Quality and Quantity of Potential Anadromous Fish Spawning Sites

Final Report

Grant No. NA88AA-D-CZ091

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Background

Striped bass (<u>Morone</u> <u>saxatilis</u>), American shad (<u>Alosa</u> <u>sapidissima</u>), hickory shad (<u>A.</u> <u>mediocris</u>), alewife (<u>A.</u> <u>pseudoharengus</u>), and blueback herring (<u>A.</u> <u>aestivalis</u>) are the primary anadromous fish species ascending Virginia's waters each spring to spawn in natal freshwater rivers or streams. These populations have historically provided extensive commercial and recreational fisheries to Virginia fishermen. However, in the 10-year period from 1976-1985, commercial harvests of these species from the Chesapeake Bay drainage declined by 82%. Probable causes for the decline of these stocks include overfishing, habitat loss (from dams and water pollution), inconsistencies in management activities, and inadequate data with which to make informed decisions (ASMFC 1985, Atran et al. 1983).

Population recovery is presently being addressed at all levels of management jurisdiction. The Atlantic State Marine Fisheries Commission developed a fishery management plan for the anadromous alosids of the East Coast of the United States. The primary goal of this plan "shall be to promote, in a coordinated coastwide manner, the protection and enhancement (including restoration) of shad and river herring stocks occurring on the Atlantic seaboard" (ASMFC 1985). In 1988, the Living Resources Subcommittee of the Chesapeake Bay Program appointed an interjurisdictional Fish Passage Workgroup to develop a strategy for implementing the 1987 Bay Agreement commitment concerning fish passage. Specifically, the agreement stipulated that the signatories would "provide for fish passage at dams, and remove stream blockages whenever necessary to restore natural passage for migratory fish" through the Basin-wide plan for removing impediments to migratory fishes (CEC 1988). This Bay-wide Strategy was implemented in July, 1989. State-level fisheries management plans are presently being prepared by the Maryland Department of Natural Resources and the Virginia Marine Resources Commission.

Since the signing of the Strategy in 1988, the Virginia Anadromous Fish Passage Committee has addressed the coordination of the activities included in the recommendations amongst its members. The Committee is composed of representatives of the Council on the Environment, the Department of Game and Inland Fisheries, the Marine Resources Commission, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service. Several of the recommendations were targeted by the Department of Game and Inland Fisheries for this particular project and are addressed throughout this report:

* The signatories work together to update the comprehensive inventory of dams and other obstructions to fish migration;

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* The signatories annually reassess their
  priorities based upon updated inventories and
  other relevant information;

* The signatories establish a priority list for
  future fishway projects at these smaller
  obstructions utilizing the inventory of
  impediments to fish passage;

* The signatories identify specific spawning
  reaches suitable for reintroduction.

Specific information needed to accomplish the above tasks is
widely scattered and often inaccessible. This project is
designed to assist the staff of the Department of Game and Inland
Fisheries (and other Bay agencies) in achieving the above
recommendations. While not all recommendations were addressed in
their entirety by the completion of this report, information has
been compiled which identifies further research or work needed.

The historic range of striped bass was not as widely distributed
in Virginia as that of the anadromous alosids (Mudre et al.
1985). One of the primary causes for the decline of the striped
bass in the Maryland/Virginia area has been due to
overharvesting. This problem has been addressed by a moritorium
on striped bass fishing in Maryland, and restricted harvesting in
Virginia. Since habitat restoration efforts are focused
predominantly on the alosids, they will be the species considered
in this project.

Project Objectives and Activities

Two primary objectives were developed to address the issues and needs concerning anadromous fish spawning habitat. These objectives were:

1. To compile the information necessary for determining the quantity of spawning area available above current obstructions to anadromous fish migration; and

2. To develop and apply the analysis techniques required to identify potential spawning sites and quantify the habitat quality of those potential spawning sites upstream of current obstructions to anadromous fish migration.

Several activities were identified to help achieve each of the above objectives.

Objective 1: To compile necessary information

Activities:

a. Current inventory sources of dams and other obstructions to fish migration were combined in a centralized location to allow a complete analysis of the obstruction problem. A survey of knowledgeable individuals was conducted to complete the information which was missing from the various inventories. This does not duplicate any current inventories being conducted but only attempts to bring together the information.

b. Stream area above the current most downstream blockage to the next blockage was determined as a measure of the quantity of potential habitat available to spawning given passage at the current blockage.

c. Combining information on historic spawning sites, current habitat conditions and stream flow characteristics, potential spawning sites were delineated within the upstream area. Potential spawning sites were evaluated as to quality of potential site. Information collected for these sites included the ownership, description, and potential threats to the site.

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Objective 2:   To develop and apply analysis techniques

Activities:

a.   Literature and reports were reviewed to
     develop a tentative model or models which,
     based on best available information, would
     provide a suitability index for potential
     spawning sites for anadromous species.

b.   Based on analysis and identification of areas
     from the above activities, the test models
     were used to identify and quantify known and
     potential spawning sites in the James River
     drainage.

c.   Field surveys using appropriate sampling
     procedures were conducted during the spring
     spawning runs to collect the data necessary
     for validation/modification of the models to
     assure their applicability to quantify
     potential habitat sites.

Inventory of Impediments to Anadromous Fish Passage

Background

The blockage of anadromous fish passage by dams or other obstructions has widely been recognized as one of the primary causes of the decline of anadromous fish populations in Virginia. Advances in transportation and energy needs resulted in many of the present impediments in Virginia. Canal dams, highway culverts, mill dams, and hydropower facilities have contributed to the loss of most of the historic anadromous fish spawning grounds in the Commonwealth.

Historic records of anadromous fish indicate that several species migrated nearly 300 miles up the James River, to the origin at the confluence of the Jackson and Cowpasture Rivers. Presently, fish may migrate only within the first 105 river miles, downstream of a series of 5 dams in the Richmond area. Passage at these facilities would open approximately 150 additional miles of historic spawning grounds before the fish are stopped at the Scots Mill Dam in Lynchburg (River Mile 252.1). This additional spawning habitat would include 139 miles of the James River proper, as well as all tributaries between Richmond and Lynchburg (Odom et al. 1988a).

Ninety-six tributaries of the lower James River (below Manchester Dam in Richmond) were evaluated by Odom et al. (1986). Of these 96, 54 were found to have confirmed river herring spawning runs, 38 were classified as "probable" spawning streams, and 4 appear to be "unlikely" for anadromous fish spawning (Odom et al. 1986). Thirty-three of the 54 tributaries known to have spawning runs are open up to the fall line. Twelve of the tributaries have dams that block fish migration; six have highway crossings that impede migration; one is open its entire length; one has an impassable private culvert; and one flows through a concrete channel at very low levels (Odom et al. 1986). Thirty of the 38 "probable" are open up to the fall line; six have dams impeding migration; one is open its entire length; and one has been altered by mining operations (Odom et al. 1986). Eighty-eight highway crossing were evaluated in this section of the James River. Seven of these crossings were classified as "impassable" or "questionably passable." All seven are on confirmed spawning streams (Odom et al. 1986).

Odom et al. (1988a) also evaluated the middle James River (from Manchester Dam in Richmond to Scots Mill Dam in Lynchburg). A total of 463 tributaries were identified as potential spawning areas. Of the 463, 106 tributaries were classified as "probable" spawning streams, 71 as "questionable," and 286 as "unlikely" (Odom et al. 1988a). The majority of the "unlikely" tributaries were classified as such because of unsuitable stream morphology in the first 0.1 river miles. Of the 222 highway crossings

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evaluated, 14 were classified as "impassable" or "questionably passable." Five of these 14 crossings were identified on streams classified as "probable" spawning habitat, 3 on streams classified as "questionable," and 6 on streams classified as "unlikely" (Odom et al. 1988a).

A similar study has also been completed for the Potomac River drainage. A total of 148 tributaries of the Potomac River (between Great Falls and Popes Creek) were identified as potential spawning streams. Of these 148 tributaries, 40 are "confirmed" spawning streams, 83 are "probable" spawning streams, and 25 are "unlikely" spawning streams (Odom et al. 1988b). Ten of these 148 tributaries are open their entire length; 116 have barriers due to stream morphology, 5 had highway crossing obstructions, and 17 had miscellaneous other impediments (Odom et al. 1988b).

Historic ranges of shad on the Rappahannock River have been estimated conservatively at Remington (Beverly's Ford), 188 miles upstream of the river mouth (Mudre et al. 1985). River herring have been reported to run further upstream, to Fauquier Springs (15 miles above Remington), 202 miles above the mouth of the river (Mudre et al. 1985). The present range of all of these species on this river is the Embry Dam, located just above Fredericksburg, approximately 110 miles above the mouth of the river (VIMS 1986). Detailed studies of comparable impediments (highway, upstream limits of tributaries) on the Rappahannock River have just been started by Dr. Paul Angermeier at VPI&SU. Several major historic spawning tributaries above the Embry Dam are presently inaccessible. Passage at the dam would open an additional 146 miles (total of 217 miles) of potential riverine habitat for anadromous fish spawning and nursery sites (VIMS 1986).

The York River presently has no dams or major impediments preventing anadromous fish from returning to historic spawning areas. Tributaries have not been adequately assessed for potential obstructions from transportation or recent impounding activities. The upstream limits are set by natural falls and a general shallowing of the river (Mudre et al. 1985). Shad and herring historically ran in the Mattaponi River above Milford, and continue to have access to virtually this entire range (Mudre et al. 1985). The entire length of the Pamunkey River (into the South and North Anna Rivers) historically provided spawning habitat for both shad and herring. This area is presently still open to these species for spawning (Mudre et al. 1985). No work concerning the assessment of any type of obstruction is presently planned on the York River.

Other specific types of obstructions have also been studied in Virginia. In 1981, the "Virginia Hydro Dam Inventory" was completed by Rockfish Corporation (1981). This inventory was

designed to provide hydroelectric information about each of the facilities, but also gives information useful for prioritizing anadromous fish restoration efforts. This inventory has not been updated since its completion in 1981, and therefore, may not presently represent all of the hydro dam facilities in Virginia.

Finally, the Department of Game and Inland Fisheries field fisheries biologists prepared a Statewide Dam Inventory. This inventory includes the largest number of dams found in all of the inventories, but specific information is sparse. This inventory also does not include highway culvert obstructions or natural impediments (e.g., fall line).

The primary purpose of this particular aspect of the project was to gather all of these hard copy maps and references and computerize the information for quicker retrieval. The time required to computerize the individual elements precluded merging the information into one comprehensive system. This consolidation will be completed by VDGIF within the next year, presently at the Department's own expense. The comprehensive inventory will include information on the current ownership and use of each impediment, the species presently obstructed, and quality/quantity of habitat upstream of the obstruction (when obtainable). The inventory will also include locational and descriptive information about the particular site. The hydro dam inventory will also be updated with current information from the Federal Energy Regulatory Commission, including information on requirements for fish passage facilities.

Data Capture

The textual information from all of the above sources (where applicable) was entered into datafiles developed using Advanced Revelation (Revelation Technologies, Inc.), the Department's chosen database management system. Each entry was given an ID number which would link it to the digital files containing X,Y coordinates for the site in question. Actual locations of highway crossings, upstream impediments, and hydro dams were captured using digitizing programs developed in Advanced Revelation by VDGIF staff. The coordinates are maintained as UTM coordinate pairs, but can be displayed or output as latitude/longitude coordinates. Samples of each datafile may be seen on pages 10-13.

The initial evaluations of the James and Potomac Rivers by VPI&SU have been computerized into one database. The data collection efforts on each segment were comparable, allowing us to combine the information into one system. The system is divided into two components: tributary analysis and highway crossing assessment. Each highway crossing is related back to the tributary on which it occurs. The following information has been entered for the tributary analysis: USGS 7.5' quadrangle name, river to which it

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is a tributary, the distance the tributary is above the mouth of
the primary river, the mileage open on the tributary, the use
category (confirmed, probable, or unlikely for anadromous fish
use), the migration obstruction on the tributary, and a narrative
of any additional information pertinent to anadromous fish use of
the tributary. The structural evaluation of highway crossings
includes: the name or route number of the road crossing the
tributary, the date the site was evaluated, the structure type,
its size and vertical drop, the depth and velocity of water
through the structure, the passage status (passable,
questionable, impassable for migrating anadromous fish), and any
notes concerning the location. Fish species using the tributary,
or blocked on the tributary, are generally mentioned in the
narrative sections. The species information will be arranged in
a separate, retrievable field when the datafiles are merged in
the next year.

Specific pieces of information were selected by Fish Division
Chief (VDGIF) from the complete "Virginia Hydro Dam Inventory"
(Rockfish Corp. 1981) for inclusion in the database. The
information captured includes: facility name, descriptive
location, river, USGS 7.5' quadrangle name, VA dam ID number,
latitude/longitude coordinates, owner, date built, length,
height, type of construction, original use, current use,
condition, access, reservoir area, flow, nearest USGS gaging
station, US Army Corps of Engineers summaries, and any specific
comments about the structure. This inventory does not provide
any information about species blocked by these facilities. No
FERC information was included. These data will be compiled in
the comprehensive inventory later in 1990.

The inventory compiled by VDGIF fisheries field biologists is
relatively comprehensive (statewide), but provides only minimal
information about each location in question. The data included
in the information system are: county, descriptive location,
river, dam name, height (if known), indication of whether or not
fish passage occurs at that structure, and which migratory
species are impeded by that facility. This information will be
added to the other inventories and elaborated upon in the
comprehensive system.

Programs have been developed by VDGIF staff to output UTM
coordinates from the Advanced Revelation system into an ARC/INFO
(ESRI) "generate" format. These files can then be processed
through the ARC/INFO system to develop coverages. Work will
begin on this conversion for in-house use by VDGIF staff within
the next 6 months.

Number NA-26   Name STAUNTON DAM

Location 8 miles south of Stokesville, Augusta County(Geo.Wash. Nat.Forest)

River NORTH   VA.Dam.ID 01518

Quad STOKESVILLE   Longitude 79 12.1

Owner CITY OF STAUNTON   Latitude 38 20.1

Date.Built 1925   Length 266   Height 46

Type.of.Construction CONCRETE GRAVITY WITH OGEE SPILLWAY

Original.Use WATER SUPPLY   Current.Use WATER SUPPLY

Condition good, gunited 1971, some erosion at right abutment

Access good, off Forestry road 95 and State Route 250

Reservoir.Area 30.4   Flow 33   Nearest.Gaging.Station

USA.Corps.Summary
 No remedial measures necessary.

Comments
 Drainage area - 28.9 square miles. Water supply dam with 16" water
 supply line to City of Staunton. 14 miles to nearest 3-phase power
 lines. 36" drain pipe could be used for hydro installation.

Stream.No LJ-77   Stream CHICKAHOMINY RIVER

Quad.No
5506   Claremont
5507   Brandon
5508   Walkers

Tributary.of JAMES RIVER   Miles.Above.Mouth 46.5

Use.Category CONFIRMED (D, L)   Mileage.Open 23.3

Migration.Obstruction WALKERS DAM

Narrative
American shad, striped bass, and herring run up the Chickahominy River to
the base of Walkers Dam. Walkers Dam is only about 30 cm high during high
tide, but it is a barrier to fish during most years. Several locals have
remarked that during some years, an unusually high tide will allow herring
to get over this dam and into the impoundment above. How far herring will
run above Walkers Dam is unknown at this time. Passage does not happen
every year, so few fisherman and locals look for them above the dam;
consequently, local knowledge is lacking. The crossings above Walkers Dam
were not evaluated in this study.

Structure.No LJ-77-1

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Structure Evaluation - VDOT Highway Project

Structure.No LJ-77-1

Road.Crossing ROUTE 5

Date.Evaluated 04-04-86   Passage.Status PASSABLE

Structure.Type BRIDGE   Size

Vertical.Drop NONE   Depth.In.Culvert > 1.0 M

Velocity.In.Culvert < 25 CM/S

Notes
This is a draw bridge with no passage problems.

VDGIF Dams Inventory   Dams in Middlesex County

T.COUNTY	NAME	RIVER.STREAM	T.TYPE	T.PURPOSE	SPECIES
Middlesex	BARRICKS DAM	MILL CREEK	Earth Gravity	Other	S.BASS SHAD HERRING
Middlesex	BEAZLEY DAM	PARROTTS CREEK	Earth	Recreation Other	S.BASS SHAD HERRING
Middlesex	BURCH MILL DAM	LAGRANGE CREEK	Earth	Recreation	SHAD HERRING
Middlesex	CONRADS DAM	WILTON CREEK	Earth Gravity	Recreation	SHAD HERRING
Middlesex	CORBIN HALL FARM DAM	TR RAPPAHANNOCK RIVER	Earth	Recreation Irrigation	SHAD HERRING
Middlesex	GRAYS DAM	DRAGON SWAMP CREEK	Earth	Recreation Irrigation	SHAD HERRING
Middlesex	HEADLEYS DAM	HEALEYS CREEK	Earth	Recreation	SHAD HERRING
Middlesex	HILLARDS DAM	NICKLEBERRY SWAMP	Earth	Recreation	SHAD HERRING
Middlesex	LOWER ROSEGILL LAKE DAM	TR RAPPAHANNOCK RIVER	Earth		
Middlesex	ROSEGILL UPPER DAM	TR RAPPAHANNOCK	Earth	Recreation Irrigation	SHAD HERRING
Middlesex	TOWN BRIDGE POND DAM	TOWN BRIDGE SWAMP	Earth	Recreation	SHAD HERRINGS

Review of Habitat Models and Habitat Assessment

Background

The most well-known comprehensive assessments of habitat
requirements for shad and river herring can be found in the
Habitat Suitability Indices developed by the U.S. Fish and
Wildlife Service. An additional source of more recent
information on species life histories and environmental
requirements can be found in the Species Profiles prepared by the
U.S. Fish and Wildlife Service for the U.S. Army Corps of
Engineers. A variety of papers also have been published
concerning species habitat requirements, but these usually target
a particular element (e.g., substrate, flow, water chemistry) and
generally are not specific for spawning.

River Herring

River herring occur on the Atlantic Coast from Newfoundland to
the northeastern Florida coast. Specifically, alewives are found
from Newfoundland to South Carolina, and blueback herring range
from Nova Scotia to northern Florida (Loesch 1987, Mullen et al.
1986, Pardue 1983). The species occur sympatrically in Virginia,
but few studies have been conducted concerning their spawning
activities specifically in the state.

The species spawn from late March to July; spawning occurs
progressively later from south to north. In the Chesapeake Bay
area, primary spawning runs for alewives begin in March; spawning
runs in Virginia tributaries to the Bay begin in mid-March
(Loesch 1987). Primary spawning runs for blueback herring begin
in early April (slightly later in the upper reaches of the Bay)
(Loesch 1987). The primary factor initiating spawning appears to
be water temperature. Alewife spawn in temperatures from 10.5C-
27C, while blueback herring spawn in slightly warmer temperatures
of 14C to 27C (Pardue 1983).

In areas such as the Bay region where alewives and blueback
herring occur sympatrically, the species are generally spatially
isolated. Alewives spawn in lentic sections of streams or ponds
and lakes, while blueback herring prefer the lotic sites (Loesch
1987, Pardue 1983). Two major areas in the eastern United States
have been intensely studied concerning river herring habitat. In
New England, where alewives are the predominant species, river
herring spawn mostly in freshwater ponds or low-flow sections of
streams and rivers (Loesch 1987, Mullen et al. 1986, Pardue
1983). In the Carolinas, where blueback herring are the
predominant species, the fish are seen spawning in more diverse
habitats (oxbows and swamps as well as riverine sections) (Loesch
1987, Mullen et al. 1986, Pardue 1983).

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Blueback herring appear to be the more dominant species of river herring in Virginia. However, both species are limited in upstream movement and occur in such numbers that they appear to partition the available riverine resource. At such sites, alewives tend to favor shore-bank eddies or deep pools, while blueback herring tend to congregate in the mainstem flow areas (J. Loesch, VIMS, 1989, pers. comm.; J. Mowrer, MD Dept. Natural Resources, 1989, pers. comm; S. Rideout, USFWS, 1989, pers. comm; C. Walton, ME Dept. Marine Resources, 1989, pers. comm; M. Odom, USFWS, 1988, pers. comm.; Loesch 1987).

American Shad

American shad are found along the Atlantic Coast from Labrador to Florida (Weiss-Glanz et al. 1986, Stier and Crance 1985). The species is most abundant in the center of its range, from Connecticut to North Carolina (Weiss-Glanz et al. 1986, Stier and Crance 1985).

The species begin spawning as early as mid-November in Florida and as late as July in some Canadian rivers (Stier and Crance 1985). The spawning run peaks at a temperature of about 18C, with a range of 13C to 20C. In Virginia, this means that the initial spawning runs begin at about the same time river herring runs begin, but taper off approximately one month before herring have finished spawning.

Unlike the river herring, shad populations in Virginia are predominantly semelparous (one-time spawners). Only about 25% of the shad running in Virginia rivers are repeat spawners (Weiss-Glanz et al. 1986).

American shad spawn over a variety of substrates, but seem to prefer a sand or gravel bottom with sufficient water velocity to eliminate silt deposits on the eggs (Stier and Crance 1985). Spawning has been observed in a wide variety of depths; depth does not appear to be a critical factor in selection of spawning sites (Weiss-Glanz et al. 1986, Stier and Crance 1985).

Review and Modification of Habitat Suitability Models

American Shad

The HSI model developed by Stier and Crance (1985) has two components: a riverine component and an estuarine component. The riverine model assumes that, if water temperatures and water velocities are suitable, all other habitat variables will be acceptable for spawning and rearing young-of-the-year until their downstream migration to the estuary.

Studies presently ongoing in Virginia and Maryland indicate that certain water quality parameters not previously associated with shad habitat suitability may be contributing to declines in shad populations (Klauda 1989, CBP 1987, ASMFS 1985). We feel that future models may want to consider pH, chlorine, and prey densities. Additionally, we have made one modification to the existing SI values for substrate type. The existing model does not give suitability index values for riverweed or *Justica* beds. Classifying these substrate types with the plant/detritus would be an under-representation of the quality of such substrate for spawning. The water flow through these living plant materials offers abundant dissolved oxygen (DO) and low siltation. These substrate types additionally offer numerous opportunities for egg attachment during the water-hardening stage and some cover from predators. Based on this assessment, we believe that the SI values for the substrate component should be modified as follows:

Substrate	SI
Living plant (riverweed, water willow)	1.0
Detritus (logs, sticks, leaf packs)	0.0
Mud/soft clay	0.1
Silt	0.2
Sand	1.0
Gravel	1.0
Cobble/rubble	1.0
Boulder	0.6
Bedrock	0.4

River Herring

The river herring model developed by Pardue (1983) has two separate models within it: model for spawning adult, egg, and larvae, and a model for juveniles.

The spawning adult model has two components to it: cover (substrate characteristics and associated vegetation) and water quality (temperatures). The cover component makes the assumption that substrates with 75% silt and other soft materials containing detritus and vegetation, and slow water flow are optimal for river herring. Harder and coarser substrates are considered less desirable. The water quality component assumes that mean daily water temperatures of 15C-20C for alewives and 20C-24C for blueback herring are optimal for spawning. This model is to be applied only in areas where water depth is 0.15m-3.0m and water velocity is greater than 0 ft/sec and less than 1.0 ft/sec. Any flow values (0 ft/sec, >1.0 ft/sec.) outside of those values are assigned an SI value of 0.0.

The juvenile model has two components: food (number of zooplankton per liter) and water quality (salinity and temperature). The food component ignores zooplankton

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composition, assuming that there will be an appropriate species composition. One hundred zooplankton per liter or more is considered optimal. Salinities of 0-5 ppt are considered optimal. Ideal water temperatures for alewives are considered to be 15-20C, and 20-30C for blueback herring.

We feel that future models for river herring in Virginia should include several additional elements. While current studies indicate that low pH levels can adversely affect egg and larval survival (Klauda 1989; D. Kelso, George Mason University, 1989, pers. comm.; CBP 1987; ASMFC 1985), the existing model does not consider pH a significant variable. We believe that this should be reconsidered in light of this new evidence. Additional evidence suggests that total residual chlorine (primarily from sewage effluent) can be high enough to extirpate or severely impact river herring runs in those streams (Kelso, 1989, pers. comm; Morgan and Prince 1977), and should be considered in the model.

We also suggest modifications in the substrate and flow elements of the existing model based on the abundance of both alewives and blueback herring. Blueback herring are the predominant river herring in Virginia. When both species occur in an area, the blueback herring use faster flowing water over harder substrate types. It appears that the existing model values for these two variables are based on information collected for alewives in New England and blueback herring in the Carolinas, using slow water over soft substrates. After conversations with J. Loesch (VIMS), S. Rideout (USFWS), C. Walton (ME Dept. Marine Resources), J. Mowrer (MD Dept. Natural Resources) concerning their knowledge and observations of river herring spawning, and our own observations in Virginia, we are suggesting the following modified SI values for the substrate and velocity components in the river herring model.

Depth

Depth (m)	SI
0.00	0.0
0.09	0.0
0.20	1.0
1.25	1.0
3.01	0.0

These values are based on the values in Pardue's (1983) HSI model with 0.15-3.0m receiving SI=1.0; S. Rideout (pers. comm.) seeing bluebacks spawning in water greater than 0.10m; C. Walton (pers. comm.) seeing bluebacks spawning in depths from 0.30m-1.22m, with most from 0.61m-0.91m; and J. Mowrer (pers. comm.) seeing bluebacks spawning in water depths for 0.20m-0.61m.

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Velocity

Velocity (m/s)	SI
0.0m/s	0.0
0.02m/s	1.0
1.22m/s	1.0
1.35m/s	0.0

These values are based on values in Pardue's (1983) HSI model; C. Walton (pers. comm.) indicating that some flow is required for both species and observing bluebacks using areas with velocities of 0.89m/s-1.34m/s; J. Mowrer (pers. comm.) indicating that although some flow is required for both species, flows in excess of 1.22m/s appear to be too high for bluebacks in Maryland.

Substrate

Substrate	SI
Live plant material (riverweed, water willow)	1.0
Woody debris	0.9
Temporarily flooded plant detritus	0.8
Gravel	1.0
Cobble/rubble	1.0
Boulder	0.7
Sand	0.6
Bedrock	0.4
Silt	0.2
Mud/soft clay	0.1
Muck/decomposing organic matter	0.0

Conversations with several recognized anadromous fish experts confirmed our own observations that this component most likely does not accurately represent spawning grounds in Virginia. Loesch (pers. comm.) agreed that the primary spawning areas for bluebacks in Virginia is relatively fast-flowing water over gravel and coarser substrates. Rideout (pers. comm.) indicated that he has seen blueback herring spawning in a tributary of the Connecticut River over gravel-cobble substrate in water as shallow as 10-15 cm. Walton (pers. comm.) indicated that in Maine, he has observed blueback herring spawning on gravel, cobble, and boulders up to 30.5-35.6 cm in diameter. Mowrer (pers. comm.) has seen blueback herring spawning in Maryland over hard substrate, especially over gravel that is 2.5-5.0 cm in diameter. He has also observed them utilizing flooded woodlands, detritus (sticks), and wetland plants.

Field Assessment of Habitat Quality and Quantity

Several areas on Virginia rivers were considered for an assessment of habitat quality and quantity, using the modified habitat suitability index models mentioned above. The intent of this portion of the project was to select two rivers with known obstructions to anadromous fish passage (James River and Appomattox River) and evaluate the habitat between the first and second blockage. A series of 5 dams occurs within a 6-7 mile stretch of the James River in the city of Richmond. The first impediment on the James River is the Manchester Dam. A comparable series of 4 dams exists on the Appomattox River just upstream of the city of Petersburg. The first obstruction on the Appomattox River is the Harvell Dam, on the western limit of Petersburg. Because each of these systems has a series of dams in such close proximity to one another, the habitat was evaluated on both rivers between the first and the last of the series of dams (pp. 21-22).

Aerial photographs were obtained from the Virginia Department of Transportation at a scale of 1":1200" for the reaches of concern on both rivers. Stream channels and islands were delineated using a stereoscope to allow for digitizing once field work was completed. Reaches were identified on each river, using obvious breaks (dams, pipelines) where available. Ten to twenty random points were selected in each reach for specific habitat measurements and marked on the photographs. The number of points in any given reach was determined by the relative size of the particular reach.

Field work on each river required 3 days, which were spread over a period of one month due to high water levels. Gage heights were noted for each field day and flow values were calculated from USGS conversion tables. Data were also verified by follow-up calls to USGS. A review of the tables on pages 23-25 indicates that the water flows encountered during the field days was comparable to flows generally found in those rivers during March to May. At each sampling site, water depth and velocity were measured, and substrate composition was determined with a qualitative assessment of a 1-meter circle around the point. The additional parameters mentioned in the review of the habitat suitability models (i.e, temperature, pH, etc.) were not measured in this study. Shad and herring already have a history of spawning in each of these rivers below the primary impediment, so we assume that these parameters are at acceptable levels during the spawning season.
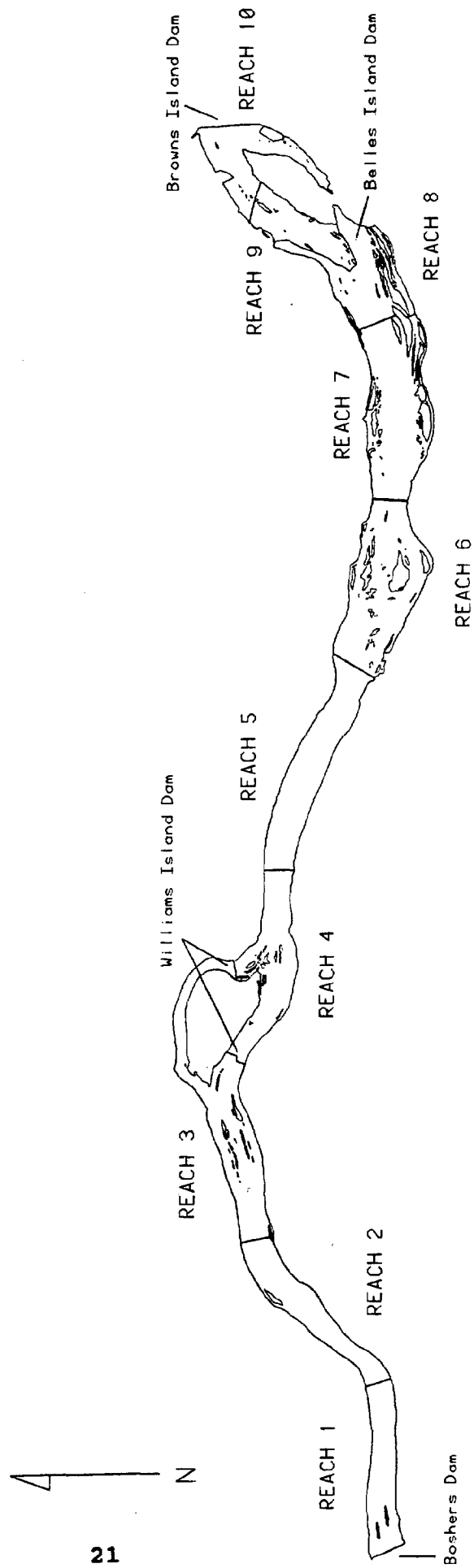
Water depth measurements were taken in meters using a 4-meter stick. Velocity measurements were made using a Oceanics flow meter. Velocities were calculated using the conversion equation provided by the manufacturer. Substrate composition was measured as percentages of specific substrate types. A range finder was

19

used to ensure that sampling points were located as accurately as possible.

Upon completion of field work, the river maps/photographs were sent to VPI&SU where project staff digitized the individual reaches using the ARC/INFO geographic information system. River system and individual reach maps were generated to illustrate the project activities (Appendix 1) and reach areas were calculated using the ARC/INFO system (p. 26).
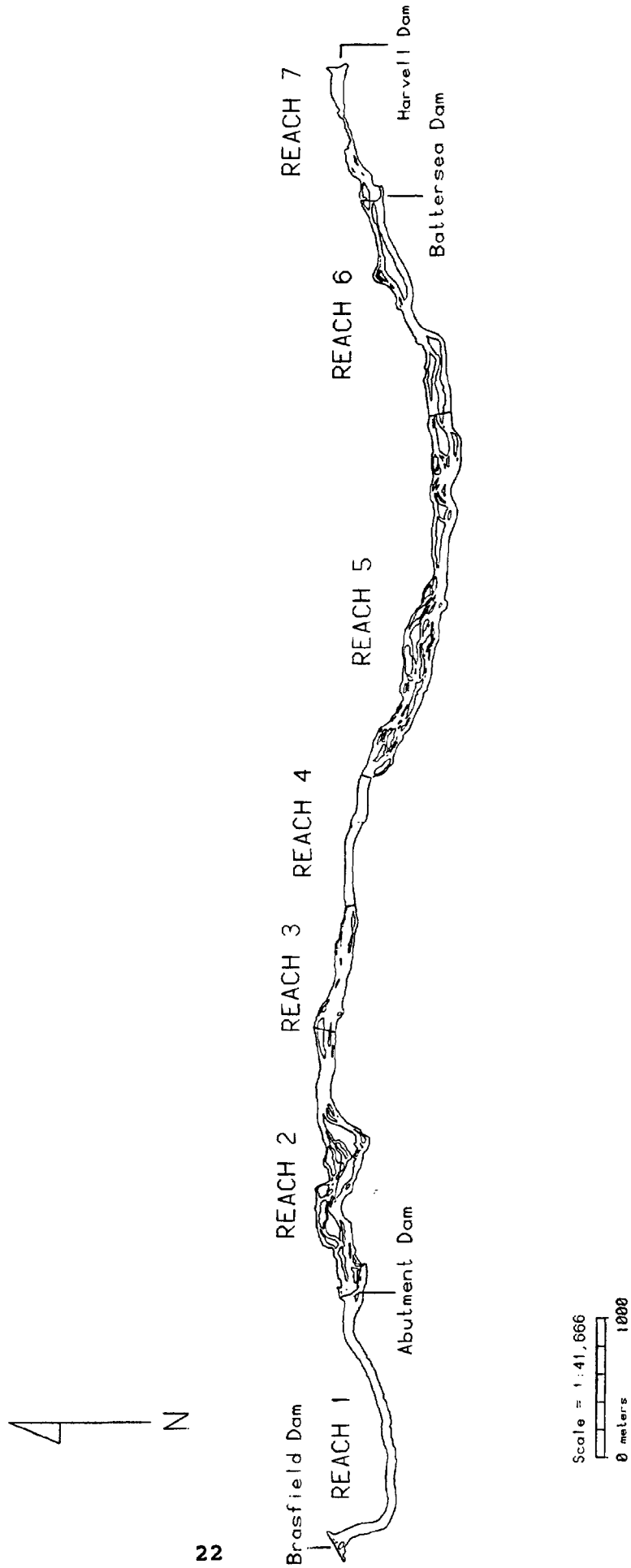
JAMES RIVER

(Boshers Dam to Brown Island Dam)

N

REACH 1

REACH 2

REACH 3

REACH 4

REACH 5

REACH 6

REACH 7

REACH 8

REACH 9

REACH 10

Boshers Dam

Williams Island Dam

Belles Island Dam

Browns Island Dam

Scale = 1:50,000

0 meters   1000

APPOMATTOX RIVER

(Brasfield Dam to Harvell Dam)

N

REACH 1

REACH 2

REACH 3

REACH 4

REACH 5

REACH 6

REACH 7

Brasfield Dam

Abutment Dam

Harvell Dam

Battersea Dam

Scale = 1:41,666

0 meters   1000

22

ESTIMATED MEAN MONTHLY FLOW OF JAMES RIVER AT RICHMOND, VIRGINIA

(Does not include flow in Kanawha Canal)

(cubic feet per second)

(USGS data: 1934-1981)

MONTH	MINIMUM	MEDIAN	MAXIMUM
January	840	8,200	22,500
February	3,240	10,270	20,750
March	5,690	11,510	25,900
April	2,770	10,050	22,760
May	2,430	6,130	16,990
June	900	3,660	30,910
July	80	2,270	11,300
August	150	1,820	21,710
September	130	1,350	16,730
October	180	1,680	18,670
November	540	3,180	19,710
December	450	4,610	20,160

23

ESTIMATED MEAN MONTHLY FLOW OF APPOMATTOX RIVER
AT MATOACA, VIRGINIA

(cubic feet per second)

(USGS data: 1969-1989)

MONTH	MINIMUM	MEDIAN	MAXIMUM
January	384	1,662	5,868
February	889	2,065	3,931
March	478	2,019	5,149
April	498	1,982	5,003
May	411	1,189	4,452
June	161	616	5,293
July	99	438	1,987
August	85	483	1,818
September	99	288	5,312
October	129	349	6,869
November	200	733	5,648
December	398	1,404	2,912

DISCHARGE ON JAMES AND APPOMATTOX RIVERS

DURING HABITAT SAMPLING PERIOD

James River, Westham Gage

10/31/89 - 11/02/89

Date	Discharge
October 31, 1989	5,920 cfs
November 1, 1989	5,920 cfs
November 2, 1989	6,070 cfs

Appomattox River, Matoaca Gage

10/11/89 - 10/12/89, 10/26/89

Date	Discharge
October 11, 1989	417 cfs
October 12, 1989	374 cfs
October 26, 1989	920 cfs*

* Estimate based on gage height 6 hours prior to sampling (3.5')

AREA OF INDIVIDUAL REACHES

APPOMATTOX AND JAMES RIVERS

(hectares)

James River

Reach	Total Area	Water Area
1	36.783	36.395
2	36.783	36.395
3	65.243	63.240
4	49.641	47.938
5	57.136	57.136
6	77.284	69.130
7	79.143	68.456
8	47.397	42.207
9	28.419	27.337
10	36.035	34.252

Appomattox River

Reach	Total Area	Water Area
1	16.495	16.241
2	34.953	22.817
3	10.155	9.100
4	6.517	6.494
5	44.030	31.556
6	22.366	15.699
7	7.653	7.158

Suitability indices (SI) were calculated for each variable at each reach for American shad and river herring using the modified habitat suitability model developed earlier in this project. Once SI were calculated, the Habitat Suitability Index (HSI) value for that particular site was determined to be the lowest SI value for any of the variables. Mean HSI values were calculated for each reach to determine a reach HSI value (p. 28).

Overall habitat suitability should not be determined by HSI values alone, but must include some measure of the area available in a given location. Habitat Units (HU) were calculated for each reach. The HU value in any reach is the product of the reach mean HSI value and the reach area (in hectares) (p. 29). The calculated HU values were then compared to an optimal HU (HSI=1 x reach area) for a relative evaluation of the available habitat for spawning.

The HU values of the James River indicate that this system is good habitat quality and area for both American shad and river herring spawning. The Appomattox River does not appear to be good habitat for American shad spawning; limiting factors appear to be water velocity or water depth. It will, however, provide good river herring habitat for spawning once passage is made to the last of the structures in that reach.

27

MEAN HSI VALUES FOR SAMPLED REACHES

Mean HSI (Standard Deviation)

James River

Reach	American Shad	River Herring
1	0.84 (0.13)	0.68 (0.22)
2	0.69 (0.17)	0.33 (0.31)
3	0.75 (0.13)	0.59 (0.21)
4	0.48 (0.25)	0.66 (0.16)
5	0.69 (0.27)	0.51 (0.28)
6	0.26 (0.29)	0.68 (0.20)
7	0.48 (0.22)	0.45 (0.21)
8	0.32 (0.27)	0.69 (0.18)
9*	-- --	-- --
10	0.31 (0.37)	0.51 (0.35)

* Due to the difficult nature of sampling in Reach 9, no habitat measurements were made

Appomattox River

Reach	American Shad	River Herring
1	0.20 (0.20)	0.37 (0.25)
2	0.13 (0.13)	0.72 (0.25)
3	0.07 (0.10)	0.79 (0.31)
4	0.64 (0.16)	0.70 (0.13)
5	0.27 (0.25)	0.77 (0.19)
6	0.34 (0.30)	0.46 (0.34)
7	0.10 (0.20)	0.31 (0.35)

HABITAT UNITS (HU) FOR JAMES AND APPOMATTOX RIVERS

(HSI Mean Reach x Water Area)

James River

Reach	American Shad HU	River Herring HU
1	13.64	11.04
2	15.74	7.53
3	6.83	5.37
4	23.01	31.64
5	39.42	29.14
6	17.97	47.01
7	32.86	30.81
8	13.51	29.12
9*	---	---
10	10.62	17.47

* Since no HSI values were calculated for Reach 9, no Habitat
Units can be calculated

Appomattox River

Reach	American Shad HU	River Herring HU
1	3.25	6.01
2	2.97	16.43
3	0.64	7.19
4	4.16	4.55
5	8.52	24.30
6	5.34	7.22
7	0.72	2.22

Summary and Recommendations

Computerized databases of existing inventories of river obstructions were developed using the Advanced Revelation database management software. These database are presently maintained by the Fish and Wildlife Information System at the Virginia Department of Game and Inland Fisheries. Gaps in inventory information were identified on the Rappahannock and York Rivers to completely cover the Chesapeake Bay drainage.

Habitat suitability models for American shad and river herring were evaluated and modified according to current literature and personal communications with individuals knowledgeable of anadromous fish populations in Virginia. Site assessments were conducted to illustrate the use of the modified models in determining habitat quality and quantity. The James River was found to be better overall for all alosid species, while the Appomattox River was identified as good river herring habitat.

During the course of this project, many information needs were identified as meriting further research. The following is a summary of these regional information needs:

1. Need for basic habitat requirements and life history information for hickory shad in Virginia. So little data are presently available that we were not able to include this species in our assessments. This species can be locally abundant and support a significant recreational fishery, such as on the Rappahannock and Occoquan Rivers. The value of this recreational resource has yet to be quantified.

2. Need for information regarding the freshwater spawning and nursery habitats of alosids in Virginia, especially for blueback herring and American shad. The majority of the information used to assess stocks in Virginia have been derived from New England or Carolina studies, and appear to be in some conflict with the actual habitat use in Virginia. Validation of the modified habitat models would be possible as a result of this activity.

3. Need for information on the effects of watershed development on known anadromous fish streams where the species have been extirpated from only certain areas of the watershed. Water chemistry information, including pH, residual chlorine, and

aluminum, need to be collected and evaluated for these areas.

4. Water quality parameters of the modified river herring and American shad models need to be quantified. This relates back to problems addressed in #3. Several studies are presently being conducted, but this research needs to be directed at larger areas of the state.

5. Highway crossing evaluations need to be conducted on the York River and its tributaries. Additional funding should be provided to complete the assessment of the Rappahannock River (above Embry Dam).

Literature Cited

Atlantic States Marine Fisheries Commossion (ASMRC). 1985. Fishery Management Plan for the Anadromous Alosid Stocks of the Eastern United: American Shad, Hickory Shad, Alewife, and Blueback Herring: Phase II in Interstate Management Planning for Migratory Alosids of the Atlantic Coast. Washington, DC. 347pp.

Atran, S.M., J.G. Loesch, W.H. Kriete, Jr., and B. Rizzo. 1983. Feasibility study of fish passage facilities in the James River, Richmond, Virginia. VIMS Special Report No. 269, Virginia Institute of Marine Science, Gloucester Point, VA. 109pp.

Chesapeake Bay Living Resources Task Force (CBP). 1987. Habitat Requirements for Chesapeake Bay Living Resources. Chesapeake Bay Program. Annapolis, MD. 86pp.

Chesapeake Executive Council (CEC). 1988. Stategy for removing impediments to migratory fishes in the Chesapeake Bay Watershad; Agreement Commitment Report, Chesapeake Bay Program. Annapolis, MD. 12pp + Appendices.

Klauda, R. 1989. Definitions of critical environmental conditions for selected Chesapeake Bay finfishes exposed to acidic episodes in spawning and nursery habitats. Prepared for Versar, Inc. ESM Operations 9200 Rumsey Road, Columbia, MD and Maryland Dept. of Nat. Resources, Tidewater Administration, Chesapeake Bay Research and Monitoring Division, Tawes State Office Bldg. Annapolis, MD. 158pp.

Loesch, J.G. 1987. Overview of life history aspects of anadromous alewife and blueback herring in freshwater habitats. American Fisheries Society Symposium 1:89-103.

Morgan, R.P., and R.D. Prince. 1977. Chlorine toxicity to eggs and larvae of five Chesapeake Bay fishes. Trans. Am. Fish. Soc. 106:380-385.

Mudre, J.M., J.J. Ney, and R.J. Neves. 1985. An analysis of the impediments to spawning migrations of anadromous fish in Virginia rivers. Final Report. Virginia Highway Research Council, Virginia Department of Highways and Transportation, Charlottesville, VA. 81pp.

Mullen, D.M., C.W. Fay, and J.R. Moring. 1986. Species
profiles: life histories and environmental requirements
of coastal fishes and invertebrates (North Atlantic)--
alewife/blueback herring. U.S. Fish and Wildlife
Service Biol. Rep. 82(11.56). U.S. Army Corps of
Engineers, TR EL-82-4. 21pp.

Odom, M.C., R.J. Neves, J.J. Ney, and J.M. Mudre. 1986. Use
of tributaries of the lower James River by anadromous
fishes. Final Report. Virginia Highway Research
Council, Virginia Department of Highways and
Transportation, Charlottesville, VA. 181pp.

Odom, M.C., R.J. Neves, and J.J. Ney. 1988a. Potential use
of tributaries of the middle James River by anadromous
fishes. Final Report. Virginia Highway Research
Council, Virginia Department of Highways and
Transportation, Charlottesville, VA. 318pp.

Odom, M.C., R.J. Neves, and J.J. Ney. 1988b. Use of
Virginia's tributaries of the Potomac River by
anadromous fishes. Final Report. Virginia Highway
Research Council, Virginia Department of Highways and
Transportation, Charlottesville, VA. 126pp.

Pardue, G.B. 1983. Habitat suitability index models: alewife
and blueback herring. U.S. Dept. of Int., Fish and
Wildlife Service.
FWS/OBS-82/1058. 22pp.

Rockfish Corporation. 1981. Virginia Hydro Dam Inventory.
Prepared for U.S. Dept. of Energy, Region III, VA State
Office of Emergency and Energy Services. Rockfish
Corp., Afton, VA. 3 Volumes.

Stier, D.J., and J.H. Crance. 1985. Habitat suitability
index models and instream flow suitability curves:
American shad. U.S. Fish and Wildlife Service Biol.
Rep. 82(10.88). 34pp.

Virginia Institute of Marine Science (VIMS). 1986.
Anadromous fish restoration demostration project on the
Embry Dam in the Rappahannock River, Virginia. VIMS,
School of Marine Science, College of William and Mary,
Gloucester Point, Virginia. 12pp.

Weiss-Glanz, L.S., J.G. Stanley, and J.R. Moring. 1986.
Species profiles: life histories and environmental
requirements of coastal fishes and invertebrates (North
Atlantic)--American shad. U.S. Fish and Wildlife
Service Biol. Rep. 82(11.59). U.S. Army Corps of
Engineers, TR EL-82-4. 16pp.

33

<u>Appendix 1</u>

JAMES RIVER

Reach 1

N

Boshers Dam
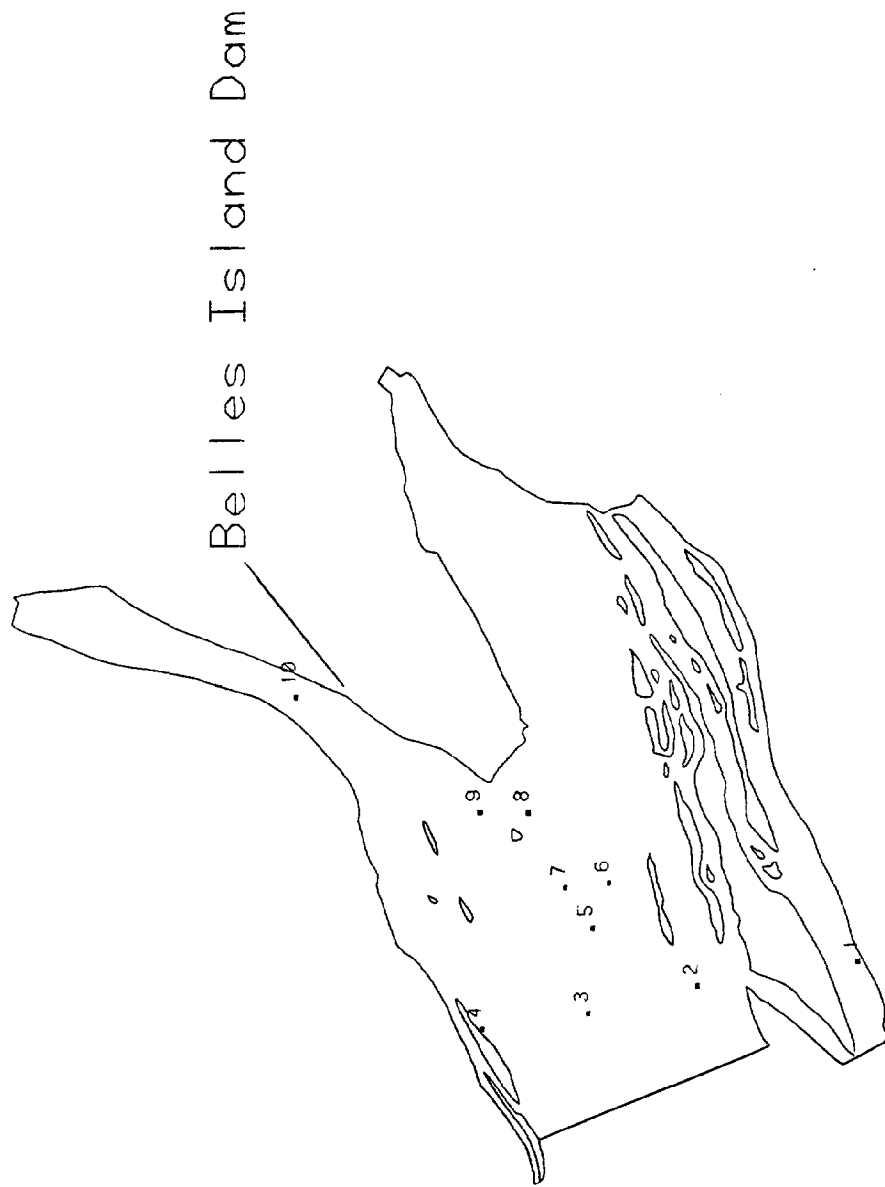
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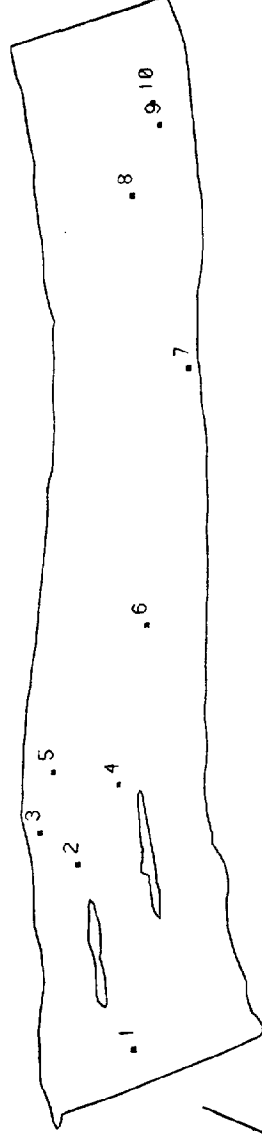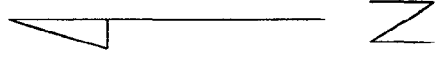
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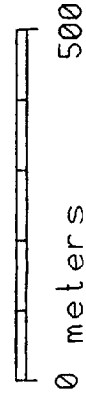
0 meters 500

JAMES RIVER

Reach 2

N
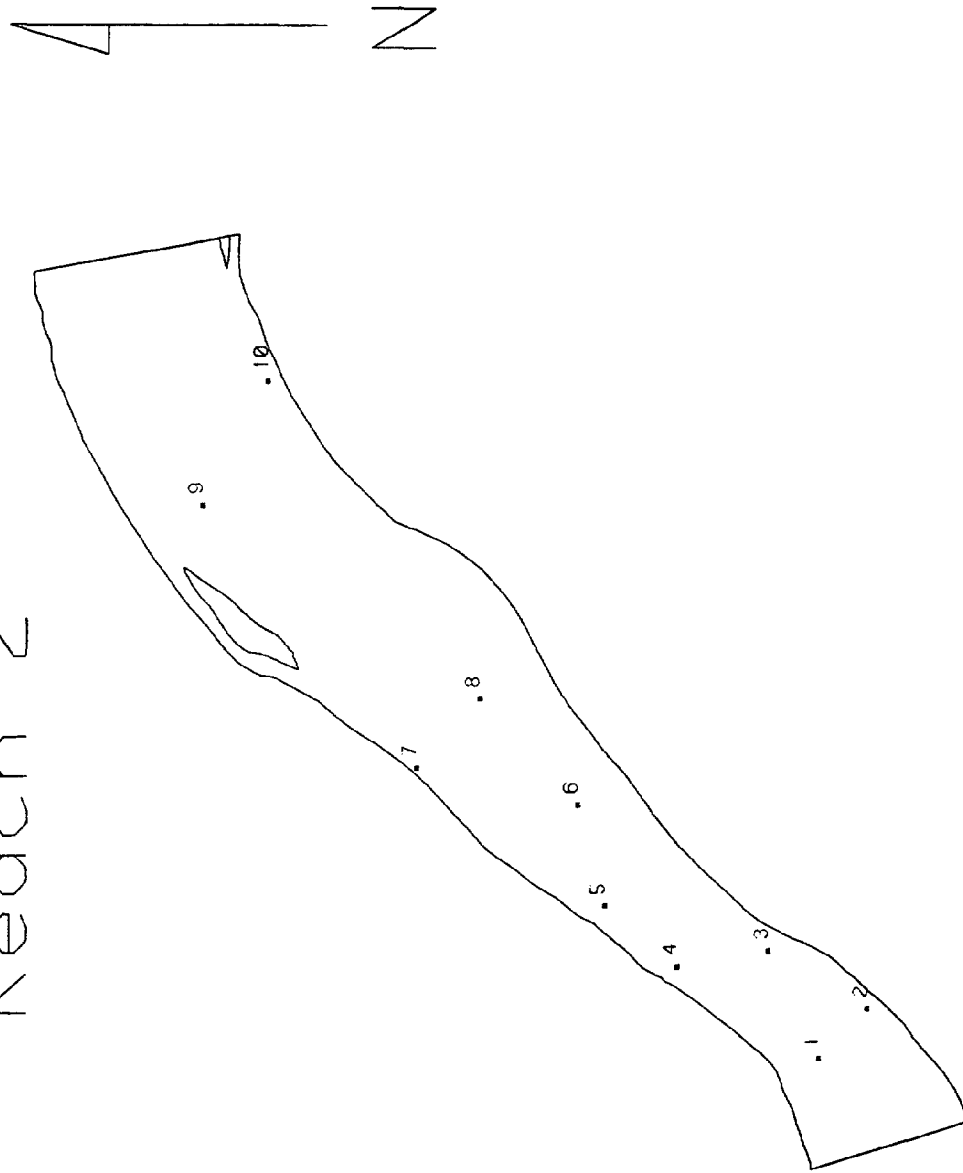
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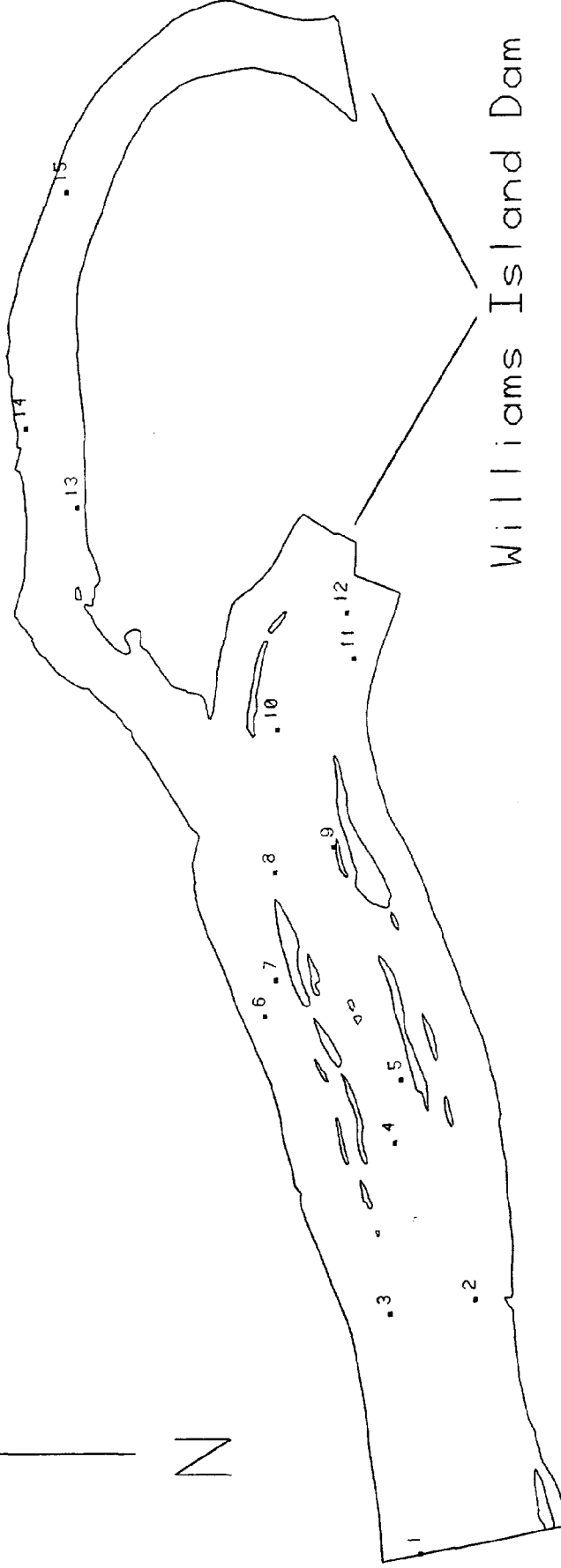
JAMES RIVER

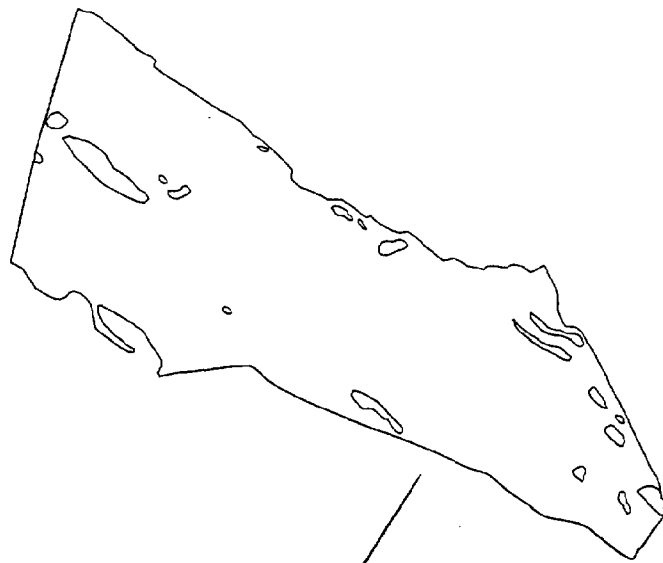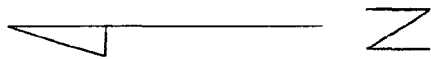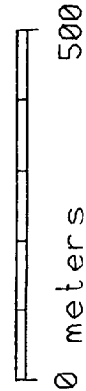## Reach 3

Williams Island Dam

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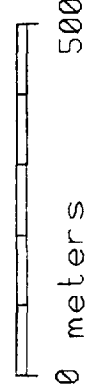
0 meters 500

JAMES RIVER

Reach 4

Williams Island Dam
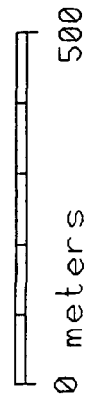
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JAMES RIVER

Reach 5
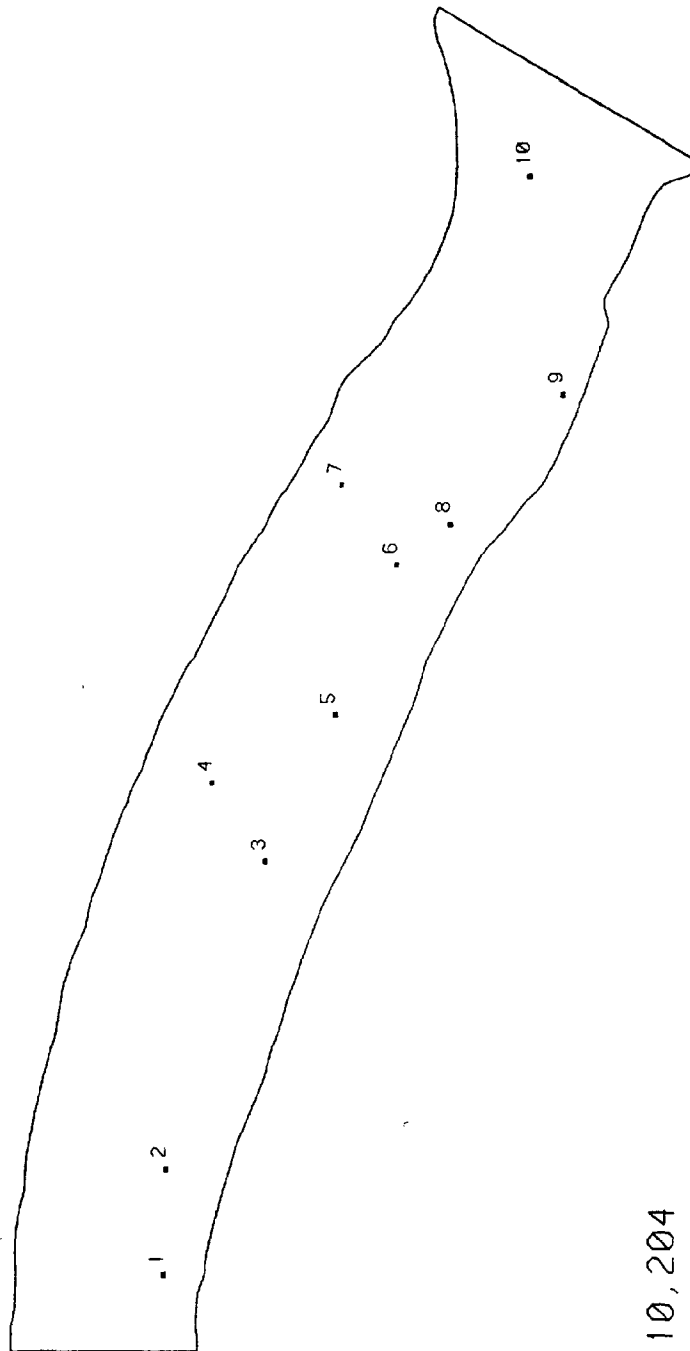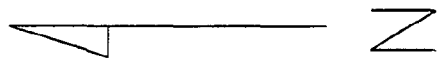
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Scale = 1:10,204

0 meters   500

JAMES RIVER
Reach 6

N

Scale = 1:10,204

0 meters   500

JAMES RIVER

Reach 7

N

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.1
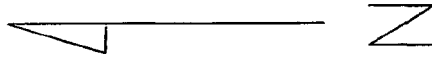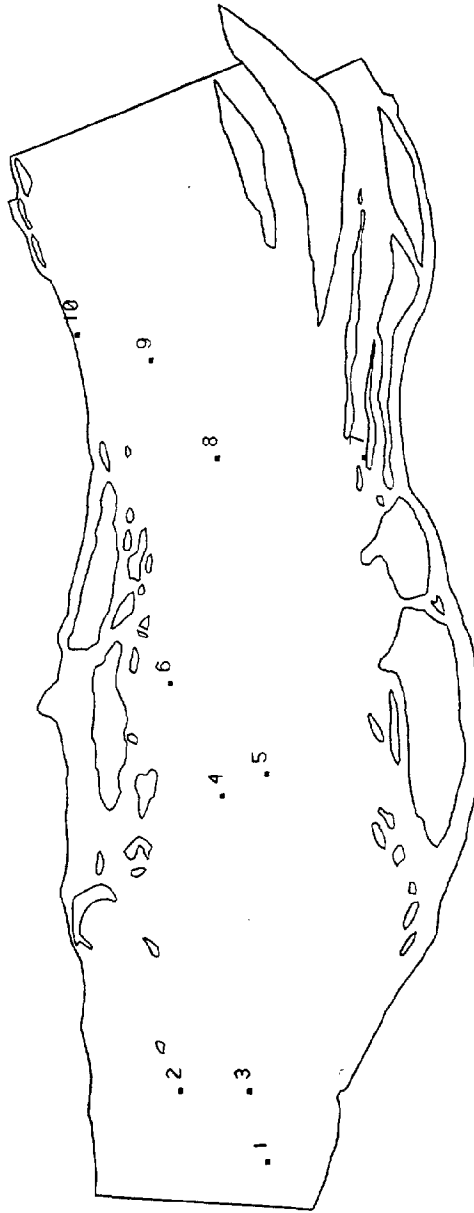
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0 meters   500

JAMES RIVER

Reach 8

Belles Island Dam

N

Scale = 1:10,204

0 meters 500

JAMES RIVER

Reach 9

N

Belles Island Dam

Scale = 1:10,204

0 meters   500

JAMES RIVER

Reach 10

Browns Island Dam

N

Scale = 1:10,204

0 meters   500

APPOMATTOX RIVER

Reach 1

Brasfield Dam

Abutment Dam

N
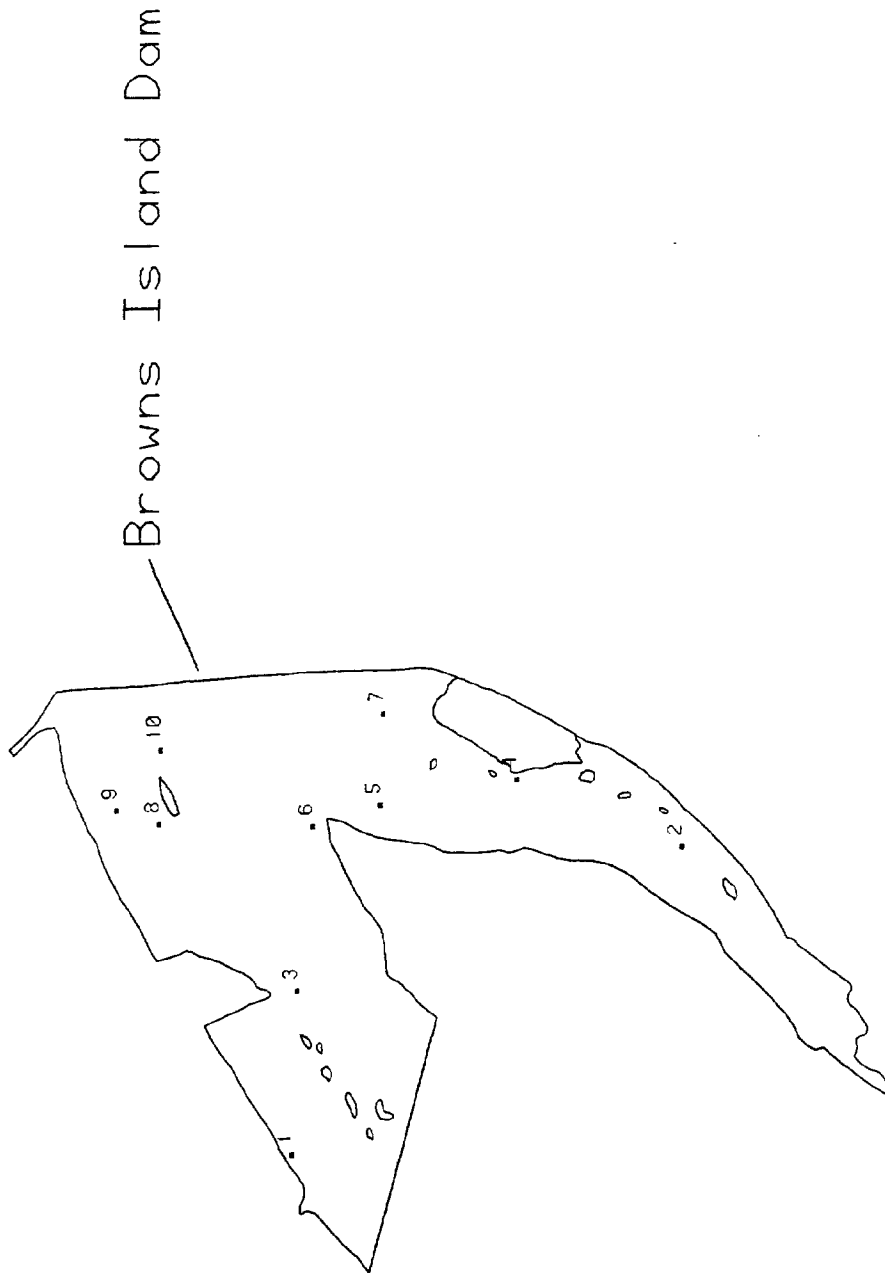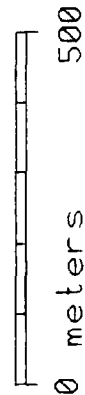
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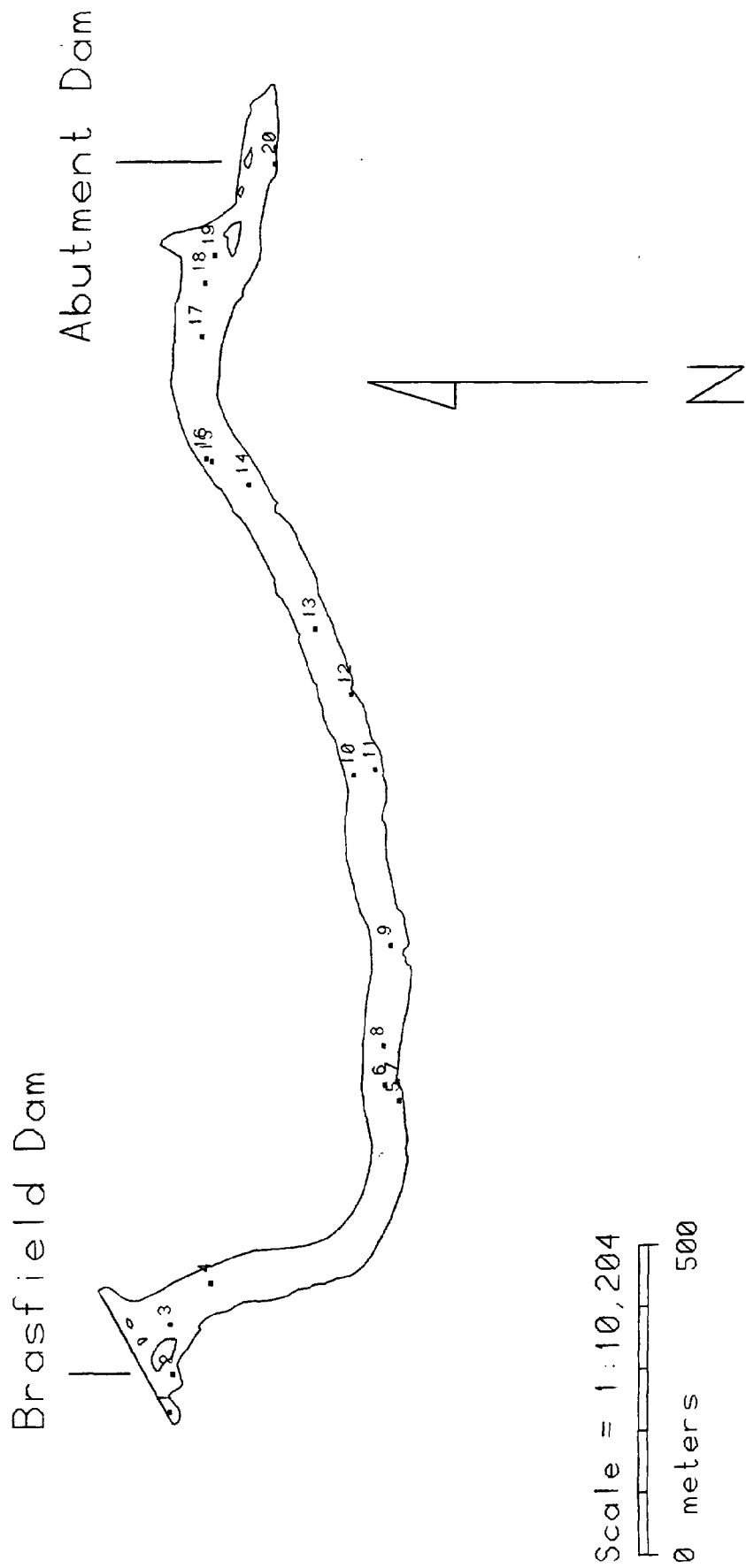
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APPOMATTOX RIVER
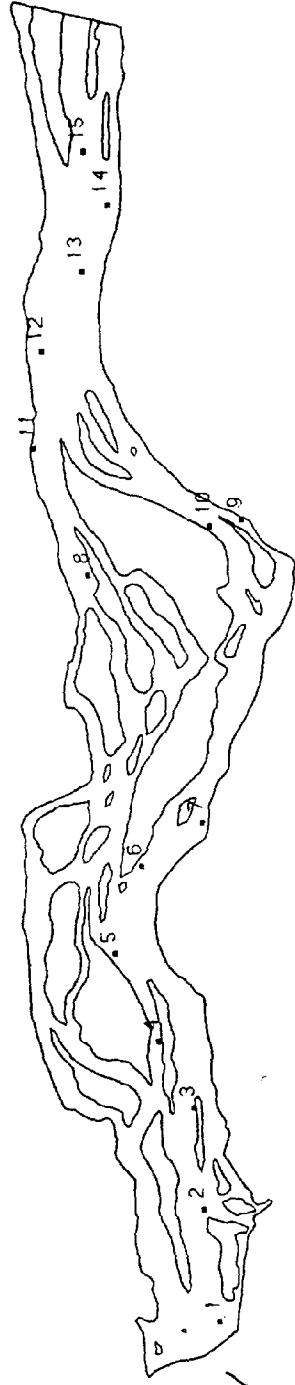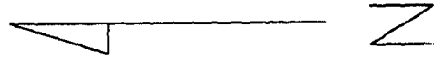
Reach 2

Abutment Dam

Scale = 1:10,204

0 meters   500

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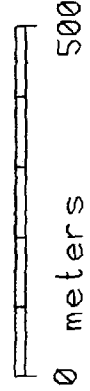
APPOMATTOX RIVER

Reach 3
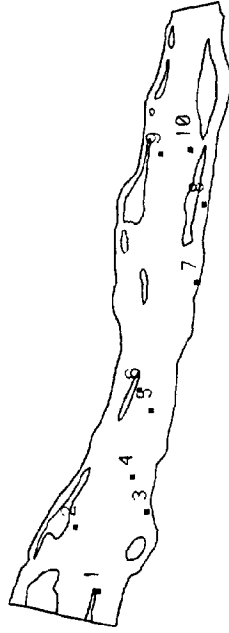
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0 meters 500

APPOMATTOX RIVER

Reach 4
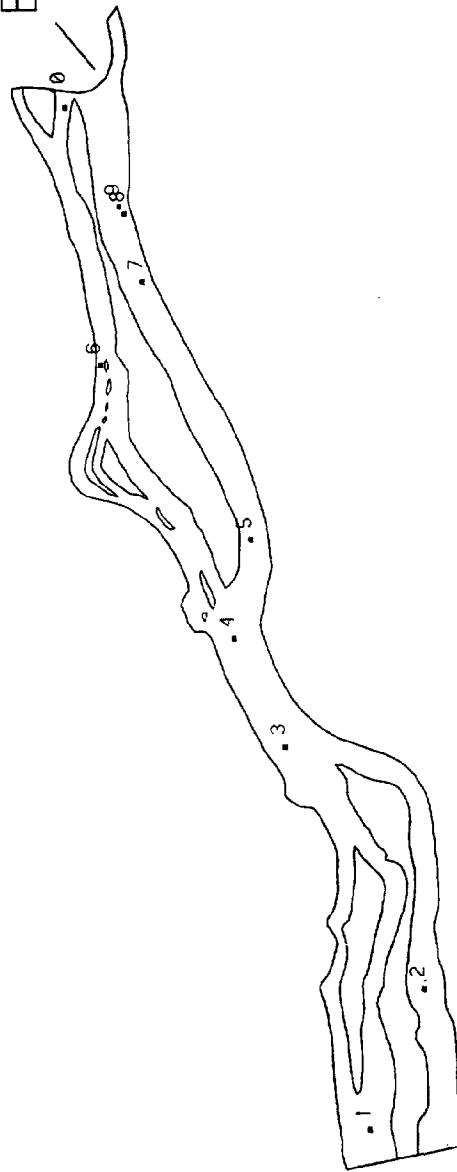
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Scale = 1:10,204

0   meters   500

APPOMATTOX RIVER

Reach 5

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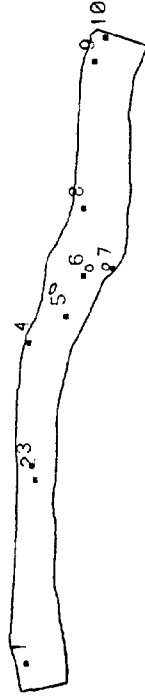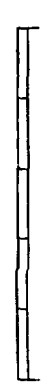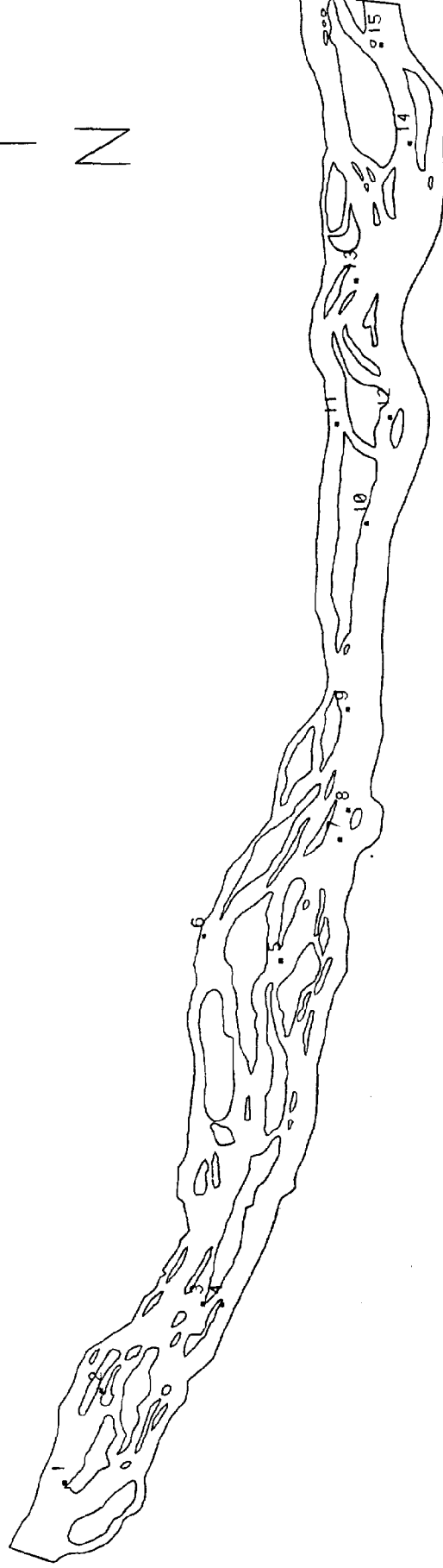
Scale = 1:10,204

0   meters   500

APPOMATTOX RIVER

Reach 6

Battersea Dam

N

Scale = 1:10,204

0 meters   500

APPOMATTOX RIVER

Reach 7

Harvell Dam

Battersea Dam

N

Scale = 1:10,204

0 meters 500

DATE DUE