INSTREAM FLOW STUDY PLAN

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Co.
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtUSA.com

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SOUTH CAROLINA ELECTRIC & GAS CO.
COLUMBIA, SOUTH CAROLINA

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1.0 INTRODUCTION

The Parr Hydroelectric Project (FERC No. 1894) (Project) is a 525 megawatt (MW) licensed hydroelectric facility located on the Broad River in Newberry and Fairfield counties of South Carolina, and is owned and operated by South Carolina Electric & Gas (SCE&G). The Project consists of the Parr Shoals Development and the Fairfield Pumped Storage Development. Both developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina (Figure 1).

The Parr Shoals Development forms Parr Reservoir along the Broad River. The Development consists of a 37-foot-high, 200-foot-long concrete gravity spillway dam with a powerhouse housing generating units with a combined licensed capacity of 14.9 MW. Parr Shoals operates in a modified run-of-river mode and normally operates to continuously pass Broad River flow. The 13-mile-long Parr Reservoir has a surface area of 4,400 acres at full pool and serves as the lower reservoir for pumped-storage operations.

The Fairfield Pumped Storage Development is located directly off of the Broad River and forms the 6,800-acre upper reservoir, Monticello Reservoir, with four earthen dams. As noted, Parr Reservoir serves as the lower reservoir for pumped storage operations. The Fairfield Development has a licensed capacity of 511.2 MW and is primarily used for peaking operations, reserve generation, and power usage.

In anticipation of the Project relicensing process, SCE&G met with a number of state and federal resource agencies and interested stakeholders to begin scoping environmental issues as they pertain to project operation. As a result, the United States Fish and Wildlife Service (USFWS), South Carolina Department of Natural Resources (SCDNR), National Marine Fisheries Service (NMFS), and several Non-governmental Organizations (NGO's) requested studies to determine the potential impact of Project operation on fishery resources and aquatic habitat, including an Instream Flow Incremental Methodology Study (IFIM) for the Broad River downstream of the Project. SCE&G formed a Technical Working Committee (TWC) composed of representatives from each interested party that consults to provide input and guidance for the study design and execution.

1.1 EXISTING OPERATIONS

As previously noted Parr Shoals Development operates in a modified run-of-river mode and normally continuously operates to pass Broad River flow. Current minimum flow license articles require that 1,000 cubic feet-per-second (cfs), or average daily natural inflow to Parr Reservoir[1], whichever is less, be provided downstream of Parr Shoals Dam from March through May. During the remainder of the year, 800 cfs daily average flows and 150 cfs minimum flows, or natural inflow minus evaporation, whichever is less, are required downstream of the Parr Shoals Dam.

1.2 SUMMARY OF TWC CONCERNS

In general, the TWC is interested in exploring the protection of instream habitat in the Broad River below the Project (see Appendix A for a detailed summary of discussions) by evaluating existing and potential flow releases. The TWC has identified the following issues that this study will:

- assist in identifying minimum flows that are protective of aquatic habitat;
- provide data that can be used to evaluate minimum flows necessary for safe navigation; and
- provide data that can be used to evaluate the flow necessary to facilitate volitional upstream fish passage.

1.3 PURPOSE OF THIS STUDY

The scope of this study is to provide data quantifying the effects of flows on aquatic habitat suitability in the Broad River for the aquatic community and its managed fish resources, including diadromous and resident fish species, and aquatic invertebrates and to assist the TWC in identifying flow targets that support habitat requirements for a balanced aquatic community.

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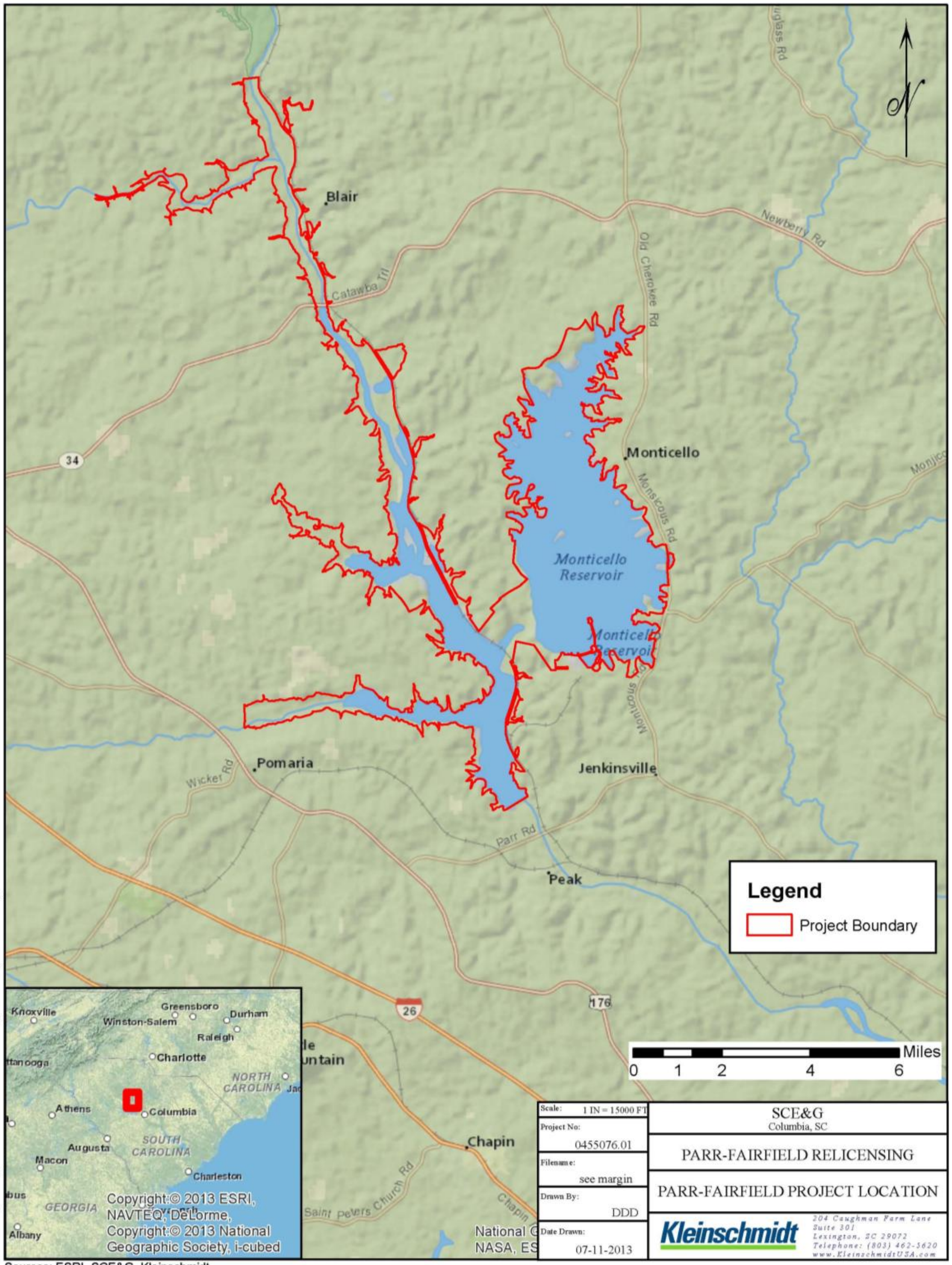
[1] Evaporative loss from Parr and Monticello Reservoirs is subtracted from average daily natural inflow to determine flows downstream of Parr Dam.

These data will then be used in conjunction with hydrologic, operational and other models to evaluate the costs and benefits of providing alternate flows to the Broad River.

FIGURE 1 PROJECT LOCATION MAP



Path: G:_Client_Data\SCE&G\ParrFairfield_MXD\Project Boundary.mxd

Sources: ESRI, SCE&G, Kleinschmidt

2.0 DESCRIPTION OF STUDY AREA

The Broad River rises on the east slope of the Appalachian Mountains, and flows southeasterly across the Piedmont geomorphic province to its confluence at the fall line with the lower Saluda River in Columbia, South Carolina (SCDHEC, 2007), where the combined flows form the Congaree River. Below the Parr Shoals Dam, the river is free flowing for approximately 26 miles through generally low gradient[2] riverine geomorphology until just below Boatrights Island. Below Boatrights Island, the Broad is influenced by backwatering from the Columbia Hydroelectric Project, which is located approximately two miles above the confluence with the lower Saluda River. The drainage area at the Parr Project is 4,750 square miles. A real time stream flow gage exists at USGS 02161000 (*Broad River at Alston, SC*), which is located approximately 1.5 miles below the Parr dam.

2.1 UPSTREAM AND DOWNSTREAM BOUNDARIES

The TWC identified the segment of the Broad River between the Parr Shoals Dam and the downstream end of the Bookman Island complex as the study area (Figure 3 and Figure 4). Flow in this reach is primarily influenced by releases from the Parr Shoals Dam and powerhouse. There are no significant flow contributions from tributaries within the study reach[3].

2.2 HABITAT AND GEOMORPHOLOGY

The Broad River flows southeasterly through a river corridor that is predominantly rural, and in general the river banks and riparian zones are forested. Overall the river is relatively straight for much of the reach, with moderate levels of sinuosity. The upper segment of the study area is dominated by well-defined banks (*i.e.* with discernible and consistent crests and toes) and relatively low-gradient pools, runs and glides, periodically segmented by short riffles. The lower segment also contains pools, glides and runs, but exhibits higher gradient bedrock drops and more pronounced riffles, and features ledge and boulder substrates which reflect down cutting through the piedmont terrace. There are a several islands with pronounced side channels and/or braids such as Haltiwanger, Bookman and Huffman islands.

[2] Reach is punctuated by short, higher gradient reaches (3-4%), near Haltiwanger and Bookman islands, but generally gradient is 1% or less.

[3] Because Little River, as well as other more minor tributaries, are ungaged, a desktop exercise using pro-rated discharge data from adjacent and/or similarly sized basins may be necessary to ensure that tributary flows during a normal water year do not exceed 10% of the total flow of the Broad River.

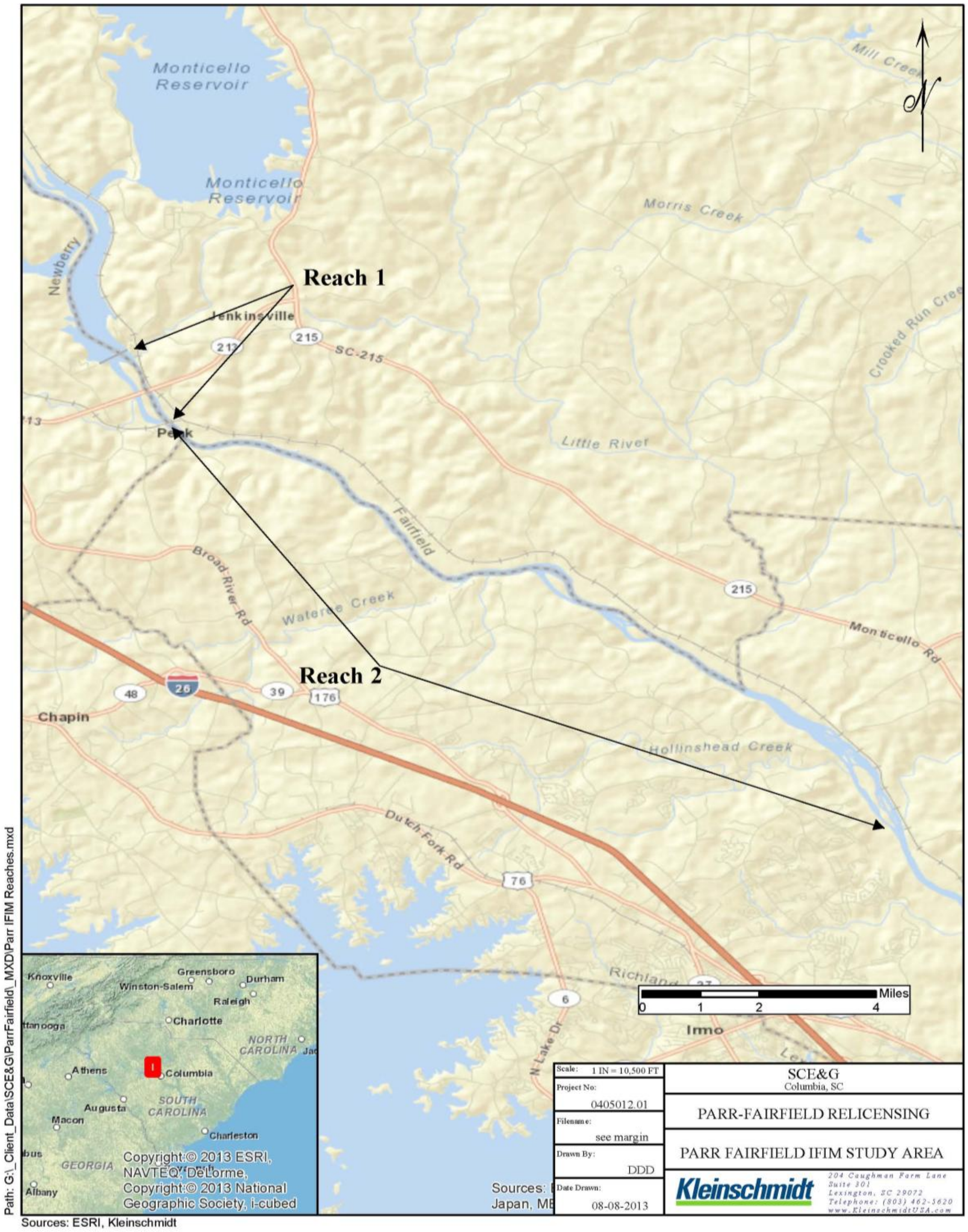
2.3 FISHERY, FISH MANAGEMENT OBJECTIVES, AND SEASONAL HABITAT USES

The varied instream features within the study area support a diverse community of warm water fish species and provide seasonal spawning and nursery habitat for anadromous American shad and striped bass. In addition, smallmouth bass, other centrarchids and catfish provide a sport fishery. Robust redhorse are rare migratory suckers present in the study area. Collaborative restoration efforts are underway to protect this fish and the USFWS describes it as an At-Risk-Species (ARS)[4]. Features within the study reach may also provide suitable conditions for Robust redhorse spawning and rearing (Appendix B). The Broad River spiny crayfish (*Cambarus spicatus*) is another ARS and has been documented from bank habitats of the Little River, a tributary that empties into the Broad River study area.

Anadromous fish restoration priorities for the Santee Basin focus on restoring runs of anadromous fish primarily up the Congaree and Broad rivers. The Santee Cooper Basin Diadromous Fish Passage Restoration Plan reports that the Broad River and its tributaries are the most promising sub-basin for diadromous fish restoration (USFWS et al., 2001).

[4] At-Risk-Species are species that the USFWS has been petitioned to list and for which a positive 90-day finding has been issued (listing may be warranted), yet no Federal protections currently exist.

FIGURE 2 PARR FAIRFIELD INSTREAM FLOW STUDY AREA



Sources: ESRI, Kleinschmidt

3.0 PROPOSED METHODS

3.1 FIELD RECONNAISSANCE AND HABITAT MAPPING

The TWC concluded that an IFIM study would be appropriate to develop an understanding of key habitat-flow relationships in the Broad River, and elected to use a Physical Habitat Simulation (PHABSIM) model to quantify these relationships. The model will be used to quantify flows that meet habitat requirements of target species and life stages, based on output representing selected diadromous and resident fish. In addition, empirical data and/or a flow demonstration approach may be required to document flows that provide adequate fish passage at limiting bedrock ledges, such as those above Haltiwanger Island and near Huffman Island.

Consistent with IFIM protocol, a TWC comprised of agency, NGO and licensee biologists was formed for the purpose of making technical decisions regarding input parameters and review of study output. Specifically, that team designated or will designate:

1. boundaries of the study area,
2. locations of specific study sites,
3. locations of study site cell boundaries and/or transects,
4. Habitat Suitability Index (HSI) criteria, and
5. calibration flows and range of flows to be assessed.

The TWC members may also participate in field and analytical activities as feasible.

Mesohabitat Classification

Initially, a field survey will be conducted to quantify and map the distribution of mesohabitats in the Broad River study area. On June 18-19, 2013, the TWC conducted a reconnaissance survey of the study area (See notes in Appendix A). On July 31, 2013 the TWC discussed and finalized functional definitions of mesohabitat classes, as follows:

Riffle	Shallow, with moderate velocity, turbulent, high gradient, moderate to large substrates (cobble/gravel). Typically > 1% gradient.
Glide	Moderately shallow, well-defined non-turbulent laminar flow, transition from low to moderate velocity, lacking a definite thalweg, typically flat stream geometry, typically finer substrates, transitional from pool.
Run	Moderately deep, well-defined non-turbulent laminar flow, range from low to moderate velocity, well-defined thalweg, typically concave stream geometry, varying substrates, gently downstream slope (<1%).
Pool	Deep, low to no velocity, well-defined hydraulic control at outlet.
Rapid/Shoal	Shallow, with moderate to high velocity, turbulent, with chutes and eddies, high gradient, large substrates or bedrock. Typically >2% gradient.
Backwater	Varying depth, no or minimal velocity, off the primary channel flow.

Mesohabitat mapping will include a review of aerial photographs followed by ground verification. A field crew will field-delineate the relative quantity and spatial distribution of each mesohabitat type in the study area. Delineation will occur during a period of relatively low-to-moderate flow so that breaks in mesohabitat, substrate, object cover and hydraulics representative of approximate base flow conditions can be readily observed. Study team members are encouraged to participate in delineation to the extent feasible. The upstream and downstream boundary of each mesohabitat within the study area will be classified and geo-referenced in the field, and the information transferred to a Geographic Information System

(GIS) format. GIS will then be used to provide both a visual map and quantitative tabular information on the abundance of mesohabitat types in the study area.

Selection of Reaches, Study Sites and Transects

The TWC consulted in May 2013 to define study reaches and select potentially applicable mesohabitat study sites within each reach (Appendix A). The TWC then selected specific study sites and cell/transects within each study reach during the reconnaissance visit in June 2013 (Appendix A).

Within each study reach, the TWC identified study sites that represent typical and/or critical mesohabitats, and selected upstream and downstream cell boundaries within each study site based on localized observable shifts in stream width, cover, substrate, and hydraulics. The area between each upstream – downstream cell boundary is considered reasonably homogenous, and thus the field crew will subsequently locate a representative transect within each longitudinal cell.

Reach One, as defined by the TWC, extends from the Parr Shoals Dam downstream to the Palmetto Trail trestle (Figure 3), just below where the tailrace and bypass channels converge below Hampton Island. This reach contains five study sties (1 through 5) (Figure 3). Although PHABSIM will be the primary analytical tool used to describe habitat suitability, the TWC made two study site-specific exceptions. Study site 1 is partially composed of bedrock pools where a PHABSIM model is not applicable. These pools will be delineated so that each pool's volume can be estimated and the amount of flow necessary to maintain suitable water quality can be calculated, as well as the minimum flow necessary to maintain fish passage through the most limiting inter-pool channel constriction. Study site 4 will be assessed by employing a wetted perimeter transect, as described in the site selection notes (Appendix A).

Reach Two extends from the trestle downstream through the Bookman Island complex, and contains an additional five study sites (6 through 10) (Figure 4). The TWC noted that study site 7 is likely the most limiting for navigation and upstream fish passage due to the large bedrock ledge, and therefore will be assessed using the deKozlowski (1988) and Bulak and Jobsis (1989) criteria. The TWC also agreed that the Bookman Island complex (study site 10) could not be effectively modeled with PHABSIM due to the complex of channels, braids and islands, but will instead be assessed using a two-dimensional (2-D) modeling approach. The 2-D model defines an overall upstream and downstream model boundary of the study site but relies on a finite elements model rather than on the transect/cell boundary approached used in one-dimensional (1-D) PHABSIM modeling. The TWC also determined that habitat suitability in study site 9 (Huffman Island) would be evaluated via an empirical flow demonstration following development and review of results from study site 10.

During preliminary relicensing meetings, TWC members also requested information characterizing spawning habitat for robust redhorse (*Moxostoma robustum*) within the study area. It was subsequently determined that potential spawning sites would be field delineated concurrent with the mesohabitat assessment and other early field work to determine their proximity to the established IFIM study sites discussed above. The purpose of this effort was to determine if potential spawning sites fall within reasonable proximity to established IFIM study sites such that spawning habitat could be evaluated as part of the PHABSIM and 2-D modeling effort. Field reconnaissance for potential spawning sites was conducted by biologists from SCNDR, SCANA Environmental Services, and Kleinschmidt in October 2013 and February 2014, results of which are summarized in the attached memorandum (Appendix B).

FIGURE 3 AERIAL VIEW OF REACH ONE STUDY SITES

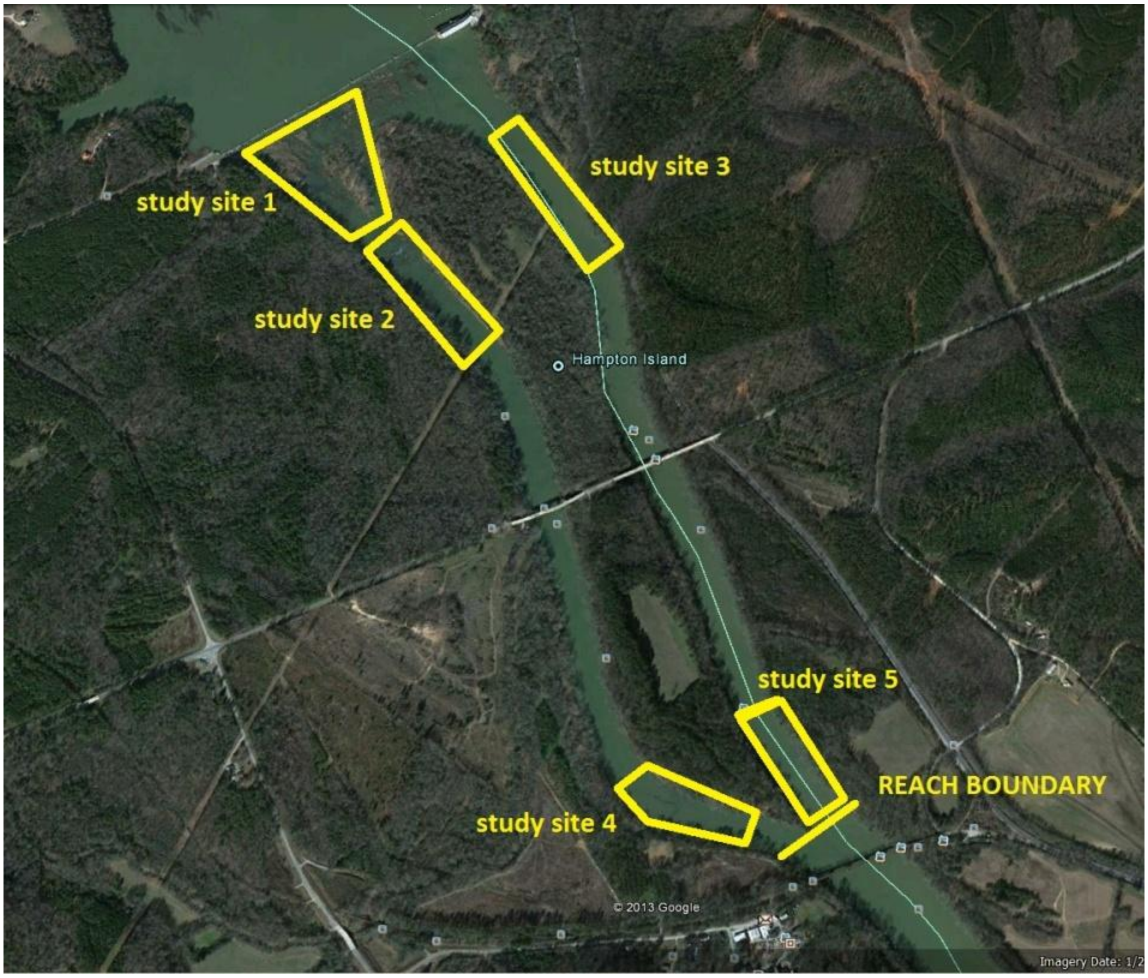
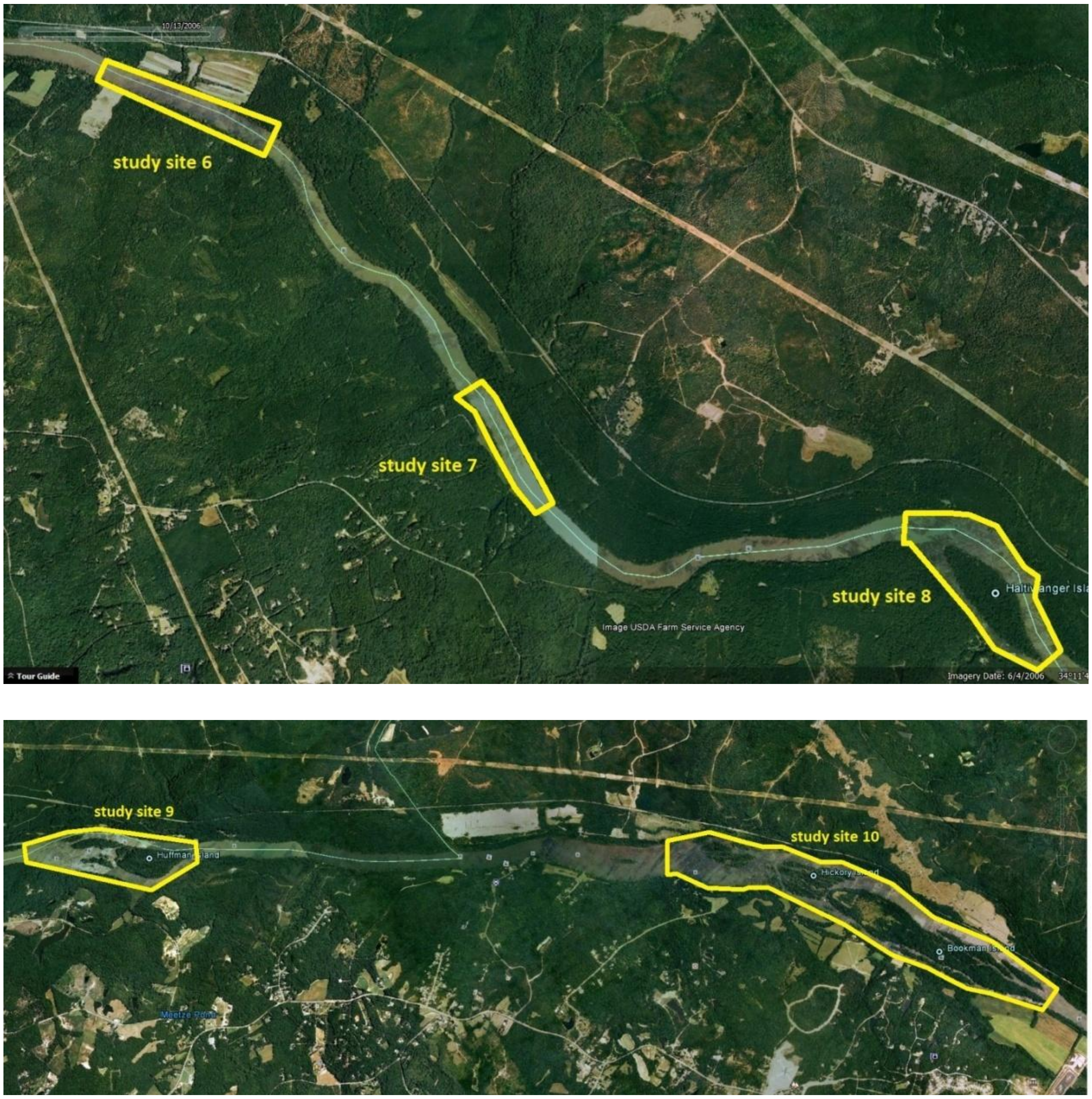


FIGURE 4 AERIAL VIEW OF REACH TWO STUDY SITES



3.2 FIELD DATA COLLECTION

3.2.1 PHABSIM STUDY SITES

General Approach

The second phase will entail the determination of habitat-discharge relationships for selected species, lifestages, and guilds as discussed by the TWC in July 2013 (Appendix A). Standard PHABSIM data collection and flow modeling procedures of the IFIM methodology (Bovee, 1982, Bovee, *et al*. 1998) will be used to evaluate habitat suitability in all 1-D reaches, and a 2-D model such as River 2-D or the equivalent will be employed to quantify habitat suitability in the Bookman Island complex (study site 10). As previously noted, empirical flow measurements will be obtained to evaluate zone-of-passage hydraulics at a limiting river channel sites, and also to evaluate habitat suitability in the Huffman Island vicinity (study site 9) following a review of flow recommendations related to the 2-D model conducted at Bookman Island (study site 10). The TWC also requested a wetted perimeter transect in Reach One at study site 4 below Hampton Island.

Modeling will be based on hydraulic data developed from cross-sectional depth, velocity, and substrate measurements using PHABSIM for Windows (V 2) (Milhouse, *et al.*, 1989), distributed by the USGS Fort Collins (CO) Science Center. River 2-D modeling will follow procedures described by Steffler and Blackburn (2002).

Flow Range to Be Modeled

Based on TWC consultation (See Appendix A), SCE&G anticipates that habitat-discharge relationships would be developed for flows ranging from 200 cfs to approximately 20,000 cfs, and that the modeling effort would focus on both selected mesohabitat types and the limiting fish passage and navigation channels selected by the TWC.

Suitability Index Criteria[5]

The TWC is presently gathering and considering specific Habitat Suitability Index (HSI) rating curves for use in this study. Based on TWC consultation, SCE&G proposes the use of HSI curves adopted primarily from prior studies, including the Saluda and Pee Dee instream flow studies. Provisional HSI curves were proposed and discussed on July 31, 2013 (Appendix A); however, collaboration on additional curve refinement is likely to occur, for example, with striped bass and smallmouth bass. In addition, appropriate cover and substrate coding for the Broad River spiny crayfish will be developed in consultation with the USFWS. Provisional curves, and related TWC discussion notes are contained in Appendix B. Additional species and life stages of interest for which stand-alone curves are unavailable or potentially inapplicable, have been classified by the TWC into habitat guild classes (*i.e*. deep slow, shallow slow, shallow fast, deep fast) and representative HSI curves for each guild selected by the team in consultation.

[5] This section will likely need modification assuming that HSI curves are finalized before submittal of the Pre-Application Document.

Data Collection (PHABSIM 1-D model)

The location of each transect will be field blazed with flagging or other appropriate means and documented using Global Position System (GPS) technology. Each study site and cell will be mapped sufficiently to quantify the area represented by each transect. The transect headpin and tailpin ends will be located at or above the top-of-bank elevation, and secured by steel rebar or other similar means. Transect orientation will be such that each headpin will be positioned on river right (looking downstream) and tailpins consequently located river left. A measuring tape accurate to 0.1 ft will be secured at each transect to enable repeat field measurements to occur at specific stream loci[6]. Stream bed and water elevations tied to a local datum will be surveyed to the nearest 0.1 ft using standard optical surveying instrumentation and methods.

Depth, velocity, cover and substrate data will be gathered at intervals (verticals) along each transect. Each vertical will be located to the nearest 0.1 ft wherever an observed shift in depth or substrate/cover[7] occurs. Between 20 and 99 verticals per transect will be established as necessary to define cross-sectional habitat. Verticals will be arranged so that no more than 10% of the river discharge passes between any pair, thus enhancing hydraulic model calibration. At least one staff gage will be located per study site, and will be monitored at the beginning and end of each set of hydraulic measurements to confirm stable flow during measurements. If flow is found to be insufficiently stable[8], the related data will be discarded and re-measured once stable flow is established.

Mean column velocity will be measured to the nearest 0.1 ft/second with either a calibrated electronic velocity meter mounted on a top-setting wading rod, or alternatively an Acoustic-Doppler Current Profiler (ADCP) transducer. In water less than 2.5 ft depth, measurements will be made at 0.6 of total depth (measured from the water surface); at greater depths, paired measurements will be made at 0.2 and 0.8 of total depth and averaged.

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[6] Supplemental transects may be located as needed to record water surface and bed elevation data at hydraulic controls to establish backwatering parameters necessary for hydraulic modeling.

[7] Cover that is clustered and in close proximity to the transect (such as woody debris important to Broad River spiny crayfish) will be documented.

[8] "Stable water conditions" refers to absence of a pronounced upward or downward trend in staff gage height during the course of a set of hydraulic measurements. It should be noted, however, that previous IFIM experience by Kleinschmidt on other large rivers suggests that minor variations in staff gage height of up approximately 0.5 inch may occur, due to wind pitch and wave action. Under most such circumstances a hydraulic engineer will be consulted to evaluate whether measurements are acceptable or not for modeling purposes.

Each calibration flow will be provided by scheduled releases from the Project via unit operation and/or spillage. Turbine rating curves, USGS gaging, and study-site field gaging will be collectively used to estimate each calibration flow release. The hydraulic model will be built from measurements gathered at a *minimum* of three calibration flows to facilitate extrapolation of hydraulic data across the range of interest. To accomplish calibration, a full set of depth, velocity and water surface elevation (WSEL) data will be gathered at the intermediate flow, and WSEL will be measured at each transect for the low and high calibration flows. At transects with complex hydraulics such as braided channels or riffles, and/or sites with unusual backwatering or eddy effects, supplemental velocity data may be gathered at the low calibration flow to enhance model accuracy. This will be determined in the field on a case-by-case basis.

Each calibration flow should ideally be separated by about an order of magnitude to provide a suitable stage-discharge curve for the hydraulic model. At a minimum, SCE&G anticipates utilizing calibration flows of approximately: 400, 2000 and 10,000 cfs, as determined in consultation with the TWC (See July 31, 2013 meeting notes, Appendix A). Depending on calibration quality, this should allow the PHABSIM model to theoretically project Weighted Usable Area (WUA) for a flow range from 200 to approximately 20,000 cfs. The need for additional calibration flow data may vary by transect and will be evaluated on a case-by-case basis.

Data Collection (2-D Model)

As previously noted, the TWC deemed that a 2-D hydraulic model is most appropriate for capturing the hydraulics and habitat suitability of the Bookman Island complex (study site 10) due to the complex channel characteristics. For the 2-D model, two calibration flows will be employed. The exact flows required are not critical but should represent hydraulic conditions including both "typical" low and "intermediate" discharge through the study reach. Inflow will be estimated by means of gaging and/or an ADCP unit. The two calibration flows will be collected under approximately steady flow conditions, as safety and hydrologic conditions allow. The calibration flow data allows the modeler to evaluate the flow directionality and magnitude under different flow conditions through the study area. Additionally, at least three water level loggers will be deployed within the study reach to assist with model calibration. In general, specific locations will include one logger in the "upper" portion of the study reach, upstream of the islands, one logger in the right main channel, and a third logger in the left main channel.

A two dimensional substrate map will be developed based on data collected during the field effort. Substrate and cover will be categorized based on codes specified within the HSI curves in Appendix B. The 2-D model will be developed using a combination of terrain (Light Detection and Ranging (LIDAR) and/or Digital Elevation Model, depending on availability) and bathymetric bed elevation survey data[9]. This will include a WSEL survey, and flow gaging at the inlet and/or outlet of the study site boundaries.

Data Collection (ledge pools below dam in study site 1)

Pool volumes will be field surveyed to create a 3-D bathymetric map to estimate pool volume. Bed elevations will be gathered and spatially located using submeter accuracy GPS to create a bathymetric profile. The volumetric turnover rate at various inflows will then be calculated, and temperature and dissolved oxygen will be empirically measured at different inflows to assess the extent to which water quality will support aquatic life. The most limiting zone of passage point among pools will be identified and a cross sectional survey will be completed, after which a stage-discharge curve will be developed to estimate the minimum flow required to facilitate volitional fish movements through the restriction.

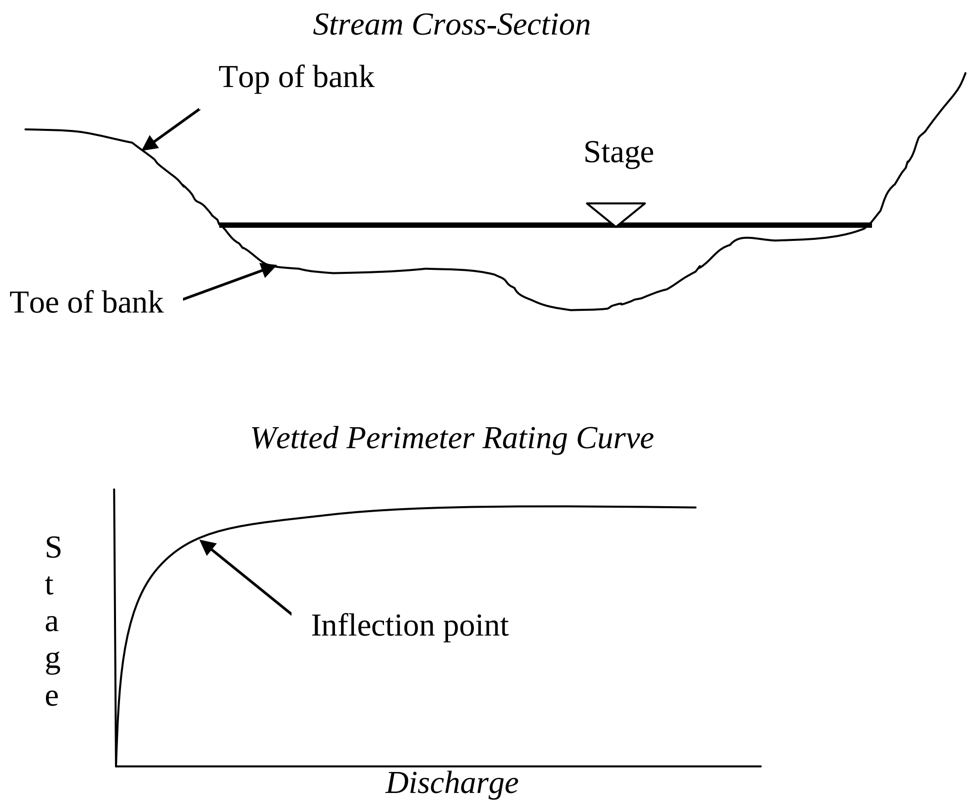
Data Collection (wetted perimeter at study site 4; backwater at lower West Channel)

Although originally established to assess the stage/discharge relationship associated with backwater effects of generation releases, efforts will be made to position this transect at the location most limiting to fish passage and one-way navigation. The transect end points at study site 4 will be field blazed with flagging or other appropriate means and documented with sub-meter GPS. The transect headpin and tailpin ends will be located at or above the top-of-bank elevation, and secured by steel rebar or other similar means. A measuring tape accurate to 0.1 ft will be secured at the transect to enable repeat field measurements to occur at specific stream locations. If necessary, streambed and water elevations tied to a local datum will be surveyed to the nearest 0.1 ft using standard optical surveying instrumentation and methods. A sufficient number of verticals will be established along the transect to accurately depict cross-sectional channel geometry. Water elevation at three flows spanning the range of releases associated with the PHABSIM data collection will be recorded through both survey and staff gaging, so that a

[9] As noted in the Rocky Shoals Spider Lily (RSSL) Study Plan, elevations of the existing RSSL colonies may also be documented concurrent with the bathymetric bed elevation survey, if deemed feasible during execution of the IFIM study.

stage-discharge relationship can be established. These data will then be used to establish a wetted perimeter rating curve, as example of which is shown in Figure 5.

FIGURE 5 SCHEMATIC DIAGRAM OF WETTED PERIMETER CROSS-SECTION, WATER ELEVATION AND CORRESPONDING RATING CURVE



Hydraulic Modeling

Hydraulic modeling and quality assurance/quality control techniques will be in accordance with standard practice for PHABSIM and River 2-D. Hydraulic modeling will be accomplished by correlating each surveyed WSEL with discharge to develop a stage-discharge relationship for each transect. Once this relationship is established, the model then adjusts velocities obtained at calibration flows to each flow increment of interest for which a defined water stage has been calculated. The model is then calibrated by comparing simulated hydraulics to empirical measurements taken at the calibration flows. Detailed steps are summarized below:

Field data collected at transects (e.g. cross section surveys, WSELs, velocities, discharge and slope measurements) will be entered into a computer database compatible with PHABSIM software. All field calculations of discharge and data entry will be proofed and cross-checked for accuracy. The field data include measurements at three calibration flows, and are used to simulate depth, velocity, substrate and cover conditions at discharges other than the calibration flows. Discharges and WSELs are determined for all calibration flows. Bed profiles, substrate and cover used in the model are derived from surveys made during low flows. Velocity calibration in the PHABSIM model typically relies on velocities measured during mid-range flows, although velocity measurements are sometimes made in the field for low flows at features such as riffles where velocities are very irregular across the cross section.

Transects within a common study site and mesohabitat type will be linked hydraulically (*i.e.* within the same datum) with adjacent contiguous transects or with downstream hydraulic controls that create backwater conditions. Stand alone transects, however, will be independently modeled. Simulation of water surface elevations at each transect will be accomplished using one of three methods within PHABSIM: IFG4, MANSQ or WSP. Often, all three models are run with the best stage-discharge relationship determined for each cross-section. The specific model used at a given transect depends on site characteristics, including gradient and backwatering from downstream hydraulic controls. IFG4 uses a log-log fit to determine a stage-discharge curve for the three calibration flows. MANSQ determines the stage-discharge relationship using the Manning's equation for stream flow, while WSP uses hydraulically-linked cross-sections in a backwater model to determine the relationship. WSP is similar to backwater models such as the U.S. Army Corps of Engineers' HEC-RAS program.

Velocity calibrations for each transect are performed using routines within the IFG4 model, usually at the mid-range flow. Where a low flow velocity set is also available, two models may be prepared, one to cover low flows and the other to represent mid-range to high flows. The range of simulated flows represented by each calibration set is determined by the hydraulic engineer based on the model's performance at the calibration flows and trends in hydraulic parameters such as water surface elevation and velocity. PHABSIM output for each simulated flow, such as Velocity Adjustment Factors (VAFs), are plotted as smooth curves with aberrations in these curves indicative of range boundaries for a given calibration flow. Typically, these fall toward extreme low or high flows in high gradient channels, at which point one of the other three calibration sets will be used to continue the model out to the extremes. The hydraulic engineer will review all hydraulic output and determine and document the acceptable range of simulated flows. This range usually extends from slightly below the low calibration flow to slightly higher than the high calibration flow. All hydraulic model output is reviewed by a second hydraulic engineer before being used in habitat modeling.

Habitat Suitability

Once the hydraulic model is calibrated, estimates of habitat suitability at each flow increment of interest will be generated by combining the HSI and hydraulic model data using the HABTAE and supporting programs within PHABSIM. These ultimately produce output known as Weighted Usable Area (WUA) for each transect at each flow increment. WUA is an index of habitat suitability based on units of square ft of optimal habitat available per 1,000 ft of represented stream length. WUA output for all transects in a given mesohabitat type are then weighted according to actual linear distance each transect represents within the mesohabitat, as mapped in the field, to provide a mesohabitat habitat-flow curve. All mesohabitat WUA within a given study reach is then weighted and summed for each flow increment to provide a net WUA estimate for the entire study reach.

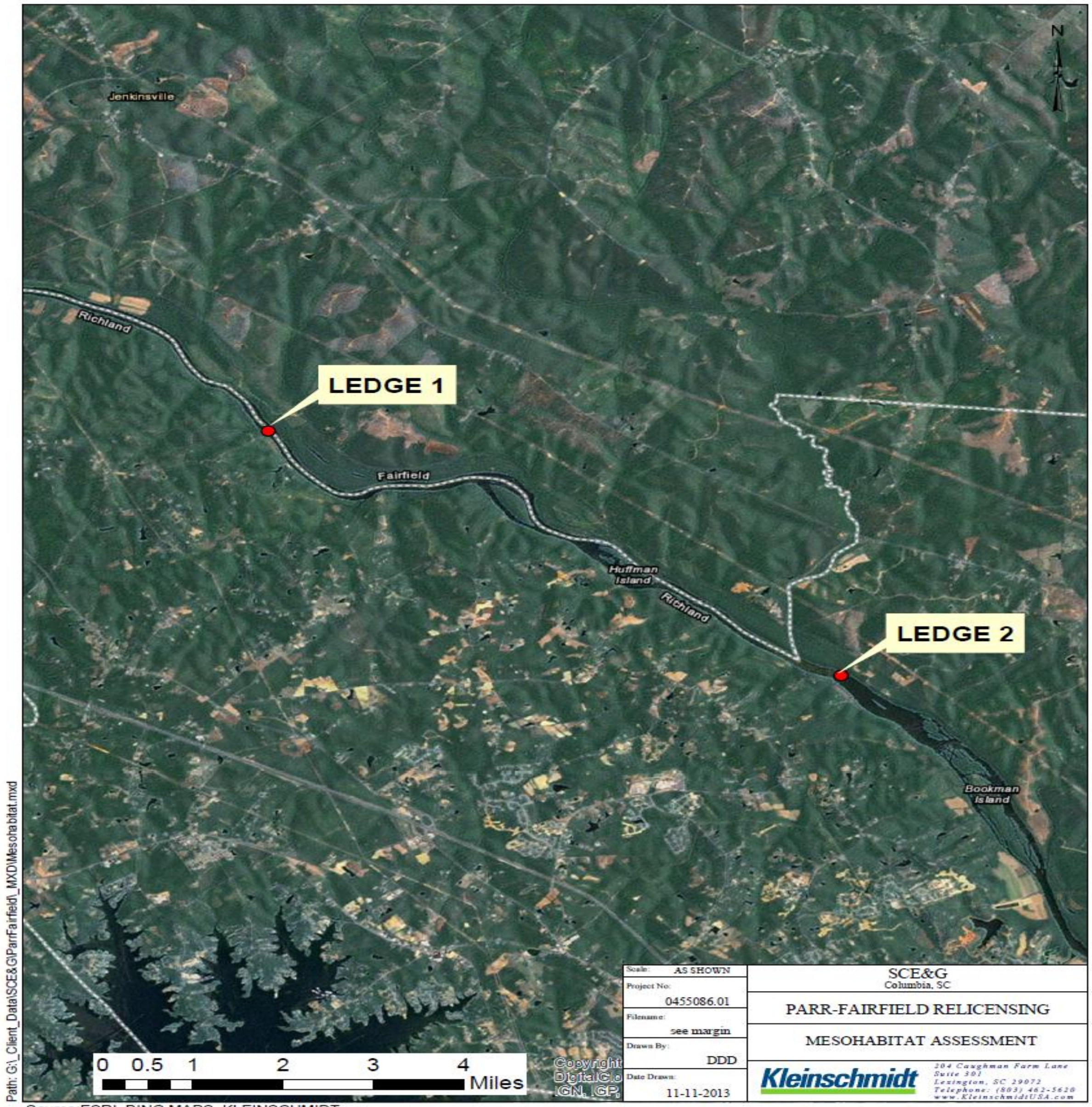
3.2.2 FISH PASSAGE AND NAVIGATION STUDY SITE(S)

During the IFIM field effort, data will also be collected to identify critical flows necessary to facilitate volitional upstream fish passage through limiting shoals areas, as well as one-way, downstream navigation through these sites. In preparation for this effort, the study area was examined during periods of low wadable flow when channel geometry and probable zone of passage routes were readily observed[10]. Two sites were selected that the TWC believes represent critical passage routes (Figure 6). The first is the bedrock ledge located approximately 2.4 mi upstream of Haltiwanger Island at Study Site 7 (81°15’46.507”W, 34°12’49.999”N). The passage point is on river left (looking upstream) and is approximately 45 ft wide (Figure 7), with an approximate change in elevation of 1.5 ft. The second is a ledge located approximately 1.3 mi upstream of Hickory Island and approximately 0.5 mi downstream of the mouth of Little River (81°10’15.941”W, 34°10’18.154”N). The passage point is also on river left (looking upstream) and is approximately 60 ft wide (Figure 8), with an estimated change in elevation of 1.5-2.0 ft.

[10] Field examinations were during the June 2013 agency field reconnaissance and during November 2013 as part of efforts to quantify mesohabitats occurring in the study area.

The field crew will obtain bed bathymetry, water elevation and velocity measurements at each calibration flow. These data will then be displayed graphically and in tabular format to develop a stage-discharge relationship that identifies flows that promote hydraulics that can provide suitable fish passage. Criteria for fish passage are presented in Bulak and Jobsis (1989). Recommendations for flows sufficient to support recreational navigation are described in the SC State Water Plan (SCDNR 2004) and deKozlowski (1988). According to those documents, instream flows in Piedmont streams should be sufficient to 1) provide one-way downstream passage of a 14 foot jon-boat without a motor through rocky shoals; and 2) provide two-way navigation in runs and pools with a 14 foot jon-boat with an outboard motor. Methodology and reporting requirements are described in greater detail in the *Parr Hydroelectric Project Downstream Navigational Flow Assessment Study Plan.*

FIGURE 6 FISH PASSAGE AND NAVIGATION PASSAGE STUDY SITES



Source:ESRI, BING MAPS, KLEINSCHMIDT

FIGURE 7 AERIAL VIEW OF BEDROCK LEDGE AT STUDY SITE 7.

FIGURE 8 AERIAL VIEW OF BEDROCK LEDGE ABOVE HICKORY ISLAND.

4.0 REPORTING

Phase 1 Report

A draft report will be prepared for TWC review and comment, documenting methods and results as encountered in the field and during modeling. This report will focus on analysis of the WUA /flow relationship at all study sites. Supporting hydraulic data will be presented in graphic and tabular form, along with an analysis of trends in the data, and documentation of study team consultation. Appendices will also include cross-sectional survey data and reference photographs of study sites. The report will be finalized and provided to the TWC following receipt of input from the study team.

Phase 2 Report - Dual Flow Analysis

During the second phase, a Dual Flow analysis will be performed following TWC review and approval of the Phase 1 report. The TWC will then consult to define the scope and parameters of the analysis. The purpose of this analysis will be to evaluate the effect on habitat suitability of various combinations of generation flows and base flows.

The assumption behind Dual Flow analysis for non-mobile organisms (e.g. macroinvertebrates, fish egg nests, *etc*) is that a specific patch of stream bed (represented by a modeled habitat cell) is only suitable as long as the hydraulic conditions remain suitable throughout the range of flows ("effectively-available habitat"). Habitat suitability is calculated by comparing the WUA of each 1-D or 2-D cell at each of two flows (a given base *vs.* generation flow pair). In the analysis, the lower of the two paired WUA values is considered to be the effectively available level of suitability for that cell. For example, if the habitat suitability value for a cell is zero at either the low *or* high flow, it is assumed to have zero effectively available habitat. The resulting WUA is then summed across all cells, to establish a composite WUA value for each flow pair of interest. For mobile lifestages, the same overall process is followed but the WUA comparison occurs at the study site scale rather than at the cell scale.

The TWC will consult to define bioperiods (seasons), and to select applicable base flow/peak flow couplets for analysis, subsets of habitat suitability criteria, and study site(s) at which to conduct the analysis. The report will provide both tabular and graphic data showing the ranges of WUA for each selected lifestage at each flow pair of interest, and a discussion of trends in the data.

5.0 CONSULTATION

This study relies upon periodic input from TWC members so that upon receipt of the final report, the TWC may provide flow recommendations to be used in other analyses such as assessing project operation issues, lake level management, and overall flow regime evaluation (see section 1.3). The TWC has thus far developed this study plan, conducted a reconnaissance of the study area, selected study reach boundaries, cell boundaries, developed provisional HSC, reviewed mesohabitat mapping of the study area, and met several times to confirm and/or refine aspects of the study plan.

SCE&G is responsible for conducting the study and analyses in accordance with this plan; during the course of the study, SCE&G will continue to consult with, and update the TWC regarding study progress, and seek input as necessary. This will include further development of HSC, advising TWC members of field data collection schedules, and modeling status prior to development of the Phase 1 Report. Following development of a draft Phase 1 Report, the TWC will conduct a workshop to review the WUA and flow relationships which are the foundation of flow recommendations and further Dual Flow analyses. The TWC will also select provisional base flow targets from the model output that can be used to conduct the empirical flow demonstration at Huffman Island (Study Site 9), and to verify modeling efficacy at other sites of interest, including zone of passage and navigability sites.

The final aspect of the study will be for the TWC to identify specific inputs for the Dual Flow analysis (described in Section 4), and to review and discuss the results of that analysis prior to developing preliminary habitat based recommendations for use in evaluating relicensing alternatives. Upon completion of the study and resulting consultation, minimum flow recommendations developed by the TWC will be provided to the Fish, Wildlife and Water Quality Resource Conservation Group (RCG) for consideration in development of the relicensing Protection, Mitigation and Enhancement (PM&E) Measures.

6.0 SCHEDULE

TASK	COMPLETION DATE[1]
Finalize target species/guilds	December 2013
Finalize HSI curves to be used	December 2013
Mesohabitat characterization; select transect locations	Winter 2014
Collect transect data	3rd Quarter 2015
Complete modeling	1nd Quarter 2016
Issue draft Phase 1 report	2rd Quarter 2016
Conduct empirical flow demonstration	2nd Quarter 2016
Develop Dual Flow analysis	3rd Quarter 2016
TWC review and analysis of Dual Flow results	3rd Quarter 2016
Issue final report	4th Quarter2016
Provide Flow Recommendations to RCG	4th Quarter 2016

[1] Schedule is tentative and is intended as a general guide.

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APPENDIX A
TECHNICAL WORKING COMMITTEE MEETING NOTES

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Instream Flows TWC Meeting

May 7, 2013

Final KDM 05-31-13

ATTENDEES:

Bill Marshall (SCDNR)
Ron Ahle (SCDNR)
Gerrit Jobsis (American Rivers)
Shane Boring (Kleinschmidt)
Alan Stuart (Kleinschmidt)
Kelly Miller (Kleinschmidt)
Bill Stangler (Congaree Riverkeeper)
Ray Ammarell (SCE&G)
Vivianne Vejdani (SCDNR)
Bill Argentieri (SCE&G)
Milton Quattlebaum (SCANA)
Steve Summer (SCANA)
Randy Mahan (SCANA)
Dick Christie (SCDNR)
Tom McCoy (USFWS) via conference call
Prescott Brownell (NOAA)
Kerry Castle (SCDNR)

These notes serve to be a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Alan opens the meeting by briefly going over the agenda, then gives the group an overview of the float trip taken on March 19th and 20th. During this review, the group looks at the Project Area on a map, which sparks a discussion on the habitat just below the Parr Dam.

Ron explains how he is concerned about the separation in the habitat along the first mile of the Broad River, just below the Parr Dam. He says this is a highly utilized area of the river by fish species, and the side of the river along the west bank can grow stagnate during periods of low flow. Shane asks if a critical habitat study should be performed in this area. Ron says there are several critical habitats that need to be studied before the rest of the river is characterized. Prescott and Ron both mention they would like to have a habitat map made for as far down river as possible. Ron says that a habitat map should at least be made for the area immediately below the Parr Dam.

Gerrit tells the group he would also like to look at access along the river, since there are several areas that aren’t accessible. Prescott mentions that he is interested in studying the tributaries along the river. Ron mentions that there is a good amount of data already available on the tributaries, collected by the DNR Stream Team.

Alan refers the group to a study on the Broad River, completed by Jason Bettinger (referred to throughout these notes as the Bettinger Study), as a possible starting point for the Parr Project’s Mesohabitat Assessment and Instream Flow Study. The group notes that the Parr Project area was not included in this study, as the area in the Bettinger Study begins at Neal Shoals and extends upstream. However, the methodology used in the paper might still be utilized by the group.

After discussion on various needs for the Mesohabitat Assessment and Instream Flow Study, Gerrit focuses the group back on the agenda by beginning to list the goals and objectives for the study. Through much discussion the group agrees on four goals with corresponding objectives, as well as additional studies that need to be completed. These goals, objectives, and studies and included as an attachment at the end of these notes.

Steve and Ron then discuss the habitat issues at the west bank area. Ron says he believes that the decrease in DO and increase in temperature along the west bank area is related to the operating of the Fairfield Pumped Storage Project. Steve asks Bill if he has a copy of some aerial photos that were taken prior to Project construction since the west bank features are the result of natural topography, of which Bill answers he is not sure. Steve says he will try to find the photos, since they might show how river flow was distributed between the east and west bank area before the Project was built. Steve says that the issue will be getting water into that west channel during low flow situations. Gerrit says that Duke Energy is building a separate dam to help control flows at one of its projects. He believes the group needs to focus first on deciding what the flow needs for the area are, by seeing the area during higher flow situations. This will allow the group to evaluate how flows might be manipulated to create an even distribution over the area during low flow situations. Steve adds that LIDAR information will also be helpful, and that baseline data on temperature and DO in the west bank area will be needed to feed into the module. Ron mentions that spring through fall data needs to be collected, since he hasn't studied the area except during the summer. Kerry asks if turbidity will need to be examined along with the temperature and DO. The group considers this but decides that turbidity data is not necessary.

While looking at a photo of the dam, the group notes that there is a bit of leakage, which could be beneficial to the seemingly flow deprived west bank area. Ron agrees, but points out that during the summer, any benefits of the slight leakage at the dam may be diminished by the time they reach the central rocky location in the west channel.

The group then focuses their attention towards defining the geographic scope of the Mesohabitat Assessment and Instream Flow Study. The next hydro on the Broad River, downstream of the Parr Fairfield Project, is the Columbia Hydro Project. The upper reach of the PBL for the Columbia Hydro is noted as being at a Rocky Shoals Spider Lily population located just above the upper tip of Boatright Island. The group discusses whether or not this should mark the end of the scope for the Mesohabitat Assessment. It is decided that the scope for the Mesohabitat Assessment will stretch from Parr Dam downstream to the lower end of Bookman Island. Bill S. points out that there is a tributary on the lower end of Bookman Island, named Big Cedar Creek, and the scope should include this as well.

After deciding the scope, the group begins discussion on which definitions to use for the various mesohabitats. Two slightly varying sets of definitions are considered, including one used during the Saluda Hydro Relicensing Project, and one used in the Bettinger Study. Alan points out that using the definitions from the Bettinger study will be good for consistency, however, the group seems to prefer the definitions used during the Saluda Relicensing. Shane points out that there are several other commonly accepted definitions for the various mesohabitats and so the group decides to consider these options also. This issue is left undecided for now.

The group agrees to stay with the methodology that was used in the Bettinger Study. The group then discusses what the ideal flow would be when conducting the study. Ron says that lower flows make it easier to delineate the habitats, while Shane says the flow should be near the mean annual flow when mapping. Ron suggests a flow that is below 2,000 cfs would be best for conducting the study, and everyone agrees.

The focus then turns to identifying target and driver species for the various Habitat Use Guilds. Ron offers his personal list of fish species he has observed in the Broad River to be used as a starting point. The group decides on a list of driver species including:

- Smallmouth Bass
- American Shad
- Brassy Jumprock
- Whitefin Shiner
- Robust Redhorse
- Santee Chub
- Striped Bass
- Piedmont Darter
- Snail Bullhead
- Redbreast Sunfish
- Channel Catfish

Although the list is longer than is customary, Alan says that it can be included in the study plan with a caveat that says some of these species will later be grouped into guilds. Alan makes the point that the species which have HSI curves need to be identified, and suggests that Shane and Brandon Kulik work together on this task. Shane and Brandon will also recommend surrogates for the group to consider that can be used for the species that do not have HSI curves and work on guild classifications.

The group then focuses on establishing general transect locations for the study. Dick mentions that in the Bettinger Study a majority of the river was categorized as being glides, pools and shoals, and that these will be areas to look for when deciding on transect locations. Ron specifies that he would like at least one transect to be established right below the Parr Dam, in the area he has identified as a critical habitat. The group launches into a heavy discussion on where the transects should go and how many are needed. Eventually everyone agrees to four general areas for the study to implement the IFIM technique. These include an area immediately below Parr Dam, upstream of Haltiwanger Island, along the Coleman property, and at Haltiwanger Island. Additionally, two other sites were identified for studying wetted perimeter/staged discharge relationships, at Huffman Island and Bookman Island. These locations are included in Figure 1. With these sites agreed upon, the group decides to schedule a field trip to identify the specific locations for transects. Group members interested in participating in this trip are Ron Ahle, Shane Boring, Gerrit Jobsis, Bill Stangler, Bill Marshall, Alan Stuart, Vivianne Vejdani, Milton Quattlebaum, Tom McCoy, Prescott Brownell, Steve Summer, Ray Ammarell and/or Bill Argentieri.

To close the meeting, the group discusses scheduling, keeping in mind that the final study plan needs to be developed by early 2014 to be included in the PAD, which is due late 2014/early 2015. The actual IFIM study will be started during the summer of 2015. The group plans to meet again during the July-August timeframe to discuss the draft study plan and HSI curves. With this, the meeting adjourns. Action items stemming from this meeting are listed below, along with an attachment that includes all decisions made during the meeting.

ACTION ITEMS:

- Shane Boring will contact Brandon Kulik to work together on identifying relevant HSI curves and surrogates for the study. Shane will also ask Brandon to make guild recommendations.

- Shane Boring will research other options for mesohabitat definitions to be used in the study.

- Kelly will schedule the "Transect Identification Recon Trip" with the interested parties for June 18th and 19th.

- Kelly will schedule a follow-up meeting/conference call during the July-August timeframe for the discussion of HSI curves and study plan development.

Goals and Objectives of Mesohabitat Assessment and Instream Flow Study

Goal 1: Characterize the flow/habitat relationships for aquatic species present in the lower Broad River below Parr Dam

- Objective A: Classify and quantify/map (characterize/define) Mesohabitats occurring within study area
- Objective B: Establish target species/guilds
- Objective C: Identify study methodology (recommended IFIM)
- Objective D: Identify tributaries and study areas (reaches) on the lower Broad River of interest for the study

Goal 2: Determine effects of Parr and FFPS operations on flows of the lower Broad River below Parr Dam

- Objective A: Identify operational ranges/constraints of two facilities
- Objective B: Evaluate effects of Project operations on Parr Dam releases at various inflow ranges into Project

Goal 3: Develop recommendations for Parr Hydro Project operations to enhance flows for aquatic resources in the Congaree River (this does not include a transect study)

- Objective A: Influence on diadromous fish (includes striped bass, sturgeon)
- Objective B: Influence on other resident aquatic species (including RT&E)
- Objective C: Influence on Congaree National Park
- Objective D: Consideration of Saluda operations consistent with goals of the Santee Basin Accord

Goal 4: Develop flow recommendations for lower Broad River below Parr Dam

- Objective A: Evaluate baseline habitat
- Objective B: Evaluate high and low flows
- Objective C: Seasonal and inter-annual variations of flow recommendations
- Objective D: Evaluate low flow protocol recommendations

Additional studies:
Temperature and DO in the west channel below Parr Dam (three monitoring locations)
Recreation flows – operation of Parr
Navigation flows – operation of Parr
Water Quality – operation of Parr

Define Geographic scopes of Mesohabitat Assessment and Instream Flow Study / Discuss Mesohabitat Assessment (including methodologies)

Geographic Boundary - Parr Dam to downstream end (lower extent) of Bookman Island, just below the confluence of Big Cedar Creek

Methodologies –
Mesohabitat unit definitions for visual assessment. (NOTE: May be modified by use of Saluda descriptions)

Habitat	Type Description
Riffle	Relatively shallow (<0.5m), swift flowing section of river where water surface is broken.
Glide	Relatively shallow (<1m); with visible flow but mostly laminar in nature; minimal observable turbulence; relatively featureless bottom.
Run	Deep (>1m), swift flowing sections with turbulent flow; surface generally not broken.
Pool	Deep (>1m) slow moving sections.
Shoals	Shoal area; which may contain a variety of habitat complexes.

Use same methods Jason Bettinger used for his study in the upper Broad River, such as GPS for start and end of each classification.

Mesohabitat study should be conducted below 2,000 CFS

Define Species of Interest for Instream Flow Study

Summary of Habitat Use Guilds

Driver Species:
American shad
Brassy jumprock
Channel catfish
Piedmont darter
Redbreast sunfish
Robust Redhorse
Santee chub
Small mouth bass
Snail bullhead
Striped bass
Whitefin shiner

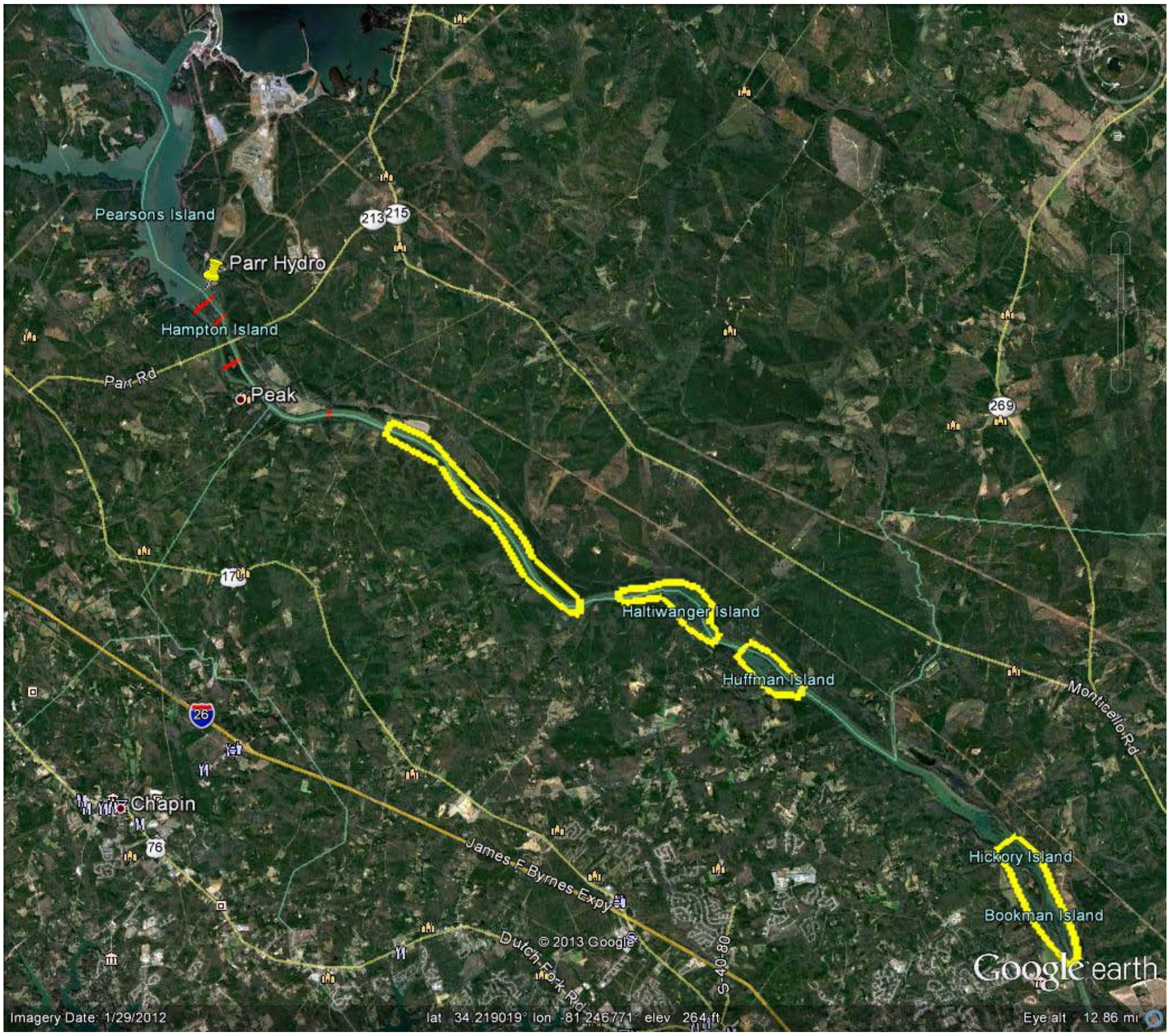
Discuss Methodology (including HSI curves, number and location of transects, areas of specific interests)

Look for HSI curves that exist for driver species and make recommendations for surrogates and guilds

Methodology (number and location of transects, areas of specific interests): IFIM above Huffman Island, wetted perimeter for Huffman and Bookman islands.

Kleinschmidt

Figure 1 **General Transect Locations**



Kleinschmidt

PARR-FAIRFIELD PROJECT

Instream Flow Study

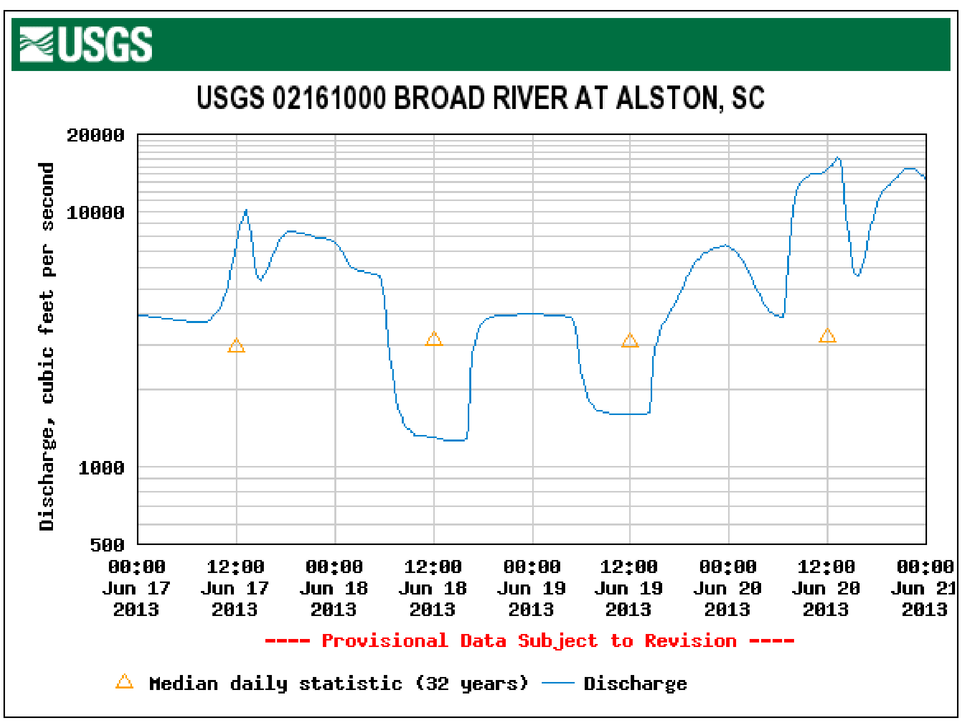
Study site and transect selection field visit summary

DATE: June 18-19, 2013

ATTENDEES:

Ron Ahl	S.C. Dept of Natural Resources (SCDNR)
Bill Marshall	SCDNR
Gerrit J¨bsis	American Rivers
Bill Stangler	Congaree Riverkeeper
Bill Argenteri	SC Electric & Gas (SCE&G)
Milton Quattlebaum	SCE&G
Alan Stuart	Kleinschmidt Associates (KA)
Shane Boring	KA
Brandon Kulik	KA

The goal of this meeting was to collaboratively select study reaches, study sites, transect cell boundaries and discuss data collection and modeling approaches for an IFIM Study of the Broad River, consistent with TWC objectives set at the May 7, 2013 TWC meeting. At that meeting, key river reaches for modeling and analysis were identified. During the site visit, participant hiked, waded and boated these reaches. During each day of the site visit, SCE&G managed discharge downstream from the Parr-Fairfield dam in the range of approximately 1,300-1,700 cfs so that the TWC could view mesohabitat and channel features.



The following notes reflect in-field study scoping decisions:

The study area was divided into two study reaches:

Reach 1 – from the dam to the confluence of the tailwater and bypass reach (near the downstream tip of Hampton Island (near the Palmetto Trail trestle crossing) and

Reach 2 - from the trestle downstream through Bookman Island complex.

<u>Reach 1 – from dam to downstream end of Hampton Island</u>

Study Site 1 – immediately below the western end of the dam, habitat is dominated by pools formed by perched bedrock ledge that primarily receive incidental flow during high flows or periodic spillage under existing operation. It was observed that there was little to no flow in this area on the day of site visits. The TWC agreed that the primary habitat issue was volitional passage of fish among pools, and adequate water circulation to maintain suitable temperature and dissolved oxygen (DO) for fish occupying pools, and that this site could not be effectively modeled using Physical Habitat Simulation (PHABSIM. Effort will focus on quantifying the turnover rate that maintains temperature and DO in pools) and adequate zone of passage at the most limiting channel constriction.

Photo 1. Ledge/pool area below dam in study site 1

Study Site 2 – Site viewed from Highway 213 bridge. Site located just to the west of the island, below site 1 on "bypass reach" side. The TWC agreed to 2 transects above power line in run/glide habitat to capture different substrate /cover conditions: one within boulder field, and a second in a more open channel between the boulder field and power line. The TWC concurred that this site could potentially be modeled with PHABSIM, and that the areas downstream from the power line within the study reach were backwatered, and composed of ephemeral fines that migrate.

Photo 2. Run/glide mesohabitat in study site 2 (in distance near transmission tower) looking upstream from highway bridge; ephemeral sand deposits are in foreground

Study Site 3 – Located on tailrace side of Hampton Island. The TWC delineated cell boundaries for this site and gathered GPS waypoints to mark upstream and downstream cell boundaries. Site consists of Run → Glide→ Riffle complex, and group agreed on one PHABSIM transect in each. Run begins at gravel bar approximately 100 yds downstream of powerhouse (GPS pt #77), transitions to glide (GPS pt "Glide3") and transitions to riffle bedrock ledge (GPS pt #77). Bottom of riffle needs to be determined from aerial or determined in field at time of transect set-up. Run transect selected at location of large sycamore near aforementioned gravel bar (flagged). Ron Stated that this is potentially a very important robust redhorse habitat site, and also important for quillback carpsucker, American shad, and represents complex habitat not represented elsewhere.

Study Site 4 - Just upstream of Palmetto Trail trestle at the lower end of channel on west side of Hampton Island. Group observed Native American weir and small shoal near lower end. Ron noted this as important habitat, noting that it is highly influenced by backwatering from powerhouse flows. The TWC decided that a stage/discharge transect would best fit for this area rather than a PHABSIM model, with the objective of evaluating response at different side channel and powerhouse flows

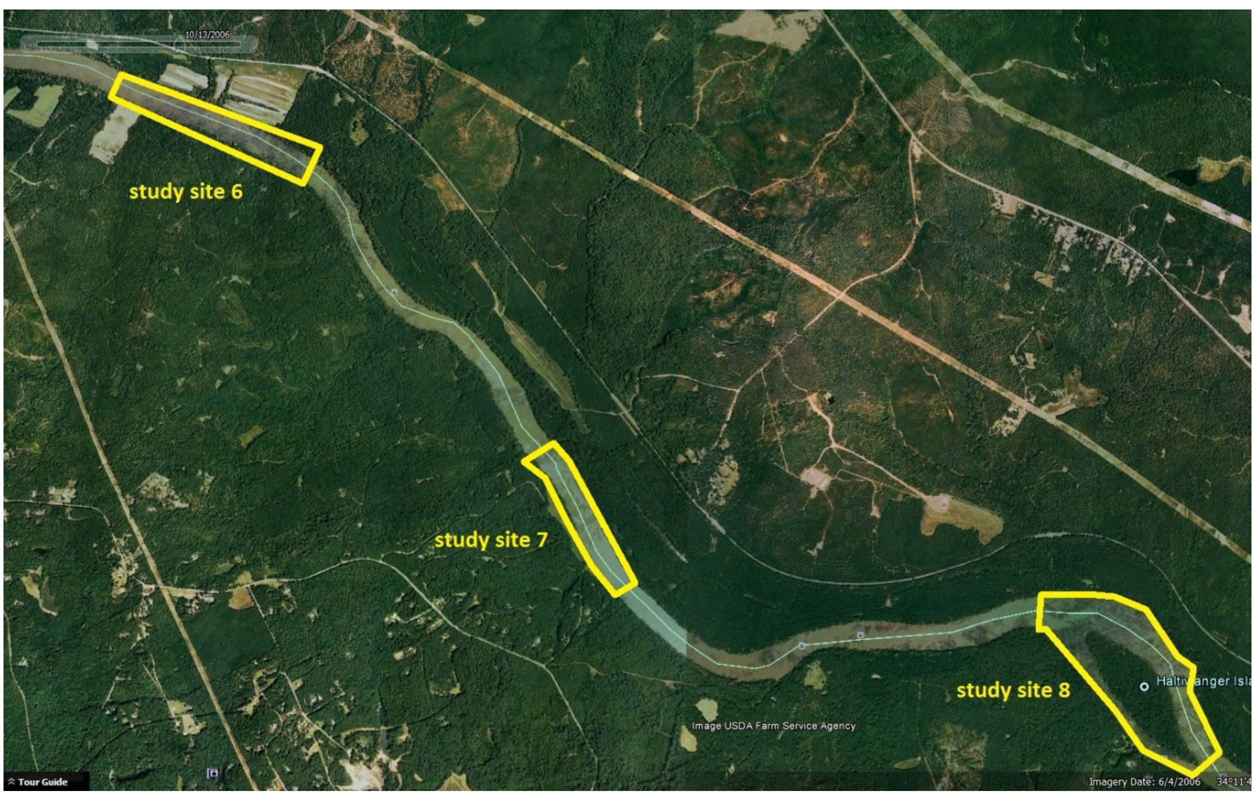
Photo 3. Run/riffle mesohabitat in study site 4, looking upstream from trestle

Study Site 5 – Just upstream of Palmetto Trail trestle on the downstream end of powerhouse side of Hampton Island. The TWC agreed to focus on 1 of the 2 shoals occurring in this area, with at least one riffle and one run transect for PHABSIM modeling.

Photo 4. Shoal mesohabitat in study site 5, looking upstream from trestle

<u>Reach 2 – from end of Reach 1 downstream through Huffman Islands</u>

The TWC then boarded canoes to traverse the next segment downstream to Haltiwanger Island. Brandon Kulik did not accompany the group on this segment due to a schedule conflict.



Study Site 6 – Large "main-channel riffle" approximately 2 miles downstream of Palmetto Trail trestle. Large field on river left, study site ends at large shed at downstream edge of field. Uppermost cell boundary at the head of riffle (GPS pt #79). Downstream end of study area delineated by GPS pt # 80. Numerous rocky areas spread across river, very different than shoal above RR bridge. Gerrit noted this area was too variable to capture with just one transect; potentially needs to 2-3. It was noted that most rocks covered at observed flow (approx 1400cfs), but many shallow areas with rocks just under surface.

Study Site 7 – “Big Ledge” (near George Addy Rd.) that Ron noted as being very unique to the River (GPS pt # 81). Consisted of Glide → Shoal → Pool complex. The TWC agreed that 2-3 PHABSIM transects likely needed, with one each in glide and riffle mesohabitats, and potentially one in the pool. The TWC was undecided on how and whether to include the pool in a PHABSIM model, or how best to document it. The TWC noted that site is likely the most limiting for navigation and upstream fish passage, and therefore should also be assessed for navigation and fish passage due to the large bedrock ledge (See DeKozlowski 1986 for methodology).

Study Site 8 – The TWC concluded the first day of site work at the Haltiwanger Island complex. The TWC noted very diverse habitat above island; river right and river left channels are at this flow (approx 1,400 cfs). The majority of water appeared to be flowing down left channel. The TWC agreed that one PHBSIM transect above island was needed and at least one for river right and river left channels adjacent to island. The group also noted that it would be important to determine how flow partitioned between channels at different flows.

Study Site 9 – The TWC boated upstream to the Chapel Shoals/Huffman Island Complex on June 19. Gerrit Jobsis was unable to participate due to a schedule conflict. Bill Argenteri joined the group.

Huffman Island divides the flow between two channels.

The TWC concluded that a wetted perimeter analysis was not suitable for this site, and initially considered this as a potential study area for River 2D modeling, with data collection occurring at the shoals at the downstream end of Huffman Island and Chapel Shoals at the upper end, with less intense data collection along the two connecting channels. The group also considered simplifying modeling by using the shoal spanning the whole channel immediately downstream from the island as a surrogate study site. However, after viewing the larger, more complex river channel located a short distance downstream at Bookman Island (see discussion of study site 10), it was concluded that a thorough modeling effort at Bookman Island would adequately account for flows at the Chapel Shoals/Huffman Island site. The TWC agreed that once potential flow targets are determined based on the Bookman Island model, a flow demonstration of such flows will be conducted at Huffman Island as necessary to empirically document habitat suitability in the Huffman Island study site.

Study Site 10 – Bookman Island complex. This complex is comprised of numerous small and large islands, main and side channels, and complex bed bathymetry. The TWC agreed that, due to the size and complexity, neither a wetted perimeter nor 1-D PHABSIM model would be sufficient, but that a 2D model of this would be the most conclusive way to quantitatively evaluate habitat suitability. The group agreed that a 2D data collection effort would be conducted throughout the reach from the upstream tip of Hickory Shoal downstream to where the channels converge below Bookman Island.

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Instream Flows TWC Meeting

July 31, 2013

Final KDM 08-20-13

ATTENDEES:

Bill Marshall (SCDNR)
Ron Ahle (SCDNR)
Gerrit Jobsis (American Rivers)
Shane Boring (Kleinschmidt)
Alan Stuart (Kleinschmidt)
Kelly Miller (Kleinschmidt)
Bill Stangler (Congaree Riverkeeper)
Vivianne Vejdani (SCDNR)
Frank Henning (Congaree National Park)
Chad Altman (SCDHEC)
Bill Argentieri (SCE&G)
Milton Quattlebaum (SCANA) via conf. call
Steve Summer (SCANA)
Brandon Kulik (Kleinschmidt) via conf. call
Dick Christie (SCDNR)
Tom McCoy (USFWS)
Byron Hamstead (USFWS)
Rusty Wenerick (SCDHEC)
Fritz Rohde (NOAA)

These notes serve to be a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

After introductions, Alan opens the meeting by reviewing the agenda. He then turns the meeting over to Brandon and Shane to give an overview of the IFIM recon trip that was held June 18th and 19th. Brandon reviews the notes from the trip, which were provided to the group via email on July 10th, giving a description of each of the ten study sites. Study site 7 was noted by Ron to be a very unique stretch of the river and a very important study area. He said this area has a defined drop with an obvious glide that is highly utilized by fish. Ron says this area of the river is unique because of the size of the drop, but it is also quite representative of the river overall, due to the types of habitats it provides. The group agreed that Site 7 should be evaluated using the DNR's navigation criteria and that other sites should also be considered.

Brandon and Ron then discussed the pool that was located at study site 7 and whether this area was going to be included in the study. Brandon says while pools don't really influence flow decision-making, this area should be documented. Frank H asked if the pool areas need to be studied from a sediment standpoint, to determine if there is enough flow to flush sediment out of the pool, and prevent sediment trapping. Ron and Shane both agree that this shouldn't be an issue, as there is plenty of flow to keep the sediment moving. Ron says the pools will be mapped during the mesohabitat study, and agrees with Brandon that transects aren't needed here.

Brandon then describes how a 2D model works, which is a possible option for study site 9. 2D modeling uses a honeycomb type of data gathering, which fit together to form a picture. This gives a different view of a site versus a straight transect. The group decided that a 2D model should be used at study site 10, at Bookman Island. Gerrit asks how the analysis for the 2D modeling will be conducted, with the flows being at the selected levels. Brandon says that field data will be collected at Bookman and then used to see what flow range makes the most sense for modeling. Alan asks if the entire Bookman Island complex will be used for modeling at Huffman Island, or will just a piece of the complex be used. Brandon says the entire Bookman Island complex will be used. He adds that the two island complexes will not be mathematically linked, but instead an empirical examination will be used to determine similarities between the two (i.e., a field verification, similar to what was done for the Saluda Project) of flow recommendations, to ensure that recommendations developed are based on work at Bookman are applicable to Huffman Island.

Gerrit mentions the importance of determining how the channels at Bookman are linked, and how some of the smaller channels may be isolated during periods of lower flow. Brandon assures Gerrit that the 2D modeling will include the small cross-channels around the islands, so that these areas may be studied as well. Gerrit says he wants to make sure the study plan captures not only the analysis using HSI curves, but also how various flows affect these small channels. He would like to have a site visit to examine Huffman and Bookman Islands during several different flows to ground truth 2D modeling results.

With this, Alan notes that there seems to be concurrence within the group on the study approach, and asks Brandon if he has enough information to develop a study plan. Brandon says he does and will begin developing a study plan to bring back to the group for review.

The group then begins discussing the HSI curves that Brandon sent to the group to review. Brandon proposes that we use the Hightower curves for the American shad. Alan mentions that these curves are the ones sent to the group by Prescott Brownell a month earlier.

Ron then questions some of the guild classifications for the various fish species. He disagrees with some of the guild assignments and Alan and Dick suggest we work through the information until everyone can agree. The group discusses the difference between shallow versus deep and fast versus slow. The group also discusses the addition of other species at various life stages to the list. Ron suggests listing all life stages for the smallmouth bass in the study plan. Ron disagrees with the curve that corresponds to the smallmouth bass spawning, saying that spawning tends to decrease in waters deeper than approximately 4.5 feet. Brandon agrees, recommending the curve be changed to a stair step, with spawning increasing after reaching a depth of approximately 0.5 feet. Shane agrees to do some research on smallmouth bass spawning and work with Brandon to develop a modified curve for this species for discussion within the TWC.

The group discussed brassy jumprock curves and the need to change the guild for adults to Deep Fast and the guild for juveniles to Shallow Fast.

Gerrit recommends that striped bass spawning lifestage be included in the study. Ron agrees. The group discussed applicable curves from the Pee Dee IFIM study and Crance. Gerrit recommended that we bring in DNR striped bass expert Dr. Jim Bulak to help determine/develop appropriate curves.

The group discussed the importance of adding snail bullhead juvenile lifestage to the study and the need to review bullhead and catfish lifestage curves.

Gerrit and Ron ask for clarification regarding the channel index scale. Brandon explains the scale where 0 corresponds to detritus, 1 to fines, 2 to small gravel, 3 to large gravel, 4 to small cobble, 5 to large cobble, 6 to small boulder, 7 to large boulder, 8 to smooth bedrock, and 9 to irregular bedrock. Shane adds that a table from Wentworth will be included in the study plan that describes these substrates. Gerrit observes that the curves use different channel indices and recommends that all curves use the same channel index.

The group then focuses on modifying the guilds and habitat suitability criteria that Brandon provided. These modifications are included at the end of these notes. Gerrit mentions that the original studies should be referenced in the study plan and not just the broader study in which they were last used, such as the Pee Dee River IFIM.

The group discusses the range of operational flows that modeled as part of the IFIM study, as well as what calibration flows would be needed to model that range. Alan mentions that a range of 250 cfs to 2100 cfs was modeled during the IFIM study for the Saluda Relicensing Project. Brandon suggests putting some level loggers out in the river ahead of the study. Gerrit suggests that a dual flow analysis should be evaluated, to determine Project effects. The group decides on the following calibration flows to allow for modeling of the full range of operational flows: low flow of 400 cfs, with a medium flow of 2000 cfs and a high flow of 10,000 cfs.

After lunch, the group discusses the mesohabitat definitions that Shane provided. Tom says he likes the measurements that are included in the Bettinger definitions and the extra details that are included in the Catawba Wateree definitions. He would like to combine these two with the Saluda definitions. Ron says he doesn't want hard lines to be set for each definition with regards to depth as depths change depending on river flow. He would like to see the depths to be used as guides, but not exact measurements. Brandon suggests adding general depths and flows to the definitions for each habitat. Brandon points out that many of these habitats have already been identified on the river by the group during the IFIM recon trip. The group just needs to agree on the wording for each definition. The group discusses the differences between a glide versus a run, deciding that the slope upstream or downstream is a determining factor. The group works to modify the Saluda definitions and these modifications are included at the end of these notes.

SCE&G and Kleinschmidt personnel will begin to develop the study plans for the IFIM study and Mesohabitat Assessment and will have a draft ready for TWC review and approval by the beginning of October. The group plans to meet or have a conference call before the mesohabitat assessment is started. Any action items stemming from this meeting are included below.

ACTION ITEMS:

- Shane will research the smallmouth bass spawning and will work with Brandon develop a new HSI curve for review within the TWC.
- Shane will refine the mesohabitat definitions and distribute to the group for approval.

DRAFT MEMORANDUM

TO: Parr-Fairfield Hydro: Instream Flow/Aquatic Habitat TWC

FROM: Brandon Kulik

DATE: July 9, 2013

RE: **PROPOSED HABITAT SUITABILITY CRITERIA**

On May 7, 2013, the Instream Flow/Aquatic Habitat Technical Working Committee (TWC) agreed upon species and lifestages for which habitat suitability should be evaluated on the Broad River below the Parr-Fairfield Project as a part of AN IFIM study (Table 1)..

Table 1: Evaluation species elected by the TWC

- Smallmouth Bass
- American Shad
- Brassy Jumprock
- Whitefin Shiner
- Robust Redhorse
- Santee Chub
- Striped Bass
- Piedmont Darter
- Snail Bullhead
- Redbreast Sunfish
- Channel Catfish

The purpose of this memo is to recommend potential Habitat Suitability Criteria (HSC) for use in this study that are applicable to the above species. Smallmouth bass and redbreast sunfish criteria were sourced from the Saluda study, as the TWC has already vetted these curves. Although the Saluda study had employed TWC-approved American shad HSC, these criteria have recently been refined, based on the research of Joe Hightower in North Carolina (Hightower, *et. al*, 2012) and provided to us by NOAA Fisheries. We propose that the TWC consider using these updated criteria.

The remaining species do not have well developed, individual HSC. However, the Pee Dee IFIM study addressed habitat suitability for these species by classifying each of them into applicable guilds. This information was provided to the Saluda IFIM TWC during study scoping (Gerrit Jobsis, October 16, 2006). Based this information (Table 2), we classified the remaining Parr-Fairfield evaluation species and lifestages into proposed guild categories (Table 3)

Attachment A displays the coordinates for the resulting HSC proposed for use, based on the source material identified in Table 3.

Kleinschmidt

Table 2. Guild classification for individual species and lifestages, from Pee Dee River IFIM study (2004)

Species and Habitat Guild Assignment Table for the Pee Dee River Instream Flow Study. Revision 2 - July 9, 2004.

Scientific Name	Common Name	Habitat Types and Guilds[1, 2, 3]			
		Shallow Slow	Shallow Fast	Deep Slow	Deep Fast
Petromyzontidae	**Lampreys**				
Petromyzon marinus	sea lamprey		A		
Acipenseridae	**Sturgeons**				
Acipenser oxyrinchus	Atlantic sturgeon				S
Acipenser brevirostrum	shortnose sturgeon				S
Lepisostedidae	**Gars**				
Lepisosteus osseus	longnose gar	A, J		A, J, S	
Amidae	**Bowfin**				
Amia calva	bowfin			A, S	
Anguillidae	**Freshwater eels**				
Anguilla rotstrata	American eel	J		A, J	J
Clupeidae	**Herrings**				
Dorosoma cepidanum	gizzard shad	A, J		A, J, S	
Dorosoma petenense	threadfin shad	A, J		A, J, S	
Alosa mediocris	hickory shad			J, S	
Alosa sapidissima	American shad			J	J, S
Alosa aestivalis	blueback herring			J, S	
Cyprinidae	**Carps and Minnows**				
Cyprinus carpio	common carp	J, S		A, J, S	
Notemigonus crysoleucas	golden shiner	A, J, S		A, J, S	
Hybognathus regius	Eastern silvery minnow	J, S		A, J, S	
Nocomis leptocephalus	bluehead chub		A, S		
Cyprinella analostana	satinfin shiner	A, J, S		A, J, S	
Cyprinella nivea	whitefin shiner	A, J	S	A	
Cyprinella pyrrhomelas	fieryblack shiner	A, J	S	A	
Notropis altipinnis	highfin shiner	J, S		A	
Notropis amoenus	comely shiner	A, J	S	A, J	
Notropis hudsonius	spottail shiner	A, J	S	A, J	
Notropis petersoni	coastal shiner	A, J	S	A	
Notropis scepticus	sandbar shiner	A, J	S	A	
Catostomidae	**Suckers**				
Catostomus commersoni	white sucker	J	S	A, J	A
Minytrema melanops	spotted sucker	J	S	A	
Scartomyzon spp.	brassy jumprock	J	S	A	A
Moxostoma macrolepidotum	shorthead redhorse	J	S	A	A[4]
Moxostoma anisurum	silver redhorse	J	S	A, J	
Moxostoma robustum	robust redhorse		S	A, J	
Moxostoma sp.	Carolina redhorse		S	A, J	
Carpiodes cyprinus	quillback		S	A	S
Erimyzon oblongus	creek chubsucker	S?		A, J, S?	
Carpiodes velifer	highfin carpsucker		S	A	S
Ictiobus bubalus	smallmouth buffalo	J	A	A, S	A
Ictiobus cyprinellus	bigmouth buffalo			A	

Table 2.
Continued

Scientific Name	Common Name	Habitat Types and Guilds[1,2,3]			
		Shallow Slow	Shallow Fast	Deep Slow	Deep Fast
Ictaluridae	**Bullhead catfishes**				
Ictalurus punctatus	channel catfish			A, J	J
Ictalurus furcatus	blue catfish			A, S	A
Ameiurus catus	white catfish			A	A, J
Ameiurus brunneus	snail bullhead			A	
Ameiurus nebulosus	brown bullhead			A	
Ameiurus platycephalus	flat bullhead			A	
Pylodictus olivaris	flathead catfish	J		A, J, S	
Esocidae	**Pikes**				
Esox americanus americanus	redfin pickerel			A, J, S	
Esox niger	chain pickerel			A, J, S	
Umbridae	**Mudminnows**				
Umbra pygmaea	Eastern mudminnow			A, J, S	
Poeciliidae	**Livebearers**				
Gambusia holbrooki	Eastern mosquitofish			A, J, S	
Aphredoderidae	**Pirate perches**				
Aphredoderus saynus	pirate perch			A	
Atherinidae	**Silversides**				
Labidesthes sicculus	brook silverside			A	
Percichthyidae	**Temperate basses**				
Morone americana	white perch	J	S	A, J	S
Morone chrysops	white bass	J	S	A, J	S
Morone saxatilis	striped bass				A, S
Centrarchidae	**Sunfishes**				
Lepomis auritus	redbreast sunfish	J, S		A, J, S	
Lepomis cyanellus	green sunfish			A, J, S	
Lepomis gibbosus	pumpkinseed	J, S		A, J, S	
Lepomis macrochirus	bluegill	J, S		A, J, S	
Lepomis microlophus	redear sunfish			A, J, S	
Lepomis punctatus	spotted sunfish			A, J, S	
Micropterus salmoides	largemouth bass	J, S		A, J, S	
Pomoxis nigromaculatus	black crappie			A, J, S	
Percidae	**Perches**				
Etheostoma olmstedi	tessellated darter	A, J	S	A	
Percina crassus	Piedmont darter		A, S		
Perca flavescens	yellow perch			A, J, S	

[1]Habitat types based on predominant habitat types present in the Pee Dee River derived from the aerial videography study.

[2]Life stages: A = adult, J = juvenile, including young-of-year, and S = spawning.

[3]Classification of species and life stages into habitat types based on Becker (1983), Hamilton and Nelson (1984), Aadland et al. (1991), Jenkins and Burkhead (1994), Rhode et al. (1994), Leonard and Dilts (2003), and Progress Energy (2003).

[4]Foraging adults based on Jenkins and Berkhead (1994).

Table 3. Proposed HSC source data for Parr-Fairfield IFIM study

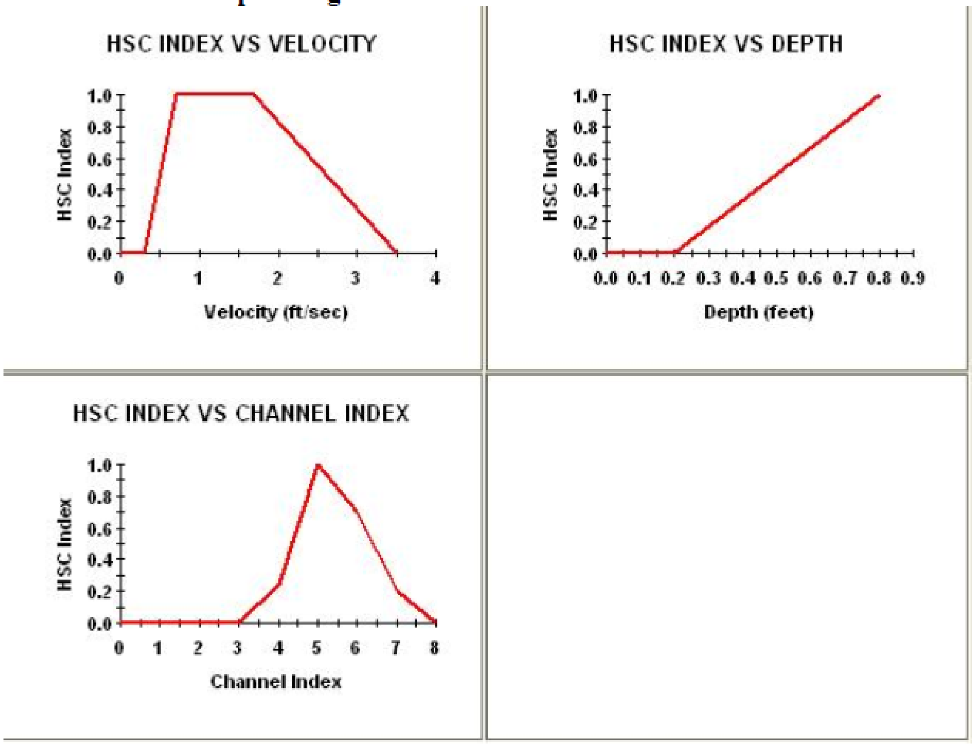
species criteria	lifestage	source	guild
Smallmouth Bass	All (spawning, fry, juvenile &adult)	Saluda	N/A
American Shad	spawning	Hightower, *et al.*, 2012	N/A
Brassy Jumprock	adult	Pee Dee River IFIM	deep ~~slow~~fast
Brassy Jumprock	juvenile	Pee Dee River IFIM	shallow ~~slow~~fast
Brassy Jumprock	spawning	Pee Dee River IFIM	shallow fast
Whitefin Shiner	adult	Pee Dee River IFIM	shallow slow; deep slow
Whitefin Shiner	juvenile	Pee Dee River IFIM	shallow slow
Whitefin Shiner	spawning	Pee Dee River IFIM	shallow fast
Robust Redhorse	adult	Pee Dee River IFIM	~~deep slow~~Stand alone species (Bud Freeman HSI)
Robust Redhorse	juvenile	Pee Dee River IFIM	Stand alone species ~~deep slow~~
Robust Redhorse	spawning	Pee Dee River IFIM	Stand alone species ~~shallow fast~~
Santee Chub	adult	Pee Dee River IFIM	shallow fast
Striped Bass	Adult	Pee Dee River IFIM	Deep slow, deep fast
Striped Bass	Spawning		N/A (Crance, Bulak)
Piedmont Darter	adult	Pee Dee River IFIM	shallow fast
Piedmont Darter	spawning	Pee Dee River IFIM	shallow fast
Snail Bullhead	Adult	Pee Dee River IFIM	deep slow
Snail Bullhead	Juvenile		shallow fast
Redbreast Sunfish	Adult	Saluda	N/A or deep slow?
Redbreast Sunfish	Spawning		Shallow slow?
Channel Catfish	adult	Pee Dee River IFIM	deep slow
Channel Catfish	juvenile	Pee Dee River IFIM	deep slow; deep fast

LITERATURE CITED

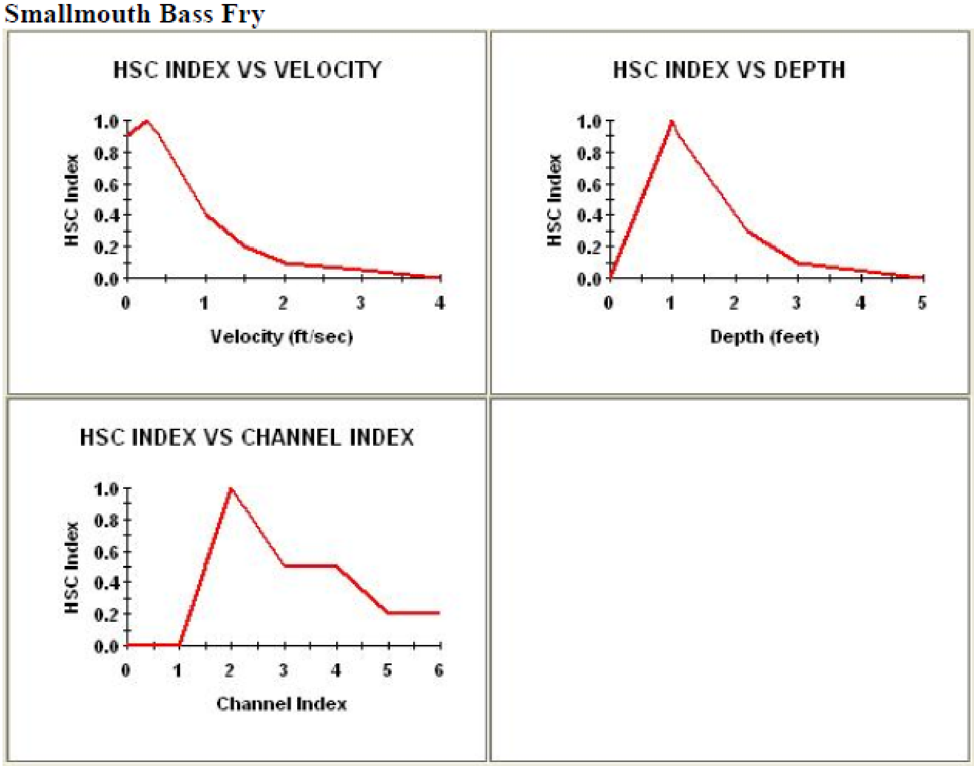
Hightower JE, Harris JE, Raabe JK, Brownell P, Drew CA. 2012. A Bayesian spawning habitat suitability model for American shad in southeastern United States rivers. Journal of Fish and Wildlife Management 3(2):184–198; e1944-687X. doi: 10.3996/082011-JFWM-047

Attachment A
Habitat Suitability Criteria

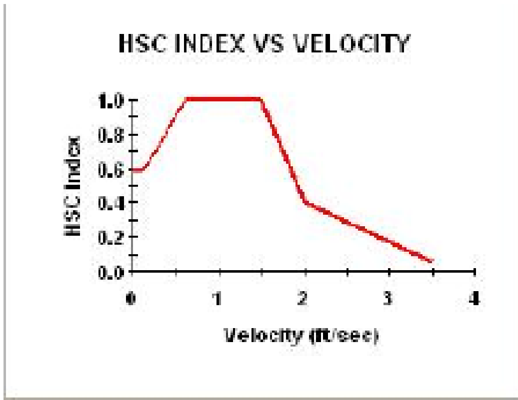
Smallmouth Bass Spawning

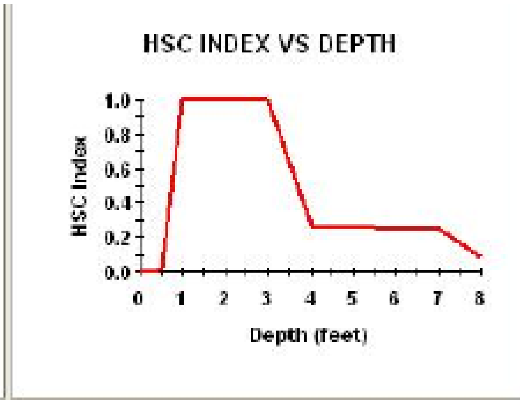


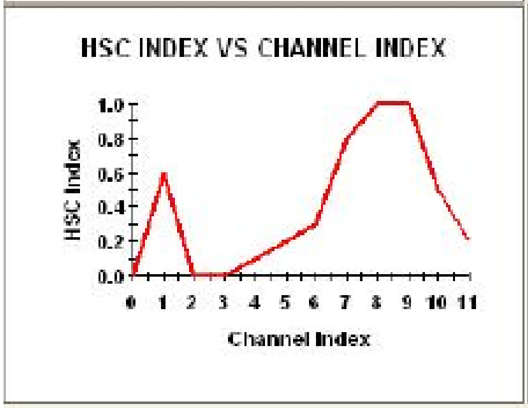
Smallmouth Bass Fry



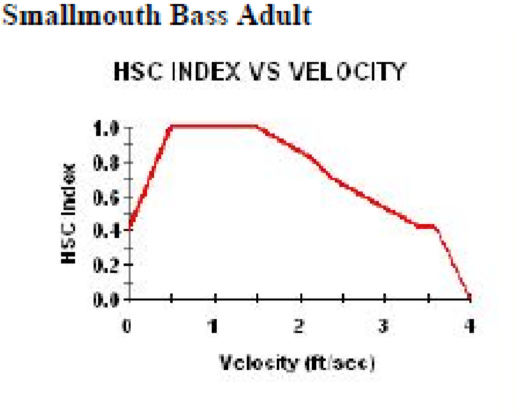
Smallmouth Bass Juvenile

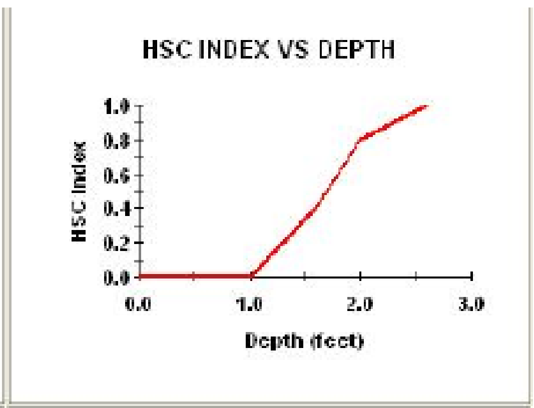


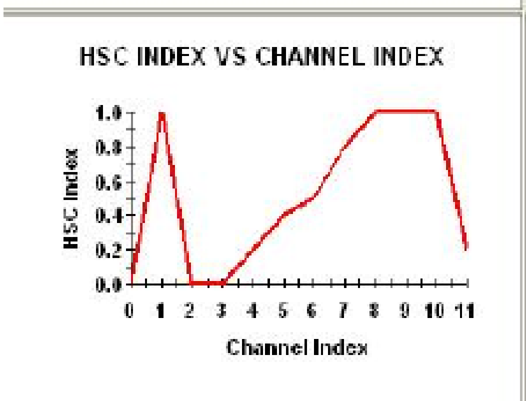




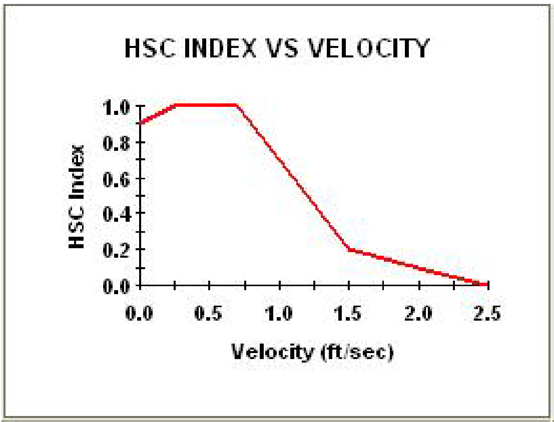
Smallmouth Bass Adult

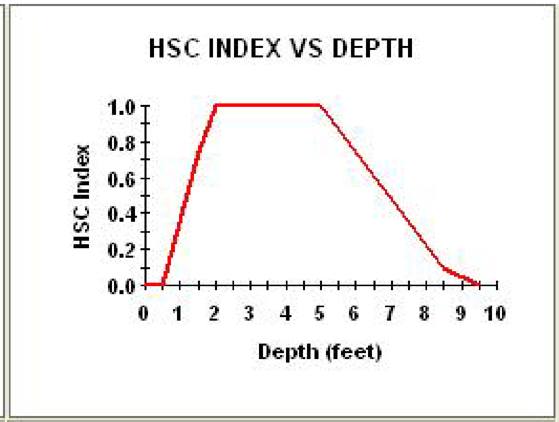


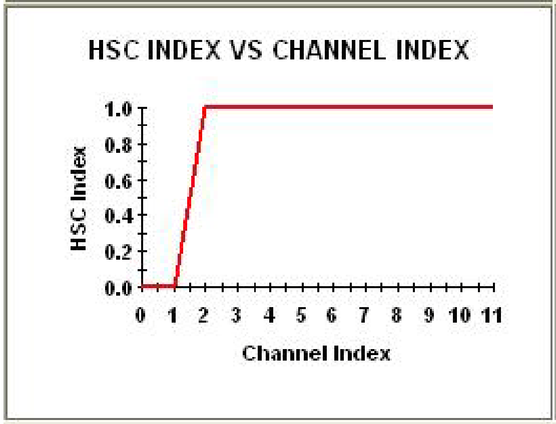




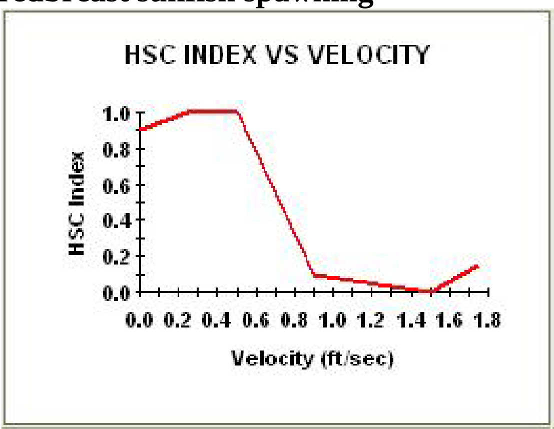
redbreast sunfish adult

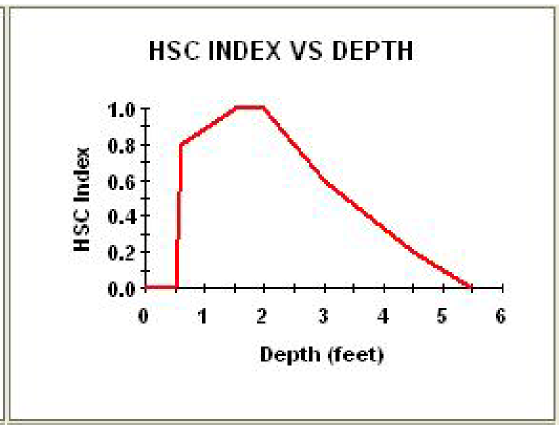


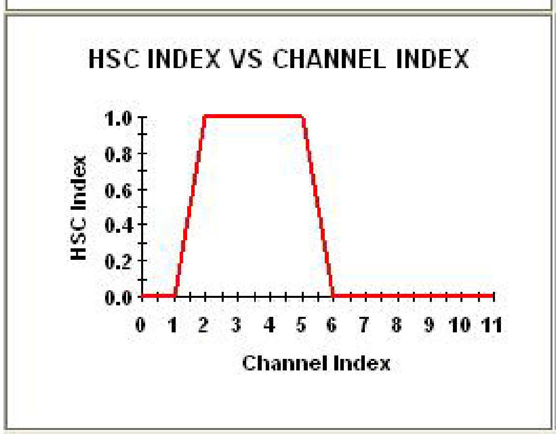




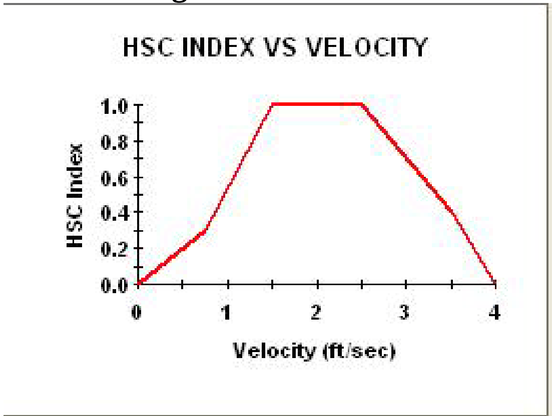
redbreast sunfish spawning

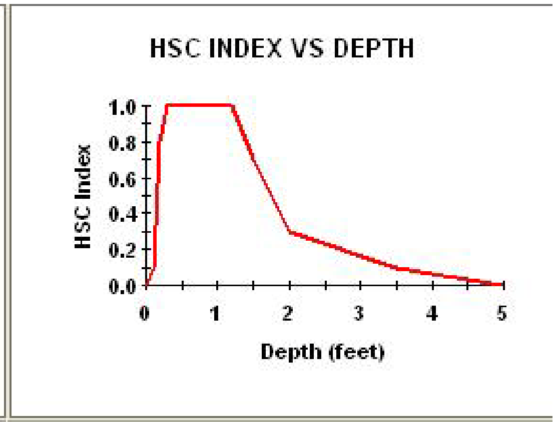


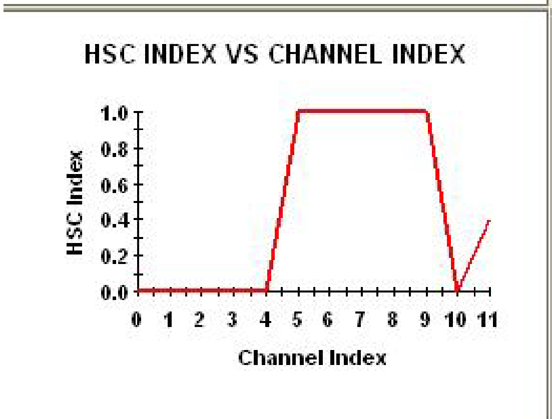




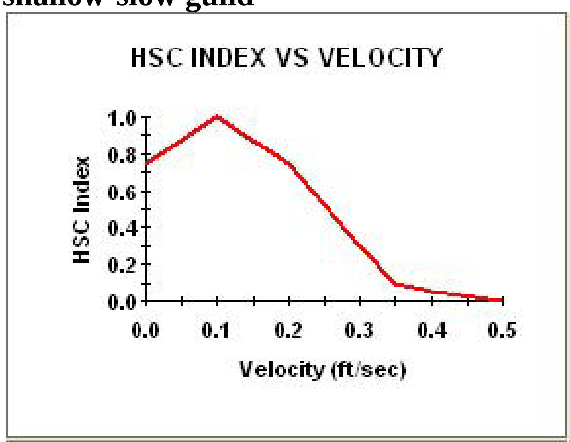
shallow-fast guild

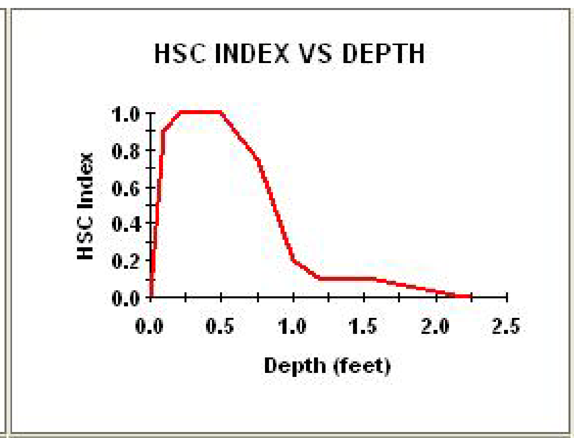


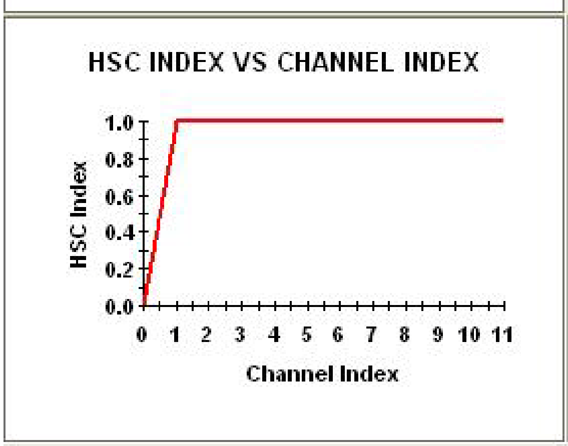




shallow-slow guild

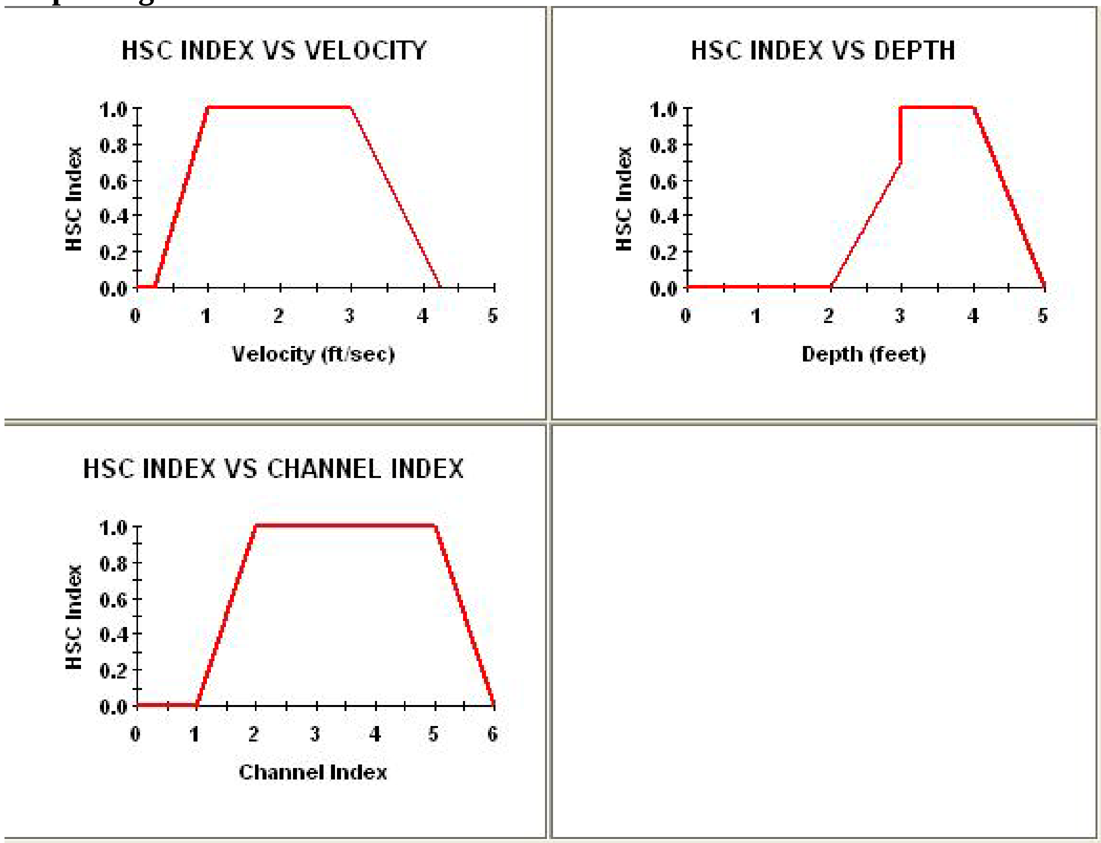






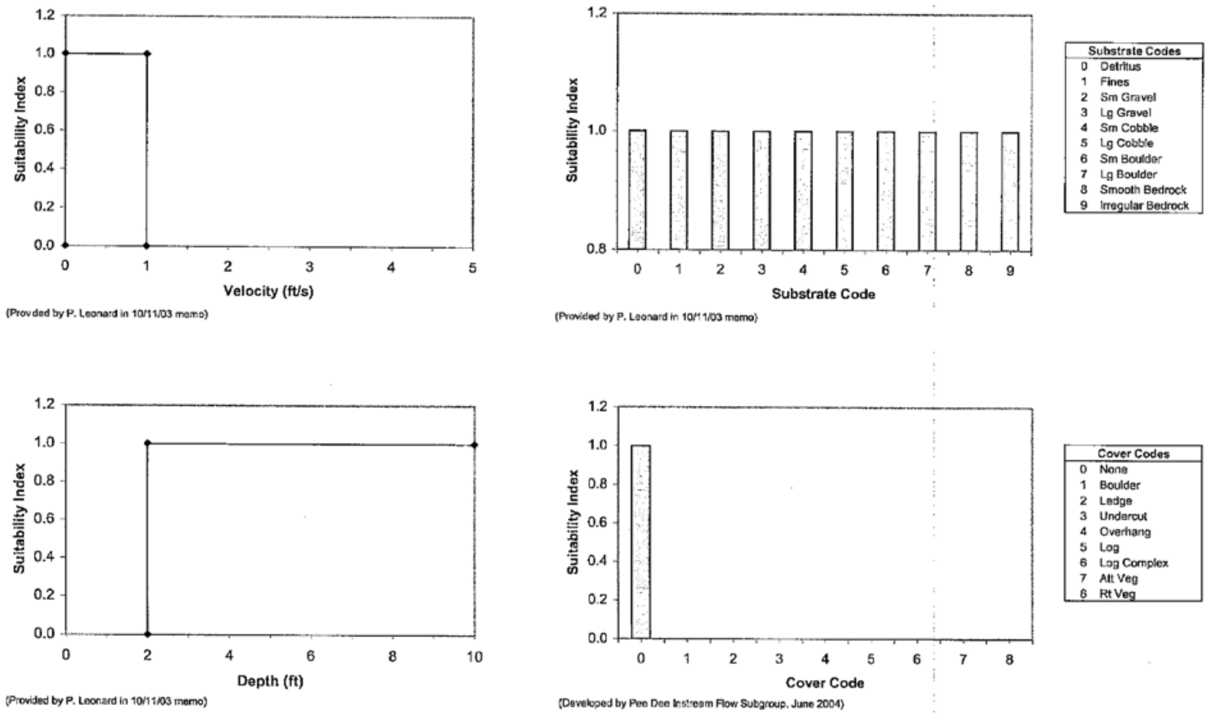
Kleinschmidt

Deep-fast guild



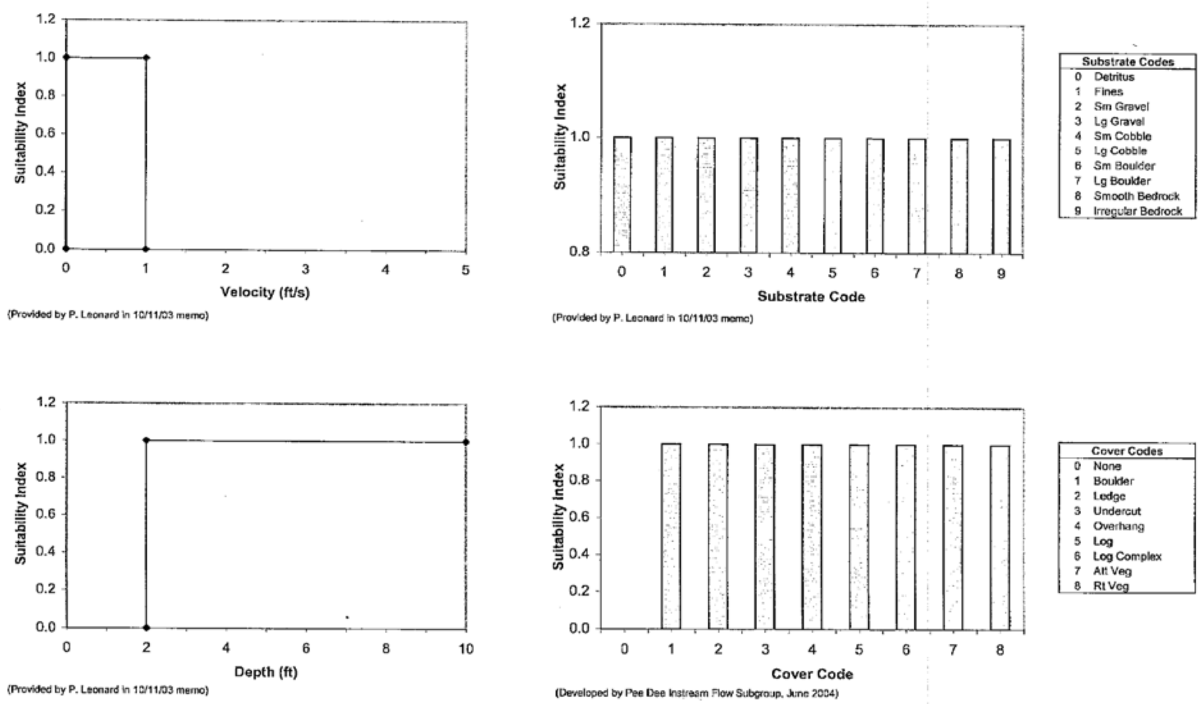
Deep Slow Guild, No Cover

Generic guild habitat suitability



Deep Slow Guild, Cover

Generic guild habitat suitability



AMERICAN SHAD spawning (*Hightower, et al., 2012*).

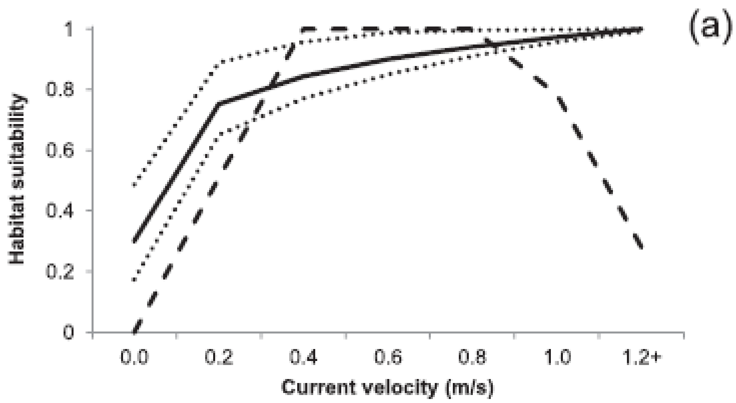


Figure 5. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for current velocity (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b**) data on habitat use vs. availability, by 0.2-m/s velocity bin. The dashed line shows the suitability curve developed by Stier and Crance (1985).

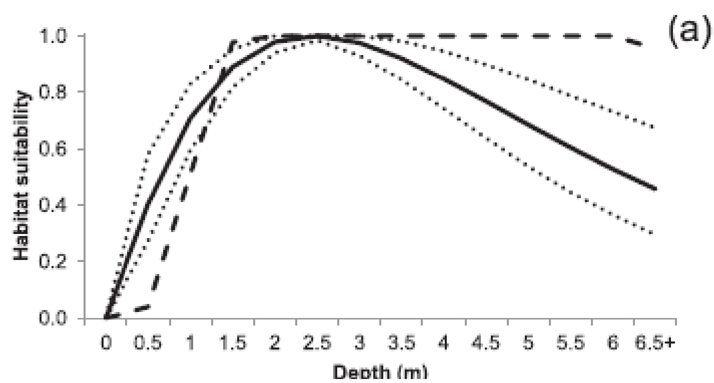


Figure 6. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for water depth in m (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b**) data on habitat use vs. availability, by 0.5-m depth bin. The dashed line shows the suitability curve developed by Stier and Crance (1985).

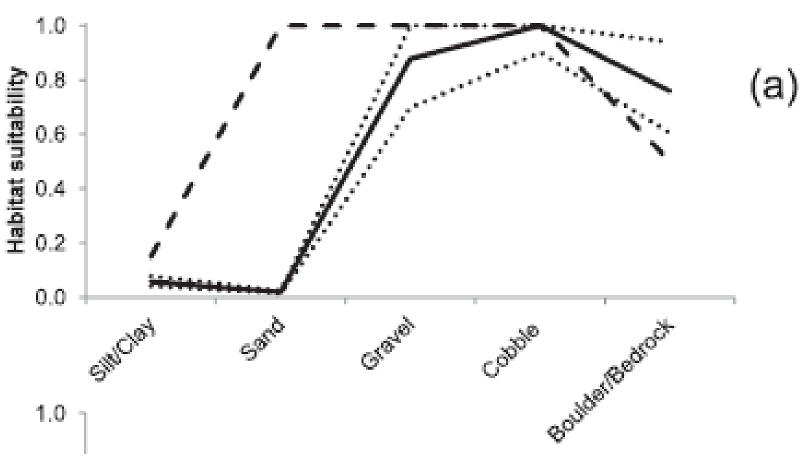


Figure 7. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for substrate (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b** and **c**) data on habitat use vs. availability, by substrate category. The dashed line shows the suitability curve developed by Stier and Crance (1985), using averages for combined categories (silt/clay, boulder/bedrock).

Mesohabitiat Classifications

Bettinger et al 2003

Habitat Type	Description
Riffle	Riffle Relatively shallow (<0.5m), swift flowing section of river where water surface is broken.
Glide	Relatively shallow (<1m); with visible flow but mostly laminar in nature; minimal observable turbulence; relatively featureless bottom
Run	Deep (>1m), swift flowing sections with turbulent flow; surface generally not broken
Pool	Deep (>1m) slow moving sections.
Shoals	Shoal area; which may contain a variety of habitat complexes.

Saluda Hydro IFIM Study

Habitat Type	Description
Riffle	Shallow, with moderate velocity, turbulent, high gradient, moderate to large substrates (cobble/gravel). Typically > 1% gradient.
Glide	Moderately shallow, well-defined non-turbulent laminar flow, transition from low to moderate velocity, lacking a definite ~~well-defined~~ thalweg, typically flat stream geometry, typically finer substrates, transitional from pool.
Run	Moderately deep ~~to deep~~, well-defined non-turbulent laminar flow, range from low to moderate velocity, well-defined thalweg, typically concave stream geometry, varying substrates, gently downstream slope (<1%).
Pool	Deep, low to no velocity, well-defined hydraulic control at outlet.
Rapid/Shoal	Shallow, with moderate to high velocity, turbulent, with chutes and eddies, high gradient, large substrates or bedrock. Typically >2% gradient.
Backwater	Varying depth, no or minimal velocity, off the primary channel flow ~~long backwatered reaches.~~

Catawba Wateree

Habitat Type	Description
Glide	Depending on the strength of the shoal and the bed profile directly upstream of the control, a glide or a pool will be created. A glide is generally defined by slower velocities and a relatively uniform bed profile, but a rough bed profile is not uncommon. Glides will either progress into a more concave bed profile just upstream of the shoal (creating a pool), or maintain their uniform hydraulic and bed features until direct contact with the shoal. Substrates can be large or small but, except at very high flows, do not create turbulence. Due to the slower velocities and increased depths, finer substrates will typically begin to settle in glides.
Run	Immediately downstream of the shoal, there is typically a transition area prior to the water entering the next pool or glide. This unit consists of relatively fast moving, turbulent water and a gradually descending bed profile. When mapping habitat in higher discharges (deeper flow), these areas can be visually identified by an upwelling of water just on the downstream edge of the shoal. This “roiling” effect is created by the sudden drop in water off of the shoal due to the lack of any backwater effect. Substrate composition varies from fine sediments to cobble and boulders. As the water begins to collect and back up further downstream, velocities slow, depths increase, and the transition into a glide or pool occurs.
Pool	If the bed profile upstream of the shoal is more concave or possesses significant undulations, a pool will be formed. Pools are visually represented by the slowest velocities of the four main habitat types and the most extreme depths. Steep banks and narrow channels relative to the rest of the reach can often be associated with pools. The stronger or more defined the downstream control (shoal), the more defined the pool. Substrate composition in pools generally consists of a layer (thick or thin) of finer substrates over boulder or bedrock.
Shoal	Shoals are relatively shallow, submerged ridges that occur with a consistent frequency down the longitudinal profile of the river. Shoals act as downstream controls to pools and glides and create the hydraulic conditions necessary to form runs immediately downstream. Substrate composition in shoals is typically bedrock, boulders, and coarse substrates. The “strength” of each hydraulic control dictates the magnitude to which it influences the upstream habitat types. Each shoal will create a unique situation upstream in which pools, glides or both may be identified.

AFS Aquatic Habitat Assessment Methods (Bain and Stevenson, 1999)

Habitat Type (macrohabitats)	Description
Glide	Nonturbulent, low-moderate velocity; gravel, cobble, sand substrate; slop 0-1%. Wide channel lacking a definite thalweg; usually at the transition between a pool and riffle; no major flow obstructions; lacks features associated with pools; moderately shallow (10-30 cm)
Run	Nonturbulent, swift velocities; gravel, cobble, boulder substrate; low slope. Occurs over a defined thalweg flat plane with a uniform channel form; no major flow obstructions; moderately shallow; deeper than riffles.
Pool	Formed from lateral construction of channel or sharp drop in water surface profile. Features: bend in channel, large-scale obstructions (e.g. boulder, log). Concave in shape; direction of flow varies widely; depth greater than riffle or runs.
Riffle	Moderate turbulence; little to no whitewater; high turbulence at points of channel construction. Moderate velocity (20-50 cm/s). Gravel, pebble, cobble substrates (totally or partially submerged). Slope <4%. Channel profile usually straight to convex.
Rapid	Considerable turbulence and whitewater. High velocity (>50 cm/s). Course, exposed, cobble, gravel substrate. Slope of 4-7%. Steps and pocket pools common; planar longitudinal profile.

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Instream Flows TWC Meeting

March 5, 2014

Final KDM 04-8-14

ATTENDEES:

Bill Marshall (SCDNR)
Ron Ahle (SCDNR)
Gerrit Jobsis (American Rivers)
Shane Boring (Kleinschmidt)
Henry Mealing (Kleinschmidt)
Kelly Miller (Kleinschmidt)
Bill Stangler (Congaree Riverkeeper)
Vivianne Vejdani (SCDNR)
Bill Argentieri (SCE&G)
Milton Quattlebaum (SCANA)
Steve Summer (SCANA)
Brandon Kulik (Kleinschmidt) via conf. call
Dick Christie (SCDNR)
Randy Mahan (SCANA)
Byron Hamstead (USFWS)
Fritz Rhode (NOAA) via conf. call

These notes serve to be a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Henry opened the meeting with introductions and then Shane lead the group in a review of the Mesohabitat Assessment Report. Shane explained the intent of the study and reviewed the results, including an overview of the maps. Ron asked to see an individual breakdown of maps 2a, 2b and 2c and Shane said he will provide these maps to the group.

Bill M. asked if we learned anything new from the study. Shane said that the most restricted point on the river for fish passage and boat navigation was identified. This area is right above the Bookman Shoals complex. This area is identified in the IFIM Study Plan as an area that needs further study. Shane said they also did a survey for Robust Redhorse spawning areas during the mesohabitat study. Two areas were identified including a location right downstream of Parr Shoals Dam and another location upstream of Bookman Shoals. Shane said that Scott Lamprecht agreed that these spots seemed ideal for Robust Redhorse spawning. Milton said he also went out on the river with Scott and they identified another area near the Bookman Shoals complex and Hickory Island. A spot near Haltiwanger Island was also identified. Shane will develop a memo summarizing all of this information on Robust Redhorse spawning sites and will distribute this memo to the group. He will also append the memo to the final IFIM report. Shane will edit the IFIM Study Plan so it mentions that the Robust Redhorse memo will be appended to the final IFIM report.

Shane also said that during the mesohabitat assessment they learned that Bookman Island is very complex with lot of cross channels, braiding and varying elevations. He said that at least seven channels had been identified in the area. Fritz added that seams of bedrock add complexity because they act as weirs, moving the water in different directions depending on flow. He said it is good that 2D modeling will be performed in this area during the IFIM study. Byron asked if the 2D modeling will include the two Robust Redhorse sites identified in the Bookman Island complex and Shane said yes. Shane added that the upstream site at Haltiwanger Island will be studied using PHABSIM along with the site right below Parr Shoals Dam at Hampton Island. Ron said that the area just downstream of the Parr Shoals Dam is good for Robust Redhorse because there seems to be a dike formed by the rock with a gravel bed, covered by deep water. Ron said suckers are often found in this area.

Ron said that the Broad River downstream of Parr Shoals Dam is very complex, and that the maps included in the Mesohabitat Assessment Report are generalized. But he believes they are fairly accurate and that the proportions of the various mesohabitat types found in the river are accurate. Shane agreed and said that sometimes while looking at a cross section of the river, one side of the river may have a run and the other side may have a backwater pool. Shane said this was hard to convey in the maps, but that overall the map delineations and the report are very accurate.

Byron asked if areas of constriction throughout the river have been mapped out. Shane said GPS points have been taken and can be provided to the group, but cross sections detailing depth and other information has not been mapped out yet and will be completed as part of the IFIM study. Shane showed the group, using Bing maps, two areas in the river where fish passage and navigation may be possible. These areas will be studied in more detail during the IFIM study.

The group began reviewing the IFIM Study Plan and Shane mentioned that the Mesohabitat Assessment Report will be added as an appendix to the final IFIM Report. Byron wanted to know how the information collected in the IFIM study would be used for determining suitable crayfish habitat. Will the amount and type of cover available at various depths be examined? Henry said this will not be done using PHABSIM, but this information can be collected as part of the general description of the study area. Gerrit asked if when determining cover types, isn't it typical to not only look at the transect, but upstream as well? Brandon said yes because at the upstream/ downstream cell boundary level, the area is reasonably homogenous but within the cross section localized substrate variations can be like a mosaic, so it is typical to look upstream and downstream a reasonable distance to characterize the substrates assigned to a particular vertical. Brandon said that in regards to crayfish, the group can establish what the important cover types are for a particular species beforehand so that the field crews know what to look for during data collection. Byron said he will do some additional research to identify the preferred covers for the spiny crayfish. He is interested in determining how much cover is available and how much is exposed at varying water levels. Henry said that this may be possible with rocky substrates since they are fairly permanent, but that the abundance and distribution of woody debris can change from year to year so only general qualitative observations can be made. Henry said that if large woody debris is located at a PHABSIM transect, it will be surveyed in depth, otherwise just general descriptions of what is located upstream and downstream will be recorded to characterize conditions and where it is located relative to water levels. Brandon said that photos and possibly videos will also be taken to document the substrate and cover types in the area. If Byron develops a specific list of the type of substrate and cover that is important for crayfish, including a description of the types of woody debris preferred (approximate size and position in the water column), it will make it easier to document these during the study. Brandon said they can look at what is exposed during low flows and also record how high flows mobilize these substrates. Ron said that in his experience the large woody debris found in the central portion of the river is usually located in areas of accumulating sand and is typically transient and moving. All other woody debris tends to be found along the shorelines. Byron said that the wetted perimeter study will provide a lot of information on the woody debris found throughout the river. He will determine what the specific habitat requirements are for the spiny crayfish, an at risk species which is currently under candidate review, and provide these to the group prior to the IFIM study.

In section 3.2.2 of the IFIM Study Plan, Shane added in a description of the downstream ledge which may be a possible navigation site.

Bill S. asked why the river directionality is positioned looking upstream. Shane said that it just depends on how the biologist is trained. The group agrees to change all direction references to looking downstream.

Prior to the meeting, Gerrit submitted a comment regarding the inclusion of a Dual Flow analysis (DFA) into the IFIM Study Plan. Brandon explained to the group what a DFA is and his description is attached to the end of these notes. He said the goal of a DFA is to assess Project generating flows and how various operating scenarios affect habitat suitability. Base flow and generating flow couplets of interest are identified, along with selection of key species and lifestages. Effectively available habitat for a particular study site is calculated at pair of stream flows. A comparison of the amount of units of WUA available at the base flow versus the units of WUA at the generating flow is completed. DFA only records WUA corresponding to the lower of the two paired values regardless of whether the lower WUA occurs at the low or high flow. The assumption is that the lower WUA value represents the level of suitability persisting under both conditions For example, if the habitat value is zero at the low or high flow, then the value for that pairing is zero. Shane said this can be done as a desktop exercise and doesn't require any extra field effort however a basic PHABSIM analysis must be completed and reviewed first since this step establishes the quantification basis.

Gerrit said DFA can also be done to mitigate the effects of peak flows by changing the base flow. He said you can iteratively move the base flow up or peak flow down to mitigate and lessen the affect on habitat to assess different operating scenarios. The idea is that if the higher the habitat suitability is a majority of the time, then the episodes of lower habitat suitability are less stressful to the aquatic species . Bill A. asked if base flows would be changed during certain times of the day or seasonally. Gerrit said this is a seasonal change. Brandon said spatially peaking effects attenuate going downstream so that the effect is most pronounced nearest the tailrace. The group would have to decide if the analysis should focus on the upstream reaches of the river or the downstream reaches.

The group decided that the study plan needs to include information on process steps regarding the DFA. The TWC will review initial WUA output and then meet to determine the DFA scope. No additional field work will be needed. Shane will add a few paragraphs to the IFIM Study Plan describing the DFA process. Kelly will send these paragraphs out to the TWC for review and comment.

Other additions to the IFIM Study Plan include mentioning the Robust Redhorse memo, adding in crayfish habitat suitability information (provided by Byron) and adding wording on the identification of substrates for crayfish during the IFIM study. Ron mentioned he would like to see a more specific schedule for when the IFIM study will take place because he would like to help. He would like to see the schedule already included in the IFIM Study Plan expanded to include more specifics. He would also like to see qualifiers added in to account for bad weather or flows that might inhibit data collection.   All of these changes will be made to the study plan in track changes and sent out to the TWC for review and approval.

Dick asked the group if they want to specify the goals of the analyses in the study plan. For example, SCDNR's recommendation is to identify a minimum flow that would provide 80 percent of maximum WUA. The group decided to add a list or table outlining the process of the study, which will include an expanded section on TWC consultation.

Gerrit asked if there will be demonstration flows scheduled following the results of the IFIM study regarding navigation and fish passage. Bill A. said that there can be demonstration flows and Shane will add this into the process schedule.

Dick mentioned the navigation component of the IFIM Study Plan and said that it was not consistent with the Navigational Flows Study Plan, which is discussed in the Recreation TWC. The Navigational Flows Study Plan needs to be changed to include a description of the two-way navigation requirement. This study will still only focus on one way navigation, but a description of two-way navigation needs to be included. This study plan will be re-circulated to the Recreation TWC for approval and then finalized.

Shane then gave the group an overview of the 2014 field season efforts for the IFIM study. Level loggers will be deployed in late March or early April in 12 different locations from the Parr Shoals Dam to the Columbia Dam pool, near the rowing facility. Level logger data is being collected to examine travel time for flows and to develop stage discharge relationships. Additionally, 2-D data collection will be completed in the Bookman Shoals area (Study Site 10), which includes latitude, longitude and elevation data for the entire two mile study area. At Study Site 1, a terrain model for quantifying pools and fish passage will be created. Cross sectional profiles including bed elevations and water surface elevations will also be collected at Study Site 4. Bill S. asked how many points will be examined at Study Site 10. Shane said he isn't sure yet, but it will be a good idea to look at existing LiDAR data and DEM data to make sure they establish an adequate number of points. This should give clarity to the density of points needed for the model. Densities could be as tight at every three meters. Shane said that the TWC is welcome to help with these efforts this year as well. Emails will be sent to the group to notify them as soon as possible when the work will be done.

The IFIM Study Plan will be updated to reflect the items discussed at the meeting and sent back out to the TWC for approval. Action items stemming from this meeting are listed below.

ACTION ITEMS:

- Byron will identify the preferred habitat substrates for the spiny crayfish and provide this information to the group for use during the IFIM study.

- Shane will change the language in the IFIM Study Plan to reflect a "looking downstream" perspective.

- Shane will add in a section describing the process steps of the IFIM study with an expanded section on TWC consultation. He will also expand the schedule to include more specific dates and times which will include demonstration flows if possible. He will also add qualifiers to account for bad weather or flows that might inhibit data collection.

- Shane will add in a section to the IFIM Study Plan discussing Dual Flow Analysis. He will also add in a few sentences discussing the information collection on Robust Redhorse spawning areas. Additionally, once Byron provides the information regarding preferred spiny crayfish habitat substrates, Shane will include this in the IFIM Study Plan.

- Kleinschmidt will update the Navigational Flows Study Plan with information on two-way navigation and redistribute to the Recreation TWC.

DUAL FLOW ANALYSIS

- The basic WUA/flow relationship is the foundation
- Base flow/generating flow couplets of interest are identified
- Key species/lifestages (or guilds) are strategically selected
- Effectively available habitat for a study site[1] is calculated at pairs of stream flows: (base) non-peaking and a (generation) peaking flow.
- Dual Flow analysis only records WUA corresponding to the lower (*"effectively available"*) of the two paired values. If the habitat value is zero at either the low or high flow, then the value for that pairing is zero.
-

Example:

basic WUA/flow relationship (*example from Chippewa River, WI*):

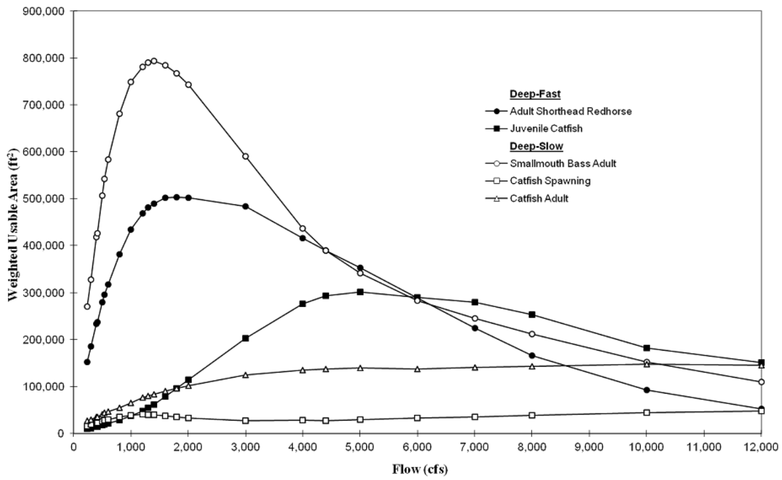
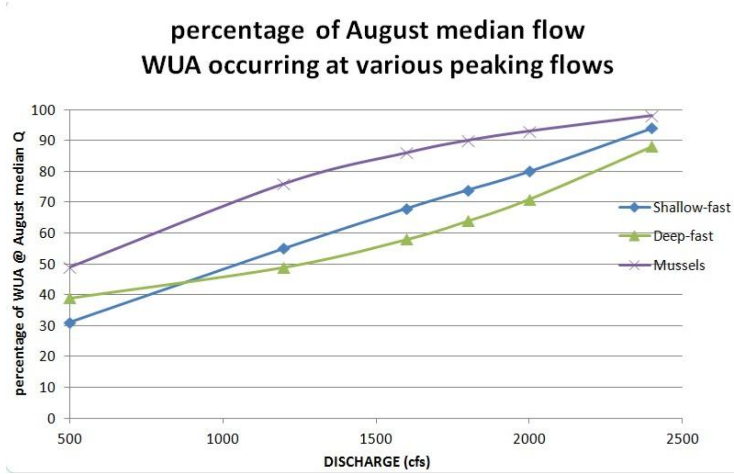


Figure 4. Habitat-discharge relations for fishes in Deep-Fast and Deep-Slow habitat guilds within the Cornell Project instream flow study area.

Effective Habitat WUA of generation vs. base flow condition plotted



[1] For non-mobile life stages such as macroinvertebrates or nest spawning, calculations can optionally be performed at the cell level using the "HABEF" routine in PHABSIM

APPENDIX B

ROBUST REDHORSE SPAWNING HABITAT MEMORANDUM

MEMORANDUM

TO: Parr/Fairfield Hydro Relicensing Fisheries and Instream Flow TWC

FROM: Shane Boring and Milton Quattlebaum

DATE: April 29, 2014

RE: Robust Redhorse Spawning Areas

An assessment of spawning habitat for robust redhorse (*Moxostoma robustum*) was requested by stakeholders during the study scoping phase of relicensing. Stakeholders agreed that a qualitative assessment of the Instream Flow Incremental Methodology (IFIM) study reach downstream of Parr Shoals Dam would be conducted concurrently with the mesohabitat assessment and other field efforts during the fall of 2013 and winter of 2014. This memorandum summarizes the assessment results.

Methods

The reach of the Broad River extending from Parr Shoals through the Bookman Island complex was observed by biologists (Milton Quattlebaum (SCANA), Ron Ahle (South Carolina Department of Natural Resources), and Shane Boring (Kleinschmidt Associates)) in October and November 2013 during the mesohabitat assessment conducted in support of the proposed IFIM Study. A follow up visit was made by Quattlebaum and Scott Lamprecht (South Carolina Department of Natural Resources) in February 2014. During the assessment, the group utilized published habitat suitability criteria to identify areas along the river reach they believed were potential robust redhorse (RRH) spawning sites. According to Freeman and Freeman (2001), RRH spawning habitat is characterized as being mid-channel gravel bars dominated by medium to coarse gravel with less that 30% sand and minimal fine particles. Spawning sites are also characterized as containing gravel small enough to be moved for egg deposition, but large enough to offer interstitial space for the eggs. Water depths are typically between 1 and 3.6 feet, with an average water column velocity of 0.85 to 2.20 ft/s. Sites encountered during the assessment that appeared to display these characteristics were noted on the field datasheets, their locations were documented with Global Positioning System (GPS), and in some instances, the sites were photographed.

Results

Four potential RRH spawning sites were examined during the assessment. The upstream-most site is located in the tailrace of the Parr development powerhouse within IFIM Study Site 3 (Figure 1). Fisheries Technical Working Committee (TWC) members have noted that RRH activity is well documented at that site, including observed potential spawning behavior. Three new sites were located during the assessment: one just upstream of Haltiwanger Island and two in the Bookman Shoals complex (IFIM Study Site 10) in the vicinity of Hickory Island (Figure 2). Results of PHABSIM and 2-D modeling conducted as part of the IFIM study will develop weighted usable area (WUA) estimates of spawning habitat under various flow scenarios, which will be taken into consideration by the TWC in developing a downstream flow recommendation that is best for multiple species, including RRH spawning.

FIGURES

FIGURE 1 POTENTIAL ROBUST REDHORSE SPAWNING AREA DOWNSTREAM OF PARR DAM

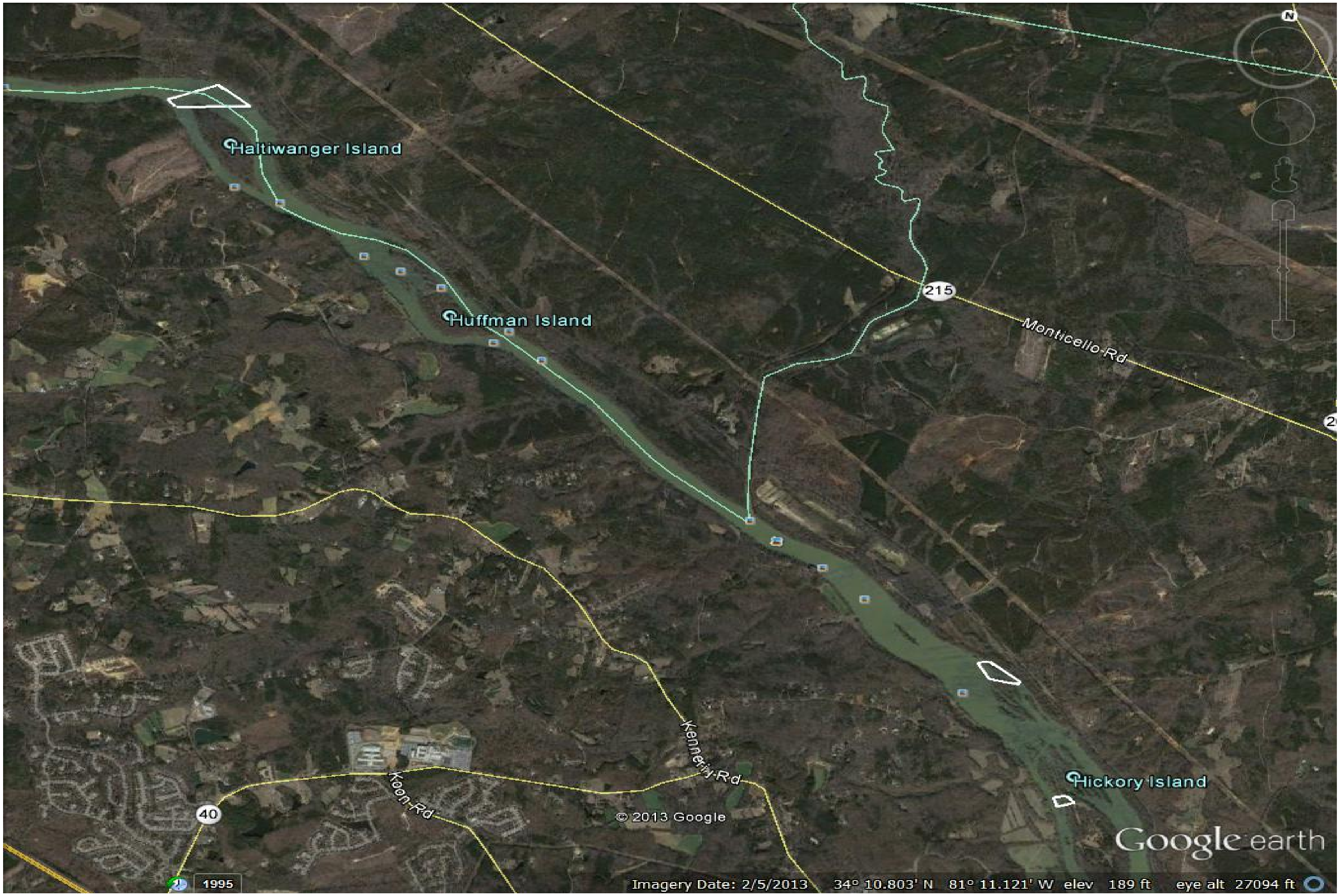


FIGURE 2 POTENTIAL ROBUST REDHORSE SPAWNING SITE AT HALTIWANGER ISLAND AND IN BOOKMAN SHOALS COMPLEX

APPENDIX C

PROVISIONAL HABITAT SUITABILITY CURVES FOR TARGET SPECIES/GUILDS

DRAFT MEMORANDUM

TO: Parr-Fairfield Hydro: Instream Flow/Aquatic Habitat TWC

FROM: Brandon Kulik

DATE: July 9, 2013

RE: **PROPOSED HABITAT SUITABILITY CRITERIA**

On May 7, 2013, the Instream Flow/Aquatic Habitat Technical Working Committee (TWC) agreed upon species and lifestages for which habitat suitability should be evaluated on the Broad River below the Parr-Fairfield Project as a part of AN IFIM study (Table 1).

TABLE 1 EVALUATION SPECIES ELECTED BY THE TWC

- Smallmouth Bass
- American Shad
- Brassy Jumprock
- Whitefin Shiner
- Robust Redhorse
- Santee Chub
- Striped Bass
- Piedmont Darter
- Snail Bullhead
- Redbreast Sunfish
- Channel Catfish

The purpose of this memo is to recommend potential Habitat Suitability Criteria (HSC) for use in this study that are applicable to the above species. Smallmouth bass and redbreast sunfish criteria were sourced from the Saluda study, as the TWC has already vetted these curves. Although the Saluda study had employed TWC-approved American shad HSC, these criteria have recently been refined, based on the research of Joe Hightower in North Carolina (Hightower, *et. al*, 2012) and provided to us by NOAA Fisheries. We propose that the TWC consider using these updated criteria.

The remaining species do not have well developed, individual HSC. However, the Pee Dee IFIM study addressed habitat suitability for these species by classifying each of them into applicable guilds. This information was provided to the Saluda IFIM TWC during study scoping (Gerrit Jobsis, October 16, 2006). Based this information (Table 2), we classified the remaining Parr-Fairfield evaluation species and lifestages into proposed guild categories (Table 3) Attachment A displays the coordinates for the resulting HSC proposed for use, based on the source material identified in Table 3.

Kleinschmidt

TABLE 2 GUILD CLASSIFICATION FOR INDIVIDUAL SPECIES AND LIFESTAGES, FROM PEE DEE RIVER IFIM STUDY (2004)

Species and Habitat Guild Assignment Table for the Pee Dee River Instream Flow Study. Revision 2 - July 9, 2004.

Scientific Name	Common Name	Habitat Types and Guilds[1, 2, 3] Shallow Slow	Shallow Fast	Deep Slow	Deep Fast
Petromyzontidae	**Lampreys**				
Petromyzon marinus	sea lamprey		A		
Acipenseridae	**Sturgeons**				
Acipenser oxyrinchus	Atlantic sturgeon				S
Acipenser brevirostrum	shortnose sturgeon				S
Lepisostedidae	**Gars**				
Lepisosteus osseus	longnose gar	A, J		A, J, S	
Amidae	**Bowfin**				
Amia calva	bowfin			A, S	
Anguillidae	**Freshwater eels**				
Anguilla rotstrata	American eel	J		A, J	J
Clupeidae	**Herrings**				
Dorosoma cepidanum	gizzard shad	A, J		A, J, S	
Dorosoma petenense	threadfin shad	A, J		A, J, S	
Alosa mediocris	hickory shad			J, S	
Alosa sapidissima	American shad			J	J, S
Alosa aestivalis	blueback herring			J, S	
Cyprinidae	**Carps and Minnows**				
Cyprinus carpio	common carp	J, S		A, J, S	
Notemigonus crysoleucas	golden shiner	A, J, S		A, J, S	
Hybognathus regius	Eastern silvery minnow	J, S		A, J, S	
Nocomis leptocephalus	bluehead chub		A, S		
Cyprinella analostana	satinfin shiner	A, J, S		A, J, S	
Cyprinella nivea	whitefin shiner	A, J	S	A	
Cyprinella pyrrhomelas	fieryblack shiner	A, J	S	A	
Notropis altipinnis	highfin shiner	J, S		A	
Notropis amoenus	comely shiner	A, J	S	A, J	
Notropis hudsonius	spottail shiner	A, J	S	A, J	
Notropis petersoni	coastal shiner	A, J	S	A	
Notropis scepticus	sandbar shiner	A, J	S	A	
Catostomidae	**Suckers**				
Catostomus commersoni	white sucker	J	S	A, J	A
Minytrema melanops	spotted sucker	J	S	A	
Scartomyzon spp.	brassy jumprock	J	S	A	A
Moxostoma macrolepidotum	shorthead redhorse	J	S	A	A[4]
Moxostoma anisurum	silver redhorse	J	S	A, J	
Moxostoma robustum	robust redhorse		S	A, J	
Moxostoma sp.	Carolina redhorse		S	A, J	
Carpiodes cyprinus	quillback		S	A	S
Erimyzon oblongus	creek chubsucker	S?		A, J, S?	
Carpiodes velifer	highfin carpsucker		S	A	S
Ictiobus bubalus	smallmouth buffalo	J	A	A, S	A
Ictiobus cyprinellus	bigmouth buffalo			A	

TABLE 2 *CONTINUED*

Scientific Name	Common Name	Habitat Types and Guilds[1, 2, 3]			
		Shallow Slow	Shallow Fast	Deep Slow	Deep Fast
Ictaluridae	**Bullhead catfishes**				
Ictalurus punctatus	channel catfish			A, J	J
Ictalurus furcatus	blue catfish			A, S	A
Ameiurus catus	white catfish			A	A, J
Ameiurus brunneus	snail bullhead			A	
Ameiurus nebulosus	brown bullhead			A	
Ameiurus platycephalus	flat bullhead			A	
Pylodictus olivaris	flathead catfish	J		A, J, S	
Esocidae	**Pikes**				
Esox americanus americanu	redfin pickerel			A, J, S	
Esox niger	chain pickerel			A, J, S	
Umbridae	**Mudminnows**				
Umbra pygmaea	Eastern mudminnow			A, J, S	
Poeciliidae	**Livebearers**				
Gambusia holbrooki	Eastern mosquitofish			A, J, S	
Aphredoderidae	**Pirate perches**				
Aphredoderus saynus	pirate perch			A	
Atherinidae	**Silversides**				
Labidesthes sicculus	brook silverside			A	
Percichthyidae	**Temperate basses**				
Morone americana	white perch	J	S	A, J	S
Morone chrysops	white bass	J	S	A, J	S
Morone saxatilis	striped bass				A, S
Centrarchidae	**Sunfishes**				
Lepomis auritus	redbreast sunfish	J, S		A, J, S	
Lepomis cyanellus	green sunfish			A, J, S	
Lepomis gibbosus	pumpkinseed	J, S		A, J, S	
Lepomis macrochirus	bluegill	J, S		A, J, S	
Lepomis microlophus	redear sunfish			A, J, S	
Lepomis punctatus	spotted sunfish			A, J, S	
Micropterus salmoides	largemouth bass	J, S		A, J, S	
Pomoxis nigromaculatus	black crappie			A, J, S	
Percidae	**Perches**				
Etheostoma olmstedi	tessellated darter	A, J	S	A	
Percina crassus	Piedmont darter		A, S		
Perca flavescens	yellow perch			A, J, S	

[1]Habitat types based on predominant habitat types present in the Pee Dee River derived from the aerial videography study.

[2]Life stages: A = adult, J = juvenile, including young-of-year, and S = spawning.

[3]Classification of species and life stages into habitat types based on Becker (1983), Hamilton and Nelson (1984), Aadland et al. (1991), Jenkins and Burkhead (1994), Rhode et al. (1994), Leonard and Dilts (2003), and Progress Energy (2003).

[4]Foraging adults based on Jenkins and Berkhead (1994).

TABLE 3 PROPOSED HSC SOURCE DATA FOR PARR-FAIRFIELD IFIM STUDY

SPECIES CRITERIA	LIFESTAGE	SOURCE	GUILD
Smallmouth Bass	all	Saluda	N/A
American Shad	spawning	Hightower, *et al.*, 2012	N/A
Brassy Jumprock	adult	Pee Dee River IFIM	deep slow
Brassy Jumprock	juvenile	Pee Dee River IFIM	shallow slow
Brassy Jumprock	spawning	Pee Dee River IFIM	shallow fast
Whitefin Shiner	adult	Pee Dee River IFIM	shallow slow; deep slow
Whitefin Shiner	juvenile	Pee Dee River IFIM	shallow slow
Whitefin Shiner	spawning	Pee Dee River IFIM	shallow fast
Robust Redhorse	adult	Pee Dee River IFIM	deep slow
Robust Redhorse	juvenile	Pee Dee River IFIM	deep slow
Robust Redhorse	spawning	Pee Dee River IFIM	shallow fast
Santee Chub	adult	Pee Dee River IFIM	shallow fast
Striped Bass	adult	Pee Dee River IFIM	deep fast
Piedmont Darter	adult	Pee Dee River IFIM	shallow fast
Piedmont Darter	spawning	Pee Dee River IFIM	shallow fast
Snail Bullhead	adult	Pee Dee River IFIM	deep slow
Redbreast Sunfish	adult	Saluda	N/A
Channel Catfish	adult	Pee Dee River IFIM	deep slow
Channel Catfish	juvenile	Pee Dee River IFIM	deep slow; deep fast

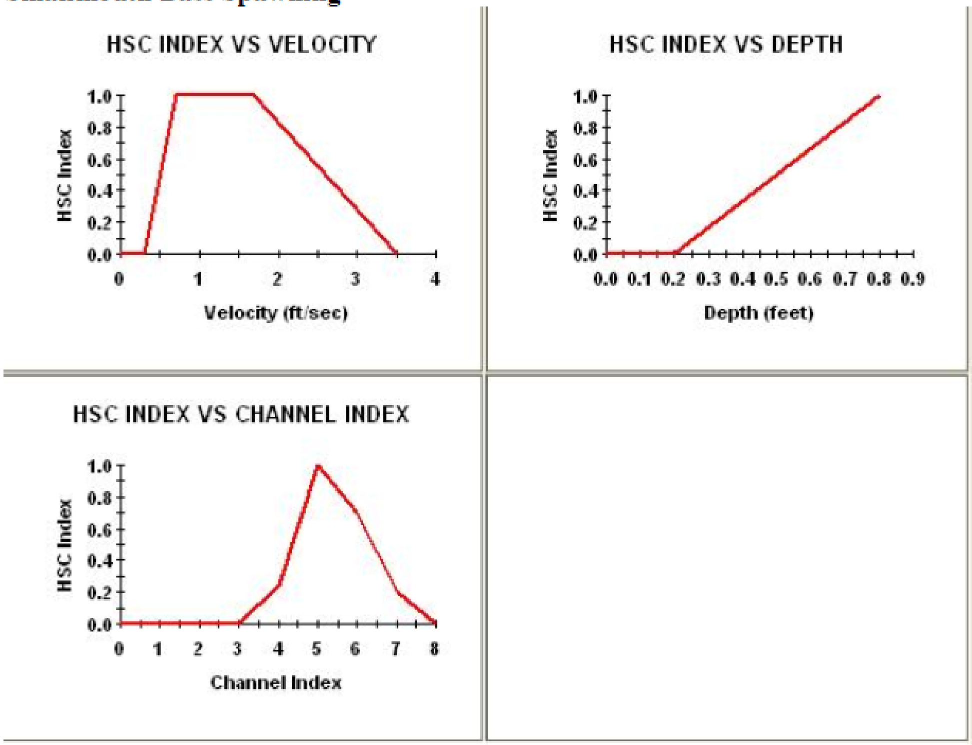
LITERATURE CITED

Hightower JE, Harris JE, Raabe JK, Brownell P, Drew CA. 2012. A Bayesian spawning habitat suitability model for American shad in southeastern United States rivers. Journal of Fish and Wildlife Management 3(2):184–198; e1944-687X. doi: 10.3996/082011-JFWM-047

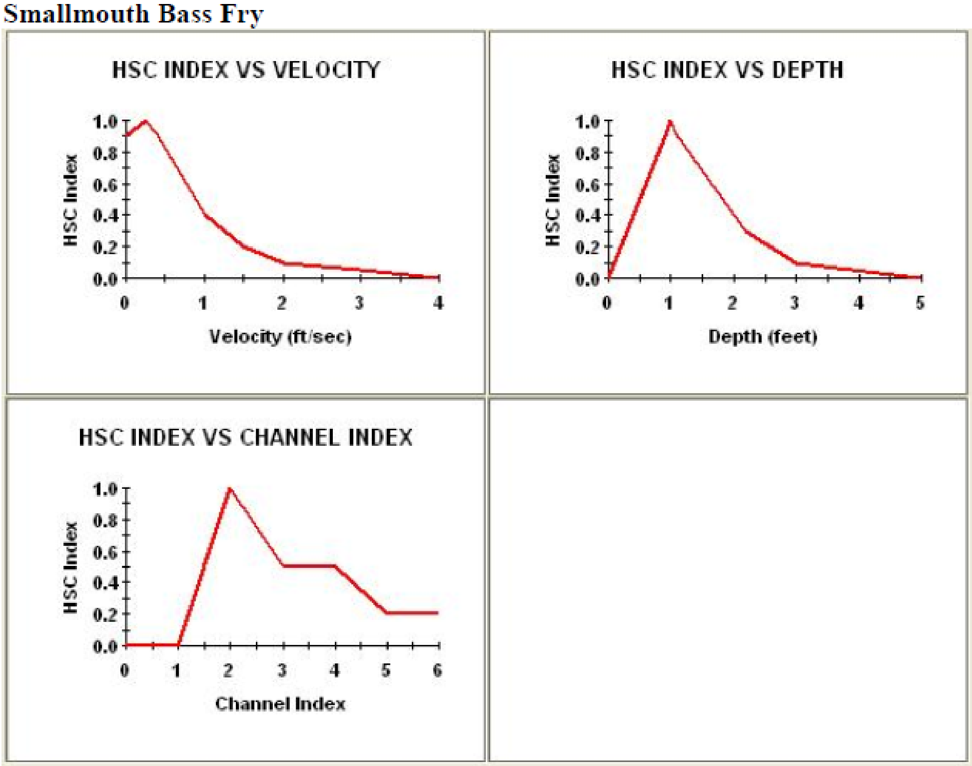
ATTACHMENT A

HABITAT SUITABILITY CRITERIA

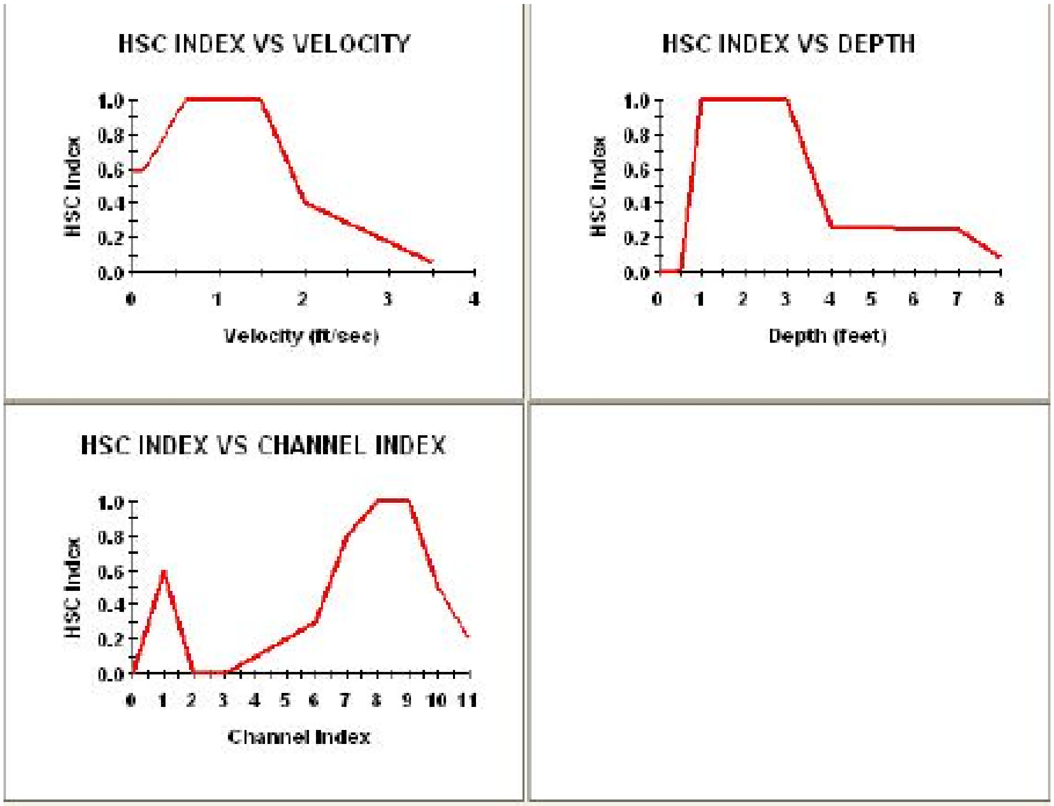
Smallmouth Bass Spawning



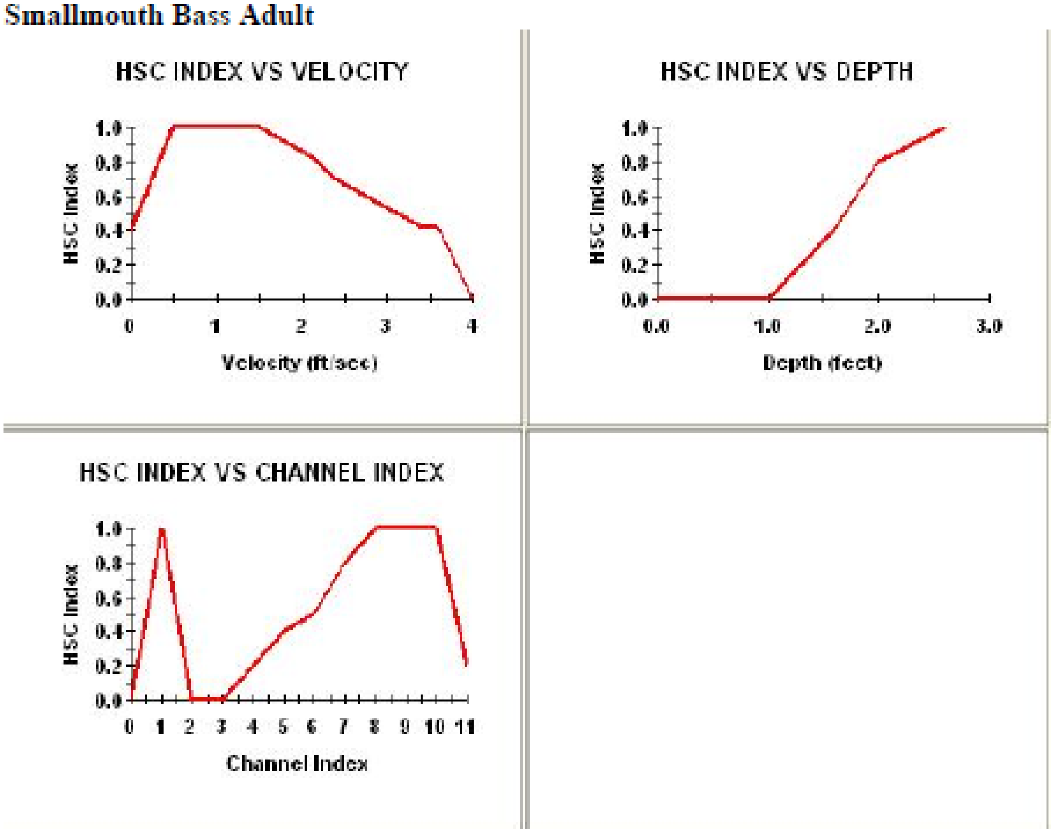
Smallmouth Bass Fry



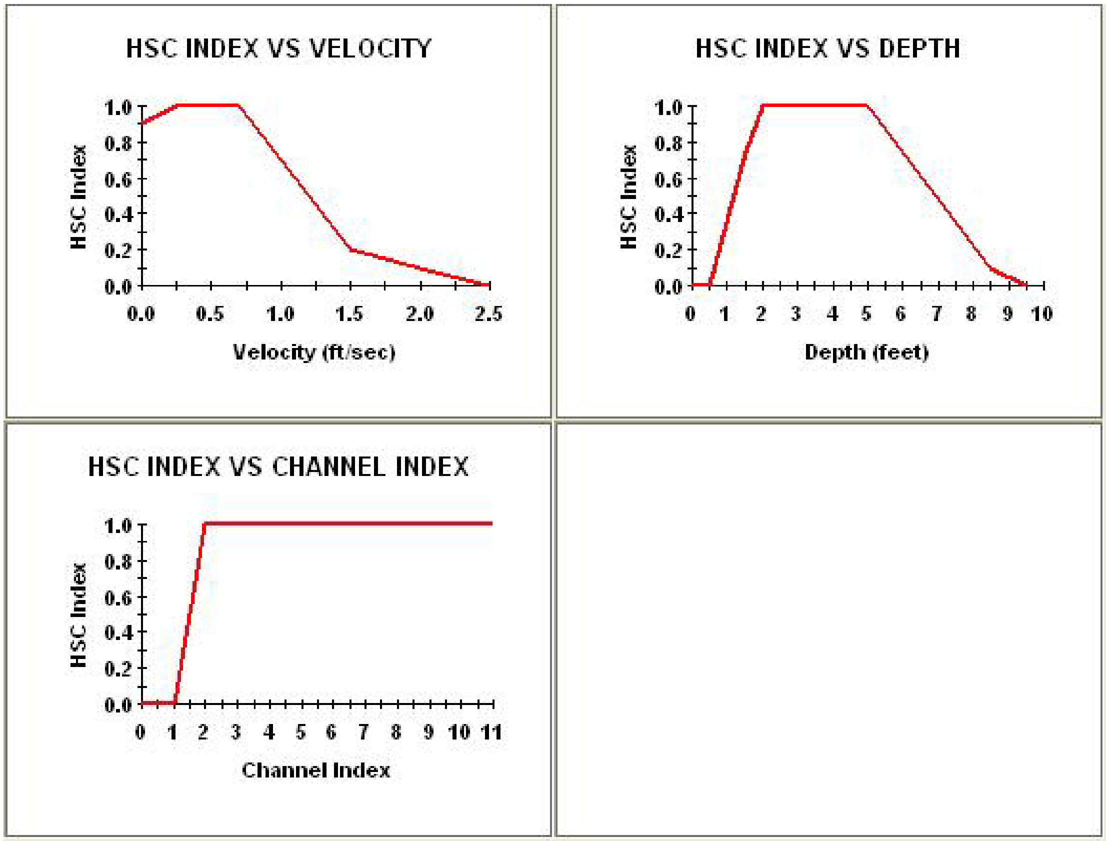
Smallmouth Bass Juvenile



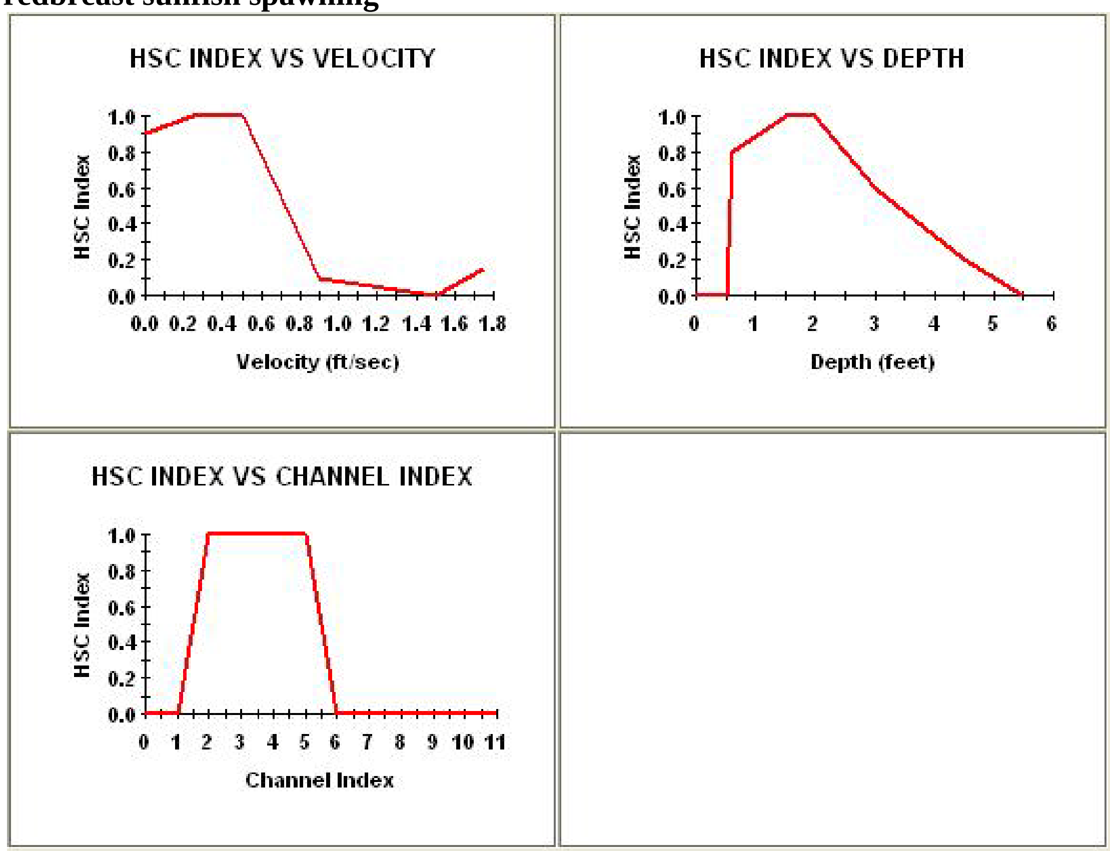
Smallmouth Bass Adult



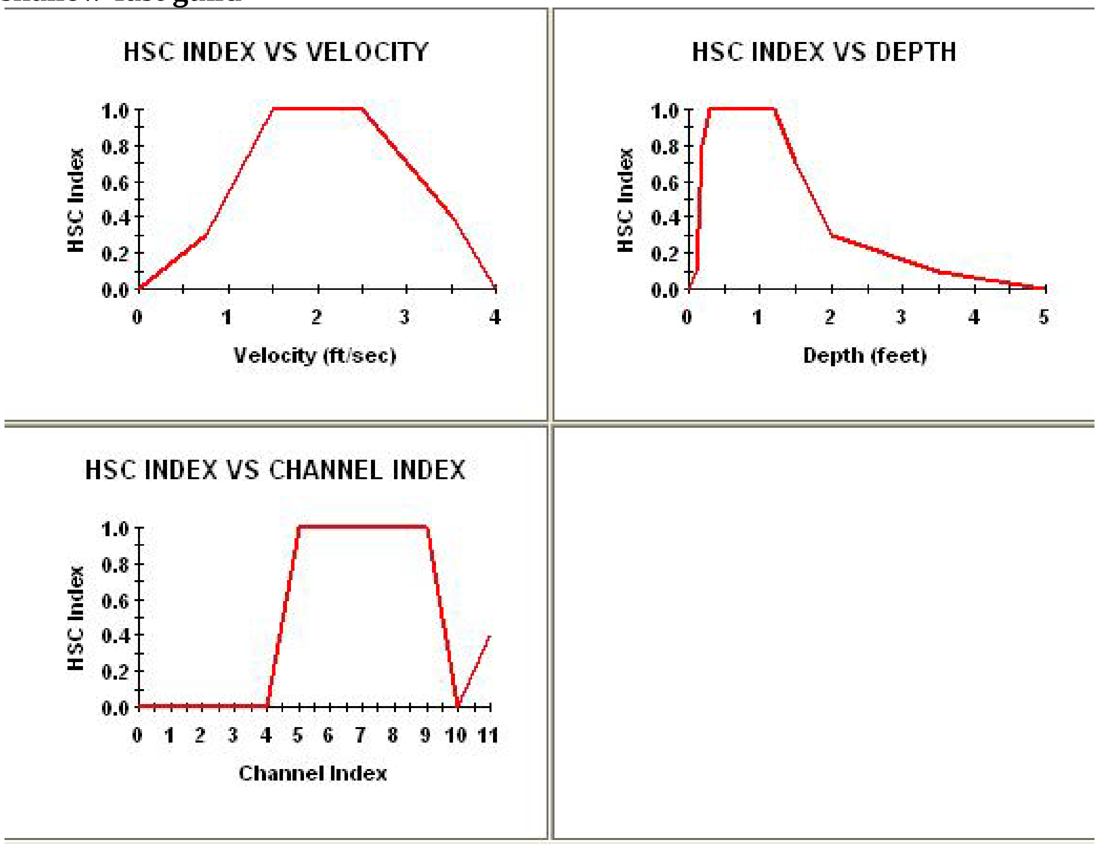
redbreast sunfish adult



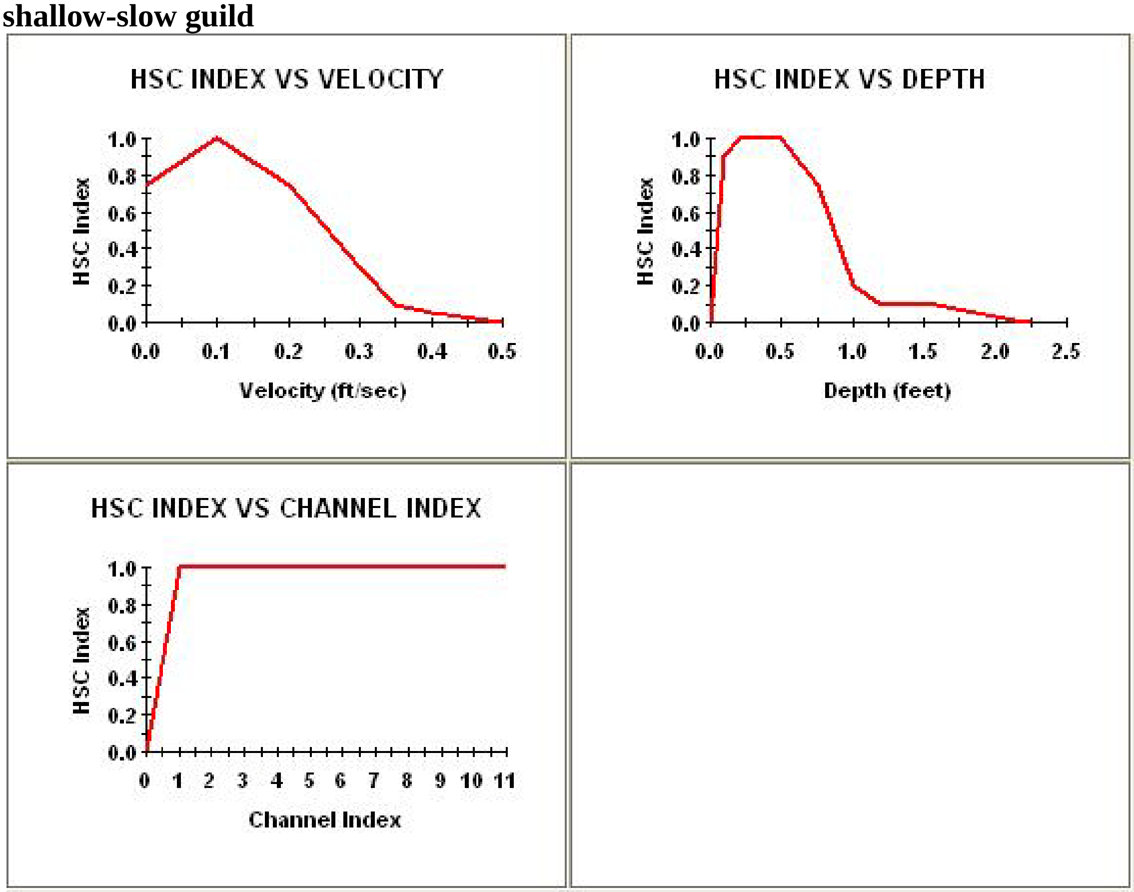
redbreast sunfish spawning



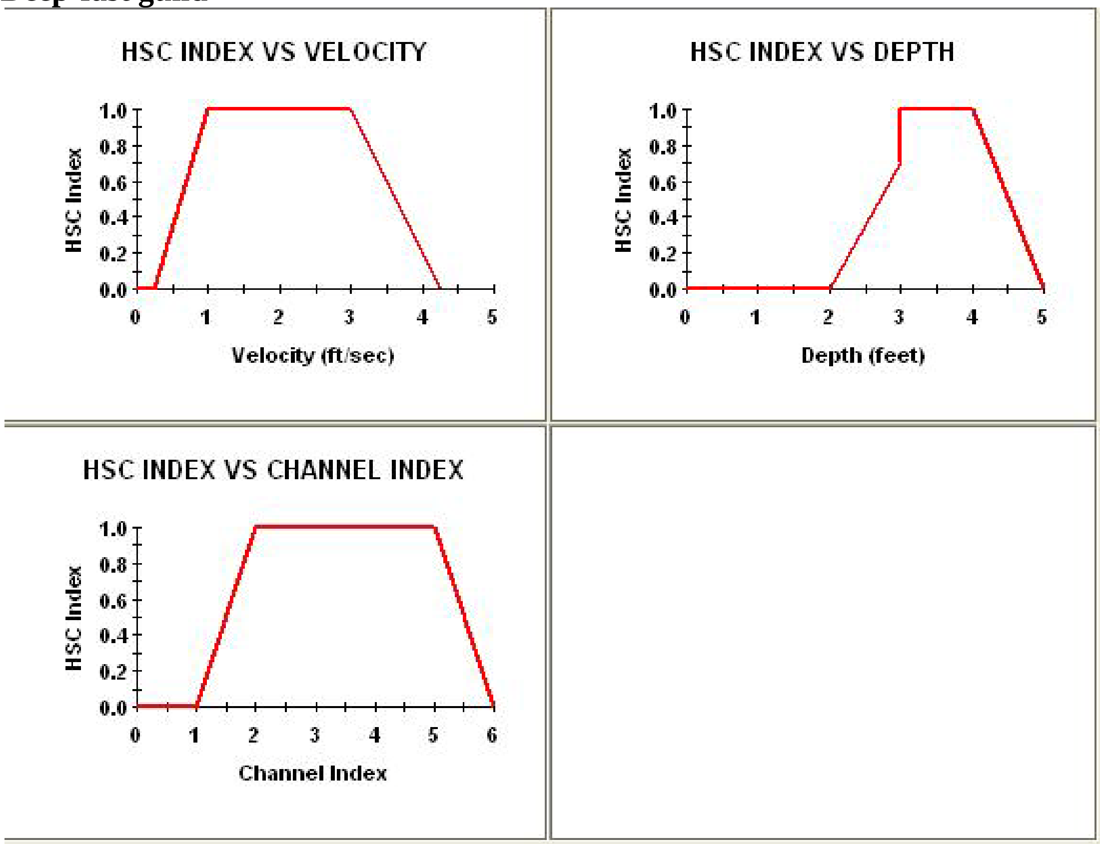
shallow-fast guild



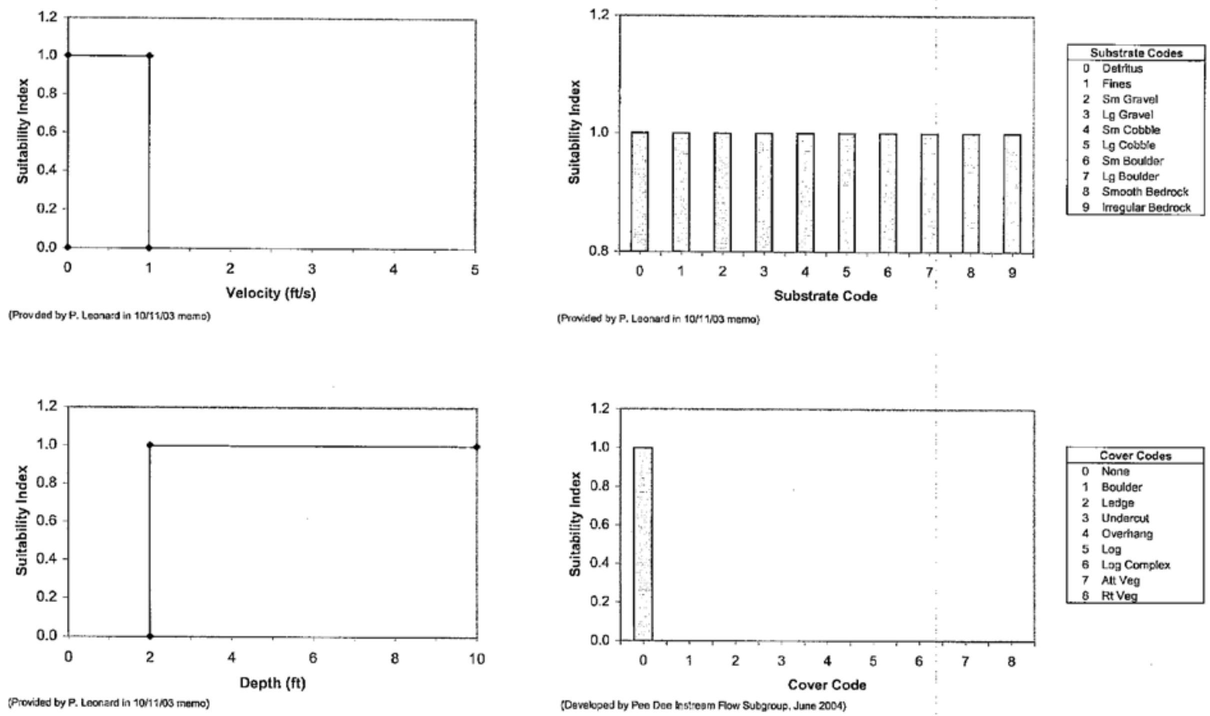
shallow-slow guild



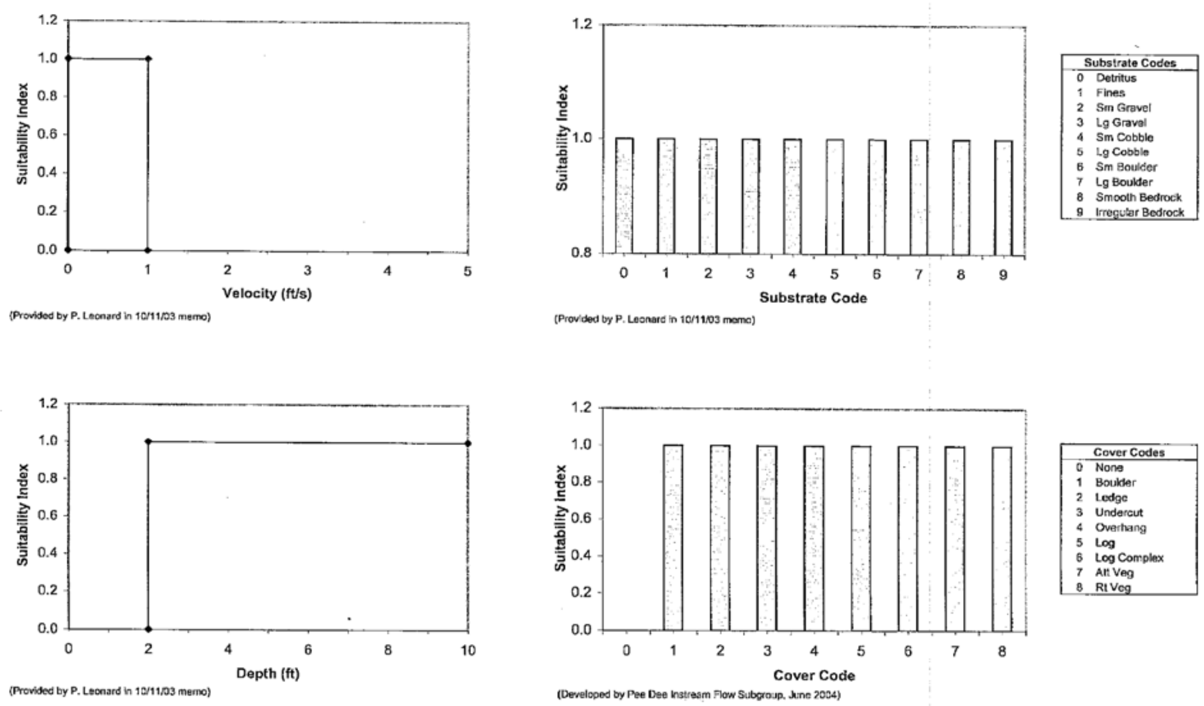
Deep-fast guild



Deep Slow Guild, No Cover
Generic guild habitat suitability



Deep Slow Guild, Cover
Generic guild habitat suitability



American Shad Spawning (*Hightower, et al., 2012).*

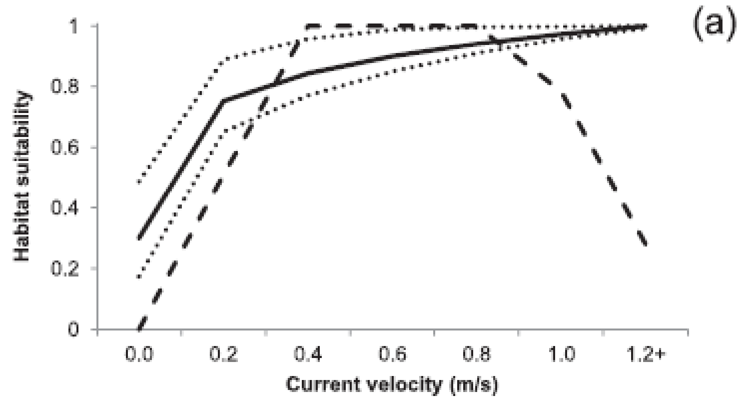


Figure 5. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for current velocity (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b**) data on habitat use vs. availability, by 0.2-m/s velocity bin. The dashed line shows the suitability curve developed by Stier and Crance (1985).

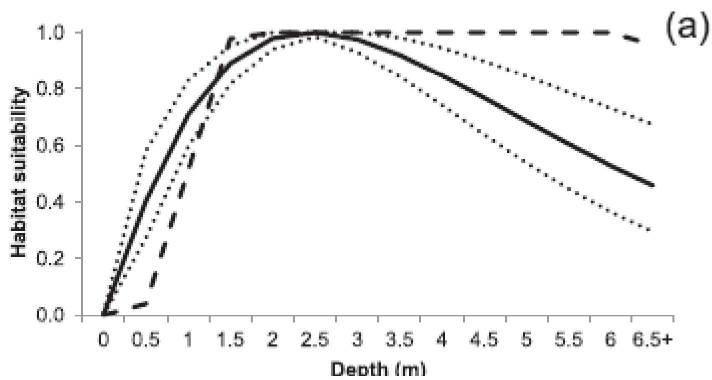


Figure 6. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for water depth in m (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b**) data on habitat use vs. availability, by 0.5-m depth bin. The dashed line shows the suitability curve developed by Stier and Crance (1985).

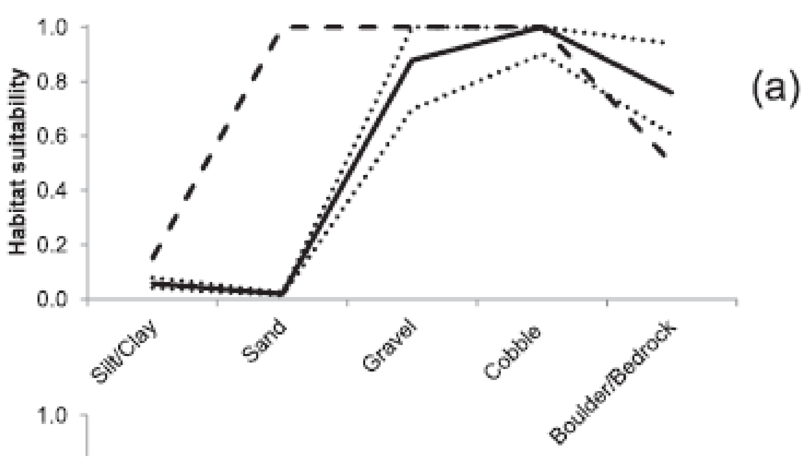


Figure 7. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for substrate (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b** and **c**) data on habitat use vs. availability, by substrate category. The dashed line shows the suitability curve developed by Stier and Crance (1985), using averages for combined categories (silt/clay, boulder/bedrock).

MEMORANDUM

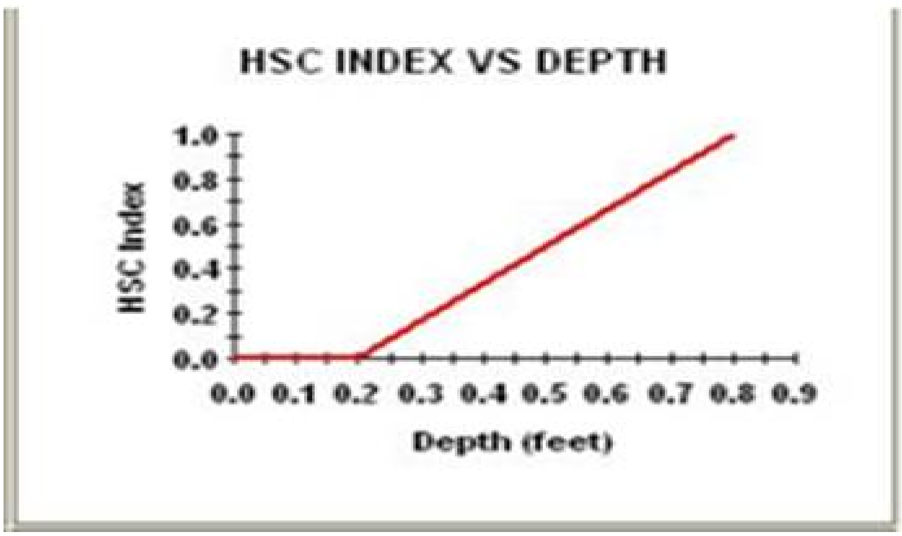
TO: Parr-Fairfield Hydro: Instream Flow/Aquatic Habitat TWC

FROM: Shane Boring

DATE: October 10, 2013

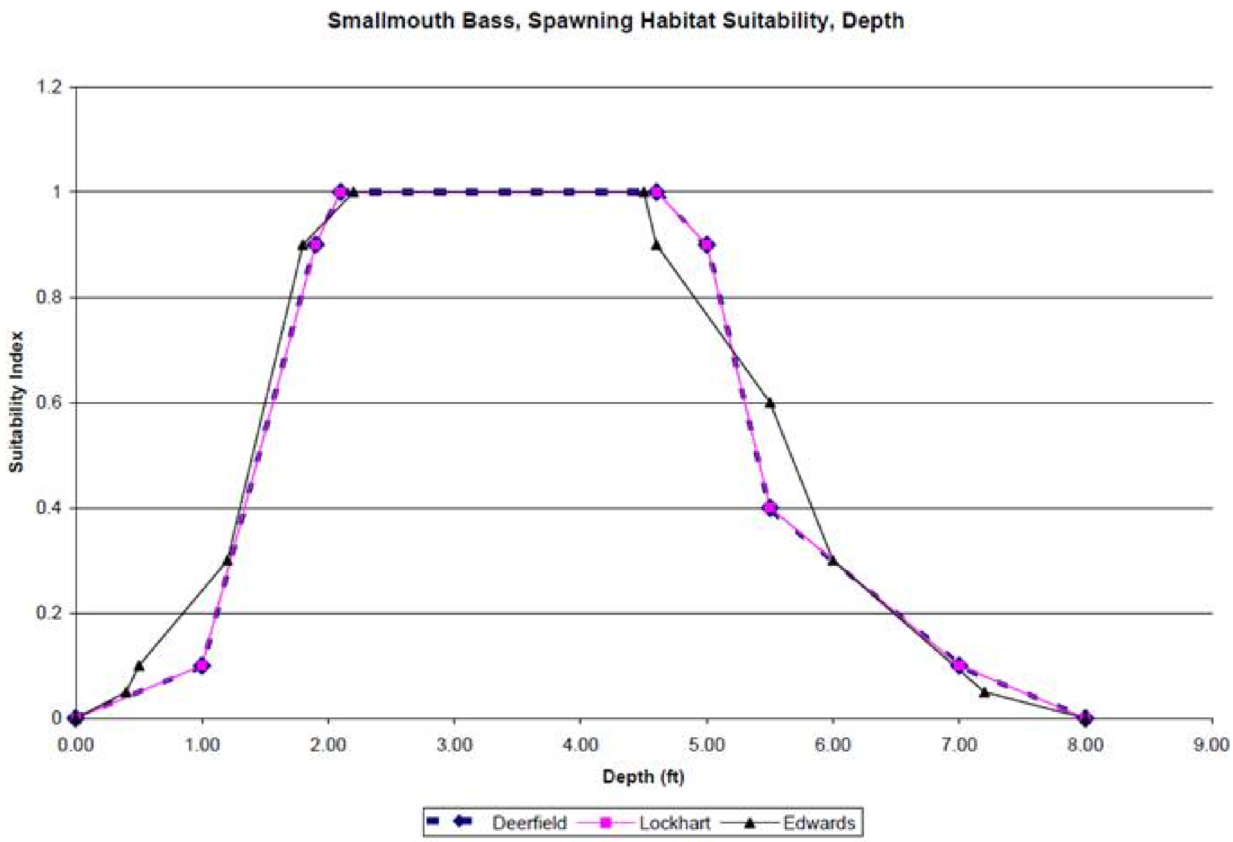
RE: **DEPTH HABITAT SUITABILITY FOR SMALLMOUTH BASS**

At the July 31, 2013, meeting of the Fisheries Technical Working Committee (TWC), Kleinschmidt presented a memo containing provisional Habitat Suitability Criteria (HSC) for target species (Memo from Brandon Kulik, dated July 9, 2013). The following curve for smallmouth bass spawning HSC index versus depth prompted some discussion, as many of the group stated that it was not reflective of their understanding of smallmouth spawning depth requirements:



There was agreement among the group that a more suitable curve would likely be a "stairstep" with habitat suitability picking up around 0.5 ft, peaking at around 2 ft and beginning to decline around 4.5 ft (the group developed a rough sketch of the curve during the meeting).

Kleinschmidt was subsequently tasked with identifying a curve more reflective of the groups understanding of SMB requirements. To that end, we recommend that the following smallmouth bass depth HSC curve developed for the Deerfield River, MA (NEP, 1990), and later used for the Lockhart Hydro instream flow study (Figure 2), be adopted in lieu of the curve cited in the original memorandum. The Lockhart/Deerfield curve appears to be a slight modification of the more general Edwards Blue Book criteria and is consistent with the TWC's understanding of smallmouth bass depth requirements for spawning.



Kleinschmidt