CONTRACT REPORT

STRATEGIES FOR IMPEDIMENT REHABILITATION TO CREATE FISH PASSAGE OPPORTUNITIES IN THE RAPPAHANNOCK RIVER BASIN

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ABSTRACT

Areas where anthropogenic development coincides with aquatic systems often impede the flow of organisms and nutrients in either an upstream, downstream, or bidirectional path. These impediments are especially outstanding in the tidal and nontidal freshwater areas of Virginia where diadromous fishes are hindered from moving upstream onto spawning grounds and the upstream ecosystems lose out on the contribution of marine derived nutrients. Recent removals of major impediments such as Embry Dam Fredericksburg, Virginia, opens large expanses of previously blocked spawning habitat for recreationally and commercially important diadromous species. Many smaller river systems require different methods of impediment rehabilitation and various fish passage systems are being used throughout the country to assist in the reconnection of previously impeded stream segments.

The primary intent of this research was to assess different fish passage systems as they relate to impediments created by road culverts and to design and install systems in Virginia. Road culverts are common throughout the state and represent one of the important types of potential barriers to upstream migration. We examined the available literature (mostly from Pacific Norwest river systems), explored extant impediment databases (created by VDGIF and VCU) for the Rappahannock River drainage, monitored the effectiveness of the two major fish passage types being used in Maryland (pool-weir designs and Alaskan steep pass design), consulted state and federal officials, chose sites for Virginia stream implementation of fish passage and had fabricated the appropriate passage structures.

It was concluded that site selections can be prioritized, if fish passage is a primary concern, by use of databases that describe anadromous fish use in the appropriate watershed. Models of spawning and nursery habitat preferences help in site selection by allowing quantification of habitat to be opened by the installation of fish passage. Detailed design of the passage structure(s) must be made on a site-by-site basis. To date, there are insufficient data to state firmly whether a steep pass design is better or worse that a pool-weir as both designs work under variable conditions. Considerations in passage design include the type, size, and height of the current impediment, future maintenance requirements, and potential use by the various species of concern and funding available for the system development, placement, and maintenance.

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INTRODUCTION

The tidal and nontidal freshwater rivers, streams, and marshes of Virginia are sites of spawning and rearing activities for several ecologically and economically important anadromous fishes (Davis et al. 1970, Travelstead 1980, Garman 1992, Browder and Garman 1994, Garman and Macko 1998, O'Connell and Angermeier 1997, McIninch and Garman 1999). Examples of these migratory fishes include the anadromous clupeid fishes (blueback herring, alewife, and American and hickory shads), striped bass, and the catadromous American eel. In many Virginia coastal rivers, a substantial portion of historically important spawning and rearing habitat for migratory species has been lost as the result of barriers to upstream passage or the modification of stream habitat by impoundment and other activities. Odom et al. (1986) estimated that approximately one-third of lower James River tributaries possessed artificial impediments to upstream migration by anadromous fish. Similarly, the lower Rappahannock River basin has potential migration impediments, including culverts, in place on over half of its primary tributaries (McIninch and Garman 1999).

The obvious advantage of impediment removal is that migratory fishes such as blueback herring and alewife will once again be able to reach historic or preferred spawning and/or nursery areas. The resultant increases in available habitat significantly benefit population abundance for target species and fish passage projects throughout Virginia and Maryland contribute substantially to fisheries restoration efforts. Recent studies have also shown that migratory species such as blueback herring are important to freshwater systems because of their role as vectors of marine-derived nutrients (Garman and Macko 1998, MacAvoy et al. 1999). Hence, impediment modification or removal will also facilitate the upstream movement of nutrients and energy in these systems. An additional advantage to impediment removal is that resident (i.e., nonmigratory) species can more freely move throughout the system. Free movement of resident fishes may be important for genetic diversity within a system as well as the recolonization of areas that have been disturbed by anthropogenic or natural disturbance.

Road culverts are common throughout the state and represent one of the important types of potential barriers to upstream migration. Culvert renovation, including the installation of fish passage structures to facilitate upstream movement, is more cost-effective than culvert removal and re-installation, or culvert removal and bridge construction (Fitch 1995). The method used to make an existing culvert passable to migratory fish will depend on the characteristics that make it impassable, as well as the biology and behavior of target species. The most common problems with fish passage in culverts are perching (height from bottom of culvert to water prevents fish from entering the culvert) and high flow in the culvert (fish unable to swim length of culvert against high flow velocities).

High velocities inside the culvert can often be corrected by matching substrate conditions in the pipe to that of the streambed. If this does not reduce flow sufficiently, or for an acceptable length of time, then baffles may be required inside the culvert (Clay 1995). This is more frequently a problem in montane conditions where natural gradients are steep. Road culverts of the lower Piedmont and Coastal Plain physiographic regions are more likely to require additional water depth or flow for efficient passage. This often involves some form of water diversion structure that will allow flows to be concentrated to a desired depth, while concurrently allowing for spillover during times of high water.

Perching problems are treated at the downstream end of the culvert and may be addressed using construction material such as rip-rap, concrete sills and baffles but may be best handled by incorporating artificial structures such as steep pass fishways similar to those used in Alaska and the Pacific Northwest for salmonid passage and in Maryland for passage of anadromous clupeid fishes (L. Leisner, MD DNR, personal communication). Decisions regarding proper design and installation of fish passage require information on stream morphology and flow dynamics, as well as culvert specifications and the habitat utilization of fish species targeted for passage. Because of the information required, passage design and installation is best finalized on a site-by-site basis. In this study we examined the two main types of fish passage structures presently in use in areas of the Coastal Plain and lower Piedmont physiographic provinces of the Northeast and Mid-Atlantic States. Following our initial examination, we made site visits to areas of potential impediment rehabilitation in the Rappahannock River basin of Virginia. Fish passage structures were engineered and constructed but alteration in site design and landowner permission difficulties have slowed progress. The project reported herein is overdue for the contract but work is continuing and will continue until completion. As of this writing, one project is under construction and near completion and the installation of the steep pass structure remains at the other site.

PURPOSE AND SCOPE

The primary intent of this research project was to aid VDOT in the implementation of culvert rehabilitation for the purpose of fish passage and general connectiveness of aquatic systems in the commonwealth of Virginia. In order to assist VDOT in the decision making process regarding site selection and passage system design, the researchers concentrated on four primary objectives:

(1) Review the available literature for information on fish passage design, installation, maintenance and effectiveness.

(2) Assemble three extant databases of (1) impediments in the Rappahannock River watershed below Fredericksburg, (2) biological information on use by fishes, including anadromous clupeid fishes, and (3) habitat data in the potential study areas above existing impediments. Use databases to locate potential sites for installation of fish passage systems.

(3) Examine the effectiveness of various fish passage design by monitoring extant systems (available in Maryland). Monitoring included fish sampling above and below fish passage stricture as well as mark and recapture methods to quantify effectiveness of both pool-weir and steep pass systems.

(4) Install two fish passage systems in stream systems of the Rappahannock River drainage and monitor their effectiveness during the following year's anadromous fish migration (spring).

METHODS AND MATERIALS

Culvert Fish Passage Monitoring

The effectiveness of an Alaskan steep-pass fishway and two varied forms of pool-weir fishways for culverts was examined at sites in Maryland. Sites were chosen to represent two different culvert rehabilitation designs; Alaskan steep-pass designs and pool-weir designs. The initial site visits and monitoring took place in the spring of 2001. Nine potential sites were visited following recommendations by Maryland Department of Natural Resources personnel. Of these nine, two Alaskan steep-pass fishways and two pool-weir fishways were chosen as study sites. A description of each of the nine sites follows. Sites 1, 4, 5, and 7 were chosen for this study.

Site 1. Sawmill Creek, Gauge Station, Anne Arundel County

The Sawmill Creek gauge station is located off Baltimore Annapolis Boulevard. It is located on the main stem of Sawmill Creek and is a second order stream in the Patapsco River Watershed. The drainage area is approximately 5 square miles. The original blockage was the concrete weir of the USGS gauge station. In the summer of 1999, Anne Arundel County installed a cross vane below the weir to raise the water surface elevation and allow fish passage, opening up 2.2 miles of stream habitat. This fish passage structure is the only 'natural design' structure of the 9 structures studied. This site is located in a highly commercial area and habitat quality is quite variable in the near vicinity.

Site 2. Sawmill Creek, 8th Avenue, Anne Arundel County

The 8th Avenue Sawmill Creek site is located downstream from the Sawmill Creek gauge station site. The drainage area is approximately 7.5 square miles. The fish blockage consists of the original Sawmill dam that was built in the late 1700s. The dam is just upstream of the 8th Avenue box culvert. In the summer of 1999, Anne Arundel County installed a pool-weir structure, opening up 3.0 miles of stream to anadromous fish. Wagner's Pond, a large wetland area, is just upstream of the dam, providing suitable habitat for spawning fish. Previous anadromous fish investigations conducted by the Maryland Department of natural Resources found river herring (identified as either alewife or blueback herring; Odell et al. 1975) at the base of the dam and it is assumed that fish spawned upstream of the dam prior to its construction.

Site 3. Cattail Creek; Anne Arundel County

Cattail Creek is located in Anne Arundel County off Asbury Road. It is a second order stream located in the Magothy River watershed. Cattail Creek Natural Area is immediately upstream of the fish passage structure. The original blockage was a pipe culvert beneath Asbury Drive. An Alaskan steep pass was installed in 1995, providing access to 2.0 miles of stream. However, there is currently a beaver dam immediately upstream from the bridge which blocks fish from traveling beyond the road culvert. Previous anadromous fish investigations conducted by MDDNR found no anadromous fish species in this area (Odell et al. 1975).

Site 4. Paint Branch, Prince Georges County.

The Paint Branch site is in the Anacostia River watershed and is a third order stream. The original blockage was a concrete four-box culvert underneath the westbound I-495 bridge. An Alaskan steep pass with a four foot wide fishway was installed in 1994 which theoretically opened 2.9 miles if stream. There is a second blockage 0.1 mile downstream of the steep pass, however. This second blockage is a pool-weir structure under the eastbound I-495 bridge.

Site 5. Hog Hole Run, Charles County

Hog Hole Run is located off Highway 6 in Charles County, Maryland. It is a third order stream in the Port Tobacco River watershed. The original fish blockage was the single concrete box culvert beneath Highway 6. Maryland State highway administration (SHA) installed an Alaskan steep pass and 4-foot-wide fishway in 1994, opening 1.8 miles of spawning habitat. Previous MDDNR anadromous fish investigations have found alewife in the vicinity of the road crossing (Odell et al. 1975).

Site 6. Gilbert Run, Charles County

The Gilbert Run fish passage is located in Charles County just upstream of the Highway 6 (New Market Road) road crossing. It is in the Wicomico River watershed. The remains of the bridge foundation beneath the old Highway 6 road crossing were a fish blockage. MD SHA placed a 1-foot notch in the bridge foundation remains in 1997, opening 2.0 miles of spawning habitat. There is suitable anadromous fish habitat both below and above the structure and it is assumed that anadromous fish traveled upstream of this location prior to the road crossing installation. Previous anadromous fish investigations conducted by MD DNR have found river herring in the vicinity of this road crossing (Odell et al. 1975).

Site 7. Budd's Creek, St. Mary's County

The Budd's Creek fish passage structure is located in St. Mary's County off Highway 234 (Budd's Creek Road). It is located on a third order tributary in the Wicomico River watershed. The original fish blockage was the double box concrete culvert beneath Highway 234. MD SHA installed an Alaskan steep pass in 1995, opening up 4.0 miles to anadromous fish spawning. Habitat above and below the road crossing is suitable for spawning and it is assumed that anadromous fish traveled upstream of the road crossing prior to roadway construction.

Site 8. Nassawango Creek, Worcester County

The Nassawango Creek site is located in Worcester County off Highway 12 (Snow Hill Road). It is located in the Pocomoke River watershed. The original fish blockage was a USGS concrete weir. MD SHA notched the concrete weir in 1997, opening up 49 miles of upstream spawning habitat for anadromous fishes. Habitat above and below the gauge station is suitable for anadromous fishes spawning and it is assumed that fish spawned upstream from this location prior to the installation of the gauge. Previous anadromous fish investigations by MD DNR have found alewife and yellow perch in this area of the stream (Odell et al. 1975).

Site 9. Turville Creel; Worcester County

The Turville Creek site is located off Highway 589 (Racetrack Road) in Worcester County. The creek is in the Isle of Wight watershed. The fish blockage resulted from a concrete weir at the concrete box culvert beneath highway 589. In 1997, MD SHA installed a pool-weir structure consisting of four pool-weirs. Installation of the pool-weir partially drained a wetland that was serving as elver (young American eels) habitat. The fish passage structure has resulted in reduced habitat for elvers and no increase in anadromous fish spawning habitat. It is doubtful that Turville Creek above the Highway 589 road crossing ever served as anadromous fish spawning habitat. However, MD DNR has previously recorded alewife in the vicinity of the road crossing (Odell et al. 1975).

Fish Sampling

Fishes were sampled from downstream of the study sites and from other sites in the area during the early spring 2001 to determine approximate timing of the anadromous fish run for the year. Collections were made about every two weeks. Once herring were noted as in the area of the fish passage structures, monitoring was done both above and below the passage structures. All fish sampling was done with Smith-Root backpack electrofishing equipment using standard collection protocols of Virginia Commonwealth University Fish Ecology Laboratory. Most stunned fishes were netted, identified, and released. Some of the fishes captured were marked to determine fish passage usage. A small subset of those fishes captured below the passage structures were marked by clipping a small portion of their anal fin (sunfishes, pickerels, catfishes) or caudal fin (herrings, eels) prior to being released. All fishes captured upstream of the passage structure were examined closely for fin clips prior to being released.

During the 2001 monitoring low flows and rainfall made it difficult for herring to reach some of the study sites and thus use of the passage structures could not adequately be tested. We found nearby populations of herring and collected them using standard methods, placed them in aerated holding tanks and transported them to the study sites. These fishes were marked and quickly released no more than 50 meters downstream of the fish passage structure.

Additional collections were made at the sites in spring of 2004 for followup monitoring. Sites were sampled in late-April while river herring were present in the tributaries. These sampling efforts focused on areas upstream of the fish passage structures and only cursory attention was paid to downstream habitats.

Virginia Rehabilitation Site Query

A four-year study of the anadromous fishes in the Rappahannock River watershed and impediments to their upstream spawning migrations, funded by VDGIF and the Chesapeake Bay Program, was completed recently by Virginia Commonwealth University (McIninch and Garman 1999). VCU has developed three GIS-compatible databases that will provide critical information for the selection of sites for experimental culvert restoration: (1) information on migration impediments in the watershed (about 500 for the watershed below Embry dam), (2) biological information on use by fishes, including anadromous clupeid fishes, and (3) habitat data including a preferred habitat model for alewife and blueback herring. Because information for the databases was collected mostly during anadromous spawning runs, variables such as water depth will be more accurate for passage purposes than if collected during non-spring months.

The impediment database was used to locate culverts of various sizes and types (concrete vs. metal, pipe vs. box, etc.) and at various placements in the Rappahannock River watershed (upper watershed vs. lower watershed). The biological database was then queried for presence of migratory fishes, and specifically anadromous clupeid fishes.

Following our database review, we chose to make site visits to three potential areas for impediment rehabilitation. VCU-CES worked with VTRC, Timmons Consulting, Watershed Services, Inc., VDOT, VDGIF, and USF&W to coordinate the selection, engineering, installation, and monitoring of the fish passage structure/system at these sites in the Rappahannock River watershed. Following site visits and discussions Claiborne Run was selected as the site of the initial passage structure and effort. The three final sites are discussed here.

Claiborne Run, Rappahannock River Drainage

This passes under Rt. 218, Stafford County, just NE of the Fredericksburg City limits. The present double box culvert is raised significantly above stream level impeding upstream movements of fishes. The placement of a fish passage structure will allow anadromous fishes such as alewife and blueback herring as well as catadromous fishes such as American eel, reach additional spawning grounds upstream of the road. In addition it will allow those resident fishes downstream access to upstream habitats, supporting a more completely connected system. (See Figure 1.)

Figure 1. Claiborne Run at Rt. 218, Stafford County. Note: Road no longer functional.

White Oak Run

This is also a tributary of the Rappahannock River drainage in Stafford County, Virginia. Just prior to the confluence with Muddy Run, White Oak Run is crossed by Co. Rt. 601. At Rt. 601, a triple pipe culvert is raised sufficiently to impede anadromous fishes and resident fishes alike. A fish passage structure at this locality will also allow for the free movements of anadromous and resident fishes. (See Figure 2.)

Figure 2. White Oak Run at Co. Rt. 601, Stafford County.

Ware Creek

This is a third Rappahannock River tributary. Ware Creek runs under Co. Rt. 766 in Caroline County southwest of Fredericksburg. The drop from the culvert to the creek downstream of the culvert suggests a steep pass structure would be best at this particular site. (See Figure 3.)

Figure 3. Ware Creek at Rte 766 (Burma Rd) Caroline County.

RESULTS/DISCUSSION

The four Maryland fish passage sites chosen for monitoring are discussed followed by the results of the fish monitoring in 2001 and 2004.

Site 1. Paint Branch, Anacostia River subdrainage, Potomac River drainage. Paint Branch flow under Interstate 495 (Capital Beltway) in Prince Georges County, Maryland. Access to the site was given by permission by USDA South Farm Agricultural Research Station off Cherry Hill Rd.

The fish passage at the Paint Branch site is a simple pool-weir design (Figure 4). Upstream of the large box culvert is a small diversion wall that is designed to force most of the streams flow into a single culvert. Downstream of the culvert two concrete boxes were formed (the pools) with notches cut allowing appropriate flow and depth for anadromous fishes. As one can see from the Figure 4, presently this design represents a failed system in that the intended channel has filled with sediment and gravel effectively raising the elevation above that of the remainder of the stream and hence reducing real and potential flow in the intended area. At present there is a need for heavy machinery to clean out the deposited sediments (too much for manual labor). It is unlikely that fishes will utilize this passage facility. Table 1 lists the species that were captured at the Paint Branch site in 2001 and 2004, as well as those that were marked. No marked fishes were captured above the culvert at any of the collections. No anadromous fishes were found above the culvert. Water quality parameters measured (temperature, dissolved oxygen, pH, conductivity, and salinity) were within acceptable range for anadromous fishes.

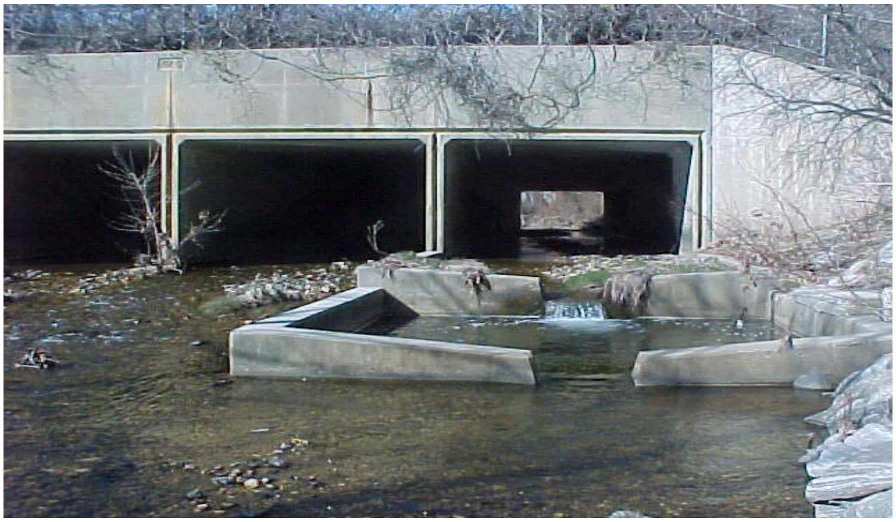

Figure 4. Paint Branch site at I-495, Prince Georges County, MD.

Table 1. Fishes captured from the Paint Branch site during spring sampling of 2001 and 2004. Species in bold type were fin clipped/marked. None was recaptured above the culvert. One fallfish was recaptured below the culvert.

Species	**Below Culvert**	**Above Culvert**
American eel	X	X (1 spm)
blacknose dace	X	X
creek chub	X	
fallfish	X	X
common shiner	X	X
satinfin shiner	X	X
rosyside dace	X	
swallowtail shiner	X	X
N. hogsucker	X	
white sucker	X	X
brown bullhead	X	X
redbreast sunfish	X	X
green sunfish	X	X
bluegill	X	X
pumpkinseed	X	
largemouth bass		X
tessellated darter	X	

Site 2: Sawmill Branch, Curtis Creek subdrainage, Patapsco River drainage. Access to the site was from a pullover area just to the south side of the road culvert.

Upstream of the large double-box culvert is a diversion wall (Figure 5; right) that is designed to force most of the streams flow into a single culvert but allow spillover when necessary. A seven-step, pool-weir raceway was developed using concrete from about 4 meters downstream of the culvert through the length of the culvert. Table 2 lists the species that were

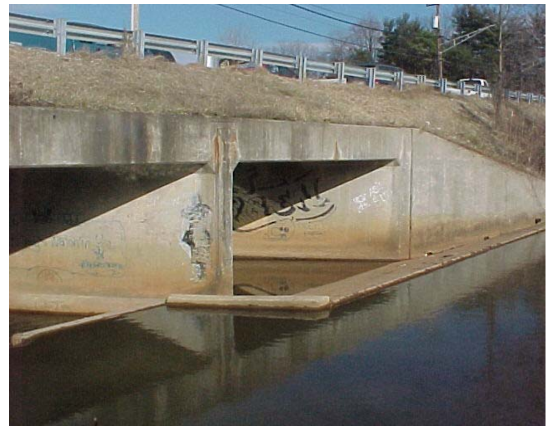

Figure 5. Sawmill Creek culvert and downstream and upstream views of the custom pool-weir fish passage.

Table 2. Fishes captured from the Sawmill Creek site during spring sampling of 2001, 2003 and 2004. Species in bold type were fin clipped/marked. Marked fishes recaptured above the culvert are indicated by a bold X in the "Above" column.

Species	**Below Culvert**	**Above Culvert**	**Captured in Pool-weir**
American eel	X	X	X
blueback herring *			
chain pickerel	X	**X**	
Eastern mudminnow	X	X	
Common carp		X	
golden shiner		X	
creek chub		X	
spottail shiner	X	X	X
creek chubsucker	X	X	
white sucker	X	X	
brown bullhead	X	**X**	X
pirate perch		X	
banded killifish	X	X	X
bluespotted sunfish		X	
redbreast sunfish	X	X	
bluegill	X	X	
pumpkinseed	X	X	X
largemouth bass	X	**X**	X
tessellated darter	X	X	

*****About 20 specimens transported to site, marked and released. None was recovered.

captured at the Sawmill Creek site in 2001, 2003, and 2004, as well as those that were marked and those found to have used the passage.

This passage facility showed the most passage of fishes at any site. See Table 2 for marked fishes found to have used the passage structure. No anadromous fishes were captured from this site in 2001. This was largely due to the lack of rainfall and subsequent low water levels reducing the ability of migrating fish to get upstream to the impediment. In early June 2001 we removed adult blueback herring from a nearby system (Severn Run), clipped their caudal fins to mark and released then about 10 meters downstream of the Sawmill Creek fish passage. The herring appeared to be in good health when released and a follow-up monitoring was scheduled for a week post-release. No herring were captured either below or above the culvert when the next sampling was performed. This may have been due to heavy rains that occurred between release and the follow-up survey. An unscheduled survey in April of 2003 also resulted in no found herring but it was noted that the fish passage structure was free of blockages and operating without problem.

Fishes that were captured inside of the pool-weir structures included American eel, brown bullhead, chain pickerel, banded killifish, and largemouth bass. Those species marked and recaptured above the culvert include brown bullhead, chain pickerel, and largemouth bass.

In May 2004, three blueback herring (*Alosa aestivalis*) were captured upstream of the culvert indicating use by an anadromous fish. Marked resident fishes from 2001 that were captured upstream of the culvert include brown bullhead, largemouth bass, and chain pickerel.

Site 3. Hog Hole Run Port Tobacco watershed, Potomac River drainage.

Access to this site was directly from Highway 6 or from a side road with a small development where landowners granted access. Although alewife have been found in this area (Odell et al. 1975), this site is not likely a major spawning ground. There were no anadromous fishes taken during any of the surveys here. This was largely due to insufficient water depth throughout the study area. Figure 6 represents the flow conditions at Hogs Hole Run during the 31 May 2001 survey. Although water is being diverted upstream and concentrated into the raceway leading to the Alaskan steep pass structure, insufficient depth exists to effectively allow passage of anadromous herrings. A few resident fish species were marked but none was later located upstream of the fish passage. No fish were shocked from within the structure.

We do not assess this as an indication of steep pass inefficiency but rather a situation of low water conditions and, perhaps, poor placement judgment. Although water conditions in the area were considerably higher in April 2004, water passing through the steep pass remained marginal in depth and flow. No anadromous fishes were captured (Table 3). A landowner said that the structure often gets clogged with woody debris (most frequently after storms) and that he cleans it regularly.

Figure 6. Hogs Hole Run fish passage at Highway 6, Charles Co., MD.

Table 3. Fishes captured from the Hogs Hole Run site during spring sampling of 2001 and 2004. Species in bold type were fin clipped/marked. None was recaptured above the culvert.

Species	Below Culvert	Above Culvert
American eel	X	X
eastern mudminnow		X
blacknose dace	X	
fallfish	X	X
rosyside dace	X	
white sucker	X	X
Creek chubsucker	X	X
mosquitofish		X
redbreast sunfish	X	X
pumpkinseed	X (2004 only)	
tessellated darter	X	X

Site 4. Budd's Creek, Wicomico River subdrainage, Potomac River drainage.

The Budd's Creek fish passage structure (Figure 7) is located on the border of Charles and St. Mary's Counties at Highway 234 (Budd's Creek Road).

Figure 7. Budd's Creek fish passage at Rte 234, Charles-St Mary's Co. line, MD.

Fishes captured at this site are presented in Table 4. Low water conditions throughout most of the spring of 2001 made the likelihood of anadromous fish usage minimal at this site. Toward the end of the regular spawning season we collected 75 blueback herring from downstream (near the mouth) marked and transported them via aerated cooler to the site. Flooding occurred prior to the next collection and the herring were not collected again. Seven blueback herring were taken just downstream of the passage structure in April of 2004; none was collected above. The anadromous sea lamprey, however were shocked while spawning upstream of the road crossing indicating usage of the fish passage structure. One marked creek chubsucker was collected above the road indicating some use of the passage system by resident fishes. No fishes were collected inside of the steep pass but a few dusky salamanders were shocked from the structure. Some beaver activity is noted from the area in 2004.

Table 4. Fishes captured from the Budd's Creek site during spring sampling of 2001 and 2004. Species in bold type were fin clipped/marked. Marked fishes recaptured above the culvert are indicated by a bold X in the above column.

Species	Below Culvert	Above Culvert
sea lamprey	X	X (2004)
American eel	X	X
redfin pickerel	X	
Eastern mudminnow	X	X
golden shiner	X	
blacknose dace	X	X
fallfish	X	X
white sucker	X	X
Creek chubsucker	X	**X**
mosquitofish	X (2004 only)	
bluegill	X	X
pumpkinseed	X	X
tessellated darter	X	X

Fish Passage Sites, Rappahannock River Drainage

Claiborne Run

Although Claiborne Run was our first and initially best choice for fish passage in the Rappahannock River system, we have formally abandoned the site for the passage project. Following our initial site visit, we met on-site with personnel from VA Dept. of Transportation (Brian Hawley, primary contact; Brain.Hawley@VirginiaDOT.org), VA Transportation Research Council (G. Michael Fitch; gmf8X@virginia.edu), VA Department of Game and Inland Fisheries (Alan Weaver; aweaver@dgif.state.va.us), US Fish and Wildlife Services (Dick Quinn; Dick_Quinn@fws.gov and David Sutherland; David_Sutherland@fws.gov) and consultants and engineers [Scott Cahill (watershedservices@yahoo.com) and Tim Davey and Mike Claude, Timmons Engineering (Mike.Claud@timmons.com, tim.davey@timmons.com)]. Dick Quinn (USFWS) fish passage expert provided engineering recommendations for effective installation of a proposed Alaskan steep pass structure. Additional meetings with VDOT and VDGIF personnel discussed necessary permits and potential for time of year restrictions on construction. We obtained cost and time estimates for the production of steep pass structures from local and out-of-state-manufacturers. After review of estimates, we settled on a local metal shop, Richmond Steel Inc. in Richmond to build the first two sections of steep pass for the Claiborne Run site (Figure 8).

Figure 8. Alaskan steep pass section built for Claiborne Run site.

A placement similar to that in Figure 9 was designed for the Claiborne Run site and additional funds (about 40 thousand dollars) for the placement of two passage structures were obtained from the U.S. Army Corp of Engineers through The Nature Conservancy. Upon final permit and right-of-way review by VDOT personnel it was determined that considerable right-of-way in the study area was owned by CSX corporation. Initial contact was attempted with local CSX offices who directed us to the proper personnel in the Florida office. After correspondence with the Florida office we were contacted by a consulting/law firm in Philadelphia. We sent them our proposal to install an Alaskan steep pass structure and replied that a contract with us would be required to compensate their personnel for time spent reviewing the project.

Figure 9. Steep pass design for Claiborne Run. Note adjustable gated flow wall to left of steep pass structure.

We re-visited the site for final citing of the structure placement and decided that further consideration would not be given to this site for the following reasons:

1. The road previously crossing the stream (218) had been diverted and VDOT would no longer be maintaining the road or culvert,

2. The culvert was currently undercut necessitating further concrete repair of portions of the culvert prior to placement of the structure

3. Additional funds for repair, placement, and CSX's needs were unavailable.

After making the decision to abandon the Claiborne Run site, we received word from the Philadelphia consultant that CSX may be able to waive the fees associated with review of the proposed project. After discussions with project personnel, we declined to examine the project further. It was decided to continue with the White Oak project and to seek additional sites for the steep pass structures already fabricated.

White Oak Run

White Oak Run (Figure 2) is presently being fitted with a pool-weir fish passage system. Water will be diverted into a single pipe culvert and the pool-weir steps will be placed in the road rubble and substrate downstream of the road culverts. Landowner permission to perform this work was obtained from Mr. Manley Turner as the written permission is archived at Virginia Commonwealth University. The upstream diversion wall will be similar to that of Figure 10.

Figure 10. Upstream diversion wall for fish passage system. Wall to right of picture has removable gates that are presently keeping water level even through the three pipes. Removable gates make maintenance and flood control easier when passage is not required.

We anticipate the construction of this passage to be completed by the end of May 2004. A recent collection of fishes from the study site (7 April 04) did not result in the capture of anadromous herring but catadromous American eel were found at the site as well as eastern silvery minnows. Eastern silvery minnows are often associated with anadromous river herrings in the spring as egg predators and are considered indicative of river herring habitat during spring months. We will monitor the area for resident and anadromous fishes prior to and following the installation of the pool-weir structures. A supplemental memo will be sent to VDGIF and VTRC following collection of monitoring data in spring of 2005.

Carter Creek, York River Drainage

An additional site in the York drainage was cited as a potential replacement for the Alaskan steep pass structures developed for the Claiborne Run site. Carter Creek at Rt. 614 in Gloucester County is impeded by culverts that empty portions of Hayes pond. We continue to work toward landowner permission for this site and will update VDGIF and VTRC as work progresses. There is some question as to the length of passage structure needed for this site and contact has been made with Alan Weaver (VDGIF) and Dick Quinn (USF&W) to address some concerns about passage at this given site. Figure 11 shows photos looking upstream toward the impediment and downstream from the impediment. This area is known to have anadromous fish runs in the spring.

Additional sites in the York and Potomac River drainages are being explored for fish passage systems.

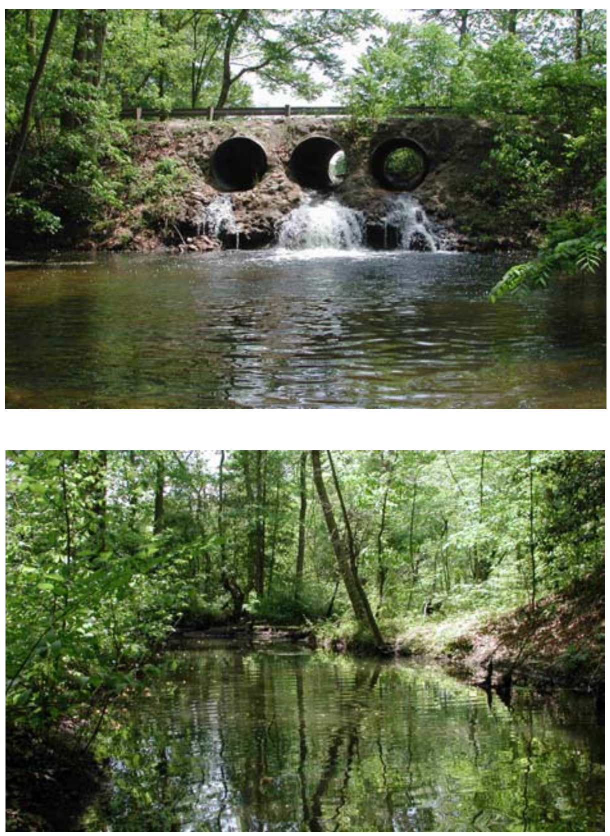

Figure 11. Carter Creek impediment, Rt. 614 Gloucester County, York drainage. Top is looking upstream toward road culverts; bottom is looking downstream from road.

Discussion

The results of the 2001 sampling and 2004 follow-up sampling suggest that both pool-weir type passage and Alaskan steep pass structures can be effective and that placement considerations, proper engineering and environmental conditions such as rainfall can greatly influence the efficiency. Little can be done to improve the effectiveness of these systems during years of drought. However, other variables need to be considered in any final site analysis for passage implementation. The large majority of these decisions need to be made on a site-by-site basis.

Maintenance

The pool-weir at Paint Branch site is obviously a failed system (Figure 4) due to a lack of required regular maintenance at this site. A different placement of the structure or, perhaps a different hydrological assessment of the site may have suggested an alteration of the passage placement. However, shifting substrates that exist in these settings and the ability of those sediments to fill constructed pool-weir systems suggests high maintenance and must be considered prior to construction. To a lesser extent the Budd's Creek Alaskan steep pass (Figure 7) requires periodic maintenance (here performed by a landowner) to clear woody debris from the structure. If not adequately removed, build up of woody debris and leaf litter may effectively clog the system rendering its passage abilities non-existent. The substrates upstream of the Sawmill Creek site are finer and thus, with ample flow in the system, are not likely to clog the pool-weir design placed therein (Figure 5).

Site Considerations

Obviously the details of the impediment are the primary consideration when designing or picking a fish passage structure. If there is a 2-foot drop to stream level from a road culvert it will be more effective to utilize the Alaskan steep pass technology for passage rather than attempting to build up a pool-weir system to that height. Conversely if the drop is significantly less and/or gently sloped than perhaps the pool-weir design would be more effective. Consideration of the road culvert type, height, length, and materials will all play a role in determining fish passage structure and the extent to which upstream and within culvert water diversion structures are required. Last, although we are of the opinion that all streams and rivers should remain connected throughout their lengths to the degree possible (no impediments), if one is actively targeting a species or group of species, such as anadromous fishes, then one will wish to know the extent of their usage of the area in question and the quality and quantity of their preferred habitat being opened by implementing a fish passage system.

The information learned in this study suggests that both the Alaskan steep pass structure and pool-weir designs can be effective for passage of both anadromous and resident fishes. Insufficient data were collected to quantify effectiveness but fishes were found to use both types of system to pass under road systems.

RECOMMENDATIONS

So that VDOT can make the best-informed decisions and target available funds for culvert rehabilitation, the following recommendations are made:

1. **Use database exploration to aid in targeting passage systems.** Fish passage projects relating to road crossings are likely to be driven by a number of factors, the simplest of which is the amount of funds available and the fish species of interest. If the objective is to open upstream habitats to spawning, then the *amount* of good habitat upstream of the blockage would help the decision process (how to get the most bang for the buck). The potential for passage structure blockage (required maintenance) as shifting substrates, the extent of floods/spates in the watershed, and the condition of upstream of downstream sections of the watershed to those species of interest are all variables that would aid in the decision making process. Databases with information on extent of "preferred" habitat and present or historical fish usage are not yet fully developed for many watersheds. At this time it remains best to assess projects on a site-by site basis in most drainages of Virginia.

2. **Consider maintenance of structure.** All fish passage projects using either Alaskan steep pass or pool-weir designs should consider regular maintenance as a variable in their design and operation. Recent advances in passage designs use slotted gates (Figure 9) both upstream (in diversion system) and downstream (near structure) to reduce maintenance needs when the passage system is not needed. For instance, the passage structure could be devoid of water when spring spawning runs of anadromous fishes are completed, alleviating the need for maintenance throughout the remainder of the year.

3. **Monitor recent installations.** We recommend that fish usage of installed passage systems being performed for at least two seasons following installation. This will give us better information as to the effectiveness of various systems on the Atlantic slope and allow more refinement of decision making and passage design.

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