified concerns with the effects of flow variability on juvenile sturgeon passage. The issue here is whether the downstream migration may be affected by flow changes. There are several aspects to this issue:

- whether downstream flow velocities are appropriate for juvenile outmigration,
- whether water depths are appropriate for juvenile sturgeon passage,
- whether, at certain flows, the channel becomes nonlinear so that physical obstructions such as bars may prevent downriver movement by juveniles.

PHABSIM data indicate whether flow velocities are appropriate. As noted above, velocities are often suboptimal at very low flows. The curves shown in Figure 4-2 indicate that in all reaches except Reach 1, WUA continues to increase across the entire range of modeled flows. This is partly due to a progressive increase in available (inundated) habitat, but also indicates that little or none of the available habitat is experiencing excessively high flows. It is thus likely that within the range of modeled flows, suboptimal conditions occur almost exclusively as a result of low, rather than high, flow velocities.

PHABSIM data also provide some insight on whether water depths are appropriate. A minimum water depth for swimming depends on the presence of sufficient water. Also, the water depth should be sufficient that swimming effort does not require a disproportionate fraction of the fish's energy budget. The State of Maine Department of Transportation has developed passage criteria for juvenile shovelnose sturgeon that consider these factors, citing FWS guidance in assigning a depth criterion of 1.5 times the body thickness of the fish (Maine Department of Transportation 2004). Juvenile sturgeon outmigrating from the Pascagoula River may be up to 2 years of age and vary considerably in size, but it is likely that waters 2 inches deep are deeper than 1.5 times the body thickness of these fish. Thus, the role of shallow water as a passage barrier for juvenile sturgeon should be proportional to the relative amount of wetted habitat that is less than or equal to 2 inches deep. Figure 4-3 shows the fraction of the wetted river channel that is less than 2 inches deep across the modeled range of transects and flow amplitudes. The figure indicates that very shallow waters are more common at very low flows, but at flows even as low as 1,000 cfs this effect has largely dissipated, and no trend is apparent at higher flows. The percent of very shallow water fluctuates around 1% to 3% of the wetted channel. Note also that fish would tend to avoid such shallow water because of the suboptimal velocity conditions. Thus, very shallow water would not likely limit juvenile sturgeon migration in the study reaches except perhaps at extreme low flows below the 7Q10 flow.

Figure 4-3. Variation in Percent of Wetted Channel Less Than 2 Inches Deep



The final consideration cited above, whether the low flow channel contains bars or other obstructions that can impede downstream fish passage, is theoretically plausible and is supported by anecdotal evidence collected during field work for this IFIM study (Slack, pers. comm.). The study reaches represent bends in the river that are typically accompanied by scour holes or deeper pools. The data collected for this IFIM study, and the resulting output of the PHABSIM model, do not present evidence of potential migratory barriers. Other reaches might present a different stream geomorphology – now or in the future. The river substrate is dominated by loose sand that could accumulate in the form of sand bars, especially between higher flushing flows. Additional analysis of these conditions would require surveys performed at various flows in additional study reaches (or extremely accurate bathymetric data coupled with hydraulic modeling) to determine whether certain flow conditions are characterized by the formation of blind leads (portions of the channel that can be entered by fish moving downstream but that do not connect back to the main channel at their downstream end). Such areas could be particularly effective traps for juvenile sturgeon if suitable water velocities entered the channel, but shallowing flows caused the lower channel to be unsuitable or impassable. It is also possible that such areas could be sites of thermal, water quality, or predation stress on juvenile sturgeon. Further field studies would be needed to understand the magnitude and extent of such potential hazards. Additional field studies, and perhaps even instream breaching of sand bars, could be conducted in association with future monitoring and mitigation programs associated with the proposed withdrawal.

4.2.2. Subadult and Adult Sturgeon

Habitat effects on subadult and adult sturgeon were only assessed for the summer holding area in the tidal portion of the river, represented by Reaches 5 and 6. The IFIM Review Team did not consider water velocity to be particularly significant to habitat condition in this area, where the tidal condition results in periodic flow reversals and water velocities are in any case very low. Rather, the sturgeon appear to congregate in areas of deep water, and the habitat suitability analysis (Figure 4-4) accordingly emphasizes water depth.

The steep slope of the WUA curve in Figure 4-4 indicates a substantial increase in usable area for each flow increment. This steep slope persists even at the highest modeled flows. As shown by Table 4-2, the 78 cfs flow change that would be caused by withdrawal operation would have a relatively minor impact, causing approximately a 6.5% change in WUA at flows of 1,200 cfs, declining to a 2% change at flows of 4,000 cfs.

Biologically, the value of these results is tempered by the same kind of timing discontinuity that affects the map turtle: extreme low flows rarely occur during the summer months when adults hold in this area. Sturgeon begin to migrate from this area to the sea between late September and mid-October, evidently in response to shorter day length, reduced water temperatures, and relatively large increases in stream flows (Heise *et al*. 2005). Since minor flow decreases have not been shown to drive sturgeon migration, there is no evidence to suggest that the small flow changes that might propagate downstream from the site of the withdrawal would have the potential to alter adult sturgeon holding and migration.

Figure 4-4. Weighted Usable Area Changes for Adult Sturgeon

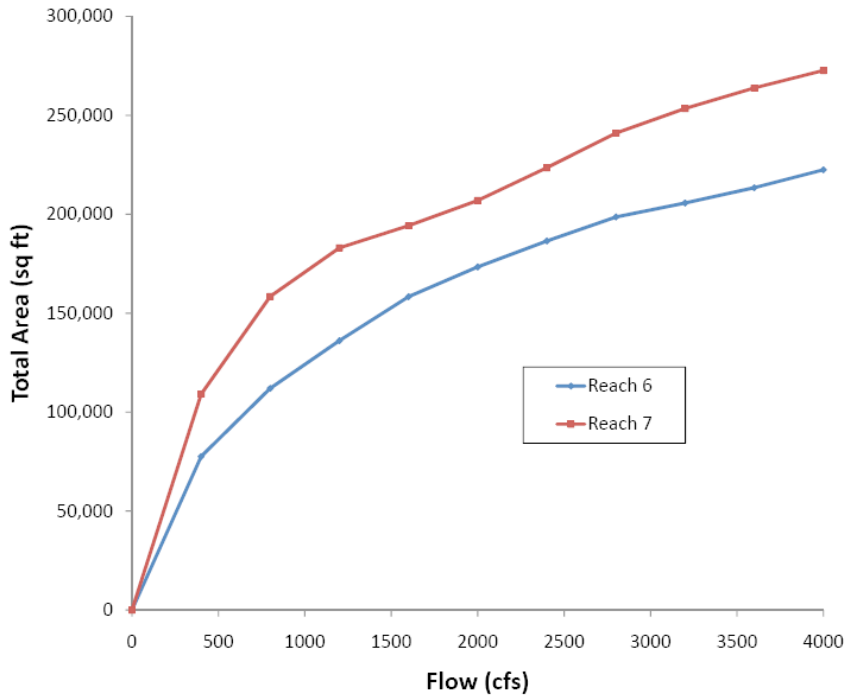


Table 4-2. Percent Change in Adult Gulf Sturgeon Weighted Usable Area Attributable to a 78 cfs Reduction in Flow

Flow (cfs)	Reach	
	6	7
400	-19.5%	-19.5%
800	-9.8%	-9.8%
1200	-6.5%	-6.5%
1600	-4.9%	-4.9%
2000	-3.9%	-3.9%
2400	-3.3%	-3.3%
2800	-2.8%	-2.8%
3200	-2.4%	-2.4%
3600	-2.2%	-2.2%
4000	-2.0%	-2.0%

4.3. Pearl Darter

Pearl darter habitat was assessed for Reaches 1 through 7. Reaches 1 and 2 are upstream of the proposed withdrawal and thus would not be affected, but these reaches also were modeled in order to observe

model sensitivity to incremental flow changes. For pearl darter, suitability curves were established for both depth and water velocity, with different curves for juvenile vs. adult exposure to water velocity (juveniles being somewhat less tolerant of higher velocities). WUA for the range of modeled flows is shown in Figure 4-5 (juveniles) and Figure 4-6 (adults).

Figure 4-5. Weighted Usable Area Changes for Juvenile Pearl Darter

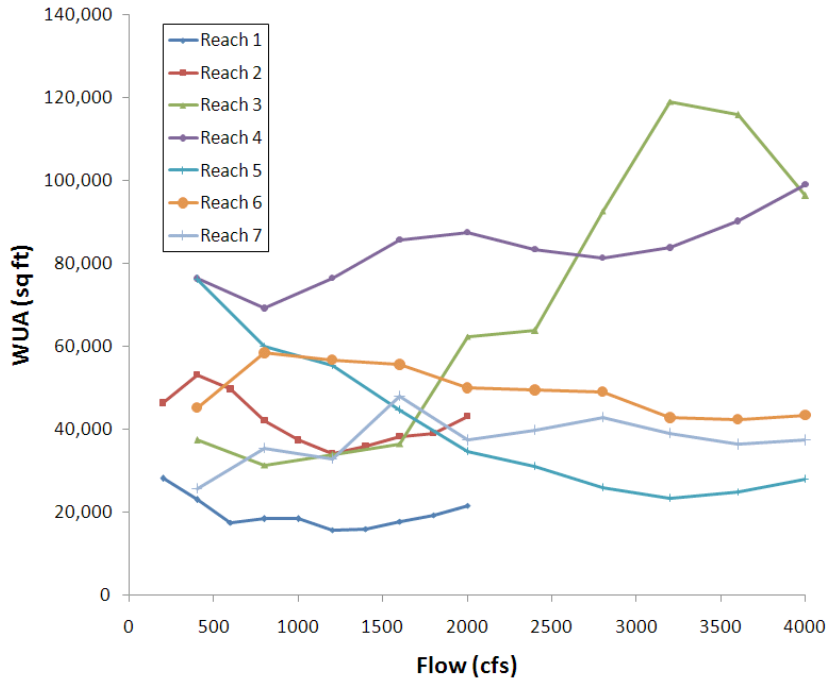
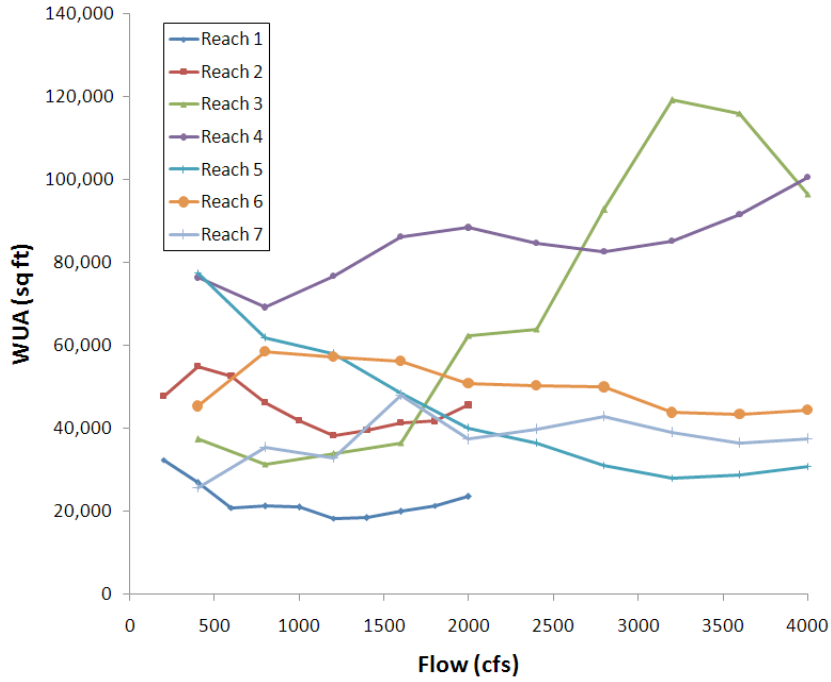


Figure 4-6. Weighted Usable Area Changes for Adult Pearl Darter



Figures 4-5 and 4-6 suggest that juveniles and adults generally demonstrate similar responses to flow variation, to within 10% at any given flow. This is not surprising, given the close similarity between habitat suitability curves for juveniles and adults. The seven reaches respond differently to flow changes in terms of their WUA. In some cases, there are large fluctuations in habitat suitability that occur in response to relatively small flow changes. The changes in WUA that occur in response to a 78 cfs flow change, for example, vary from +9.4% to -13.9%, with a standard deviation of 3.7%. This is substantially more variability than was seen in responses for juvenile Gulf sturgeon. The variability decreases somewhat with increasing flows, but not nearly to the same extent as with the sturgeon. Reaches 1, 2, 4, 6, and 7 show roughly constant WUA across the range of modeled flows. Reaches 1, 2, and 4 sample large point bars, a highly suitable habitat for the darter. The observed results suggest that rising waters create suitable habitat in shallow nearshore locations about as quickly as such habitat is lost in faster, deeper water. Reaches 6 and 7 sample deep pools with steep shorelines and very slow flow, and the observed results indicate that habitat availability remains roughly constant despite flow variability. Conversely, Reach 3 shows fairly constant WUA at low flows, but then a steep increase in WUA as flows increase from 1,600 to 3,200 cfs. As shown in Figure 3-5, Reach 3 has a large, nearly flat sand bar that is progressively inundated across that range of flows (the water level shown in Figure 3-5 corresponds to 2,085 cfs). This produces a substantial increase in shallow water habitat. At even higher flows, the wetted area shows little further change while habitat is degraded by deeper water and higher flow velocity, producing a reduction in WUA. Finally, Reach 5 shows a continual reduction in WUA with increasing flow. The bathymetric data (Figure 3-7) indicate that there is little increase in wetted area as flows rise in this reach; thus, increasing flows result in increasing water velocity, thereby reducing habitat suitability despite the increases in wetted area.

The PHABSIM habitat model, as described in Section 2, subdivides the river channel into discrete cells. The channel is basically a linear feature (although bifurcations may occur) comprised of similar-sized cells. This is a reasonable approximation for a large and highly mobile fish, such as a sturgeon or bass, which is able to range freely throughout the channel. The pearl darter, however, is a small fish that is capable of identifying and exploiting micro-scale habitats, sometimes only a few meters in extent, that are not adequately resolved at the scale of mapping normally employed in a PHABSIM simulation. Moreover, the PHABSIM hydraulic model is not capable of resolving boundary-layer effects that may be expressed within a few inches of the substrate, but which, within that small zone, may generate steep velocity gradients. It is therefore plausible that, by exploiting fine-scale habitats and boundary layer hydraulics, the pearl darter may be capable of occupying velocity fields modeled as unsuitable under PHABSIM. Similarly, the darter may be capable of locating and occupying areas of suitable habitat that cannot be resolved with the coarse spatial scale of the PHABSIM channel morphology matrix. The differences in scale between pearl darter habitat utilization and PHABSIM model results should be considered when interpreting the WUA curves for this species.

There is high confidence in PHABSIM model results showing large scale changes in velocity. These results suggest that during low flow periods mainstem channel velocities are low enough for pearl darters to move freely along many reaches of the channel, whereas increasing flows likely restrict opportunities for such migration and result in pearl darter use of localized velocity refugia. It is plausible that dispersal and migration in this species (at least, in the upstream direction) are keyed to seasonal low flows. This possibility, however, does not appear to be addressed in the existing literature on the darter's biology.

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Chapter 5. Summary and Conclusions

Proposed operation of the withdrawal near Merrill on the Pascagoula River would result in a consumptive use of approximately 78 cfs from the river. Based on physical conditions, this flow alteration has the potential to affect habitat and health of three ESA-protected species inhabiting the river: the yellow blotched map turtle, Gulf sturgeon, and pearl darter. The DOE and FWS, pursuant to informal consultation on the effects of the proposed diversion, agreed to use IFIM as an appropriate technique to quantify and assess those effects. The IFIM approach is being guided by an IFIM Review Team consisting of representatives from the DOE, FWS, MDEQ, MDWFP, MMNS, EEE Consulting, and ICF.

This report summarizes the work scoped by the IFIM Review Team, describes the IFIM methodology in general terms, and describes the relevant biological and hydrologic context of the study species as they occur in the Pascagoula River Basin. The hydraulic and biological components of the IFIM are herein presented and described, and the outcome of those model elements is appended. These results are interpreted in the context of the biology of the study species.

With regard to nesting female yellow blotched map turtles, the proposed water withdrawal has a low potential to alter habitat conditions significantly. Decreasing flows by the proposed 78 cfs withdrawal would only change the distance that a turtle must travel to its nest site by approximately 2% during the time when hatchlings move from the nest to the water (August, September, and October). The river changes that would be imposed by the water withdrawal would likely have very little impact on the known or suspected factors of decline for this species. Yellow blotched map turtles suffer from declining fecundity and extremely high incidences of nest predation, both of which seem to be greatly elevated from historical levels for reasons that are unclear.

Because low flow conditions and life history timing of subadult and adult sturgeon are not connected, withdrawal operations seem to have negligible potential to alter the summer holding by subadults and adults. These fish occupy habitat some 40 miles downstream of the withdrawal, and would in any event be unlikely to be affected by the small decreases in WUA that would be produced if the full effect of the

water withdrawal were expressed within their habitat. Tidal influences in the reach may dampen and mask these effects.

The withdrawal has a somewhat greater potential to affect juvenile sturgeon. Juvenile sturgeon would be present in the river near the location of the withdrawal, and the proposed withdrawal would result in as much as a 7% reduction in WUA at flows of 1,000 cfs, although the WUA reduction would diminish substantially at higher flows. When juvenile sturgeon are stressed during low flow conditions this loss of habitat could have local impacts. Further study of how and when juvenile sturgeon use the habitat available in Reaches 3, 4, and 5 would help to determine the probability and magnitude of this potential impact.

The IFIM was informative with regard to potential effects of water withdrawal on pearl darters, but caution is advised when interpreting these results. Model results indicate large changes in habitat suitability resulting from relatively small changes in flow, and large differences in response between the seven reaches. This may reflect a scale problem, in which the pearl darter is capable of exploiting a very heterogeneous velocity and water depth environment at a spatial scale too small to be resolved by the reach-scale models employed in this IFIM. The PHABSIM results do indicate that low flow conditions in the river may be needed in order to allow pearl darters to disperse or migrate, especially in an upstream direction. The co-occurrence of low flow conditions and pearl darter rearing is likely because the fish are present in the study reaches year round. There is no evidence to suggest that the proposed withdrawal would significantly affect this species.

This study was limited to an evaluation of the impact of flow changes on WUA conditions under lower flows. The results can be related to the withdrawal because it is relatively small compared to even the lowest flows in the Pascagoula (less than10% of the 7Q10 flows). This analysis does not address peak flows or sustained high flows, and should not be used to assess the overall water budget requirements of the Pascagoula flora and fauna. At low flows the withdrawal will decrease the quantity of wetted habitat available to the focal species and life stages relative to the fraction of water that is being removed, and may also cause changes in flow velocity within the river. This effect may be most pronounced for juvenile sturgeon, the migration of which is affected by low flow velocities in all of the study reaches.

Across the 78-year period of record for the USGS flow gage at Merrill the average change in flow is 1,041 cfs per day. Under the average conditions the amount of water being removed from the river from the withdrawal will be far less than the natural hourly or daily variance in flow associated with variability in precipitation, groundwater inputs, other anthropogenic impacts, or measurement error. Under most conditions the proposed withdrawal would not likely be detectable in the field, and may not have an impact on the focal species discussed in this report. Flow changes, positive or negative, less than 78 cfs occur approximately 20% of the time in the Pascagoula River. During those periods the withdrawal would be greater than or equal to the daily fluctuations in flow, resulting in a detectable and discernable decrease in WUA for pearl darter and juvenile sturgeon, and a small increase in travel distance for migrating turtles. These relatively small but detectable changes should be considered when evaluating the impacts of the proposed withdrawal at Merrill or other flow alterations in the Pascagoula.

The DOE has proposed limits to withdrawals in order to maintain the MIF as follows:

- no withdrawals would occur during flows of less than 1,000 cfs,
- withdrawals of up to 39 cfs would occur at flows of 1,000 to 1,100 cfs, and
- withdrawals of up to 78 cfs would occur at flows of more than 1,100 cfs.

Since yearly low flows predictably occur in October, DOE would also schedule system maintenance to occur at that time, thereby reducing the need to operate the diversion during annual low flows (U.S. Department of Energy 2009).

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Appendix A

Detailed PHABSIM Results

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Yellow Blotched Map Turtle

Table A-1. Dry Channel Length from Water's Edge to Vegetation Line by Discharge and Transect, Reach 1, Leaf River

Discharge =200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	96.61	1.1	1.3	1.3	134.7	377.7	134.8	429.0	31.4%	68.6%	294.2
2	95.68	1.2	2.0	2.0	87.3	330.2	88.2	478.5	18.4%	81.6%	390.3
3	95.68	0.9	2.3	2.3	90.7	413.7	91.3	480.4	19.0%	81.0%	389.2
4	95.27	0.6	3.1	3.1	110.2	594.0	111.5	486.6	22.9%	77.1%	375.2
5	96.54	0.7	2.1	2.1	130.1	509.9	131.2	488.4	26.9%	73.1%	357.2
6	96.02	0.9	1.9	1.9	116.1	458.1	116.5	419.7	27.8%	72.2%	303.2
7	95.63	0.5	3.0	3.0	144.3	773.3	145.0	374.9	38.7%	61.3%	229.9
										Mean Dry Distance (ft) =	**334.2**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**11%**

Discharge =400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	97.36	1.4	1.9	1.9	151.5	377.7	151.7	429.0	35.4%	64.6%	277.3
2	96.57	1.6	2.5	2.5	103.1	330.2	104.2	478.5	21.8%	78.2%	374.3
3	96.73	1.3	3.0	3.0	104.7	413.7	105.5	480.4	22.0%	78.0%	374.9
4	96.21	0.9	3.8	3.7	119.1	594.0	120.6	486.6	24.8%	75.2%	366.0
5	97.48	1.0	2.6	2.6	160.4	509.9	161.7	488.4	33.1%	66.9%	326.7
6	96.99	1.2	2.6	2.6	131.6	458.1	132.3	419.7	31.5%	68.5%	287.4
7	96.81	0.6	3.7	3.7	166.4	773.3	167.2	374.9	44.6%	55.4%	207.7
										Mean Dry Distance (ft) =	**316.3**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**5%**

Discharge =598 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	97.93	1.6	2.3	2.3	163.3	377.7	163.6	429.0	38.1%	61.9%	265.4
2	97.24	1.8	2.9	2.8	115.3	330.2	116.5	478.5	24.3%	75.7%	362.0
3	97.62	1.4	3.4	3.4	122.1	413.7	123.2	480.4	25.6%	74.4%	357.3
4	97.3	1.0	4.1	4.0	145.6	594.0	147.4	486.6	30.3%	69.7%	339.3
5	98.06	1.2	3.0	3.0	169.3	509.9	170.7	488.4	35.0%	65.0%	317.6
6	97.8	1.3	3.0	3.0	151.8	458.1	152.6	419.7	36.4%	63.6%	267.1
7	97.69	0.8	4.3	4.3	179.6	773.3	180.7	374.9	48.2%	51.8%	194.2
										Mean Dry Distance (ft) =	**300.4**

Discharge =600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	97.93	1.6	2.3	2.3	163.4	377.7	163.7	429.0	38.2%	61.8%	265.3
2	97.25	1.8	2.9	2.8	115.4	330.2	116.6	478.5	24.4%	75.6%	361.9
3	97.63	1.4	3.4	3.4	122.5	413.7	123.6	480.4	25.7%	74.3%	356.9
4	97.3	1.0	4.1	4.0	145.7	594.0	147.5	486.6	30.3%	69.7%	339.1
5	98.07	1.2	3.0	3.0	169.3	509.9	170.8	488.4	35.0%	65.0%	317.6
6	97.81	1.3	3.0	3.0	152.0	458.1	152.8	419.7	36.4%	63.6%	266.9
7	97.7	0.8	4.3	4.3	179.7	773.3	180.8	374.9	48.2%	51.8%	194.1
										Mean Dry Distance (ft) =	**300.3**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-0.1%**

Discharge =676 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	98.12	1.6	2.5	2.5	166.8	377.7	167.1	429.0	38.9%	61.1%	261.9
2	97.47	1.9	3.0	3.0	119.3	330.2	120.5	478.5	25.2%	74.8%	358.0
3	98.01	1.5	3.4	3.4	135.5	413.7	136.7	480.4	28.5%	71.5%	343.7
4	97.57	1.1	4.2	4.2	150.1	594.0	151.9	486.6	31.2%	68.8%	334.7
5	98.26	1.2	3.2	3.1	170.9	509.9	172.5	488.4	35.3%	64.7%	315.9
6	98.08	1.3	3.1	3.1	159.2	458.1	160.1	419.7	38.2%	61.8%	259.5
7	98	0.8	4.5	4.5	184.2	773.3	185.4	374.9	49.5%	50.5%	189.5
										Mean Dry Distance (ft) =	**294.7**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-2%**

Discharge =800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	98.41	1.7	2.7	2.7	171.9	377.7	172.2	429.0	40.1%	59.9%	256.7
2	97.92	1.9	3.0	3.0	136.7	330.2	137.9	478.5	28.8%	71.2%	340.6
3	98.44	1.5	3.6	3.5	146.4	413.7	147.7	480.4	30.7%	69.3%	332.7
4	97.93	1.2	4.5	4.4	153.7	594.0	155.7	486.6	32.0%	68.0%	331.0
5	98.55	1.3	3.4	3.4	173.5	509.9	175.1	488.4	35.9%	64.1%	313.3
6	98.46	1.4	3.4	3.3	167.3	458.1	168.3	419.7	40.1%	59.9%	251.4
7	98.45	0.9	4.8	4.8	191.3	773.3	192.6	374.9	51.4%	48.6%	182.3
										Mean Dry Distance (ft) =	**286.9**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-5%**

Discharge =1000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	98.84	1.9	3.0	3.0	179.4	377.7	179.8	429.0	41.9%	58.1%	249.2
2	98.42	2.1	3.2	3.2	150.0	330.2	151.4	478.5	31.6%	68.4%	327.1
3	98.96	1.7	3.9	3.9	153.9	413.7	155.4	480.4	32.3%	67.7%	325.1
4	98.47	1.3	4.9	4.8	158.9	594.0	161.0	486.6	33.1%	66.9%	325.6
5	98.98	1.5	3.8	3.7	177.3	509.9	179.1	488.4	36.7%	63.3%	309.3
6	98.99	1.5	3.7	3.7	177.2	458.1	178.3	419.7	42.5%	57.5%	241.4
7	99.13	1.0	5.2	5.2	201.9	773.3	203.3	374.9	54.2%	45.8%	171.6
										Mean Dry Distance (ft) =	**278.5**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-7%**

Discharge =1110 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	
1	99.05	1.9	3.1	3.1	182.7	377.7	183.2	429.0	42.7%	57.3%	245.8
2	99.14	1.8	3.7	3.6	163.4	330.2	164.8	478.5	34.5%	65.5%	313.6
3	99.22	1.7	4.1	4.0	157.7	413.7	159.3	480.4	33.2%	66.8%	321.1
4	98.74	1.4	5.1	5.0	161.4	594.0	163.6	486.6	33.6%	66.4%	323.0
5	99.21	1.6	4.0	3.9	179.5	509.9	181.4	488.4	37.1%	62.9%	307.0
6	99.26	1.6	3.9	3.8	182.2	458.1	183.4	419.7	43.7%	56.3%	236.3
7	99.47	1.0	5.4	5.3	207.2	773.3	208.8	374.9	55.7%	44.3%	166.1
										Mean Dry Distance (ft) =	**273.3**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-9%**

Discharge =1200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	99.22	2.0	3.3	3.3	185.0	377.7	185.5	429.0	43.2%	56.8%	243.5
2	98.81	2.2	3.5	3.4	157.8	330.2	159.2	478.5	33.3%	66.7%	319.3
3	99.44	1.8	4.2	4.1	162.2	413.7	163.9	480.4	34.1%	65.9%	316.6
4	98.95	1.4	5.2	5.1	163.4	594.0	165.7	486.6	34.1%	65.9%	320.9
5	99.39	1.6	4.1	4.0	181.4	509.9	183.2	488.4	37.5%	62.5%	305.1
6	99.47	1.6	4.0	4.0	186.0	458.1	187.3	419.7	44.6%	55.4%	232.4
7	99.72	1.0	5.6	5.5	210.6	773.3	212.3	374.9	56.6%	43.4%	162.6
										Mean Dry Distance (ft) =	**271.5**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-10%**

Discharge =1400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	99.57	2.1	3.5	3.5	189.5	377.7	190.1	429.0	44.3%	55.7%	238.9
2	99.16	2.3	3.7	3.6	163.5	330.2	165.0	478.5	34.5%	65.5%	313.4
3	99.95	1.8	4.4	4.3	175.4	413.7	177.2	480.4	36.9%	63.1%	303.3
4	99.42	1.5	5.5	5.4	168.2	594.0	170.7	486.6	35.1%	64.9%	315.9
5	99.83	1.7	4.3	4.3	192.0	509.9	193.9	488.4	39.7%	60.3%	294.5
6	99.9	1.7	4.3	4.2	192.9	458.1	194.2	419.7	46.3%	53.7%	225.5
7	100.3	1.1	5.9	5.9	217.8	773.3	219.5	374.9	58.6%	41.4%	155.4
										Mean Dry Distance (ft) =	**263.8**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-12%**

Discharge =1600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	99.89	2.2	3.8	3.8	193.8	409.3	194.4	429.0	45.3%	54.7%	234.6
2	99.49	2.4	3.9	3.8	170.1	356.1	171.7	478.5	35.9%	64.1%	306.8
3	100.4	1.9	4.5	4.5	187.1	462.2	189.0	480.4	39.3%	60.7%	291.4
4	99.91	1.6	5.8	5.7	176.1	634.0	178.7	486.6	36.7%	63.3%	307.9
5	100.2	1.8	4.5	4.4	201.9	542.1	203.9	488.4	41.8%	58.2%	284.5
6	100.3	1.8	4.5	4.5	199.2	500.1	200.6	419.7	47.8%	52.2%	219.0
7	100.8	1.1	6.2	6.2	224.4	827.8	226.3	374.9	60.4%	39.6%	148.6
										Mean Dry Distance (ft) =	**256.1**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-15%**

Discharge =1800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	100.2	2.3	4.0	4.0	197.8	409.3	198.5	429.0	46.3%	53.7%	230.5
2	99.8	2.5	4.0	4.0	176.5	356.1	178.1	478.5	37.2%	62.8%	300.4
3	100.8	2.0	4.7	4.6	197.7	462.2	199.7	480.4	41.6%	58.4%	280.7
4	100.4	1.6	6.0	5.9	183.4	634.0	186.2	486.6	38.3%	61.7%	300.5
5	100.6	1.8	4.7	4.6	211.1	542.1	213.2	488.4	43.6%	56.4%	275.2
6	100.7	1.8	4.8	4.7	205.1	500.1	206.7	419.7	49.2%	50.8%	213.0
7	101.2	1.2	6.5	6.5	230.6	827.8	232.7	374.9	62.1%	37.9%	142.2
										Mean Dry Distance (ft) =	**248.9**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-17%**

Discharge =2000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
1	100.5	2.4	4.2	4.2	201.6	572.8	202.4	429.0	47.2%	52.8%	226.6
2	100.1	2.6	4.2	4.2	182.4	600.3	184.1	478.5	38.5%	61.5%	294.4
3	101.2	2.0	4.8	4.8	207.5	643.0	209.5	480.4	43.6%	56.4%	270.9
4	100.8	1.7	6.2	6.1	190.1	816.9	193.1	486.6	39.7%	60.3%	293.5
5	101	1.9	4.8	4.8	219.6	709.2	221.7	488.4	45.4%	54.6%	266.7
6	101	1.9	5.0	4.9	210.7	703.5	212.4	419.7	50.6%	49.4%	207.3
7	101.7	1.2	6.8	6.7	236.6	1116.8	238.7	374.9	63.7%	36.3%	136.2
										Mean Dry Distance (ft) =	**242.2**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-19%**

Figure A-1. Yellow Blotched Map Turtle: Percent Dry Channel by Flow and Transect, Reach 1, Leaf River

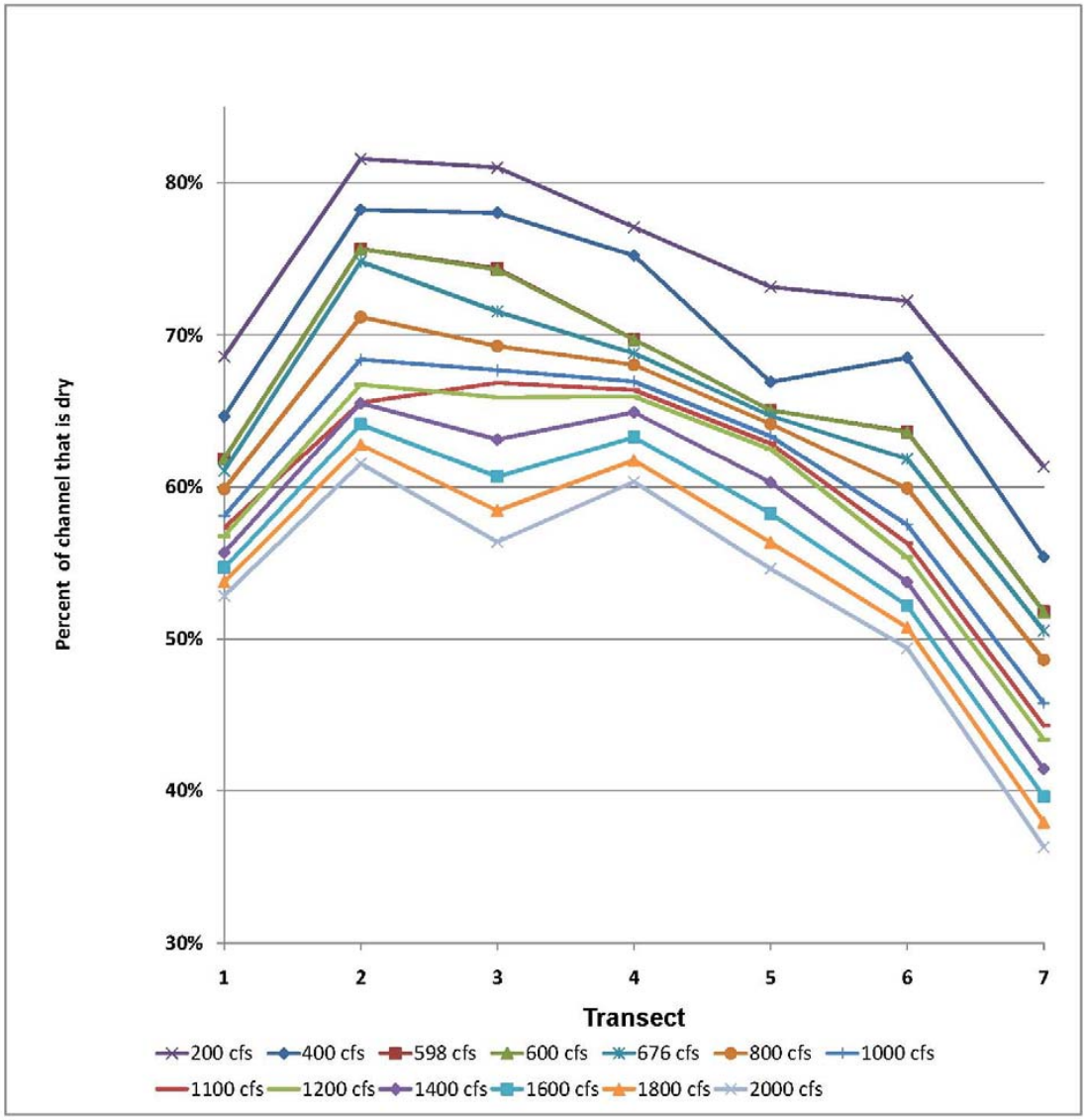


Table A-2. Dry Channel Length from Water's Edge to Vegetation Line by Discharge and Transect, Reach 2, Leaf River

Discharge =200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	90.38	0.3	4.7	4.6	145.7	1171.5	147.5	307.7	47.9%	52.1%	160.2
9	87.62	0.3	7.0	6.7	100.3	1238.2	105.6	283.8	37.2%	62.8%	178.2
10	87.63	0.4	6.8	6.5	81.8	980.1	86.1	325.5	26.4%	73.6%	239.4
11	91.24	0.4	4.0	3.9	113.3	805.9	114.3	413.3	27.7%	72.3%	299.0
12	94.98	0.7	1.3	1.3	216.2	456.0	216.7	403.9	53.6%	46.4%	187.2
13	95.02	0.7	1.3	1.3	219.5	474.5	220.2	349.3	63.0%	37.0%	129.1
										Mean Dry Distance (ft) =	**198.9**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**22%**

Discharge =400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	92.46	0.4	5.9	5.8	170.8	1171.5	173.2	307.7	56.3%	43.7%	134.6
9	90.85	0.4	8.6	8.1	124.9	1238.2	131.7	283.8	46.4%	53.6%	152.1
10	90.76	0.5	8.5	8.1	98.4	980.1	104.0	325.5	31.9%	68.1%	221.5
11	93.14	0.6	4.8	4.7	145.0	805.9	146.5	413.3	35.4%	64.6%	266.9
12	95.53	1.0	1.7	1.7	237.2	456.0	237.7	403.9	58.8%	41.2%	166.2
13	95.57	1.0	1.8	1.8	231.5	474.5	232.2	349.3	66.5%	33.5%	117.1
										Mean Dry Distance (ft) =	**176.4**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**8%**

Discharge =598 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	94	0.5	6.6	6.6	193.4	1171.5	196.2	307.7	63.8%	36.2%	111.5
9	92.93	0.4	9.9	9.4	135.0	1238.2	142.9	283.8	50.4%	49.6%	140.9
10	92.93	0.6	9.7	9.2	109.9	980.1	116.3	325.5	35.7%	64.3%	209.1
11	94.34	0.7	5.4	5.4	161.5	805.9	163.2	413.3	39.5%	60.5%	250.2
12	95.91	1.2	2.0	2.0	246.3	456.0	247.0	403.9	61.1%	38.9%	157.0
13	95.98	1.2	2.1	2.1	240.5	474.5	241.2	349.3	69.1%	30.9%	108.0
										Mean Dry Distance (ft) =	**162.8**

Discharge =600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	94.01	0.5	6.7	6.6	193.6	1171.5	196.5	307.7	63.8%	36.2%	111.3
9	92.95	0.4	9.9	9.4	135.1	1238.2	143.0	283.8	50.4%	49.6%	140.8
10	92.94	0.6	9.7	9.2	110.0	980.1	116.4	325.5	35.8%	64.2%	209.0
11	94.35	0.7	5.4	5.4	161.7	805.9	163.3	413.3	39.5%	60.5%	250.0
12	95.91	1.2	2.0	2.0	246.4	456.0	247.0	403.9	61.2%	38.8%	156.9
13	95.98	1.2	2.1	2.1	240.6	474.5	241.3	349.3	69.1%	30.9%	107.9
										Mean Dry Distance (ft) =	**162.7**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-0.1%**

Discharge =676 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	94.53	0.5	6.8	6.7	203.6	1171.5	206.6	307.7	67.1%	32.9%	101.1
9	93.64	0.5	10.4	9.8	138.5	1238.2	146.7	283.8	51.7%	48.3%	137.1
10	93.63	0.6	10.1	9.5	113.2	980.1	119.9	325.5	36.8%	63.2%	205.6
11	94.74	0.7	5.6	5.6	166.9	805.9	168.6	413.3	40.8%	59.2%	244.7
12	96.04	1.3	2.1	2.1	249.5	456.0	250.1	403.9	61.9%	38.1%	153.8
13	96.12	1.2	2.2	2.2	243.8	474.5	244.6	349.3	70.0%	30.0%	104.7
										Mean Dry Distance (ft) =	**157.8**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-3%**

Discharge =800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	95.25	0.5	7.2	7.1	214.6	1171.5	217.7	307.7	70.8%	29.2%	90.0
9	94.66	0.5	11.0	10.4	143.5	1238.2	152.2	283.8	53.6%	46.4%	131.6
10	94.63	0.6	10.7	10.1	117.4	980.1	124.6	325.5	38.3%	61.7%	200.9
11	95.32	0.8	5.9	5.9	175.2	805.9	177.0	413.3	42.8%	57.2%	236.3
12	96.23	1.4	2.3	2.2	254.1	456.0	254.8	403.9	63.1%	36.9%	149.1
13	96.32	1.3	2.4	2.4	248.7	474.5	249.5	349.3	71.4%	28.6%	99.8
										Mean Dry Distance (ft) =	**151.3**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-7%**

Discharge =1000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	96.2	0.6	7.8	7.6	225.9	1171.5	229.3	307.7	74.5%	25.5%	78.5
9	96.13	0.6	11.9	11.2	150.6	1238.2	160.1	283.8	56.4%	43.6%	123.7
10	96.06	0.7	11.6	10.9	123.3	980.1	131.2	325.5	40.3%	59.7%	194.3
11	96.15	0.8	6.3	6.3	187.8	805.9	189.8	413.3	45.9%	54.1%	223.6
12	96.51	1.6	2.5	2.5	260.6	456.0	261.3	403.9	64.7%	35.3%	142.6
13	96.62	1.5	2.6	2.6	255.1	474.5	255.9	349.3	73.3%	26.7%	93.3
										Mean Dry Distance (ft) =	**142.6**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-12%**

Discharge =1110 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	96.46	0.6	7.9	7.8	229.0	1171.5	232.5	307.7	75.5%	24.5%	75.3
9	96.53	0.6	12.2	11.5	152.6	1238.2	162.3	283.8	57.2%	42.8%	121.5
10	96.49	0.7	11.8	11.1	126.1	980.1	134.1	325.5	41.2%	58.8%	191.4
11	96.38	0.9	6.5	6.4	191.1	805.9	193.1	413.3	46.7%	53.3%	220.2
12	96.58	1.6	2.5	2.5	262.3	456.0	263.0	403.9	65.1%	34.9%	140.9
13	96.7	1.5	2.7	2.7	256.6	474.5	257.5	349.3	73.7%	26.3%	91.7
										Mean Dry Distance (ft) =	**140.2**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-14%**

Discharge =1200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	97.01	0.6	8.3	8.2	232.9	1171.5	236.6	307.7	76.9%	23.1%	71.1
9	97.41	0.6	12.8	12.0	156.3	1238.2	166.5	283.8	58.7%	41.3%	117.3
10	97.61	0.7	11.9	11.2	137.8	980.1	146.0	325.5	44.9%	55.1%	179.4
11	96.87	0.9	6.7	6.6	198.4	805.9	200.7	413.3	48.6%	51.4%	212.7
12	96.75	1.7	2.7	2.7	265.5	456.0	266.2	403.9	65.9%	34.1%	137.7
13	96.88	1.6	2.8	2.8	260.1	474.5	261.1	349.3	74.8%	25.2%	88.2
										Mean Dry Distance (ft) =	**134.4**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-17%**

Discharge =1400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	97.7	0.7	8.9	8.7	236.7	1171.5	240.6	307.7	78.2%	21.8%	67.1
9	98.54	0.6	13.5	12.6	161.1	1238.2	171.9	283.8	60.6%	39.4%	111.9
10	98.94	0.8	12.0	11.4	152.0	980.1	160.5	325.5	49.3%	50.7%	165.0
11	97.53	1.0	7.0	6.9	209.6	805.9	212.0	413.3	51.3%	48.7%	201.3
12	96.97	1.8	2.8	2.8	269.3	456.0	270.1	403.9	66.9%	33.1%	133.8
13	97.12	1.8	3.0	3.0	264.7	474.5	265.7	349.3	76.1%	23.9%	83.6
										Mean Dry Distance (ft) =	**127.1**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-22%**

Discharge =1600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	98.34	0.7	9.4	9.2	240.1	1171.5	244.4	307.7	79.4%	20.6%	63.4
9	99.54	0.7	14.2	13.3	164.3	1238.2	175.3	283.8	61.8%	38.2%	108.5
10	100	0.8	12.3	11.7	162.0	980.1	170.7	325.5	52.4%	47.6%	154.8
11	98.11	1.0	7.2	7.2	219.3	805.9	221.8	413.3	53.7%	46.3%	191.5
12	97.17	1.9	3.0	3.0	272.8	456.0	273.7	403.9	67.8%	32.2%	130.2
13	97.33	1.9	3.2	3.2	268.9	474.5	270.0	349.3	77.3%	22.7%	79.3
										Mean Dry Distance (ft) =	**121.3**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-25%**

Discharge =1800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	98.93	0.8	9.9	9.7	243.1	1291.2	247.6	307.7	80.5%	19.5%	60.2
9	101	0.7	14.0	13.2	185.4	1347.1	196.5	283.8	69.2%	30.8%	87.3
10	101	0.8	12.5	11.9	173.3	1071.0	182.0	325.5	55.9%	44.1%	143.5
11	98.63	1.1	7.5	7.4	227.3	879.6	229.9	413.3	55.6%	44.4%	183.4
12	97.36	2.1	3.2	3.2	276.2	492.9	277.1	403.9	68.6%	31.4%	126.9
13	97.54	2.0	3.3	3.3	272.9	512.9	274.0	349.3	78.4%	21.6%	75.3
										Mean Dry Distance (ft) =	**112.8**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-31%**

Discharge =2000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
8	99.48	0.8	10.3	10.1	245.2	1865.2	249.7	307.7	81.1%	18.9%	58.0
9	102.3	0.7	13.6	12.9	209.2	1866.8	220.3	283.8	77.6%	22.4%	63.5
10	102.8	0.8	11.2	10.8	224.9	1471.4	233.6	325.5	71.8%	28.2%	91.8
11	99.13	1.1	7.7	7.6	235.3	1244.1	237.9	413.3	57.6%	42.4%	175.4
12	97.54	2.2	3.3	3.3	279.3	761.1	280.2	403.9	69.4%	30.6%	123.7
13	97.73	2.1	3.5	3.5	276.6	630.6	277.7	349.3	79.5%	20.5%	71.5
										Mean Dry Distance (ft) =	**97.3**
										Percent change relative to 598 cfs in mean dry distance to vegetation =	**-40%**

Figure A-2. Yellow Blotched Map Turtle: Percent Dry Channel by Flow and Transect, Reach 2, Leaf River

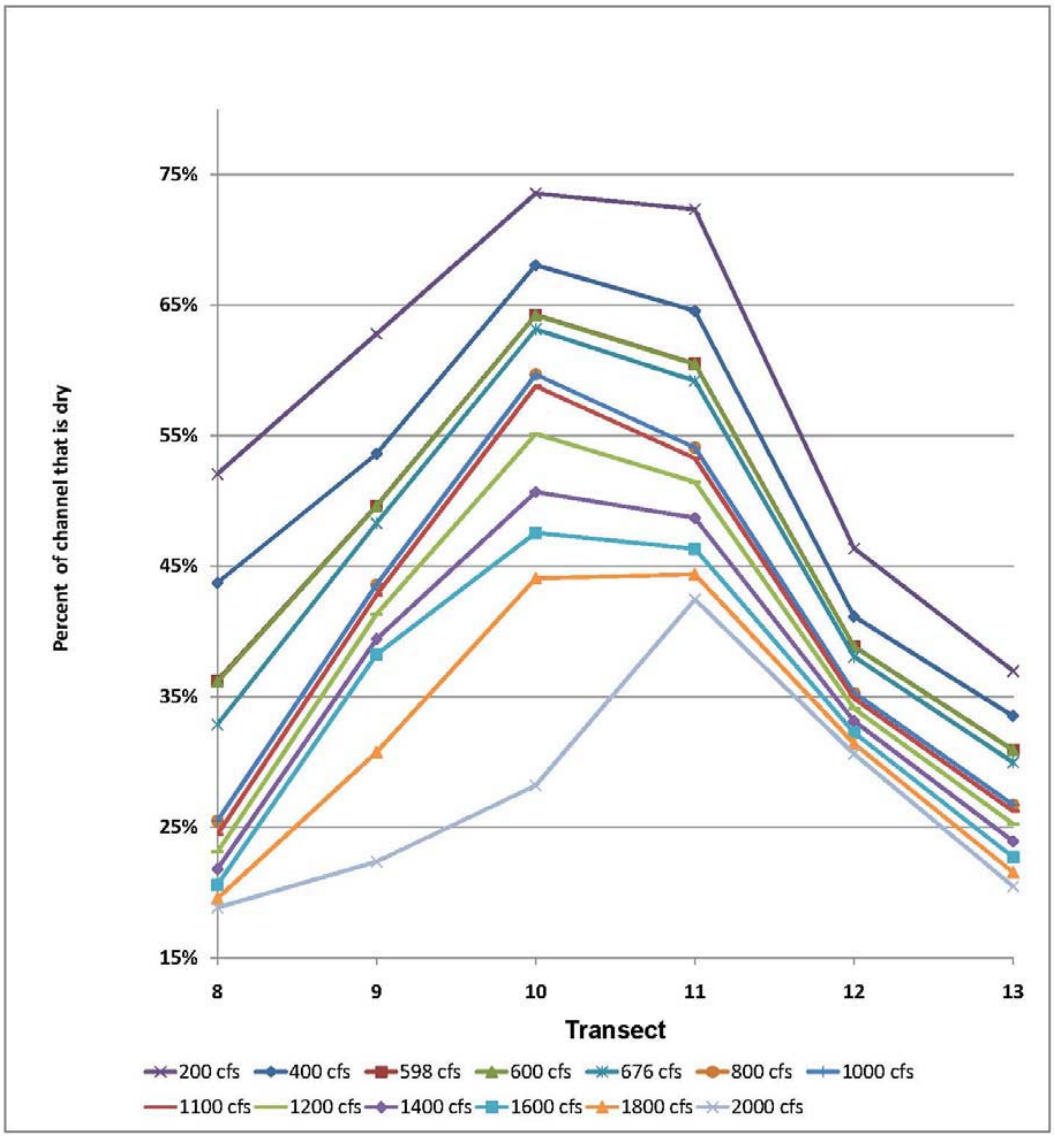


Table A-3. Dry Channel Length from Water's Edge to Vegetation Line by Discharge and Transect, Reach 3, Pascagoula River

Discharge =400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	90.42	0.6	4.8	4.8	134.2	1144.5	135.5	377.9	35.9%	64.1%	242.4
15	90.17	0.7	4.7	4.6	129.2	1054.9	130.9	355.6	36.8%	63.2%	224.7
16	93.24	0.9	2.9	2.9	148.0	759.2	148.9	555.7	26.8%	73.2%	406.8
										Mean Dry Distance (ft) =	**291.3**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**11%**

Discharge =800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	93.15	0.8	6.7	6.6	155.6	1208.2	157.6	377.9	41.7%	58.3%	220.3
15	92.78	0.8	6.7	6.5	144.2	1113.8	147.5	355.6	41.5%	58.5%	208.1
16	94.88	1.2	4.1	4.0	169.8	805.1	171.2	555.7	30.8%	69.2%	384.5
										Mean Dry Distance (ft) =	**271.0**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**3%**

Discharge =917 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	93.8	0.8	7.1	7.0	160.2	1208.2	162.4	377.9	43.0%	57.0%	215.5
15	93.42	0.9	7.1	7.0	147.9	1113.8	151.6	355.6	42.6%	57.4%	204.0
16	95.28	1.2	4.3	4.3	175.5	805.1	176.9	555.7	31.8%	68.2%	378.8
										Mean Dry Distance (ft) =	**266.1**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**1%**

Discharge =995 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	94.2	0.8	7.4	7.3	162.7	1208.2	165.1	377.9	43.7%	56.3%	212.8
15	93.83	0.9	7.4	7.2	150.2	1113.8	154.2	355.6	43.4%	56.6%	201.4
16	95.54	1.2	4.5	4.4	180.4	805.1	181.9	555.7	32.7%	67.3%	373.8
										Mean Dry Distance (ft) =	**262.7**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**0%**

Discharge =1200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	95.2	0.9	8.1	8.0	169.1	1208.2	171.8	377.9	45.5%	54.5%	206.1
15	94.82	0.9	8.1	7.9	155.6	1113.8	160.2	355.6	45.0%	55.0%	195.4
16	96.21	1.3	4.8	4.7	195.7	805.1	197.4	555.7	35.5%	64.5%	358.4
										Mean Dry Distance (ft) =	**253.3**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-4%**

Discharge =1600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	96.99	0.9	9.2	9.0	183.8	1208.2	187.1	377.9	49.5%	50.5%	190.8
15	97.08	1.0	8.5	8.2	193.9	1113.8	199.8	355.6	56.2%	43.8%	155.8
16	98.24	1.1	3.6	3.5	423.2	805.1	425.3	555.7	76.5%	23.5%	130.5
										Mean Dry Distance (ft) =	**159.0**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-39%**

Discharge =2000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	98.6	1.0	10.0	9.8	199.9	1208.2	203.7	377.9	53.9%	46.1%	174.2
15	98.74	1.0	8.9	8.6	224.1	1113.8	231.0	355.6	65.0%	35.0%	124.6
16	98.8	1.1	4.0	4.0	439.1	805.1	441.3	555.7	79.4%	20.6%	114.4
										Mean Dry Distance (ft) =	**137.8**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-48%**

Discharge =2085 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	98.91	1.0	10.2	10.0	202.7	1208.2	206.6	377.9	54.7%	45.3%	171.3
15	98.01	1.1	8.6	8.4	212.8	1113.8	219.2	355.6	61.7%	38.3%	136.3
16	98.91	1.2	4.1	4.0	441.9	805.1	444.1	555.7	79.9%	20.1%	111.6
										Mean Dry Distance (ft) =	**139.8**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-47%**

Discharge =2400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	100.4	1.0	10.0	9.9	238.0	1309.5	242.1	377.9	64.1%	35.9%	135.8
15	100.1	1.0	9.4	9.1	245.1	1207.1	252.9	355.6	71.1%	28.9%	102.7
16	99.31	1.2	4.4	4.3	452.1	878.1	454.4	555.7	81.8%	18.2%	101.3
										Mean Dry Distance (ft) =	**113.3**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-57%**

Discharge =2800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	102.4	1.0	9.3	9.2	315.1	1469.5	319.3	377.9	84.5%	15.5%	58.5
15	101.8	1.0	9.0	8.7	307.9	1350.2	316.7	355.6	89.1%	10.9%	38.8
16	99.77	1.3	4.7	4.7	464.6	1029.3	466.9	555.7	84.0%	16.0%	88.8
										Mean Dry Distance (ft) =	**62.1**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-76%**

Discharge =3200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	103.2	1.0	10.0	9.9	316.8	1626.3	321.2	377.9	85.0%	15.0%	56.7
15	102.9	1.0	9.1	8.9	344.3	1560.5	353.3	355.6	99.3%	0.7%	2.3
16	100.2	1.3	5.0	5.0	475.0	1020.0	477.4	555.7	85.9%	14.1%	78.4
										Mean Dry Distance (ft) =	**45.8**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-83%**

Discharge =3600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	103.9	1.1	10.8	10.6	317.1	1787.1	321.6	377.9	85.1%	14.9%	56.2
15	103.5	1.1	9.7	9.5	345.8	1746.3	354.9	355.6	99.8%	0.2%	0.7
16	100.6	1.4	5.3	5.3	483.8	1578.2	486.2	555.7	87.5%	12.5%	69.5
										Mean Dry Distance (ft) =	**42.1**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-84%**

Discharge =4000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
14	104.6	1.1	11.5	11.3	317.1	2062.8	321.6	377.9	85.1%	14.9%	56.2
15	104.2	1.1	10.4	10.1	347.1	2054.6	356.3	355.6	100.2%	-0.2%	-0.7
16	101	1.4	5.6	5.6	492.2	1795.9	494.6	555.7	89.0%	11.0%	61.1
										Mean Dry Distance (ft) =	**38.9**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-85%**

Figure A-3. Yellow Blotched Map Turtle: Percent Dry Channel by Flow and Transect, Reach 3, Pascagoula River

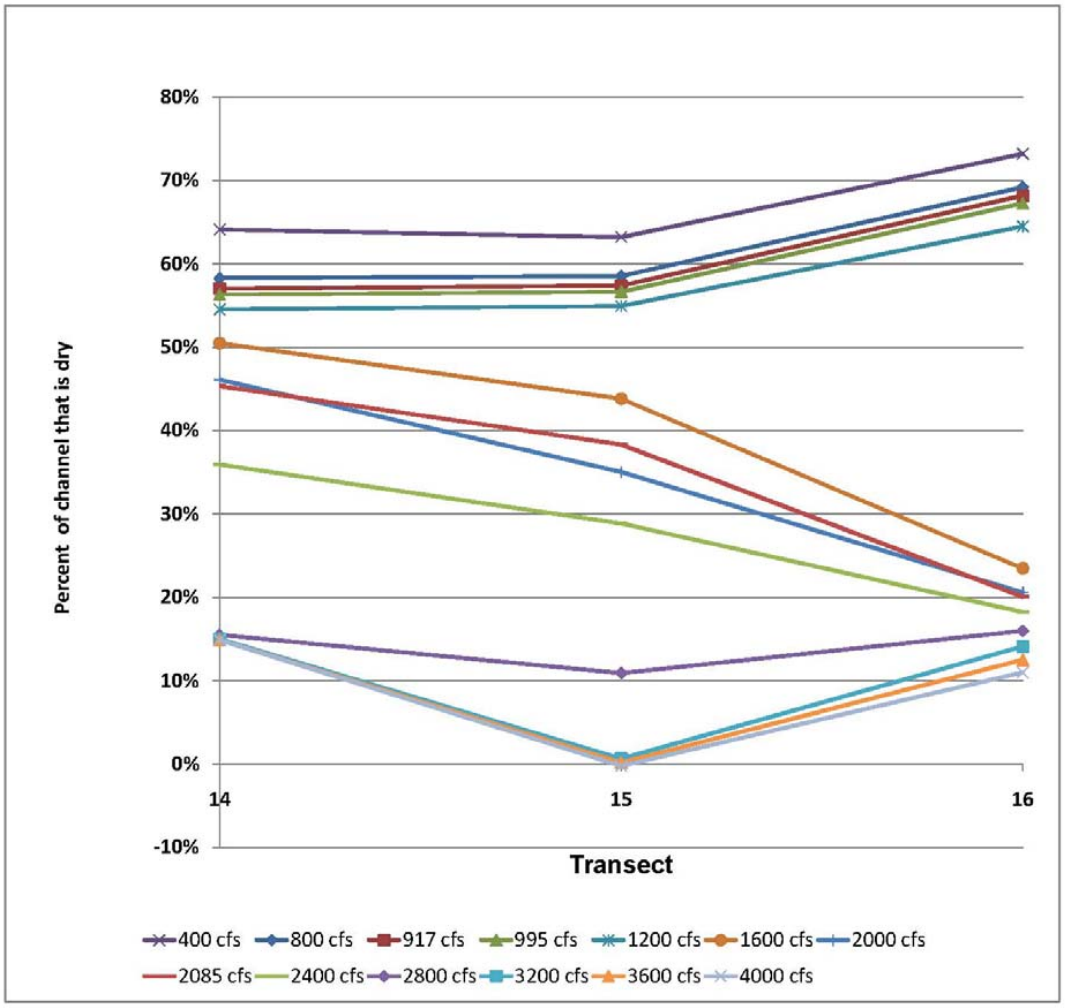


Table A-4. Dry Channel Length from Water's Edge to Vegetation Line by Discharge and Transect, Reach 4, Pascagoula River

Discharge =400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	90.1	0.6	3.7	3.6	171.0	1145.1	172.3	527.3	32.7%	67.3%	355.0
18	90.33	0.7	3.7	3.7	156.3	1137.7	157.1	741.7	21.2%	78.8%	584.6
19	90.17	0.7	3.9	3.8	158.0	1155.6	159.0	751.1	21.2%	78.8%	592.1
20	89.91	0.6	4.3	4.3	144.2	1138.1	146.3	721.8	20.3%	79.7%	575.5
21	89.68	0.7	4.2	4.2	136.5	1045.2	138.2	695.3	19.9%	80.1%	557.0
22	90.86	0.8	3.2	3.2	156.7	887.0	157.8	593.7	26.6%	73.4%	436.0
23	89.94	0.9	3.6	3.6	123.4	844.9	124.3	631.3	19.7%	80.3%	506.9
24	91.76	0.8	2.6	2.6	189.1	876.7	189.6	589.1	32.2%	67.8%	399.6
25	92.01	0.7	2.7	2.7	202.4	946.6	203.4	575.2	35.4%	64.6%	371.9
										Mean Dry Distance (ft) =	**486.5**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**16%**

Discharge =800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	92.25	0.8	4.9	4.9	211.1	1218.9	212.8	527.3	40.4%	59.6%	314.5
18	92.61	0.8	4.5	4.5	223.6	1209.4	224.7	741.7	30.3%	69.7%	517.0
19	92.45	0.8	4.8	4.7	218.2	1226.9	220.3	751.1	29.3%	70.7%	530.8
20	92.29	0.8	5.4	5.3	187.9	1213.6	190.9	721.8	26.5%	73.5%	530.8
21	92.02	0.8	5.2	5.1	182.2	1105.8	184.5	695.3	26.5%	73.5%	510.8
22	92.65	1.0	4.3	4.3	187.1	938.2	188.8	593.7	31.8%	68.2%	404.9
23	92.15	1.1	4.7	4.6	160.7	903.1	162.0	631.3	25.7%	74.3%	469.3
24	93.27	1.0	3.5	3.5	228.9	931.5	229.8	589.1	39.0%	61.0%	359.4
25	93.42	0.9	3.6	3.5	238.1	1023.8	239.2	575.2	41.6%	58.4%	336.1
										Mean Dry Distance (ft) =	**441.5**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**5%**

Discharge =917 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	92.76	0.8	5.2	5.1	222.1	1218.9	223.9	527.3	42.5%	57.5%	303.5
18	93.14	0.8	4.7	4.7	242.3	1209.4	243.5	741.7	32.8%	67.2%	498.2
19	92.94	0.8	5.1	5.0	228.7	1226.9	231.0	751.1	30.8%	69.2%	520.1
20	92.94	0.8	5.5	5.4	207.5	1213.6	210.8	721.8	29.2%	70.8%	510.9
21	92.54	0.9	5.5	5.4	191.5	1105.8	193.9	695.3	27.9%	72.1%	501.4
22	93.07	1.0	4.6	4.5	194.1	938.2	195.9	593.7	33.0%	67.0%	397.8
23	92.71	1.1	4.8	4.8	175.8	903.1	177.2	631.3	28.1%	71.9%	454.1
24	93.62	1.0	3.7	3.7	237.6	931.5	238.6	589.1	40.5%	59.5%	350.6
25	93.82	1.0	3.7	3.6	258.3	1023.8	259.4	575.2	45.1%	54.9%	315.8
										Mean Dry Distance (ft) =	**428.0**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**2%**

Discharge =995 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	93.1	0.8	5.3	5.3	230.6	1218.9	232.5	527.3	44.1%	55.9%	294.8
18	93.43	0.8	4.8	4.8	250.7	1209.4	252.0	741.7	34.0%	66.0%	489.7
19	93.26	0.8	5.2	5.2	236.2	1226.9	238.6	751.1	31.8%	68.2%	512.5
20	93.3	0.8	5.6	5.5	217.9	1213.6	221.4	721.8	30.7%	69.3%	500.4
21	92.86	0.9	5.6	5.5	197.3	1105.8	199.8	695.3	28.7%	71.3%	495.5
22	93.34	1.1	4.7	4.7	198.5	938.2	200.5	593.7	33.8%	66.2%	393.2
23	93.04	1.1	4.9	4.9	184.6	903.1	186.0	631.3	29.5%	70.5%	445.3
24	93.85	1.1	3.8	3.8	245.7	931.5	246.7	589.1	41.9%	58.1%	342.4
25	94.12	1.0	3.7	3.7	279.3	1023.8	280.5	575.2	48.8%	51.2%	294.7
										Mean Dry Distance (ft) =	**418.7**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**0%**

Discharge =1200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	93.9	0.8	5.6	5.6	252.0	1218.9	254.0	527.3	48.2%	51.8%	273.3
18	94.13	0.9	5.2	5.2	267.4	1209.4	268.9	741.7	36.3%	63.7%	472.8
19	94.02	0.8	5.6	5.5	254.9	1226.9	257.6	751.1	34.3%	65.7%	493.4
20	94.15	0.9	5.8	5.7	242.3	1213.6	246.1	721.8	34.1%	65.9%	475.6
21	93.72	0.9	5.9	5.8	219.5	1105.8	222.1	695.3	31.9%	68.1%	473.2
22	93.99	1.1	5.1	5.1	209.5	938.2	211.7	593.7	35.7%	64.3%	382.0
23	93.99	1.1	4.9	4.8	225.3	903.1	226.9	631.3	35.9%	64.1%	404.4
24	94.44	1.1	4.0	4.0	270.5	931.5	271.6	589.1	46.1%	53.9%	317.5
25	94.7	1.0	3.8	3.8	314.9	1023.8	316.2	575.2	55.0%	45.0%	259.0
										Mean Dry Distance (ft) =	**394.6**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-6%**

Discharge =1600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	95.18	0.9	6.3	6.2	280.1	1218.9	282.4	527.3	53.5%	46.5%	245.0
18	95.25	0.9	5.9	5.9	288.5	1209.4	290.4	741.7	39.1%	60.9%	451.3
19	95.26	0.9	6.2	6.1	283.3	1226.9	286.6	751.1	38.2%	61.8%	464.5
20	95.35	0.9	6.4	6.3	267.0	1213.6	271.3	721.8	37.6%	62.4%	450.5
21	95.08	1.0	6.3	6.2	254.7	1105.8	257.6	695.3	37.0%	63.0%	437.7
22	95.32	1.2	5.4	5.4	253.5	938.2	256.1	593.7	43.1%	56.9%	337.6
23	95.31	1.1	5.0	5.0	286.1	903.1	287.8	631.3	45.6%	54.4%	343.4
24	95.39	1.2	4.4	4.4	311.1	931.5	312.5	589.1	53.0%	47.0%	276.6
25	95.5	1.1	4.3	4.2	343.2	1023.8	344.6	575.2	59.9%	40.1%	230.6
										Mean Dry Distance (ft) =	**359.7**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-14%**

Discharge =1783 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	95.83	0.9	6.5	6.5	297.7	1218.9	300.1	527.3	56.9%	43.1%	227.2
18	95.74	1.0	6.2	6.2	296.4	1209.4	298.4	741.7	40.2%	59.8%	443.2
19	95.74	0.9	6.5	6.4	290.6	1226.9	294.2	751.1	39.2%	60.8%	456.9
20	95.86	1.0	6.8	6.7	274.4	1213.6	278.9	721.8	38.6%	61.4%	442.8
21	95.68	1.0	6.4	6.4	275.3	1105.8	278.3	695.3	40.0%	60.0%	416.9
22	95.81	1.2	5.5	5.4	274.2	938.2	277.0	593.7	46.7%	53.3%	316.7
23	95.74	1.1	5.2	5.2	299.8	903.1	301.6	631.3	47.8%	52.2%	329.7
24	95.71	1.2	4.6	4.6	320.4	931.5	321.9	589.1	54.6%	45.4%	267.2
25	95.73	1.2	4.4	4.4	351.1	1023.8	352.5	575.2	61.3%	38.7%	222.7
										Mean Dry Distance (ft) =	**347.0**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-17%**

Discharge =2000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	96.28	1.0	6.8	6.7	306.4	1218.9	309.2	527.3	58.6%	41.4%	218.2
18	96.2	1.0	6.6	6.5	301.5	1209.4	303.6	741.7	40.9%	59.1%	438.0
19	96.28	1.0	6.8	6.7	299.8	1226.9	303.7	751.1	40.4%	59.6%	447.4
20	96.29	1.0	7.1	7.0	278.7	1213.6	283.4	721.8	39.3%	60.7%	438.4
21	96.23	1.0	6.7	6.6	288.3	1105.8	291.6	695.3	41.9%	58.1%	403.7
22	96.34	1.2	5.7	5.7	289.6	938.2	292.6	593.7	49.3%	50.7%	301.1
23	96.19	1.2	5.4	5.4	313.0	903.1	315.0	631.3	49.9%	50.1%	316.3
24	96.14	1.2	4.8	4.8	334.4	931.5	336.0	589.1	57.0%	43.0%	253.1
25	96.16	1.2	4.7	4.7	361.4	1023.8	363.0	575.2	63.1%	36.9%	212.3
										Mean Dry Distance (ft) =	**336.5**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-20%**

Discharge =2400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	97.22	1.0	7.3	7.2	324.2	1338.8	327.8	527.3	62.2%	37.8%	199.5
18	97.04	1.1	7.2	7.2	310.8	1319.3	313.1	741.7	42.2%	57.8%	428.6
19	97.2	1.0	7.4	7.3	315.5	1340.5	319.9	751.1	42.6%	57.4%	431.1
20	97.13	1.1	7.7	7.6	286.9	1332.8	291.9	721.8	40.4%	59.6%	429.9
21	97.16	1.1	7.1	7.0	310.5	1210.0	314.1	695.3	45.2%	54.8%	381.2
22	97.07	1.3	6.3	6.2	299.0	1019.8	302.1	593.7	50.9%	49.1%	291.6
23	96.96	1.2	5.8	5.8	336.1	995.3	338.4	631.3	53.6%	46.4%	292.9
24	96.82	1.3	5.1	5.1	358.7	1019.3	360.7	589.1	61.2%	38.8%	228.5
25	96.74	1.3	5.1	5.1	373.1	1130.9	374.9	575.2	65.2%	34.8%	200.3
										Mean Dry Distance (ft) =	**320.4**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-23%**

Discharge =2800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	98.06	1.1	7.8	7.7	339.6	1515.8	343.8	527.3	65.2%	34.8%	183.5
18	97.81	1.1	7.8	7.7	319.4	1488.8	321.9	741.7	43.4%	56.6%	419.8
19	98.04	1.1	7.9	7.8	329.9	1522.0	334.8	751.1	44.6%	55.4%	416.3
20	98.12	1.1	8.0	7.9	313.5	1515.7	318.9	721.8	44.2%	55.8%	402.9
21	97.96	1.1	7.5	7.4	327.6	1388.9	331.4	695.3	47.7%	52.3%	363.8
22	98	1.3	6.3	6.2	343.9	1146.5	347.2	593.7	58.5%	41.5%	246.5
23	97.63	1.3	6.2	6.1	353.4	1190.3	355.9	631.3	56.4%	43.6%	275.4
24	97.42	1.4	5.5	5.4	376.6	1175.3	378.7	589.1	64.3%	35.7%	210.4
25	97.27	1.3	5.5	5.5	384.0	1280.0	385.9	575.2	67.1%	32.9%	189.3
										Mean Dry Distance (ft) =	**300.9**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-28%**

Discharge =3200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	98.84	1.1	8.3	8.2	353.3	1280.0	358.2	527.3	67.9%	32.1%	169.1
18	98.52	1.2	8.3	8.3	325.6	1682.6	328.2	741.7	44.2%	55.8%	413.5
19	98.86	1.1	8.3	8.1	348.3	1642.5	353.7	751.1	47.1%	52.9%	397.4
20	99.17	1.1	8.0	7.9	357.8	1690.2	363.2	721.8	50.3%	49.7%	358.6
21	98.83	1.2	7.7	7.6	359.6	1661.0	363.7	695.3	52.3%	47.7%	331.6
22	98.73	1.3	6.5	6.4	375.0	1546.3	378.4	593.7	63.7%	36.3%	215.3
23	98.27	1.3	6.5	6.4	372.5	1307.3	375.2	631.3	59.4%	40.6%	256.1
24	97.94	1.4	5.8	5.8	388.4	1374.4	390.7	589.1	66.3%	33.7%	198.4
25	97.76	1.4	5.8	5.8	394.2	1312.4	396.2	575.2	68.9%	31.1%	179.0
										Mean Dry Distance (ft) =	**279.9**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-33%**

Discharge =3600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	99.56	1.1	8.7	8.6	365.9	1857.5	370.9	527.3	70.3%	29.7%	156.4
18	99.18	1.2	8.9	8.8	331.2	1790.8	333.7	741.7	45.0%	55.0%	407.9
19	99.7	1.1	8.5	8.4	375.5	1840.7	381.4	751.1	50.8%	49.2%	369.7
20	100	1.1	8.1	8.0	394.2	1799.4	399.6	721.8	55.4%	44.6%	322.2
21	99.71	1.2	7.7	7.6	401.8	1708.1	405.9	695.3	58.4%	41.6%	289.4
22	99.34	1.3	6.7	6.7	397.8	1467.1	401.2	593.7	67.6%	32.4%	192.5
23	98.9	1.4	6.7	6.6	397.5	1512.8	400.2	631.3	63.4%	36.6%	231.0
24	98.44	1.5	6.1	6.1	401.6	1434.7	404.1	589.1	68.6%	31.4%	185.1
25	98.23	1.4	6.2	6.1	403.7	1536.1	405.9	575.2	70.6%	29.4%	169.3
										Mean Dry Distance (ft) =	**258.2**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-38%**

Discharge =4000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
17	100.2	1.2	9.1	9.0	377.7	1943.0	382.7	527.3	72.6%	27.4%	144.7
18	99.95	1.3	9.1	9.1	349.6	1846.9	352.3	741.7	47.5%	52.5%	389.4
19	100.4	1.2	8.7	8.6	399.3	1889.1	405.1	751.1	53.9%	46.1%	345.9
20	100.7	1.2	8.3	8.2	418.4	1856.4	423.8	721.8	58.7%	41.3%	298.0
21	100.5	1.2	7.6	7.6	450.5	1769.1	454.6	695.3	65.4%	34.6%	240.6
22	100	1.4	6.8	6.7	432.7	1505.0	436.1	593.7	73.5%	26.5%	157.6
23	99.49	1.4	6.9	6.8	422.6	1557.2	425.4	631.3	67.4%	32.6%	205.9
24	98.93	1.5	6.4	6.3	416.4	1464.7	418.8	589.1	71.1%	28.9%	170.3
25	98.74	1.5	6.4	6.3	423.8	1541.7	426.2	575.2	74.1%	25.9%	149.0
										Mean Dry Distance (ft) =	**233.5**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-44%**

Figure A-4. Yellow Blotched Map Turtle: Percent Dry Channel by Flow and Transect, Reach 4, Pascagoula River

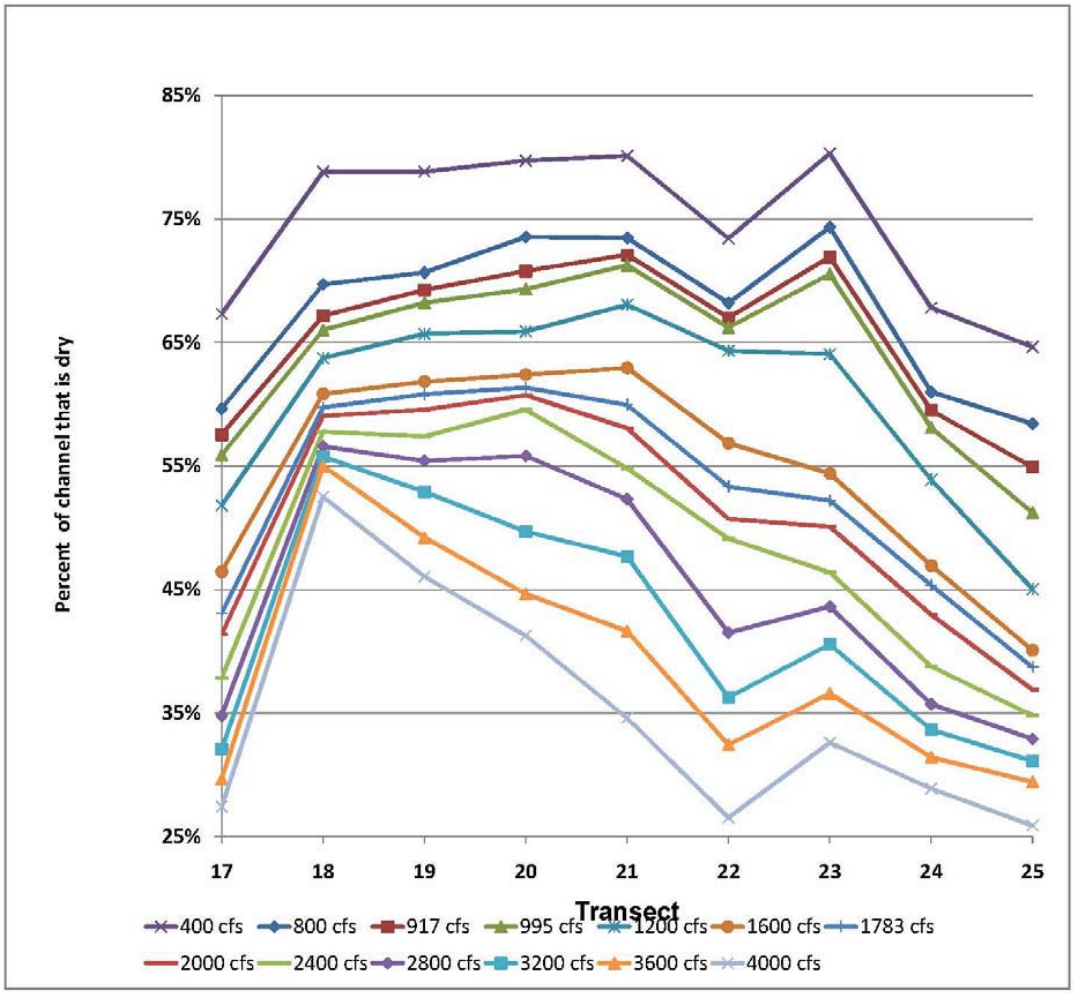


Table A-5. Dry Channel Length from Water's Edge to Vegetation Line by Discharge and Transect, Reach 5, Pascagoula River

Discharge =400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	89.87	1.4	2.8	2.7	106.9	596.7	107.5	276.5	38.9%	61.1%	169.1
27	89.28	1.2	3.2	3.2	105.3	641.7	106.0	389.3	27.2%	72.8%	283.3
28	89.88	1.5	2.7	2.7	98.4	488.0	99.1	400.5	24.7%	75.3%	301.4
29	90.47	1.2	2.3	2.3	141.4	582.7	142.1	439.9	32.3%	67.7%	297.8
30	90.36	1.2	2.6	2.6	129.3	625.0	130.1	408.7	31.8%	68.2%	278.5
31	90.77	0.9	2.3	2.3	184.0	736.7	184.4	399.0	46.2%	53.8%	214.6
32	89.81	0.8	3.6	3.6	138.1	908.8	138.8	322.9	43.0%	57.0%	184.1
										Mean Dry Distance (ft) =	**247.0**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**28%**

Discharge =800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	91.68	1.5	3.1	3.1	174.4	630.5	175.2	276.5	63.4%	36.6%	101.3
27	91.1	1.4	3.8	3.8	153.7	680.8	154.8	389.3	39.8%	60.2%	234.5
28	91.47	1.8	3.6	3.5	123.0	519.5	124.1	400.5	31.0%	69.0%	276.4
29	91.77	1.5	3.1	3.1	167.1	618.8	168.0	439.9	38.2%	61.8%	271.9
30	91.9	1.4	3.3	3.3	170.5	661.9	171.6	408.7	42.0%	58.0%	237.1
31	92.04	1.2	3.3	3.3	205.6	776.0	206.3	399.0	51.7%	48.3%	192.7
32	91.3	1.1	4.7	4.7	152.1	946.0	153.3	322.9	47.5%	52.5%	169.6
										Mean Dry Distance (ft) =	**212.0**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**10%**

Discharge =917 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	91.98	1.5	3.3	3.3	179.7	684.1	180.5	276.5	65.3%	34.7%	96.0
27	91.46	1.4	4.0	4.0	160.8	742.7	162.0	389.3	41.6%	58.4%	227.3
28	91.87	1.9	3.7	3.7	131.2	569.6	132.4	400.5	33.1%	66.9%	268.1
29	92.1	1.6	3.3	3.3	176.8	676.3	177.7	439.9	40.4%	59.6%	262.2
30	92.25	1.5	3.5	3.5	180.0	720.0	181.1	408.7	44.3%	55.7%	227.6
31	92.34	1.2	3.5	3.5	209.6	838.0	210.3	399.0	52.7%	47.3%	188.7
32	92.32	1.0	4.3	4.3	212.2	1005.0	213.7	322.9	66.2%	33.8%	109.3
										Mean Dry Distance (ft) =	**197.0**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**2%**

Discharge =995 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	92.17	1.6	3.4	3.4	183.1	767.4	183.9	276.5	66.5%	33.5%	92.6
27	91.7	1.5	4.1	4.1	167.0	838.5	168.2	389.3	43.2%	56.8%	221.1
28	92.11	1.9	3.8	3.8	136.3	702.4	137.5	400.5	34.3%	65.7%	263.0
29	92.31	1.6	3.4	3.4	182.8	761.2	183.7	439.9	41.8%	58.2%	256.2
30	92.46	1.5	3.6	3.6	184.4	810.3	185.6	408.7	45.4%	54.6%	223.1
31	92.54	1.3	3.7	3.7	211.8	933.7	212.6	399.0	53.3%	46.7%	186.4
32	92.5	1.1	4.4	4.4	213.7	1096.2	215.2	322.9	66.6%	33.4%	107.7
										Mean Dry Distance (ft) =	**192.9**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**0%**

Discharge =1200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	92.64	1.7	3.8	3.7	191.3	847.3	192.3	276.5	69.5%	30.5%	84.3
27	92.28	1.5	4.3	4.3	181.6	930.0	183.0	389.3	47.0%	53.0%	206.3
28	92.93	1.9	3.5	3.5	181.4	776.5	182.7	400.5	45.6%	54.4%	217.8
29	92.8	1.7	3.6	3.6	196.2	842.2	197.2	439.9	44.8%	55.2%	242.7
30	92.96	1.6	3.9	3.9	194.6	897.2	195.9	408.7	47.9%	52.1%	212.8
31	93.01	1.4	4.0	4.0	217.2	1025.1	218.0	399.0	54.6%	45.4%	180.9
32	92.95	1.2	4.8	4.8	217.4	1183.2	219.1	322.9	67.8%	32.2%	103.8
										Mean Dry Distance (ft) =	**178.4**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-8%**

Discharge =1600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total Dry Distance to Veg (ft)
26	93.45	1.8	4.3	4.3	205.6	923.5	206.6	276.5	74.7%	25.3%	69.9
27	93.23	1.7	4.7	4.7	205.6	1018.2	207.2	389.3	53.2%	46.8%	182.1
28	93.79	2.0	4.0	4.0	200.1	848.2	201.7	400.5	50.4%	49.6%	198.8
29	93.59	1.8	4.1	4.1	214.2	920.4	215.3	439.9	48.9%	51.1%	224.6
30	93.82	1.7	4.4	4.4	212.1	981.2	213.5	408.7	52.3%	47.7%	195.1
31	93.84	1.5	4.7	4.7	226.5	1112.9	227.7	399.0	57.1%	42.9%	171.3
32	93.74	1.3	5.4	5.4	224.1	1266.7	226.0	322.9	70.0%	30.0%	97.0
										Mean Dry Distance (ft) =	**162.7**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-16%**

Discharge =1941 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	93.76	2.1	4.5	4.5	210.2	944.3	211.3	276.5	76.4%	23.6%	65.2
27	94.21	1.6	4.6	4.6	255.4	1185.5	257.2	389.3	66.1%	33.9%	132.1
28	94.36	2.1	4.4	4.3	211.0	925.2	212.8	400.5	53.1%	46.9%	187.7
29	94.17	1.9	4.4	4.4	226.7	1003.7	227.9	439.9	51.8%	48.2%	212.0
30	94.46	1.8	4.8	4.7	225.1	1072.3	226.7	408.7	55.5%	44.5%	182.0
31	94.47	1.6	5.2	5.1	233.7	1207.7	235.0	399.0	58.9%	41.1%	164.0
32	94.35	1.4	5.9	5.9	229.2	1357.0	231.3	322.9	71.6%	28.4%	91.7
										Mean Dry Distance (ft) =	**147.8**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-23%**

Discharge =2000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	94.44	1.8	4.2	4.2	261.4	944.3	262.8	276.5	95.0%	5.0%	13.7
27	94.37	1.6	4.6	4.6	265.2	1185.5	267.1	389.3	68.6%	31.4%	122.3
28	94.46	2.1	4.4	4.4	212.4	925.2	214.2	400.5	53.5%	46.5%	186.3
29	94.27	2.0	4.5	4.5	228.5	1003.7	229.8	439.9	52.2%	47.8%	210.1
30	94.56	1.8	4.8	4.8	226.8	1072.3	228.4	408.7	55.9%	44.1%	180.3
31	94.58	1.6	5.2	5.2	235.1	1207.7	236.4	399.0	59.3%	40.7%	162.6
32	94.46	1.4	6.0	5.9	230.2	1357.0	232.3	322.9	71.9%	28.1%	90.6
										Mean Dry Distance (ft) =	**138.0**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-28%**

Discharge =2400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	94.99	1.9	4.6	4.6	271.9	944.3	273.5	276.5	98.9%	1.1%	3.0
27	94.88	1.8	5.1	5.0	269.5	1185.5	271.5	389.3	69.7%	30.3%	117.8
28	95.04	2.2	4.8	4.8	221.5	925.2	223.3	400.5	55.8%	44.2%	177.2
29	94.85	2.1	4.9	4.9	237.6	1003.7	239.1	439.9	54.3%	45.7%	200.8
30	95.19	1.9	5.3	5.2	236.6	1072.3	238.4	408.7	58.3%	41.7%	170.3
31	95.26	1.7	5.7	5.7	244.6	1207.7	246.1	399.0	61.7%	38.3%	152.9
32	95.12	1.6	6.5	6.4	236.7	1357.0	239.0	322.9	74.0%	26.0%	83.9
										Mean Dry Distance (ft) =	**129.4**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-33%**

Discharge =2800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	95.45	2.0	5.1	5.0	272.6	944.3	274.3	276.5	99.2%	0.8%	2.2
27	95.35	1.9	5.5	5.4	273.5	1185.5	275.6	389.3	70.8%	29.2%	113.7
28	95.58	2.3	5.2	5.1	229.8	925.2	231.8	400.5	57.9%	42.1%	168.7
29	95.37	2.2	5.3	5.2	244.7	1003.7	246.4	439.9	56.0%	44.0%	193.5
30	95.78	2.0	5.6	5.6	245.7	1072.3	247.6	408.7	60.6%	39.4%	161.1
31	95.89	1.8	6.1	6.1	253.3	1207.7	255.0	399.0	63.9%	36.1%	144.0
32	95.74	1.7	6.9	6.9	242.7	1357.0	245.2	322.9	75.9%	24.1%	77.7
										Mean Dry Distance (ft) =	**123.0**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-36%**

Discharge =3200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	95.87	2.1	5.5	5.4	273.3	944.3	275.1	276.5	99.5%	0.5%	1.4
27	95.8	2.0	5.8	5.8	277.3	1185.5	279.5	389.3	71.8%	28.2%	109.8
28	96.07	2.4	5.5	5.5	236.4	925.2	238.4	400.5	59.5%	40.5%	162.1
29	95.86	2.3	5.6	5.6	251.4	1003.7	253.3	439.9	57.6%	42.4%	186.6
30	96.32	2.1	6.0	5.9	254.1	1072.3	256.2	408.7	62.7%	37.3%	152.5
31	96.48	1.9	6.5	6.5	261.4	1207.7	263.3	399.0	66.0%	34.0%	135.7
32	96.32	1.8	7.4	7.3	248.2	1357.0	251.0	322.9	77.7%	22.3%	72.0
										Mean Dry Distance (ft) =	**117.1**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-39%**

Discharge =3600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	96.28	2.2	5.9	5.8	273.9	944.3	275.9	276.5	99.8%	0.2%	0.6
27	96.22	2.1	6.2	6.1	280.8	1185.5	283.2	389.3	72.7%	27.3%	106.1
28	96.53	2.5	5.8	5.8	242.2	925.2	244.2	400.5	61.0%	39.0%	156.2
29	96.32	2.4	5.9	5.9	257.7	1003.7	259.7	439.9	59.0%	41.0%	180.2
30	96.83	2.2	6.3	6.3	261.4	1072.3	263.5	408.7	64.5%	35.5%	145.2
31	97.03	1.9	6.9	6.8	268.9	1207.7	270.9	399.0	67.9%	32.1%	128.1
32	96.85	1.8	7.8	7.7	252.5	1357.0	255.3	322.9	79.0%	21.0%	67.7
										Mean Dry Distance (ft) =	**112.0**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-42%**

Discharge =4000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
26	96.67	2.3	6.2	6.2	274.5	944.3	276.6	276.5	100.0%	0.0%	-0.1
27	96.63	2.2	6.5	6.4	284.2	1185.5	286.7	389.3	73.6%	26.4%	102.6
28	96.96	2.6	6.1	6.1	247.7	925.2	249.8	400.5	62.4%	37.6%	150.7
29	96.75	2.4	6.2	6.2	263.1	1003.7	265.2	439.9	60.3%	39.7%	174.7
30	97.3	2.3	6.6	6.6	267.4	1072.3	269.6	408.7	66.0%	34.0%	139.1
31	97.54	2.0	7.2	7.2	275.0	1207.7	277.0	399.0	69.4%	30.6%	122.0
32	97.35	1.9	8.1	8.0	256.5	1357.0	259.3	322.9	80.3%	19.7%	63.6
										Mean Dry Distance (ft) =	**107.5**
										Percent change relative to 995 cfs in mean dry distance to vegetation =	**-44%**

Figure A-5. Yellow Blotched Map Turtle: Percent Dry Channel by Flow and Transect, Reach 5, Pascagoula River

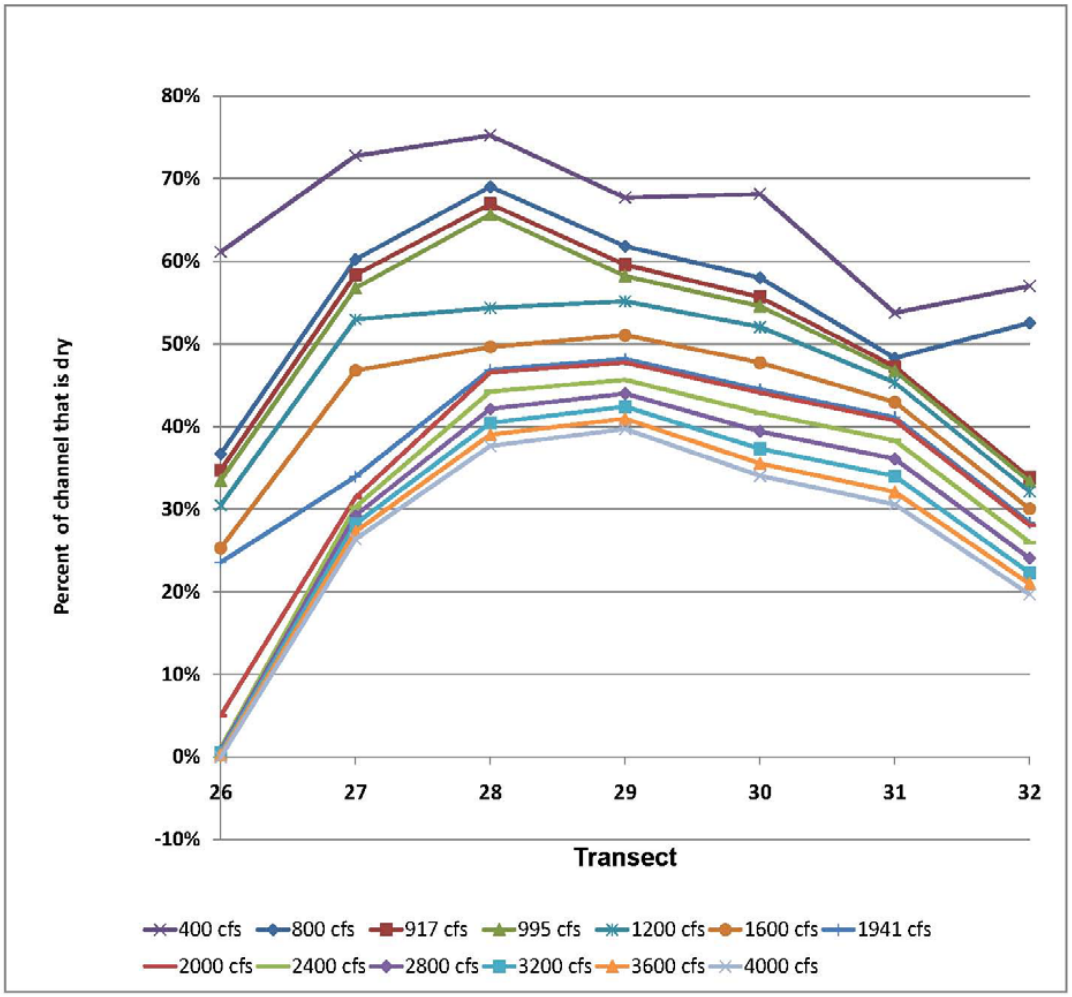


Table A-6. Dry Channel Length from Water's Edge to Vegetation Line by Discharge and Transect, Reach 6, Pascagoula River

Discharge =400 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	89.97	1.1	3.6	3.6	97.1	712.8	98.3	396.1	24.8%	75.2%	297.8
34	90.59	1.1	3.6	3.5	102.1	758.1	104.2	406.6	25.6%	74.4%	302.4
35	84.9	0.2	11.4	11.1	184.2	2889.0	189.2	487.1	38.8%	61.2%	297.9
										Mean Dry Distance (ft) =	**299.3**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**18%**

Discharge =800 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	92.08	1.4	4.7	4.7	122.5	752.4	124.4	396.1	31.4%	68.6%	271.7
34	92.75	1.3	4.4	4.3	141.9	797.6	144.3	406.6	35.5%	64.5%	262.3
35	87.46	0.3	12.8	12.4	203.7	2978.8	209.4	487.1	43.0%	57.0%	277.7
										Mean Dry Distance (ft) =	**270.6**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**7%**

Discharge =1043 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	93.09	1.5	5.2	5.1	136.8	752.4	139.2	396.1	35.1%	64.9%	256.9
34	93.63	1.4	4.9	4.8	154.9	797.6	157.4	406.6	38.7%	61.3%	249.2
35	88.83	0.4	13.5	13.1	214.1	2978.8	220.2	487.1	45.2%	54.8%	266.9
										Mean Dry Distance (ft) =	**257.7**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**2%**

Discharge =1121 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	93.38	1.5	5.3	5.3	141.0	752.4	143.4	396.1	36.2%	63.8%	252.7
34	93.89	1.4	5.0	5.0	158.7	797.6	161.3	406.6	39.7%	60.3%	245.3
35	89.26	0.4	13.7	13.3	217.5	2978.8	223.7	487.1	45.9%	54.1%	263.3
										Mean Dry Distance (ft) =	**253.8**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**0%**

Discharge =1200 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	93.66	1.5	5.5	5.4	144.8	752.4	147.4	396.1	37.2%	62.8%	248.7
34	94.15	1.4	5.2	5.1	163.1	797.6	165.7	406.6	40.8%	59.2%	240.9
35	89.68	0.4	13.9	13.5	221.1	2978.8	227.4	487.1	46.7%	53.3%	259.7
										Mean Dry Distance (ft) =	**249.8**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-2%**

Discharge =1600 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	94.92	1.6	6.1	6.0	161.4	752.4	164.6	396.1	41.6%	58.4%	231.5
34	95.31	1.5	5.7	5.6	182.9	797.6	185.7	406.6	45.7%	54.3%	220.9
35	91.67	0.5	14.8	14.4	237.9	2978.8	244.6	487.1	50.2%	49.8%	242.5
										Mean Dry Distance (ft) =	**231.6**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-9%**

Discharge =2000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	95.99	1.7	6.6	6.5	175.6	752.4	179.3	396.1	45.3%	54.7%	216.8
34	96.27	1.6	6.2	6.1	197.0	797.6	199.9	406.6	49.2%	50.8%	206.7
35	94.1	0.5	15.3	14.9	271.7	2978.8	278.9	487.1	57.3%	42.7%	208.2
										Mean Dry Distance (ft) =	**210.6**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-17%**

Discharge =2400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	96.97	1.8	7.0	6.9	190.8	752.4	194.8	396.1	49.2%	50.8%	201.3
34	97.12	1.7	6.7	6.6	209.5	797.6	212.5	406.6	52.3%	47.7%	194.1
35	96.07	0.5	15.7	15.3	300.4	2978.8	308.0	487.1	63.2%	36.8%	179.1
										Mean Dry Distance (ft) =	**191.5**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-25%**

Discharge =2650 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	97.49	1.8	7.3	7.1	199.2	752.4	203.5	396.1	51.4%	48.6%	192.6
34	97.61	1.8	6.9	6.8	216.7	797.6	219.8	406.6	54.1%	45.9%	186.8
35	97.52	0.5	15.7	15.4	328.3	2978.8	336.1	487.1	69.0%	31.0%	150.9
										Mean Dry Distance (ft) =	**176.8**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-30%**

Discharge =2800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	97.83	1.8	7.4	7.3	204.1	752.4	208.6	396.1	52.7%	47.3%	187.5
34	97.88	1.8	7.1	7.0	219.7	797.6	222.9	406.6	54.8%	45.2%	183.6
35	98.34	0.5	15.7	15.4	345.9	2978.8	353.9	487.1	72.7%	27.3%	133.2
										Mean Dry Distance (ft) =	**168.1**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-34%**

Discharge =3200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	98.6	1.9	7.8	7.6	214.9	752.4	219.9	396.1	55.5%	44.5%	176.2
34	98.55	1.9	7.5	7.4	227.0	797.6	230.5	406.6	56.7%	43.3%	176.1
35	99.68	0.5	16.1	15.8	367.0	2978.8	375.0	487.1	77.0%	23.0%	112.0
										Mean Dry Distance (ft) =	**154.8**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-39%**

Discharge =3600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	99.39	1.9	8.0	7.8	230.9	752.4	236.3	396.1	59.7%	40.3%	159.8
34	99.18	1.9	7.9	7.8	233.8	797.6	237.5	406.6	58.4%	41.6%	169.1
35	101.6	0.5	16.1	15.8	413.7	2978.8	421.8	487.1	86.6%	13.4%	65.3
										Mean Dry Distance (ft) =	**131.4**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-48%**

Discharge =4000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
33	100.1	2.0	8.2	8.0	249.5	752.4	254.9	396.1	64.4%	35.6%	141.2
34	99.79	2.0	8.3	8.2	241.3	797.6	245.1	406.6	60.3%	39.7%	161.5
35	103.6	0.5	15.9	15.6	473.2	2978.8	481.3	487.1	98.8%	1.2%	5.7
										Mean Dry Distance (ft) =	**102.8**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-59%**

Figure A-6. Yellow Blotched Map Turtle: Percent Dry Channel by Flow and Transect, Reach 6, Pascagoula River

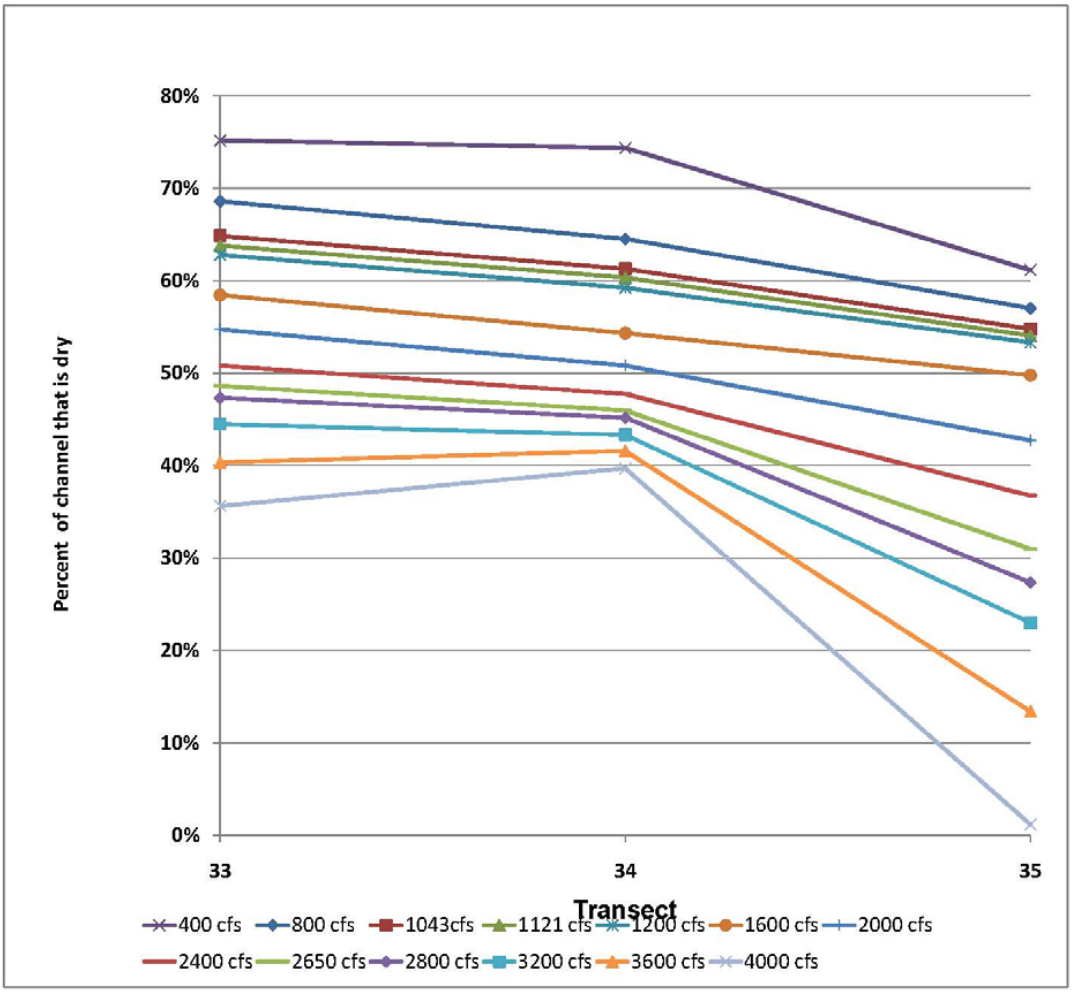


Table A-7. Dry Channel Length from Water's Edge to Vegetation Line by Discharge and Transect, Reach 7, Pascagoula River

Discharge =400 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	72.35	0.3	7.5	7.4	156.8	2398.9	159.6	396.1	40.3%	59.7%	236.5
37	67.28	0.2	12.4	11.7	158.2	3428.4	166.5	406.6	40.9%	59.1%	240.1
38	69.8	0.2	10.0	9.8	179.4	3455.8	183.3	487.1	37.6%	62.4%	303.8

Mean Dry Distance (ft) = 260.2

Percent change relative to 1,121 cfs in mean dry distance to vegetation = 34%

Discharge =800 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	76.79	0.4	9.7	9.6	202.8	2531.7	206.7	396.1	59.0%	41.0%	189.4
37	72.81	0.3	15.5	14.7	187.6	3582.7	198.4	406.6	54.0%	46.0%	208.2
38	75.21	0.3	12.4	12.2	235.2	3614.2	240.6	487.1	53.0%	47.0%	246.5

Mean Dry Distance (ft) = 214.7

Percent change relative to 1,121 cfs in mean dry distance to vegetation = 11%

Discharge =1043 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	78.79	0.4	10.9	10.6	220.9	2531.7	225.4	396.1	59.0%	41.0%	170.7
37	75.46	0.3	17.0	16.1	201.7	3582.7	213.6	406.6	54.0%	46.0%	193.0
38	77.41	0.3	14.0	13.6	247.1	3614.2	253.8	487.1	53.0%	47.0%	233.2

Mean Dry Distance (ft) = 199.0

Percent change relative to 1,121 cfs in mean dry distance to vegetation = 3%

Discharge =1121 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	79.39	0.4	11.1	10.9	227.6	2531.7	232.2	396.1	59.0%	41.0%	163.9
37	76.24	0.3	17.4	16.4	205.8	3582.7	218.1	406.6	54.0%	46.0%	188.5
38	78.06	0.3	14.4	14.0	250.6	3614.2	257.8	487.1	53.0%	47.0%	229.3

Mean Dry Distance (ft) = 193.9

Percent change relative to 1,121 cfs in mean dry distance to vegetation = 0%

Discharge =1200 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	79.98	0.4	11.4	11.2	234.1	2531.7	238.9	396.1	59.0%	41.0%	157.2
37	77.02	0.3	17.8	16.8	210.3	3582.7	223.1	406.6	54.0%	46.0%	183.5
38	78.7	0.3	14.9	14.4	254.1	3614.2	261.7	487.1	53.0%	47.0%	225.4

Mean Dry Distance (ft) = 188.7

Percent change relative to 1,121 cfs in mean dry distance to vegetation = -3%

Discharge =1600 cfs

X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	82.6	0.5	12.7	12.4	262.4	2531.7	267.9	396.1	59.0%	41.0%	128.2
37	80.59	0.4	19.6	18.4	230.9	3582.7	246.0	406.6	54.0%	46.0%	160.6
38	81.92	0.3	16.5	16.0	280.0	3614.2	289.6	487.1	53.0%	47.0%	197.5

Mean Dry Distance (ft) = 162.1

Percent change relative to 1,121 cfs in mean dry distance to vegetation = -16%

Discharge =2000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	84.79	0.5	13.8	13.5	283.3	2531.7	289.3	396.1	59.0%	41.0%	106.8
37	83.54	0.4	21.3	19.9	245.8	3582.7	262.9	406.6	54.0%	46.0%	143.7
38	84.31	0.4	18.5	17.8	287.3	3614.2	298.7	487.1	53.0%	47.0%	188.4
										Mean Dry Distance (ft) =	**146.3**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-25%**

Discharge =2400 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	86.67	0.5	14.9	14.6	299.0	2531.7	305.5	396.1	59.0%	41.0%	90.6
37	86.05	0.4	23.0	21.4	255.3	3582.7	274.2	406.6	54.0%	46.0%	132.4
38	86.51	0.4	20.2	19.4	294.0	3614.2	307.0	487.1	53.0%	47.0%	180.1
										Mean Dry Distance (ft) =	**134.4**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-31%**

Discharge =2800 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	88.36	0.6	16.0	15.6	311.7	2743.7	318.6	396.1	80.4%	19.6%	77.5
37	88.36	0.4	24.5	22.7	264.0	3837.6	284.6	406.6	70.0%	30.0%	122.0
38	88.55	0.4	21.8	20.8	300.2	3866.4	314.7	487.1	64.6%	35.4%	172.4
										Mean Dry Distance (ft) =	**123.9**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-36%**

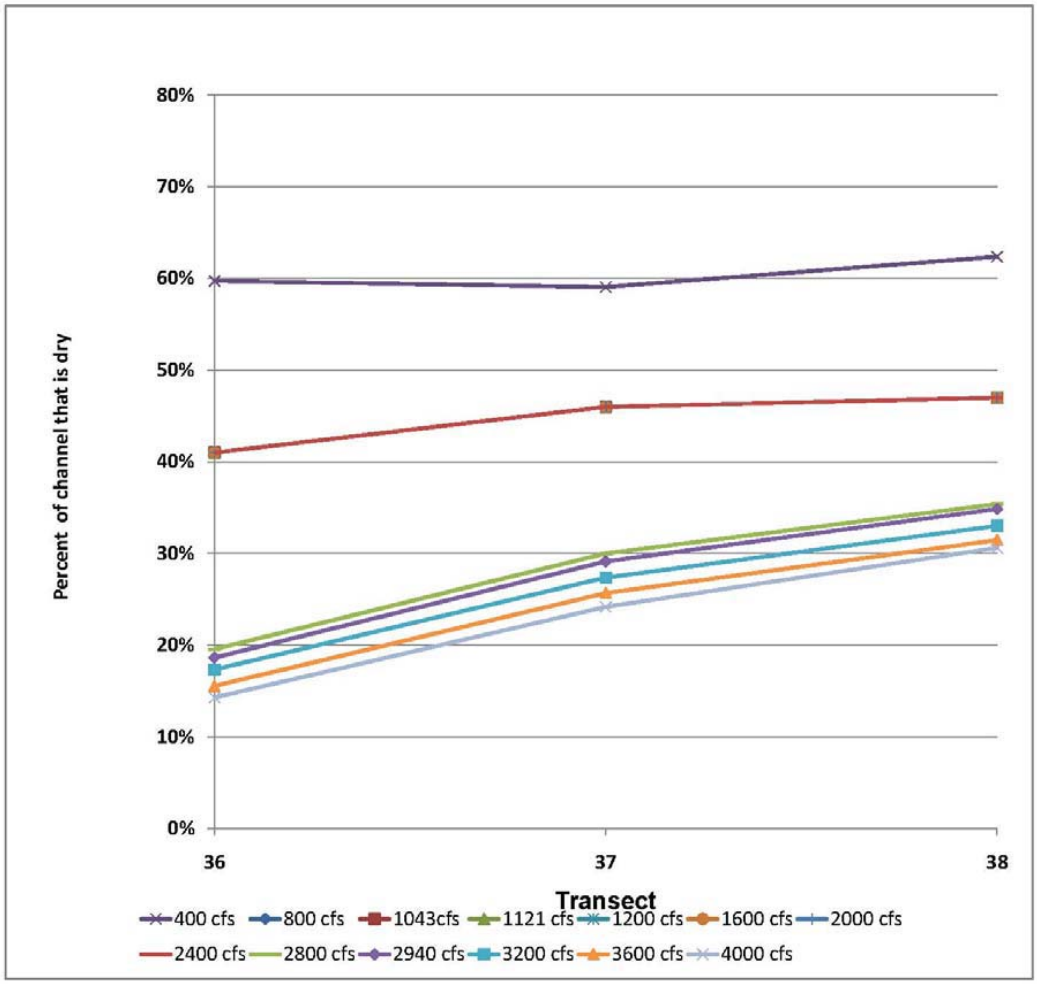
Discharge =2940 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	88.9	0.6	16.4	16.0	315.1	3074.9	322.3	396.1	81.4%	18.6%	73.8
37	89.13	0.4	25.0	23.2	266.9	4234.6	288.1	406.6	70.9%	29.1%	118.5
38	89.24	0.4	22.4	21.3	302.3	4259.1	317.3	487.1	65.1%	34.9%	169.8
										Mean Dry Distance (ft) =	**120.7**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-38%**

Discharge =3200 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	89.86	0.6	17.1	16.7	319.6	3388.4	327.4	396.1	82.7%	17.3%	68.7
37	90.55	0.5	25.8	23.9	273.4	4616.6	295.3	406.6	72.6%	27.4%	111.3
38	90.6	0.4	23.1	22.0	310.1	4705.6	326.2	487.1	67.0%	33.0%	160.8
										Mean Dry Distance (ft) =	**113.6**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-41%**

Discharge =3600 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	91.26	0.6	18.1	17.7	325.9	3688.2	334.5	396.1	84.5%	15.5%	61.6
37	92.48	0.5	27.1	25.1	280.0	4985.1	302.2	406.6	74.3%	25.7%	104.4
38	92.42	0.5	24.5	23.2	316.7	5048.0	333.8	487.1	68.5%	31.5%	153.3
										Mean Dry Distance (ft) =	**106.4**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-45%**

Discharge =4000 cfs											
X-Sec	WSL	Ave Vel.	Hyd. Depth	Hyd. Radius	Wetted Width	C/S Area (ft^2)	Wetted Per.	Distance veg to veg (ft)	% Wetted Channel	% Dry Channel	Total dry distance to vegetation line (ft)
36	92.54	0.6	19.1	18.6	330.7	5154.3	339.5	396.1	85.7%	14.3%	56.6
37	94.29	0.5	28.4	26.3	285.9	6675.6	308.4	406.6	75.8%	24.2%	98.2
38	94.11	0.5	25.8	24.5	320.8	6760.8	338.0	487.1	69.4%	30.6%	149.0
										Mean Dry Distance (ft) =	**101.3**
										Percent change relative to 1,121 cfs in mean dry distance to vegetation =	**-48%**

Figure A-7. Yellow Blotched Map Turtle: Percent Dry Channel by Flow and Transect, Reach 7, Pascagoula River



Gulf Sturgeon

Table A-8. Weighted Useable Area Results for Juvenile Sturgeon at Modeled Discharges, Reach 1, Leaf River

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		200	112,721	93,810	-55,806	83.22%	-4.90%	
		400	130,622	115,132	-34,485	88.14%	2.02%	
	7Q10	598	146,619	130,669	-18,947	89.12%	3.40%	
		600	146,789	130,823	-18,793	89.12%	3.40%	
	7Q10+78	676	152,731	136,445	-13,171	89.34%	3.71%	Inapplicable: upstream of RWI.
		800	160,260	143,808	-5,808	89.73%	4.26%	
		1000	167,921	148,640	-977	88.52%	2.55%	
	Flow on date of survey	1110	172,557	149,616	0	86.71%	0.00%	Survey date flow
		1200	174,627	151,624	2,008	86.83%	0.17%	
		1400	182,852	153,042	3,426	83.70%	-4.24%	
		1,600	190,953	152,281	2,664	79.75%	-9.80%	
		1,800	198,447	149,686	69	75.43%	-15.88%	
		2,000	205,427	145,897	-3,719	71.02%	-22.08%	

Figure A-8. Juvenile Sturgeon, Weighted Usable Area vs. Discharge, Reach 1, Leaf River

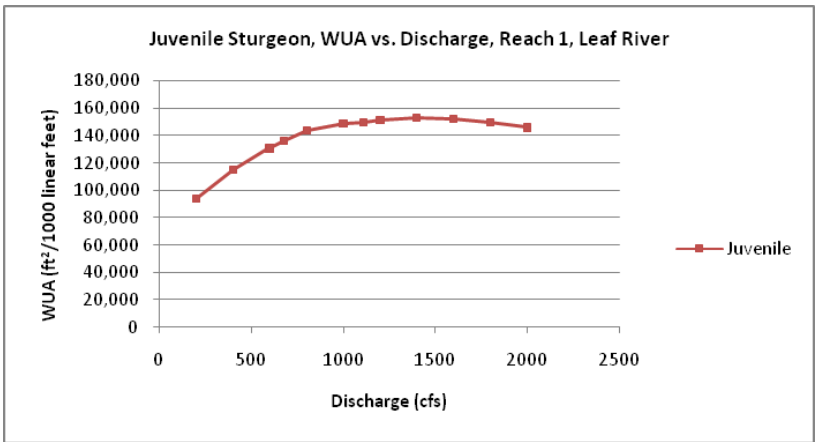


Table A-9. Weighted Useable Area Results for Juvenile Sturgeon at Modeled Discharges, Reach 2, Leaf River

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		200	137,112	60,566	-69,130	44.17%	-31.44%	
		400	161,465	83,565	-46,131	51.75%	-19.78%	
	7Q10	598	176,285	101,145	-28,551	57.38%	-11.13%	
		600	176,434	101,338	-28,358	57.44%	-11.04%	
	7Q10+78	676	181,726	108,260	-21,436	59.57%	-7.75%	Inapplicable: upstream of RWI.
		800	188,779	116,770	-12,927	61.86%	-4.24%	
		1000	198,031	126,757	-2,940	64.01%	-0.93%	
	Flow on date of survey	1060	200,726	129,696	0	64.61%	0.00%	Survey date flow
		1200	206,962	135,800	6,104	65.62%	1.54%	
		1400	214,929	142,157	12,461	66.14%	2.35%	
		1,600	221,411	147,599	17,902	66.66%	3.15%	
		1,800	228,737	152,519	-5,974	66.68%	2.56%	
		2,000	243,788	158,493	0	65.01%	0.00%	

Figure A-9. Juvenile Sturgeon, Weighted Usable Area vs. Discharge, Reach 2, Leaf River

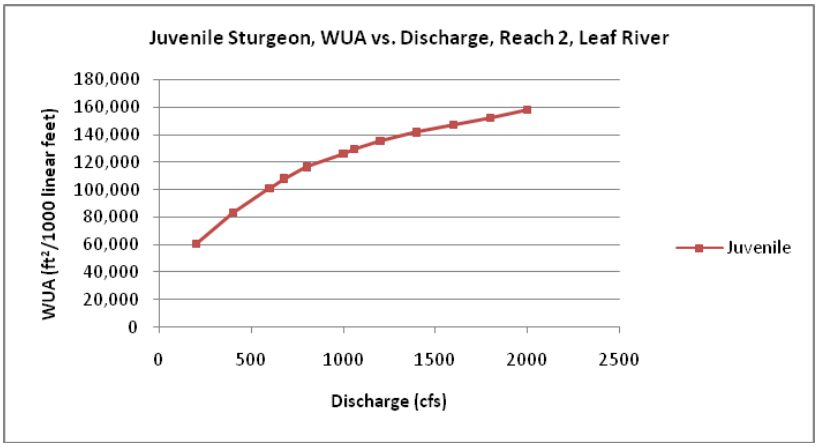


Table A-10. Weighted Useable Area Results for Juvenile Sturgeon at Modeled Discharges, Reach 3, Pascagoula River

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	130,299	29,839	-36,310	22.90%	-27.11%	
		800	146,730	42,145	-24,004	28.72%	-8.58%	
	7Q10	917	150,607	45,183	-20,966	30.00%	-4.51%	
	7Q10+78	995	152,994	47,060	-19,089	30.76%	-2.09%	
		1200	158,596	51,663	-14,486	32.58%	3.69%	
		1600	191,644	60,917	-5,232	31.79%	1.18%	
		2,000	218,738	68,597	2,448	31.36%	-0.18%	
	Flow on date of survey	2,085	210,549	66,149	0	31.42%	0.00%	Survey date flow
		2,400	243,493	76,803	10,654	31.54%	0.40%	
		2,800	309,503	91,036	24,887	29.41%	-6.38%	
		3,200	338,187	101,953	35,804	30.15%	-4.04%	
		3,600	339,443	108,350	42,201	31.92%	1.60%	
		4,000	340,434	114,017	47,868	33.49%	6.60%	

Figure A-10. Juvenile Sturgeon, Weighted Useable Area vs. Discharge, Reach 3, Pascagoula River

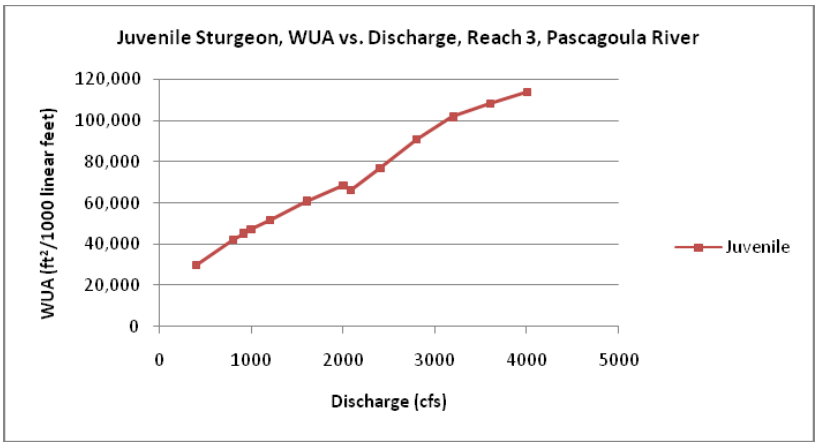


Table A-11. Weighted Useable Area Results for Juvenile Sturgeon at Modeled Discharges, Reach 4, Pascagoula River

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	155,176	58,065	-102,027	37.42%	-32.24%	
		800	201,520	93,641	-66,452	46.47%	-15.85%	
	7Q10	917	214,199	103,431	-56,662	48.29%	-12.56%	
	7Q10+78	995	221,974	109,721	-50,372	49.43%	-10.49%	
		1200	243,458	125,685	-34,407	51.63%	-6.51%	
		1600	276,337	150,493	-9,599	54.46%	-1.38%	
	Flow on date of survey	1,783	289,904	160,093	0	55.22%	0.00%	Survey date flow
		2,000	299,696	169,282	9,189	56.48%	2.28%	
		2,400	315,465	184,055	23,963	58.34%	5.65%	
		2,800	334,951	197,341	37,248	58.92%	6.69%	
		3,200	356,940	209,563	49,470	58.71%	6.32%	
		3,600	379,626	221,361	61,269	58.31%	5.59%	
		4,000	404,714	233,447	73,354	57.68%	4.45%	

Figure A-11. Juvenile Sturgeon, Weighted Useable Area vs. Discharge, Reach 4, Pascagoula River

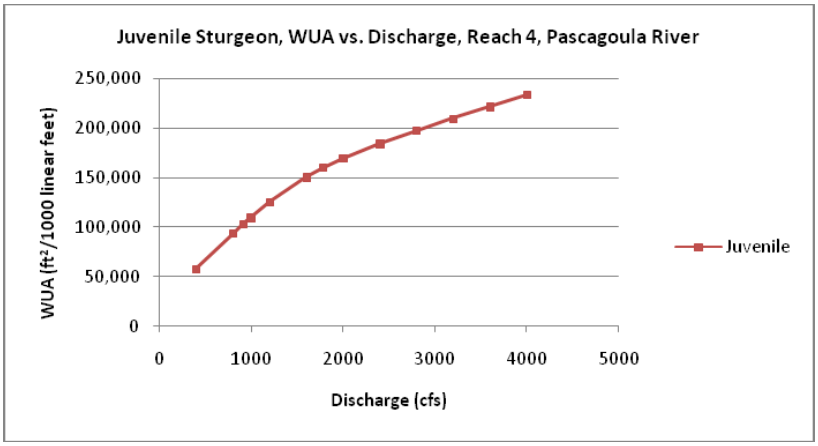


Table A-12. Weighted Useable Area Results for Juvenile Sturgeon at Modeled Discharges, Reach 5, Pascagoula River

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	123,587	76,587	-108,794	61.97%	-24.59%	
		800	166,148	115,337	-70,043	69.42%	-15.53%	
	7Q10	917	173,199	120,991	-64,389	69.86%	-15.00%	
	7Q10+78	993	177,481	125,575	-59,805	70.75%	-13.90%	
		1200	192,865	140,702	-44,678	72.95%	-11.23%	
		1600	209,721	165,016	-20,364	78.68%	-4.25%	
	Flow on date of survey	1,941	225,578	185,381	0	82.18%	0.00%	Survey date flow
		2,000	241,682	198,571	13,190	82.16%	-0.02%	
		2,400	250,513	216,440	31,059	86.40%	5.13%	
		2,800	256,144	227,615	42,234	88.86%	8.13%	
		3,200	261,230	235,972	50,592	90.33%	9.92%	
		3,600	265,819	242,551	57,171	91.25%	11.03%	
		4,000	269,821	248,037	62,657	91.93%	11.86%	

Figure A-12. Juvenile Sturgeon, Weighted Useable Area vs. Discharge, Reach 5, Pascagoula River

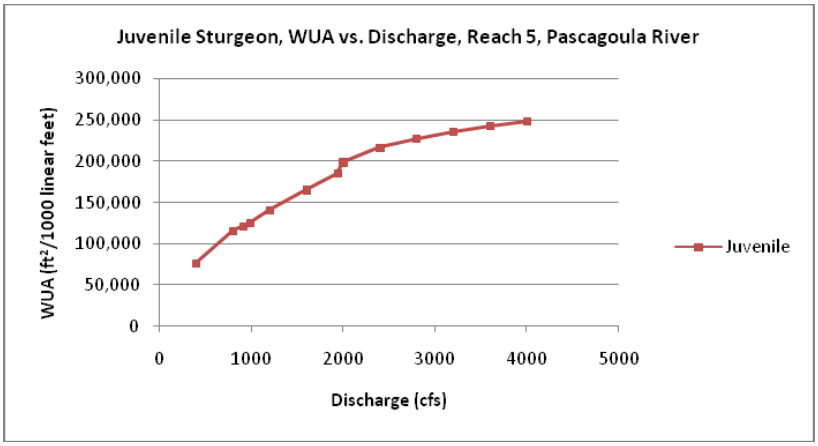


Table A-13. Weighted Useable Area Results for Adult Sturgeon at Modeled Discharges, Reach 6, Pascagoula River

Adult	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	100,769	77,581	-117,002	76.99%	-16.14%	
		800	136,633	112,028	-82,556	81.99%	-10.69%	
	7Q10	1043	149,976	127,927	-66,656	85.30%	-7.09%	
	7Q10+78	1121	153,899	131,855	-62,728	85.68%	-6.67%	
		1200	158,168	136,102	-58,482	86.05%	-6.27%	
		1600	177,090	158,320	-36,263	89.40%	-2.62%	
		2,000	191,209	173,359	-21,224	90.66%	-1.24%	
		2,400	204,434	186,473	-8,110	91.21%	-0.64%	
	Flow on date of survey	2,650	211,957	194,583	0	91.80%	0.00%	Survey date flow
		2,800	215,510	198,605	4,022	92.16%	0.38%	
		3,200	223,721	205,653	11,070	91.92%	0.13%	
		3,600	232,992	213,403	18,820	91.59%	-0.23%	
		4,000	243,530	222,456	27,873	91.35%	-0.50%	

Figure A-13. Adult Sturgeon, Weighted Useable Area vs. Discharge, Reach 6, Pascagoula River

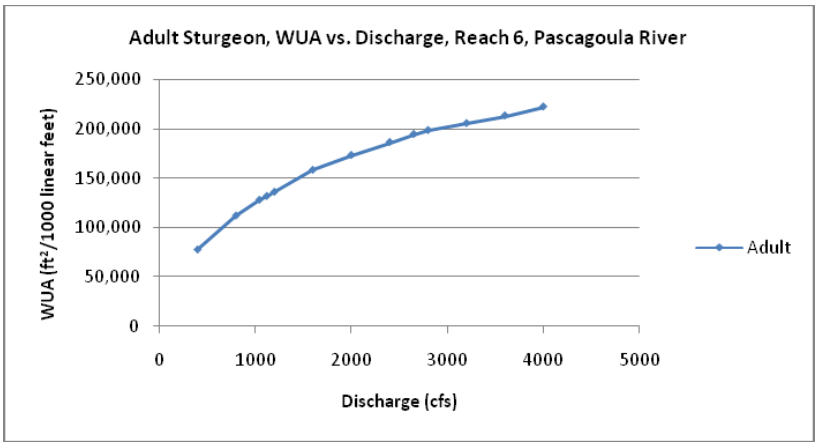
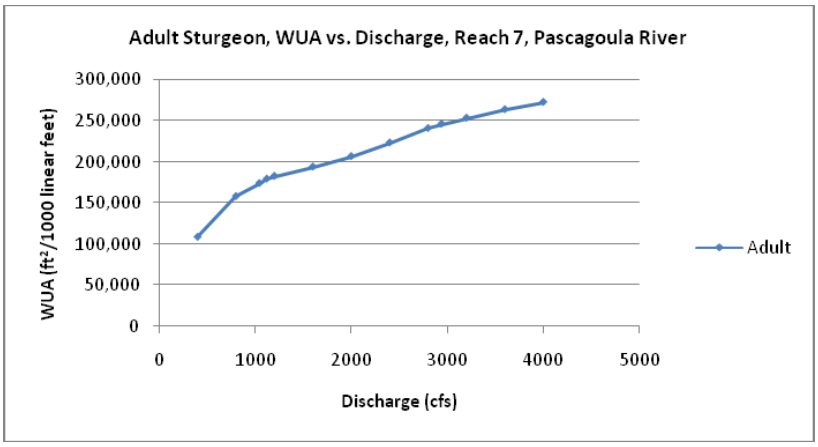


Table A-14. Weighted Useable Area Results for Adult Sturgeon at Modeled Discharges, Reach 7, Pascagoula River

Adult	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	157,510	109,094	-137,182	69.26%	-17.96%	
		800	195,441	158,483	-87,793	81.09%	-3.95%	
	7Q10	1043	211,573	174,279	-71,997	82.37%	-2.43%	
	7Q10+78	1121	217,027	179,603	-66,673	82.76%	-1.98%	
		1200	222,582	182,997	-63,280	82.22%	-2.62%	
		1600	247,113	194,219	-52,057	78.60%	-6.91%	
		2,000	265,097	206,930	-39,346	78.06%	-7.54%	
		2,400	277,753	223,516	-22,760	80.47%	-4.68%	
		2,800	288,541	240,981	-5,295	83.52%	-1.08%	
	Flow on date of survey	2,940	291,704	246,276	0	84.43%	0.00%	Survey date flow
		3,200	297,199	253,416	7,140	85.27%	1.00%	
		3,600	303,606	263,794	17,518	86.89%	2.91%	
		4,000	308,940	272,648	26,372	88.25%	4.53%	

Figure A-14. Juvenile Sturgeon, Weighted Useable Area vs. Discharge, Reach 7, Pascagoula River



Pearl Darter

Table A-15. Weighted Useable Area Results for Pearl Darter at Modeled Discharges, Reach 1, Leaf River

Adult	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		200	112,721	32,357	11,445	28.71%	130.50%	
		400	130,622	26,804	5,892	20.52%	64.77%	
	7Q10	598	146,619	20,834	-78	14.21%	14.10%	
		600	146,789	20,836	-76	14.19%	13.98%	
	7Q10+78	676	152,731	21,509	597	14.08%	13.08%	Inapplicable: upstream of RWI.
		800	160,260	21,201	289	13.23%	6.23%	
	Flow on date of survey	1000	167,921	20,912	0	12.45%	0.00%	Survey date flow
		1110	172,557	19,826	-1,086	11.49%	-7.74%	
		1200	174,627	18,310	-2,602	10.49%	-15.81%	
		1400	182,852	18,379	-2,533	10.05%	-19.29%	
		1,600	190,953	19,959	-953	10.45%	-16.07%	
		1,800	198,447	21,390	478	10.78%	-13.45%	
		2,000	205,427	23,539	2,626	11.46%	-7.99%	

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		200	112,721	28,094	10,932	24.92%	150.60%	
		400	130,622	22,977	5,815	17.59%	76.87%	
	7Q10	598	146,619	17,437	275	11.89%	19.58%	
		600	146,789	17,449	287	11.89%	19.52%	
	7Q10+78	676	152,731	18,537	1,376	12.14%	22.04%	Inapplicable: upstream of RWI.
		800	160,260	18,426	1,264	11.50%	15.60%	
		1000	167,921	18,382	1,221	10.95%	10.07%	
	Flow on date of survey	1110	172,557	17,161	0	9.95%	0.00%	Survey date flow
		1200	174,627	15,731	-1,430	9.01%	-9.42%	
		1400	182,852	15,975	-1,187	8.74%	-12.16%	
		1,600	190,953	17,697	536	9.27%	-6.81%	
		1,800	198,447	19,361	2,199	9.76%	-1.90%	
		2,000	205,427	21,562	4,401	10.50%	5.54%	

Figure A-15. Pearl Darter, Weighted Useable Area vs. Discharge, Reach 1, Leaf River

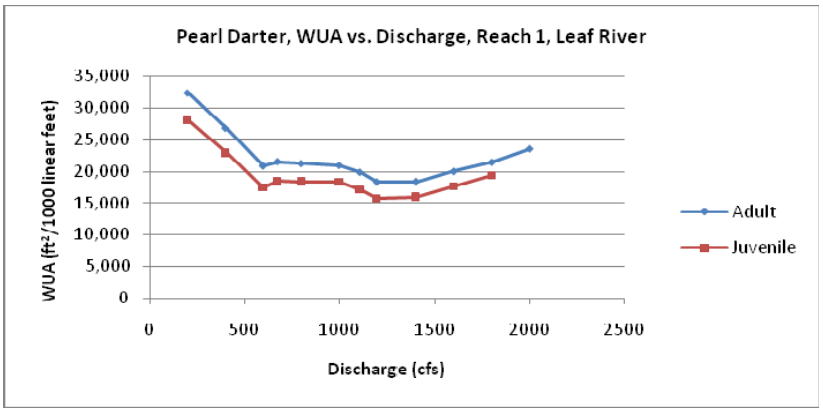


Table A-16. Weighted Useable Area Results for Pearl Darter at Modeled Discharges, Reach 2, Leaf River

Adult	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		200	137,112	47,661	7,337	34.76%	73.03%	
		400	161,465	54,810	14,486	33.95%	68.97%	
	7Q10	598	176,285	52,777	12,453	29.94%	49.03%	
		600	176,434	52,666	12,341	29.85%	48.59%	
	7Q10+78	676	181,726	48,917	8,592	26.92%	33.99%	Inapplicable: upstream of RWI.
		800	188,779	46,095	5,771	24.42%	21.55%	
		1000	198,031	41,797	1,473	21.11%	5.06%	
	Flow on date of survey	1060	200,726	40,325	0	20.09%	0.00%	Survey date flow
		1200	206,962	38,313	-2,011	18.51%	-7.85%	
		1400	214,929	39,515	-810	18.38%	-8.48%	
		1,600	221,411	41,348	1,024	18.67%	-7.04%	
		1,800	228,737	41,714	1,390	18.24%	-9.22%	
		2,000	243,788	45,499	5,174	18.66%	-7.10%	

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		200	137,112	46,284	10,510	33.76%	89.41%	
		400	161,465	53,155	17,382	32.92%	84.72%	
	7Q10	598	176,285	49,753	13,979	28.22%	58.36%	
		600	176,434	49,626	13,853	28.13%	57.82%	
	7Q10+78	676	181,726	45,366	9,593	24.96%	40.08%	Inapplicable: upstream of RWI.
		800	188,779	42,162	6,388	22.33%	25.32%	
		1000	198,031	37,323	1,549	18.85%	5.75%	
	Flow on date of survey	1060	200,726	35,773	0	17.82%	0.00%	Survey date flow
		1200	206,962	34,042	-1,732	16.45%	-7.71%	
		1400	214,929	35,850	77	16.68%	-6.41%	
		1,600	221,411	38,219	2,446	17.26%	-3.14%	
		1,800	228,737	39,002	-4,101	17.05%	-3.56%	
		2,000	243,788	43,103	0	17.68%	0.00%	

Figure A-16. Pearl Darter, Weighted Useable Area vs. Discharge, Reach 2, Leaf River

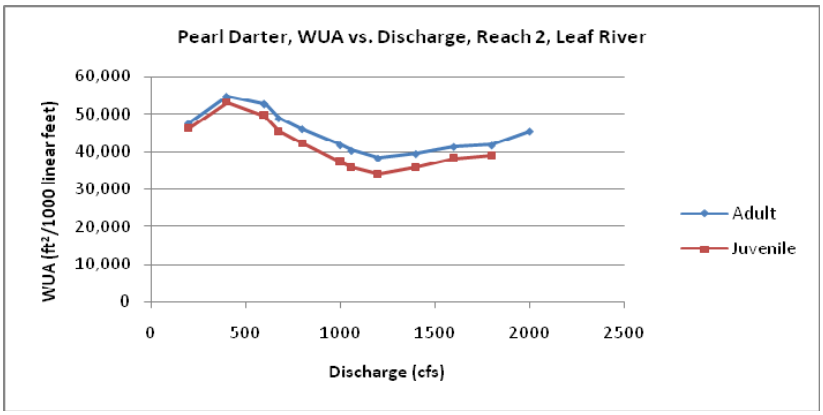


Table A-17. Weighted Useable Area Results for Pearl Darter at Modeled Discharges, Reach 3, Pascagoula River

Adult	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	130,299	37,367	-16,613	28.68%	11.86%	
		800	146,730	31,323	-22,658	21.35%	-16.74%	
	7Q10	917	150,607	34,342	-19,639	22.80%	-11.06%	
	7Q10+78	995	152,994	35,356	-18,625	23.11%	-9.86%	
		1200	158,596	33,731	-20,250	21.27%	-17.04%	
		1600	191,644	36,381	-17,599	18.98%	-25.95%	
		2,000	218,738	62,383	8,402	28.52%	11.24%	
	Flow on date of survey	2,085	210,549	53,981	0	25.64%	0.00%	Survey date flow
		2,400	243,493	63,772	9,791	26.19%	2.15%	
		2,800	309,503	92,660	38,679	29.94%	16.77%	
		3,200	338,187	119,038	65,057	35.20%	37.29%	
		3,600	339,443	115,881	61,900	34.14%	33.16%	
		4,000	340,434	96,411	42,431	28.32%	10.46%	

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	130,299	37,367	-16,613	28.68%	11.86%	
		800	146,730	31,323	-22,658	21.35%	-16.74%	
	7Q10	917	150,607	34,342	-19,639	22.80%	-11.06%	
	7Q10+78	995	152,994	35,356	-18,625	23.11%	-9.86%	
		1200	158,596	33,731	-20,250	21.27%	-17.04%	
		1600	191,644	36,381	-17,599	18.98%	-25.95%	
		2,000	218,738	62,383	8,402	28.52%	11.24%	
	Flow on date of survey	2,085	210,549	53,981	0	25.64%	0.00%	Survey date flow
		2,400	243,493	63,765	9,784	26.19%	2.14%	
		2,800	309,503	92,619	38,638	29.93%	16.72%	
		3,200	338,187	118,939	64,958	35.17%	37.18%	
		3,600	339,443	115,744	61,763	34.10%	33.00%	
		4,000	340,434	96,238	42,257	28.27%	10.26%	

Note: WUA are equal for juvenile and adult in this reach.

Figure A-17. Pearl Darter, Weighted Useable Area vs. Discharge, Reach 3, Pascagoula River

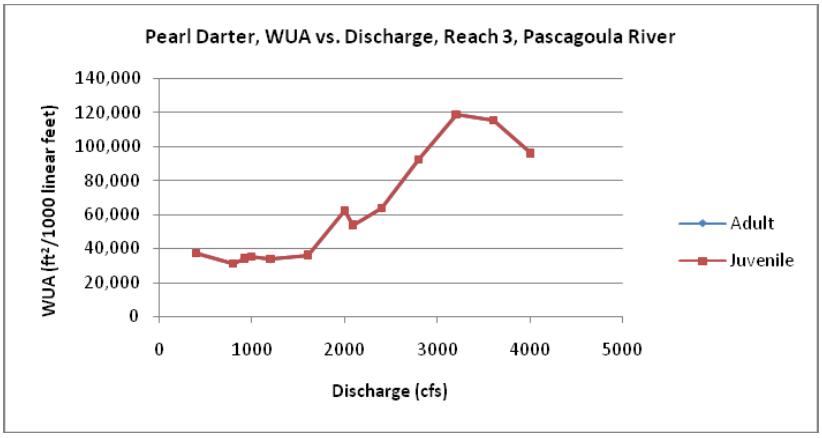


Table A-18. Weighted Useable Area Results for Pearl Darter at Modeled Discharges, Reach 4, Pascagoula River

Adult	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	155,176	76,239	-11,913	49.13%	61.58%	
		800	201,520	69,109	-19,043	34.29%	12.78%	
	7Q10	917	214,199	71,951	-16,201	33.59%	10.47%	
	7Q10+78	995	221,974	72,445	-15,707	32.64%	7.33%	
		1200	243,458	76,618	-11,534	31.47%	3.50%	
		1600	276,337	86,125	-2,027	31.17%	2.50%	
	Flow on date of survey	1,783	289,904	88,152	0	30.41%	0.00%	Survey date flow
		2,000	299,696	88,352	200	29.48%	-3.05%	
		2,400	315,465	84,533	-3,619	26.80%	-11.88%	
		2,800	334,951	82,615	-5,537	24.66%	-18.89%	
		3,200	356,940	85,116	-3,036	23.85%	-21.58%	
		3,600	379,626	91,578	3,426	24.12%	-20.67%	
		4,000	404,714	100,441	12,289	24.82%	-18.38%	

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	155,176	76,239	-11,173	49.13%	62.94%	
		800	201,520	69,095	-18,316	34.29%	13.71%	
	7Q10	917	214,199	71,885	-15,526	33.56%	11.30%	
	7Q10+78	995	221,974	72,349	-15,063	32.59%	8.10%	
		1200	243,458	76,428	-10,984	31.39%	4.12%	
		1600	276,337	85,591	-1,821	30.97%	2.72%	
	Flow on date of survey	1,783	289,904	87,412	0	30.15%	0.00%	Survey date flow
		2,000	299,696	87,441	29	29.18%	-3.24%	
		2,400	315,465	83,304	-4,107	26.41%	-12.42%	
		2,800	334,951	81,235	-6,177	24.25%	-19.56%	
		3,200	356,940	83,707	-3,705	23.45%	-22.22%	
		3,600	379,626	90,139	2,728	23.74%	-21.25%	
		4,000	404,714	98,949	11,538	24.45%	-18.91%	

Figure A-18. Pearl Darter, Weighted Useable Area vs. Discharge, Reach 4, Pascagoula River

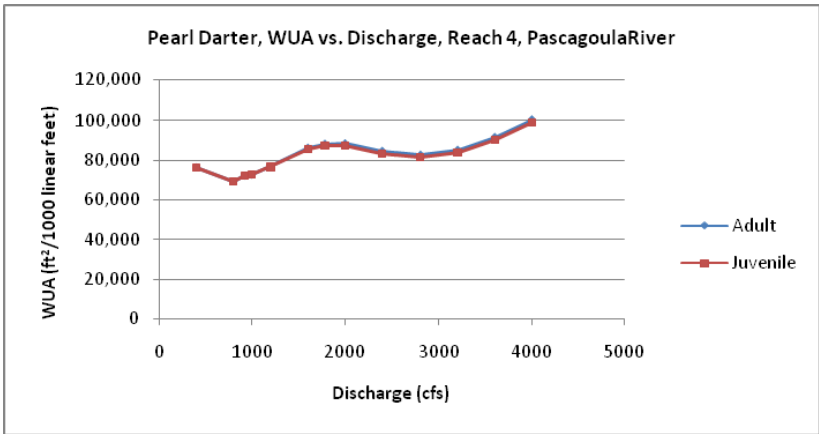


Table A-19. Weighted Useable Area Results for Pearl Darter at Modeled Discharges, Reach 5, Pascagoula River

Adult	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	123,587	77,471	34,779	62.69%	231.22%	
		800	166,148	61,740	19,047	37.16%	96.34%	
	7Q10	917	173,199	60,064	17,371	34.68%	83.24%	
	7Q10+78	993	177,481	59,894	17,202	33.75%	78.31%	
		1200	192,865	57,792	15,099	29.97%	58.33%	
		1600	209,721	48,540	5,847	23.14%	22.29%	
	Flow on date of survey	1,941	225,578	42,693	0	18.93%	0.00%	Survey date flow
		2,000	241,682	39,966	-2,727	16.54%	-12.63%	
		2,400	250,513	36,287	-6,405	14.49%	-23.46%	
		2,800	256,144	31,081	-11,612	12.13%	-35.89%	
		3,200	261,230	28,011	-14,682	10.72%	-43.34%	
		3,600	265,819	28,649	-14,044	10.78%	-43.05%	
		4,000	269,821	30,866	-11,827	11.44%	-39.56%	

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	123,587	75,997	38,238	61.49%	267.37%	
		800	166,148	60,065	22,306	36.15%	115.98%	
	7Q10	917	173,199	58,311	20,553	33.67%	101.13%	
	7Q10+78	993	177,481	58,106	20,348	32.74%	95.59%	
		1200	192,865	55,244	17,486	28.64%	71.12%	
		1600	209,721	44,579	6,820	21.26%	26.99%	
	Flow on date of survey	1,941	225,578	37,759	0	16.74%	0.00%	Survey date flow
		2,000	241,682	34,557	-3,202	14.30%	-14.58%	
		2,400	250,513	30,978	-6,781	12.37%	-26.12%	
		2,800	256,144	25,831	-11,928	10.08%	-39.75%	
		3,200	261,230	23,374	-14,385	8.95%	-46.54%	
		3,600	265,819	24,954	-12,805	9.39%	-43.92%	
		4,000	269,821	27,903	-9,856	10.34%	-38.22%	

Figure A-19. Pearl Darter, Weighted Useable Area vs. Discharge, Reach 5, Pascagoula River

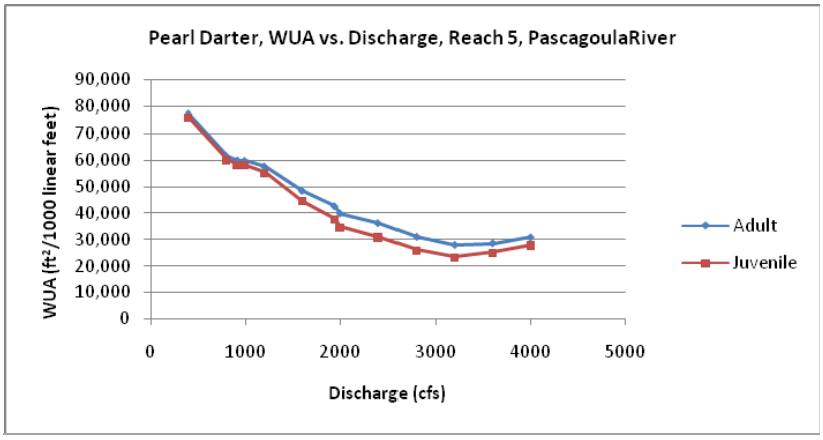


Table A-20. Weighted Useable Area Results for Pearl Darter at Modeled Discharges, Reach 6, Pascagoula River

Adult	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	100,769	45,241	-5,543	44.90%	69.04%	
		800	136,633	58,514	7,731	42.83%	61.25%	
	7Q10	1043	149,976	58,645	7,861	39.10%	47.23%	
	7Q10+78	1121	153,899	56,794	6,010	36.90%	38.95%	
		1200	158,168	57,167	6,383	36.14%	36.09%	
		1600	177,090	56,165	5,381	31.72%	19.41%	
	Flow on date of survey	2,000	191,209	50,783	0	26.56%	0.00%	Survey date flow
		2,400	204,434	50,275	-508	24.59%	-7.41%	
		2,650	211,957	50,412	-371	23.78%	-10.45%	
		2,800	215,510	49,900	-883	23.15%	-12.82%	
		3,200	223,721	43,746	-7,037	19.55%	-26.38%	
		3,600	232,992	43,360	-7,423	18.61%	-29.93%	
		4,000	243,530	44,440	-6,344	18.25%	-31.29%	

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	100,769	45,241	-4,660	44.90%	70.78%	
		800	136,633	58,345	8,444	42.70%	62.52%	
	7Q10	1043	149,976	58,334	8,434	38.90%	48.19%	
	7Q10+78	1121	153,899	56,449	6,548	36.68%	39.84%	
		1200	158,168	56,767	6,867	35.89%	36.87%	
		1600	177,090	55,513	5,612	31.35%	19.77%	
	Flow on date of survey	2,000	191,209	49,900	0	26.10%	0.00%	Survey date flow
		2,400	204,434	49,376	-525	24.15%	-7.32%	
		2,650	211,957	49,507	-393	23.36%	-10.32%	
		2,800	215,510	49,016	-884	22.74%	-12.63%	
		3,200	223,721	42,739	-7,162	19.10%	-26.33%	
		3,600	232,992	42,290	-7,610	18.15%	-29.92%	
		4,000	243,530	43,294	-6,607	17.78%	-31.33%	

Figure A-20. Pearl Darter, Weighted Useable Area vs. Discharge, Reach 6, Pascagoula River

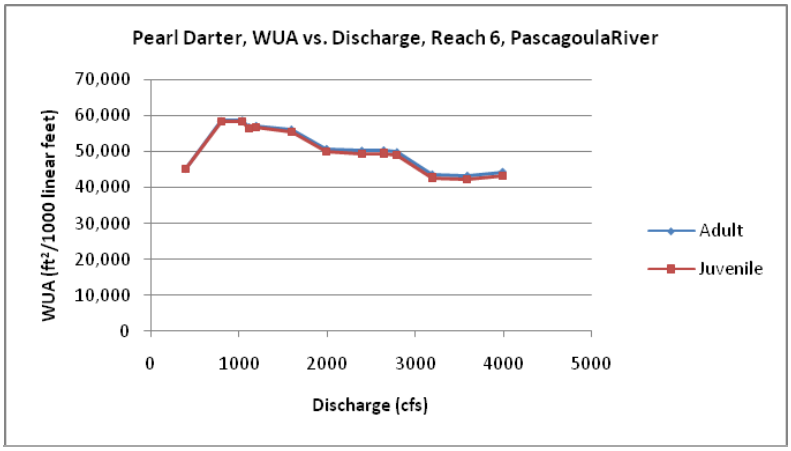
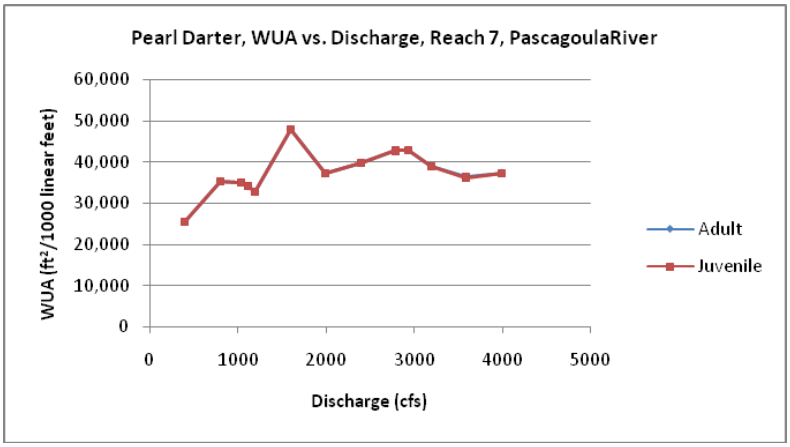


Table A-21. Weighted Useable Area Results for Pearl Darter at Modeled Discharges, Reach 7, Pascagoula River

Adult	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	157,510	25,638	-11,744	16.28%	15.43%	
		800	195,441	35,419	-1,962	18.12%	28.52%	
	7Q10	1043	211,573	35,200	-2,181	16.64%	17.99%	
	7Q10+78	1121	217,027	34,194	-3,187	15.76%	11.73%	
		1200	222,582	32,844	-4,537	14.76%	4.64%	
		1600	247,113	47,921	10,540	19.39%	37.52%	
	Flow on date of survey	2,000	265,097	37,381	0	14.10%	0.00%	Survey date flow
		2,400	277,753	39,839	2,458	14.34%	1.72%	
		2,800	288,541	42,822	5,441	14.84%	5.25%	
		2,940	291,704	42,903	5,522	14.71%	4.30%	
		3,200	297,199	39,041	1,660	13.14%	-6.84%	
		3,600	303,606	36,408	-974	11.99%	-14.96%	
		4,000	308,940	37,474	93	12.13%	-13.98%	

Juvenile	Description	Discharge	Total Area	WUA	Change in WUA from survey date	% Useable Area	Change in % Useable Area relative to survey date	Comment
		400	157,510	25,638	-11,744	16.28%	15.43%	
		800	195,441	35,419	-1,962	18.12%	28.52%	
	7Q10	1043	211,573	35,200	-2,181	16.64%	17.99%	
	7Q10+78	1121	217,027	34,194	-3,187	15.76%	11.73%	
		1200	222,582	32,844	-4,537	14.76%	4.64%	
		1600	247,113	47,921	10,540	19.39%	37.52%	
	Flow on date of survey	2,000	265,097	37,381	0	14.10%	0.00%	Survey date flow
		2,400	277,753	39,839	2,458	14.34%	1.72%	
		2,800	288,541	42,822	5,441	14.84%	5.25%	
		2,940	291,704	42,903	5,522	14.71%	4.30%	
		3,200	297,199	39,041	1,660	13.14%	-6.84%	
		3,600	303,606	36,354	-1,028	11.97%	-15.08%	
		4,000	308,940	37,367	-14	12.10%	-14.22%	

Figure A-21. Pearl Darter, Weighted Useable Area vs. Discharge, Reach 7, Pascagoula River



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Appendix B

Hydrological Data for the Leaf River at McLain, the Pascagoula River at Merrill, and the Pascagoula River at Graham Ferry

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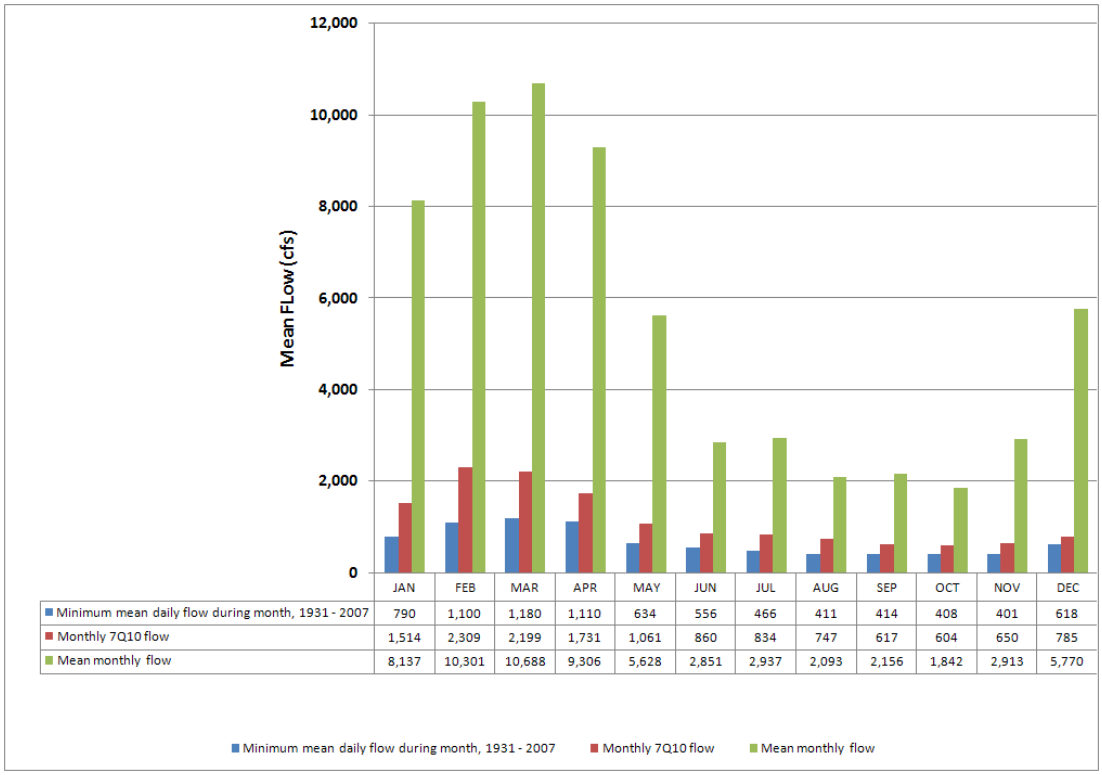
Leaf River at McLain

Table B-1. Hydrological data for the Leaf River at McLain, USGS Gauge 2475000, for the period October 1, 1939 through September 30, 2007

Month	Monthly Mean Flow (cfs)	Monthly 7Q10 Flow (cfs)	Minimum Mean Daily Flow During Month (cfs)	Maximum Mean Daily Flow During Month (cfs)	Coefficient of Variation of Flow	Sandard Deviation of Flow
JAN	8,137	1,514	790	60,600	100%	8,105
FEB	10,301	2,309	1,100	126,000	99%	10,197
MAR	10,688	2,199	1,180	86,100	91%	9,766
APR	9,306	1,731	1,110	106,000	121%	11,272
MAY	5,628	1,061	634	71,000	136%	7,653
JUN	2,851	860	556	28,400	110%	3,147
JUL	2,937	834	466	47,700	141%	4,128
AUG	2,093	747	411	24,800	93%	1,951
SEP	2,156	617	414	31,000	152%	3,283
OCT	1,842	604	408	33,000	138%	2,549
NOV	2,913	650	401	54,500	155%	4,507
DEC	5,770	785	618	63,900	124%	7,131

Figure B-1. Mean Flow data for the Leaf River at McLain, 1931-2007

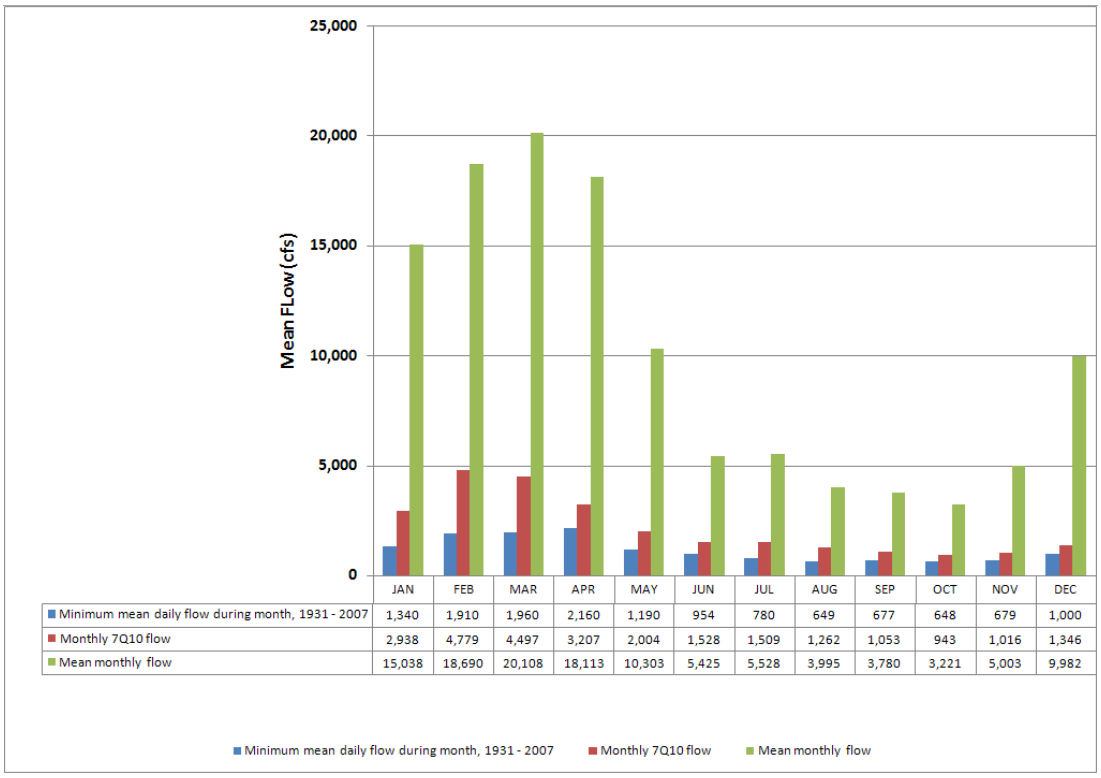


Pascagoula River at Merrill (USGS Gauge 2479000)

Table B-2. Hydrological data for the Pascagoula River at Merrill, USGS Gauge 247900, for the period January 1, 1931 through december 31, 2007

Month	Monthly Mean Flow (cfs)	Monthly 7Q10 Flow (cfs)	Minimum Mean Daily Flow During Month (cfs)	Maximum Mean Daily Flow During Month (cfs)	Coefficient of Variation of Flow	Sandard Deviation of Flow
JAN	15,038	2,938	1,340	90,800	89%	13,437
FEB	18,690	4,779	1,910	176,000	87%	16,174
MAR	20,108	4,497	1,960	152,000	82%	16,446
APR	18,113	3,207	2,160	150,000	103%	18,604
MAY	10,303	2,004	1,190	84,800	117%	12,079
JUN	5,425	1,528	954	49,800	106%	5,754
JUL	5,528	1,509	780	64,800	124%	6,831
AUG	3,995	1,262	649	31,200	84%	3,371
SEP	3,780	1,053	677	47,100	140%	5,295
OCT	3,221	943	648	52,700	132%	4,266
NOV	5,003	1,016	679	87,400	147%	7,376
DEC	9,982	1,346	1,000	89,500	114%	11,385

Figure B-2. Mean Flow data for the Pascagoula River at Merrill, 1931-2007

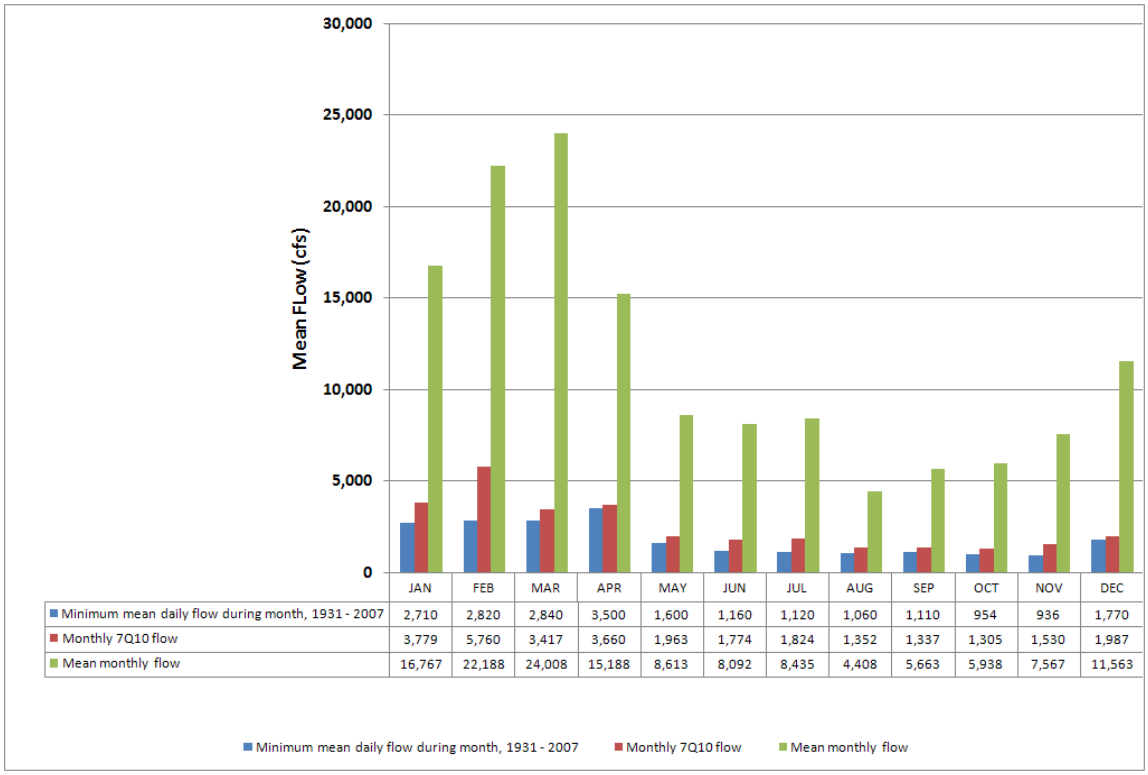


Pascagoula River at Graham Ferry (USGS Gauge 2479310)

Table B-3. Hydrological data for the Pascagoula River at Graham Ferry, USGS Gauge 2479310, for water years 1994 through 2007

Month	Monthly Mean Flow (cfs)	Monthly 7Q10 Flow (cfs)	Minimum Mean Daily Flow During Month (cfs)	Maximum Mean Daily Flow During Month (cfs)	Coefficient of Variation of Flow	Sandard Deviation of Flow
JAN	16,767	3,779	2,710	102,000	98%	16,438
FEB	22,188	5,760	2,820	78,300	69%	15,409
MAR	24,008	3,417	2,840	118,000	79%	19,070
APR	15,188	3,660	3,500	104,000	92%	13,909
MAY	8,613	1,963	1,600	67,500	116%	9,953
JUN	8,092	1,774	1,160	61,100	108%	8,711
JUL	8,435	1,824	1,120	68,700	128%	10,769
AUG	4,408	1,352	1,060	25,000	74%	3,263
SEP	5,663	1,337	1,110	68,500	176%	9,950
OCT	5,938	1,305	954	70,000	143%	8,482
NOV	7,567	1,530	936	52,500	114%	8,602
DEC	11,563	1,987	1,770	60,200	90%	10,403

Figure B-3. Mean Flow data for the Pascagoula River at Graham Ferry, 1931-2007



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Appendix C

Attendees at June, 2008 Scoping Meeting

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Attendees at June, 2008 Scoping Meeting

Name	Company/Agency	Phone	Email
Wayne Elias	DOE	504-734-4397	wayne.elias@spr.doe.gov
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Lloyd Inmon	USFWS	601-321-1134	lloyd_inmon@fws.gov
Paul Necaise	USFWS	228-493-6631	paul_necaise@fws.gov
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