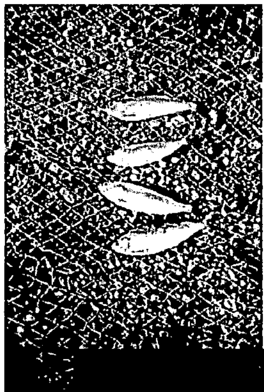
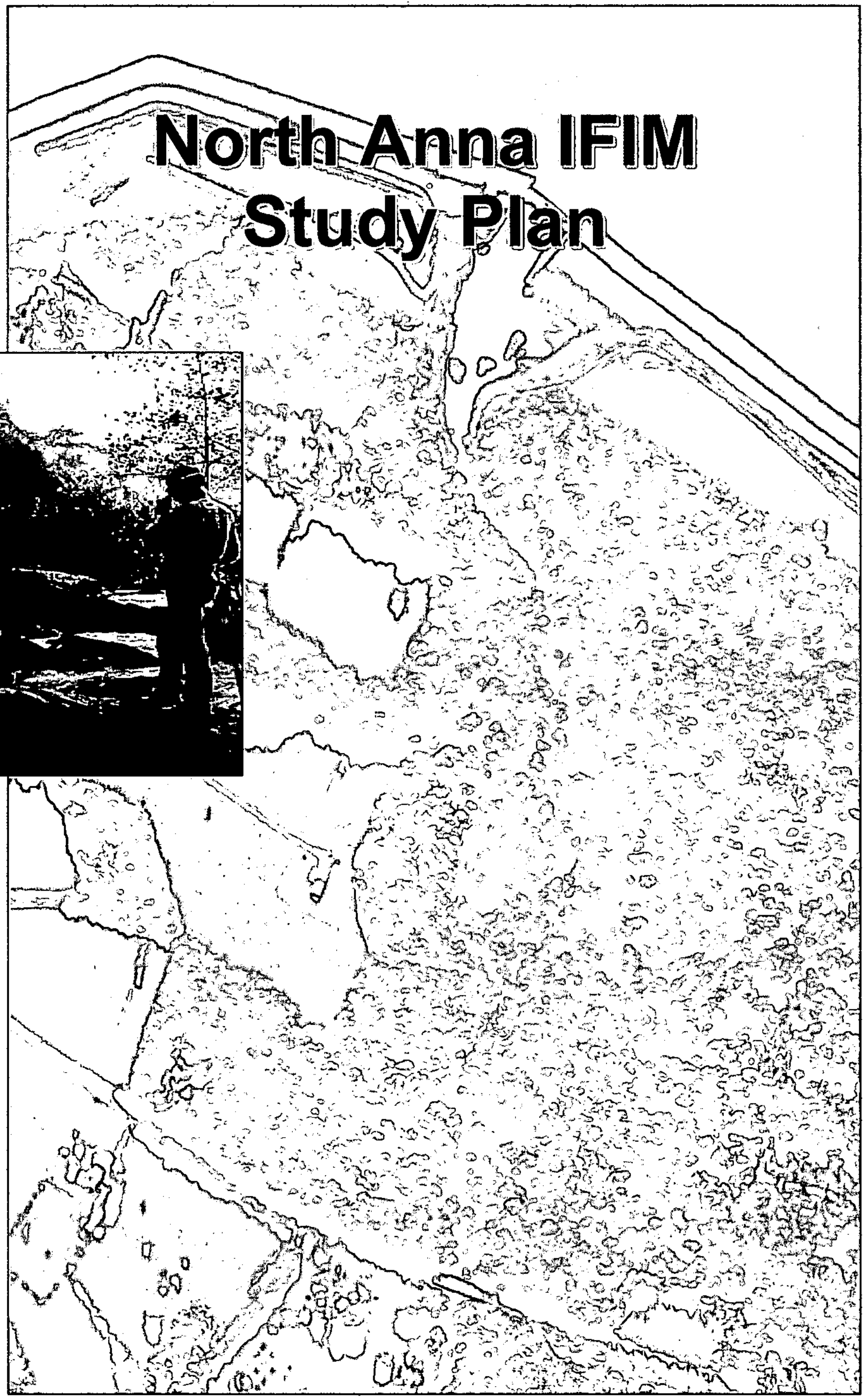




North Anna IFIM Study Plan

Prepared for:

Dominion

Dominion Resources Services, Inc.
5000 Dominion Boulevard
Glen Allen, VA 23060

Prepared by

EA

EA Engineering, Science, and Technology, Inc.
15 Loveton Circle
Sparks, MD 21152

14391.01
28 March 2007

North Anna IFIM
Study Plan

Prepared for:

Dominion Resources Services, Inc.
5000 Dominion Boulevard
Glen Allen, VA 23060

Prepared by:

EA Engineering, Science, and Technology, Inc.
15 Loveton Circle
Sparks, MD 21152

14391.01
28 March 2007

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION AND PROJECT OVERVIEW

1.1 DESCRIPTION OF THE NORTH ANNA PROJECT

Dominion is evaluating the construction of two additional generating units within the property boundary of the existing North Anna Power Station, and has submitted an Early Site Permit (ESP) application to the Nuclear Regulatory Commission (NRC) for the proposed site. As presented in the ESP, a closed-cycle, dry and wet cooling tower system with make-up water supply from Lake Anna would be used for the new Unit 3, whereas closed-cycle cooling, using dry towers, would be used for Unit 4. Dry cooling towers use water-to-air finned-fan coolers to transfer heat through the finned tubes to the atmosphere. The wet cooling towers remove heat by spraying the water to a forced air or induced stream. Wet cooling towers are more efficient and require considerably less energy to operate than dry towers, but involve higher consumptive water loss. If constructed and operated as proposed, it has been noted that the new Unit 3 *could* reduce the amount of water released from the North Anna Dam in comparison to current operations. It has been suggested that the change in dam releases could have an impact on aquatic resources below the dam.

To address these concerns, Dominion has committed to perform an Instream Flow Incremental Methodology (IFIM) study, which is to be designed and monitored in cooperation and consultation with the resource agencies. As part of the Coastal Consistency Certification, Dominion has agreed to the inclusion of the following IFIM study requirement as an enforceable permit condition in the ESP should the NRC approve the Company's ESP application.

> *Dominion Nuclear North Anna, LLC (Dominion) shall conduct a comprehensive Instream Flow Incremental Methodology (IFIM) study, designed and monitored in cooperation and consultation with VDGIF and VDEQ, to address potential impacts of the proposed Units 3 and 4 upon the fishes and other aquatic resources of Lake Anna and downstream waters. Development of the Scope-Of-Work for the IFIM study shall begin in 2007, and the IFIM study shall be completed prior to issuance of a combined construction and operating license (COL) for this project. Dominion agrees to consult with VDGIF and VDEQ regarding analysis and interpretation of the results of that study, and to abide by surface water management, release, and instream flow conditions prescribed by VDGIF and VDEQ upon review of the completed IFIM study, and implemented through appropriate state or federal permits or licenses. The NRC herein agrees to include this proposed condition as an enforceable permit condition, should the agency approve the North Anna ESP application and ultimately issue a permit.* (NRC transmission to E. Grecheck dated 14 November 2006).

1.2 STUDY AREA

The study area comprises approximately 70 miles of stream between the North Anna Dam and the head of tide in the Pamunkey River (Figure 1). This area is primarily rural in character. The first 34 miles below the North Anna Dam consist of the North Anna River. The remaining 36 miles consists of the Pamunkey River—formed by the confluence of the North and South Anna Rivers—down to the head of tide at the U.S. Route 360 bridge. This entire river reach is thought to be potentially affected by flow changes at the North Anna Dam.

The study area contains two major physiographic provinces: 1) the Piedmont, covering approximately the upper one-half of the North Anna River below the dam, and 2) the Coastal Plain, covering the entirety of the Pamunkey River above the tidal portion, and the lower approximate 10 miles of the North Anna River. Based on input from VDGIF and VDEQ during scoping meetings, these two physiographic regions, along with the Fall Zone separating them, will be considered three distinct study reaches within the overall study area. Additionally, because the flow regime approximately doubles below the confluence with the South Anna River, the Coastal Plain will be subdivided into two reaches representing the North Anna and Pamunkey Rivers. The stream gradient from the North Anna Dam to the Route 360 bridge is displayed in Figure 2.

Jenkins and Burkhead (1994) reviewed the general characteristics of these physiographic regions in Virginia. The approximate 15 miles of the North Anna River below the Dam lie within the Piedmont Lowlands subprovince. This area is characterized by low, rounded ridges and shallow ravines. Streams in the lower portion of this subprovince tend to be moderately slow with infrequent and short riffles. Substrates vary from sand, silt, clay, and detritus. Siltation is chronic. The average gradient in this portion of the North Anna River is 2.3 ft/mile (Figure 2).

Although sometimes called the Fall Line, the Fall Zone actually ranges between 4 and 11 miles long depending on which Virginia stream is considered. This is a geologic area, consisting of exposed metamorphic rock, which divides the Piedmont and Coastal Zone physiographic provinces. Stream gradients in the Fall Zone are usually substantially higher than in the adjacent Piedmont Province. Based on Figure 2, the gradient of the North Anna River Fall Zone ranges from approximately 11 to 18 ft/mile. Aquatic habitats vary, but riffles are more prevalent in the Fall Zone than in the adjacent provinces.

Downstream of the Fall Zone is the Coastal Plain, a region characterized by sluggish, slow moving, streams. Sand and mud substrates and woody debris are often present. Riffles and pools with gravel substrates may be present in the upper portion near the Fall Zone. The Pamunkey River from its formation at the confluence of the North and South Anna Rivers downstream to the U.S. Route 360 bridge lies entirely within the Coastal Plain physiographic province (Figure 1) as do the lower 10 miles of the North Anna River. The average gradient of this reach is 0.45 ft/mile.

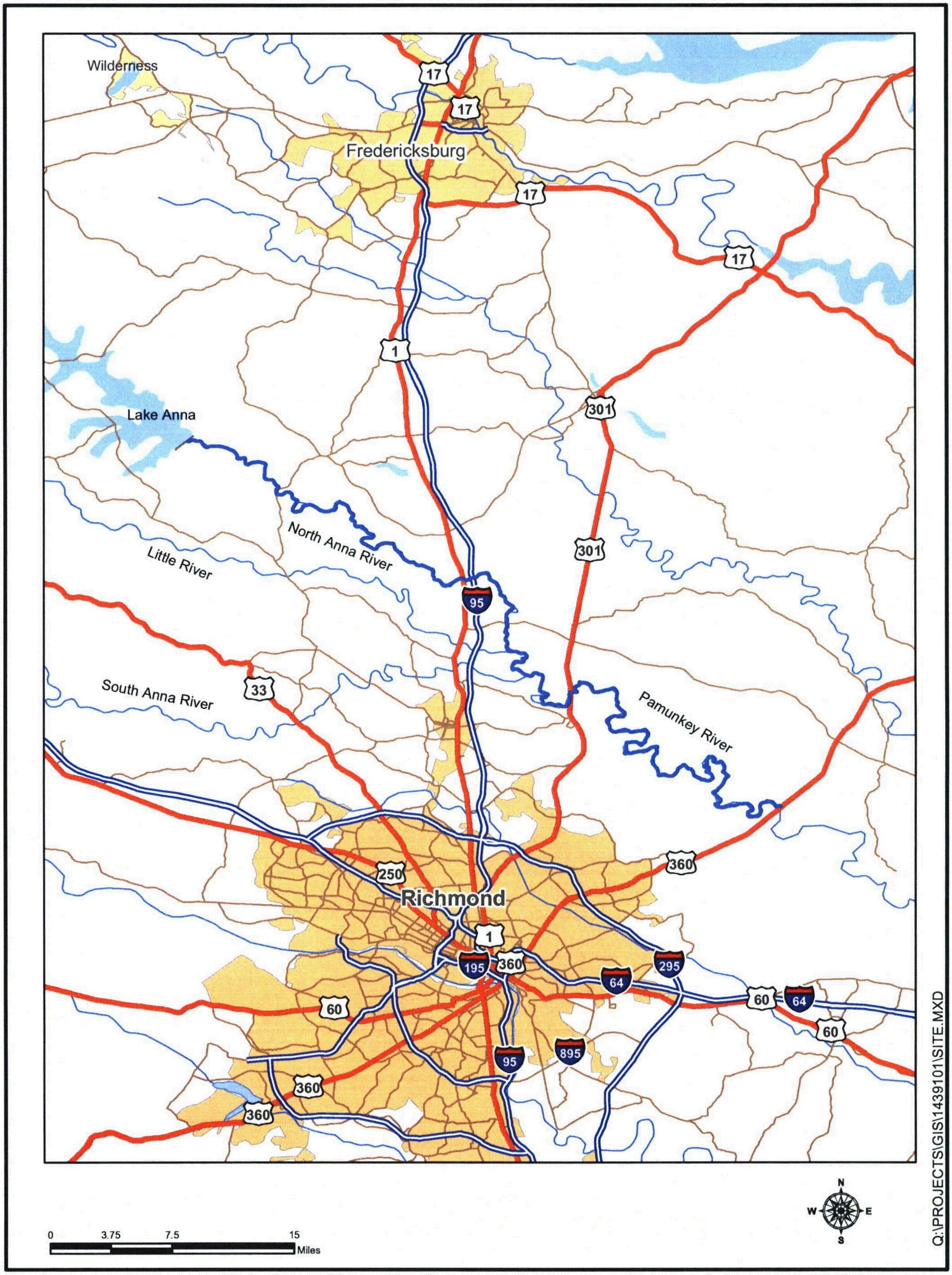
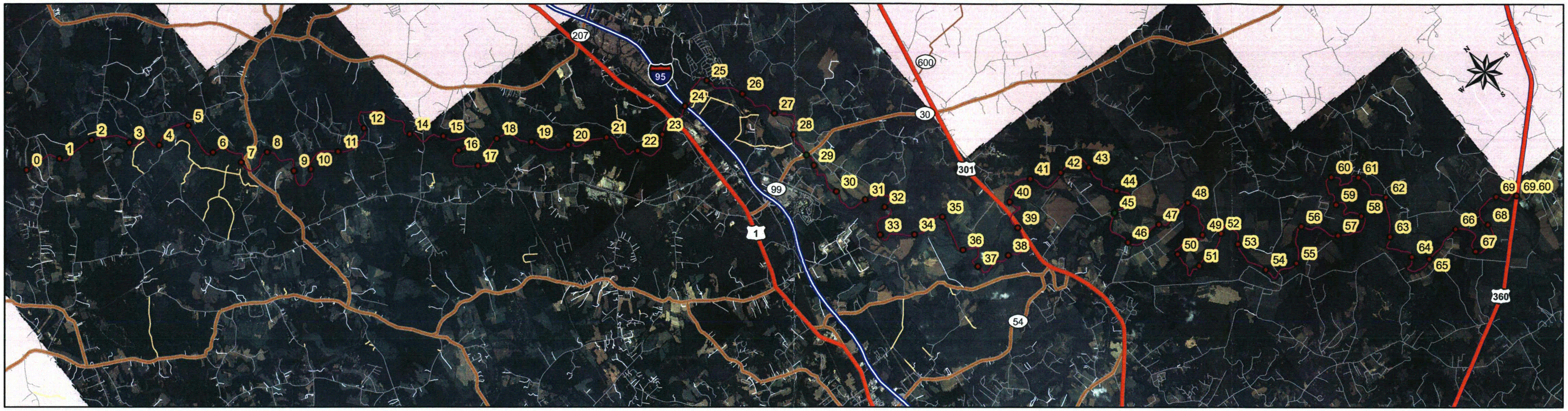
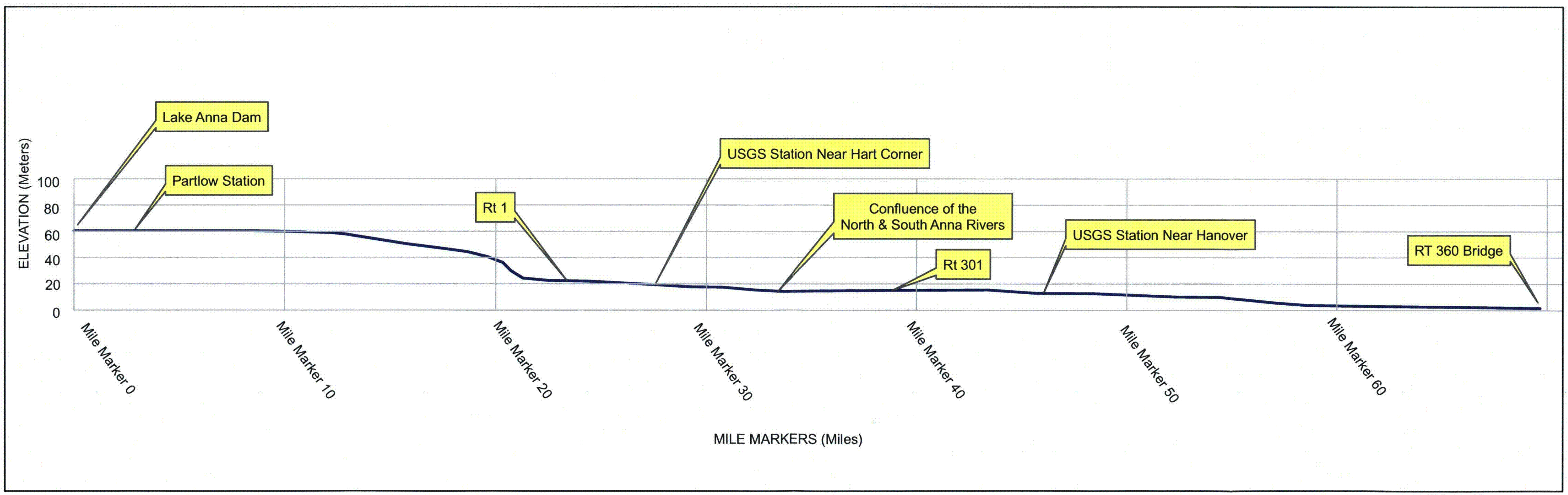


Figure 1. General Site Area.





Q:\PROJECTS\GIS\1439101\PROFILE_360_FINAL.MXD

Figure 2. North Anna River Gradient Photo and Graph

1.3 HYDROLOGIC OVERVIEW

The North Anna River flows from Lake Anna and joins with the South Anna River to form the Pamunkey River, which then merges with the Mattaponi River to form the York River which flows into Chesapeake Bay. The tidal influence on the Pamunkey River extends upstream to about the Route 360 Bridge, which is located approximately 70 miles downstream of the North Anna Dam. Daily flows along the North Anna and Pamunkey Rivers and their major tributaries are well documented by four USGS gaging stations.

- North Anna River: USGS gage 01671020 near Hart Corner
- Little River: USGS gage 01671100 near Doswell
- South Anna River: USGS gage 01672500 near Ashland
- Pamunkey River: USGS gage 01673000 near Hanover

The USGS station at Partlow, below the North Anna Dam, was discontinued in 1995. This station will be reactivated by the USGS during Spring 2007, to be available during this IFIM study. Drainage areas and distances downstream from the North Anna Dam of USGS gaging stations and major tributaries are provided in the following table.

Location	Distance Dstr. from Dam (mi)	Drainage Area at USGS Station (mi^2)
North Anna River		
Dam	0.0	343
Partlow	0.5	344
Hart Corner	29.1	463
Little River	31.0	107
South Anna River	34.6	394
Pamunkey River		
Hanover	46.4	1,081

An examination of the above table indicates that the drainage area of the North Anna River doubles with the addition of the Little River and South Anna River. The 343-mi^2 drainage area at the North Anna Dam contributes 74-percent of the drainage area downstream on the North Anna at Hart Corner, decreasing to 32-percent on the Pamunkey River at Hanover.

Historical flows are available through 2006 at the corresponding USGS stations, except for Partlow. The USGS gage at Partlow was discontinued in 1995, and a record of river flows based on dam release data is currently available through 2003. Frequency distributions of the USGS daily flow data are presented in Table 1 for the five USGS stations associated with the North Anna and Pamunkey Rivers. These flow distributions are presented for the 28-year 1979 to 2006 period (25 years at Partlow), representing the post construction period for the reservoir and Unit 1 and 2 operation. At Partlow, the existing reservoir operating rule is evident in the data. Currently a minimum release flow at the dam of 40 cfs is required when the reservoir elevation is at or above 248 ft msl. The required flow release decreases to 20 cfs when the reservoir elevation is less than

TABLE 1 FREQUENCY DISTRIBUTIUON OF FLOWS ALONG THE NORTH ANNA and PAMUNKEY RIVERS, 1979-2006

Less Than Percentile (%)(a)	Flow (cfs)				
	N Anna at Partlow (b)	N Anna at Hart Corner	Little River nr Doswell	S Anna at Ashland	Pamunkey at Hanover
1	20	37	0.6	15	55
5	40	46	2.0	27	80
10	40	55	5.0	43	104
15	40	60	8.3	59	130
20	42	66	13	75	161
25	45	72	17	92	200
30	47	78	22	110	245
35	50	87	28	134	297
40	55	99	34	159	355
45	59	118	41	184	437
50	66	162	49	214	526
55	92	217	58	244	617
60	167	251	67	278	706
65	178	279	77	311	808
70	197	324	90	355	937
75	254	400	103	409	1080
80	323	486	120	480	1300
85	407	630	145	594	1620
90	541	827	195	800	2310
95	1350	1580	328	1350	4150
Mean	287	398	95	381	1034
Max	10000	12704	3970	7680	20400
Obs	8866	10180	9827	8087	10186

a) The percentile corresponds to the occurrence of flows less than or equal to the tabulated flow

b) Partlow 1979 to 2003

248 ft msl. At Partlow, a 20 cfs flow is present at a frequency of less than 5-percent of the time (Table 1). Partlow flows less than or equal to 50 cfs, associated with the 40-cfs flow release at the dam, are present approximately 35-percent of the time. Flows in the North Anna River increase substantially moving downstream. As shown in Table 1, the annual median (50-percentile) flow on the North Anna River increases by a factor of 2.5 from 66 cfs at Partlow to 162 cfs at Hart Corner. The median flow further increases to 526 cfs on the Pamunkey River at Hanover. The median annual flow at Partlow is 41-percent of the median flow at Hart Corner and 12.5-percent of the median flow on the Pamunkey at Hanover. The 287 cfs annual mean flow at Partlow is 72-percent of the mean flow at Hart Corner and 28-percent of the 1,034-cfs mean flow on the Pamunkey River at Hanover.

Downstream flow increases along the North Anna and Pamunkey Rivers with increasing drainage area and tributary entrances. Figure 3 provides the 10-percentile, 30-percentile, and 50-percentile downstream flows interpolated between gaging stations for the 1979 to 2006 period. The doubling of the downstream flow with the addition of the Little River and the South Anna River is clearly evident.

1.4 OVERVIEW OF THE IFIM METHODOLOGY

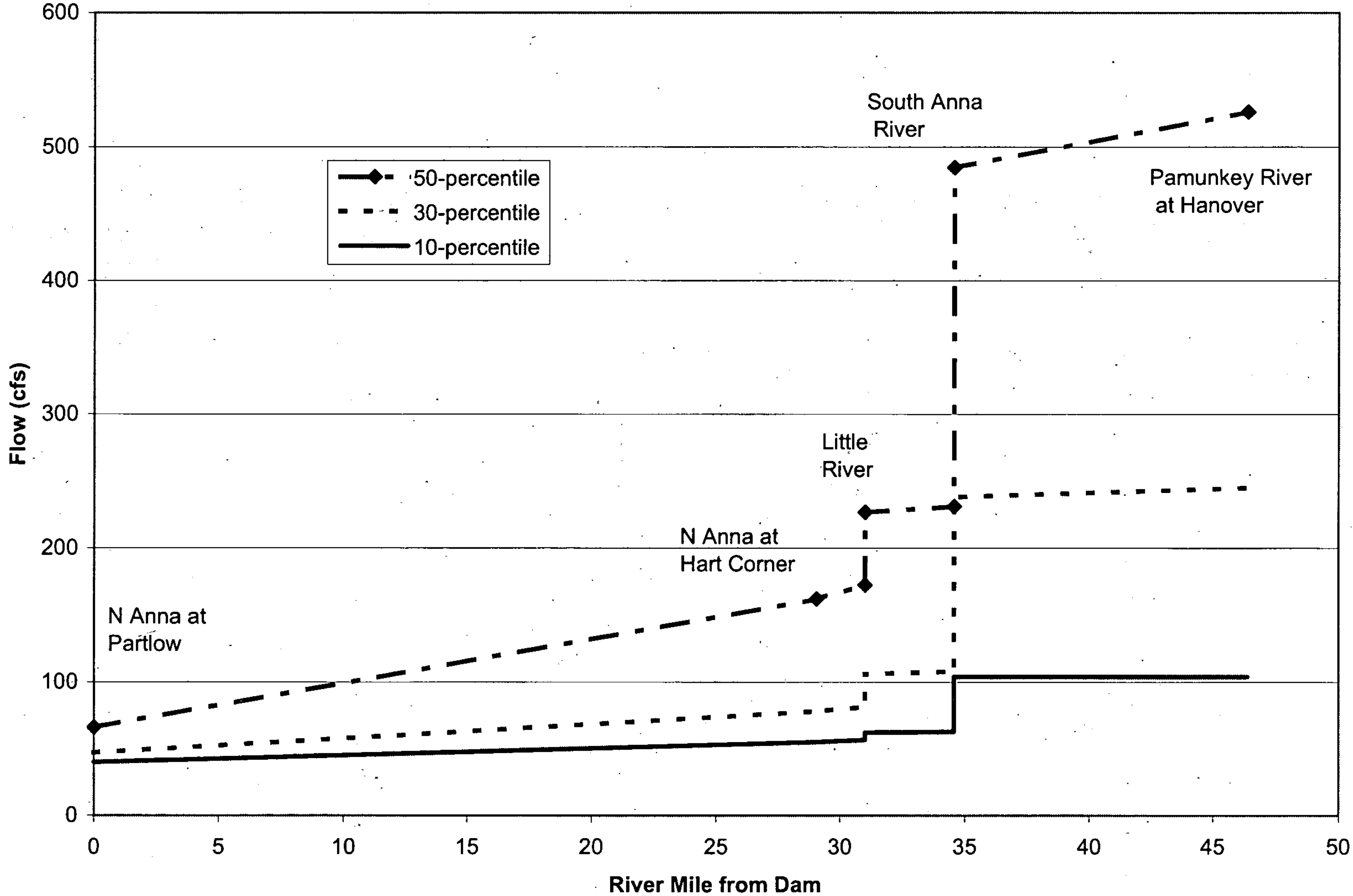
The IFIM was designed to support natural resource managers in making decisions regarding the consequences of different water management alternatives (Stalnaker et al. 1995; Bovee et al. 1998). Although many think of the IFIM as a "computer model," it is more properly described as a process consisting of sequential phases: 1) problem identification and diagnosis, 2) study planning, 3) study implementation (which often involves computer modeling), and 4) alternatives analysis/problem resolution. In the case of the North Anna study, the problem identification and diagnosis phases are largely complete. Based on discussions with Virginia's Department of Game and Inland Fisheries (VDGIF) and the Department of Environmental Quality (VDEQ), concerns have been raised regarding potential impacts to aquatic communities in the North Anna and Pamunkey rivers from flow alterations at the North Anna Dam resulting from operation of the proposed Unit 3 of the North Anna Power Station. The study planning phase is under way; this Study Plan provides a mechanism for final adjustment of the study approach by Dominion and/or agency personnel.

Following Study Plan approval, data collection will be initiated. Data collection is described below in more detail, but the general sequence of data collection activities will be:

1. Identification of mesohabitats (riffle, runs, pools) within each of three key regions—Piedmont, Fall Zone, and Coastal Plain—through the use of maps, video (from helicopter over flight), and site visits;

2. Selection of transects in each mesohabitat and physiographic region; that will require site visits and interaction with agency staff;

Figure 3 Flow Distribution Along the North Anna and Pamunkey Rivers, 1979 - 2006



3. Selection of IFIM focus species of fish and macroinvertebrates; compilation of habitat suitability criteria (HSC) for both organisms and recreation (canoeing);

4. Collection of field hydraulic and habitat data at selected transects at target flows of approximately 40, 140, and 250 cfs at North Anna Dam;

5. Implementation of the Physical Habitat Simulation System (PHABSIM) model which integrates instream microhabitat characteristics with microhabitat requirements of key species. The output is Weighted Usable Area (WUA) for each species and flow of interest.

The final phase of the IFIM process involves alternatives analysis/problem resolution. This phase is crucial to the IFIM process because, unlike most other instream flow methods, the IFIM process does not result in a single "best" flow value. Rather, the IFIM generates weighted usable area (WUA) estimates over a range of flows or for alternative flow time-series and these WUA estimates form the basis of negotiations among interested parties. The North Anna IFIM study will be reviewed by VDEQ, VDGIF, Virginia Department of Conservation and Recreation (VDCR), and Dominion with the objectives of (1) examining the incremental change in WUA resulting from altered releases that may occur with the operation of proposed Unit 3, and (2) confirming or establishing low flow limits at the North Anna Dam appropriate to the operation of proposed Unit 3.

2. STUDY PLAN COMPONENTS

2.1 INTRODUCTION

The IFIM process involves addressing key initial study components sequentially beginning in the problem identification phase and carrying through the project planning phase. These initial components include:

- selection of habitat types and river reaches,
- transect placement selection,
- evaluation of biological community and recreational potential of the study area, and
- selection of Habitat Suitability Criteria (HSC) for key species and recreation.

At least tentative decisions on some of these components have been arrived at among VDEQ, VDGIF, VDCR, and Dominion personnel. These components are expanded upon in the following chapter for final review by all parties. The subsequent study components of field data collection and PHABSIM modeling are addressed in Chapters 3 and 4.

2.2 HABITAT TYPES AND RIVER REACHES

The IFIM study area will extend downstream to the location where changes from baseline flow are expected to be *de minimus*, but, no farther downstream than where there is tidal influence. Low flow analysis for the period 1979-2006 indicates that the North Anna River (measured at Hart Corner) provides 53 percent of the flow in the Pamunkey River (Hanover) during the lower 10^{th} percentile flow condition, and 79 percent of the flow during the7Q10 condition. Therefore, it is likely that changes to the baseline flow condition of the North Anna River could affect instream habitat downstream to the point where the Pamunkey River becomes tidally influenced. Based on the literature, Dominion believes the Pamunkey becomes tidally influenced at the Rt. 360 Bridge. The Rt. 360 Bridge is approximately 36 river miles (RM) downstream of the confluence of the North and South Anna rivers and approximately 70 RM downstream from the North Anna Dam.

An IFIM study should include representative habitat types within the defined "study area." The IFIM approach requires that a stream be divided into separate reaches for study where significant changes in channel morphology occur or where there is significant change in flow. For the North Anna River IFIM study, Dominion believes that there are four distinct reaches within the study area:

- Piedmont
- Fall zone
- Coastal Plain – North Anna River
- Coastal Plain – Pamunkey River

Significant changes in flow occur at locations where the Little River and the South Anna River enter the main channel. The locations of these features are summarized in the following table.

Feature	River Mile (RM) below North Anna Dam
North Anna Dam	0
Piedmont	0 – 15
Fall Zone	15 – 22
Little River	31
South Anna	35
Coastal Plain	22 – 70
Rt. 360 Bridge	70

The primary types of mesohabitats within each of these river reaches need to be identified to facilitate transect site selection. To accomplish the habitat mapping, a combination of existing institutional knowledge, aerial photographs, and site-specific data obtained through a "float" trip will be used. Agency participation in the float trip for the selection of transects and the determination of site access is requested. The float trip will be conducted at low or moderate flow (~40 cfs or 140 cfs, measured at the dam), and mesohabitats (e.g., riffles, runs, pools) will be defined based on:

- Gradient
- Water velocity and turbulence
- Streambed substrate
- Channel morphology

Based upon existing maps, video from the helicopter flyover, and the float-trip, the project team will produce maps of the defined study area that include the following features and will be used to help select specific transect locations for detailed study.

- Key riffle, run, pool areas
- Key habitat types (and their percentage contributions so that dominant habitats can be emphasized in the study)
- Off-channel features (wetlands, tributaries, withdrawals)
- Unique habitats

Final selection of transects will be dependent on visual inspection and agency approval. The placement of transects will be made based on several considerations:

1. Representativeness – Transects will be located in areas representative of hydraulic/habitat conditions in each mesohabitat type. For the North Anna River, these include riffles, runs, and pools

2. Access and Safety – Transect sampling is not feasible in all areas of the North Anna River study area. Any area that is very difficult to access, and which is not

a critical area or is not representative of unique stream habitat will be avoided in the interest of safety.

2.3 NUMBER OF TRANSECTS PER HABITAT TYPE/RIVER REACH

After the river reaches and habitat types have been identified and mapped, transect locations for the actual collection of field hydraulic measurements will be determined. The goal is to locate transects in representative mesohabitat types. The number of transects should be weighted to either the degree of variability within mesohabitat type, or the abundance of a particular mesohabitat type (depending on the outcome of the previous task).

Preliminary recommendation of the number of transects in the four river reaches are provided in the following table. The number of transects will be refined after data from the helicopter fly-over and float trip are collected and analyzed. It is recognized that substrate differences in the Piedmont areas could affect the number of transects.

River Reach	Number of Transects			
	Riffle	Run	Pool	Total
Piedmont – North Anna	5	4	1	10
Fall Zone – North Anna	2	2	1	5
Coastal Plain – North Anna		2	1	3
Coastal Plain - Pamunkey		4*	1	5
Total	7	12	4	23

* 2 shallow runs and 2 deep runs

Institutional knowledge indicates that riffle and pool habitat is not significant in the Coastal Plain. However, the run habitat in the Coastal Plain will be characterized as deep run and shallow run to account for habitat variability.

This preliminary design yields a total of 23 transects. It is recognized that site access can be a very important issue within the study area and will have to be considered during transect site selection.

The selected transects will normally be represented with one-dimensional analysis. However, it is possible that a riffle transect, particularly in the Fall Zone, may be more appropriately represented as a 2-dimensional transect. If during the transect selection process, the agencies and Dominion jointly select a riffle transect that requires 2-D representation, then a 2-D habitat modeling component will be added for the selected transect.

2.4 SPECIES AND RECREATIONAL ACTIVITIES SELECTION

2.4.1 Overview of North Anna and Pamunkey Rivers Biological Communities

The study area contains a diverse assemblage of fish species owing to its Piedmont, Fall Zone, and Coastal Plain habitats. Jenkins and Burkhead (1994) provided records for 67 species of fish from either the North Anna River below the dam or the Pamunkey River, or both (Table 2). Species ranged from strictly freshwater, upper-watershed species such as mountain redbelly dace and rosyface shiner reported only in the North Anna River, to anadromous species such as American shad, hickory shad, and striped bass reported only in the Pamunkey River.

Dominion (2004) reported the results of fish sampling conducted in an approximately 20-mile reach of the North Anna River in 2002. A total of 1,474 fish among 27 species was recorded during three seasonal electrofishing surveys (Table 2). Dominant species included American eel, satinfin, rosefin, and comely shiners, margined madtom, and redbreast sunfish.

Dominion (2004) also reported the results of two benthic surveys in the North Anna River study reach, one in November 2001 and one in August 2003. The community was dominated by caddisflies, mayflies, riffle beetles, and midges. Unionid mussels were rare in these collections, but subsequent communications with VDGIF personnel identified records for several species in the study area whose status may be of concern to both federal and state resource agencies.

2.4.2 Recommended Species for IFIM Analysis

Bovee et al. (1998) pointed out that selection of target species for IFIM studies is an important part of the process, but also potentially difficult since ultimate habitat predictions may differ substantially among target species and life stages. A species/life stage preferring deep, slow water will be poorly served by flows that maximize habitat for a species/life stage that prefers shallow, fast water. Consequently, these authors recommend selection of a mix of species and life stages. This has been done for the North Anna IFIM study through various interactions between VDGIF and Dominion personnel, and final agreement was confirmed during a review meeting on 13 February 2007. The recommended target species, life stages, and sources of Habitat Suitability Criteria (HSC) for the North Anna River IFIM study are as follows:

Species/Guild	Life Stage	Potential HSC Sources
American shad	Juvenile	Stier and Crance (1985) [modified by Odom (2003)]
American shad	Spawning	Stier and Crance (1985)
Smallmouth bass	Juvenile	Groshen (1993)
Smallmouth bass	Adult	Groshen (1993)
Smallmouth bass	Spawning	Leonard & Orth (1986)
Redbreast sunfish	Spawning	EA (1994)

Species/Guild	Life Stage	Potential HSC Sources
Northern hogsucker	Adult	Aadland & Kuitunen (2006)
Northern hogsucker	Spawning	Aadland & Kuitunen (2006)
Shallow-Fast guild	All	Orth (2001)
Shallow-Slow guild	All	Orth (2001)
Deep-Fast guild	All	Orth (2001)
Deep-Slow guild	All	Orth (2001)
Benthic macroinvertebrates	NA	Gore et al. (2001)

Habitat Suitability Criteria for each species and life stage are presented in Attachment A to this Study Plan.

In addition to the fish and macroinvertebrate assessment, the effect of flow changes on recreation, i.e., canoeing, will be evaluated. Canoeing criteria, analogous to the HSC for biological species will be evaluated with the PHABSIM model. Criteria developed by EA (1991) for Novice and Mid-Level canoe experience are provided in Attachment A. In addition to the PHABSIM evaluation, a canoeing quality demonstration will be conducted at two flows. These flows will be approximately 40 cfs and 140 cfs at the North Anna Dam. The North Anna River reach for the canoeing demonstration will be selected in cooperation with the VDCR.

TABLE 2 LIST OF FISH SPECIES REPORTED FROM THE PAMUNKEY AND NORTH ANNA RIVERS

Family		Common Name	Scientific name	Jenkins and Burkhead (1994) Records Pamunkey	Jenkins and Burkhead (1994) Records N. Anna	Dominion (2004) N. Anna
Petromyzontidae	Lampreys	Sea lamprey	*Petromyzon marinus*	X	X	1
		American brook lamprey	*Lampetra appendix*	X	X	
		Least brook lamprey	*Lampetra aepyptera*	X	X	
Acipenseridae	Sturgeons	Atlantic sturgeon	*Acipenser oxyrinchus*	X		
Lepisosteidae	Gars	Longnose gar	*Lepisosteus osseus*	X		
Amiidae	Bowfins	Bowfin	*Amia calva*	X	X	
Anguillidae	Freshwater eels	American eel	*Anguilla rostrata*	X	X	221
Clupeidae	Herrings	Blueback herring	*Alosa aestivalis*	X		
		Alewife	*Alosa pseudoharengus*	X		
		Hickory shad	*Alosa mediocris*	X		
		American shad	*Alosa sapidissima*	X	X	
		Gizzard shad	*Dorosoma cepedianum*	X	X	
		Threadfin shad	*Dorosoma petenense*	X		
Cyprinidae	Carps and minnows	Rosyside dace	*Clinostomus funduloides*	X	X	
		Satinfin shiner	*Cyprinella analostana*	X	X	195
		Common carp	*Cyprinus carpio*	X	X	
		Eastern silvery minnow	*Hybognathus regius*	X	X	
		Common shiner	*Luxilus cornutus*	X	X	
		Rosefin shiner	*Lythrurus ardens*		X	246
		River chub	*Nocomis micropogon*	X	X	14
		Bluehead chub	*Nocomis leptocephalus*	X	X	10
		Golden shiner	*Notemigonus crysoleucas*	X	X	
		Comely shiner	*Notropis amoenus*	X	X	2
		Swallowtail shiner	*Notropis procne*	X	X	112
		Spottail shiner	*Notropis hudsonius*	X	X	

TABLE 2 (Continued)

Family		Common Name	Scientific name	Jenkins and Burkhead (1994) Records Pamunkey	Jenkins and Burkhead (1994) Records N. Anna	Dominion (2004) N. Anna
		Rosyface shiner	*Notropis rubellus*		X	1
		Mountain redbelly dace	*Phoxinus oreas*		X	
		Eastern blacknose dace	*Rhinichthys atratulus*	X		
		Fallfish	*Semotilus corporalis*	X	X	50
		Creek chub	*Semotilus atromaculatus*	X	X	
Catostomidae	Suckers	White sucker	*Catostomus commersonii*		X	
		Creek chubsucker	*Erimyzon oblongus*	X	X	11
		Northern hog sucker	*Hypentelium nigricans*		X	2
		Shorthead redhorse	*Moxostoma macrolepidotum*	X	X	
Ictaluridae	North American catfishes	Yellow bullhead	*Ameiurus natalis*	X	X	7
		Brown bullhead	*Ameiurus nebulosus*	X	X	
		White catfish	*Ictalurus catus*	X		
		Channel catfish	*Ictalurus punctatus*	X	X	1
		Margined madtom	*Noturus insignis*	X	X	130
		Tadpole madtom	*Noturus gyrinus*	X		2
Esocidae	Pikes	Chain pickerel	*Esox niger*	X	X	6
		Redfin pickerel	*Esox americana*	X	X	
Umbridae	Mudminnows	Eastern mudminnow	*Umbra pygmaea*		X	
Aphredoderidae	Pirate perches	Pirate perch	*Aphredoderus sayanus*	X	X	1
Fundulidae	Topminnows	Banded killifish	*Fundulus diaphanus*	X		
		Mummichog	*Fudulus heteroclitus*	X		
Poeciliidae	Livebearers	Eastern mosquitofish	*Gambusia holbrooki*	X	X	3

TABLE 2 (Continued)

Family		Common Name	Scientific name	Jenkins and Burkhead (1994) Records Pamunkey	Jenkins and Burkhead (1994) Records N. Anna	Dominion (2004) N. Anna
Moronidae	Temperate basses	White perch	*Morone americana*	X		
		Striped bass	*Morone saxatilis*	X		
Centrarchidae	Sunfishes	Mud sunfish	*Acantharchus pomotis*	X	X	
		Rock bass	*Ambloplites rupestris*	X	X	
		Flier	*Centrarchus macropterus*	X	X	
		Bluespotted sunfish	*Enneacanthus gloriosus*	X	X	
		Redbreast sunfish	*Lepomis auritus*	X	X	360
		Pumpkinseed	*Lepomis gibbosus*	X	X	
		Warmouth	*Lepomis gulosus*		X	
		Bluegill	*Lepomis macrochirus*	X	X	14
		Redear sunfish	*Lepomis microlophus*		X	
		Largemouth bass	*Micropterus salmoides*	X	X	9
		Smallmouth bass	*Micropterus dolomieu*	X	X	1
		Spotted bass	*Micropterus punctulatus*		X	
		Black crappie	*Pomoxis nigromaculatus*	X	X	1
Percidae	Perches	Tessellated darter	*Etheostoma olmstedi*	X	X	28
		Glassy darter	*Etheostoma vitreum*	X	X	13
		Yellow perch	*Perca flavescens*	X	X	
		Stripeback darter	*Percina notogramma*		X	
		Shield darter	*Percina peltata*		X	13

Note: Common and scientific names of finfish follow Nelson et al. (2004).
Dominion (2002) data are electrofishing catch data from four locations in the Piedmont and Fall Zone portions of the North Anna River below the Dam.

3. FIELD DATA COLLECTION

3.1 OVERVIEW

After study reaches, mesohabitats, and transect locations have been fully delineated and agreed upon, as discussed in Section 2, collection of hydraulic and habitat data will be performed at each transect as described below.

3.2 HYDRAULIC SAMPLING METHODS

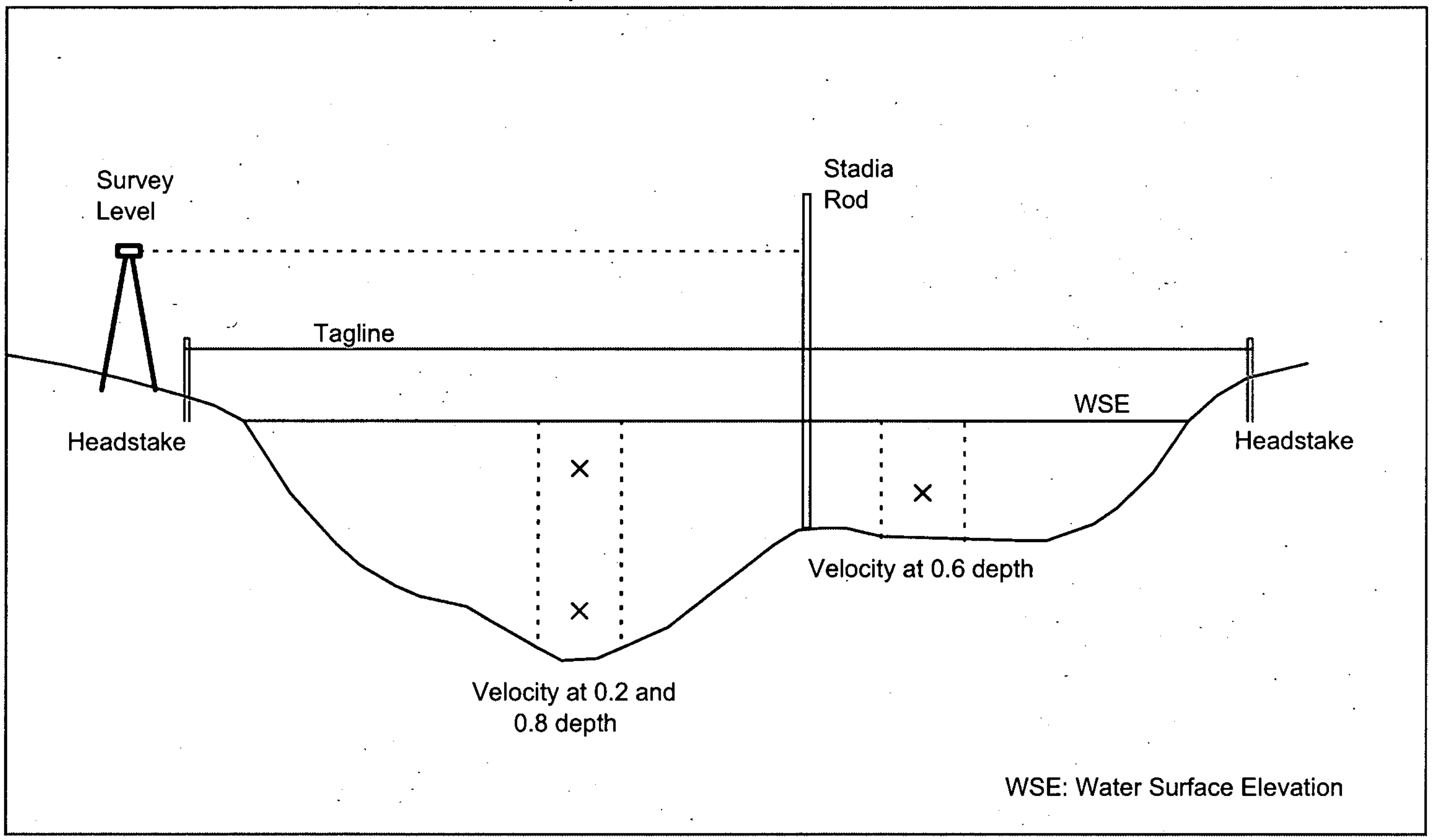
Field data collection is the step in the IFIM process where site-specific data are collected under a range of flow regimes to develop the hydraulic component of the PHABSIM model. These data will be used to calibrate the hydraulic portion of the PHABSIM model including flow and velocity as a function of water surface elevation (WSE).

Based on the cumulative frequency distribution of North Anna Dam flows under existing Unit 1 and 2 operations, the flow range of interest for the IFIM study is from approximately 20 cfs to 500 cfs at North Anna Dam. The existing minimum flow release at the North Anna Dam is 20 cfs. A 500 cfs flow at the dam is an upper 85-90 percentile flow (Table 1). The selected IFIM study transects will be characterized under three different flows. These flows will be approximately 40 cfs, 140 cfs, and 250 cfs measured at North Anna Dam. The 40 cfs and 140 cfs flows are representative of the capacity of the two hydroelectric units at North Anna Dam. A 140 cfs flow corresponds to an upper 55 to 60-percentile of historical flows at Partlow (Table 1). It is generally reported that PHABSIM can provide representative extrapolation of habitat/discharge relationships down to 0.4 times the lowest flow measured, and up to 2.5 times the highest flow measured. The expected simulated flow range for PHABSIM scenarios of 20 cfs to 500 cfs is within these limits.

Prior to the field data collection, a field sampling protocol manual will be developed. This manual will be used by the field staff to define data collection techniques and to record data in a format that easily translates to the electronic files required in the PHABSIM model. The general procedures that will be performed are identified in the following section and will be expanded in a field sampling manual. The sampling manual will ensure that data collected by different field crews meet the same quality standards.

All transects will be sampled using the same methodology. A schematic illustrating transect sampling methodology is provided in Figure 4. At each transect, two permanent headstakes will be established, one on each bank. These will be located above the high water elevation anticipated to be encountered during the study, but no lower than top of bank. The two headstakes will define a cross-sectional transect line perpendicular to the stream flow. The headstakes will not necessarily be used to secure the tagline for delimiting sampling locations along the transect. The tagline may be secured to a more permanent structure beyond, with the headstakes directly in line and marking the actual left/right bank transect end-points. A benchmark will be established at each transect and

Figure 4 Schematic of Transect Sampling Methodology



assigned an arbitrary 100-ft elevation. A headstake may serve as the benchmark if sufficiently secure. Sampling stations along each transect line will be established at appropriate intervals to ensure that at least 20 stations will be under water at low flow. Under normal conditions, the stations will be located along the transect using an equal distance increment. An unequal increment will be used if necessary to delineate sudden changes in depth or velocity.

It is anticipated that the majority of the transects will be wadable. However, if a non-wadable transect is selected for inclusion in the study, a second line will be secured slightly upstream of the tagline and used for positioning a small boat from which measurements can be collected.

Water column velocities will be measured using a Marsh McBirney electronic flow meter attached to a top setting wading rod. Use of an Acoustic Doppler Current Profiler (ADCP) unit was considered for measuring velocity and depth, but was not selected due to a concern with having multiple field techniques. ADCP units commonly have a minimum 1-ft operational depth, although minimum depth 0.5-ft units are now available. Due to the size of the North Anna River, ADCP measurements would most likely not be possible in the riffles or in near shore areas of runs and pools. Thus, deploying an ACDP may result in up to 50 percent of the transect data still being collected with traditional methods. The use of two different field methodologies thus raises a concern over input data consistency to PHABSIM.

Water surface elevations at each transect will be measured under three flow conditions (40 cfs, 140 cfs, and 250 cfs at North Anna Dam). However, the PHABSIM methodology does not require that depth and velocity data be measured at all three flows. Depth and velocity data will be measured at the lower two flows. For the third (higher) flow, depth and velocity data will not be collected at transects where it is judged to be unsafe to access the stream.

An example standardized instream flow data sheet is provided in Figure 5. Data collected at each transect includes transect-specific and station-specific information. Transect-specific data collected during the study includes:

- Date and time – Date/time information documents when data were collected. Time of sampling can be very important, particularly when transect measurements are taken under conditions of gradually varying flow.

- Left and right bank headstake elevation - The headstakes will serve as elevation control points. During each field visit surveying with an automatic level will be performed to verify the vertical datum used for water surface elevation. With the automatic level, a backsight will be made on the benchmark and foresights on the control points. These measurements will be used as a check to ensure that the transect benchmark has not changed in elevation.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

INSTREAM FLOW DATA SHEET (#4)

Page _____ of _____

Stream______________________ Reach______________ Transect__________ Project No.______________

Station Depth and Velocity Data

		Date_______ Q1		Date_______ Q2		Date_______ Q3				
Distance (ft)	Bed Rod	Vel. (fps)	Depth (ft)	Vel. (fps)	Depth (ft)	Vel. (fps)	Depth (ft)	Substrate (Code Sheet)	Cover (Code Sheet)	Comments

Figure 5. Sample Instream Flow Data Sheet.

- Water surface elevation – The water surface elevation near the left and right bank will be measured during each survey relative to the transect datum. A water surface elevation determination will also be made at the beginning and end of the data collection period to identify a gradually varying flow condition. This may include the deployment of a staff gage at the transect. Transect data will be judged acceptable if variation in flow is less than 10-percent.

- Stage of zero flow – At transects influenced by a downstream hydraulic control, the location of the thalweg will be identified and a streambed elevation cross-section determined. The lowest elevation along the transect containing the thalweg is the stage at zero flow.

Station-specific data will be collected at a series of uniform intervals along the transect.

- Distance from headstake – The lateral distance from the left bank headstake (looking downstream) will be measured to identify the position of each station measurement. The IFIM methodology requires that each transect data set use the same lateral distances.

- Stream bottom elevation – The elevation of the streambed at each lateral position selected as a sampling station will be surveyed with an automatic level relative to the transect datum. The streambed elevation measurements will extend beyond the water surface to include the channel cross-section expected to be associated with the maximum flows simulated with PHABSIM. For the IFIM methodology, and assuming a stable cross-section, it is only necessary to perform these streambed elevation measurements a single time.

- Depth – Depth will be measured at each station along the transect using a top-setting wading rod. These depths do not serve directly as model input. The modeled depths are based on the initial streambed profile and the water surface elevation determined relative to the transect datum. The depth data aids in the accurate placement of the top-setting wading rod to the same location during repeated visits to the site. This is particularly useful in streams with rough substrates where minor lateral position variation has noticeable differences in depth.

- Mean water column velocity – The mean water column velocity will be measured at each station using a Marsh McBirney electronic flow meter attached to a top-setting wading rod. When depths are less than 2.5 ft, the mean water column velocity is located at 0.6 of the water depth. When depths exceed 2.5 ft, the mean water column velocity is the average of two readings measured at 0.2 and 0.8 of the water depth.

- Cover and substrate – At each station location along the transect, a rectangular cell within the stream will be visualized that is as wide as the distance between stations and approximately 20-ft long (10-ft up and downstream). Within each cell, streambed substrate and cover will be visually assessed and assigned to categories in accordance with the substrate criteria to be used within the PHABSIM model. Dominant substrate type, percent of cell area covered by dominate substrate, and sub dominant substrate type will be recorded. Cover and substrate are discussed further in Section 3.3.

- Transect station comments – Station-specific comments regarding unique features will be recorded. General comments such as immediate location of station (e.g. back edge of bolder) or velocity patterns (e.g. under influence of velocity break) help in understanding anomalies that sometimes arise when data are being reviewed for model application.

To ensure consistent velocity/depth data sets, it is important that the field data be collected during steady conditions. Water surface elevations at the beginning and end of the sampling period will be recorded to identify potential changes in flow. These WSE measurements in conjunction with a post survey examination of USGS records will be used as an acceptance criterion. Transect data will be judged acceptable if variation in flow was less than 10-percent.

USGS flow data on field survey days will be used as a quality control check on measured flows and to document variable flow conditions. Real-time 15-minute USGS data are available at up to five gaging stations on the North Anna and Pamunkey Rivers and major tributaries. Interpolation between USGS gaging stations using drainage area scaling will allow the estimation of a stream flow at each transect during its data collection period.

3.3 COVER/SUBSTRATE SUITABILITY CODES AND INDICES

Cover and substrate are two of the four parameters that are integrated in PHABSIM to predict an instream location's suitability for a given species and life stage. Dominion proposes an 18-point coding system that has been used successfully in several prior instream flow studies. The coding system is based on a system used by the North Carolina Wildlife Resources Commission (NCWRC) and is designed to account for cover-substrate combinations that may be encountered in a natural stream (Table 3).

With the NCWRC system as a template, Dominion has compiled suitability criteria for the IFIM target species, based on several published sources. These criteria are listed in Table 4 for each target species and life stage, and will be incorporated into the PHABSIM model as described below.

During field data collection, cover/substrate codes will be assigned to each transect station in conjunction with collection of hydraulic data. At a given transect station, the predominant cover and substrate will be characterized and recorded. The lateral area to be examined will be that area that is one-half the distance to the transect stations to either side of the one in question. An area 10 ft upstream and 10 ft downstream of the station will be included in the cover/substrate coding for that station. Note that cover and substrate data need only be collected during one (the lowest) of the target flows.

TABLE 3 CODING SYSTEM FOR COVER/SUBSTRATE SUITABILITY CRITERIA

Code	Cover	Substrate
1	No Cover	silt or terrestrial vegetation
2	No Cover	sand (<0.1")
3	No Cover	gravel (0.1-3.0")
4	No Cover	cobble (3.0-12.0")
5	No Cover	small boulder (12-36")
6	No Cover	boulder, angled bedrock, or WD
7	No Cover	mud or flat bedrock
8	Overhead	vegetation and terrestrial vegetation
9	Overhead	vegetation and gravel
10	Overhead	vegetation and cobble
11	Overhead	vegetation and small boulder, boulder, angled bedrock, or WD
12	Instream	cobble
13	Instream	small boulder, boulder, angled bedrock, or WD
14	Proximal	cobble
15	Proximal	small boulder, boulder, angled bedrock, or WD
16	Inst/Prox	gravel
17	Inst/Prox/Ovh	silt or sand
18	Aquatic Veg	macrophytes

TABLE 4 COVER/SUBSTRATE SUITABILITY CRITERIA FOR IFIM TARGET SPECIES

			American Shad		Smallmouth Bass			Redbreast Sunfish
Code	Cover	Substrate	Juvenile	Spawn	Juvenile	Adult	Spawn	Spawn
			(a)	(b)	(c)	(c)	(c)	(d)
1	No Cover	silt or terrestrial vegetation	0.10	0.10	0.20	0.10	0.00	0.10
2	No Cover	sand (<0.1")	0.30	0.50	0.20	0.10	0.00	0.70
3	No Cover	gravel (0.1-3.0")	0.75	1.00	0.40	0.15	0.80	0.80
4	No Cover	cobble (3.0-12.0")	1.00	1.00	0.70	1.00	1.00	0.70
5	No Cover	small boulder (12-36")	0.30	1.00	1.00	1.00	0.20	0.20
6	No Cover	boulder, angled bedrock, or WD	1.00	1.00	0.80	1.00	0.20	0.00
7	No Cover	mud or flat bedrock	0.20	0.50	0.60	0.50	0.00	0.00
8	Overhead	vegetation and terrestrial vegetation	0.50	0.55	0.35	0.30	0.50	0.20
9	Overhead	vegetation and gravel	0.75	1.00	0.45	0.33	0.90	0.60
10	Overhead	vegetation and cobble	1.00	1.00	0.60	1.00	1.00	0.40
11	Overhead	vegetation and small boulder, boulder, angled bedrock, or WD	1.00	1.00	0.90	1.00	0.60	1.00
12	Instream	cobble	1.00	1.00	0.85	1.00	1.00	1.00
13	Instream	small boulder, boulder, angled bedrock, or WD	1.00	1.00	0.95	1.00	0.60	0.70
14	Proximal	cobble	1.00	1.00	0.85	1.00	1.00	0.90
15	Proximal	small boulder, boulder, angled bedrock, or WD	1.00	1.00	0.95	1.00	0.60	0.60
16	Inst/Prox	gravel	0.75	1.00	0.70	0.58	0.90	0.90
17	Inst/Prox/Ovh	silt or sand	0.10	0.75	0.60	0.55	0.50	0.85
18	Aquatic Veg	macrophytes	0.50	0.10	0.50	1.00	0.00	0.00

Suitability Criteria sources:
(a) Gore (2006)
(b) Stier and Crance (1985), modified
(c) Leonard et al. (1986)
(d) RMC (1992)

TABLE 4 (Continued)

			Northern Hogsucker		Fish Habitat Guilds				Benthic Macroinvertebrates	
					Shallow		Deep			
Code	Cover	Substrate	Adult	Spawn	Slow	Fast	Slow	Fast	Pool	Riffle
			(c)	(c)						
1	No Cover	silt or terrestrial vegetation	0.10	0.00	1.00		0.10	0.10	0.25	0.10
2	No Cover	sand (<0.1")	0.40	0.00	1.00			0.30	0.95	0.20
3	No Cover	gravel (0.1-3.0")	0.90	1.00	0.50	0.75	0.50	0.75	1.00	0.50
4	No Cover	cobble (3.0-12.0")	1.00	0.50	0.45	1.00	0.80	1.00	1.00	1.00
5	No Cover	small boulder (12-36")	1.00	0.00	0.10			0.30	0.10	0.90
6	No Cover	boulder, angled bedrock, or WD	1.00	0.00	0.40			1.00	0.15	0.70
7	No Cover	mud or flat bedrock	1.00	0.00	0.40			0.20	0.40	0.10
8	Overhead	vegetation and terrestrial vegetation	0.55	0.50	0.50	0.50	1.00	0.50	0.25	0.50
9	Overhead	vegetation and gravel	0.95	1.00	1.00	0.75	0.75	0.75	1.00	0.75
10	Overhead	vegetation and cobble	1.00	0.75	0.30	1.00	0.90	1.00	1.00	1.00
11	Overhead	vegetation and small boulder, boulder, angled bedrock, or WD	1.00	0.50	0.10		0.50	1.00	0.50	0.50
12	Instream	cobble	1.00	0.75	0.30	1.00	0.95	1.00	1.00	1.00
13	Instream	small boulder, boulder, angled bedrock, or WD	1.00	0.50	0.25		0.47	1.00 1.00	0.50	0.50
14	Proximal	cobble	1.00	0.75	0.25	1.00	0.97	1.00	1.00	1.00
15	Proximal	small boulder, boulder, angled bedrock, or WD	1.00	0.50	0.25		0.47	1.00	0.50	0.50
16	Inst/Prox	gravel	0.95	1.00	1.00	0.75	0.70	0.75	1.00	0.80
17	Inst/Prox/Ovh	silt or sand	0.70	0.50	1.00		0.50	0.10	0.65	0.10
18	Aquatic Veg	macrophytes	1.00	0.00						

3.4 FLOW RELEASE CONTROLS BY DOMINION

Coordination between EA and Dominion will be necessary with regard to predicted rainfall and flow releases at the North Anna Dam. Not only will it be necessary to maintain steady releases during field data collection, but it will also be necessary to confirm that the effect of a given release has reached a given downstream reach or transect location. The study area comprises 70 stream miles, and there will be time lags between releases at the dam and arrival/stabilization at downstream locations. For example, assuming an average instream velocity of 0.5 feet per second (fps), it will take 4 days for a given dam release to reach the confluence with the South Anna River. Preliminary evaluations may suggest slower or faster mean velocities that will have to be taken into account in establishing the duration of releases necessary for a given reach.

During January 2007 when flows at the North Anna Dam were reduced to 40 cfs for the helicopter flyover, flows on the North Anna River at Hart Corner were initially above 300 cfs and it took approximately 2-days for the reduced flow to begin to stabilize downstream at Hanover.

4. PHABSIM MODELING APPROACH

The Physical Habitat Simulation system (PHABSIM) will be used for modeling habitat along the North Anna and Pamunkey Rivers. PHABSIM for Windows – Version 1.20 has been developed and supported by USGS-MESC at Fort Collins, Colorado. The habitat model integrates habitat suitability criteria (HSC) with the stream hydraulic characteristics to produce habitat indices for the target species, guilds or resource use. The development of the habitat suitability criteria for the target species, guilds, and uses was discussed in Section 2. The ultimate objective of an IFIM study is a comparison of usable habitat between a baseline condition and alternative hydraulic regimes. This comparison is made using a habitat index based on weighted usable area (WUA) determined for a range of stream flows.

4.1 OPERATING SCENARIOS FOR EVALUATION

PHABSIM will be applied to assess the impacts of consumptive use associated with the operation of the proposed North Anna Unit 3, compared to the existing Units 1 and 2 baseline. The proposed design of Unit 4 includes only dry cooling towers, such that when built, Unit 4 water usage would be negligible. Thus, the IFIM study will be based only on the proposed water usage for Unit 3. The Unit 3 design includes both wet and dry cooling towers. Operating Unit 3 with only wet cooling towers provides maximum energy conservation (EC). The dry cooling towers are designed to dissipate a minimum of one-third of the heat during summer conditions. Operating the dry cooling towers provides maximum water conservation (MWC). The decision to switch between EC and MWC operations would be based on the availability of water from Lake Anna for evaporation in the wet towers. This was modeled for the Early Site Permitting (ESP) application process using reservoir levels as an indicator of available water for determining when to switch between operating modes.

Based on input received during the ESP process[1], Dominion believes that the following alternative flow scenarios are appropriate for consideration during this study including the Unit 1 and 2 baseline condition.

1. Unit 1 and 2 existing baseline condition
2. Proposed Unit 3 normal operations (switching between EC and MWC)
3. Proposed Unit 3 operations using maximum water conservation (MWC)
4. Increased lake level scenario to provide flow augmentation (250.3 ft msl)

VDGIF has indicated that the maximum considered reservoir elevation increase to provide flow augmentation is 250.3 ft msl. The PHABSIM model will be executed using the HSC for the selected species, guilds, and uses at each transect and for a flow range appropriate for the transect location within the study area. The selection of transects in the Piedmont, Fall Zone, and Coastal Plain was discussed in Section 2. The simulated

[1] See the 7 July 2006 Coastal Consistency Determination letter from R. Fernald (VDGIF) to C. Ellis (VDEQ); and the 21 November 2006 Federal Consistency Certification Under the CZMA letter from R. Weeks (VDEQ) to P. Faggert (Dominion).

flow range is expected to be 20 cfs to 500 cfs at Partlow, just below the North Anna Dam. The flow range will increase at downstream transects as a result of increasing drainage area. Daily flows along the North Anna and Pamunkey Rivers and their major tributaries are well documented by USGS gaging stations.

- North Anna River: USGS gage 01671020 near Hart Corner, 463 mi^2
- Little River: USGS gage 01671100 near Doswell, 107 mi^2
- South Anna River: USGS gage 01672500 near Ashville, 394 mi^2
- Pamunkey River: USGS gage 01673000 near Hanover, 1,081 mi^2

The USGS station at Partlow, below the North Anna Dam, was discontinued in 1995. This station will be reactivated by the USGS during Spring 2007, to be available during the field study. A flow range associated with 20 cfs to 500 cfs at Partlow, below the North Anna Dam, will be estimated for all downstream transects based on historical USGS gaging data and drainage area scaling.

A North Anna Reservoir model has been developed by Bechtel that calculates weekly average releases at the North Anna Dam as a function of historical reservoir inflows, meteorological conditions and Unit operating conditions. The reservoir model will be executed for a 28-year period (1979 to 2006) for each alternative Unit 3 operating scenario. The reservoir model includes a temperature model of Lake Anna as input to the reservoir evaporation routine, and inclusion of meteorological data allows the determination of wet and dry cooling tower efficiency/water consumption.

The calculated 28-year weekly time-series of dam release flows will be used to develop a 28-year time-series of North Anna and Pamunkey River flows at each transect for each operating scenario. The existing baseline flow at each transect will be interpolated using drainage area scaling from the historical USGS data available for the study area. This will result in a flow time-series at each transect with increasing flows with downstream distance. The change in the weekly North Anna Dam release flow will be applied to the baseline flow time-series to create a 28-year flow time series for each operating scenario at each transect. The lag time for flow propagation through the study area is not important when using 7-day average flows because the averaging period is longer than the propagation time. For example, when the flow was reduced to 40 cfs at the dam for the January 2007 fly over, the flow response on the North Anna River at Hart Corner occurred within 0.5-1.2 days, and on the Pamunkey River near Hanover within 1.0-1.9 days.

Application of PHABSIM to the study area for the proposed Unit 3 operating scenarios involves several steps:

- Development of a hydraulic model within PHABSIM for each transect.
- PHABSIM is executed over a range of flows to develop a habitat (WUA)-discharge relationship for each transect and species (habitat modeling).
- The habitat-discharge relationships are applied to the flow time-series for each operating scenario to develop a habitat time-series for each transect and species.

- Appropriate weighting is performed between transects to obtain a habitat time-series for each reach.
- The habitat results are summarized to illustrate the incremental effects between the alternative Unit 3 operating scenarios and the baseline condition.

These IFIM project steps are discussed in the following sections.

4.2 HYDRAULIC MODELING

PHABSIM will be used for the hydraulic modeling, which is performed in two steps:

Step 1. A water surface model is developed based on the cross-sectional areas and measured water surface elevations.

Step 2. A velocity model is developed to provide the lateral velocity distributions within each cross-section simulated in Step 1.

The development and calibration of the hydraulic model within PHABSIM will be based on the three field data sets obtained at each transect (Section 3).

PHABSIM has three options for water surface modeling:

1. STGQ – water surface elevations based on a stage-discharge regression
2. MANSQ – water surface elevations based on Manning's equation
3. WSP – water surface elevations based on a step-backwater method

It is anticipated that the MANSQ model will be used for the North Anna River IFIM study because Manning's equation generally provides a more realistic extrapolation to simulation flows beyond the range of observed field data than the stage-discharge method (STGQ). The WSP method assumes that the transects are sequential along a river segment, and not independent transects as in the North Anna River IFIM study.

Calibration of the MANSQ model will be based on minimizing the error between predicted and observed water surface levels for the range of observed flows at each transect. MANSQ includes a power-law relationship that allows Manning's "n" to decrease slightly with increasing flow. An appropriate power-law coefficient is selected for each independent transect.

The second major step in hydraulic modeling with PHABSIM is simulating lateral velocity profiles at each transect. The VELSIM program within PHABSIM has several different empirical approaches to simulate velocity. When several velocity data sets are available, it is generally recommended to use the highest observed velocity data set to simulate all flows higher than the highest measured flow, and the lowest observed velocity data set to simulate flows lower than the lowest measured flow. The remaining flow range can be either modeled as a transition region (interpolated between velocity data stets) or the velocity data set can be changed based on break points in the channel profile. VELSIM uses the observed velocity data set as a template from which to scale velocities at other flows. A velocity adjustment factor (VAF) is used to maintain mass-balance within the cross-section for varying flows. The validity of the velocity simulation is examined including removing velocity artifacts at stream margins, ensuring that varying VAF relationships are rational based on cross-section characteristics, and by comparing predicted velocities to alternative calibration data sets.

The resulting calibrated hydraulic model at transects within the study area will be executed for a range of flows corresponding to a 20 cfs to 500 cfs release at the North Anna Dam. The flow range will increase at downstream transects as a result of increasing drainage area. The appropriate flow range at each transect will be evident as a result of the 28-year existing conditions flow time-series developed in conjunction with the reservoir release modeling (Section 4.1). For each flow, the hydraulic model will be capable of predicting depth and velocity at individual cells along each transect for use in the habitat model.

<u>2-D Modeling Option</u>

A 2-D hydrologic model may be applied to specific riffle transects if specifically determined to be necessary based upon discussions between the agencies and Dominion. Hydraulic models that would be considered for this task include:

- River2D: developed by Steffler and Blackburn, University of Alberta
- FESWMS: Finite Element Surface Water Modeling System, developed by Federal Highway Administration

Both of these are 2-D finite-difference models that include sub-critical and super-critical flow capabilities. River2D can accurately model flows with surface slopes of up to 10-percent. FESWMS has the capability of embedding weir elements within the model grid that might be used to represent ledges.

4.3 HABITAT MODELING

Application of PHABSIM to the study area for habitat modeling involves several steps.

- PHABSIM is executed over a range of flows to develop a habitat-discharge relationship for each transect and species.
- The habitat-discharge relationships are applied to the flow time-series for each operating scenario to develop a habitat time-series for each transect and species.

PHABSIM will be executed for a range of flows corresponding to a 20 cfs to 500 cfs release at the North Anna Dam. The flow range will increase at downstream transects as a result of increasing drainage area. The appropriate flow range at each transect will be evident as a result of the 28-year existing conditions flow time-series developed in conjunction with the reservoir release modeling (Section 4.1). The weighted useable area (WUA) at each transect will use the multiplicative approach where the suitability index for depth, velocity, and channel index are multiplied together. The multiplicative method produces a lower WUA than the geometric mean option. The execution of PHABSIM over a range of flows will result in approximately 299 habitat-discharge relationships (23 transects x 13 species/life stages). The resulting PHABSIM data base will form the basis for all subsequent analysis, although data for some transects and species/life stages may not be individually presented. Representative habitat-discharge relationships will be presented for key species and transects to illustrate the change in available habitat with flow regime.

The 28-year weekly flow time-series for each operating scenario will be processed in conjunction with the habitat-discharge relationships to develop a habitat (WUA) time-series for selected transects and species/life stages. For this processing, a WUA is determined for the selected transect and species/life stage from the habitat-discharge data base corresponding to each weekly time-series flow. The resulting WUA time-series is representative of the operating scenario flow time-series.

The WUA time-series at individual transects for each species can be combined within a mesohabitat (riffle, run, pool) and by reach to provide appropriate summary representations of the study area. Within each reach, the WUA for transects of the same mesohabitat will be combined with equal weighting *unless* observed transect characteristics provide differentiation within the mesohabitat. To perform a composite WUA representing a reach (Piedmont, Fall Zone, Coastal Plain) the WUA for each of the three mesohabitats will be combined using a weighting factor determined as part of the IFIM study. At this point in the IFIM processing there can be up to 52 WUA time-series (4 reaches x 13 species) for each alternative Unit 3 operating scenario. Additional processing to provide targeted summary statistics to illustrate project impacts and to form a basis of negotiations among interested parties is provided in the next section.

4.4 PRESENTATION OF RESULTS

For the IFIM study, results from the PHABSIM model will be used to compare the change in WUA between the "base case" Unit 1 and 2 scenario and the proposed scenarios that address Unit 3 operations. An initial review of the model results will be used to identify the species/life stages more sensitive to changes in river flow. This review will allow the IFIM analysis to focus on a smaller subset of species. Combining WUA transect results using weighting factors will be performed by reach (Piedmont, Fall Zone, Coastal Plain), but it is unlikely that the reaches will be combined into a single study area value. Incremental WUA differences between alternative scenarios are expected to be more significant on the North Anna, and particularly in the Piedmont, than downstream in the Coastal Plain. A single study area WUA value would mask changes taking place in individual reaches.

The incremental change in WUA between the baseline Unit 1 and 2 condition and proposed Unit 3 operation will be presented by reach (Piedmont, Fall Zone, Coastal Plain) for selected species/life stages. The PHABSIM modeling results including the 28-year WUA time-series for each reach and species can be summarized in multiple ways.

Habitat-Discharge Relationship

Tabular data for the habitat-discharge relationships for each transect/species will be provided. These data will assist in the selection of a subset of representative species/life stages.

Cumulative Frequency Distribution

Cumulative frequency distributions using the 28-year weekly WUA time series data provides an excellent overview of incremental differences between operation scenarios for a specified transect and species/life stage.

Monthly Analysis

The 28-year WUA time-series data can be summarized by month. Statistics including monthly mean and median values can be tabulated and presented as a percent change from the baseline Unit 1 and 2 values. Monthly analysis can also be performed to target individual species and biological critical periods. Months associated with life stages for the species included in the NAR are provided in Table 5.

A combination of analysis techniques including cumulative frequency distributions and statistical summaries for critical monthly/seasonal periods can be performed to address additional areas of concern as they are identified. This analysis may include:

- WUA analysis for selected flows
- WUA analysis between dry and normal years
- WUA analysis during biologically significant seasons

During the modeling phase of the IFIM study, multiple analyses will be performed on the PHABSIM model output in order to compare the change in WUA between the "base case" Unit 1 and 2 scenario and the proposed scenarios including Unit 3. These results will be summarized and presented using appropriate figures and tables in a manner deemed suitable to address potential impacts of the proposed Unit 3. During this process, Dominion will consult with VDGIF and VDEQ regarding analysis and interpretation of the results.

Table 5 Significant Months by Life Stage for Target Species of the North Anna Instream Flow Study

Species	Life Stage	Month											
		J	F	M	A	M	J	J	A	S	O	N	D
American Shad	Juvenile					X	X	X	X	X	X		
	Spawning			X	X	X							
Smallmouth Bass	Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
	Adult	X	X	X	X	X	X	X	X	X	X	X	X
	Spawning				X	X							
Northern Hogsucker	Adult	X	X	X	X	X	X	X	X	X	X	X	X
	Spawning				X	X							
Redbreast Sunfish	Spawning						X	X					
Macroinvertebrates		X	X	X	X	X	X	X	X	X	X	X	X
Guilds		X	X	X	X	X	X	X	X	X	X	X	X

5. RESERVOIR STUDY

5.1 Wetlands Assessment

Various alterations to current lake level operating scenarios have been proposed by representatives of state agencies. Dominion has agreed to conduct a survey of portions of the reservoir to estimate potential impacts associated with raising the full-pool elevation of Lake Anna or increasing the frequency of lake levels below 250 ft msl.

Five coves within the Lake Anna Reservoir have been selected as possible study locations. Figures 6 through 10 depict the location of the selected coves and the study area boundaries within the coves. The selected coves are associated with the confluence of tributaries entering Lake Anna. These areas were selected for study because they are located at the interface between tributary streams and the current full-pool elevation of Lake Anna and support wetland areas. Wetlands in these and similar situations may be affected by proposed changes in lake level elevation in Lake Anna due to the operation of proposed Unit 3.

Existing Conditions Surveys

Field data will be collected to determine the existing conditions present within the study area. Elevation data will be collected using Light Detection and Ranging (LIDAR) and hydrographic surveys. Direct observations of wetland communities will also be made during field activities.

Surface Elevations

The water surface elevation and adjacent land area elevation will be determined using LIDAR. LIDAR data have been collected (January 2007) and will be processed as part of this study. The LIDAR data will be used to produce a digital elevation model (DEM) of the survey areas. This model will allow proposed alterations in water level elevation to be depicted geographically. The areal extent of changes in inundation, within the study area, caused by full-pool elevation changes may be quantified by using GIS techniques. Field observations of the vegetation community will be combined with the DEM to assign elevation ranges to the wetland communities.

Water Depths

Bathymetric surveys of the selected coves will be performed to determine the depths of inundation for the wetlands that are currently present within the study area. Transects for the bathymetric survey will be established perpendicular to the shoreline, spaced at 500-ft intervals. Coordinates for the start and end points of the transects will be created in the office prior to conducting the field activities.

The bathymetric survey will be performed in accordance with USACE Hydrographic Manual EM 1110-2-1003 specifications. Depths will be recorded using an Innerspace

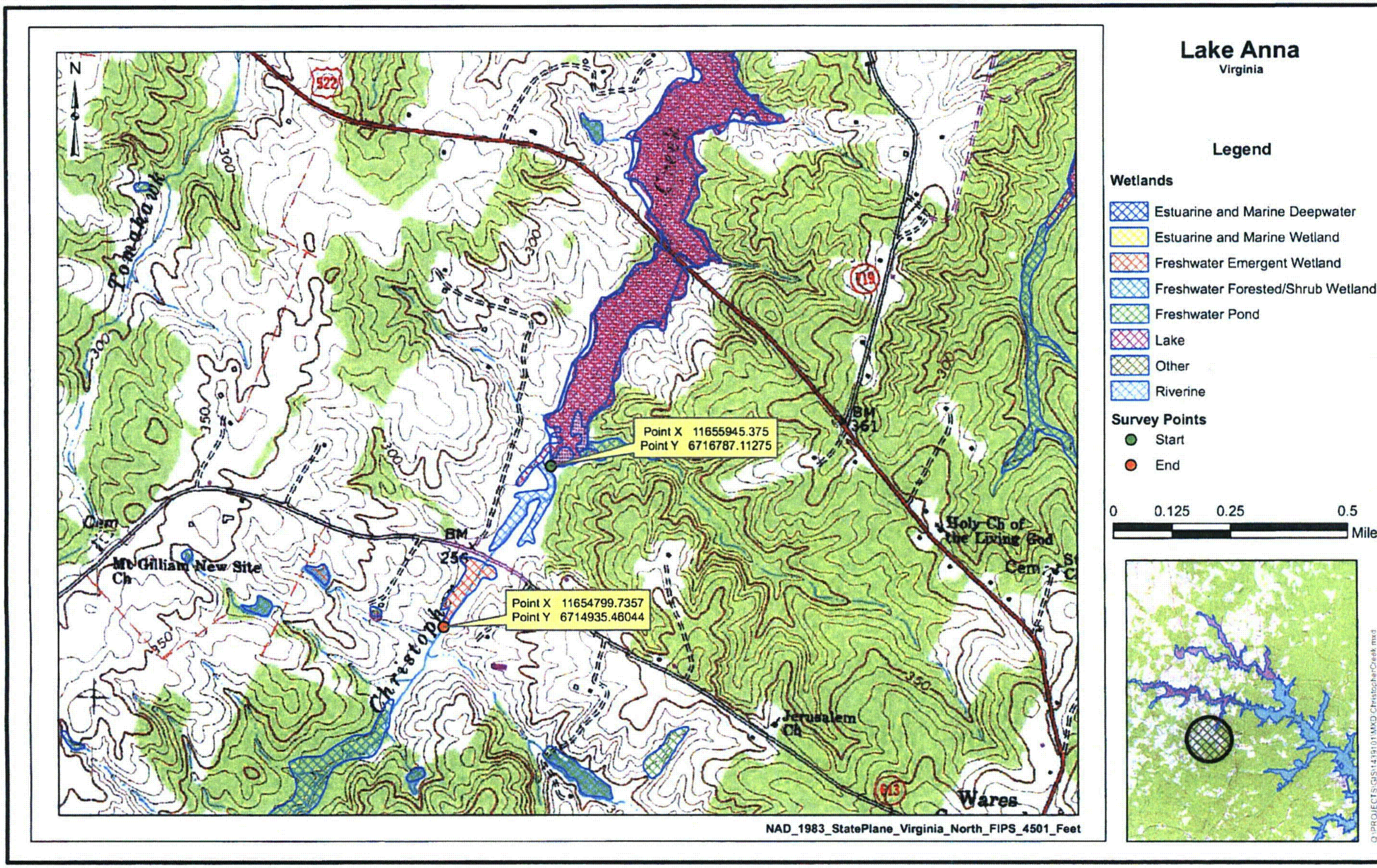


Figure 6 Christopher Creek Wetland Community Study Area

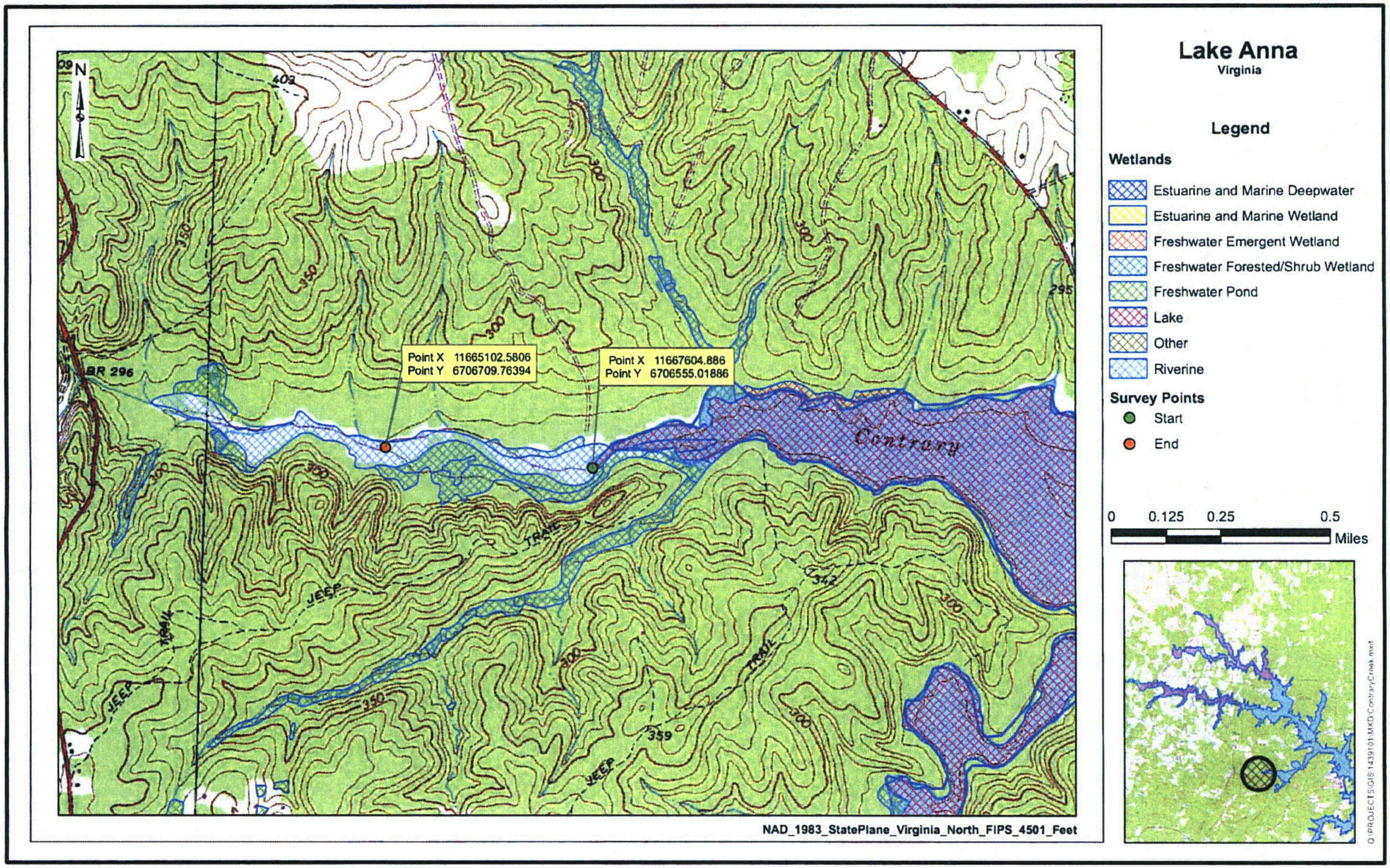


Figure 7 Contrary Creek Wetland Community Study Area

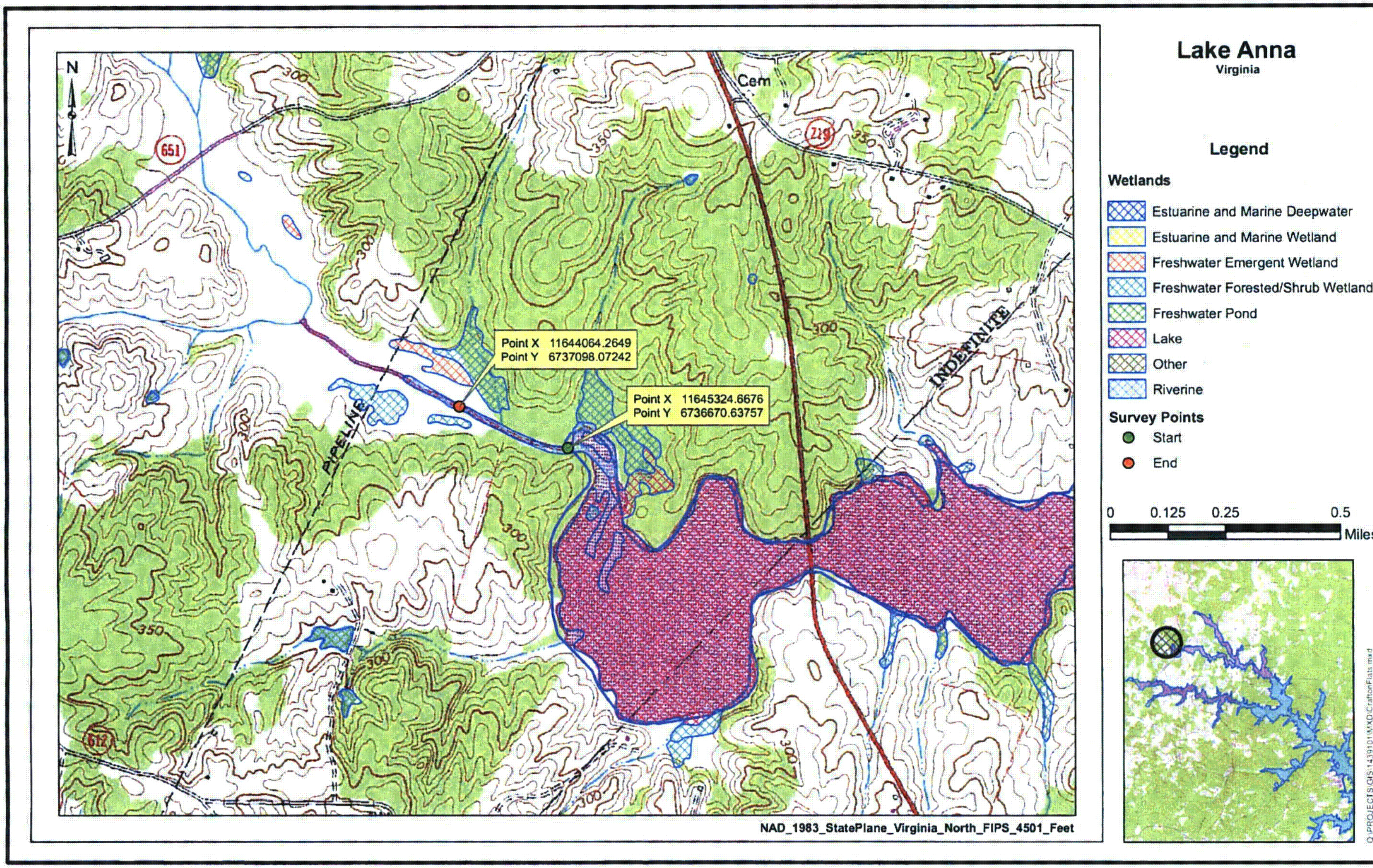


Figure 8 Crafton Creek Wetland Community Study Area

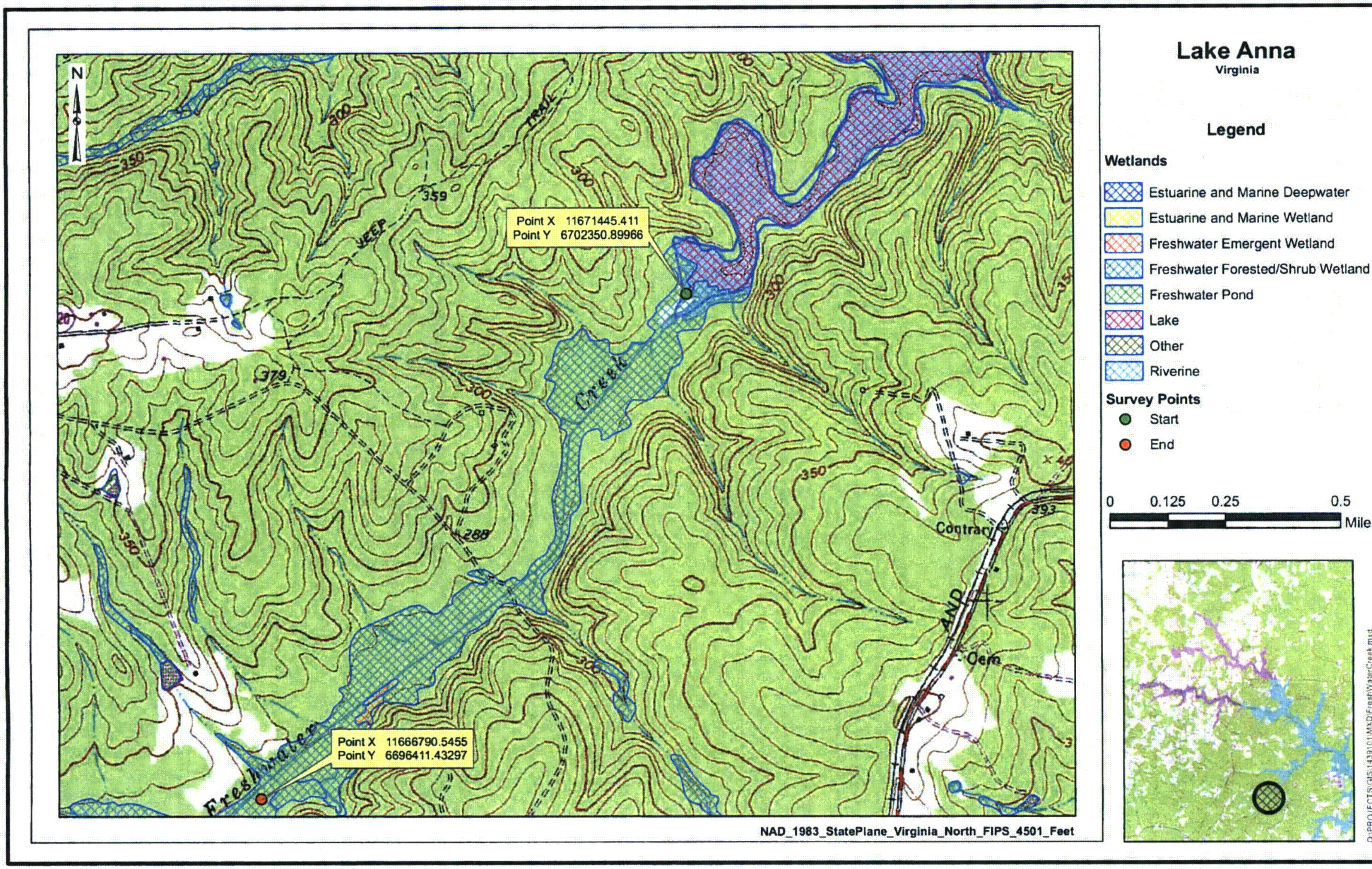


Figure 9 Freshwater Creek Wetland Community Study Area

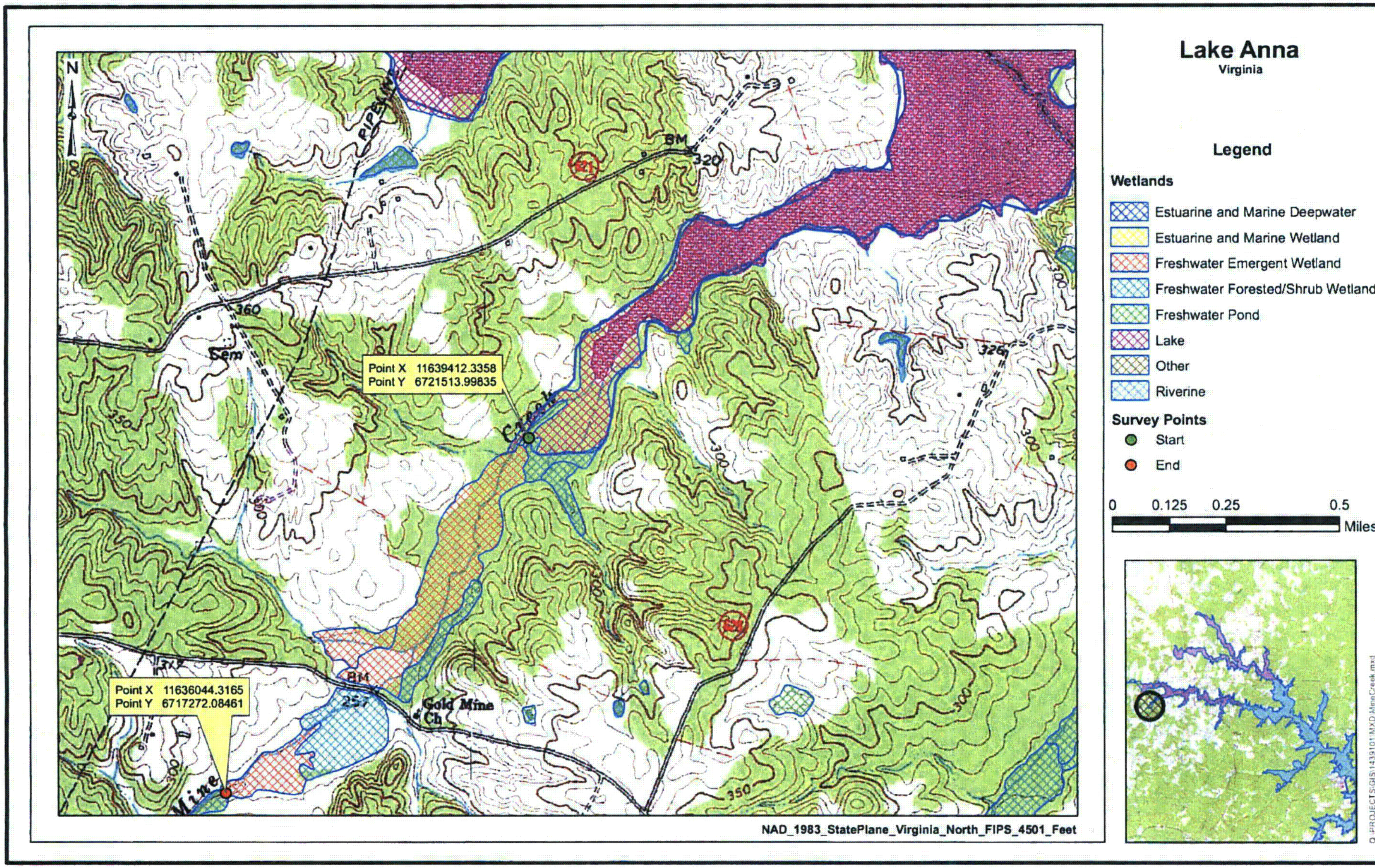


Figure 10 Gold Mine Creek Wetland Community Study Area

Technology Model 448 Depth Sounder; horizontal positions will be obtained using a Trimble AG124 differential global positioning system (DGPS). Horizontal positions and depths will be recorded every 1-2 seconds to a laptop computer using Innerspace Technology's software DLWG (data logger with guidance). Surveying will be completed aboard an EA open work boat. In accordance with specifications from the USACE Hydrographic Manual, depth readings on the Model 448 will be checked pre-survey, every two hours during the survey, and post-survey using a stadia rod to verify accurate readings.

In areas that will not accommodate the open work boat, the survey will be conducted on foot using a stadia rod. Depths will be recorded at five foot intervals along the transect. Geographic positions at each depth reading will be recorded manually using a Trimble® ProXR Global Positioning System (GPS).

This information collected during the bathymetric surveys will be used to correlate existing wetland plant communities to current inundation depths.

Wetland Communities

Transects will be established perpendicular to the shoreline to assess the wetland communities. The transects will be spaced approximately 1,000 ft apart and sampling will occur at 50 ft intervals along the vegetated portions of the transects. Sampling stations will be comprised of an area with a 6-ft radius centered on the transect. Transects will extend landward to elevation 252 msl. At each sampling point, observations of plant species present, their distribution, dominance, and condition will be recorded. A qualitative assessment of plant density will also be recorded. Data observations will be recorded with GPS positions. Table 6 presents the approximate number of transects proposed for each study reach.

Table 6. Approximate Number of Transects for Each of the Five Study Reaches

Creek Name	Approximate Number of Transects
Christopher Creek	3
Contrary Creek	3
Crafton Creek	3
Freshwater Creek	16
Gold Mine	7

The survey will be conducted from an open work boat and on foot. A Trimble® ProXR Global Positioning System (GPS) will be used to navigate to station locations. The coordinates for the sampling stations will be determined in the office and uploaded to the GPS unit prior to starting the field surveys.

Measurements of density will be recorded as 1 through 5, based upon the Braun-Blanquet method for assessing cover classes. A description of the cover class codes is presented in Table 7.

Table 7. Braun-Blanquet Vegetative Cover Classes

Code	Description	Cover class
5	Any number of plants covering more than ¾ of the sample site	> 75%
4	Any number of plants covering between ½ and ¾ of the sample site	50% - 75%
3	Any number of plants covering ¼ to ½ of the sample site	25% - 50%
2	Any number of plants covering between 1/5 and ¼ of the sample site	5% - 25%
1	Numerous individuals, but cover < 1/5 of the sample site, or scattered with cover up to 1/5 of the sample site	< 5%

Presentation of Results

The range of elevations and inundation depth information will be combined with wetland community field observations to determine the existing wetland conditions within the study area. Hydrologic regimes will be assigned to the mapped wetland plant communities. Wetland plant community structure and observed tolerances for inundation, or lack of inundation, will be used to predict possible impacts associated with a change in lake elevation. Possible predictions may include:

- community shifts up or down slope
- changes in wetland plant species
- overall loss or gain of wetland areas

The surface area of possible impacts to wetlands associated with a proposed change in lake full-pool elevation will be calculated.

5.2 Dock and Boat Ramp Functionality Assessment

Proposed changes in lake elevation have the potential to impact the functionality of existing docks and boat ramps. As part of this study, Dominion will evaluate a sub-set of existing docks and boat ramps in the study area.

Up to five commercial, publicly accessible boat ramps and up to five commercial, publicly accessible boat docks will be assessed as part of this study. Distance measurements will be collected between the lake water surface and the top of the docks. The distance between the lake water surface and the existing bumper guards, if present, will also be collected. Distance measurements will be recorded and the likely tolerance to a change in water surface elevation will be estimated.

As-built or other design drawings of boat ramps will be reviewed to assess the functionality of the ramps at water elevations from 248 to 251 ft msl. Water depth measurements at the end of the boat ramps will be collected. This assessment will be based on the extent of the paved ramp that is in the water to assure that at lower water elevations, the boat trailer tires will not extend beyond the limits of the paved ramp surface. The water depth at the ends of the boat ramps as a function of reservoir elevation will be evaluated to determine the potential for successfully launching boats of the sizes typically used in Lake Anna.

Limited interviews with owners and users of the docks and boat ramps within the study area will also occur. Of particular interest will be perceived impacts associated with historic events when lower than normal lake levels were experienced. The information gathered will be used to estimate the likelihood that structures will be able to function at altered lake elevations that may result from operation of the proposed Unit 3.

6. PROPOSED SCHEDULE FOR IFIM ACTIVITIES

This IFIM program is being conducted as part of regulatory requirements for obtaining regulatory permits from the Commonwealth of Virginia. To meet the requirements of the involved agencies, the field work for the IFIM study needs to be completed during the spring and summer period of 2007. More specifically, the proposed IFIM schedule is as follows:

13 Feb 07	Meet with resource agencies to discuss key IFIM issues
29 Mar 07	Submit IFIM study plan to agencies
18 April 07	Agencies approve IFIM study plan
Apr – Aug 07	IFIM field program implemented
14 Dec 07	Submit draft IFIM report to agencies
16 Jan 08	Presentation of IFIM results to agencies
15 Feb 08	Receive comments from agencies
16 Apr 08	Final IFIM report

It is understood that environmental conditions beyond Dominion's control could impact the amount of time needed to perform the IFIM study (e.g., extended high river flows, prolonged drought). In addition, results of the study could affect station design and/or operation. Consequently, Dominion would like to initiate the study as soon as possible so that the outcome can be given appropriate consideration during the facility design process.

7. LITERATURE CITED

Aadland, Luther P., and Ann Kuitunen. 2006. Habitat Suitability Criteria for Streams, Fishes, and Mussels of Minnesota. Minnesota Department of Natural Resources. Report 162.

Bovee, K., B. Lamb, J. Bartholow, C. Stalnaker, J. Taylor, and J. Henriksen. 1998. *Stream Habitat Analysis Using the Instream Flow Incremental Methodology.* U.S. Geological Survey, Biological Resources Division, Information and Technology Report USGS/BRD-1998-0004.

Dominion. 2004. *North Anna River Low Flow Monitoring, Final Report – October 2001 to September 2003.* Prepared by Dominion Electric Environmental Services, Environmental Biology.

EA. 1994. Sinclair Hydroelectric Project Relicensing Technical Studies: Habitat Suitability Criteria. Prepared for Georgia Power.

EA. 1991. James River Instream Flow Study. Henrico County Water Supply Withdrawal Final Report.

Gore, J. 2006. *Roanoke River Instream Flow Study, Clover Power Station.* Final Report, January 31, 2006.

Gore, J., J. Layzer, and J. Mead. 2001. Macroinvertebrate instream flow studies after 20 years; a role in stream management and restoration. *Regul. Rivers: Res. Mgmt 17:527-542.*

Groshens, T. 1993. *An Assessment of the Transferability of Habitat Suitability Criteria for Smallmouth Bass,* Micropterus dolimieu. M.S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Jenkins, R. and N. Burkhead. 1994. *Freshwater Fishes of Virginia.* American Fisheries Society, Bethesda, MD.

Leonard, P., D. Orth, and C. Goudreau. 1986. Development of a method for Recommending instream flows for fishes in the upper James River, Virginia. *Bulletin 152, Virginia Water Resources Res. Center, Virginia Polytechnic Institute and State University.*

Nelson, J., E. Crossman, H. Espinosa-Perez, L. Findley, C. Gilbert, R. Lea, and J. Williams. 2004. *Common and Scientific Names of Fishes from the United States, Canada, and Mexico.* Sixth Edition. American Fisheries Society Special Publication 29, Bethesda, MD.

Odom. 2003. Personal communication from M. Odom (US Fish and Wildlife Service) to J, Kauffman (DGIF) and Bob Graham (Dominion), 21 January 2003.

RMC. 1992. Results of Instream Flow Study in the Bypasssed Reach at the Walters Hydroelectric Project, Pigeon River, North Carolina, Vol I and II.

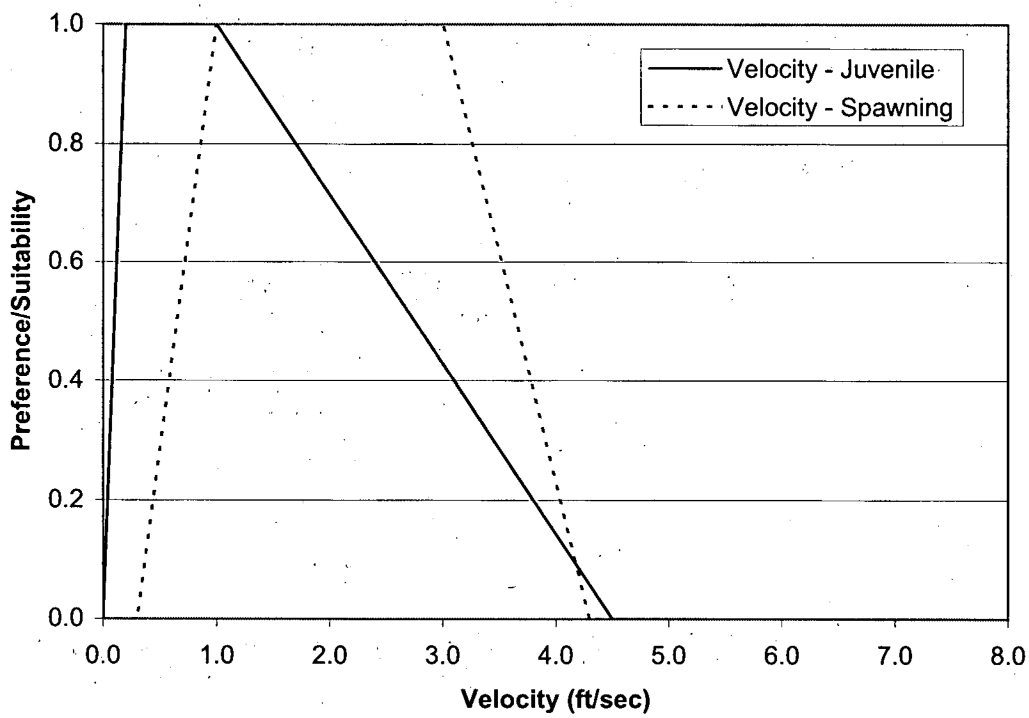
Stalnaker, C., B. Lamb, J. Henriksen, K. Bovee, and J. Bartholow. 1995. The Instream Flow Incremental Methodology: a primer for IFIM. *National Biological Service Biological Report 29.*

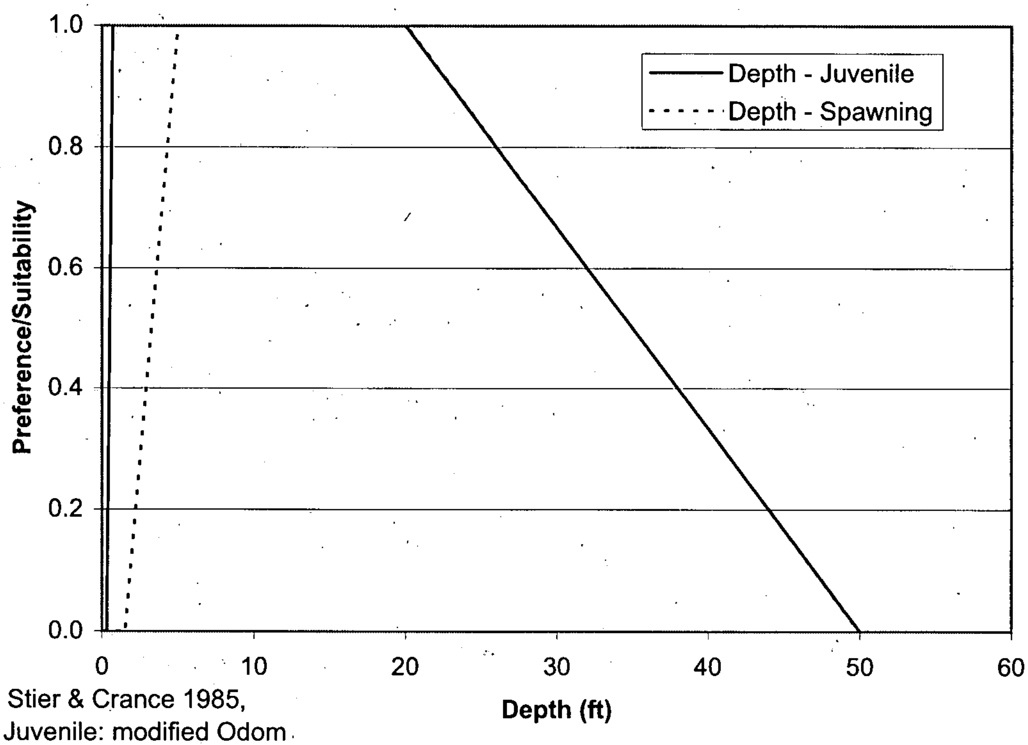
Stier and Crance. 1985. Habitat Suitability Index Models and Instream Flow Suitability Curves: American Shad. U.S. Department of Interior. Fish and Wildlife Service. Biological Report 82(10.88), June 1985.

ATTACHMENT A

Habitat Suitability Curves

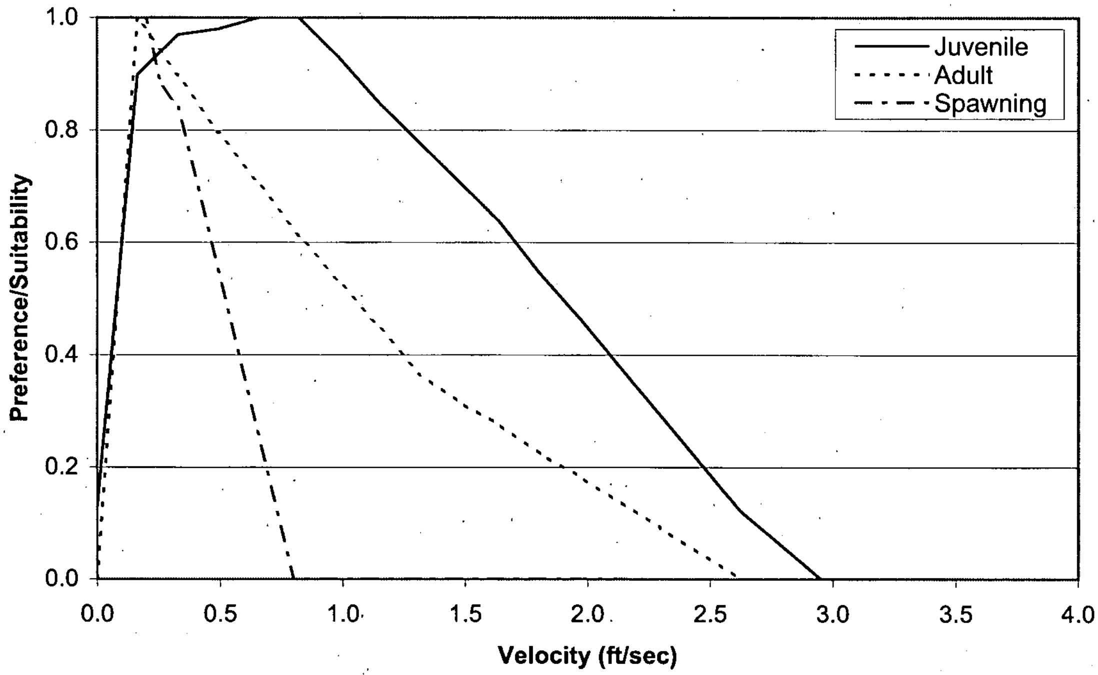
Figure A-1 Velocity and Depth Suitability Curves for Juvenile and Spawning American Shad

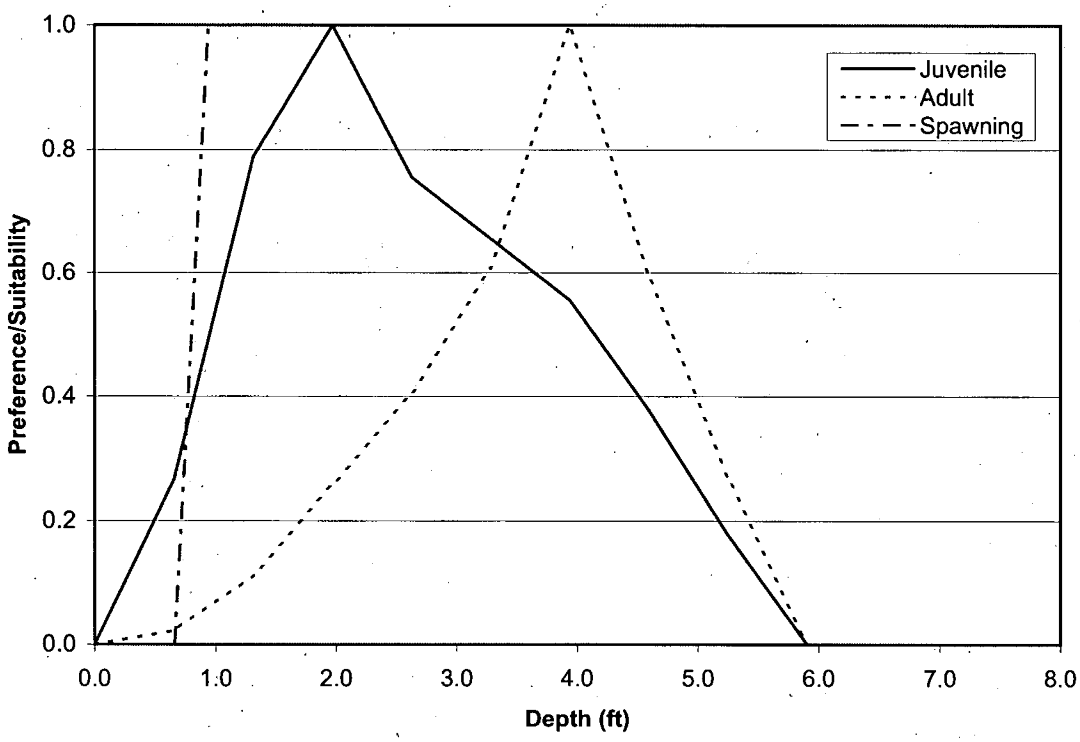




Ref: Stier & Crance 1985,
Juvenile: modified Odom

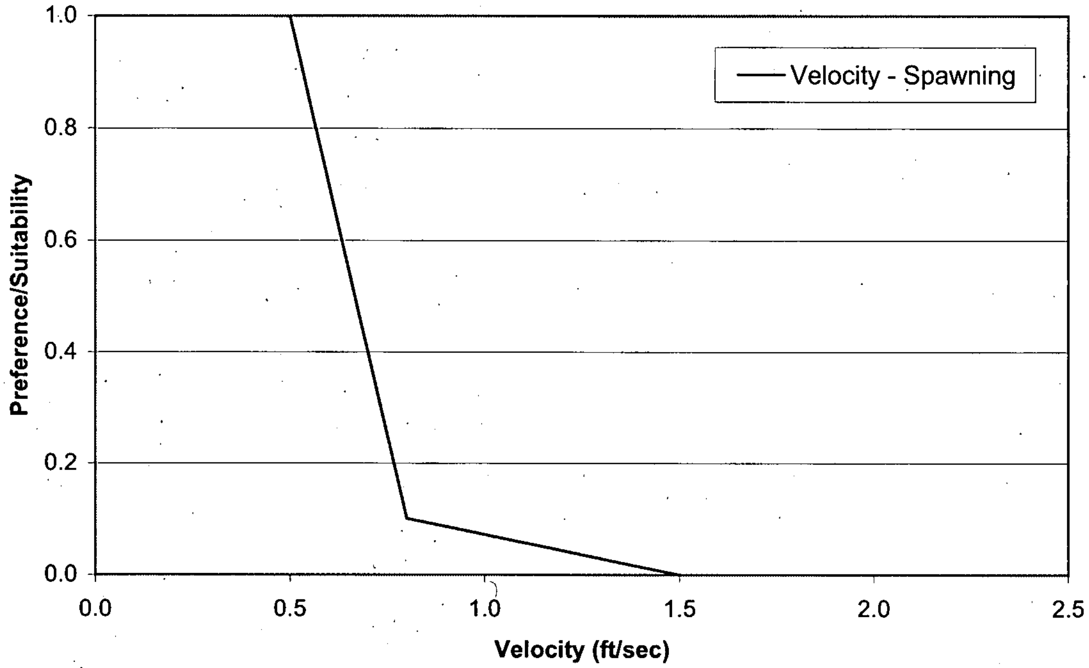
Figure A-2 Velocity and Depth Suitability Curves for Smallmouth Bass (Juvenile, Adult, Spawning)

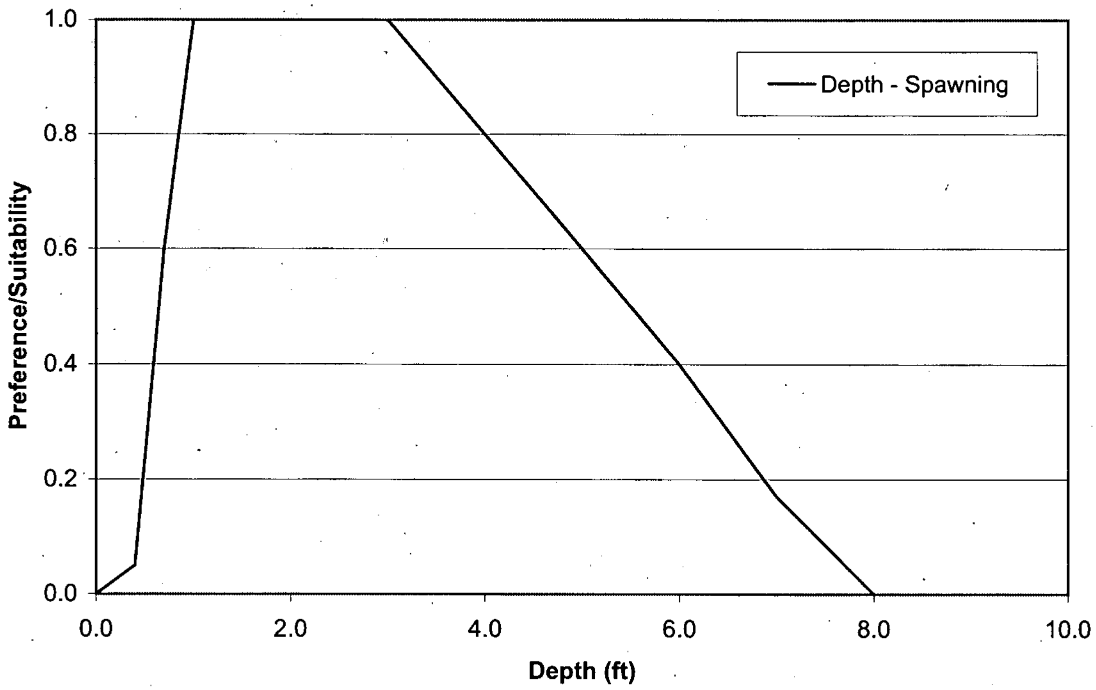




Ref: Groshen 1993, Spawning: Leonard & Orth 1986

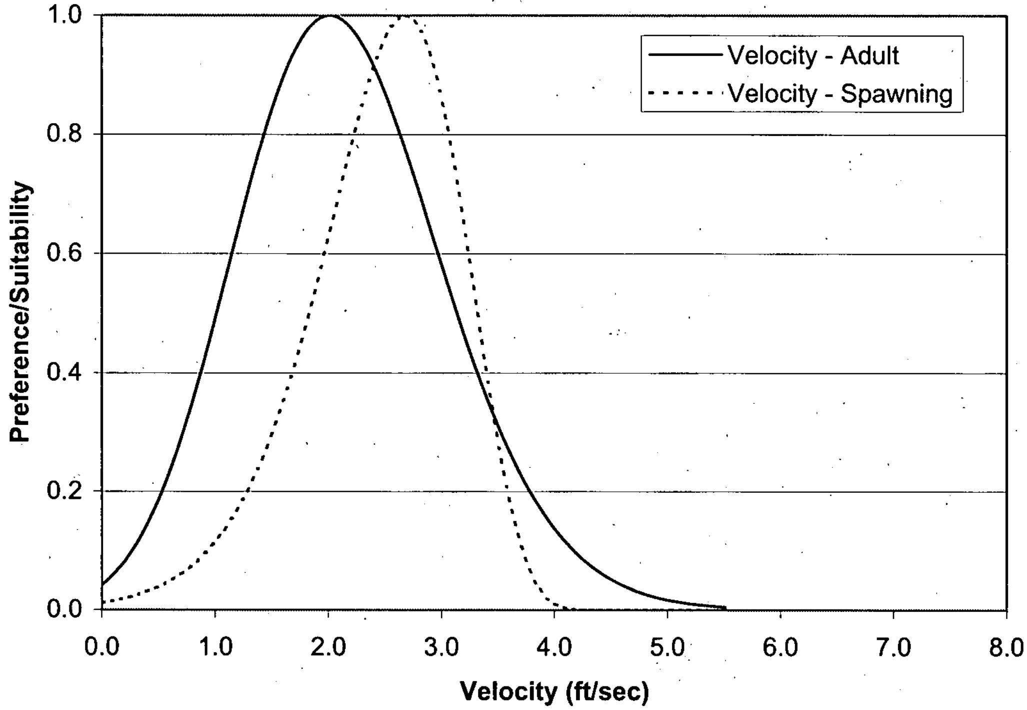
Figure A-3 Velocity and Depth Suitability Curves for Redbreast Sunfish (Spawning)

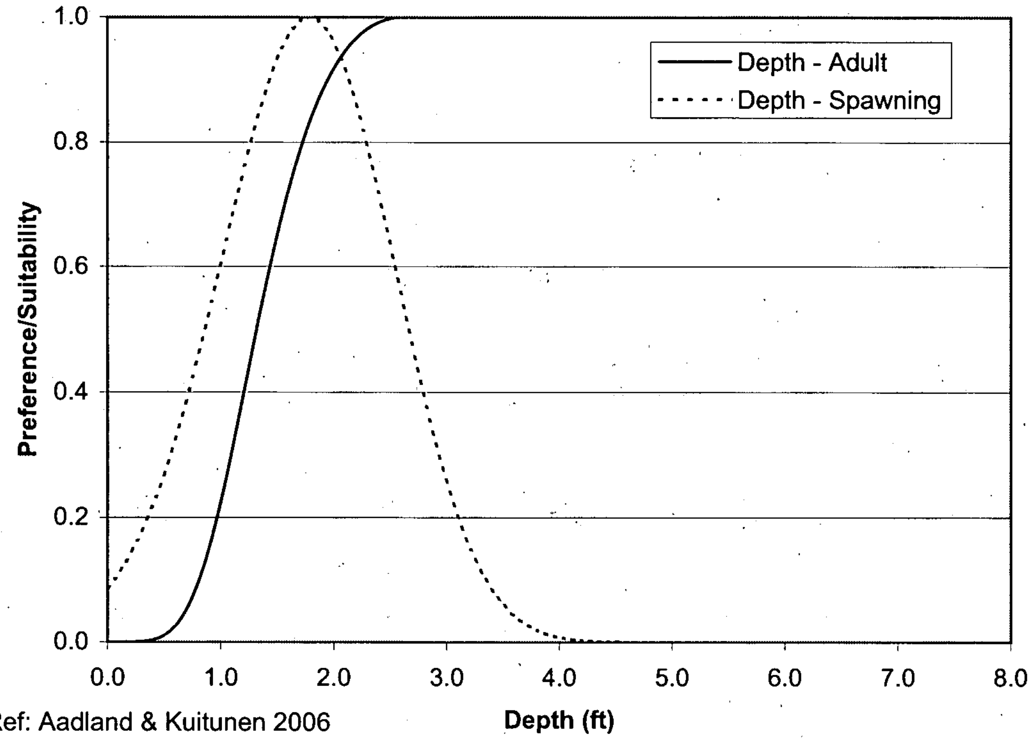




Ref: EA 1994

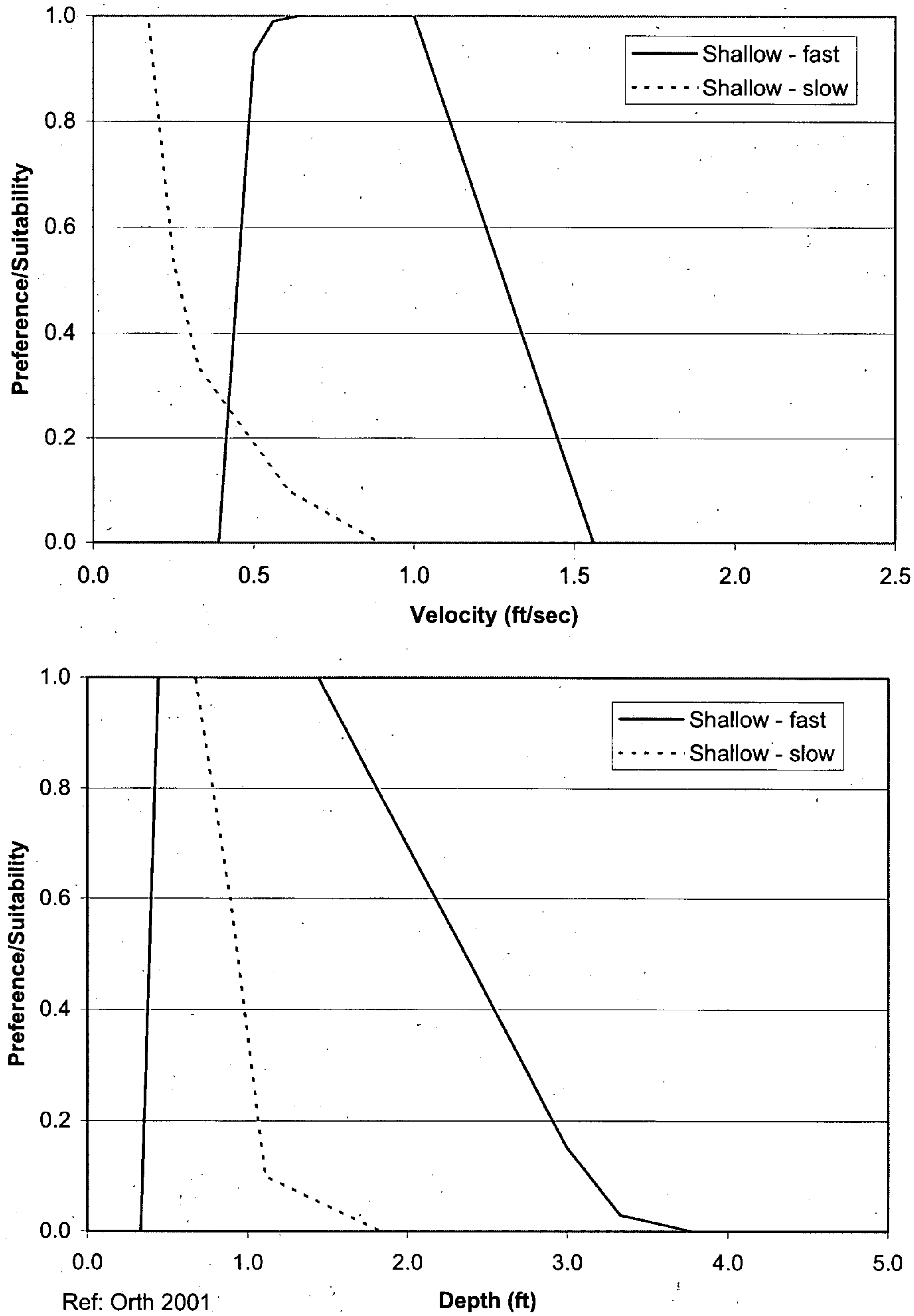
Figure A-4 Velocity and Depth Suitability Curves for Adult and Spawning Northern Hogsucker





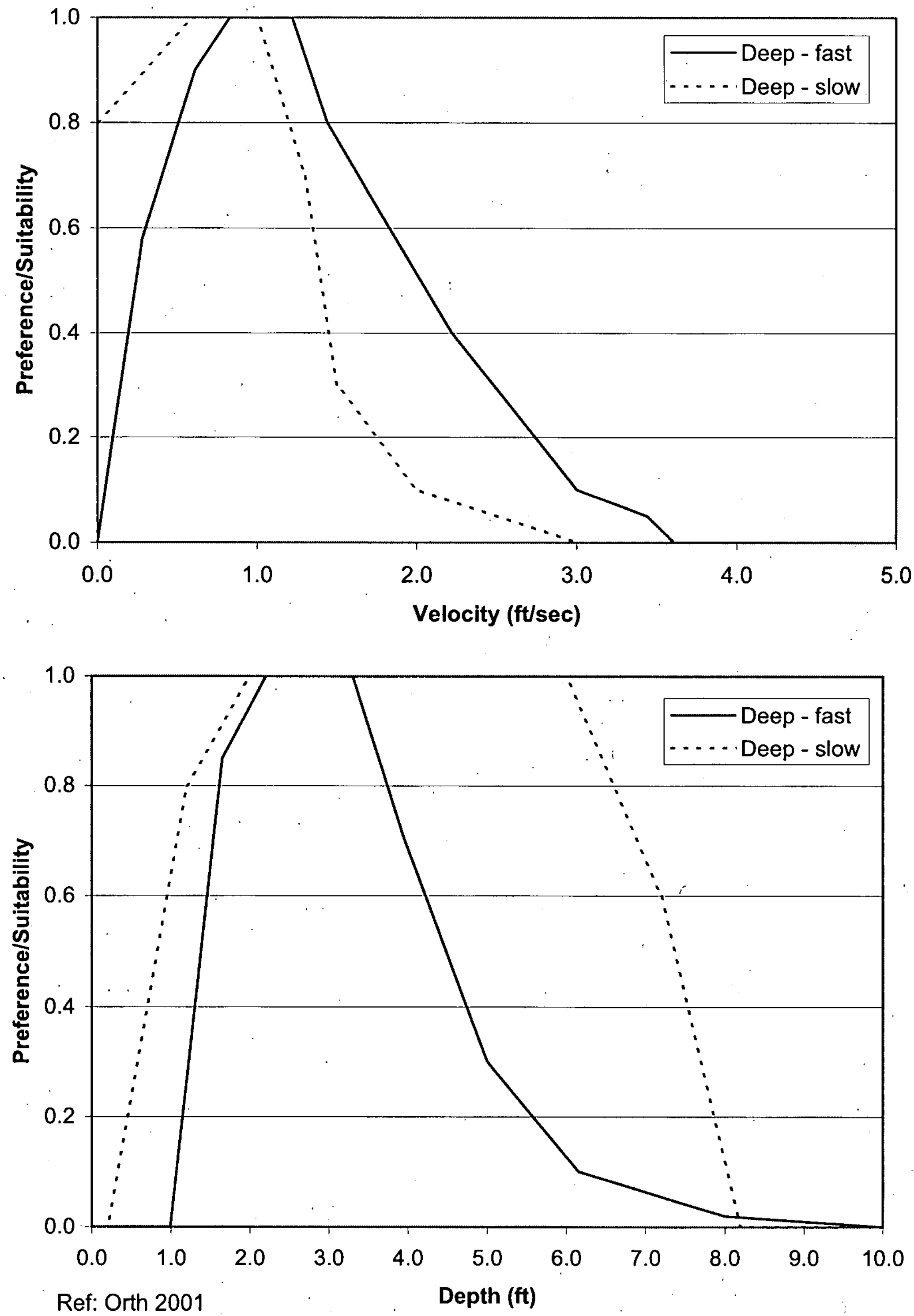
Ref: Aadland & Kuitunen 2006

Figure A-5 Velocity and Depth Suitability Curves for the Shallow Habitat Guild



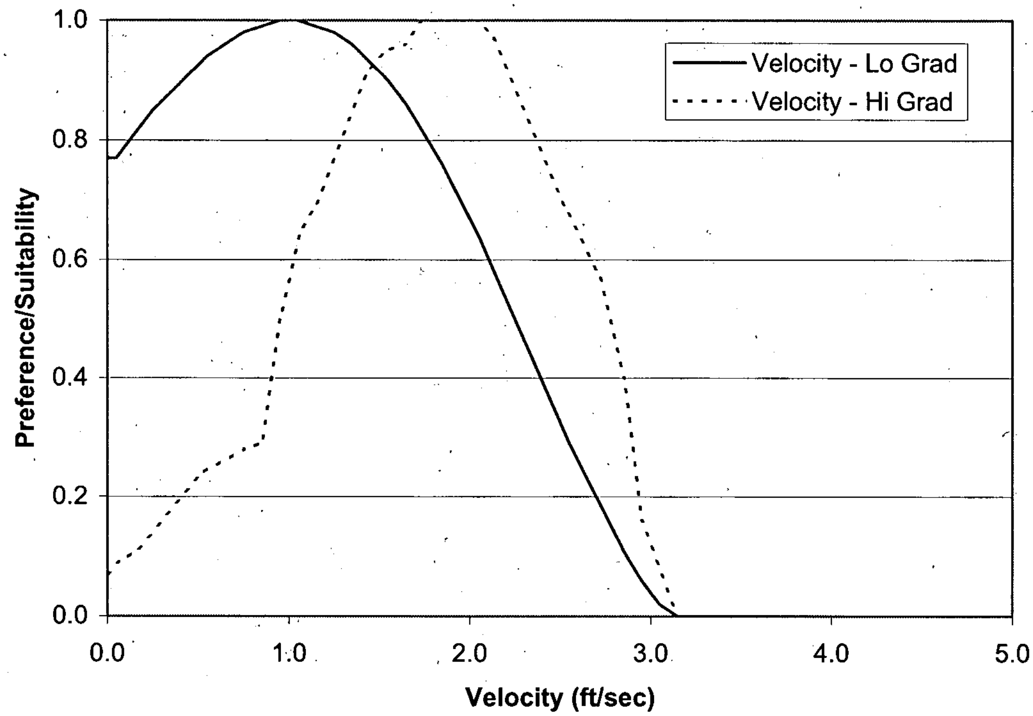
Ref: Orth 2001

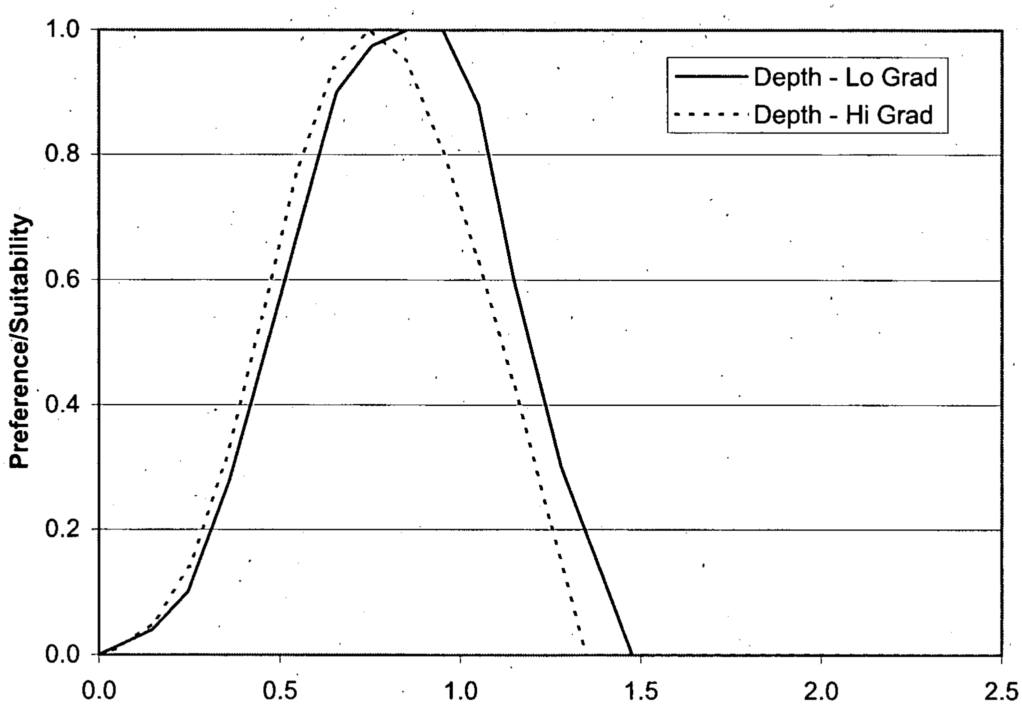
Figure A-6 Velocity and Depth Suitability Curves for the Deep Habitat Guild



Ref: Orth 2001

Figure A-7 Velocity and Depth Suitability Curves for Benthic Macroinvertebrates Diversity





Ref: Gore et al. 2001

Figure A-8 Velocity and Depth Suitability Curves for Canoeing