Stream Crossings in the Ashuelot River Watershed

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Introduction

The New Hampshire Department of Environmental Services (NHDES) and New Hampshire Fish and Game Department (NHFGD) are collaborating on a project to collect and analyze data on stream crossings in the Ashuelot River Watershed. The Nature Conservancy (TNC) was also involved with the project as TNC has conducted stream crossing assessments at 663 road-stream crossings in the Ashuelot River Watershed using a slightly different assessment protocol specifically developed to be used by volunteers with no training on identifying bankfull indicators. Additionally, faculty at Antioch University New England in Keene, NH, have collected data on twenty-four stream crossings in the White Brook Watershed, a tributary to the Ashuelot River, to evaluate the influence of climate change and development on the potential for stream crossings to become hydraulically overwhelmed during various estimated storm flows. It is anticipated that in the future, the data collected for the present report could be compared to that collected by TNC and Antioch University.

Methods

The protocol used (Appendix A-datasheets and Standard Operating Procedures) was developed by NHFGD and NH Geologic Survey and is nearly the same as the protocol developed by Vermont Agency of Natural Resources (VANR 2009). The New Hampshire protocol includes the additional parameters of reference bankfull widths, slope of the channel and crossing and adding a site sketch. Data were collected at 87 randomly chosen stream crossings in the Ashuelot River and Nash Stream Watersheds in 2008, 2009 and 2010 by NHFGD and NHDES staff. No attempt was made to specifically determine whether or not a stream was perennial, but crossings on channels that were obviously intermittent or only drainage swales were not surveyed.

For purposes of this report, the crossings have been evaluated in terms of 1) the relationship between the relative size of the crossing compared to the size of the stream channel, 2) fish passage and 3) the new stream rules adopted by NHDES in May 2010. Fish passage was evaluated using the models developed by Coffman (2005) based on empirical research conducted at twenty-six crossings in Virginia with most of the same fish species that are native to New Hampshire. Fish passage is evaluated (i.e., predicted) by 1) whether or not there is a natural or constructed streambed in the structure, 2) how much of the structure is backwatered, 3) the height of the outlet perch, where one exists, (vertical distance between the crossing outlet and the water surface immediately downstream of the crossing structure) and 4) the slope times the length of the structure.

Results

Once on site, a survey typically took about 30 to 40 minutes for a single person to complete. Two people could complete a survey in about 25 to 30 minutes. We surveyed 87 stream crossings in the Ashuelot River and Nash Stream Watersheds in 2008, 2009 and 2010 (Table 1). Most appeared to be perennial streams based on the presence of fish and/or flowing water during typical low flow conditions, but some were probably intermittent streams. The drainage area at the crossing sites ranged from 13.4 to 8,763 acres, with almost one-half having a drainage area of less than 200 acres (Figure 1).

Table 1. Number of stream crossings surveyed in the Ashuelot River and Nash Stream Watersheds in 2008, 2009 and 2010 by crossing type.

Crossing type	Number surveyed – Ashuelot River Watershed	Number surveyed – Nash Stream Watershed
Single culvert (pipe)	54	9
Multiple culvert (pipe)	8	1
Bridge (span)	9	0
Box culvert	4	0
Not recorded	2	0
Total	77	10

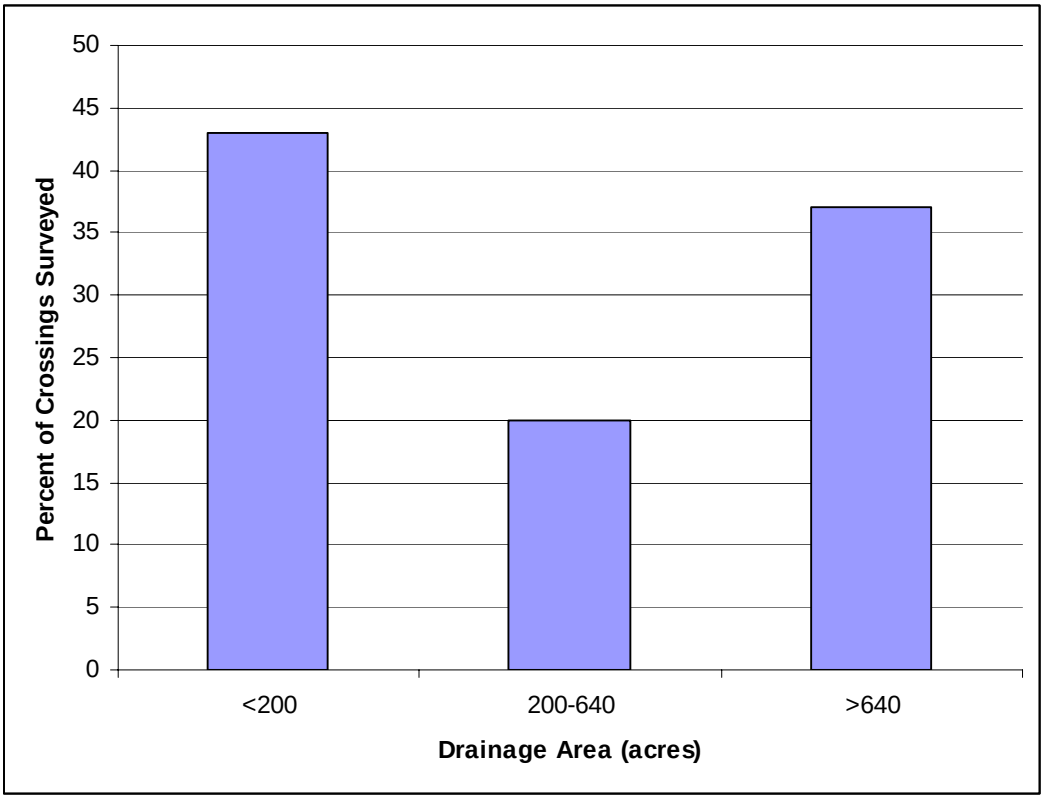


Figure 1. Surveyed Crossings by Drainage Area. The categories correspond to those in the stream crossing rules adopted in May 2010 by NHDES

In 2008 and 2009, surveys were conducted during typical low flow conditions. In August and September 2010, surveys were conducted during extremely low flow conditions. The USGS gage, 01161000 Ashuelot River at Hinsdale, NH, which is very close to the confluence with the Connecticut River and thus indicative of flows in the watershed as a whole, indicated that the flow there was less than the 7Q10 when the surveys were conducted. Additionally, observations by John Magee in the southern part of New Hampshire outside of the Ashuelot River Watershed, indicated that many, small perennial fish-bearing streams were completely dry (no standing pools) by late July 2010. Therefore, it is possible that some of the crossings surveyed in 2010 were on perennial streams even though they were completely dry during the survey.

Of the 87 crossings surveyed, reference bankfull measurements were collected at 66 of them. Of those 66, only three were wider than the bankfull width (Figure 2). Two of those were bridges, and one was on a stream that is potentially intermittent. Of particular note is that the widths of 39 of those 66 (59%) crossings were 50% or less of the bankfull width at the site. At most of these sites, there was a plunge pool that was typically wider than the reference channel width, indicating that the plunge pool was created by the crossing (typically a round pipe) over time and that the sediment that was eroded to create the plunge pool must have moved downstream. Although the amount of sediment that may have been eroded was not estimated during the surveys, it was apparent that a very large amount (compared to the natural channel) had been eroded at many of these

sites. This represents a significant disturbance to wetlands (stream channels) that occurs over a period of years after construction. Appendix B contains examples of this.

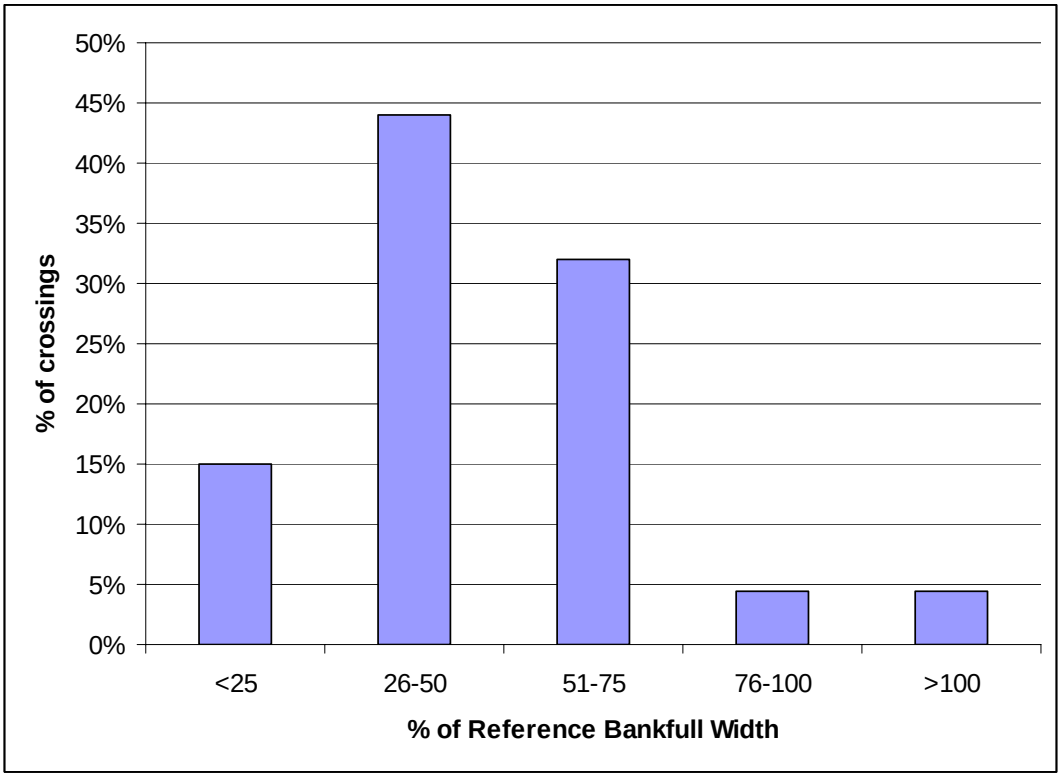


Figure 2. Percent of crossings within categories of percent of reference bankfull width.

From observations made at the surveyed sites and the dataset generated, it is clear that the geomorphic response of a given stream to a stream crossing is dependent on the slope of the channel and crossing, the degree to which the crossing narrowed the flow of water, and the substrate present at the crossing. Geomorphic responses to the channel due to the crossings were not apparent at some sites and very unclear for bridges. Because bridges span nearly the entire bankfull width at the sites we surveyed, there is likely to be little or no obvious signs of geomorphic changes due to the bridge.

The geomorphic changes at a site are likely to be very dependent on the substrate at the site. Channels with very large substrate such as large boulders and ledge have little opportunity for bed and bank erosion, while the bed and bank of channels with small substrate such as sand and gravel can easily erode.

Although not always specifically recorded, it was apparent that many crossings had been overtopped (e.g., pavement or lots of road fill material in the downstream side of the stream) in the last several years, possibly during the floods of 2005, 2006 and 2007, or more recently.

It is clear that many crossings (37%) are predicted to be impassable by all species of fish, but the majority (78%) of crossings are predicted to be passable by adult brook trout (Table 2 and Figures 3 through 6), a Species of Greatest Conservation Need in the New Hampshire Wildlife Action Plan and for which the Eastern Brook Trout Joint Venture was developed by State and Federal agencies and non-governmental organizations. It is not known if the remaining 22% are passable by adult brook trout; some of those crossings contain a range a values of slope and length through which it is not known whether a particular group of fish can successfully move upstream, and the slope of some of those crossings could not be measured in the field with a clinometer (because the crossing structure was too small to see through or the road fill obscured one's vision from upstream to downstream of the crossing).

Table 2. Fish Passage, by Fish Group, for Stream Crossings in the Ashuelot River and Nash Stream Watersheds.

	Ashuelot River Watershed			**Nash Stream Watershed**		
	Group A	**Group B**	**Group C**	**Group A**	**Group B**	**Group C**
Passable	55	44	35	6	3	3
Impassable	2	17	22	2	6	6
Unsure	9	5	9	1	0	0
Unknown*	3	3	3	1	1	1
Total	69	69	69	10	10	10

Group A = Fish one year old and older in the Family Salmonidae (trout and salmon).
Group B = Young of year in the Family Salmonidae and all fish in the Family Cyprinidae (minnows).
Group C = Fish in the Families Percidae (except walleye and yellow perch) and Cottidae (sculpins).
"Unsure" means that the models produced by Coffman (2005) indicate that there is less known about the passability of crossings with a certain range of values of slope and length.
Groups by Coffman (2005).
*Crossings for which the slope was not able to be measured.

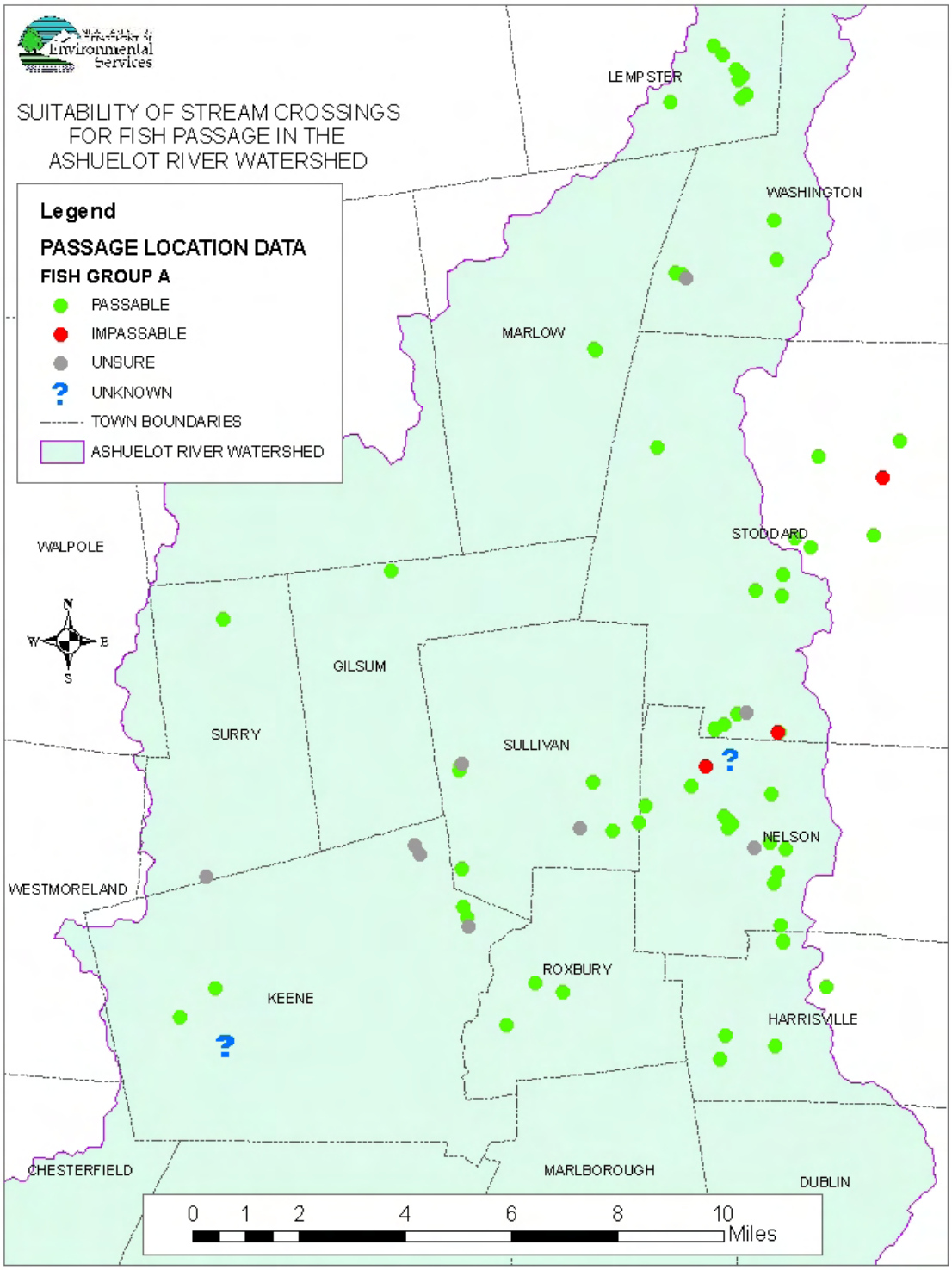


Figure 3. Fish passage for Fish Group A (Fish one year old and older in the Family Salmonidae [trout and salmon]) in the Ashuelot River Watershed.

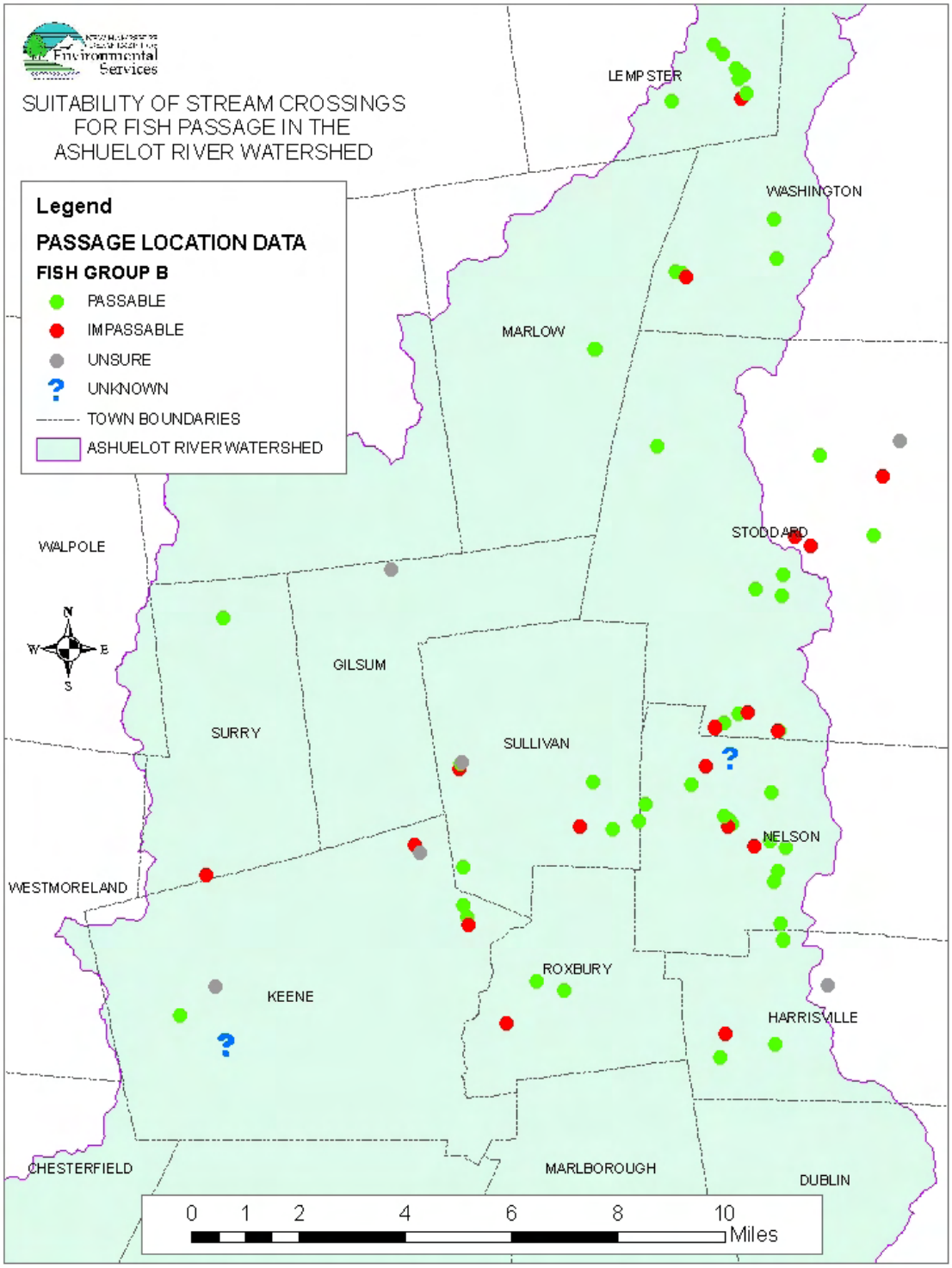


Figure 4. Fish passage for Fish Group B (Young of year in the Family Salmonidae and all fish in the Family Cyprinidae) in the Ashuelot River Watershed.

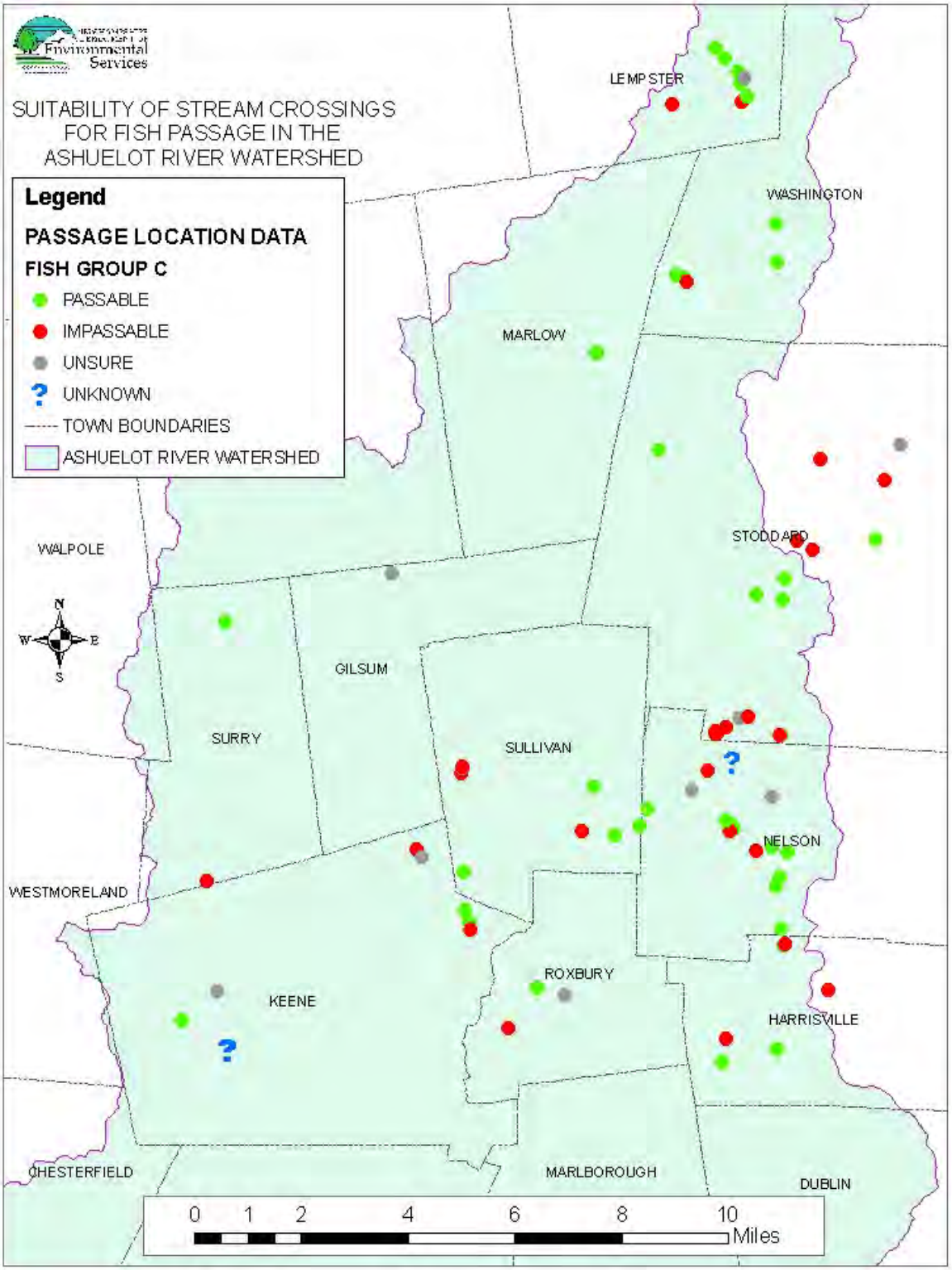


Figure 5. Fish passage for Fish Group C (Fish in the Families Percidae (except walleye and yellow perch) and Cottidae) in the Ashuelot River Watershed.

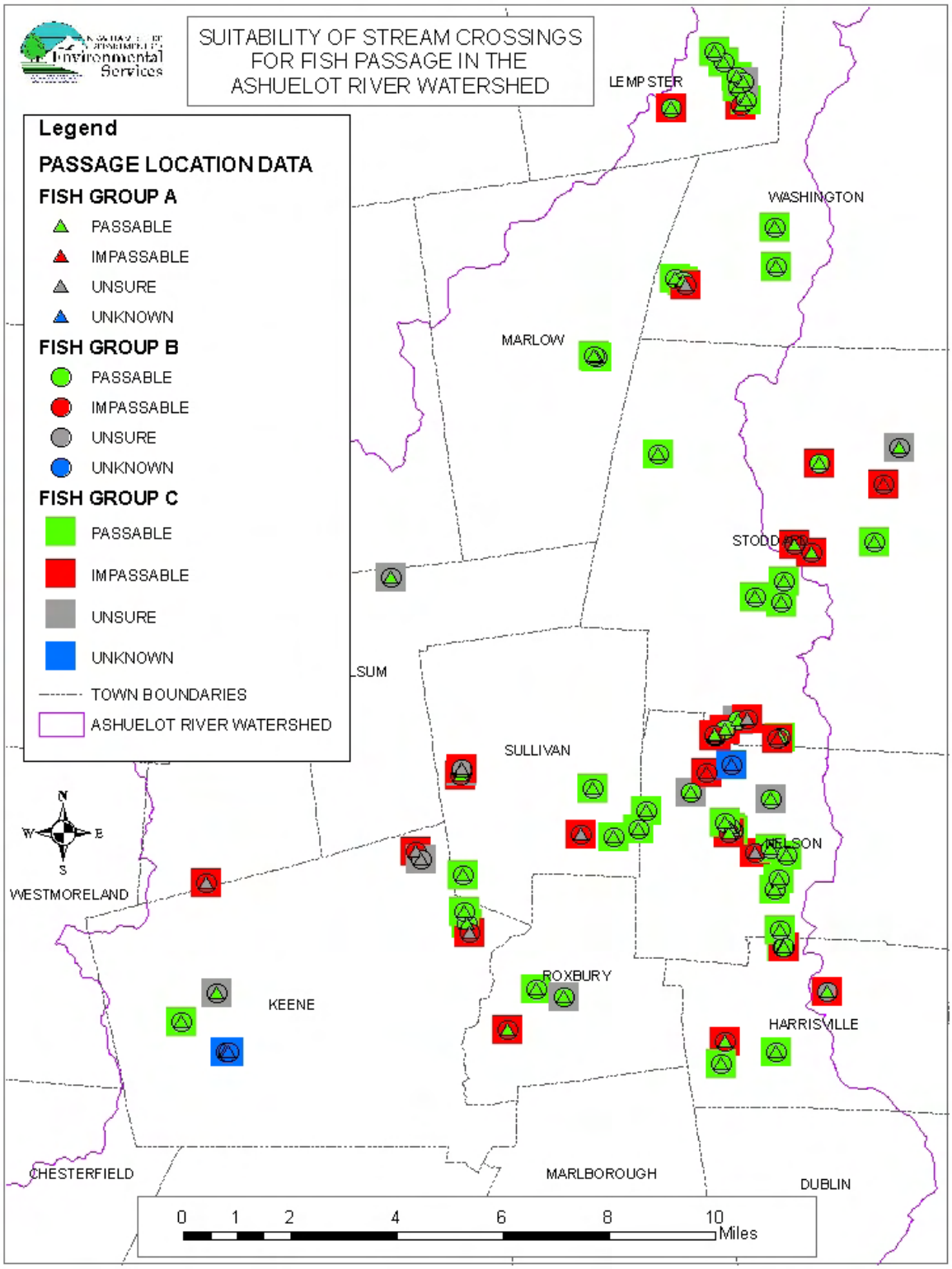


Figure 6. Fish passage for all Fish Groups in the Ashuelot River Watershed.

This tool proved to be very useful in determining if fish passage is currently being provided by the crossing. Where it is not clear if fish passage exists, it is due to an incomplete understanding of fish swimming abilities through crossings – this may be due to the variation in fish behavioral responses to stream crossings.

Relative to the recently adopted rules for stream crossings, we were able to estimate the drainage area at 84 of the 87 crossings surveyed, which ranged from 13.4 to 12,102 acres. Thirty-six (43%) had a drainage area less than 200 acres. This is relevant to the recently adopted stream rules as Tier I crossings are those in which the contributing drainage area is less than 200 acres. Fish were observed at 11 (31%) of these Tier I crossings. The smallest drainage area at which fish, in this case brook trout, were observed was 28 acres. Of particular note is that, even though fish were observed in streams with very small drainage areas, we found other streams with even larger drainage areas with no flow (only standing pools of water) or be completely dry during the same day (e.g., on September 8, 2010). One stream with a drainage area of 520 acres had almost no flow on August 30, 2010, although it had both brook trout and blacknose dace. Although drainage area can provide useful information regarding hydrology for flood flows, it is not a reliable indicator of the living aquatic resources in the stream.

In terms of prioritizing stream crossings for restoration or mitigation projects, at least two physical attributes of the existing crossing should be considered: 1) the degree to which it is causing erosion and 2) the degree to which aquatic animals are precluded from moving upstream through it. The former can be quantified at a given site, but requires some time to collect these data, and ultimately it may be very difficult to rank sites because erosion on small streams is likely to be much less than on larger rivers. Aquatic organism passage is relatively easy to assess in most cases, but not all cases (e.g., scientists lack data for certain slope and crossing length conditions). Ultimately, if a central objective is to improve water quality and aquatic habitat conditions such that aquatic organisms and the human use of them (e.g., fishing) benefit, then some type of survey for these aquatic organisms is needed at the sites being considered before funding is allocated toward them.

Conclusions

We demonstrated that an individual survey can be done by one person in about 30 minutes once on site. The methodology appears robust in terms of predicting fish passage for species that are found in many New Hampshire, and New England, streams.

The width of nearly all (95%, 63 of 66 for which reference bankfull width could be measured) of the crossings was less than the reference bankfull width, indicating they may be geomorphically undersized. Bridges appeared to have the least visible geomorphic impacts; typically, little or no bed or bank erosion or sedimentation was apparent at bridge sites. A large proportion (43%, 32 of 75) of the crossings with bottoms (round pipe culverts and box culverts) were not passable by at least some species of fish, while all bridges were passable by all fish.

The recently adopted rules on stream crossings in New Hampshire will lead to dramatic improvements in terms of 1) aquatic organism passage, 2) reducing the likelihood that crossing will fail during floods, and reducing erosion and water quality impacts.

The protocol used for this report is a good tool for assessing stream crossings relative to fish passage. Although we did not analyze the capability of this tool to predict causative relationships between crossing width relative to bankfull width and erosion at the site, this could likely be done on a larger dataset.

When prioritizing crossings for restoration or mitigation projects, other data should be collected, such as fish and other aquatic animals that currently live in a given stream.

References

Coffman, J.S. 2005. Evaluation of a Predictive Model for Upstream Fish Passage Through Culverts. M.S. Thesis. James Madison University, Virginia, USA.

NHDES. 2010. Stream Crossing Rules, Env-Wt 100-900. Access through the Streams and Stream Crossings web page:
http://des.nh.gov/organization/divisions/water/wetlands/streams_crossings.htm

Vermont Agency of Natural Resources (VANR). 2009. Vermont Stream Geomorphic Assessment, Appendix G, Bridge and Culvert Assessment.

Appendix A. Datasheets and Standard Operating Procedures

Page 1 of Culvert assessment form used in 2008 and 2009.

Structure ID	Road Name	
Observers	Stream name	
Date and Time	Number of travel lanes ____	**Structure material**: concrete plastic-corrugated plastic-smooth tank stone steel-corrugated steel-smooth aluminum-corrugated other (describe)_____
Town	Number of shoulder lanes ____	
Location	Road surface __paved ___unpaved	
Lat	Road type unpaved paved trail railroad	**Headwall material**: concrete, metal, stone
Long	**Reference bankfull widths (ft)** _____ _____ _____ _____ _____	

Flow conditions are: ___ unusually low ___typical low flow ___higher than average ___flood conditions

# of culverts at crossing_____ | Overflow pipe(s) yes no | Structure skewed to roadway yes no

Crossing type __ford ___bridge ___open bottom arch ___single culvert ___multiple culverts (# or culverts___)

Condition of crossing: __New ___Old ___Collapsing ___eroding ___rusted

General **Geomorphic and Fish Passage Data**

Floodplain filled by roadway approaches: Entirely Partially not significant

Structure located at a significant break in valley slope: yes no unsure

Culvert slope as compared with the channel slope is: higher lower about the same

Water depth in the crossing matches that of the stream? __Yes ___No (significantly deeper ___No (significantly shallower)

Water velocity in crossing matches that of stream? ___Yes ___No (significantly faster) ___No (significantly slower)

Reference bankfull widths (ft) ____ ____ ____ ____ ____ Reference slope (%) _____

Ref bank-bank widths (ft) ____ ____ ____ ____ ___ Reference Bed widths (ft) ___ ___ ___ ___ ___

Upstream

Culvet inlet: at grade cascade free fall

Structure opening partially obstructed by: wood sediment wood and sediment deformation of culvert none

Steep riffle present immediately upstream of structure: yes no

If channel avulses: stream will: cross road follow road cross and follow road unsure

Estimated distance avulsion would follow road: _____(feet)

Angle of stream flow approaching structure: sharp bend mild bend naturally straight channelized straight

Evidence of streambed erosion or aggradation immediately upstream of culvert: erosion aggradation none

Upstream Bankfull widths ____ ____ ____ _____ _____ (feet) Upstream slope % _____

Downstream

Water depth in culvert (at outlet): _____(0.0 feet)

Culvert outlet at grade cascade free fall backwatered _____ft Stepped footers yes no

Outlet drop (invert to water surface) _____(0.0 feet) Pool present immediately downstream of structure: yes no

Pool depth at point of streamflow entry: _____(0.0 feet) Maximum pool depth: _____(0.0 feet)

Downstream bank heights are substantially higher than upstream bank heigths: yes no

Hydraulic control type: boulders cobble wood other_____

Distance from downstream end of culvert to hydraulic control

Evidence of streambed erosion or aggradation immediately downstream of culvert: erosion aggradation none

Downstream Bankfull widths ____ ____ ____ _____ _____ (feet) Downstream slope % _____

	Upstream	**Downstream**	**In structure**
Dominant bed material at structure	1 2 3 4 5 UNK bedrock present:Y N	1 2 3 4 5 UNK bedrock present:Y N	1 2 3 4 5 UNK sediment throughout:Y N
If substrate is present in the structure, how deep is it? ___< 1 foot ___1-2 feet ___>2feet UNK			
Bedrock present in channel at structure yes no Material throughout yes no			
Sediment deposit types	none delta side point mid-channel	none delta side point mid-channel	none delta side point mid-channel
Elevation of sediment deposits is greater than or equal to 1/2 bankful elevation	yes no	yes no	yes no
Beaver dam near structure Distance from structure to dam	yes no distance: feet	yes no distance: feet	Bed Materials: 0 - none
Hard bank armoring	intact failing none unknown	intact failing none unknown	1 - bedrock
Bank erosion	high low none	high low none	2 - boulder
Streambank scour causing undermining around/under structure	none culvert footer wing walls	none culvert footer wing walls	3 - cobble
			4 - gravel
			5 - sand
			UK - unknown
	LEFT RIGHT	LEFT RIGHT	Vegetation Type codes:
Dominant vegetation type			C - coniferous forest
Does a band or shrub/forest vegetation that is at least 50ft wide start within 25ft of structure and extends 500ft or more up/downstream?	yes no yes no	yes no yes no	D - deciduous forest M - mixed forest S - shrub/sapling H - herbaceous/grass B - bare R - road embankment

Page 2 of culvert assessment form used in 2008 and 2009.

Page 2

Spatial data collected w/GPS yes no

Photos taken : yes no

Photo filename	Photo view	Description of features in photo

FULD=from u/s looking d/s
FRLU = from road looking u/s
FRLD = from road looking d/s
FDLU - from d/s looking u/s

Site sketch

Upstream

Looking upstream into culvert

Flow

Looking downstream into culvert

Site comments:

Downstream

Crossing Type (from SOP) ☐ 1. ☐ 2. ☐ 3. ☐ 4. ☐ 5.
☐ 6. ☐ 7. ☐ 8. ☐ 9. ☐ Ford

Upstream Dimensions (ft.): A) B) C) D)

Downstream Dimensions (ft.): A) B) C) D)

Length of stream through crossing (ft.):_____ **Crossing slope (%)** _____

Culvert and bridge assessment forms and instructions used in 2010 follow. (Revisions were made to the format.)

<u>Culvert Assessment Field Form</u> – Geomorphic & Habitat Parameters

Structure ID	Unknown ☐			Structure Number	
Observer(s)/ Organization(s)				Date & Time	
Town				Latitude (N/S)	
Location				Longitude (E/W)	
SGA Reach ID				Stream Name	
Road Name				Road Type	**paved gravel trail railroad**
# of shoulder lanes				Crossing Condition	**new old eroding collapsing rusted**
# of travel lanes		Structure Materials	**Concrete Plastic-Corrugated Plastic-Smooth Tank Stone Steel-Corrugated Steel-Smooth Aluminum-Corrugated Other: _____**	Structure skewed to roadway	**yes no**
# of culverts at crossing				Flow Conditions	**unusually low typical low higher than average flood conditions**
Overflow pipe(s)	**yes no**				

<u>Geomorphic and Fish Passage Data</u>

General

Floodplain filled by roadway approaches: **entirely** (> $^3/_4$ of floodplain) **partially** ($^1/_4$ – ¾ of floodplain) **not significant**
Structure within ⅓ mile downstream of a significantly steeper segment of stream: **yes no unsure**
Culvert slope as compared with the channel slope is: **higher lower about the same**
Water depth in the crossing matches that of stream: **yes no (significantly deeper) no (significantly shallower)**
Water velocity in crossing matches that of stream: **yes no (significantly faster) no (significantly slower)**

Upstream

Structure opening partially obstructed by (circle all that apply): **wood sediment wood & sediment deformation of culvert none other: _____**

Steep riffle present immediately upstream of structure: **yes no**
If channel avulses, stream will: **cross road follow road cross and follow road unsure**
Estimated distance avulsion would follow road: _____ **(ft.)**
Angle of stream flow approaching structure: **sharp bend (45° - 90°) mild bend (5° - 45°) naturally straight channelized straight**
Evidence of streambed erosion or aggradation immediately upstream of culvert: **erosion aggradation none**
Culvert inlet: **at grade cascade free fall**
Upstream bankfull widths: 1.)_____ 2.)_____ 3.)_____ 4.)_____ 5.)_____ (ft.)

Reference bankfull widths: 1.)_____ 2.)_____ 3.)_____ 4.)_____ 5.)_____ (ft.)

Downstream

Water depth in culvert (at outlet): _____ **(0.0 ft.)**
Culvert outlet: **at grade cascade free fall backwatered** _____ **(ft.)** Stepped footers: **yes no**
Outlet drop (invert to water surface): _____ **(0.0 ft.)**
Pool present immediately downstream of structure: **yes no**
Pool depth at point of streamflow entry: _____ **(ft.)**
Maximum pool depth: _____ **(0.0 ft. or > 4.0 ft.)**
Downstream bank heights are substantially higher than upstream bank heights: **yes no**
Hydraulic control type: **bedrock boulders cobble gravel sand wood other:**_____
Distance from downstream end of culvert to hydraulic control: _____ **(ft.)**
Evidence of streambed erosion or aggradation immediately downstream of culvert: **erosion aggradation none**
Downstream bankfull widths: 1.)_____ **2.)**_____ **3.)**_____ **4.)**_____ **5.)**_____ **(ft.)**

	Upstream	Downstream	In Structure	
Dominant bed material (substrate) at structure (use codes below)	**1 2 3 4 5 6 UNK**	**1 2 3 4 5 6 UNK**	**NONE 1 2 3 4 5 6 UNK**	
Bedrock present	**yes no**	**yes no**	Depth of Substrate	**< 1 foot 1-2feet >2 feet UNK N/A**
Sediment Deposit Type	**none delta side point mid-channel**	**none delta side point mid-channel**	**none delta side point mid-channel**	
Elevation of sediment deposits is greater than or equal to ½ bankfull elevation	**yes no N/A**	**yes no N/A**	**yes no N/A**	
			Substrate Throughout? **yes no**	
Beaver dam near structure Distance from structure to dam	**yes no distance: _____ (ft.)**	**yes no distance: _____ (ft.)**	**Bed Material Codes**	
Hard bank armoring	**intact failing none UNK**	**intact failing none UNK**	**1 –** bedrock	
Bank erosion	**high low none**	**high low none**	**2 –** boulder	
Stream bank scour causing undermining around/under structure (circle all that apply)	**none culvert footers wing walls**	**none culvert footers wing walls**	**3 –** cobble **4 –** gravel **5 –** sand **6** – silt/clay **UNK -** unknown	

Wildlife Data (left/right bank determined facing downstream)	Upstream		Downstream		**Vegetation Type Codes**
	LEFT	**RIGHT**	**LEFT**	**RIGHT**	
Dominant vegetation type (use codes to the right)					**C –** coniferous forest **D –** deciduous forest **M –** mixed forest **S –** shrub/sapling **H –** herbaceous/grass **B –** bare **R –** road embankment
Does a band of shrub/forest vegetation that is at least 50' wide start within 25' of structure and extend 500' or more up/downstream?	**yes no**	**yes no**	**yes no**	**yes no**	

Road-killed wildlife within ¼ mile of structure (circle none or list species)	**species:**		**none**	
Wildlife sign and species observed near (up/downstream) and inside structure (circle none or list species and sign types)	**Outside Structure**		**Inside Structure**	
	species (none)	**sign**	**species (none)**	**sign**

Spatial data collected with GPS: **yes** **no** **Comments/Drawings:**

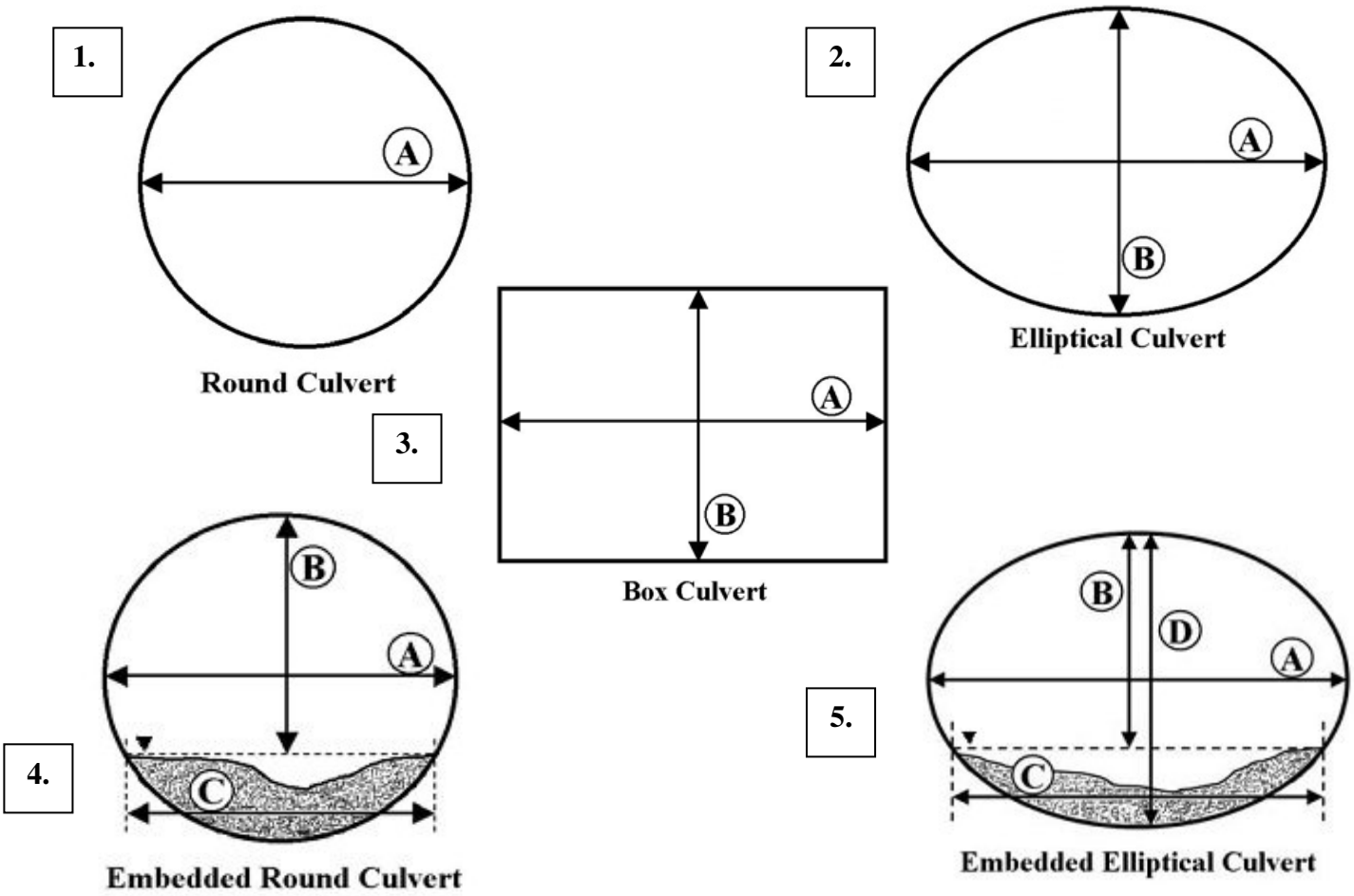
Photos taken: **yes** **no**

Please fill out photo log below

Folder Name:	**Structure Inlet**	**Structure Outlet**	**Above Structure**
Photo View - Upstream	☐	☐	☐
Photo View - Downstream	☐	☐	☐

Record the file name for each photo taken in the appropriate box

Crossing Dimensions



Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.** ☐ **5.** ☐**Ford**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): _____
Crossing Slope (%):_____

Note: When inventorying multiple culverts, label left culvert 1 and go in increasing order from left to right from downstream end (outlet) to looking upstream.

Culvert Cell 2 of _____

Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.** ☐ **5.**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): _____
Crossing Slope (%):_____

Culvert Cell 3 of _____

Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.** ☐ **5.**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): _____
Crossing Slope (%):_____

Culvert Cell 4 of _____

Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.** ☐ **5.**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): _____
Crossing Slope (%):_____

Bridge and Arch Assessment Field Form – Geomorphic & Habitat Parameters

Structure type: **bridge / arch**

Structure ID	Unknown ☐			Structure Number	
Observer(s)/ Organization(s)				Date & Time	
Town				Latitude (N/S)	
Location				Longitude (E/W)	
SGA Reach ID				Stream Name	
Road Name				Road Type	**paved gravel trail railroad**
# of shoulder lanes				Crossing Condition	**new old eroding collapsing rusted**
# of travel lanes		Structure Materials	**Aluminum Concrete Masonry (arches) & Slabs Prestressed Concrete/ Post-tensioned Steel Timber Other: _____**	Structure skewed to roadway	**yes no**
# of bridge cells or arches at crossing				Flow Conditions	**unusually low typical low higher than average flood conditions**
Overflow pipe(s)	**yes no**				

Geomorphic and Fish Passage Data

General

Floodplain filled by roadway approaches: **entirely** (> $^3/_4$ of floodplain) **partially** ($^1/_4$ – ¾ of floodplain) **not significant**
Structure within ⅓ mile downstream of a significantly steeper segment of stream: **yes no unsure**
Water depth in the crossing matches that of stream: **yes no (significantly deeper) no (significantly shallower)**
Water velocity in the crossing matches that of stream: **yes no (significantly faster) no (significantly slower)**

Upstream

Structure opening partially obstructed by (circle all that apply): **wood sediment wood & sediment failure of bridge none other: _____**

Steep riffle present immediately upstream of structure: **yes no**
If channel avulses, stream will: **cross road follow road cross and follow road unsure**
Estimated distance avulsion would follow road: _____ **(ft.)**
Angle of stream flow approaching structure: **sharp bend (45° - 90°) mild bend (5° - 45°) naturally straight channelized straight**
Evidence of streambed erosion or aggradation immediately upstream of bridge: **erosion aggradation none**
Upstream bankfull widths: 1.)_____ 2.)_____ 3.)_____ 4.)_____ 5.)_____ (ft.)

Reference bankfull widths: 1.)_____ 2.)_____ 3.)_____ 4.)_____ 5.)_____ (ft.)

Downstream

Pool present immediately downstream of structure: **yes no**
Pool depth at point of streamflow entry: _____ **(0.0 feet)**
Maximum pool depth: _____ **(0.0 ft. or > 4.0 ft.)**
Downstream bank heights are substantially higher than upstream bank heights: **yes no**
Stepped footers: **yes no**
Hydraulic control type: **bedrock boulders cobble gravel sand wood other:**_____
Distance from downstream end of bridge/arch to hydraulic control: _____ **(ft.)**
Evidence of streambed erosion or aggradation immediately downstream of bridge: **erosion aggradation none**
Downstream bankfull widths: 1.)_____ **2.)**_____ **3.)**_____ **4.)**_____ **5.)**_____ **(ft.)**

	Upstream	**Downstream**	**In Structure**
Dominant bed material at structure (use codes below)	**1 2 3 4 5 6 UNK**	**1 2 3 4 5 6 UNK**	**1 2 3 4 5 6 UNK**
Bedrock present	**yes no**	**yes no**	**yes no**
Sediment deposit types (circle all that apply)	**none delta side point mid-channel**	**none delta side point mid-channel**	**none delta side point mid-channel**
Elevation of sediment deposits is greater than or equal to ½ bankfull elevation	**yes no N/A**	**yes no N/A**	**yes no N/A**
Beaver dam near structure Distance from structure to dam	**yes no** **distance: _____ (ft.)**	**yes no** **distance: _____ (ft.)**	**Bed Material Codes** **1 –** bedrock **2 –** boulder **3 –** cobble **4 –** gravel **5 –** sand **6 –** silt/clay **UNK -** unknown
Hard bank armoring	**intact failing none UNK**	**intact failing none UNK**	
Bank erosion	**high low none**	**high low none**	
Stream bank scour causing undermining around/under structure (circle all that apply)	**none abutments footers wing walls**	**none abutments footers wing walls**	

Wildlife Data (left/right bank determined facing downstream)	**Upstream**		**Downstream**		
	LEFT	**RIGHT**	**LEFT**	**RIGHT**	
Dominant vegetation type (use codes to the right)					**Vegetation Type Codes** **C –** coniferous forest **D –** deciduous forest **M –** mixed forest **S –** shrub/sapling **H –** herbaceous/grass **B –** bare **R –** road embankment
Does a band of shrub/forest vegetation that is at least 50' wide start within 25' of structure and extend 500' or more up/downstream?	**yes no**	**yes no**	**yes no**	**yes no**	
Road-killed wildlife within ¼ mile of structure (circle none or list species)	**species:**			**none**	

Wildlife sign and species observed near (up/downstream) and inside structure (circle none or list species and sign types)	Outside Structure		Inside Structure	
	species (none)	sign	species (none)	sign

Spatial data collected with GPS: **yes** **no** **Comments/Drawings:**

Photos taken: **yes** **no**

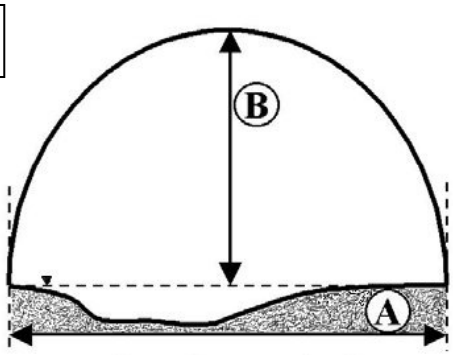
Please fill out photo log below

Folder Name:	Structure Inlet	Structure Outlet	Above Structure
Photo View - Upstream	☐	☐	☐
Photo View - Downstream	☐	☐	☐

Record the file name for each photo taken in the appropriate box

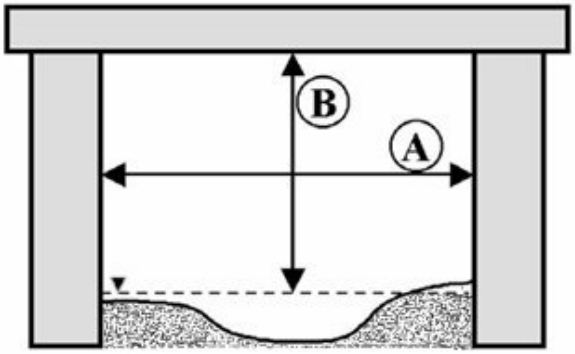
Crossing Dimensions

1.

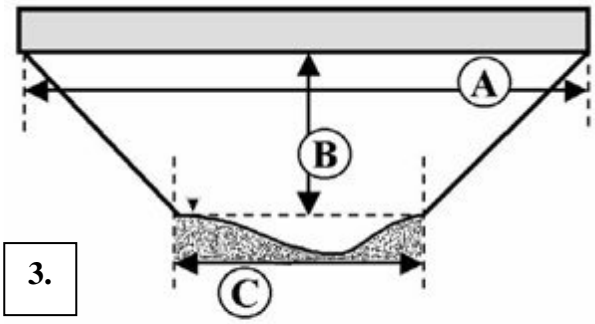


Open Bottom Arch

2.

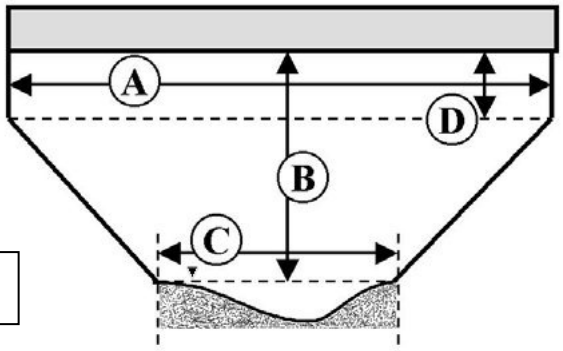


Bridge with Abutments



3.

Bridge with Side Slopes



4.

Bridge w/ Side Slopes & Abutments

Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.** ☐**Ford**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): _____
Crossing Slope (%):_____

Note: When inventorying multiple culverts, label left culvert 1 and go in increasing order from left to right from downstream end (outlet) to looking upstream.

Bridge/Arch Cell 2 of _____

Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): _____
Crossing Slope (%):_____

Bridge/Arch Cell 3 of _____

Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): _____
Crossing Slope (%):_____

Bridge/Arch Cell 4 of _____

Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): _____
Crossing Slope (%):_____

New Hampshire Culvert Assessment Protocol Instructions: Completing the Field Forms

Form Selection

The New Hampshire Stream Crossing Protocol is comprised of two separate field forms for crossing assessment. Both forms are used to document the present condition of stream crossing sites. The two forms are as follows:

The Bridge and Arch Assessment Field Form
- Designed for use at sites with bridges or arches
- This form is used for crossings without an artificial bottom.

The Culvert Assessment Field Form
- Designed for use at sites with culverts.
- This form contains a number of specific questions which apply only to culverts.

Top of form

Structure ID: This is the unique identifier (primary key) for all structures in the database for this project. Please check "Unknown" if the ID in not known.

Structure Number: Will be used in the future. This field may remain blank at present.

Observer(s)/Organization(s): Name of observer(s)/organization(s) collecting the data.

Date and Time: Record the date and time (in 24-hour format) when the crossing assessment is performed.

Town: Record the town(s) in which the structure is located.

Location: Describe the location of the structure, using nearby landmarks and road mileage distances. The location narrative should be sufficient to help future surveyors to locate the structures in the field.

Example: Bridge is located on Smith Road 5 miles south of intersection of Mountain Rd. and Smith Rd.

Latitude (N/S) and Longitude (E/W): Latitude and Longitude are north/south and east/west values, respectively, recorded in decimal degrees. This information should be collected with a GPS unit. Most GPS units give you the option of viewing lat/long data in decimal degrees. The lat/long information can then be read directly from the GPS unit and recorded on the data sheet.

SGA Reach ID: Record the stream geomorphic assessment reach ID that has been assigned to the stream.
**This identifier will only be used when the crossing assessment is associated with a river geomorphic assessment project.*

Stream Name: Name of the water body the structure crosses, as printed on the USGS topographic map. It is also helpful to note the name of the receiving water in parentheses after the stream name.

Road Name: Record the full road name.

Road Type: Circle the type of road on which the structure is located:

Gravel = Road surface is packed gravel
Paved = Road surface is paved with tar or other surface material other than dirt
Trail = A travel lane not used, or no longer used, by cars. May accommodate foot traffic or recreational motor vehicles (i.e., snow mobiles or ATVs)
Railroad = Active or abandoned railroad bed

# of shoulder lanes : Enter the number of shoulder lanes for the cross road

# of travel lanes: Enter the number of travel lanes for the cross road

Structure Material: Circle the type of material of which best describes the construct of the crossing.
(circle the primary material type only)

Crossing Condition: Circle the choice which best describes the current condition of the crossing

Number of bridge cells or arches at crossing (bridge/arch form only) – Record how many bridge cells or arches are present. Include ones that may not have any flow.

Number of culverts at crossing (culvert form only)**:** Record the number of culverts installed at the road crossing. Though there is usually only one culvert per road crossing, there can also be two or more installed side-by-side. Count all culverts that are installed at or below the bankfull elevation. Do not count overflow pipes (see below) or nearby culverts carrying tributary or road drainage flows (i.e. those not installed to carry the main stream flow).

Overflow pipes: Overflow pipes are typically smaller in dimension than the main bridge or culvert(s) at a stream crossing and are usually installed at a higher elevation. In this protocol, all culverts located above the bankfull elevation are considered overflow pipes. **Do not include overflow pipes when determining the number of culverts at the crossing.** Indicate the presence or absence of overflow pipes on the field form by circling "yes" or "no" in the appropriate space. Also, do not include the width(s) of overflow pipe(s) when determining total culvert width.

Structure skewed to roadway: Indicate whether the structure is skewed (or angled) in comparison to the roadway by circling "yes" or "no" on the field form. Keep in mind when measuring the structure span/diameter that if the structure is installed at an angle under the roadway the structure opening(s) may have been cut or built at an angle, resulting in a structure opening that is larger than the span/diameter inside the structure. Be sure to measure the actual inside span/diameter of the structure perpendicular to the stream channel.

Flow conditions: Circle the appropriate option to indicate whether flow conditions during the survey were: unusually low, typical low-flow, higher than average flow (compared to typical low-flow conditions), or flood conditions. Survey results are most useful when data is collected during typical low-flow conditions. **It is highly recommended that bridge/culvert assessments be conducted during typical summer low flow conditions.**

Geomorphic and Fish Passage Data

General Data

Floodplain filled by roadway approaches: Circle the **approximate** amount of floodplain filled up to or above the floodprone elevation by the roadway approaches on either side of the structure (see diagram below). The **floodprone elevation** is the height equal to 2 times the maximum bankfull channel depth measured above the streambed.

Entirely = More than ¾ of the floodplain width is occupied by approach ramps
Partially = Between ¼ and ¾ of the floodplain width is occupied by approach ramps
Not Significant = Less than ¼ of the floodplain width is occupied by approach ramps

Geomorphic and Fish Passage Data

Floodplain filled by roadway approaches: Circle the approximate amount of floodplain filled up to or above the floodprone elevation by the roadway approaches on either side of the structure. The **floodprone elevation** is the height equal to 2 times the maximum bankfull channel depth measured above the streambed (see Phase 2, Step 2.7).

Entirely = More than ¾ of the floodplain width is occupied by approach ramps (see Figure 4)
Partially = Between ¼ and ¾ of the floodplain width is occupied by approach ramps (see Figure 3)
Not Significant = Less than ¼ of the floodplain width is occupied by approach ramps

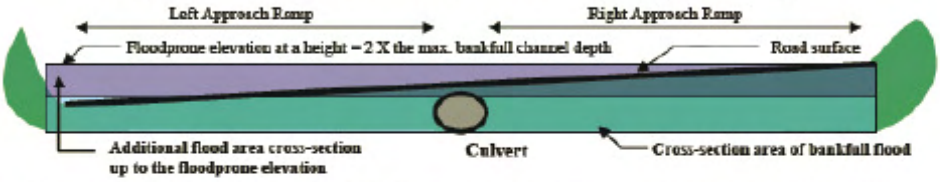


Figure 3. Valley cross-section where the left and right approach ramps partially occupy floodprone area.

Figure 4. Cross-section view of culvert site where the left and right approach ramps entirely occupy the floodprone area.

Solid Black Line = elevation of road surface and approaches to culvert site

Dashed White Line = floodprone elevation at a height that is 2 X the maximum bankfull channel depth (height **B** as measured from the bed)

Dotted White Line = maximum depth from the stream bed to the elevation of bankfull (height A). See Channel Width discussion.

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Structure within 1/3 mile downstream of a significantly steeper segment of stream: Circle "yes" if the structure is located on a stream segment of relatively gentle-gradient that is within 1/3 mile downstream of a significantly steeper segment of stream. If this is not the case, circle "no." Use a topographic map to assist with this evaluation. If you do not have a topo map or the forest cover obscures your view of upstream topography, circle "unsure" on the field form. Significant changes in channel slope are usually reflective of breaks in valley slope and may result in a dramatic decrease in the stream's sediment transport capacity. A structure may be particularly prone to failure if it is located on an alluvial fan or similar high deposition area.

Culvert slope as compared with channel slope (culvert form only)**:** Circle whether the culvert slope, as compared to the channel slope, is significantly higher, lower, or about the same. This is a visual estimate intended to red flag locations where the culvert was placed at a noticeably different slope than that of the channel.

Water depth in crossing matches that of stream: Check "yes" if water depth in the crossing is comparable to the depths upstream and downstream in the natural stream channel. Comparable means that the depth in the crossing falls within the range of depths naturally occurring in that reach of the stream. Compare the depth in the crossing within ~100 feet (or "line of site") both up and downstream of the crossing. Check "no, significantly deeper" if the water depth in the crossing is deeper from that found in the stream, and "no, significantly shallower" if the depth is shallow compared to the natural stream channel.

Water velocity in crossing matches that of stream: Check "yes" if water velocities in the crossing are comparable to the velocities in the natural stream channel upstream and downstream of the crossing. Comparable means that the velocities in the crossing fall within the range of velocities naturally occurring in that reach of the stream. Compare the velocity in the crossing within ~100 feet (or "line of site") both up and downstream of the crossing. Check "no, significantly faster" if

the water velocity in the crossing is moving faster from that found in the stream, and "no, significantly slower" if the velocity is slower compared to the natural stream channel.

Upstream Data

Structure opening partially obstructed by: Circle all the types of material that are obstructing any part of the structure's opening.

Wood = Woody material such as logs, branches, and trees
Sediment = Soil and rocks, typically transported and deposited by the stream.
Note: *If the entire culvert bottom is filled with sediment, this is not considered an obstruction of the structure opening. The retention of sediment throughout the length of a culvert usually facilitates the passage of fish and wildlife through the structure and is an indication that the structure is maintaining sediment transport. Only record sediment as an obstruction if it fills some of the structure opening* <u>*and*</u> *results in a drop of the water flow down into the culvert.*
Deformation (culvert only) **=** Crushed, bent, or broken structure covering structure opening
Failure of bridge (bridge/arch only) **=** Part or all of the structure has collapsed and is now blocking the upstream opening
None = No part of structure opening is covered
Other: If none of the choices are appropriate, record the type of blockage

Steep riffle present immediately upstream of structure: Indicate yes or no whether a steep riffle spans or nearly spans the cross-section of the stream immediately upstream of the structure opening. Steep riffles are a wedge of sediment that has deposited across the stream as a result of the backwater that occurs during high water events at inadequately sized structures. Steep riffles located just upstream of the structure opening are not recorded as an obstruction of the opening and they may not appear as a mid-channel bar, however they are indicative of a depositional process that is being caused or exacerbated by the structure, similar to the process that leads to the formation of a mid-channel bar.

If channel avulses: Looking upstream, imagine the stream flowing up and out of the channel at the structure due to an obstruction, high flows, or both. Before eventually re-entering the channel at some point downstream, will the stream flow:

Cross Road = Re-entering the channel immediately downstream of the structure. This typically occurs when the road approaches are higher in elevation than the road surface at the crossing;
Follow Road = Traveling down the ditch or shoulder of the road for a distance before leaving the road vicinity and traveling overland to re-enter the stream channel.
If the "Follow Road" option is chosen, **estimate in feet the distance the stream would follow the road** before reentering the stream channel.
Unsure = The topography in the vicinity of the crossing is too subtle to ascertain whether the stream will cross the roadway immediately returning to the channel or follow the road for some distance before re-entering the channel.

Angle of stream flow approaching structure: Circle the type of angle that best describes the way that the stream flow is entering the structure.

Sharp bend = Severe angle of entry, 45 to 90 degree bend
Mild bend = Gentle angle of entry, 5 to 45 degree bend
Naturally straight = flow enters the structure straight-on with no channelization evident
Channelized straight = Channel was modified to a straight planform and flow enters the structure straight-on. Indicators of channelization include: armored streambanks, channel just upstream of straightened section is naturally sinuous, or documentation of past channel-straightening activities.

Culvert Inlet: Circle the descriptor that best describes the water surface profile as it enters the inlet of the culvert:

At grade = The culvert inlet is at or below the streambed surface, and the streambed <u>directly</u> upstream of the culvert inlet is of a gradient typical to the channel at the structure site. If the channel directly upstream of the structure inlet is much steeper than the typical channel gradient at the site, then the inlet condition should be described as a cascade.

Cascade = The culvert inlet is below the stream bed surface and the flow spills into the culvert from a steep section of rip rap or stream bed (typically bedrock or large boulders). To be considered a cascade, the streambed directly upstream of the culvert inlet should be substantially steeper than the general stream gradient at the structure site. Stream flow over the cascade may be sheet flow (as in over bedrock) or dispersed flow (as in splashing off riprap or large boulders). Typically, steep riffles composed of cobble and/or gravel are not considered cascades. The following must also be true to classify a cascade:

- Cascade must extend ≥ 1 foot in length beyond the culvert invert, measured longitudinally along the cascade.
- Flow exiting the culvert must drop < 1 foot before hitting the cascade below. Flows dropping ≥ 1 ft. before hitting a cascade are considered "free fall" (see below).

Free fall = The invert of the culvert inlet is below the stream bed surface and the flow spills vertically into the culvert down to the water surface (commonly referred to as a "perched" culvert). If the flow falls vertically into the culvert outlet and then hits a cascade, it is still considered "free fall" if the vertical drop from the outlet invert to the streambed (cascade) below is ≥ 1 foot.

Upstream bankfull widths: Record the bankfull width directly upstream of the crossing in the area that has the potential to be within the influence of the culvert. Generally, this will be from the crossing upstream to a point at which the top of the crossing is at the same elevation as the streambed, but this can vary especially for relatively tall bridges. Bankfull width will be measured across the channel at the bankfull flow elevation, which is considered to be the flood height that occurs on an annual to biannual basis. Additional bankfull widths should be measured so that a total of three (with 5 preferred) are collected upstream of the crossing. The second bankfull width measurement should be collected ½ bankfull width upstream of the first measurement. Continue spacing the width measurements ½ bankfull width upstream of the previous measurement until the total number (3 or 5) is collected.

Reference bankfull widths: Record the bankfull width of the **reference** channel (i.e., far enough upstream of the crossing such that there are no apparent effects on sediment transport from the existence of the crossing). Once the upstream bankfull widths are collected, proceed upstream 1 width from the last upstream bankfull width measurement collected. Then, space the remaining reference bankfull widths so that they are ½ bankfull width apart until a minimum of three have been collected, although 5 are preferred.

Downstream Data

Water depth in culvert (at outlet) (culvert only)**:** At the culvert invert, measure the depth of the water in the culvert to the nearest tenth of a foot.

Culvert outlet (culvert only)**:** Circle the descriptor that best describes the water surface profile as it exits the outlet of the culvert:

At grade = The invert of the culvert outlet is at or below the streambed surface, and the streambed directly downstream of the culvert outlet is of a gradient typical to the channel at the structure site. If the channel directly downstream of the structure outlet is much steeper than the typical channel gradient at the site, then the outlet condition should be described as a cascade.

Cascade = The invert of the culvert outlet is above the stream bed surface and the flow spills out of the culvert onto a steep section of rip rap or stream bed (typically bedrock or large boulders). To be considered a cascade, the streambed directly downstream of the culvert outlet should be substantially steeper than the general stream gradient at the structure site. Stream flow over the cascade may be sheet flow (as in over bedrock) or dispersed flow (as in splashing off riprap or large boulders). Typically, steep riffles composed of cobble and/or gravel are not considered cascades. The following must also be true to classify a cascade:

- Cascade must extend ≥ 1 foot in length beyond the culvert invert, measured longitudinally along the cascade.
- Flow exiting the culvert must drop < 1 foot before hitting the cascade below. Flows dropping ≥ 1 ft. before hitting a cascade are considered "free fall" (see below).

Free fall = The invert of the culvert outlet is above the stream bed surface and the flow spills vertically out of the culvert down to the water surface (commonly referred to as a "perched" culvert). If the flow falls vertically from

the culvert outlet and then hits a cascade, it is still considered "free fall" if the vertical drop from the outlet invert to the streambed (cascade) below is ≥ 1 foot.
Backwatered: Measure in feet the distance that the crossing outlet is backwatered.

Stepped Footers (culvert only)**:** Indicate yes if there is evidence that more than one set of footers was poured (out of concrete) or constructed to support the bridge abutments or arch. Stepped footers that are poured of concrete have the appearance of a stair step. Footers are retrofitted in this way in an attempt to stop the failure of the structure due to streambed scour around and below the structure that occurs after initial installation of the structure.

Outlet drop (invert to water surface) (culvert only)**:** With a depth rod, measure the vertical distance to the nearest tenth of a foot from the outlet invert to the water's surface at the time of survey. If the culvert flow spills onto a cascade, measure the vertical distance from the outlet invert to the water's surface directly downstream of the cascade.

Pool present immediately downstream of structure: Circle yes or no to indicate if a pool is directly below the outlet of the structure. If the structure is a culvert that flows onto a cascade (as defined above) then answer "no" to this question.

Pool depth at point of stream flow entry (applicable only if a pool is present directly below the outlet): At the point where the streamflow enters the pool, measure the depth from the water surface to the stream bed to the nearest tenth of a foot.

Maximum pool depth (applicable only if a pool is present directly below the outlet): At the point of maximum pool depth, estimate the pool depth. If the estimated depth is less than four feet measure the distance from the water surface to the stream bed to the nearest tenth of foot. If the estimated depth is greater than four feet simply record it as such.

Downstream bank heights are substantially higher than upstream bank heights: Circle yes or no to indicate whether streambank heights downstream of the structure are greater than bank heights upstream of the structure. This parameter is designed to measure whether erosion has occurred downstream of the structure, and should be considered as relative to the streambed. If bank heights are higher downstream as compared to upstream, ensure that the form of the banks is similar to that observed upstream. For example, if a bank is high and comprised of a bedrock outcrop downstream that was not observed upstream, then it is possible that the difference in height may be caused by natural features as opposed to erosion caused by the culvert. In such cases, the presence of such features should be noted by marking this beside this parameter on the form.

Hydraulic control type: Circle the type of hydraulic control at the downstream end of the outlet pool.

Distance from downstream end of culvert/bridge to hydraulic control: Essentially, this is the pool length, and is measured in feet.

Evidence of streambed erosion or aggradation immediately downstream of culvert/bridge: Circle the appropriate choice. This is for the entire streambed, not isolated features that may be a single pool or point bar.

Downstream bankfull widths: Record the bankfull width directly downstream of the crossing. Additional bankfull widths should be measured so that a total of three (with 5 preferred) are collected downstream of the crossing. The second bankfull width measurement should be collected ½ bankfull width downstream of the first measurement. Continue spacing the width measurements ½ bankfull width downstream of the previous measurement until the total number (3 or 5) is collected.

Upstream - Downstream - In Structure Table

Completing the Upstream/Downstream/In Structure table on the field form requires evaluating the channel and riparian area adjacent to the structure. In general, consider an area extending 100 feet upstream or downstream from the structure..

Size Class	Name	Millimeters	Inches	Relative Size
0	**None**	Applies to culverts where the absence of natural stream substrates within the culvert is the dominant condition		
1	**Bedrock**	> 4096	> 160	Bigger than a Volkswagen Bug
2	**Boulder**	256 – 6	10.1 – 160	Basketball to Volkswagen Bug
3	**Cobble**	409 64 – 256	2.5 – 10.1	Tennis ball to basketball
4	**Gravel**	2 – 64	0.08 – 2.5	Pepper corn to tennis ball
5	**Sand**	< 2.00	< 0.08	Silt size to pepper corn
6	**Silt/Clay**	<.062	<.002	Smaller than sand
UNK	**Unknown**	Applies when the stream bed is not visible due to deep or turbid water or darkness within the structure		

Dominant bed material at structure: Circle the sediment size class that covers the majority of the stream bed area upstream of, downstream of, and within the structure. If the streambed is not visible, choose "UNK" for unknown. If larger materials are embedded with fine sediment, such as cobbles embedded with silt-sand, record the dominant bed material as cobble even if the silt-sand fraction seems to be in equal proportion to the cobble.

Bedrock present: Circle "yes" or "no" whether there is any bedrock visible in the channel upstream or downstream of the structure. For bridge and arches also note if there is any bedrock within the crossing.

Depth of substrate (culvert only)**:** Circle the appropriate choice. Circle "UNK" for unknown if it is not possible to determine the substrate depth.

Sediment deposit types: Circle the type of sediment deposits observed upstream of, downstream of, and within the structure.

Mid-Channel bar = Areas of sediment deposition (bars) built up above the streambed elevation of the nearby area, located in the channel away from the banks and generally found in areas where the channel runs straight
Point bar = Bars that are adjacent to the bank typically occurring on the inside edge of meander bends
Delta bar = Sediment deposits where a tributary enters a mainstem channel, often fan-shaped
Side bar = Unvegetated sediment deposits located along the margins of the channel in locations other than the inside of channel meander bends (not point bars)
None = No sediment deposits observed

Elevation of sediment deposits is greater than or equal to ½ bankfull elevation: Circle yes or no whether sediment deposits observed upstream, downstream, and within the structure fill the channel to an elevation that is greater than or equal to half of the bankfull elevation. In locations where this is not applicable, such as in a reach that is dominated by wetland features, "N/A" should be circled.

Substrate throughout (culvert only): Indicate yes or no whether sediment material is present on the bottom surface of the culvert.

Beaver dam near structure: Indicate yes or no whether a beaver dam is located within 100 feet upstream or downstream of the structure.

Distance from structure to beaver dam: Enter the estimated distance, in feet, from the structure opening to the beaver dam.

Hard bank armoring: If hard bank armoring is present, circle the general condition of the armoring observed upstream and downstream of the structure. If armoring is not present, circle "none".

Intact = Hard bank armoring is not falling into stream, there are few missing or out of place pieces of armoring material
Failing = Parts of the hard bank armoring are falling into the stream, missing, or out of place
None = No hard bank armoring present
Unknown (UNK) = Unable to assess the condition or presence of hard bank armoring

Bank erosion: Circle the degree of bank erosion observed upstream and downstream of the structure. Note that raw substrate occurring below the bankfull elevation is not considered erosion, unless associated with active bank failures, fractures, slabbing or undercutting.

High = Nearly continuous erosion along banks, especially on medium to high banks
Low = Occasional erosion along banks, mostly found on low banks
None = No bank erosion evident

Streambed scour causing undermining around/under structure: Circle the structure or part of structure that is affected by scour. Scour is the erosive action of running water in streams, which excavates and carries away material from the bed and banks. Indicators of scour are: exposed areas of structure that are typically covered by stream bed material (e.g., bridge footings), leaning or hanging structures, water visibly flowing under or to the side of the inlet of a culvert, and deep water along one or both sides of a bridge or arch when the bed feature through the structure is a riffle.

Culvert (culvert only) **=** Structure that supports a roadway over a water body by means of a complete pipe or box embedded in fill that **always** has a constructed bottom and does **not** have abutments or piers.
Abutments (bridge/arch only) **=** Bridge end support structures
Footers = Support structures under bridge abutments, the ends of an arch, or the invert of a culvert
Wing walls = Concrete, wooden, or metal walls that flare out from the side of the opening of the bridge, arch, or culvert
None = No scour is seen around/under structure

Wildlife Data

Dominant vegetation type: Record the dominant type of vegetation in the riparian area on the upstream left and right banks and the downstream left and right banks (left and right banks are determined facing downstream). For this evaluation consider an area extending 100 ft. along the stream from the end of the structure and 100 ft. out from the top of the bank.

Vegetation Types Codes
C = coniferous forest
D = deciduous forest
M = mixed forest
S = shrub/sapling
H = herbaceous/grass
B = bare
R = road embankment

Does a band of shrub/forest vegetation that is at least 50' wide start within 25' of structure and extend 500'or more up/downstream? Record yes or no for both upstream and downstream banks of the structure to indicate whether a continuous wooded riparian area (dominated by trees and/or shrubs) that is at least 50 feet wide (extending from the top of bank out perpendicular to the stream) begins within 25' of the structure edge and continues for 500 feet or more along the stream edge. Such wooded areas along streams are often used as travel corridors for some wildlife species. The purpose of this parameter is to determine whether the structure is located in an area that abuts potentially viable wildlife travel corridors.

Road-killed wildlife within ¼ mile of structure? Indicate whether or not you observed dead wildlife along or adjacent to the road within a ¼ mile of the structure by circling **none** on the field form if no road-killed wildlife was observed or by

listing the **species** of road-kill observed. This does not have to be an intensive survey in the road ditches or down the embankments, but rather a documentation of any road kills observed by chance in the course of accessing the structure and conducting the rest of the assessment.

Record "unsure" if you do not know the species or if you cannot identify the species due to damage and/or decay. Multiple recordings are possible in the database by simply recording all the species observed.

Wildlife sign and species observed near (up/downstream) and inside structure? Record any visible wildlife sign outside of the structure (either upstream or downstream) and inside the structure. If there was no wildlife observed throughout the course of conducting the assessment, circle (none). Consider an area extending 100 feet upstream and downstream of the structure on both right and left banks, including the channel bed and banks. This does not have to be an exhaustive survey, but rather a documentation of any wildlife sign observed in the course of conducting the assessment. If you are experienced in identifying wildlife signs, record the species that made the sign. If you do not know the species write, "unsure".

Spatial data collected with GPS: Circle yes or no to indicate whether or not spatial data was collected with a GPS unit to document the location of the structure. Circle yes here if you are actually collecting data points and planning to process the data to create a spatial data layer. Do not circle yes if you are only using a GPS unit to determine latitude and longitude for the purposes of completing the field form header.

Photos taken: Circle yes or no to indicate whether or not photos were taken at the site. Taking photos is required**.** Record the filenames of the photos from the camera.

Photo log: Record the filenames of the photos from the camera, in the appropriate spaces within the table. Place a checkmark in each box to show that the task was completed. The following photo views are required:

- Upstream view of stream above structure
- Downstream view of stream above structure
- Upstream view of structure inlet
- Downstream view of structure inlet
- Upstream view of structure outlet
- Downstream view of structure outlet
- Evidence of wildlife use
- Any features or parameters on the field form that you have questions about or are not sure how to answer

Be sure to include scale in your photos, such as a person or a depth rod, especially when photographing the structure openings.

Comments/Drawings: This space provides an opportunity to note observations about the site that have not been captured by the other parameters.

Space is provided to draw site sketches of the following:

1) looking upstream into the culvert,
2) looking downstream into the culvert, and
3) a plan view of the site.

The intent is to provide information on the general nature of the overall features you see from these perspectives. This information is very important in the QA process when the data is entered into electronic form.

Crossing Dimensions

Bridges and Arches

1. Open Bottom Arch will look like a pipe culvert on the top half, but you will not see a bottom half. Instead for the bottom, it has metal footings that are sunk into concrete below the stream channel.
2. Bridge with Abutments will have sides at right angles, but no bottom structure.
3. Bridge with Side Slopes will have angled sides, and no bottom structure.
4. Bridge with Side Slopes & Abutments will have both sloping sides as well as sides at right angles to give the bridge height over the stream.

Ford is a shallow water crossing directly across the streambed, often with logs, stone, or gravel to protect or stabilize the bottom. These are rare, and are mostly found on roads that are not frequently used.

Culverts

1. Round Culvert will be a circular pipe.
2. Elliptical Culvert will have a wider, squashed look than a round pipe culvert.
3. Box Culvert will usually be made of concrete.
4. Embedded Round Culvert means that the culvert is partially buried below the stream channel so that natural sediment will flow through and you won't see the bottom of the culvert.
5. Embedded Elliptical Culvert Also known as a "pipe arch" this is an elliptical culvert where the bottom has been buried below the stream channel.

Ford is a shallow water crossing directly across the streambed, often with logs, stone, or gravel to protect or stabilize the bottom. These are rare, and are mostly found on roads that are not frequently used.

Crossing Type – Choose the most appropriate choice of bridge/arch or culvert you are assessing, or Ford that describes the type of crossing.

Upstream/Downstream Dimensions (ft.): Provide the measurements shown in the appropriate diagram for the crossing type. (**If measurements cannot be taken, please estimate and write EST. after estimated measurement**).

A. Measure interior width of crossing.
B. Measure height from underside of crossing to water surface. (Measure to stream bottom if there is no flow.)
C. Measure width of actual stream channel (wetted width) through crossing structure if natural bottom exists (i.e. bridges or embedded culverts).
D. Measure height of vertical abutments from underside of bridge to where sides start sloping.

Length of stream through crossing (ft.): Measure the crossing from inlet to outlet by walking through it if it is large enough and safe. If walking through culvert is not possible, then hold measuring tape at inlet and let current carry it to outlet where someone else catches it and measures the length. Another option is to stand on top of it and measure length along road.

Crossing slope (%):
For Bridges, enter the slope of the streambed through the structure.
For culverts, record the slope from inlet to outlet

For multiple culvert/bridge crossings:
When inventorying multiple culverts at one site, label left culvert/bridge #1 and go in increasing order from left to right, from downstream end (outlet) looking upstream.

Appendix B - Fish Groups

Coarse Filter A (Coffman, 2005)

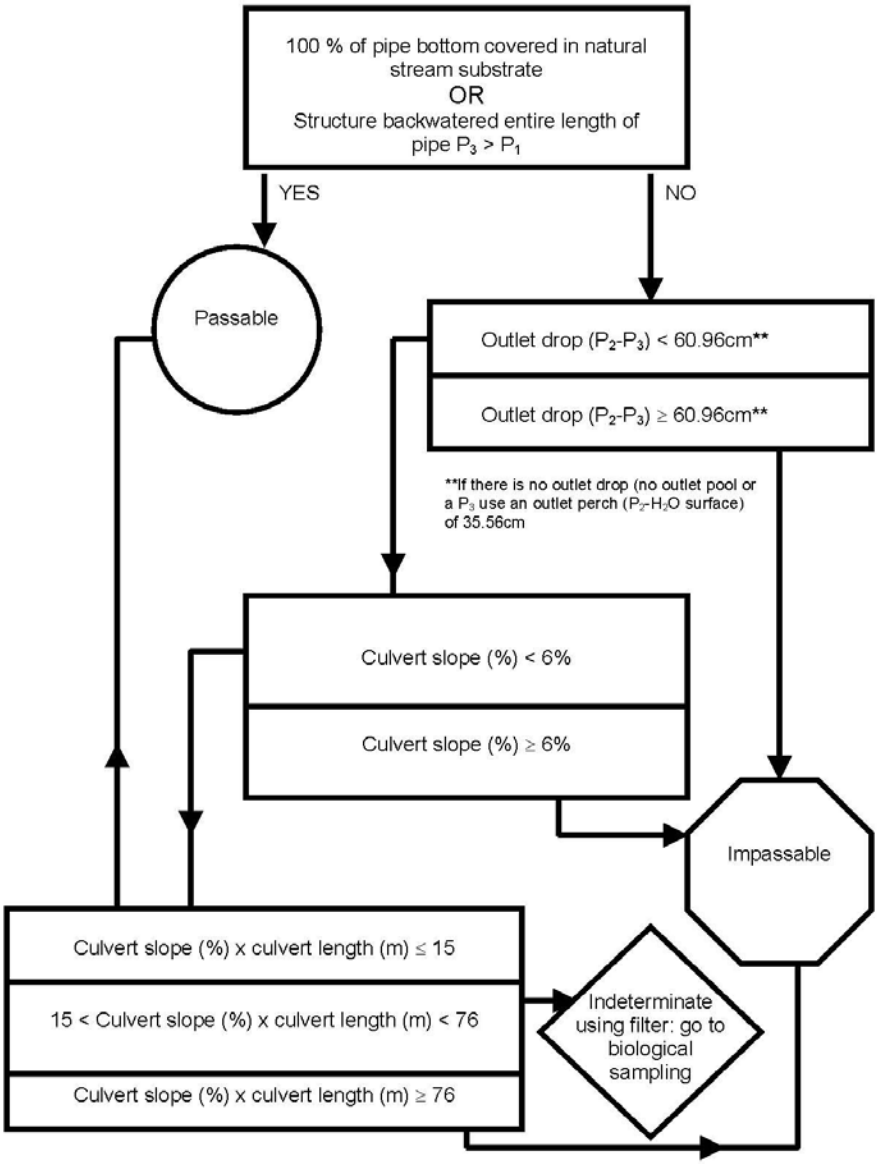


Figure 1.2. Upstream fish passage predictive model A for Salmonidae. See Figure 1.1 for profile of survey points used in fish passage predictive model. P_n = elevation measurements.

Coarse Filter B (Coffman 2005)

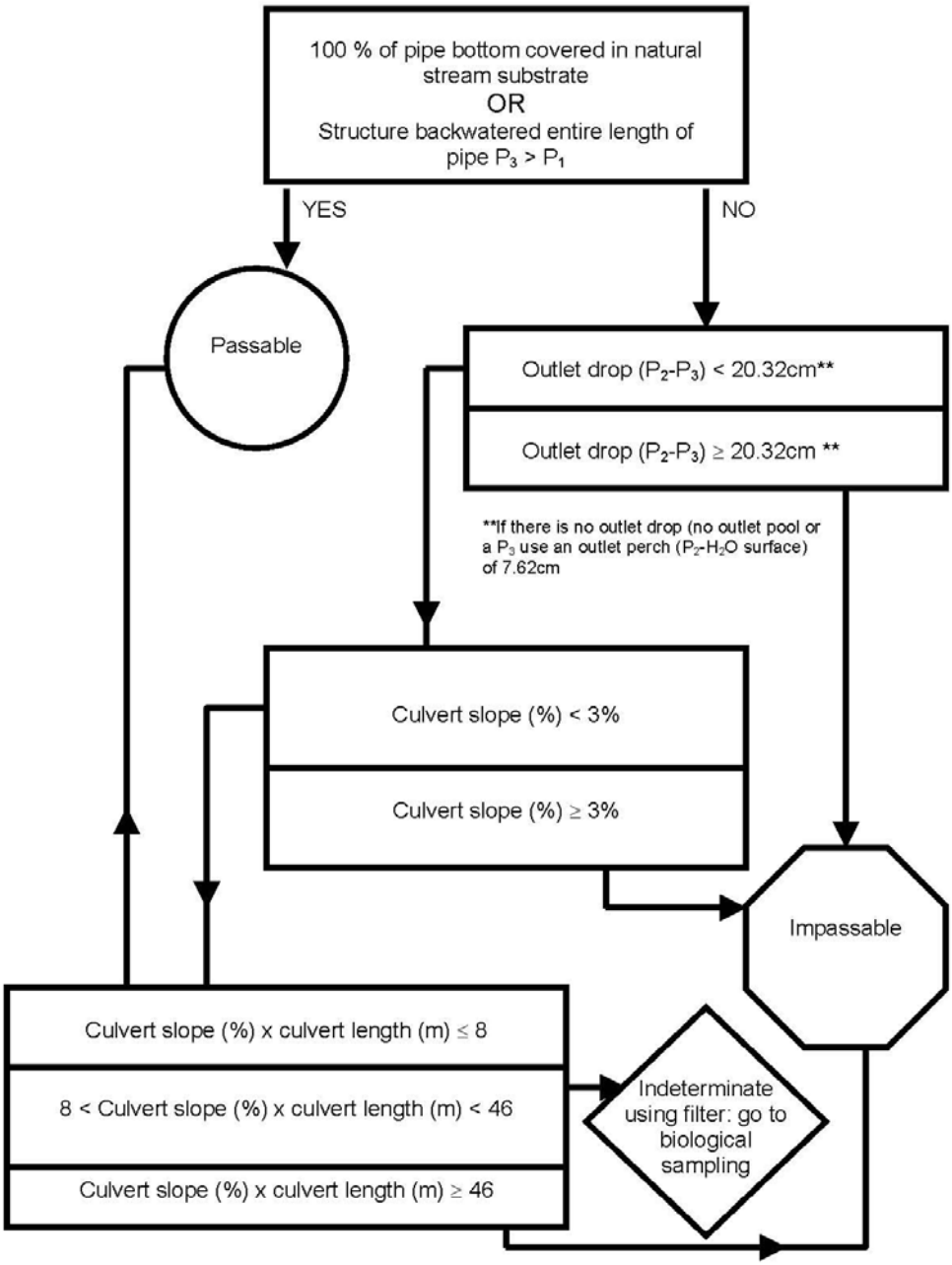


Figure 1.3. Upstream fish passage predictive model B for Cyprinidae and young-of-year Salmonidae. See Figure 1.1 for profile of survey points used in fish passage coarse filter. P_n = elevation measurements.

Coarse Filter C (Coffman 2005)

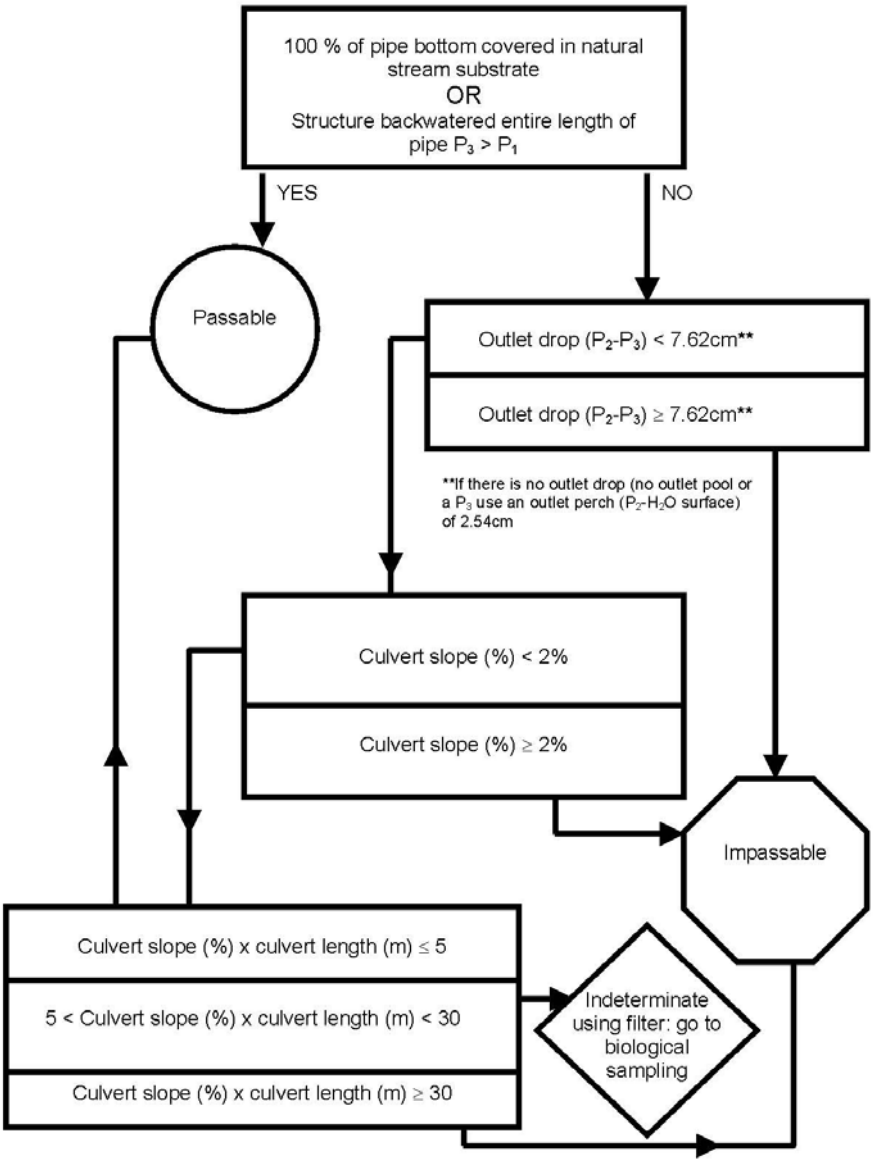
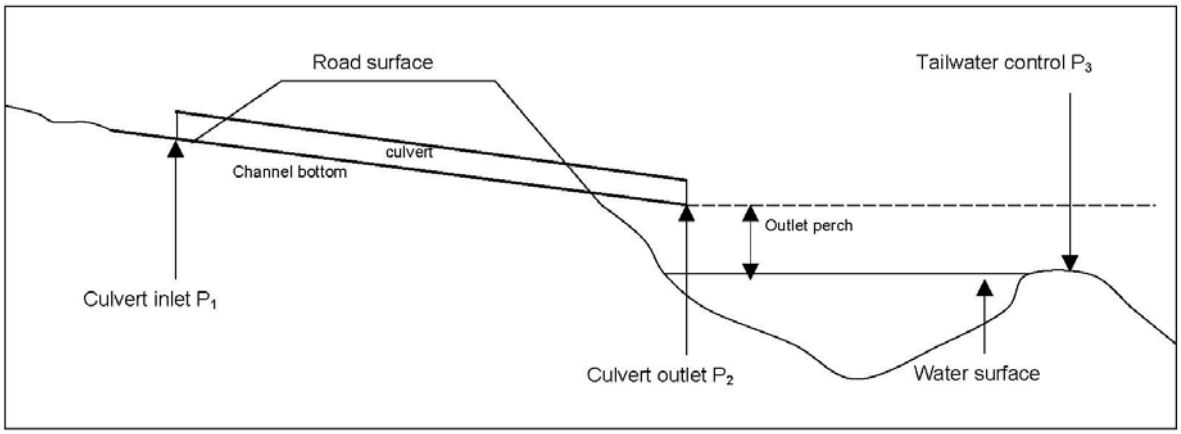


Figure 1.4. Upstream fish passage predictive model C for Percidae (except *Stizostedion sp.*, and *Perca flavescens*), and Cottidae families. See Figure 1.1 for profile of survey points used in fish passage coarse filter. P_n = elevation measurements.



Profile of survey points used in fish passage coarse filters A, B, and C. Distance and elevation is measured (in feet) for each location point designated by Pn. Adapted from Clarkin, K., et al. 2003. National inventory and assessment procedure for identifying barriers to aquatic organism passage at road-stream crossings. USDA Forest Service, San Dimas Technology and Development Center. San Dimas, CA. (From Coffman 2005)

Appendix C. Pictures of example crossings.

Crossing restricts the natural width of the channel leading to a wide area just downstream of the crossing.

Example of a perched culvert with plunge pool immediately downstream.

Undersized culvert that is largely filled with sediment, reducing its hydraulic capacity.

Bridge with no visible geomorphic impact on the channel. Channel slope is approximately 4% with very large boulders.

Very large box culvert under Route 9. Outlet drop is at least 6 feet.

Perched culvert with outlet drop of 6 inches, which is impassable to Group C fish.